

C O N T E N T S

	page
1) Mineral Production of India during 1917 by H.H.Hayden. Vol.49 Pt.2 1918.	55-116
<i>XO (DB) : 2.2sh, M E7</i>	
2) Support of the Mountains of Central Asia (Being an Appendix to the memoir on the Structure of the Himalayas, and of the Gangetic Plain, as Elucidated by Geodetic Observations in India by R.D.Oldham. Vol.49 Pt.2 1918.	117-136
<i>4136. A</i>	
3) General Report of the Geological Survey of India for the year 1918 by H.H.Hayden. Vol.50 Pt.1 1918.	1-27
<i>H. 2 ✓</i>	
4) Potash Salts of the Punjab Salt Range and Kohat by Murray Stuart. Vol.50 Pt.1 1919.	28-56
<i>XO (H1712) - 236</i>	
5) Suggestions Regarding the Origin and History of the Rock-Salt Deposits of the Punjab and Kohat by Murray Stuart. Vol.50 Pt.1 1919.	57-99
<i>X H14 - 236</i>	
6) On Pitchblende, Monazite and Other Minerals from Pichhli, Gaya District, Bihar and Orissa by G.H.Tipper. Vol.50 Pt.4 1919.	255-266
<i>H11. 25</i>	
7) Natural Gas in Bituminous Salt from Kohat by Murray Stuart. Vol.50 Pt.4 1919.	263-266
<i>H1193. 235/1</i>	
8) Mineral Resources of the Central Provinces by L. Leigh Fermor. Vol.50 Pt.4 1919.	268-300
<i>H1113. 271</i>	
9) Miscellaneous Note: Note on Sipylite from the Nellore District, Madras Presidency by G.H.Tipper.	303
<i>H1142. 212</i>	
10) Mineral Production of India during 1919 by E.H.Pascoe. Vol.51 Pt.3 1921.	159-222
<i>XO (DB) : 2.2m, M E</i>	
11) Results of a Revision of some Portions of Dr. Noetling's Second Monograph on the Tertiary Fauna of Burma by E. Vredenburg. V.51 Pt.3 1921.	224-300
<i>H6. 252. A.1</i>	
12) Note on the Marine Fossils collected by Mr. Pinfold in the Garo Hills by E. Vredenburg. Vol.51 Pt.3 1921.	303-333
<i>H6. 261. A.1</i>	

C O N T E N T S.

1. Records of Geological Survey of India  
H. 2cm, M70 1918 Vol. XLIX. Part II.
2. do. " 1919 Vol. L. Part I.
2. do. " 1919 Vol. L. Part IV.
4. do. " 1921 Vol. LI. Part III.

annual returns are available—is gradually increasing, and it is hoped that before long the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will be reduced to a very small number. In the case of minerals still exploited chiefly under primitive native methods and thus forming the basis of an industry carried on by a large number of persons each working independently and on a very small scale, the collection of reliable statistics is impossible, but the total error from year to year is not probably approximately constant and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible.

From table I it will be seen that there has been an apparent increase of nearly £1½ million or 12½ per cent. in the value of the total production over that of 1916. The value figures, however, are largely artificial. In some instances although the output has fallen in quantity, it has increased in value; such increase does not necessarily give a true indication of the state of an industry, since the prevailing high freights and increased cost of production have in certain cases resulted in the closing down of all but high-grade propositions.

The number of mineral concessions granted during the year amounted to 574 as against 532 in the preceding year; 515 of these were prospecting licenses and 39 mining leases. As in the preceding year, most of the increase is due to prospecting activity in Lower Burma

TABLE 1.—*Total value of Minerals for which returns of Production are available for the years 1916 and 1917.*

Mineral.	1916.	1917.	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Coal . . . . .	3,878,564	4,511,645	633,081	...	+16·3
Gold . . . . .	2,303,023	2,221,889	...	81,134	-3·5
Manganese-ore . . . . .	1,487,026	1,501,080	14,054	...	+·9
Petroleum . . . . .	1,119,405	1,092,964	...	26,441	-2·4
Salt . . . . .	728,358	983,157	254,799	...	+34·9

TABLE 1.—Total value of Minerals for which returns of Production are available for the years 1916 and 1917—contd.

Mineral.	1916.	1917.	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Tungsten-ore . . .	497,397	623,074	125,677	...	+25.3
Saltpetre . . .	607,488	527,666	...	79,822	-13.1
Lead and Lead-ore . . .	428,383	510,539	82,156	...	+19.1
Mica(a) . . .	311,680	508,173	196,493	...	+63
Building materials and road metal . . .	209,334	249,776	40,442	...	+19.3
Silver . . .	88,687	237,216	148,529	...	+167.5
Tin-ore and tin . . .	39,302	66,533	27,231	...	+69.3
Jadestone(a) . . .	48,926	67,502	18,576	...	...
Monazite . . .	37,714	56,489	18,775	...	+50
Ruby, sapphire and spinel . . .	37,513	51,831	14,318	...	+38.2
Iron-ore . . .	37,981	39,977	1,996	...	+5.2
Copper-ore . . .	3,259	30,162	26,903	...	+825.5
Chromite . . .	16,401	26,216	9,815	...	+59.8
Magnesite . . .	14,065	14,559	494	...	+3.5
Clay . . .	4,645	9,019	4,374	...	+94.1
Steatite . . .	2,628	6,470	3,842	...	+146.2
Corundum . . .	2,783	3,874	1,091	...	+39.2
Alum . . .	6,205	3,707	...	2,498	-40.3
Diamond . . .	361	1,826	1,465	...	+405.8
Ochre . . .	941	1,630	689	...	+73.2
Gypsum . . .	745	1,034	289	...	+38.8
Amber . . .	157	684	527	...	+335.7
Molybdenite . . .	202	626	424	...	+209.9
Bauxite . . .	463	620	157	...	+33.9
Graphite . . .	1,501	547	...	954	-63.5
Asbestos . . .	...	303	303	...	...
Agate . . .	783	255	...	528	-67.5
Bismuth . . .	...	163	163	...	...
Antimony-ore . . .	503	139	...	364	-72.4
Platinum . . .	46	19	...	27	-58.7
<b>Total</b> . . .	<b>11,916,469</b>	<b>13,351,364</b>	<b>1,626,663</b>	<b>191,768</b>	<b>+12.4</b>
			+1,434,895		

(a) Export values.



## II.—MINERALS OF GROUP I.

Chromite.	Gold.	Lead.	Monazite.	Salt.
Coal.	Graphite.	Magnesite.	Petroleum.	Saltpetre.
Copper.	Iron.	Manganese.	Platinum.	Silver.
Diamonds.	Jadeite.	Mica.	Ruby, Sapphire and Spinel.	Tin. Tungsten.

**Chromite.**

The remarkable rate of increase in the production of chromite recorded in the preceding year was not maintained in 1917. There was, however, an increase of over 34 per cent. in the output. This was due almost entirely to operations in Baluchistan, where the output was more than doubled. There was a slight increase in the Singhbhum production, and a decrease in Mysore.

TABLE 2.—*Quantity and Value of Chromite produced in India during 1916 and 1917.*

	1916.		1917.	
	Quantity	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
Baluchistan . . . . .	7,620	7,620	15,659	15,659
Bihar and Orissa . . . . .	2,737	2,495	3,266·4	3,111
Mysore . . . . .	9,802	6,286	8,136	7,446
<b>Total</b> . . . . .	<b>20,159</b>	<b>16,401</b>	<b>27,061·4</b>	<b>26,216</b>

**Coal.**

There was an increase of nearly a million tons or 5½ per cent., and a proportionately greater increase in value —16·3 per cent.—in the output of coal. The pit's mouth value increased largely everywhere, except in the case of Hyderabad. There was an increase of Rs. 9 per ton in pit's mouth value in the North-West Frontier Province, but as the output is less than 100 tons, the figures for that province may be left out of consideration. In the fields of Bengal and Bihar and Orissa, the rates of increase were respectively Re. 0-6-4 and Re. 0-6-0 per ton.

TABLE 3.—*Average price (per ton) of Coal extracted from the Mines in each province during the year 1917.*

Province.	Average price per ton.		
	Rs.	A.	P.
Assam . . . . .	7	0	7
Baluchistan . . . . .	11	0	11
Bengal . . . . .	3	15	1
Bihar and Orissa . . . . .	2	5	10
Central India . . . . .	3	6	2
Central Provinces . . . . .	4	1	3
Hyderabad . . . . .	6	0	0
North-West Frontier Province . . . . .	14	0	0
Punjab . . . . .	7	8	8
Rajputana . . . . .	4	5	8

TABLE 4.—*Origin of Indian Coal raised during 1916 and 1917.*

	Average of last five years.	1916.	1917.
Gondwana Coalfields . . . . .	15,937,670	16,863,466	17,814,524
Tertiary Coalfields . . . . .	409,700	390,843	398,394
Total . . . . .	...	17,254,309	18,212,918

There was a fall of over 50 per cent. in the amount of coal exported, and a small rise in imports. The total amount of coal, coke and patent fuel imported, however, was only 37,626 tons. The quantity exported was 408,117 tons against nearly 882,000 tons in 1916.

There was a general increase in the output of coal in most provinces, with the exception of Baluchistan, Bengal, Central India and Rajputana. The decrease in Bengal amounted to nearly 361,000 tons; Bihar and Orissa, on the other hand, shows an increase of over a million tons, the Central Provinces nearly 84,000 tons, and Hyderabad over 65,000 tons. The decrease in the output of the Bikaner coalfield in Rajputana amounted to more than 50 per cent. as compared with the preceding year.

TABLE 5.—*Provincial Production of Coal during the years 1916 and 1917.*

Province.	1916.	1917.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Assam . . . . .	287,315	301,480	14,165	...
Baluchistan . . . . .	42,163	40,785	...	1,378
Bengal . . . . .	4,992,376	4,631,571	...	360,805
Bihar and Orissa . . . . .	10,767,683	11,932,419	1,164,736	...
Burma . . . . .	200,285	198,407	...	1,878
Central India . . . . .	287,832	371,498	83,666	...
Central Provinces . . . . .	615,290	680,629	65,339	...
Hyderabad . . . . .	75	215	140	...
North-West Frontier Province . . . . .	47,449	49,869	2,420	...
Punjab . . . . .	13,841	6,045	...	7,796
Rajputana (Bikaner) . . . . .	...	...	...	...
<b>Total</b> . . . . .	<b>17,254,309</b>	<b>18,212,918</b>	<b>1,330,466</b>	<b>371,857</b>

TABLE 6.—*Output of the Gondwana Coalfields for the years 1916 and 1917.*

Coalfields.	1916.		1917.	
	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.
<i>Bengal, Bihar and Orissa—</i>				
Daltonganj . . . . .	76,298	·44	79,627	·44
Giridih . . . . .	866,055	5·02	824,007	4·52
Jaintia . . . . .	75,089	·44	86,894	·48
Jharia . . . . .	8,950,318	51·87	9,783,788	53·72
Bokaro-Ramgarh . . . . .	197,255	1·14	360,760	1·98
Raniganj . . . . .	5,535,307	32·09	5,376,022	29·52
Sambalpur (Hingir-Ram-pur). . . . .	59,737	·35	52,892	·29
<i>Central India—</i>				
Umaria . . . . .	200,285	1·16	198,407	1·09
<i>Central Provinces—</i>				
Ballarpur . . . . .	84,889	·49	95,303	·52
Pench Valley . . . . .	154,548	·9	204,502	1·12
Mohpani . . . . .	48,395	·28	71,693	·39
<i>Hyderabad—</i>				
Singareni . . . . .	615,290	3·56	680,629	3·74
<b>Total</b> . . . . .	<b>16,863,466</b>	<b>97·74</b>	<b>17,814,524</b>	<b>97·81</b>

TABLE 7.—Output of Tertiary Coalfields for the years 1916 and 1917.

Coalfields.	1916.		1917.	
	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.
<i>Assam—</i>				
Makum . . . . .	283,830	1.66	291,484	1.65
Naga Hills . . . . .	3,135		8,906	
Sibsagar . . . . .	...		915	
Khasi and Jaintia Hills . . . . .	350		175	
<i>Baluchistan—</i>				
Khost . . . . .	32,995	.19	29,517	.22
Sor Range . . . . .	9,168	.05	11,268	
<i>North-West Frontier Province—</i>	75		215	
<i>Punjab—</i>				
Jhelum . . . . .	44,944	.28	40,322	.29
Mianwali . . . . .	817		2,916	
Shahpur . . . . .	1,688		6,631	
<i>Rajputana—</i>				
Bikaner . . . . .	13,841	.08	6,045	.03
<b>Total . . . . .</b>	<b>390,843</b>	<b>2.26</b>	<b>398,394</b>	<b>2.19</b>

The average number of persons employed daily in the coalfields increased by nearly 11,000 or rather less than 7 per cent. The average output per person employed was 108.88 tons as against 110.21 in the preceding year. The total number of fatal accidents was 172 or 1.02 per thousand persons employed.

TABLE 8.—Average number of persons employed daily in the Indian Coalfields during 1916 and 1917.

Province.	Number of persons employed daily.		Output per person employed.	Number of deaths by accidents.	Death-rate per 1,000 persons employed
	1916.	1917.	1917.	1917.	1917.
Assam . . . . .	2,814	2,952	102.1	24	8.13
Baluchistan . . . . .	1,111	955	42.7	8	8.37
Bengal . . . . .	43,040	38,585	120.03	35	.9
Bihar and Orissa . . . . .	92,053	106,571	111.96	83	.77
Central India . . . . .	1,480	1,244	159.49	1	.8
Central Provinces . . . . .	3,558	4,245	87.51	11	2.59
Hyderabad . . . . .	11,299	11,566	58.84	8	.69
North-West Frontier Province.	7	14	15.35	...	...
Punjab . . . . .	1,049	1,033	48.27	2	1.93
Rajputana (Bikaner) . . . . .	143	107	56.5	..	...
<b>Total</b> . . . . .	<b>156,554</b>	<b>167,272</b>	...	<b>172</b>	...
<b>AVERAGE</b> . . . . .			108.88		1.02

**Copper.**

There was a large increase in the output of copper ore in Singhbhum from 2,173 tons, valued at £3,259, in 1916 to 20,108 tons valued at £30,162 in the year under review. It is hoped that the smelting operations of the Cape Copper Co. will soon result in a considerable increase in output.

TABLE 9.—Production of Copper-ore during 1916 and 1917.

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
<i>Bihar and Orissa—</i> Singhbhum . . . . .	2,173	3,259	20,108	30,162
<i>Burma—</i> Katha . . . . .	498	1,347	...	...
<b>Total</b> . . . . .	<b>2,671</b>	<b>4,606</b>	<b>20,108</b>	<b>30,162</b>

**Diamonds.**

The output of diamonds was again insignificant, being only 18.2 carats. The value (£1,827), however, shows a marked increase over that of the output of the preceding year.

**Gold.**

There was a further decrease amounting to 24,000 oz. in the output of gold. As in the preceding year, this was due chiefly to fall in the Kolar production. There was also a fall of over 5,000 oz. in the Hyderabad fields and of nearly 2,000 oz. in Madras. The output in Singhbhum increased from 864 oz. to 2,462 oz.

TABLE 10.—*Quantity and value of Gold produced in India during 1916 and 1917.*

	1916.		1917.		
	Quantity.	Value.	Quantity.	Value.	Labour
	ozs.	£	ozs.	£	
<i>Bihar and Orissa— Singhbhum</i>	864	3,977	2,462	10,133	119
<i>Burma—</i>					
Myitkyina.	1,901.05	7,289	1,005.55	3,895	} 165
Katha . . .	21.21	85	31.19	113	
Upper Chindwin	46.96	276	42.18	240	
Shwebo . . .	7.41	36	...	...	...
Salween . . .	6	24	...	...	...
<i>Hyderabad</i>	18,657.2	71,577	13,466.7	52,013	1,140
<i>Madras</i> . . . .	22,371	94,789	20,529	87,066	1,768
<i>Mysore</i> . . . .	554,301	2,124,129	536,559	2,067,541	24,531
<i>Punjab</i> . . . .	186.23	810	190.08	857	407
<i>United Provinces</i>	7.63	31	7.31	31	39
<b>Total</b> . . . .	<b>593,369.69</b>	<b>2,303,023</b>	<b>574,293.01</b>	<b>2,221,389</b>	<b>28,169</b>

**Graphite.**

There was a considerable reduction in the production of graphite in Kalahandi, where the output fell from 252 tons, valued at £168, in 1916 to 60.4 tons, valued at £242, in the year under review, while in Rajputana there was a still greater fall from 1,066.4 to 42.3 tons valued at £305.

**Iron.**

There was a small rise in the output of iron-ore. The Tata Iron and Steel Company produced 167,870 tons of pig iron and 114,027 tons of steel including steel rails, while the Bengal Iron and Steel Company produced 80,262 tons of pig and 2,256 tons of cast-iron castings. In the Central Provinces there was a slight increase in the number of indigenous furnaces at work, 312 being operated during the year; at the same time there was a fall in production.

TABLE 11.—Quantity and value of Iron ore produced in India during 1916 and 1917.

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
<i>Bihar and Orissa—</i>				
Singhbhum . . . . .	150,258	10,919	184,815	13,778
Orissa . . . . .	240,918	21,271	195,998.5	17,543
<i>Burma</i> . . . . .	16,081	4,288	28,763	7,670
<i>Central Provinces</i> . . . . .	4,464.3	1,493	3,669	978
<i>Rajputana</i> . . . . .	33.5	9	25	7
<i>United Provinces</i> . . . . .	3	1	2.2	1
<b>Total</b> . . . . .	<b>411,757.8</b>	<b>37,981</b>	<b>413,272.7</b>	<b>39,977</b>

**Jadeite.**

There was a slight increase in the output of jadeite produced in Burma from 3,783.37 cwt. in 1916 to 3,961.28 cwt. in the year under review. There was a very marked increase in the value from £9,315 to £28,931. This increase is attributed to a preponderance in the output of the high-grade qualities used for jewellery and other ornamental purposes.

## Lead.

There was a very large increase in the output of ore from the Bawdwin mines, which rose from about 14,000 tons in 1916 to over 71,000 tons in the year under review. There was not, however, a commensurate increase in the amount of lead extracted, which was only 16,962 tons, as against 13,790 tons in the preceding year. There was an increase of over 100 per cent., however, in the quantity of silver extracted, which amounted to 1,580,557 oz. in 1917 as against 759,012 oz. in the preceding year.

TABLE 12.—Production of Lead and Silver ore during 1916 and 1917.

	1916.			1917.		
	QUANTITY.	VALUE.		QUANTITY.	VALUE.	
	Lead-ore and lead.	Lead-ore and slag.	* Silver.	Lead-ore and slag.	Lead-ore and lead.	Silver.
	Tons.	£	£	Tons.	£	£
<i>Burma—</i>						
Northern Shan States.	8,839 (ore)	273,850(a)	70,732	54,616 (ore)	451,555(g)	228,756
	4,771 (slag)	147,976(b)	15,989	6,282 (slag)	48,017(h)	4,361
	202 (gossan flux)	6,239(c)	1,831	10,589 (gossan flux)	9,292(i)	3,966
Southern Shan States.	143.58	275	...	146.8	1,675	...
<i>Central Provinces—</i>						
Drug . . .	7	43	...	...	...	...
Kashmir . . .	7.2(d)	...	...	...	...	...
<i>Mysore—</i>						
Chitaldrug . .	1.78	(e)	...	.09	(j)	...
<b>Total . . .</b>	<b>13,971.56</b>	<b>428,383</b>	<b>88,552(f)</b>	<b>71,633.89</b>	<b>510,539</b>	<b>237,083(k)</b>

(a) Value of 8,822 tons of lead extracted.

(b) Value of 4,767 tons of lead extracted.

(c) Value of 201 tons of lead extracted.

(d) Dug-out by a licensee under a prospecting license. Value not returned.

(e) Value not returned.

(f) Value of 759,012 ozs. of silver extracted

(g) Value of 15,061.85 tons of lead extracted.

(h) Value of 1,600.56 tons of lead extracted.

(i) Value of 309.72 tons of lead extracted.

(j) Value not returned.

(k) Value of 1,580,557 ozs. of silver extracted



**Magnesite.**

There was a further slight increase in the production of magnesite, which rose from 17,640 tons in 1916, to 18,202 tons, valued at £14,559, in the year under review.

TABLE 13.—*Quantity and value of Magnesite produced in India during 1916 and 1917.*

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value
	Tons.	£	Tons.	£
<i>Madras—</i> Salem . . . . .	17,540	14,032	18,192	14,554
<i>Mysore</i> . . . . .	100	33	10	5
<b>Total</b> . . . . .	<b>17,640</b>	<b>14,065</b>	<b>18,202</b>	<b>14,559</b>

**Manganese.**

There was a slight fall in the production of manganese, but at the same time the value of the output was higher than that of the preceding year. This, of course, is due to the artificial conditions prevailing at present.

TABLE 14.—*Quantity and value of Manganese ore produced in India during 1916 and 1917.*

	1916.		1917.	
	Quantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b. at Indian ports.
	Tons.	£	Tons.	£
<i>Bihar and Orissa—</i> Singbhum . . . . .	2	4	126	292
Gangpur . . . . .	2,832	6,018	11,780	27,290

TABLE 14.—Quantity and value of Manganese ore produced in India during 1916 and 1917—contd.

	1916.		1917.	
	Quantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b. at Indian ports.
	Tons.	£	Tons.	£
<i>Bambay—</i>				
Belgaum . . . . .	1,765	3,751		
Chota Udepur . . . . .	7,951	16,896	417	966
Panch Mahals . . . . .	46,160	98,090	26,690	61,832
<i>Central Provinces—</i>				
Balaghat . . . . .	264,032	627,076	260,706	686,526
Bhandara . . . . .	86,344	205,067	44,997	118,492
Chhindwara . . . . .	53,977	128,195	66,235	174,419
Nagpur . . . . .	153,899	365,510	145,603	383,421
Jubbulpore . . . . .	576	727	300	790
<i>Madras—</i>				
Vizagapatam . . . . .	2,755	2,893	1,682	1,864
<i>Mysore . . . . .</i>	24,911	32,799	32,277	45,188
<b>Total . . . . .</b>	<b>645,204</b>	<b>1,487,026</b>	<b>590,813</b>	<b>1,401,080</b>

### Mica.

As in the case of manganese, there was an apparent fall in the amount of mica produced, but a rise in the value of the output, the total production in 1917 being returned as 40,907.6 cwt. valued at £141,605. The amount exported, on the other hand, was 62,434 cwt., or over 50 per cent. more than the quantity reported as produced in the country. This cannot be due entirely to stocks held from previous years, and, as has been pointed out before, indicates imperfect returns. Owing to the recent heavy demand for mica and to the higher prices offered, there was increased activity in mining during the past year, and there is very little doubt that the output figures are too low. There is a thriving trade in mica theft in some of the mining areas, and stolen mica naturally does not appear in the output returns.

TABLE 15.—*Quantity and Value of Mica produced in India during 1916 and 1917.*

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Cwt.	£	Cwt.	£
Bihar and Orissa . . . . .	26,819·8	76,940	34,137	91,825
Madras . . . . .	15,675	28,945	6,050·4	45,718
Mysore . . . . .	18	72		
Rajputana . . . . .	887	3,287	720·2	4,062
Total . . . . .	43,399·8	109,244	40,907·6	141,605

**Monazite.**

The production of monazite in Travancore rose from 1,292·48 tons valued at £37,714 in 1916 to 1,940·3 tons valued at £56,489 in 1917.

**Petroleum.**

There was a decrease of over 14 million gallons in the output of petroleum in Burma and India, the total production being 282,759,523 gallons. The details of the respective fields are shown in the attached table. The production of the Yenangyaung Oilfield fell from nearly 199 million gallons in 1916 to 176,979,020 gallons in the year under review. The yield of the Singu Oilfield was 85,639,166 gallons, approximately the same as in the preceding year. There were slight increases in the output of the Yenangyat and Minbu fields, but a falling off in Kyaukpyu. In Assam the output of the Digboi Field increased by over 1 million gallons, or nearly 23 per cent, while the new Badarpur field in Assam produced nearly 3 million gallons. In the Punjab the Attock Oilfield increased its production more than threefold, the output having risen from a little over 182,000 gallons to 618,598 gallons in 1917.

TABLE 16.—*Quantity and Value of Petroleum produced in India during 1916 and 1917.*

	1916		1917.	
	Quantity.	Value.	Quantity.	Value.
	Gallons.	£	Gallons.	£
<i>Burma—</i>				
Akyab . . . . .	11,882	228	10,894	210
Kyaukpyu . . . . .	68,843	321	46,821	1,408
Yenangyaung Field . . . . .	199,152,938	766,562	176,979,020	681,212
Singu Field . . . . .	85,146,138	305,002	85,639,166	329,635
Yenangyat Field . . . . .	5,310,740	19,980	6,620,908	24,825
Minbu . . . . .	2,043,542	8,515	3,468,382	14,452
Thayetmyo . . . . .	35,000	293	30,000	253
<i>Assam—</i>				
Digboi (Lakhimpur) . . . . .	5,236,890	17,274	6,419,840	21,176
Badarpur . . . . .			2,924,975	14,625
<i>Punjab—</i>				
Attock . . . . .	182,480	1,216	618,598	5,155
Mianwali . . . . .	1,334	14	919	13
<b>Total</b> . . . . .	<b>297,189,787</b>	<b>1,119,405</b>	<b>282,759,523</b>	<b>1,092,964</b>

The imports of kerosene oil decreased largely in 1917, being only a little over 33 million gallons as compared with nearly 60 million gallons in the preceding year. 438,888 cwt. of paraffin wax, valued at £669,479, were exported.

### Platinum.

The output of platinum fell to almost nothing, being only 3.79 oz; this was obtained, as usual, during the dredging operations of the Burma Gold Dredging Company at Myitkyina.

### Ruby, Sapphire and Spinel.

There was a slight decrease in the output of the Ruby Mines during the year under review. The estimated value of the output however, rose to £51,831.

TABLE 17.—*Quantity and Value of Ruby, Sapphire and Spinel produced in India during 1916 and 1917.*

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Carats.	£	Carats.	£
<i>Burma—</i>	136,783	35,848	132,409	43,575
Mogok . . . . .	(Rubies) 34,100	1,442	(Rubies) 32,369	8,017
	(Sapphires) 38,841	223	(Sapphires) 33,422	239
	(Spinel)		(Spinel)	
<b>Total</b> . . . . .	<b>209,724</b>	<b>37,513</b>	<b>198,200</b>	<b>51,831</b>

**Salt.**

There was a slight decrease in the amount, and a slight rise in the value, of the output of salt in 1917 as compared with that of the preceding year. There was also a slight decline in the amount imported, from 446,069 tons, valued at £1,260,295 in 1916, to 341,986 tons valued at £1,360,093 in the year under review.

TABLE 18.—*Quantity and Value of Salt produced in India during 1916 and 1917.*

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
Aden . . . . .	129,406	45,614	122,926	65,952
Bengal. . . . .	2	1	21	28
Bombay and Sind . . . . .	484,742	128,420	457,989	229,832
Burma. . . . .	38,774	184,812	43,650	114
Central India . . . . .	6·7	32	25·1	854
Gwalior State . . . . .	114	364	269	...
Kashmir . . . . .	36·7	27	...	...
Madras . . . . .	481,170	267,065	394,985	136,917
Northern India . . . . .	354,398	102,023	405,731	247
Rajputana . . . . .	...	...	2,057	
<b>Total</b> . . . . .	<b>1,488,649·4</b>	<b>728,358</b>	<b>1,427,653·1</b>	<b>983,157</b>

TABLE 19.—Quantity and Value of Rock-Salt produced in India during 1916 and 1917.

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
Salt Range . . . . .	160,358	27,283	152,351	25,921
Kohat . . . . .	19,978	1,983	23,787	2,509
Mandi . . . . .	4,568	5,440	4,829	5,752
<b>Total</b> . . . . .	<b>184,904</b>	<b>34,706</b>	<b>180,967</b>	<b>34,182</b>

### Saltpetre.

The production of saltpetre fell from over 25,000 tons in 1916 to 21,283·8 tons valued at £527,666 in 1917. Most of the reduction occurred in the United Provinces. There was an increase in the quantity exported, which amounted to 515,374 cwt., valued at £677,856, in 1917 as against 485,000 cwt. in the preceding year.

TABLE 20.—Quantity and value of Saltpetre produced in India during 1916 and 1917.

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£.	Tons.	£.
Bihar . . . . .	5,904	143,188	5,024·3	122,995
Central India . . . . .	25·1	481	29·9	252
Punjab . . . . .	8,140·	191,878	9,141	226,793
Rajputana . . . . .	244	5,700	234·2	6,893
United Provinces . . . . .	10,743	266,241	6,855·4	170,733
<b>Total</b> . . . . .	<b>25,056·1</b>	<b>607,488</b>	<b>21,283·8</b>	<b>527,666</b>

**Silver.**

Practically the whole of the silver production comes from the Badwin lead-zinc mines, which, as already stated (see *Lead*), produced 1,580,557 oz. in the year under review. The Anantapur gold mine in Madras also produced 1,281 oz.

**Tin.**

There was a considerable increase—amounting to 43 per cent.—in the amount of tin-ore produced. This all came from Burma, which yielded 13,326 cwt. valued at £65,533. 2,817.9 cwt. of block tin were also produced in Mergui district as the result of local smelting operations. The imports of block tin amounted to 28,180 cwt., valued at £292,135.

*N.B.*—The tin-ore of the Southern Shan States is produced in the form of mixed cassiterite-wolfram concentrates; the output is therefore returned in terms of the mixed concentrate, the approximate composition of which is usually 43 per cent. wolfram to 57 per cent. cassiterite. The total figure for 1917 is 14,239 cwt.; for the purposes of this *Review* it has been assumed that 8,088 cwt. of this represent tin-ore and the remainder wolfram.

TABLE 21.—*Quantity and value of Tin and Tin-ore for the years 1916 and 1917.*

	1916.				1917.			
	Block Tin.		Tin Ore.		Block Tin.		Tin Ore.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwt.	£.	Cwt.	£.	Cwt.	£.	Cwt.	£.
<i>Burma—</i>								
Amherst . . .	...	...	10	16	...	...	33	176
Mergui . . .	2,257.19	19,802	1,897	10,531	2,817.9	27,962	1,761	10,930
Southern Shan States.	...	...	4,862	16,965	...	...	8,088	40,440
Tavoy . . .	...	...	1,644	8,192	...	...	1,762	11,015
Thaton . . .	...	...	900	3,598	...	...	1,677	3,972
<b>Total . . .</b>	<b>2,257.19</b>	<b>19,802</b>	<b>9,313</b>	<b>39,302</b>	<b>2,817.9</b>	<b>27,962</b>	<b>13,321</b>	<b>66,533</b>

## Tungsten.

The production of wolfram rose by nearly 22 per cent., from a little under 3,700 tons in 1916 to over 4,500 tons in the year under review. The Central Provinces have now ceased to produce, and there has only been a small increase in the output in Singhbhum. The output of the Degana mines in Rajputana has increased somewhat but is still insignificant, the absence of water being a serious handicap to efficient treatment of the material. Over 80 per cent. of the total output of wolfram came from Tavoy, where the industry has shown highly satisfactory progress, the production having increased by nearly 75 per cent. during the last two years.

TABLE 22.—*Quantity and value of Tungsten-ore produced in India during 1916 and 1917.*

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
<i>Bihar and Orissa—</i>				
Singhbhum . . . . .	8	640	20	1,333
<i>Burma</i> <sup>1</sup>				
Mergui . . . . .	340	46,014	368	49,541
Southern Shan States <sup>2</sup> . . . . .	185	18,500	307	39,910
Tavoy . . . . .	3,034	410,586	3,697.5	508,794
Thaton . . . . .	91.5	15,079	107.5	15,366
<i>Central Provinces—</i>				
Nagpur . . . . .	1.3	220	...	...
<i>Rajputana—</i>				
Marwar . . . . .	32.7	6,358	42	8,130
<b>Total . . . . .</b>	<b>3,692.5</b>	<b>497,397</b>	<b>4,542</b>	<b>623,074</b>

<sup>1</sup> Figures taken from "Note on the mineral production of Burma" for 1916 and 1917.

<sup>2</sup> See note under Tin.



## III.—MINERALS OF GROUP II.

**Agate.** The output of agates amounted to 120 tons valued at £255. All of these came from Rajpipla.

The production of alum fell by nearly 50 per cent. from 9,419 cwt. in 1916 to 5,434 cwt. valued at £3,707 in 1917. This production was from the Mianwali district in the Punjab.

**Alum.** 59.6 cwt. of amber, valued at £684, were produced during the year in the Myitkyina district of Upper Burma.

**Amber.** The production of antimony ore fell from 1,040 tons in the year 1916 to 130.5 tons valued at £139 in the year under review. Of this 105 tons came from the Amherst district in Upper Burma and 25½ from the Chitaldrug district of Mysore.

**Antimony.** Nearly 26,000 carats of aquamarine were produced from the Kashmir workings during the year under review. The output was valued at £297.

**Aquamarine.** A small quantity of asbestos was produced during the year, the total output being 148 tons valued at £303, of which 7 tons were produced in the Central Provinces and 141 tons in the Hassan district of Mysore.

**Asbestos.** The output of bauxite in the Jubbulpore district amounted to 1,363 tons. The estimated value was £620. The output in the preceding year was 750 tons.

**Bauxite.** A small quantity (5 cwt.) of bismuth was mined in the Tavoy district, where native bismuth is occasionally found associated with the wolfram. The estimated value of the output was £163.

**Bismuth.** The total estimated value of building stone and road-metal produced during the year 1917 was £249,776.

**Building Materials.** The production of clay was 86,745 tons valued at £9,019.

**Clay.** There was a slight increase in the output of corundum from 37,361 cwt. in 1916 to 41,425.8 cwt. in the year under review. With the exception of 200 cwt. from Rewah and 26 cwt. from South Canara, the whole of the production came from Assam.

**Corundum.**

TABLE 21.—Production of Building Materials and road metal in India during the year 1917.

	GRANITE.		LATERITE.		LIME.		LIMESTONE AND KANKAR.		MARBLE.		SANDSTONE.		SLATE.		TRAP.		MISCELLANEOUS.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Assam . . . . .	..	..	..	..	..	..	57,100	5,178	..	..	..	..	..	..	..	..	..	..
Bihar and Orissa.	17,995	3,678	38,405	1,242	121	3	264,966	69,039	..	..	70,166	2,249	2,000	1,900	13,584	220	179,837	7,334
Bombay . . . . .	..	..	..	..	..	..	1,192	100	..	..	..	..	..	..	..	..	..	..
Burma . . . . .	255,290	18,730	286,924	13,091	..	..	174,034	12,437	..	..	86,636	6,195	..	..	677	34	295,954	19,723
Central India . . . . .	..	..	..	..	17,057	8,959	69,512	4,420	..	..	..	..	..	..	..	..	3,028	30
Central Provinces.	..	..	..	..	..	..	86,444	6,917	..	..	..	..	..	..	..	..	..	..
Hyderabad . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Madras . . . . .	58,878	2,466	97,042	3,905	..	..	9,541	551	..	..	..	..	..	..	..	..	83,518	5,900
North-West Frontier Province	..	..	..	..	..	..	2,541	114	..	..	..	..	..	..	..	..	..	..
Punjab . . . . .	..	..	..	..	..	..	15,497	895	..	..	109,432	7,269	6,831	7,798	..	..	9,208	143
Rajputana . . . . .	..	..	..	..	..	..	820	479	3,082	3,182	38,894	11,479	..	..	..	..	49,995	2,897
United Provinces.	..	..	..	..	63	28	3,361	805	..	..	5,000	1,500	43,025	546	..	..	196,452	18,440
<b>TOTAL . . . . .</b>	<b>332,163</b>	<b>24,374</b>	<b>422,371</b>	<b>18,238</b>	<b>17,241</b>	<b>8,990</b>	<b>685,008</b>	<b>100,935</b>	<b>2,022</b>	<b>3,182</b>	<b>210,128</b>	<b>23,692</b>	<b>51,856</b>	<b>10,244</b>	<b>14,261</b>	<b>254</b>	<b>757,990</b>	<b>54,307</b>

PART 2.] HAYDEN: Mineral Production, 1917. 75

The output of gypsum shows a slight increase over that of the preceding year. The figures are given in table 22.

TABLE 23.—*Production of Gypsum during 1916 and 1917.*

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
<i>Punjab—</i>				
<i>Jhelum . . . . .</i>	615	31	1,068	53
<i>Rajputana—</i>				
<i>Bikaner (Jamsar) . . . . .</i>	11,613	520	8,116	661
<i>Marwar . . . . .</i>	3,800	194	7,499	320
<b>Total . . . . .</b>	<b>16,028</b>	<b>745</b>	<b>16,683</b>	<b>1,034</b>

27 cwt. of molybdenite, valued at £626, were produced from the Tavoy wolfram mines during the year 1917.

Molybdenite.

The output of ochre rose from 850·5 tons in 1916 to 3,143 tons valued at £1,630 in the year under review.

Ochre.

TABLE 24.—*Production of Ochre during 1916 and 1917.*

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
<i>Bihar and Orissa . . . . .</i>	3·5	1	69	49
<i>Central India . . . . .</i>	839	939	2,174	773
<i>Central Provinces . . . . .</i>	8	1	900	808
<b>Total . . . . .</b>	<b>850·5</b>	<b>941</b>	<b>3,143</b>	<b>1,630</b>

67 lbs. of samarskite, valued at £2, were produced from the Sankara mica mine in Nellore. There was a very marked rise in the quantity of steatite produced. The total production amounted to 7,828.7 tons valued at £6,470.

TABLE 25.—Quantity and value of Steatite produced in India during 1916 and 1917.

	1916.		1917.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
<i>Bihar and Orissa—</i>				
Singhbhum . . . . .	(a)	250	...	...
Mayurbhanj . . . . .	52	333	50	267
<i>Burma —</i>				
Meiktila . . . . .	...	...	4,846	1,197
Myingyan . . . . .	...	...	16	25
<i>Central India—</i>				
Bijwar . . . . .	...	...	73.3	386
<i>Central Provinces—</i>				
Jubbulpore . . . . .	891.75	794	2,421.8	2,619
<i>Madras—</i>				
Bellary . . . . .	36	12	23	8
Kurnool . . . . .	10.45	116	10.3	115
Nellore . . . . .	50.5	251	19.5	77
Salem . . . . .	87	325	149.6	762
<i>Mysore</i>	...	...	8.5	17
<i>Rajputana (Ajmer-Marwara)</i>	...	...	119.7	319
<i>United Provinces—</i>				
Hamirpur . . . . .	76	504	80	630
Jhansi . . . . .	10	43	11	48
<b>Total</b>	<b>1,213.7</b>	<b>2,628</b>	<b>7,828.7</b>	<b>6,470</b>

(a) Quantity not returned.

## IV.—MINERAL CONCESSIONS GRANTED.

TABLE 26.—Statement of Mineral Concessions granted during 1917.

## ASSAM.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cachar	(1) Mr. F. H. Carslaw	Mineral oils	P. L.	16,000	21st May 1917.	1 year.
Khasi and Jaintia Hills.	(2) Khasi Hills prospecting and mining syndicate, Ltd.	Ore of tin, lead, titanium, silver, mercury, bismuth, nickel, cobalt, copper, zinc, antimony, arsenic, sulphur, tungsten, molybdenum, vanadium, uranium, tantalum, niobium, thorium, cerium, beryllium, zirconium, lanthanum, praseodymium, neodymium, samarium, yttrium, terbium, dysprosium, gadolinium, holmium, erbium, thulium, thallium, ytterbium, scandium, radium, iron and manganese, the miner's corundum and emery, the metal gold and miner's and metals carrying gold, the metal platinum and the platinum metals, and minerals and metals containing platinum and the platinum metals.	M. L.	1,920	1st March 1917.	30 years.
Lakhimpur	(3) Assam Railways and Trading Co., Ltd.	Coal, iron, slate and shale.	M. L.	2,227.2	1st April 1917.	Do.
Do.	(4) Durga Datta and Srilal Beria.	Coal . . .	P. L.	8,238.08	5th October 1917.	1 year.
Sylhet	(5) The Burma Oil Co., Ltd.	Mineral oils	P. L.	11,608.2	15th May 1917.	Do.
Do.	(6) Do. . .	Do. . .	P. L.	2,944	Do. . .	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

## BALUCHISTAN.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kalat	(7) The Indo-Burma Petroleum Co., Ltd., Rangoon, through their Managing Agents, Messrs. Steel Brothers & Co.	Oil . . . .	P. L. . . .	15,360	20th May 1917.	1 year.
Do.	(8) Do.	Do. . . . .	P. L. . . .	17,920	Do. . . .	Do.
Do.	(9) The Burma Oil Co., Ltd., Rangoon.	Do. . . . .	P. L. . . .	24,960	18th December 1916.	Do.
Quetta-Pishin.	(10) Khan Bahadur B. D. Patel, C.I.E., Quetta.	Chromite . . .	M. L. . . .	80	1st July 1917.	30 years.
Do.	(11) Mr. Tikam Dass Girdhari Dass of Shikarpore.	Coal . . . . .	M. L. . . .	80	Do. . . .	Do.
Sibi . . . .	(12) W. C. Clements, Esq., through his Agent Babu Ganda Singh.	Do. . . . .	M. L. . . .	16-46	1st January 1917.	Do.
Do.	(13) Mr. Tikam Dass Girdhari Dass of Shikarpore.	Do. . . . .	M. L. . . .	80	Do. . . .	Do.

## BIHAR AND ORISSA.

Gya . . . .	(14) Mr. Surendra Nath Tagore of Calcutta.	Mica . . . . .	M. L. . . .	1,557-05	1st October 1915.	20 years.
Hazaribagh	(15) Babu Probodh Chandra Mukharji.	Do. . . . .	P. L. . . .	80	29th August 1917.	1 year.
Do.	(16) Babu Shivasjee Waljee	Do. . . . .	P. L. . . .	3-70	25th June 1917.	Do.
Do.	(17) Babu Jagannath Basan Lal.	Do. . . . .	P. L. . . .	280	18th September 1917.	Do.
Do.	(18) Babu Lakshmi Narain Suchani.	Do. . . . .	P. L. . . .	137-07	23rd August 1917.	Do.
Do.	(19) Babu Shivaji Walji	Do. . . . .	P. L. . . .	3-23	10th October 1917.	Do.
Do.	(20) Babu Banks Behari Chaudhuri.	Do. . . . .	M. L. . . .	70	Lease not yet executed.	30 years.
Sambalpur .	(21) Mr. T. P. Yeoman .	Coal . . . . .	M. L. . . .	1,300	1st July 1917.	Do.
Santal Parganas.	(22) Babu Bansi Ram Marwari.	Do. . . . .	M. L. . . .	33	1st October 1917.	6 months up to 31st March 1918.

P. L.=Prospecting License. M. L.=Mining Lease.

## BIHAR AND ORISSA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Santal Parganas.	(23) Babu Bansi Ram Marwari.	Coal . . . .	M. L. . . .	1-90	1st October 1917.	6 months up to 31st March 1918.
Do.	(24) Babu Jamuna Prasad.	Do. . . . .	M. L. . . .	2-60	Do. . . . .	Do.
Do.	(25) Babu Benode Behari Dey.	Do. . . . .	M. L. . . .	2-15	Do. . . . .	Do.
Do.	(26) Messrs. Jardine Skinner & Co.	Do. . . . .	P. L. . . .	5,158-48	License not yet executed.	
Do.	(27) E. Villiers, Esq.	Do. . . . .	P. L. . . .	5,081-28	Do. . . . .	
Do.	(28) Baidya Nath Dey	Do. . . . .	M. L. . . .	10-15	17th December 1917.	Up to 31st March, 1918.
Singhbhum	(29) Singhbhum Chromite Co., Ltd., Calcutta.	Chromite . . .	P. L. . . .	521-9	25th January 1917.	1 year.
Do.	(30) Do.	Do. . . . .	P. L. . . .	633-6	Do. . . . .	Do.
Do.	(31) Babu Ajit Kumar Mallik, Howrah.	Yellow ochre .	P. L. . . .	11-90	8th January 1917.	Do.
Do.	(32) Mr. S. Luxman Rao Naidu, Nagpur.	Chromite . . .	M. L. . . .	216	25th April 1917.	15 years.
Do.	(33) Do.	Do. . . . .	M. L. . . .	596-30	Do. . . . .	Do.
Do.	(34) F. Dundas Whiffin, Esq., Panposh.	Manganese and iron ore.	P. L. . . .	12,800	14th October 1917.	1 year.
Do.	(35) Mr. A. C. Maitra of Calcutta.	Chromite . . .	P. L. . . .	200	22nd May 1917.	Do.
Do.	(36) The Bengal Iron and Steel Co., Ltd.	Manganese and iron ore.	P. L. . . .	1,088	Do. . . . .	Do.
Do.	(37) Mr. A. C. Maitra of Calcutta.	Galena, gold and other kindred minerals.	P. L. . . .	1,330	22nd August 1917.	Do.
Do.	(38) Babu Moti Lal Iswar Das of Calcutta.	Manganese . . .	P. L. . . .	75-90	16th May 1917.	Do.
Do.	(39) Babu Ajit Kumar Mallik of Howrah.	Red ochre . . .	P. L. . . .	150	18th April 1917.	Do.
Do.	(40) The Bengal Iron and Steel Co., Ltd.	Iron ore . . . .	P. L. . . .	56	16th June 1917.	Do.
Do.	(41) Do.	Do . . . . .	M. L. . . .	800	7th December 1917.	30 years.
Do.	(42) Mr. A. C. Moitra	Chromite . . .	P. L. . . .	360	24th July 1917.	1 year.
Do.	(43) The Bengal Iron and Steel Co., Ltd.	Manganese and iron ore.	M. L. . . .	1,267-2	Lease not yet executed.	30 years.

P. L.=Prospecting License. M. L.=Mining Lease.

BIHAR AND ORISSA—*concl'd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Singhbhum	(44) The Tata Iron and Steel Co.	Manganese and iron ore.	P. L.	22,144	The area consisted of two plots of lands, one measuring 9,792 acres and the other 12,352 acres. The license for the former land has been executed and the date of the commencement is 30th November, 1917. The license of the latter area has not yet been executed.	1 year.
Do.	(45) Messrs. M. D'Costa and Gorodutt Ganesh Lal.	Chromite	P. L.	810	30th November 1917.	Do.
Do.	(46) Babu Mangi Lal Marwari.	Yellow and red ochre.	P. L.	4.60	16th October 1917.	Do.
o.	(47) Mr. A. C. Maitra .	Gold . . . .	M. L.	1	Draft lease not yet executed.	20 years
Do.	(48) Singhbhum Chromite Co., Ltd.	Chromite . . .	M. L.	400 320	Lease not yet executed.	30 years

## BOMBAY.

Dharwar (also in Kanara district).	(49) Mr. L. C. Oliver .	Galena . . . .	P. L.	1,143	18th June 1917.	1 year.
Ka'ra	(50) Shivrajpur Syndicate, Limited, by their agent H. J. Winch, Esq., Mine Manager, Shivraipur.	Manganese and Aluminium.	P. L.	201.95	2nd July 1917.	Do.
Panch Mahals.	(51) Messrs. Shaw Wallace & Co., Managing Agents to the Bamankuva Mines.	Manganese ore .	M. L.	680.22	1st June 1912.	8 years 1 month and days.
Do.	(52) H. J. Winch, Mine Manager, Shivrajpur Syndicate, Shivrajpur.	Manganese . . .	P. L. (renewal).	45.5	5th October 1917.	1 year.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*



## BOMBAY—concl'd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Sukkur	(53) The Managing Agents, Indo-Burma Petroleum Co., Ltd., Rangoon.	Mineral oil .	P. L.	6,008	20th August 1917.	1 year.

## BURMA.

Akyab	(54) Messrs. The Burmah Oil Co., Ltd.	Mineral oil .	P. L.	8,620	1st September 1916.	1 year.
	(55) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L. (renewal).	5,440	15th December 1917.	2 years.
Amherst	(56) Mukunda Lall Kunda	All minerals (except oil).	P. L.	640	23rd November 1916.	1 year.
Do.	(57) Messrs. J. W. Darwood & Co.	Do.	P. L.	1,280	15th February 1917.	Do.
Do.	(58) Messrs. T. D. Findlay & Son.	Do.	P. L.	426-66	10th February 1917.	Do.
Do.	(59) Saw Bein Nga	Do.	P. L.	640	13th February 1917.	Do.
Do.	(60) Abdul Bari Chowdhry.	Do.	P. L.	640	5th February 1917.	Do.
Do.	(61) Maung Ba Thein	Do.	P. L.	640	10th March 1917.	Do.
Do.	(62) Messrs. T. D. Findlay & Son.	Do.	P. L.	1,920	Do.	Do.
Do.	(63) Maung Tun Hla	Do.	P. L.	426-66	13th February 1917.	Do.
Do.	(64) Maung Ba Tsee	Do.	P. L.	640	20th April 1917.	Do.
Do.	(65) Mr. L. Hong Seng	Do.	P. L.	960	17th April 1917.	Do.
Do.	(66) Mr. L. Gwan Shein	Do.	P. L.	1,280	20th April 1917.	Do.
Do.	(67) Messrs. T. D'Ca tro & Son.	Do.	P. L.	640	17th April 1917.	Do.
Bhamo	(68) Messrs. S. Crawshaw and B. Hardings.	All minerals (except oil and jade).	P. L.	5,516 8	11th December 1917.	Do.
Katha	(69) Messrs. Jamal Bros. & Co., Ltd.	Tin, wolfram, silver, copper, lead, zinc and gold.	P. L. (renewal).	24,320	4th November 1916.	Do.
Lower Chindwin.	(70) Mr. A. K. A. S. Jamal.	All minerals (except oil).	P. L. (renewal).	1,680	23rd March 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Lower Chin-dwin.	(71) Messrs. Jamal Bros. & Co., Ltd.	All minerals (except oil).	P. L. (renewal).	140	23rd March 1917.	1 year.
Do.	(72) Do.	Do.	P. L. (renewal).	1,120	Do.	Do.
Do.	(73) Messrs. The Burma Oil Co., Ltd.	Mineral oil	P. L.	640	15th August 1917.	Do.
Do.	(74) Do.	Do.	P. L. (renewal).	960	1st May 1917.	Do.
Do.	(75) Messrs. Jamal Bros. & Co., Ltd.	Do.	P. L. (renewal).	1,440	1st August 1917.	2 years.
Mergu'	(76) U Shan Byu	All minerals (except oil).	P. L.	91-90	1st October 1916.	1 year.
Do.	(77) Tan Kar Lim and two others.	Tin	P. L.	29-16	15th January 1917.	Do.
Do.	(78) Maung San Mo	All minerals (except oil).	P. L.	583-68	26th January 1917.	Do.
Do.	(79) Maung Nyun	Do.	P. L.	2,876-43	10th March 1917.	Do.
Do.	(80) Messrs. Wightman & Co.	Tin	P. L.	53-76	26th February 1917.	Do.
Do.	(81) Maung Po Thaik	Wolfram and Tin	P. L.	486-40	12th February 1917.	Do.
Do.	(82) Mr. H. W. Watts	All minerals (except oil)	P. L.	2,343-60	22nd March 1917.	Do.
Do.	(83) Maung Pan On	Do.	P. L.	135-60	19th March 1917.	Do.
Do.	(84) Maung Po	Do.	P. L.	691-20	3rd April 1917.	Do.
Do.	(85) M. Haniff	Do.	P. L.	350-72	24th March 1917.	Do.
Do.	(86) Mrs. B. I. Jewett	Do.	P. L. (renewal).	3,056-64	12th February 1916.	Do.
Do.	(87) Do.	Do.	P. L. (renewal).	471-04	Do.	Do.
Do.	(88) M. Haniff	Do.	P. L. (renewal).	2,580-48	6th January 1917.	Do.
Do.	(89) Yew Shwe Ni	Do.	P. L. (renewal).	1,449	28th January 1917.	Do.
Do.	(90) C. Soo Don	Do.	P. L. (renewal.)	1,176-64	28th February 1917.	Do.
Do.	(91) U. Shwe Don	Do.	P. L. (renewal).	793-60	1st February 1917.	3 months.
Do.	(92) U. Shwe Thi	Do.	P. L. (renewal).	852-48	14th February 1917.	6 months.

P. L.—Prospecting License. M. L.—Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui	(93) Nyaung Tat . . .	All minerals (except oil).	P. L. (renewal).	353	13th March 1917.	1 year.
Do.	(94) Messrs. Bulloch Bros. & Co., Ltd.	Do.	P. L.	1,530-88	1st January 1917.	Do.
Do.	(95) Yew Shwe Ni . . .	Do.	P. L.	1,775-52	20th April 1917.	Do.
Do.	(96) Mr. C. Swee Htin .	Wolfram . . .	P. L. . .	2,626-56	2nd May 1917.	Do.
Do.	(97) Maung Ngwe Thi .	Wolfram and tin	P. L. . .	746-52	3rd April 1917.	Do.
Do.	(98) Mr. Meera Saib . .	All minerals (except oil).	P. L. (renewal).	327-68	19th January 1917.	Do.
Do.	(99) Maung Shwe Don .	Do.	P. L. (renewal).	793-60	1st May 1917	3 month
Do.	(100) Tan Po Chit . . .	Do.	P. L. . .	320	18th September 1917.	1 year.
Do.	(101) Ma Mo Thu . . .	Do.	P. L. . .	320	Do.	Do.
Do.	(102) Messrs. Finlay Fleming & Co.	Do.	P. L. . .	983-04	17th September 1917.	Do.
Do.	(103) Mr. A. H. Noyes .	Do.	P. L. (renewal).	100	26th November 1916.	Do.
Do.	(104) U. Shwe Thi . . .	Do.	P. L. (renewal).	852-48	15th August 1917.	6 months
Do.	(105) Mr. J. C. Galsbann	Do.	P. L. . .	1,971-20	8th December 1917.	1 year.
Do.	(106) Maung Maung . .	Do.	P. L. . .	640	1st November 1917.	Do.
Do.	(107) Mr. G. H. Hand .	Wolfram and tin	P. L. . .	2,150-40	Do.	Do.
Minbu	(108) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . . .	P. L. (renewal).	320 northern half of block 16 N of the Minbu Oil Field.	6th August 1916.	Do.
Do.	(109) Maung Talk Gyi and Maung Shwe Mo.	Do.	M. L. . .	19 in Block 20 P of the Minbu Oil Field.	23rd February 1916.	30 years.
Do.	(110) Messrs. The Yomah Oil Co., Ltd.	Do.	P. L. . .	2,570-24 Blocks 4 P, 8 P, 12 P, 24 P and portion of 11 P of the Minbu Oil Field.	23rd October 1917.	1 year.
Myingyan	(111) Maung Tun Hman and three others.	Do.	P. L. . .	270	18th January 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Myingyan .	(112) Batjnath Singn .	Mineral oil .	P. L. .	11,520	27th August 1917.	1 year.
Myitkyina .	(113) Mr. H. F. Leslie .	Gold and platinum	P. L. .	1,132.8	4th January 1917.	Do.
Do. .	(114) Messrs. The Burma Gold Dredging Co. (1911), Ltd.	Gold and Iridio-Platinum.	P. L. (renewal).	3,200	23rd February 1917.	Do.
Do. .	(115) Mr. H. F. Leslie .	Gold . . . .	P. L. (renewal).	2,931.2	1st April 1917	Do.
Do. .	(11) Do. . . . .	Do. . . . .	P. L. (renewal).	640	1st November 1917.	Do.
North ern Shan States.	(117) Messrs. The Burma Mines, Ltd.	Iron . . . .	P. L. .	640	12th February 1917.	Do.
Do. .	(118) Do. . . . .	Do. . . . .	P. L. .	2,560	14th March 1917.	Do.
Do. .	(119) Do. . . . .	Coal . . . .	P. L. .	3,200	17th March 1917.	Do.
Do. .	(120) Do. . . . .	Do. . . . .	P. L. .	2,560	14th March 1917.	Do.
Do. .	(121) Messrs. The Moho-chaung Exploration Co., Ltd.	Gold, silver, iron and zinc.	P. L. (renewal).	3,200	8th April 1917	Do.
Pakokku .	(122) Messrs. The British Burma Petroleum Co., Ltd.	Mineral oil .	P. L. .	261 & 614.40	19th December 1916.	Do.
Do. .	(123) Do. . . . .	Do. . . . .	P. L. (renewal).	76.80 & 371.20	14th November 1916.	Do.
Do. .	(124) Messrs. The Nath Singh Oil Co., Ltd.	Do. . . . .	P. L. (renewal).	1,920	12th January 1917.	Do.
Do. .	(125) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . . . .	P. L. .	800 East of Blocks Nos. 18, 19 and 20 in the Yenangyat Oil Field.	6th September 1917.	Do.
Do. .	(126) Messrs. The Nath Singh Oil Co., Ltd.	Do. . . . .	P. L. (renewal).	12,399.4	26th April 1917.	2 years.
Do. .	(127) Messrs. The British Burma Petroleum Co., Ltd.	Do. . . . .	P. L. (renewal).	640	16th August 1917.	Do.
Do. .	(128) Messrs. The Rangoon Oil Co., Ltd.	Do. . . . .	P. L. (renewal).	320	Do.	Do.
Prome	(129) Maung Gyi . . .	Do. . . . .	P. L. .	249.6	25th January 1917.	1 year.

P. L.—Prospecting License. M. L.—Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Prome	(130) Messrs. The Burmah Oil Co., Ltd.	Mineral oil	P. L. (renewal).	3,200	7th June 1917	1 year.
Ruby Mines	(131) Ma Shwe Ewin	Copper	P. L.	640	25th April 1917.	Do.
Salween	(132) Messrs. Steel Bros. & Co., Ltd.	All minerals (except oil).	P. L.	3,840	5th December 1917.	Do.
Shwebo	(133) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil	P. L.	1,280	9th January 1917.	Do.
Do.	(134) Do.	Do.	P. L.	3,424	23rd February 1917.	Do.
Southern Shan States.	(135) Maung Law Pan	Lead, copper and silver.	M. L.	2,680	1st July 1916	10 years.
Do.	(136) Maung Ye	Wolfram	P. L.	140	7th January 1917.	1 year.
Do.	(137) Messrs. Bachardass Manekchand Kharwar.	Lead	P. L.	2,560	10th February 1917.	Do.
Do.	(138) Maung Hnya	Wolfram	P. L.	228-73	5th April 1917.	Do.
Do.	(139) The Hon'ble Mr. Lam Chin Tsong.	All minerals (except oil).	P. L. (renewal).	166	20th November 1916.	Do.
Do.	(140) Messrs. Steel Bros. & Co., Ltd.	Do.	P. L.	3,680	17th September 1917.	Do.
Do.	(141) Do.	Do.	P. L.	2,560	4th September 1917.	Do.
Do.	(142) Ko Law Pan	Wolfram	P. L.	64	17th August 1917.	Do.
Do.	(143) Maung San Hein	All minerals (except oil).	P. L.	160	4th September 1917.	Do.
Do.	(144) Messrs. Bechardass Manekchand Kharwar.	Wolfram	P. L.	2,355-20	13th September 1917.	Do.
Do.	(145) Maung Kya Ywet, A.T.M.	All minerals (except oil).	P. L.	640	12th September 1917.	Do.
Do.	(146) Saw Lein Lee	Do.	P. L. (renewal).	599	30th May 1917.	Do.
Do.	(147) Rathana	Gold	P. L.	3,200	27th December 1917.	Do.
Do.	(148) Do.	Do.	P. L.	1,440	Do.	Do.
Do.	(149) Do.	Do.	P. L.	4,920	Do.	Do.
Do.	(150) Maung Pan Aung	All minerals (except oil).	P. L.	640	28th December 1917.	Do.
Do.	(151) Shain Thwe	Do.	P. L.	960	27th November 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Southern Shan States.	(152) Maung Po Ku .	All minerals (except oil).	P. L.	2,560	21st November 1917.	1 year.
Mayoy .	(153) Messrs. The Hpaungdaw Prospecting Co., Ltd.	Do.	P. L.	2,688	3rd January 1917.	6 months.
Do.	(154) Mr. H. G. Mathews	Do.	P. L.	829	14th February 1917.	Do.
Do.	(155) Messrs. Hitakari & Co.	Do.	P. L.	512	27th January 1917.	Do.
Do.	(156) Mr. A. E. Wallenberg.	Do.	P. L.	1,600	13th March 1917.	Do.
Do.	(157) A. S. Mahomed	Do.	P. L.	358	5th February 1917.	Do.
Do.	(158) Mr. James I. Milne	Do.	P. L.	813	2nd January 1917.	3 months.
Do.	(159) Mr. A. G. Fraser	Do.	P. L.	922	22nd January 1917.	6 months.
Do.	(160) Messrs. Lim Kim Seng Bros. & Co.	Do.	P. L.	922	4th January 1917.	Do.
Do.	(161) Eu Shwe Swai .	Do.	P. L.	578	22nd March 1917.	Do.
Do.	(162) Maung Sein Kaing	Do.	P. L.	640	8th January 1917.	Do.
Do.	(163) Maung Ba Don .	Do.	P. L.	640	18th January 1917.	Do.
Do.	(164) Eu Shwe Swai .	Do.	P. L.	640	15th March 1917.	Do.
Do.	(165) Maung Ba Maung	Do.	P. L.	1,806	25th January 1917.	Do.
Do.	(166) Maung Saw Hlaing	Do.	P. L.	548	2nd January 1917.	Do.
Do.	(167) Netram Rambux	Do.	P. L.	240	4th January 1917.	Do.
Do.	(168) Maung Saw Hlaing	Do.	P. L.	1,144	2nd January 1917.	Do.
Do.	(169) Maung Po Swe .	Do.	P. L.	931	22nd January 1917.	Do.
Do.	(170) Maung E Zin .	Do.	P. L.	485	15th February 1917.	Do.
Do.	(171) Do. . . .	Do.	P. L.	640	Do.	Do.
Do.	(172) Messrs. The High Speed Steel Alloys, Ltd.	Do.	P. L.	256	24th March 1917.	Do.
Do.	(173) Maung Ba Maung	Do.	P. L.	1,920	Do.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

D

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(174) Lim Eng Cheong	All minerals (except oil).	P. L.	671	22nd February 1917.	6 months.
Do.	(175) Maung Sein Thwe	Do.	P. L.	589	19th February 1917.	Do.
Do.	(176) Maung Khine	Do.	P. L.	809	24th February 1917.	Do.
Do.	(177) Maung Ni	Do.	P. L.	640	17th March 1917.	Do.
Do.	(178) Mr. R. C. N. Twite	Do.	P. L.	460	22nd March 1917.	Do.
Do.	(179) Mr. A. D. Brown	Do.	P. L.	189	8th March 1917.	Do.
Do.	(180) Ma Thaw	Do.	P. L.	563	5th March 1917.	Do.
Do.	(181) Mr. S. Crawshaw	Do.	P. L.	640	27th March 1917.	Do.
Do.	(182) Ma Mo Thu	Do.	P. L.	973	12th March 1917.	Do.
Do.	(183) Maung Gun	Do.	P. L.	768	3rd March 1917.	Do.
Do.	(184) Maung Shwe Gaing	Do.	P. L.	512	23rd March 1917.	Do.
Do.	(185) Ma Mya Yin	Do.	P. L.	1,075	26th March 1917.	Do.
Do.	(186) Maung Po Hnan	Do.	P. L.	640	Do.	Do.
Do.	(187) Mr. S. Merican	Do.	P. L.	512	22nd March 1917.	Do.
Do.	(188) Messrs. Steel Bros. & Co., Ltd.	Do.	P. L. (renewal).	640	16th November 1916.	Do.
Do.	(189) Ma Chein	Do.	P. L. (renewal).	808	8th November 1916.	Do.
Do.	(190) Maung Ni To	Do.	P. L. (renewal).	1,375	22nd December 1916.	Do.
Do.	(191) Maung Kyaw	Do.	P. L. (renewal).	435	19th November 1916.	Do.
Do.	(192) Mahomed Aslam Khan.	Do.	P. L. (renewal).	1,536	16th December 1916.	Do.
Do.	(193) Khoo Zun Ni	Do.	P. L. (renewal).	1,280	7th December 1916.	Do.
Do.	(194) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L. (renewal).	770	Do.	Do.
Do.	(195) Do.	Do.	P. L. (renewal).	222	Do.	Do.
Do.	(196) Cng Hoe Kyin	Do.	P. L. (renewal).	179	13th December 1916.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

## BURMA—contd.

Distric.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(197) Mr. A. S. Mahomed	All minerals (except oil).	P. L. (renewal).	1,894	12th December 1916.	6 months.
Do.	(198) San Sine Tin	Do.	P. L. (renewal).	107	16th December 1916.	Do.
Do.	(199) Mr. S. S. Halkar	Do.	P. L. (renewal).	1,587	1st January 1917.	Do.
Do.	(200) Messrs. Tata Sons & Co.	Do.	P. L. (renewal).	1,656	5th January 1917.	Do.
Do.	(201) Do.	Do.	P. L. (renewal).	780	9th December 1916.	Do.
Do.	(202) Mr. A. E. Wallenberg.	Do.	P. L. (renewal).	720	20th November 1916.	Do.
Do.	(203) Messrs. Steel Bros. & Co., Ltd.	Do.	P. L. (renewal).	1,818	28th December 1916.	3 months.
Do.	(204) M. A. Sooratee	Do.	P. L. (renewal).	609	17th January 1917.	1 year.
Do.	(205) D.	Do.	P. L. (renewal).	640	1st February 1917.	Do.
Do.	(206) Maung Mya Pe	Do.	P. L. (renewal).	537	26th December 1916.	6 months.
Do.	(207) Ong Hoe Kyin	Do.	P. L. (renewal).	605	4th January 1917.	3 months.
Do.	(208) Quah Cheng Gwan	Do.	P. L. (renewal).	640	9th January 1917.	1 year.
Do.	(209) Messrs. Balthazar and Sons.	Do.	P. L. (renewal).	896	22nd December 1916.	6 months.
Do.	(210) Chan Kin Way	Do.	P. L. (renewal).	256	8th January 1917.	Do.
Do.	(211) San Sine Tin	Do.	P. L. (renewal).	911	9th February 1917.	Do.
Do.	(212) Chan Kin Way	Do.	P. L. (renewal).	371	26th January 1917.	1 year.
Do.	(213) Kho Zun Nee	Do.	P. L. (renewal).	614	28th January 1917.	Do.
Do.	(214) Messrs. The Tavoy Concessions, Ltd.	Do.	P. L. (renewal).	500	18th January 1917.	6 months.
Do.	(215) Maung Min Gyaw	Do.	P. L. (renewal).	1,182	8th February 1917.	Do.
Do.	(216) Maung Po Htin	Do.	P. L. (renewal).	988	9th March 1917.	Do.
Do.	(217) Ung Kyi Pe	Do.	P. L. (renewal).	279	15th September 1916.	Do.
Do.	(218) Mr. G. N. Marks	Do.	P. L. (renewal).	476	26th February 1917.	1 year.

P. L.—Prospecting License. M. L.—Mining Lease.



## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy.	(219) Mr. A. Rowland H. Ady.	All minerals (except oil).	P. L.	1,280	28th June 1917.	1 year.
Do.	(220) Maung Me . . .	Do.	P. L.	614	5th June 1917	6 months.
Do.	(221) Maung Paw Tun .	Do.	P. L.	947	19th April 1917.	Do.
Do.	(222) Messrs. The Bombay Burma Trading Corp., Ltd.	Do.	P. L.	708	10th April 1917.	Do.
Do.	(223) Messrs. Foucar & Co., Ltd.	Do.	P. L.	112	17th May 1917.	Do.
Do.	(224) Maung Ba Thaug Bros. & Co.	Do.	P. L.	1,280	22nd May 1917.	Do.
Do.	(225) Maung Paw Tun .	Do.	P. L.	343	14th June 1917.	Do.
Do.	(226) Messrs. Finlay, Fleming & Co.	Do.	P. L.	276	19th May 1917.	Do.
Do.	(227) Maung Kya Pe, Maung Lu Chaw and Ma Kin.	Do.	P. L.	282	22nd June 1917.	1 year.
Do.	(228) Maung Saw Hlaing	Do.	P. L.	179	17th May 1917.	Do.
Do.	(229) Mr. H. G. Mathews	Do.	P. L.	71	13th June 1917.	Do.
Do.	(230) Mr. A. Rowland Ady.	Do.	P. L.	184	11th June 1917.	Do.
Do.	(231) Ma Hnit . . .	Do.	P. L.	691	14th June 1917.	Do.
Do.	(232) Mr. Ung Kyi Pe .	Do.	P. L.	205	18th June 1917.	Do.
Do.	(233) Maung Ze Ya	Do.	P. L.	484	31st May 1917.	Do.
Do.	(234) Maung Shwe Yin .	Do.	P. L.	240	19th June 1917.	Do.
Do.	(235) Ma Kin . . .	Do.	P. L.	860	Do.	6 months.
Do.	(236) Mr. S. Crawshaw .	Do.	P. L.	527	1st June 1917.	1 year.
Do.	(237) Maung Tun Mya .	Do.	P. L.	282	15th June 1917.	Do.
Do.	(238) Mr. Rowland H. Ady.	Do.	P. L.	588	28th June 1917.	Do.
Do.	(239) Messrs. The High Speed Steel Alloys Ltd.	Do.	P. L.	51	27th June 1917.	Do.
Do.	(240) Messrs. Finlay Fleming & Co.	Do.	P. L.	1,434	22nd June 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(241) Mr. Khoo Tun Byan.	All minerals (except oil).	P. L.	148	18th June 1917.	1 year.
Do	(242) Maung Than and Ma Thein.	Do.	P. L.	589	29th June 1917.	Do.
Do.	(243) Mr. A. E. Wallenberg.	Do.	P. L.	320	28th June 1917.	Do.
Do.	(244) Maung Lun Bin .	Do.	P. L. (renewal).	947	6th September 1916.	Do.
Do.	(245) Messrs. Hossain Hamadance, Rowland Ady and E. S. Giles.	Do.	P. L. (renewal).	765	6th December 1916.	Do.
Do.	(246) Messrs. The Bombay Burma Trading Corporation, Ltd.	Do.	P. L. (renewal).	1,000	7th December 1916.	6 months.
Do.	(247) Maung Kya Pe, Maung Lu Chaw and Ma Kin.	Do.	P. L. (renewal).	358	9th December 1916.	1 year.
Do.	(248) Eu Kya Ban and Mr. A. G. Fraser.	Do.	P. L. (renewal).	584	29th December 1916.	6 months.
Do.	(249) Messrs. The London and Burmese Wolfram Co. (transferred from Messrs. Turnbulls (Glasgow), Ltd.)	Do.	P. L. (renewal).	2,409	12th January 1917.	1 year.
Do.	(250) Messrs. Steel Bros. & Co., Ltd.	Do.	P. L. (renewal).	716	1st February 1917.	Do.
Do.	(251) Messrs. Booth & Milne.	Do.	P. L. (renewal).	405	14th February 1917.	Do.
Do.	(252) Maung Sein Daing Broe. & Co.	Do.	P. L. (renewal).	276	23rd February 1917.	Do.
Do.	(253) Do. . .	Do.	P. L. (renewal).	717	Do.	Do.
Do.	(254) Sam Sine Tin .	Do.	P. L. (renewal).	460	16th December 1916	6 months.
Do.	(255) Maung Sein Thwe	Do.	P. L. (renewal).	256	9th April 1917.	Do.
Do.	(256) C. Gyaw Saing .	Do.	P. L. (renewal).	1,106	22nd February 1917.	Do.
Do.	(257) Maung Sein Daing	Do.	P. L. (renewal).	700	23rd March 1917.	1 year.
Do.	(258) Ong Hoe Kyin .	Do.	P. L. (renewal).	605	4th April 1917.	6 months.
Do.	(259) Maung Ba Don .	Do.	P. L. (renewal).	829	Do.	Do.
Do.	(260) Do. . .	Do.	P. L. (renewal).	282	11th May 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(261) Mr. Mahomed Aslam Khan.	All minerals (except oil).	P. L. (renewal).	392	24th March 1917.	1 year.
Do.	(262) Mr. Khoo Tun Byan.	Do.	P. L. (renewal).	322	21st March 1917.	Do.
Do.	(263) Mr. M. A. Sooratee	Do.	P. L. (renewal).	1,024	4th May 1917.	Do.
Do.	(264) Mr. Osman Musti Khan.	Do.	P. L. (renewal).	2,278	12th April 1917.	6 months.
Do.	(265) Maung Ba Thaung Bros. & Co.	Do.	P. L. (renewal).	737	23rd March 1917.	1 year.
Do.	(266) Mr. C. Soo Don	Do.	P. L. (renewal).	604	23rd April 1917.	Do.
Do.	(267) Mr. A. D. Brown	Do.	P. L. (renewal).	666	5th April 1917.	Do.
Do.	(268) Mr. A. S. Minus	Do.	P. L. (renewal).	768	27th April 1917.	6 months.
Do.	(269) Mr. Chew Lu Yin	Do.	P. L. (renewal).	870	4th May 1917.	Do.
Do.	(270) Maung Po Htin	Do.	P. L. (renewal).	460	4th April 1917.	1 year.
Do.	(271) Maung Ni	Do.	P. L. (renewal).	1,917	11th March 1917.	6 months.
Do.	(272) Messrs. Gillanders Arbuthnot & Co.	Do.	F. L. (renewal).	760	25th November 1916.	1 year.
Do.	(273) Mr. R. C. N. Twite	Do.	P. L. (renewal).	625	14th May 1917.	6 months.
Do.	(274) The Shwe Zun	Do.	P. L. (renewal).	512	20th May 1917.	Do.
Do.	(275) Ong Hoe Kyin	Do.	P. L. (renewal).	610	29th May 1917.	1 year.
Do.	(276) A. S. Mahomed	Do.	P. L. (renewal).	1,894	12th June 1917.	Do.
Do.	(277) Messrs. The Rangoon Mining Co., Ltd.	Wolfram and tin.	M. L.	3,209.86	4th October 1913.	30 years.
Do.	(278) Messrs. The Wagon-Pachaung Wolfram Mines, Ltd.	Do.	M. L.	1,763.10 at Wagon.	20th July 1914.	Do.
Do.	(279) Messrs. The Hermyngyi Mining Co., Ltd.	All minerals except oil and precious stones.	M. L.	1,782.85	17th December 1913.	Do.
Do.	(280) Messrs. The Tavoy Concessions, Ltd.	Do.	M. L.	750.94 at Thingandon.	Do.	Do.
Do.	(281) Do.	Do.	M. L.	994.22 at Kadwe.	Do.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(282) Messrs. The Wagon-Pachaung Wolfram Mines, Ltd.	Wolfram and tin	M. L.	2,162.38 at Pachaung.	5th September 1914.	30 years.
Do.	(283) Messrs. Radcliff & Co., Ltd.	All minerals except oil and precious stones.	M. L.	4,848.79	30th December 1913.	Do.
Do.	(284) Messrs. The Tavoy Concessions, Ltd.	Do.	M. L.	1,092.86 at Kalonta.	18th January 1917.	Do.
Do.	(285) Do.	Do.	M. L.	616.72 at Byaukchaung.	19th January 1917.	Do.
Do.	(286) Mr. Quah Cheng Guan.	Wolfram and tin	M. L.	199.69	16th June 1915.	Do.
Do.	(287) Oosman Musti Khan.	All minerals (except oil).	P. L.	747	10th August 1917.	6 months.
Do.	(288) Mr. C. Willison	Do.	P. L.	26	1st August 1917.	1 year.
Do.	(289) Quah Cheng Gwan	Do.	P. L.	1,003	3rd September 1917.	Do.
Do.	(290) Messrs. Finlay Fleming & Co.	Do.	P. L.	287	30th July 1917.	6 months.
Do.	(291) Maung Po Gywe	Do.	P. L.	604	6th August 1917.	1 year.
Do.	(292) Quah Cheng Tock	Do.	P. L.	2,176	10th July 1917.	Do.
Do.	(293) Do.	Do.	P. L.	988	3rd September 1917.	Do.
Do.	(294) Seinbondaung Mining Co.	Do.	P. L.	502	17th September 1917.	Do.
Do.	(295) Mr. A. R. H. Ady	Do.	P. L.	400	8th August 1917.	Do.
Do.	(296) Maung Maung	Do.	P. L.	563	26th September 1917.	Do.
Do.	(297) Maung Po Gywe	Do.	P. L.	297	Do.	Do.
Do.	(298) Maung Lu Pe and Mr. A. G. Fraser.	Do.	P. L. (renewal).	780	5th December 1916.	6 months.
Do.	(299) Messrs. Steel Bros. & Co., Ltd.	Do.	P. L. (renewal).	589	16th May 1917.	1 year.
Do.	(300) Ung Kyi Pe	Do.	P. L. (renewal).	614	17th May 1917.	Do.
Do.	(301) Messrs. The Bombay-Burma Trading Corporation, Ltd.	Do.	P. L. (renewal).	1,459	18th May 1917.	6 months.
Do.	(302) Do.	Do.	P. L. (renewal).	947	Do.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(303) Maung Kya Tun	All minerals (except oil).	P. L. (renewal).	307	20th May 1917.	6 months.
Do.	(304) Maung Po Mye	Do.	P. L. (renewal).	855	1st June 1917.	1 year.
Do.	(305) Messrs. Tata Sons & Co.	Do.	P. L. (renewal).	292	6th June 1917.	Do.
Do.	(306) Mahomed Aslam Khan.	Do.	P. L. (renewal).	1,536	16th June 1917.	6 months.
Do.	(307) Maung Me	Do.	P. L. (renewal).	1,280	22nd June 1917.	1 year.
Do.	(308) Khoo Zun Nee	Do.	P. L. (renewal).	739	7th June 1917.	Do.
Do.	(309) Maung Saw Hlaing	Do.	P. L. (renewal).	1,280	21st June 1917.	6 months.
Do.	(310) Do.	Do.	P. L. (renewal).	548	2nd July 1917.	Do.
Do.	(311) Ong Hoe Kyin	Do.	P. L. (renewal).	179	13th June 1917.	1 year.
Do.	(312) Ganpat Rai	Do.	P. L. (renewal).	384	16th June 1917.	6 months.
Do.	(313) Mr. Fowle	Do.	P. L. (renewal).	320	13th June 1917.	Do.
Do.	(314) The High Speed Steel Alloys, Ltd.	Do.	P. L. (renewal).	1,433	Do.	Do.
Do.	(315) Khoo Tun Byan	Do.	P. L. (renewal).	148	30th May 1917.	Do.
Do.	(316) Mr. A. E. Wallenberg.	Do.	P. L. (renewal).	720	20th May 1917.	Do.
Do.	(317) Chan Kin Way	Do.	P. L. (renewal).	256	8th July 1917.	1 year.
Do.	(318) Netram Rambux	Do.	P. L. (renewal).	240	4th July 1917.	6 months.
Do.	(319) Messrs. The Bombay-Burma Trading Corporation, Ltd.	Do.	P. L. (renewal).	1,000	7th June 1917.	1 year.
Do.	(320) Ma Yin Bi	Do.	P. L. (renewal).	640	29th November 1916.	Do.
Do.	(321) Mr. Fitzherbert	Do.	P. L. (renewal).	238	24th February 1917.	6 months.
Do.	(322) Eu Kya Ban & Mr. Fraser.	Do.	P. L. (renewal).	584	29th June 1917.	Do.
Do.	(323) Mr. S. S. Halker	Do.	P. L. (renewal).	1,587	1st July 1917.	3 months.
Do.	(324) Messrs. Finlay Fleming & Co., Ltd.	Do.	P. L. (renewal).	445	7th July 1917.	6 months.

P. L.—Prospecting License. M. L.—Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(325) San Sine Tin	All minerals (except oil).	P. L. (renewal).	911	9th August 1917.	6 months.
Do.	(326) Messrs. Hitakari & Co.	Do.	P. L. (renewal).	589	28th May 1917.	Do.
Do.	(327) Maung Mya Pe	Do.	P. L. (renewal).	537	26th June 1917.	Do.
Do.	(328) Maung Sein Khaing.	Do.	P. L. (renewal).	640	8th July 1917.	Do.
Do.	(329) Maung Sein Khaing.	Do.	P. L. (renewal).	682	23rd May 1917.	Do.
Do.	(330) Mr. A. R. H. Ady	Do.	P. L. (renewal).	620	6th July 1917.	Do.
Do.	(331) Maung E. Zin	Do.	P. L. (renewal).	435	15th August 1917.	3 months.
Do.	(332) Mr. A. Fraser	Do.	P. L. (renewal).	922	22nd July 1917.	6 months.
Do.	(333) Maung Paw Tun	Do.	P. L. (renewal).	450	19th April 1917.	Do.
Do.	(334) Maung Min Gyaw	Do.	P. L. (renewal).	1,182	8th August 1917.	1 year.
Do.	(335) Maung Mo Thu	Do.	P. L. (renewal).	1,536	14th June 1917.	6 months.
Do.	(336) Maung Khine	Do.	P. L. (renewal).	809	24th August 1917.	Do.
Do.	(337) Maung Sein Thwe	Do.	P. L. (renewal).	589	19th August 1917.	Do.
Do.	(338) Mr. Fitzherbert	Do.	P. L. (renewal).	238	4th August 1917.	Do.
Do.	(339) Maung Shwe Gaing	Do.	P. L. (renewal).	512	23rd September 1917.	Do.
Do.	(340) Ma Mya Yin	Do.	P. L.	1,039	21st December 1917.	1 year.
Do.	(341) Mr. G. Willison	Do.	P. L.	548	22nd October 1917.	Do.
Do.	(342) San Sine Tin	Do.	P. L.	620	7th November 1917.	Do.
Do.	(343) Mr. J. J. Page	Do.	P. L.	701	19th October 1917.	Do.
Do.	(344) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L.	320	12th October 1917.	Do.
Do.	(345) Eu Kya Ban	Do.	P. L.	640	28th December 1917.	Do.
Do.	346) Mr. A. R. H. Ady	Do.	P. L.	512	28th November 1917.	6 months.

P. L.=Prospecting License. M. L.=Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(347) Maung Me . . .	All minerals (except oil).	P. L.	858	30th November 1917.	1 year.
Do.	(348) Mr. G. Willison . .	Do.	P. L.	317	26th November 1917.	Do.
Do.	(349) Messrs. Tata Sons & Co.	Do.	P. L. (renewal).	780	9th June 1917.	6 months.
Do.	(350) Mr. A. E. Wallenberg.	Do.	P. L. (renewal).	1,422	21st June 1917.	Do.
Do.	(351) Maung Po Swe . .	Do.	P. L. (renewal).	488	22nd July 1917.	Do.
Do.	(352) C. Gyaw Saing . .	Do.	P. L. (renewal).	1,106	22nd August 1917.	1 year.
Do.	(353) Maung Gun . . .	Do.	P. L. (renewal).	768	3rd September 1917.	6 months.
Do.	(354) Mr. A. E. Wallenberg.	Do.	P. L. (renewal).	1,600	13th September 1917.	Do.
Do.	(355) Mr. R. C. N. Twite	Do.	P. L. (renewal).	460	22nd September 1917.	Do.
Do.	(356) Maung Ba Maung-	Do.	P. L. (renewal).	1,920	24th September 1917.	Do.
Do.	(357) Messrs. The High Speed Steel Alloys Mining Co., Ltd.	Do.	P. L. (renewal).	256	26th September 1917.	Do.
Do.	(358) Ma Mya Yin . . .	Do.	P. L. (renewal).	1,075	Do.	Do.
Do.	(359) Maung Po Hnan . .	Do.	P. L. (renewal).	640	Do.	Do.
Do.	(360) Lim Kyee Yan . . .	Do.	P. L. (renewal).	161.28	28th September 1917.	1 year.
Do.	(361) Maung Sein Thwe . .	Do.	P. L. (renewal).	256	9th October 1917.	6 months.
Do.	(362) Mr. S. S. Halker . .	Do.	P. L. (renewal).	681	1st October 1917.	Do.
Do.	(363) Maung Tun Mya . .	Do.	P. L. (renewal).	988	9th September 1917.	1 year.
Thaton	(364) Ma Nyein . . .	Do.	P. L.	608	2nd January 1917.	Do.
Do.	(365) Mr. H. F. Singleton and Messrs. Binning & Co.	Do.	P. L.	512	26th January 1917.	Do.
Do.	(366) Mr. J. W. Darwood . .	Do.	P. L.	1,145.6	22nd January 1917.	Do.
Do.	(367) Ma Nyein . . .	Do.	P. L.	576	18th January 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thaton	(368) Maung Tun Hla	All minerals (except oil).	P. L.	1,241.6	25th January 1917.	1 year.
Do.	(369) Maung Ba Si	Do.	P. L.	601.6	10th February 1917.	Do.
Do.	(370) Lim Kar Chang	Do.	P. L.	3,238.4	1st March 1917.	Do.
Do.	(371) Mr. A. Samed	Do.	P. L.	9.50	3rd March 1917.	Do.
Do.	(372) Li Ah Lye	Do.	P. L. (renewal).	640	18th December 1916.	Do.
Do.	(373) Ma Thein Zin	Do.	P. L. (renewal).	320	14th February 1917.	Do.
Do.	(374) Mr. C. H. Stork	Do.	P. L. (renewal).	819.2	17th February 1917.	Do.
Do.	(375) U Pan Dwe and Ma Khin, alias Messrs. Bah Too.	Do.	P. L. (renewal).	2,649.6	10th March 1917.	Do.
Do.	(376) Dr. Shaw Loo	Do.	P. L.	1,536	4th April 1917.	Do.
Do.	(377) Mr. P. M. Pillay	Do.	P. L.	1,491.2	11th April 1917.	Do.
Do.	(378) Maung Pu	Do.	P. L.	1,574.4	Do.	Do.
Do.	(379) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L.	1,318.4	22nd May 1917.	Do.
Do.	(380) Do.	Do.	P. L.	396.8	18th April 1917.	Do.
Do.	(381) Maung Ba Tin	Do.	P. L.	672	26th April 1917.	Do.
Do.	(382) Mr. F. A. Boog	Do.	P. L.	3,968	25th April 1917.	Do.
Do.	(383) Mr. A. D. Keith	Do.	P. L.	5,657.6	Do.	Do.
Do.	(384) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L.	825.6	15th April 1917.	Do.
Do.	(385) Mr. F. A. Boog	Do.	P. L.	4,313.6	Do.	Do.
Do.	(386) Maung Shan Byu	Do.	P. L.	4,640	10th April 1917.	Do.
Do.	(387) Mr. Tan Toe	Do.	P. L.	518.4	5th June 1917.	Do.
Do.	(388) Mr. L. Hong Seng	Do.	P. L.	378.4	15th March 1917.	Do.
Do.	(389) Mr. C. H. Noyce	Do.	P. L.	2,981.2	2nd May 1917.	Do.
Do.	(390) Mr. C. E. Connell	Do.	P. L.	3,513.6	27th April 1917.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.



## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thaton	(391) Mr. C. R. Connel	All minerals (except oil).	P. L.	2,444.8	25th April 1917.	1 year.
Do.	(392) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L.	864	19th May 1917.	Do.
Do.	(393) Mr. Tan Kim Chye	Do.	P. L.	51.2	21st May 1917.	Do.
Do.	(394) Maung Ni	Do.	P. L.	1,350.4	19th May 1917.	Do.
Do.	(395) Maung Pu	Do.	P. L.	563.2	25th April 1917.	Do.
Do.	(396) Mr. L. Ah Chóy	Do.	P. L.	563.2	19th May 1917.	Do.
Do.	(397) Mr. Tan Kim Chye	Do.	P. L.	4,064	28th May 1917.	Do.
Do.	(398) Maung Ni	Do.	P. L.	953.6	24th May 1917.	Do.
Do.	(399) Mr. C. A. Meredith	Do.	P. L.	1,305.6	7th June 1917.	Do.
Do.	(400) Maung Shwe Goh	Do.	P. L.	1,049.6	6th June 1917.	Do.
Do.	(401) Maung Kaing	Do.	P. L. (renewal).	678.4	14th February 1917.	Do.
Do.	(402) Mr. H. E. Singleton.	Do.	P. L. (renewal).	1,657.6	21st February 1917.	Do.
Do.	(403) Mr. A. Kader	Do.	P. L. (renewal).	499.2	1st April 1917.	Do.
Do.	(404) Maung Pu	Do.	P. L. (renewal).	108.8	7th April 1917.	Do.
Do.	(405) Mr. A. J. Salvador	Do.	P. L. (renewal).	851.2	Do.	Do.
Do.	(406) Messrs. A. V. Joseph & Co.	Do.	P. L. (renewal).	524.8	2nd May 1917.	Do.
Do.	(407) Maung Chit Maung	Do.	P. L. (renewal).	1,836.8	11th April 1917.	Do.
Do.	(408) Mr. C. Soo Don	Do.	P. L. (renewal).	876.8	2nd February 1917.	Do.
Do.	(409) Mr. C. R. Connell	Do.	P. L.	1,881.6	29th May 1917.	Do.
Do.	(410) Ko Chang Kaing	Do.	P. L.	889.6	26th April 1917.	Do.
Do.	(411) M. Ah Khee	Do.	P. L.	563.2	27th June 1917.	Do.
Do.	(412) Mr. C. P. Vileland	Mineral oil	P. L.	819.2	14th July 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Baton	(418) Mr. P. M. Pillay .	Mineral oil .	P. L. .	29.44	20th June 1917.	1 year.
Do.	(414) Maung Po Gyi .	All minerals (except oil).	P. L. .	1,920	23rd July 1917.	Do.
Do.	(415) U. Shan Byu .	Do. .	P. L. .	2,144	23rd March 1917.	Do.
Do.	(416) Maung Tun Hla .	Do. .	P. L. .	1,952	24th May 1917.	Do.
Do.	(417) Maung San Dun .	Do. .	P. L. .	1,075.2	12th July 1917.	Do.
Do.	(418) Mr. C. A. Meredith	Do. .	P. L. .	236.5	27th June 1917.	Do.
Do.	(419) U. Pan Dwe .	Do. .	P. L. .	128	20th June 1917.	Do.
Do.	(420) U Po Ngwe . .	Do. .	P. L. .	2,048	5th June 1917.	Do.
Do.	(421) Tan Kin Chye .	Do. .	P. L. .	691.2	31st August 1917.	Do.
Do.	(422) Ma Pyu Pyu .	Do. .	P. L. .	1,254.4	14th July 1917.	Do.
Do.	(423) U Po Ngwe . .	Do. .	P. L. (renewal).	729.6	7th August 1917.	6 months.
Do.	(424) U Ba Wet . .	Do. .	P. L. (renewal).	1,190.4	16th August 1917.	1 year.
Do.	(425) M. A. Kader .	Do. .	P. L. .	640	18th October 1917.	Do.
Do.	(426) The Hon'ble Mr. Lim Chin Tsong.	Do. .	P. L. .	6,368	17th September 1917.	Do.
Do.	(427) Maung Ba Si .	Do. .	P. L. .	1,260.8	7th August 1917.	Do.
Do.	(428) Lim Tha Nyein .	Do. .	P. L. .	2,003.2	31st July 1917.	Do.
Do.	(429) Mr. C. A. Meredith	Do. .	P. L. .	3,174.4	12th July 1917.	Do.
Do.	(430) M. Hashim . .	Do. .	P. L. .	640	27th September 1917.	Do.
Do.	(431) M. Ah Khee .	Do. .	P. L. (renewal).	467.2	20th July 1917.	2 years.
Do.	(432) Maung Pu . .	Do. .	P. L. (renewal).	108.8	22nd November 1917.	6 months.
Thayotmyo.	(433) Messrs. The Twinas Oil Co., Ltd.	Mineral oil .	P. L. .	1,920 Blocks Nos. 13, 20 and 23 of the Minbia Oil Field.	21st December 1916.	1 year.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thayetmyo.	(434) Mr. B. Cowasjee	Mineral oil	P. L.	1,123.2 Blocks 1, 2 and 8 and the eastern half of block 9 of the Minhla Oil Field.	21st December 1916.	1 year.
Do.	(435) Messrs. The Burma Oil Co., Ltd.	Do.	P. L.	5,120 Eastern halves of blocks Nos. 18, 25, 28 and 29, western halves of blocks Nos. 19 and 30 and the whole of blocks 24, 29, 33, 34, and 40 of the Minhla Oil Field.	Do.	Do.
Do.	(436) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L.	2,858.9 Blocks Nos. 3 and 4 excluding area held by the B. B. P. Co. in block No. 4, blocks Nos. 16 and 17; western half of block 18 and eastern half of block 19 of the Minhla Oil Field.	Do.	Do.
Do.	(437) Messrs. The British-Burma Petroleum Co., Ltd.	Do.	P. L. (renewal).	94.72 Block 4 of the Minhla Oil Field.	23rd December 1916.	Do.
Do.	(438) Messrs. The London-Rangoon Trading Co., Ltd.	Do.	P. L.	2,560 (Blocks Nos. 26 and 27, E½ of 30, W¼ of 9, 25 and 28 of the Minhla Oil Field.	9th March 1917.	Do.
Do.	(439) Do.	Do.	P. L.	10,240	30th May 1917.	Do.
Do.	(440) Messrs. The Nath Singh Oil Co., Ltd.	Do.	P. L.	4,800	18th October 1917.	Do.
Do.	(441) Mrs. H. V. Murray	Do.	P. L.	3,200	13th November 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease

BURMA—*concl'd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Upper Chindwin.	(442) Messrs. Osman Mustie Khan & Co.	Mineral oil	P. L.	3,840	18th December 1916.	1 year.
Do.	(443) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L. (renewal).	12,800	12th September 1916.	Do.
Do.	(444) Do.	Do.	P. L.	3,200	24th May 1917.	Do.
Yamethin.	(445) Messrs. Beehardass Manockchand Kharwar.	Lead	P. L.	2,560	20th April 1917.	Do.

## CENTRAL PROVINCES.

Balaghat	(446) Khan Bahadur Byramji Pestonji.	Manganese	P. L.	280	7th February 1917.	1 year.
Do.	(447) Indian Manganese Company, Limited.	Do.	P. L.	1	18th January 1917.	Do.
Do.	(448) Do.	Do.	P. L.	153	Do.	Do.
Do.	(449) Babu Kripashankar.	Do.	P. L. (renewal).	271	5th February 1917.	6 months.
Do.	(450) Do.	Do.	P. L. (renewal).	350	8th January 1917.	Do.
Do.	(451) Khan Bahadur Byramji Pestonji.	Do.	M. L.	346	28th April 1917.	30 years.
Do.	(452) Seth Gowardhandas.	Do.	P. L.	20	5th May 1917.	1 year.
Do.	(453) Babu Kripashankar.	Do.	P. L. (renewal).	272	5th August 1917.	6 months.
Do.	(454) Indian Manganese Company, Limited.	Do.	P. L.	60	28th August 1917.	1 year.
Do.	(455) Khan Bahadur Byramji Pestonji.	Do.	M. L.	4	27th June 1917.	5 years.
Do.	(456) Do.	Do.	M. L.	48	13th August 1917.	Do.
Do.	(457) Babu Kripashankar.	Do.	P. L. (renewal).	38	29th August 1917.	6 months.
Do.	(458) Khan Bahadur Byramji Pestonji.	Do.	P. L.	171	13th October 1917.	1 year.
Do.	(459) Babu Kripashankar.	Do.	P. L.		Do.	Do.
Do.	(460) Pandit Rewashankar.	Do.	P. L.	35	Do.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(461) Messrs. Rampershad Lakshminarayan.	Manganese	P. L.	2	17th December 1917.	1 year.
Do.	(462) Babu Kripashankar.	Do.	P. L.	171	13th October 1917.	Do.
Do.	(463) Messrs. Tata Sons & Co.	Bauxite	P. L.	63	31st December 1917.	Do.
Do.	(464) Do.	Do.	P. L.	107	Do.	Do.
Do.	(465) Do.	Do.	P. L.	241	Do.	Do.
Do.	(466) Do.	Do.	P. L.	96	21st December 1917.	Do.
Bhandara	(467) Nagpur Manganese Mining Syndicate, Ltd.	Manganese	M. L.	18	23rd January 1917.	10 years.
Do.	(468) Messrs. Lalbehari and Ramcharan.	Do.	M. L.	26	15th December 1916.	Do.
Do.	(469) Seth Gowardhandas.	Do.	M. L.	62	12th December 1916.	30 years.
Do.	(470) Hon'ble Dewan Bahadur Sir Kasturchand Daga, K.C.I.E.	Do.	M. L.	87	18th December 1916.	5 years.
Do.	(471) Khan Bahadur Byramji Pestonji.	Do.	M. L.	13	21st February 1917.	Do.
Do.	(472) Seth Gowardhandas.	Do.	P. L.	232	15th January 1917.	1 year.
Do.	(473) Seth Mahadeo	Do.	P. L.	29	27th March 1917.	Do.
Do.	(474) Pandit Rewashankar.	Do.	P. L.	47	3rd February 1917.	Do.
Do.	(475) Seth Gowardhandas.	Do.	P. L.	30	21st June 1917.	Do.
Do.	(476) Do.	Do.	P. L.	50	Do.	Do.
Do.	(477) Seth Mahadeo	Do.	P. L. (renewal).	8	26th September 1917.	Do.
Do.	(478) Do.	Do.	P. L. (renewal).	38	15th June 1916.	Do.
Do.	(479) Do.	Do.	P. L. (renewal).	30	26th August 1917.	Do.
To.	(480) Do.	Do.	P. L.	348	13th September, 1917.	Do.
Do.	(481) Do.	Do.	P. L.	611	Do.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

## CENTRAL PROVINCES—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara	(482) Seth Gowardhandas.	Manganese	M. L.	19	19th April 1917.	Will expire with the original lease dated the 5th March 1916, to which it is supplementary.
Do.	(483) Seth Shriram	Do.	P. L.	89	9th August 1917.	1 year.
Do.	(484) Seth Jagannath	Do.	P. L.	313	13th August 1917.	Do.
Do.	(485) Seth Shriram	Do.	P. L.	274	29th September 1917.	Do.
Do.	(486) Messrs. Lal Behari and Ramcharan.	Do.	P. L. (renewal.)	16	11th July 1917.	Do.
Do.	(487) Seth Mahadeo	Do.	P. L.	45	30th September 1917.	Do.
Do.	(488) Seth Shriram	Do.	P. L.	47	29th September 1917.	Do.
Do.	(489) Seth Gowardhandas.	Do.	M. L.	29	17th October 1917.	4 years.
Do.	(490) Seth Shriram	Do.	P. L.	89	8th December 1917.	1 year.
Do.	(491) Do.	Do.	P. L.	20	13th October 1917.	Do.
Bilaspur	(492) Tata Iron and Steel Co., Ltd.	Iron ore and other minerals (Dolomite and limestone).	P. L.	6,799	28th May 1917.	Do.
Chanda	(493) Messrs. H. Verma and Kanhaiyalal.	Coal	M. L.	1,221	5th February 1917.	Will expire with the original lease dated the 30th October 1915 to which it is supplementary.
Do.	(494) Mr. Padamsy Narsimbhoy.	Do.	P. L.	3,827	17th May 1917.	1 year.
Do.	(495) Do.	Do.	P. L.	400	17th June 1917.	Do.
Do.	(496) Do.	Do.	P. L.	840	17th May 1917.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

## CENTRAL PROVINCES—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chanda	(497) Messrs. Hashambhoy & Sons.	Coal . . . .	P. L. . . .	2,439	10th October 1917.	1 year.
Do.	(498) Mr. Padamay Narsibhoy.	Do. . . . .	P. L. . . .	70	26th November 1917.	Do.
Chhindwara	(499) Khan Bahadur Byramji Pestonji.	Manganese . .	P. L. . . .	134	27th January 1917.	Do.
Do.	(500) Do.	Do. . . . .	M. L. . . .	88	21st February 1917.	5 years.
Do.	(501) Messrs. H. Verma and Kanhaiyalal.	Coal . . . .	P. L. . . .	437	21st May 1917	1 year.
Do.	(502) Rai Bahadur Bishesar Das Daga.	Manganese . .	P. L. . . .	39	2nd April 1917.	Do.
Do.	(503) The Hon'ble Mr. M. B. Dadabhoy, C.I.E.	Do. . . . .	P. L. . . .	129	3rd April 1917.	Do.
Do.	(504) Messrs. H. Verma and Kanhaiyalal.	Coal . . . .	P. L. . . .	146	4th October 1917.	Do.
Do.	(505) Do.	Do. . . . .	P. L. . . .	370	19th December 1917.	Do.
Do.	(506) Indian Manganese Co.	Manganese . .	M. L. . . .	21	17th October 1917.	Will expire with the original lease dated the 6th February 1904 to which it is supplementary.
Drug .	(507) Messrs. Bahman-shah Fouzdar Bros.	Bauxite, silver, cobalt and copper.	M. L. . . .	3	2nd November 1917.	Will expire with the original lease, dated the 20th June, 1910, to which it is supplementary.
Jubbulpore	(508) Messrs. Burn & Co.	Coal . . . .	P. L. . . .	1,127	29th January 1917.	1 year.
Do.	(509) Mr. P. C. Dutt .	Bauxite . . .	P. L. . . .	448	5th January 1917.	Do.
Do.	(510) Do.	Manganese . .	P. L. . . .	55	22nd May 1917.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

## CENTRAL PROVINCES—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore	(511) Mr. F. C. Dutt	Manganese	M. L.	19	2nd April 1917.	Will expire with the original lease, dated the 4th September 1915, to which it is supplementary.
Do.	(512) Do.	Do.	P. L.	82	Do.	1 year.
Do.	(513) Do.	Bauxite and iron	P. L. (renewal).	148	22nd October 1916.	Do.
Do.	(514) Do.	Bauxite	M. L.	52	12th July 1917.	30 years.
Do.	(515) Do.	Bauxite and iron oxide.	P. L.	404	9th August 1917.	1 year.
Do.	(516) Do.	Coal	P. L.	384	23rd July 1917.	Do.
Do.	(517) Do.	Manganese, iron, thallium, bauxite, vanadium, caesium, cerium, columbium, didymium, erbium, gallium, germanium, indium, lithium, niobium, rubidium, tantalum, thorium, uranium, yttrium and zirconium.	P. L.	566	30th November 1917.	Do.
Do.	(518) Do.	Bauxite lead, gold, barytes, silver, and copper.	P. L.	212	5th November 1917.	Do.
Do.	(519) Do.	Bauxite and iron	P. L.	653	Do.	Do.
Do.	(520) Do.	Manganese, iron, Bauxite, nickel, cobalt, cadmium, molybdenum, thallium, vanadium, titanium, copper, caesium, cerium, columbium, didymium, erbium, gallium, germanium, indium, lithium, niobium, rubidium, tantalum, thorium, uranium, yttrium and zirconium.	P. L.	293	21st December 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.



CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore	(521) Khan Bahadur Byramji Pestonji.	Manganese	P. L.	75	7th December 1917.	1 year.
Do.	(522) Messrs. Burn & Co.	Bauxite	P. L.	4,159	17th November 1917.	Do.
Do.	(523) Mr. S. R. Dutt	Bauxite and barytes.	P. L.	154	7th December 1917.	Do.
Nagpur	(524) Messrs. H. Verma and Kanhaiyalal.	Manganese	M. L.	171	15th January 1917.	30 years.
Do.	(525) Mr. Lakshman Damodhar Lele.	Do.	M. L.	59	28th November 1916.	Do.
Do.	(526) Khan Bahadur Byramji Pestonji.	Do.	P. L.	489	16th January 1917.	1 year.
Do.	(527) Messrs. Goredutt, Ganeshlal and M. D'Costa.	Do.	P. L.	44	1st May 1917	Do.
Do.	(528) Messrs. Bahmansha Fouzdar Bros.	Do.	P. L.	184	21st April 1917.	Do.
Do.	(529) Central India Mining Co., Ltd.	Do.	P. L.	545	27th April 1917.	Do.
Do.	(530) Messrs. Bahmansha Fouzdar Bros.	Do.	P. L.	30	19th September 1917.	Do.
Do.	(531) Seth Gowardhandas	Mica	P. L.	39	21st August 1917.	Do.
Do.	(532) Nagpur Manganese Mining Syndicate.	Manganese	P. L.	53	20th July 1917.	Do.
Do.	(533) Rao Sahib D. Lakshminarayan.	Manganese and pyrolusite.	P. L.	20	31st August 1917.	Do.
Do.	(534) Central India Mining Co., Ltd.	Manganese	P. L.	7	9th November 1917.	Do.
Do.	(535) Do.	Do.	P. L.	475	7th December 1917.	Do.
Do.	(536) Do.	Do.	P. L.	153	18th October 1917.	Do.
Do.	(537) Do.	Do.	P. L.	240	Do.	Do.
Do.	(538) Mir Aslam Khan	Do.	P. L.	7	9th November 1917.	Do.
Do.	(539) Rai Bahadur Bissessardas Daga.	Do.	P. L.	81	7th December 1917.	Do.
Do.	(540) Do.	Do.	P. L.	70	21st November 1917.	Do.

P. L.—Prospecting License. M. L.—Mining Lease

## CENTRAL PROVINCES—concl'd.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(541) Mir Aslam Khan .	Manganese .	P. L. .	629	12th October 1917.	1 year.
Do.	(542) Messrs. Bahmansha Fousdar Bros.	Do. .	P. L. .	32	9th November 1917.	Do.)
Do.	(543) Mir Aslam Khan .	Do. .	P. L. .	442		Do.
Do.	(544) Mr. N. Venkat Ramannah.	Do. .	P. L. .	111	21st November 1917.	Do.
Yeotmal	(545) Mulla Hasan Ali Nathubhoj.	Coal .	M. L. .	1,206	26th January 1917.	80 years
Do.	(546) Do. .	Do. .	M. L. .	563	Do. .	Do.
Do.	(547) Do. .	Do. .	M. L. .	1,291	17th February 1917.	Do.

## MADRAS.

Coimbatore	(548) Messrs. Startin & Co. of London.	Mica . . .	P. L. .	4-37	24th March 1917.	1 year.
Do.	(549) Messrs. Startin & Co.	Do. . .	P. L. .	9-34	2nd August 1917.	Do
Kurnool	(550) A. Ghose, Esq. .	Barytes . .	P. L. .	62-57	27th February 1917.	Do.
Do.	(551) Do. .	Do. . .	P. L. .	20-85	18th May 1917.	Do.
Do.	(552) Do. .	Do. . .	P. L. .	66-70	4th August 1917.	Do.
Do.	(553) Do. .	Do. . .	P. L. .	58-82	18th July 1917.	Do.
Nellore	(554) P. Krishnasami Mudaliyar.	Mica . . .	M. L. .	174-76	10th December 1913.	80 years
Do.	(555) Messrs. F. F. Chrestien & Co.	Do. . .	M. L. .	2-32	28th November 1916.	Do.
Do.	(556) P. Venkatasami Chetti.	Do. . .	P. L. .	0-74	10th January 1917.	1 year.
Do.	(557) Indupur Subbarami Reddi.	Do. . .	P. L. .	31-26	26th June 1917.	Do.
Do.	(558) V. K. M. K. R. Karuppan Chetti.	Do. . .	P. L. .	5	2nd March 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

## MADRAS—concl'd.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore	(559) K. Venkataramaniah	Mica . . . .	P. L. . . .	15	1st April 1917.	1 year.
Do.	(560) Khan Bahadur Muhammad Safdar Hussain.	Do. . . . .	M. L. . . .	844.54	1st April 1914.	30 years.
Do.	(561) M. R. M. A. Subramania Chettiar.	Do. . . . .	M. L. . . .	34.71	5th August 1911.	Do.
Do.	(562) B. Venkata Subba Reddi.	Do. . . . .	P. L. . . .	17.76	1st September 1917.	1 year.
Do.	(563) P. Venkataswami Chetti.	Do. . . . .	P. L. . . .	48.28	9th April 1917.	Do.
Do.	(564) V. K. M. K. R. Karuppan Chetti.	Do. . . . .	P. L. . . .	64.02	28th July 1917.	Do.
Do.	(565) I. Subbarami Reddi	Do. . . . .	P. L. . . .	30.09	15th August 1917.	Do.
Do.	(566) The Sankara Mining Syndicate.	Do. . . . .	M. L. . . .	136.80	1st December 1905.	30 years.
Do.	(567) A. Govindu Reddi	Do. . . . .	P. L. . . .	26.58	20th October 1917.	1 year.
Do.	(568) N. Raghavulu Nayakkar.	Do. . . . .	P. L. . . .	11.96	5th December 1917.	Do.
Do.	(569) V. K. M. K. R. Karuppan Chetti.	Do. . . . .	P. L. . . .	24.62	1st December 1917.	Do.
Do.	(570) N. Raghavulu Nayakkar.	Do. . . . .	P. L. . . .	9.41	5th October 1917.	Do.
Do.	(571) Moolji Govindji .	Do. . . . .	P. L. . . .	20	15th October 1917.	Do.
Trichinopoly	(572) Messrs. T. Stanes & Co., Ltd., Coimbatore.	Phosphatic nodules	P. L. . . .	430.69	23rd June 1917.	Do.

## PUNJAB.

Attock	(573) Attock Oil Co., Ltd.	Mineral oil . . .	P. L. . . .	1,280	5th June 1917.	1 year.
Shahpur	(574) The Burma Oil Co., Ltd.	Do. . . . .	P. L. . . .	4,992	10th July 1917.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

## SUMMARY.

Province.	Prospecting Licenses.	Mining Leases.	Total of each Province.
Assam . . . . .	4	2	6
Baluchistan . . . . .	3	4	7
Bihar and Orissa . . . . .	21	14	35
Bombay . . . . .	4	1	5
Eurma . . . . .	380	12	392
Central Provinces . . . . .	81	21	102
Madras . . . . .	20	5	25
Punjab . . . . .	2	..	2
<b>Total of each kind and Grand Total 1917</b>	<b>515</b>	<b>50</b>	<b>574</b>
<b>TOTAL OF 1916</b>	<b>482</b>	<b>50</b>	<b>532</b>

**CLASSIFICATION OF LICENSES AND LEASES.****TABLE 27.**—*Prospecting Licenses and Mining Leases granted in Assam during 1917.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Cachar . . . . .	1	16,000	Mineral oils
Lakhimpur . . . . .	1	8,238.08	Coal.
Sylhet . . . . .	2	14,547.2	Mineral oils.
<b>TOTAL</b> . . . . .	<b>4</b>	<b>...</b>	

<b>Mining Leases.</b>			
Khasi and Jaintia Hills . . . . .	1	1,920	Metallic ores.
Lakhimpur . . . . .	1	2,227.2	Coal, iron, slate and shale.
<b>TOTAL</b> . . . . .	<b>2</b>	<b>...</b>	

**TABLE 28.**—*Prospecting Licenses and Mining Leases granted in Baluchistan during 1917.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Kalat . . . . .	3	58,240	Oil.

TABLE 28.—*Prospecting Licenses and Mining Leases granted in Baluchistan during 1917.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.
<b>Mining Leases.</b>			
Quetta Pishin . . . . .	1	80	Chromite.
Do . . . . .	1	80	Coal.
Sibi . . . . .	2	96-46	Do.
TOTAL . . . . .	4	...	

TABLE 29.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during 1917.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Hazaribagh . . . . .	5	504	Mica
Santal Parganas . . . . .	2	10,239-76	Coal.
Singbhum . . . . .	5	2,025-5	Chromite.
Do. . . . .	1	11-90	Yellow ochre.
Do. . . . .	3	36,032	Manganese and iron ore
Do. . . . .	1	1,330	Galena, gold and other kindred minerals
Do. . . . .	1	75-90	Manganese.
Do. . . . .	1	150	Red ochre.
Do. . . . .	1	56	Iron ore.
Do. . . . .	1	4-60	Yellow and red ochre.
TOTAL . . . . .	21	...	

TABLE 29.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during 1917.*

DISTRICT.	1917.		
	No.	Area, in acres.	Mineral.
<b>Mining Leases.</b>			
Gya . . . . .	1	1,557.05	Mica.
Hazaribagh . . . . .	1	70	Do.
Sambalpur . . . . .	1	1,300	Coal.
Santal Parganas . . . . .	5	17.13	Do.
Singhbhum . . . . .	3	1,532.30	Chromite.
Do. . . . .	1	800	Iron-ore.
Do. . . . .	1	1,267.2	Manganese and iron ore.
Do. . . . .	1	1	Gold.
<b>TOTAL</b> . . . . .	14	...	

TABLE 30.—*Prospecting Licenses and Mining Leases granted in Bombay during 1917.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Dharwar (also in Kanara district) . . . . .	1	1,143	Galena.
Kaira . . . . .	1	301.95	Manganese and aluminium.
Panch Mahals . . . . .	1	45.5	Manganese.
Sukkur . . . . .	1	6,008	Mineral oil.
<b>TOTAL</b> . . . . .	4	...	

<b>Mining Leases.</b>			
Panch Mahals . . . . .	1	680.22	Manganese ore.

TABLE 31.—*Prospecting Licenses and Mining Leases granted in Burma during 1917.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Akyab . . . . .	2	9,060	Mineral oil.
Amherst . . . . .	12	10,133.2	All Minerals (except oil).
Bhamo . . . . .	1	5,516.8	All minerals (except oil and jade).
Katha . . . . .	1	24,320	Tin, wolfram, silver, copper, lead, zinc and gold.
Lower Chindwin . . . . .	3	2,940	All minerals (except oil).
Do. . . . .	3	3,040	Mineral oil.
Mergui . . . . .	26	27,420.46	All minerals (except oil)
Do. . . . .	2	82.92	Tin.
Do. . . . .	3	3,383.32	Wolfram and tin.
Do. . . . .	1	2,626.56	Wolfram.
Minbu . . . . .	2	2,890.24	Mineral oil.
Myingyan . . . . .	2	11,790	Do.
Myitkyina . . . . .	1	1,132.8	Gold and platinum.
Do. . . . .	1	3,200	Gold and iridio-platinum.
Do. . . . .	2	3,571.2	Gold.
Northern Shan States . . . . .	2	3,200	Iron.
Do. . . . .	2	5,760	Coal.
Do. . . . .	1	3,200	Gold, silver, iron and zinc.
Pakokku . . . . .	7	17,402.80	Mineral oil.
Prome . . . . .	2	3,449.6	Do.
Ruby Mines . . . . .	1	640	Copper.
Salween . . . . .	1	3,840	All minerals (except oil).
Shwebo . . . . .	2	4,704	Mineral oil.
Southern Shan States . . . . .	4	2,787.93	Wolfram.
Do. . . . .	1	2,560	Lead.
Do. . . . .	9	11,965	All minerals (except oil).
Do. . . . .	3	9,560	Gold.
Tavoy . . . . .	201	147,824.28	All minerals (except oil).
Thaton . . . . .	68	98,825.5	All minerals (except oil).
Do. . . . .	1	29.44	Mineral oil.
Thayetmyo . . . . .	9	31,916.82	Do.
Upper Chindwin . . . . .	3	19,840	Do.
Yamethin . . . . .	1	2,560	Lead.
<b>TOTAL . . . . .</b>	<b>380</b>		



TABLE 31.—*Prospecting Licenses and Mining Leases granted in Burma during 1917—contd.*

DISTRICT	1917.		
	No.	Area in acres.	Mineral.
<b>Mining Leases.</b>			
Minbu . . . . .	1	19	Mineral oil.
Southern Shan States . . . . .	1	2,680	Lead, copper and silver.
Tavoy . . . . .	4	7,335-03	Wolfram and tin.
Do. . . . .	6	10,081-38	All minerals except oil and precious stones.
<b>TOTAL</b> . . . . .	<b>12</b>		

TABLE 32.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1917.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Balaghat . . . . .	14	2,135	Manganese.
Do. . . . .	4	507	Bauxite.
Bhandara . . . . .	18	2,274	Manganese.
Bilaspur . . . . .	1	6,799	Iron ore and other minerals (Dolomite and Limestone).
Chanda . . . . .	5	7,376	Coal.
Chingwara . . . . .	3	302	Manganese.
Do. . . . .	3	953	Coal.
Jubbulpore . . . . .	2	1,511	Do.
Do. . . . .	2	4,602	Bauxite.
Do. . . . .	3	212	Manganese.
Do. . . . .	2	801	Bauxite and iron.
Do. . . . .	1	404	Bauxite and iron oxide.
Do. . . . .	1	566	Manganese, iron, bauxite, and all metals of the rare earth.

TABLE 32—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1917—contd.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.

**Prospecting Licenses—contd.**

Jubbulpore . . . . .	1	212	Bauxite, lead, gold, barytes, silver and copper.
Do. . . . .	1	293	Manganese, iron, bauxite, nickel, cobalt, cadmium, molybdenum, lithium, copper and minerals of the rare earths.
Do. . . . .	1	154	Bauxite and barytes.
Nagpur . . . . .	17	3,592	Manganese.
Do. . . . .	1	39	Mica.
Do. . . . .	1	20	Manganese and pyrolusite.
<b>TOTAL</b> . . . . .	<b>81</b>		

**Mining Leases.**

Balaghat . . . . .	3	398	Manganese.
Bhandara . . . . .	7	253	Do.
Chanda . . . . .	1	1,221	Coal.
Chindwara . . . . .	2	104	Manganese.
Drug . . . . .	1	3	Bauxite, lead, silver, gold, cobalt and copper.
Jubbulpore . . . . .	1	19	Manganese.
Do. . . . .	1	52	Bauxite.
Nagpur . . . . .	2	230	Manganese.
Yeotmal . . . . .	3	3,069	Coal.
<b>TOTAL</b> . . . . .	<b>21</b>		

TABLE 33.—*Prospecting Licenses and Mining Leases granted in Madras during 1917.*

DISTRICT.	1917.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Coimbatore . . . . .	2	13-71	Mica.
Kurnool . . . . .	4	208-94	Barytes.
Nellore . . . . .	13	304-63	Mica.
Trichinopoly . . . . .	1	430-69	Phosphatic nodules.
TOTAL . . . . .	20		
<b>Mining Leases.</b>			
Nellore . . . . .	5	692-63	Mica.

TABLE 34.—*Prospecting Licenses and Mining Leases granted in the Punjab during 1917.*

DISTRICT	1917.		
	No.	Area in acres.	Mineral
<b>Prospecting Licenses.</b>			
Attock . . . . .	1	1,280	Mineral oil.
Shahpur . . . . .	1	4,992	Do.
TOTAL . . . . .	2		

THE SUPPORT OF THE MOUNTAINS OF CENTRAL ASIA  
(BEING AN APPENDIX TO THE MEMOIR ON THE STRUCTURE OF THE HIMALAYAS, AND OF THE GANGETIC PLAIN, AS ELUCIDATED BY GEODETIC OBSERVATIONS IN INDIA). BY R. D. OLDHAM, F.R.S. (With Plate 3).

IN the memoir on "The Structure of the Himalayas and of the Gangetic Plain, as elucidated by Geodetic Observations in India,"<sup>1</sup> it was shown that the outer zone of the hills was a region of partial defect of compensation, or, in other words, of super-elevation of the surface, which increased in amount from the outer edge of the hills to as far in as definite observations have been made. This being only about 40 miles, the ultimate course of the discrepancy between topography and compensation cannot be traced, but less certain observations, and other considerations, indicate that the defect of compensation disappears at greater distances from the edge of the hills and may even be replaced by an excess. The conclusion, being an important one in view of its bearing on theories of the origin of mountains, requires confirmation and, in the absence of observations in the Himalayan region, this had to be looked for elsewhere. In the search for such information I came across a series of gravity measurements, made by the Russian Government, in the region of the Pamirs and neighbouring parts of Central Asia, which are of special interest as giving a complete section across a group of mountains not only comparable in elevation with the Himalayas but also, in other ways, of importance in the discussion of theories of mountain origin.

The geology of this region is still imperfectly known, but this is of no very great importance as the present investigation is not concerned with details of stratigraphy. Enough is known to show that the general strike of the strata, and of the axes of the folds, is about east and west right across the northern part of the district. In the southern part, the same strike is found towards the centre, but on the east it bends round to south-eastwards, and westwards

<sup>1</sup> *Mem., Geol. Surv. Ind., XLII, pt. 2, 1917.*

to the south-west. The topography shows a general agreement with the geological structure; on the north the upper waters of the Sir Daria, or Jaxartes, flow through the valley plain of Fergana, in what is evidently a structural depression between the mountains to the north and south. South of the Fergana valley come the parallel ranges of the Alai and Trans-Alai, separated by the Alai plain, near the head of the valley of the Kizil Su. These ranges are continued, further west, by others named on maps as the Peter the Great, Hissar, and Zerafshan, which together with the Alai ranges, may be regarded as the westerly continuation and termination of the Tian Shan mountains, now separated by the erosion of valleys, cut more or less along the strike of the rocks. To the south of these high ranges a number of minor ridges stretch in a more or less south-westerly direction towards the valley of the Oxus, following, in a general way, the strike of the rocks. The valley of the Oxus, or Amu Daria, occupies a structural depression to the westwards of the junction of the Kunduz river, but the upper reaches occupy what has all the characters of a valley of erosion, cut through the mountains, at times along, and at others across, the strike. Further still to the south comes the range of the Hindu Kush and its western continuation.

Throughout this region there is, as has been indicated, a general agreement between the geological structure of the rocks exposed at the surface and the geographical aspect of the country, but upon this general agreement of what may be called the minor topography, the course of crest and valley, there is superimposed a major relief, which is quite independent of the structure of the surface rocks and arranged along an axis transverse to the strike. This is very well seen in the hills of the drainage area of the Amu Daria, where we have the lowlands of Bokhara, on the west, eastwards comes a series of low hills which do not rise above 5,000 feet, followed by the high plateau of the Pamirs, and, still further east, by the mountains of Kungur and Mustagh Ata, which rise to heights of over 25,000 feet and form the highest summits of the region. The same feature may be recognised in the increase in average height from east to west of the series of ranges which form the backbone of the region and is also, and perhaps most conspicuously, marked by the feature known to geographers as the Mustagh Ata range, which lies outside the region covered by the gravity observations, but must be considered, as it will be shown to have an import-

ant bearing on the interpretation of them, and as its character is generally misunderstood.

Maps show a series of high mountains ranged along the border of the plains of Kashgaria, which are separated from the Pamir plateau by deep valleys, and are so conspicuously arranged along a nearly meridional line that, in spite of the interruption by two deeply cut valleys, it is natural to look upon them as forming a distinct and definite mountain range, which is variously designated as the Kashgar, Tagharma, or Mustagh Ata, range; the appearance is, in fact, so striking that it has even misled some geologists into regarding it as a true tectonic range, and accepting a system of disturbance of the strata which would cut right across the trend of the structure of the region immediately to the west, and of which no trace can be found in observation in the field. The Mustagh Ata and Kungur are composed of granite, and doubtless owe their preservation as the highest summits of the region to this, but to the north Dr. H. H. Hayden found that an easterly strike continued right across the line of the supposed range, up to the margin of the Kashgar plain,<sup>1</sup> and to the south Dr. F. Stoliczka found a south-easterly strike continued, with only a brief local occurrence of northerly strike from the edge of the plain till it bent round into the east-south-easterly strike of the Pamirs.<sup>2</sup> The similitude to a mountain range is largely due to the valleys which separate the summits from the Pamir plateau, and even if these valleys are not wholly due to erosion, there remains the fact that the greatest actual elevations lie in the extreme east of the region, and the common geographical interpretation has this much genetic justification, that the axis of the greatest uplift lies on the eastern edge of the hills, whence there is a rapid descent to the plains of Kashgar.

The major relief of the country is thus seen to cut right across the minor relief, or course of ridge and valley, and for this no satisfactory explanation can be found in the visible geological structure of the country. The structure very clearly indicates that the region has undergone compression in a north and south direction, and this compression would give rise to a thickening of the crust, to which the elevation of the hills might, and very commonly is, attributed; but there is nothing in our limited knowledge of this region to suggest that the compression has been greater in the east than in the

<sup>1</sup> *Rec., Geol. Surv. Ind.*, XLV, 318 (1916).

<sup>2</sup> *Scientific Results of the Second Yarkand Mission Geology*, pp. 35-37 (1873).

western portion, at any rate to the extent necessary to account for the difference in the present elevation of the ground. This, however, is merely a repetition of what may be found in other parts of the world. Even in those districts where the relation between inward structure and outward form are most intimate and obvious, there is not the same apparent connection between structure and absolute elevation. The Alps and the Himalayas, for instance, have both been compressed in a direction transverse to the general course of the range, and the amount of compression seems to be of much the same order of magnitude in both cases; the geology of the Himalayas is less fully known than that of the Alps, but so far as our knowledge goes the compression seems to have been, if anything, less in amount, and certainly there is nothing like the twofold greater compression, which would be needed to account in this way for the twofold greater elevation. In both these cases, as in others of a similar character, the major relief is ranged along much the same general direction as the minor, so that it is difficult to disentangle the effects of the two and decide how far each may or may not be determined by the geological structure. In the mountains of Turkestan the opposite is the case, and here the major and the minor relief are arranged along different lines, which cross each other nearly at right angles, and, for this reason, the region seems particularly favourable for the study of those problems of mountain formation, the solution of which seems impossible by geological observation and only to be approached by the study of geodetic measurements.

The results of the observations are published in the report of the 1909 meeting of the International Geodetic Association, but in less detailed form than is customary, for only the free air correction is given. The Bouguer correction for visible mass and the Hayford correction for local topography are easily obtained, but the orographic correction for departure of the actual surface from a plateau could not be determined with accuracy from the maps accessible to me. As the stations are mostly situated in open valleys or out in the plain, this correction will in the majority of cases be less than  $\cdot 01$  dyne and only in a few cases, where the station is situated in a deep and narrow valley, will it exceed  $\cdot 02$  dyne, and is not likely to be greater than  $\cdot 03$  at any station of the series.

The correction for the effect of topography at a greater distance than 104 miles from the station has been determined. It was computed in detail by Messrs. Hayford and Bowie for the station of Kala Khum,<sup>1</sup> which is almost centrally situated in the group of stations being dealt with, and, as the amount of this correction varies comparatively slowly from station to station, the adoption of the same value at all would probably not introduce an error of more than .02 dyne at any one. Moreover, the error would be a systematic one, changing gradually from one margin of the map towards the other, and so easily recognisable, if not obscured by other and greater irregularities. As will be seen in the sequel, the differences in the anomalies are much greater in amount and more rapid in their variation than can possibly be accounted for by the neglect of this correction. Another consideration is the fact that the correctness of the adopted value for the force of gravity at Tashkent, on which all the other values depend, is in doubt,<sup>2</sup> and for this reason it has seemed best to confine attention to the differences, which are most conveniently expressed as positive or negative variations from the mean value of the whole group, excluding the anomalous station of Kala Wamar. The stations are numerous enough, and the area sufficiently extensive and diversified in character, to make it probable that the mean of the anomalies will approximately represent the true zero value for the area, while the exclusion of Kala Wamar is justified by the anomalous character of the record. The negative anomaly at this station is not only abnormally high, but is nearly two-tenths of a dyne higher than at the nearest stations. There is no apparent explanation of so great an anomaly at this station, and it is difficult to avoid the conclusion that a clerical error has crept into either the calculations or their transcription, the alternative explanation being that there is some exceptional and quite local peculiarity at this station; in either case its exclusion is justified.

On the map attached to this note (Pl. 3) the relief of the surface is indicated by the contours at intervals of 5,000 feet and the positions

<sup>1</sup>The effect of Topography and Isostatic compensation upon the Intensity of gravity. Washington; 1912; p 84.

<sup>2</sup>Comptes Rendues de la seizieme Conference generale de l'Association Geodesique Internationale, Vol. III, pp. 138-141.



of the gravity stations, with the amount, expressed in hundredths of a dyne, by which the anomaly differs from the mean value. As has been mentioned, these values require a correction for irregularity of the surface, which may reach  $\cdot 03$  dyne and will be less at most of the stations in the mountain region; they are also subject to a correction on account of distant topography and its compensation, which will vary gradually from a positive value near one margin to a negative value at the other, or possibly may vary in either positive or negative direction from some point within the area. Another possible correction is a divergence of the actual distribution of the compensation from that assumed in the Hayford and Bowie tables, from which the figures made use of were derived; any such assumption, however, not inadmissible on other grounds, would make very small change in the amount of the anomaly, the maximum change, at the stations in the very heart of the mountains, could not exceed  $\cdot 02$  dyne at any individual station and would vary in amount with the altitude.

An inspection of the map shows that the actual variation in the amount of the anomaly is not susceptible of explanation in any of these ways; not only is the amount of the difference too large, reaching as it does about two-tenths of a dyne, but the distribution shows no relation to the situation of the stations, whether in deep and narrow valleys or in the open plain, nor to the elevation, nor does it vary in a manner that could be attributed to the effect of distant topography. On the other hand, the variation does show a very decided relation to the general relief of the country; in the lowlands to the west we find the anomalies all positive, and the positive values continue into the hills on the east; as the higher hills are entered the anomalies become negative, and all the eastern stations show a negative anomaly, with the exception of two groups, one in the central region of the Pamir plateau, and the other in the depression of Fergana. Expressed in general terms, it may be said that the character of the anomaly is such that where lower ground borders on higher the anomaly is positive, and negative where high ground is bordered by lower. In the case of the western plains of Bokhara, and again in the Fergana depression this relationship is obvious, but not so on the Pamir plateau, yet there, too, high as the stations lie, there is higher ground on all sides, though the barrier on the west is breached by river valleys. The station of Jekindi, which shows a small positive anomaly, isolated in a region of defect of gravity, is no exception.

for, though situated in a mountain region, it lies in the upper valley of the Kizil Su and not very far from the edge of the Alai plain, which, lying between the Alai and Trans Alai ranges, appears to mark a structural depression between two lines of excess of uplift.

Bearing in mind the fact that a positive anomaly, where the effect of compensation has been considered, means that the surface level stands higher than it would if a condition of complete isostatic equilibrium existed under the station, the distribution of the anomalies may be expressed in a different way, as indicating that the low ground is borne up above, and the ranges depressed below, their respective proper levels. This is the condition which was established as regards one part, and shown to be probable as regards the other, in the case of the Himalayas, and, in that connection, was shown to suggest a certain amount of residual rigidity in the crust of the earth. The way in which this would work can be illustrated by the diagram, fig. 1, where an originally level surface is supposed to have been subjected to elevatory forces such as would result in a surface as represented by the firm line between A and H, if the surface level everywhere coincided with the upward or downward forces; if, however, the crust were possessed of a degree of permanent rigidity which would not allow it to adapt itself to the flexures, the resulting surface would take some such form as that represented by the dotted line, the exact form depending on the degree of rigidity of the crust and the abruptness of the flexures.



Fig. 1.

Here we see that on either side of the central uplifted tract, the level surface is bent upwards and stands at a higher level than it otherwise would, while the outer edges of the uplift are held down below the level which they should have reached. In the centre of the plateau it might be that the surface would be forced up above its proper level by an arching upwards of the crust, as a result of the bending down on either side.

The conditions assumed in the diagram have been reduced to an extreme simplicity, but a similar result would follow in more

complicated circumstances, and, further, if we suppose the elevatory force to be the result of the same changes which have given rise to the compensation, we should find an apparent excess of gravity in all those regions where the dotted line runs above the firm one, and where the actual amount of the compensation would be less than that deduced from the measured altitude; where the dotted line runs below the firm there would, similarly, be an apparent defect of gravity, the real compensation being greater in amount than was allowed for in the computation.

Before passing on to the consideration of the observations it may be well to point out that if the compensation were an indirect result of the accumulation of surface material to form the plateau, the relationship between the real surface and the surface of equilibrium would be the opposite of that shown in the diagram. In this case the ground on either side of the plateau would be borne down, and a defect of gravity would be observed, while the plateau would be supported above the level of equilibrium and show an excess of gravity.

Examining the anomalies in the light of this explanation, we find, in the first place, high positive values in the most westerly stations; then, entering the hills, this positive anomaly decreases in amount in an easterly direction, as the high plateau of the Pamirs is approached, till it disappears and is replaced by a negative anomaly both in the stations along the course of the Oxus and in the hills to the north of it.

In the upper Oxus valley, the anomaly has a negative value of about  $\cdot 06$  dyne at Kala Khum, of which  $\cdot 01$  is due to the omission of the orographic correction. At Kala Wanj, Kharuk and Ishkasham the negative anomaly amounts to  $\cdot 08$ , of which some  $\cdot 02$  to  $\cdot 03$  may be due to the orographic correction, and at Langar Kisht, where this correction is probably larger than at any other station, the negative anomaly of  $\cdot 11$  would be reduced to  $\cdot 07$  or  $\cdot 08$ .

Eastwards of these high negative values there are no stations till the Pamir plateau is reached, where a group of positive anomalies is met with, the greatest of which amounts to  $\cdot 11$  dyne, at Robot Muskol. This very high value may be attributable, in part, to a purely local variation in the density of the rocks under the station, and it may be that the lesser positive anomalies at the neighbouring

stations would be made negative by a computation including the effect of more distant topography, but any such change would still leave the values positive in comparison with the anomalies at the stations round about.

Taking an anomaly of .03 dyne as representing in round numbers the attraction of 1,000 feet thickness of average rock, we may interpret the figures as showing a superelevation of about 3,000 feet in the plain about Bokhara, a depression of rather less along the edge of the high plateau of the Pamirs, about Kala Khum or Kala Wanj, and a superelevation of about the same amount in the central part of the plateau round about Robat Muskol. The distance from Charjui to Robat Muskol is about 550 miles and the maximum difference of load equivalent to about 5,000 feet of rock, indicating a permanent strength of the crust of more than double that which, according to Prof. Barrell, is revealed by the observations in the United States, but only about one-half to three-quarters of that exhibited by part of the floor of the Pacific Ocean.<sup>1</sup>

On this line of section, a disturbing element may come in, of the effect of which we can form no estimate, for the line is flanked on the north by the high ranges stretching westwards between the Oxus and Jaxartes valleys, and on the south by the Hindu Kush and its westerly continuation. Nothing of the same proportionate amount needs consideration on the transverse section from north to south across the Pamirs. Beginning from the south, we find a negative anomaly at Langar Kisht which, allowing for the effect of the orographic correction, is equivalent to a depression of about 3,000 feet. This station is close to the crest of the Hindu Kush and to peaks which rise to an altitude of 22,000 to 24,000 feet. At Murghabi, the depression has sunk to -.04 dyne and, as the orographic correction would be comparatively small, the depression may be put at about 1,000 feet. At the next station, Robat Ak Baital, there is a superelevation of about the same amount, which increases to 3,000 feet or more at Robat Muskol. Lake Karakul seems to stand at about the level due to the compensation but northwards the depression at Bordaba amounts to 1,000 feet and to 3,000 feet at Ak Bossaga, diminishing again to about 1,000 feet at Sufi Kurgan and Gulcha. At Liansar and Osh, in the Fergana valley, there is a positive anomaly, indicating a superelevation of

<sup>1</sup> *Journ. Geol.*, XXII, 30, 37, 38 (1918).

less than 1,000 feet, surrounded on three sides by stations indicating a depression of the surface level, as the mountains are neared.

On this section the bearing up of the low ground, and the bearing down of the high, is very clearly exhibited. In the case of the Fergana valley it is obvious enough, and, as has been pointed out, the central region of the Pamir plateau is in much the same case, in spite of its altitude, but here another cause may co-operate in producing superelevation. The observations indicate a bending down of the crust towards the north and south, and towards the west; on the east no observations exist but we may infer that a similar condition would be found towards the plains of Kashgar.

Granted the correctness of this interpretation, the strength and rigidity of the crust implied by it might well give rise to an upward bending of the portion of the crust lying between and so to an uplift, reaching its maximum in the centre and dying out on either side, as was suggested in dealing with the suppositious case illustrated in fig. 1.

However this may be, we have a section which may be regarded as something over a complete wave, having a length of about 150 miles from crest to crest or trough to trough, and a height of about 7,000 feet from trough to crest. This last figure may be excessive, and partly due to this increase of the maximum anomalies by purely local causes, but the general average of the observations shows that the difference is at least equivalent to some 5,000 feet or 2,500 above and below the mean level of equilibrium.

Westwards from Fergana the stations in the drainage area of the Sir Daria, or Jaxartes, show the same features, of negative anomalies on the east giving place to positive anomalies to the westwards, as was found further south. It is not possible to recognise any influence of the high mountains which lie between the two rivers, as there are no stations within the ranges or close to them, and the elevated mass is so insignificant in volume, as compared with the Pamir plateau, that the effect of the latter would be predominant, and any influence exerted by the former only recognisable by a larger number of more closely set stations than are available.

Taken as a whole, the results agree in a remarkable manner with those obtained from the study of the geodetic observations in the Himalayas, indicating that a condition of general isostatic equilibrium, of the mountains as a whole, is subject to considerable

local departures from this condition. In both cases these departures from complete equilibrium are distributed with a marked relation to the greater relief of the surface and are just such as would result from the uplift being due to some deep-seated cause, acting mainly in a vertical direction, combined with some considerable strength and permanent rigidity of the overlying crust, which is, consequently, prevented from adapting itself completely to the bending, and so may hold the surface level down below or upraised above that at which it would otherwise stand. The limit to the amount of the departure from the level of equilibrium is about the same in both regions and reaches a maximum of some 3,000 feet; the observations which have been made in the Andes suggest a similar departure from complete equilibrium and to about the same amount. We find, then, that three great mountain ranges, each of about the same magnitude, and the three greatest in the world, agree in showing the same phenomenon and to the same degree. This would in itself give great support to the supposition that there is a real connection and a cause common to all. There are, besides, within the limits of the region now under consideration, two groups of facts, wholly independent of each other, and each in its way giving support to the deduction that the greater relief of the surface is independent of the superficial geological structure, but is directly due to the same processes as have given rise to the compensation.

The first of these is the fact that the course and distribution of the principal mountain ranges and the larger features of the relief of the ground are not directly determined by the geological structure. The point is very clearly brought out in a paper by Dr. Ellsworth Huntington, on the Mountains of Turkestan, and can hardly be more graphically and succinctly expressed than by three brief extracts from his account, in which he consistently writes of the Tian Shan Mountains as a plateau and never as a range.<sup>1</sup>

“In physiographic terms, the Tian Shan plateau may be described as a peneplain which has been highly uplifted and warped, and is now in a state of extreme youth”. \* \* \* “The result of these geological changes is that, although the *internal structure* of the Tian Shan region is highly mountainous, its *external appearance*, or, in other words, its geographical aspect, is that of a plateau” \* \* \* “The ridges rise by long gentle slopes to flat summits,

<sup>1</sup> *Geog. Journ.*, XXV, pp. 22-40, 139-158 (1905).

where often for many miles the sky-line is an almost straight crest from which the rounded slopes of pure white snowfields descend gradually toward the basins. Here and there the crest line is notched by high passes, the lowest of which are but 1,000 or 2,000 feet below the top of the ridge. Oftener the summit of the ridge is broken into individual mountains, broadly flat topped and of nearly equal height."

The description of this author is borne out by that of every other traveller, and the region appears as one which has undergone a very considerable amount of disturbance, accompanied by a general compression of the strata, which may have given rise to true tectonic irregularities in the form of the surface. These original features had been worn down and the country reduced to a lowland type of gentle relief, such as it is the fashion to describe as a peneplain, when, at a later date, the country was uplifted and, by the opportunity so given to the action of denudation, the surface carved into steep slopes, and deep-cut valleys, converting a downland plateau into the aspect of a series of mountain ranges. The uplift was not uniform, but greater along certain lines than elsewhere, and in some cases these lines of greater elevation followed the general course of the earlier axes of disturbance of the strata, so that the present range of high crests has the appearance of being a true tectonic range, but even in these cases the amount of the later elevation varies along the length of the range, and the variation has no relation to the geological structure. More generally, however, there seems no direct connection, and the most conspicuous geographical feature of the region, the line of mountains running north and south, between the Pamirs and the Plains of Yarkand and Kashgar, runs right across the trend of the geological structure. This series of mountains is so distinctly ranged along a definite axis that it may naturally be regarded as a definite range, and the study of the topographical map has even led geologists to infer the existence of a meridional range of true tectonic character. As has already been mentioned, the surface observations are opposed to this conclusion, and show that, if the range is in any sense of the word a tectonic one the tectonics are more deeply seated than those of the disturbance of the rocks near the surface.

The consideration of this range, which is seen to be probably a true range, genetically as well as in superficial appearance, merely emphasises the conclusion drawn from the general study of the region,

that the broad features of the major relief, as well as the determination of the more restricted zones of greater uplift, are not the result of processes apparent in the structures visible at the surface, but of more deeply seated, and possibly quite independent, processes, which are not accessible to surface observations, and are, presumably, connected with the cause of compensation.

The second group of facts has a more direct bearing on the particular nature of the changes, or processes, which produce the compensation. It is known that great earthquakes send out two sets of waves, which are transmitted through the interior of the earth and recorded at distant stations. In addition to the record of the waves which have travelled by direct courses, there are subsidiary records which are attributed to those which have been one or more times reflected; though the interpretation of the records has been questioned, and is certainly doubtful as to some of the supposed twice or more times reflected waves, the concordance of a very large proportion of the records seems to have established the presence of the two types of singly reflected waves, the condensational and the distortional, each reflected from a midway point as the same form of wave. In the mathematical treatment of this question it is usual to assume a reflection from the surface of a solid sphere, and this is too often taken to mean that it takes place at the surface of the earth; this, however, is impossible, in the case of the actual records, for the rocks of which the outer shell of the earth is composed are too heterogeneous to transmit a simple form of wave-motion without repeated breaking up into waves of more than one form, and the constituent rocks have, almost without exception, so different a degree of elasticity in different directions that they are incapable of transmitting either of the simple forms of wave-motion. The result is, that the simple waves, on entering the outer crust, become broken up into more complex forms and lost; consequently, it is not at the surface of the earth that we must look for the surface of reflection, but at the under surface of the heterogeneous crust, and it is reasonable to find an explanation, of the greater or less conspicuousness of the record of the reflected waves, in the varying degree of abruptness of transition to the more uniform material below. Now it has been observed that, of all the earthquakes registered at European observatories, those originating in the neighbourhood of the Philippines, that is, those which have the central point of reflection under the region of high



mountains of Kashmir and the Pamirs, give the most conspicuous record of the reflected waves, usually even larger than that of the distant ones.

The obvious interpretation of this is that the transition from the outer crust to the underlying material is more than usually rapid and sharply defined in the region under the Pamirs, and it is natural to associate this with the changes which have given rise to the compensation of this group of mountain ranges, the largest and loftiest in the world. And so we reach the same conclusion as was drawn from the gravity observations, that the processes and changes, to which the effect is due, are localised, or at least concentrated, in the lower part of the crust, or in the layer immediately beneath it.

The conclusion reached in the course of this investigation may not be without importance on the geodetic side, as a guide in the determination of the nature, and distribution in depth, of the compensation. On the geological side it is of great interest as showing that two distinct causes and actions have been at work and must be taken into account in any attempt to elucidate the origin of mountain ranges. On the one hand, we have the actions which have given rise to the disturbance of sedimentary rocks from their originally horizontal position, and to the intrusion of igneous rocks among them. The well-established importance of trend-lines of structure is unimpaired, and to the structure set up in this way, combined with the effects of surface denudation, the details of surface form and the course of ridge and valley are due. The boundary between hill and plain is often determined by the same cause, and to it ranges of hills may sometimes be due, but there is a distinct limit to the amount of the difference of elevation which can be produced in this way. No exact figure can be given for these limits; they are probably incapable of precise numerical definition, but the limit of height must be somewhere about 2,000, or possibly, 3,000 feet, and the limit of breadth 150 to 200 miles. Where the difference becomes greater than this, we must look to some other cause than compression of the rocks, for the load imposed on the crust becomes too great for it to bear, and so the conclusion is reached that the larger differences in elevation, and the more extensive areas of uplift, are due to some cause which is independent of that which has given rise to the structures revealed by the geological examination of surface rocks.

As a speculation this is not new, but the present investigation has given clearer indication of its truth than had previously been published, within my knowledge, and more especially has shown, in the first place, that the uplift of the higher mountain ranges is directly connected with those changes which have given rise to the defect of density under the ranges, known as their compensation, and, in the second place, that these changes are deep-seated and take place at the lower limit of the outer crust. Of the nature of these changes, or the way in which they are brought about, the investigation gives no direct indication, but, from the intimate connection between the uplift and the compensation, it follows that the centre of gravity of the two is probably at the same average depth, and this, according to Mr. Hayford's investigation, is somewhere about 35 miles below the surface. Further, the distribution of the departures from complete local equilibrium are such as to show that the compensation is not the indirect effect of the formation of the mountain ranges, but that it is the primary phenomenon and the originating cause of the uplift, of which the mountains are the indirect result and to which they owe their present altitude.

LIST OF STATIONS AND DETAILS OF OBSERVATIONS UTILISED.

[NOTE.—The Stations in this list belong to two series of observations, one based on Tashkent, the other on Tiflis. As the value adopted for the base station in the former differs from that determined for the same place in the latter, and earlier in point of date, by .015 dyne, a correction of this amount has been made at the other stations in order to bring the two series into uniformity. Stations of the series based on Tiflis, to which the correction has been applied, are distinguished by an asterisk. Spelling of place names follows the Survey of India, or a similar system where the name is not to be found on published maps.]

Station.	Longitude.	Latitude.	Elevation (in metres).	Observed value of gravity.	Theoretical value of gravity.	Apparent amount of defect.	CORRECTIONS.			Resulting anomaly.	Difference from mean.
							Height.	Mass.	Compensation.		
1. Murghabi . . . . .	73° 58.2'	38° 10.0'	3,700	978.832	980.004	1.172	1.142	.407	.320	—117	—04
2. Irkeshtam . . . . .	55.7'	39° 41.9'	2,850	9.203	0.139	0.936	0.880	.313	.232	—137	—06
3. Robat-Ak-Baital . . . . .	51.5'	38° 29.7'	4,100	8.842	0.033	1.191	1.265	.451	.326	—051	+03
4. Robat Muskol . . . . .	31.7'	38° 42.0'	4,200	8.924	0.051	1.127	1.296	.462	.328	+035	+11
5. Lake Karakul . . . . .	31.2'	39° 6.4'	3,920	8.912	0.087	1.175	1.210	.431	.315	—081	00
6. Sufi Kurgan . . . . .	30.0'	40° 1.5'	2,115	9.424	0.168	0.744	0.653	.232	.210	—113	—03
7. Gulcha . . . . .	25.7'	40° 19.0'	1,583	9.580	0.195	0.615	0.489	.174	.185	—115	—03
8. Bordaba . . . . .	16.2'	39° 30.9'	3,470	9.028	0.122	1.094	1.071	.382	.293	—112	—03
9. Ak Bossaga . . . . .	13.7'	39° 48.6'	2,875	9.134	0.149	1.015	0.887	.316	.259	—185	—10
10. Liansar . . . . .	5.7'	40° 24.6'	1,685	9.615	0.202	0.587	0.520	.185	.174	—078	00
11. Osh . . . . .	72° 46.6'	40° 31.4'	1,021	9.791	0.212	0.421	0.315	.112	.156	—062	+02
12. Langar Kisht . . . . .	38.5'	37° 2.6'	2,915	8.847	979.906	1.059	0.900	.320	.289	—190	—11
13. Andijan . . . . .	20.6'	40° 45.8'	530	9.885	980.234	0.349	0.164		.111	—132	—05
14. Karaul Kishlak . . . . .	6.0'	40° 2.2'	1,300	9.611	0.169	0.558	0.401	.143	.166	—134	—05

15. Jekindi . . . . .	71° 54-5'	39° 30-0'	2,380	9-321	0-121	0-800	0-734	-262	-260	—-068	+01
16. Margilan . . . . .	46-7'	40° 23-7'	581	9-863	0-201	0-338	0-179	-064	-122	—-101	—-02
17. Namangan . . . . .	38-7'	40° 59-7'	440	9-941	0-255	0-314	0-136	-048	-098	—-128	—-05
18. Kharuk . . . . .	32-2'	37° 29-5'	2,105	9-132	979-944	0-812	0-650	-231	-236	—-157	—-08
19. Kala Wamar . . . . .	32-0'	37° 56-7'	1,985	9-019	9-984	0-965	0-615	-218	-230	—-340	—-28
20. Ishkasham . . . . .	30-2'	36° 52-4'	2,460	8-967	9-981	0-924	0-759	-271	-277	—-159	—-08
21. Kala Wanj . . . . .	27-0'	38° 22-2'	1,795	9-290	980-021	0-731	0-554	-197	-218	—-156	—-08
22. Damburachi . . . . .	22-7'	39° 16-1'	1,795	9-393	0-101	0-708	0-554	-197	-228	—-123	—-04
23. Chust . . . . .	13-9'	40° 59-3'	639	9-916	0-254	0-338	0-197	-070	-098	—-113	—-03
24. Khokand . . . . .	70° 57-0'	40° 30-5'	437	9-913	0-211	0-298	0-135	-048	-089	—-122	—-04
25. Kala Chait . . . . .	52-0'	39° 10-8'	1,600	979-443	0-093	0-650	0-494	-176	-209	—-123	—-04
26. Kala Khum . . . . .	46-5'	38° 27-3'	1,345	9-462	0-029	0-567	0-415	-148	-165	—-135	—-06
27. Tabidarreh . . . . .	28-2'	38° 41-9'	1,630	9-440	0-051	0-611	0-503	-179	-167	—-120	—-04
28. Garm . . . . .	22-2'	39° 1-5'	1,370	9-498	0-079	0-581	0-423	-151	-189	—-120	—-04
29. Jol . . . . .	7-7'	37° 45-8'	1,380	9-437	979-968	0-531	0-426	-152	-127	—-130	—-05
30. Saripul . . . . .	5-5'	38° 24-5'	1,500	9-462	980-025	0-563	0-463	-165	-150	—-115	—-04
31. Muminabad . . . . .	1-7'	38° 6-5'	1,280	9-491	979-999	0-508	0-395	-141	-130	—-124	—-04
32. Bogarak . . . . .	69° 50-2'	37° 37-0'	610	9-609	9-956	0-347	0-188	-067	-160	—-120	—-04
33. Baljuan . . . . .	39-2'	38° 18-2'	890	9-591	0-015	0-424	0-275	-098	-113	—-134	—-05

Station.	Longitude.	Latitude.	Elevation (in metres).	Observed value of gravity.	Theoretical value of gravity.	Apparent amount of defect.	CORRECTIONS.			Resulting anomaly.	Difference from mean.
							Height.	Mass.	Compensation.		
34. Khodjend . . .	34-7'	40° 17-1'	320	9-953	0-192	0-239	0-099	-035	-076	-099	-02
35. Parkhar . . .	23-7'	37° 29-9'	475	9-659	9-945	0-286	0-147	-052	-078	-113	-03
36. Nau . . .	22-4'	40° 9-2'	415	9-951	0-180	0-229	0-128	-045	-074	-072	+01
37. Faizabad . . .	18-7'	38° 30-9'	1,210	9-581	0-034	0-453	0-373	-133	-122	-091	-01
38. Sarai . . .	5-0'	37° 13-9'	405	9-661	979-922	0-261	0-125	-045	-061	-120	-03
39. Ura Tyube . . .	0-7'	39° 55-3'	1,025	9-814	980-159	0-345	0-316	-113	-095	-047	+03
40. Dushambe . . .	68° 46-7'	38° 34-5'	835	9-673	0-040	0-367	0-258	-092	-109	-092	-01
41. Chernajajewo . . .	43-6'	40° 13-0'	360	980-003	0-186	0-183	0-111	-040	-065	-047	+03
42. Nishne Panj . . .	31-7'	37° 11-5'	355	979-699	779-918	0-219	0-110	-039	-051	-097	-02
43. Zamin . . .	23-5'	39° 58-2'	650	9-896	980-163	0-267	0-201	-071	-074	-063	+02
44. Karatagh . . .	20-0'	38° 36-7'	905	9-684	0-043	0-359	0-279	-099	-114	-065	+02
45. Aivanj . . .	1-7'	36° 56-9'	340	9-693	979-897	0-204	0-105	-037	-052	-084	00
46. Deh Nau . . .	67° 53-7'	38° 16-3'	550	9-751	980-013	0-262	0-170	-060	-089	-063	+02
47. Jisak* . . .	48-7'	40° 6-8'	386	980-018	0-176	0-158	0-119	-043	-052	-030	+05

48. Panjikand . . . . .	36-2'	39° 29-8'	980	997-768	0-121	0-353	0-302	-108	-108	-051	+ -03
49. Sangardak . . . . .	33-0'	38° 32-8'	1,330	9-600	0-037	0-437	0-410	-146	-115	-058	+ -02
50. Urgut . . . . .	15-2'	39° 24-6'	995	9-755	0-113	0-358	0-307	-109	-095	-065	- -02
51. Termez . . . . .	13-6'	37° 13-7'	346	9-711	979-922	0-211	0-107	0-38	-041	-101	- -02
52. Baisun . . . . .	12-5'	38° 12-0'	1,230	9-624	980-007	0-383	0-380	-135	-096	-042	+ -04
53. Derbent* . . . . .	3-2'	38° 12-0'	1,012	9-687	0-007	0-320	0-312	-111	-089	-030	+ -05
54. Shirabad* . . . . .	2-6'	37° 40-9'	479	9-756	979-961	0-205	0-148	-053	-063	-047	+ -03
55. Samarkand* . . . . .	60° 58-7'	39° 39-1'	719	9-898	980-135	0-237	0-222	-079	-074	-020	+ -06
56. Yaka Bagh . . . . .	52-0'	38° 55-4'	700	9-802	0-070	0-268	0-216	-077	-092	-037	+ -04
57. Sharshauz* . . . . .	50-2'	39° 3-4'	646	9-907	0-082	0-175	0-199	-071	-086	+039	+ -12
58. Guzar* . . . . .	17-0'	38° 36-6'	555	9-861	0-043	0-182	0-171	-061	-071	-001	+ -08
59. Kiliif* . . . . .	15-7'	37° 20-7'	290	9-821	979-932	0-111	0-089	0-32	-038	-016	+ -06
60. Katta Kurgan* . . . . .	15-5'	39° 54-2'	477	9-994	980-157	0-163	0-147	-053	-041	-028	+ -05
61. Kermine* . . . . .	65° 23-1'	40° 4-4'	398	980-038	0-173	0-135	0-123	-044	-030	-026	+ -05
62. Kerki* . . . . .	13-8'	37° 50-1'	262	979-884	979-974	0-090	0-081	-020	-019	-019	+ -06
63. Bokhara* . . . . .	64° 34-7'	39° 43-0'	225	980-091	980-141	0-050	0-069	0-25	-017	-011	+ -09
64. Karakul . . . . .	63° 52-7'	39° 29-9'	198	0-062	0-121	0-069	0-061	-022	-015	-005	+ -08
65. Charjui* . . . . .	36-1'	39° 6-2'	192	0-029	0-086	0-057	0-059	-021	-015	-004	+ -08
66. Repetek* . . . . .	14-1'	38° 33-7'	188	979-946	0-039	0-093	0-058	-021	-015	-041	+ -04

NANABHAI DAYABHAI DARU.

IT is with much regret that I have to record the death on September 26th of Mr. N. D. Daru, Assistant Superintendent in this Department. Mr. Daru, after training in England and Canada, joined the Geological Survey of India on December 4th, 1907, and was employed at first in reporting on the alum industry in the Salt Range. He was subsequently attached to the Central India and Rajputana party, and carried out the revision of the geological map of Dungarpur State. His natural bent, however, led him rather to the educational side of his subject, and he occupied the post of Lecturer on Geology at the Poona Engineering College for three years and of Professor of Geology at the Presidency College, Madras, for two years. Soon after his resumption of field-work in 1916 his health gave way; he returned from leave on medical certificate only in April last, but was again compelled to take similar leave almost immediately. His early death is sincerely regretted by all his colleagues.

H. H. HAYDEN.

CALCUTTA  
SUPERINTENDENT GOVERNMENT PRINTING, INDIA  
8, HASTINGS STREET



RECORDS  
OF  
THE GEOLOGICAL SURVEY OF INDIA.

Part I.]

1919.

[ June.

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA  
FOR THE YEAR 1918. BY H. H. HAYDEN, C.S.I.,  
C.I.E., F.R.S., *Director, Geological Survey of India.*

CONTENTS.

	PARAS.	PAGE.
DISPOSITION LIST . . . . .	1	2
ADMINISTRATIVE CHANGES . . . . .	2, 3	5
MILITARY SERVICE . . . . .	4	5
STUDENTS . . . . .	5	5
PROFESSORSHIPS AND LECTURERSHIPS . . . . .	6	5
LIBRARY . . . . .	7	6
PUBLICATIONS . . . . .	8	6
MUSEUM AND LABORATORY . . . . .	9-14	6
PETROLOGY . . . . .	15	8
PALAEONTOLOGY . . . . .	16	8
HIMALAYAN STRATIGRAPHY . . . . .	17, 18	8
ECONOMIC ENQUIRIES—		
<i>Antimony</i> :—Burma ; <i>Apatite</i> :—Bihar and Orissa ;		
<i>Chromite</i> :—Bihar and Orissa ; <i>Coal</i> :—Burma ;		
<i>Engineering questions</i> :—Central Provinces, Bombay ;		
Bihar and Orissa ; <i>Gold</i> :—Burma ; <i>Iron-ores</i> :—		
Bihar and Orissa ; <i>Kaolin</i> :—Delhi, Burma ; <i>Lead</i> :—		
Burma ; <i>Mica</i> :—Bihar and Orissa, Rajputana,		
Travancore ; <i>Soda</i> :—Sind ; <i>Sulphur</i> :—Persian Gulf ;		
<i>Tin</i> :—Burma ; <i>Tungsten</i> :—Burma, Bihar and Orissa . . . . .	19-53	9
GEOLOGICAL SURVEYS—		
<i>Burma</i> . . . . .	54	20
<i>Bihar and Orissa</i> . . . . .	55-62	20
BIBLIOGRAPHY . . . . .	63	23

## DISPOSITION LIST.

1. During the period under report, the officers of the Department were employed as follows :—

*Superintendents.*

MR. E. VREDENBURG . At headquarters as Palæontologist throughout the period.

DR. L. L. FERMOR . Returned to headquarters on 23rd April 1918. Services placed at the disposal of the Indian Munitions Board during the following periods—  
from 20th May to 13th June 1918,  
from 8th July to 3rd August 1918,  
from 29th October to 7th November 1918.

On privilege leave from 21st to 28th October 1918. At headquarters from 15th November 1918.

DR. E. H. PASCOE . Returned to headquarters on 19th January 1918. Deputed to Mesopotamia and left for the field on 5th November 1918.

*Assistant Superintendents.*

DR. G. E. PILGRIM . On deputation in Persia throughout the year except for a brief period from 24th March to 22nd April 1918.

MR. G. H. TIPPER . Employed in the mica-mining area of Hazaribagh.

MR. H. WALKER . Returned from the field on 18th April 1918. Appointed Curator with effect from 27th October 1918.

MR. K. A. K. HALLOWES Returned to headquarters on 13th April 1918. Posted to Burma and left headquarters on 30th October 1918.

MR. G. DE P. COTTER At headquarters as Curator up to 26th October 1918. Examined dam sites on the Usri and Barakar rivers, near Giridih from 17th to 21st April 1918. Deputed to examine the kaolin of Kasumpur, Delhi, and the soda deposits of Sind and left for the field on 26th October 1918.

MR. J. COGGIN BROWN Employed in Tavoy in connection with the wolfram mining industry.

MR. H. C. JONES Returned to headquarters on 13th February 1918. Posted to Burma to examine the antimony deposits of the North Shan States and left headquarters on 25th February 1918. Returned from Burma on 2nd August 1918. From 1st November 1918 engaged in examining dam sites in Saugor and Bilaspur districts, Central Provinces and iron ore deposits in Singhbhum.

MR. A. M. HERON Employed in Tavoy in connection with the wolfram mining industry.

DR. M. STUART Returned from Burma on 3rd June 1918. Engaged from 17th July to 9th August 1918 in investigating the area affected by the Srimangal earthquake of 8th July 1918. Deputed to examine limestone deposits in various parts of India and left headquarters on 24th November 1918.

MR. C. S. FOX . . . Completed on the 19th April 1918 the investigation of bauxite deposits in Chota Nagpur; was placed in charge of Jorasimar mica mine, Hazaribagh, with effect from 30th April 1918.

MR. R. W. PALMER . . . On military duty.

*Chemist.*

DR. W. A. K. CHRISTIE Services placed temporarily at the disposal of the Government of India in the Finance Department with effect from 12th April 1918.

*Artist.*

MR. K. F. WATKINSON At headquarters. Granted privilege leave for one month and 22 days from 2nd December 1918.

*Sub-Assistants.*

MR. S. SETHU RAMA Returned from the field on 8th May 1918.  
RAU. On privilege leave from 1st to 8th October 1918. Posted to Tavoy and left headquarters on 22nd October 1918.

\*MR. M. VINAYAK RAO. Returned from the field on 16th May 1918. Granted privilege leave for one month and four days from 5th September 1918. Posted to Tavoy and left headquarters on 30th October 1918.

*Assistant Curator.*

BABU BANKIM BEHARI Appointed on the 26th August 1918 at  
GUPTA. headquarters.

**ADMINISTRATIVE CHANGES.**

2. Dr. G. E. Pilgrim officiated as Superintendent from 20th May to 13th June 1918, from 8th July to 3rd August 1918 and from 21st October to 7th November 1918, *vice* Dr. L. L. Fermor, on deputation to the Indian Munitions Board.

Promotion and ap-  
pointments.

Mr. H. Walker was appointed Curator with effect from the 27th October 1918.

Babu Bankim Behari Gupta was appointed Assistant Curator with effect from the 26th August 1918.

3. Dr. L. L. Fermor was granted privilege leave from the 21st to 28th October 1918.

Mr. K. F. Watkinson was granted privilege leave for one month and 22 days with effect from 2nd December 1918.

Leave.

Mr. Sethu Rama Rau was granted privilege leave from the 1st to the 8th October 1918.

Mr. M. Vinayak Rao was granted privilege leave for one month and four days with effect from the 5th September 1918.

**MILITARY SERVICE.**

4. Only Mr. R. W. Palmer remained in the Army throughout the year, all other members of the Department having been recalled for civil duty. Lt. Colin Campbell, whose services have been lent to the Geological Survey by the military authorities, remained with this Department throughout the year.

**STUDENTS.**

5. Babu Harendra Mohan Lahiri, M.Sc., post-graduate scholar, continued to carry on research work in the Museum and Laboratory throughout the year.

**PROFESSORSHIPS AND LECTURERSHIPS.**

6. On proceeding to the field in October, Mr. G. de P. Cotter was relieved by Mr. H. Walker in his appointment as Lecturer on Geology at the Presidency College, Calcutta.

Mr. E. Vredenburg continued to act as a Professor of Geology at the Calcutta University, in addition to his own duties, throughout the year.

## LIBRARY.

7. The additions to the library amounted to 1,887 volumes, of which 726 were acquired by purchase and 1,161 by presentation and exchange.

## PUBLICATIONS.

8. Owing to pressure of work, it has been found impossible to issue the usual number of publications during the year: only three parts of *Records* Volume XLIX, were published, the fourth part standing over till the beginning of the new year. The issue of a very important work, however, was completed; in 1917, the first part of the new Bibliography of Indian Geology and Physical Geography, compiled by Mr. La Touche, was published, while the second part, consisting of an Annotated Index of Minerals of Economic Value, was issued during the year under review. This work is already in considerable request, and should prove of great value to those interested in the economic development of the country. One memoir of *Palaeontologia Indica* (New Series, Vol. III, No. 2) dealing with the Brachiopoda of the Namyau beds, Northern Shan States, was also issued during the year.

## MUSEUM AND LABORATORY.

9. Mr. G. de P. Cotter was Curator of the Geological Museum and Laboratory from the beginning of the year until the end of October, when he left Calcutta for field-work in Sind. Mr. H. Walker took charge of the duties for the remainder of the year. Mr. A. K. Banerji was Assistant Curator until the 26th August, on which date he was transferred to the post of Head Clerk. The senior Field Collector, Babu Bankim Behari Gupta, was promoted to Assistant Curator. Babu Baroda Charan Gupta, senior Museum Assistant, was promoted Field Collector.

10. Dr. W. A. K. Christie was Chemist in the Department from the beginning of the year to the 12th April on which day his services were placed temporarily at the disposal of the Government of India in the Finance Department.

11. The number of specimens referred to the Curator for examination and report was 460, of which assays and analyses were made of 93. The corresponding figures for the previous year are 600 and 83. The chemical work included analyses of kaolinite, limestone, coal, wolfram and sulphur-bearing rocks and assays of ores of antimony and lead.

12. During the year various specimens of rocks, minerals and fossils were given to:—  
Donations to Museums, etc.

- (1) The Islamia High English School, Gaibandha (Rangpur).
- (2) University College of Science, Calcutta.
- (3) The Superintendent, Mayurbhanj State.
- (4) St. Mary's Convent, Allahabad.
- (5) The Mining Engineer, Gwalior State.
- (6) Agricultural College, Poona.
- (7) McMahon Museum, Quetta.
- (8) Agricultural Museum, Muzaffarpur.

A small collection was sent on loan for the Gwalior State Exhibition.

13. The following foreign specimens were added to the collections during the year:—  
Additions to the collections.

- (1) Asbestos, from the Belingwe District, Rhodesia, presented by Captain L. Ludlow, Bedfordshire Regiment.
- (2) Asbestos (chrysotile), from the Goedverwacht mine, Transvaal, presented by A. G. Grimley, Esq.

Amongst the Indian specimens received, the following may be mentioned:—

- (1) Allanite, from Bahea, Ranchi District, presented by P. E. Billingham, Esq.
- (2) Scheelite and wolfram with copper pyrites from the Pagaye mine, Tavoy District, presented by Messrs. The Bombay-Burma Trading Co., Ltd.
- (3) Mica from Chauparan, Hazaribagh District, presented by C. C. Augier, Esq.

14. During the year the rearrangement of the show-cases in the fossil gallery has been completed and in all except a few cases new printed labels have been placed in position. The work will be completed early in 1919.  
Rearrangement of the fossil gallery.

## PETROLOGY.

15. In his account of the geology and coal resources of Korea State, Central Provinces,<sup>1</sup> Dr. Fermor described some puzzling rocks under the name of the Chirmiri volcanic series. Subsequent work on the Bokaro coalfield showed that these rocks were the products of the fusion of shales and sandstone due to the burning of coal-seams at the outcrop.<sup>2</sup> Dr. Fermor has now studied the microscopic aspects of these products and finds them to consist of vitrophyric rocks containing crystals of various minerals in a glassy base, amongst the minerals recognised being cordierite, sillimanite, pyroxenes, plagioclase, black ores, and a mineral closely allied to fayalite. These rocks show the structures and textures of volcanic rocks; but on account of their production from sedimentary rocks with resultant peculiarities in chemical and mineral composition, Dr. Fermor designates them *para-lavas* on the analogy of the terms *para-schist* and *para-gneiss*.

## PALÆONTOLOGY.

16. Mr. Vredenburg has continued his work on the Tertiary *Gastropoda*, which, however, is not yet complete. He hopes to finish shortly a monograph containing a complete review of the *Cypridæ* and *Ovulidæ*.

## HIMALAYAN STRATIGRAPHY.

17. In my *General Report* for the year 1917 I referred to the supposed discovery at Solan, by Babu Hem Chandra Das Gupta, M.A., of fossils in rocks regarded as of Infra-Krol age. I pointed out at the time that the fossils were badly preserved, and that their determination as Palæozoic brachiopods was not entirely convincing. An opportunity, afforded by a journey to Simla, enabled me to visit the locality; the only fossiliferous rocks observed were of lower Tertiary age, and although the matter can not yet be regarded as definitely decided, my visit confirmed the accuracy of Mr. Medlicott's map, on which the locality in question is shown as lying on Tertiary beds.

18. It is interesting to record the discovery of fossils in the neighbourhood of the Shali peak a few miles to the north of Simla,

<sup>1</sup> *Mem. G. S. I.*, XLI, Pt. 2, p. 138, (1914) and *Rec. G. S. I.*, XLIV, p. 13, (1914).

<sup>2</sup> *Trans. Min., Geol. Inst. of India*, XII, pp. 50-63, (1918).



The locality lies on the ridge running from Matiana to the Shali peak and at about one mile north-west of the village of Barhana. The fossiliferous beds consist chiefly of shaly limestones, and can be traced for over a mile or more to the N. N. E. along the ridge towards Kanda Devi. The fossils are extremely badly preserved, but have a general Upper Mesozoic aspect. They consist chiefly of lamellibranchs, but there are also numerous irregular tubular structures for the determination of which as chaetopod worms I am indebted to my colleague, Mr. G. H. Tipper. These annelids belong to the genus *Serpula* and are remarkably like certain Jurassic and Cretaceous forms. So far I have only been able to spend a few hours at the locality, but it is hoped that further examination may yield a better preserved and more characteristic fauna.

#### ECONOMIC ENQUIRIES.

##### Antimony.

19. Mr. H. C. Jones visited during the year antimony deposits in Mong Hsu State and also in the neighbourhood of Keng Tung, Southern Shan States. Two localities were visited in Mong Hsu, viz., Loi Hpwe (Nakeng) and Loi Hke. A certain amount of prospecting work has been done by private individuals or by companies on these ore-bodies, but most of the ore hitherto recovered has been obtained from detrital boulders lying on the surface. Most of the workings were inaccessible owing to water. No definite conclusion could be arrived at therefore with regard to the Nakeng deposit, although the fact that the boulders lying on the surface have all been found along a narrow band seems to indicate that the stibnite ore-body is not a large one. Mr. Jones considered that the Loi Hke deposit was not promising.

20. Small quantities of stibnite were also noticed at Hkumhpok and Loisanh in the Mong Kung State, where small quantities of ore had been extracted from time to time by the local inhabitants, but the amount available was apparently insignificant.

21. Small quantities of stibnite were noticed in pits in the neighbourhood of the Railway near Lebyin station between Kalaw and Pyinyaung. The stibnite appears to be sparsely distributed through a small vein of fine-grained quartz; it is considered by Mr. Jones to be of no economic value.

22. Mr. Jones also took the opportunity of visiting a locality in Keng Tung State from which specimens of antimony ore had been sent to this Department. The ore occurs near the village of Mong Ing, which lies in the hills about 25 miles south of Tongta, 241 miles from Taungyi on the road to Keng Tung. The deposit is a small stibnite vein or pocket in limestone, and is too small in extent and too poor in quality to hold out any hopes of successful working.

#### Apatite.

23. Although the magnetite-apatite-rocks of Singhbhum contain on the average more apatite than magnetite they are for the sake of convenience referred to under Iron (p. 14).

#### Chromite.

24. The discovery of chromite at the Suru Pass in the Kolhan in Singhbhum was recorded some years ago.<sup>1</sup>

During succeeding years numerous small deposits of chromite have been discovered in the same country, leading to the export during the past few years of some 8,000 tons of chromite. In March and April, 1918, Dr. Fermor re-visited this area and prepared a map of the occurrences on a scale of 4 inches to the mile. Three separate patches of peridotite give rise to prominent hill masses known respectively as Kimsi Buru, Kitta Buru, and Chitung Buru-Roro Buru, and these are surrounded by a comparatively little metamorphosed Dharwar terrane of slates, slaty shales, and quartzites, with occasional thin bands of limestone. The ultrabasic rocks appear to be laccolitic intrusions several hundred feet thick that have participated in the later stages of folding of the Dharwars. The component rocks have been much altered, but were originally saxonite, dunite, and subordinate pyroxenite,—saxonite, with fluidal arrangement of pyroxene (enstatite) being the most abundant type; one specimen of lherzolite was also found. These rocks have been very largely serpentinised, so that it is very difficult to find a specimen showing unaltered olivine; but fairly fresh enstatite is common. Chromite occurs almost invariably as scattered grains in the serpentinised dunites, and frequently, but not always, in the altered saxonites.

<sup>1</sup> *Rec., G. S. I.*, Vol. XXXVIII, p. 34, (1909).

In addition bands of ore are found in both serpentinised dunite and altered saxonite. These bands of ore are rarely a foot thick, usually less, but are the source of the chromite exported from this area. The evidence collected proves conclusively, even more satisfactorily than in Baluchistan, that the chromite bands are of primary (magmatic) origin, contemporaneous with the dunite and saxonite.

25. Whereas the chromite deposits of Baluchistan usually take the form of irregular masses or lenses, rendering it difficult to make reliable estimates of quantity of ore available, the Singhbhum deposits are definite bands, which in some cases have been traced by quarrying operations for thousands of feet. Thus on the east side of Inde Buru (a portion of Roro Buru) and the south slope of Chitung Buru, one band of ore has been traced at intervals for over a mile, the interruptions being due to numerous small cross faults. This ore-band is sometimes single and from 7 to 10 inches thick, but in other places it is split into several thin bands of about the same aggregate thickness, but distributed through a total thickness of  $1\frac{1}{2}$  of 2 feet to rock.

26. The alteration of these peridotites has not always resulted in the production of serpentine. At or close to the margins, talc-slates or schists have almost always been formed, but in places schistose serpentine is found. Further, the thin tongues of ultrabasic rock, where the effects of folding have been most intense, have usually been converted entirely into talc-rocks.

27. The formation of the Singhbhum serpentine appears to have been effected by the action of siliceous solutions, for the occurrences are characterised by the absence of magnesite and by the formation of great quantities of chert, usually along the margins of the ultrabasic masses, but sometimes as dyke-like streaks penetrating the serpentinous rocks, as in Chitung Buru. These cherts have been formed by the replacement of the magnesian rocks and reveal their origin, both by their position, their structures, and their residual enclosed chromite grains. Where the magnesian rocks are free from chromite, the adjacent cherts are found to follow suit.

28. Too strong emphasis cannot be laid on the chemical stability of chromite in nature. Chromite-bearing magnesian rocks have been replaced by silica with formation of chrome-cherts; in one place later carbonate solutions have attacked the cherts with

replacement to a marble still containing unaltered chromite grains, giving, in fact, a chromite-marble. Subsequent siliceous solutions have veined this rock with quartz.

29. As regards economic prospects the chromite deposits of the Kolhan may be stratigraphically continuous to as great depths as the enclosing ultrabasic rocks, but the thinness of the chromite bands and the numerous small faults will render it economically impracticable to resort to underground mining, so that the industry will probably cease as soon as all the ore that can be extracted by opencast methods has been removed. At present only first-grade ore is removed, but the possibility of treating in concentration mills low-grade ores containing not less than 10 per cent of  $\text{Cr}_2\text{O}_3$ , as in Canada, may one day be worth consideration, especially if future prospecting should lead to the discovery of additional peridotite massifs in the unexplored portions of the Kolhan to the south.

30. Numerous veins of chrysotile, some of which appears to be of good quality, have been found in some of the chromite excavations.

### Coal.

31. A considerable amount of interest was aroused in Burma during the year by reports of the discovery of valuable coal-seams on the flanks of the Arakan Yoma near Minbu and in the Northern Shan States. The Geological Survey was called upon to investigate the matter. On enquiry it was found that the reports with reference to coal in the Northern Shan States referred to the Namma and Lashio fields, which had already been examined by Messrs La Touche, Simpson and Brown of the Geological Survey some years ago. More extended prospecting operations have, as might have been expected, resulted in an increased amount of fuel being shown to be available. The material in question, however, was shown by Mr. Simpson to be a lignite of poor quality; it was found unsuitable for locomotive purposes, while its lack of coking qualities has rendered it hitherto unsuitable for metallurgical purposes. The advances that have recently been made in the employment of inferior coals in the pulverised form may possibly provide use for these lignites of the Shan States, but even if the conditions of exploitation and distribution prove favourable, their use will probably be restricted.

32. In consequence of promising reports on the coal found in the foot-hills to the west of Minbu, Mr. K. A. K. Hallowes was deputed to examine the seams. It had been stated that locomotive trials on a bulk sample had shown the coal to be not greatly inferior to Bengal steam coal, and it was hoped that it might be possible to reduce the cost of transport sufficiently to make successful competition with the latter possible. Unfortunately, however, the so-called bulk sample proved to be a carefully hand-picked specimen which represented merely a band of two or three inches of fairly pure lignite occurring in the middle of a seam of extremely inferior quality containing from 13 to 26 per cent. of moisture and 14 to 30 per cent. of ash. The seams themselves also proved to be typical of all the lignite occurring on the eastern flanks of the Arakan Yoma and to be merely small lenticular patches extending, as a rule, for only a few hundred feet.

### Engineering Questions.

33. A large number of sites for dams were examined during the year on behalf of various Local Governments. Mr. H. C. Jones reported on five sites in the Saugor and Bilaspur districts of the Central Provinces. Mr. Walker reported on the foundations of the Lake Arthur Hill dam at Bhandardara in the Bombay Presidency, and Mr. Cotter examined sites in connection with proposed reservoirs on the Usri and Barakar rivers.

### Gold.

34. During the course of his investigation of the mineral resources of Putao district in Upper Burma, Dr. Stuart examined some small alluvial workings for gold on the banks of the Nmai Hka about half a mile below the confluence of the Nam Tamai and the Taron. The workings proved to be small and of no particular economic value. Other workings are reported to be found in the Akyang valley, where nuggets of fair size are said to have been obtained; but as the locality is extremely inaccessible and the information available very scanty and unreliable, it was considered advisable to postpone the investigation of the Akyang valley until further information had been collected.

## Iron.

35. Some years ago the Bengal Iron Steel Co., Ltd., secured two deposits of iron-ore in Saranda (Singhbhum) forming parts of two large hill masses known as Notu Buru and Buda Buru respectively. During the past two years further prospecting in this part of Singhbhum has led to the discovery of numerous additional deposits of iron-ore, the extension of which has been traced into Keonjhar and Bonai States in Orissa, a total distance of some 40 miles in a S. S. W. direction. On account of the reports from various sources of the large supplies of iron-ore thus found Dr. Fermor paid a visit to the Bengal Iron & Steel Co.'s mine at Pansira Buru, a portion of Notu Buru, the only deposit yet opened up, and the one that now feeds the Barakar ironworks. Pansira Buru rises to over 2,500 feet above sea-level, the low ground on the west side being at about 1,100 feet above sea-level. The uppermost 400 to 450 feet of this hill has now been opened up, and the workings indicate the existence of a deposit about a quarter of a mile long, perhaps 400 feet thick and proved on the dip for about 500 feet. The ore-body appears to be interbedded with the Dharwar slates, from which it is separated by banded hematite-jaspers. The ore itself is high-grade micaceous hematite, often lateritised at the outcrop. Cross-cuts into the interior of the deposit show that the hematite becomes very friable not far below the outcrop. In fact the characteristics of this ore, including the surface lateritisation, are almost exactly reproduced in the iron-ore deposits of Goa and Ratnagiri, and this agreement serves to confirm Maclaren's correlation of the Singhbhum "sub-metamorphics" with the Dharwars of Southern India.

36. At the end of the year Mr. H. C. Jones commenced a more detailed examination of the iron-ore ranges in Saranda.

37. The existence of apatite-magnetite-rocks at Patharghara and Musaboni in Dhalbhum has been known for some years,<sup>1</sup> and deposits have now been located along a belt stretching for 12 miles in a direction S. 37° E. from Patharghara to Khejurdari, and included in concessions secured by the Bengal Iron & Steel Co., Ltd., for iron-ore, and by the Great India Phosphates Limited for apatite.

<sup>1</sup> *Rec., G. S. I.*, Vol. XXXVI, p.128, (1907).

An opportunity was taken this year of deputing Dr. Fermor to make a study of these occurrences. He finds that the magnetite-apatite-rocks occur as lenses in the Dharwar schists parallel to the strike and varying in size from 90 feet long by 24 feet thick in the middle, through lenses 2 feet or 3 feet by 1 foot down to lenticles a few inches long, and then to separate granules and crystals disseminated in the associated schists. As a rule apatite is the predominant mineral. The apatitic belt coincides roughly with the belt of old copper workings and the introduction into the Dharwar schists of the apatite, magnetite, and chalcopyrite has been accompanied by chloritisation of the schists. It was anticipated that the magnetite-apatite rocks would prove to be igneous introductions analogous to the apatitic magnetite ore-bodies of Lapland, but the facts prove to be better explained by regarding the magnetite-apatite rocks as due to pneumatolytic introductions from the Singhbhum granite. Where they occur together the chalcopyrite seems to be later than the magnetite-apatite rocks and may be referred to a later hydrothermal phase of activity. The apatite itself seems to be slightly earlier than the magnetite. At one locality (Sunrgi) incrustations of uranium mica are found on the magnetite-apatite rocks, but the primary uranium mineral has not yet been detected.

38. During his visit to Pal Lahara State to examine mica deposits

Dr. Fermor obtained specimens from the  
**Pal Lahara.** mountain mass known as Malayagiri (3,895 feet)

which he was unable personally to visit, proving the existence, hitherto unsuspected in this part of Orissa, of hematitic quartzites of Dharwar aspect. Amongst the specimens was some high-grade micaceous hematite, pointing to the desirability of examining this part of Orissa for still another iron-ore field.

### Kaolin.

39. At the request of the Chief Commissioner, Delhi, Mr. G. de P. Cotter visited the kaolin quarries at Kasumpur and submitted a report.

40. At the request of the Local Government, Mr. Hallows has been employed in Burma in examining reported deposits of kaolin in Pakokku and Yamethin. The investigation had not been completed at the end of the year.

### Lead.

41. In consequence of the reported occurrence of large quantities of lead slag in the district of Putao, which has recently been brought under the administration of the Government of Burma, the Local Government asked that a member of the Geological Survey should investigate the mineral resources of that district. Dr. Murray Stuart was detailed for the work, and spent the greater part of the field-season in Putao and the neighbouring valleys. He found the reports regarding the lead slag to have been exaggerated; the total quantity seen by him during the whole of his tour did not amount to more than about a ton, while the veins from which the lead-ores had originally been won were merely thin stringers of no possible economic importance.

### Mica.

42. The demand for mica continued throughout the year. Mr. G. H. Tipper was in charge of the Bihar and Orissa party, and devoted most of his attention to the Hazaribagh district, including the Kodarma forest, where he was frequently called upon for advice and assistance by the local district officers, as well as by the mining community. He also did a considerable amount of geological work in the neighbourhood of Mahesri in Monghyr district, where his investigations proved of great assistance in the subsequent mining operations.

43. Two mica-bearing properties in the province of Bihar and Orissa, which were lying idle owing to litigation, were taken over by the Local Government under the Defence of India Act. The larger of the two was handed over to a commercial firm to be worked on behalf of the Government, and, owing to the difficulty of finding mining engineers, it was arranged that the services of Lieutenant Colin Campbell, at present attached to the Geological Survey, should be made available for the supervision of the mining operations in that area. Mr. Campbell threw himself into the work with the greatest enthusiasm and energy, and prepared for development on a large scale; and although his operations were seriously hampered by rain and cholera, he succeeded ultimately in bringing his output up to 90 maunds of rough mica, equivalent to over  $\frac{1}{2}$  ton of cut mica, per diem.



44. The second property taken over by the Government of Bihar and Orissa is situated in the *gadi* Masnodih. It was worked first under the direct supervision of the Local Government, but was subsequently handed over to the Geological Survey. The property is a small one, but has been developed during the last few months with great success by Mr. C. S. Fox, whose work deserves high praise.

45. The occurrence of mica in Udaipur State was referred to in the *General Report* for last year, in which it was stated that the attention of the Udaipur Darbar had been drawn to the promising nature of the pegmatites. Unfortunately, however, no immediate steps were taken by the Darbar for their development but, after prolonged negotiations a lease was granted to Messrs. Chrestien and Dadabhoy for the joint working of the property.

46. Attention was also directed during the year to the Travancore phlogopite, small quantities of which had been extracted and exported in the past, and one of the leading firms engaged in mica-mining in India has now opened up negotiations with the Travancore Darbar for the development of the properties.

### Soda.

47. From the end of November 1918 till the beginning of February 1919, Mr. G. de P. Cotter was engaged in examining the carbonate of soda (*chaniho*) deposits of Sind. These are distributed over two areas, the first being a belt of country about ten miles in breadth, bisected by the channel of the Eastern Nara river, and lying between latitudes  $26^{\circ} 47'$  and  $26^{\circ} 5'$ , and the second area being a tract near the border of Sind and Jaisalmir, lying between latitudes  $26^{\circ} 21'$  and  $26^{\circ} 30'$ , and longitudes  $69^{\circ} 40'$  and  $69^{\circ} 55'$ . The first area lies mainly in the Khairpur State and the Nawabshah (formerly called the Nasrat) taluqa of the Nawabshah district, but includes a small portion of the Sanghar taluqa of Thar and Parkar district. The second area lies entirely in the Khairpur State west of the old fort known as Kot Jubbo. Both these tracts are covered with hills of desert sand, under which is concealed the old alluvial soil, which in the exposed portions is full of *reh* or *kalar* efflorescence. The rain water which sinks through the sand is held up by the old alluvial soil underneath, and flows horizontally underneath the sand, emerging in any low lying places or hollows in the sand hills where the

alluvial soil is exposed or close to the surface. Here shallow lakes are formed, locally known as *dhands*. The water of these *dhands* is continually being supplied with the soluble salts of the soil and sub-soil, so that eventually they contain concentrated solutions of whatever salts are in the soil. In the areas above named carbonate of soda is the predominant salt, with lesser portions of chloride and sulphate. In other parts of Sind the chloride predominates. The lakes are at their highest concentration in the early summer just before the rains, and it is then that most of the *chaniko* is collected. An analysis made of the *chaniko* clearly shows that it is the same mineral as trona or urao, ( $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$ ). Only those lakes which are very shallow (usually 1 to 3 feet deep), and which thus form natural evaporating pans, are worked for *chaniko*. There are however many *dhands*, which are over 3 feet deep, which never become sufficiently concentrated to deposit *chaniko*. Mr. Cotter is of opinion that, provided that the price of soda does not fall considerably as a result of the development of the Magadi deposit in British East Africa, it would be profitable to work the larger *dhands*. The quality of the urao obtained from those at present worked might also be much improved by the intelligent use of hydrometers. Chatard has shown that the concentration should not be allowed to pass a specific gravity of 1.280. (*Bull., U. S. Geol. Survey* No. 60, p. 65). As no attention is now paid to this point, and as the *dhand* is sometimes allowed to dry completely before any *chaniko* is collected, the mineral is contaminated by the presence of the impurer fractions which are deposited after the urao, and thus it contains large or small quantities of chloride or sulphate according to the original composition of the solution. The traffic in *chaniko* in the Sanghar and Khipro taluqas of Thar and Parkar district was put down by the Salt Department in 1902, because the product put on the market contained more than 50 per cent. of chloride, and was therefore dutiable.

48. A portion of the *chaniko* is sold in the bazaars of Hyderabad and Karachi, and is used in washing, dyeing, cookery, etc. The main portion is exported, the export figures for 1916 being 14,519 cwt. valued at Rs. 87,116, or Rs. 6 per cwt. The amount produced might be considerably increased, doubled or possibly trebled, if the larger *dhands* were worked by means of constructing "soda gardens" near their margins, and allowing the solution to concentrate by solar evaporation. The amount of soda annually produced

will never be very great, and is not likely to exceed four or five thousand tons.

### Sulphur.

49. Dr. Pilgrim completed his examination of the sulphur mines at Linga and Bostanah in the Persian Gulf, but, owing to his absence from headquarters in connection with other investigations, he has not yet been able to submit his report. The samples collected by him from the above deposits yielded, on analysis, sulphur contents ranging from 12 to over 55 per cent.

50. It was not possible to take up during 1918 the re-examination of the old sulphur mines near Sanni in Baluchistan, but this will be completed during the current field-season.

### Tin.

51. The Geological Survey Department has frequently drawn attention to the fact that certain alluvial deposits of the Tavoy district carry cassiterite and that their valuation by modern methods of testing was worth undertaking, to prove finally whether the ore can be won from them on a profitable scale or not. It is gratifying to report that considerable attention was paid to the subject by various large firms during the year and that a boring campaign was initiated in several localities.

### Tungsten.

52. The Geological Survey party continued its work in Tavoy and Messrs. Coggin Brown and Heron remained in Burma throughout the year. In the open season Mr. Heron was employed in geological survey work but during the rains he visited other parts of the province and while in Tavoy assisted Mr. Coggin Brown in his routine duties. These consist in advising the local authorities on matters connected with the mining industry, such as the grant of prospecting licenses and mining leases, water rights, boundary disputes, etc., and in periodical visits to all parts of the field in connection with the upkeep and development of wolfram and tin mining. The Tavoy output for the year amounted to 3,636 tons compared with 3,654 tons in 1917. The small decrease is attributed to the severe influenza epidemic of October and November. Mr. Coggin Brown continued

to act as a member of the Mining Advisory Board and as Inspector of Mines.

53. The small deposit of wolfram being worked near Kalimati in Singhbhum was visited by Dr. Fermor in April. The wolfram has been obtained from pockets on the surface of a bed of Dharwar quartzite overlain by muscovite-quartz-schist and dipping  $42^{\circ}$  to N.  $35^{\circ}$  E. The quartzite contains some interbedded veins of quartz, and the introduction of the wolfram was probably connected with the formation of these veins. The wolfram has been followed to a depth of 108 feet from the surface and was still in evidence at this depth at the bottom of an inclined shaft.

#### GEOLOGICAL SURVEYS.

54. It was not possible to resume systematic survey operations during the year 1918 except in Tavoy and neighbouring districts, where such operations had a direct bearing on the output of wolfram. Mr. J. C. Brown remained in charge of the Tavoy party. He was not able to take any active part in the surveys, but Mr. Heron and Messrs. Sethu Rama Rau and M. Vinayak Rao continued the survey of the Tenasserim province on the scale of  $1''=1$  mile. Sufficient material has now been collected for the publication of a geological map of Tavoy on the scale of  $1''=4$  miles, and this is now in the hands of the Survey of India Department for reproduction. Mr. Heron has completed large-scale geological maps of some of the chief mines of Tavoy using as a basis the mine-plans kindly put at his disposal by the companies concerned.

55. In his tour through the Orissa Feudatory States in the winter of 1917-18 in search of mica, Dr. Fermor was enabled to visit a tract of India much of which had not been previously traversed by a geologist. The brief examination thus rendered possible of the Archæan rocks over a wide tract of country showed that from the geological point of view Orissa must be regarded as a composite province, the northern portion being related to Chota Nagpur and the southern to the Eastern Ghats.

56. Throughout Sonpur, Baudh, the western end of Daspalla, in southern Rairakhol, Athmallik and southern Angul, and in Hindol and Dhenkanal, nearly all the varieties of Archæan rocks

are rich in garnet, and in addition to porphyritic garnet-gneisses and garnet-granulites, khondalite ranges occur. Such rocks are also known to occur in Kalahandi and west of Borasambar, and of course are amongst the chief constituents of the Eastern Ghats. In the area now referred to they extend, approximately, as far north as the southern edge of the Talcher coalfield.

57. On the north side of the Talcher coalfield, as seen in Talcher and Pal Lahara States, and in Bonai State further to the north, the rocks are of a totally different facies, the gneisses being as a rule devoid of garnets, whilst instead of the khondalites we have high ranges of schistose sericitic quartzites, with sericite and mica-schists and hematitic quartzites, in fact rocks of a Dharvarian facies. The entire facies is indeed, reminiscent of Singhbhum.

58. Using garnet as an index Dr. Fermor regards the Eastern Ghats as a portion of the crust that has been subjected to more intense metamorphism than Chota Nagpur. But it must be left to future research to decide whether the differences between these two regions are entirely a function of dynamic history or whether there were also original differences as regards composition both stratigraphical and mineralogical. Whatever the relative ages of the rocks of these two regions, however, the deduction that the rocks of the Eastern Ghats facies have been subjected to a more intense grade of metamorphism than those of Chota Nagpur indicates, according to Dr. Fermor, the existence between the two regions either of some form of shear or fault zone or of a zone of passage: and considering both the facts of distribution referred to above and the results of interpreting the statements as to the distribution of the crystalline and metamorphic rocks contained in the papers on Orissa in Vol. I of the *Memoirs*, Dr. Fermor deduces that the boundary between the Dharwar-nongarnet-gneiss facies and the khondalite-garnet-gneiss facies must run roughly westwards from the coast, through the break in the coastal hill ranges occupied by the Brahmani river, through the Talcher coalfield, across the Mahanadi river between Sambalpur and Sonpur, and thence to the north of Borasambar.

59. As the result of his visits to Singhbhum this year and in the past Dr. Fermor is able to formulate certain conclusions concerning the geology of this interesting district, and the sequence of ore deposition therein. Broadly speaking the district is occupied by a wide spread of

Dharwar rocks with various igneous intrusions, of which the chief are the granite of Central Singhbhum and the Dalma Trap and epidiorite dykes, with subordinate ultrabasic intrusions in the Kolhan (see p. 10). Still speaking broadly the Dharwars have suffered a much higher degree of metamorphism in Dhalbhum at the eastern end of the district than in the Kolhan at the western end. Slates have become phyllites and schists, and quartzites with recognisable detrital grains have become vitreous quartzites. Interbanded with the Dharwars of Dhalbhum are numerous potstones, but no chromite has been found.

60. It seems a fair hypothesis to regard the Dhalbhum potstones as the representatives of the Kolhan peridotites, serpentines, and talc-schists, in which a greater degree of metamorphism has led to the complete conversion of the magnesian rocks to talc; no detailed mapping of the Dhalbhum potstones has been attempted, but they appear to occur in smaller masses than the Kolhan magnesian rocks. A smaller thickness would also have aided the more complete metamorphism.

61. With the correlation of the Dhalbhum potstones with the Kolhan magnesian rocks, the parallelism of Dhalbhum and the Kolhan seems complete. The facts as to the order of the various intrusions are regarded by Dr. Fermor as conclusive, and the sequence of events in Archæan times is believed to have been:—

- (1) deposition of clays, sands, and limestones (and hematite deposits): extent of metamorphism prior to 2 unknown;
- (2) intrusion of ultrabasic laccolites and sills;
- (3) last period of severe earth movement, more intense in Dhalbhum than in the Kolhan;
- (4) intrusions of granite (sometimes streaky);
- (5) intrusions of dolerite, since altered to epidiorite.

Associated with the phyllites and schists of Dhalbhum are also some hornblende-schists. These must represent an earlier set of basic eruptions prior to the granites. Their age relative to the ultrabasic rocks, and whether lavas (basalts) contemporaneous with the sediments, or sills (dolerites) intrusive therein, is at present undetermined.

62. With reference to the sequence of mineralisation in Singhbhum Dr. Fermor considers that the iron of the hematites was probably deposited contemporaneously with the Dharwar sediments,

but the extent to which this iron has suffered subsequent rearrangement is at present unknown; the chromite was introduced with the ultrabasic rocks, and the wolfram, apatite-magnetite, and chalcopyrite, were probably introduced into the Dharwars from the granitic magma in the order mentioned. According to Maclaren the deposition of the gold was connected with the dolerite magma, but there seems to be no reason why the introduction of the gold also should not be due to the granitic intrusions.

#### BIBLIOGRAPHY.

63. The following papers dealing with Indian geology and minerals were published during the year 1918 :—

- ADAMSON, SIR HARVEY . . . . . The Material Resources of Burma. *Bull. Imp. Inst.*, XVI, 68-79.
- ANON . . . . . Tin in Burma. • *Mining Journal*, CXXIII, 683-684.
- BATHER, F. A. . . . . Notes on Yunnan Cystidea. *Geol. Mag.*, Decade VI, Vol. V. 507-515, 532-540.
- BELAJEW, COL. N. . . . . Damascene Steel. *Jour. Iron and Steel Inst.*, XCVII, 417-439.
- BROWN, J. COGGIN . . . . . (a) Tin ores in Tavoy. *Jour. and Proc. As. Soc. Bengal*, New Series, XIV, clxxxv. (Abstract).  
(b) The Cassiterite deposits of Tavoy. *Rec. Geol. Surv. India*, XLIX, 23-33.  
(c) Economic Geology of Tavoy. *Pub. by Govt. Mining Advisory Board, Tavoy.*
- BUCKMAN, S. S. . . . . The Brachiopoda of the Namyau Beds, Northern Shan States, Burma. *Palæontologia Indica*, New Series, III, No. 2.

- BURRARD, SIR SIDNEY . (a) Geological Interpretation of Geodetic Results. A Critical Examination of Mr. R. D. Oldham's recent Treatise on Himalayan Structure. *Geog. Jour.*, LII, 237-248.  
(b) Investigation of Isostasy in Himalayan and Neighbouring Regions. *Survey of India Professional Paper*, No. 17.
- BUSK, H. G. AND MAYO, H. T. Some notes on the Geology of the Persian Oilfields *Jour. Inst. Petrol. Technologists*, V., 3-33.
- CAMPBELL, J. MORROW The Ore Minerals of Tavoy District. *Pub. by Govt. Mining Advisory Board, Tavoy.*
- CHAKO, I. C. . The materials available in Travancore for the manufacture of Lime-Sand Bricks, Slabs and Tiles. *Geological Department, Travancore.*
- COLQUHOUN, ALLAN B. High Temperature from Broken Ore in the Stope. *Mining Mag.*, XIX, 202-203.
- COTTER, G. DE P. . (a) The Geotectonics of the Tertiary Irrawaddy Basin. *Jour. and Proc. As. Soc. Bengal*, New Series, XIV, 409-420; *Ibid.*, clxxxvii (Abstract).  
(b) The Lamellibranchiata of the Eocene of Burma. *Ibid.*, clxxxvii (Abstract).
- CROOKES, SIR WILLIAM. On the Photographic Spectra of Meteorites *Phil. Trans., Roy. Soc., Ser. A.*, Vol. 217, pp. 411-430.
- DAS-GUPTA, H. C. . On a peculiar polished Hammerstone, from Singhbhum, Chota Nagpur, India. *Ind. Antiquary*, XLVII, 135-136.
- DAVIES, A. MORLEY . The Problem of the Himalaya and the Gangetic Trough. *Geog. Journal*, LI, 175-183.



- FERMOR, L. L. . . Preliminary note on the burning of coal seams at the outcrop. *Trans. Min. Geol. Inst. Ind.*, XII, 50-63.
- FOURTAU, R. . . Les Échinides des "Bagh Beds," *Rec. Geol. Surv. India*, XLIX, 34-53.
- HAYDEN, H. H. . . (a) General Report of the Geological Survey of India for the year 1917. *Rec. Geol. Surv. India*, XLIX, 1-22.  
(b) The Mineral Production of India during 1917. *Ibid.*, 55-116.  
(c) The Relationship between Geology and Earthquakes in India. *Jour. and Proc. As. Soc., Bengal*, New Series, XIV, xviii-xxiv.
- IYER, V. S. SAMBASIVA On the distinct Sedimentary Origin of some Quartzites of Mysore. *Ibid.*, clxxvi (Abstract).
- JAYARAM, B. . . Annual Report of the Depart. of Mines and Geology, Mysore State, for the year 1916-17. *Rec. Dept. Mines and Geol., Mysore*, XVI, 1-50.
- JOHNSTONE, SYDNEY J. Tungsten within the Empire. *Jour. Soc. Chem. Industry*, XXXVII, 294R-296R.
- LA TOUCHE, T. H. D. . A Bibliography of Indian Geology and Physical Geography, with an Annotated Index of Minerals of Economic Value, Pt. II. *Geological Survey of India*.
- MATLEY, C. A. Note on some Dinosaurian Remains recently discovered in the Lameta beds at Jubulpore. *Jour. and Proc. As. Soc., Bengal*, New Series, VIV, clxxxvi-clxxxvii (Abstract).

- McWILLIAM, ANDREW . Technical Aspects of the Establishment of the Heavy Steel Industry in India, with Results of some Researches connected therewith. *Jour. Iron and Steel Inst.*, XCVII, 451-468.
- MIDDLEMISS, C. S. AND JOTI PARSHAD, LALA. Note on the Aquamarine Mines of Daso on the Braldu River, Shiga Valley, Baltistan. *Rec. Geol. Surv., India*, XLIX, 161-172; *Jour. and Proc., As. Soc., Bengal*, New Series, XIV, clxxxiv-clxxxv. (Abstract).
- MOORE, E. S. . . . . Air Blasts in the Kolar Gold Field, India, *Bull. Amer. Inst. Min. Engineers*, Vol. 135, pp. 687-694.
- NEOGI, PANCHANAN . . . . . Copper in Ancient India. *Ind. Assoc. Science, Special Bulletin* No. 1.
- OLDHAM, R. D. . . . . The Support of the Mountains of Central Asia (Being an Appendix to the Memoir on the structure of the Himalayas and of the Gangetic Plain, as elucidated by Geodetic observations in India). *Rec. Geol. Surv., India*, XLIX, 117-135.
- ” ” . . . . . The Geological Application of Geodetic Results. *Geog. Journal*, LII, 363-367.
- PINFOLD, E. S. . . . . (a) The conditions governing the occurrence of Oil in the Punjab. *Jour. and Proc., As. Soc., Bengal*, New Series, XIV, clxxxiii-clxxxiv.
- (b) Notes on structure and stratigraphy in the North-West Punjab. *Rec. Geol. Surv., India*, XLIX, 137-160; *Jour. and Proc., As. Soc. Bengal*, New Series, XIV, clxxxiv. (Abstract).

- RASTALL, R. H. . . . The Genesis of Tungsten Ores. *Geol. Mag.*, V., (Decade VI), 193-203, 241-246, 293-296, 367-370.
- SMEETH, W. F. . . . Air Blasts in the Kolar Gold Field, India. *Bull. Amer. Inst. Mining Engineers*, 142, 1542-1553.
- “ ” AND  
WATSON, H. E. . . . The Radioactivity of Archæan Rocks from the Mysore State, South India. *Phil. Mag.*, ser. 6, 35, 206-214.
- STUART, MURRAY . . . Preliminary Note on the Srimangal Earthquake of July 8th, 1918. *Rec. Geol. Surv. India*, XLIV, 173-189.
- TUCKWELL, H. M.  
SURTEES. . . . The Tata Iron and Steel Works: their Origin and Development. *Jour. Roy. Soc. Arts.*, LXVI, 189-205.
- VREDENBURG, E. . . . (a) Considerations regarding a possible relationship between the Charnockites and the Dharwars. *Jour. and Proc. As. Soc. Bengal*, New Series, XIV, clxxxv. (Abstract).  
(b) Suggestions regarding the mechanism of *Charriages*. *Ibid.*, clxxxv-clxxxvi. (Abstract).
- VREDENBURG, E. AND  
DAS GUPTA, H. C. . . . On the discovery of Upper Palæozoic Fossils in the Krol beds of the Simla region. *Ibid.*, clxxxv. (Abstract).
- WADIA, D. N. . . . *Stegodon Ganesa* in the Middle Siwaliks of Jammu. *Ibid.*, clxxxvii. (Abstract).

THE POTASH SALTS OF THE PUNJAB SALT RANGE AND KOHAT. BY MURRAY STUART, D.SC., *Assistant Superintendent, Geological Survey of India.* (With Plates 1 to 8).

I.—INTRODUCTORY.

THE re-examination of part of the salt deposits of the Punjab Salt Range and Kohat, described below, was undertaken to ascertain as far as possible what amounts of potash<sup>1</sup> occur in the salt beds, and their economic value. The investigation was begun in December 1915 and extended over the two field-seasons 1915-16 and 1916-17. The deposits had been examined by A. B. Wynne in the early seventies, but they had not been examined especially from the point of view of the potash salts, although the presence of potash in places was detected by him.

Comparatively recently the section opened up by the Mayo salt mine at Khewra in the Punjab was examined in detail by Dr. W. A. K. Christie for the existence of potash seams, and potash was detected by him also in the Nurpur mine, but beyond that no systematic work had been done on potash in the area.

Although the examination of the salt deposits was incidental to the potash investigation the former are described below with details of their peculiarities and nature, as far as they are known, and the potash deposits fall naturally into this description in their proper place, since they are part of the great salt formation as a whole. In the present note I deal only with the observed facts as to the distribution of the salt and with the economic aspect of the included potash deposits, while in a subsequent paper I propose to suggest a new interpretation of those facts and a new theory regarding the salt and gypsum formations.

The area examined (*infra*, Pl. 25) comprises most of the exposures in the Punjab Salt Range between the Nilawan ravine in the Jhelum district and Kalabagh on the Indus; thence the salt exposures

<sup>1</sup> Throughout this report the word potash means any of the naturally occurring potassium compounds, and where the compound  $K_2O$  is referred to it is called potassium oxide to avoid confusion.

were followed up through the Lun Wan pass to Nandrakka in Kohat, and from there westwards along the range through Malgin to Bahadur Khel on the Waziristan frontier, a total distance of over 200 miles. In addition to the above, isolated exposures at Banda Daud Shah and Jatta Ismail Khel in Kohat were also examined.

I am greatly indebted to the Commissioner and officers of the Northern India Salt Revenue Department for the assistance they gave me throughout my investigation, and especially to Mr. F. Reid, Assistant Commissioner of Mines at Khewra, whose knowledge of the salt beds and the various mines, saved me both time and labour, and helped very considerably to the results I have obtained.

I do not propose here to give a complete list of previous observers. The salt deposits have been thoroughly examined by Wynne and Warth, and the results of their work together with a bibliography is published in the *Memoirs* of the Geological Survey of India, Vols. XI, pt. 2, and XIV. C. S. Middlemiss did further work on the salt marl and published his views in the *Records* of the Geological Survey, Vol. XXIV, page 19. Finally, recently, Dr. Christie thoroughly examined the salt deposits of the Mayo mine at Khewra and also the Nurpur mine, and published his results in the *Records*, Vol. XLIV, pt. 4.

These four publications incorporate everything having any bearing on the economic question that had been done up to the date of their publication, and consequently are all that I need mention here.

The Punjab salt is red or brown in colour and occasionally grey; it is massive, and sometimes coarsely crystalline. The Kohat salt is grey, and generally strikingly schistose (see Plate 1); red salt is exceedingly rare in Kohat, but is not entirely absent as stated by Wynne and Warth.

The rocks of the Kohat district are classified by Wynne in their natural order of superposition as follows:—

- (6) Upper and Middle Tertiary sandstones, etc.
- (5) Lower Tertiary sandstones, etc., or Murree beds.
- (4) Nummulitic limestone.
- (3) Red clay zone.
- (2) Gypsum.
- (1) Rock-salt.

The Nummulitic limestone and the red clay zone both contain nummulites, and are classified by him as Eocene, a classification with which I am entirely in accord. The underlying gypsum and rock-salt are classified by him as probably Eocene also, a deduction for which I have failed to find support.

The salt is described by Wynne, but, as my observations differ materially from his description, I will give them first, and will then point out wherein they differ from his description. The rock-salt of the Kohat area is a schist. It frequently cleaves easily along the planes of schistosity, and in the west of the district, as for instance at Bahadur Khel and Karak, it is sufficiently fissile to be quarried by simply splitting into slabs by means of iron wedges held between the quarryman's toes and tapped with round stones about six inches in diameter. Plate 1, fig. 1 shows a photograph, natural size, of Bahadur Khel salt, and illustrates its schistose character. Plate 1, fig. 2 represents a salt quarry at Bahadur Khel, and shows the steep angle at which the planes of schistosity dip towards the north, and the iron wedges, rounded stone, and freshly fractured slabs of salt, illustrating the method of working described above. The foliation of the salt in the Bahadur Khel salt-field will be discussed in detail below. In the east of the district the cleavage of the salt is less apparent but its schistose nature is still evident, even at Malgin and Jatta, where the salt is blasted out instead of being split along planes of schistosity. In other words the schistosity is greatest in the west of the district and least in the east, but it is still perceptible even in the east.

The salt possesses a characteristic whitish or grey colour throughout the district. Red salt does occur, but I have only found it in two places, in the clays to the west of the middle of the eastern salt hill at Bahadur Khel (see sketch plan, Plate 8), where it is obviously recrystallised, and in bands in the dark grey salt of Nandrakka in the extreme east of the Kohat district. The Nandrakka outcrop is of special interest because it is a distinct link between the Punjab and the Kohat salt, and shows not only both red and grey salt, but also chemical characters intermediate between the two types. Earthy impurities are commonest in the western part of the district, where the largest exposures of salt occur; they consist of bands of bluish-grey clay, generally discontinuous, and isolated fragments of the same clay scattered through the schistose salt as constituent

components of the rock. When the salt weathers these fragments of clay are left on the surface of the salt as projecting particles, and show up the foliation bands in a most marked manner. Plate 2 shows a photograph taken on Bahadur Khel salt-field illustrating this—the hummocks of salt in the middle distance are about four feet high—and it will be seen that the foliation of the salt is strikingly delineated by the clayey particles left projecting, owing to the fairly rapid solution of the salt under the action of the usual weathering agents. The direction of foliation of the salt at Bahadur Khel does not correspond with the run or arrangement of the overlying gypsum formation, and is frequently at right angles to it. The sketch-plan of the Bahadur Khel salt-field, Plate 8, shows this well. The foliation planes were followed out and mapped wherever well seen, and their arrangement is shown by the broken lines on the sketch map. It will be seen that there is no apparent connection between them and the overlying gypsum and Eocene formations, neither of which follow the run of the foliation planes exhibited by the salt.

The field was extensively tested for the presence of potash but none was detected. This may mean either that no potash was present in the original salt from which the schist was formed, or that, being more soluble than rock-salt, any potash that may have originally been present, has been removed in solution. In either case the Bahadur Khel salt does not offer any encouragement to further search for potash.

*Kark and Guruza.*—The salt here is exactly like that of Bahadur Khel and is worked by splitting it along its foliation planes. No trace of potash was detected.

*Intervening outcrops between Bahadur Khel and Malgin.*—The various outcrops intervening between Guruza and Bahadur Khel and Malgin were all examined, but no trace of potash was detected in any of them. The salt is of the usual grey colour in all of them and is distinctly schistose, although the cleavage is not so marked as at Bahadur Khel and Karak.

*Malgin.*—The salt is grey and shows less tendency to cleave along the planes of schistosity than is the case in the west of the district. It is worked by blasting; nevertheless, here also, distinct schistosity can be distinguished, especially on weathered surfaces of salt.

*Jatta.*—Here again the salt is less markedly schistose, but nevertheless distinctly a schist.

*Nandrakka*.—The salt here occurs in two solution craters. The underlying salt has been removed in solution and the overlying gypsum has fallen in, leaving a deep crater-like hole, into which streams flow in the wet weather and find their way through dissolved-out channels in the salt to the Teri Tawi to the north. Salt is exposed in vertical cliffs in the sides of these craters in two places at the Nandrakka post and also near the Eja post.

The salt is blackish-grey with bituminous matter incorporated in its upper layers, and also in the overlying gypsum. Irregular streaky bands of pink salt occur in the grey salt in both exposures immediately east of the Nandrakka guard-post. Also numerous stalactites of salt are formed in the salt caves by percolating water, and the water dripping from these was in numerous instances found to give a distinct reaction for both potassium and magnesium. I do not suggest that potassium is present in quantities of commercial importance, but the interest of the observation lies in the fact that this exposure, which is intermediate in position between Kohat and the Punjab contains both grey and red salt and also traces of potassium and magnesium, which are strikingly absent throughout all the Kohat exposures investigated. The next exposure of salt, in the Lun Wan pass, approximately 20 miles to the south, near Kacho, belongs to the Punjab type. Consequently the Nandrakka exposures are intermediate in type; they are a distinct link between the two salt areas and of themselves give rise to the very strong presumption that the two salt deposits are parts of one great salt formation and are not distinct and unconnected formations.

As I have already pointed out, the Punjab salt is red and occasionally grey, and generally contains salts of magnesium and potassium. Its usual position is below the Purple Sandstone of the Salt Range, which underlies the Obolus Shales of undoubted Cambrian age. Occasionally it is overlain by Nummulitic limestone, as at Vasnal in the Jhelum district, or by Tertiary sandstones and clays, as at Kalabagh. But in every case, just as in the Kohat area, it is the lowest formation seen, and nothing has ever been found definitely underlying it.

The salt does not occur in regular stratified beds, but as has been noticed also by Wynne and Christie, frequently occurs in lenticular and irregular bands; these possess a foliated character although on a scale much larger than is usually understood by that



term. It in fact appears to be a foliated deposit, but whereas in Kohat the foliation is on such a fine scale that the rock can be called a schist, in the Punjab the foliation is on such a large scale that the individual foliated bands are feet, and sometimes yards, across.

This first became evident when I was investigating the Nurpur mine. On tracing out the potash seams in detail there it became at once clear that they are not only discontinuous, but thicken and thin abruptly along their length. A glance at the plan of the seams investigated in the Nurpur mine will make this evident (Plate 5). The western seam ends abruptly just to the south of the point at which it was tested by Dr. Christie,<sup>1</sup> and its eastern boundary follows a very curved course. The eastern seam thickens and thins in an abrupt and extraordinary manner along its length, varying, for instance, from a thickness of a few inches, at a distance of twenty-five feet from the southern end of the drift, to more than thirty times that thickness fifteen feet further north. The curves of the eastern boundary of the western potash band do not agree with the curves in the western boundary of the eastern band and obviously neither of them is an ordinary stratified bed bounded by planes of stratification. Equally obviously the salt and salt marl bands occurring between the two potash bands cannot exhibit planes of stratification in the ordinary sense of the words since they must thicken and thin in agreement with the boundaries of the potash bands. The salt bands were not examined in detail, but the thickening and thinning of some of the marl bands in them is abundantly evident.

An examination of the Mayo salt mine at Khewra, in order to ascertain if the dip of the beds changed in the north-east corner of the mine, showed that here also the banding of the salt was not due to stratification.<sup>2</sup>

## II.—POTASH IN THE SALT DEPOSITS.

During the investigation for potash salts the whole of the Nilawan ravine was examined and every outcrop tested. The Nurpur mine was examined in detail as was also the Warcha mine. Khewra had already been examined by Dr. Christie, but as most of the potash salts there had already been worked out with the salt from the

<sup>1</sup> *Rec., Geol. Sur. Ind.*, XLIV, 247.

<sup>2</sup> This will be dealt with further in a subsequent paper.

chambers and what was left remained chiefly in the pillars, the investigation was largely of scientific interest only, while I understand that owing to the present great demand for salt it is considered inadvisable to attempt the production of potash at Khewra, unless of course some hitherto unsuspected thick band comes to light—an event which I regard as extremely unlikely.

After Warcha, Kalabagh was inspected and from there the investigation was carried on through the Lun Wan pass into Kohat and thence westwards to the Waziristan frontier. Potash was detected and mapped in the Nurpur mine, and in the Warcha mine. Traces of it were detected at Kalabagh and at Nandrakka in Kohat, but in each of these two latter cases no seam of potash salt was found, its presence being merely detected in dripping water, or in the water lying in some of the quarries.

The method of testing adopted was the perchloric acid method. A measured quantity of pulverised material from the band to be tested was dissolved in a fixed quantity of water and then treated with perchloric acid, any potash present being brought down as a white precipitate. By using graduated test tubes the volume of precipitate obtained could be measured and from that a roughly approximate idea gained of the percentage of potassium oxide present. The quantity of pulverised material taken was measured in a small quartz spoon containing about one cubic centimetre. This was dissolved in 4 c.c. of distilled water and the potash then precipitated with perchloric acid. After precipitation the tube was allowed to stand for exactly five minutes—to allow the precipitate to settle—and then the volume of precipitate obtained was read off in cubic centimetres.

From actual experiments the following results were obtained :

Precipitate obtained in cubic centimetres.	Percentage of potassium oxide present in material being tested.
0.2	5 per cent.
0.4	7. "
0.6	9. "
0.8	11. "
1.0	13. "
1.2	15. "
1.4	17½ "
1.6	20. "
2.0	23. "
2.5	27½ "
3.0	32. "
4.0	43. "

These figures are more accurate in the lower quantities than in the higher as experimental error is greater in more highly concentrated solutions. They are in any case only approximately quantitative.

In order to keep the quantities correct in the tests, the method adopted was to take a double quantity of material and dissolve it in 8 c.c. of water; this was then filtered through a dry filter paper and exactly 4 c.c. of filtrate taken. By this means one is sure of obtaining the full 4 c.c., and the degree of concentration of the solution is unaltered.

As regards the taking of material, potash seems to be generally exceedingly soluble, and much more deliquescent than salt, consequently it would not be satisfactory to test the surface of a salt outcrop if it showed the least signs of weathering. I came to the conclusion, however, that the material six inches inside perfectly solid fresh salt was unaffected by weathering, and that therefore material tested from such a depth was to be relied upon. I consulted Mr. F. D. Reid, Assistant Commissioner at Khewra on this point and he agreed with me. Confirmation also seems to be given by the one test in the Nilawan ravine giving a potassium reaction, where the potassium-bearing material was found in the very face—clean and unweathered, it is true—of the outcrop, where it had been exposed to the rain and air: the effect of the rain being apparently simply to remove a film off the surface by solution and leave the undissolved material unaffected.

In cases, where weathering or differential solution had taken place or where there was an efflorescence on the face of the outcrop, the outcrop was cut into until hard fresh material was obtained, and material was then taken from a depth of six inches by drilling into the face with a jumper.

The actual taking of samples, and cutting into the salt, as well as the work in the mines, was done by a number of experienced miners kindly lent me by the Salt Department. In testing an outcrop a sample was taken from every band of salt, and, where the bands were more than a foot in thickness, at intervals of a foot, except in a few cases where the bands of salt were very thick and obviously of uniform character and purity, when tests were taken only every two feet.

While it is possible, therefore, that insignificant pockets of potash may have escaped unnoticed, nothing of any commercial or economic value can have done so.

In Kohat, at Bahadur Khel, a cut was made right across the salt and all the material from this was tested, so that there none was missed.

### The Nilawan Ravine.

The Nilawan ravine occupies the centre of a steep, faulted anticline running in a general north and south direction. The prevailing dip of the rocks of the Salt Range in the neighbourhood is N.N.W., but the Nilawan ravine anticline seems to have been a subsidiary sharp pucker in the rocks due to east and west compression. The fault seems generally to occupy the centre of the anticline, and is probably very largely the cause of the ravine.

Generally the anticline is steep and narrow, and the salt marl only occurs at the bottom of one or both sides; but in the neighbourhood of the Nurpur mine the anticline seems to have domed up, and a much greater thickness of salt-bearing rocks is seen. In fact the salt seams opened up by the mine are probably the lowest exposed in the ravine.

The following is a list of the outcrops tested in the Nilawan Ravine:—

#### *Outcrop facing north under guard-post 12.*

Every seam tested—20 tests—result *nil*.

#### *Southern outcrop under guard-post 12.*

Tested every two feet—41 tests—result *nil*.

#### *Outcrop under guard-post 11.*

30 tests—potash detected in uppermost band (gave 0.1 c.c precipitate). Exhaustive tests proved, however, that this was merely an isolated occurrence, and the salt around the spot, and also behind it, gave no reaction whatsoever. Practically all the potash was removed in the first material taken for testing purposes. The outcrop was cut into to a depth of ten feet but there was no recurrence of potash. Everywhere else the tests in the outcrop gave no result.

#### *Outcrop at guard-post 11 on east side of stream.*

Tested every seam—46 tests—result *nil*.

*Outcrop in west bank of stream, south of guard-post 11.*

Tested every seam—15 tests—result *nil*.

*Outcrop N.W. of guard-post 10, east of ravine in side stream.*

Tested in every impure band and where the bands were thick at intervals of 18 inches—25 tests—result *nil*.

*Western outcrop opposite guard-post 10.*

Tested every band of any thickness and, where the bands are thick, at intervals of 18 inches—51 tests—result *nil*.

*Eastern outcrop south of guard-post 10 in right bank of stream.*

Tested every band of any thickness and, where the bands are thick, at intervals of 18 inches—61 tests—result *nil*.

*Small cleared outcrop 300 yards S. of guard-post 10 and east of 9.*

4 tests—result *nil*.

*Outcrop 100 yards S. 55° W. of guard-post 9 in west bank of small stream.*

Tested every two feet—46 tests—result *nil*.

*Outcrop east of, and opposite, guard-post 9 in left bank of stream.*

Tested every foot—27 tests—result *nil*.

*Old mine at guard-post 9.*

This is unsafe to work in owing to the state of the roof. It was examined as much as possible—result *nil*.

*Outcrop between present mine and guard-post 9 in right bank of stream.*

Tested every foot—8 tests—result *nil*.

*First outcrop west of present mine in same bank in Bhal ravine.*

Tested every foot—6 tests—result *nil*.

*Second outcrop west of present mine in same bank in Bhal ravine.*

Tested every foot—7 tests—result *nil.*

*Third outcrop, west of present mine in same bank in Bhal ravine.*

Tested at approximately one foot intervals—4 tests—result *nil.*

*Fourth outcrop, west of present mine in same bank in Bhal ravine.*

Tested at one foot intervals—9 tests—result *nil.*

*Outcrop (exposed by me) east of guard-post 7 in right bank.*

Tested every seam—24 tests—result *nil.*

*Outcrop opposite guard-post 7.*

Tested every seam—57 tests—result *nil.*

*Two small outcrops facing north in right bank of stream just below mine.*

Tested every salt band—24 tests—result *nil.*

*Outcrop in small stream in left bank S.S.E. of guard-post 13.*

Tested every foot—15 tests—result *nil.*

*Outcrop N.N.E. of guard-post 14 in left bank.*

Tested every foot—17 tests—result *nil.*

*Outcrop north of guard-post 14, facing north in left bank.*

Tested in every seam—34 tests—result *nil.*

*Bottom outcrops opposite guard-post 14.*

Tested in every seam—57 tests—result *nil.*

*Outcrops in enclosed ravine just north of above.*

4 tests—result *nil.*

*Northern end of main outcrop opposite guard-post 14.*  
Tested every foot—21 tests—result *nil*.

*Middle of main outcrop opposite guard-post 14.*  
Tested every two feet—26 tests—result *nil*.

*Southern end of main outcrop opposite guard-post 14.*  
Tested every foot—26 tests—result *nil*.

*Outcrop in left bank at stepping stones between guard-posts 14 and 15.*  
Tested every seam—27 tests—result *nil*.

*Outcrop under guard-post 15.*  
Tested every seam—35 tests—result *nil*.

*Northern outcrop under guard-post 16.*  
Tested every seam—69 tests—result *nil*.

*Outcrop at top of bank under guard-post 16.*  
Tested every seam—17 tests—result *nil*.

*Second outcrop from north under guard-post 16.*  
Tested every seam—89 tests—result *nil*.

*Main portion under guard-post 16.*  
Tested every seam—95 tests—result *nil*.

*Outcrop opposite guard-post 17.*  
Tested every seam—117 tests—result *nil*.

*Two outcrops under guard-post 18.*  
Tested every seam—45 tests—result *nil*.

*Outcrops in bluff opposite guard-post 19.*  
Tested every seam—110 tests—result *nil*.

*Outcrops south-west of guard-post 20, facing north.*

Tested every seam—53 tests—result *nil.*

*Small outcrop west of above, beside stream.*

4 tests—result *nil.*

*Outcrop south of guard-post 20, facing south.*

Tested every seam—19 tests—result *nil.*

*Outcrop south of guard-post 20, facing west.*

Tested every seam—46 tests—result *nil.*

*Outcrop under guard-post 21.*

Tested every seam—30 tests—result *nil.*

### The Nurpur Salt Mine.

There are two potash seams in this mine, in the east and west alls of what is known as the "potash drift." I have already

#### *East Wall.*

DIS- TANCE F TEST FROM SOUTH WALL TO END OF POTASH DRIFT.	APPROXIMATE PERCENTAGE OF POTASH.												
	Depth into wall.												
	6"	1'	1' 6"	2'	2' 6"	3'	3' 6"	4'	4' 6"	5'	5' 6"	6'	6' 6"
10'	<i>nil.</i>	9	5	8	2	2	..	..	..	..	..	..	..
20'	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	..	..	..	..	..	..	..
30'	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	..	..	..	..	..	..	..
40'	9	9	10	17	17	15	13	13	25	13	..	..	..
50'	5	6	13	13	8	15	32	15	17	18	15	13	2
60'	16	16	11	5	21	21	18	..	..	..	..	..	..
70'	17	9	5	marly <i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	..	..	..	..	..	..
80'	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	..	..	..	..	..	..	..
90'	<i>nil.</i>	<i>nil.</i>	<i>nil.</i>	<i>ni</i>	<i>nil.</i>	<i>nil.</i>	..	..	..	..	..	..	..



West Wall.

DISTANCE OF TEST FROM SOUTHERN END OF POTASH DRIFT.	APPROXIMATE PERCENTAGE OF POTASH.																			
	Depth into wall.																			
	0'	1'	1' 0"	2'	2' 0"	3'	3' 0"	4'	4' 0"	5'	5' 0"	6'	6' 0"	7'	7' 0"	8'	8' 0"	9'	9' 0"	10'
10'	13	13	13	11	12	15	..	..	4	..	..	..	..	..	..	..	..	..	..	..
20'	7	nil.	7	11	12	13	18	10	..	..	..	..	..	..	..	..	..	..	..	..
30'	nil.	nil.	nil.	nil.	trace	9	11	..	..	..	..	..	..	..	..	..	..	..	..	..
40'	6	nil.	6	7	12	16	18	..	..	..	..	..	..	..	..	..	..	..	..	..
50'	nil.	nil.	6	7	9	7	7	..	..	..	..	..	..	..	..	..	..	..	..	..
60'	nil.	nil.	nil.	trace	13	13	..	..	..	..	..	..	..	..	..	..	..	..	..	..
70'	nil.	nil.	nil.	trace	8	7	11	..	..	..	..	..	..	..	..	..	..	..	..	..
80'	nil.	nil.	nil.	nil.	nil.	nil.	trace	13	8	..	..	..	..	..	..	..	..	..	..	..
90'	nil.	nil.	nil.	nil.	nil.	nil.	nil.	trace	nil	9	nil.	13	13	13	13	11	17	32	15	21

PART I.] STUART: Potash in the Salt Range and Kohat. 41

West Wall—continued

DISTANCE OF TEST FROM SOUTHERN END OF POTASH DRIFT.	APPROXIMATE PERCENTAGE OF POTASH.																			
	Depth into wall.																			
	10' 6"	11'	11' 6"	12'	12' 6"	13'	13' 6"	14'	14' 6"	15'	15' 6"	16'	16' 6"	17'	17' 6"	18'	18' 6"	19'	19' 6"	20'
10'	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20'	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
30'	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
40'	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
50'	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
60'	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
70'	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
80'	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
90'	13	14	13	13	14	11	21	12	13	15	12	14	16	15	11	37	32	trace	2	nil.

referred to the way in which they thicken and thin and even end abruptly: phenomena which I ascribe to metamorphism that has occurred in the salt deposits. Not only do the potash bands vary abruptly in thickness and direction, but they vary throughout their length in the percentage of potassium present in them. A glance at the above figures will make this evident. They represent the results of tests made in the sides of the potash drift in the Nurpur mine. This drift was run with the intention of keeping in touch with, but just outside the eastern boundary of, the western potash band which had been located by Dr. Christie.

In order to test the deposit, holes were drilled into the side walls of the drift on both the east and west sides, by means of a jumper, and the material extracted was collected and tested after each six inches of progress. In this way a series of tests was made, giving the average potassium content of every six inches drilled into the walls. These drill holes were carried into the walls as far as was possible with the jumpers at my disposal and where it seemed necessary to get further in than could be done in this way, the walls were blasted out when the jumpers had been driven in as far as possible, and so further progress was made possible. These tests were made into both walls at intervals of ten feet starting from the southern end of the drift.

From these tests it will be seen that the potassium contents of the two seams, or bands, of potash are not fixed quantities for the respective seams, but vary throughout their length. For instance, it is obvious that material excavated to a depth of two feet six inches into the west wall at a distance of 10 feet from the southern end of the potash drift, would have an approximate content of 12 per cent.  $K_2O$  (corresponding to an average precipitate of 0.94 c.c.), while potash excavated from a similar depth into the band at a distance of 50 feet from the southern end of the drift—the potash band is separated from the drift by a thickness of one foot of salt at this point—would only have an average content of 6 per cent.  $K_2O$  (corresponding to an average precipitate of 0.3 c.c.).

This is of great importance in any statement made regarding the analysis of samples taken from the potash seam. In each case the results of the analysis are merely indicative of the average potassium content of the band at a particular point, the point where the sample was taken. The potassium content may be, and almost certainly is, very different a short distance away. For instance, in the particular

cases mentioned above there is a variation of something like 100 per cent. in the potassium content of the potash band in a length of 40 feet.

A series of investigations was also carried out, on material taken from the southern face of the western potash band, by the Director of Industries, United Provinces, the results of which were kindly communicated to me by the Commissioner, Northern India Salt Revenue; and permission to use them in this report was given me by the Director of Industries.

The first results were obtained by the platonic chloride and the mixed chlorides methods of analysis for potassium, and gave a result of 22.6 per cent. potassium chloride, KCl, which is equivalent to approximately 14.3 per cent  $K_2O^1$ . This agrees very closely with the rougher analysis done in the ordinary course of my investigations, 1.0 c.c. of precipitate being obtained by me.

The Director of Industries, United Provinces, further suggested "the composition corresponds very closely to that of kainite." This agrees with my own conclusions.

At the risk of being thought to repeat myself I would again point out that these figures and conclusions merely refer to the potash band at the southern end of the drift and not to any other point in it.

The above brings me to the precautions necessary in the mining of potash at Nurpur. What has to be avoided is the mixing of salt with potash either when excavating the material or when bringing it out of the mine. Crude potash has a definite value and that value is diminished if the potash contains an admixture of salt. It may, I think, be taken that the value does not decrease in proportion to the percentage of salt included, but that there is a very rapid decrease in value as the salt increases. That being so it is obviously necessary to prevent salt becoming mixed with the potash while extracting the latter in the mine.

1 The detailed analysis obtained was:—		Per cent.
"K	. . . . .	11.8
Mg	. . . . .	9.8
SO <sub>4</sub>	. . . . .	46.3
Cl	. . . . .	17.9
		85.8

. The rest being presumably sodium, water, and traces of insoluble matter."

Since the bands of potash do not behave as normal stratified deposits their boundaries can be determined only by actual experiments. Appearance is of no use at all; potash can sometimes be detected in this way, but confirmatory tests show that one is misled as often as one is correct in identifications made thus, and frequently there is no visible difference whatever between the material just inside the boundary of a potash band and the adjoining material just outside it.

Taste is a fairly reliable test once; after that one's palate is so affected by the bitter taste of the potash compounds that it is impossible for about half an hour to distinguish between potash and salt. Consequently the only test that remains is the chemical one. Chemical tests should be made continuously, therefore, and the position of the boundaries of a band indicated to the miners, so that they may extract only the potash and leave the salt; and as the bands vary so greatly in thickness, these determinations will have to be made every foot or so along the run of the band.

The best plan will probably be to have the drift a little wider than the potash band, and to mark out the two boundaries of the band on the working face; the miners should then cut into the salt, or salt marl, immediately outside these boundaries to a depth of a foot, and blast out the potash between their cuts. After this, the position of the boundaries should be verified or corrected, and the same procedure repeated; and so on. It is necessary that the edges or boundaries should be cut, and not blasted, since blasting will give an irregular edge and bring in a certain amount of salt. Miners find the potash hard to cut with picks, but, in the procedure suggested it will be noticed that they need not cut into the potash, but into the salt or marl immediately outside the boundaries of the bands.

As progress proceeds it will be necessary to keep the sides of the drift wider than the potash band so as to allow for the ready following of any widening of the band, but there should be no difficulty in keeping the potash extracted from between the two cuts separate from the material removed from outside them.

### The Warcha Mine.

Potash was found to occur in three chambers in the Warcha salt mine. It occurs in the working faces of the disused portions of chambers 2 and 3, and also in the middle of the old exploration

tunnel in chamber 4 (see plan and sections of part of Warcha mine, Plates 6 and 7).

Its occurrence is peculiar. It was encountered unexpectedly while the chambers were being worked for salt, and since its presence made the salt unpalatable, work was stopped in these particular chambers (2 and 3).

In view of the experience gained at Nurpur, it would appear that the end of a potash band has been reached in each case, and that that band is starting abruptly, just as the western band at Nurpur does. How far it runs in a forward direction it is impossible to say, but some information is given by the new exploratory drift run by the Salt Department at my request from the bottom of chamber No. 4. All the three occurrences first mentioned are sufficiently nearly on the same plane for them to belong to one and the same potash band. The new exploratory drift at the bottom of chamber No. 4 cuts through potash also on this plane, so that the inference that they are one and the same seam is justified. The potash in the new exploratory tunnel is only a trace, however, and shows that under the lower portion of chamber 4 the potash, rather than thickening, thins away to almost nothing. Another small seam of potash about eight inches in thickness and yielding about 12 per cent. of  $K_2O$  occurs in this new tunnel, at a higher horizon than that just mentioned.

The structure of the salt deposits opened up by the mine is interesting. More or less through the centre of the working chambers of the present mine there runs a band of marl and magnesium salts which is a very characteristic feature of the mine. We may in fact call it the 'main marl band' of the mine. About 50-55 feet below this in the section of the salt, is a peculiar red salt-marl breccia about two feet thick. It seems to consist of a salt-marl matrix with brecciated lumps of marl containing less salt than the matrix. It is quite characteristic, and, once seen, cannot be mistaken; throughout the mine it is parallel to the foliation of the salt, forming a valuable, and easily recognizable, horizon. It is seen in both the exploratory tunnels in chamber 4, and also in the tunnel just to the north of the disused chamber in No. 2, and also in the new lower tunnel now being driven to open up the lower workings of the mine. About 20 feet below this Red Marl breccia is the potash in chamber No. 2 and in the exploratory drifts in No. 4.

About 20 feet below the potash horizon in the exploratory drifts in No. 4 is the line of an apparent overthrust, marked by shattered and brecciated beds containing clay, gypsum, red and grey salt, in shattered lumps<sup>1</sup>; beneath this is grey salt with grey clay, not regularly banded as the red salt is above the line of the overthrust, but much contorted, and in its upper portions overfolded towards the south; it is best seen in the lower exploratory tunnel in No. 4. It indicates that the overthrust has come from the north; and the plane of faulting seems to be approximately parallel to the general direction of foliation of the overlying red salt.

The strike of the foliation of the salt is not always uniform, however. The main marl band is found to rise when traced along the low-level tunnel through chambers 3, 2 and 1 and then to dip down again under the floor of the old mine, until at the extreme north-east corner of the old mine I estimate that it is about 24 feet below the floor of the mine. This would bring it across the new lower tunnel just east of survey peg 81, and one finds, 23 feet along the tunnel in a westerly direction measured from peg 80, a marl band resembling it so closely that there is little doubt as to the identity of the two. 43 feet along the tunnel in an easterly direction from peg 80 is the Red Marl breccia, in its right place, about 50 feet in section below the main marl band, and immediately below this is the overthrust showing the same characteristics that it did in the bottom of the lower exploratory tunnel in No. 4. This is followed by a bad 'wash-out,' and for some distance eastwards in the tunnel only earth débris and rock fragments are seen, and then comes contorted grey salt with grey clay and brecciated gypsum fragments comparable with that seen below the overthrust in the lower exploratory drift in No. 4.

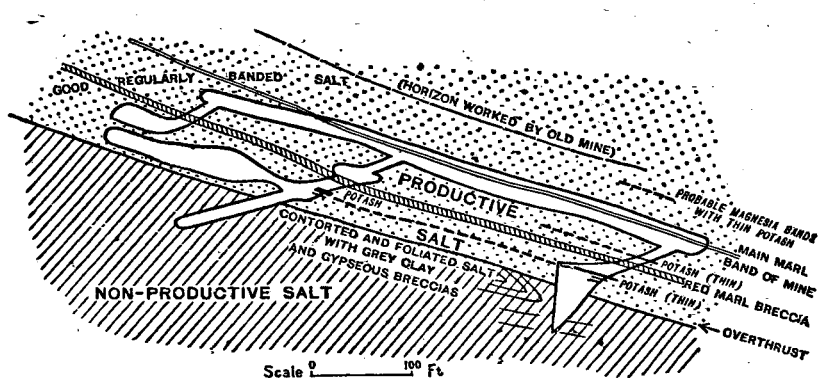
The potash seam of chambers 2, 3 and 4, seems to be cut out by the overthrust here, and consequently is not seen; if the overthrust were not there, its position would be about the middle of the section occupied by the wash-out. The new lower tunnel gives us no assistance in the matter of this potash seam therefore.

There is evidence of more potash above the level opened up by the mine. Water dripping in the disused chamber No. 2 reacts for potash. Also water dripping in the high-level tunnel at the corner of chamber 2, and water dripping in the Brattice tunnel near No. 2, react for potash; also water dripping from the roof of No. 0. This

<sup>1</sup> This is discussed more fully in the following paper.

may be the same as a thin seam of combined magnesium and potassium sulphates that crosses the new lower tunnel at survey peg 82. There is only a trace of potash in it there, but quite sufficient to be collected by percolating water. It is at a higher level in the section of the salt than the main marl band and therefore, if continuous, would be somewhere above the roof of the existing mine.

The following sketch section of chamber No. 4 shows the arrangement of the various bands I have been discussing and of the overthrust :—



The potash so far exposed in the mine is not promising. The following are the results of the tests made :—

#### Chamber No. 2.

Tests were made every six inches vertically in four positions in the face with the following results (giving approximate percentage of  $K_2O$ ) :—

No. of test.	Position A.	Position B.	Position C.	Position D.
	Per cent.	Per cent.	Per cent.	Per cent.
1	nil.	nil.	nil.	nil.
2	7	nil.	11	7
3	nil.	6	nil.	11
4	nil. x	2	10	trace
5	nil.	13	trace	13
6	nil.	nil.	11	nil.



No. of test.	Position A.	Position B.	Position C.	Position D.
	Per cent.	Per cent.	Per cent.	Per cent.
7	nil.	nil.	trace	11
8	nil.	9	nil.	16
9	trace	6	7	8
10	trace	9	7	13
11	nil.	2	18	11
12	nil.	5	5	8
13	nil.	9	nil.	trace
14	nil.	9	trace	8
15	nil.	trace	5	5
16	nil.	nil.	5	7
17	nil.	trace	8	21
18	nil.	nil.	8	17
19	nil.	trace	21	19
20	nil.	nil.	40.5	nil.
21	nil.	trace	5	trace
22	nil.	nil.	trace	11
23	nil.	nil.	nil.	nil.
24	nil.	2	..	nil.
25	nil.	13	..	nil.
26	nil.	nil.	..	trace
27	nil.	nil.	..	..
28	nil.	nil.	..	..
29	..	nil.	..	..
30	..	trace	..	..

In addition to the above a small isolated mass in the south wall of the chamber gave, when tested, 40.5 per cent.  $K_2O$ .

Chamber No. 3.

Tests were taken in three positions in the face of the salt, the test holes being six inches apart, with the following result:—

No. of test.	Position A.	Position B.	Position C.
		Per cent.	Per cent.
1	nil.	7	nil.
2	nil.	nil.	7
3	nil.	nil.	trace
4	nil.	6	8
5	trace	nil.	nil.
6	nil.	trace	nil.
7	nil.	6	nil.
8	nil.	trace	nil.
9	nil.	nil.	nil.

No. of test.	Position A.	Position B.	Position C.
		Per cent.	Per cent.
10	nil.	nil.	nil.
11	nil.	5	nil.
12	nil.	8	.5
13	nil.	trace	trace
14	nil.	7	6
15	nil.	nil.	nil.
16	nil.	nil.	nil.
17	nil.	nil.	nil.
18	nil.	8	nil.
19	nil.	nil.	nil.
20	nil.	nil.	nil.
21	nil.	trace	nil.
22	nil.	trace	5
23	nil.	nil.	nil.
24	nil.	nil.	nil.
25	nil.	2	nil.
26	nil.	5	nil.
27	..	trace	nil.
28	..	13	trace
29	..	10	5
30	..	13	nil.
31	..	8	nil.
32	..	trace	nil.
33	..	5	nil.
34	..	nil.	nil.
35	..	11	nil.
36	..	trace	nil.
37	..	nil.	nil.
38	..	nil.	nil.
39	..	nil.	nil.
40	..	nil.	nil.

*Upper exploratory drift off Chamber No. 4.*

20 tests across the potash band at intervals of six inches.

No. of test.	Percentage of K <sub>2</sub> O.
1	5
2	16
3	trace.
4	12
5	10
6	8
7	8
8	nil.
9	trace.
10	nil.

No. of test.	Percentage of $K_2O$ .
11 . . . . .	nil.
12 . . . . .	5
13 . . . . .	trace
14 . . . . .	nil.
15 . . . . .	nil
16 . . . . .	nil.
17 . . . . .	nil.
18 . . . . .	nil.
19 . . . . .	trace.
20 . . . . .	nil.

The same seam in the lower exploratory drift off No. 4 had thinned away to almost the merest string and only gave a faint reaction for potash.

### Kalabagh.

The salt quarries at Kalabagh were all fairly thoroughly examined. Potash was detected either in dripping water, or in water lying in the quarries, in Nos. 6, 10, 17 and 18.

As the numbers at Kalabagh are not numbers of the quarries, but are numbers assigned to certain quarrymen it is obvious that a number may take itself off to some other situation; Plate 3 is from a plane-table plan of the Kalabagh quarries indicating those in which potash was detected.

No seam of potash was detected in any of the quarries, the only trace being shown by the percolating water.

Calcium sulphate is generally present in the salt and can be detected always in a chemical test, while magnesium compounds seem to be present only in very small quantities. I also noticed the formation of stalactites covered with a cotton-wool-like growth of sodium sulphate; bands of grey salt also occur.

## III.—ECONOMIC CONSIDERATIONS.

### Potash.

In discussing the economic possibilities of potash in the salt deposits, I will deal first of all with the various localities at which it is known to occur, and then with the Salt Range as a whole.

Potash salts occur in the Mayo mine at Khewra. They were discovered in 1873 by H. Warth. They have recently been very thoroughly examined by Dr. Christie and described in a paper published in Vol. XLIV, of the *Records, Geological Survey of India*. He describes the deposits in detail, and gives an idea of their magnitude. It must be realized, however, that most of the exposures seen by Dr. Christie are in the pillars between the chambers, and that the potash has been excavated from the chambers, together with the salt, many years ago. It is, of course, impossible to excavate anything from the pillars, since this might endanger the stability of the mine; hence most of the exposures are only of scientific interest and represent no economic possibilities. What Dr. Christie calls the Buggy potash seam, however, appears to be thickening in a forward direction down the dip of the foliation, and it might be that if this were followed beyond the present end of the mine a workable quantity of potash would be found. Its thickest exposure, as seen by Dr. Christie, is only 0.95 metre, but as it thins out as it is traced up the rise of the foliation bands, it is quite possible that it may thicken somewhat down the dip. As Khewra is the main source of supply of salt in Northern India, and as the excavation of irregular lenticles and foliæ of potash would upset the scheme of pillars and chambers of the mine, it is a question whether it would be worth while to attempt to do anything with the potash. It might be worth while to run an exploratory drift down the dip of the band from the point described by Dr. Christie as "s" in chamber No. 30, to see whether the potash thickens to any appreciable extent.

If further prospecting is attempted at Khewra, the best course would be to put a boring down at the northern end of the Khewra glen, and so cut through a greater thickness of the salt than is opened up in the Mayo mine. A certain amount of potash will always occur as lenticles in the foliated salt of Khewra and Warcha. The evidence so far obtained indicates that these lenticles will, however, be discontinuous, and will not all lie on the same foliation plane, and a boring put down through the salt at any particular point may—and, if deep enough, almost certainly will—pass close by the end of one or more of these lenticles, or foliæ, of potash, without showing, in the core obtained, any indication of its presence. It is

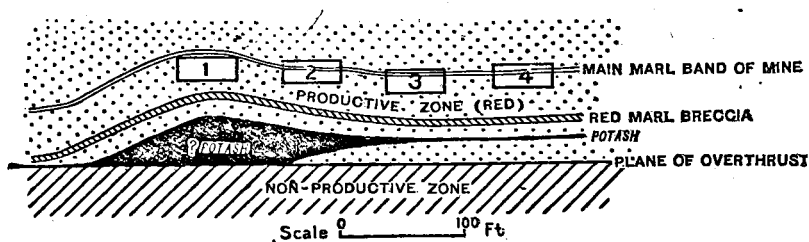
unfortunate that this should be so, but it is one of the disadvantages from which the Indian deposits suffer as compared with unmetamorphosed deposits in other parts of the world.

The potash bands at Nurpur have been discussed and a plan showing their position and extent is appended (Plate 4). The salt at Nurpur is more contorted and disturbed than that at Khewra, and is foliated rather than banded. The lenticles of potash are more irregular than those at Khewra, and thicken and thin, and even end, abruptly. The greatest care should be exercised in working them, and the only plan to adopt would be to follow them so long as they continue to exist. Once they end there is no reason to suppose that they will continue again further along the same foliation plane; the next potash lenticle may be on another foliation plane. Prospecting in the mine could be done by exploring in a horizontal direction towards the west beyond the most westerly point yet opened up by the mine, but there is no particular evidence to show that potash will be met with close at hand. A boring could of course be put down anywhere along the ravine, south of the mine, where the salt is less intensely folded, but owing to the fact that the Nilawan ravine lies along a faulted subsidiary anticline, and that the centre of it is a running stream, there are many other places in the Salt Range where a boring could be put down with greater advantage; the difficulty and cost of transport is another unfavourable factor at Nurpur.

There is one main potash seam in the mine at Warcha. It is seen in the working faces of the abandoned chambers Nos. 2 and 3 and also in the upper and lower exploratory drifts in chamber No. 4. It has indications of being of some thickness in the working faces of chambers Nos. 2 and 3, is only a few feet thick in the upper exploratory drift in chamber No. 4, and where cut by the lower drift it has thinned out down the dip of the foliation to the merest string of potash. There is another small string of potash cut by this lower drift, but it is only a few inches thick and evidently does not continue up the rise of the foliation planes. There is also a trace of potash in the new lower tunnel at peg 82, but it is a mere trace. It probably continues over the mine, for water dripping from the roof frequently shows traces of potash when tested.

As I have pointed out above (p. 45) the salt bands rise along the low-level tunnel as one passes from chambers 3 to 2 and thence to 1, and then fall away again rapidly and dip down below the floor of chamber 01. A bulge, which may be due to a thick lenticle, appears to occur under the floor of the chambers at this place, since all around it the dip and strike of the foliation planes is unchanged; and it is possible that the potash thickens here into a large augen-shaped lenticle. This is of course purely hypothetical, but I think it is sufficiently probable to merit exploration. The top of the lenticle should be 40 or 50 feet below the floor of the existing chambers; hence, if there, it could be safely excavated in chambers below those now existing; at the same time there is no reason why it should not be thirty feet or even more in thickness, but the lower portion would probably be cut off by the subsidiary overthrust which divides the red salt of Warcha—which may be called the productive zone of the mine—from the impure and grey contorted salt which underlies it,—which latter may be called the non-productive zone of the mine. Even so a considerable quantity of potash would be present. In order to determine whether this presumed potash lenticle really exists, either a direct boring might be put down or an exploratory drift might be run from chamber No. 1 at right angles to the foliation of the salt and approximately under the low-level tunnel. If it be found impracticable to run an exploratory drift so steeply, it should be run in such a way that it will intersect a line, drawn from chamber No. 1 at right angles to the foliation, at a point 50 or 60 feet from that chamber.

The following diagram shows a hypothetical section along the line of the low-level tunnel :—



As in the case of Khewra, a boring might also with advantage be put down through the salt deposits at the northern end of the

Warcha glen, close to the northern guard-post, and on the western side of the glen. This would pass through a considerable thickness of salt not seen in the mine. Nothing can be deduced, in this connection, from the dip of the foliation planes, but investigation would be interesting and should yield lenticles of potash. The same disadvantage exists here as at Khewra, and indeed throughout the Salt Range, that the lenticles of potash are discontinuous and many may be missed owing to the boring passing just outside their limits.

Warcha is now connected with Gunjyal railway station by a broad-gauge siding, hence the cost of transport would be low.

No seams of potash were found at Kalabagh, though potash was detected in both dripping water and in water lying in the quarries, in Nos. 6, 10, 17 and 18 (see Pl. 3). The salt is more contorted than at either Khewra or Warcha, and no thick seams occur. For reasons which I will give in a subsequent paper, I do not think that Kalabagh calls for any further investigation, or offers any prospect of success.

This salt is the grey variety of the Kohat zone, with a few bands of pink salt interfoliated with it. Traces of potash were detected in water dripping from the deposit, but no potash seams. I do not think the locality offers any promise or calls for any further exploration; and its inaccessible situation renders it of still less economic interest.

Other than at Nandrakka, no traces of potash have been detected in Kohat. From the point of view of potash, therefore, the Kohat area must be condemned.

On the whole the evidence collected during my investigations points to the conclusion that no continuous bed of potash will be found in the Salt Range or in Kohat. The salt is a foliated rock and the potash salts occur in discontinuous lenticles and irregular foliæ. Where the foliation is of the nature of banding, bands of potash may persist for some little distance, but even then they will probably thicken and thin throughout their length. The prospects of obtaining potash in the Salt Range are not therefore promising, and it is not likely to be worked profitably except as a by-product of salt-mining.

**EXPLANATION OF PLATES.**

- PLATE 1.**—**FIG. 1.** Bahadur Khel salt showing schistose structure.  
**FIG. 2.** A salt quarry at Bahadur Khel
- PLATE 2.**—The schistosity of Bahadur Khel salt.
- PLATE 3.**—Plan of salt quarries at Kalabagh.
- PLATE 4.**—Plan of Nurpur mine.
- PLATE 5.**—Plan of potash drift, Nurpur mine.
- PLATE 6.**—Plan of portion of Warcha salt mine.
- PLATE 7.**—Section of chambers in Warcha mine.
- PLATE 8.**—Sketch map of portion of Bahadur Khel salt-field.



SUGGESTIONS REGARDING THE ORIGIN AND HISTORY OF  
THE ROCK-SALT DEPOSITS OF THE PUNJAB AND  
KOHAT. BY MURRAY STUART, D.ŚC., *Assistant  
Superintendent, Geological Survey of India.* (With  
Plates 9 to 25).

I.—INTRODUCTION.

IN the preceding paper I have dealt with the general nature of the potash deposits as far as they are known, and have given details of the experimental work carried out in an investigation recently made with a view to ascertaining their economic value. During that investigation a number of facts were observed which have hitherto attracted little or no attention. The consideration of these has suggested to me a new and simple hypothesis of the history and arrangement of the salt and gypsum formations.

As pointed out in the preceding paper the area examined comprises most of the exposures in the Salt Range between the Nilawan ravine in the Jhelum district and Kalabagh on the Indus; thence the salt exposures were followed up through the Lun-Wan pass to the Nandrakka salt exposure in Kohat, and from there westwards along the range through Malgin to Bahadur Khel on the Waziristan frontier, a distance of over 200 miles. In addition to the above, isolated exposures at Banda Daud Shah and Jatta Ismail Khel in Kohat were also examined.

Since Wynne's time the salt deposits have always been the object of much speculation, and Sir Thomas Holland and many other geologists have offered suggestions attempting to link up the two great deposits of the Punjab and Kohat, joining them as one salt formation rather than considering them, as Wynne was content to leave them, two widely separated formations in point of time, the one of pre-Cambrian<sup>1</sup>, and the other of Tertiary, age.

<sup>1</sup> Wynne merely classed the Punjab salt as pre-Purple Sandstone, but the discovery by Warth—subsequently confirmed by Middlemiss (*Rec. G. S. I.*, XXIV, p. 24)—of trilobites in the overlying Obolus Shales established the age of the Purple Sandstone as earliest Cambrian at least.

In the preceding paper reference has already been made to the literature on the subject of the salt and it is only necessary to add here one further reference, *viz.*, to the article on the geology of India, by Sir Thomas Holland, published in the *Imperial Gazetteer* (1907).

## II.—GEOLOGY.

The salt is everywhere the lowest formation seen. Whether it is in its normal position, or not, has been the subject of much speculation. Wynne apparently came to the conclusion that it was in its normal position in the geological section in each case, in both the Punjab and Kohat and that there had been two salt-forming periods, the one pre-Cambrian, and the other early Tertiary; whereas Sir Thomas Holland suggested that the two salt sheets are parts of one extensive formation, and, taking Wynne's interpretation of the Kohat area as correct, and assuming the Kohat salt to be approximately early Tertiary in age, he suggested the existence in the Punjab of an overthrust bringing the Purple sandstone and Cambrian beds above the Salt marl, which would in that case be early Tertiary in age.<sup>2</sup>

The origin of the salt and Salt Marl has always been the subject of conjecture and theory. Fleming first attempted to explain it by considering it to be of an eruptive character. Subsequently he abandoned this view, and assumed that the salt deposits were originally stratified, but that they had probably undergone metamorphism from igneous influence. Warth always took it for granted that the deposits were sedimentary in character, but does not appear to have stated his reasons for holding this view. Owing to the numerous instances of lenticular arrangement in the deposits, to his frequent observation of "layers of the salt thinning out, convex above and below" and instances of anomalous contortion in certain bands of salt, Wynne hesitated to enunciate any definite opinion on this question in his memoir on the Salt Range. Christie weighs up the evidence for and against a sedimentary origin, and thinks that the observed facts may be explained by the evaporation of a saline inland lake, preferably shallow, and that the lenticular beds observed by him in the deposits were due to the fact that under such conditions "crystallization would not necessarily

<sup>2</sup> *Op. cit.*, I, p. 64. (1907).

proceed uniformly, but the mother liquors would accumulate in the lower basins of the region, there depositing their potassium and magnesium salts and giving rise to lenticular beds such as we find in the Buggy section of the Khewra mines."<sup>1</sup> This suggestion, however, does not seem to explain satisfactorily the convexity of the lenticular layers both above as well as below; it appears probable that under such conditions the upper surfaces of the lenticles could at most only be flat, and would in all probability be concave. The hypothesis, therefore, fails to explain the present observed lenticular nature of the deposits, for which some further explanation must be sought. At the same time Christie does not regard the salt deposits as wholly unaltered sedimentary strata, but expresses the view that they have experienced a certain amount of thermal metamorphism, and also that they have assumed a pasty character, under pressure, and have to a slight extent undergone some form of internal flow movement under its influence; the present banded character of the salt, however, and its lenticular arrangement, is attributed by him to original stratification.

The salt generally has a distinctly banded appearance and consists of layers of different colour and purity. Wynne describes this appearance as follows:—

"The rock-salt .. alternates with thick, dark-brownish red beds of impure saline marl, called by the natives *kallar*, and is pink, reddish, or white, rarely having grey blotches, but frequently showing numerous alternations of laminae of small thickness, reddish and white colour and different degrees of opacity.

\* \* \* \* \*

The banded structure of the salt beds is chiefly caused by layers of different colour, the bands being most solid looking or of darkest colour about the middle and softened into a paler tint on the edge; sometimes there are alternating layers of a red earthy nature from which Epsom salt effloresces. . . . . the bands or layers having in some places for considerable distances vertical to their planes a general thickness of 6 to 8 inches varying to 2 feet, while for several yards across the strike in some of the larger beds no lamination at all is seen. There are also numerous irregularities of the bedding showing much lenticular arrangement of deposition . . . . . No sign of current (ripple) mark or of well-developed oblique lamination could be found. Layers of the salt thinning out, convex above and below, were frequently seen."

A photograph of this banding effect in the salt is shown on Plate 20, which also shows the lenticular nature of some of the bands. (Seen best if Plate is viewed from a distance of several feet).

<sup>1</sup> *Rec. Geol. Surv. India*, XLIV, p. 259.

After careful study of the salt deposits throughout the Salt Range and up to the borders of Waziristan, I have been forced to the conclusion that the present banding in the salt is not original stratification. It frequently shows a distinctly lenticular arrangement, the individual crystals very often have a lenticular shape, corresponding almost exactly to the *augen* in an augen-gneiss, and when the salt contains a certain amount of marl the appearance of flow-structure is frequently so striking that I have been forced to the conclusion that at some time subsequent to their original deposition the deposits have been subjected to pressure, and under this, aided probably by the action of heat and the presence of water, have become sufficiently plastic to flow, and have thus acquired a flow structure very similar to that produced by movements in a nearly solidified igneous magma,—the result having been to produce a banded flow structure, which is sometimes a foliated structure consisting of lenticular bands of salt and associated minerals, and sometimes more or less regular bands similar to those occurring in a banded gneiss, but differing, in this case, in that the individual bands may be feet and even yards across.

There is an interesting confirmation of this idea, beyond the observed behaviour and frequently lenticular form of the bands of salt and allied minerals, and this is given by the existing salt marl (*kallar*) bands. These bands consist of rock-salt, with calcium sulphate, impalpable ferruginous clay, and innumerable quartz grains, of all sizes up to about 0.2 mm. and almost all highly angular in outline (see Christie, *op. cit.*, page 260). If a series of sediments consisting of strata of different hardness (such as a series of salt beds with occasional interbedded bands of argillaceous and arenaceous material) were subjected to dynamic metamorphism, it might be expected on theoretical grounds that the hard bands would be converted into a sort of crush-breccia. If, in addition to this, movement of the nature of flow took place, these crush-breccias would assume the form of bands in the direction of the flow, and should give, in the instance cited above, a rock corresponding to the salt-marl bands existing at the present day. This indeed would seem to be the simplest method of accounting for those bands and for the manner in which they repeatedly vary in thickness, as well as for their behaviour generally. It would also offer a satisfactory explanation of the lenticular form of some of the salt bands and

the potash bands, as well as of the anomalous occurrences observed by Wynne and Middlemiss.

In order to avoid confusion, therefore, I do not propose to refer in this paper to beds and bedding in connection with the salt deposits as they exist at the present day, but to bands and banding, or foliation planes.

Middlemiss suggested an igneous origin for the Salt Marl of the Salt Range, but this does not seem to have found much acceptance. The possible reasons are: firstly no parallel instance can be pointed to in any large salt deposit and secondly the composition of the seams, and of the minerals they contain, corresponds closely with that of undoubted salt-lake and desert deposits, such as the Stassfurt salt of Germany, the resemblance extending even to the occurrence of the peculiar bluish or indigo staining sometimes found in salt crystals at Stassfurt and attributed by S. W. Johnson to the presence of sodium subchloride, by Oehsenius to the presence of sulphur, and by Wittjen and Precht to an optical effect due to the presence of thin cavities, having parallel surfaces, with gas inclusions (*Ber. Chem. Ges.*, XVI, 1454, p. 1883). Crystals showing this bluish or indigo colour were shown me from the Mayo mine, Khewra, and I also found them at Warcha in an exploration drift which the Salt Department were excavating for me in the lower levels of the mine. So far as my own observations are concerned, I have no reason to doubt that the salt was originally deposited from an evaporating saline solution, but I am also of opinion that since their original deposition, the deposits have acquired flow structure under the influence of pressure, probably assisted also by heat and the presence of a certain amount of water.

In my earlier paper I have dealt fully with the foliated character of the Kohat salt, but I left for subsequent consideration the observation that the bluish-grey clay in the salt at Bahadur Khel contains sulphide of iron. Crystals of sulphide of iron are not rare in the blue clay, in fact in places in the Bahadur Khel salt-field they are sufficiently abundant, and decompose sufficiently rapidly under atmospheric agencies, for the particular clay bands to smell distinctly of sulphuretted hydrogen after a heavy shower of rain. A sample of clay containing no visible pyrites placed in the end of a closed tube, the other end of which was connected to an ordinary filter pump, caused the immediate darkening of a lead test paper

placed in the outer end of the tube, when the end containing the clay was gently warmed. Moreover, not only do the clay bands contain sulphide of iron, but crystals of pyrites occur in the salt itself. This was also recorded by Wynne, who writes:—"In the eastern parts of the district, besides the foreign matter previously noted, the uppermost portion of the salt . . . is sometimes slightly pyritous . . ." Similarly at Bahadur Khel samples of salt taken by my staff were found to contain crystals of pyrites. It may therefore be said that pyrites is not confined to any particular part of the salt, or of the area, but occurs occasionally throughout the Kohat salt. The grey coloration of the Kohat salt is probably intimately connected with this presence of iron sulphide in the salt deposits. If anything occurred to convert the ferruginous matter into sulphide during the deposition of the Kohat salt, it would follow naturally that the deposits would be coloured grey rather than red. Sulphuretted hydrogen springs or an accession in any other way of sulphuretted hydrogen to the evaporating saline solution is the only assumption necessary to account fully for both the presence of iron sulphide in the salt and clays deposited at the time and also for their grey colour as opposed to the more usual red. When the blue clay, or the salt, comes into contact with calcareous alluvium, such as is carried by the brine stream that flows over the Bahadur Khel field, crystals of selenite form. Plate 9 shows such a formation of selenite crystals. It is a photograph of a grey clay band where the surface has had a thin covering of calcareous alluvium washed on to it, with the result that the surface is now covered with selenite crystals, which only occur on the surface of the clay and are not incorporated with it. Below the surface the clay is entirely free from selenite. On exposure to the sun and atmosphere the selenite crystals split into flakes, become stony and opaque, and finally coalesce into a band of gypsum, which in course of time becomes solid, shows no trace of the constituent "devitrified" selenite crystal, and is indistinguishable from the massive gypsum that overlies the salt deposits in order of sequence. Plate 9, fig. 2, shows a number of different stages in this process, starting with fresh selenite crystals in the middle foreground; devitrifying selenite crystals in the left foreground; the same at a further stage cemented into a rock, but still showing their characters and distinctly recognizable, in the left background; and, in the right background, the final stage of massive gypsum. Plate 10, fig. 2, shows a diminutive

cliff of gypsum formed in the same way; to the left there is grey clay, and to the right ordinary recent calcareous alluvium; the gypsum has formed at the contact of the two, and is not yet sufficiently consolidated to have lost all trace of the original selenite crystals. Not only is this instance seen, but, where the salt is covered to any extent with calcareous alluvium, a thick, fairly continuous sheet of gypsum is forming at the junction of the salt and the alluvium at the present day. For instance, at the eastern end of the Bahadur Khel salt-field, where the salt is much covered with thin calcareous sand and alluvium, this sheet of gypsum, formed at the contact plane, is strikingly evident and is sometimes four or five feet thick. Plate 12 illustrates this.

Gypsum forms also in the same way where the salt is brought into contact with calcareous rocks. Along the south-eastern end of the Bahadur Khel field a fault cuts out the gypsum, the red bed, and the nummulitic limestone, and brings the salt against the Murree beds. Gypsum is forming along this fault in exactly the same way as the sheet of gypsum mentioned above is forming in places over the surface. Plate 11 shows a photograph looking west along the fault and it will be seen that the line of the fault is clearly marked by the band of secondary gypsum which in the background forms a hill of marked size. To the left (south) of the gypsum are Murree clays, which are calcareous, and sandstones; to the right (north) of the gypsum band is salt.

Where there is no calcareous detrital material resting on the Bahadur Khel salt, or grey clays, crystals of selenite are not found, indicating that the selenite is not merely recrystallised calcium sulphate, originally present in the salt formation and left behind owing to the removal, in solution, of the salt, but is due to the definite reaction of sulphuric acid with the calcareous material brought into juxtaposition with the salt or grey clay.

It may be thought that I am rather labouring this point of the presence of iron sulphide in the salt and clays, and its decomposition under atmospheric agencies, with the liberation of sulphuric acid, but it will be seen shortly what an important factor it is, in my opinion, in the deduction of the origin and nature of the salt deposits and the gypsum. Another effect produced by the decomposition of this included iron sulphide is the formation of sulphate of soda (mirabilite) by the action of the liberated sulphuric acid on the salt. Plate 22 is a view northwards across the Bahadur Khel field,

taken between the two salt-hills. Most of the white patches on the alluvium in the foreground are sulphate of soda, especially those beside which the men are standing.

Plate 15, fig. 2, shows feathery growths of sulphate of soda breaking through a salt deposit in the site of a dried-up brine puddle on the alluvium. The same feathery crystals creep up the sides of the alluvium above the level of the salt along the sides of the brine stream, and in places break through the salt crust of the stream itself; the same feathery growth forms on the surface of the salt. This efflorescence is not free from sodium chloride—one would not expect it to be—, but its form is due to the creeping and crystallisation of sodium sulphate, and the greater part of the efflorescence consists of that material. From the efflorescent nature of the crystals, and the fact that the fresh salt itself does not contain sulphate of soda, the latter is obviously forming under atmospheric agencies at the surface of the salt, owing to the decomposition of the sulphide of iron contained in the salt and clay particles, and the consequent formation of mirabilite.

In addition to sulphide of iron bituminous matter frequently occurs in the salt. I will quote Wynne on the subject, as I have nothing to add to his observations:

“In the eastern parts of the district the uppermost portion of the salt is frequently bituminous, this salt and the adjacent gypsum smelling strongly of petroleum. The bituminous salt prevails, however, only for a few feet from the upper surface of the deposit, though layers of bituminous or fœtid clay may be found apparently in the body of the salt rock.”

I have found this bitumen even in the *shishi nimak* mentioned by Wynne; this is clear salt which occurs in blotches throughout the formation, and is recrystallised salt. In the case that I mention some *shishi nimak* at Malgin contained enough bituminous matter to make it black in colour, and when a thin crystal was held up to the light it was seen that the bituminous matter was arranged as if along planes of foliation through the crystal. The rock appears in fact to be a salt-bitumen schist in which the salt has rearranged itself by recrystallisation, so as to give a sort of semi-pegmatitic structure, the salt being in crystalline continuity, while the bituminous matter, not being of a crystalline nature, is not continuous, but merely retains its original position throughout the recrystallised salt.

Small fragments of gypsum also occur scattered through the salt schist in the Kohat area and form a part of the schist. These



fragments may be secondary and were possibly calcareous clayey material originally.

The points on which my observations differ from those of Wynne and Warth are therefore the foliation of the salt; the widespread presence of sulphide of iron in the Kohat salt, over and above the few instances, recorded by Wynne, of the occurrence of isolated crystals of pyrites; and the discordance between the foliation bands in the salt and the run of the succeeding gypsum formation.

There is one point worthy of notice here while discussing the salt and the presence in it of sulphide of iron. In his memoir on the Trans-Indus salt, Wynne describes an interesting section near Lakkona (*Memoirs, Geological Survey of India, XI, pt. 2, page 174*); he says:—

“An interesting but complicated section is exposed in the Algud (stream which crosses the range running northward in a deep ravine between the Kurar synclinal, and the Speena gypsum tract. Descending this ravine from near Shaidan red and grey tertiary sandstones and clays are passed through, dipping southward at 70°, or more nearly vertical. Red clays of the red zone, with a thickness of 150 feet, underlie these, or would if there was any underlie to speak of. Gypsum, nearly vertical or dipping at a very high angle to the south, 155 feet thick, and with greenish clays on both sides, is then passed. In the lower part of this gypsum the southerly dip lessens to 60°, and the beds are contorted. A few yards further on apparently the same mass of gypsum, curved and undulated, seems to increase enormously in thickness up to 300 or 400 feet, 30 feet of its lowest part being dark, or black, bituminous, calcareous shale. At this place sulphurous springs break out at the sides of, and in, the Algud, the whole place smelling strongly of sulphuretted hydrogen.”

I visited these springs and found them to be sulphuretted hydrogen springs as Wynne had stated, but an interesting point that he did not mention is that they are not ordinary fresh-water springs containing sulphuretted hydrogen, but springs of saturated brine, containing also enough sulphuretted hydrogen to make the neighbourhood smell unpleasantly. There can be little doubt that they pass through the salt which underlies the gypsum, and the association of brine and sulphuretted hydrogen is interesting in view of the observation of the presence of sulphide of iron throughout the Kohat salt and its included clays.

Wynne gives an accurate description of the gypsum. It is generally white, showing up plainly even on dark days at long distances among the hills, but it sometimes has a greyish hue, more rarely variegated with deep

red, from decomposition of iron, and in its lower part often passes into shaly beds, quite black, and smelling strongly of petroleum; its texture varies from sub-compact to more crystalline varieties. As a rule the gypsum is pure and homogeneous, but foreign matter is observable in hand-specimens in places, the chief being grey clay, crystals of iron pyrites, crystals of quartz, dolomite, more rarely anhydrite, and the bituminous portions of the black parts. Associated with the gypsum in the eastern part of the district are one or more bands of alum shales, so charged with pyrites as to have formerly led to their being worked for sulphur, which occurs native in small quantities, the result, apparently, of chemical reaction going on at the places where the shale occurs, and from which sulphurous gases emanate. Closely associated with the gypsum itself are certain thick zones of greenish, sometimes smoothly stratified, clay, often containing translucent crystalline plates or fragments of selenite.

In appearance the gypsum shows every gradation between the sheet that is forming at the present day over the surface of the Bahadur Khel salt-field, and massive compact gypsum. Its stratification is not uniformly evident. In some places the beds appear to be thick and massive, or the bedding laminae are indistinct. In others it is thinly divided and flaggy. The gypsum of the gypsum formation is indistinguishable from that which has formed along the fault to the south-west of the Bahadur Khel salt-field, and yet the latter has undoubtedly arisen as a secondary product from the interaction of sulphuric acid, set free by the decomposition of the sulphide of iron in the salt formation, and the calcareous material in the Murree beds which are here faulted against the salt formation; the similarity even extends to the presence in both of gypsum in which the decaying selenite crystals are still strikingly obvious.

The lamination of the gypsum is usually contorted and obscure, but where it is well seen it follows the surface of the salt on which it is resting and shows no relationship to the direction of foliation of the salt.

In places gypsum that is not really part of the gypsum formation proper—by this I mean the formation that overlies the salt—has undoubtedly been formed by the interaction of sulphuric acid, set free from decomposing pyrites, and carbonate of lime; as, for instance, in the case of the gypsum around the sulphur mines at Ganjalli on the extreme north-east of the area mapped by Wynne. This

gypsum was treated by Wynne as part of the gypsum formation but I append a photograph (Plate 10, fig. 1) showing a weathered boulder of nummulitic limestone that had rolled down on to the alum shale area; the remains of the coating of gypsum that had formed all round it are still visible in the hollows of the boulder, and this gypsum, which is part and parcel of the gypsum of this locality, was not part of the great gypsum formation that overlies the salt formation. The fact that it has in this instance formed around a weathered boulder of nummulitic limestone, shows that its age is not only subsequent to the nummulitic limestone but to the present arrangement of the rocks, that it is, in fact, recent. In this locality the alum shales are now almost entirely replaced by gypsum.

No further explanation need, I think, be sought for the origin of the gypsum that overlies the salt formation beyond the view that it has been formed—like the sheet of gypsum over the present surface of the Bahadur Khel field, the gypsum along the fault at the south-west end of the field, and the Ganjalli gypsum—by the reaction of sulphuric acid, set free by the decomposition of sulphide of iron in the salt, on adjacent calcareous material. It occurs exactly where it should occur, if such had been its origin, and the frequent appearance in it of portions in which the partially broken down selenite crystals are still clearly distinguishable, gives it every appearance of having been so formed, thus making it similar in character to the gypsum formed along the fault on the south-west of the Bahadur Khel field. The suggested origin is extremely simple and seems more probable than the suggested derivation from warmed-up mother liquors, or from a solution of calcium chloride coming into contact with water impregnated with sulphate of magnesia or soda. Finally, it is a process which can be seen taking place at the present day whenever the salt comes into contact with calcareous material. It has one important bearing on the geology of the area: it makes the gypsum a subsequent rock—some of it is undoubtedly forming at the present day, if one may judge by the freshness of the selenite crystals—and not a geological formation that is part of a stratified series. Also it simplifies the geology of the area; for the gypsum then occurs in its proper place above the salt and no longer requires a variety of assumptions to account for its present position. What the exact process is by which the selenite loses its crystalline form and becomes consolidated

into a massive rock, I do not know. I have analysed both the fresh selenite crystals and the gypsum rock for combined water and have found no appreciable difference between them in this respect. But the process may be one of partial dehydration and re-combination with water under the somewhat extreme variations of temperature prevailing here, the crystals losing some of their water, of crystallisation in the heat of the day and re-absorbing an equal amount during the cool of the night, or during subsequent rain. But whatever the explanation, the process of change from selenite to massive gypsum undoubtedly occurs, and can be observed occurring.

One of Wynne's observations I was unable to confirm. He states :—

“The alternation of the gypsum with the grey clays is in places very distinct, in others most obscure, and towards the top of the main gypseous band, this frequently passes by alternation of thin layers into the red clay zone which follows. Where the soft clay has been washed from between these upper gypsum layers, as well as occasionally in other parts where the stratification is clear, distinct current or ripple marks have been observed on the surfaces of the beds, indicating their having been accumulated in shallow water.”

I have not succeeded in finding any traces of ripple-marks, though the effect of solution on the surface often produces a pseudo-ripple-marked appearance. Even if ripple-marks do exist, I think it unsafe to draw any definite deductions from them, since they may originate in so many ways. Wynne also writes :

“Though prevalent in great, and more or less continuous, masses, the gypsum cannot be said to form an unbroken sheet, its apparent discontinuity being perhaps due to dislocation or denudation, or both. Nor is it limited either above or below by any arbitrary boundary. Thus, in the Malgeer Sāya Hills, a layer of salt was seen to separate a mass of gypsum from the rest above; in other parts of the eastern side of the district layers of limestone, or of limestone and clay, were observed near the top of the main gypsum mass; beneath a less strongly developed bed of the latter, and in about the centre of the salt region, thick bands of gypsum occur among the basal beds of the nummulitic series. They are not however constant, and one was traced until it thinned out between the adjacent beds of limestone.”

The bearing of the above on my interpretation of the geology of the Salt area is so important that I have ventured to reproduce it.

### The Kohat Salt.

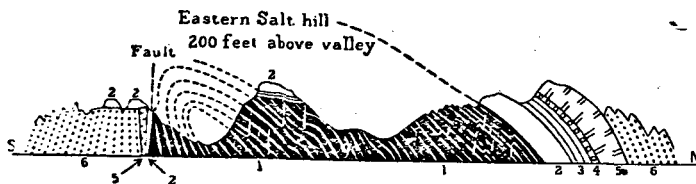
*Bahadur Khel.*—I do not propose to repeat the whole of Wynne's description but only to explain in what my observations differ from

his. The Bahadur Khel salt-field is about eight miles long and about a quarter of a mile wide. In the western end the salt is more or less bare, whilst in the eastern end the salt is more covered with alluvium. Except in the south-western corner the salt is bounded on both sides by gypsum, followed by the red zone and this by nummulitic limestone and the Tertiary clays and sandstones. In the south-western corner a fault cuts off a corner of the salt and throws it against Tertiary clays and sandstones: I have already discussed how secondary gypsum is forming along this fault, and is already massive enough in places to form large cliffs.

On the salt-field are two salt hills about 200 feet high, each covered by a cap (see Plate 8) of greenish-grey clays and gypsum. The gypsum cliffs on both sides of the field are of approximately the same height.

As stated in the preceding paper, the salt of the Bahadur Khel field is a schist and is worked by splitting it along its planes of schistosity. The direction of the foliation planes in the salt is shown on the sketchmap, Plate 8, which also shows that the foliation does not follow the run of the gypsum or of the Red bed or of the Nummulitic limestone. There is in fact obvious discordance.

The section drawn by Wynne to illustrate the structure of the Bahadur Khel salt-field in the neighbourhood of the salt hills is the following:—



1. Rock-Salt. 2. Gypsum. 3. Red clay. 4. Sandstone. 5. Nummulitic limestone. 6. Murree series.

To him, one of the most puzzling things in connection with the Bahadur Khel field was the existence on the top of each of the two central hills of salt of a cap of gypsum having greenish-grey clay interposed between it and the underlying salt. He says (page 145):—

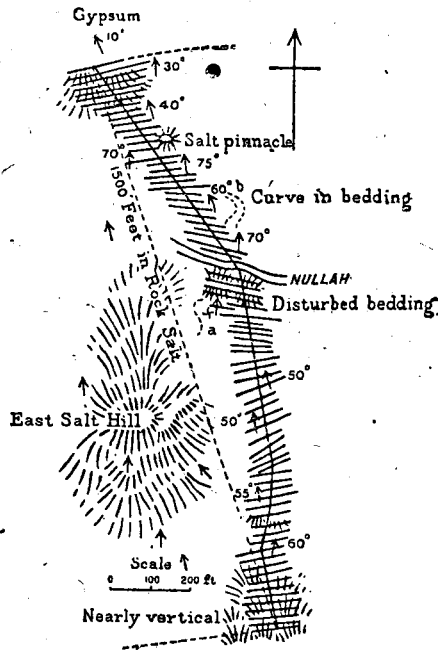
“It is difficult to account for such appearances as these except under the supposition that before the ground assumed its present denuded form, the

solution and removal of salt beneath allowed portions of the gypsum to slide bodily from their places to lower positions."

On the following page he continues his description of the field as follows :—

Figure 39 is a reduced sketch of a rough survey from one side of the salt exposure to the other with the dips marked, from which it has been calculated that the thickness of the salt at this place is from 1,000 to 1,230 feet, or even more. Its stratification is almost everywhere distinct, and rendered more evident by thin earthy layers alternating with the beds. Here the dip is everywhere northerly—in the lower beds from vertical to 70° declining to 50° or 55°, forming a bold half arch in the central hills, again high after passing these, but gradually becoming lower to 30°, where the last of the salt is seen. There are only two points, marked *a* and *b* on the plan, where some curvature of the beds or disturbance of the steady high dips occurs, likely to reduce the total thickness of the section, and these curvatures appeared to be quite local, not being traceable for any distance, but though the consecutive high dips follow from bed to bed, the strike is not parallel throughout, a result which may be due to pressure or even to concealed fractures or faults, though no such features could be observed in this section, the only marked divisional planes indeed, besides those of bedding, being some strong nearly horizontal joints.

¶ The gypsum capping the central hills presents more difficulty with regard to accepting the measured thickness of the salt as true. That to the north succeeds the salt as elsewhere with apparently perfect conformity. The capping on the hills has the same arrangement as already noticed to the west in the interposition of a greenish-gray clay band between it and the salt, and there is, at all events, a certain amount of parallelism among these beds. Still it is clear that if the salt beds to the north of the hill were produced upwards, they would pass, even at a



much lower slope, far above the outlying patches; hence, if the latter are conformable and in their original place, they must either have been embedded in the great salt deposit, or else, being really the lower part of the succeeding zone, the enormous thickness which the salt exhibits must be a false appearance due to concealed faults or to curves the connexion of which is no longer visible.

"But these cappings of gypsum need not necessarily be now in their original places, we have the same rock to the south in utterly abnormal positions, and there is no good reason why these two patches should not also have transversely subsided from higher levels owing to dissolving of under-lying salt; the situations in which they rested having decided the formation of the hills, to the soluble strata of which they formed a protection against the atmospheric erosion.

"One of the hills considered by itself presents much the appearance of half of an anticlinal curve, and where inversion of curvature in bedding is so common (the rule rather than the exception) there would be little difficulty in supposing the salt beds to the southward all inverted, if any clue could be found to the fact beyond the reversed dips of some portions of the series just at the line of fault (already mentioned) where local complication lessens their value.

"By introducing faulting to the north of the hills, the appearances might also be explained with great probability, but of this no evidence has been detected.

"The similarity of the salt-rock throughout gives it as a mass a unity of character, rendering contortion repeating the same beds more probable than dislocation; a sameness of aspect, too, all but fatal to the hope of discovering repetitions among the layers, more particularly as these are in places strongly obliquely laminated (or false bedded) inducing distrust of discordant appearances.

"However the case may be, the fact remains that a cutting 1,500 feet in length could be made as the shortest straight line from side to side through highly inclined rock-salt and nothing else, except the small quantity of clay associated with it, yet it does seem strange, that while the anticlinal structure pointed out to the west recurs even more strongly about a mile and a half to the east, its disappearance should be at this the widest exposure of the salt, by an apparently enormous thickness of the deposit, and at the same time the clearest evidence of disturbance at the place, instead of explaining this appearance, should be limited to a large downthrow fault at the outer limit of the salt to the south, which it is not easy to connect in any way with the usual thickness of the salt itself, a thickness which, even if capable of reduction from the above considerations, would still remain large, probably from 350 to 700 feet."

The explanation appears to be that the salt is not an ordinary stratified deposit, as I have already pointed out, but is a schist, and

that what Wynne took to be bedding-planes are really foliation planes, and are not bent into a simple anticline, or even a faulted anticline, as he supposed, but have the structure shown in the accompanying sketch :—

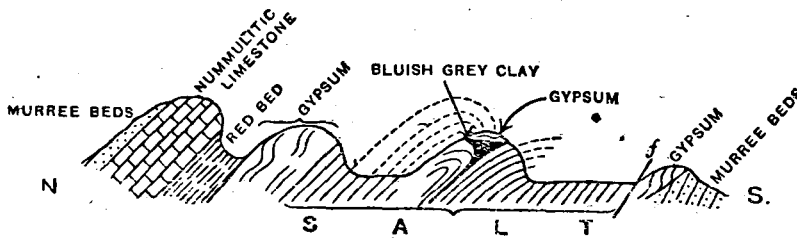


Plate 14 is a drawing from a photograph and shows the sharp bend over of the foliation planes to the north on the northern side of the salt hill. Plate 15, figure 1 shows a nearer view of the same hill.

The eastern side of the hill shows the same sharp bend over of the foliation planes to the north. In this case the complexity of the bending and folding is strikingly evident. Plate 15 is a near view of the north-east side of the hill and shows the folding in greater detail.

It would seem therefore that the salt of the Bahadur Khel field is not only foliated but has been overfolded by movement from the north : probably the same movement that ridged up the rocks of the country into the long steep east and west anticlines and synclines that are the feature of the area. The explanation of the two salt hills of the field being capped by gypsum follows as a natural sequence. The salt was overfolded and the line of the reversed limb runs through the two hills. Its course is indicated on the sketch-plan of the field, Plate 8, by the line of clay which occupies a more or less central position along the western end of the field for some distance east and west of the hills. The sketch-map shows also the difference in the complexity of the foliation to the north and south, respectively, of this overfold, the foliation being much more complex in the northern half of the field than it is in the southern, this again seeming to indicate a thrust from the north. As shown on the map, clay was caught up in this overfold and now occupies an irregular



course along the position of the fold. This clay is not a uniform band; sometimes it is pulled out to the finest string, and in other places it occurs as thick lenticular patches. Two such patches apparently occurred in the original undenuded salt in the positions occupied by the clay caps to the two hills; during denudation these clay lenticles came into contact with calcareous material and a covering of gypsum was formed. The clay and overlying gypsum then formed a protective cover, or umbrella, and shielded the salt underneath from subaërial denudation. The surrounding unprotected salt was denuded, and so the two hills were left standing above the level of the rest of the field. The fact that the two hills and the gypsum hills bounding the field are approximately of the same height makes it probable that the height of the hills represents the amount of denudation that has occurred in the field, and that if we knew the approximate rate at which the level of the field is being lowered at the present time we could approximate to a rough estimate of the period that has elapsed since denudation first began to operate on the field.

The field was extensively tested for the presence of potash but none was detected. This indeed is only what might have been expected, for, just as the original clay beds appear to have been sheared across, and the brecciated fragments strung out along the foliation planes, with the result that the clay now occurs as isolated fragments which are integral constituents of the salt schist, so potash, if any seams of it existed in the original beds from which this salt schist was formed, would also exist now as isolated particles scattered through the schist. As already stated the failure to detect any in the schist may mean that no beds of potash existed in the original beds from which the schist was formed, or it may mean that, being more deliquescent than salt, and the salt schist being distinctly pervious to water in places, any particles there may have been in it may have been removed in solution.

In the preceding paper I have given details regarding the Malgin, Jatta and Nandrakka exposures and have pointed out that the last-named are intermediate in type and seem to form a link between the two salt areas, thus giving rise to the presumption that the two salt deposits are part of one great salt formation and are not distinct and unconnected formations.

### The Punjab Salt.

I have also already pointed out that the Punjab salt is red and occasionally grey, and generally contains salts of magnesium and potassium. Its usual position is below the Purple Sandstone of the Salt Range, which underlies the Obolus Shales of undoubted Cambrian age. Occasionally it is overlain by Nummulitic limestone, as at Vasnal in the Jhelum district, or by Tertiary sandstones and clays, as at Kalabagh. But in every case, just as in the Kohat area, it is the lowest formation seen, and nothing has ever been found definitely underlying it. In the Punjab the salt occurs in a peculiar red marl and the junction between this Salt Marl and the Purple Sandstone is a disturbed one, generally marked by a breccia. The relationships of the Salt Marl to the other rocks have been thoroughly investigated by Middlemiss (*Rec. Geol. Surv. Ind.*, XXIV, pt. I, 1891), who found that the normal junction was a breccia, and that occasionally the Salt Marl behaved as if it had been injected or squeezed into abnormal positions in the overlying rocks. I cannot do better than quote him on the point. He says:—

“Mr. Wynne, though unable to find in the range or elsewhere any evidence of what lies beneath the Red Marl, does not appear to have had any misgivings as to the relation of the Red Marl to what comes above it. He states (p. 85) that the Red Marl apparently passes up into the Purple Sandstone. If therefore, my efforts to show that the marl is not in normal stratified succession beneath the Purple Sandstone are to be successful, I must show this apparent passage to be unreal.

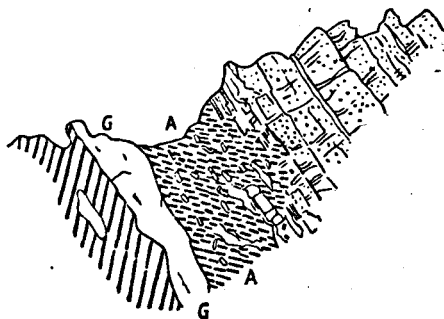
“Now continuous sequence between two formations is best established by the one formation being found *interbedded* with the other. But there is no such continuous sequence as this between the Red Marl and the Purple Sandstone—no alternating layers, first of marl and then of sandstone, dovetailing the two together. The very few isolated and doubtful cases in which some apparent interbedding takes place are justly mentioned with considerable reserve by Mr. Wynne himself. Speaking broadly, there is no interbedding between the two.”

“The only sense then in which the Red Marl could be said to pass up into the Purple Sandstone would be by the existence of an intervening layer of rock petrologically neither a marl nor a sandstone, but a mixture of the two. And this is what Mr. Wynne relies on to show the above passage. For my own part I could never satisfy myself of such a passage bed indicating continuous sequence. I admit that in nearly every section of the two rocks

in contact there is what at first sight might be mistaken for a passage bed, but which I was able to determine at very many places to be of an entirely different nature.

“The Red Marl, from its proneness to soften at the surface when rain falls upon it and to become in consequence much mixed up with fragments of rocks from the cliffs above, is generally a difficult rock to study. In a country less arid and bare indeed, it would be almost impossible to find a natural section of the rock free from its load of surface *débris*. As it is, there are occasionally exposed reliable junction sections of the Red Marl and Purple Sandstone in close conjunction. In every one of these the layer of rock at the junction is *brecciated*—such a junction in fact as might be understood in a variety of ways *other than* that of the natural deposition of the Purple Sandstone conformably above the Red Marl. I will now detail some sections, which will, I hope, tend to clear up the mystery in part at least.

“The first instance I will give occurs at the north edge of the exposure of Red Marl west of the main road from Khewra to Choya-Saidan-Shah. It is a continuation of the band of Red Marl which crosses the road about two miles north-west of Khewra railway station. On descending into the depths of the little cañons among the masses of white and red rock mixed largely with surface *débris*, we find at the north edge of the marl, where it comes in juxtaposition with the Purple Sandstone, an arrangement as seen in Sketch Section No. 3, Plate III. To the right of the section there is the massive,



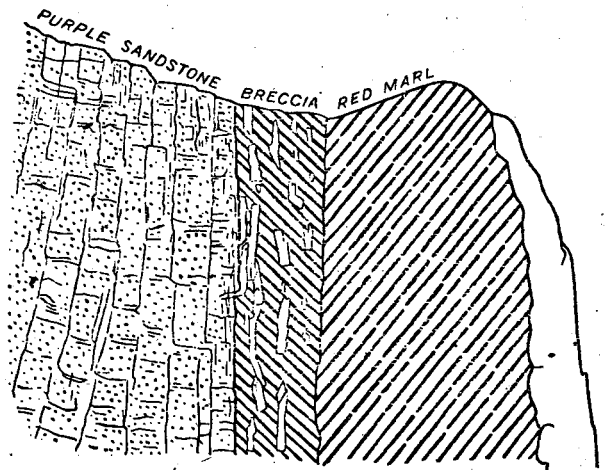
SKETCH SECTION No. III.

well-bedded Purple Sandstone, which, as it approaches the marl, becomes much shattered, more like a rock approaching a fold-fault than anything else that I can think of. The masses of the sandstone first keep a rough parallelism, though broken across, shattered, and detached from the consecutive layers of sandstone. Further on, towards the marl, there comes a well-marked layer, 3 or 4 feet across, AA of the section, in which the fragments of Purple Sandstone are smaller, though keeping their angularity and turned about in all directions; the matrix in which they are scattered being a mixture of what appears to be powdered-up portions of the sandstone mixed with Red Marl. This abruptly ceases, and a band of gypsum, G, follows, and then a layer of the pure amorphous Red Marl.

"The junction layer AA is an important one to which attention must be drawn. Its internal evidence proves that it was formed subsequent to the contained fragments of Purple Sandstone, which oriented, as they are, in all directions, nevertheless keep their individuality in a most perfect way. We must, I think, conclude that it is of the nature of a breccia, and marks a line of relative movement between the two formations.

"A similar section up the Khewra glen, where a mass of very pure Red Marl underlies the Purple Sandstone at a much lower angle, presents the same features, there being a distinctly brecciated band a few feet wide separating the sandstone from the marl.

"At Kavhad, where the glen bifurcates, there is also a very good exposure of the above rocks in conjunction. This is illustrated in Sketch Section No. 4, Plate III. On the left is good, strong, normal Purple Sandstone,



SKETCH SECTION No. IV.

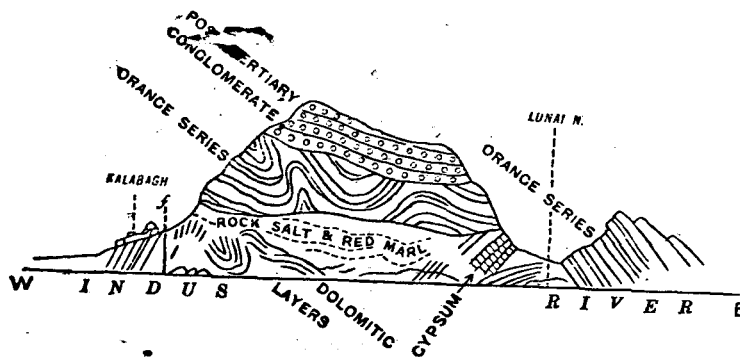
sometimes veined with pale green tints, whilst on the right is bright, scarlet and sometimes vesicular Red Marl, of a wavy tufaceous aspect, already described (see *ante*). In between the two comes a zone which in the distance often has the appearance of a passage, as stated above. It is two yards across, and is in truth half marl and half purple sandstone, but in this way the two are not interbedded in the ordinary sense of the term, nor is there a gradual passage from the one rock into the other, but there is a matrix of reddish and greenish marl which is stuck full of fragments of Purple Sandstone, sometimes roughly indicating bedding. Certainly, all the fragments are angular and lie more or less in the direction of the general bedding, but there is no suggestion of a passage from the marl to the sandstone. The appearance in fact is just that of a brecciation of one rock by intrusion of a later one among it. This line of junction can be followed along

the glen for some way up stream. I have selected it for description partly on account of the verticality of the beds in a cliff section, which can be trusted as being entirely free from surface re-arrangement.

"These three examples may, I think, stand by themselves as sufficient proof of the general statement that I have made, to the effect that there is never any real passage upwards from the Red Marl to the Purple Sandstone."

Mr. Middlemiss also describes in detail numerous instances where he regards the Salt Marl as having been squeezed into abnormal positions and as now occupying the core of inverted flexures or the line of the middle limb of a sigmaflexure, or the line of a tearing or thrust which has followed on the formation of the sigmaflexure.

He mentions<sup>1</sup> also the following section at Kalabagh which obviously means either overthrust or intrusion of the Salt Marl :



"The... section at Kalabagh... has always been a puzzle of no simple order on the accepted idea that the Red Marl is the basal formation of the Range. I have copied it from

The section at Kalabagh. Mr. Wynne's own drawing (Memoirs of the Geological Survey of India, Vol. XIV, p. 269), as it is not his observations but his conclusions which must be called in question with regard to it. I have, however, altered the index names of the conglomerate and the Tertiary Sandstones, in conformity with later observations made by Mr. Wynne and by Dr. Waagen.

"It will be observed that in that section the orange coloured beds (called the Orange series by Dr. Waagen in his Geological Results, Vol. IV, Part I) are in direct superposition on the red, white, grey, or bluish-grey rock salt of the Saline series.

"I infer from the following considerations that this junction cannot be a normal one due to the deposition of these beds on the top of some exposed reef of Salt Marl :—

- (1) The Orange series, whatever be their particular age, undoubtedly belong to the younger Tertiary epoch, and may with certainty

<sup>1</sup> l. c., p. 37.

be placed stratigraphically somewhere above the Nahans Sandstone and somewhere beneath the Upper Siwalik Conglomerate. Stated differently, they are the middle portion of a geological and petrological series, of immense extent and thickness, which covers vast regions on the North-West-frontier, along the southern borders of the Himalaya, and in Assam and Burma. Throughout this great extent of territory the middle rock-stages of that series are never found in superposition above anything but a lower stage of the same series. What is perhaps of more importance for the present argument, is that in the immediate neighbourhood of Kalabagh, along the very wonderful and striking section up the Indus river from that place, the same fact is above all manifest. There is no trace of unconformability in it.

(2) A still more comprehensive local generalization may even be made. The Tertiary system, as a whole, though showing a distinct break between the Nummulitic Limestone and the Nahans Sandstone, does not anywhere in the Punjab exhibit the Nahans superposed above anything but nummulitic strata. Thus, there is no parallel instance anywhere in the Empire on which to frame a line of marked unconformability among the middle stages of the Upper Tertiaries, and we must therefore admit that the abnormal junction of the Orange series on the top of the Saline series is not due to the position of the Orange beds above, but to that of the Saline series beneath.

(3) A further point strengthening this conclusion is that the Orange coloured beds, composed of soft sandstones and clays, or shales, begin as such immediately in contact with the salt-bearing beds. There is no basal conglomerate, and there is no gradual or rapid change downwards in the nature of the sediment of the Orange series as the Saline series is approached—nothing to indicate the beginning, at this point, of a set of detrital rocks of such marked features and extent as those of the Upper Siwaliks.

“A painting with the foreground and middle distance cut away would not more plainly indicate mutilation than does this ruptured section of the Orange beds.

“According to Dr. Waagen, the whole of his Red series, Grey Sandstone series, and Purple series, which come beneath the Orange series, are absent in this Kalabagh section, whilst they are in full thickness further up the Indus river.

“In the Sketch Section above I have copied from Mr. Wynne's figure, because I think it truly represents the relation of the rocks visible on the river face. In his Trans-Indus memoir (Memoirs, Geological Survey of India, Vol. XVII, part 2, p. 46) a section through the same hill, but along a different line, is given. As it primarily represents other points, the above relation of the Orange series to the Saline series is not given due prominence.”

As a matter of fact, from a close investigation of this section in the field, I believe that most of the apparent contortion of the

Orange series, is false and is merely a deceptive appearance given by uneven slipping of the outcrop down the steep slope of the hill. This, however, does not upset Middlemiss' deductions in any way, and is merely mentioned as this section is so often quoted.

From the above facts it may be taken, I think, that the junction between the Salt Marl and the overlying beds in the Punjab is not either a conformable one or a simple unconformity, and the inference seems unavoidable that movement has occurred along the junction, and that a certain amount of intrusion has occurred, the Salt Marl having been squeezed in places into flexures and fissures in the overlying rocks.

The Salt Marl has been thoroughly studied by Middlemiss and again I have nothing to add to his observations, the most important of which are<sup>1</sup> :—

"The Red Marl, with its immense masses of rock salt and gypsum, has been very thoroughly described by Mr. Wynne in his memoir, pages 70-84. I shall cull a few of his paragraphs as being of special interest, or as bearing on the present theory. Of the Red Marl itself, he gives Dr. Fleming's remarks on its chemical composition, which run as follows:—

'It does not disintegrate when treated with hydrochloric acid, but in powder effervesces strongly, the greater part remaining undissolved as a red mud, composed of clay and sulphate of lime; the portion soluble in acid consists of carbonate of lime and carbonate of magnesia in about equal proportions with a little alumina and peroxide of iron, to which it owes its colour.'

"Mr. Wynne concludes from the above that the term "gypseous marl" is not inapplicable. As to its petrological nature and aspect he writes—

The marl forms the most noticeable portion of the saline group, but in close association with it are thick beds of gypsum and thicker ones of rock salt. It is tough rather than hard, but when very dry, possesses much the consistence of sun-dried brick.

"He further writes—

'Beyond the gypseous, saline, and dolomitic layers the red marl bears few original traces of stratification, or inter-stratification, generally none at all; hence it is difficult to form any correct idea of its thickness. \* \* \* It may be doubted whether another example could be found of such a homogeneous, argillaceous and aqueous deposit of the same depth in which signs of stratification are equally absent. In strong contrast to this is the perfect lamination frequently seen in the enclosed salt,

<sup>1</sup> *Ibid*, p. 27.

and in the platy dolomitic layers. From the contorted state of the latter and the curvature of the beds of salt in some of the mines, it may be presumed that, whether stratified or not, the salt marl is likewise disturbed.'

"It is necessary to emphasize some of the points quoted above. So far as I have seen, I should say that the Red Marl, No divisional planes. except when it encloses masses of the dolomitic rock, or when it is in combination with beds of gypsum and rock salt, never shows any stratification whatever; nor is there the slightest trace of any divisional planes in it. On taking a lump in the hand, the broken edges are precisely such as one would get in any structureless, amorphous mass. The likeness to a sun-dried brick mentioned by Mr. Wynne applies as much in the matter of homogeneity as in hardness. Seen in large masses on the hillsides, it equally displays a lack of structural planes. In this respect it differs from limestone and other similar, chemically formed rocks; for a compact amorphous limestone, though evincing but little trace of stratification in the hand specimen, very often gives to the surface of the earth either a scarp, cliff, or moulded slope, by which its obscure planes of original deposition can be discerned. But there is no such hint thrown out by the Red Marl. Denudation acts on it as it would on a heap of sand, making streamlets here, and rough hillocks there, the former winding in a capricious manner, and the latter strewing the slopes at random.

"With the absence of divisional planes there is also an 'absence of No colour banding.' The Red Marl, though varying somewhat in the brilliancy and depth of its colour; is of one general hue throughout. There is no parallel system of tints, such as the colour banding of slates (which reveals the original stratification of the slates, although the power to split along it has been taken away).

\* \* \* \* \*

"..... I have some new facts to bring forward now regarding the interrelations between the dolomitic layers and the Positive evidence. Red Marl on the one hand, and the dolomitic layers and the gypsum on the other.

"At Kavhad there is a good exposure of the Red Marl showing the following peculiarities:—(1) Its brick-red colour and Absorption of the dolomite rock by the Red Marl. homogeneous aspect is broken by a network or sporge-work of filmy, anastomosing strings of gypsum; (2) The pale grey dolomite involved in the Red Marl is not disposed in continuous beds but in vesicular or honey-combed lumps, of irregular shape and size; (3) The bright red matrix, if examined carefully, is seen to be dotted all over with pale greenish grey patches. Some of these are as large as an inch across but most of them are mere specks. It is noticeable, however, that these specks are drawn out like the sputtering of a pen, and that in their course through the rock they keep very generally a more or less parallel direction for a short distance, but waving about. They give an irregular streaky and patchy appearance to the marl, as if the former had been kneaded up with the latter, just as patches of white bread are sometimes found incorporated by mistake in a



loaf of whole meal flour. But the most important point in connection with these grey specks is that they may be traced by every gradational form into disintegrated patches of the honey-combed dolomite. The latter, in its larger pieces, is as distinct from the marly matrix as an included fragment of schist often may be in a granite; but as these lumps become more honey-combed, and more vesicular, they split into groups of three or more straggling and corroded<sup>1</sup> remnants of dolomite, and these again into clusters showing a gradual change into the greenish-grey specks previously mentioned. In the latter condition they are one with the Red Marl. The Red Marl in fact seems to have devoured the dolomite, to have absorbed or digested it, just as a pot of molten lead absorbs the solid bits thrown into it. Of course the actual process of the transformation described above is not seen, but only the various stages which I have thus vivified for facility of description.

"A parallel change from the dolomite into gypsum is also indicated by numberless passage forms at a great many places in the Salt Range. Two miles north of Buri Khel there is a good example. The dolomite, roughly bedded in some places, solid in its central portions, but crumbling and honey-combed at the edges, occupies areas of many square yards among the gypsum and Red Marl. The smaller patches of the dolomite exhibit the following stages of change:—(1) the hard flinty-looking rock becomes dotted with minute punctures, either in rows or nebulous patches. These holes are as fine as a pin-point. (2) In the near neighbourhood another lump of dolomite may be taken in which there are larger ragged holes, such as appear in a moth-eaten garment. Close examination shows that these larger holes are bordered by the minute punctures, and indicate that the former were made by the close approximation and fusion of the latter. (3) Joining these larger ragged holes there run canals sometimes roughly following joint planes in the dolomite. (4) Another stage of change may be seen by the dolomite assuming a honey-combed structure, somewhat resembling pumice in which the holes are larger than before. At the same time the joint planes at right angles to one another are converted into widened fissures cutting up the lump into irregular cubes and masses, gypsum taking the place of the dolomite along the cracks and holes. (5) Groups and strings and lumps of the dolomite in the final stages are honey-combed to a spongy and then to a reticulate fibrous texture, the holes and meshes being occupied by gypsum.

"I take it as beyond dispute that the one rock has gradually replaced the other original rock, probably by some metamorphic change that finds a parallel in the well-known example of laterite formed from gneiss. It would thus seem that, according to circumstances, a genuine stratified deposit of dolomite has been converted, either into a pure gypsum, or into a less pure gypseous marl."

It will be observed that the mode of formation of gypsum, as described by Middlemiss, agrees perfectly with that of the Kohat

<sup>1</sup> I use the verb 'to corrode' here in a general sense for want of a better word."

gypsum observed by me, and no further explanation seems necessary if the two salt deposits are really parts of one formation.

There is nothing new to record about the gypsum. It agrees in character in every way with the Kohat gypsum

**The gypsum.** except that a pink colour is perhaps more common. Here, as in Kohat, abundant instances can be found of half-formed gypsum, intermediate in character between selenite and gypsum rock and showing clearly the breaking down or devitrifying selenite crystals. As in Kohat too, the gypsum contains not only foreign minerals, such as the famous bipyramidal quartz crystals of Mari and Kalabagh, and the Lun Wan pass into Kohat, but also incorporated foreign rocks such as dolomite, and grey shales, as at Kalabagh, and even trap as at Khewra, where trap, apparently unconnected with anything else, occurs in the gypsum. The gypsum often occurs in a disconnected way through the Salt Marl and its relationships with the marl and the salt are difficult to determine.

As already stated the salt does not occur in regular stratified beds, but in lenticular and irregular bands having

**The salt.** a foliated character, the foliation, however, being on a much larger scale than is usually associated with that term; and whereas in Kohat the foliation is such that the rock can be called a schist, in the Punjab it is on such a large scale that the individual bands are feet and sometimes yards across, and the foliation suggests flow structure.

The variation in thickness and the discontinuity of the potash bands at Nurpur have already been referred to in detail in the preceding paper, in which I have also pointed out that in the Mayo mine at Khewra the banding of the salt does not appear to be due to ordinary stratification. The first thing that struck me on going into the latter mine by the main entrance was the appearance of frequent marl bands in the salt. These cut the new tram tunnel obliquely and give a striking appearance of flow structure. The marl is strung out in streaks that twist and ramify and coalesce exactly as the streaks in a solidified magma showing flow structure, and they surround and include lenticular patches of salt, all arranged, with their long axes parallel to the apparent direction of flow. Whatever they are due to, one realises at once that the present arrangement of these particular parts of the salt formation is not due to original stratification.

An examination of the banding in good salt showed that here also it does not conform to the laws governing ordinary sedimentary strata. I attach a photograph to illustrate this. Plate 20 shows what is called well stratified salt. On studying it, it is seen that the bands are not regular stratified beds, but that they thicken and thin and branch into other bands as beds of deposited salt could not do.<sup>1</sup> I may add that I have never seen anything of the nature of false bedding occur in crystallizing salt. There is a brine stream running over the Bahadur Khel field and depositing salt by evaporation. The stream is shallow and flows fairly swiftly, but no sign of false bedding appears in the deposited salt on its floor, or bed. Each crystal is firmly fixed in the place where it first began to grow, and there it remains cemented to the other salt on which it lies, and no movement such as might produce the effect of false bedding is possible. I am loath to admit therefore that false bedding could occur in deposited salt beds<sup>2</sup>, but in any case it would not explain this particular instance. Plates 18 and 23 show the bands of marl that occur in the salt; they show clearly that they are not stratified beds. Finally Plate 19, figure 2 taken in the new lower tunnel that is just being run, and showing some of the lowest Salt Marl exposed in the mine, strongly suggests flow structure rather than stratification.

Thus, everywhere the salt apparently shows signs of foliation—most intense in the Kohat area and least in the Punjab—and nowhere does it seem to be entirely unmetamorphosed.

### III.—GENERAL DEDUCTIONS.

I am of opinion that the salt in the Punjab, and Kohat, all belongs to the same period, and is part of the same formation, and that the overthrust suggested by Sir Thomas Holland as occurring between the salt deposits and the overlying rocks in the Salt Range (*op. cit.*) undoubtedly occurs, but that it extends through Kohat as well, its age being, of course, earlier than the folding movements which ridged up the Kohat rocks into their existing arrangement of steep anticlines and synclines.

<sup>1</sup> The lenticularity is much more obvious if the photograph is looked at from a distance of four or five feet.

<sup>2</sup> Wynne also records the fact that "no sign of current mark or well-developed oblique lamination could be found" in the salt deposits. *Mem. G. S. I.*, XIV, page 78.

The brecciated junction between the Purple Sandstone and the Salt Marl, and all the various abnormal occurrences noticed by Middlemiss and Wynne, are explicable on the assumption that there is an overthrust bringing the other rocks on to the salt—a view that is greatly strengthened by the existence of subsidiary overthrusts in the salt itself at Khewra and Nurpur.

Up to the present it has merely been shown that the gypsum not only need not be, but does not appear to be, a geological formation following on the salt in natural order of sedimentary sequence; but that, on the contrary, it may be a contact mineral formed at the junction of the salt formation with other sediments containing calcium carbonate or holding water carrying calcium carbonate in solution. This being realized not only as a possibility but as a probability, its influence on the reasoning applied to the salt formation is of great importance. So long as it was assumed that the gypsum was a normal geological formation having its place in a definite and conformable stratigraphical sequence, the conclusion was unavoidable that the salt exposed underneath the gypsum must all belong to the same horizon, or approximately so. But if the gypsum is not a stratigraphical formation but a contact mineral formed by chemical reaction subsequent to the deposition of the overlying beds, then the possibility becomes apparent that the salt found beneath it in the various exposures need not belong to the same salt zone or horizon, unless the strata overlying the gypsum are always the same and conformable to the salt, a condition which certainly is not the case.

Further than this, if the gypsum is a subsequent rock formed at the junction of the salt deposits and the adjacent rocks, then all the various foreign rocks that occur in it, or partly in it and partly mixed with the topmost layers of the salt, such as the bituminous salt and gypsum of Kohat, the alum shales on the north-east of the Kohat area, the dolomitic beds, the greenish grey calcareous clays, and even the trap at Khewra, can be regarded as fractured and isolated patches of rock that have been caught up and carried forward along the line of the overthrust. The corrosion of the dolomite that was such a puzzle to Middlemiss needs no further explanation; and the confused arrangement of salt and gypsum observed by Wynne in Kohat, and in the upper layers of the Salt Marl, is to be expected.

The simplest interpretation of the evidence at present available then, seems to be that the sedimentary formations at present overlying the salt have been brought into place by an overthrust, and that along the plane of this overthrust secondary gypsum has been formed by the reaction of calcareous material in the sediments with the sulphuric acid formed by the decomposition of iron sulphide in the salt formation. Now if the salt were originally deposited from an evaporating saline solution, which I agree with Wynne and Christie in thinking was the case, it is improbable that it would be of uniform composition throughout, but it would have been deposited originally in zones. An example of this may be seen in the Stassfurt deposits of Germany. F. Bischof divides the Stassfurt beds proper into four regions vertically, corresponding, he observes, to the natural order of origin from an evaporating solution<sup>1</sup>:—

- (4) the carnallite zone,
- (3) the kieserite zone,
- (2) the polyhalite zone,
- (1) the anhydrite zone;

and if the Indian salt deposits were deposited from solution, it is probable that they too followed originally some such arrangement as that detailed by Bischof. Subsequent alteration and metamorphism in the Indian deposits might alter the actual mineral constituents of the zones, but nevertheless some kind of differentiation into zones should still be recognizable in the Indian deposits. Viewed from this standpoint, the different constitutional characters exhibited by the different salt exposures in the Salt Range and Kohat become significant. It becomes no longer necessary to try and find reasons why the salt in different places exhibits different constitutional characters, and the probability becomes clear that these differences may be explained by the fact that in the different exposures the salt represents portions of different zones or horizons in the original salt formation. For instance, the Kohat salt deposits exhibit different characteristics from the Kalabagh salt, the Kalabagh salt from the Warcha salt, and the Warcha salt from the

<sup>1</sup> *Ann. Chem. Phys.*, 5,305, 1865; *Berg-und hüttenmännische Zeitung*, Leipzig, 24, 1865.

See also H. Everding, *Deutschlands Kalibergbau*, page 36, 1907.

Nurpur and Khewra salt, and these differences may be due to the fact that the Kohat salt, the Kalabagh salt, the Warcha salt, and the Khewra salt each represent a different horizon or region of the original deposits. This I believe to be the case, and though no exact parallel can be drawn with the Stassfurt deposits, nevertheless a certain similarity can be observed in the differences exhibited by these presumed zones and the differences exhibited amongst the recognised zones of the Stassfurt deposits. The Kohat salt deposits on analysis show the presence of calcium sulphate but no potash or magnesia, and this would seem to imply that they represent a low horizon of the original deposits corresponding to the period when only calcium sulphate and sodium chloride were being deposited. The Kalabagh deposits begin to show traces of potash and magnesia, but no recognizable thickness of these latter salts has been found; they are merely found in brine pools in some of the mines, having obviously been dissolved from the particular salt in which the mine is situated. Calcium sulphate is still common in the salt.

The Warcha salt differs from the Kohat salt and the Kalabagh salt in that it contains a large quantity of magnesium sulphate and a certain amount of combined magnesium and potassium sulphates. The outstanding feature of the Warcha salt is, however, magnesium sulphate. The Khewra and Nurpur salt does not contain so much magnesium sulphate, but contains potash compounds in a higher percentage compared to magnesium sulphate than the Warcha salt. It, therefore, seems that the suggestion that these different exposures of salt represent different horizons of the original salt formation is justified, and that their relationship to one another in the original vertical section of the salt deposits may have been approximately the following:—

- (d) the Khewra salt zone,
- (c) the Warcha salt zone,
- (b) the Kalabagh salt zone,
- (a) the Kohat salt zone.

An exact parallel between these zones and the Stassfurt zones cannot, of course, be made, but I suggest that the Kohat zone corresponded probably originally with the anhydrite zone of Stassfurt, the Kalabagh zone probably to something between the anhy-

drite and the polyhalite zones, the Warcha zone to something between the polyhalite and the kieserite zones, and the Khewra zone to about the kieserite, or something between the kieserite and the carnallite zones.

The foliation of the salt may be due to overthrusting, at least in part; and the fact that the foliation is most intense in Kohat and the discordance between it and the strike of the overlying Tertiary beds most marked there, seems more than significant when it is also realized that in Kohat the salt deposits do not follow the run of the Salt range, but swing away to the north-west from Kalabagh, while the trans-Indus continuation of the Salt Range continues westwards and southwards across the Indus.

The next-point for consideration is the age of the salt deposits. Wynne put the age of the Punjab salt as pre-Purple Sandstone, *i.e.*, approximately pre-Cambrian, and, in view of the fact that in the whole section of rocks above it there is neither a repetition of the salt nor of continental, desert or salt-lake deposits, it seems improbable that the age of the salt is post-Purple Sandstone. Moreover in Kohat the great salt deposits occur within ten miles of the Trans-Indus continuation of the Salt Range in which neither the section of the Tertiary rocks, nor of any of the rocks exposed down to the Permo-Carboniferous, gives any evidence of salt-lake conditions. So that it seems reasonable to suppose that the Kohat salt is at least earlier than Permo-Carboniferous in age, a conclusion that does not disagree with my supposition that the salt in the Punjab is pre-Cambrian. I therefore place the age of the salt formation as pre-Cambrian. Whether any connection can be traced between the "sulphur" period of the salt deposits indicated by the Kohat zone, and the volcanic activity of either Vindhyan or Bijawar times, or whether the Purple Sandstone is part of the desert sands that must have accumulated during the salt period, and has been brought forward on to the salt by the overthrust, and is thus approximately contemporaneous with it instead of subsequent to it in age, are matters of conjecture; but the evidence, in my opinion, points to the salt deposits having formed about that time, and being of either Cuddapah or Vindhyan age, or possibly astride the two periods.

I am aware that my views necessarily increase the estimated thickness of the salt deposits as a whole; but in salt that has been

foliated and has been folded and overfolded in places, it is impossible to estimate the original thickness of the beds.

With reference to the Khewra mine, although I regard the salt exposed in the mine as belonging to the kieserite and possibly partly to the carnallite zones, it does not necessarily follow that the Warcha and Kalabagh zones will be found underneath it, since at the bottom of the deep exploration drift in No. 12 Pharwala, what appears to be a fault-breccia is found along the line of subsidiary overthrust, and below it is grey salt; and it looks as if the equivalents of the Warcha and Kalabagh salt might have been cut out by the subsidiary overthrust.

The age of the gypsum is uncertain; it may be anything from that of the overthrust to the present day. Much of it is undoubtedly recent, and some is forming now. Probably the truth is that the formation of the gypsum extends over the whole period from the time of the overthrust to the present day, its formation being quickest along exposed and denuding junctions.

#### IV.—SUMMARY.

The observations seem to fit into and support one another, and to leave little unexplained; they seem also to point to the inference that the salt was originally sedimentary in origin and belonged to one formation. The chief arguments in favour of this are:—

- (1) the Kohat salt is grey; the Nandrukka salt grey with bands of pink salt; the Kalabagh salt red with bands of grey salt; and the Punjab Salt Range salt red;
- (2) the salt in Kohat contains calcium sulphate, but no potassium or magnesium compounds; the Nandrakka salt contains traces of potassium and magnesium, as well as calcium sulphate; the Kalabagh salt contains more potassium and magnesium compounds, but still only in small quantities, and calcium sulphate; and the salt stalactites on the mines frequently have a "cotton-wool" appearance due to the presence of sodium sulphate; the Warcha salt contains combined magnesium and potassium sulphates; while the Nurpur and Khewra salt contains no combined calcium sulphate, but sulphates and chlorides, both combined and free of magnesium and potassium;



- (3) the foliation and schistosity of the salt is greatest in the western part of Kohat, and gradually diminishes in an easterly direction, until it is least evident in the eastern end of the formation around Khewra; this may arise from the overthrust being greatest in Kohat and least on the east of the salt area.

The above observations coupled with the fact that an evaporating saline solution deposits salts in successive zones, each differing from the one below it in mineralogical composition, in the order given by Bischof, suggest that the rock-salt of Kohat and the Punjab belongs to one great salt formation, and that the differences in character of the salt exposed in the different exposures are due to different zones of the salt being exposed at different places. It is suggested that the Kohat salt belongs to approximately the lowest zone, and there may be a gradual transition through salt which originally belonged to higher and higher zones in the original stratified section until, at Khewra, salt which may have belonged to the kieserite or possibly to the carnallite zone, is met with.

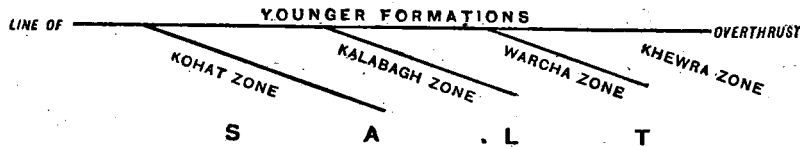
Since they have apparently undergone metamorphism, and since this metamorphism affects the included potassium, magnesium and calcium compounds chiefly, it is obvious that an exact parallel cannot be expected between the mineralogical composition of the Indian salts and unmetamorphosed deposits such as those of Stassfurt. There is a certain apparent parallelism, but not enough to make it desirable to adopt Bischof's nomenclature. It is more convenient to give the different salt zones assumed here names that will have more meaning in these particular deposits. It is now suggested that the salt was deposited in a great salt lake by evaporation, and in zones comparable to those of Bischof, but that it has since been metamorphosed. The following classification of the Indian salt is now proposed:—

- (4) the Khewra zone,
- (3) the Warcha zone,
- (2) the Kalabagh zone,
- (1) the Kohat zone.

The Kohat zone would thus represent the first salt to crystallize out, and would therefore contain calcium sulphate and little or no other salt except sodium chloride, and ferruginous materia. Its difference from the anhydrite zone of Stassfurt may be due, either

to sulphurous springs in the original salt lake, or to the presence of sulphuretted hydrogen introduced in some other way—how, does not affect the present question—, the ferruginous material present being converted into sulphide of iron, which would colour the salt mud grey instead of red. It is further assumed that the sulphuretted hydrogen period ceased before the accumulation of the Kalabagh salt, since it and the Warcha and Khewra salt are red. Whether any representative of the carnallite zone of Bischof is present in the Salt Range or not, it is impossible to say. It may be that it is represented in part by some of the Khewra salt, or it may be that the overthrust has everywhere removed it. With the knowledge at our disposal at present it is impossible to offer a decided opinion.

Neglecting, for a moment, the foliation of the salt, the suggested general arrangement of the deposits is approximately that shown in the following section :—



Above the salt comes the secondary gypsum that has formed along the line of the overthrust and represents that line approximately; and above this are the various geological formations.

The Salt Marl of the Punjab may be composed of comminated material resulting from the overthrust and thus be comparable with the ground moraine or till that forms below an ice-sheet; and if so it possibly consists largely of original salt-lake and desert material. Its absence in the Kohat area may be explained by the amount of overthrust being greater there than in the Salt Range. If, as seems possible, the Purple Sandstone represents some of the desert deposits that surrounded the drying up, or dried up, salt-lake, and consequently is contemporaneous with, or just younger than, the salt itself, the actual overthrust in the east of the salt area, such as at Khewra, need not be very great.

It is further assumed that the gypsum is a contact product between the salt and the overthrust calcareous formations; and

although the Khewra and Warcha zones of the salt do not contain much sulphide of iron, the presence of grey salt of the Kohat zone in both the Warcha and Khewra mines, owing to subsidiary overthrusting, enables me to suggest that sufficient sulphide of iron was incorporated in the Salt Marl during the overthrusting, to result in the formation of gypsum in the latter.

If the above assumption is correct, it follows that the gypsum masks the overthrust, and that had it not been for the secondary formation of that mineral, the brecciated junction with the overlying rocks, the complicated fractures, and the masses of foreign rock caught up in the overthrust—such as the alum shales, the bituminous shales, the dolomite, the green clays, the Khewra trap, and all the various isolated, and, what might well be called "erratic," fragments of other geological formations now incorporated in the gypsum, would have made the overthrust strikingly evident at once.

I have neglected the foliation of the salt in the discussion of the present general arrangement of the salt zones, since what I regard as foliation has no relationship to the arrangement of the zones, and only produces a false impression of stratification. The general run of the Salt Range, and the salt-bearing ranges in Kohat, is east—west. The general strike of the salt, except in subsidiary puckers and folds, such as are found in the Nilawan ravine, ranges between E.N.E.—W.S.W. and N.E.—S.W. and the dip between N.N.W. and N.W.; this is opposite to the arrangement of the zones shown in the sketch section and described above. From this I infer that the dip and strike of the salt, as now seen, are the dip and strike of foliation planes, and do not necessarily coincide with the dip and strike of the original stratified beds and zones. Hitherto it has been customary to regard the salt bands as normal stratified beds, a view which was unquestioned by Wynne, and was definitely adopted by him. I now suggest on the other hand that the existing dip and strike of the salt bands is not stratification, but is foliation in a different and opposite direction, due to the original stratified deposits having been sheared or having flowed in a plastic state in a direction oblique to the original stratification planes, and thus become converted into foliated material having its foliation planes in a new and different direction. If this view is correct, and if the present dip has in general no relationship to the original

bedding-planes but is usually in a different direction, its bearing on prospecting operations for potash will be of great importance, since inferences based on the assumption that the banding corresponds to stratification would inevitably lead to wrong conclusions.<sup>1</sup>

The Kohat zone being the lowest, it would appear that the salt deposits should end not very far west of Bahadur Khel, and that the salt is not likely to extend far into Waziristan.<sup>2</sup>

In the foregoing pages I have recorded the facts observable at the present day, and from them I have deduced what appears to me to be their logical outcome. I have also shown how these deductions fit in with and offer an explanation of the various existing characteristics of the salt formation and the gypsum taken as a whole. They seem to me to lead up to a simpler explanation than any yet put forward and the manner in which they account for many observed phenomena that hitherto have been distinctly puzzling gives them a high probability of being correct. It is worthy of note too that deductions based on entirely different observations lead to the same conclusion. Thus the nature of the banding of the salt, its frequent lenticular arrangement, the occasional striking appearance of flow structure in it, and the nature of the salt marl bands led me to infer that the originally stratified beds of salt had subsequently been subjected to flow and that the direction of movement had not coincided with the direction of the original bedding.

The occurrence of marl particles as isolated fragments scattered through the Bahadur Khel salt schist instead of as continuous bands, seems to make this inference inevitable. Furthermore, if the salt was originally a stratified deposit, it must, presumably, have been arranged in zones and was not uniform in composition from bottom to top. The characteristics of the different existing

<sup>1</sup> It is no doubt possible that in certain places the direction of flow or foliation may coincide with the original stratification. If the salt strata were folded at all before the foliation occurred, then places must almost certainly have existed where the two were coincident. But these places would be few, and have not yet been observed; hence on general grounds the possibility is ignored in this report.

<sup>2</sup> Judging from the reports of the trans-border people it seems probable that salt exposures do not exist west of Bahadur Khel in the trans-frontier country, and it is interesting to note that deductions based on the arrangement of the salt zones agree with this information.

exposures are consistent with this view, and, assuming it to be correct, the following zones are suggested as occurring in the Indian salt, in ascending order:—(1) the Kohat zone, (2) the Kalabagh zone, (3) the Warcha zone and (4) the Nurpur and Khewra zone. These salt zones are thus arranged as if they had a dip containing an easterly component. Now the general dip of the present banding (which I regard as foliation) is N.W. to N.N.W., or in the opposite direction to the suggested arrangement of the zones which must of course have coincided originally with the stratification. These two different lines of reasoning, therefore, both lead to the same conclusion, and suggest an hypothesis by which to explain the undoubted irregularity in thickness and composition, and the lenticular and discontinuous character of the potash bands. Another instance of the way in which these deductions mutually support one another is afforded by the gypsum. This, as has been shown by Wynne, overlies the salt. From what I have seen taking place on the Bahadur Khel salt-field and especially along the line of fault on its south-western extremity, and from the nature and characteristics of the gypsum itself, I have inferred that the gypsum may be a contact mineral formed at the junction of the salt with neighbouring formations. If the salt was originally a stratified deposit and arranged in zones, then the gypsum, if also part of this stratified formation, would occupy a definite position in the vertical scale. We find, however, that this is not the case, but that it lies indiscriminately on the Kohat, the Kalabagh, the Warcha and Khewra zones, and this leads to the inference that it has come into its present position after the salt was arranged in its present form and position. It seems impossible, by any conceivable process of folding or overfolding, to account for its present unconformity with the salt zones and frequently with the banding in the salt. If it were a sedimentary deposit one would expect to find it below the salt, since it should have come out of solution earlier than the salt; whereas, if it is a contact mineral, we should expect to find it just where it now occurs.

#### V.—ECONOMIC RESULTS OF THE HYPOTHESIS.

If the deductions drawn by me in the foregoing pages are correct, it follows that the salt exposed in the Khewra mine belongs to the Khewra zone and should be underlain normally by the Warcha zone, followed in turn, in

descending order, by the Kalabagh and Kohat zones. The presence of the Warcha zone, however, is doubtful. Near the bottom of the deep exploratory drift in No. 12 Pharwala, is a subsidiary overthrust, marked by a fault-breccia, and below this is grey salt resembling that of the Kohat zone. It is possible therefore that the Warcha and Kalabagh zones with their included potash foliæ and lenticles, are cut out by a subsidiary overthrust under the Khewra zone. The Kohat zone contains no potash, and therefore prospecting for potash below the salt exposed in the Khewra mine is not likely to succeed; the subsidiary overthrust may have cut out the Warcha zone altogether and brought the Khewra zone directly on to the Kohat zone, or still more disturbance may have occurred below, and some salt of the Warcha zone may be present. There are, however, no indications that the latter is the case. It has already been pointed out in the preceding paper that if further prospecting is attempted at Khewra, the best course would be to put a boring down at the northern end of the Khewra glen, and so cut through more bands of the salt than are opened up in the Mayo mine. Whether the suggestions put forward in the foregoing pages are right or wrong, it has been amply demonstrated by actual experience that a certain amount of potash will, as already stated in my preceding paper (*supra*, p. 52), occur as irregular lenticular bands in the salt of Khewra and Warcha. These bands will be discontinuous and, almost certainly, very variable in width and composition throughout their length, and will not all lie on the same foliation plane; hence a boring put down through the salt at any particular point will miss certain lenticles. Whether the salt under the northern end of the Khewra glen is foliated material derived from an originally higher zone in the deposits than that which went to form the foliated salt exposed in the Mayo mine, or whether the opposite is the case, there is no evidence at our disposal to show; but it seems probable that it is from a different zone, and that a boring put down through it either to the grey salt or right through the deposit, is likely to pass through potash foliæ that are not seen in the Mayo mine.

As in the case of Khewra, a boring might also with advantage be put down through the salt deposits at Warcha. the northern end of the Warcha glen, close to the northern guard-post, and on the western side of the glen. This would pass through a considerable thickness of foliated salt

not seen in the mine, and might possibly pass through part of the Khewra zone. Nothing can be deduced, in this connection from the dip of the foliation planes, but investigation would be interesting and should yield lenticles of potash. The same disadvantage exists here as at Khewra, and indeed throughout the Salt Range, that the lenticles of potash are discontinuous and many may be missed owing to the boring passing just outside their limits.

No seams of potash were found at Kalabagh, though it was detected both in dripping water and in water lying in the quarries.

The Kalabagh salt seems to be transitional between that of the Kohat zone and of the Warcha zone; potash is not likely to occur in it in any quantity, and for this reason further search here does not seem to offer any prospect of success.

This salt is the grey variety of the Kohat zone, with a few bands of pink salt interfoliated with it. It probably represents the top of the Kohat zone and a lower horizon than that of the Kalabagh salt.

Except at Nandrakka, no traces of potash have been detected in Kohat. Owing to the fact that the salt of the Kohat zone was presumably the first to crystallize out of the evaporating saline solution, it is unlikely that any valuable potash seams ever existed in it; and if as now suggested, it has been subsequently sheared across its bedding-planes and converted into a foliated rock sometimes comparable in texture with a schist, the presence in it of potash of commercial value is improbable; but if potash does occur, it will be found only in minute and isolated fragments scattered through, and forming an intergral part of, the schist, a mode of occurrence which would render it valueless commercially.

If the hypotheses put forward in this paper are correct, the highest salt zones exposed along the southern scarp of the Salt Range as a whole will be found at the eastern end of the range, and the lowest zones in the western portions of the Kohat Range; it is therefore, advisable to prospect for potash in the eastern portion of the Salt Range. Speaking broadly, the further prospecting is carried towards the east, the greater the probability of finding the higher salt zones. The salt exposed at Khewra and Nurpur seems, before foliation, to have belonged to a

zone corresponding to the kieserite, and possibly to the lower portion of the carnallite, zone of Stassfurt. It is possible that, to the east of Khewra, there may be salt belonging originally to a still higher horizon than that seen at Khewra. It is doubtful, however, whether this is worth investigating. The section around Chambal ( $33^{\circ} 20' : 73^{\circ} 29'$ ) consists, according to Wynne, of faulted and steeply dipping rocks, and it would, therefore, seem preferable to bore near Khewra, where the salt is less tilted. A boring at the head (north) of the Khewra glen through the Salt Marl and right through the salt formation would be exceedingly instructive. If it were intended merely to prospect for potash, the boring could be stopped on reaching the grey salt of the Kohat zone. It seems certain that subsidiary overthrusting has occurred in the salt itself and improbable, therefore, that the whole section of salt would be met with, but this is likely to be the case everywhere throughout the range. The advantage of prospecting near Khewra is that here is perhaps the most easterly gently-dipping salt of the range, or sufficiently nearly so to make it the most suitable spot, owing to its proximity to the railway and to the mining village. Another place where a boring might be put down with advantage is at the northern extremity of the Warcha glen, opposite to the northern guard-post and on the western side of the glen. The salt of the eastern side seems to be more disturbed and the western side is therefore the more suitable. Although the dip of the foliation planes in the salt at Warcha would indicate that higher foliæ are exposed at the head of the glen than near its mouth, it by no means follows that the original salt zone, from which the salt seen at the head of the glen is derived, is a higher zone than that to which the foliated salt seen in the Warcha mine belongs, but it is probably a different zone, and a boring at the head of the glen would probably pass through more salt than one at the mouth of the glen. There is no evidence that salt corresponding to that of Warcha will be met with in the Khewra boring just advocated, and it therefore seems desirable that both should be undertaken. In either case potash is not likely to be met with after the grey salt of the Kohat zone is reached, although the continuation of the boring right through the salt formation would be of great scientific interest.

I have already pointed out the possibility of the bore-holes passing near to, but just outside, potash lenticles, and thus giving no indication of their presence; this, unfortunately, cannot be avoided,



and is one of the disadvantages consequent on the foliation of the salt. Although I have been able to suggest a rough idea of the arrangement of the original salt zones in an east-west direction, I have no data which will enable me to do so in a north-south direction, and in this connection I would again lay stress on the suggestion that the foliation planes are not the original bedding-planes and have no connection with them, and that if they be regarded as such, any deductions drawn therefrom will be based on a false hypothesis and consequently misleading.

As already stated in the preceding paper, it is not probable that any continuous bed of potash will be found either in the Salt Range or in Kohat. If the salt has been foliated as now suggested, the potash salts will have been re-arranged in discontinuous and irregular lenticles. Where the foliation is of the nature of banding, bands of potash may persist for some little distance, but even then they will probably thicken and thin throughout their length; for if the salt, with its potash, was originally deposited in stratified beds which have been sheared across their bedding-planes obliquely, and the whole converted into a foliated rock; it is improbable that any continuous thick bands or foliæ of potash will be found in the present salt, although a band or lenticle may thicken out abruptly here and there. The prospects of obtaining potash from the salt of the Salt Range are not promising, and the Indian deposits, having been foliated, are at a great disadvantage as compared with the stratified deposits of Stassfurt, where the presence of potash, once known at any point, can be predicted over large areas with tolerable certainty, both as regards position and thickness. In the Indian foliated salt, it is like looking for a needle in a bundle of hay; beyond the fact that the Kohat zone does not contain potash in detectable quantities, no assertion can be made as to where a lenticle of potash will occur, or as to its dimensions or shape when located.

## LOCALITY INDEX.

Bahadur Khel . . . . .	33° 10'	71° 0'
Banda Daud Shah . . . . .	33° 17'	71° 11'
Chambal . . . . .	33° 20'	73° 29'
Chashanna Ghanda . . . . .	33° 22'	71° 36'
Ganjalli . . . . .	33° 25'	71° 46'
Guruza . . . . .	33° 7'	71° 2'
Jatta Ismail Khel . . . . .	33° 18'	71° 17'
Kacho . . . . .	33° 6'	71° 33'
Kalabagh . . . . .	33° 58'	71° 33'
Karak . . . . .	33° 7'	71° 9'
Khewra . . . . .	32° 33'	73° 4'
Kurar . . . . .	33° 13'	71° 20'
Malgin . . . . .	33° 18'	71° 31'
Mari . . . . .	32° 58'	71° 35'
Nandrakka . . . . .	33° 15'	71° 33'
Nilawan Ravine . . . . .	32° 34'	72° 38'
Nurpur . . . . .	32° 39'	72° 36'
Shahidan . . . . .	33° 12'	71° 16'
Speena (Spina) . . . . .	33° 13'	71° 16'
Vasnal . . . . .	32° 43'	72° 33'
Warcha . . . . .	32° 25'	71° 58'

## LIST OF PLATES.

- PLATE 9.—Fig. 1. Formation of crystals of selenite on grey clay.  
Fig. 2. Stages in formation of rock gypsum.
- PLATE 10.—Fig. 1. Gypsum crust coating a limestone boulder.  
Fig. 2. Formation of a modern miniature cliff of gypsum.
- PLATE 11.—Formation of gypsum along line of fault.
- PLATE 12.—Formation of a modern sheet of gypsum over Bahadur Khel salt field.
- PLATE 13.—Overfolding and puckering of grey salt, Warcha mine.
- PLATE 14.—Sketch of western face of western salt hill, Bahadur Khel.
- PLATE 15.—Fig. 1. Western face of western salt hill, Bahadur Khel.  
Fig. 2. Sulphate of soda breaking through salt crust.
- PLATE 16.—N. E. corner of western salt hill Bahadur Khel.
- PLATE 17.—Flow structure in the Warcha mine.
- PLATE 18.—Main marl-band, Warcha mine.
- PLATE 19.—Fig. 1. Augen-shaped lenticle of magnesian salt, Warcha.  
Fig. 2. Flow structure exhibited by salt, Khewra.
- PLATE 20.—Well banded Khewra salt.
- PLATE 21.—Lenticles of salt outlined naturally by marl.
- PLATE 22.—Patches of sulphate of soda, Bahadur Khel salt field.
- PLATE 23.—Bands of marl in Khewra salt.
- PLATE 24.—The western end of the Bahadur Khel salt field.
- PLATE 25.—Map of the Salt area.

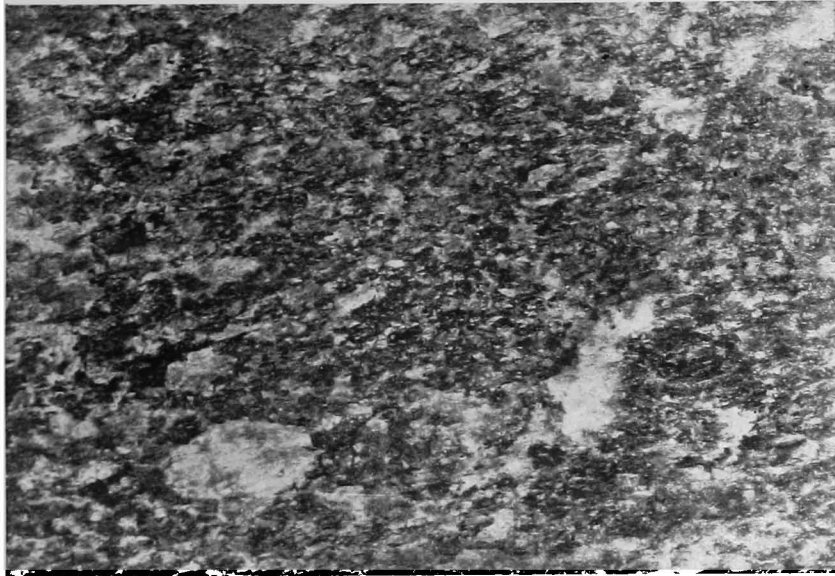


FIG. 1. BAHADUR KHEL SALT SHOWING SCHISTOSE STRUCTURE.  
(Natural size.)



*Photographs by Murray Stuart.*

*G. S. I. Calcutta.*

FIG. 2. A SALT QUARRY AT BAHADUR KHEL.



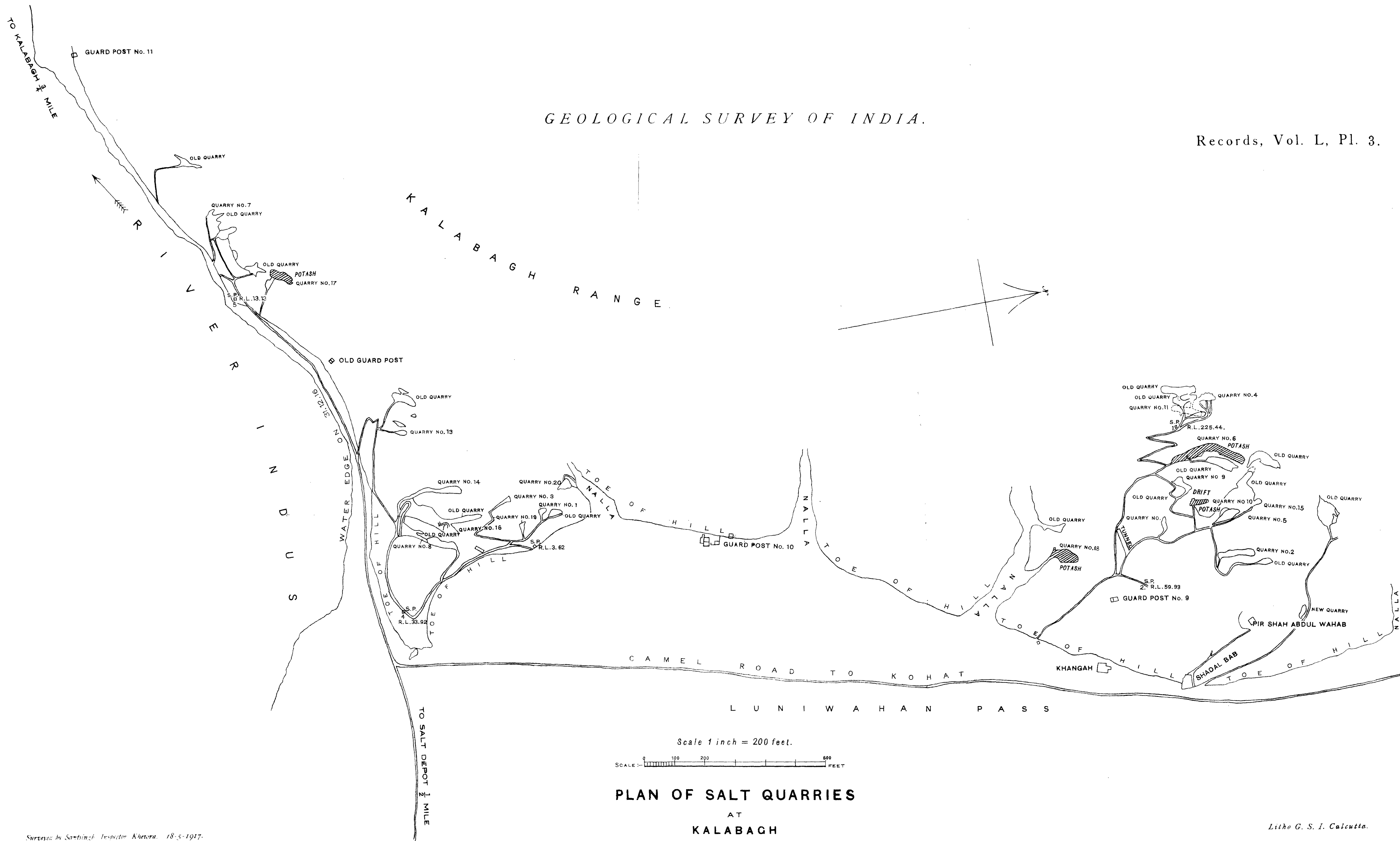
*Photograph by Murray Stuart.*

**THE SCHISTOSITY OF BAHADUR KHEL SALT**

*G. S. I. Calcutta.*

GEOLOGICAL SURVEY OF INDIA.

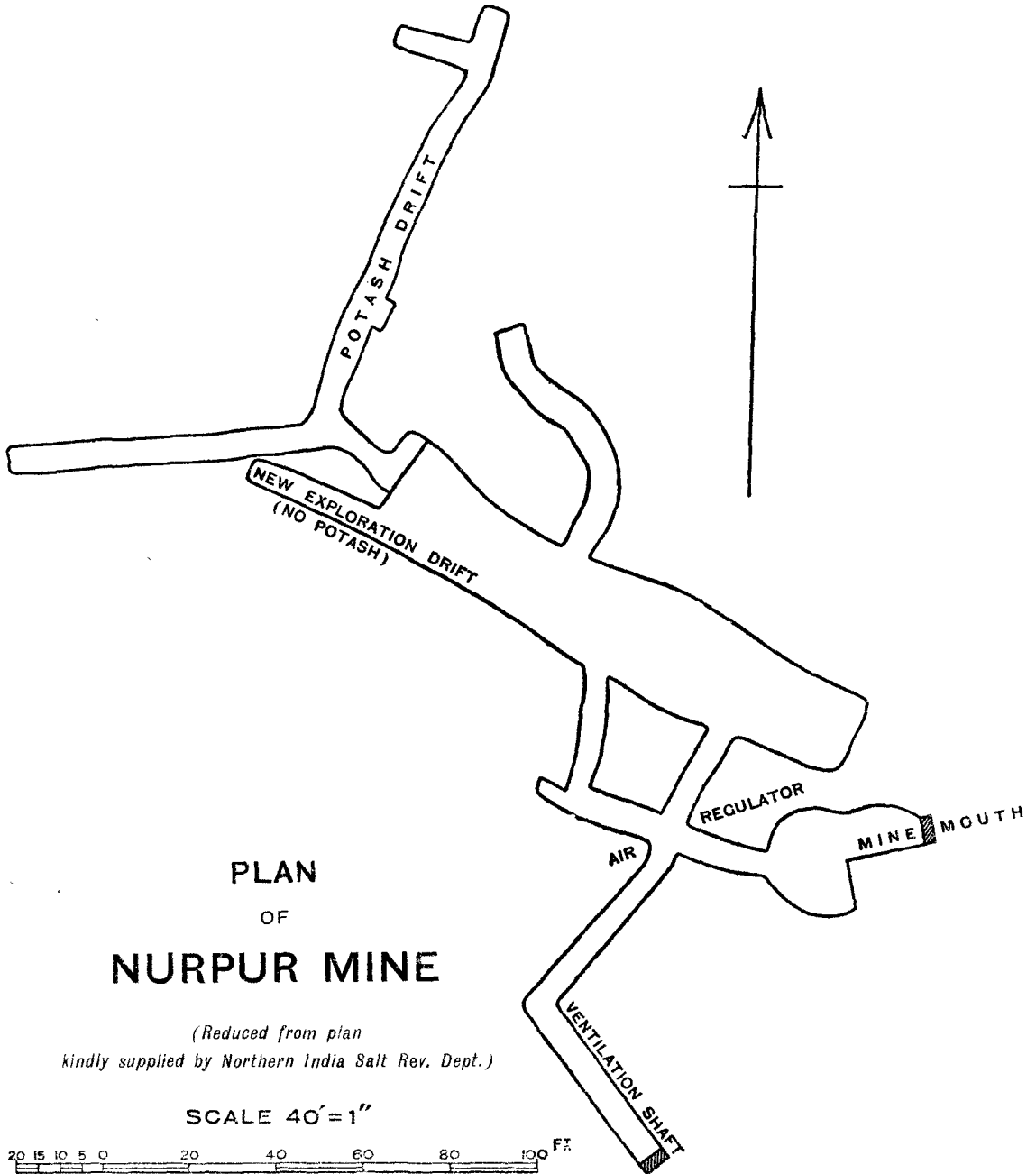
Records, Vol. L, Pl. 3.



PLAN OF SALT QUARRIES  
AT  
KALABAGH

Surveyed by Sant Singh, Inspector, Khetwara, 18-5-1917.

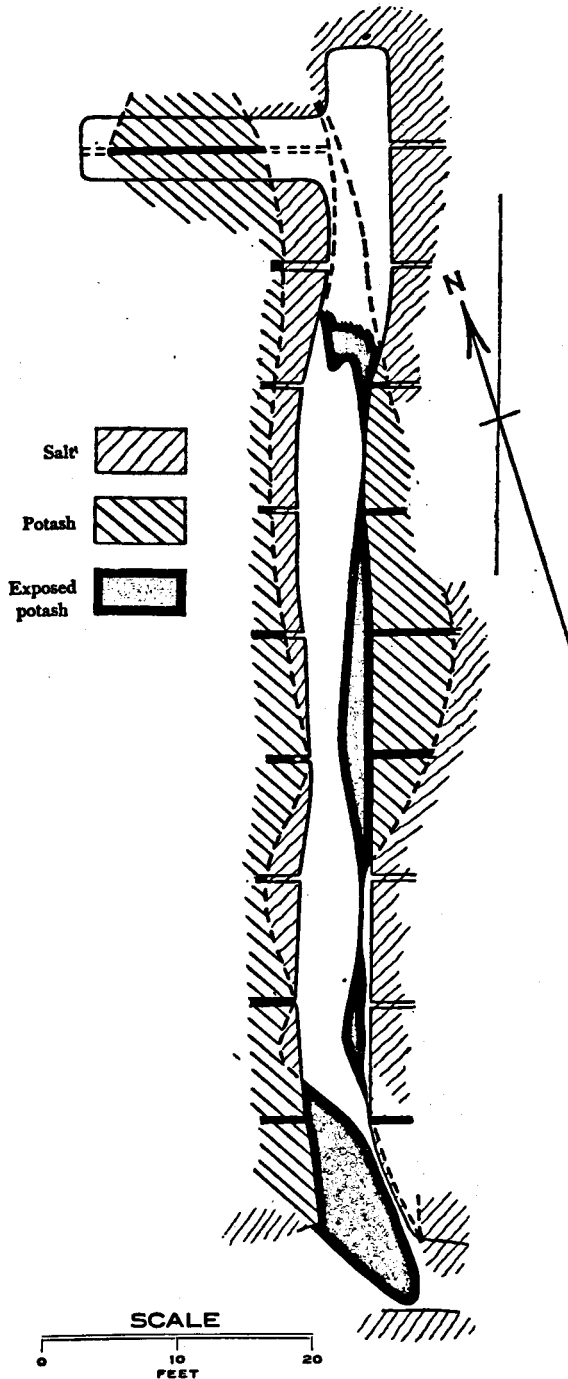
Litho G. S. I. Calcutta.



PLAN  
OF  
NURPUR MINE

(Reduced from plan  
kindly supplied by Northern India Salt Rev. Dept.)

SCALE 40' = 1"

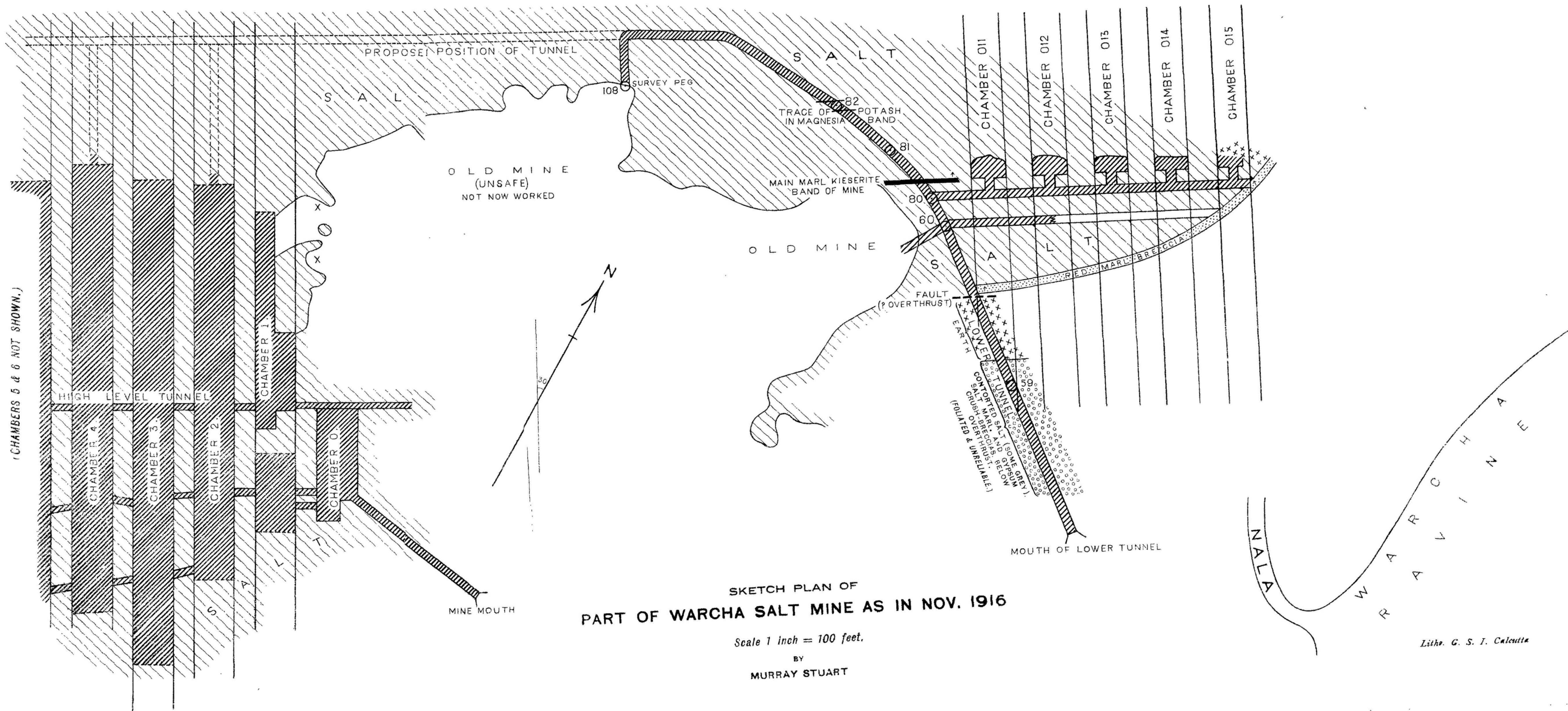


Sketch by Murray Stuart.

G. S. I. Calcutta.

PLAN OF THE POTASH DRIFT, NURPUR MINE,  
(Showing test holes drilled into the walls, and the potash bands.)



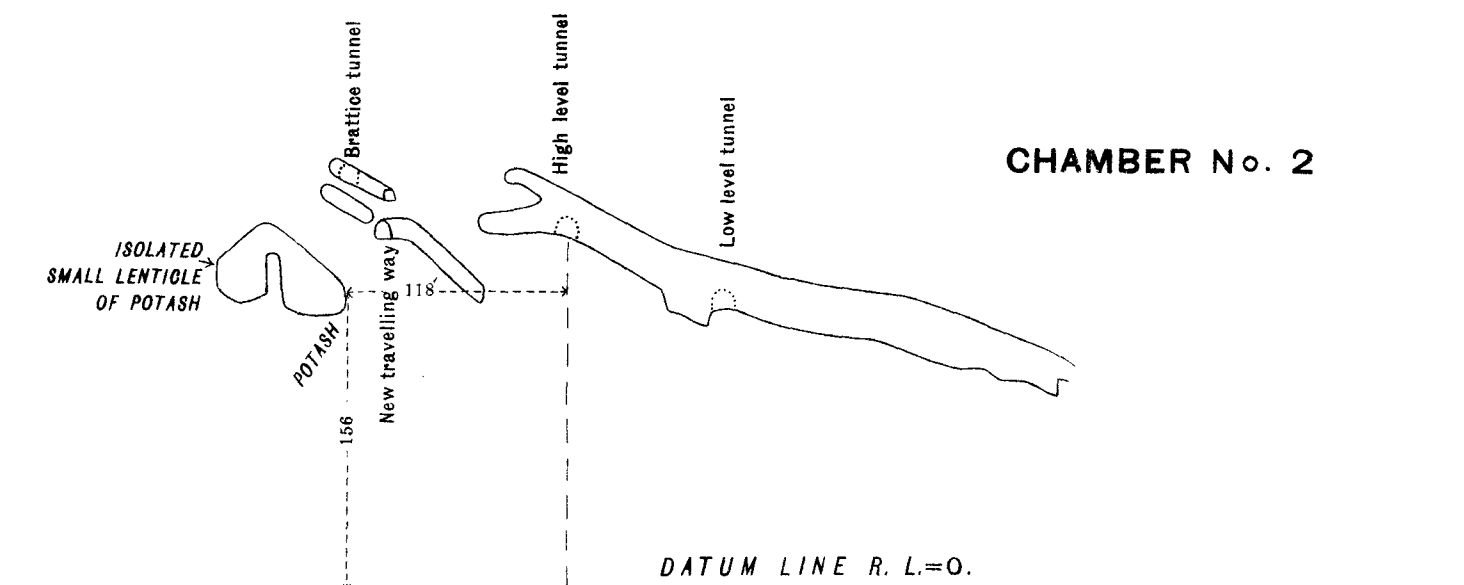
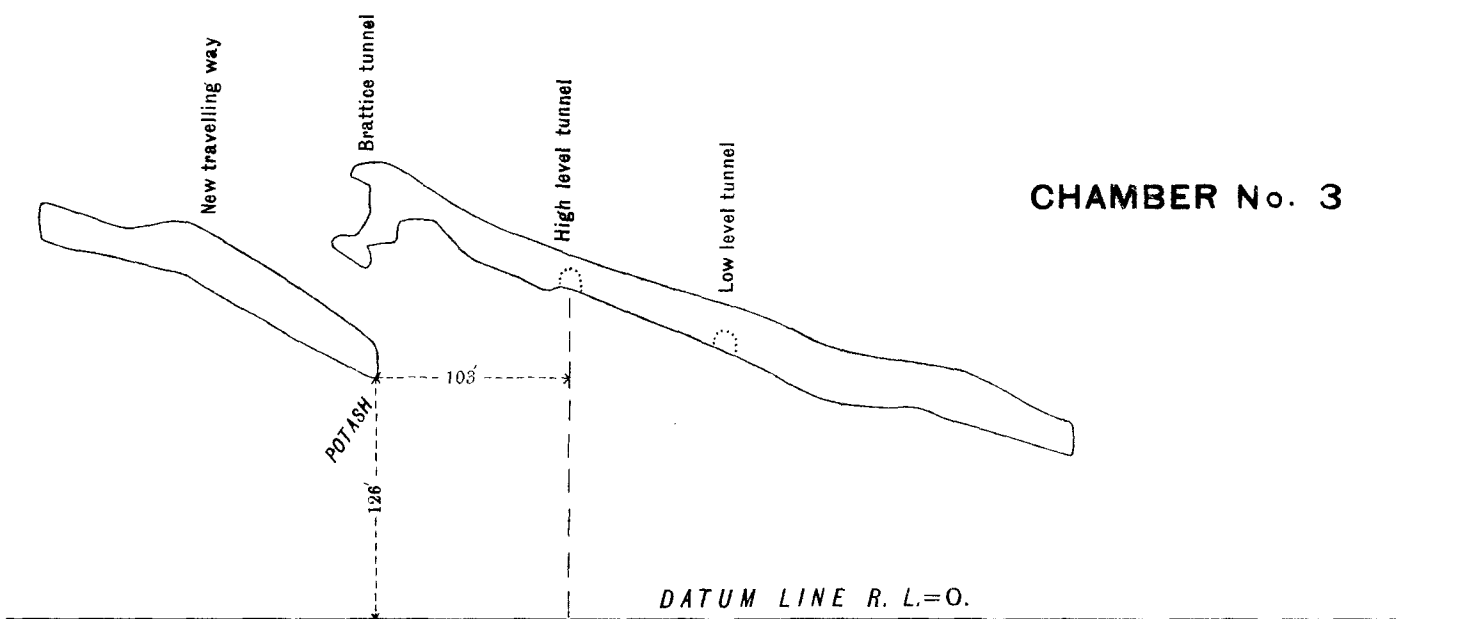
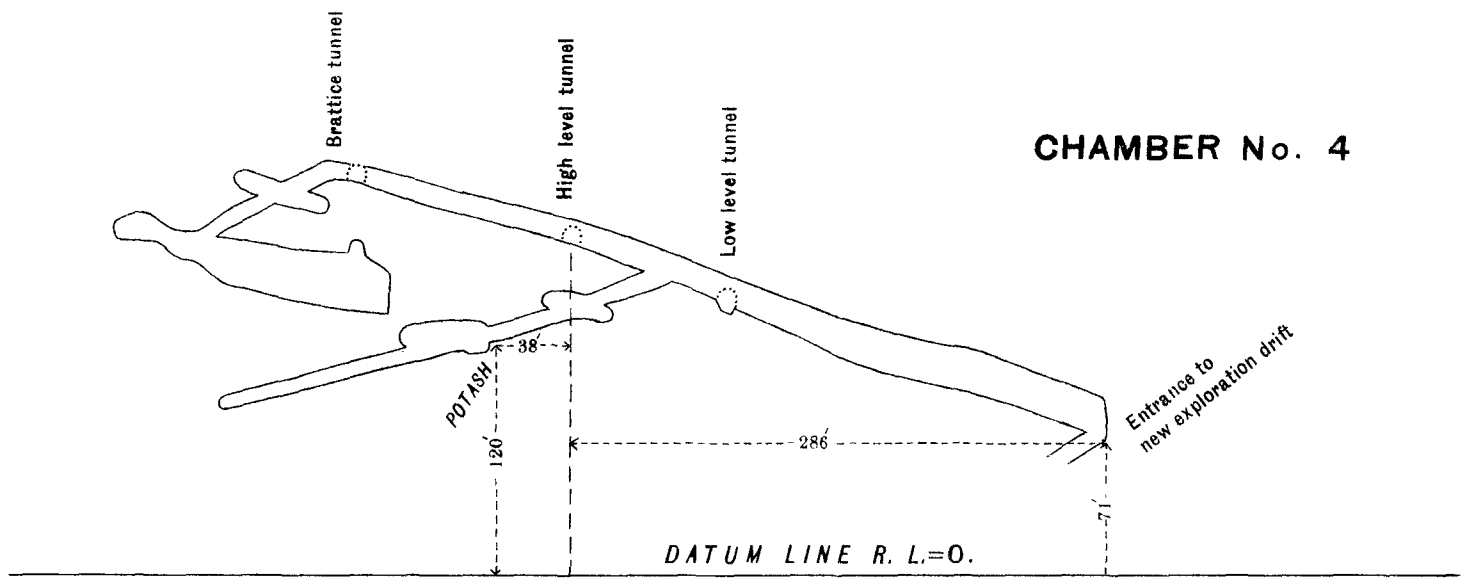


SKETCH PLAN OF  
PART OF WARCHA SALT MINE AS IN NOV. 1916

Scale 1 inch = 100 feet.

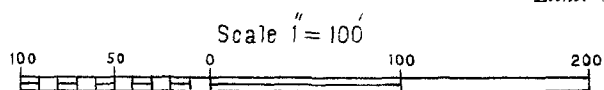
BY  
MURRAY STUART

Litho. G. S. I. Calcutta

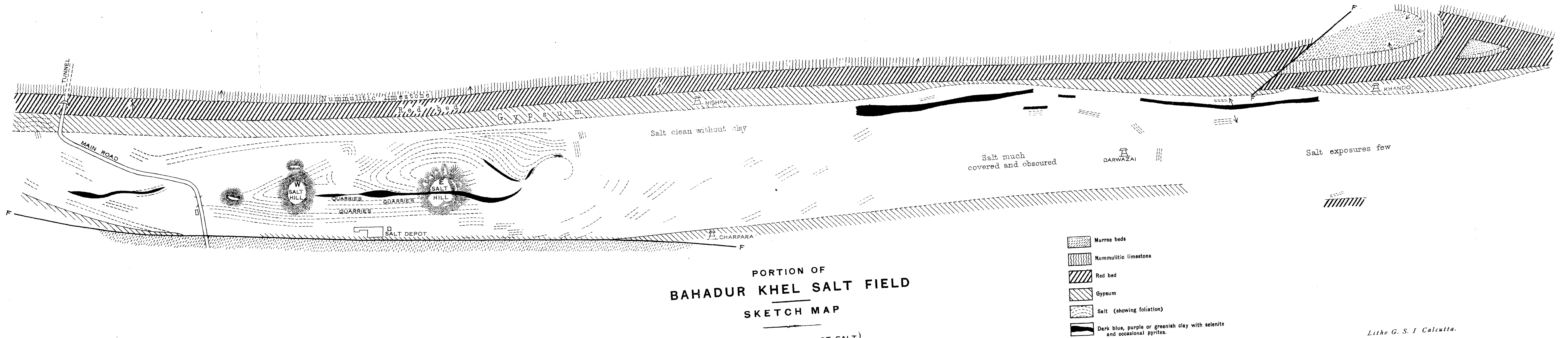


Litho. G. S. I. Calcutta.

From a survey supplied by the Northern India Salt Rev. Dept.



SECTIONS OF CHAMBERS IN WARCHA SALT MINE, NOV. 1916,  
SHOWING POSITION OF POTASH OCCURENCES.



PORTION OF  
BAHADUR KHEL SALT FIELD  
SKETCH MAP

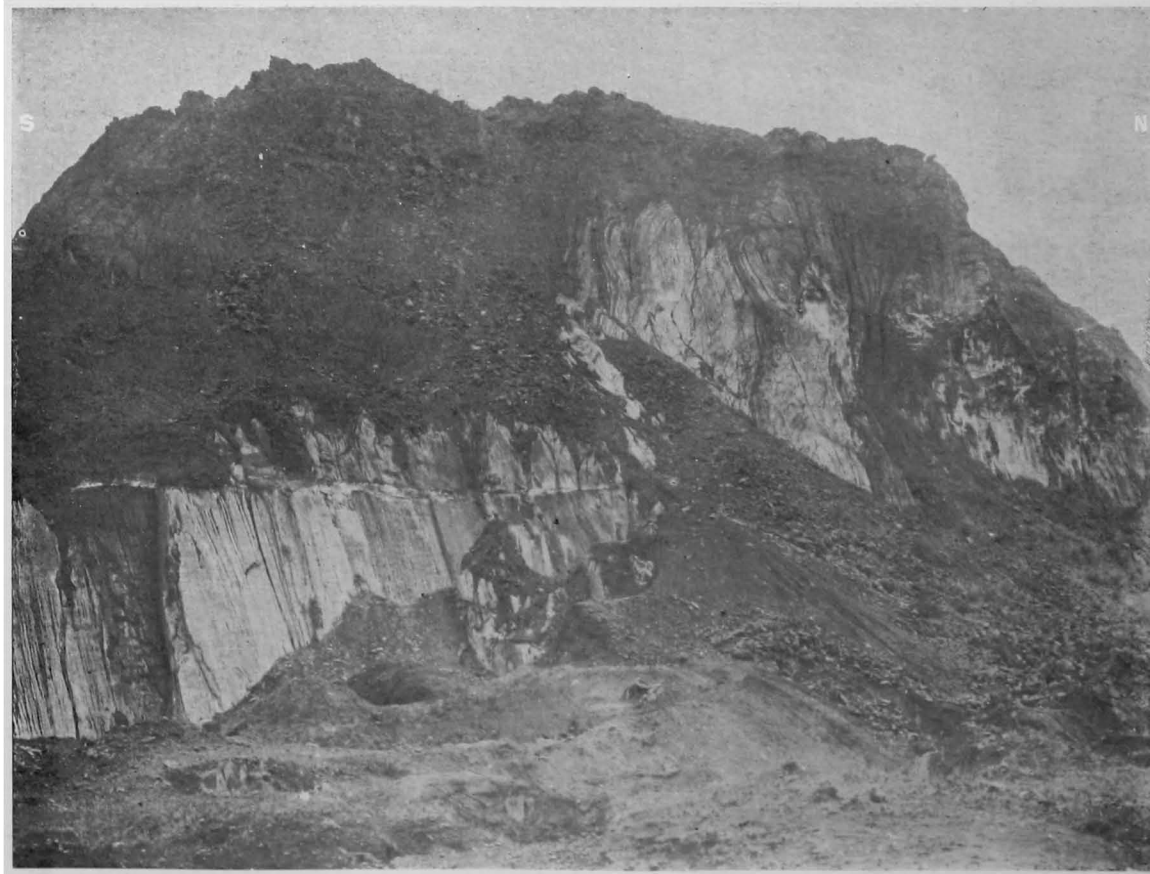
(SHOWING FOLIATION OF SALT)  
Scale about 6 inches = 1 mile.

Sketch by Murray Stuart.

Litho G. S. I. Calcutta.

*GEOLOGICAL SURVEY OF INDIA.*

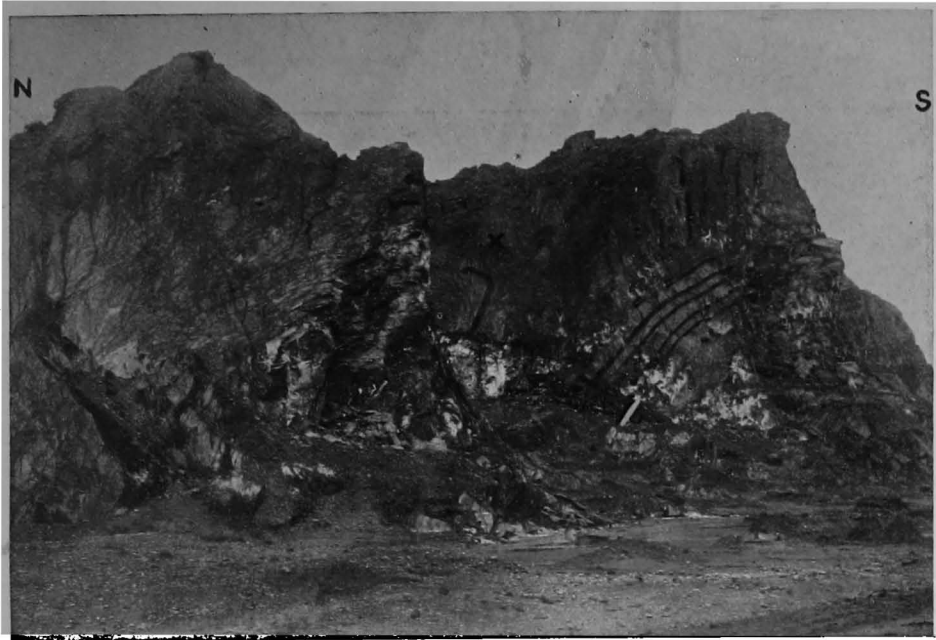
Records, Vol. L, Pl. 16.



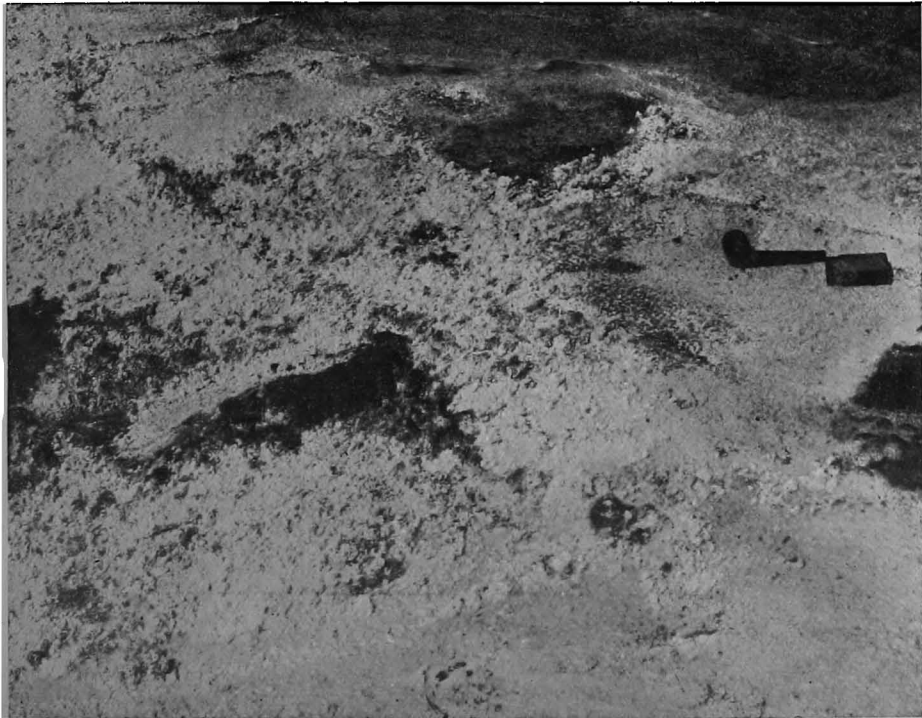
*Photograph by Murray Stuart.*

**NORTH-EAST CORNER OF THE WESTERN SALT HILL, BAHADUR KHEL**

*G. S. I. Calcutta.*



**FIG. 1, WESTERN FACE OF THE WESTERN SALT HILL, BAHADUR KHEL. Showing folding.**



*Photographs by Murray Stuart.*

*G. S. I. Calcutta.*

**FIG. 2, SULPHATE OF SODA BREAKING THROUGH SALT CRUST.**





*Photograph by Murray Stuart.*

*G. S. I. Calcutta.*

**OVERFOLDING AND PUCKERING OF GREY SALT BELOW THE OVERTHRUST IN THE WARCHA SALT MINE. ( $\frac{1}{3}$  Natural size)  
(G, G, are brecciated fragments of gypsum from the fault breccia.)**



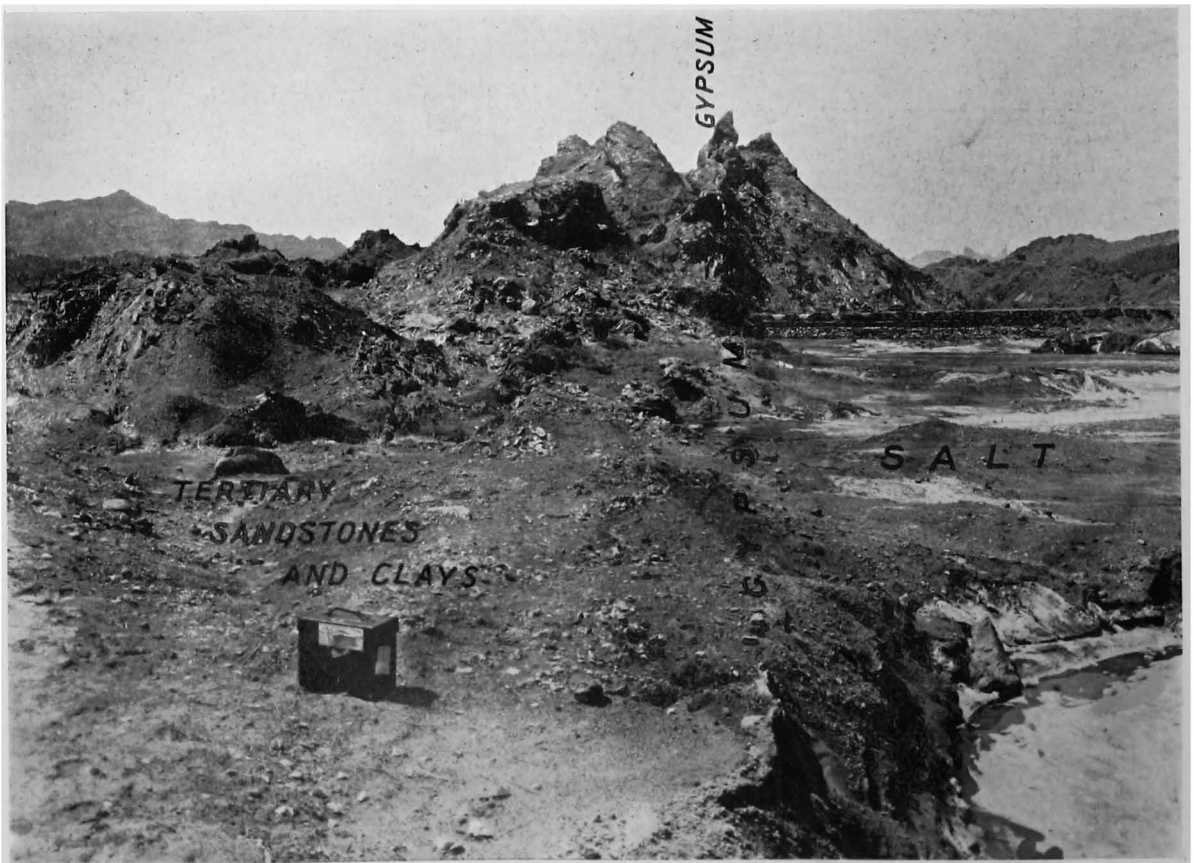
*Photograph by Murray Stuart*

*G. S. I. Calcutta.*

**FORMATION OF A MODERN SHEET OF GYPSUM (G) OVER BAHADUR KHEL SALT.**

GEOLOGICAL SURVEY OF INDIA.

Records, Vol. L, Pl. 11.



*Photograph by Murray Stuart.*

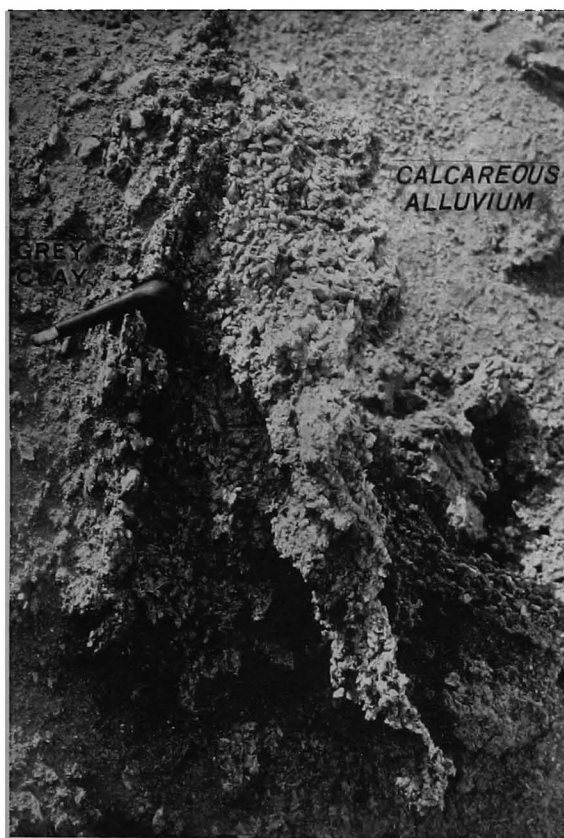
*G. S. I. Calcutta.*

FORMATION OF GYPSUM ALONG THE LINE OF THE FAULT AT THE SOUTH-WEST BOUNDARY OF THE BAHADUR KHEL SALT-FIELD.





**FIG. 1. GYPSUM CRUST COATING LIMESTONE BOULDER.**



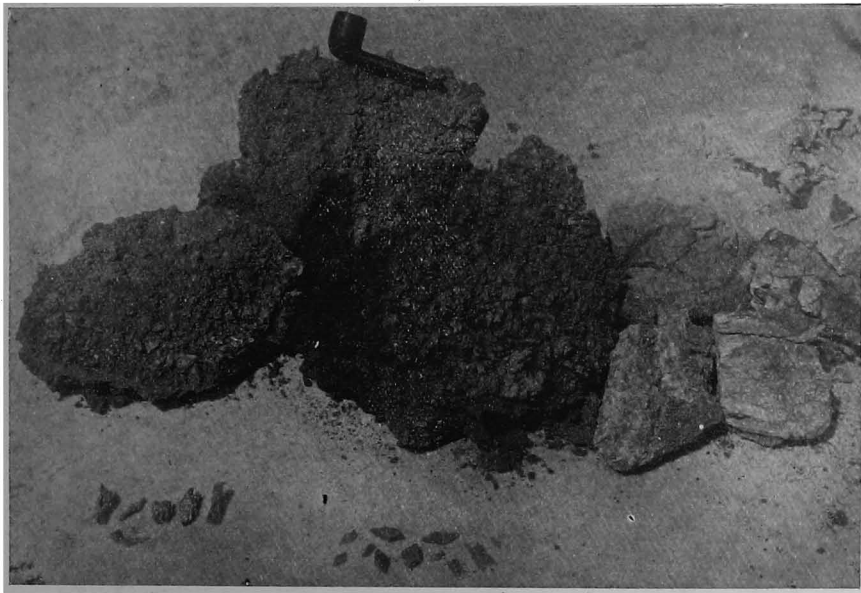
*Photographs by Murray Stuart.*

*G. S. I. Calcutta.*

**FIG. 2. FORMATION OF A MODERN CLIFF OF GYPSUM, IN MINIATURE.**



**FIG. 1. FORMATION OF CRYSTALS OF SELENITE ON THE SURFACE OF GREY CLAY, BAHADUR KHEL SALT-FIELD.**



*Photographs by Murray Stuart.*

*G. S. I. Calcutta.*

**FIG. 2. STAGES IN THE FORMATION OF ROCK GYPSUM.**



*Photograph by Murray Stuart.*

*G. S. I. Calcutta*

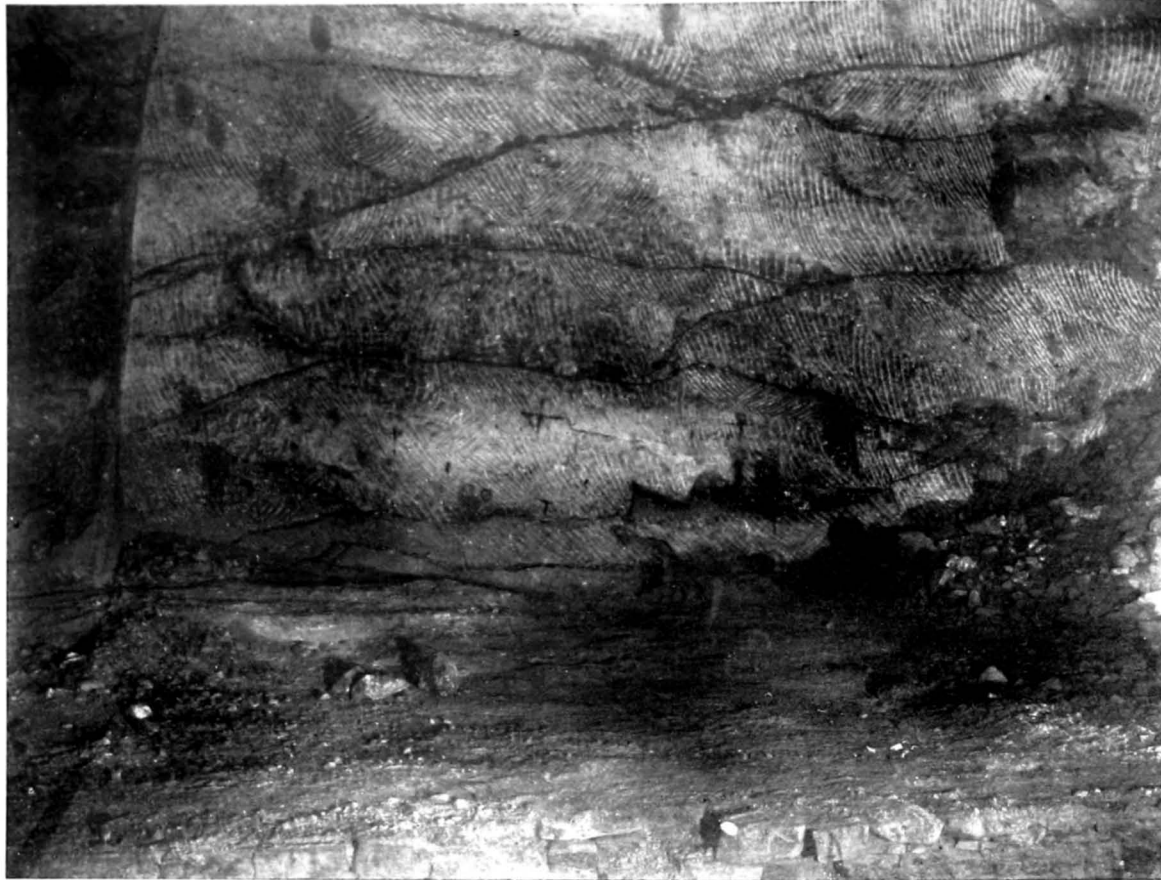
FLOW STRUCTURE EXHIBITED BY THE POTASH AND MAGNESIA BANDS (P), IN CHAMBER No. 3 OF THE WARCHA SALT MINE.



*Photograph by Murray Stuart.*

*G. S. I. Calcutta.*

**THE MAIN MARL BAND OF THE WARCHA MINE**  
Showing thickening and thinning of the included magnesia band. (Chamber No. 4)



*Photograph by Murray Stuart.*

*G. S. I. Calcutta.*

LENTICLES OF SALT OUTLINED NATURALLY BY MARL BANDS, IN THE NEW LOWER TUNNEL, KHEWRA SALT MINE.

*GEOLOGICAL SURVEY OF INDIA.*

Records, Vol. L. Pl. 22.

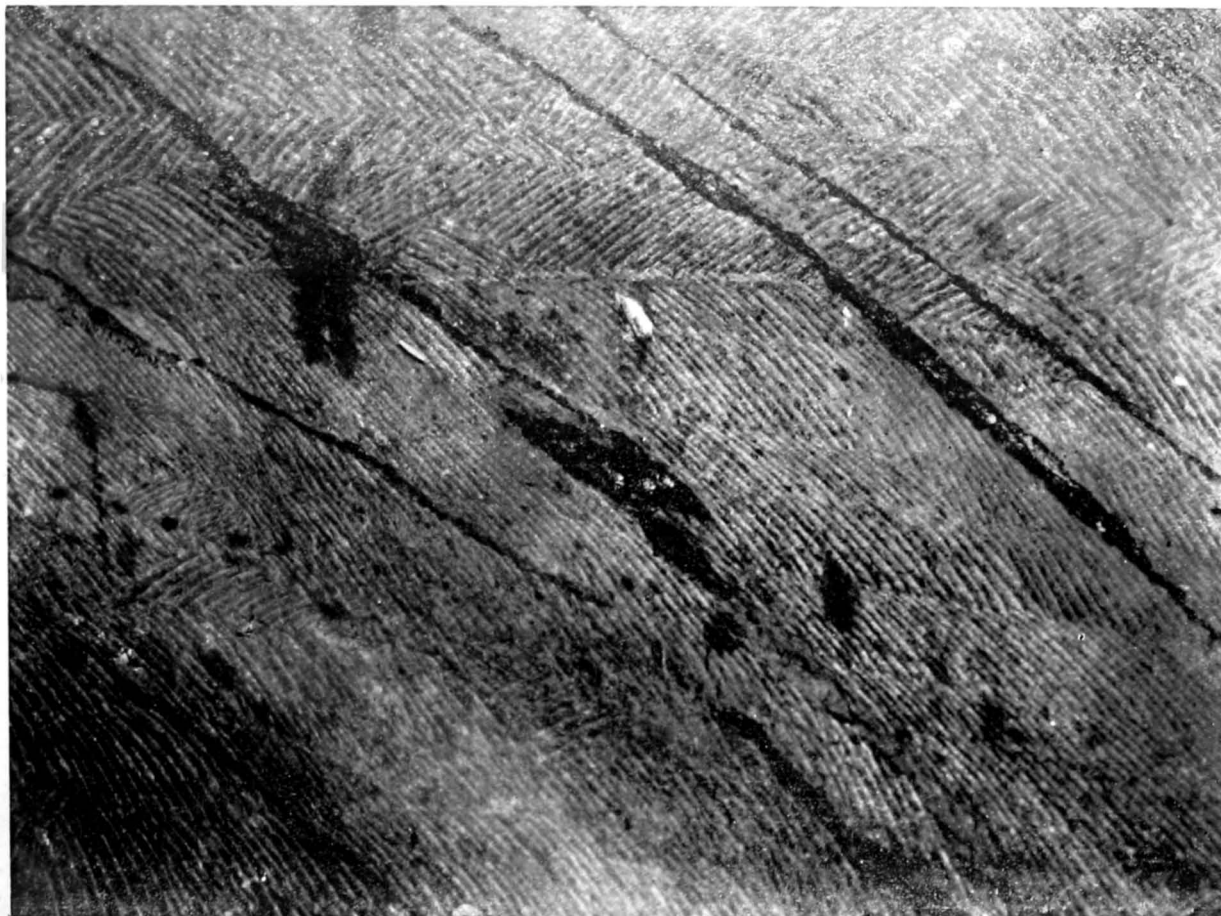


*Photograph by Murray Stuart.*

*G. S. I. Calcutta.*

**PATCHES OF SULPHATE OF SODA ON ALLUVIUM, BAHADUR KHEL SALT-FIELD.**





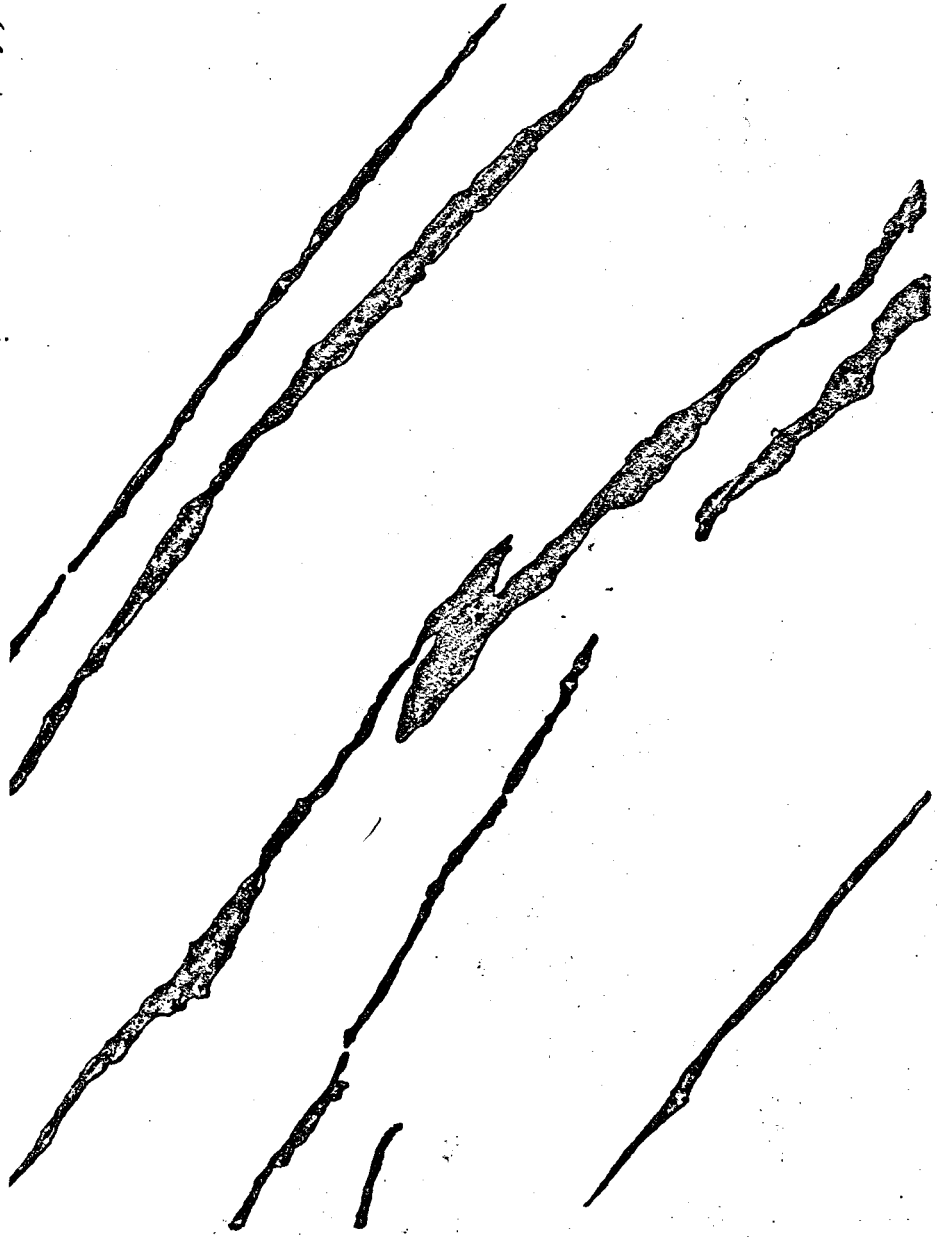
*Photograph by Murray Stuart.*

*G. S. I. Calcutta.*

**BANDS OF MARL IN KHEWRA SALT ( $\frac{1}{2}$  Natural size) Showing clearly that structure is not ordinary stratification.**

*GEOLOGICAL SURVEY OF INDIA.*

Records, Vol. L, Pl. 28. (*Key.*)



A = MARL BANDS.

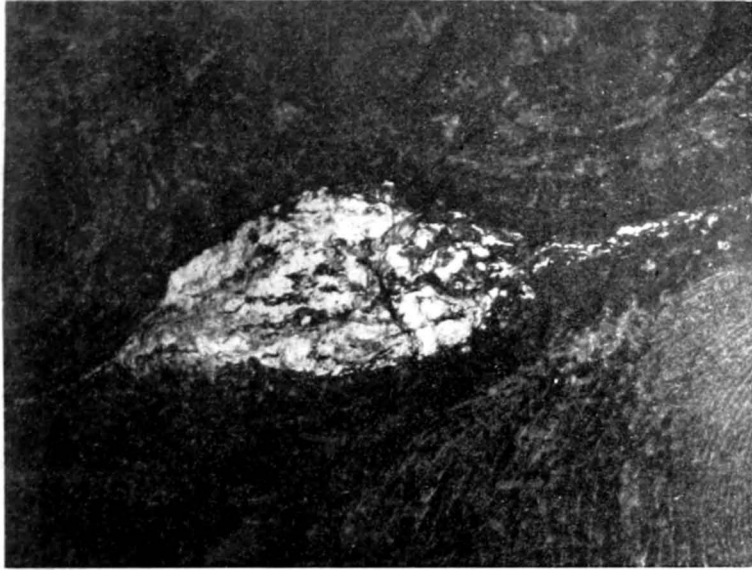




*Photograph by Murray Stuart.*

*G. S. I. Calcutta*

THE WESTERN END OF THE BAHADUR KHEL SALT-FIELD,  
as seen westwards from the Nishpa guard-post, showing the two salt hills in the left middle distance, and the rectangular fracturing of the salt shown up by the clay bands and alluvium which occupy the cracks. Two men are seen taking samples of salt, immediately below the x.



**FIG. 1. AUGEN - SHAPED LENTICLE OF MAGNESIA SALT, 4 FEET THICK, IN THE MAIN MARL BAND OF THE WARCHA SALT MINE.**



*Photographs by Murray Stuart.*

*G. S. I. Calcutta.*

**FIG. 2. FLOW STRUCTURE EXHIBITED BY THE SALT AT KHEWRA.**

*( $\frac{1}{12}$  Natural size.)*

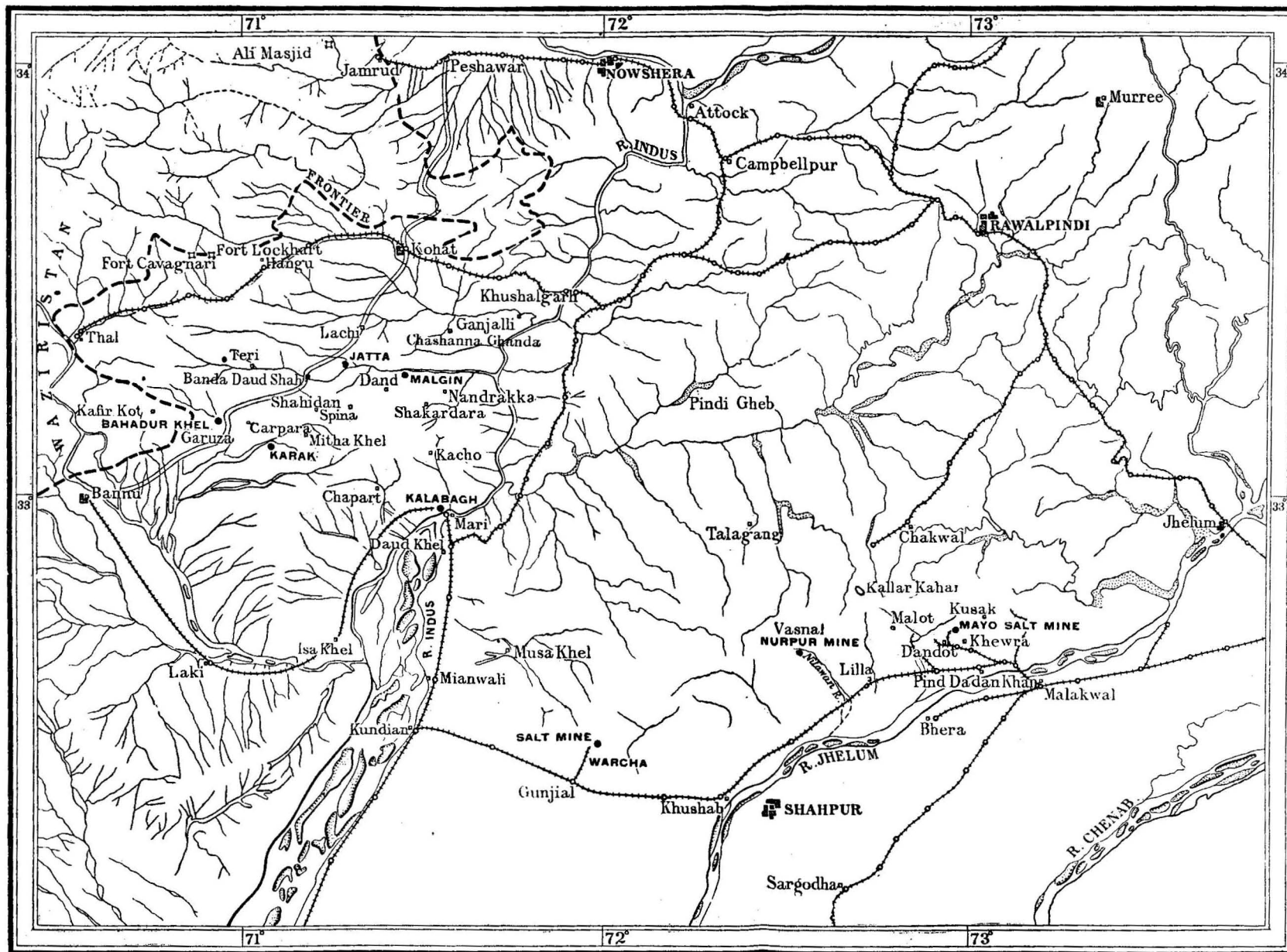
GEOLOGICAL SURVEY OF INDIA



*Photograph by Murray Stuart.*

*G. S. I. Calcutta.*

WELL BANDED KHEWRA SALT, showing lenticular nature. ( $\frac{1}{2}$  natural size).



Scale 1 inch = 24 miles.

G. S. I. Calcutta.

MAP SHOWING SALT LOCALITIES AND DEPÔTS, NORTH-WEST FRONTIER PROVINCE AND PUNJAB.

• GOVERNMENT SALT DEPÔT.

CALCUTTA  
SUPERINTENDENT GOVERNMENT PRINTING, INDIA  
8, HASTINGS STREET



cannot be made out as it is largely obscured by a thick overburden of quartz and felspar rubble derived from the weathering of the finer grained portion of the pegmatite and partly from the quartz core. The texture of the pegmatite varies from a comparatively fine crystalline mixture of quartz, felspar and mica with black tourmaline intergrown with the quartz, to fairly large segregated masses of the main constituent minerals. It is in the latter that a small prospecting pit had been sunk for mica and from which the collection of minerals to be described was made. The felspar is microcline and in the larger masses is graphically intergrown with quartz. It is generally yellowish in colour but crystals were found pink and flesh red. The mica is distinctly greenish in colour and often badly cleaved. The quartz is dark, almost black, but transparent. The colour is completely destroyed at a bright red heat leaving the mineral clear and white. Pink garnets are not uncommon and occur flattened and platy in the small books of mica. The rarer accessory minerals, pitchblende, monazite and columbite occurred together in the small pit and in the coarser portion of the pegmatite.

### Pitchblende.

In the felspar of the pegmatite and particularly in that near the masses of columbite and in one case intergrown with the latter mineral, occur a large number of nodules of a light yellow colour varying in size from a quarter of an inch to two inches or more in diameter. On breaking some of the larger nodules a black core of pitchblende is exposed. The smaller nodules are completely decomposed and no core now remains.

The black core is never quite unaltered. The mineral is usually dull and pierced by a network of cracks filled with a reddish translucent substance. The radiogram on Plate 41, fig. 5, obtained by exposing a plate direct to a smoothed piece of pitchblende shows this feature quite well. The black core shades off gradually into the yellow aureole of decomposition for which uranium ochre is a convenient term. The specific gravity of a piece of the black mineral is only 6.68.

The chemical changes involved in the formation of uranium ochre from pitchblende are shown in the following partial analyses. These analyses have no claim to great accuracy but they were done

**PART 4.] TIPPER: *Monazite & other Minerals from Pichhli.* 257**

under similar conditions and seem to represent fairly the changes involved.

	Pitchblende.	Uranium Ochre.
SiO <sub>2</sub> . . . . .	1.16	12.09
U <sub>3</sub> O <sub>8</sub> . . . . .	66.24	34.74
Rare earths including Thorium	13.9	23.16
PbO . . . . .	12.49	19.1

In addition both contain iron, manganese and barium. The ochre reacts strongly for phosphates. The changes are chiefly leaching out of the uranium which no doubt goes to form uranium bearing minerals of secondary origin, the phosphatisation of the ochre and probably also carbonatisation. It is interesting to note that there is evolution of large quantities of gas from both on solution in nitric acid.

**Crystals in Uranium-Ochre.**

The mode of occurrence of the uranium ochre as rounded nodules in the felspar is very suggestive of an isometric habit for the original mineral. Careful search with a little development brought to light five beautiful specimens of a crystallised variety. The faces are clean and well formed with sharp edges. Parallel growths are not uncommon. No complete crystal has been found but there is more than sufficient material to enable the forms to be determined as a combination of the cube (100) and the octahedron (111). The uranium ochre being rather soft and friable, the measurement of the angles without injuring the faces was a matter of some difficulty. This was solved by cutting an approximate angle as judged by eye in a piece of moderately stiff paper. This was then trimmed until it fitted when the angle was measured direct.

There can be no reasonable doubt that these crystals are pseudomorphs in uranium ochre after uraninite. The largest and most perfect of these crystals is shown on Plate 39, fig. 1. To the right of the large example is another smaller but similar.

**Other Uranium-bearing Minerals.**

Torbernite is common and occurs encrusting mica, apatite and other minerals of the pegmatite, lining cavities and along cleavage cracks in the felspar.

Torbernite.



The form is the usual thin, square table and the mineral is bright green in colour.

Autunite occurs as a lemon yellow-incrustation on some of the minerals. It is, however, much less common than torbernite and is not found crystalline. Both these minerals seem to be of secondary origin, the uranium being derived from the decomposition of the uraninite.

The occurrence of pitchblende at Abraki Pahar, which lies about 5 miles east-south-east of Pichhli, was described by the late Mr. R. C. Burton and his description given in the Annual Report of Geological Survey of India for the year 1913 (*Rec., G. S. I.*, Vol. XLIV, p. 24). I also have had two opportunities of examining this locality and I merely wish to compare and contrast the occurrences.

The mode of occurrence of the pitchblende is similar in the two cases as nodules surrounded by an aureole of yellow uranium ochre but at Abraki Pahar the nodules are of much larger size and in addition are often found in masses of "triplite." As a consequence of the larger size the central uraninite is much less altered and the density is much higher. No crystals or pseudomorphs have yet been found at Abraki Pahar. As at Pichhli autunite and torbernite occur. Columbite is common at both places but whereas at Pichhli it is generally in well-formed crystals, at Abraki it is generally in flattened striated plates.

The "triplite" of Abraki is not by any means a simple mineral but is a complex mixture of at least four phosphates, the relationships of which have not been worked out. One is grey and resembles apatite, a second is dark green and transparent, a third is brown and may be true triplite, the fourth is a beautiful dark purple. They differ in physical and chemical properties. At Pichhli the phosphates found are apatite and monazite, often intergrown. At Abraki a common mineral is a dark brown, almost black zircon. It occurs in crystalline masses in the pegmatite and as isolated crystals in the felspar and occasionally in the quartz. The forms are  $a$  (100) and  $p$  (111). An interesting feature is the presence of well-marked and beautiful zoning (Plate 40, fig. 2). The dark colour of the mineral is destroyed by heat. No mineral of this type has yet been found at Pichhli. As at Pichhli the felspar is generally microcline and the quartz is dark coloured.

### Monazite.

This mineral occurs as isolated crystals and semi-crystalline masses in the felspar. Frequently it is intergrown with columbite and in one instance a small crystal of monazite is completely enclosed in the former mineral. It is also intergrown with mica. With apatite it forms an intimate mixture illustrated on Plate 41, fig. 1. In this many small crystals of monazite are seen enclosed in a matrix of light green apatite. The density of the mixture is 3.8 corresponding to 30 per cent. monazite. A single di-hexagonal crystal of apatite was found growing on a portion of a monazite crystal (Plate 41 fig. 4).

The size of the crystals varies but many are of exceptional size. A fragment of one weighs 500 grams and is some 8 cm. long, while the smallest is a little over 1 cm. in length. One of the semi-crystalline masses weighs over 1½ kilos.

The smaller crystals are sharper and better preserved than the larger, but all have suffered considerably from corrosion from some other mineral, mica, felspar, etc., with the effect that some of the faces are so badly scarred and distorted as to be useless for the purposes of measurement. Curved faces are common, particularly on the larger crystals. Parallel growths (Plate 41, fig. 2) and interpenetration groups (Plate 41, fig. 3) are frequent.

The crystals are prismatic and also flattened || to  $a$ . The following forms have been distinguished:—

$a$ (100)	$n$ (120)
$b$ (010)	$e$ (011)
$m$ (110)	$u$ (021)
$w$ (101)	$r$ (111)

The dominant faces in all the crystals are in order of importance  $w$ ,  $a$ , and  $m$ . The face  $r$  is usually present and conspicuous;  $u$  and  $e$  are small;  $b$  is only developed sparingly on a portion of a large crystal. The tendency is for the right hand part of the crystals to be more fully developed than the remainder (see Plate 42, fig. 1). The illustrations of three good small crystals on Plate 39, figs. 2, 3, 4, give an excellent idea of the habit and external characters of the mineral.

The colour of the mineral is reddish-brown with a resinous lustre. The specific gravity is 5.2. Thin sections show that the mineral has undergone a considerable change from weathering and also that the colour is yellowish. The cleavages are those usual in monazite.

Absorption bands can be readily obtained with a direct vision spectroscopé.

The thoria content is high, an average of three determinations giving 9.95 per cent. Th O<sub>2</sub>. (As these determinations were done on a single fragment, they do not necessarily represent the average of the whole of the monazite found.) The thoria was precipitated by means of hydrogen peroxide.

As is well known extensive deposits of monazite occur in the sands on the coast of the State of Travancore. It has also been found in the pegmatites in the State. The mineral as there found does not resemble that of Pichhli in its physical characters. Monazite occurring near Bangalore, Mysore State (5th milestone, Bangalore-Kakarihalhi road) referred to in *Mineral Resources of Mysore*, p. 191, resembles the material from Pichhli very closely. It is similar in colour, density and external physical characters. It is, however, fresher and its thoria content is lower. The cleavages are more perfectly developed and it shows in a very striking manner multiple twinning, parallel to the face *b*, which in thin section under polarised light makes it an object of great beauty (Plate 40, fig. 1).

### Columbite.

This mineral occurs as crystals of varying sizes arranged as fan-shaped aggregates in the felspar of the pegmatite, the terminations of the crystals being directed outwards. Its association with monazite and uranium ochrè has already been noted. Practically every piece of columbite was crystalline, either complete in itself or broken from some other crystal. The size of the crystals varies from a small good crystal weighing only 5½ grams to one weighing over 6 kilos.

The crystals are well formed but only singly terminated. The faces are sometimes bright and clean but more often covered with a thin, brownish limonitic deposit or a yellowish crust reacting for uranium. Pitting and slight corrosion by quartz and felspar also occur. Groups of crystals in parallel growth (Plate 39, fig. 5) are very common. Sometimes the growths are not truly parallel, as in the specimen figured on Plate 39, fig. 7, where the smaller growths are distinctly curved.

The crystals are prismatic and elongated vertically and if doubly terminated would resemble a double-edged axe. The following forms have been identified:—

<i>a</i> (100)		<i>g</i> (130)
<i>b</i> (010)		<i>e</i> (021)
<i>c</i> (001)		<i>u</i> (133)
<i>m</i> (110).		<i>n</i> (163)

The face *c*, is often missing or only slightly developed. The other faces are generally fairly equally shown. Three good examples are illustrated on Plate 39, figs. 5, 6, 7 and a clinographic projection on Plate 42, fig. 2.

The mineral is opaque even in the thinnest sections. Inclusions parallel to the direction of cleavage comprise quartz, monazite, feldspar and a yellow mineral which reacts microchemically for uranium and may possibly be autunite.

The specific gravities of nine clean crystals are respectively 5.28, 5.3, 5.37, 5.41, 5.41, 5.42, 5.42, 5.44, 5.52 showing that the mineral falls well within the limits of the columbite species.

A single di-hexagonal crystal of apatite was found growing on a fragment of a monazite crystal (Plate 41, fig. 4). The apatite is completely encrusted with bright green scales of torbernite and was at first mistaken for beryl. The question was quickly settled by a chemical test. Apatite also occurs intergrown with monazite forming small semi-crystalline nodular masses in the feldspar (Plate 41, fig. 1).

Two crystals of this feldspar were found. One is flesh-red and the other pinkish. Although dull to the eye thin sections show them to be quite fresh and clear. The better preserved crystal is twinned on the Carlsbad law with *a* (100) as the composition face. The forms present are

<i>b</i> (010)
<i>c</i> (001)
<i>m</i> (110)

It is figured on Plate 39, fig. 8.

Interesting as this occurrence is from a scientific point of view and the rarity of such an association of minerals in India, it seems advisable to emphasise the fact that no conclusions can be drawn as to the commercial prospects of a find of this kind. All the minerals

Commercial possibilities of the deposit.

described come from one small prospecting pit in a pegmatite of some size and no definite run of the minerals has been established. Much more work is necessary, particularly in the sinking of prospecting pits, as, owing to the weathered condition of both the pitchblende and the monazite, they are apt to be overlooked in mere surface searching. It is also necessary to point out that there is little chance of mining monazite at a cost which will enable the product to compete with the extensive and more easily worked deposits on the coast of Travancore. There is no hope of finding concentrates in the stream-bed near Pichhli as the conditions there are in no way suitable.

I should like to thank my colleague Mr. C. S. Fox for much generous help and our artist for the care taken in the preparation of the photographs.

#### EXPLANATION OF PLATES.

PLATE 39.—Fig. 1. Pseudomorph in uranium ochre after uraninite. To the right of the large example is a smaller but similar crystal.

- |         |   |                     |
|---------|---|---------------------|
| Fig. 2. | } | Monazite crystals.  |
| Fig. 3. |   |                     |
| Fig. 4. |   |                     |
| Fig. 5. | } | Columbite crystals. |
| Fig. 6. |   |                     |
| Fig. 7. |   |                     |
| Fig. 8. |   | Microcline crystal. |

PLATE 40.—Fig. 1. Multiple twinning in monazite from Mysore. Crossed nicols.  $\times 19$ .

Fig. 2. Zoned zircons from Abraki Pahar. Ordinary light.  $\times 19$ .

PLATE 41.—Fig. 1. Intergrowth of monazite and apatite. Small crystals of monazite in a matrix of apatite. Reflected light.  $\times 3$ .

Fig. 2. Monazite crystals showing parallel growth. The prominent face is  $w$  (101). Natural size.

Fig. 3. Interpenetration group of monazite crystals. Natural size.

Fig. 4. Dihexagonal crystal of apatite on monazite. Natural size.

Fig. 5. Contact photograph with a piece of pitchblende from Pichhli showing cracks filled with decomposition product.

PLATE 42.—Fig. 1. Clinographic projection of monazite. The face  $r$  has been transferred to the left hand to enable  $u$  and  $e$  to appear.

Fig. 2. Clinographic projection of columbite.

NATURAL GAS IN BITUMINOUS SALT FROM KOHAT. BY  
MURRAY STUART, D.Sc., *Assistant Superintendent,*  
*Geological Survey of India.* (With Plates 43 and 44.)

THE object of this short note is to place on record certain phenomena observed in connection with the bituminous salt of Kohat. This salt, which has already been mentioned in my report on the rock-salt deposits of the Punjab and Kohat,<sup>1</sup> occurs locally in the uppermost few feet of the rock-salt, generally in the form of salt-bitumen schist, though in some places the salt has recrystallized naturally into large crystals which, when held up to the light, show the bituminous matter arranged along what appear to be the original planes of schistosity.

Plate 43, fig. 1, shows a photograph (natural size) of bituminous salt from Malgin in eastern Kohat; the schistose nature of the salt is well seen, as is also the abrupt nature of the contact between the bands of black bituminous salt schist and the non-bituminous pale grey salt. Fig. 2 on the same plate shows a photograph, by transmitted light, of a portion of a crystal of recrystallized bituminous salt (twice natural size), and illustrates how the bituminous matter remains distributed through the crystal along what were the planes of schistosity in the original bitumen-salt schist.

My attention was drawn to the presence of natural gas in this recrystallized material by the fact that, when placed in water and allowed to dissolve, the salt gave off a continual stream of bubbles. I collected some of the gas and found it to be inflammable, burning with a practically non-luminous flame. As the amount of gas collected was surprisingly large, I made the following experiments to ascertain, as far as possible, how the gas is contained in the salt and what is the nature of the other inclusions.

Since the black bituminous contents of the salt-schist are by no means uniformly distributed, I selected, for the experiments, what appeared to be an average specimen of salt. The specific gravity, taken in a saturated brine prepared from the same salt, was found to be 2.49. A portion of a crystal of recrystallized bituminous salt,

<sup>1</sup> *Rec., Geol. Surv. Ind., Vol. I, p. 64.*

similar to that illustrated in Plate 43, fig. 2, was weighed and then placed in distilled water, and the liberated gas collected in a graduated tube. The salt weighed 90.0 grammes, and the amount of gas collected was 19.5 c.c., the temperature at which the experiment was carried out being 30°. That is to say, a piece of a bituminous salt crystal having an approximate volume of 36 c.c. liberated, on solution in water, 19.5 c.c. of gas. In addition to the gas, a trace of oil appeared on the surface of the water, and a quantity of insoluble solid matter remained at the bottom of the vessel. The gas is colourless, and has a characteristic paraffin smell. On analysis in a Hempel apparatus, it was found to belong to the saturated hydrocarbon series (paraffins), and to contain no carbon dioxide, oxygen, unsaturated hydrocarbons, carbon monoxide, or nitrogen. It burned with only a slightly luminous flame. A test for sulphuretted hydrogen with lead acetate paper showed the presence of a small quantity of that gas; it is uncertain, however, whether this may not have come from the salt, as its presence is not rare in the salt of Kohat. In order to determine the amount and nature of the insoluble residue, a second piece of the re-crystallized bituminous salt crystal was weighed and dissolved on a filter paper by allowing water to drip slowly on it. In this way all the soluble matter passed away in the filtrate and the insoluble matter remained behind on the filter. This insoluble residue was dried at 100° C, weighed, and then treated successively with benzene, carbon disulphide and ether to dissolve out any bitumen, dried again at 100° C, and again weighed. As much of the final residue proved to be gypsum, it was not considered desirable to burn off the filter paper and ignite the residue before weighing, and the method of two counterbalanced filter papers was used, the second being subjected to exactly the same conditions as those to which the paper containing the residue was subjected. The result of the experiment was that 25.801 grammes of salt yielded 1.345 grammes of insoluble mineral matter and 0.08 grammes of bitumen. As stated above, the amount of oil liberated in the experiment is merely a film on the surface of the water. By dissolving a large quantity of salt, however, and then extracting this liberated oil, it was possible to obtain sufficient to test its boiling point. It began to distil over at 70° C, but nearly half its volume consisted of an oil distilling over between 250° and 300° C. The insoluble mineral residue consisted of minute highly angular quartz grains and fragments of selenite in about equal

proportions, together with some stony gypsum containing black bituminous matter. The average size of these angular grains of quartz and selenite was between .07 mm. and .036 mm. In addition to this fragmental matter, the residue contained one minute bipyramidal quartz crystal about 1 mm. long and two nearly perfect crystals of selenite, each about  $\frac{1}{2}$  mm. long.

In order to ascertain, if possible, how the gas is contained in the bituminous salt crystals, I took a photomicrograph, focussed into the centre of a crystal, with a magnification of 53 diameters. The result (Plate 44) shows minute bubbles of what appears to be liquified gas scattered through the salt. These bubbles do not seem to be necessarily associated with solid bitumen, but are scattered through the clear portions of the salt as well, probably, as with the black bitumen inclusions. This is further evidenced by the fact that the grey, non-bituminous salt-schist, where it adjoins the black bituminous layers, also contains this gas. It will be seen that in many cases the diameter of these bubbles is less than .01 mm., and in only a few cases is it more than .07 mm.; while the wide distribution of the bubbles probably accounts for the strong smell of paraffin noticed when a crystal of this bituminous salt is merely bruised. That these minute bubbles contain gas in a highly compressed and probably liquid form may be demonstrated by placing a dissolving crystal in a beaker of water and on a suitable sounding board, when, as the salt dissolves, the bubbles can be actually heard bursting their way out of the containing salt, and little bursts of bubbles may be seen, exploding out of the surface of the dissolving crystal as each report is heard. There can be no doubt that the gas is present in the salt under considerable pressure, sufficient probably, except in the case of methane, to convert it to the liquid state.<sup>1</sup> It is clear that the gas could not get into the salt in the gaseous state by sedimentary deposition, neither is it likely that it originated in it by a process analogous to the artificial "cracking" of saturated hydrocarbons, since it is found to contain no unsaturated hydrocarbons. There remain, therefore, two alternatives. The first, suggested by my colleague Dr. E. H. Pascoe, is that the *Ur*-material from which the gas and bitumen subsequently developed was contemporaneous with the salt, and that the bitumen and gas

<sup>1</sup> Methane would not, of course, be liquid, since the critical temperature of methane is considerably below the present temperature of the salt, but even so the gas would have a specific gravity comparable to that of a liquid.



are subsequent products of this contemporaneous *Ur*-material. The second alternative is that suggested in my report on the rock-salt of the Punjab and Kohat, *viz.*, that the occasional bituminous matter in the uppermost layers of the salt and the occasional bituminous matter incorporated in the gypsum immediately overlying the salt may be regarded as extraneous material caught up by and carried forward along the plane of an overthrust and incorporated in places into the uppermost layers of the salt.<sup>1</sup> This would mean that the salt was not the original home of the bitumen, oil and gas, but that they have escaped from their parent rock<sup>2</sup> along the overthrust and have been incorporated in places in the topmost layers of the salt schist immediately under the thrust-plane. Of these two alternatives I prefer the second. The first seems improbable, in view of the fact that the bituminous material occurs in small isolated patches in the uppermost few feet of the salt schist. These patches of bituminous salt schist are exceedingly scarce and occur in only a few exposures, notably at Malgin, Jatta and Nandrakka in eastern Kohat. They are generally associated with bituminous gypsum or with bituminous shales incorporated in the overlying gypsum. The salt itself is devoid of any indication of organic matter associated with it other than those few small patches of bituminous salt.<sup>3</sup> One is faced, therefore, with a discontinuous outcrop of salt schist and foliated salt extending from the frontier in Kohat to the Jhelum district in the Punjab, a distance of over 200 miles, showing no trace of organisms of any kind, but containing in its uppermost layers a very few<sup>4</sup> isolated patches of bituminous salt schist, each only a few cubic yards in volume. It seems unlikely that *Ur*-material would occur only in a few isolated patches of this kind in a length of salt stretching for over 200 miles if that material were contemporaneous with the salt and had been incorporated in it when the salt was first deposited. If *Ur*-material could and did exist in the saline water from which the salt was deposited, it should be fairly evenly distributed throughout the area of deposition, and not isolated in a very few minute patches. It seems more probable that the bituminous matter, oil and gas

<sup>1</sup> *Rec., Geol. Surv., Ind.*, Vol. L, pp. 84 & 91.

<sup>2</sup> Probably the nummulitic limestone or shales.

<sup>3</sup> This observation is confirmed by Wynne (*Mem., Geol. Surv. India*, XI, pt. 2, p. 44 and XIV, p. 84).

<sup>4</sup> Probably not more than five or six such patches are known to exist.

escaped from some other formation during the process of overthrusting, and that some of it became incorporated locally into the uppermost few feet of the salt schist, while some, together with bituminous shale, remained in the brecciated material along the line of the overthrust, being incorporated later in the gypsum sheet which formed along the overthrust plane. Petroleum is known to occur in the rocks which have in places been brought into contact with the salt by the postulated overthrust, and such incorporation of bituminous matter in the uppermost few feet of the salt schist seems not only possible but probable<sup>1</sup>. The above observations seem to confirm the conclusion already arrived at on other grounds and put forward in my report quoted above, that the paraffins and the bitumen are extraneous matter introduced into the uppermost few feet of the salt along the thrust-plane during the formation of an important overthrust. If this view is correct, it is probable that the gas occurs in the re-crystallized bituminous salt in practically the same state as that in which it existed in the oil-bearing rock from which it escaped during the overthrust; and since these crystals are transparent, they afford a valuable means of studying the state in which the gas actually occurs.

#### EXPLANATION OF PLATES.

PLATE 43.—Fig. 1. Bituminous salt schist from Malgin (Kohat), natural size.

Fig. 2. Portion of re-crystallized bituminous salt in transmitted light, twice natural size.

PLATE 44.—Photomicrograph of centre of crystal of re-crystallized bituminous salt, showing bubbles of liquid gas ( $\times 53$  diameters).

<sup>1</sup> As examples of petroleum occurring in formations which have in places been brought into contact with the salt by the overthrust, the following may be cited:—

- (i) the oil issuing from the nummulitic limestone at Jaba (Wynne, *Mem., G. S. I.*, XIV, 264-5, 297);
- (ii) the bituminous shale and clay included in the gypsum at Jatta (Wynne, *Mem., G. S. I.*, XI, 120).

X90(11). 271

THE MINERAL RESOURCES OF THE CENTRAL PROVINCES.  
 BY L. LEIGH FERMOR, O.B.E., D.Sc., A.R.S.M.,  
 F.A.S.B., F.G.S., *Superintendent, Geological Survey of  
 India.* (With Plate 45.)<sup>1</sup>

## CONTENTS.

	PAGE.
I.—INTRODUCTION—	
Geology . . . . .	269—271
Geological occurrence of mineral deposits . . . . .	271—272
Statistics of mineral production . . . . .	272
II.—MINERAL DEPOSITS—	
Aluminium-ore (bauxite) . . . . .	273—275
Asbestos . . . . .	275
Barytes . . . . .	275
Building materials . . . . .	275—277
Coal . . . . .	278—281
Copper-ore . . . . .	281—282
Fire-clay . . . . .	282
Fluor-spar . . . . .	282
Fuller's earth . . . . .	282
Gemstones . . . . .	282—283
Gold . . . . .	283
Iron-ore . . . . .	283—288
Lead and silver . . . . .	289
Lignite . . . . .	289
Lithographic stone . . . . .	290
Manganese-ore . . . . .	290—294
Mica . . . . .	294
Mineral waters . . . . .	294
Ochre . . . . .	295
Salt . . . . .	295
Soda . . . . .	295—296
Steatite . . . . .	296
Tungsten-ore . . . . .	296—297
III. BIBLIOGRAPHY. . . . .	297—302

<sup>1</sup> This note, which has been written for the new edition of the Mining Manual of the Central Provinces and Berar, is also published here in order to render it more generally available.

## I.—INTRODUCTION.

THE geological formations hitherto identified in the Central Provinces are shown in the following list in order of increasing antiquity, the Dharwarian formations being, as far as is known the most ancient rocks identified not only in the Central Provinces but in India:—

Alluvium	{	Newer.
		Older.
Laterite.		
Deccan Trap with Intertrappeans.		
Lameta and other Infra-trappeans.		
Gondwana	{	Upper Gondwana.
		Lower Gondwana.
Purana	{	Upper Vindhyan.
		Lower Vindhyan (with ? the Sullavai series).
		Cuddapah (including the Bijawars and the Penganga series).
Archæan	{	Pegmatites, granites, gneissose granites, and basic intrusives.
		Schistose gneisses.
		Dharwarian formations—including Chilpi Ghat series, Sónakhan beds, Sonawani series, etc.

The foundations of the province are, of course, constructed of the various Archæan formations, which are exposed over a large portion of the province and build up many of the hill ranges. Furthermore, the structure of the Archæan complex has to a large extent determined the disposition of the later geological formations. In the northern portions of the province the average direction of the Archæan fold axes is E. to E.N.E., this being also the strike of the most important orographical feature, *viz.*, the Satpura range, built of Archæan rocks, covered at intervals by the lavas of the Deccan Trap formation, and extending as a geological entity at least as far east as Koréa State and probably as far as Ranchi. Speaking generally, it separates the drainage of the Nerbudda and Son rivers on the north from that of the Godavari and Mahanadi on the south. The general strike of the Bijawars, Vindhyan and Gondwanas, as well as the alignment of the Nerbudda alluvial valley, also conform to this direction. In the southern portions of the province the average direction of the Archæan fold axes tends to be

N.N.E., *i.e.*, parallel to the Eastern Ghats, and certain Vindhyan and Cuddapah ranges also conform to this strike.

The N.E. and S.W. margins of the province are, however, bounded by terranes with a totally different strike, *viz.*, N.W., or at right angles to the average Archæan strike. This strike is exhibited by the Rampur (Raigarh-Hingir) coalfield on the north-east and by the Wardha valley and Godavari valley coalfields in the south-west, with, in the latter case, belts of Lower Vindhyan and Cuddapah rocks of the same average strike. Of a different type is the structure of the wide spread of Cuddapah rocks forming the gently dipping Chhattisgarh basin.

The wide-spreading flows of the Deccan Trap occupy nearly the whole of Berar, as well as wide stretches of the Satpuras, and give rise to the plateaus known as *pats* in Sarguja and Udaipur; this formation appears also as intrusive dykes and sills in various parts of the province, particularly in Korea State, where the dykes show the E.N.E. Archæan strike and where there is also an enormous doleritic sill intrusive in the Gondwanas and extending for many miles to the west into Rewah State in Central India. Immediately underlying the traps in many places are various Infra-trappean rocks, some of which (the limestones) are due to the replacing action of waters derived from the trap upon underlying gneisses and other rocks, whilst others are sedimentary sandstones and clays of Upper Cretaceous age. The Deccan Trap is apparently horizontal, but careful surveys show that there have been wide-spread post-trappean earth movements, causing gentle warping and dips and sometimes faults of considerable magnitude. Capping the Trap in many places, *e.g.*, in Seoni, Balaghat, Mandla, and on the *pats* of Sarguja and Udaipur, are roughly horizontal sheets of laterite occurring at altitudes of 2,000 to 3,500 feet above sea-level.

Finally, the majority of the rivers are bordered by strips of alluvium, amongst which two divisions may be detected: an older (probably Pleistocene) often rich in kankar, and now suffering denudation, in consequence of slight earth movements; and a newer (often darker) alluvium in process of formation at the present day. The wide-spread older alluvium of the Nerbudda and the Purna rivers appears to occupy basins formed as the result of gentle post-Deccan Trap warping of the Peninsula along an axis having a N.N.W. alignment. Finally, resting upon all the geological

formations are the recent-soils varying greatly in character and fertility according to the underlying formation and ranging from the light sandy soils so often found on the crystalline rocks to the heavy black cotton soil characteristic of Berar and usually associated with the Deccan Trap.

The mineral resources might be discussed in two ways—either according to their mode of geological occurrence, or in alphabetical order. For general purposes the latter is the more convenient and will be followed here; but, in order to give an idea of the relative value of the various formations as sources of mineral wealth the following list has been compiled showing the mineral substances of possible economic value known to exist in each formation. Those substances that have proved in the past, or are likely to prove in the near future, to be of considerable economic value are shown in italics. From this list it will be seen that the most important formations from the mineral point of view are the Dharwars, with their deposits of manganese-ore, iron-ore, steatite, red ochre, limestone and dolomite; the Gondwanas, with their stores of coal, fire- and pottery-clays; the laterite, with its bauxite and building stone; and the alluvium with its supplies of brick-clays and kankar. Excellent building stones may be obtained from almost all the formations, as well as materials for the manufacture of cement, particularly in the Lower Vindhyan and Cuddapahs; and many minor mineral products may be developed in the future. Unfortunately, none of the pegmatite veins (with mica, quartz, and rose quartz) or mineral veins (with copper, lead, silver, wolfram, fluorspar, and barytes) hitherto discovered have proved to be of much value.

*Mineral deposits classified according to geological formations.*

ALLUVIUM—*Brick-clays, kankar, salt, gold.*

LATERITIC FORMATIONS—

LATERITE—*Bauxite, building-stone, pyrolusite, iron-ore, ochre, diamonds.*

LATERITOID—*Iron-ore, manganese-ore, ochre.*

DECCAN TRAP—*Building stone (basalt), agate, carnelian, jasper, opal, rock-crystal, soda (trona), mineral waters, Iceland spar.*

INFRA-TRAPPEAN (“LAMETA”)—*Limestone, manganese-ore.*

## GONDWANA—

UPPER—*Pottery clay, fireclay, coal, jasper pebbles.*LOWER—*Coal, fireclay, sandstone, pottery clay, iron-ore, manganese-ore.*

## VINDHYAN—

UPPER—*Sandstone, limestone, lithographic stone, manganese-ore, lead-ore.*LOWER—*Limestone, fuller's earth, shale, lithographic stone, sandstone, diamond.*BIJAWAR—*Limestone, sandstone, jasper, iron-ore, lead-ore, silver.*CUDDAPAH—*Limestone, lithographic stone.*PEGMATITES AND MINERAL VEINS CUTTING ARCHÆANS—*Mica, quartz, rose quartz, fluorspar, barytes, wolfram and ores of copper, lead, silver and gold.*GRANITE—*Building stone.*GNEISS—*Building stone.*DHARWARIAN (including Chilpi Ghat and Sonakhan beds)—*Manganese-ore, iron-ore, limestone, dolomite, marble, ochre, steatite, asbestos, jasper, garnet, opal, spinel.*

The relative importance of the various mineral industries hitherto  
 Statistics of mineral established in the Central Provinces can be  
 production. judged from the following table:—

*Mineral Production of the Central Provinces from 1909 to 1918.*

—	Average. 1909-13	1914	1915	1916	1917	1918
	Tons. (1910) 3	Tons.	Tons.	Tons.	Tons.	Tons.
Asbestos . . .	449	514	876	750	1,363	1,192
Bauxite . . .	17,382	33,738	33,359	—	—	2,918
Clay . . .	227,960	244,745	253,118	287,832	371,498	481,470
Coal . . .	—	—	—	—	—	80
Corundum . . .	100	109	139	179	334	218
Fuller's earth . . .	2,612	18,402	4,747	4,464	3,669	6,097
Iron-ore . . .	—	—	16,445	—	—	—
Laterite . . .	—	3	7	7	—	3
Lead-ore . . .	—	—	—	—	—	—
Limestone and kankar . . .	79,816	148,471	63,079	45,555	86,444	134,798
Manganese-ore . . .	488,485	564,890	399,215	558,828	517,841	438,628
Marble . . .	—	—	—	143	—	—
Ochre . . .	258	108	12	8	900	16
Steatite . . .	476	502	329	892	2,422	3,493
Wolfram . . .	1·3	—	—	1·3	—	—

To all students of the mineral resources of India LaTouche's "A Bibliography of Indian Geology and Physical Geography, with an Annotated Index of Minerals of Economic Value," issued by the Geological Survey of India in two parts in 1917 and 1918 respectively, must prove a standard work; and in compiling the following account of the mineral resources of the Central Provinces, I have drawn freely upon this work and upon the Quinquennial Review of Mineral Production in India published in Vol. LXVI of the *Records of the Geological Survey of India*. In this account I have judged it unnecessary to refer in detail to the original papers, as the full references can usually be obtained in LaTouche's Bibliography. But at the end I have given a bibliography of the more important papers dealing with the mineral resources of the Central Provinces.

## II.—MINERAL DEPOSITS.

### Aluminium-ore (Bauxite).

Some years ago it was discovered that many of the lateritic deposits of India are highly aluminous, such aluminous varieties being identical with bauxite. Field-work carried out since 1903 by the officers of the Geological Survey has revealed the existence of extensive deposits of this material in various parts of India, and chemical investigation in the Geological Survey Laboratory and at the Imperial Institute has shown that certain of the Indian bauxites compare very favourably with the Irish, French and American bauxites placed on the English market.

The richest areas yet discovered in India are the Baihir plateau in the Balaghat district and the neighbourhood of Katni in the Jubbulpore district, both in the Central Provinces. But valuable ores have also been found in other parts of India, as well as in the Sarguja and Jashpur States and in the Mandla and Seoni districts of the Central Provinces. The bauxites to which most attention has been up to the present devoted are those of Balaghat and Jubbulpore. Eight analyses of specimens and samples of the Balaghat bauxites have given results ranging between the following limits:—

	Per cent.
Al <sub>2</sub> O <sub>3</sub> . . . . .	51.62 to 58.83
Fe <sub>2</sub> O <sub>3</sub> . . . . .	2.70 to 10.58
TiO <sub>2</sub> . . . . .	6.22 to 13.76
SiO <sub>2</sub> . . . . .	0.05 to 2.65
H <sub>2</sub> O . . . . .	22.76 to 30.72
Moisture . . . . .	0.40 to 1.14



corresponding to 71.2 to 80.8 per cent. of  $\text{Al}_2\text{O}_3$  after calcination.

Two Katni bauxites gave the following analyses:—

	No. 1	No. 2
$\text{Al}_2\text{O}_3$ . . . . .	65.48	52.67
$\text{Fe}_2\text{O}_3$ . . . . .	3.77	7.04
$\text{TiO}_2$ . . . . .	11.61	7.51
$\text{SiO}_2$ . . . . .	0.38	1.26
$\text{H}_2\text{O}$ . . . . .	19.38	29.83

From these figures it will be seen that the Balaghat and Jubbulpore bauxites are of very high grade. There seems also to be little doubt that large quantities of this ore are available, and the commercial feasibility of making use of these deposits has consequently been under investigation for some years. There are three ways in which the Indian bauxites might be developed:—

- (1) Simple export of the raw or calcined material to Europe or America for use in the alumina factories.
- (2) Manufacture of pure alumina locally by extraction with alkali, and export of the pure oxide to European or American aluminium works.
- (3) Manufacture of the metal in India.

The first proposal is impracticable on account of the low prices of raw bauxite at European ports (22s. to 23s. per ton was an ordinary pre-war price), whilst the third would involve a heavy capital outlay under untried conditions, and elaborate preliminary investigation before power works could be erected. The second proposal involves much smaller risks, and it has been found on investigation that there are no technical difficulties in the way of manufacturing alumina from Indian bauxites<sup>1</sup>; and in this connection it is of interest to note that the price obtained for manufactured alumina in England varied from £5-10-0 to £7-10-0 in pre-war years. Several concessions have been taken out for working the bauxites of the Central Provinces, in the practical investigation of which considerable progress has been made.

The occurrence of aluminous laterite at Tikari near Katni, Jubbulpore district, was first noticed by Mr. F. R. Mallet in 1883.<sup>2</sup>

<sup>1</sup> *Rec. Geol. Surv. Ind.*, XXV, p. 29; XXXVI, p. 220.

<sup>2</sup> *Rec. Geol. Surv. Ind.*, XVI, p. 113.

Early in 1905, after the Geological Survey had drawn attention to the identity of aluminous laterites with bauxite, Mr. P. C. Dutt of Jubbulpore secured an exploring license over this area, and later prospecting licenses were taken out by Mr. Dutt and a syndicate formed by him called the Bombay Mining and Prospecting Syndicate, with Messrs. C. Macdonald & Co., of Bombay, as Managing Agents. The objects of this syndicate were varied, including the manufacture of hydrated alumina, alum and aluminium, of cement and lime, and of pottery, fire-bricks, etc., materials for all these purposes being found within the bauxite concessions.

In August, 1912, the Katni Cement and Industrial Company, Ltd., was floated to acquire the Katni properties of the above syndicate, including the bauxite deposits.

It is understood that investigations are now in progress concerning the feasibility of utilising the bauxites of this province for the manufacture of aluminium.

### Asbestos.

Small quantities of crude asbestos have been won at Tumkhera Khurd in the Bhandara district, but the samples received by the Geological Survey of India were of very inferior quality. The mode of occurrence has not been investigated.

### Barytes.

One of the copper lodes at Sleemanabad in the Jubbulpore district proved to be rich in barytes, and a wagon load of this was despatched to Calcutta about the year 1904 for use in the works of the Shalimar Paint, Colour and Varnish Co., Ltd. The quality was, however, found to be poor. This locality is, in any case, not likely to be of much value as a source of barytes unless it should prove feasible to work the lodes for their metalliferous contents.

### Building Materials.

Materials suitable for building purposes occur in great variety and abundance throughout the province and in all the geological

formations. The alluvial tracts, not only of the Narbada, Purna, Wainganga, Kanhan and other big rivers, but also of many of the smaller streams, yield excellent brick-clays, whilst kankar is frequently abundant in the tracts of older alluvium. Laterite, as is well known, forms an excellent material for roads and culverts, and is abundant in some parts of the province, and its valuable variety, bauxite, has at times been unwittingly used for road-metal and building purposes (*e.g.*, in Balaghat). The Deccan Trap areas provide an excellent building stone, *viz.*, basalt (*e.g.* at Sitabaldi, on the Satpura branches of the Bengal-Nagpur Railway, and in many parts of Berar). The so-called Lameta or Infra-trappean limestone, cropping out from below the Deccan Trap in many parts of the province, *e.g.*, in the Satpuras and in Nagpur and Chanda (Karamgaon), constitutes an excellent ragstone, and has been successfully used for bridges on the Nagpur-Chhindwara branch of the Bengal-Nagpur Railway.

Turning next to the Gondwana formation, clay suitable for pottery purposes is quarried at Jubbulpore from the Jabalpur group of the Upper Gondwanas, whilst sandstones suitable for ashlar work and fine carving may be obtained from the Kamthi division of the Lower Gondwanas. Well-known localities are Bhutara hill and Isapur in the Chanda district, Silewada near Kamthi, Akhund in Nimar and Ellichpur in Amraoti. Fine white sandstones are quarried at Sirgora and Pathe in Betul from the Talchir stage.

The Vindhyan formation is a well-known source of good building stones, the red, yellow and buff sandstones used in so many of the famous buildings of Northern India being derived from various divisions of the Upper Vindhyan. In the Central Provinces, the Rewah group near Hoshangabad has yielded thin red sandstone flags for use as roofing tiles.

The Lower Vindhyan limestone of Katni has been quarried for some years by Messrs. Cook & Sons and others for lime-burning and building purposes, and is also now utilised by the Katni Cement and Industrial Co., Ltd., together with Lower Vindhyan shales, for the manufacture of cement. Similar materials are to be used by the newly-floated Central Provinces Portland Cement Co., Ltd., the works of which are also to be placed near Katni.

The Raipur limestones and underlying Chandarpur sandstones of the Chhattisgarh basin are variously regarded as of Lower Vindhyan and Cuddapah age, more probably the latter. The limestones are now being extensively used for building purposes; in particular, a dark bluish limestone from Sikosa in the Drug district has been used extensively for flooring in buildings at Nagpur. The Pem or Penganga limestones (Cuddapah) are said to yield good building stone in places in the Chanda district (at Kandara). Future investigation may prove the suitability of Chhattisgarh for the establishment of a cement industry based on the use of the Raipur limestone, with shale derived from one of the neighbouring coal-fields.

The building stones obtainable from the Bijawar formation are of inferior quality. The limestone has been used in the construction of temples at Khudia in Hoshangabad, but, owing to siliceous bands, is usually too hard to be worked with ease. The coarse sandstone of Chirakhan in the same district has been used for building the fort at Joga and temples in the neighbourhood. The red jaspers occurring in this formation might be used for ornamental purposes.

In the Archæan formations several excellent building and ornamental stones occur. The most valuable and beautiful is marble, often dolomitic, of Dharwarian age. The best known locality is the Marble Rocks in the Jubbulpore district, but numerous excellent marbles occur in the Betul, Chhindwara, Nagpur and Seoni districts. The most accessible localities are at Khorari in the Nagpur district, and in the Sausar tahsil of the Chhindwara district, where some beautifully marked serpentine marbles are found (*e.g.*, near Devi); but hitherto they have been used only for local railway culverts and bridges. In the Dharwar outcrops there are also bedded quartzites, *e.g.*, in the Ambagarh range in the Bhandara district. Such quartzites have been used in the forts at Ramtek and Ambagarh. Amongst the various phyllitic and schistose rocks of the Chilpi Ghat series, slabby rocks suitable for roofing and flooring could perhaps be discovered. In the Archæan tracts of the Central Provinces there are also wide stretches of gneiss and granite, many of which would form excellent polished ornamental stone, *e.g.*, the gneissose granite near Jubbulpore and in the Satpuras near Lamta on the Jubbulpore-Gondia branch of the Bengal-Nagpur Railway.

## Coal.

The province contains over 30 coalfields, of which the following is a list:—

## SATPURA AREA—

*Narsingpur district—*

1. Mohpani (8).

*Betul district—*

2. Lokartalai.
3. Shapur.

*Chhindwara district—*

4. Tawa R. (partly in Betul)
5. Kanhan R.
6. Hingladevi.
7. Barkui or Pench Valley.
8. Sirgora.

## CHHATTISGARH &amp; CHHATTISGARH FEUDATORIES—

*Korea State—*

9. Sanhat (part of Sohagpur field in Rewah).
10. Jhagrakhand do.
11. Kurasia (30-50)
12. Koreagarh.

*Jhilmilli State—*

13. Jhilmilli.

*Sarguja State—*

14. Ramkola-Tatapani (partly in Central India).
15. Panchbarni.
16. Bisrampur.
17. Bansar.
18. Lakhanpur (partly in Bilaspur).
19. Rampur.

*Bilaspur district—*

20. Damhamunda (in Matin).
21. Sendurgar (in Matin).
22. Lapha (part of the Korba field).
23. Korba.

CHHATTISGARH & CHHATTISGARH FEUDATORIES—*contd.**Udaipur State—*

24. Mand R.

*Raigarh State—*

25. Raigarh-Hingir (Rampur), partly in Bihar &amp; Orissa.

## WARDHA VALLEY GROUP—

*Chanda district—*

26. Bandar.

27. Warora (14).

28. Ghugus (45).

29. Ballarpur (partly in Hyderabad) (36).

*Yeotmal district—*

30. Wun-Papur (50).

31. Wun (2,100).

32. Junara &amp; Chicholi (partly in Chanda) (75).

Space will not permit an account of all these fields, for which references should be made to the "Coalfields of India" by V. Ball and R. R. Simpson.

All the above coalfields belong to the Barakar division of the Lower Gondwanas, but, in addition, coal has been found in Upper Gondwana rocks at Lameta Ghat and other localities in the Narbada valley; such coal has, however, never been considered worthy of exploitation except for local purposes, and will not be referred to further.

Considering now the Lower Gondwana coals of the Central Provinces, it may be said that, generally speaking, those hitherto worked have yielded coal of second- or third-class quality as compared with the best coals of Bihar and Orissa. Samples from some of the unworked fields, such as the Kurasia field in Korea State, show, however, that the province does possess coal of first-class quality, though usually in the less accessible parts. As regards quantity the amount of coal in some of these fields is very considerable, and, according to the estimate of Hughes, the fields of the Wardha valley contain 2,525 million tons of coal, of which 1,714

million tons is regarded as available: of this 1,500 million tons lies in the Wun field. In cases where estimates have been made, the quantities are indicated in millions by the figures placed after the names of the fields in the list given above.

In spite, however, of the existence of this large number of coal-fields, the majority have not been worked, partly owing to their situation as regards communications and partly on account of inferior quality. The Warora field, after being worked for 33 years as a Government colliery, was closed down in 1906, and replaced by the Ballarpur colliery, which was handed over to a private firm in 1913. The Mohpani field was first opened up in 1862 by the Nerbudda Coal & Iron Co., Ltd., and in 1904 was sold to the Great Indian Peninsular Railway. In the Pench Valley (Barkui) field, collieries have been at work since 1905, and this field is now served by both the Bengal-Nagpur Railway and the Great Indian Peninsular Railway; and, as will be seen from the figures given below, this field is now the chief producer in the Central Provinces. A colliery is also being opened out on the Ghugus field, where a pit was sunk and worked for a time as long ago as 1870. Prospecting operations are being conducted in the Kurasia field in Kosea, to which it is proposed to construct a branch line from the Katni-Bilaspur Chord of the Bengal-Nagpur Railway. Coal is also being raised from the Raigarh-Hingir field, but from the portion situated in the Sambalpur district of Bihar and Orissa. The following figures show the output of coal from the coalfields of the Central Provinces during the years 1914-1918:—

—	1914	1915	1916	1917	1918
	Tons.	Tons.	Tons.	Tons.	Tons.
Ballarpur . . .	89,292	94,880	48,889	95,303	135,375
Mohpani . . .	59,774	55,086	48,395	71,693	78,792
Pench Valley . . .	95,679	103,152	154,548	204,502	267,303
TOTAL .	244,745	253,118	287,832	371,498	481,470

The quality of the coals of the Central Provinces may be judged from the following selected table of analyses of coals from some of the best-known fields.

—	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	
<i>Satpura coalfields—</i>						Average of—
Mohpani, coal . . .	2.52	24.26	48.71	24.01	0.50	10 samples.
do. splint . . .	2.84	20.55	37.42	38.24	0.95	
Barkui field . . .	—	22.8	53.6	23.6	—	3 samples.
Barkui . . . . .	1.73	24.07	52.59	21.61	0.73	1 sample.
Sirgona . . . . .	—	28.0	61.6	10.4	—	
<i>Chhattisgarh coalfields—</i>						
Sanhat field, lower seam	5.79	28.22	44.80	21.19	—	3 samples.
do. upper do.	4.19	24.00	44.00	27.81	—	5 „
Kurasia field, Kurasia	8.66	30.92	48.86	11.56	—	6 „
do. Chirmiri	7.7	29.1	51.2	12.0	—	10 „
Bisrampur, Rer & Pasang rivers.	—	37.6	57.0	5.4	—	2 „
Bisrampur Mahan & Masan rivers	—	19.5	48.0	19.6	—	3 „
Lakhanpur (Parsa) . .	7.50	28.70	50.90	12.90	—	5' 6" seam
Korba (Ghordewa) . .	6.91	29.06	53.93	10.10	—	5' seam (2 samples.)
<i>Wardha Valley coalfields—</i>						
Wun-Papur (Pisgaon).	—	19.4	63.9	16.7	—	2 samples.
Ghugus . . . . .	—	33.49	45.61	20.90	—	32 boring samples (32" seam).
Ballarpur . . . . .	11.10	31.56	45.47	11.87	—	1 sample from boring core.

### Copper-ore.

Copper-ores have been discovered at several localities but none of these occurrences has hitherto proved to be large enough for exploitation by modern methods. The best known occurrence is at Sleemanabad in the Jubbulpore district, where a series of veins up to 4 feet wide, and cutting across the strike of dolomites of Dharwarian age, were made the object of prolonged prospecting operations by Messrs. P. C. Dutt and Burn & Co. some years ago. The chief ores found were chalcopyrite, tetrahedrite, and galena, with barytes; and selected samples yielded up to 200 ounces of silver per ton. The lodes did not, however, prove to be large



enough nor sufficiently persistent to justify mining operations. Azurite and malachite with oxides of copper occur disseminated through schists regarded as of Bijawar, but more probably of Dharwar age, at Birman Ghat on an island in the Narbada in Narsinghpur district. These ores were mined by the Narbada Coal and Iron Company some 45 years ago, and a certain quantity of the ore was sent to England, but the mine was ultimately abandoned. Several of the early samples yielded from 12.6 to 47.8 per cent. of copper, the average yield being 28 per cent. Incrustations of copper carbonates have been found in excavations on a quartz reef in the Chilpi Ghat series at Malanjhandi in the Balaghat district, and also in the galena-quartz vein traversing the gneiss near Chicholi in the Drug district (see page 289).

#### **Fire-clay.**

Fireclay is often found in the Indian coal measures associated with coal-seams, frequently as an under-clay, and could probably be obtained from most of the coalfields of the Central Provinces if required. In particular, it has been noticed as a stratum 11' 3" thick above No. 2 seam at the Warora colliery. Some of the white Upper Gondwana clays of Jubbulpore are found to be exceedingly refractory and are used in Messrs. Burn & Co.'s and other local pottery works.

#### **Fluor-spar.**

Fluorite is found in small quantities in the galena-quartz vein at Chicholi in the Drug district, and has also been found in minute quantities in a vein of altered quartz-porphry carrying copper and lead-ores at Sleemanabad in the Jubbulpore district. Neither occurrence appears to be of any value as a source of fluor-spar.

#### **Fuller's Earth.**

This substance has been raised for some years from the Lower Vindhyan rocks at Katni, the average annual output for the 5 years (1914-1918) being 196 tons.

#### **Gemstones.**

Diamonds were formerly worked at Wairagarh in the Chanda district, but by 1843 the workings had been abandoned. The gems

are said to have been obtained from a lateritic grit, and it is suggested that the source of the diamonds was the Lower Vindhyan (?Cud-dapah) rocks of this district. The geodes of the Deccan Trap formation are the source of many varieties of semi-precious stones, all of them forms of silica, such as agate, carnelian, onyx, jasper, amethyst, and rock crystal. These minerals are commonly found in rivers draining off the Deccan Trap, and their abundance in the bed of the Narbada has led to the establishment of an Indian lapidary industry at Jubbulpore, where many varieties of polished agate may be purchased. Although it is not a gemstone, yet it is convenient to mention here that crystal-clear pieces of calcite suitable for use as Iceland spar for optical purposes are sometimes found in geodes in the Deccan Trap. Such material would probably prove to have a considerable market value.

The Archæan rocks occasionally contain rose-quartz suitable for use as an ornamental stone, as at Khairi in the Chhindwara district. The crystalline limestones of this district sometimes carry a lilac-coloured spinel, which has not hitherto been found in gem quality, however.

### Gold.

Alluvial gold has been obtained from time immemorial by local gold-washers or *jhoras* from the river-sands and gravels of the province, but there is no evidence that it exists anywhere in sufficient quantity to be worth exploitation by modern methods. Amongst the districts and states that have thus yielded alluvial gold are Balaghat, Bastar, Bhandara, Bilaspur, Jashpur, Mandla, Raipur, Seoni, and Udaipur. Such alluvial gold has probably been derived ultimately from the ancient Archæan rocks, but the only localities where gold has been obtained *in situ* are Sonakhan in the Bilaspur district, where a gold mine is said formerly to have existed, and Sleemanabad in the Jubbulpore district, where gold has been found in the copper-ores in quantities ranging up to 15 dwt. per ton.

### Iron-ore.

Iron-ores are widely distributed throughout the province, which is now perhaps the chief home in India of iron-smelting in small

indigenous blast furnaces. The following table shows the number of furnaces at work during recent years:—

	1909	1913	1917
Bilaspur . . . . .	103	99	103
Balaghat . . . . .	4	—	(a)
Chanda . . . . .	9	20	(a)
Drug . . . . .	56	40	52
Jubbulpore . . . . .	26	29	[(a)
Mandla . . . . .	65	49	(a)
Narsinghpur . . . . .	4	(a)	(a)
Raipur . . . . .	230	181	157
Saugor . . . . .	13	19	(a)
TOTAL . . . . .	510	437	312

(a) No figures available.

Returns showing the quantity of iron produced in these furnaces are no longer available, but the average annual yield per furnace is only about  $1\frac{1}{2}$  tons. At one locality, Ghogra, in the Jubbulpore district, manganiferous iron-ore is smelted with production of a steely iron known as *kheri*.

The iron-ores are found in four geological formations, *viz.*, laterite, the Chikiala and Barakar divisions of the Gondwana, the Bijawar, and the Dharwar, of which the last is the most important to the modern smelter.

Lateritic ores are most abundant near Katni in the Jubbulpore district, but are also found in Drug, Saugor, Yeotmal and other districts. In the Jubbulpore district the lateritic ores are well seen at Bijori and in the Kanhwara hills; in the latter locality three bands of ore, ranging from 2 to  $2\frac{1}{2}$  feet thick, are estimated to contain 49 million tons of ore. One sample yielded 57.52 per cent. of iron and 0.76 per cent. of  $P_2O_5$ .

Further south in this district, the upturned edges of the Dharwar hematites are capped by lateritoid limonitic ores formed by replacement.

Brown and red hematite occur abundantly in the sandstones of the Chikiala stage in the valley of the Pranrita, and are smelted in native furnaces at Yemlapali in Hyderabad territory and at neighbouring localities in the Chanda district.

The ores of Barakar age occur as ironstone zones at two horizons in the Raigarh-Hingir coalfield in Raigarh State, being most abundant near Kodoloi.

Iron-ores are also found in the Bijawar rocks in Nimar, Hoshangabad and Narsinghpur. In the two former districts the ores are almost invariably hematite, obtained from breccias occurring in the Bijawar series near the junction with the Vindhyan, or from debris derived from the same rocks. There is no evidence that these ores exist in sufficient quantity to interest a modern smelter, although they have been largely used in the past by the native smelter.

At Omarpani near Tendukhera in the Narsinghpur district both hematite and limonite occur irregularly distributed in fissures and hollows among the Bijawar limestones and quartzites, and were formerly smelted extensively by indigenous methods. In 1855 to 1857 some 70 to 80 furnaces were at work with a production of about 140 tons of iron annually. This metal was of unusually good quality, and a portion of it was converted into steel by re-heating, hammering, rolling in burnt cow-dung, and plunging into water. No estimate of the quantity of ore available appears to have been made.

The most valuable and abundant of the Central Provinces iron-ores occur in the Dharwarian rocks, particularly in the Chanda, Drug, and Jubbulpore districts, but also in Bastar State. Magnetite has been reported from the Archæan tracts of Kenda zamindari, Bilaspur district.

With the exception of the Chikiala ores referred to, the iron-ore deposits of the Chanda district are all situated in the Archæan tracts, where they form well-marked bands (possibly beds) usually associated with Dharwarian rocks. The ore is usually hematite associated with banded hematite-quartzites, but magnetite is sometimes present. At least ten separate deposits have been located, and although they have not yet been exhaustively prospected, there is little doubt that some of them are of large size. The two best known are Lohara, where the iron-ore forms a hill  $\frac{3}{4}$ th of a mile long, 200 yards wide, and 120 feet

high, and has been traced for a further distance of 2½ miles; and Pipalgaon, where a very fine mass of red hematite has been located.

In 1875 unsuccessful experiments were made at Warora in smelting iron-ore from Lohara and Ratnapur with Warora coal and a few years later a scheme was proposed for the establishment of modern iron works at Durgapur on the Erai river to smelt the ores of Lohara and Pipalgaon with charcoal fuel, the suggested scale of production being 25,000 tons of pig iron annually. Nothing, however, resulted from this proposal, and the Lohara deposit is now leased to the Tata Iron & Steel Co., Ltd., and held in reserve, except when small quantities of this very low-phosphorus ore are required, for special purposes at Jamshedpur. The quality of the Chanda ores can be judged from the following analyses:

	Fe.	SiO <sub>2</sub> .	S.	P.
Asola . . . . .	65.99	3.89	—	—
Dewalgaon . . . . .	61.2	11.04	—	—
	67.76	1.50	—	—
Lohara . . . . .	69.21	0.82	0.012	0.005
Pipalgaon . . . . .	71.05	4.5	trace.	trace.
Poser . . . . .	69.8	—	—	—
Ratnapur (limonite) . . . . .	49.7	26.0 (insol.)	—	—

The occurrence of valuable iron-ores in parts of the Raipur district (now included in Drug) was not known until Drug district. Mr. P. N. Bose briefly referred to the chief deposits in a paper published in the *Records, Geological Survey of India*, Vol. XX, page 167 (1887). The district having been explored again on behalf of Messrs. Tata, Sons & Co., by

Iron-ores of the Drug district, C. P. Mr. C. M. Weld, a large area in the Dondi-

Lohara zamindari<sup>1</sup> in the western part of the district was taken up under prospecting license for detailed examination. The iron-ores, on account of their resistance to weathering agents, stand up as conspicuous hillocks in the general peneplain. The most striking of these is the ridge which includes the Dhalli and Rajhara hills, extending for some 20 miles in a zigzag, almost continuous line, and rising to heights of sometimes 400 feet above the general level of the flat country around. The iron-ores are

<sup>1</sup> This portion of the Raipur district has been included in the new district of Drug.

associated with phyllites and are often of the usual type of banded quartz-iron-ore schists characteristic of the Dharwar system. But in places, thick masses, apparently lenticular in shape, are formed of comparatively pure hematite, and one of these in the Rajhara hills has been subjected to very careful examination by diamond drilling. The Rajhara mass was carefully sampled across the surface at each point selected for a drill hole, and the cores obtained were also analysed in lengths representing successive depths of 10 feet each from the surface, giving altogether 64. samples, which were assayed for iron, phosphorus, sulphur, silica, and manganese. The average results obtained for the surface samples were as follows: Fe, 66.35; P, 0.058; S, 0.108;  $\text{SiO}_2$ , 1.44; Mn, 0.151 per cent; while for the cores the averages were Fe, 68.56; P, 0.064; S, 0.071;  $\text{SiO}_2$ , 0.71; Mn, 0.175 per cent.

In this mass the prospecting operations thus proved the existence of  $2\frac{1}{2}$  million tons of ore carrying about 67.5 per cent. of iron and a phosphorus content slightly below the Bessemer limit. The quantity estimated is that which may be regarded as ore in sight, while almost certainly much larger quantities may be obtained by continuation of the ore-bodies beyond their proved depth. There are other large bodies of ore in this area which have not been examined in the same detail. These masses of hematite include small quantities of magnetite, but separate determinations of the iron in the ferric state have not been made in order to determine the relative proportions of the two minerals.

The iron-ores of the Jubbulpote district have long been famous, and although the native industry now exists on only a small scale, some of the localities such as Majhgaon near Sihora, are very accessible, so that the indigenous processes of iron smelting can be readily studied. A fine red ochre has been quarried for some years for paint manufacture at Jauli. The lateritic limonite deposits of this district have already been referred to. The hematite deposits, apparently interbedded with the Dharwar phyllites, had for years been supposed to be very rich, but prospecting operations conducted in this area by E. P. Martin and H. Louis have shown that while iron-ore is widely distributed, and the formations in which it occurs are prominent in the district, there are no rich ore-bodies of large size that could be relied on for the output necessary to maintain an important industry, and most of the ore, being in the form of soft micaceous

hematite, would be physically unfit in its natural condition for use in a blast furnace. Generally, also, the ores in this district contain a proportion of phosphorus too high for acid Bessemer steel.

The following analyses, extracted from Messrs. Martin and Louis' report (*Agricultural Ledger*, Calcutta, 1904, No. 3), give an idea of the nature of the ore in the principal occurrences in the Jubbulpore district:—

—	Iron.	SiO <sub>2</sub> .	S.	P.	Moisture.
I. Agaria hill. Lateritic cap covering most of the hill. 3 samples	57.58	7.28	0.02	0.125	0.45
	56.85	8.17	0.02	0.125	0.67
	45.67	13.90	0.03	0.187	0.69
Soft micaceous hematitic schists. Ore-layers only. 2 samples.	60.70	7.45	0.019	0.075	0.25
	58.40	8.40	0.022	0.081	0.33
II. Agaria ridge. Bed of hematite 4 to 5 feet thick, dipping 50°.	50.07	11.37	0.036	0.074	0.44
III. Jauli. Soft banded hematite-quartzschists. Picked samples.	64.67	3.70	0.027	0.023	0.30
	54.64	16.05	0.033	0.200	0.48
	65.50	3.37	0.032	0.110	0.33
	55.22	17.32	0.030	0.053	0.21

The hematitic ores occur interbedded with Dharwar phyllites.

Near Sihora siliceous brown hematites were found, poorer in iron, but physically more suitable for the blast furnace, and in this area there occur patches of manganiferous iron-ore.<sup>1</sup> The following analyses were obtained from samples obtained at Mansakra (Silondi) near Sihorā:—

—	Fe.	Mn.	SiO <sub>2</sub> .	S.	P.	Moisture
Wider band . . . . .	52.15	0.36	14.70	0.022	0.385	0.10
Narrower band . . . . .	44.95	6.28	14.55	0.027	0.352	0.27
Manganiferous iron-ore . . . . .	24.45	21.47	19.60	0.022	0.163	0.80

The above ores occur as lateritoid replacement products on the upturned edges of the Dharwar hematite ores.

<sup>1</sup> Cf. *Rec., Geol. Surv. Ind.*, XVI, pp. 101-103, (1883); *Trans. Min. Geol. Inst. Ind.*, I, p. 99, (1906) and *Mem., Geol. Surv. Ind.*, XXXVII, pp. 814, 815, 821-823, (1909).

### Lead and Silver.

Lead-ores have been located in several places in this province, but in no case have these occurrences been found to be of sufficient magnitude for exploitation by modern methods. As would be expected, the majority of these deposits are in Archæan rocks, but strings and nests of galena have been found in Lower Vindhyan limestone in the bed of the Mahanadi river near Padampur in the Bilaspur district, whilst some old excavations in the Bijawar limestone at Joga Khurd in the Hoshangabad district yielded a sample of limestone with disseminated galena carrying 21 ounces of silver to the ton of lead.

The other occurrences are in Archæan rocks. The most important deposit is probably that at Ranitalao near Chicholi in the Drug district, where a well-marked quartz-vein, ranging in width from 6 to 30 feet, has been traced for a distance of  $1\frac{1}{2}$  miles through gneiss. The vein contains both galena and fluorspar, but the proportion of galena to vein-stuff appears to be small. Specimens of ore yielded over 9 ounces of silver per ton of lead. A small output of lead-ore from this district was reported in the years 1914 to 1916, but it is not known whether the production was from the locality mentioned above.

Argentiferous galena also occurs in association with the copper-lodes of Sleemanabad in the Jubbulpore district, whilst fragments of galena have been found near Nimbha in the Nagpur district. Finally, galena has been recorded from two localities (Bhelaunda and Chirai Khurd) in Sarguja State.

### Lignite.

In 1884, Mr. P. N. Bose described an occurrence of lignite in logs up to 6 inches in diameter embedded in alluvial peaty clay below the sand of the Karun river 3 miles south-west of Raipur. Similar deposits were said to occur at other localities in the same neighbourhood, and Mr. Bose concluded that the quantity available might be considerable. The composition was as follows (average of two samples):—

Moisture . . . . .	16.70
Volatile matter . . . . .	48.60
Fixed carbon . . . . .	28.15
Ash . . . . .	5.55
	<hr/>
	100.00



### Lithographic Stone.

The occurrence of stone suitable for lithographic purposes has been recorded from two localities in the province. The material from one source, *viz.*, the Raipur district, and therefore presumably a Cuddupah limestone, was formerly used at the Raipur jail press. The other locality is near Hatta in the valley of the Sonar river in Damoh district, where a thin-bedded compact limestone of Upper Vindhyan age is found. No trial of this stone appears, however, to have been made.

### Manganese-ore.

Judged either from quantity or value of the annual production, the manganese-ore industry is the most important mineral industry of the province, which contains some of the finest manganese-ore deposits in the world. These deposits are associated with a series of rocks known as the gondite series, regarded as metamorphosed manganeseiferous sediments of Dharwar age and characterised by the presence of various manganeseiferous silicates, the most important of which are the manganese garnet, spessartite, and the manganese-pyroxene, rhodonite. The ore-bodies consist typically of braunite and psilomelane, occasionally with hollandite, vredenburgite and sitaparite, and occur as lenticular masses and bands intercalated in quartzites, schists, and gneisses of Archæan age. The rocks of the gondite series are developed typically in the Chhindwara, Nagpur, Bhandara and Balaghat districts (and to a small extent in Seoni); in the portion of the Balaghat district east of the Wainganga river the manganese-ore horizon occurs near the base of the Chilpi Ghat series, which is regarded as a less metamorphosed facies of the rocks to the west of the Wainganga. That a portion at least of these ores is of primary origin is proved by the occurrence in intrusive pegmatites of fragments of the invaded manganese-ore deposit.

Although the occurrence of manganese-ores in this province has been recorded on several occasions from 1829 onwards, it was not until 1899 that the first prospecting license was applied for in the Nagpur district, the first shipment taking place in 1900. Work commenced in the Balaghat district in 1901, in the Bhandara district in 1903, and in the Chhindwara district in 1906, and together these four districts have been responsible for practically the whole of the output of manganese-ore from this province up to date. In the first year, 1900, the production totalled 47,257 tons, rising to 351,880

tons in 1906 and 565,017 tons in 1907; thereafter it has averaged about 500,000 tons annually, the maximum production being 649,307 tons in 1913. Except for small quantities of this ore that have been smelted at Jamshedpur and Kulti with production of ferro-manganese, the whole of this ore is exported. The export values of the Central Provinces manganese-ore production since 1906 have fluctuated between £403,526 in 1909 and £1,363,648 in 1917, the highest pre-war total being £1,314,412 in 1907.

As an index to the large size of some of these deposits, the following table may be of interest:—

*Total Production of Manganese-Ore from certain Central Provinces Manganese-Ore Deposits.*

Mine	District.	Year of commencement of work.	Total production to end of 1918.
Balaghat . . . . .	Balaghat.	1901	Tons. 1,069,192
Kandri . . . . .	Nagpur.	1900	670,281
Chikhla (with Yedarbuchi) . . . . .	Bhandara.	1901	638,196
Thirori . . . . .	Balaghat.	1902	503,194
Kachi Dhana . . . . .	Chhindwara	1906	441,740
Mansar . . . . .	Nagpur.	1900	438,023
Lohdongri . . . . .	do.	1900	268,161
Kodegaon . . . . .	do.	1903	214,219
Miragpur . . . . .	Bhandara.	1905	199,976
Sukli . . . . .	do.	1905	191,620
Gumgaon . . . . .	Nagpur.	1901	184,560
Ukua (with Gudma and Samnapur) . . . . .	Balaghat.	1906	135,891
Kosumba . . . . .	Bhandara.	1905	107,161
Junawani . . . . .	Nagpur.	1906	102,167
Shodan Hurki . . . . .	Balaghat.	1912	105,783
Ramrama . . . . .	do.	1906	103,853
Kacharwahi . . . . .	Nagpur.	1902	103,901

The quality of the manganese-ores from these four districts may be judged from the following figures:—

*Range of Analyses of Manganese-Ores from the gonditic deposits of the Central Provinces.*

	Balaghat.	Bhandara.	Chhindwara.	Nagpur.
Number of analyses.	13	13	9	30
Manganese . . . .	49.08—54.51	49.00—54.07	48.95—54.97	42.28—56.52
Iron . . . . .	5.28— 9.10	3.86—10.25	5.00—11.77	2.09—16.34
Silica . . . . .	1.62— 6.02	2.08— 6.50	4.98—10.63	2.90—18.43
Phosphorus . . . .	0.04— 0.24	0.06— 03.4	0.06— 0.28	0.04— 0.65
Moisture . . . . .	0.12— 0.85	0.09— 1.00	0.00— 1.27	0.11— 1.32

*Means of above analyses.*

	Balaghat.	Bhandara.	Chhindwara.	Nagpur.
Number of analyses.	13	13	8	30
Manganese . . . .	51.88	51.94	52.72	51.53
Iron . . . . .	7.40	7.27	7.08	6.24
Silica . . . . .	3.74	4.59	7.16	7.25
Phosphorus . . . .	0.11	0.14	0.11	0.215
Moisture . . . . .	0.37	0.44	0.38	0.49

The above samples were taken at or close to the surface, and deeper working is revealing a tendency towards a progressive increase of phosphorus contents with depth.

For information as to costs of working and other economic conditions, reference should be made to pages 135 to 169 of *Records* Vol. XLVI, (1913).

In addition to the gonditic areas referred to above, relatively unimportant manganese-ore deposits are found near Sihora and Gosalpur in the Jubbulpore district on the outcrops of rocks of Dharwar age, associated with the latter in such a manner as to leave little doubt that the ores have been formed by the replacement at the surface of Dharwar phyllites and quartzites. The masses of ore thus formed do not consist entirely of manganese-ore, but

often contain considerable quantities of iron-ore; and every gradation is to be found from manganese-ores through ferruginous manganese-ores and manganiferous iron-ores, to iron-ores. The masses of ore thus formed are often more or less cavernous and bear considerable resemblance to ordinary laterite and have in consequence been called lateritoid ores. The mineral composition of the ores thus formed is usually fairly simple. The manganese-ores are pyrolusite, psilomelane, and wad, whilst the iron ores are limonite and earthy hematite. Chemically, these lateritoid ores show a greater range of composition than the gonditic ores. The manganese is usually relatively low, so that the ores won consist mainly of second-grade manganese-ores and third-grade ferruginous manganese-ores. Such deposits would be worked to the greatest advantage if a market could be found for the iron-ores and manganiferous iron-ores, as well as for the manganese-ores. The ores of this district are of little value economically, but there has been a small output of recent years, possibly for special purposes:—

	Tons.
1907 . . . . .	7,100
1908 . . . . .	48
1910 . . . . .	300
1915 . . . . .	11
1916 . . . . .	576
1917 . . . . .	300
1918 . . . . .	65

The quality of the ores available is shown by the following analyses:—

	MANGANESE-ORE.		MANGANIFEROUS IRON-ORE.	
	Range.	Mean.	Range.	Mean.
Number of analyses.	3	3	7	7
Manganese . . . . .	34.53—56.80	45.56	6.20—25.60	20.26
Iron . . . . .	1.60—10.30	4.79	19.17—47.10	28.78
Silica . . . . .	1.40—4.79	2.68	4.40—23.40	12.99
Phosphorus . . . . .	0.03—0.46	0.215	0.02—0.85	0.25
Moisture . . . . .	0.39—0.90	0.56	0.12—0.65	—

Two occurrences of manganese-ore, at Ratanpur and Gorakona in the Bilaspur district, consist of pyrolusite, psilomelane, and wad.

formed by the replacement of rocks mapped as belonging to the Chilpi Ghat series.

In addition to the occurrences referred to above, manganese-ores of no economic significance have been found in several other districts. Impure wad has been found at Sontulai in the Hoshangabad district associated with rocks of presumed Bijawar age. In the Chandgarh and Harsud tahsils of the Nimar district four occurrences are known associated with four different geological formations, viz., Bijawar, Vindhyan, Lameta and Deccan Trap, and, except the last, are probably examples of surface impregnation and replacement, and are of no economic value. In the Yeotmal district, manganeseiferous sandstone and nodules of manganese-ore in red clay, both of Lower Gondwana age but of no value, have been found.

### Mica.

In the Central Provinces pegmatitic rocks abound, but although a certain amount of attention has been given to mica by prospectors, no deposits worth exploitation have yet been located. The largest plates hitherto discovered were obtained from Jungani in Bastar State and measured 4 to 5 inches across, but they were weathered and damaged by gliding planes. Attempts to work mica have also been made at Chitadongri and Bamni in the Balaghat district and at Komochoiki in Bilaspur district.

### Mineral Waters.

Although India is endowed with a large number of thermal and medicinal springs, yet no attempt has been made by modern enterprise to turn these resources to account. In the Central Provinces the following springs are known :—

District.	Locality.	Situation.	Temperature.	Properties.
Chhindwara . . .	Anhoni . . .	Trap dyke . . .	134°F.	Sulphurous.
Hoshangabad . . .	Anhoni Samoni . . .	Trap dyke . . .	114°F.	Sulphuretted hydrogen.
Sarguja . . . . .	Tatapani . . . . .	Line of fracture . . . . .	136°—190°F.	Sulphuretted hydrogen & deposits siliceous sinter.
Yeotmal . . . . .	Khaur . . . . .	— . . . . .	87°F.	Deposits calcareous tufa.

### Ochre.

Both red and yellow ochres occur at several localities in the province, and for many years there has been a small industry for the manufacture of paint from the red ochre mined at Jauli in the Jubbulpore district. The occurrence is in rocks of Dharwar age.

Red ochre is also obtained in the Gandai and Thakurtola zamindaries in the Drug district and in the Salitekri hills in the Balaghat district—in all cases probably from the Chilpi Ghat series, the local form of the Dharwars.

Yellow ochres are said to be found in the Chanda district and near Kalmeshwar in the Nagpur district.

Both red and yellow ochres are used locally for colouring houses, whilst the red ochre is also used for dyeing the clothes of particular castes.

### Salt.

In the valley of the Purna river in Berar, there was formerly a salt industry dependent upon brine obtained from wells sunk in the alluvium, the brine being found at a depth of 90 to 120 feet with a head of 15 to 20 feet. The brine was evaporated by solar heat in shallow pans. The centre of the industry was Dahihanda in the Akot tahsil of the Akola district. In 1885-86 there were four hundred wells, yielding to Government a revenue of Rs. 24,000; each well produced about 20 maunds of salt per mensem.

A certain quantity of salt is obtained as a bye-product in the manufacture of carbonate of soda from the brine of the Lonar lake in the Buldana district of Berar. It has also been noted that beneath the alluvial deposits of Western Chanda is a deposit of saliferous sand or clayey sandstone. The salt appears as an efflorescence, and two samples gave an average of 85.23 per cent. NaCl and 13.94 per cent. MgSO<sub>4</sub>.

### Soda.

In the Deccan Trap basalts near the village of Lonar, in the Buldana district, Berar, is a circular crateriform hollow 300 feet deep and about a mile in diameter, and probably of volcanic origin, although views differ as to its exact mode of formation. This hollow is occupied by a shallow lake, the waters of which contain a large proportion of carbonates of soda, which crystallise out on the evaporation of the lake during the hot season and are used in the manufacture of glass and soap. According to one estimate, in March,

1910, when the maximum depth of the lake was 2 feet, the water contained 2,000 metric tons of sodium carbonate, whilst the upper layer of the lake mud to a depth of 1.5 metres contained about 4,500 tons. Six varieties of salt are prepared of the following range of composition :—

	Per cent.
Na <sub>2</sub> CO <sub>3</sub> . . . . .	46.90 to 11.67
NaHCO <sub>3</sub> . . . . .	33.18 to 8.58
NaCl . . . . .	nil to 71.11

The ratio of carbonate to bicarbonate corresponds closely to that for the mineral trona or urao.

The rights to work the lake are let out on short-period contracts, and the output from 1909 to 1913 was about 450 tons.

The occurrence of *reh* at Paunar in the Wardha district has been noticed. It is used for washing clothes and making soap.

### Steatite.

Steatite (talc, soapstone, potstone) has been found at several localities in the Central Provinces, usually in the Archæan terrane. The best-known locality is the Marble Rocks near Jubbulpore, where the steatite forms steeply dipping pockets in the Dharwarian dolomites. This steatite is slightly schistose, and varies from white to pale sea-green in colour. The deposits yield several hundred tons of steatite annually (see page 272), and one of the concessionaires has established at Jubbulpore a special plant for grinding the mineral, which is marketed in the powdered form.

Potstone and steatitic schist—probably of Dharwarian age—have been reported from several localities in the Bhandara district, whilst at Jambal Ghat in the crystalline area of Chanda is a dark-coloured potstone formerly used for carving into idols and household vessels.

Soapstone has also been reported from near Wun; the geological association of this occurrence is unknown, but it must be with post-Archæan rocks.

### Tungsten-ore.

The only known occurrence of wolfram in this province is that discovered at Agargaon in the Nagpur district in 1907. The wolfram occurs sparsely scattered in veins and stringers of quartz interbedded with mica-schists and tourmaline-schists of Dharwar age. The veins, however, are small, and the total amount of wolfram

obtained appears to have been some 3 or 4 tons. Traces of scheelite have been found in association with the wolfram.

### III.—BIBLIOGRAPHY.

This list does not pretend to be exhaustive, but only contains a selection of the more important papers. A complete list of references can be obtained in LaTouche's "Bibliography of Indian Geology and Physical Geography with an Annotated Index of Minerals of Economic Value."

#### *General.*

1. The Annual and Quinquennial Reviews of Mineral Production, published in the *Records* of the Geological Survey of India.
2. Ball, V.—1881.—A Manual of the Geology of India. Part III. Economic Geology.
3. Holland, Sir T. H.—1908.—Sketch of the Mineral Resources of India.

#### *Aluminium.*

- 1883—Mallet, F. R.—On the Iron Ores, and Subsidiary Materials for the Manufacture of Iron in the North-Eastern part of the Jabalpur District. *Rec., G.S.I.*, XVI, p. 113.
- 1905—Holland, Sir T. H.—The Occurrence of Bauxite in India. *Rec., G. S. I.*, XXXII, pp. 175-184.
- 1908—Dunstan, Wyndham R.—Report on Laterites from the Central Provinces, *Rec., G. S. I.*, XXXVII, pp. 213-220.
- 1911—Fermor, L. L.—What is Laterite? *Geol. Mag.*, Dec. 5, VIII, pp. 454-462, 507-516, 559-566.
- 1914—L. L. Fermor, M. Vinayak Rao & R. C. Burton.—*Rec., G. S. I.*, XLV, pp. 111, 112.
- 1918—Burton, R. C.—On the Origin of the Laterite of Seoni. *Rec., G.S.I.*, XLVIII, pp. 204-218.

#### *Coal.*

- 1856—Medlicott, J. G.—Report on the Coal of the Nerbudda Valley. *Sel. Rec. Govt. India*, X, pp. 12-29.
- 1870—Blanford, W. T.—Note on the occurrence of Coal east of Chhatisgarh in the country between Bilaspur and Ranchi. *Rec., G.S.I.*, III, pp. 71-72; *Ind. Economist*, II, pp. 43-44.



- 1870—Medlicott, H. B.—The Mohpani Coal-field. *Rec., G.S.I.*, III, pp. 63-70.
- 1871—Ball, V.—The Raigur and Hengir (Gangpur) Coal-field. *Rec., G.S.I.*, IV, pp. 101-107.
- 1873—Ball, V.—The Bistrampur Coal-field. *Rec., G.S.I.*, VI, pp. 25-41.
- 1875—Ball, V.—The Raigarh and Hingir Coal-field. *Rec., G.S.I.*, VIII, pp. 102-121.
- 1875—Medlicott, H. B.—The Shapur Coal-field, with notice of Coal-explorations in the Narbada Region. *Rec., G.S.I.*, VIII, pp. 65-86.
- 1877—Hughes, T. W. H.—The Wardha Valley Coal-field—*Mem., G.S.I.*, XIII, pp. 1-154.
- 1880—Griesbach, C. L.—Geology of the Ramkola and Tatapani Coal-fields. *Mem., G.S.I.*, XV, pp. 129-192.
- 1882—Ball, V.—On the Coal-bearing Rocks of the Valleys of the Upper Rer and the Mand rivers in Western Chutia Nagpur. *Rec., G.S.I.*, XV, pp. 108-121.
- 1885—Hughes, T. W. H.—The Southern Coal-fields of the Rewah Gondwana Basin. Umaria, Korar, Johilla, Sohagpur, Kurasia, Koreagarh, Jhilmili. *Mem., G.S.I.*, XXI, pp. 137-249.
- 1886—King, W.—Boring Exploration in the Chhatisgarh Coal-fields. *Rec., G.S.I.*, XIX, pp. 210-234.
- 1887—King, W.—Boring Exploration in the Chhatisgarh Coal-fields. *Rec., G.S.I.*, XX, pp. 194-202.
- 1887—Jones, E. J.—The Southern Coal-fields of the Satpura Gondwana Basin. *Mem., G.S.I.*, XXIV, pp. 1-58.
- 1900—Reader, G. F.—Preliminary Report on the Rampur Coal-field. *Gen. Rep., G.S.I.*, 1899-1900, pp. 63-69.
- 1901—Reader, G. F.—Report on the Rampur Coal-field. *Mem., G.S.I.*, XXXII, pp. 89-124.
- 1911—Ditmas, F. I. Leslie.—The Pench Valley Coal-field. *Trans. N.E. Inst. Min. Eng.*, LXI, pp. 115-146; *Trans. Inst. Min. Eng.*, XLI, pp. 133-164.
- 1913—Ball V. and Simpson, R. R.—The Coal-fields of India. *Mem., G.S.I.*, XLI, pp. 1-147.
- 1914—Fermor, L. L.—On the Geology and Coal Resources of Korea State, Central Provinces. *Mem., G.S.I.*, XLI, pp. 148-245.

*Copper.*

- 1874—Ball, V.—On the discovery of a new locality for Copper in the Narbudda Valley. *Rec., G.S.I.*, VII, pp. 62-63.  
1907—*Engineering and Mining Journal*, LXXXIII, p. 657.  
1910—Quinquennial Review of Mineral Production of India during 1904-1908. *Rec., G.S.I.*, XXXIX, p. 236.

*Fire-clay.*

- 1889—Mallet, F. R.—On some of the Materials for Pottery obtainable in the neighbourhood of Jabbalpur, and of Umaria. *Rec., G.S.I.*, XXII, pp. 140-148.

*Fluor-spar.*

- 1870—Blanford, W. T.—Notes on the Lead Vein near Chicholi, Raipur District. *Rec., G.S.I.*, III, pp. 44-45.

*Gemstones.*

- 1915—Quinquennial Review of Mineral Production for 1909 to 1913. *Rec., G.S.I.*, XLVI, p. 269.

*Gold.*

- 1904—Maclaren, J. M.—The Auriferous Occurrences of Chota Nagpur, Bengal. *Rec., G.S.I.*, XXXI, p. 59-91.  
1904—Nunn, H.—Industrial Monograph on Gold and Silverware of the Central Provinces, Fol. Allahabad.

*Iron-ore.*

- 1855—Jacob, A. A.—Report on the Iron and Coal Districts of the Nerbudda Valley, from Poonassa to Jubbulpore. *Sel. Rec. Bom. Govt., N. S.*, IX, pp. 42-48; XIV, pp. 136-141.  
1856—Medlicott, J. G.—Report on the Coal of the Nerbudda Valley. *Sel. Rec. Govt. India*, X, p. 24.  
1870—Oldham, T.—Assays of Iron Ores from Hāzaribagh and the Central Provinces. *Rec., G.S.I.*, III, p. 77.

- 1873—Hughes, T. W. H.—Note on some of the Iron Deposits of Chanda, Central Provinces. *Rec., G.S.I.*, VI., pp. 77-81; *Gazette of India, Suppl.*, 22nd Aug. 1874, pp. 1489-1491.
- 1875—Ness, W.—The Government Experiments in Iron-making in India. *Coll. Guard.*, XXX, p. 925; *Min. Journ.*, XLV, p. 1436; XLVI, p. 215; *Eng. Min. Journ.*, XXI, p. 56; *Journ. I. S. Inst.*, IX, pp. 616-617; X, pp. 210-211.
- 1876—Ness, W.—Report on the Experiment of Iron (at Warora). *Gazette of India, Suppl.*, pp. 480-482.
- 1877—Hughes, T. W. H.—The Wardha Valley Coal-field. *Mem., G.S.I.*, XIII, p. 141.
- 1881—King, W.—The Geology of the Pranhita-Godavari Valley. *Mem., G.S.I.*, XVIII, p. 197.
- 1882—Schwarz, C. Ritter von.—Report on the Financial Prospects of Iron Working in the Chanda District. Fol., 30 pp., Simla.
- 1883—Mallet, F. R.—On the Iron Ores, and Subsidiary Materials for the Manufacture of Iron in the North-Eastern part of the Jabbalpur District. *Rec., G.S.I.*, XVI, pp. 94-115.
- 1887—Bose, P. N.—The Iron Industry of the Western Portion of the District of Raipur. *Rec., G.S.I.*, XX, pp. 167-170.
- 1888—Bose, P. N.—The Manganese-iron and Manganese-ores of Jabbalpur. *Rec., G.S.I.*, XXI, pp. 71-89.
- 1898—Hole, R. S.—The Iron Industry in the Central Provinces. *Agric. Ledger*, V, No. 17, pp. 1-27.
- 1899—Bose, P. N.—See General Report on the work carried on by the Geological Survey of India, 1898-1899, p. 38.
- 1900—Hole, R. S. and others.—The Iron Industry in the Central Provinces. *Agric. Ledger*, VII, No. 14, pp. 146-160.
- 1904—Martin, E. P. and Louis, H.—On Iron Ores in the Jabbalpur District, Central Provinces. *Agric. Ledger*, XI, No. 3, pp. 19-23; *Coll. Guard.*, LXXXVIII, *Suppl.*, p. 58.
- 1904—Wynne, F. H.—Native Methods of Smelting and Manufacturing Iron in Jabbalpur, Central Provinces, India. *Trans. Inst. Min. Eng.*, XXVI, pp. 231-245.
- 1909—Fermor, L. L.—Minerals of the Jubbulpore District, Central Provinces. *Jubbulpore District Gazetteer*, A, pp. 259-261.
- 1910—Datta, P. N.—On some Iron ores of Chanda, Central Provinces. *Rec., G.S.I.*, XXXVIII, pp. 308-312.
- 1915—Weld, C. M.—The Ancient Sedimentary Iron Ores of British India. *Econ. Geol.*, X, pp. 435-452.

*Lead and Silver.*

- 1870—Blanford, W. T.—Notes on the Lead Vein near Chicholi, Raipur District. *Rec., G.S.I.*, III, pp. 44-45.
- 1870—Hughes, T. W. H.—Note on the Lead-ore at Slimanabad, Jabbalpur District, Central Provinces. *Rec., G.S.I.*, III, pp. 70-71.
- 1879—Nicholls, G. J.—Note on the Joga neighbourhood and old mines on the Nerbudda. *Rec., G.S.I.*, XII, pp. 173-175.

*Lignite.*

- 1884—Bose, P. N.—Note on Lignite near Raipur, Central Provinces. *Rec., G.S.I.*, XVII, pp. 130-131.

*Manganese.*

- 1888—Bose, P. N.—The Manganese-iron and Manganese-ores of Jabbalpur. *Rec., G.S.I.*, XXI, pp. 71-89.
- 1889—Bose, P. N.—The Manganiferous Iron and Manganese ores of Jabbalpur. *Rec., G.S.I.*, XXII, pp. 216-226.
- 1906—Fermor, L. L.—Manganese in India. *Trans. Min. Geol. Inst. Ind.*, I, pp. 69-131.
- 1909—Fermor, L. L.—The Manganese-ore Deposits of India. *Mem., G.S.I.*, XXXVII, pp. i-xcvii+1-1294.
- 1910—Fermor, L. L.—Manganese-ore in Bilaspur District, Central Provinces. *Rec., G.S.I.*, XL, pp. 334-335.
- 1911—Fermor, L. L.—On the Age and Continuation in Depth of the Manganese-Ores of the Nagpur-Balaghat area, Central Provinces. *Rec., G.S.I.*, XLI, pp. 1-11.
- 1914—Burton, R. C.—See General Report of the Geological Survey of India for the year 1913. *Rec., G.S.I.*, XLIV, p. 21.

*Mica.*

- 1902—Holland, Sir T. H.—The Mica Deposits of India. *Mem., G.S.I.*, XXXIV, p. 55.

*Ochre.*

- 1843—Wilkinson, T.—Note on Minerals in Nagpur Territory. *Cal. Journ. Nat. Hist.*, III, pp. 290-292.
- 1898—Hole, R. S.—Letters on the Iron Industry in the Jabbalpur District. *Agric. Ledger*, V, No. 17, p. 22.

302 *Records of the Geological Survey of India.* [VOL. L.]

*Salt.*

1869—Wynne, A. B.—The Valley of the Poorna River, West Berar. *Rec., G.S.I.*, II, p. 3.

*Soda.*

1912—LaTouche, T. H. D. and Christie, W. A. K.—The Geology of the Lonar Lake. With a Note on the Lonar Soda Deposit by W. A. K. Christie, Ph. D. *Rec., G.S.I.*, XLI, pp. 266-285.

*Steatite.*

1889—Mallet, F. R.—Note on Indian Steatite. *Rec., G.S.I.*, XXII, p. 64.

*Tungsten.*

1908—Fermor, L. L.—Note on the Occurrence of Wolfram in the Nagpur District, Central Provinces. *Rec., G.S.I.*, XXXVI, pp. 301-311.

## MISCELLANEOUS NOTE.

## Note on Sipylite from the Nellore District, Madras Presidency.

During a recent visit to the Nellore Mica Belt I had an opportunity to look over a quantity of samarskite which had been obtained from the Sankara mine. (See *Rec. G. S. I.*, Vol. XLI, p. 210, 1911.) With the samarskite was a piece of a quite distinct mineral. I took this for further examination. More recently Mr. F. Gaston of Messrs. F. F. Chrestien & Co. has sent another specimen of the same mineral from the Ruzulapad Mica mine. The latter locality is about two miles north-west of Sankara and not far from the village of Orupalle. The two specimens agree in every respect and there is no doubt as to their identity.

The specific gravity is 4.89. The mineral is brittle and the fracture splintery and uneven. The lustre is resinous and almost splendid. The colour of small splinters and thin sections is a bright red-brown. The streak is cinnamon brown. There is one prominent cleavage. Neither of the specimens show any approach to crystal outline.

The powdered mineral is partially decomposed by hydrochloric acid and completely by concentrated sulphuric acid. A qualitative analysis has proved the presence of niobium, rare earths, iron, uranium, calcium and magnesium. Zirconium is probably present but the test was not conclusive.

The physical and chemical characters correspond very closely with those of the mineral *Sipylite*.

[G. H. TIPPER.]

## INDEX TO RECORDS, VOLUME L

SUBJECT.	PAGE.
Alum . . . . .	66.
Aluminium . . . . .	273—275.
Alunogen . . . . .	131, 133, 136.
Amherst District . . . . .	103.
<i>Amnicola</i> . . . . .	223, 225.
——— ( <i>Alocinma</i> ) <i>alticola</i> . . . . .	217, 219, 225.
Andesite . . . . .	248.
Anhydrite zone . . . . .	85.
Annandale, N. . . . .	209.
Antimony . . . . .	9, 10.
Apatite . . . . .	10, 14, 15.
——— in Gaya District . . . . .	258, 259, 261.
Arakan Yoma coal . . . . .	12.
Archaean beds . . . . .	269—270.
Arsenical pyrites . . . . .	118, 119.
Asbestos . . . . .	275.
Autunite in Gaya District . . . . .	258.
Burton, R. C. . . . .	258.
Bagmara . . . . .	127, 128.
Bahadur Khel salt . . . . .	30, 31, 68—73.
Banerji, A. K. . . . .	6.
Barhana . . . . .	9.
Barytes . . . . .	275.
Bauxite . . . . .	273—275.
Bawlake State . . . . .	103.
Beer, E. J. . . . .	139.
Belugyun Island . . . . .	103.
Beryl . . . . .	102, 120.
Bismuth . . . . .	107, 108, 114, 115, 118
——— ochre . . . . .	116.
Bismuthinite . . . . .	109.
<i>Bithynia (Fossarulus) marginata</i> . . . . .	211.
——— ( <i>Hydrobioides</i> ) <i>nana</i> . . . . .	219.
——— <i>nassa</i> . . . . .	216, 217, 219.
——— <i>physcus</i> . . . . .	219.

SUBJECT.	PAGE.
<i>Bithynia (Hydrobioides) turrita</i>	217.
Bituminous matter in salt	32, 64, 263.
Bokaro coalfield	8.
Bolintaung tin mine	109.
Bonai State	14, 21.
Brown, J. C.	3, 12, 19, 20, 101.
Bostanah	19.
Building stone	271, 275—277.
Byaukchaung wolfram mine	108.
Byingyi	102.
Campbell, Colin	5, 16.
Carnallite, zone	85, 103.
Cassiterite	19, 101.
Cement materials	271.
Central Provinces	268—302.
<i>Cervus eldi</i>	218.
Chalcopyrite	109, 110, 119.
<i>Chanho</i>	17, 18.
Chert	11.
Chirmiri volcanics	8
Chitung Buru-Roro Buru	10, 11.
Chrestien and Dadabhoy, Messrs.	17.
Christie, W. A. K.	4, 6, 28, 29, 32, 33, 43, 52, 58, 60, 85.
Chromite	10—12.
Chrysotile	12.
Coal	8, 12—13, 278—281.
Columbite in Gaya District	258, 260, 261.
Copper	107, 281—282.
— pyrites	118.
Cotter, G. de P.	3, 5, 6, 13, 15, 17, 18, 130.
Covellite	110.
<i>Crassataia</i>	223, 231.
Crest wolfram mine	115.
Cretaceous	9.
Dalu	127, 128.
Dams	13.
Dhalbhum	22.
<i>Dhanda</i>	18.
Dharwar	10, 15, 22, 23, 246— 247.
<i>Diana</i>	228, 229.



SUBJECT.	PAGE.
Dunite . . . . .	10, 11.
Egani wolfram mines . . . . .	107.
Eocene . . . . .	30.
Fermor, L. L. . . . .	2, 5, 8, 10, 14, 15, 20, 21, 268.
Fireclay . . . . .	282.
Fleming, A. . . . .	58.
Fluorite . . . . .	107, 110, 111, 113, 115, 120.
Fluorspar . . . . .	110, 279
<i>Fossarulus</i> . . . . .	211.
Fox, C. S. . . . .	4, 17.
Fullers' Earth . . . . .	282.
Fumarole . . . . .	138.
Galena . . . . .	110, 111, 241—254.
Garó Hills, Fossils in . . . . .	126—129.
Gas in bituminous salt, Natural	263.
Gaya District, Apatite in . . . . .	258, 259, 261.
Autunite in . . . . .	258.
Columbite in . . . . .	258, 260, 261.
Microcline in . . . . .	255, 258, 261.
Monazite in . . . . .	258, 259.
Pitchblende in . . . . .	255, 256, 258.
Triplite in . . . . .	258.
Torbernite in . . . . .	257, 258.
Uranium ochre in . . . . .	257, 258.
Zircon in . . . . .	258.
Gemstones . . . . .	282—283.
Gold . . . . .	13, 117, 252—253, 283.
Graphite . . . . .	249.
Gravelly, F. H. . . . .	215.
Gupta, Bankim Behari . . . . .	4, 5, 6.
Baroda Charan . . . . .	6.
Hem Chandra Das . . . . .	8.
Guruza salt . . . . .	31.
Gypsum . . . . .	65—68, 70, 71.
Formation of . . . . .	62—64, 67—68.
<i>Gyraulus convexiusculus</i>	217.
<i>velifer</i> . . . . .	219.
Hæmatite . . . . .	14, 15.
Hallowes, K. A. K. . . . .	3, 13, 15.
Hayden, H. H. . . . .	1, 141, 209.

SUBJECT.	PAGE.
He-Ho basin . . . . .	215.
Heinda wolfram mines . . . . .	114.
Hermyingale molybdenite lode . . . . .	111.
Hermyingyi wolfram mine . . . . .	110—111.
Heron, A. M. . . . .	3, 19, 20, 101.
Hkumhpok . . . . .	9.
Hlutsha . . . . .	104.
Holland, Sir T. H. . . . .	57, 58, 83.
Hsin-Dawng valley . . . . .	215, 217—218.
Hutton, Captain . . . . .	130, 132.
<i>Hydrobia</i> . . . . .	223.
Hydrobiidæ . . . . .	209—213, 225—231.
Hydrobioides . . . . .	220.
Inde Buru . . . . .	11.
Inle Lake . . . . .	215, 218—222.
Intrusive granite . . . . .	119.
Iron . . . . .	14—15, 107, 113, 253, 283—288.
— sulphide . . . . .	116.
Jatta salt . . . . .	30, 31.
Jones, H. C. . . . .	3, 9, 10, 13, 14.
Jurassic . . . . .	9.
Kadando wolfram lode . . . . .	109.
Kainite . . . . .	44.
Kalabagh salt . . . . .	51, 77—79.
<i>Kalar</i> . . . . .	17.
Kalimati . . . . .	20.
<i>Kallar</i> . . . . .	59, 60.
Kalonta wolfram and cassiterite mine . . . . .	109.
Kanbauk wolfram and cassiterite mines . . . . .	106—107.
Kaolin . . . . .	15, 113.
Kark salt . . . . .	31.
Karwar, Messrs. B. M. . . . .	102.
Kasumpur . . . . .	15.
Kechaung wolfram mines . . . . .	107.
Keng Tung . . . . .	9, 10.
Keonjhar . . . . .	14.
Khewra . . . . .	28, 29.
Kieserite zone . . . . .	85.
Kimsi Buru . . . . .	10.
Kitta Buru . . . . .	10.
Kodarma . . . . .	16.
Kohat salt . . . . .	30—32, 62, 68—73.

## INDEX.

v

SUBJECT.	PAGE.
Kohat salt, Natural gas in . . . . .	263.
Kolhan . . . . .	10, 12, 22.
Korea State . . . . .	8.
Kotli . . . . .	122.
Kyankanya wolfram . . . . .	109.
Laccolitic intrusions . . . . .	10.
Lahiri, H. M. . . . .	5.
Lake-beds, Gastropod fauna of old . . . . .	209—240.
Lashio coal . . . . .	12.
LaTouche, T. H. D. . . . .	6, 12, 222, 223.
Lead . . . . .	16, 107, 241—254, 289.
Leaf impressions in Putao Tertiaries . . . . .	246.
Lebyin . . . . .	9.
Lherzolite . . . . .	10.
Lignite . . . . .	289.
<i>Limnæa andersoniana</i> . . . . .	219, 220.
— <i>mimetica</i> . . . . .	219.
— <i>ovalis</i> (prox.) . . . . .	216.
— <i>shanensis</i> . . . . .	216, 217, 219.
Limonite . . . . .	253.
Linga . . . . .	19.
Lithographic Stone . . . . .	290.
Loi Hke . . . . .	9.
— Hpwe . . . . .	9.
Loisang . . . . .	9.
Lun Wan salt . . . . .	32.
Magnesium sulphate in salt . . . . .	86.
Magnetite . . . . .	14, 15.
Mahesri . . . . .	16.
Malayagiri . . . . .	15.
Malgin salt . . . . .	30, 31.
Maliwun wolfram mine . . . . .	118—119.
Manganese . . . . .	290—294.
<i>Margarya</i> . . . . .	210.
— <i>melanoides</i> . . . . .	210.
Masnodih . . . . .	17.
Mawchi . . . . .	103.
Mawpalaw Hill . . . . .	104.
Mawton wolfram concession . . . . .	118.
Mayo Salt Mine . . . . .	28, 33.
Medlicott, H. B. . . . .	8.
Meke wolfram area . . . . .	115—116.

SUBJECT.	PAGE.
<i>Melania (Brotia) baccata</i> subsp. <i>elongata</i> . . . . .	216, 217, 220.
————— <i>terebra</i> . . . . .	220.
————— <i>variabilis</i> . . . . .	218, 221.
<i>Melanoides tuberculata</i> . . . . .	216, 220.
Mergui wolfram . . . . .	117—119.
Mesozoic . . . . .	9.
Mica . . . . .	16—17, 294.
Microcline in Gaya District . . . . .	255, 258, 261.
Middlemiss, C. S. . . . .	29, 61, 74, 77, 79, 84, 122.
Minbu coal . . . . .	12, 13.
Mineral waters . . . . .	294.
Molybdenite . . . . .	102, 108, 111, 113, 115, 116, 117.
Monazite . . . . .	117.
—————, Thorium contents of . . . . .	260.
————— in Gaya District . . . . .	258, 259.
————— in Mysore . . . . .	264.
Mong Hsu State . . . . .	9.
———— Ing . . . . .	10.
———— Kung State . . . . .	9.
Mysore, Monazite in . . . . .	260.
<i>Mysoria</i> . . . . .	211.
Nakeng . . . . .	9.
Nam Lang galena deposit . . . . .	251—252.
Namma beds . . . . .	213, 214, 222—224, 225—240;
———— coal . . . . .	12.
Nandrakka salt . . . . .	30—31, 32.
Nellore District, Sipyrite in . . . . .	303.
Nilawan Ravine . . . . .	36—40.
Nurpur salt . . . . .	28, 29, 33, 40—45.
Ochre . . . . .	295.
Oldham, R. D. . . . .	122.
<i>Oncomelania</i> . . . . .	212, 214, 223, 224, 225—226;
————— <i>conoidalis</i> . . . . .	222, 223.
————— <i>fragilis</i> . . . . .	222, 226—227;
————— <i>longiscata</i> . . . . .	227.
Orange Series . . . . .	77, 78, 79.
Orissa . . . . .	14, 15, 20;
<i>Orygoceras</i> . . . . .	211.
Pachaung wolfram mines . . . . .	107.

SUBJECT.	PAGE.
<i>Pachylabra winkleyi</i> . . . . .	219.
Pagaye wolfram mine . . . . .	110
Pakokku . . . . .	15.
Pal Lahara State . . . . .	15, 21.
Palauk wolfram concession . . . . .	117.
Palmer, R. W. . . . .	4, 5.
Pansira Buru . . . . .	14.
Para-lavas . . . . .	8.
<i>Paraprososthenia</i> . . . . .	214, 223, 225, 228— 229.
————— <i>minuta</i> . . . . .	223, 230—231.
Pascoe, E. H. . . . .	2, 265.
Paungdaw wolfram mines . . . . .	114, 115.
Paya . . . . .	104.
Peneichaung wolfram . . . . .	109.
Peridotite . . . . .	10, 11, 12, 247.
Petroleum indications in gypsum . . . . .	66.
Pilgrim, G. E. . . . .	2, 5, 19.
Pinfold, E. S. . . . .	126.
Pitchblende, Analysis of. . . . .	256—257.
————— in Gaya District . . . . .	255, 256, 258.
<i>Planorbis exustus</i> . . . . .	216, 219.
————— ( <i>Tropidodiscus</i> ) <i>trochoideus</i> . . . . .	216, 219.
<i>Plectopylis</i> . . . . .	217.
Polyhalite zone . . . . .	85.
Potash. . . . .	28—56.
—————, Identification of . . . . .	34—35, 45.
—————, Mining of . . . . .	44.
————— at Kalabagh . . . . .	55.
————— at Khewra . . . . .	52—53.
————— in Kohat . . . . .	55.
————— at Nandrakka . . . . .	55.
————— at Nurpur . . . . .	53.
————— at Warcha . . . . .	53—54.
Presidency College, Calcutta . . . . .	5.
<i>Prososthenia</i> . . . . .	211, 225.
<i>Pseudovivipara</i> . . . . .	212.
Punjab salt . . . . .	74—83.
————— gypsum . . . . .	82.
Putao . . . . .	13, 16, 241—254.
<i>Pyrgula</i> . . . . .	229.
Pyrite . . . . .	107, 109, 110, 111, 113, 115, 119, 120.

SUBJECT.	PAGE.
Pyroxenite . . . . .	10.
Pyrrhotite . . . . .	109.
Red Marl ( <i>See</i> Salt Marl).	
<i>Reh</i> . . . . .	17.
Reid, F. . . . .	29, 35.
Ripple-marking . . . . .	68.
<i>Rivularia</i> . . . . .	223.
<i>Rivularioides</i> . . . . .	214, 232, 236—238.
Rock-salt . . . . .	57—99.
Sakangyi . . . . .	104.
Salt . . . . .	295.
— Banding in . . . . .	58—61, 82—83.
— Foliation in . . . . .	30, 31, 32, 33, 47, 61, 69, 91.
— Metamorphism in . . . . .	43.
— Natural gas in bituminous . . . . .	263.
— Schistosity of . . . . .	30, 31, 69, 71—72.
— Stratification of . . . . .	33.
— Sulphide of iron in . . . . .	61—64.
— Zoning of . . . . .	89—90.
Salt Marl . . . . .	58, 61, 74—81.
— Breccia in . . . . .	46, 47.
Salt Range . . . . .	28—56.
Sanni . . . . .	130.
Saranda . . . . .	14.
Saxonite . . . . .	10, 11
Scheelite . . . . .	110.
<i>Segmentina calathus</i> . . . . .	219.
— <i>coenosus</i> . . . . .	219.
Selenite . . . . .	62, 66, 67, 68, 131.
Seludayang Range . . . . .	103.
Serpentine . . . . .	11.
<i>Serpula</i> . . . . .	9.
Sethu Rama Rau . . . . .	4, 5, 20.
Shali . . . . .	8.
Sheng Wang galena mine . . . . .	250—251.
Siderite . . . . .	107.
Silver . . . . .	242, 243—244, 250, 251, 253, 289.
Simpson, R. R. . . . .	12.
Sind . . . . .	17, 18.
Singbhum . . . . .	10, 11, 14, 21—23.
Sipylite from Nellore District . . . . .	303.

SUBJECT.	PAGE.
Siwalik series . . . . .	131.
——— Fossils in . . . . .	126—129.
Soda . . . . .	17—19, 295—296.
——, Sulphate of . . . . .	63, 64.
Solan . . . . .	8.
Steatite . . . . .	293.
Stibnite . . . . .	9, 118.
Stuart, M. . . . .	3, 13, 16, 28, 57, 241, 263.
<i>Succinea</i> . . . . .	217.
—— <i>indica</i> . . . . .	217, 219.
Sulphur . . . . .	19, 66, 130—138.
Sulphuretted hydrogen . . . . .	65, 136.
Suru Pass . . . . .	10.
<i>Taia</i> . . . . .	209, 210, 213, 214, 216, 220, 221, 231— 233.
—— <i>analoga</i> . . . . .	216, 221.
—— <i>conica</i> . . . . .	218, 221.
—— <i>cylindrica</i> . . . . .	218, 221.
—— <i>elitoralis</i> . . . . .	219, 221.
—— ( <i>Crassitaia</i> ) <i>infracrassata</i> . . . . .	214, 223, 224, 234— 236.
—— <i>intha</i> . . . . .	210, 220.
—— <i>intermedia</i> . . . . .	216, 217, 218, 221, 222.
—— <i>lacustris</i> . . . . .	216, 217, 221.
—— <i>naticoides</i> . . . . .	214, 220, 221, 222, 223, 224, 233— 234.
—— <i>shanensis</i> . . . . .	219, 221.
—— <i>spinifera</i> . . . . .	224, 236—238.
—— <i>theobaldi</i> . . . . .	214, 217, 218, 220, 221.
Tale . . . . .	11.
Talchir . . . . .	21.
Tar, Mineral . . . . .	136, 138.
<i>Temnotaia</i> . . . . .	231.
Taungpila wolfram and cassiterite mine . . . . .	112.
Tavoy . . . . .	19, 20, 102, 105— 117.
Thaton District . . . . .	104—105.
Thingandon wolfram concession . . . . .	112, 113.

SUBJECT.	PAGE.
Thorium . . . . .	259.
Thrust-plane, Inclination of . . . . .	122—125.
Tiery, H. E. . . . .	255.
Tin . . . . .	19, 101—121.
Tipam series, Fossils in . . . . .	126—129.
Tipper, G. H. . . . .	2, 9, 16, 131, 209, 223, 235, 255, 303.
Topaz . . . . .	111, 117.
Torbernite in Gaya District . . . . .	257, 258.
Travancore . . . . .	17.
"Triplite" in Gaya District . . . . .	258.
Trona . . . . .	18.
<i>Tulotoma</i> . . . . .	210.
Tungsten . . . . .	19—20, 101—121, 296—297.
Tura Ridge . . . . .	126.
<i>Turritella</i> . . . . .	128.
<i>Tylopoma</i> . . . . .	211, 212.
Udaipur State . . . . .	17.
Uranium mica . . . . .	15.
——— minerals in Gaya District . . . . .	256—258.
——— ochre from Gaya District, Crystals in . . . . .	257.
———, Analysis of . . . . .	
Urao . . . . .	18.
<i>Valvata multicarinata</i> . . . . .	211.
Vinayak Rao, M. . . . .	4, 5, 20.
Vindhyan rocks, Spiral impression in . . . . .	139.
<i>Vivipara</i> . . . . .	210, 212.
——— <i>lecythis</i> . . . . .	219.
Viviparidæ . . . . .	209—213, 231—238.
Vredenburg, E. . . . .	2, 8, 209, 222.
Wagon wolfram area . . . . .	112—113.
Walker, H. . . . .	2, 5, 6, 13.
Warcha Salt mine . . . . .	45—51.
Warth, H. . . . .	29, 52, 58, 65.
Watkinson, K. F. . . . .	4, 5.
Widnes wolfram mine . . . . .	114.
Wolfram . . . . .	20, 101, 103.
Wunna wolfram concessions . . . . .	118.
Wynne, A. B. . . . .	28, 29, 30, 57, 58, 59, 61, 64, 65, 66, 67, 68, 69, 74, 78, 79, 84, 85. -



INDEX.

xi

SUBJECT.	PAGE.
Yamethin . . . . .	15, 102.
Yawnghwe lakes, Gastropod fauna of . . . . .	215—222.
Ya . . . . .	103.
Yenangyat, Gastropod fauna of the Conglomerate Beds of	224—240.
Yengan wolfram concession . . . . .	118.
Zimba wolfram mine . . . . .	108.
Zinc . . . . .	107, 111.
Zircon in Gaya District . . . . .	258.

**RECORDS**  
**OF**  
**THE GEOLOGICAL SURVEY OF INDIA**

**RECORDS**  
**OF**  
**THE GEOLOGICAL SURVEY OF INDIA**  
**VOLUME L**

---

*Published by order of the Government of India*

---

**CALCUTTA:**  
**SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY OF INDIA,**  
**27, CHOWRINGHEE ROAD**

---

**1919**

## CONTENTS

### PART 1.

	PAGE.
General Report of the Geological Survey of India for the year 1918. By H. H. Hayden, C.S.I., C.I.E., F.R.S., Director, Geological Survey of India . . . . .	1—27
The Potash Salts of the Punjab Salt Range and Kohat. By Murray Stuart, D.Sc., Assistant Superintendent, Geological Survey of India. (With Plates 1 to 8) . . . . .	28—56
Suggestions regarding the Origin and History of the Rock-salt Deposits of the Punjab and Kohat. By Murray Stuart, D.Sc., Assistant Superintendent, Geological Survey of India. (With Plates 9 to 25)	57—99

### PART 2.

The Distribution of Ores of Tungsten and Tin in Burma. By J. Coggin Brown, O.B.E., M.Sc., F.G.S., and A. M. Heron, B.Sc., F.G.S., Assistant Superintendent, Geological Survey of India. (With Plates 26 and 27) . . . . .	101—121
On the Inclination of the Thurst-plane or Reversed Fault, between the Siwalik and Murree zone of formations, near Kotli, Jammu Pro- vince. By C. S. Middlemiss, C.I.E., B.A., F.G.S., F.A.S.B., Superintendent, Mineral Survey of Jammu and Kashmir State. (With Plate 28) . . . . .	122—125
Two New Fossil Localities in the Garo Hills. By E. S. Pinfold, B.A., F.G.S. . . . .	126—129
Report on the Sanni Sulphur Mine. By G. de P. Cotter, B.A., F.G.S., Assistant Superintendent, Geological Survey of India. (With Plate 29) . . . . .	130—138
Miscellaneous Notes— Note on a Spiral Impression on Lower Vindhyan Limestone. (With Plate 30) . . . . .	139

**PART 3.**

	PAGE.
The Mineral Production of India during 1918. By H. H. Hayden, C.S.I., C.I.E., F.R.S., Director, Geological Survey of India . . . . .	141—208
The Gastropod Fauna of Old Lake-Beds in Upper Burma. By N. Annandale, D.Sc., F.A.S.B., Zoological Survey of India. (With Plates 31 to 33) . . . . .	209—240
The Galena Deposits of North-Eastern Putao. By Murray Stuart, D.Sc., F.G.S., Assistant Superintendent, Geological Survey of India. (With Plates 34 to 38) . . . . .	241—254

**PART 4.**

On Pitchblende, Monazite and other Minerals from Pichhli, Gaya District, Bihar and Orissa. By G. H. Tipper, M.A., F.G.S., F.A.S.B., Assistant Superintendent, Geological Survey of India (With Plates 39 to 42) . . . . .	255—262
Natural Gas in Bituminous Salt from Kohat. By Murray Stuart, D. Sc., Assistant Superintendent, Geological Survey of India. (With Plates 43 and 44) . . . . .	263—267
The Mineral Resources of the Central Provinces. By L. Leigh Fermor, O.B.E., D.Sc., A.R.S.M., F.A.S.B., F.G.S., Superintendent, Geological Survey of India. (With Plate 45) . . . . .	268—302
Miscellaneous Notes—	
Note on Sipylite from the Nellore District, Madras Presidency . . . . .	303

## LIST OF PLATES, VOLUME I

- PLATE 1.**—Fig. 1. Bahadur Khel salt showing schistose structure.  
Fig. 2. A salt quarry at Bahadur Khel.
- PLATE 2.**—The schistosity of Bahadur Khel salt.
- PLATE 3.**—Plan of salt quarries at Kalabagh.
- PLATE 4.**—Plan of Nurpur mine.
- PLATE 5.**—Plan of potash drift, Nurpur mine.
- PLATE 6.**—Plan of portion of Warcha salt mine.
- PLATE 7.**—Section of chambers in Warcha mine.
- PLATE 8.**—Sketch map of portion of Bahadur Khel salt-field.
- PLATE 9.**—Fig. 1. Formation of crystals of selenite on grey clay.  
Fig. 2. Stages in formation of rock gypsum.
- PLATE 10.**—Fig. 1. Gypsum crust coating a limestone boulder.  
Fig. 2. Formation of a modern miniature cliff of gypsum.
- PLATE 11.**—Formation of gypsum along a line of fault.
- PLATE 12.**—Formation of a modern sheet of gypsum over Bahadur Khel salt field.
- PLATE 13.**—Overfolding and puckering of grey salt, Warcha mine.
- PLATE 14.**—Sketch map of western face of western salt hill, Bahadur Khel.
- PLATE 15.**—Fig. 1. Western face of western salt hill, Bahadur Khel.  
Fig. 2. Sulphate of soda breaking through salt crust.
- PLATE 16.**—N. E. corner of western salt hill, Bahadur Khel.
- PLATE 17.**—Flow structure in the Warcha mine.
- PLATE 18.**—Main marl-band, Warcha mine.
- PLATE 19.**—Fig. 1. Augen-shaped lenticle of magnesian salt, Warcha.  
Fig. 2. Flow structure exhibited by salt, Khewra.
- PLATE 20.**—Well banded Khewra salt.
- PLATE 21.**—Lenticles of salt outlined naturally by marl.
- PLATE 22.**—Patches of sulphate of soda, Bahadur Khel salt field.
- PLATE 23.**—Bands of marl in Khewra salt.
- PLATE 24.**—The western end of the Bahadur Khel salt field.
- PLATE 25.**—Map of the Salt area.
- PLATE 26.**—Index map to tin and tungsten localities in Burma. Scale 1"=120 miles.
- PLATE 27.**—Geological map of Tavoy district. Scale 1"=16 miles.
- PLATE 28.**—Map showing trace of thrust-plane between Murree and Siwalik beds, Jammu. Scale 2"=1 mile.
- PLATE 29.**—Sketch-map of sulphur mine 12 miles S. W. of Sanni. Scale 1"=100 feet.
- PLATE 30.**—Spiral impression on Lower Vindhyan limestone.
- PLATE 31.**—Convergence in Lacustrine Molluses.
- PLATE 32.**—Fossil Hydrobioidæ from the Namma fresh-water beds, Northern Shan States.

- PLATE 33.**—Fossil Viviparidæ from the Namma beds, Northern Shan States and the Yenangyat beds, Pakokku district, Upper Burma.
- PLATE 34.**—The Pit Wang galena mine.
- PLATE 35.**—View in the Nam Tamai valley under Salamkong showing westerly dip of joints in granite.
- PLATE 36.**—Confluence of the Nam Tamai (left) with the Taron (right).
- PLATE 37.**—Fig. 1. Gold washings in the river alluvium in the west bank of the Nma Hka.  
 Fig. 2. *Lit par lit* injection of granite into calcareous schist.
- PLATE 38.**—Geological map of Northern Putao.
- PLATE 39.**—Fig. 1. Pseudomorph in uranium ochre after uraninite. To the right of the large example is a smaller but similar crystal.  
 Figs. 2 to 4. Monazite crystals.  
 Figs. 5 to 7. Columbite crystals.  
 Fig. 8. Microcline crystal.
- PLATE 40.**—Fig. 1. Multiple twinning in monazite from Mysore, crossed nicols.  $\times 19$ .  
 Fig. 2. Zoned zircons from Abraki Pahar. Ordinary light.  $\times 19$ .
- PLATE 41.**—Fig. 1. Intergrowth of monazite and apatite. Small crystals of monazite in a matrix of apatite. Reflected light.  $\times 3$ .  
 Fig. 2. Monazite crystals showing parallel growth. The prominent face is  $w(101)$ . Natural size.  
 Fig. 3. Interpenetration group of monazite crystals. Natural size.  
 Fig. 4. Dihexagonal crystal of apatite on monazite. Natural size.  
 Fig. 5. Contact photograph with a piece of pitchblende from Pichhli showing cracks filled with decomposition product.
- PLATE 42.**—Fig. 1. Clinographic projection of monazite. The face  $r$  has been transferred to the left hand to enable  $u$  and  $e$  to appear.  
 Fig. 2. Clinographic projection of columbite.
- PLATE 43.**—Fig. 1. Bituminous salt schist from Malgin (Kohat). Natural size.  
 Fig. 2. Portion of re-crystallized bituminous salt in transmitted light, twice natural size.
- PLATE 44.**—Photomicrograph of centre of crystal of re-crystallized bituminous salt, showing bubbles of liquified gas ( $\times 53$  diameters).
- PLATE 45.**—Map showing the chief mineral deposits of the Central Provinces.

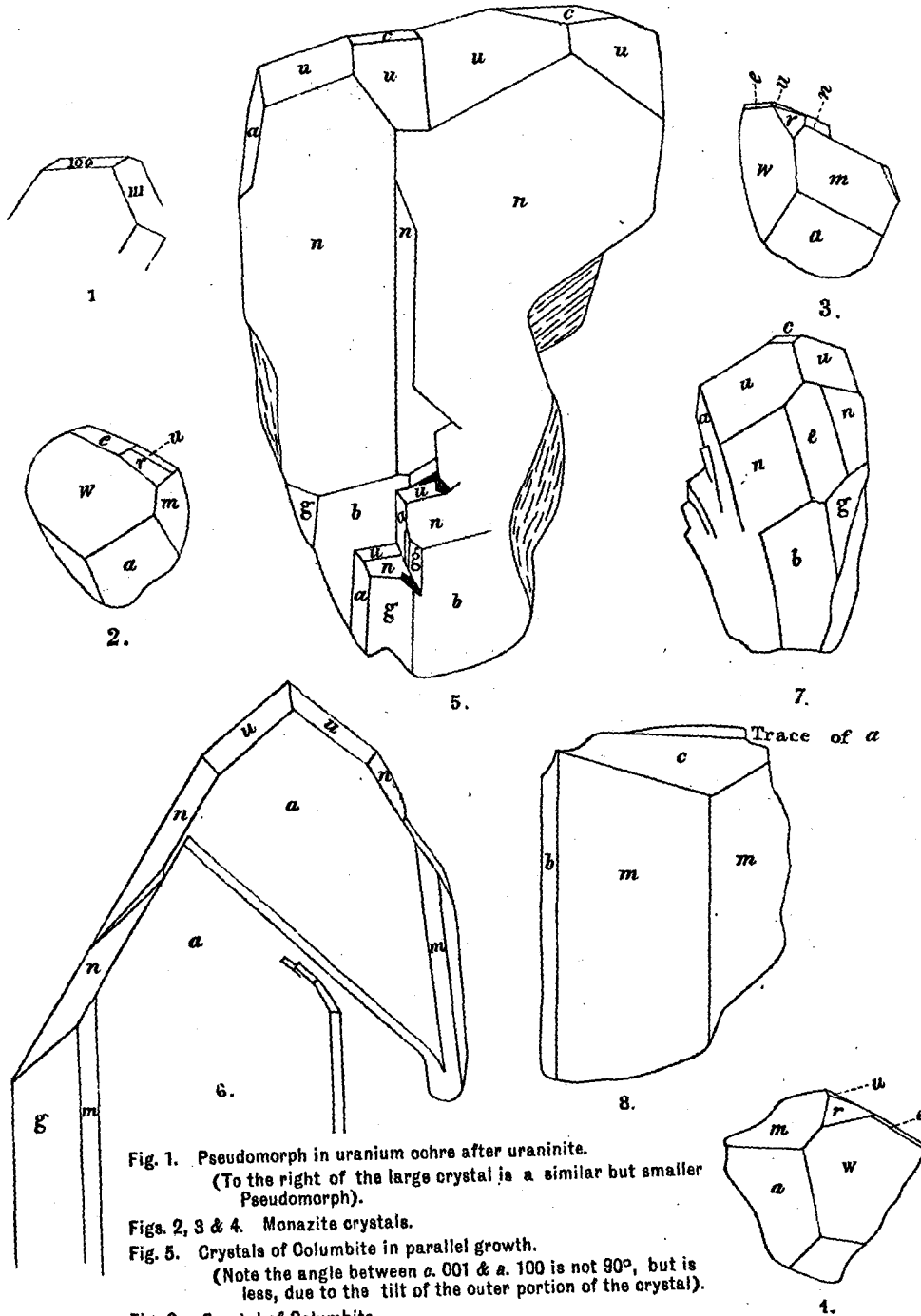
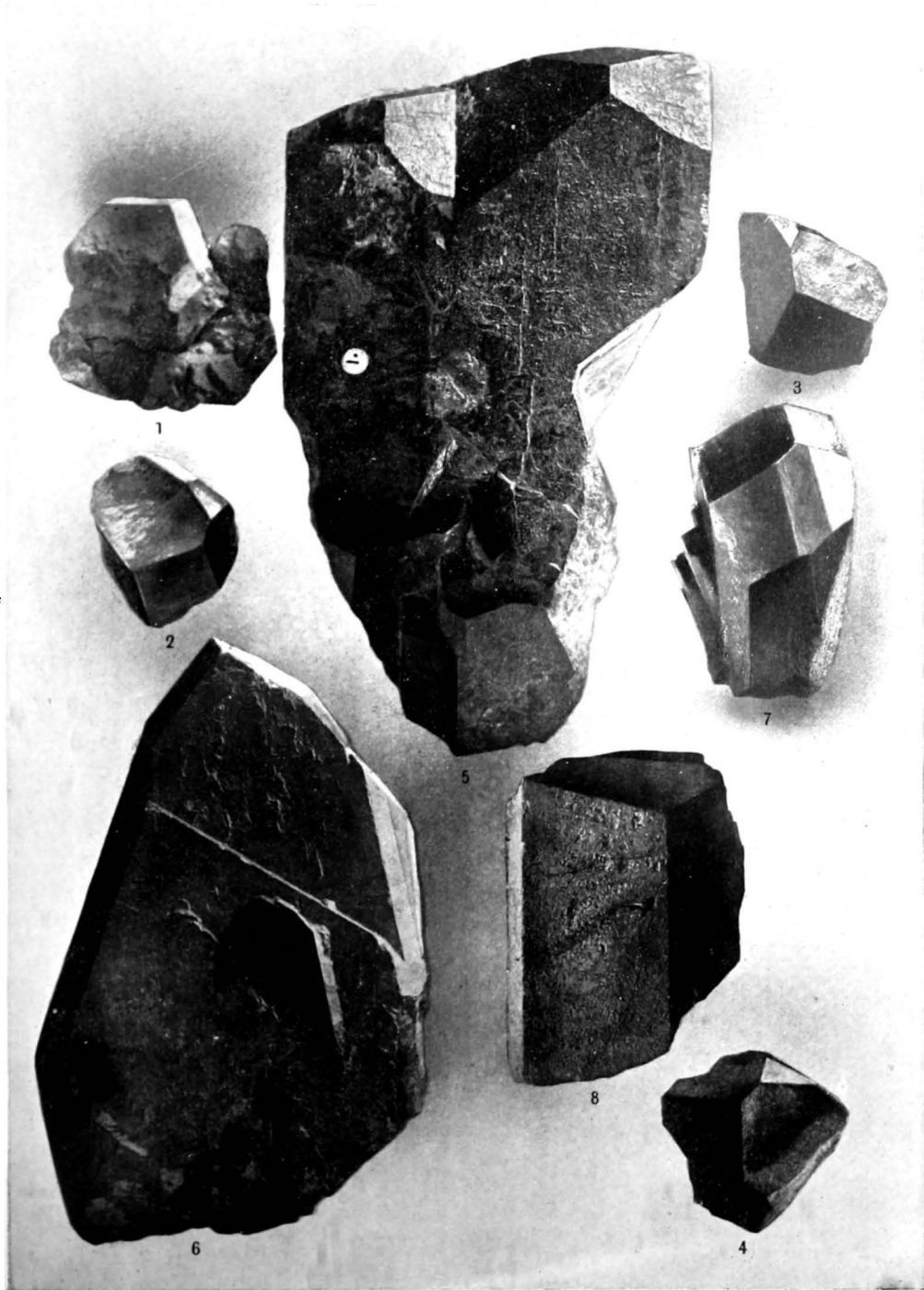


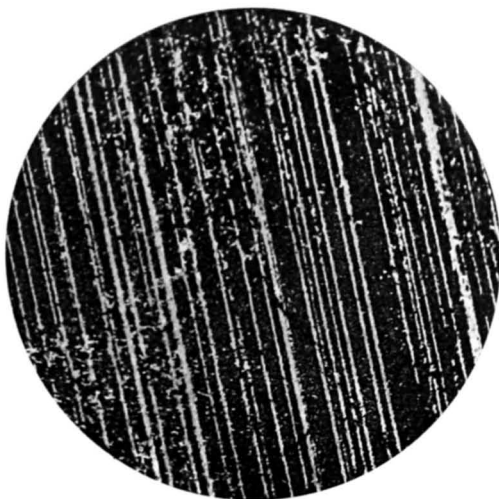
Fig. 1. Pseudomorph in uranium ochre after uraninite.  
 (To the right of the large crystal is a similar but smaller Pseudomorph).  
 Figs. 2, 3 & 4. Monazite crystals.  
 Fig. 5. Crystals of Columbite in parallel growth.  
 (Note the angle between  $a. 001$  &  $a. 100$  is not  $90^\circ$ , but is less, due to the tilt of the outer portion of the crystal).  
 Fig. 6. Crystal of Columbite.  
 Fig. 7. Do. showing curvature of the small side units.  
 Fig. 8. Crystal of Microcline.

(All figures natural size).





Photographs by K. F. Watkinson.



**FIG. 1. MULTIPLE TWINNING IN MONAZITE FROM MYSORE.**  
Crossed Nicols ( $\times 19$ ).

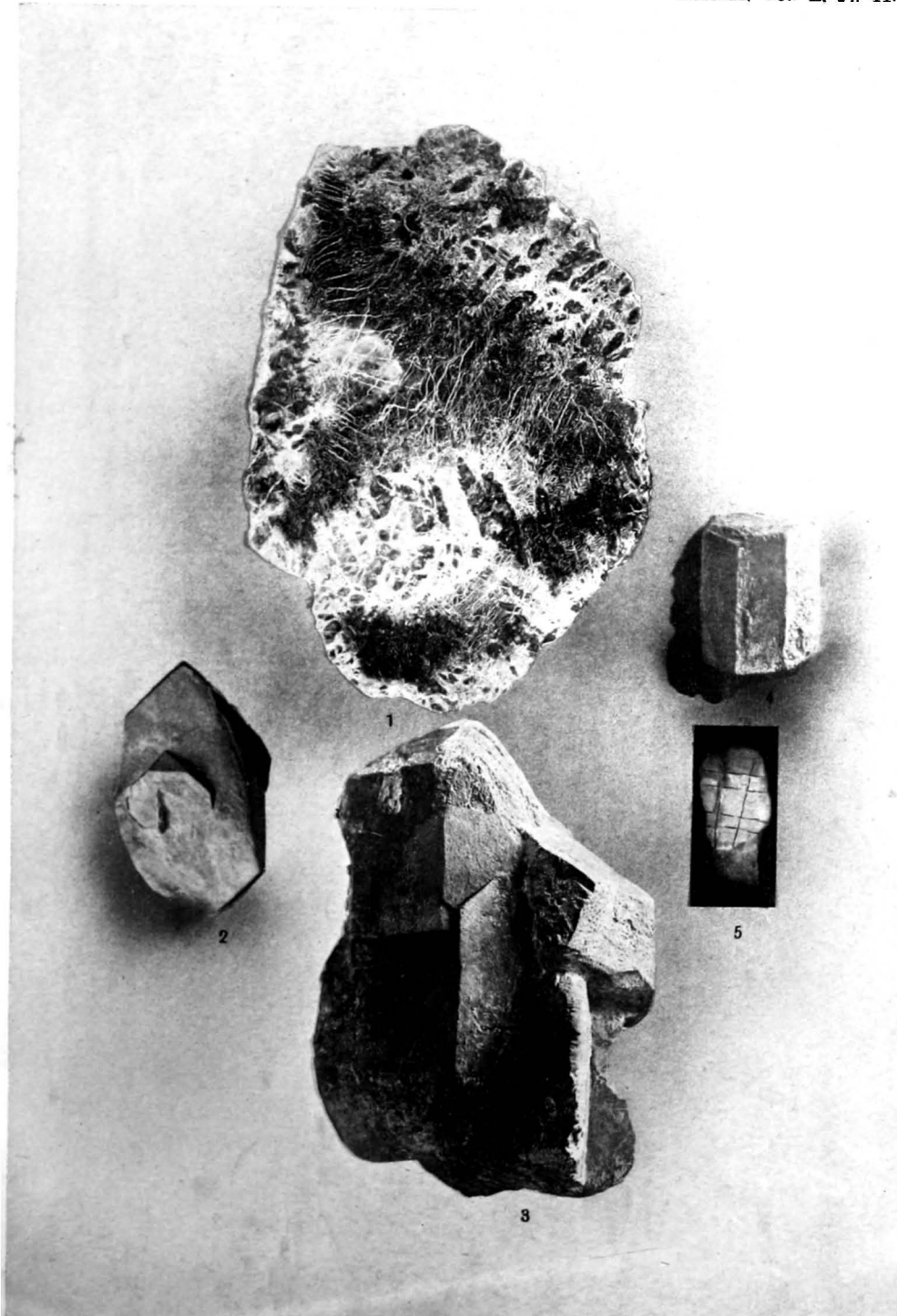


*Photomicro. by K. F. Watkinson.*

**FIG. 2. ZONING IN ZIRCONS FROM ABRAKI PAHAR.**  
Ordinary light ( $\times 19$ ).

*G. S. I. Calcutta.*

- Fig. 1.** Intergrowth of monazite & apatite. Monazite crystals in a matrix of green apatite. (Reflected light X 3).
- Fig. 2.** Monazite crystals showing parallel growth. The prominent face is  $w. 101$ . (Natural size).
- Fig. 3.** Monazite crystals. Interpenetration group. (Natural size.)
- Fig. 4.** Dihexagonal crystal of apatite on monazite. ( „ )
- Fig. 5.** Contact photograph with a piece of pitchblende from Pichhli showing cracks filled with decomposition product.



*Photographs by K. F. Watkinson.*

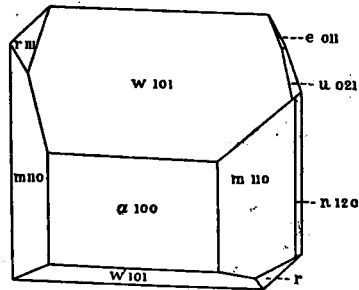
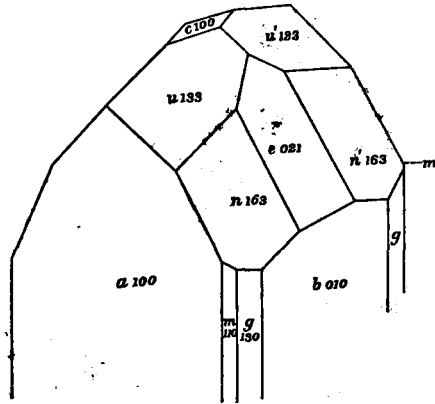


FIG. 1. CLINOGRAPHIC PROJECTION OF MONAZITE.



G. S. I. Calcutta.

FIG. 2. CLINOGRAPHIC PROJECTION OF COLUMBITE.

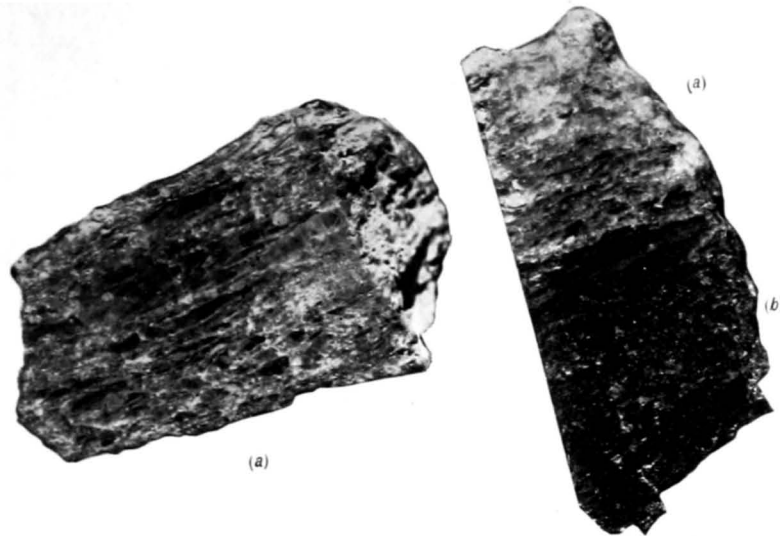


FIG. 1. PLANE POLISHED SURFACE OF SALT SCHIST,  
(a) Grey, non-bituminous (b) Black, bituminous. Photographs by reflected light.  
(Natural size).



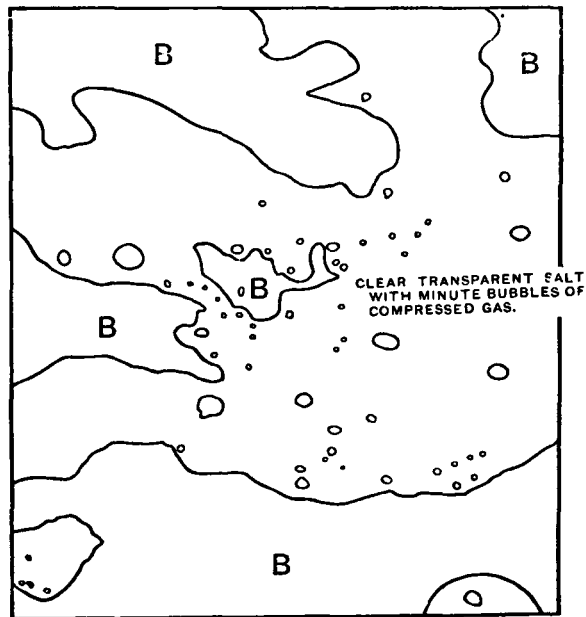
Photographs by K. F. Watkinson.

G. S. I. Calcutta.

FIG. 2. PORTION OF CRYSTAL OF NATURALLY RECRYSTALLIZED BITUMINOUS SALT,  
Showing schistose arrangement of the bituminous matter through the crystal.  
Photographed by transmitted light (  $\times 2$  ).



PHOTOMICROGRAPH OF THE CENTRE OF A CRYSTAL OF NATURALLY RECRYSTALLIZED BITUMINOUS SALT SHOWING MINUTE INCLUDED BUBBLES OF LIQUIFIED NATURAL GAS. (Transmitted light  $\times 53$ .)



*Photograph by Murray Stuart.*

*G. S. I. Calcutta*

KEY TO PHOTOMICROGRAPH. **B** = Bituminous Salt.





ing the returns are becoming more precise every year and the machinery employed for the purpose more efficient. Hence the number of minerals included in Class I—for which approximately trustworthy annual returns are available—is gradually increasing, and it is hoped that before long the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will be reduced to a very small number. In the case of minerals still exploited chiefly under primitive native methods and thus forming the basis of an industry carried on by a large number of persons each working independently and on a very small scale, the collection of reliable statistics is impossible, but the total error from year to year is not improbably approximately constant and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible.

From table 1 it will be seen that there has been an apparent increase of over £6,000,000 or 38·39 per cent. in the value of the total production over that of 1918. The value figures, however, are largely artificial. In some instances although the output has increased in quantity, it has decreased in value. This decrease is principally due to the fall in the market prices of ores and metals which indicate that the market is gradually returning to normal conditions as a result of the cessation of the war. In accordance with an order of the Government of India, the sterling values in all tables for the year 1919 have been derived from rupee values by conversion at the rate of Rs. 10=£1. The actual average value of the rupee during 1919 was 1s.  $8\frac{27}{32}d.$  (Rs. 11·514=£1); the highest value reached was 2s.  $4\frac{7}{8}d.$  and the lowest value 1s.  $5\frac{31}{32}d.$  The values for the year 1918 have been calculated at the rate of one rupee=1s. 4d. (Rs. 15=£1), the actual average value of the rupee being 1s.  $5\frac{11}{16}d.$ ; the highest value reached in that year was 1s.  $5\frac{31}{32}d.$  and the lowest 1s.  $4\frac{31}{32}d.$

The number of mineral concessions granted during the year amounted to 708 as against 719 in the preceding year; 602 of these were prospecting licenses and 106 mining leases,

Mineral Concessions  
granted.

TABLE 1.—Total value of Minerals for which returns of Production are available for the years 1918 and 1919.<sup>1</sup>

—	1918.	1919.	Increase.	Decrease.	Variation per cent.
	(Rupee = 1s. 4d.)	(Rupee=2s.)			
	£	£	£	£	
Coal . . . . .	6,017,215	10,119,256	4,102,041	...	+68.1
Gold . . . . .	2,060,152	2,256,039	195,887	...	+9.5
Petroleum . . . . .	1,131,904	1,834,308	702,404	...	+62
Salt . . . . .	1,645,195	1,823,522	178,327	...	+10.8
Manganese(a) . . . . .	1,481,735	1,546,330	64,595	...	+4.36
Mica(a) . . . . .	625,271	863,448	238,177	...	+38.1
Lead and Lead-ore . . . . .	450,477	668,642	218,165	...	+48.32
Tungsten-ore . . . . .	726,681	539,544	...	187,137	-25.75
Silver . . . . .	295,696	487,246	191,550	...	+64.72
Saltpetre . . . . .	589,190	471,247	...	117,943	-20
Building materials . . . . .	263,290	436,183	172,893	...	+65.7
Tin and Tin-ore . . . . .	134,635	241,150	106,515	...	+79.1
Ruby, Sapphire and Spinel . . . . .	40,310	108,087	67,777	...	+168.1
Chromite . . . . .	52,063	88,724	36,661	...	+70.4
Jadestone(a) . . . . .	124,113	87,102	...	37,011	-29.8
Monazite . . . . .	58,819	60,712	1,893	...	+3.2
Copper-ore . . . . .	4,053	52,416	48,363	...	+1193.2
Clay . . . . .	14,084	49,960	35,876	...	+254.7
Iron-ore . . . . .	41,105	45,887	4,782	...	+11.6
Diamond . . . . .	2,625	20,825	18,200	...	+693.3
Magnesite . . . . .	4,641	19,728	15,087	...	+325.08
Steatite . . . . .	7,708	6,498	...	1,210	-15.7
Corundum . . . . .	4,108	5,347	1,239	...	+30.16
Alum . . . . .	960	4,800	3,840	...	+400
Ochre . . . . .	2,890	3,600	710	...	+24.6
Gypsum . . . . .	1,139	2,869	1,730	...	+151.9
Bauxite . . . . .	894	1,934	1,040	...	+116.4
Asbestos . . . . .	965	1,656	691	...	+71.6
Barytes . . . . .	2,948	1,561	...	1,387	-47.05
Antimony . . . . .	6	203	197	...	...
Graphite . . . . .	361	819	458	...	+126.9
Amber . . . . .	87	616	529	...	+608
Apatite . . . . .	3,400	500	...	2,900	-85.3
Molybdenite . . . . .	62	101	39	...	+63
Potaah . . . . .	46	42	...	4	-8.7
Samarakite . . . . .	4	10	6	...	+150
Aquamarine . . . . .	180	...	...	180	...
Platinum . . . . .	2	...	...	2	...
<b>Total</b> . . . . .	<b>15,789,014</b>	<b>21,850,912</b>	<b>6,409,672</b>	<b>347,774</b>	<b>+38.39</b>
			+ 6,061,898		

(a) Export values.

<sup>1</sup> The increases or decreases are shown in sterling values, taking the rupee at 1s. 4d. for 1918 and at 2s. for 1919. (The true average for 1918 was 1s. 5½d., and for 1919, 1s. 8½d.)

## II.—MINERALS OF GROUP I.

Chromite.	Gold.	Lead.	Monazite.	Salt.
Coal.	Graphite.	Magnesite.	Petroleum.	Saltpetre.
Copper.	Iron.	Manganese.	Ruby, Sapphire	Silver.
Diamonds.	Jadeite.	Mica.	and Spinel.	Tin.
		Tungsten.		

## Chromite.

The marked increase in the output of chromite during the year 1918 was not repeated during the present year. In fact there was a distinct decrease in output, especially in Baluchistan, but a decided increase in the total value of the material won, which is due largely to the increase in the exchange value of the rupee. The recently discovered property in Mysore all but maintained its yield of the year previous.

TABLE 2.—Quantity and value of Chromite produced in India during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value.		Quantity.	Value.	
		(Rupee=1s. 4d.)			(Rupee=2s.)	
	Tons.	Ra.	£	Tons.	Ra.	£
Baluchistan . . .	22,944	3,44,160	22,944	13,223·3	4,29,757	42,976
Bihar and Orissa . . .	1,085·5	24,666	1,644·4	843·8	12,721	1,272
Mysore . . .	33,740	4,12,115	27,474·3	22,372	4,44,766	44,476
<b>Total . . .</b>	<b>57,769·5</b>	<b>7,80,941</b>	<b>52,062·7</b>	<b>36,439·1</b>	<b>8,87,244</b>	<b>88,724</b>

## Coal.

There was an increase of about 2 million tons, or over 9 per cent., in the output of coal. This increase was due largely to Bengal and Bihar and Orissa; Central India and Baluchistan shewed a decided decrease. There was a small increase in the pit's mouth value everywhere, except in Central India and the Central Provinces. In the fields of Bengal and Bihar and Orissa, the rates of increase were respectively Re. 0-1-2 and Re. 0-2-11 per ton.

TABLE 3.—Average price (per ton) of coal extracted from the Mines in each province during the year 1919.

Province.	Average price per ton.		
	Rs.	A.	P.
Assam . . . . .	7	10	6
Baluchistan . . . . .	15	12	2
Bengal . . . . .	5	0	1
Bihar and Orissa . . . . .	4	1	2
Burma . . . . .	(a)0	4	0
Central India . . . . .	3	9	7
Central Provinces . . . . .	5	7	0
North-West Frontier Province . . . . .	5	0	0
Punjab . . . . .	11	12	8
Rajputana . . . . .	6	9	0

(a) The low value is due to difficulty of transport.

TABLE 4.—Origin of Indian Coal raised during 1918 and 1919.

—	Average of last five years.	1918.	1919.
	Tons.	Tons.	Tons.
Gondwana Coalfields . . . . .	17,542,676	20,322,892	22,238,802
Tertiary Coalfields . . . . .	408,907	399,601	389,235
Total . . . . .	...	20,722,493	22,628,037

TABLE 5.—Provincial Production of Coal during the years 1918 and 1919.

Province.	1918.	1919.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Assam . . . . .	294,484	291,734	...	2,750
Baluchistan . . . . .	43,125	34,328	...	8,797
Bengal . . . . .	5,302,295	5,777,632	475,337	...
Bihar and Orissa . . . . .	13,680,030	15,119,812	1,439,782	...
Burma . . . . .	...	1,500	1,500	...
Central India . . . . .	199,975	182,141	...	17,834
Central Provinces . . . . .	481,470	497,021	15,551	...
Hyderabad . . . . .	659,122	662,196	3,074	...
North-West Frontier Province . . . . .	240	20	...	220
Punjab . . . . .	50,418	46,893	...	3,525
Rajputana . . . . .	11,334	14,760	3,426	...
Total . . . . .	20,722,493	22,628,037	1,938,670	33,126

TABLE 6.—Output of the Gondwana Coal fields for the years 1918 and 1919.

	1918.		1919.	
	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.
<i>Bengal, Bihar and Orissa—</i>				
Daltonganj . . . . .	81,816	.39	63,250	.28
Giridih . . . . .	846,592	4.09	950,045	4.20
Jainti . . . . .	140,373	.68	154,850	.69
Jharia . . . . .	10,952,010	52.85	12,145,917	53.68
Bokaro-Ramgarh . . . . .	541,977	2.62	722,682	3.19
Raniganj . . . . .	6,368,519	30.74	6,815,126	30.11
Sambalpur (Hingir-Rampur)	51,038	.25	45,574	.20
<i>Central India—</i>				
Umaria . . . . .	199,975	.96	182,141	.80
<i>Central Provinces—</i>				
Ballarpur . . . . .	135,375	.65	126,366	.56
Pench Valley . . . . .	267,303	1.29	285,356	1.26
Mohpani . . . . .	78,792	.38	85,299	.38
<i>Hyderabad—</i>				
Singareni . . . . .	659,122	3.18	662,196	2.93
<b>Total</b> . . . . .	<b>20,322,892</b>	<b>98.08</b>	<b>22,238,802</b>	<b>98.28</b>

TABLE 7.—Output of Tertiary Coalfields for the years 1918 and 1919.

	1918.		1919.	
	Tons.	Per cent of Indian Total.	Tons.	Per cent of Indian Total.
<i>Assam—</i>				
Makum . . . . .	267,749	} 1.42 }	259,652	} 1.29 }
Naga Hills . . . . .	24,299			
Sibsagar . . . . .	1,827			
Khasi and Jaintia Hills . . . . .	609			
<i>Baluchistan—</i>				
Khost . . . . .	29,600	} .21 }	23,703	} .16 }
Sor Range . . . . .	13,525			
North-West Frontier Province . . . . .	240			
<i>Burma—</i>	...		1,500	
<i>Punjab—</i>				
Jhelum . . . . .	39,651	} .24 }	35,845	} .21 }
Mianwal . . . . .	5,152			
Shahpur . . . . .	5,615			
<i>Rajputana—</i>				
Bikanir . . . . .	11,334	.05	14,760	.06
<b>Total</b> . . . . .	<b>399,601</b>	<b>1.92</b>	<b>389,235</b>	<b>1.72</b>

Exports of coal rose to over half a million tons. Imports, on the other hand, fell from 54,000 tons to 49,000 tons.

TABLE 8.—*Exports of Indian Coal.*

	1918.		1919.	
	Quantity.	Value. (Rupee = <i>ls. 4d.</i> )	Quantity.	Value. (Rupee=2s.)
	Tons.	£	Tons.	£
Ceylon . . . . .	51,935	36,442	296,192	353,169
Straits Settlements (including Labuan).	10,279	6,853	116,304	128,899
Sumatra . . . . .	...	...	41,756	51,350
Other Countries . . . . .	12,121	8,703	53,678	67,476
<b>TOTAL</b> . . . . .	<b>74,335</b>	<b>51,998</b>	<b>507,930</b>	<b>600,894</b>
Coke and Patent Fuel . . . . .	131	346	607	2,917
<b>Total Coal, Coke and Patent Fuel</b>	<b>74,466</b>	<b>52,344</b>	<b>508,537</b>	<b>603,811</b>

TABLE 9.—*Imports of Coal, Coke and Patent Fuel during 1918 and 1919.*

	1918.		1919.	
	Quantity.	Value. (Rupee = <i>ls. 4d.</i> )	Quantity.	Value. (Rupee=2s.)
	Tons.	£	Tons.	£
Australia (including New Zea- land).	4,857	9,741	3,329	6,364
Natal . . . . .	13,020	29,805	18,089	54,302
Portuguese East Africa . . . . .	22,680	37,416	16,880	43,716
United Kingdom . . . . .	7,680	33,944	4,656	19,750
Other Countries . . . . .	5,065	17,578	4,734	10,588
<b>TOTAL</b> . . . . .	<b>53,202</b>	<b>128,484</b>	<b>47,688</b>	<b>134,720</b>
Coke . . . . .	1,144	6,227	957	6,773
Patent Fuel . . . . .	...	11	30	171
<b>Total</b> . . . . .	<b>54,346</b>	<b>134,722</b>	<b>48,675</b>	<b>141,664</b>

The average number of persons employed daily in the coalfields increased by over 12,000 or about  $6\frac{1}{2}$  per cent. The average output per person employed was more than that in the preceding year, viz., 111.05 tons as against 108.3. The total number of fatal accidents was 287 corresponding to a death-rate of 1.41 per thousand persons employed.

TABLE 10.—Average number of persons employed daily in the Indian Coalfields during 1918 and 1919.

Province.	Number of persons employed.		Output per person employed.	Number of deaths by accident.	Death-rate per 1,000 persons employed.
	1918.	1919.	1919.	1919.	1919.
Assam . . . . .	3,085	3,230	90.3	13	4.02
Baluchistan . . . . .	993	1,006	34.1	4	3.97
Bengal . . . . .	46,149	48,642	118.8	72	1.48
Bihar and Orissa . . . . .	118,849	129,927	116.4	161	1.24
Burma . . . . .	...	70	21.4	...	...
Central India . . . . .	3,047	1,293	140.9	1	.77
Central Provinces . . . . .	6,052	6,306	78.8	9	1.43
Hyderabad . . . . .	11,582	11,974	55.3	26	2.17
North-West Frontier Province.	12	5	4.0	...	...
Punjab . . . . .	1,358	1,191	39.4	1	.84
Rajputana . . . . .	198	108	136.7	...	...
<b>Total</b> . . . . .	<b>191,325</b>	<b>203,752</b>	...	<b>287</b>	...
<b>AVERAGE</b> . . . . .	...	...	<b>111.05</b>	...	<b>1.41</b>

### Copper.

The output of copper ore in Singhbhum fell from 20,108 tons in 1917 to only 3,619 tons in 1918. The industry more than recovered itself, however, in 1919, when 32,750 tons, valued at over £52,000, were obtained (see Table 1). Smelting operations were begun at the Rakha Mines during the year 1918 and resulted in the production of 980½ tons of refined copper in the year 1919.

### Diamonds.

The output of diamonds from Central India amounted to 311·9 carats valued at Rs. 2,08,253 (£20,825) as against 73·29 carats valued at Rs. 39,377 (£2,625) in the preceding year.

### Gold.

There was again a decrease, amounting to 28,858 oz. in the output of gold. All provinces with the exception of the Punjab shared in this decrease which, however, was borne chiefly by the Mysore fields where the output fell by 19,164 oz.

TABLE 11.—*Quantity and value of Gold produced in India during 1918 and 1919.*

	1918.			1919.			Labour.
	Quantity.	Value.		Quantity.	Value.		
		(Rupee=1s. 4d.)			(Rupee=2s.)		
	ozs.	Rs.	£	ozs.	Rs.	£	
<i>Bihar and Orissa—</i>							
<i>Singhbhum</i>	2,085	1,48,573	9,905	173	11,776	1,178	223
<i>Burma—</i>							
<i>Myitkyina</i>	105·57	6,069	404	.. 7·79	..	.. 44	..
<i>Katha</i>	19·23	1,060	71	..	440	298	38
<i>Upper Chindwin</i>	48·40	3,960	264	30·84	2,981	298	
<i>Hyderabad</i>	11,502·8	6,74,046	44,936	10,647·6	6,10,195(a)	61,019(a)	919
<i>Madras</i>	17,831	10,08,279	67,219	11,018	5,62,918(b)	56,292(b)	554
<i>Mysore</i>	504,412	2,90,51,774	1,936,785	485,248	2,13,62,846(c)	2,136,285(c)	24,400
<i>Punjab</i>	109·95	8,119	541	130·73	8,914	891	288
<i>United Provinces</i>	6·37	398	27	4·6	321	32	20
<b>Total</b>	<b>536,118·32</b>	<b>3,09,02,278</b>	<b>2,060,152</b>	<b>507,260·56</b>	<b>2,25,60,391</b>	<b>2,256,039</b>	<b>28,454</b>

(a) Figures for actual sales not available.

(b) English sales £36,011; Indian sales Rs. 2,02,808.

(c) English sales £1,236,155; Indian sales Rs. 90,01,296.

### Graphite.

There was a recovery in the output of graphite which rose from 81 tons valued at Rs. 5,410 in 1918 to 127 tons valued at Rs. 8,189 in the year under review. Rajputana produced only 5 tons; in Kalahandi the output rose from 80 to 100 tons and in Patna amounted to 22 tons.

### Iron.

There was a considerable increase in the output of iron-ore. The Tata Iron and Steel Company produced 232,368 tons of pig iron, 134,061·2 tons of steel including rails and 2,650 tons of ferro-manganese, while the Bengal Iron and Steel Company produced



84,965 tons of pig iron, 4,732 tons of ferro-manganese and 29,635 tons of cast iron castings. In the Central Provinces there was a reduction of over 31 per cent. in the number of indigenous furnaces which fell from 232 in 1918 to 159 in the year under review. The Burma Corporation Limited are extracting limonite at Wetwun near Maymyo, Burma, for use as a flux in their lead smelting at Namtu; large quantities are said to be available.

TABLE 12.—Quantity and value of Iron-ore produced in India during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value.		Quantity.	Value.	
		(Rupee=1s. 4d.)			(Rupee=2s.)	
	Tons.	Rs.	£	Tons.	Rs.	£
<i>Bihar and Orissa—</i>						
<i>Singhbhum</i> .	120,363	1,27,239	8,483	104,728.5	139,639	13,963.9
<i>Orissa</i> .	339,304.6	4,52,163	30,144	424,543.6	294,566	29,456.6
<i>Burma</i> .	26,680	13,982	932	31,880	15,947	1,594.7
<i>Central Provinces</i>	6,097	23,185	1,546	2,596	8,716	871.6
<i>Other Provinces and States.</i>	224.5	(a)	...	2.1	(a)	...
<b>Total</b> .	<b>492,669.1</b>	<b>6,16,569</b>	<b>41,105</b>	<b>563,750.2</b>	<b>458,868</b>	<b>45,886.8</b>

(a) Not available.

### Jadeite.

There was a decrease of nearly 37 per cent. in the output of jadeite in Burma, which fell from 3,203.1 cwt. valued at Rs. 3,78,135 (£25,209) in 1918 to 2,019.2 cwt. valued at Rs. 2,80,454 (£28,045) in the year under review.

### Lead.

There was an increase of some 6,600 tons in the amount of ore and slag produced at the Bawdwin mines; the amount of metal extracted was also greater than that recovered in the year 1918, the total output being 19,090 tons valued at Rs. 66,86,416 as against 18,995 tons valued at Rs. 67,51,842 in the preceding year. The quantity of silver extracted rose from 1,970,614 oz. valued at Rs. 44,33,881 in 1918 to 2,164,854 oz. valued at Rs. 48,70,919 in the year under review.

TABLE 13.—Production of Lead and Silver Ore during 1918 and 1919.

		1918.					1919.				
		QUANTITY.	VALUE. (Rupee=1s. 4d.)				QUANTITY.	VALUE. (Rupee=2s.)			
			Lead-ore and slag.	Lead-ore and lead.		Silver.		Lead-ore and slag.	Lead-ore and lead.		Silver.
	Tons.	Rs.	£	Rs.	£	Tons.	Rs.	£	Rs.	£	
<b>Burma—</b>											
Northern States.	Shan	50,679 (ore)	61,97,478(a)	413,165	41,50,793	276,720	67,816 (ore)	66,56,300(g)	665,630	48,62,113	486,211-3
		2,042 (slag)	2,69,040(b)	17,936	26,388	1,759	98 (slag)	12,250(h)	1,225	754	75-4
		9,254 (gossan flux)	1,61,070(c)	10,738	83,675	5,578	1,124 (gossan flux)	12,950(i)	1,295	7,958	795-8
		425 (secondaries)	1,24,254(d)	8,284	1,73,025	11,535	2 (copper-ore)	..	..	94	9-4
Southern States.	Shan	117-05	4,865	324	..	..	125-61	4,466	446-6	..	..
<b>Central Provinces—</b>											
Drug		3	450	30	..	..	2-5	450	45	..	..
<b>Mysore—</b>											
Chitaldrug		·03	(e)	..	..	..	..	..	..	..	..
<b>Total</b>		<b>62,520-03</b>	<b>67,57,157</b>	<b>450,477</b>	<b>44,33,881(f)</b>	<b>295,592</b>	<b>69,168-11</b>	<b>66,86,416</b>	<b>668,641-6</b>	<b>48,70,919(f)</b>	<b>487,091-9</b>

(a) Value of 17,507-84 tons of lead extracted.  
 (b) Value of 769-18 tons of lead extracted.  
 (c) Value of 376-40 tons of lead extracted.  
 (d) Value of 351-03 tons of lead extracted.  
 (e) Value not returned.

(f) Value of 1,970,614 ozs. of silver extracted.  
 (g) Value of 19,018-06 tons of lead extracted.  
 (h) Value of 34-98 tons of lead extracted.  
 (i) Value of 37-07 tons of lead extracted.  
 (j) Value of 2,164,853-68 ozs. of silver extracted.

## Magnesite.

The sudden demand for Indian magnesite, which arose during the war owing to the temporary loss of Styrian supplies, ceased during the year 1918 and the Salem output fell from over 18,000 tons in 1917 to a little under 6,000 tons. In 1919, however, the industry revived and the output reached a figure only 1,000 tons short of the quantity raised in 1917.

TABLE 14.—Quantity and value of Magnesite produced in India during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value.		Quantity.	Value.	
		(Rupee=1s. 4d.)			(Rupee=2s.)	
	Tons.	Rs.	£	Tons.	Rs.	£
Madras—						
Salem . . . . .	5,773	69,276	4,618	13,012	156,144	15,614
Mysore . . . . .	80	342	23	4,114	41,140	4,114
<b>Total . . . . .</b>	<b>5,853</b>	<b>69,618</b>	<b>4,641</b>	<b>17,126</b>	<b>197,284</b>	<b>19,728</b>

## Manganese.

The output of manganese ore increased slightly from about 518,000 tons in 1918 to about 538,000 tons in the year under review. As usual, over 80 per cent. of the production came from the Central Provinces. The amount exported (exclusive of exports from Mormugao) was only 370,000 tons, resulting in a further increase in stocks held in this country.

TABLE 15.—Export of Manganese ore during 1918 and 1919.

	1918.		1919.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
To—				
United Kingdom . . . . .	246,005	321,360	224,157	422,516
France . . . . .	48,400	66,908	52,300	92,163
Italy . . . . .	2,475	3,185	3,250	7,249
Japan . . . . .	24,846	43,912	1,690	5,170
United States of America . . . . .	29,100	47,217	12,800	22,951
Other Countries . . . . .	...	...	76,262	147,683
<b>Total . . . . .</b>	<b>350,826</b>	<b>482,582</b>	<b>370,459</b>	<b>697,732</b>

TABLE 16.—*Quantity and value of Manganese ore produced during 1918 and 1919.*

	1918.		1919.	
	Quantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b. at Indian ports.
	Tons.	£	Tons.	£
<i>Bihar and Orissa—</i>				
Singhbhum . . .	450	1,170	325	877
Gangpur . . .	15,895	41,327	21,208	57,262
<i>Bombay—</i>				
Chota Udepur . . .	7,202	18,725	14,993	40,481
Panch Mahals . . .	30,893	80,322	29,540	79,758
<i>Central Provinces—</i>				
Balaghat . . .	214,972	634,167	238,681	704,109
Bhandara . . .	32,245	95,123	34,632	102,254
Chindwara . . .	72,398	213,574	55,310	163,165
Jubbulpore . . .	65	192	...	...
Nagpur . . .	118,948	350,897	115,852	341,763
<i>Madras—</i>				
Vizagapatam . . .	2,230	3,382	2,778	5,047
<i>Mysore</i> . . .	22,655	42,856	24,676	51,614
<b>Total</b> . . .	<b>517,953</b>	<b>1,481,735</b>	<b>537,995</b>	<b>1,546,330</b>

### Mica.

The declared output of mica shows a decrease of nearly 9,000 cwt., over that of the previous year, having dropped from about 54,700 cwt. to 45,700 cwt. These figures are, however, not very reliable, and cannot be regarded as indicating a relaxation of the urgent demand for this mineral in all the allied countries. As usual, the exports considerably exceeded the recorded production

and amounted to 59,098 cwt. valued at £863,448. This figure is less by 856 cwt. than the exports of the year 1918.

TABLE 17.—Quantity and value of Mica produced in India during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value. (Rupee=1s. 4d.)		Quantity.	Value. (Rupee=2s.)	
		Cwts.	Rs.		£	Cwts.
Bihar and Orissa	45,607.5	18,60,714	124,047.6	34,230.2	15,96,781	159,678.1
Central India (Gwalior State).	290.2	(a)	...	...	...	...
Madras . . .	6,544.7	4,61,593	30,772.9	8,320.6	5,25,800	52,580
Mysore . . .	17.9	781	52	...	...	...
Rajputana . .	2,250	56,429	3,762	3,232.9	75,845	7,584.5
<b>Total .</b>	<b>54,710.3</b>	<b>23,79,517</b>	<b>153,634.5</b>	<b>45,783.7</b>	<b>21,93,426</b>	<b>219,842.6</b>

(a) Value not returned.

### Monazite.

There was a slight decrease in the output of monazite in Travancore, which fell from 2,117.2 tons, valued at £58,819 in the year 1918 to 2,023.7 tons, valued at £60,712, in the year under review.

### Petroleum.

There was an increase of about 19 million gallons in the output of petroleum, the total production being 305,651,816 gallons. The chief increases were over 32½ million gallons from the Singu field, over ½ million from the Upper Chindwin field and 1 million from the Badarpur field in Assam. The Yenangyaung field was responsible for the principal decrease in production, its output having fallen by about 13½ million gallons. There were also falls in the outputs of Yenangyat, Minbu, Digboi, and Attock.

TABLE 18.—*Quantity and value of Petroleum produced in India during 1918 and 1919.*

	1918.			1919.		
	Quantity.	Value. (Rupee=1s. 4d.)		Quantity.	Value. (Rupee=2s.)	
		Gallons.	Rs.		£	Gallons.
<b>Burma—</b>						
Akyab . . . . .	10,821	3,122	208	10,718	3,092	309-2
Kyaukpadaung . . . . .	46,598	22,305	1,487	43,944	22,865	2,286-5
Yenangyaung Field . . . . .	203,638,043	1,17,57,392	783,826	190,322,077	1,09,88,797	1,098,879-7
Singua Field . . . . .	61,035,972	35,24,016	234,934	93,826,506	54,05,802	540,580-2
Yenangyat Field . . . . .	4,739,587	2,63,310	17,554	4,123,387	2,32,828	23,282-8
Minbu . . . . .	4,826,735	6,03,342	40,223	4,423,361	8,29,380	82,938
Thayetmyo . . . . .	63,000	7,900	527	113,784	14,223	1,422-3
Upper Chindwin . . . . .	473,800	35,535	2,369	1,085,080	81,377	8,137-7
<b>Assam—</b>						
Digboi (Lakhimpur) . . . . .	5,425,580	2,68,453	17,897	5,242,617	2,59,400	25,940
Badarpur . . . . .	5,574,068	4,18,055	27,870	6,546,062	4,90,953	49,095-3
<b>Punjab—</b>						
Attock . . . . .	750,000	75,000	5,000	113,360	14,170	1,417
Misrawali . . . . .	807	129	9	970	191	19-1
<b>Total . . . . .</b>	<b>286,685,011</b>	<b>1,69,78,559</b>	<b>1,131,904</b>	<b>305,651,816</b>	<b>1,83,43,078</b>	<b>1,834,307-8</b>

There was a very large increase in the imports of kerosene oil, which rose from 21½ gallons in 1918 to 3½ times that amount in 1919, viz., 74½ million gallons, valued at over £5¼ million. The exports of paraffin wax rose from 508,952 cwt., valued at £775,962 in the year 1918 to 532,479 cwt., valued at £1,216,252 in the year under review.

TABLE 19.—*Imports of Kerosene oil during 1918 and 1919.*

	1918.		1919.	
	Quantity.	Value. (Rupee =1s. 4d.)	Quantity.	Value. (Rupee=2s.)
<b>From—</b>				
Borneo . . . . .	Gallons.	£	Gallons.	£
. . . . .	...	...	19,160,462	1,017,638
Persia . . . . .	8,193,438	315,946	11,986,659	871,997
Straits Settlements (including Labuan) . . . . .	...	...	4,431,042	232,917
United States of America . . . . .	13,574,515	772,719	38,635,385	3,142,300
Other Countries . . . . .	223	16	444	55
<b>Total . . . . .</b>	<b>21,768,176</b>	<b>1,088,681</b>	<b>74,213,992</b>	<b>5,264,907</b>

TABLE 20.—Exports of Paraffin wax from India during 1918 and 1919.

	1918.		1919.	
	Quantity.	Value. (Rupee = 1s. 4d.)	Quantity.	Value. (Rupee = 2s.)
To—	Cwt.	£	Cwt.	£
United Kingdom . . .	103,680	157,099	131,764	290,639
China . . . . .	12,592	28,818	44,300	108,289
Japan . . . . .	88,520	134,255	129,308	294,199
Egypt . . . . .	46,959	71,223	21,909	50,019
Portuguese East Africa .	61,200	92,820	11,280	25,662
United States of America	14,000	21,233	32,800	74,621
Australia (including New Zealand).	61,441	93,209	48,569	110,496
Other Countries . . .	120,560	177,305	112,549	262,327
<b>Total . . . . .</b>	<b>508,952</b>	<b>775,962</b>	<b>532,479</b>	<b>1,216,252</b>

### Ruby, Sapphire and Spinel.

There was a fall in the output of the Ruby Mines, from 164,115 carats valued at Rs. 6,04,649 to 158,577 carats valued at Rs. 10,80,870.

TABLE 21.—Quantity and value of Ruby, Sapphire and Spinel produced in India during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value. (Rupee=1s. 4d.)		Quantity.	Value. (Rupee=2s.)	
<i>Burma—</i>	Carats.	Rs.	£	Carats.	Rs.	£
<i>Mogok . . . . .</i>	1,01,637 (Rubies)	5,17,367	34,491	88,847 (Rubies)	8,74,343	87,434
	34,949 (Sapphires)	83,571	5,571	47,286 (Sapphires.)	2,01,699	20,170
	27,529 (Spinels)	3,711	248	22,444 (Spinels)	4,828	483
<b>Total . . . . .</b>	<b>164,115</b>	<b>6,04,649</b>	<b>40,310</b>	<b>158,577</b>	<b>10,80,870</b>	<b>108,087</b>

## Salt.

The large increase in the output of salt in the year 1918 was maintained in the year under review, the total approaching 2 million tons. The chief increase was one of 150,000 tons in Bombay and Sind. With the exception of Burma all other localities registered small decreases. Imports rose from 388,500 tons in 1918 to 481,700 tons in the year under review, more than half of the total imports being from Egypt and Aden.

TABLE 22.—*Quantity and value of Salt produced in India during 1918 and 1919.*

	1918.			1919.		
	Quantity.	Value. (Rupee=1s. 4d.)		Quantity.	Value. (Rupee=2s.)	
	Tons.	Rs.	£	Tons.	Rs.	£
Aden . . . . .	142,075	14,78,063	98,538	127,561	15,34,454	153,445.4
Bengal . . . . .	30	582	39	10	161	16.1
Bombay and Sind	481,808	55,92,452	372,830	630,481	50,23,066	502,306.6
Burma . . . . .	62,828	51,60,774	344,051	74,492	48,77,182	487,718.2
Central India . . . . .	5.3	362	24	...	...	...
Gwalior State . . . . .	312	14,864	991	149	7,080	708.0
Madras . . . . .	596,671	92,62,352	617,490	552,308	42,54,068	425,406.8
Northern India . . . . .	572,668	31,53,660	210,244	505,864	25,25,843	252,584.3
Rajputana . . . . .	299.4	14,816	988	273	13,367	1,336.7
<b>Total . . . . .</b>	<b>1,856,696.7</b>	<b>2,46,77,925</b>	<b>1,645,195</b>	<b>1,891,138</b>	<b>1,82,35,221</b>	<b>1,823,522.1</b>

TABLE 23.—*Quantity and value of Rock-Salt produced in India during 1918 and 1919.*

	1918.			1919.		
	Quantity.	Value. (Rupee=1s. 4d.)		Quantity.	Value. (Rupee=2s.)	
	Tons.	Rs.	£	Tons.	Rs.	£
Salt Range . . . . .	159,497	4,07,034	27,136	174,598	4,99,550	49,955
Kohat . . . . .	21,260	37,215	2,481	25,931	53,050	5,305
Mandi . . . . .	5,085	90,834	6,055	4,800	85,750	8,575
<b>Total . . . . .</b>	<b>185,842</b>	<b>5,35,083</b>	<b>35,672</b>	<b>205,329</b>	<b>6,38,350</b>	<b>63,835</b>



TABLE 24.—Quantity and value of Salt imported into India during 1918 and 1919.

	1918.		1919.	
	Quantity.	Value. (Rupee = 1s. 4d.)	Quantity.	Value. (Rupee = 2s.)
From—	Tons.	£	Tons.	£
United Kingdom . . .	19,233	94,513	85,017	417,954
Spain . . . . .	38,305	172,088	53,707	274,928
Aden and Dependencies . . .	94,061	385,502	136,936	639,219
Egypt . . . . .	203,662	821,832	145,513	693,729
Italian East Africa . . . . .	33,085	123,990	60,418	282,328
Other Countries . . . . .	213	1,357	158	3,010
<b>Total</b> . . . . .	<b>388,559</b>	<b>1,599,282</b>	<b>481,749</b>	<b>2,311,168</b>

### Saltpetre.

There was a decided fall in the total production of saltpetre due chiefly to a decrease of 41 per cent. in the production of the United Provinces. The output of the Punjab fell by about 18½ per cent. and that of Bihar by 20 per cent. The total Indian production amounted to 17,550 tons valued at Rs. 47,12,474 (£471,247). Exports fell from 23,000 tons in 1918 to 17,000 tons in the year under review. The exports to the United Kingdom fell from 17,000 tons to 6,700 tons, and those of the United States from 5,500 tons to 1,300 tons.

TABLE 25.—Quantity and value of Saltpetre produced in India during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 2s.)	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar . . . . .	6,299.3	23,13,103	154,207	5,044.4	11,66,268	116,627
Central India . . . . .	26.2	2,698	180	47.6	4,185	418
Punjab . . . . .	6,946.7	19,84,956	132,330	5,661.8	17,13,277	171,328
Rajputana . . . . .	245	80,290	5,353	180	46,005	4,600
United Provinces . . . . .	11,223.6	44,56,808	297,120	6,616.2	17,82,739	178,274
<b>Total</b> . . . . .	<b>24,740.8</b>	<b>88,37,855</b>	<b>589,190</b>	<b>17,550</b>	<b>47,12,474</b>	<b>471,247</b>

TABLE 26.—*Distribution of Saltpetre exported during 1918 and 1919.*

	1918.		1919.	
	Quantity.	Value. (Rupee = 1s. 4d.)	Quantity.	Value. (Rupee = 2s.)
	Cwt.	£	Cwt.	£
Ceylon . . . . .	...	...	59,749	76,044
Japan . . . . .	11,968	14,775	10,145	20,733
Mauritius and Dependencies . . . . .	...	...	39,534	58,463
United Kingdom . . . . .	337,828	445,825	133,898	235,875
United States of America . . . . .	110,067	141,947	25,896	38,947
Other Countries . . . . .	8,717	11,908	75,192	124,014
<b>Total . . . . .</b>	<b>468,580</b>	<b>614,455</b>	<b>344,414</b>	<b>554,076</b>

### Silver.

The output of silver from Bawdin has already been shown under lead. In addition to this a small quantity, amounting to 753 oz., was produced from the Anantapur gold mine in Madras. The total Indian production of silver was 2,165,606·7 oz., valued at Rs. 48,72,456 (£487,246).

### Tin.

The output of tin-ore was nearly doubled rising from 15,607 cwt. in 1918 to 26,891 cwt. in the year under review. The whole of the ore was produced in Lower Burma, nearly 38 per cent. of it in Tavoy, and 39 per cent. in the Southern Shan States. Mergui also produced 2,700 cwt. of block tin. The imports of tin rose from 24,596 cwt. in 1918 to 41,860 cwt. in the year under review. By far the greater part of the tin imported came from the Straits Settlements.

TABLE 27.—Quantity and value of Tin and Tin-ore for the years 1918 and 1919.

	1918.						1919.					
	BLOCK TIN.			TIN-ORE.			BLOCK TIN.			TIN-ORE.		
	Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 2s.)		Quantity.	Value. (Rupee = 2s.)	
	Cwt.	Rs.	£	Cwt.	Rs.	£	Cwt.	Rs.	£	Cwt.	Rs.	£
<i>Burma—</i>												
Amherst .	..	..	..	1,817.5	1,81,500	8,767	..	..	..	1,232.5	85,040	8,504
Mergui* .	2,013.6	4,21,854	28,123	1,471.2	1,86,483	12,432	2,742	4,88,183	48,818	3,807.7	3,81,904	38,190
Southern Shan States.	..	..	..	7,609	7,70,415	51,361	..	..	..	10,540	6,56,115	65,612
Tavoy* .	..	..	..	4,052.7	4,65,837	31,056	..	..	..	10,180.9	6,81,073	68,107
Thaton .	..	..	..	1,157	43,440	2,896	..	..	..	1,149.9	1,19,193	11,919
<b>Total .</b>	<b>2,013.6</b>	<b>4,21,854</b>	<b>28,123</b>	<b>15,607.4</b>	<b>15,97,675</b>	<b>106,512</b>	<b>2,742</b>	<b>4,88,183</b>	<b>48,818</b>	<b>23,831</b>	<b>19,23,325</b>	<b>192,332</b>

\* Figures taken from "Note on the Mineral Production of Burma for 1918 and 1919."

TABLE 28.—*Imports of Tin unwrought (blocks, ingots, bars and slabs) into India during 1918 and 1919.*

	1918.		1919.	
	Quantity.	Value. (Rupee = 1s.4d.)	Quantity.	Value. (Rupee = 2s.)
From—	Cwt.	£	Cwt.	£
United Kingdom . . . . .	289	3,993	1,429	10,419
Straits Settlements (including Labuan). . . . .	323,833	323,860	39,574	706,392
Other Countries . . . . .	474	4,869	857	14,466
<b>Total . . . . .</b>	<b>24,596</b>	<b>332,722</b>	<b>41,860</b>	<b>731,277</b>

### Tungsten.

There was a decided decrease in the output of wolfram, which fell from 4,431 tons in 1918 to 3,577 tons in the year under review. As usual, most of the output came from Tavoy.

TABLE 29.—*Quantity and value of Tungsten-ore produced in India during 1918 and 1919.*

	1918.			1919.		
	Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 2s.)	
<i>Bihar and Orissa—</i>	Tons.	Rs.	£	Tons.	Rs.	£
Singhbhum . . . . .	2.5	7,465	498	1.5	3,867	387
<i>Burma—</i>						
Kyaukse . . . . .	.1	250	17	.2	100	10
Mergui* . . . . .	376.6	7,87,359	52,490	194.4	3,02,842	30,284
Southern Shan States. . . . .	287	6,24,225	41,615	397.6	5,72,544	57,254
Tavoy* . . . . .	3,636.1	91,62,490	610,833	2,889.5	44,15,722	441,572
Thaton . . . . .	91.5	2,04,945	13,663	48.1	1,00,370	10,037
<i>Rajputana—</i>						
Marwar . . . . .	37.4	1,13,479	7,565	45.5	(a)	...
<b>Total . . . . .</b>	<b>4,431.2</b>	<b>1,09,00,213</b>	<b>726,681</b>	<b>3,576.8</b>	<b>53,95,445</b>	<b>539,544</b>

\* Figures taken from "Note on the Mineral Production of Burma for 1918 and 1919."  
(a) Not available.

## III.—MINERALS OF GROUP II.

The production of alum rose from 1,322 cwt. in 1918 to 1,853 cwt. valued at Rs. 48,000 (£4,800) in the year under review. The whole output came from the Mianwali district of the Punjab.

Alum.

The production of amber in Burma rose from 2·9 cwt. in 1918 to 7·4 cwt. valued at Rs. 6,160 (£616) in the year under review.

Amber.

6·4 tons of antimony ore valued at Rs. 2,000 (£200) were produced in the Southern Shan States during the year under review. The value represents the actual cost of extraction. There was also a production of 2 lbs. of antimony valued at Rs. 32 from the Jhelum District in the Punjab.

Antimony.

The production of apatite from the apatite-magnetite deposits of Singhbhum fell from 5,100 tons in 1918 to 500 tons in 1919. The estimated value of the production was Rs. 5,000 (£500).

Apatite.

There was a rise in the output of asbestos from 357 tons in 1918 to 388 tons valued at Rs. 16,556 (£1,656) in the year under review. Of this 379 tons were won in the Hassan district of Mysore and 9 tons in the Bhandara district of the Central Provinces.

Asbestos.

2,590 tons of barytes valued at Rs. 15,615 (£1,561) were produced in the Karnul district of the Madras Presidency, against 2,724 tons in 1918.

Barytes.

There was an increase of 490 tons in the output of bauxite, which amounted to 1,682 tons valued at Rs. 19,343 (£1,934). The whole output came from Jubbulpore. Important bauxite deposits have been recently discovered by Mr. C. S. Middlemiss in the neighbourhood of Chakar in the province of Jammu. The quantity available by quarrying at the surface has been estimated at over one million tons, the beds extending uninterruptedly for many miles. Patches of the same mineral were also observed by Sir Henry Hayden at Sangar. Analyses of three specimens yielded 79·43, 67·03 and 59·56 per cent. of  $Al_2O_3$  and 1·32, 14·15 and 20·67 per cent. of  $SiO_2$  respectively.

Bauxite.

TABLE 30.—Production of Building Materials and Road Metal in India during the year 1919.

(Rupee = 2s.)

	GRANITE.		LATHRITE.		LIME.		LIMESTONE AND KANKAR.		MARBLE.		SANDSTONE.		SLATE.		TRAP.		MISCELLANEOUS.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Assam . . . . .	..	..	..	..	..	..	63,674	14,207	..	..	..	..	..	..	..	..	..	..
Baroda . . . . .	1,400	1,722	..	..	..	..	..	..	4	118	..	..	..	..	..	..	..	..
Bihar and Orissa . . . . .	..	..	1,523	56	150	0	880,288	82,808	..	..	18,988	1,115	8,085	4,980	40,418	4,392	246,377	20,080
Burma . . . . .	177,517	84,810	247,444	32,785	..	..	214,274	32,555	..	..	89,097	13,854	..	..	..	..	387,344	86,288
Central India . . . . .	..	..	..	..	18,779	23,477	66,960	6,688	..	..	..	..	..	..	..	..	..	..
Central Provinces . . . . .	..	..	..	..	..	..	137,488	18,930	..	..	..	..	..	..	..	..	..	..
Hyderabad . . . . .	52	(a)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Madras . . . . .	53,930	1,860	108,314	8,141	..	..	17,490	1,034	..	..	..	..	..	..	..	..	146,688	15,870
North-West Frontier Province . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Punjab . . . . .	..	..	..	..	..	..	81,040	6,081	..	..	1,840	300	8,058	12,830	..	..	10,158	227
Rajputana . . . . .	..	..	..	..	..	..	812	719	8,229	5,947	62,025	17,780	..	..	..	..	81,570	4,288
United Provinces . . . . .	..	..	..	..	38	20	2,432	927	..	..	6,000	2,950	17,786	538	..	..	141,709	29,045
<b>Total . . . . .</b>	<b>839,599</b>	<b>37,398</b>	<b>859,881</b>	<b>40,098</b>	<b>18,978</b>	<b>23,503</b>	<b>925,681</b>	<b>164,700</b>	<b>8,238</b>	<b>6,005</b>	<b>178,495</b>	<b>35,530</b>	<b>23,879</b>	<b>18,804</b>	<b>40,413</b>	<b>4,392</b>	<b>988,881</b>	<b>105,207</b>

(a) Not available.

The total estimated value of building-stone and road-metal produced during the year 1919 was Rs. 43,61,833 (£436,183).

**Clay.** The recorded production of clay was 176,007 tons valued at Rs. 4,99,603 (£49,960).

**Corundum.** The output of corundum amounted to 14,131 cwt. in the year under review, scarcely more than a third of what it was in 1918.

TABLE 31.—Quantity and value of corundum produced during the years 1918 and 1919.

	1918.			1919.		
	Quantity.	Value (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 2s.)	
	Cwt.	Rs.	£	Cwt.	Rs.	£
<i>Assam—</i>						
Khasi and Jaintia Hills.	37,920	57,930	3,862	12,660	47,475	4,747
<i>Central India—</i>						
Rewah State .	736	3,022	201	1,471	6,002	600
<i>Central Pro- vinces—</i>						
Bhandara .	1,600	490	33	...	...	...
Hyderabad .	(a)	38	2	...	...	...
<i>Madras—</i>						
South Canara	25	151	10	...	...	...
<b>Total .</b>	<b>40,281</b>	<b>61,631</b>	<b>4,108</b>	<b>14,131</b>	<b>53,477</b>	<b>5,347</b>

(a) Quantity not available.

The production of gypsum shewed a marked increase, the total output being 28,318 tons valued at Rs. 28,692 (£2,869), against 16,746 tons in 1918.

**Gypsum.**

TABLE 32.—Production of Gypsum during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 2s.)	
		Tons.	Rs.		£	Tons.
<i>Punjab—</i>						
<i>Jhelum . . .</i>	1,871	1,403	93·5	4,719	10,705	1,070
<i>Rajputana—</i>						
<i>Bikanir . . .</i>	8,469	11,576	771·7	14,326	12,030	1,203
<i>Merwar . . .</i>	6,406	4,115	274·3	9,273	5,957	596
<b>Total . . .</b>	<b>16,746</b>	<b>17,094</b>	<b>1,139·5</b>	<b>28,318</b>	<b>28,692</b>	<b>2,869</b>

Only 4½ cwt. of molybdenite, valued at Rs. 1,012 (£101) were won during the year 1919; this amount was recovered in the course of wolfram mining operations in Tavoy.

Molybdenite.

The output of ochre fell from 8,109 tons in 1918 to 2,704 tons valued at Rs. 35,998 (£3,600) in the year under review.

Ochre.

TABLE 33.—Production of Ochre during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 2s.)	
		Tons.	Rs.		£	Tons.
<i>Bihar and Orissa</i>	145	9,589	639	281·3	18,807	1,881
<i>Burma . . .</i>	...	...	...	4·6	855	85
<i>Central India . . .</i>	7,874	32,883	2,192	1,948	9,737	974
<i>Central Provinces</i>	16	5	...	12	3	...
<i>Madras . . .</i>	...	...	...	250	1,500	150
<i>Mysore . . .</i>	74	888	59	208	5,096	510
<b>Total . . .</b>	<b>8,109</b>	<b>43,365</b>	<b>2,890</b>	<b>2,703·9</b>	<b>35,998</b>	<b>3,600</b>



83 tons of potash salts were produced by the Northern India Salt Revenue Department at Nurpur in the Salt Range. The pit's-mouth value of the output is stated to be Rs. 422 (£42).

**Potash Salts.****Pyrites.**

During the year under consideration 100 tons of pyrites were produced in Mysore.

**Samarskite.**

2½ cwt. of samarskite valued at Rs. 101 were won from the Sankara mica mine in Nellore.

The output of steatite was less than half what it was during 1918, falling from 4,538 tons to 2,135 tons valued at Rs. 64,986 (£6,498) in 1919.

**Steatite.**

TABLE 34.—Quantity and value of Steatite produced in India during 1918 and 1919.

	1918.			1919.		
	Quantity.	Value.		Quantity.	Value.	
		(Rupee = 1s. 4d.)			(Rupee = 2s.)	
	Tons.	Rs.	£	Tons.	Rs.	£
<i>Bihar and Orissa—</i> Mayurbhanj .	40	3,500	233	45	3,400	340
<i>Central Provinces—</i> Jubbulpore .	3,492·8	61,038	4,069	1,452	27,539	2,754
<i>Madras—</i> Bellary . .	44·5	220	15	...	...	...
Karnul . .	10·1	1,650	110	4	662	66
Nellore . .	51	3,272	218	74	4,762	476
Salem . . .	642·8	13,630	909	450·6	15,990	1,599
<i>Mysore</i> . . .	·1	5	...	10	163	16
<i>United Provinces—</i> Hamirpur .	247	31,661	2,111	95	12,150	1,215
Jhansi . . .	10	650	43	4	320	32
<b>Total</b> . .	<b>4,538·3</b>	<b>1,15,626</b>	<b>7,708</b>	<b>2,134·6</b>	<b>64,986</b>	<b>6,498</b>

## IV.—MINERAL CONCESSIONS GRANTED.

TABLE 35.—*Statement of Mineral Concessions granted during 1919.*

## ASSAM.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cachar .	(1) J. Blair, Esq. . . .	Mineral oil . . .	P. L. . . .	114.3	4th March 1919.	1 year.
Do. .	(2) The Burma Oil Company, Limited.	Oil . . . . .	P. L. . . .	8,377.6	15th September 1919.	Do.
Do. .	(3) J. M. Barry, Esq. . .	Oil and Coal . . .	P. L. . . .	934.4	10th November 1919.	Do.
Khasi and Jaintia Hills.	(4) The Khasia Hills Prospecting and Mining Syndicate, Ltd. . .	Minerals other than mineral oils.	P. L. . . .	7,142.4	11th March 1919.	Do.
Do. .	(5) Lieutenant-Colonel E. P. R. Gilman, V.D., J.P.	Do. . . . .	P. L. . . .	5,760	18th February 1919.	Do.
Lakhimpur	(6) The Assam Oil Company.	Oil . . . . .	P. L. . . .	10,240	1st April 1919	Do.
Do. .	(7) Do. . . . .	Do. . . . .	P. L. . . .	2,080	3rd July 1919	Do.
Do. .	(8) Do. . . . .	Do. . . . .	M. L. (renewal.)	2,560	1st January 1917.	25 years.
Do. .	(9) Do. . . . .	Do. . . . .	M. L. (renewal.)	2,560	Do. . . . .	Do.

## BALUCHISTAN.

Kalat .	(10) The Burmah Oil Co., Ltd. of Rangoon.	Oil . . . . .	P. L. . . .	24,960	18th December 1918.	1 year.
Do. .	(11) The Indo-Burmah Petroleum Co. of Rangoon through their Agents Messrs. Steel Bros. & Co.	Do. . . . .	P. L. . . .	17,920	20th May 1919.	Do.
Do. .	(12) The Burmah Oil Co. of Rangoon.	Do. . . . .	P. L. . . .	3,200	1st September 1919.	Do.
Zhob .	(13) Manager, Baluchistan Chrome Co., Ltd.	Chromite . . . .	P. L. . . .	60	1st September 1919.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

## BIHAR AND ORISSA.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Hazaribagh	(14) Messrs. Hoare Miller & Co.	Mica . . . .	M. L. . . .	160	4th February 1919.	30 years.
Do.	(15) Chhattoo Ram . .	Do. . . . .	P. L. . . .	117.89	12th October 1918.	1 year.
Do.	(16) B. N. Daw . . . .	Do. . . . .	P. L. . . .	200	13th March 1919.	Do.
Do.	(17) Dwijendra Nath Mukherji.	Do. . . . .	P. L. . . .	58	26th April 1919.	Do.
Do.	(18) The Mica Mining and Manufacturing Co., Ltd.	Do. . . . .	P. L. . . .	892	11th March 1919.	Do.
Do.	(19) N. N. Sumanto . .	Do. . . . .	P. L. . . .	400	19th February 1919.	Do.
Do.	(20) Babu Probodh Chandra Mukharji.	Do. . . . .	M. L. . . .	80	29th April 1919.	30 years.
Do.	(21) Babu P. C. Roy . .	Do. . . . .	P. L. . . .	80	15th June 1919.	1 year.
Do.	(22) Babu Kiran Shashi Chattarji.	Do. . . . .	P. L. . . .	160	4th June 1919.	Do.
Do.	(23) Babu Banka Behari Choudhury.	Do. . . . .	P. L. . . .	221	28th June 1919.	Do.
Do.	(24) Messrs. Jagarnath Roshan Lal.	Do. . . . .	M. L. . . .	120	23rd August 1919.	30 years.
Sambalpur .	(25) Seth Puranmal Marwari.	Do. . . . .	P. L. . . .	5,849.79	28th August 1919.	1 year.
Do.	(26) Debi Prosad Misra .	Coal . . . .	P. L. . . .	2,376.99	Do. . . .	Do.
Do.	(27) Mr. T. P. Yeoman .	Oxide of iron .	P. L. . . .	57	22nd March 1919.	Do.
Santal Parganas.	(28) Bhudhar Chandra De.	Coal . . . .	M. L. . . .	.99	1st April 1919.	2 years.
Do.	(29) Do. . . . .	Do. . . . .	M. L. . . .	.99	Do. . . .	Do.
Do.	(30) Do. . . . .	Do. . . . .	M. L. . . .	1	Do. . . .	Do.
Do.	(31) Bansi Ram Marwari	Do. . . . .	M. L. . . .	.83	Do. . . .	Do.
Do.	(32) Do. . . . .	Do. . . . .	M. L. . . .	1.9	Do. . . .	Do.
Do.	(33) Jamuna Prasad Marwari.	Do. . . . .	M. L. . . .	2.6	Do. . . .	Do.
Do.	(34) Bhudhar Chandra De.	Do. . . . .	M. L. . . .	3.9	Do. . . .	Do.
Do.	(35) Binode Bihari De .	Do. . . . .	M. L. . . .	2.15	Do. . . .	Do.
Do.	(36) Jardine Skinner & Co.	Do. . . . .	P. L. . . .	5,158.48	Do. . . .	Do.
Do.	(37) The Villiers & Co., Ltd.	Do. . . . .	P. L. . . .	5,081.26	Do. . . .	1 year.

P. L. = Prospecting License. M. L. = Mining Lease.

BIHAR AND ORISSA—*concl'd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Santal Parganae.	(38) Shital Prashad Marwari.	Coal . . .	M. L. .	66	1st April 1919	15 years.
Do.	(39) Babu Madhab Chandra De.	Do. . . .	M. L. .	2	1st July 1919	1 year and 9 months.
Singhbhum	(40) Mr. A. C. Moitra .	Gold and galena	P. L. (renewal.)	1,330	22nd August 1918.	1 year.
Do.	(41) Messrs. Bird & Co..	General license .	P. L. .	26,240	1st August 1919.	Do.
Do.	(42) The Bengal Iron and Steel Co., Ltd.	Manganese and iron ore	P. L. (renewal.)	992	21st December 1918.	6 months.
Do.	(43) The Bengal Iron and Steel Co., Ltd.	Iron ore. . . .	P. L. .	512	3rd July 1919	1 year.
Do.	(44) Messrs. Byramjee Featonjee & Co.	Do. . . .	P. L. .	1,798-4	22nd December 1919.	Do.
Do.	(45) Mr. A. C. Moitra .	Gold and galena .	P. L. (renewal.)	1,330	22nd August 1919.	10 months.

## BOMBAY.

Belgaum .	(46) Messrs. Tata and Sons, Ltd.	Bauxite (Aluminium ore).	P. L. (renewal.)	1,087-4	24th May 1919.	2 years.
Do. .	(47) Do. .	Do. .	P. L. .	797-5	7th May 1919	1 year.
Do. .	(48) Do. .	Do. .	P. L. .	180	Do. .	Do.
Do. .	(49) Do. .	Do. .	P. L. .	249-6	Do. .	Do.
Do. .	(50) Do. .	Do. .	P. L. .	50-85	Do. .	Do.
Do. .	(51) Do. .	Do. .	P. L. .	377-57	Do. .	Do.
Katra. .	(52) Khan Bahadur Mohmedalli Abdul Kadar.	Manganese .	P. L. .	79-82	20th August 1919.	Do.

## BURMA.

Akyab .	(53) Messrs. The Indo-Burmah Petroleum Co., Ltd.	Mineral oil . . .	P. L. (renewal.)	1,280	22nd April 1919.	2 years.
Do. .	(54) Messrs. The Burmah Oil Co., Ltd.	Do. . . .	P. L. .	3,620	17th October 1919.	1 year.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Amherst	(55) Mr. Mirza Mahomed Sadeq.	All minerals (except oil).	P. L.	1,280	8th February 1919.	1 year.
Do.	(56) Saw Eu Hoke	Do.	P. L.	426.66	27th February 1919.	Do.
Do.	(57) Chew Whee Shain	Do.	P. L.	640	15th February 1919.	Do.
Do.	(58) Maung Choon	Do.	P. L.	3,036.16	12th February 1919.	Do.
Do.	(59) Maung Po Thaing	Do.	P. L.	2,560	15th February 1919.	Do.
Do.	(60) L. Htain Whet	Do.	P. L.	2,560	13th February 1919.	Do.
Do.	(61) Do.	Do.	P. L.	96	Do.	Do.
Do.	(62) Ma Shwe Bwa	Do.	P. L.	960	17th March 1919.	Do.
Do.	(63) Maung Kyin Sein	Do.	P. L.	640	15th January 1919.	Do.
Do.	(64) Mr. W. A. Henry	Do.	P. L.	1,920	7th February 1919.	Do.
Do.	(65) Mr. M. Shawloo	Do.	P. L.	640	21st January 1919.	Do.
Do.	(66) L. Ah Choy	Do.	P. L.	280	24th February 1919.	Do.
Do.	(67) Maung Wan	Do.	P. L.	814	17th February 1919.	Do.
Do.	(68) Mr. V. Palmgren	Do.	P. L.	1,920	20th June 1919.	Do.
Do.	(69) L. Ah Choy	Do.	P. L.	640	8th May 1919	Do.
Do.	(70) U Tha Zan	Do.	P. L.	4,160	7th May 1919	Do.
Do.	(71) Do.	Do.	P. L.	1,280	Do.	Do.
Do.	(72) Do.	Do.	P. L.	512	Do.	Do.
Do.	(73) Do.	Do.	P. L.	338	10th June 1919.	Do.
Do.	(74) Mrs. M. M. Hla Oung.	Do.	P. L. (renewal.)	640	5th September 1917.	2 years.
Do.	(75) P. Murugasen Pillay	Do.	P. L.	640	5th August 1919.	1 year.
Do.	(76) Mr. A. M. Morris	Do.	P. L.	320	Do.	Do.
Do.	(77) Messrs. T. D. Findlay & Son.	Do.	P. L.	640	Do.	Do.
Do.	(78) Maung Po Thaing	Do.	P. L.	640	28th August 1919.	Do.

P. L. = Prospecting License.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Amherst .	(79) Dr. K. S. Kanga .	All minerals (except oil).	P. L. .	640	5th August 1919.	1 year
Do. .	(80) Maung San Win .	Do.	P. L. .	640	27th September 1919.	Do.
Do.	(81) Messrs. T. D. Findlay & Son.	Do.	P. L. .	640	9th July 1919	Do.
Do.	(82) Ma Twe . . .	Do.	P. L. .	1,920	27th September 1919.	Do.
Do. .	(83) Maung Myat Hein, Mr. Felix Boog, M. H. Hamadance and M. A. Hosain.	Do.	P. L. (renewal.)	640	23rd April 1919.	Do.
Do. .	(84) Mrs. M. M. Hla Oung.	Do.	P. L. (renewal.)	850	20th May 1919.	Do.
Do. .	(85) Ma Thein Nwe .	Do.	P. L. (renewal.)	1,280	3rd May 1919	Do.
Do. .	(86) Dr. M. Shawloo .	Do.	P. L. (renewal.)	640	12th July 1919.	Do.
Do. .	(87) Ma Thin Hlaing .	Do.	P. L. .	640	8th December 1919.	Do.
Do.	(88) Maung San Win	Do.	P. L. .	640	27th November 1919.	Do.
Do. .	(89) Dr. M. Shawloo .	Do.	P. L. .	160	22nd November 1919.	Do.
Do. .	(90) Maung Tarak and Maung Ou Maung. .	Do.	P. L. .	960	13th November 1919.	Do.
Do. .	(91) Maung Saw Maung and Ma Kywe.	Do.	P. L. .	1,824	Do. .	Do.
Do. .	(92) L. Ah Ngon .	Do.	P. L. .	320	Do. .	Do.
Do. .	(93) Mr. F. A. Boog and two others.	Do.	P. L. (renewal.)	737-28	1st August 1919.	Do.
Do. .	(94) Mr. F. A. Boog and three others.	Do.	P. L. (renewal.)	213-33	14th November 1919.	Do.
Do. .	(95) Do. .	Do.	P. L. (renewal.)	128	13th December 1919.	Do.
Do. .	(96) K. P. N. K. Narainan Chetty.	Do.	P. L. (renewal.)	640	Do.	Do.
Bhamo .	(97) D. A. Ahuja .	Do.	P. L. .	5,516-8	28th November 1919.	Do.
Do. .	(98) Messrs. The Tavoy Tin Syndicate, Ltd.	All minerals (except oil and jade).	P. L. .	6,400	22nd December 1919.	Do.
Henzada .	(99) Mr. L. D'Attalides	All minerals (except oil).	P. L. (renewal.)	4,736	11th May 1919.	2 years.
Do. .	(100) Do. .	Do.	P. L. (renewal.)	499-52	30th May 1919.	Do.

P. L. = *Prospecting License.*

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Henzala	(101) Maung Kyi . . .	All minerals (except oil).	P. L. . .	892.50	19th November 1919.	1 year.
Katha	(102) Messrs. Jamal Bros. & Co.	Do.	P. L. . .	23,040	2nd December 1918.	10
Do.	(103) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L. . .	2,572.8	20th August 1919.	Do.
Do.	(104) Do.	Do.	P. L. . .	4,857.6	8th September 1919.	Do.
Do.	(105) Do.	Do.	P. L. . .	5,760	11th September 1919.	Do.
Do.	(106) Maung Aung . . .	Gold . . . .	P. L. (renewal.)	2,752	9th January 1919.	2 years.
Do.	(107) Mr. R. E. Smith . .	All minerals (except oil).	P. L. (renewal.)	3,200	16th April 1919.	1 year.
Do.	(108) Mr. J. A. Begbel . .	Do.	P. L. (renewal.)	3,200	13th August 1919.	Do.
Do.	(109) Mr. J. F. Crisp . . .	Do.	P. L. . .	3,200	29th December 1919.	Do.
Do.	(110) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L. . .	1,171.20	12th December 1919.	Do.
Do.	(111) Mr. T. Ba Thwin . .	All minerals (except oil and jade).	P. L. . .	3,392	12th November 1919.	Do.
Do.	(112) Mr. Lim Kar Chang.	All minerals (except oil).	P. L. . .	3,200	29th December 1919.	Do.
Kyaukpyu	(113) U Doe Kaing . . .	Mineral oil . . .	P. L. . .	640	26th December 1918.	Do.
Kyaukse	(114) Maung Ko . . . .	All minerals (except oil).	P. L. . .	1,656.32	2nd August 1919.	Do.
Magwe	(115) Messrs. The Burma Oil Co., Ltd.	Mineral Oil. . .	P. L. . .	3,840	23rd March 1919.	2 years.
Do.	(116) Mr. Sassoon Solomon.	Do. . . . .	P. L. (renewal.)	208.10	21st February 1919.	1 year.
Do.	(117) Messrs. The Union Oil Co. of Burma, Ltd.	Do. . . . .	P. L. . .	20,480	28th October 1919.	Do.
Do.	(118) Messrs. The Burmah Oil Co., Ltd.	Do. . . . .	P. L. (renewal.)	2,259.2	10th December 1919.	2 years.
Mandalay	(119) Mr. M. G. H. Surty	Silver and lead . .	P. L. . .	2,355.2	28th March 1919.	1 year.
Mergui	(120) Saw Lein Lee . . .	Wolfram and tin . .	M. L. . .	646.98	25th February 1916.	30 years.
Do.	(121) Maung Ne Gyi	All minerals (except oil).	M. L. . .	883.13	22nd June 1915.	Do.
Do.	(122) Mr. D. D. Mukerjee	Tin and Wolfram	P. L. . .	194.56	15th December 1918.	1 year.

P. L.—Prospecting License. M. L.—Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(123) Mr. Chan Elliam .	All minerals (except oil).	P. L. .	1,126'40	27th February 1919.	1 year.
Do. .	(124) Do. . . . .	Do. . . . .	P. L. .	1,141'76	Do. . . . .	Do.
Do. .	(125) Miss S. M. G. Penny	Do. . . . .	P. L. .	3,527'68	25th March 1919.	Do.
Do. .	(126) Tan Po Chit .	Tin and Wolfram	P. L. .	1,176'64	6th January 1919.	Do.
Do. .	(127) Maung Pe Kin .	Tin, Wolfram and allied minerals.	P. L. .	788'48	5th February 1919.	Do.
Do. .	(128) Maung Kyin Bu .	Tin . . . . .	P. L. .	409'60	Do. . . . .	Do.
Do. .	(129) Mr. G. H. Hand .	Tin, gold and allied minerals.	P. L. .	1,720'32	31st March 1919.	Do.
Do. .	(130) Maung San Moe .	Tin and Wolfram	P. L. .	286'72	24th February 1919.	Do.
Do. .	(131) Maung Po . . . .	Tin . . . . .	P. L. .	547'84	31st March 1919.	Do.
Do. .	(132) Yew Shwe Ni .	All minerals (except oil).	P. L. (renewal).	1,449	29th January 1919.	6 months.
Do. .	(133) Maung Kyin Bu .	Tin . . . . .	P. L. (renewal).	349'44	5th February 1919.	1 year.
Do. .	(134) Maung Po Thaik .	Tin and Wolfram	P. L. (renewal).	486'4	13th February 1919.	Do.
Do. .	(135) Maung Pe Kin .	Wolfram, tin and allied minerals.	P. L. (renewal).	250'88	5th February 1919.	Do.
Do. .	(136) Maung Po . . . .	Do. . . . .	P. L. (renewal).	256	24th December 1918.	Do.
Do. .	(137) Mr. J. F. Leslie .	Wolfram and allied minerals.	P. L. (renewal).	220'16	21st February 1919.	Do.
Do. .	(138) Do. . . . .	Do. . . . .	P. L. (renewal).	512	26th February 1919.	Do.
Do. .	(139) Mr. A. S. Mahomed	All minerals (except oil).	P. L. (renewal).	1,013'76	5th January 1919.	Do.
Do. .	(140) Ma Shwe Ma and Hoe Cheng Kiat.	Wolfram and tin	M. L. .	167'35	3rd December 1915.	30 years.
Do. .	(141) Mr. D. D. Mukerjee	All minerals (except oil).	P. L. .	2,304	19th March 1919.	1 year.
Do. .	(142) Lim Shain . . . .	Do. . . . .	P. L. .	778'24'	80th July 1919.	Do.
Do. .	(143) Messrs. Wightman & Co.	Tin . . . . .	P. L. .	3,114'02	1st January 1919.	Do.
Do. .	(144) Mr. A. M. G. Forbes	Do. . . . .	P. L. .	988'16	21st August 1919.	Do.
Do. .	(145) Lim Shain . . . .	All minerals (except oil).	P. L. .	665'60	31st July 1919.	Do.

P. L.—*Prospecting License, M. L.—Mining Lease.*



## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui	(146) Mr. A. H. Noyes .	Wolfram and tin	P. L.	640	19th March 1919.	1 year.
Do.	(147) Messrs. The Rangoon Wolfram Co., Ltd.	All minerals (except oil).	P. L.	1,459.2	20th August 1919.	Do.
Do.	(148) Mr. Charles Ellis .	Tin . . . . .	P. L.	701.44	5th May 1919	Do.
Do.	(149) Mr. M. E. Bymeah	All minerals (except oil).	P. L.	317.44	12th August 1919.	Do.
Do.	(150) Mr. Low Boon Teck	Do. . . . .	P. L.	890.88	30th July 1919.	Do.
Do.	(151) Mr. A. H. Noyes .	Wolfram and tin .	P. L.	2,739.20	1st August 1919.	Do.
Do.	(152) Mr. S. Crawshaw .	All minerals (except oil).	P. L.	640	26th September 1919.	Do.
Do.	(153) U Shwe I. . . . .	Wolfram and tin .	P. L.	271.36	25th July 1919.	Do.
Do.	(154) Maung San Dun .	All minerals (except oil).	P. L.	343.04	Do.	Do.
Do.	(155) Mr. T. Greenhow .	Wolfram and tin .	P. L.	1,463	29th July 1919.	Do.
Do.	(156) Maung Kya Tun .	All minerals (except oil).	P. L.	640	26th September 1919.	Do.
Do.	(157) Y Gwan Swee .	Tin and wolfram .	P. L.	112.64	30th August 1919.	Do.
Do.	(158) Mr. A. M. G. Forbes	Tin . . . . .	P. L.	640	21st August 1919.	Do.
Do.	(159) Mr. S. V. Norris .	Do. . . . .	P. L.	2,560	31st August 1919.	Do.
Do.	(160) Mr. L. A. Maing .	All minerals (except oil).	P. L.	1,971.20	30th July 1919.	Do.
Do.	(161) Mr. Hoe Cheng Kiat.	Do. . . . .	P. L.	604.16	Do. . . . .	Do.
Do.	(162) Messrs. Marshall Cottrell & Co., Ltd.	Do. . . . .	P. L.	1,530.88	30th September 1919.	Do.
Do.	(163) Mr. G. H. Hand .	Wolfram and tin .	P. L. (renewal).	2,150.40	1st November 1918.	Do.
Do.	(164) The Haiyadaung Concession.	All minerals (except oil).	P. L. (renewal).	3,200	19th December 1918.	Do.
Do.	(165) Maung Pan On .	Do. . . . .	P. L. (renewal).	153.60	20th March 1919.	Do.
Do.	(166) Mr. M. Haniff .	Do. . . . .	P. L. (renewal).	350.72	25th March 1919.	Do.
Do.	(167) Messrs. Bulloch Bros. & Co., Ltd.	Do. . . . .	P. L. (renewal).	442.88	3rd January 1919.	Do.

P. L. = Prospecting License.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui	(168) Yew Shwe Ni	Wolfram and tin	P. L. (renewal).	1,775.52	20th April 1919.	1 year.
Do.	(169) Lim Shain	Do.	P. L. (renewal).	256.00	20th May 1919.	Do.
Do.	(170) Mr. M. Haniff	All minerals (except oil).	P. L. (renewal).	1,054.72	30th July 1919.	Do.
Do.	(171) Lim Shain	Wolfram and tin	P. L. (renewal).	517.12	16th August 1919.	Do.
Do.	(172) Do.	All minerals (except oil).	P. L. (renewal).	450.56	Do.	Do.
Do.	(173) Do.	Wolfram and tin	P. L. (renewal).	517.36	Do.	Do.
Do.	(174) Do.	Do.	P. L. (renewal).	404.48	Do.	Do.
Do.	(175) Mr. A. D. Keith	Do.	P. L.	1,344	29th July 1919.	Do.
Do.	(176) Mr. F. Fitzherbert	Do.	P. L.	460.80	4th October 1919.	Do.
Do.	(177) Messrs. The Indo-Burma Tin Corporation, Ltd.	Tin	P. L.	148.48	25th November 1919.	Do.
Do.	(178) Mr. S. Crawshaw	All minerals (except oil).	P. L.	3,194.88	30th November 1919.	Do.
Do.	(179) Maung Po	Do.	P. L.	793	29th October 1919.	Do.
Do.	(180) Messrs. Marshall Cotterell & Co.	Do.	P. L.	916.48	23th October 1919.	Do.
Do.	(181) Mr. W. H. Olivant	Do.	P. L.	665.60	25th October 1919.	Do.
Do.	(182) Lim Shain	Do.	P. L.	476.16	1st November 1919.	Do.
Do.	(183) Messrs. Wightman & Co., Ltd.	Tin	P. L.	800	5th December 1919.	Do.
Do.	(184) Messrs. Marshall Cotterell & Co., Ltd.	All minerals (except oil).	P. L.	2,362.88	10th November 1919.	Do.
Do.	(185) Messrs. Wightman & Co., Ltd.	Tin	P. L.	10	8th November 1919.	Do.
Do.	(186) Maung Po	All minerals (except oil).	P. L.	665.60	4th December 1919.	Do.
Do.	(187) Mr. H. G. Mathews	Wolfram and tin	P. L.	2,539.52	12th December 1919.	Do.
Do.	(188) Mr. Mahomed Essoof Bhyameah.	All minerals (except oil).	P. L.	414.72	1st December 1919.	Do.
Do.	(189) Mr. O. F. Misquith	Do.	P. L.	1,587.20	27th November 1919.	Do.

P. L.—*Prospecting License.*

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergul	(190) Mr. Thomas Greenhow.	Tin . . . .	P. L. . . .	501.76	9th December 1919.	1 year.
Do.	(191) C. Po Kun . . . .	All minerals (except oil).	P. L. . . .	977.92	17th December 1919.	Do.
Do.	(192) Messrs. Wightman & Co., Ltd.	Coal . . . .	P. L. . . .	400	5th December 1919.	Do.
Do.	(193) Do. . . . .	Tin . . . .	P. L. . . .	158.72	9th December 1919.	Do.
Do.	(194) Messrs. The Hpaungdaw Prospecting Co., Ltd.	All minerals (except oil).	P. L. (renewal).	1,409.60	30th July 1919.	Do.
Do.	(195) Do. . . . .	Do. . . . .	P. L. (renewal).	1,976.52	Do. . . . .	Do.
Do.	(196) Mr. W. H. Olivant	Tin and tungsten ores.	P. L. (renewal).	517.12	27th September 1919.	Do.
Do.	(197) Messrs. The Rangoon Wolfram Co., Ltd.	All minerals (except oil).	P. L. (renewal).	1,203.20	9th September 1919.	Do.
Do.	(198) Mr. H. H. Bateman	Wolfram and tin .	P. L. (renewal).	1,824	17th September 1919.	Do.
Do.	(199) Do. . . . .	Wolfram . . . .	P. L. (renewal).	640	27th September 1919.	Do.
Do.	(200) Do. . . . .	Wolfram and tin .	P. L. (renewal).	480	Do. . . . .	Do.
Do.	(201) Ho Cheng Kiat .	All minerals (except oil).	P. L. (renewal).	588.80	14th November 1919.	Do.
Do.	(202) Maung Choon .	Do. . . . .	P. L. (renewal).	25.37	22nd November 1919.	Do.
Do.	(203) Messrs. The Mergui Tin Dredging Co., Ltd.	Tin and wolfram .	P. L. (renewal).	2,150.40	1st November 1919.	Do.
abu	(204) Mr. Esmail Essof Esmail.	Mineral oil . . . .	P. L. . . . .	320	8th February 1919.	Do.
Do.	(205) Maung Tun Aung Gyaw.	Coal . . . . .	P. L. . . . .	620	28th January 1919.	Do.
Do.	(206) Yeo Eng Byan .	Do. . . . .	P. L. . . . .	1,542	Do. . . . .	Do.
Do.	(207) Mr. Mahomed Golam Hussein Surty.	Do. . . . .	P. L. . . . .	4,857.6	Do. . . . .	Do.
Do.	(208) Messrs. The Bombay-Burma Trading Corporation, Ltd.	Mineral oil . . . .	P. L. (renewal).	336	12th November 1918.	2 years.
Do.	(209) Messrs. The Yomah Oil Co., Ltd.	Coal . . . . .	P. L. . . . .	480	1st April 1919.	1 year.
Do.	(210) Maung Tun Aung Gyaw.	Do. . . . .	P. L. . . . .	1,280	Do. . . . .	Do.
Do.	(211) Maung Ba Thi .	Do. . . . .	P. L. . . . .	2,560	2nd May 1919	Do.

P. L.—Prospecting License.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Minbu	(212) Maung Ba Thi	Coal	P. L.	620	2nd May 1919	1 year.
Do.	(213) Messrs. The Yomah Oil Co., Ltd.	Mineral oil	P. L.	2,570-24 Blocks 4P, 8P, 12P, 24P, and part of 11P of the Minbu Oil Field.	11th April 1919.	Do.
Do.	(214) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L. (renewal).	1,692	12th January 1919.	2 years.
Do.	(215) Maung Tha Ya	Coal	P. L.	640	11th August 1919.	1 year.
Do.	(216) M. E. Bhyameah & Co.	Mineral oil.	P. L.	320 (Western half of block I. S. in the Minbu Oil Field.)	21st August 1919.	Do.
Do.	(217) Yeo Eng Byan	Coal	P. L.	1,432	28th May 1919.	Do.
Do.	(218) Maung Tun Aung Gyaw.	Do.	P. L. (renewal).	640	4th April 1919.	2 years.
Iyngyan	(219) Maung Hmon and Maung Thin.	Mineral oil	P. L.	400	2nd June 1919	1 year.
Do.	(220) Mr. Baij Nath Singh.	Do.	P. L. (renewal).	11,897 6	27th August 1919.	2 years.
Do.	(221) Messrs. The Burma Oil Co., Ltd.	Do.	P. L. (renewal).	1,280	7th May 1919	Do.
Do.	(222) Messrs. The Union Oil Co., of Burma, Ltd.	Do.	P. L.	6,720	17th September 1919.	1 year.
Do.	(223) Maung Tha Ya	All minerals	P. L.	167-75	18th November 1919.	Do.
Do.	(224) Maung Kyi	Mineral oil	P. L.	31-50	14th November 1919.	Do.
Iytkyina	(225) Mr. R. C. J. Swinhoe.	Silver and copper	P. L.	640	2nd January 1919.	Do.
Do.	(226) Mr. H. F. Leslie	Gold and platinum	P. L.	2,931-20	15th January 1919.	Do.
Do.	(227) Messrs. The Burma Gold Dredging & Co., Ltd.	Gold and Iridio platinum	P. L.	3,200	3rd February 1919.	Do.
Do.	(228) Mr. H. F. Leslie	Gold	P. L.	640	2nd January 1919.	Do.
Do.	(229) Mr. A. J. Beale	All minerals (except oil).	P. L.	4,851-20	9th December 1919.	Do.
Pakokku	(230) Messrs. Balthazar and Son.	Mineral oil	P. L.	640	9th May 1919.	Do.

P. L.—*Prospecting License.*

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Pakokku .	(231) Messrs. Balthazar and Son.	Mineral oil . . .	P. L. . . .	1,280	9th May 1919	1 year.
Do. . .	(232) Messrs. The British Burma Petroleum Co., Ltd.	Do. . . . .	M. L. . . .	1,280	5th May 1919.	30 years.
Do. . .	(233) Do. . . . .	Do. . . . .	P. L. . . .	960	16th May 1919.	1 year.
Do. . .	(234) Messrs. The Rangoon Oil Co., Ltd.	Do. . . . .	P. L. . . .	1,068·8	19th May 1919.	Do.
Do. . .	(235) Do. . . . .	Do. . . . .	P. L. . . .	624	Do. . . . .	Do.
Pakokku Hill Tracts.	(236) M. J. C. Galstaun	All minerals (except oil).	P. L. (renewal).	3,840	9th September 1919.	Do.
Prome . .	(237) Ma Nyein Hla . .	Mineral oil . . .	P. L. . . .	123	25th August 1919.	Do.
Do. . .	(238) Essof Abdul Shakoor Bros.	Coal . . . . .	P. L. . . .	2,668·8	2nd December 1919.	Do.
Do. . .	(239) Maung Pe Tok and Maung Myat Tbin.	Mineral oil . . .	P. L. (renewal).	320	28th October 1919.	Do.
Ruby Mines	(240) Ko Ko Gyi . . .	All minerals (except oil).	P. L. . . .	7,680	23rd June 1919.	Do.
Do. . .	(241) Ma Shwe Ewin	Copper ore . . .	P. L. (renewal).	640	14th May 1919.	Do.
Do. . .	(242) Messrs. Balthazar & Son.	All minerals (except oil).	P. L. . . .	2,560	9th August 1919.	Do.
Do. . .	(243) Mr. S. S. Halker .	Mica . . . . .	P. L. (renewal).	41	21st June 1919.	Do.
Salween .	(244) Mr. B. H. Hardinge	All minerals (except oil).	P. L. . . .	1,920	12th March 1919.	Do.
Do. . .	(245) Mr. S. Crawshaw .	Do. . . . .	P. L. . . .	3,220	Do. . . . .	Do.
Shwebo .	(246) Mr. Y. A. Ganny .	Do. . . . .	P. L. . . .	200	15th January 1919.	Do.
Do. . .	(247) Messrs. The Burma Oil Co., Ltd.	Mineral oil . . .	P. L. . . .	7,040	27th September 1919.	Do.
Do. . .	(248) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . . . .	P. L. (renewal).	1,230	29th November 1919.	2 years.
Southern Shan States.	(249) Maung San Hein .	Lead . . . . .	P. L. . . .	1,280	17th February 1919.	1 year.
Do. . .	(250) Mr. M. A. S. Jamal	All minerals (except oil).	P. L. . . .	3,520	18th January 1919.	Do.
Do. . .	(251) Maung Ba Cho . .	Do. . . . .	P. L. . . .	640	10th February 1919.	Do.
Do. . .	(252) Maung Kya Ywet	Do. . . . .	P. L. (renewal).	640	12th September 1918.	Do.
Do. . .	(253) Sawbwa of Kengtung.	Gold . . . . .	P. L. (renewal).	1,440	27th December 1918.	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Southern Shan States.	(254) Sawbwa of Kōng-tung.	Gold . . .	P. L. (renewal).	1,920	27th December 1918.	1 year.
Do.	(255) Mr. W. H. Cowling	Do. . . . .	P. L. . . .	10,560	27th June 1919.	Do.
Do.	(256) Ma Ngwe Nyun .	Do. . . . .	P. L. . . .	640	13th June 1919.	Do.
Do.	(257) Mr. S. K. Solomon	Antimony and associated minerals.	P. L. . . .	640	28th June 1919.	Do.
Do.	(258) Maung Kya Ywet	Lead and silver .	M. L. (renewal).	2.1	1st September 1917.	5 years.
Do.	(259) Ma Chit Su . . .	All minerals (except oil).	P. L. (renewal).	640	9th October 1918.	2 years.
Do.	(260) Saw Lein Lee . .	Do. . . . .	P. L. . . .	599	5th September 1919.	1 year.
Do.	(261) Maung Tun Maung	Do. . . . .	P. L. (renewal).	320	14th June 1919.	Do.
Do.	(262) Mr. W. H. Cowling	Do. . . . .	P. L. . . .	2,880	10th December 1919.	Do.
Tavoy	(263) Ong Hoe Kyin . .	Do. . . . .	P. L. . . .	845	3rd March 1919.	Do.
Do.	(264) Tavoy Tin Syndicate.	Do. . . . .	P. L. . . .	2,099	8th January 1919.	Do.
Do.	(265) Do. . . . .	Do. . . . .	P. L. . . .	1,782	Do. . . . .	Do.
Do.	(266) Messrs. Tata Sons, Ltd.	Do. . . . .	P. L. . . .	584	8th February 1919.	Do.
Do.	(267) Maung Ba Oh . .	Do. . . . .	P. L. . . .	274	13th January 1919.	6 months.
Do.	(268) Mr. H. G. Mathews	Do. . . . .	P. L. . . .	937	1st February 1919.	Do.
Do.	(269) Maung Tun . . .	Do. . . . .	P. L. . . .	422	18th November 1918.	1 year.
Do.	(270) Mr. C. Beadon . .	Do. . . . .	P. L. . . .	2,768	3rd January 1919.	6 months.
Do.	(271) Do. . . . .	Do. . . . .	P. L. . . .	4,137	Do. . . . .	Do.
Do.	(272) Do. . . . .	Do. . . . .	P. L. . . .	159	28th March 1919.	1 year.
Do.	(273) Messrs. Steel Bros. & Co., Ltd.	Do. . . . .	P. L. . . .	2,386	5th March 1919.	6 months.
Do.	(274) Do. . . . .	Do. . . . .	P. L. . . .	1,742	10th January 1919.	Do.
Do.	(275) Messrs. Booth & Milne.	Do. . . . .	P. L. . . .	2,365	11th February 1919.	1 year.
Do.	(276) Do. . . . .	Do. . . . .	P. L. . . .	410	4th March 1919.	6 months.

P. L.—*Prospecting Licenses.* M. L.—*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(277) Tavoy Wolfram, Ltd.	All minerals (except oil).	P. L.	174	9th January 1919.	1 year.
Do.	(278) Maung Lu Pe	Do.	P. L.	497	13th January 1919.	6 months.
Do.	(279) Messrs. Maung Min Gyaw Bros. & Co.	Do.	P. L.	576	5th February 1919.	Do.
Do.	(280) Mr. P. M. Haines	Do.	P. L.	709	6th March 1919.	1 year.
Do.	(281) Maung Sein Khaing	Do.	P. L. (renewal).	1,182	8th August 1918.	Do.
Do.	(282) Maung Po Gywe	Do.	P. L. (renewal).	486	6th August 1918.	Do.
Do.	(283) Messrs. The High Speed Steel Alloys Mining Co., Ltd.	Do.	P. L. (renewal).	1,163	11th August 1918.	Do.
Do.	(284) Quah Cheng Tock	Do.	P. L. (renewal).	988	3rd September 1918.	Do.
Do.	(285) Maung Tun Mya	Do.	P. L. (renewal).	558	9th September 1918.	Do.
Do.	(286) Maung Po U	Do.	P. L. (renewal).	1,920	24th September 1918.	Do.
Do.	(287) Maung Ba Don	Do.	P. L. (renewal).	282	11th November 1918.	Do.
Do.	(288) Mr. A. E. O. Mahomed Yusuf.	Do.	P. L. (renewal).	415	16th November 1918.	Do.
Do.	(289) Maung Sein Khaing.	Do.	P. L. (renewal).	494	23rd November 1918.	Do.
Do.	(290) Maung Me	Do.	P. L. (renewal).	358	30th November 1918.	Do.
Do.	(291) Eu Kya Ban	Do.	P. L. (renewal).	660	20th November 1918.	6 months.
Do.	(292) Khoo Tun Byan	Do.	P. L. (renewal).	148	30th November 1918.	Do.
Do.	(293) Ong Hoe Kyin	Do.	P. L. (renewal).	179	13th December 1918.	Do.
Do.	(294) Messrs. The Bombay-Burma Trading Corporation, Ltd.	Do.	P. L. (renewal).	708	10th October 1918.	Do.
Do.	(295) Messrs. Steel Bros. & Co., Ltd.	Do.	P. L. (renewal).	1,422	21st December 1918.	1 year.
Do.	(296) Maung Mya Pe	Do.	P. L. (renewal).	469	26th December 1918.	6 months.
Do.	(297) Mr. Naitram Rambux.	Do.	P. L. (renewal).	240	4th January 1919.	1 year.
Do.	(298) Ma Mya Yin	Do.	P. L. (renewal).	1,039	21st December 1918.	6 months.

P. L. = *Prospecting License.*

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(299) Messrs. Steel Bros. & Co., Ltd.	All minerals (except oil).	P. L. (renewal).	620	6th January 1919.	6 months.
Do.	(300) Maung E Zin	Do.	P. L. (renewal).	435	15th February 1919.	1 year.
Do.	(301) Maung Po Hnan	Do.	P. L. (renewal).	589	Do.	Do.
Do.	(302) Messrs. The Tavoy Concessions, Ltd.	All minerals (except oil) and precious stones.	M. L.	676.69	23rd April 1918.	30 years.
Do.	(303) Quah Cheng Tock	Wolfram and tin.	M. L.	660.73	1st August 1916.	Do.
Do.	(304) Lim Kye Yan	All minerals (except oil) and precious stones.	M. L.	380.10	11th January 1917.	Do.
Do.	(305) Messrs. The High Speed Steel Alloys Mining Co., Ltd.	All minerals (except oil).	P. L.	3,442	14th August 1918.	6 months.
Do.	(306) Do.	Do.	P. L.	896	21st May 1919.	Do.
Do.	(307) Mr. A. R. H. Ady	Do.	P. L.	402	1st April 1919	1 year.
Do.	(308) Mr. G. Willison	Do.	P. L.	640	24th April 1919.	Do.
Do.	(309) Messrs. Tata Sons, Ltd.	Do.	P. L.	394	3rd May 1919.	Do.
Do.	(310) Quah Cheng Gwan	Do.	P. L.	300	4th April 1919	Do.
Do.	(311) Maung Ba Oh	Do.	P. L.	1,024	Do.	6 months.
Do.	(312) Do.	Do.	P. L.	407	19th June 1919.	Do.
Do.	(313) Messrs. Foucar & Co., Ltd.	Do.	P. L.	1,822	26th June 1919.	1 year.
Do.	(314) Mr. G. Willison	Do.	P. L. (renewal).	807	24th February 1918.	Do.
Do.	(315) Quah Cheng Gwan	Do.	P. L. (renewal).	1,003	3rd September 1918.	Do.
Do.	(316) Maung Saw Hlaing	Do.	P. L. (renewal).	548	2nd January 1919.	Do.
Do.	(317) Khoo Zun Nee	Do.	P. L. (renewal).	739	7th December 1918.	6 months.
Do.	(318) Maung Ngwe Thi	Do.	P. L. (renewal).	548	14th December 1918.	Do.
Do.	(319) Ma Mo Thu	Do.	P. L. (renewal).	389	14th June 1918.	Do.
Do.	(320) Ma Kin	Do.	P. L. (renewal).	719	19th June 1918.	1 year.
Do.	(321) Messrs. Osman Musti Khan & Co.	Do.	P. L. (renewal).	551	26th February 1919.	Do.

P. L. = Prospecting License. M. L. = Mining Lease.



BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(322) Quah Cheng Gwan	All minerals (except oil).	P. L. (renewal).	190	1st March 1919.	1 year.
Do.	(323) Messrs. Osman Musti Khan & Co.	Do.	P. L. (renewal).	747	10th February 1919.	6 months.
Do.	(324) Maung Po Hnan	Do.	P. L. (renewal).	640	26th March 1919.	1 year.
Do.	(325) Messrs. Osman Musti Khan & Co.	Do.	P. L. (renewal).	297	30th April 1919.	Do.
Do.	(326) Mr. A. E. O. Mahomed Yusuf.	Do.	P. L. (renewal).	487	9th April 1919.	6 months.
Do.	(327) Maung Ba Don	Do.	P. L. (renewal).	84	22nd April 1919.	1 year.
Do.	(328) Maung Sein Thwe	Do.	P. L. (renewal).	256	9th April 1919.	6 months.
Do.	(329) C. Soo Don	Do.	P. L. (renewal).	640	23rd April 1919.	Do.
Do.	(330) Messrs. The Rangoon Wolfram Co., Ltd.	Do.	P. L. (renewal).	1,725	9th May 1919.	1 year.
Do.	(331) Messrs. Tata Sons, Ltd.	Do.	P. L.	282	3rd May 1919.	Do.
Do.	(332) Messrs. The Tavoy Tin Syndicate.	Do.	P. L.	2,752	1st September 1919.	Do.
Do.	(333) Do.	Do.	P. L.	1,894	Do.	Do.
Do.	(334) Do.	Do.	P. L.	3,802	Do.	Do.
Do.	(335) Messrs. The Tavoy Syndicate.	Do.	P. L.	1,644	Do.	Do.
Do.	(336) Messrs. The Tavoy Tin Syndicate.	Do.	P. L.	1,769	Do.	Do.
Do.	(337) Mr. A. E. H. Ady	Do.	P. L.	410	10th September 1919.	Do.
Do.	(338) Maung Maung	Do.	P. L.	404	26th August 1919.	Do.
Do.	(339) Mr. H. G. Mathews	Do.	P. L.	4,057	1st July 1919.	6 months.
Do.	(340) Messrs. The Bombay Burma Trading Corporation, Ltd.	Do.	P. L.	839.68	22nd July 1919.	1 year.
Do.	(341) Mr. G. Lovell	Do.	P. L.	118	30th September 1919.	Do.
Do.	(342) S. Boon Thi	Do.	P. L.	1,088	15th September 1919.	Do.
Do.	(343) C. Soo Don	Do.	P. L.	1,387	24th September 1919.	Do.

P. L. = *Prospecting License.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(344) Maung Maung	All minerals (except oil).	P. L.	638	26th August 1919.	1 year.
Do.	(345) Quah Cheng Gwan	Do. . . .	P. L. (renewal).	640	9th January 1919.	Do.
Do.	(346) Messrs. The Bombay Burma Trading Corporation, Ltd.	Do. . . .	P. L. (renewal).	860	19th March 1919.	Do.
Do.	(347) Messrs. The Tavoy Wolfram, Ltd.	Do. . . .	P. L. (renewal).	543	26th April 1919.	Do.
Do.	(348) Mr. F. G. Fitzherbert.	Do. . . .	P. L. (renewal).	389	20th May 1919.	Do.
Do.	(349) Mr. C. Beadon	Do. . . .	P. L. (renewal).	3,674	3rd July 1919.	Do.
Do.	(350) Maung Po Myee	Do. . . .	P. L. (renewal).	179	25th May 1919.	Do.
Do.	(351) Mr. C. Beadon	Do. . . .	P. L. (renewal).	2,371	3rd July 1919.	Do.
Do.	(352) Mr. A. R. H. Ady	Do. . . .	P. L. (renewal).	809	28th June 1919.	Do.
Do.	(353) Messrs. Foucar & Co., Ltd.	Do. . . .	P. L. (renewal).	460	1st July 1919.	Do.
Do.	(354) Do. . . .	Do. . . .	P. L. (renewal).	476	27th August 1919.	Do.
Do.	(355) Messrs. The Indo-Burma Tin Corporation, Ltd.	Do. . . .	P. L. (renewal).	410	4th September 1919.	Do.
Do.	(356) Maung Min Gyaw Bros.	Do. . . .	P. L. (renewal).	483	5th August 1919.	6 months.
Do.	(357) Quah Cheng Tock	Do. . . .	P. L. (renewal).	988	3rd September 1919.	1 year.
Do.	(358) Messrs. Tata Sons, Ltd.	Do. . . .	P. L.	2,312	24th October 1919.	Do.
Do.	(359) Messrs. The Indo-Burma Tin Corporation, Ltd.	Do. . . .	P. L.	1,827	14th November 1919.	6 months.
Do.	(360) Maung Ni Toe	All minerals (except oil and jade).	P. L.	1,772	1st December 1919.	Do.
Do.	(361) Maung Ba On	Do. . . .	P. L.	312	17th October 1919.	1 year.
Do.	(362) Quah Cheng Tock	All minerals (except oil).	P. L.	657	24th October 1919.	Do.
Do.	(363) Maung Maung	Do. . . .	P. L.	256	20th October 1919.	Do.
Do.	(364) Do. . . .	Do. . . .	P. L.	1,059	4th November 1919.	Do.

P. L.—*Prospecting License.*

## BURMA—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(365) Eu Shwe Swai	All minerals (except oil).	P. L.	353	1st December 1919.	1 year.
Do.	(366) Ong Hoe Kyin	Do.	P. L.	1,113	19th November 1919.	Do.
Do.	(367) Maung Kya Tun	Do.	P. L.	586	4th December 1919.	6 months.
Do.	(368) Messrs. Bulloch Bros. & Co., Ltd.	Do.	P. L.	640	18th December 1919.	Do.
Do.	(369) Maung Po Swe	Do.	P. L.	617	20th October 1919.	Do.
Do.	(370) Gunpat Rai Kutwul.	Do.	P. L. (renewal).	384	16th December 1918.	1 year.
Do.	(371) Do.	Do.	P. L. (renewal).	333	13th May 1919.	Do.
Do.	(372) Messrs. Osman Musti Khan & Co.	Do.	P. L. (renewal).	747	10th August 1919.	Do.
Do.	(373) Maung Po Gaung	Do.	P. L. (renewal).	230	14th August 1919.	Do.
Do.	(374) Quah Cheng Gwan	Do.	P. L. (renewal).	1,003	3rd September 1919.	Do.
Do.	(375) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L. (renewal).	320	12th October 1919.	Do.
Do.	(376) A. E. O Mahomed Yusuf.	Do.	P. L. (renewal).	487	9th October 1919.	6 months.
Thaton	(377) Maung Paung	Do.	P. L.	607.50	18th January 1919.	1 year.
Do.	(378) Foo Beng Seng	Do.	P. L.	2,022.4	3rd January 1919.	Do.
Do.	(379) Khing Beng Chong	Do.	P. L.	2,009.6	15th January 1919.	Do.
Do.	(380) Maung Chit Maung	Do.	P. L.	307.2	9th January 1919.	8 months and 2 days.
Do.	(381) Maung E Cho	Do.	P. L. (renewal).	793.6	8th December 1918.	1 year.
Do.	(382) Maung Khaing	Do.	P. L. (renewal).	153.6	7th February 1919.	Do.
Do.	(383) Do.	Do.	P. L. (renewal).	1,094.4	29th January 1919.	Do.
Do.	(384) The Hon'ble Mr. Lim Chin Tsong.	Do.	P. L.	742.4	7th May 1919	Do.
Do.	(385) Maung Kyi	Do.	P. L.	1,241.6	9th May 1919	Do.
Do.	(386) C. Chan Shwe	Do.	P. L.	640	5th May 1919	Do.
Do.	(387) Maung Pe Gyi	Do.	P. L. (renewal).	1,920	23rd July 1913.	Do.

P. L.—Prospecting Licenses.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thaton	(388) Tan Kin Chye	All minerals (except oil).	P. L. (renewal).	691.2	31st August 1918.	1 year.
Do.	(389) Ong Ba Wet and Tan Kin Chye.	Do.	P. L. (renewal).	576	13th February 1919.	Do.
Do.	(390) Maung Pu	Do.	P. L.	601.6	29th October 1918.	Do.
Thayetmyo	(391) Messrs. The London-Rangoon Trading Co., Ltd.	Mineral oil	P. L.	4,576	13th December 1918.	Do.
Do.	(392) Do.	Do.	P. L.	2,880	26th November 1918.	Do.
Do.	(393) Do.	Do.	P. L.	1,920	Do.	Do.
Do.	(394) Do.	Do.	P. L.	9,600	8th January 1919.	Do.
Do.	(395) Do.	Do.	P. L. (renewal).	9,574.4	18th December 1918.	2 years.
Do.	(396) Mrs. H. V. Murray	Do.	P. L. (renewal).	3,200	12th November 1918.	Do.
Do.	(397) Messrs. The British Burma Petroleum Co., Ltd.	Do.	M. L.	94.72	18th June 1918.	30 years.
Do.	(398) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L.	4,680	31st March 1919.	1 year.
Do.	(399) Messrs. The London-Rangoon Trading Co., Ltd.	Do.	P. L. (renewal).	2,880	10th April 1919.	2 years.
Do.	(400) Do.	Do.	P. L.	11,520 (Blocks 48, 44 and 45 of the Minnia Oil Field and an undemarcated area of 15 square miles).	14th June 1919.	1 year.
Do.	(401) Ma Saw Hein	Do.	P. L.	460	22nd April 1919.	Do.
Do.	(402) Messrs. The London-Rangoon Trading Co., Ltd.	Do.	P. L. (renewal).	2,560 (Blocks 26 and 27, the western half of blocks 9, 25 and 28 and the eastern half of block 30).	13th July 1919.	2 years.
Toungoo	(403) Mr. J. Curri	All minerals (except oil).	P. L.	1,920	15th May 1919.	1 year.
Do.	(404) Mr. H. J. Davies	Do.	P. L.	747.52	17th November 1919.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

## BURMA—concl'd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Upper Chindwin.	(405) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. (renewal.)	12,800	12th September 1918.	2 years.
Yamethia .	(406) Mr. W. H. Heard-White.	All minerals (except oil).	P. L. .	640	31st January 1919.	1 year.
Do. .	(407) Messrs. H. Abdul Shakoer Hajee Cassim & Sons.	Do. .	P. L. .	4,268·8	6th February 1919.	Do.
Do. .	(408) Maung Tun Mya .	Do. .	P. L. .	531·2	22nd February 1919.	Do.
Do. .	(409) Mr. Tan Ba Thwin	Do. .	P. L. .	652·8	27th March 1919.	Do.
Do. .	(410) Do. .	Do. .	P. L. .	1,152	Do.	Do.
Do. .	(411) Maung Ba Tin .	Do. .	P. L. .	1,337·6	30th June 1919.	Do.
Do. .	(412) Messrs. B. M. Kharwar & Co.	Do. .	P. L. (renewal.)	1,715·2	15th January 1919.	2 years.
Do. .	(413) Messrs. H. Abdul Shakoer Hajee Cassim & Sons.	Do. .	P. L. .	1,779·2	26th July 1919.	1 year.
Do. .	(414) Messrs. B. M. Kharwar.	Do. .	P. L. (renewal.)	1,369·6	20th May 1919.	Do.
Do. .	(415) Maung Kyi . .	Do. .	P. L. (renewal.)	582·4	18th May 1919.	Do.
Do. .	(416) L. Ah Lye . .	Do. .	P. L. (renewal.)	1,600	21st August 1919.	Do.

## CENTRAL PROVINCES.

Balaghat .	(417) Seth Shiram .	Manganese . .	P. L. (renewal.)	348	13th September 1918.	6 months.
Do. .	(418) Do. .	Do. . .	P. L. .	128	17th February 1919.	1 year.
Do. .	(419) Do. .	Do. . .	P. L. (renewal.)	45	30th September 1918.	6 months.
Do. .	(420) Do. .	Do. . .	P. L. .	496	17th February 1919.	1 year.
Do. .	(421) Do. .	Do. . .	P. L. .	395	Do. .	Do.
Do. .	(422) Do. .	Do. . .	P. L. .	77	Do. .	Do.
Do. .	(423) Do. .	Do. . .	P. L. .	1	Do. .	Do.
Do. .	(424) Do. .	Do. . .	P. L. .	2	Do. .	Do.
Do. .	(425) Do. .	Do. . .	P. L. .	11	Do. .	Do.

P. L.—Prospecting License.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(426) Seth Shriram .	Manganese .	P. L. .	1	17th February 1919.	1 year.
Do. .	(427) Do. .	Do. .	P. L. .	2	Do. .	Do.
Do. .	(428) Mr. C. S. Harris .	Copper and bauxite.	P. L. (renewal.)	12	1st February 1919.	6 months.
Do. .	(429) Messrs. Tata Sons, Ltd.	Bauxite .	P. L. (renewal.)	68	31st December 1918	2 years.
Do. .	(430) Do. .	Do. .	P. L. (renewal.)	107	Do. .	Do.
Do. .	(431) Do. .	Do. .	P. L. (renewal.)	66	1st February 1919.	Do.
Do. .	(432) Do. .	Do. .	P. L. (renewal.)	96	31st December 1918.	Do.
Do. .	(433) Do. .	Do. .	P. L. (renewal.)	533	1st February 1919.	Do.
Do. .	(434) Do. .	Do. .	P. L. (renewal.)	151	Do. .	Do.
Do. .	(435) Do. .	Do. .	P. L. (renewal.)	525	Do. .	Do.
Do. .	(436) Do. .	Do. .	P. L. (renewal.)	26	Do. .	Do.
Do. .	(437) Do. .	Do. .	P. L. (renewal.)	20	Do. .	Do.
Do. .	(438) Do. .	Do. .	P. L. (renewal.)	116	Do. .	Do.
Do. .	(439) Do. .	Do. .	P. L. (renewal.)	93	Do. .	Do.
Do. .	(440) Do. .	Do. .	P. L. (renewal.)	64	Do. .	Do.
Do. .	(441) Khan Bahadur Byramji Pestonji.	Manganese .	P. L. .	136	31st March 1919.	1 year.
Do. .	(442) Central Provinces Prospecting Syndicate.	Do. .	M. L. .	13	1st March 1919.	Will expire with the original lease, dated the 22nd December 1902, to which it is supplementary.
Do. .	(443) Pandit Kripashanker.	Do. .	M. L. .	44	2nd January 1919.	Will expire with the original lease, dated the 20th April 1918, to which it is supplementary.

P. L.—Prospecting License. M. L.—Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(444) Mr. M. B. Chopra .	Manganese . . .	P. L. . .	101	26th March 1919.	1 year.
Do.	(445) Khan Bahadur Byramji Pestonji.	Do. . . .	P. L. (renewal.)	52	27th May 1919.	5 months.
Do.	(446) Do. . . .	Do. . . .	P. L. . .	173	7th June 1919.	1 year.
Do.	(447) Do. . . .	Do. . . .	P. L. . .	128	Do. . .	Do.
Do.	(448) Messrs. Tata Sons, Ltd.	Bauxite . . .	P. L. (renewal.)	28	28th June 1919.	2 years.
Do.	(449) Do. . . .	Do. . . .	P. L. (renewal.)	16	7th May 1919	Do.
Do.	(450) Do. . . .	Do. . . .	P. L. (renewal.)	781	5th May 1919	Do.
Do.	(451) Do. . . .	Do. . . .	P. L. (renewal.)	40	1st August 1919.	Do.
Do.	(452) Do. . . .	Do. . . .	P. L. (renewal.)	69	Do. . .	Do.
Do.	(453) Do. . . .	Do. . . .	P. L. (renewal.)	77	Do. . .	Do.
Do.	(454) Do. . . .	Do. . . .	P. L. (renewal.)	1,365	27th August 1919.	Do.
Do.	(455) Do. . . .	Do. . . .	P. L. (renewal.)	187	1st August 1919.	Do.
Do.	(456) Do. . . .	Do. . . .	P. L. (renewal.)	469	Do. . .	Do.
Do.	(457) Do. . . .	Do. . . .	P. L. (renewal.)	27	21st May 1919.	Do.
Do.	(458) Do. . . .	Do. . . .	P. L. (renewal.)	187	Do. . .	Do.
Do.	(459) Do. . . .	Do. . . .	P. L. . .	56	Do. . .	Do.
Do.	(460) Do. . . .	Do. . . .	P. L. . .	44	Do. . .	Do.
Do.	(461) Do. . . .	Do. . . .	P. L. . .	412	Do. . .	Do.
Do.	(462) Do. . . .	Do. . . .	P. L. . .	118	Do. . .	Do.
Do.	(463) Mr. M. B. Dadabhoy, C.I.E.	Manganese . . .	P. L. . .	118	17th May 1919.	1 year.
Do.	(464) Pandit Rewashankar.	Do. . . .	P. L. . .	186	11th June 1919.	Do.
Do.	(465) Shriram Seth .	Do. . . .	M. L. . .	70	17th July 1919.	30 years
Do.	(466) Do.] . . .	Do. . . .	P. L. . .	17	27th August 1919.	1 year.
Do.	(467) Do. . . .	Do. . . .	P. L. . .	13	20th September 1919.	Do.

P. L. = *Prospecting License*. M. L. = *Mining Lease*.

## CENTRAL PROVINCES—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Ealaghat .	(468) Shriram Seth .	Manganese .	P. L. .	5	20th September 1919.	1 year.
Do. .	(469) Do. .	Do. .	P. L. .	131	Do. .	Do.
Do. .	(470) K. B. Byramji Pestonji.	Do. .	M. L. .	29	2nd August 1919.	5 years.
Do. .	(471) Do. .	Do. .	M. L. .	4	Do. .	Do.
Do. .	(472) Do. .	Do. .	M. L. .	13	Do. .	Do.
Do. .	(473) Do. .	Do. .	M. L. .	15	Do. .	Do.
Do. .	(474) Do. .	Do. .	M. L. .	13	Do. .	Do.
Do. .	(475) Do. .	Do. .	M. L. .	25	Do. .	Do.
Do. .	(476) Do. .	Do. .	M. L. .	18	26th August 1919.	Do.
Do. .	(477) Do. .	Do. .	M. L. .	22	2nd August 1919.	Do.
Do. .	(478) Do. .	Do. .	M. L. .	4	Do. .	Do.
Do. .	(479) Do. .	Do. .	M. L. .	3	Do. .	Do.
Do. .	(480) Do. .	Do. .	P. L. (renewal.)	552	27th August 1919.	6 months.
Do. .	(481) Do. .	Do. .	M. L. .	20	2nd August 1919.	5 years.
Do. .	(482) Do. .	Do. .	M. L. .	11	Do. .	Do.
Do. .	(483) Baboo Kripashankar.	Do. .	M. L. .	19	9th August 1919.	Do.
Do. .	(484) Do. .	Do. .	M. L. .	88	Do. .	Do.
Do. .	(485) Pandit Rewashankar.	Do. .	M. L. .	41	2nd July 1919.	15 years.
Do. .	(486) Do. .	Do. .	M. L. .	36	Do. .	10 years.
Do. .	(487) Messrs. Bahmansha Fouzdar Brothers.	Do. .	P. L. (renewal.)	131	4th September 1919.	6 months.
Do. .	(488) Messrs. Tata Iron and Steel Co., Ltd.	Do. .	M. L. .	678	30th July 1919.	5 years.
Do. .	(489) Messrs. Tata Sons, Ltd.	Bauxite .	P. L. .	7,187	2nd August 1919.	1 year.
Do. .	(490) Do. .	Do. .	P. L. .	650	Do. .	Do.
Do. .	(491) Do. .	Do. .	P. L. .	964	Do. .	Do.
Do. .	(492) Do. .	Do. .	P. L. .	188	Do. .	Do.
Do. .	(493) Do. .	Do. .	P. L. .	125	Do. .	Do.
Do. .	(494) Do. .	Do. .	P. L. .	242	Do. .	Do.
Do. .	(495) Do. .	Do. .	P. L. .	397	Do. .	Do.

P. L.—Prospecting License. M. L.—Mining Lease.



CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(496) Messrs. Tata Sons, Ltd.	Bauxite . . .	P. L. . .	119	2nd August 1919.	1 year.
Do.	(497) Do. . .	Do. . . .	P. L. . .	91	Do. . .	Do.
Do.	(498) Do. . .	Do. . . .	P. L. . .	628	Do. . .	Do.
Do.	(499) Do. . .	Do. . . .	P. L. . .	316	Do. . .	Do.
Do.	(500) Do. . .	Do. . . .	P. L. . .	188	Do. . .	Do.
Do.	(501) Do. . .	Do. . . .	P. L. . .	125	Do. . .	Do.
Do.	(502) Seth Gowardhandas.	Manganese . . .	P. L. . .	70	27th August 1919.	Do.
Do.	(503) Messrs. M. D'Costa and Goredutt Ganeshlal.	Do. . . .	P. L. . .	53	2nd July 1919.	Do.
Do.	(504) Mr. C. S. Harris . .	Do. . . .	P. L. . .	528	27th August 1919.	Do.
Do.	(505) Do. . .	Do. . . .	P. L. . .	61	Do. . .	Do.
Do.	(506) Do. . .	Do. . . .	P. L. . .	14	Do. . .	Do.
Do.	(507) Shri Ram Seth . .	Do. . . .	P. L. . .	142	18th October 1919.	Do.
Do.	(508) Do. . .	Do. . . .	P. L. . .	85	21st Decem-1919.	Do.
Do.	(509) Do. . .	Do. . . .	P. L. . .	4	Do. . .	Do.
Do.	(510) Khan Bahadur Byramji Pestonji.	Do. . . .	P. L. . .	422	18th October 1919.	Do.
Do.	(511) Do. . .	Do. . . .	P. L. . .	59	Do. . .	Do.
Do.	(512) Do. . .	Do. . . .	M. L. . .	18	28th October 1919.	5 years.
Do.	(513) Do. . .	Do. . . .	M. L. . .	4	Do. . .	Do.
Do.	(514) Do. . .	Do. . . .	M. L. . .	2	Do. . .	Do.
Do.	(515) Do. . .	Do. . . .	M. L. . .	58	2nd October 1919.	Do.
Do.	(516) Do. . .	Do. . . .	M. L. . .	21	25th Novem-1919.	Do.
Do.	(517) Pandit Kripashankar.	Do. . . .	P. L. . .	48	8th Novem-ber 1919.	1 year.
Do.	(518) Do. . .	Do. . . .	M. L. . .	76	28th October 1919.	15 years.
Do.	(519) Messrs. Tata Sons, Ltd.	Bauxite . . .	P. L. (renewal.)	387	13th Decem-1919.	2 years.
Do.	(520) Do. . .	Do. . . .	P. L. (renewal.)	213	Do. . .	Do.
Do.	(521) Do. . .	Do. . . .	P. L. (renewal.)	522	Do. . .	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(522) Rajputana Minerals Syndicate, Ltd.	Manganese .	P. L. .	911	17th December 1919.	1 year.
Do. .	(523) Mr. C. S. Harris .	Copper . .	M. L. .	127	17th October 1919.	30 years.
Do. .	(524) Do. .	Manganese .	M. L. .	30	25th September 1919.	Do.
Do. .	(525) Do. .	Do. . .	P. L. .	21	10th November 1919.	1 year.
Do. .	(526) Messrs. Lalbehari Ram Charan.	Do. . .	P. L. .	212	18th October 1919.	Do.
Do. .	(527) Do. .	Do. . .	P. L. .	42	Do. .	Do.
Do. .	(528) Do. .	Do. . .	P. L. .	3	Do. .	Do.
Do. .	(529) Do. .	Do. . .	P. L. .	3	21st November 1919.	Do.
Betul .	(530) Shaikh Shahabuddin.	Graphite . .	M. L. .	57	2nd August 1919.	30 years.
Do. .	(531) Mr. M. R. Dixit, Barrister-at-Law, Nagpur.	Do. . .	M. L. .	231	6th August 1919.	Do.
Do. .	(532) Seth Lakhmichand.	Lead . . .	P. L. .	177.28	1st December 1919.	1 year.
Bhandara .	(533) Khan Bahadur Byramji Pestonji.	Manganese .	P. L. (renewal.)	17	27th February 1919.	6 months.
Do. .	(534) Mr. Shriram Seth .	Corundum . .	P. L. .	32	27th July 1919.	1 year.
Do. .	(535) Do. .	Manganese .	P. L. .	30	9th August 1919.	Do.
Do. .	(536) Seth Cowardhandas.	Do. . .	P. L. (renewal.)	27	20th November 1919.	Do.
Do. .	(537) Shri Ram Seth .	Do. . .	M. L. .	49	4th October 1919.	5 years.
Chanda .	(538) Mr. M. B. Dadabhoy, C.I.E.	Coal . . .	P. L. .	2,208	12th May 1919.	1 year.
Do. .	(539) Mr. Padamsy Narasimhai.	Do. . .	P. L. .	453	2nd June 1919.	Do.
Do. .	(540) Messrs. Hajibhoy Lalji & Co., Bombay.	Do. . .	P. L. .	213	26th September 1919.	Do.
Do. .	(541) Messrs. Jagjivan Vallabhdas Padamsy & Co., Bombay.	Do. . .	M. L. .	360	8th December 1919.	30 years.
Do. .	(542) Do. .	Do. . .	M. L. .	771	Do. .	Do.
Chhindwara	(543) Babu Kripashankar.	Do. . .	P. L. .	417	26th February 1919.	1 year.
Do. .	(544) Sheikh Shahabuddin.	Do. . .	P. L. .	1,452	4th March 1919.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(545) Rao Sahib D. Lakshminarain.	Manganese .	P. L. .	237	19th May 1919.	1 year.
Do.	(546) Do.	Do.	P. L. .	82	7th June 1919.	Do.
Do.	(547) Khan Bahadur Byramji Pestonji.	Do.	P. L. .	517	17th June 1919.	Do.
Do.	(548) Mir Aslam Khan .	Coal . . .	P. L. .	588	23rd June 1919.	Do.
Do.	(549) The Pench Consolidated Coal Co., Ltd.	Do. . . .	M. L. .	463	30th July 1919.	30 years.
Do.	(550) Messrs. Shaw Wallace & Co.	Do. . . .	M. L. .	455	Do. .	Do.
Do.	(551) Do.	Do. . . .	M. L. .	442	Do. .	Do.
Do.	(552) Do.	Do. . . .	M. L. .	214	Do. .	Do.
Do.	(553) Messrs. H. Verma and M. Kanhaiya Lal of Chhindwara.	Do. . . .	M. L. .	268	29th July 1919.	Will expire with the original lease, dated 7th June 1916 to which it is supplementary, <i>i.e.</i> , on 7th June 1946.
Do.	(554) Messrs. Byramji Pestonji & Co.	Do. . . .	M. L. .	1,485	12th August 1919.	30 years.
Do.	(555) Do.	Do. . . .	M. L. .	436	26th August 1919.	Do.
Do.	(556) Do.	Do. . . .	M. L. .	492	Do. .	Do.
Do.	(557) Rai Bahadur Bisesardas Daga and others of Kamptee.	Manganese-ore	M. L. .	174	10th July 1919.	15 years.
Do.	(558) Mr. B. V. Buti of Nagpur.	Do.	M. L. .	4	8th September 1919.	30 years.
Do.	(559) Indian Manganese Co., Ltd., Nagpur.	Do.	P. L. .	284	4th July 1919.	1 year.
Do.	(560) Do.	Do.	P. L. .	1,008	Do. .	Do.
Do.	(561) Mr. B. V. Buti of Nagpur.	Manganese .	M. L. .	133.49	21st October 1919.	30 years.
Do.	(562) Mir Aslam Khan of Nagpur.	Coal . . .	P. L. .	567.55	1st December 1919.	1 year.
Do.	(563) Messrs. A. H. Vasudeo Rao and Brothers of Nagpur.	Do. . . .	P. L. .	25.64	3rd November 1919.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara	(564) Mr. B. V. Buti of Nagpur.	Coal . . .	P. L. .	75-97	7th October 1919.	1 year.
Do.	(565) Messrs. H. Verma and Munshi Kanhaiyalal of Chhindwara.	Do. . . .	P. L. .	243-14	20th November 1919.	Do.
Do.	(566) Mr. B. V. Buti of Nagpur.	Manganese . .	P. L. .	185-46	11th December 1919.	Do.
Do.	(567) Do.	Coal . . .	P. L. .	396-00	4th December 1919.	Do.
Jubbulpore	(568) Mr. C. Stanley Harris.	Manganese . .	P. L. .	94	15th May 1919.	Do.
Do.	(569) Mr. Venkat Ramanna.	Bauxite . . .	P. L. .	317	13th June 1919.	Do.
Do.	(570) Mr. J. C. Wilson .	Manganese, copper and mica.	P. L. .	874	12th May 1919.	Do.
Do.	(571) Mr. George Forrester.	Bauxite . . .	P. L. .	39	17th September 1919.	Do.
Do.	(572) D. B. Balabhdas, Mannual and Kanhaiya Lal	Iron, manganese, tin, zinc and silver.	P. L. .	266	10th July 1919.	Do.
Do.	(573) Do.	Do. . . .	P. L. .	268	3rd September 1919.	Do.
Do.	(574) Do.	Do. . . .	P. L. .	412	10th July 1919.	Do.
Do.	(575) Diwan Bahadur Balabhdas, Manoolal Kanhaiyalal of Jubbulpore.	Do. . . .	P. L. .	592-14	10th November 1919.	Do.
Do.	(576) Messrs. Byramji Pestonji of Nagpur.	Manganese . .	M. L. .	15-97	25th November 1919.	5 years.
Nagpur	(577) Mr. Laxman Rao Damodhar Lele.	Do. . . .	P. L. .	94	31st March 1919.	1 year.
Do.	(578) Mr. T. Cooverji Bhoja.	Do. . . .	P. L. .	89	27th March 1919.	Do.
Do.	(579) Do.	Do. . . .	P. L. .	128	Do. . .	Do.
Do.	(580) Do.	Do. . . .	P. L. .	160	Do. . .	Do.
Do.	(581) Do.	Do. . . .	P. L. .	33	Do. . .	Do.
Do.	(582) Mr. G. E. Bright .	Do. . . .	P. L. .	561	28th March 1919.	Do.
Do.	(583) Do.	Do. . . .	P. L. .	1,082	Do. . .	Do.
Do.	(584) Khan Bahadur Byramji Pestonji.	Do. . . .	P. L. .	329	22nd March 1919.	Do.
Do.	(585) Do.	Do. . . .	P. L. .	400	Do. . .	Do.
Do.	(586) Rao Sahab D. Laxminarayan.	Do. . . .	P. L. .	620	27th March 1919.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.]	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(587) Rao Saheb D. Laxminarayan.	Manganese .	P. L. .	58	27th March 1919.	1 year.
Do. .	(588) Do. .	Do. . .	P. L. .	462	Do. .	Do.
Do. .	(589) Messrs. Lalbehari and Ramcharan.	Do. . .	P. L. .	243	28th March 1919.	Do.
Do. .	(590) Mr. M. B. Dadabhoy, C.I.E.	Coal . . .	P. L. .	3,381	26th May 1919.	Do.
Do. .	(591) Messrs. A. H. Wasudeo Rao and A. Damodhar Rao.	Manganese .	M. L. .	49	27th May 1919.	30 years.
Do. .	(592) Do. .	Do. . .	M. L. .	10	Do. .	Do.
Do. .	(593) Messrs. Bahmansha Fouzdar Brothers.	Do. . .	M. L. .	40	25th June 1919.	Do.
Do. .	(594) Do. .	Do. . .	M. L. .	30	13th May 1919.	Do.
Do. .	(595) Do. .	Do. . .	M. L. .	28	Do. .	Do.
Do. .	(596) Do. .	Do. . .	M. L. .	5	25th June 1919.	Do.
Do. .	(597) Do. .	Do. . .	P. L. .	205	14th May 1919.	1 year.
Do. .	(598) Do. .	Do. . .	P. L. (renewal.)	56	4th April 1919.	3 months.
Do. .	(599) Messrs. Goredutt Ganesh Lal and M. D'Costa.	Do. . .	M. L. .	27	20th June 1919.	10 years.
Do. .	(600) Messrs. Lalbehari and Ramcharan.	Do. . .	M. L. .	13	12th June 1919.	30 years.
Do. .	(601) Do. .	Do. . .	M. L. .	27	Do. .	Do.
Do. .	(602) Messrs. Ramprasad Lakshminarayan.	Do. . .	P. L. .	19	30th April 1919.	1 year.
Do. .	(603) Rao Sahib D. Lakshminarayan.	Do. . .	P. L. .	530	19th May 1919.	Do.
Do. .	(604) Do. .	Do. . .	P. L. .	450	Do. .	Do.
Do. .	(605) Mir Aslam Khan .	Do. . .	P. L. .	68	24th June 1919.	Do.
Do. .	(606) Do. .	Do. . .	P. L. .	47	9th June 1919.	Do.
Do. .	(607) Do. .	Do. . .	P. L. .	28	14th May 1919.	Do.
Do. .	(608) Do. .	Do. . .	P. L. .	56	24th June 1919.	Do.
Do. .	(609) Do. .	Do. . .	P. L. .	130	22nd May 1919.	Do.
Do. .	(610) Do. .	Do. . .	P. L. .	163	Do. .	Do.

P. L. = *Prospecting License*. M. L. = *Mining Lease*.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(611) Mir Aslam Khan .	Manganese .	P. L. (renewal.)	111	18th May 1919.	8 months.
Do .	(612) Mr. G. E. Bright .	Do .	P. L.	28	22nd June 1919.	1 year.
Do .	(613) Rai Bahadur Bisesardas Daga.	Do .	P. L. (renewal.)	219	30th July 1919.	7 months
Do .	(614) The Central India Mining Co., Ltd.	Do .	M. L.	2	4th August 1919.	30 years.
Do .	(615) Do .	Do .	M. L.	35	12th July 1919.	10 years.
Do .	(616) R. S. D. Laxmi- narayan.	Do .	M. L.	37	8th July 1919.	30 years.
Do .	(617) Do .	Do .	M. L.	49	Do .	Do.
Do .	(618) Do .	Do .	P. L.	56	26th August 1919.	1 year.
Do .	(619) Mir Aslam Khan .	Do .	M. L.	17	4th Septem- ber 1919.	10 years.
Do .	(620) Do .	Do .	M. L.	206	Do .	Do.
Do .	(621) Do .	Do .	M. L.	69	Do .	Do.
Do .	(622) Do .	Do .	M. L.	31	Do .	15 years.
Do .	(623) Do .	Do .	P. L.	25	10th July 1919.	1 year.
Do .	(624) Do .	Do .	P. L.	176	Do .	Do.
Do .	(625) Do .	Do .	P. L.	52	1st August 1919.	6 months
Do .	(626) K. B. Byramji Pestonji.	Do .	M. L.	27	26th August 1919.	5 years.
Do .	(627) R. B. Bisesardas Daga.	Do .	P. L.	219	28th June 1919.	8 months.
Do .	(628) Ramkrishnapuri Gosal.	Do .	P. L.	75	25th Septem- ber 1919.	1 year.
Do .	(629) Do .	Do .	P. L.	110	Do .	Do.
Do .	(630) Rao Sanib D. Laxminarayan.	Do .	P. L.	272	11th October 1919.	Do.
Do .	(631) Mr. Venkat Rama- nna.	Do .	P. L.	300	7th October 1919.	Do.
Do .	(632) Mir Aslam Khan, Contractor.	Do .	M. L.	49	18th Novem- ber 1919.	30 years.
Do .	(633) Mr. Laxman Damodar Lele.	Do .	M. L.	16	5th Novem- ber 1919.	Do.
Do .	(634) Do .	Do .	M. L.	7	Do .	Do.

P. L. = Prospecting License. M. L. = Mining Lease.

## CENTRAL PROVINCES—concl'd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(635) Mr. Ramkrishnapuri Gosai.	Manganese . .	P. L. .	131	2nd December 1919.	1 year.
Do.	(636) Do.	Do. . .	P. L. .	40	Do. .	Do.
Do.	(637) Do.	Do. . .	P. L. .	29	Do. .	Do.
Narsingpur	(638) Mr. J. Reid . .	Coal . . .	P. L. .	1,844	2nd January 1919.	Do.
Raipur .	(639) Debiprasad Benia	Copper . . .	P. L. (renewal.)	586	7th February 1919.	Up to 31st December 1919.
Saugor .	(640) Mr. Pragharayan, B.A., LL.B., Pleader, Agra.	Iron pyrites, Sulphur and iron.	P. L. .	75	5th September 1919.	1 year.
Do.	(641) Rao Bahadur Damodar Rao Shrikhande, Pleader of Damoh.	Copper . . .	P. L. .	254	11th December 1919.	Do.
Seoni .	(642) Messrs. Byramji Pestonji of Nagpur.	Mica . . .	P. L. .	411-60	13th October 1919.	Do.
Yeotmal .	(643) Muhamad Anwar Pasha, minor by guardian Munshi Sheikh Alimuddin of Chikhla	Coal . . .	M. L. .	205	30th August 1919.	30 years.
Do.	(644) Mr. M. B. Dadabhoy, Barrister-at-Law, Nagpur.	Do. . . .	M. L. .	592	Do. .	25 years, 1 month and 15 days.
Do.	(645) Do.	Do. . . .	M. L. .	372	13th August 1919.	30 years.

## MADRAS.

Anantapur.	(646) B. P. Sessa Reddi.	Barytes . . .	P. L. .	2-84	13th July 1919.	1 year.
Do.	(647) A. Ghose, Esq. .	Do. . . .	P. L. .	56-90	27th July 1919.	Do.
Do.	(648) Agent, Anantapur Gold Fields (Ltd.).	Gold . . . .	P. L. .	3,604-81	8th October 1919.	Do.
Kurnool .	(649) B. P. Sessa Reddi.	Barytes . . .	P. L. .	19-13	20th September 1919.	Do.
Do.	(650) Do.	Do. . . .	P. L. .	8-06	Do. .	Do.
Do.	(651) A. Ghose, Esq. .	Do. . . .	P. L. .	65	18th September 1919.	Do.
Do.	(652) Do.	Do. . . .	P. L. .	1-73	Do. .	Do.
Do.	(653) Do.	Do. . . .	P. L. .	7-78	Do. .	Do.

P. L.=Prospecting License. M. L.=Mining Lease.

MADRAS—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kurnool	(654) B. P. Sessa Reddi.	Barytes	P. L.	4-20	16th August 1919.	1 year.
Do.	(655) A. Ghose, Esq.	Do.	P. L.	86	18th September 1919.	Do.
Do.	(656) B. P. Sessa Reddi.	Do.	P. L.	0-80	20th September 1919.	Do.
Do.	(657) Do.	Do.	P. L.	12-50	Do.	Do.
Do.	(658) B. Pulla Reddi	Do.	P. L.	1-40	16th August 1919.	Do.
Do.	(659) Do.	Do.	P. L.	0-80	Do.	Do.
Do.	(660) Do.	Do.	P. L.	3-30	Do.	Do.
Do.	(661) A. Ghose, Esq.	Do.	P. L.	1-90	18th September 1919.	Do.
Do.	(662) B. P. Sessa Reddi.	Do.	P. L.	13-50	20th September 1919.	Do.
Do.	(663) A. Ghose, Esq.	Do.	P. L.	32-36	23rd December 1919.	Do.
Do.	(664) Do.	Do.	P. L.	21-80	16th October 1919.	Do.
Do.	(665) Do.	Do.	P. L.	1-15	5th December 1919.	Do.
Do.	(666) Do.	Do.	P. L.	2-88	16th October 1919.	Do.
Do.	(667) Do.	Do.	P. L.	2-62	5th December 1919.	Do.
Do.	(668) Do.	Do.	P. L.	6-90	23rd December 1919.	Do.
Do.	(669) Do.	Do.	P. L.	295-39	Do.	Do.
Do.	(670) Do.	Do.	P. L.	0-98	5th December 1919.	Do.
Do.	(671) Do.	Do.	P. L.	6-05	23rd December 1919.	Do.
Nellore	(672) P. K. Vengama Nayudu.	Mica	M. L.	19-97	11th October 1918.	30 years.
Do.	(673) N. Raghavulu Naicker.	Do.	P. L.	3-38	31st January 1919.	1 year.
Do.	(674) G. Venkatachalam Chetti.	Do.	M. L.	27-86	7th December 1918.	30 years.
Do.	(675) C. H. Jefferson	Do.	M. L.	1-10	3rd October 1918.	Do.
Do.	(676) Messrs. Startin & Co.	Do.	M. L. (This lease is in extension of the one already held by the company.)	30-74	15th September 1918.	For the unexpired portion of the original lease.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*



## MADRAS—contd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore	(677) P. Venkataswami Chetti.	Mica	P. L.	48-28	18th March 1919.	1 year.
Do.	(678) N. Raghavulu Naicker.	Do.	P. L.	19-22	7th November 1918.	Do.
Do.	(679) T. Venkatasubba Rao.	Do.	P. L.	18-65	13th December 1918.	Do.
Do.	(680) K. Penchulu Reddi	Do.	M. L.	89-05	24th October 1918.	30 years.
Do.	(681) P. Venkata Narapa Reddi.	Do.	M. L.	82-43	12th August 1918.	Up to 1st August 1944.
Do.	(682) K. Adinarayana Reddi.	Do.	M. L.	121-98	9th October 1918.	Up to 4th April 1947.
Do.	(683) Messrs. W. A. Beardsell & Co.	Do.	M. L.	308-27	3rd February 1917.	30 years.
Do.	(684) Do.	Do.	M. L.	182-96	Do.	Do.
Do.	(685) Do.	Do.	M. L.	305-24	Do.	Do.
Do.	(686) Do.	Do.	M. L.	76	Do.	Do.
Do.	(687) K. Penchelu Reddi	Do.	P. L.	13-41	1st July 1919	1 year.
Do.	(688) P. Venkataswami Chetti.	Do.	P. L.	2-68	18th April 1919.	Do.
Do.	(689) N. Raghavulu Nayakar.	Do.	M. L.	9-41	14th December 1918.	30 years.
Do.	(690) V. K. M. K. R. Karuppan Chetti.	Do.	P. L.	24-62	26th February 1919.	1 year.
Do.	(691) G. Subrahmanyam	Do.	P. L.	145-46	1st October 1919.	Do.
Do.	(692) Indur Subbarami Reddi.	Do.	P. L.	30-00	28th July 1919.	Do.
Do.	(693) G. Gopalakrishnayya.	Do.	P. L.	136-86	31st July 1919.	Do.
Do.	(694) Moolji Govindjee .	Do.	P. L.	20	8th April 1919.	Do.
Do.	(695) V. Rami Reddi .	Do.	P. L.	10-06	2nd June 1919.	Do.
Do.	(696) B. V. Subba Reddi	Do.	P. L.	5-05	Do.	Do.
Do.	(697) V. K. M. K. R. Karuppan Chetti.	Do.	P. L.	0-32	24th May 1919.	Do.
Do.	(698) K. Venkatasubbayya.	Do.	P. L.	12-89	6th August 1919.	Do.
Do.	(699) G. V. Subba Reddi	Do.	P. L.	43-30	1st October 1919.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

## MADRAS—concl'd.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(700) Indupur Subbarami Reddi.	Mica . . . .	P. L. . . .	31-26	20th September 1919.	1 year.
Do. .	(701) V. Venkata-subbayya.	Do. . . . .	P. L. . . .	1-61	29th September 1919.	Do.
Do. .	(702) V. K. M. K. R. Karuppan Chetti.	Do. . . . .	P. L. . . . (renewal).	13-65	Not stated .	Not stated.
Do. .	(703) R. K. Subbaraghava Ayyar.	Do. . . . .	P. L. . . .	19-25	6th November 1919.	1 year.
Do. .	(704) N. Viraraghavayya	Do. . . . .	P. L. . . .	3-17	9th October 1919.	Do.
Do. .	(705) N. Baghavali Nayakar.	Do. . . . .	P. L. . . .	37-40	12th July 1919.	Do.
Trichinopoly	(706) Messrs. Stanes & Co., Coimbatore.	Phosphatic nodules	M. L. . . .	Blocks nos. 3 and 6 in the survey map of 1862 and 1895.	The date on which the lessee begins operations.	5 years.

## PUNJAB.

Attock .	(707) The Attock Oil Co., Ltd.	Mineral oil . . .	P. L. . . .	3,264	3rd September 1919.	1 year.
Jhelum .	(708) R. S. L. Thakar Dass Ramji Das of Dandot.	Coal . . . . .	P. L. . . .	839-7	11th April 1918.	Do.

P. L.—Prospecting License. M. L.—Mining Lease.

## SUMMARY.

PROVINCE.	Prospecting Licenses.	Mining Leases.	Total of each Province.
Assam . . . . .	7	2	9
Baluchistan . . . . .	4	..	4
Bihar and Orissa . . . . .	19	13	36
Bombay . . . . .	7	..	7
Burma . . . . .	355	9	364
Central Provinces . . . . .	160	69	229
Madras . . . . .	48	13	61
Punjab . . . . .	2	..	2
Total of each kind and Grand total, 1919 . . . . .	692	106	798
TOTAL for 1918 . . . . .	675	44	719

## CLASSIFICATION OF LICENSES AND LEASES.

TABLE 36.—*Prospecting Licenses and Mining Leases granted in Assam during 1919.*

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Cachar . . . . .	2	8,491.9	Mineral oil.
Do. . . . .	1	934.4	Oil and coal.
Khasi and Jaintia Hills . . . . .	2	12,902.4	Minerals other than mineral oils.
Lakhimpur . . . . .	2	12,320	Oil.
<b>TOTAL</b> . . . . .	<b>7</b>	<b>...</b>	

<b>Mining Leases.</b>			
Lakhimpur . . . . .	2	5,120	Oil.

TABLE 37.—*Prospecting Licenses and Mining Leases granted in Baluchistan during 1919.*

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Kalat . . . . .	3	46,080	Oil.
Zhob . . . . .	1	60	Chromite.
<b>TOTAL</b> . . . . .	<b>4</b>	<b>...</b>	

TABLE 38.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during 1919.*

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Hazaribagh . . . . .	8	2,128-89	Mica.
Sambalpur . . . . .	1	5,849-79	Do.
Do. . . . .	1	2,376-99	Coal.
Do. . . . .	1	57	Oxide of iron.
Santal Parganas . . . . .	2	10,239-74	Coal.
Singhbhum . . . . .	2	2,660	Gold and galena.
Do. . . . .	1	26,240	General license.
Do. . . . .	1	992	Manganese and iron-ore.
Do. . . . .	2	2,310-4	Iron-ore.
<b>TOTAL . . . . .</b>	<b>19</b>	<b>...</b>	

<b>Mining Leases.</b>			
Hazaribagh . . . . .	3	360	Mica.
Santal Parganas . . . . .	10	79-86	Coal.
<b>TOTAL . . . . .</b>	<b>13</b>	<b>...</b>	

TABLE 39.—*Prospecting Licenses and Mining Leases granted in Bombay during 1919.*

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Belgaum . . . . .	6	2,722-92	Bauxite.
Kaira . . . . .	1	79-82	Manganese.
<b>TOTAL . . . . .</b>	<b>7</b>	<b>...</b>	

TABLE 40.—Prospecting Licenses and Mining Leases granted in Burma during 1919.

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Akyab . . . . .	2	4,900	Mineral oil.
Amherst . . . . .	42	41,095.43	All minerals (except oil).
Bhamo . . . . .	1	5,516.8	Do.
Do. . . . .	1	6,400	All minerals (except oil and jade).
Henzada . . . . .	3	5,628.02	All minerals (except oil).
Katha . . . . .	9	50,201.60	Do.
Do. . . . .	1	2,752	Gold.
Do. . . . .	1	3,392	All minerals (except oil and jade).
Kyaukpyu . . . . .	1	640	Mineral oil.
Kyaukse . . . . .	1	1,656.32	All minerals (except oil).
Magwe . . . . .	4	26,787.30	Mineral oil.
Mandalay . . . . .	1	2,355.2	Silver and lead.
Mergui . . . . .	21	21,790.12	Wolfram and tin.
Do. . . . .	38	43,313.65	All minerals (except oil).
Do. . . . .	3	1,295.36	Wolfram, tin and allied minerals.
Do. . . . .	13	10,929.46	Tin.
Do. . . . .	1	1,720.32	Tin, Gold and allied minerals.
Do. . . . .	2	732.16	Wolfram and allied minerals.
Do. . . . .	1	400	Coal.
Do. . . . .	1	517.12	Tin and tungsten ores.
Do. . . . .	1	640	Wolfram.
Minbu . . . . .	5	5,238.24	Mineral oil.
Do. . . . .	10	14,671.6	Coal.
Myingyan . . . . .	5	20,329.10	Mineral oil.
Do. . . . .	1	167.75	All minerals.
Myitkyina . . . . .	1	640	Silver and copper.
Do. . . . .	1	2,931.20	Gold and platinum.
Do. . . . .	1	3,200	Gold and iridio platinum.
Do. . . . .	1	640	Gold.
Do. . . . .	1	4,851.20	All minerals (except oil).
Pakokku . . . . .	5	4,572.8	Mineral oil.
Pakokku Hill Tracts . . . . .	1	3,840	All minerals (except oil).
Prome . . . . .	2	443	Mineral oil.
Do. . . . .	1	2,668.3	Coal.
Ruby Mines . . . . .	2	10,240	All minerals (except oil).
Do. . . . .	1	640	Copper ore.
Do. . . . .	1	41	Mica.

TABLE 40.—*Prospecting Licenses and Mining Leases granted in Burma during 1919—contd.*

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.

Prospecting Licenses—*contd.*

Salween . . . . .	2	5,140	All minerals (except oil).
Shwebo . . . . .	1	200	Do.
Do. . . . .	2	8,320	Mineral oil.
Southern Shan States . . . . .	1	1,280	Lead.
Do. . . . .	7	9,239	All minerals (except oil).
Do. . . . .	4	14,560	Gold.
Do. . . . .	1	640	Antimony and associated minerals.
Tavoy . . . . .	123	116,509.78	All minerals (except oil).
Do. . . . .	2	2,084	All minerals (except oil and jade).
Thayetmyo . . . . .	11	53,850	Mineral oil.
Toungoo . . . . .	2	2,667.52	All minerals (except oil).
Upper Chindwin . . . . .	1	12,800	Mineral oil.
Yamethin . . . . .	11	15,628.8	All minerals (except oil).
<b>TOTAL . . . . .</b>	<b>355</b>	<b>...</b>	

## Mining Leases.

Mergui . . . . .	2	814.33	Wolfram and tin.
Do. . . . .	1	983.13	All minerals (except oil).
Pakokku . . . . .	1	1,280	Mineral oil.
Southern Shan States . . . . .	1	2.1	Lead and Silver.
Tavoy . . . . .	2	1,056.79	All minerals (except oil and precious stones).
Do. . . . .	1	660.73	Wolfram and tin.
Thayetmyo . . . . .	1	94.72	Mineral oil.
<b>TOTAL . . . . .</b>	<b>9</b>	<b>...</b>	

TABLE 41.—Prospecting Licenses and Mining Leases granted in the Central Provinces during 1919.

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Balaghat . . . . .	41	5,927	Manganese.
Do. . . . .	1	12	Copper and bauxite.
Do. . . . .	43	18,083	Bauxite.
Betul . . . . .	1	177-28	Lead.
Bhandara . . . . .	3	74	Manganese.
Do. . . . .	1	32	Corundum.
Chanda . . . . .	3	2,874	Coal.
Chhindwara . . . . .	8	3,765-30	Do.
Do. . . . .	6	2,313-46	Manganese.
Jubbulpore . . . . .	1	94	Do.
Do. . . . .	2	356	Bauxite.
Do. . . . .	1	874	Manganese, copper and mica.
Do. . . . .	4	1,538-14	Iron, Manganese, tin, zinc and silver.
Nagpur . . . . .	39	7,854	Manganese.
Do. . . . .	1	3,381	Coal.
Narsingpur . . . . .	1	1,844	Do.
Raipur . . . . .	1	586	Copper.
Saugor . . . . .	1	75	Iron pyrites, sulphur and iron.
Do. . . . .	1	254	Copper.
Seoni . . . . .	1	411-60	Mica.
<b>TOTAL</b> . . . . .	<b>160</b>	<b>...</b>	
<b>Mining Leases.</b>			
Balaghat . . . . .	27	1,375	Manganese.
Do. . . . .	1	127	Copper.
Betul . . . . .	2	288	Graphite.
Bhandara . . . . .	1	49	Manganese.
Chanda . . . . .	2	1,131	Coal.
Chhindwara . . . . .	8	4,255	Do.
Do. . . . .	3	311-49	Manganese.
Jubbulpore . . . . .	1	15-97	Do.
Nagpur . . . . .	21	774	Do.
Yeotmal . . . . .	3	1,169	Coal.
<b>TOTAL</b> . . . . .	<b>69</b>	<b>...</b>	

TABLE 42.—*Prospecting Licenses and Mining Leases granted in Madras during 1919.*

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Anantapur . . . . .	2	59.74	Barytes.
Do. . . . .	1	3,604.81	Gold.
Kurnool . . . . .	23	596.23	Barytes.
Nellore . . . . .	22	640.60	Mica.
<b>TOTAL</b> . . . . .	<b>48</b>	<b>...</b>	
<b>Mining Leases.</b>			
Nellore . . . . .	12	1,255.01	Mica.
Trichinopoly . . . . .	1	Blocks Nos. 3 and 6 in the Survey map of 1862 and 1895.	Phosphatic nodules.

TABLE 43.—*Prospecting Licenses and Mining Leases granted in the Punjab during 1919.*

DISTRICT.	1919.		
	No.	Area in acres.	Mineral.
<b>Prospecting Licenses.</b>			
Attock . . . . .	1	3,264	Mineral oil.
Jhelum . . . . .	1	839.7	Coal.
<b>TOTAL</b> . . . . .	<b>2</b>	<b>...</b>	



RESULTS OF A REVISION OF SOME PORTIONS OF DR. NOETLING'S SECOND MONOGRAPH ON THE TERTIARY FAUNA OF BURMA. BY E. VREDENBURG, *Superintendent, Geological Survey of India.* (With one text figure.)

CONTENTS.

	PAGE.
I. STRATIGRAPHICAL DISTRIBUTION OF THE FAUNAS DEALT WITH BY DR. NOETLING . . . . .	225
(1) INTRODUCTORY: THE PEGU SYSTEM AS CLASSIFIED RESPECTIVELY BY THEOBALD AND BY NOETLING . . . . .	225
(2) MUTUAL RELATIONSHIP OF THE PRINCIPAL FOSSILIFEROUS LAYERS OF YENANGYAT, MINBU, SINGU AND KAMA . . . . .	227
(3) DR. NOETLING'S "ZONES."	
(a) Preliminary remarks . . . . .	244
(b) The "zone of <i>Turritella acuticarinata</i> " . . . . .	246
(c) The "zone of <i>Pholas orientalis</i> " . . . . .	246
(d) The "zone of <i>Aricia humerosa</i> " . . . . .	247
(e) The "zone of <i>Cytherea erycina</i> " . . . . .	249
(f) The "zones of <i>Ostrea peguensis</i> and <i>Ostrea promensis</i> ." . . . .	250
(g) The "zone of <i>Dione dubiosa</i> " . . . . .	254
(h) The "zone of <i>Cardita tjidamarensis</i> " . . . . .	255
(i) The "zone of <i>Anoplotherium birmanicum</i> " . . . . .	255
(j) The "zone of <i>Cyrena Crawfurdi</i> " . . . . .	257
(k) Summary . . . . .	258
II. REVISION OF SOME OF THE FORMS FIGURED IN DR. NOETLING'S SECOND MONOGRAPH . . . . .	259
III. REVISED SYNONYMY OF THE FORMS CRITICALLY RE-EXAMINED FROM DR. NOETLING'S SECOND MONOGRAPH . . . . .	281
IV. STRATIGRAPHICAL LIST OF THE FOSSILS SPECIFICALLY IDENTIFIED AND CONCLUDING REMARKS . . . . .	294

## I.—STRATIGRAPHICAL DISTRIBUTION OF THE FAUNAS DEALT WITH BY DR. NOETLING.

## (1) Introductory: the Pegu system as classified respectively by Theobald and by Noetling.

THE post-eocene Tertiary fauna of Burma has been dealt with by Dr. Noetling in two monographs, the first of which was published in 1895 in Volume XXVII of the Memoirs of the Geological Survey of India, the second, in 1901, in the *Palæontologia Indica*, new series, Volume I.

The specimens dealt with in the first monograph were collected by Dr. Noetling principally at Yenangyat and at Minbu. To these, in the second memoir, were added a number of specimens collected by Dr. Noetling at Singu, together with some collections previously brought by Theobald from Lower Burma principally from Kama, a town situated on the right or western bank of the Irrawadi, about midway between Prome and Thayetmyo.

The inclusion of Theobald's collections from Lower Burma, while revealing a number of fossil forms of great geological interest, led to consequences which were not altogether happy from the stratigraphical point of view. Without re-visiting the type-sections in Lower Burma, Noetling amended Theobald's classification in a manner which has given rise to a great deal of confusion. The post-eocene beds of Burma were classified by Theobald into two main divisions, a lower one, the Pegu Group, named after the Pegu range or Pegu Yoma, and an upper one, the Fossil Wood Group (*Rec. Geol. Surv. Ind.*, 1869, Vol. II, pp. 79, 80). The Fossil Wood Group, as originally defined, included marine strata in its lower portion, and fresh-water beds at its upper limit. To remedy what appeared to be an inconsistency, Noetling, in Upper Burma, discarded the name "Fossil Wood Group," and distinguished the exclusively fresh-water upper beds under the name of "Irrawadi Group," retaining the name "Pegu Division" for the underlying beds mainly of marine origin. Noetling took it for granted that the Irrawadi Group or Irrawadi Series of Upper Burma coincides exclusively with the uppermost fresh-water portion of Theobald's "Fossil-Wood Group" of Lower Burma. The researches of Dr. Stuart in Lower Burma, which will again be alluded to in a subsequent part of this review, have thrown great doubt upon this conclusion, for the marine beds in the lower part of

Theobald's "Fossil Wood Group" of Lower Burma may possibly be contemporaneous with some of the fresh-water strata in the Irrawadi Series of Upper Burma. Several geologists have drawn attention to the fact that the marine sequence, in the Irrawadi region of Burma, becomes gradually curtailed in a northern direction, owing to the encroachment of the fresh-water facies, especially amongst the later Tertiary formations. Mr. Cotter's researches on this subject are, particularly convincing (*Rec. Geol. Surv. Ind.*, Vol. XLIV, p. 166, Vol. XLVII, p. 63; *Journ. As. Soc. Bengal*, new ser., Vol. XIV, p. 609). During the earlier stages of geological investigation in Burma, the existence of these variations of facies were unknown to Noetling, and, *a fortiori*, to Theobald. Some of the strata constituting the southern part of the Pegu Yoma, in which Theobald discovered the conspicuous forms of oysters described by Noetling as *Ostrea promensis* and *Ostrea peguensis*, which will again be referred to in the sequel, included in the Pegu Group in the geological map published by Theobald, are possibly contemporaneous with a portion of Noetling's Irrawadi Series, and almost certainly contemporaneous with a portion of Theobald's own Fossil Wood Group as defined in the Prome and Thayetmyo region. Thus, instead of representing two superposed geological units, the Pegu and Irrawadi divisions, in the light of recent research, may eventually prove to be partly vicarious.

Nevertheless, the question is not yet fully elucidated, and, whatever may be the exact relationships of the Pegu and Irrawadi divisions, these designations correspond, over large areas, to well defined types, the interpretation of which, by different geologists, has not seriously varied.

Where Noetling's scheme is particularly unfortunate, is in the re-distribution of the subdivisions originally established by Theobald within the Pegu Group. The lowest beds, mainly shaly, were distinguished by Theobald as the Sitsayan Shales (*Mem. Geol. Surv. Ind.*, 1874, Vol. X, p. 269), the remainder, with a considerable admixture of sandstones, constituting the Prome beds (*loc. cit.*, p. 270). The upper part of the Prome division, where studied by Theobald, includes some richly fossiliferous bands. Noetling re-defined the Prome division so as to include the Sitsayan Shales and the unfossiliferous or less fossiliferous lower portion of Theobald's original Prome beds. All the richly fossiliferous marine strata of Upper Burma in the region of the oil-fields were united with those previous-

ly recognized by Theobald in various parts of Lower Burma to constitute a "Yenangyoung Stage" (*Rec. Geol. Surv. Ind.*, 1895, Vol. XXVIII, p. 64), eventually regarded by Noetling as newer than the totality of the re-defined "Prome Stage" or "Promeian." Not only does the amended scheme introduce a serious source of confusion by reversing the use of the term "Prome," with which Theobald designated the newer part of the Pegu Group, while Noetling, on the contrary, applied it to the older part, but recent research has shown, beyond the possibility of further doubt, that some of the richly fossiliferous strata in the region of the oil-fields, included in Noetling's "Yenangyoungian," are on the same geological horizon as part of the Sitsayan Shales, while the "Yenangyoungian" includes, at the same time, the newest marine strata recognised in Lower Burma, those constituting Noetling's "zones of *Ostrea promensis* and *Ostrea peguensis*", which are perhaps as late in age as a portion of the Irrawadi Series of Upper Burma. Consequently, the fossil fauna described by Noetling as the fauna of the Yenangyoungian is, in reality, the aggregate fauna of the entire Pegu System. Unintentionally though it may be, the term "Yenangyoungian" is practically synonymous with the term Pegu Group or Pegu System and is decidedly unsatisfactory. We shall therefore avoid much confusion if we adopt the recommendation of Dr. Pascoe (*Mem. Geol. Surv. Ind.*, Vol. XL, p. 16) in discarding the further use of the term "Yenangyoungian." The terms "Pegu" and "Irrawadi" are very useful as designations for some of the major divisions. Some re-adjustment of their definition may eventually become necessary, though an attempt at a more precise demarcation than that at present in use, may wisely be postponed until the geological study of the region has made further progress. For the present, the Pegu System may be taken to correspond essentially with the marine facies of the post-eocene Tertiary in the eastern part of the Arakan Yoma, in the Pegu Yoma, and in the intervening Irrawadi valley.

## (2) Mutual relationships of the principal fossiliferous layers of Yenangyat, Minbu, Singu, and Kama.

If now we turn our attention to the minor details of the classification, we find that two causes of error have affected Dr. Noetling's conclusions regarding the vertical distribution of the fossiliferous layers in the region personally studied by him in greatest detail, that is, in the petroliferous anticlines of Upper Burma. The anti-

clines had not yet been surveyed in detail, and the thicknesses of exposed strata were generally greatly under estimated. Moreover, Dr. Noetling's interpretation of the stratigraphy is founded on the assumption, now known to be erroneous, that the uppermost petroliferous layers in the several petroliferous anticlines occupy the same stratigraphical level.

Since the conditions for the storage of petroleum depend on the existence of an unbroken anticlinal roof, it naturally follows that strata which have long been exposed, even if originally petroliferous, must have lost their petroleum contents. Noetling's division of the pre-Irrawadi beds of Upper Burma into an underlying petroliferous and overlying non-petroliferous portion, merely coincides respectively with the exposed and subterranean portions of the beds. The uppermost exposed zones of the beds underlying the Irrawadi Series at Yenangyoung, Singu, and Yenangyat, undoubtedly belong approximately to the same geological horizon. If we take into account the great differences of thickness of pre-Irrawadi strata in these three regions, we must necessarily conclude that the petroliferous beds of Yenangyoung (apart, naturally, from some of those that may have been reached in the deepest borings) are exposed at Singu, where, from the mere fact of their being exposed, they must be non-petroliferous, and that the petroliferous beds of Singu are exposed at Yenangyat where they have, in their turn, become non-petroliferous. Therefore, the uppermost petroliferous layers occupy widely divergent stratigraphical horizons respectively at each of these three localities. It is therefore incorrect to estimate the stratigraphical position of any layer by measuring upwards, as has been done by Noetling, from the newest petroliferous horizon at the separate localities. Considering the undoubted correspondence between the upper exposed portions of the pre-Irrawadi beds in the several areas, a correct approximation can only be obtained by measuring the thicknesses of the strata downwards from the base of the Irrawadi Series. A still closer approximation is obtainable where, as in the Singu-Yenangyat region, there is actually a stratigraphical continuity between the exposed strata of the upper portion of the pre-Irrawadi beds, and where, therefore, datum lines can be selected at a lower horizon than the base of the Irrawadi Series.

Judging from Mr. Sethu Rama Rao's detailed surveys, the thickness of pre-Irrawadi strata exposed at Singu is about 3,000 feet, of which the lower 1,500 feet contain numerous intercalations of marine

fossiliferous layers, some of which yielded the Singu fossils dealt with by Noetling in his second monograph. A number of successive fossiliferous bands have been separately mapped by Mr. Sethu Rama Rao who has, at the same time, obtained representative collections of their fossil contents. Up to the present, no differences have been observed in the faunas of these successive bands other than might depend on differences of facies. Various species occur indifferently at almost all horizons, sometimes in the lowest as well as in the uppermost fossiliferous beds. For the present, therefore, the fauna may be treated as representing a single palæontological stage. The specimens dealt with by Noetling were principally obtained from two layers constituting the so-called "zones of *Meiocardia metavulgaris* and *Mytilus nicobaricus*" situated respectively at about 1,000 feet and 1,500 feet above the lowest exposed horizon.

By combining the detailed surveys of the late Mr. Grimes and of Mr. Sethu Rama Rao, the thickness of strata at Yenangyat, according to various modes of interpreting the correspondence between individual layers in the Singu and Yenangyat areas, is to be estimated at from slightly less than 4,000 feet, to slightly more than 5,000 feet. The main fossiliferous layer examined by Dr. Noetling at Yenangyat, the so-called "zone of *Paracyathus coeruleus*," is situated at about 50 feet or less above the lowermost exposed beds. Even therefore by adopting a minimum estimate for the total thicknesses of exposed pre-Irrawadi beds at Yenangyat, the main fossiliferous layer must be situated at a much lower horizon than the fossiliferous stage of Singu.

There is reason to believe that a stratigraphical gap exists between the Irrawadi and pre-Irrawadi beds in the region of the oil fields, although its existence has been questioned. Whether or not the existence of the stratigraphical gap be accepted, the succession along the western undisturbed flank of the Singu-Yenangyat anticline, at least in its more southern portion, seems very regular, without clear indications of erosion unconformity. Certain characteristic variegated kaolinic strata occupy a constant position at the upper limit of the pre-Irrawadi beds. Yet, due caution is evidently necessary in a region where a stratigraphical gap is at least suspected, and it is gratifying therefore to observe that, not only have the characteristic boundary beds been followed from the Singu to the Yenangyat region, but that the evidence deduced from them is corroborated by the identification of some of the fossiliferous bands of

Singu in the Yenangyat region. A general account of the stratigraphy has been published by Dr. Pascoe (*Mem. Geol. Surv. Ind.*, Vol. XL, pp. 104-114). Mr. Sethu Rama Rao's detailed surveys have fully confirmed the wide discrepancy of level between the main fossiliferous bed of Yenangyat and the oldest fossiliferous beds exposed at Singu.

The Minbu anticline, owing to the distance at which it is situated from Singu and Yenangyat, is less directly comparable. Here again, nevertheless, the general sequence of pre-Irrawadi beds appears to be essentially the same. Reckoning downwards from the base of the Irrawadi Series, the horizon of the fossiliferous layers that yielded the specimens dealt with by Noetling must be situated at a level somewhat lower than the lowest fossiliferous layers exposed at Singu, and intermediate between the fossiliferous stage of Singu and the main fossiliferous layer of Yenangyat. The character of the fauna confirms this conclusion as it is somewhat intermediate between that of Yenangyat and that of Singu.

In ascending order, the succession of the three principal faunas of Upper Burma is therefore the following:—

1 Yenangyat. 2 Minbu. 3 Singu.

We still have to determine the relative position of the fourth standard fauna, that of Kama. In order to estimate the position of the fossiliferous beds of Kama relatively to those of the oil-fields, we must rely chiefly on the character of the fauna. The revision of the Burmese Tertiary fauna upon which I am engaged at present, has yielded results so distinct as to leave room for no further hesitation. While the Yenangyat, Minbu and Singu faunas are related to that of the Nari of western India and exhibit an oligocene character, the Kama fauna is distinctly miocene and is related to the Gaj fauna of western India. The Kama fauna must therefore be regarded as newer than the newest marine faunas of the oil-fields. The detailed evidence for this conclusion will be found in Parts II to IV of the present work. In addition to the data furnished by the faunistic characters, the conclusion is also corroborated by other circumstances which will be briefly alluded to further on. For the present, if we accept the relative age of the Kama fauna as sufficiently secure, let us consider the consequences of this attribution in relation to the succession of strata exposed in the Prome and Kama region.

Apart from the rocks attributed to the "nummulitic," the oldest stratigraphical unit recognised by Theobald in this region is an assemblage consisting principally of shales which were distinguished as the Sitsayan shales after the name of a town situated on the right bank of the Irrawadi about half way between Kama and Prome. (*Mem. Geol. Surv. Ind.*, Vol. X. 1874, p. 269). Theobald did not detect any fossils in the Sitsayan Shales. At the type-locality, Sitsayan, I obtained, in 1913, close to the landing-place, specimens of fish teeth and scales, and of shells belonging to the genera *Capulus*, *Corbula*, *Pecten*, exhibiting the general facies of the fauna of the oil-fields, but not sufficiently well preserved for a thoroughly secure determination. Opposite Prome, the Sitsayan Shales are overlaid by Theobald's division "A" of the Prome Series, about 1,500 feet thick, consisting of alternating shales and sandstones, the sandstones somewhat prevailing. Immediately overlying the upper limit of division "A" is a highly fossiliferous layer about 5 feet thick, containing abundant specimens of a species of *Cytherea*. This layer was distinguished by Theobald as the "*Cytherea promensis* bed or Prome sandstone." (*Rec. Geol. Surv. Ind.*, Vol. II, 1869, p. 80). The strata overlying the *Cytherea promensis* bed again consist of alternating shales and sandstones, but this time with a prevalence of shales. They are imperfectly seen opposite Prome because the section is interrupted by the course of the Irrawadi. They are well exposed at Kama where they contain a particularly fossiliferous horizon designated by Theobald as the Kama Clay or Kama Shale (*Rec. Geol. Surv. Ind.*, Vol. II, 1869, p. 273). These fossiliferous clay beds are situated at about 700 to 1,000 feet above the uppermost limit of division "A". They are not visible at Prome, because, as remarked by Theobald, their stratigraphical position must carry their outcrop into the bed of the Irrawadi opposite that city. A considerable thickness of marine strata further overlies the horizon of the Kama Clay.

We must now observe that, if we accept the age of the fauna of the Kama Clay as newer than that of the newest well-characterised marine fauna of the oil-fields, the stratigraphical position of the Sitsayan shales, relatively to the succession observed in the oil-fields, is fixed within rather narrow limits. The available palæontological data have fully established the miocene character of the Kama Clay which is undoubtedly newer than the newest marine fauna of Singu which still maintains an oligocene character. The



interpretation that best suits the symmetry of the sequence at Kama and at Singu-Yenangyat is the one suggested in the present review, according to which the upper limit of Theobald's division "A" would lie at about the level of the newest marine fossiliferous beds of Singu. This would place the equivalent of the main fossiliferous horizon of Kama at 700 to 1,000 feet above that of the newest marine fossiliferous beds of Singu. The upper limit of the Sitsayan shales of the Kama region would then approximately coincide with the horizon of the oldest beds exposed at Singu. Accordingly, the principal fossiliferous horizon of Minbu might occupy an approximately central position within the Sitsayan Stage, within which the Yenangyat main fossiliferous horizon, though at a lower level, would still be included.

As the Kama fauna, from its constitution, must be regarded as newer than the newest Singu fauna, we are not at liberty to depart very much in a downward direction from the hypothesis here advocated. The Kama horizon must still be placed above the newest marine fossiliferous horizon of Singu. Even if we displace it as much as 500 feet below the position here accepted as most probable, and if, therefore, we lower the presumed equivalents of the Sitsayan Shales by that same amount, we shall merely bring the Minbu main horizon into the upper zones of the Sitsayan Stage and give a more central position, within the Sitsayan Stage, to the Yenangyat fauna. Even if purely gratuitous suppositions of variations of thickness were brought into play, we would fail to exclude from the Sitsayan Stage the Yenangyat main fossiliferous horizon, unless we accepted a most unwarranted degree of stratigraphical variation. With the data at present available, the most that could be obtained by forcing downwards the horizon of the Kama Clay to a somewhat improbable extent, would be to shift the main centre of gravity of the Sitsayan Stage from the Minbu to the Yenangyat horizon, a difference of no serious consequence in the general scheme of the succession.

If, on the contrary, we raise the equivalent level of the Kama Clay in the Singu section much higher than is regarded as probable in the present enquiry, the horizon of the Sitsayan Shales will be made to encroach upon the Singu marine fossiliferous stage, and the Sitsayan horizon will be raised to the uppermost limit of the oligocene. Such a supposition deviates so widely from ascertained facts that a serious discussion may be regarded as superfluous.

We should keep in mind that the terms "sandstones" and "shales" frequently used in describing the divisions of the pre-Irrawadi beds of this region, are relative only, and merely refer to the preponderance of one or other of these elements. In most instances, rigidly defined boundaries of the subdivisions have not been demarcated in the present state of the survey and could not be established without a vast amount of minutely detailed work. Yet the main divisions are recognisable, and if, in a preliminary scheme, they are accepted as stratigraphical stages, they will be of use in attempting to unify the geology of this important and interesting region.

The conclusions regarding the age of the Kama Clay relatively to the fossiliferous beds of the oil-fields were at first based entirely upon the results of a careful re-examination of the Kama fauna. The geological surveys of Upper and Lower Burma have not yet been continuously connected. Nevertheless we now possess evidence both of a palæontological and stratigraphical character which further corroborates the conclusions originally arrived at from merely faunistic considerations.

In the type-locality, at Kama, the fossils yielded by the Kama Clay are neither very numerous nor very well preserved. Yet they are readily determinable, and include a number of species amply sufficient to provide sound data for comparison with other fossiliferous occurrences. In the country situated east of the eastern or left bank of the Irrawadi, at some distance to the north-east of Thayetmyo, Mr. Sethu Rama Rao has discovered a number of outcrops where the Kama Clay assumes the character of a typical "Pleurotoma-shale" with a molluscan fauna of bewildering richness. The specimens are admirably preserved, sometimes even showing traces of their original colours. The richest localities are: Tit-tabwe (19° 31', 95° 28'), Thanga (19° 32', 95° 23'), Myaukmigon (19° 31', 95° 24'), Myauktin (19° 26', 95° 22'), Dalabe (19° 37', 95° 17'). Mr. Sethu Rama Rao has estimated that these highly fossiliferous layers are situated at about 1,200 feet below the base of the beds attributed to the Irrawadi Series. In the region under consideration they constitute the highest readily recognisable horizon of the pre-Irrawadi beds. Several years will be necessary to complete the study of the astonishingly rich fauna yielded by these beds, but the description is already far enough advanced to yield thoroughly reliable data. The examination of the Siphonostomata

is practically complete. These include no less than 155 fully identified species of which complete descriptions already exist in manuscript. In the Kama fauna of the type-locality, 22 Siphonostomata have been securely identified, of which three only, *Clavatula munga*, *Drillia kamaensis*, and *Eburna lutosa* have not been recognised in the richly fossiliferous outcrops of eastern Thayetmyo<sup>1</sup>. The proportion of identical species is therefore so great as to imply complete identity between the fossiliferous clays exposed at Kama and those discovered by Mr. Sethu Rama Rao in eastern Thayetmyo. We can safely assert that, in eastern Thayetmyo, the Kama Clay occupies a high horizon in the pre-Irrawadi succession.

Along both banks of the Irrawadi, in a northern direction from Thayetmyo to Singbaungwe (19° 43', 95° 12'), wherever the lowest beds locally exposed become visible as the results of anticlinal structures, the late Mr. Bion and Mr. Sethu Rama Rao have recognised a highly characteristic layer distinguished by the presence of three particular species belonging to the genera *Dendrophyllia*, *Schizaster* and *Nucula*. The *Dendrophyllia* and the *Nucula* agree specifically with some fossils yielded by the lowest fossiliferous beds exposed at Singu, so that Mr. Bion and Mr. Sethu Rama Rao came to the conclusion that the oldest beds exposed in the anticlines in the country to the north and north-east of Thayetmyo belong to the same horizon as the oldest beds exposed at Singu. Strata approximately on the horizon of the *Dendrophyllia* bed are exposed along an anticlinal rise at Leptanzeik (19° 24', 95° 14') about six miles north of Thayetmyo. They have yielded three determinable Siphonostomata:—

*Terebra quettensis* n. sp.,  
*Surcula fusus* n. sp.,  
*Tritonidea Martiniana* n. sp.

*Terebra quettensis* cf. Vredenburg, Descriptions of Mollusca from the Post-Eocene Tertiary formation of North-Western India; Cephalopoda, Opisthobranchiata, Siphonostomata. (*Mem. Geol. Surv. Ind.*, unpublished volume), a characteristic fossil of the Nari of Baluchistan, is one of the commonest fossils of the Singu fauna. The extraordinary, and very easily recognisable shell designated as *Surcula fusus*, an illustrated full description of which will shortly appear, is known

<sup>1</sup> *Eburna lutosa*, a species still living, is known from the *Ostrea latimarginata* beds of the Pyalo anticline, east of the Irrawadi, almost opposite Kama, at a somewhat higher horizon than the Kama Clay.

from Payagyigon ( $20^{\circ} 43'$ ,  $95^{\circ} 4'$ ) in the Gwegyo anticline of Upper Burma (see: Cotter, *Rec. Geol. Surv. Ind.*, Vol. XXXVI, p. 131, Vol. XXXVII, p. 230), where it occurs amidst a fauna of the Minbu type. *Tritonidea Martiniana* is one of the commonest fossils of Yenangyat, Minbu, and Singu, and of many other localities yielding the fauna of the oil-fields.

The Siphonostomatous fauna of Leptanzeik, scanty though it may be, is thoroughly characteristic and entirely corroborates the conclusions arrived at by Mr. Bion and Mr. Sethu Rama Rao in placing the oldest beds exposed in the anticlines upon a horizon at least as low as that of the lowest beds exposed at Singu. We may, therefore, observe that, amongst the pre-Irrawadi beds of the country situated to the north and north-east of Thayetmyo, the newest zones include beds containing the fauna of the Kama Clay, while the oldest exposed zones contain the typical fauna of the oil-fields of Upper Burma. We have, therefore, the direct evidence of visible superposition in confirmation of the conclusions arrived at from a study of the faunistic characters.

It is not possible, at present, to estimate accurately the exact thickness of strata intervening between the equivalents of the Kama Clay and the *Dendrophyllia-Schizaster* zone in eastern Thayetmyo, because the precise degree to which the measurements are affected by subsidiary synclinal and anticlinal rolls cannot be exactly ascertained in the present state of the survey. The intervening thickness must certainly be reckoned by thousands of feet. The succession is particularly clear at about the latitude of Nyaungbintha ( $19^{\circ} 35'$ ,  $95^{\circ} 14'$ ) situated on the east or left bank of the Irrawadi about nineteen miles north of Thayetmyo and about five miles west by south of Dalabe. The latter place has already been mentioned as one of the richly fossiliferous localities discovered by Mr. Sethu Rama Rao as yielding the Kama Clay fauna. From Nyaungbintha which occupies an anticlinal axis where the *Dendrophyllia-Schizaster* zone is well exposed, the section continually ascends to Dalabe. Making the most generous allowance for the possible influence of undetected rolls of the strata, the intervening thickness cannot be less than 2,500 feet and may be more. Not only has the superposition of the Kama horizon on that of the fossiliferous zones of the oil-fields been established in eastern Thayetmyo beyond all possibility of further doubt, but the available thickness of intervening beds is amply sufficient to allow the parallelism which we

propose to recognise between the stratigraphical succession in the Prome-Kama region and that recognised in the region of the oil-fields of Upper Burma. In view of the great thickness of strata which, in eastern Thayetmyo, intervene between the equivalents of the Kama Clay and the *Dendrophyllia-Schizaster* zone, the latter must correspond approximately with the upper limit of the Sitsayan Shales. At the same time, the *Dendrophyllia-Schizaster* zone, on faunistic evidence, is known to correspond approximately with the lowest beds exposed at Singu. We are once more, therefore, led to the conclusion that the Sitsayan Shales essentially coincide with the strata underlying the Singu fossiliferous marine stage, and must coincide essentially with the Yenangyat-Minbu horizons.

We have noticed that, in the neighbourhood of Kama, the Sitsayan shales are succeeded by a thickness of about 1,500 feet of strata containing a considerable proportion of sandstones, which constitute division "A" of the Prome beds of Theobald's classification. If we are right in identifying the Yenangyat-Minbu main fossiliferous horizons with the Sitsayan Shales, then the Singu fossiliferous stage must coincide with Theobald's division "A" of the Kama section. Like Theobald's division "A", the Singu fossiliferous stage includes a thickness of about 1,500 feet of strata.

Dr. Murray Stuart has published a detailed geological map of the neighbourhood of Kama, in which, as a consequence of a misinterpretation of Theobald's original description, the position of the Kama Shale has been misplaced. (*Rec. Geol. Surv. Ind.*, Vol. XXXVIII, Pl. 23). In this map the outcrop of the Kama Clay is shown about two miles to the north-west of Kama, while the rock at Kama itself is referred to the "Upper Prome" as interpreted by Stuart, therefore to the beds which, in Stuart's revised scheme of classification, should underlie the Kama Clay. According to Theobald, the type-outcrop of the Kama Clay or Kama Shales is situated along the banks of the Irrawadi "under" Kama (*Mem. Geol. Surv. Ind.*, Vol. X, p. 273). There are a few obscure exposures *above* Kama, but these could not be spoken of as *under*. The beds mapped by Stuart as "Kama Clays" outcrop at a considerable distance from the Irrawadi river, and, if they were visible along its banks, their strike would carry the exposure above Kama and not below. Theobald's type-exposure must therefore be sought below Kama, and is still recognisable along the slopes of a pagoda-crowned ridge close to the Irrawadi, at a short distance from the town in a south by east

direction. The true position of the type-outcrop was recognised by

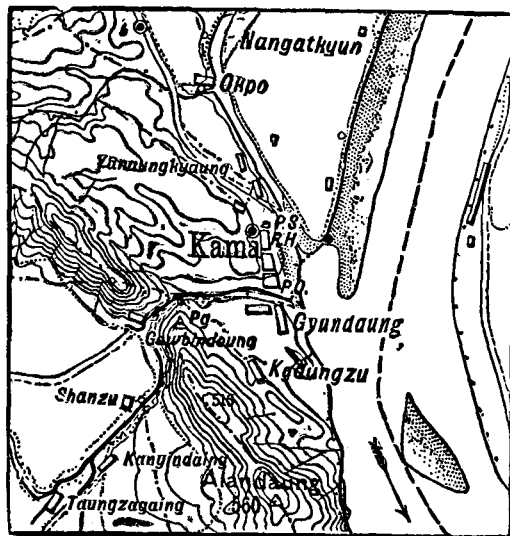


FIG. 1.—Map of the country round Kama, showing Theobald's type outcrop of the Kama clay (scale lin. = 1m.)

Dr. Stuart on re-visiting Kama, although too late to introduce this correction on the published map and report. There are several (two at least) relatively narrow bands of shale, probably each of them less than fifty feet in thickness, intercalated amongst thick-bedded sandstones with an aggregate thickness of some 300 feet. That any of these bands should separately correspond with Noetling's so-called "zones of *Arca Theobaldi* and *Parallelipipedum protortuosum*" is more than unlikely. The fossils from the several bands, all of which correspond specifically with forms already obtained by Theobald, all exhibit similar lithological characters which agree with those of the specimens in Theobald's collection. Theobald did not separate into distinct zones the specimens in his collection which must have been gathered from the talus slope where alone there is a moderately abundant supply, but where the shells from different layers are mixed.

According to Dr. Noetling, the fragments of enclosing rock attached to specimens which he refers to the "zone of *Arca Theobaldi*" are of a bluish-green colour, while the rock associated with the

specimens referred to the "zone of *Parallelipipedum prototortuosum*" is more yellowish. The yellowish colour, at Kama as elsewhere, characterises those fragments of rock that are more weathered. The Kama fauna must be treated as representing a single palæontological zone.

The rocks to the north-west of Kama which Dr. Stuart, on the map already referred to, has erroneously referred to the Kama Shales are situated, stratigraphically, 1,000 feet or more above the level of Theobald's Kama Clay. They consist principally of ill-exposed coarse grits in which the only recognisable fossils are large specimens of *Ostrea latimarginata* and otoliths. Dr. Stuart informs me that these belong perhaps to the lower beds of his Akauktaung Series. We shall again allude to this question. (See below, pages 251 ff.)

The recognition of the *Ostrea latimarginata* horizon to the north-west of Kama is of the greatest importance since it brings the Kama sequence into complete harmony with that observed by Mr. Davies in the Pyalo anticline on the opposite bank of the Irrawadi, which has already been commented upon in a previous number of these Records (Vol. XXXVIII, p. 128). According to the stratigraphical details recorded by Mr. Davies, *Ostrea latimarginata*, in the Pyalo anticline, occurs some 900 or 1,000 feet above the beds containing the Kama Clay fauna alluded to by Mr. Davies as the fauna of the "zone of *Parallelipipedum prototortuosum*." This, in its turn, was considered by Mr. Davies to be situated about 500 or 600 feet above the upper limit of Theobald's Division "A." This is in total agreement with the succession ascertained at Kama where the Kama Clay lies at a horizon estimated as between 700 to 1,000 feet above the upper limit of Theobald's Division "A," shown on Dr. Stuart's map as "Lower Prome Series," while, about 800 to 1200 feet above the Kama clay, occurs the zone of *Ostrea latimarginata* shown on the same map as "Kama Clays."

Allusion has already been made to the fact that the fauna of the Kama clay is equivalent to the Gàj fauna. In western India, *Ostrea latimarginata* characterises the Upper Gàj. We may therefore conclude that the Kama horizon corresponds with a portion of the Lower Gàj, while the *Ostrea latimarginata* zone of the neighbourhood of Pyalo and Kama, which we may provisionally distinguish as the Pyalo zone or Pyalo stage, must coincide with the Upper Gàj.

In the notice above alluded to, previously published in these Records, I stated that *Ostrea latimarginata* characterises the horizon of the Kama Clay. This notice was written before I had visited Kama, and the stratigraphical references were made in accordance with the scheme founded on the data then available. I hasten to add that the geological boundaries indicated on Dr. Stuart's map are perfectly accurate in all the localities which I have visited in the neighbourhood of Kama; the necessary amendment merely affecting the interpretation of the subdivisions.

If, upon Dr. Stuart's map, we plot the type-locality of the Kama Clay according to the position above indicated, we find that the map entirely corroborates Theobald's detailed account of the Prome beds in the Kama and Prome region; for we then observe that the trend of the Kama Clay will approximately bisect the outcrop of the division mapped by Stuart as "Upper Prome." If we follow this division southward from Kama towards Prome, we will observe that the outcrop of the Kama Clay must necessarily fall within the bed of the Irrawadi opposite Prome, exactly in the position inferred by Theobald.

The recognition of the true horizon of the beds characterised by *Ostrea latimarginata*, or, as we may provisionally call it, the Pyalo Stage, adds another palæontological argument to the stratigraphical evidence in favour of regarding Theobald's Division "A" as the equivalent of the Singu fossiliferous stage; for the infraposition of the Kama Clay beneath the zone of *Ostrea latimarginata*, taken in connection with its faunistic relationship to the Gàj, necessarily places it on the level of the Lower Gàj. As the Sitsayan Shales correspond with the Yenangyat-Minbu fossiliferous beds which contain a fauna of Nari character, presumably referable to the Lower Nari, there only remains the intervening Division "A" to represent the Upper Nari. We have already shown that the Singu fossiliferous stage, from stratigraphical as well as from palæontological evidence must also be regarded as equivalent to the Upper Nari. We have therefore every reason to regard the Singu fossiliferous stage of Upper Burma and Division "A" of Lower Burma as equivalent.

It will be noticed that the succession recorded in the present review conflicts with the conclusions arrived at in 1910 by Dr. Stuart who then regarded the Kama fauna as older than that of the oil-fields. Dr. Stuart's opinion which, at that time, was fully



shared by Mr. Cotter and by myself; was founded on a study of the material then available, which clearly showed that the Kama fauna widely differs from that of the oil-fields of Upper Burma and cannot be intercalated amongst any of the fossiliferous zones then recognised in Upper Burma (*Rec. Geol. Surv. Ind.*, Vol. XXXVIII, p. 287). The Kama Clay, therefore, differs in age from the totality of the marine fossiliferous sequence of the oil-fields of Upper Burma, and must be either newer or older than the fossiliferous series of Upper Burma. The evidence then available seemed to indicate an older age. The study of the molluscan post-eocene faunas had at that time scarcely been commenced, while the available collections of fossils from Burma were still relatively scanty. To Dr. Stuart is due the credit of having for the first time clearly detected the autonomy of the Kama fauna, while the present amendment to the stratigraphical conclusions that were arrived at more than ten years ago is the result of the study of a vastly increased amount of palæontological and stratigraphical data.

Although the relative position of the Kama fauna can no longer be doubted, we may nevertheless, in the light of the now available data, enquire into the possible consequences of an acceptance of the original conclusion as to the supposed position of the Kama horizon below that of the fossiliferous series of the oil-fields.

Throughout the area surveyed in the neighbourhood of Ngape, in the Minbu district, Mr. Cotter observed a band of shales which is situated, on an average, some 5,000 feet below the base of the Irrawadi Series, and which contains the various fossil species of the Yenangyat-Minbu fauna. These shales and their equivalents, which have received various local names, such as "Padaung Clay" (*Rec. Geol. Surv. Ind.*, Vol. XLIV, p. 165), "Kinmungyon Shales" (*Rec. Geol. Surv. Ind.*, Vol. XLV, p. 249), were originally regarded by Cotter (*Rec. Geol. Surv. Ind.*, Vol. XLI, p. 224), as the probable representatives of the Sitsayan Shales. All reasonable doubt as to this correlation has been removed by the data now available. Along the further northward extension of the same belt, from Ngape to Ngahlaindwin, numerous detailed sections surveyed by the late Mr. Bion, by Mr. Cotter, Mr. Cunningham Craig, Mr. Lewer, Dr. Porro, Mr. Sethu Rama Rao, and other able geologists, have revealed the continuous outcrop of this same shale band, invariably at the same stratigraphical horizon, and invariably containing the Yenangyat-Minbu fauna.

Between the lower limit of these shales and the upper limit of the undoubtedly eocene rocks constituting the Yaw Stage of Mr. Cotter, there intervene some 3,000 feet of strata, largely arenaceous, which Mr. Cotter has distinguished as the Shwezetau Sandstone (*Rec. Geol. Surv. Ind.*, Vol. XLIV, p. 165; *Journ. As. Soc. Bengal*, new ser., Vol. XIV, p. 416). The Shwezetau Stage is poorly fossiliferous. The only securely identified fossil so far known from that horizon is a large *Ampullina* closely related to *Ampullina crassatina*. It is, therefore, a species of oligocene facies. Underlaid as it is by undoubtedly upper eocene beds and overlaid by undoubtedly oligocene strata, presumably referable to the middle oligocene, the Shwezetau Stage can only be lower oligocene. This conclusion accords with the characters of the solitary, well-preserved fossil which it has, so far, yielded.

If, then, the Kama Clay were older than the main fossiliferous beds of the petroliferous anticlines, we should be compelled to regard it as the equivalent of the Shwezetau Stage. Stratigraphically, the possibility of this supposition is now disposed of by the researches of Mr. Bion and Mr. Sethu Rama Rao in Eastern Thayetmyo where the Kama fauna clearly overlies the fauna of the oil-fields. Palæontologically, the now well established miocene character of the Kama fauna also renders this supposition untenable.

From whatever point of view we may consider the problem with the data now available, we are always led to the same result: the fauna of Kama is not older than that of the petroliferous anticlines of Upper Burma, but is, on the contrary, newer.

In thus amending our previous conclusions, it is but fair to note that many points that appear self-evident at the present day were involved in obscurity ten years ago. Mr. Cotter's description of the Ngape section which marks the first great advance in the later progress of the study of Burmese geology, was published two years after Dr. Stuart's valuable survey of the Prome and Kama region. Both stratigraphically and palæontologically the study of Tertiary geology in Burma and in other parts of continental India has advanced enormously during the last ten years; while, thanks to the researches of many able scientists, amongst whom we may specially mention Tobler, Douvillé, Miss Provale, Miss Osimo, Rutten, Schepman, and especially Mr. and Mrs. Martin, the same period has witnessed a quite unparalleled advance in the study of the Tertiary formations of the Indian archipelago. For Java in particular, it is no

exaggeration to say that the magnificent results of Mr. and Mrs. Martin's expedition of 1910, have established the stratigraphy of the Tertiary in that region on as sound a basis as that of some of the best known Tertiary regions of Europe, and have marked the commencement of a new era in the study of the Tertiary Geology of the East-Indies. We are also only just beginning to realize the vast importance of Cossmann's study of the late Tertiary formation of Karikal.

Under the circumstances, the radical change at which we have arrived in our present conception of the stratigraphical relationship of the Kama zone implies no disparagement of the excellent work performed by the able pioneers who have first contributed precise data towards the unravelling of this difficult problem. We may now take it as settled beyond the possibility of further doubt that the Kama fauna is newer than any of the three main faunas of the petroliferous region. The true sequence, in ascending order, of the four principal faunas dealt with by Noetling is therefore as follows:—

1. Yenangyat.
2. Minbu.
3. Singu.
4. Kama.

These remain the four standard post-eocene faunas of Burma, upon a comparison with which we have to depend for the more or less successful classification of all the post-eocene formations of that region.

During the last decade, considerable progress has been made in the study of the post-eocene molluscan faunas of Burma and western India. The completion of this research will require many years, but the greater part of the Siphonostomata amongst the gastropods have been described, and some of the results are already in course of publication. In connection with this investigation, a considerable portion of Noetling's monograph of the post-eocene fauna of Burma has been revised, and the object of the present note is to place on record the amendments necessitated in Noetling's determinations.

The number of forms now identified from amongst the post-eocene Siphonostomata of Burma greatly exceeds that of the determinable representatives of that group amongst the collections studied by Noetling. We hope that an opportunity will soon arise for discussing the stratigraphical and palæontological results of their

study. The Tertiary faunas of Burma occupy a position of unique importance in the geology of Asia, as forming the most efficient link that we possess for comparing the stratigraphy of the Indian Archipelago and Philippines with that of Europe; for it contains numerous forms in common, on the one hand, with the Tertiary faunas of the Eastern Islands, and, on the other hand with the Tertiary faunas of western India; and, while the faunistic connection of the Tertiary formations of the Archipelago with those of Europe, is practically *nil*, the faunas of western India, during the periods coinciding with the marine transgressions, especially in the middle eocene and lower oligocene, exhibit a considerable intermingling with the European faunas, the exact equivalence of the Tertiary sequence in western India being thereby established on a secure basis. Consequently the faunas of western India afford now a means of identifying the formations of Burma with a degree of precision hitherto unknown; and these, in their turn, afford now a most useful clue to the interpretation of the geology of the Indian Archipelago.

For the present, it will be sufficient to indicate what are the main conclusions so far arrived at. The Yenangyat and Minbu faunas are closely connected with the lower Nari fauna of western India, the age of which is either lower oligocene, or more probably middle oligocene. The beds containing the Minbu-Yenangyat fauna are separated from the lower limit of the oligocene by the whole thickness of the Shwezetaw sandstone, and, from the upper limit of the oligocene, by the whole thickness of the Singu fossiliferous stage. Their age may safely, therefore, be regarded as approximately middle oligocene, that is, approximately Stampian, the Minbu fauna being situated nearer to the upper limit of the Stampian than the fauna of Yenangyat.

The Singu fauna, as shown by the stratigraphy, is newer than the Yenangyat-Minbu horizon. It is still closely related to the Nari fauna, though it shows a certain admixture of forms characterising the Gaj of western India, or the Burmese equivalents of the Gaj. It is therefore, faunistically somewhat intermediate between the Lower Nari and the Gaj, and evidently occupies a correspondingly intermediate stratigraphical position coinciding with that of the Upper Nari.

The Kama zone is unquestionably the equivalent of the Lower Gaj of western India and of the Rembang Series of Java.

## (3) Dr. Noetling's "Zones."

## (a) PRELIMINARY REMARKS.

We may next enquire into the relative stratigraphical position of the various "zones" of Noetling's nomenclature. Noetling has endeavoured to distinguish, both in Lower and in Upper Burma, a number of palæontological zones, each of which has been named after a particular species. These species have not been selected according to the principle generally recognised in stratigraphical classifications, whereby a particular division should be characterised by a form whose range is truly restricted to that particular division. If we consult the lists of fossils published by Noetling, we will frequently observe that a certain form is recorded from so-called zones other than the one bearing the name of the particular fossil. Either then the supposed zones are not well-defined stratigraphical units, or else the forms selected are not true zone-fossils. Noetling's method is to name the supposed zone after a form that happens to be particularly abundant at the locality yielding the fauna under consideration. This method cannot lead to any useful results. As has been judiciously remarked by Dr. Stuart (*Rec. Geol. Surv. Ind.*, Vol. XXXVIII, p. 264), a species such as *Cytherea erycina* which is living at the present day, cannot be used as a characteristic zone-fossil for a particular subdivision of the miocene; for, if the species already existed in miocene times, its existence obviously was continued throughout every intervening stage down to the present epoch. We may mention *en passant* that the form thus designated by Noetling does not coincide with the living shell to which it has been referred. A preliminary examination of the available specimens has shown that they are closely related to another living form, *Cytherea florida* Lam, though it is uncertain whether they are specifically identical. Until an opportunity arises for a complete study of this shell, it will be wise, when referring to it, to continue to use Theobald's original designation of *Cytherea promensis*. At any rate, the shell does not characterise solely Theobald's "*Cytherea promensis* bed or Prome sandstone," for it is just as abundant in the Kama zone and in the overlying zone of *Ostrea latimarginata*, and perhaps even higher. Dr. Stuart has already commented on the extensive range of this species (*Rec. Geol. Surv. Ind.*, Vol. XXXVIII, p. 263).

While recognising that the designations adopted by Noetling for the various zones are unsatisfactory, we must nevertheless enquire into their stratigraphical and palæontological value.

Dr. Noetling has established two sets of zones respectively for Lower and Upper Burma. The zones of Lower Burma, in the order regarded by Dr. Noetling as their probable ascending succession are the following:—

- (7) Zone of *Turritella acuticarinata*.
- (6) Zones of *Ostrea peguensis* and *Ostrea promensis*.
- (5) Zones of *Arca Theobaldi*.
- (4) Zone of *Parallelipipedum prototortuosum*.
- (3) Zone of *Pholas orientalis*.
- (2) Zone of *Aricia humerosa*.
- (1) Zone of *Cytherea erycina*.

In Upper Burma, seven zones containing marine fossils were defined, the sequence of which, in ascending order, was supposed to be as follows:—

- (7) Zone of *Cardita tjidamarensis*.
- (6) Zone of *Mytilus nicobaricus*.
- (5) Zone of *Meiocardia metavulgaris*.
- (4) Zone of *Dione dubiosa*.
- (3) Zone of *Cancellaria martiniana*.
- (2) Zone of *Paracyathus cæruleus*.
- (1) Zone of *Anoplotherium birmanicum*.

To these was added an estuarine bed, the so-called "zone of *Cyrena Crawfordi*" regarded as equivalent to the zone of *Cardita tjidamarensis* or to the zone of *Mytilus nicobaricus*.

Out of these fifteen "zones," six have already been dealt with in the foregoing pages: these are zones 4 and 5 of Lower Burma, the so-called zones of *Parallelipipedum prototortuosum* and *Arca Theobaldi* which represent the Kama Clay; and, in Upper Burma, zones 2, 3, 5 and 6, of which zone 2, the so-called "zone of *Paracyathus cæruleus*" represents the main fossiliferous layer of Yenangyat, zone 3, the so-called "zone of *Cancellaria Martiniana*" coincides with the main fossiliferous horizon of Minbu, while zones 5 and 6, the so-called zones of *Meiocardia metavulgaris* and *Mytilus nicobaricus*, coincide with two of the principal fossiliferous layers of the Singu fossiliferous stage.

There still remain to be considered five of the Lower Burma zones, those numbered 1, 2, 3, 6 and 7 in the above tabulated list and four zones from Upper Burma, those numbered 1, 4 and 7 together with the "zone of *Cyrena Crawfurdi*."

(b) THE "ZONE OF *Turritella acuticarinata*."

Several of these zones must be definitely or provisionally discarded. We must, in the first place, entirely leave out of account zone 7 of Lower Burma, the so-called "zone of *Turritella acuticarinata*," from which no fossils are available, of which the exact locality is ill-defined, the exact horizon uncertain, and the designation of which rests on the mere surmise that the fossil referred to by Theobald in his allusion to certain beds of which the exact locality is not recorded (*Mem. Geol. Surv. Ind.*, Vol. X, pp. 275, 281), may be a particular form of *Turritella* which occurs abundantly at many spots in the Tertiary beds of Burma, and which Dr. Noetling has referred to *T. acuticarinata* Dunker. Even if the surmise should prove to be correct, the form in question has an extremely extensive geological range and is quite useless by itself for fixing the age of the strata in which it may occur.

(c) THE "ZONE OF *Pholas orientalis*."

There are two other so-called zones represented by fossils from Lower Burma for which the exact locality is unknown, though there appears to be reason to believe that the specimens were obtained from the neighbourhood of Thayetmyo. They are represented by two different sets of fossils for which Noetling established the so-called zones of *Pholas orientalis* and *Aricia humerosa*.

In attempting to refer these so-called zones to their correct stratigraphical horizons, we have no other guide but the fossil collections. The sequel of the present note will show that, even amongst the figured specimens of the collections dealt with by Noetling, there are numerous instances in which forms belonging to one species have been referred to different species or even genera, or else in which, conversely, forms belonging to several species or even genera have been referred to a single species. From this it necessarily follows that no reliance can be placed upon the lists of fossils published by Noetling for the different fossiliferous occurrences, especially when they refer to unfigured forms as they often do to

a large extent. It is necessary to check every identification, a course which, for the unfigured forms is often unpracticable, as the specimens are often not available, or else frequently consist of specifically indeterminable fragments. The Museum contains many unfigured specimens from Noetling's and Theobald's collections that have either been labelled by Noetling himself, or else have been determined by comparison with the descriptions in Noetling's second monograph. Whenever there has arisen an occasion of referring to these collections, numerous errors of identification have been detected.

We must, therefore, entirely disregard Noetling's published lists, and we can depend on no other data but the figured specimens or such unfigured specimens as have been critically examined. At present, we are not acquainted with a single recognisable fossil from the so-called zone of *Pholas orientalis*. Eventually some characteristic forms may perhaps be recognized after the critical examination of the Tertiary Lamellibranchiata has been completed. For the present, the so-called "zone of *Pholas orientalis*" must be provisionally discarded.

(d) THE "ZONE OF *Aricia humerosa*."

From the so-called "zone of *Aricia humerosa*" we are at present acquainted with only three forms the specific determination of which may be regarded as sufficiently secure. These are:—

*Conus Icke* Martin,  
*Clavilithes seminudus* Noetl.  
*Cypræa singuensis*.

The form last named is the one erroneously identified by Noetling as "*Aricia humerosa*." *Conus Icke* has not been found elsewhere in Burma, and occurs in Java at an unknown geological horizon, *Clavilithes seminudus* occurs in Burma at every horizon from the Yenangyat zone to the Kama zone. For determining the age of the fauna, there only remains, therefore, *Cypræa singuensis*, the most characteristic fossil of the Singu fossiliferous stage. As will be shown in the descriptions of the fossil Cypræidæ of India which we hope shortly to publish, *Cypræa singuensis* is a true zone-fossil. It is undoubtedly a mutation of a form which will be described as *Cypræa iravadica* which characterises the Minbu horizon. The so-called "zone of *Aricia humerosa*" is newer, therefore, than the age of



the Yenangyat-Minbu fauna, and equally so than that of the Sitsayan Shales. The upper limit of the vertical distribution of *Cypræa singuensis* is not known at present, and, from the data at present available, we cannot fix with absolute accuracy the level of the so-called "zone of *Aricia humerosa*." Noetling placed it provisionally above the horizon of the *Cytherea promensis* bed. The presence of *Cypræa singuensis* rather suggests that it belongs to Theobald's Division "A" underlying the horizon of the *Cytherea promensis* bed, since it has been shown that the Division "A" is the equivalent of the Singu fossiliferous stage. In assigning to the so-called "zone of *Aricia humerosa*" an age newer than that of the *Cytherea promensis* bed, Noetling was influenced by Theobald's statement that Division "A" is unfossiliferous. We know now, from the researches of Dr. Stuart (*Rec. Geol. Surv. Ind.*, Vol. XXXVIII, p. 263) that this horizon contains fossils, though none of them have been sufficiently closely examined to be made use of for purposes of stratigraphical comparison. There appears to be some reason for believing that the fossils of the so-called "zone of *Aricia humerosa*" were obtained in the neighbourhood of Thayetmyo; an occurrence which favours the conclusion that they may belong to a horizon older than that of the *Cytherea promensis* bed, for we know that the neighbourhood of Thayetmyo undoubtedly includes outcrops of strata older than that particular bed. The type-locality of *Lepidocyclina Theobaldi* is undoubtedly close to Thayetmyo. I vainly sought to recover the type-locality of this important species in 1913. The original outcrop may have been hidden or destroyed since the time of Theobald's survey, but Theobald's indication of its situation admits of no ambiguity. The fossil is said to occur "in a hardish sandstone on the bank of the Irrawadi, a little above the lime-hill (*Mem. Geol. Surv. Ind.*, Vol. X, p. 275), the "lime-hill" in question being the hill containing limestone and also coal which is situated close to the Irrawadi, about four miles south by west of Thayetmyo. From Mr. Cotter's survey of the Ngape section, we know that *Lepidocyclina Theobaldi* is the characteristic zone-fossil of the horizon containing the Yenangyat-Minbu fauna corresponding with the horizon of the Sitsayan Shales (*Rec. Geol. Surv. Ind.*, Vol. XLI, p. 232). Close to Thayetmyo there are, therefore, exposures of rocks coinciding with the horizon of the Sitsayan Shales and consequently older than the Singu fossiliferous stage, not to mention the "lime-hill" itself which is apparently eocene.

Moreover, we have already observed that, north of Thayetmyo, the oldest beds exposed in the neighbourhood of the Irrawadi include the *Dendrophyllia-Schizaster* zone, regarded by the late Mr. Bion and by Mr. Sethu Rama Rau as approximately equivalent to the base of the Singu Stage. Six miles north of Thayetmyo, at Leptanzeik, there occurs a fossil fauna related to that of Singu.

There is every reason, therefore, to believe that the equivalent of the Singu fossiliferous stage is extensively exposed near Thayetmyo. The fossils of the so-called "zone of *Aricia humerosa*" may very well, therefore, have been obtained from that horizon. That they may have been obtained, as suggested by Noetling, from a level higher than that of the *Cytherea promensis* bed is certainly possible, but it is far more probable that they belong to the horizon of the Singu fossiliferous stage.

(e) THE "ZONE OF *Cytherea erycina*."

As already explained, Noetling's "zone of *Cytherea erycina*" corresponds with Theobald's "*Cytherea promensis* bed" of which the horizon is well known, as this stratum immediately rests upon the uppermost bed of Theobald's division "A". Since this division "A" is regarded as the equivalent of the Singu fossiliferous stage, the *Cytherea promensis* bed is either equivalent to the uppermost zone of the Singu fossiliferous stage, or belongs to a slightly higher level.

As has already been explained (see above, page 244), the fossil after which this zone has been named does not correspond with *Cytherea erycina*, but is closely related to *Cytherea florida* if not specifically identical. For the present it must be designated as *Cytherea promensis*. Moreover it is not a true zone-fossil, since it has an extensive vertical range.

Up to the present, only three forms have been securely identified from the *Cytherea promensis* bed:—

*Conus (Lithoconus) odengensis* var. *birmanica*,  
*Ancilla (Sparella) birmanica*,  
*Melongena (Pugilina) præponderosa*.

These designations will be defined in the second and third parts of the present note.

*Conus odengensis* is represented by a form which does not correspond either with the typical form occurring in the Kama horizon,

or with the variety *avaënsis* which characterises the Minbu and Singu horizons. *Ancilla birmanica* has been obtained by Mr. Sethu Rama Rau at Myauktin from beds which are on the horizon of the Kama Clay. *Melongena præponderosa* is known from the Minbu and Singu horizons, and from the equivalents of the Kama Clay.

The small fauna at present identified is, therefore, uncharacteristic, yet it is consistent with the stratigraphical position of the bed.

(f) THE ZONES OF *Ostrea peguensis* AND *Ostrea promensis*.

Noetling was not acquainted with the original locality of the fossils which he designated as *Ostrea peguensis* and *O. promensis*, and which, owing to a fancied difference in the appearance of the rock adhering to the specimens, he referred to two possibly distinct zones.

As already stated on a previous occasion (*Rec. Geol. Surv. Ind.*, Vol. XLI, pp. 37, 40), the locality of the fossil described as *Ostrea promensis* is known from a label in Theobald's hand-writing. The specimens were obtained from the southern Pegu Yoma, about 50 miles north by west of Rangoon. There is no label with the specimens described as *Ostrea peguënsis* which were probably obtained from the same bed at the same locality. The note above alluded to, further established the specific identity of *Ostrea peguënsis* and *Ostrea promensis* respectively with *Ostrea Virleti* Desh, and *Ostrea digitata* Eichw., both of which occur in the Mekran Series of Baluchistan.

*Ostrea Virleti* and *Ostrea digitata* both occur in the Akauktaung Series which has been regarded as possibly a marine equivalent of the fresh-water Irrawadi Series of Upper Burma. The data for fixing the equivalence of the Irrawadi Series are rather scanty. Correctly identified fossils are known from one locality only, Yenangyoung, where, distributed through the lower 2,000 feet of the Irrawadi Series, there occur mammalian remains which, according to the valuable researches of Dr. Pilgrim (*Rec. Geol. Surv. Ind.*, Vol. XL, p. 196), indicate the horizon of the "Middle Siwalik", equivalent to the Pontian. The uppermost pre-Irrawadi strata of Yenangyoung are undoubtedly the same as those of Singu. The characteristic variegated kaolinic clays which distinguish the upper horizons of the pre-Irrawadi beds at Singu and in the southern part of the Yenangyat anticline, and which have already been alluded to (see above page 229) are also observed at Yenangyoung. If the upper-

most pre-Irrawadi beds of Singu are the same as those of Yenangyoung, we are justified in identifying corresponding beds at both localities by measuring downwards from the base of the Irrawadi Series. We must therefore conclude that the base of the Irrawadi Series at Yenangyoung is situated at about 1,500 feet above the equivalents of the highest level of the Singu fossiliferous stage. We have already observed that the Singu fossiliferous stage is not newer than oligocene. As the base of the Irrawadi Series already contains a fauna of uppermost miocene age, there must be a stratigraphical gap of some importance below the Irrawadi Series, unless we suppose that practically the whole of the miocene is compressed within the 1,500 feet of strata intervening between the summit of the Singu fossiliferous stage and the base of the Irrawadi Series, a contingency which, although possible, is improbable in view of the considerable average development of the various geological stages in the Irrawadi region of Burma.

Let us now consider what are the available data for estimating the age of the Akauktaung Series of Lower Burma. The two characteristic species of Dr. Noetling's "zones of *O. peguënsis* and *O. promensis*," that is *O. Virleti* and *O. digitata* have both been discovered together by Dr. Stuart near Yethyauksan ( $18^{\circ} 26'$ ,  $95^{\circ} 21'$ ), some five miles north of Pauktaing in Henzada (*Rec. Geol. Surv. Ind.*, Vol. XLI, p. 245). According to Dr. Stuart's surveys, the Akauktaung Series is unconformable to the beds containing the fauna of the Kama Clay. Dr. Stuart is of opinion that the *Ostrea latimarginata* beds of Kama and Pyalo may represent a basal member of the Akauktaung Series, but that this supposition needs further confirmation. *Ostrea latimarginata* and the fossils associated with it cannot, therefore, safely be taken into account in attempting to estimate the equivalence of the Akauktaung Series. As securely identified species safely referable to the Akauktaung beds, there only remain then the four species of *Ostrea* recorded by Dr. Stuart (*loc. cit. supra*), namely *O. Virleti*, *O. digitata*, *O. gingsensis*, and a form probably referable to *O. crassicosata*. All four of these forms are amongst the characteristic fossils of the lower zone of the Mekran Series of Balúchistán which it is proposed, in a separate note, to distinguish as the Talar Stage, after the richly fossiliferous beds of the Talar Pass, along the northern flanks of the Talar mountains, some 50 miles north-east of Gwádar. The evidence afforded by their presence clearly encourages the supposition that the Akauk-

taung Series partly coincides with the Talar Stage. *Ostrea gingensis* is a form of wide stratigraphical range occurring at all horizons of the miocene. *Ostrea Virleti* and *O. digitata* are not known from any strata that can unhesitatingly be referred to an age as low as burdigalian. Formerly, the beds now classified in the Talar Stage of western India were attributed by me to the middle miocene, and were thought to reach downwards to the limit of the burdigalian. The study of the rich fauna of gastropods from the Talar Stage has now advanced far enough to make this view untenable. The proportion of living species is so great that the Talar fauna cannot be regarded as older than Pontian. It approximately corresponds with the horizon of the Odeng beds of Java of which it contains, in extreme abundance, the most characteristic species, *Melongena ponderosa*.

If we admit the equivalence of the *O. Virleti* and *O. digitata* beds of the Akauktaung Series with the Talar Stage, the interpretation of their position in the Burmese sequence becomes very simple: they must evidently then correspond with the Irrawadi beds of Upper Burma, the lower portion of which contains, at Yenangyoung, a vertebrate fauna the age of which has been determined by Dr. Pilgrim as Pontian (*Rec. Geol. Surv. Ind.*, Vol. XI, p. 196). This is indeed the conclusion originally arrived at by Dr. Stuart.

We must nevertheless take into consideration the possibility that the *Ostrea latimarginata* beds of Kama and Pyalo may represent a basal member of the Akauktaung Series. So far as can be judged from our present experience, *O. latimarginata* characterises an older horizon than *O. Virleti* and *O. digitata*. Dr. Stuart informs me of having found, in Henzada, a fragment of a valve of *O. latimarginata* together with the usual *Ostrea* species of the Akauktaung beds, though under circumstances which do not preclude the possibility of its being a derived fossil. Future research may enable us to modify our views as to the distribution of these various species of *Ostrea*. For the present, we are justified in believing that the range of *O. latimarginata* on the one hand, and, on the other hand, the range of *O. Virleti* and *O. digitata* do not mutually encroach upon one another, and that strata characterised by *O. latimarginata* must be older than other strata characterised by *O. Virleti* and *O. digitata*.

Dr. Stuart has discovered *O. Virleti* and *O. digitata* in the basal members of the Akauktaung Series at Yethyauksan, the locality already alluded to. This observation need not necessarily con-

flict with the admission into the Akauktaung Series of the *O. latimarginata* beds of Kama and Pyalo, for in a series of such great thickness as the Akauktaung beds, the basal members need not be necessarily everywhere on the same horizon. If the *O. latimarginata* beds of Kama and Pyalo really belong to the Akauktaung Series, all that we need suppose is that the base of the series is more curtailed at Yethauksan than at Kama and Pyalo. This interpretation affects the geological age of the Akauktaung Series in so far as we cannot attribute an age newer than middle miocene to the strata with *O. Virleti* and *O. digitata* since we must allow for a sufficiently close connection with the *O. latimarginata* beds, regarded as burdigalian. According to this interpretation, the *O. Virleti* and *O. digitata* horizon of the Akauktaung Series would be approximately equivalent to the stratigraphical gap below the Irrawadi Series of Upper Burma. The *O. Virleti* and *O. digitata* beds of the Akauktaung Series would then correspond with the Tjilang Series of Java rather than with the Odeng beds. The Akauktaung Series attains a considerable thickness, as much as 4,000 feet, so that, even if we adopt this interpretation, its upper portion, at least, would still probably coincide with a portion of the Irrawadi Series of Upper Burma.

The choice between these two alternative interpretations has a very important bearing upon the nature of the basal unconformity of the Akauktaung Series. If the unconformity is situated below the zone of *O. latimarginata*, the stratigraphical gap must have become extremely reduced or even completely obliterated at Kama and at Pyalo where *O. latimarginata*, a species which we regard as characterising the Upper Gáj, is separated by several hundred feet of underlying strata from the Kama Clay fauna which we consider to be referable to the Lower Gáj; a disposition which does not necessitate the assumption of any unconformity. On this interpretation, the basal unconformity of the Akauktaung Series, extremely pronounced in Henzada, must become greatly reduced and finally obliterated when followed northward.

If, on the contrary, the unconformity is situated above the horizon of *O. latimarginata*, the reduction of the unconformity in a northern direction from Henzada towards Prome must be less pronounced. Although the base of the Akauktaung Series would still rest upon oligocene strata in Henzada and upon miocene strata at Prome, yet the upper limit of the stratigraphical gap would remain

at an approximately uniform level and the basal unconformity of the Akauktaung Series in Lower Burma would essentially coincide with the basal unconformity of the Irrawadi Series in Upper Burma.

The latter interpretation has the advantage of greater simplicity, for it necessitates the supposition of only one main unconformity in the post-eocene Tertiary stratigraphy of the Irrawadi region, while there is scarcely any escape from the necessity of admitting two important unconformities if the basal Akauktaung unconformity is situated below the zone of *Ostrea latimarginata*, unless we postulate, for the Tertiary strata of the Irrawadi basin, a degree of inconstancy in lateral development which is not supported by the details of the data at present available.

In any case, whatever may be the final result of further stratigraphical and palæontological studies, the now well ascertained fact must remain that the beds with *O. Virleti* and *O. digitata* are undoubtedly newer than the horizon of the Kama Clay. Noetling's "zones of *Ostrea peguënsis* and *O. promensis*" are therefore undoubtedly newer than the "zones of *Arca Theobaldi* and *Parallelipipedum prototortuosum*."

(g) THE "ZONE OF *Dione dubiosa*."

According to Noetling, there occurs both at Yenangyat and at Singu, a fossiliferous horizon which has been designated as the "zone of *Dione dubiosa*" and which is said to occupy the same stratigraphical level at both localities. Judging from the detailed surveys of the late Mr. Grimes and of Mr. Sethu Rama Rau, the so-called "zone of *Dione dubiosa*" of Yenangyat, Grimes' "Signal Hill Sandstone," is situated at a considerably lower horizon than its supposed equivalent of Singu, the difference of stratigraphical level amounting perhaps to as much as 1,000 feet. The supposed zone, therefore, would have to be rejected as built up from two widely diverging horizons.

Nevertheless, we must take it as established beyond all possibility of a doubt that an error has crept into Noetling's account of the Singu and Yenangyat zones. On page 33 of his monograph in the Palæontologia Indica, Noetling gives a list of four fossils supposed to characterise the "zone of *Dione dubiosa*" of Singu. On page 35, the same list of four fossils is again exactly reproduced as characterising the "zone of *Dione dubiosa*" of Yenangyat. That, amongst such scanty faunas, the only forms identified should, in either case,

be exactly the same species, is incredible. That the repetition of the list is due to an error of compilation becomes a certainty as soon as we refer to the descriptive portion of the monograph: the locality of every one of the four species is invariably mentioned as Yenangyat, not once as Singu. In transcribing the details of the Yenangyat and Singu sequence, the account of the Yenangyat "zone of *Dione dubiosa*" appears to have been inadvertently repeated in the Singu section.

The supposed "zone of *Dione dubiosa*" of Singu, therefore, does not exist. At Yenangyat there occurs, in all probability, a poorly fossiliferous zone some 400 or 500 feet above the main fossiliferous layer. Pending fuller stratigraphical and palæontological information, this zone may be provisionally discarded.

(h) THE "ZONE OF *Cardita tjidamarensis*"

According to Noetling, the so-called zone of *Cardita tjidamarensis* of Singu has yielded no other recognizable fossil besides the one species after which it has been named, the specific attribution of which has never been critically verified. The supposed zone is therefore palæontologically negligible, and, moreover, as it is situated only 100 feet above the so-called "zone of *Mytilus nicobaricus*," it would probably, in any case, constitute nothing more than a mere appendage of the latter.

For all practical purposes, the so-called "zone of *Cardita tjidamarensis*" may, for the present, be discarded.

(i) THE "ZONE OF *Anoplotherium birmanicum*."

The so-called "zone of *Anoplotherium birmanicum*" was regarded by Noetling as the oldest of the fossiliferous zones in Upper Burma. Its estimated stratigraphical position occurs at about 1,300 feet below the summit of the Pegu System as exposed in the Yenangyoung anticline. The variegated shales and sands at the upper limit of the exposed Pegu beds of the Yenangyoung anticline are also observed at Singu, and, as we have already noticed (see above, pages 228, 250), the upper part of the stratigraphical sequence must be identical at Singu and Yenangyoung. According to the thicknesses calculated from available surveys, the fossiliferous band constituting Noetling's so-called "zone of *Cardita tjidamarensis*" must be situated about 1,400 feet below the uppermost horizon of the Pegu



sequence as exposed at Singu<sup>1</sup>. The so-called "zone of *Cardita tjidamarensis*" must therefore occupy a somewhat lower horizon than the so-called "zone of *Anoplotherium birmanicum*." Therefore, the so-called "zone of *Anoplotherium birmanicum*," instead of being the oldest fossiliferous zone in the Pegu System as developed in Upper Burma, represents, on the contrary, the newest bed with marine fossils observed by Dr. Noetling in that region.

As already explained (see above, page 228) the succession in Upper Burma and the mutual equivalence of the strata exposed in the several anticlines have been misinterpreted by Noetling under the erroneous impression that the petroliferous layers are everywhere of one age.

The fossils obtained from the so-called "zone of *Anoplotherium birmanicum*" are said to have been obtained from a conglomerate layer six inches thick in a petroleum well at a depth of 150 feet from the surface. Remains of fresh-water, marine, or estuarine fish, of terrestrial and fluviatile reptiles, of terrestrial mammalia, of marine lamellibranches and of corals are mentioned as having been found together in this one layer. One of the corals was referred to the living *Paracyathus cœruleus* Dure. A list of bivalve species was published in Noetling's monograph of 1901. It is extremely doubtful whether these mollusca were specifically determinable, for already in 1895, when they had been determined only generically, they were said to be "only casts or moulds," and it was stated that "notwithstanding repeated coatings of varnish, they have, in the damp climate of Calcutta, almost entirely crumbled to pieces with considerable efflorescence." (*Rec. Geol. Surv. Ind.*, Vol. XXVIII, p. 69).

<sup>1</sup> This amount is essentially based on those estimates according to which the total thickness of strata exposed at Singu amounts to 3,000 feet, a figure which has been accepted by Dr. Pascoe (*Mem. Geol. Surv. Ind.*, Vol. XL, p. 107). Other estimates give, for the total thickness, somewhat lower values, varying from 2,400 to 2,700 feet. By combining the maximum estimates of the Yenangyoung sequence with the minimum estimates at Singu, the "zone of *Anoplotherium birmanicum*", instead of occurring at a higher level than the "zone of *Cardita tjidamarensis*," would be lowered approximately to the level of the "zone of *Meiocardia metavulgaris*." This interpretation is improbable as it would necessitate the supposition that the richly fossiliferous horizon of the "zone of *Mytilus nicobaricus*," which is remarkably constant over a vast area in Singu and Yenangyat, is also fully exposed in Yenangyoung, where it would be mostly unfossiliferous, or else would only contain local bands of fragmentary fossils (see Pascoe, *Rec. Geol. Surv. Ind.*, Vol. XXXVI, pp. 135 ff.). In any case, the position of the "zone of *Anoplotherium birmanicum*" would be affected only to a minor extent, and would still remain connected with the same palæontological and stratigraphical sub-stage.

The mammalian teeth were referred by Noetling, in 1895, to *Antilope* and to *Anthracotherium silistrense*, an association that might indicate an upper miocene age. In 1901, the specimens were referred to *Anoplotherium* which would imply an approximately upper eocene age for the beds containing them. In 1910 (*Rec. Geol. Surv. Ind.*, Vol. XL, p. 196), Dr. Pilgrim identified the specimens as the molars of Tragulidæ, one of them being generically referred to *Dorcatherium*, an identification consistent with a miocene or perhaps upper oligocene age. If we are justified in identifying the Singu fossiliferous stage with Theobald's division "A" of Lower Burma, the so-called "zone of *Anoplotherium birmanicum*" which is situated at a horizon about 100 or 200 feet higher than the upper limit of the marine fossiliferous beds of the Singu stage, must belong approximately to the same level as the so-called "zone of *Cytherea erycina*" which overlies Theobald's division "A" in Lower Burma.

(j) THE "ZONE OF *Cyrena Crawfurdi*."

Connected with the variegated clays and sands which occupy the uppermost pre-Irrawadi strata at Yenangyoung, there occur locally some estuarine beds containing the shells which Noetling has described as *Cyrena Crawfurdi* and *Cyrena kodoungensis*. The same variegated beds are observed at the uppermost limit of the pre-Irrawadi beds at Singu, and there can be no doubt that the upper beds of Singu correspond with those of Yenangyat. Under the erroneous impression that the true equivalence of the Singu and Yenangyat succession is to be sought in the petroliferous beds of both localities, Noetling came to the conclusion that the *Cyrena* bed of Yenangyoung is approximately on a level with the newest fossiliferous bands recognized at Singu. This equivalence cannot be accepted if the beds exposed at Yenangyoung correspond with the uppermost beds exposed at Singu. Since we have every reason to admit the equivalence of the uppermost pre-Irrawadi beds at both localities, the *Cyrena* bed of Yenangyoung must belong to a horizon situated about 1,400 or 1,500 feet above that of the newest fossiliferous bands of Singu. If we are justified in identifying the Singu fossiliferous stage with Theobald's division "A" of the Prome region, and if the thicknesses of strata are even approximately the same in the Prome-Thayetmyo neighbourhood and in the region of the petroliferous anticlines—a reasonable enough supposition considering that the intervening distance is less than 100 miles,—then

the bed must be situated some 1,400 or 1,500 feet above the horizon corresponding to that of the *Cytherea promensis* beds, and the *Cyrena* bed of Yenangyoung may correspond with a horizon even higher than that of the Kama Clay, perhaps as high as the beds which, in the marine facies, are characterised by the presence of *Ostrea latimarginata*.

In the Yenangyat region, the researches of Mr. Sethu Rama Rau have revealed the existence of some very interesting fresh-water beds which certainly occur above the marine fossiliferous Singu stage, although we cannot determine their exact stratigraphical equivalence relatively to the *Cyrena* beds of Yenangyoung. They contain a giant form of *Batissa* which has been referred to *Batissa kodoungensis*, from which, nevertheless, it appears to differ specifically as will be shown in Part II of the present study. A specimen of this giant species from the neighbourhood of Palanyon, obtained from the eastern flank of the Minbu anticline, has already been figured by Dr. Pascoe (*Rec. Geol. Surv. Ind.*, Vol. XXXVI, Pl. XX, fig. 2). The species may be distinguished as *Batissa Sethuramæ*. According to Mr. Sethu Rama Rau, the beds containing these giant shells in the Yenangyat anticline, are laterally continuous with those yielding the remarkable gastropod described by Dr. Annandale as *Taia (Rivularioides) spinifera*. (*Rec. Geol. Surv. Ind.*, Vol. I, p. 238). We cannot be too grateful to Dr. Annandale for his investigations of the difficult fresh-water fossil faunas of India. In Burma in particular, a full knowledge of the fresh-water and estuarine molluscan faunas may eventually prove of great assistance in elucidating the vexed question of the exact equivalence of the marine and fresh-water beds.

In conclusion, the *Cyrena Crawfurdii* bed of Yenangyoung may be equivalent to the horizon of the Kama Clay, or, more probably perhaps, to that of the zone of *Ostrea latimarginata*.

(k) SUMMARY.

Omitting such "zones as must be definitely or provisionally discarded, the stratigraphical succession of Dr. Noetling" "zones" may be tabulated as follows:

Zones of <i>Ostrea peguensis</i> and <i>Ostrea promensis</i> .	Pontian or Vindobonian.	Probably the marine equivalents of the Irrawadi Series; probably equivalent to the Talar Stage of the Mekran Series and to the Odeng beds of Java; or else
--	-------------------------	--

			mainly intermediate in age between the zone of <i>Ostrea latimarginata</i> and the Irrawadi Series and, if so, equivalent to the Nahan, to the Lower Manchhar, and, in Java, to the Tji Lanang series.
Zone of <i>Cyrena Craufurdi</i>	Perhaps Burdigalian.	Burdigalian.	Perhaps the estuarine equivalent of the Pyalo beds with <i>Ostrea latimarginata</i> and of the Upper Gáj of western India, as well as of the Njalindung beds of Java, or else one stage lower and equivalent to the Kama beds and [Lower Gáj.
Zones of <i>Arca Theobaldi</i> and <i>Parallelpepedum prototortosum</i> .	Approximately Aquitanian.		Kama zone equivalent to the Rembang beds of Java and to the Lower Gáj.
Zone of <i>Anoplotherium birmanicum</i> . Zone of <i>Cytherea erycina</i> .	.....		Probably equivalent to the horizon of junction of the Nari and Gáj, or to the base of the Lower Gáj.
Zones of <i>Mytilus nicobaricus</i> and <i>Meiocardia metavulgaris</i> , with probably the zone of <i>Arcia humerosa</i> .	Approximately Chattian.		Equivalent to the Upper Nari.
Zone of <i>Cancellaria Martiniana</i> .	Approximately Upper Stampian.	}	Sittsayan horizon, equivalent to the Lower Nari.
Zone of <i>Paracyathus caruleus</i> .	Approximately Stampian.		

This table does not agree with the stratigraphical statement published by Dr. Stuart in a previous volume of these Records (Vol. XLI, p, 253) for which I am personally to a large extent responsible. The vastly increased accumulation of trustworthy data that have become available during the last ten years (see above, page 241) sufficiently accounts for the amendments here introduced.

## II.—REVISION OF SOME OF THE FORMS FIGURED IN DR. NOETLING'S SECOND MONOGRAPH.

The preparation of a re-cast of Dr. Noetling's second monograph would need the work of a life-time. If we consider that scarcely one-third of the forms dealt with by Dr. Noetling have as yet been revised, we may realize the magnitude of the task that still awaits us. Nevertheless, a very useful purpose can be served

by tabulating the results of the investigation of all those forms that have, so far, been critically examined.

Noetling regarded many of the Burmese fossils as predecessors of living forms, or else as descendants of eocene species, and gave expression to this opinion by prefixing, respectively, the greek terms *proto* and *neo* to the usually Latin names of the supposed related species. The result is frequently unfortunate, as the forms in question often belong to other genera than those with which they have been compared, with the result that many of Noetling's designations are not only meaningless, but misleading.

In the following notes, all these forms which, so far, have been critically examined, are referred to according to the pages of Dr. Noetling's second monograph. The revised synonymy will constitute Part III of the present notice.

Forms dealt with by Noetling and not mentioned in the following pages have not yet been critically examined. Forms mentioned without any comment require no amendment.

#### PARACYATHUS CÆRULEUS Duncan, p. 102.

In his first monograph, in 1895, Noetling described and figured a fossil from Yenangyat which he regarded as specifically identical with the living *Paracyathus cæruleus* and which, in 1901, was selected as a characteristic fossil for the so-called "zone of *Paracyathus cæruleus*" at Yenangyat. It is needless to comment on the selection as a zone-fossil for a division of the Tertiary, of a form regarded as specifically identical with one living at the present day, all the more so as Noetling himself has deprived the supposed species of any possible stratigraphical value by recording it from five more of the so-called "zones." These five occurrences are tabulated, on page 103 of the monograph of 1901, in a list from which only the supposed type-occurrence at Yenangyat has been omitted.

That the Yenangyat fossil bears no resemblance to the living species to which it has been referred is obvious from the illustrations to Noetling's first monograph of 1895, where the Yenangyat coral and the living species have been figured side by side (*Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, Pl. I, figs. 1, 2). Although, in 1901, the talented artist who prepared the illustrations to the monograph of 1895 was blamed for the apparent specific discrepancy, yet Noetling did not again venture on this direct comparison in

the second monograph in which fossil specimens only were figured one from Yenangyat (the same which had previously been figured in 1895) and one from the so-called "zone of *Cancellaria Martiniana*" of Minbu.

My former pupil, Mr. Harendra Mohan Lahiri, has carefully examined all the Yenangyat and Minbu specimens referred by Dr. Noetling to *Paracyathus cæruleus*. There is not a single specimen in a state of preservation such as will allow a definite specific diagnosis. Nevertheless, enough can be made out to ascertain that the Yenangyat and Minbu forms differ specifically from one another, and that both are specifically distinct from the living species.

The characters which differentiate these fossils from one another and from the living form have been ascertained by Harendra Mohan Lahiri. The Yenangyat form is considered to be closely related to certain fossil forms from the upper eocene of Australia, such as *Paracyathus tasmanicus* and *P. supracostatus*.

EUPSAMMIA REGALIS, Alcock, p. 103.

The specimen thus identified by Dr. Noetling has also been carefully examined by Harendra Mohan Lahiri. Like the Yenangyat and Minbu specimens of *Paracyathus*, it is in a state of preservation that renders it totally unfit for a specific diagnosis. It bears no relation to the living form to which it has been referred by Noetling, for it apparently belongs to the sub-genus or genus *Balanophyllia*, while *Eupsammia regalis* is a typical member of the genus *Eupsammia*.

CLYPEASTER DUNCANIANUS, p. 105.

Although there are a few connections between the floor and roof of the test towards the margin, I have failed to detect the characteristic internal pillars of *Clypeaster*. The closed ambulacral petals with their extremely broad poriferous zones, and the extremely crowded minute tuberculation are totally unlike anything with which I am acquainted within the genus *Clypeaster*. The fragment is almost certainly not a *Clypeaster*, but is too imperfect either for generic or for specific determination.

OSTREA PEGUËNSIS, p. 107.

This is *Ostrea Virleti* Desh. (See *Rec. Geol. Surv. Ind.*, Vol. XLI, p. 36).

## OSTREA PROMENSIS, p. 109.

This is *Ostrea digitata* Eichw. var. *Rohlfssii* Fuchs. (See *Rec. Geol. Surv. Ind.*, Vol. XLI, p. 37).

## CYRENA (BATISSA) KODOUNGENSIS, p. 183.

When first describing this species, in 1901, Noetling noticed that it was the largest fossil *Cyrena* recorded at that time. Since then, almost every large fossil *Cyrena* that has been found in Burma seems accordingly to have been referred, as a matter of course, to *Batissa kodoungensis*. Nevertheless, as has already been pointed out (see above, page 258), we must not confound the Khodaung shell with another still larger form, which is known from the southern part of the Yenangyat anticline, and from the neighbourhood of Palanyon along the eastern limb of the Minbu anticline. The largest specimen of *Batissa kodoungensis* in Noetling's collection has a height of 75mm. Specimens of even larger size were observed by Dr. Pascoe east of Khodaung. The shape of the shell, as restored by Dr. Noetling, is sub-orbicular, with practically median umbo. The sub-orbicular character of the outline is confirmed by the measurements published by Dr. Pascoe who records 115 + 101mm. as the largest specimen observed near Khodaung (*Rec. Geol. Surv. Ind.*, Vol. XXXVI, p. 144). The length, therefore, only slightly exceeds the height, and the measurements recorded by Dr. Pascoe imply an approximately circular shell.

It should be mentioned that the Khodaung shell must attain even larger dimensions than those of the largest measured specimen, for one of the fragments figured by Dr. Pascoe (*vol. cit. supra*, Pl. XIX, fig. 2) must have belonged to a specimen measuring about 130 + 120mm.

The figure of the Palanyon specimen published by Dr. Pascoe (*vol. cit. supra*, Pl. XX, fig. 2) will show at a glance that the length of this shell reaches nearly twice the largest measured dimension recorded for the Khodaung species, that, instead of exhibiting a sub-orbicular outline, it is elongate, with the length considerably exceeding the height, and that the umbo is greatly shifted forward. (We should remember that, to save space, the drawing here referred to has been placed obliquely). Several of the specimens from the Yenangyat region attain the same colossal dimensions as the Palanyon specimen. One individual, of relatively moderate size, which

owing to its good state of preservation, best displays the true shape of the species, measure  $124 + 96 + 51$ mm. The height therefore is equal to less than four-fifths of the length. The hinge-plate, in the Yenangyat shells, is taller than in *Batissa kodoungensis*, the cardinal teeth generally less obliquely disposed in Noetling's illustration of the left valve of *Batissa kodoungensis*, the cardinal tooth designated as 2a is shown as practically vertical. In reality, it has a steep slope directed posteriorly downward (opisthocline). The corresponding tooth in the Yenangyat form has a pronounced slope in the opposite direction. The other elements of the hinge are much more oblique in *Batissa kodoungensis* than in any of the Yenangyat specimens.

If, as there is reason to think, Mr. Dalton has correctly referred to *Batissa kodoungensis* the magnificent specimen of a right valve represented in figures 1 and 2, Plate LVI of Volume LXIV of the Quarterly Journal of the Geological Society, the exact locality and horizon of which are unfortunately unknown, then the right valve of that species is characterised by a bifid central cardinal tooth. In the Yenangyat form, the corresponding tooth is entire. Mr. Dalton's specimen measures  $100 + 96$ mm., and is, therefore, even more orbicular than the one recorded by Dr. Pascoe. Unfortunately, we are not acquainted with the hinge of the right valve in the Khodaung shell. Until we can obtain a right valve from Khodaung, there must subsist some uncertainty as to whether *Batissa kodoungensis* is identical with the species described by Mr. Dalton.

At any rate, the contrast between the left valve of *Batissa kodoungensis* and the corresponding valve of the Yenangyat shell suffices to establish the specific distinctness of the latter. As already mentioned above (page 258), I wish to dedicate this magnificent shell to Mr. Sethu Rama Rau, under the name of *Batissa Sethuramæ*. It is the largest *Batissa* on record, extinct or recent, exceeding in size even the colossal *Cyrena ingens* Dautzenberg (*Journ. Conch.*, Vol. XLVIII, p. 105, Pl. V), at present living in the New Hebrides, the largest known specimen of which measures  $150 + 120 + 102$  mm. This recent form is readily distinguished from *Batissa Sethuramæ* by its relatively much greater thickness and by a very different build of the hinge.

From the observations above discussed, it will be noticed that there still remain a number of uncertain points in connection with



the large Burmese fossil shells. The conclusions at present arrived at may be summarised as follows:

1stly, the characters ascertained in the South-Yenangyat shells preclude their specific union with the Khodaung shells in spite of our incomplete knowledge of the latter.

2ndly, if the specimens described by Mr. Dalton eventually prove to belong approximately to the same stratigraphical horizon as the Khodaung shell, they may be safely accepted as plesiotypes, and the species *Batissa kodoungensis* may be re-defined in accordance with their characters.

3rdly, if the specimens described by Mr. Dalton are eventually shown to differ widely in age from the Khodaung shell, their specific reference to the latter would not be sufficiently justified, and they should be classified, provisionally at least, under a different specific name.

4thly, in the latter alternative, unless better material than at present available can be obtained from Khodaung, the species *Batissa kodoungensis* must remain un-identifiable, although the name may still be used to designate the large shell occurring at Khodaung.<sup>1</sup>

#### CYRENA (BATISSA) CRAWFURDI, p. 184.

At its type-locality, near Minlindaung, in the southern part of the Yenangyoung anticline, this shell is moderately variable. Its characters have been sufficiently clearly defined by Dr. Noetling.

The fossils from various parts of Burma that have been referred to *Batissa Crawfordi* frequently represent a separate species, distinguished by its tall triangular shape, narrow umbo occupying a median or even slightly posterior situation, its relatively short hinge-plate, and by the presence of a distinct though rounded bend extending from the umbo to the postero-ventral edge; between this bend and the posterior margin, the surface is steep and flattened, and carries one or two blunt radial ridges. The species attains much larger dimensions than *B. Crawfordi*, from which it is distinguished by its tall and triangular outline, the different po-

<sup>1</sup> The name of the locality has been spelt "Kodoung", "Kodaung", and "Khodaung." The shell was described as *Cyrena kodoungensis*, and we should adhere to this name. So far as possible, alterations in the orthography of a specific name should always be avoided as they complicate the nomenclature and especially impair the usefulness of alphabetical references.

sition of the umbo which, in *B. Crawfordi*, occupies an anterior position, the shorter hinge-plate, and the characters of the posterior surface which, in *B. Crawfordi*, is rounded and does not clearly exhibit the radial ridges above mentioned. These various differences invariably distinguish *B. Crawfordi*, even in the most exceptionally elevated specimens.<sup>1</sup>

A specimen of the form under consideration, obtained near Beme in the Yenangyoung anticline at a stratigraphical level situated some 300 feet below that of the "zone of *Cyrena Crawfordi*," has been figured by Dr. Pascoe (*Rec. Geol. Surv. Ind.*, Vol. XXXVI, Pl. XIX, fig. 5), who has already noticed that it probably represents a new species (*loc. cit.*, p. 145). We may distinguish this form as *Batissa birmanica*. It is accompanied, near Beme, by another form which, instead of being, like *B. birmanica*, taller than *B. Crawfordi*, is, on the contrary, more depressed. Dr. Pascoe has named it *B. Crawfordi* var. *yedwinensis*. The sub-central position of its umbo seems to exclude the possibility of a specific identity with *Batissa Crawfordi*, and it may preferably be treated as a distinct species under the name of *Batissa yedwinensis* Pascoe. It is therefore omitted from the synonymy of *Batissa Crawfordi* in Part III of the present study.

The precise limits of the stratigraphical range of *Batissa Crawfordi* cannot exactly be determined at present. Outside of the Yenangyoung anticline, the only specimens at present known that seem to be referable to *Batissa Crawfordi* were collected by Mr. Cotter on the road one mile south-west of Myin-ngan (21° 38', 94° 28' one-inch sheet 84 K-6) in the northern part of the Pakokku district where the pre-Irrawadi beds are, to a considerable extent, invaded by the fresh-water facies.

*Batissa birmanica* undoubtedly has a wide stratigraphical range and probably extends downwards at least to a horizon equivalent to the upper limit of the Singu fossiliferous stage: for instance, the specimens obtained by Mr. Sethu Rama Rau in the stream section of the Taungmachaung tributary west of Kamedaung (20° 49', 94° 24') in the Ngahlaingdwin area occur at about 1,400 feet below the base of the Irrawadi Series.

<sup>1</sup> The specimen illustrated by Noetting in figure 3, Plate XI of the second monograph exhibits an exceptionally elevated outline, the apparent character of which is, nevertheless, much exaggerated owing to the circumstance that the posterior portion of the shell is broken.

*Batissa Crawfurdi* and *Batissa birmanica* both exhibit, along the edge of the lateral teeth, the characteristic striations of the genus *Batissa*.

The distribution of the various forms of fossil Cyrenidæ at present recognised in Burma is perhaps connected with different local conditions of salinity. Thus, in the Taungmachaung exposure above alluded to, *Batissa birmanica* is accompanied by a brackish fauna including *Telescopium*, *Vicarya*, and *Cytherea*. Specimens obtained by Mr. Cotter half-a-mile west of Kayingyauk ( $20^{\circ} 40'$ ,  $94^{\circ} 26'$ ) also in the Ngahlaingdwin region, at a horizon which may also approximately correspond with the upper limit of the Singu fossiliferous stage, are apparently associated with *Arca*, *Turcica*, *Paracyathus*, etc. The Kayingyauk bed is probably the southern extension of the Taungmachaung bed. On the contrary, *Batissa Sethuramæ*, in South-Yenangyat, occurs in the same bed as the fresh-water *Taia spinosa*. There is, at present, no evidence as to the conditions of salinity connected with the occurrence of *Batissa Crawfurdi*.

#### CYRENA (BATISSA) PETROLEI, p. 188.

The type of *Cyrena petrolei*, like that of *Cyrena Crawfurdi*, is from the neighbourhood of Minlindaung. Noetling has not recorded any strictly precise character by means of which it would be possible to distinguish the form designated as *Cyrena petrolei* from the type of *Cyrena Crawfurdi*. The large series of shells now available from Minlindaung cannot be sorted into two separate forms as they exhibit every possible intermediate gradation between extremes of height or thickness of outline, thickness of shell, and relative coarseness or delicacy of hinge. The form "*petrolei*" must therefore be discarded.

#### CALLIOSTOMA BLANFORDI, p. 253.

Two species are figured under this name in Noetling's second monograph. Those illustrated in figures 6 to 8, Plate xvii, correspond with *Trochus Blanfordi* as described and figured in Noetling's first monograph. The specimen shown in figure 5 of the same plate is different, and should constitute the type of another species which may be distinguished as *Calliostoma singuense*.

*Calliostoma singuense* attains considerably larger dimensions than the genuine *Calliostoma Blanfordi*. The spire-whorls of *Calliostoma Blanfordi* are much more concave than those of *Calliostoma sing-*

*uense*. At early stages of growth, both forms are quadricarinate. While, however, the posterior keel in *Calliostoma Blanfordi*, is immediately contiguous to the suture, there intervenes a small space in *Calliostoma singuense*. In both species, the second keel is the feeblest, the fourth, the most prominent; not, as stated by Noetling, the third, a statement contradicted by his own illustrations. On the later spire-whorls of *Calliostoma Blanfordi*, there invariably appears a secondary granulated keel bisecting the posterior interval, and almost always a similar secondary keel similarly bisecting the next interval; so that the later spire-whorls nearly always exhibit as many as six keels, and never less than five. A similar change takes place in *Calliostoma singuense*, but only in the posterior interval, so that there are never more than five keels, and the subsidiary keel is relatively much less prominent than in *Calliostoma Blanfordi*. Moreover, owing to the great difference in size between the two species, *Calliostoma singuense* still shows only four keels at a size equal to that of the full-grown specimens of *Calliostoma Blanfordi*.

The base is totally different in both species. In addition to a thick peripheral granulated keel, the base of *Calliostoma Blanfordi* exhibits an extremely beautiful ornamentation consisting of thirteen concentric granulated keels alternating in two sizes. On the base of *Calliostoma singuense*, there are ten concentric, smooth, flat bands, exhibiting an imbricated or stepped disposition, each band being separated from the next outer one by a small declivity facing outward.

TURRITELLA ANGULATA Sow., p. 272.

TURRITELLA SIMPLEX Jenkins, p. 273.

The form figured by Noetling is specifically identical with *T. angulata*. The Javanese fossil first described by Jenkins as *T. simplex* probably also belongs to the same species, though this identification needs to be verified.

TURRITELLA ACUTICARINATA Dunker, p. 274.

The specimens thus identified by Noetling also correspond with *T. angulata*. Martin has expressed the opinion that they do not coincide with the Javanese *T. acuticarinata* which, therefore, may represent a different species.

## TURRITELLA sp., p. 277.

This form, of which we now possess well-preserved specimens, may be distinguished as *T. Noetlingi*.

## TURRITELLA AFFINIFORMIS, p. 277.

This is *Turritella Magnasperula* Sacco.

## RIMELLA CRISPATA Sow., p. 288.

The figured specimens differ specifically from the form to which they have been referred, and may be designated as *Rimella promensis*. They are distinguished from *Rimella crispata* by the thinness of the spiral incisions, the almost conical outline of the spire-whorls, the smoothness of the ribs, the absence of crenulations along the outer margin of the outer lip, and finally the elongate shape and small size.

## CYPRÆA GRANTI d'A. and H., p. 290.

This shell does not bear the slightest resemblance to *C. Granti* d'Archiac (*not* d'Archiac *et* Haime) which is synonymous with *C. nasuta* Sow., itself a variety of *C. prunum* Sow., a *Cypræa sen. str.* The fossil erroneously referred by Noetling to *C. Granti* belongs to the very peculiar group of extinct forms which includes *C. Duclosiana* Bast. and several other Tertiary species, which it is proposed to distinguish as a section *Cypræotrivia*. The Burmese species may be distinguished as *Cypræa (Cypræotrivia) Oppenheimi*.

## ARICIA HUMEROSA Sow., p. 291.

This shell differs from the Gáj fossil to which it has been referred by Noetling. It may be distinguished as *Cypræa (Bernayia) singuënsis*. The main difference resides in the disposition of the aperture, invariably almost straight in *Cypræa singuënsis*, while it is rather strongly bent in *Cypræa humerosa*. The depressed dorsal area of *Cypræa humerosa* is much larger than that of *C. singuënsis* and is centrally situated instead of being shifted posteriorly; consequently, the anterior transverse ridge is situated much further anteriorly in *Cypræa humerosa*.

## TRIVIA SMITHI Martin, p. 293.

This remarkable shell does not belong to the same group as the Javanese species to which it has been referred by Noetling. It may

be distinguished as *Trivia Noetlingi*. It is undoubtedly a fossil representative of the singular group of shells constituted by the two Mexican forms *T. radians* Linn. and *T. Solandri* Gray. In general shape it comes nearest to *T. radians*, but is readily distinguished by its smaller size and by its less numerous, narrower ribs.

CASSIS D' ARCHIACI, p. 294.

The specific name was already preoccupied as early as 1851 by Bellardi. (*Mem. Soc. Geol. Fr.*, 2d ser., Vol. IV, p. 224, Pl. xiv; figs. 3, 5). The shell may be distinguished as *Cassidea birmanica*.

SEMICASSIS PROTOJAPONICA, p. 295.

This shell is a *Tritonium*. We cannot perpetuate an absurdity by maintaining the specific name "*protojaponicum*." In Noetling's first monograph, the shell was described and figured as *Cassidaria dubia* Noetling. It may therefore be known as *Tritonium (Lampusia) dubium* [Noetling].

GALEODA MONILIFERA, p. 297.

Under this name Noetling has illustrated two different forms which agree specifically with *Cassidaria echinophora* Linn., from which they cannot be separated otherwise than varietally. The variety designation *monilifera* may be retained for the specimen figured in Plate xix, fig. 16. The second specimen, shown in fig. 17 of the same plate, may be distinguished as *Cassidaria echinophora* var. *promensis*. It is distinguished from the variety *monilifera* by its broad ribbon-shaped bands without any trace of spiral subdivisions.

ONISCIDIA MINBUENSIS, p. 297.

This exceedingly remarkable shell belongs to the sub-genus *Lozotaphrus* of *Cyrtochetus*, of which *Phos varicifer* Tate, from the Tertiary of Australia, has been hitherto the only recognized species. The resemblance between the Burmese and Australian forms is so close as to suggest their possible identity.

FIGULA THEOBALDI, p. 298.

Two different forms have been figured by Noetling under that name. The one shown in fig. 21, Pl. xix, agrees exactly with *Pirula condita* Brongniart. The other specimen, shown in fig. 20, though

closely allied, may be regarded as constituting a variety *singuënsis*, in which the spiral threads as well as the axial ribs are thicker than in the typical form.

FICULA sp., p. 299.

This form, which is now represented by numerous well preserved specimens, may be distinguished as *Pirula promensis*. It belongs to the same group as the fossil *Pirula pamotanensis* Martin from Java and the living *Pirula Investigatoris* of the Indian Ocean, but is readily distinguished by the peculiar ornamentation of the body-whorl in which the extremely exaggerated breadth of the spiral and axial ribs reduces the intervening spaces to small square depressions.

TRITON NEASTRIATULUS, p. 301.

This shell is a *Hindsia*. The specific name, founded on a fancied resemblance to *Tritonium striatulum* Lam., is, therefore, most unfortunate.

TRITON PARDALIS, p. 302.

This is also a *Hindsia*.

TRITON NEACOLUBRINUS, p. 304.

This shell is a *Hindsia* and is therefore totally unrelated to *Tritonium* (*Sassia*) *colubrinum* Lam.

PERSONA GAUTAMA, p. 305.

This shell is without any relationship whatever to the Tritonidæ. It belongs to *Peristernia*, a sub-genus of *Lathyrus*.

RANELLA PROTOTUBERCULARIS, p. 306.

Two separate species have been illustrated under this name in Noetling's second monograph. The one shown in fig. 9, Pl. xx, had previously been described and figured in Noetling's first monograph under the name of *Ranella tubercularis* Lam., evidently a *lapsus* for *Ranella bitubercularis*. It would be necessary therefore, to alter the name used in the second monograph to *Ranella protobitubercularis*; but as there never was any species described with the specific name "*tubercularis*," either by Lamarck or any other author, we may just as well designate the Burmese shell as *Ranella tubercularis* Noetling.

The species illustrated in figure 8 of the same plate, may be distinguished as *Ranella antiqua*. Compared with *Ranella tubercularis*, it is larger though it generally has fewer spire-whorls, and is distinguished by a more rounded aperture. The varices of *Ranella tubercularis* frequently do not correspond from one whorl to another during the later stages of growth, while they always coincide in *Ranella antiqua*.

Compared with *Ranella bitubercularis* Lam. of which it is evidently a pre-mutation, *Ranella antiqua* is uniformly smaller, with fewer spire-whorls.

RANELLA ELEGANS Beck, p. 309.

This shell differs specifically and even sectionally from Beck's type which is an *Apollon s. str.* It may be distinguished as *Ranella (Pseudobursa) promensis*. This beautiful shell closely recalls, in shape and ornamentation, *Ranella foliata* Desh., *R. margaritula* Desh., and *R. crumena* Lam., from all of which it is clearly distinguished by the peculiar tubular structure of the posterior apertural channel, corresponding with that exhibited in *Ranella bufonia* [Gmelin], the genotype of *Pseudobursa* Rovereto. The anterior canal, nevertheless, is nearly vertical, slightly oblique to the left of the shell as in *Ranella crumena*, not to the right as in *Ranella bufonia*, and the shell is perhaps genetically related to the point of parting between the sections *Apollon s. str.* and *Pseudobursa*.

EBURNA PROTOZEYLANICA, p. 310.

This shell cannot be specifically distinguished from *E. jutosa* Lam., from which its smaller dimensions entitle to be separated at most as a variety for which the utterly misleading name "*protozeylanica*" is, of course, quite inadmissible.

FUSUS SEMINUDUS, p. 312.

The specific name is preoccupied in the genus *Fusus* by a species of Deshayes; as, however, the Burmese shell is a *Clavilithes*, in which genus the specific name is not preoccupied, it may be maintained.

FUSUS VERBEEKI Martin, p. 313.

This fossil does not correspond with the Javanese fossil to which it has been referred by Noetling, but rather with *Clavilithes seminudus* [Noetl.] The shell assumes a rather different appearance



according as to whether the callosity usually characterising the full-grown stage has been developed or not. Amongst the Burmese specimens, there are individuals, practically of maximum dimensions, apparently adult, in which the callosity has never been developed, and others, much smaller, in which it assumes the most exaggerated proportions. Both modes of development occur together and are connected by every intermediate gradation. With only a small amount of material at his disposition, Noetling came to the conclusion that these two modes or stages of development characterise different species, one of which was described as new under the name of *Fusus seminudus*, while the specimens with a large callosity were referred to *Fusus Verbeeki* Martin. It is now certain that all the Burmese specimens belong to a single species which, however closely related to *Clavilithes Verbeeki*, must be regarded as a distinct species, or at least a very pronounced variety, the main difference being the much smaller size of the Burmese form which is like a miniature edition of *Clavilithes Verbeeki* of which it perhaps represents an ancestral pre-mutation.

In *Clavilithes Verbeeki*, the axial ribs disappear at a relatively earlier stage of growth than in *Clavilithes seminudus*, for, while, in *Cl. seminudus*, the axial ribs cease only either on the two last whorls, or more generally only on the last one, in *Cl. Verbeeki*, the three last spire whorls are without axial ribs. If, instead of comparing corresponding stages of development, we compare actual dimensions of growth, it will be observed, nevertheless, that the ribs usually persist up to a much larger size in *Cl. Verbeeki* as a consequence of the usually much larger size of that species.

#### FASCIOLARIA NODULOSA Sow., p. 314.

Under this name Noetling has figured three specimens, none of which coincided with the Gáj fossil to which the specimens have been referred. Those reproduced in pl. xx, fig. 16 and pl. xxi, fig. 11 represent a *Lathyrus* and, therefore, bear no relation to the Gáj fossil which is a *Siphonalia*. The species may be distinguished as *Lathyrus indicus*. It is the earliest example so far known of the group of *Lathyrus Lynchi* [Basterot] (genus *Polygona* Schumard), abundantly represented in the miocene of Europe, and surviving in the deep-water *Lathyrus infundibulum* [Gmelin] of the West-Indies. It is extraordinarily closely related to *Lathyrus infundi-*

*bulum*, but has broader ribs and taller whorls. The European miocene species of this group are generally more angulated.

The specimen represented in pl. xx, fig. 17, is a *Siphonalia*, but differs from the Gáj species, and may be distinguished as *Siphonalia* (*Kelletia*) *iravadica*. It is smaller and less elongate than the living *Siphonalia Kelletii*, with a broader spire, and lacks the distinct umbilicus of the living shell.

PYRULA PUGILINA Born, p. 315.

This shell is clearly a pre-mutation of the living *Melongena pugilina*, and illustrates the difficulties of nomenclature experienced when a connected succession of mutations is observed through the successive stages of the Tertiary. The Burmese fossil scarcely differs specifically from the upper miocene or pliocene *Melongena ponderosa* Mart., which, in its turn can scarcely be regarded as differing more than varietally from the living *M. pugilina*; yet, when the Burmese shell is compared with the living form, it cannot possibly be maintained in the same species. For the sake of convenience it may be distinguished as *Melongena* (*Pugilina*) *præponderosa*. It is distinguished both from *Melongena ponderosa* and from the recent shell, by its constantly wider-spaced spines. The obliteration of the spines, restricted to a portion of the body-whorl in *Melongena præponderosa*, usually also invades a portion of the spire in *Melongena ponderosa*. The spire of *Melongena præponderosa* is generally more elongate than that of *M. ponderosa* and *M. pugilina*. The internal walls of the living shell and, probably, of *Melongena ponderosa*, are smooth instead of lirate as in the Burmese fossil which, moreover, is generally somewhat smaller than the living shell and especially than *M. ponderosa*.

PYRULA BUCEPHALA Lam., p. 317.

Under this name, two species, belonging to different genera, have been figured, neither of which coincides with Lamarck's species. The one shown in pl. xxi, fig. 3, corresponds with Noetling's *Pyrula pseudobucephala* and is a *Melongena*. The other, shown in fig. 4, is a *Vasum*. So far as can be judged from published illustrations, good specimens of the Burmese shell coincide in every smallest detail with *Melongena basilica* Bellardi from the oligocene of Liguria. The fossil should therefore be known as *Vasum basilicum* [Bellardi].

The interior of the Ligurian shell has been neither figured nor described, and we are not in a position, therefore, to ascertain whether it contains the characteristic spiral folds of *Vasum*. If the one shell were truly a *Melongena* and the other a *Vasum*, we would be in presence of a most astounding example of mimicry, and, if that were so, the name "*basilicum*" might well be maintained for the Burmese shell to recall such an astonishing resemblance.

PYRULA PSEUDOBUCEPHALA, p. 318.

As already mentioned, amongst the specimens erroneously referred to *Melongena bucephala*, the one represented in pl. xxi, fig. 3, belongs to this species.

MUREX ARRAKANENSIS, p. 319.

This species belongs to the sub-genus *Chicoreus*.

MUREX (?) TCHIHATCHEFFI d'A. and H., p. 320.

Two different forms, neither of which coincides with d'Archiac and Haime's species, have been figured under this name in Noetling's second monograph. The inclusion of the specimen represented in fig. 9, pl. xxi, is due to an oversight, as Dr. Noetling expressly states (p. 321) that "no other specimens have come under examination in addition to the one described in my previous memoir." The second specimen, represented in fig. 9 is in a much better state of preservation than the one described in the first monograph and represented in fig. 8 of the second monograph. It may be taken as the type of a species *Murex (Muricantha) iravadicus*, and is now represented in the Calcutta collection by numerous good specimens. The specimen shown in fig. 8 is to be regarded as a variety *yananensis* or perhaps even a distinct species. Attention may be drawn to the fact that, whereas the Burmese shells belong to the subgenus *Muricantha*, *Murex Tchihatcheffi* is a member of the section *Haustellum* of *Murex* s. str. As represented by the type of the proposed species, in pl. xxi, fig. 9 of Noetling's monograph, *Murex iravadicus* seems scarcely distinguishable specifically from *Murex Dannebergi* Beyrich of the lower oligocene of Germany. Judging from the available illustrations, the Indian fossil has more sharply delineated, narrower spiral threads. *Murex Grooti* Jenkins, from the miocene of Java, is also closely related, but its spiral decoration is apparently coarser.

The specimen represented by fig. 8, pl. xxi, of Noetling's monograph may provisionally be regarded as a variety *yenangensis* distinguished by the sharper posterior angulation of the whorls, the somewhat more numerous varices, and, apparently, the more profuse and more delicate spiral threads.

## VOLVARIA BIRMANICA, p. 322.

## VOLUTA DENTATA Sow., p. 324.

The shell does not coincide with the Gáj fossil to which Noetling has referred it, but represents a distinct species which is dedicated to the memory of the late Mr. Jacobs of Yenangyoung as *Athleta (Volutospina) Jacobsi*. This beautiful shell resembles *Voluta mutata* Desh. from the upper eocene of the Paris basin. The European species lacks the very characteristic double convexity of the base exhibited by the Burmese shell; its spire, instead of exhibiting a tendency to assume an extraconic outline as in *Athleta Jacobsi*, rather tends to be conoidal.

## OLIVA (STREPHONA) RUFULA Duclos, p. 326.

The figures in Noetling's monograph do not represent an *Oliva* but an *Olivella* which may be distinguished as *Olivella minbuensis*. The description and measurements refer largely to specimens of *Olivancillaria nebulosa* Lam. var. *pupa* Sow. from Singu.

*Olivella minbuensis* appears to be closely related to *Olivella leucozonias* Gray from Senegal, the spire of which, compared with that of the fossil, is somewhat longer, as is generally the case with most of the living forms. The insufficiently described and figured *Olivella brevis* Bellardi from the miocene of Piedmont (*Moll. terr. terz. Piem. e Lig.*, pt. 3, p. 213, pl. xii, fig. 34) exhibits some similarity in shape.

## ANCILLARIA cf. VERNEDEI Sow., p. 327.

The discovery of better preserved specimens has shown that this shell is not an *Ancilla s. str.* and therefore not related to the much larger *A. Vernedei*, but a *Sparella* which may be distinguished as *A. (Sparella) birmanica*.

Compared with *Ancilla indica* from the Nari of Sind, *Ancilla birmanica* has a slightly shorter spire and a slightly longer body-whorl. The outline of the last spire-whorl is more continuous with

that of the body-whorl in the Sind shell than in the Burmese one. The earlier whorls of the Burmese shell are more distinctly divided off from one another by grooved pseudo-sutures, and the apex is more conoidal. Lastly the Sind fossil lacks the feeble angulation of the whorls which characterises *Ancilla birmanica*. Both the Sind and Burma fossils are related to the living *Ancilla mamillata* Hinds of the Indo-Pacific regions which has a more inflated body-whorl.

CANCELLARIA NEAVOLUTELLA Noetl., p. 328.

This is *Rimella javana* Martin.

CANCELLARIA PSEUDOCANCELLATA Noetl., p. 330.

This is a *Merica*.

CANCELLARIA DAVIDSONI d'A. and H., p. 331.

This shell is a *Hindsia*. It differs specifically from d'Archiac and Haime's *Triton Davidsoni* which is also a *Hindsia* and which corresponds with *Fusus granosus* Sow., its correct name being, therefore, *Hindsia granosa* [Sow.]. The Burmese shell may be distinguished as *Hindsia birmanica*.

*Hindsia birmanica* somewhat resembles *Hindsia pardalis* Noetl. from which it is distinguished by its larger dimensions, its vertically more compressed shape, its relatively thinner main spiral threads, the presence, in the intervals, of fine striations and the inconstant development or absence of threads of a second order, the persistence in thickness of the axial ribs on the body-whorl, the less prominent varices. In general appearance, *Hindsia birmanica* closely recalls the living *Hindsia nivea* [Gmelin], but it has a shorter canal and is clearly distinguished by the well-defined, relatively narrow apertural varix instead of the broad, somewhat indefinite swollen zone which characterises the forms belonging to the group of *Hindsia nivea*.

CANCELLARIA MARTINIANA, p. 332.

As already noticed by Dalton (*Quart. Journ. Geol. Soc.*, Vol. LXIV, pp. 619, 630), this shell is a *Tritonidea*.

TREBRA PROTOMYUROS, p. 335.

This form belongs to the section *Myurella*.

STRIOTEREBRUM UNICINCTUM, p. 336.

This is *Terebra samarangana* Martin.

STRIOTEREBRUM BICINCTUM Mart., p. 337.

This is not the Javanese form described by Martin. It corresponds with the previously mentioned *Terebra (Myurella) protomyuros* Noetling.

It may here be mentioned that Martin's specific designation was pre-employed in 1843 by Hinds (*Proc. Zool. Soc. p. 150*). The Javanese species described by Martin, which occurs also in Burma, may be distinguished as *Terebra Martini*.

TEREBRUM PROTODUPLICATUM, p. 338.

TEREBRUM SMITHI Mart., p. 339.

This is not the Javanese fossil described by Martin. It corresponds with Noetling's *Subula* sp., p. 341. It may be distinguished as *Terebra (Subula) Noetlingi*.

TEREBRUM sp. 1, p. 340.

The badly preserved specimen from Yenangyat figured by Noetling probably corresponds with a species which has been described from north-western India as *Terebra (Myurella) quettensis*, and which occurs abundantly at Singu.

SUBULA sp., p. 341.

As already mentioned, this is a form erroneously referred to *Terebra Smithi* Martin, which may be distinguished as *T. Noetlingi*.

PLEUROTOMA KARENAICA, p. 344.

This is a *Surcula*.

SURCULA FEDDENI, p. 346.

Under this name two species have been illustrated in Noetling's second monograph. The specimens shown in figures 22 and 23, pl. xxii, correspond respectively with the type of *Fasciolaria Feddeni* and with one of the specimens referred to *Drillia interrupta* in the first monograph. The specimen shown in fig. 24 of the same plate

represents a different species which may be distinguished as *Surcula scala*.

There is a close resemblance between *Surcula scala* and *Surcula Lamarcki* Bellardi from the tortonian of Piedmont. The anterior contraction of the anterior slope is much more pronounced in the Piedmontese species, with the result that its body-whorl lacks the characteristic angulation circumscribing the base of *Surcula scala*.

GENOTIA IRRAVADICA, p. 347.

CLAVATULA MUNGA, p. 347.

This form belongs to the section *Perrona*.

CLAVATULA FULMINATA Kiener, p. 349.

This shell does not correspond with Kiener's species. It is a pre-mutational variety of a form which occurs abundantly in lower Burma at a horizon equivalent to that of the Kama Clay. Though it would seem more logical to take the older form as the type, the abundance and fine preservation of the specimens of the later fossil make it more convenient to adopt as the typical form. The shell described and figured by Noetling may be distinguished therefore as *Clavatula (Perrona) birmanica* var. *singuensis*.

CLAVATULA PROTONODIFERA, p. 350.

DRILLIA YENANENSIS, p. 353.

This shell belongs to the genus *Pleurotoma*, in which Noetling had correctly classified it when publishing his first monograph. It is a member of the section *Hemipleurotoma*.

DRILLIA PROTOINTERRUPTA, p. 354.

Three different species have been figured under this name. The first figure (fig. 8, pl. xxiii) may be accepted as representing the type. The name is unfortunate as the shell bears no resemblance to *D. interrupta* Lam. The second form (fig. 9) belongs to the sub-genus *Crassispira* and may be distinguished as *Drillia (Crassispira) Cotteri*. The third form (fig. 10) is also a *Crassispira* and may be distinguished as *Drillia (Crassispira) kamaensis*.

*Drillia Cotteri* closely resembles *Drillia Geslini* Desm. from the miocene of Piedmont, which is distinguished by its much larger dimensions.

*Drillia kamaënsis* bears some resemblance to *Drillia sinensis* Hinds, living in the eastern seas, and also known in a fossil condition from the Upper Tertiary of Karikal, from which the Burmese fossil is clearly distinguished by its more prominent and broader ribs. From *Drillia kachensis*, fossil in the miocene of Kachh, it is distinguished by its relatively lower spire-whorls and much shorter body-whorl. It also resembles *Drillia semisulcata* Bellardi from the Helvetian of Piedmont, which is larger than the Burmese fossil, with a somewhat taller body-whorl and slightly more crowded axial ribs.

DRILLIA PROMENSIS, p. 355.

This species belongs to the sub-genus *Crassispira*.

DRILLIA PROTOCINCTA, p. 356.

*D. madiunensis* Martin, 1906, is identical.

CONUS LITERATUS Linn., p. 359.

Under this name, Noetling has illustrated three specimens (pl. xxiii, figs. 12-14), none of which agree with the Linnean species. Two of the specimens (figs. 12, 14) correspond with *C. (Lithoconus) Ickei* Martin. The remaining specimen, which is immature, probably corresponds with Noetling's *Conus avaënsis*, which may be regarded as a variety of *Conus odengensis* Martin.

CONUS (RHIZOCONUS) MALACCANUS Hwass, p. 360.

This shell, although closely related to *C. malaccanus*, is specifically distinct, and corresponds with *C. (Lithoconus) ineditus* Michelotti.

CONUS AVAËNSIS, p. 362.

Two different forms have been figured under this name. The first one (pl. xxiii, fig. 15) corresponds with one of the forms included by Noetling under *C. literatus*, regarded as a variety of *Conus odengensis* Martin. The second one (fig. 16) also appears to be specifically identical with *C. odengensis* and may be distinguished as a variety *birmanica*.



In the variety *avaënsis*, the outer lip exhibits a somewhat broader convexity next to the posterior angulation than is observed in the type. Moreover, while the greater part of the outer lip is practically vertical in the type, it is distinctly, though not strongly, oblique in the variety under consideration. The spiral decoration of the base is more restricted to the anterior third of the body-whorl than in the type; it is more effaced than in the type, and, at the same time, more even, consisting of shallow, rather close-set grooves of the same width as the raised intervals.

In the variety *birmanica*, the later spire-whorls, when seen from above, instead of gradually increasing as in the type and in the variety *avaënsis*, appear to be all approximately of the same width, conveying the impression, at first sight, that the whorls are narrower and more crowded than in the type, while, in reality their number is the same. The disposition of the outer lip and of the spiral ornamentation of the base coincides with that observed in the variety *avaënsis*.

#### CONUS YULEIANUS, p. 363.

There is some doubt as to whether this beautiful shell should be classified as a *Leptoconus* or *Lithoconus*. The specific identity of one of the specimens figured in Noetling's monograph (pl. xxiii, fig. 21) is doubtful.

#### CONUS HANZA, p. 364.

Two species have been figured under this name, one of which (pl. xxiii, fig. 23) corresponds with the previously described *Conus* (*Leptoconus*) *Bonneti* Cossmann. The other specimen (fig. 24) remains as the type of *C.* (*Leptoconus*) *hanza* which is distinguished from *Conus Bonneti* by its smaller dimensions, its much more ventricose body-whorl, and the absence of a rim to the spire-whorls.

#### CONUS PROTOFURVUS, p. 365.

Two specimens belonging to separate species have been figured under this name in Noetling's second monograph. The first specimen (pl. xxiii, fig. 25) represents the type of *C.* (*Leptoconus*) *protofurvus*, the second corresponds with the living *Conus* (*Leptoconus*) *vimineus* Reeve.

#### CONUS GALENSIS, p. 366.

This species belongs to the section *Conospira*.

III.—REVISED SYNONYMY OF THE FORMS CRITICALLY RE-EXAMINED FROM DR. NOETLING'S SECOND MONOGRAPH.

TEREBRA (DUPLICARIA) PROTODUPLICATA Noetling.

1901. *Terebrum protoduplicatum* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 333, pl. xxii, fig. 17.

Kama.

TEREBRA (SUBULA) NOETLINGI n. sp.

1895. *Terebra fuscata* Brocc. sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 39, pl. ix, figs. 3, 4.  
1901. *Terebrum smithi* K. Martin sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 339, pl. xxii, fig. 18.  
1901. *Subula* spec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 341, pl. xxii, fig. 20.

Both the figured specimens are from Minbu.

TEREBRA (NODITEREBRA) SAMARANGANA Martin.

1884. *Terebra samarangana* Martin, *Samml. des geol. Reichsmus.* in Leiden, ser. I, Vol. III, p. 75, pl. v, fig. 78.  
1901. *Strioterebrum uncinatum* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 336, pl. xxii, fig. 16.

Kama.

TEREBRA (MYURELLA) PROTOMYUROS Noetling.

1901. *Strioterebrum protomyuros* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 335, pl. xxii, fig. 14.  
1901. *Strioterebrum bicinctum* Martin sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 337, pl. xxii, fig. 15.

The figured specimens are both from Kama.

TEREBRA (MYURELLA) QUETTENSIS n. sp.

1901. *Terebrum*, spec. 1, Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 340, pl. xxii, fig. 19.

The figured specimen, the identification of which is somewhat doubtful is from Yenangyat. The species is known to occur abundantly at Singu.

CLAVATULA PROTONODIFERA Noetling.

1895. *Pleurotoma Voysei*<sup>1</sup> d'Arch. and Haime sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 40, pl. ix, fig. 5.  
1901. *Clavatula protonodifera* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 350, pl. xxiii, figs. 3, 4.

Minbu and Singu.

<sup>1</sup> Misprinted "Voysei" and attributed to d'Archiac instead of d'Archiac and Haime in Noetling's first monograph, and misprinted "Voyesi" in the second.

## CLAVATULA (PERRONA) BIRMANICA n. sp. var. SINGUENSIS.

1901. *Clavatula fulminata* Kiener sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 349, pl. xxiii, fig. 2.

Singu.

## CLAVATULA (PERRONA) MUNGA Noetling.

1901. *Clavatula munga* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 347, pl. xxiii, fig. 1.

Kama.

## SURCULA KARENAICA [Noetling.]

1901. *Pleurotoma* (s. s.) *karenaica* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 344, pl. xxii, fig. 21.

Kama.

## SURCULA (PLEUROFUSIA) FEDDENI Noetling.

1895. *Fasciolaria feddeni* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 35, pl. viii, fig. 4.

1895. *Pleurotoma* (*Drillia*) *interrupta* Lam. sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 41, pl. x, fig. 1 (non fig. 2 = *Drillia protointerrupta*).

1901. *Surcula Feddeni* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 346, pl. xxii, figs. 22, 23 (non fig. 24 = *Surcula scala*).

The figured specimens are both from Yenangyat. The existence of this species at Minbu and Singu has also been ascertained.

## SURCULA (PLEUROFUSIA) SCALA n. sp.

1901. *Surcula Feddeni* Noetling (*pars*), *Pal. Ind.*, new ser., Vol. I, part 3, pl. xxii, fig. 24 (non fig. 22, 23 = *Surcula Feddeni*).

Kama.

## PLEUROTOMA (HEMPLEUROTOMA) YENANENSIS Noetling.

1895. *Pleurotoma yenanensis* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 42, pl. x, fig. 3.

1901. *Drillia yenanensis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 353, pl. xxiii, fig. 5.

Yenangyat.

A variety of this same species is known from the Nari beds of Sind.

## DRILLIA PROTOCINCTA Noetling.

1901. *Drillia protocincta* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 356, pl. xxiii, figs. 6, 7.

1906. *Pleurotoma* (*Drillia*) *madiunensis* Martin, *Samm. des geol. Reichsmus. in Leiden*, new ser., Vol. I, p. 296, pl. xliii, fig. 707.

Kama.

DRILLIA PROTOINTERRUPTA Noetling.

1895. *Pleurotoma (Drillia) interrupta* Lam. sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 41, pl. x, fig. 2 (non fig. 1 = *Surcula Feddeni*).  
1901. *Drillia protointerrupta* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 354, pl. xxiii, fig. 8 (non fig. 9 = *Drillia Cotteri*, nec. fig. 10 = *Drillia kamaënsis*).

Minbu.

DRILLIA (CRASSISPIRA) KAMAËNSIS n. sp.

1901. *Drillia protointerrupta* Noetling (*pars*). *Pal. Ind.*, new ser., Vol. I, part 3, p. 354, pl. xxiii, fig. 10 (non fig. 8 = *Drillia protointerrupta*, nec. fig. 9, = *Drillia Cotteri*).

Kama.

DRILLIA (CRASSISPIRA) PROMENSIS Noetling.

1901. *Drillia promensis* Noetling, *Pal. Ind.*, new ser., Vol. I, p. 355, pl. xxiii, fig. 11.

Kama.

DRILLIA (CRASSISPIRA) COTTERI n. sp.

1901. *Drillia protointerrupta* Noetling (*pars*). *Pal. Ind.*, new ser., Vol. I, part 3, p. 354, pl. xxiii, fig. 9 (non fig. 8 = *Drillia protointerrupta*, nec. fig. 10 = *Drillia kamaënsis*).

Kama.

GENOTIA IRAVADICA Noetling.

1895. *Pleurotoma (Cryptoconus) iravadicus* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 41, pl. ix, fig. 6.  
1901. *Genota iravadica* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 347, pl. xxii, figs. 25, 26.

The figured specimens are both from Minbu.

CONUS (CONOSPIRA) GALENSIS Noetling.

1901. *Conus galensis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 366, pl. xxiii, fig. 27.

Yenangyat.

CONUS (LEPTOCONUS) PROTOFURVUS Noetling.

1895. *Conus (Leptoconus) marginatus* Sowerby sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 43, pl. x, fig. 8.  
1901. *Conus (Leptoconus) protofuvus* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 365, pl. xxiii, fig. 25 (non fig. 26 = *Conus vimineus* Reeve).

Yenangyat.

## CONUS (LEPTOCONUS) VIMINEUS Reeve.

- ? 1844. *Conus aculeatus* Reeve, Monograph of the genus *Conus*, pl. xlv, sp. 240.  
 1849. *Conus vimineus* Reeve. Monograph of the genus *Conus*, suppl. pl. vii, sp. 269.  
 1895. *Conus vimineus* Reeve. Martin, *Samml. des geol. Reichsmus. in Leiden*, new ser., Vol. I, p. 16, pl. ii, figs. 23-25.  
 1895. *Conus palabuanensis* Martin, *Samml. des geol. Reichsmus. in Leiden*, new ser., Vol. I, p. 16, pl. ii, fig. 26.  
 1900. *Conus (Chelyconus) subvimineus* Cossmann, *Journ. Conch.*, Vol. XLVIII, p. 64, pl. iv, figs. 47, 48.  
 1901. *Conus (Leptoconus) protofurvus* Noetling (*pars*). *Pal. Ind.*, new ser., Vol. I, part 3, p. 365, pl. xxiii, fig. 26 (*non* fig. 25 = *Conus protofurvus*).

Kama.

This shell also occurs in the Upper Tertiary of Karikal and in the Mekran beds of Baluchistan.

## CONUS (LEPTOCONUS) BONNETI Cossmann.

1900. *Conus (Leptoconus) Bonneti* Cossmann, *Journ. Conch.* Vol. XLVIII, p. 59, pl. iv, figs. 15, 16.  
 1901. *Conus hanza* Noetling (*pars*). *Pal. Ind.*, new ser., Vol. I, part 3, p. 364, pl. xxiii, fig. 23 (*non* fig. 24 = *Conus hanza*).

Kama.

Also in the Upper Tertiary of Karikal.

## CONUS (LEPTOCONUS) HANZA Noetling.

1901. *Conus hanza* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 364, pl. xxiii, fig. 24 (*non* fig. 23 = *Conus Bonneti*).

Kama.

## CONUS (LEPTOCONUS) YULEIANUS Noetling.

1901. *Conus yuleianus* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 363, pl. xxiii, fig. 22 (? fig. 21).

The fairly well preserved specimen shown in fig. 22, which must be regarded as the type, is from Kama. The incomplete specimen shown in fig. 21, of which the specific identity is doubtful, is from the so-called "zone of *Aricia humerosa*" presumably near Thayetmyo.

## CONUS (LITHOCONUS) ODENGENSIS Martin.

1895. *Conus odengensis* Martin, *Samml. des geol. Reichsmuseums in Leiden*, new ser., Vol. I, p. 19, pl. iii, figs. 39-44.  
 ? 1906. *Conus madurensis* Martin, *Samml. des geol. Reichs-Mus. in Leiden*, new ser., Vol. I, p. 288, pl. xlii, fig. 690.

Typical examples of this shell are extremely abundant in Burma at a horizon equivalent to that of the Kama clay, but are not represented amongst the fossils figured by Noetling. The same form also occurs in the Gaj beds of Kachh.

CONUS (LITHOCONUS) ODENGENSIS var. AVAËNSIS Noetling.

1901. *Conus literatus* Linn. sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 359, pl. xxiii, fig. 13 (non fig. 12, 14 = *Conus Ickeii*).  
1901. *Conus avaënsis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 362, pl. xxiii, fig. 15 (non fig. 16 = var. *birmanica*).

The type of *Conus avaënsis* is from Singu. An immature specimen from the so-called "zone of *Aricia humerosa*" presumably near Thayetmyo, apparently belongs to this same form which has also been recognized at Minbu.

CONUS (LITHOCONUS) ODENGENSIS var. BIRMANICA.

1901. *Conus avaënsis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 362, pl. xxii, fig. 16 (non fig. 15 = var. *avaënsis*).

Zone of *Cytherea promensis* opposite Prome.

CONUS (LITHOCONUS) INEDITUS Michelotti.

1861. *Conus ineditus* Michelotti, Et. mioc. inf. Italie septentrionale, p. 105, pl. xii, figs. 11, 12.  
1893. *Lithoconus ineditus* Micht., Sacco, *Moll. terr. terz. Pieme. Lig.*, XIII, p. 26, pl. iii, figs. 16-24.  
1895. *Conus malaccanus* Hwass sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 42, pl. x, figs. 4-7.  
1901. *Conus (Rhizoconus) malaccanus* Hwass sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 360, pl. xxiii, figs. 17-20.

The specimens figured by Noetling are all from Minbu. The species occurs abundantly also at Singu, and also in the Nari beds of western India.

CONUS (LITHOCONUS) ICKEI Martin.

1901. *Conus (Lithoconus) literatus* Linn. sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 359, pl. xxiii, figs. 12, 14 (non fig. 13 = *Conus odengensis*).  
1906. *Conus Ickeii* Martin, *Samml. des geol. Reichs-Mus. in Leiden*, new ser., Vol. I, p. 289, pl. xlii, fig. 692.

The specimens figured by Noetling are both from the so-called "zone of *Aricia humerosa*" presumably near Thayetmyo.

MERICA PSEUDOCANCELLATA [Noetling].

1895. *Cancellaria cancellata* Lam. sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 39, pl. ix, fig. 2.  
1901. *Cancellaria pseudocancellata* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 330, pl. xxii, fig. 10.

Yenangyat.

## OLIVELLA MINBUENSIS n. sp.

1895. *Oliva djocdjocartæ* K. Martin sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 33, pl. ix, fig. 1.  
 1901. *Oliva (Strephona) rufula* Duclos sec. Noetling, (*pars.*), *Pal. Ind.*, new ser., Vol. I, part 3, p. 326, pl. xxii, figs. 4, 5.

The specimens figured by Noetling are both from Yenangyat. The species also occurs at Minbu.

## ANCILLA (SPARELLA) BIRMANICA n. sp.

1901. *Ancillaria* cf. *Vernedei* Sow. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 327, pl. xxii, fig. 6.

The figured specimen is from the *Cytherea promensis* bed opposite Prome.

## ATHLETA (VOLUTOSPINA) JACOBSI n. sp.

1895. *Voluta dentata* Sow. sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 37, pl. viii, figs. 8-10.  
 1901. *Voluta dentata* J. de C. Sowerby sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 324, pl. xxi, figs. 14, 15, pl. xxii, figs. 1-3.

The figured specimens are from Yenangyat and Minbu. The species also occurs at Singu.

## VOLVARIA BIRMANICA Noetling.

1895. *Volvaria birmanica* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 37, pl. viii, fig. 7.  
 1901. *Volvaria birmanica* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 322, pl. xxi, fig. 11.

Minbu.

## CLAVILITHES SEMINUDUS Noetling.

1895. *Clavella djocdjocartæ* K. Martin sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 33, pl. vii, figs. 5-7.  
 1901. *Fusus seminudus* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 312, pl. xx, figs. 12, 13, (*non Fusus seminudus* Deshayes).  
 1901. *Fusus verbecki* <sup>1</sup> Martin sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 313, pl. xx, figs. 14, 15.

The figured specimens are from Minbu, and from the so-called "zone of *Aricia humerosa*," presumably near Thayetmyo. The species also occurs abundantly at Yenangyat, at Singu, and at the horizon of the Kama clay.

<sup>1</sup> Mis-spelt "Verbecki."

LATHYRUS INDICUS n. sp.

1895. *Fasciolaria nodulosa* sec. Noetling (*pars*), *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 34, pl. viii, figs. 1, 2, (non fig. 3 = *Siphonalia iravadica*).  
 1901. *Fasciolaria nodulosa* J. de C. Sowerby sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 314, pl. xx, fig. 16, pl. xxi, fig. 1, (non pl. xx, fig. 17 = *Siphonalia iravadica*).

The almost undeterminable fragments figured by Noetling are from Yenangyat. The species is well represented at Minbu.

LATHYRUS (PERISTERIA) GAUTAMA [Noetling].

1901. *Persona gautama* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 305, pl. xx, figs. 6, 7.

Kama.

VASUM BASILICUM [Bellardi].

1872. *Myristica basilica* Bellardi, *Moll. terr. terz. Piemonte e Liguria*, parte I, p. 158, pl. x, figs. 4, 5.  
 1900. *Melongena (Myristica) basilica* Bell., Rovereto, *Ill. moll. tongr.*, p. 170.  
 1901. *Pyrula bucephala* Lam. sec. Noetling (*pars*), *Pal. Ind.*, new ser., Vol. I, part 3, p. 317, pl. xxi, fig. 4 (non fig. 3 = *Pyrula pseudobucephala* Noetling).  
 1904. *Melongena (Myristica) basilica* Bell.—Sacco, *Moll. terr. terz. Piem. e Lig.* parte XXX, p. 32.

Singu.

MELONGENA PSEUDOBUCEPHALA Noetling.

1901. *Pyrula bucephala* Lank. sec. Noetling (*pars*), *Pal. Ind.*, new ser., Vol. I, part 3, p. 317, pl. xxi, fig. 3, (non fig. 4 = *Vasum basilicum*).  
 1901. *Pyrula pseudobucephala* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 315, pl. xxi, figs. 5, 6.

Singu.

MELONGENA (PUGILINA) PRÆPONDEROSA n. sp.

1901. *Pyrula pugilina* Born sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 315, pl. xxi, fig. 2.

The figured specimen is from the zone of *Cytherea promensis* opposite Prome. The same form occurs at Minbu and Singu.

SIPHONALIA (KELLETTIA) IRAVADICA n. sp.

1895. *Fasciolaria nodulosa* Sow. sec. Noetling (*pars*), *Mem. Geol. Surv. Ind.*, Vol. XXVII, pl. viii, fig. 3 (non figs. 1, 2 = *Lathyrus indicus*).  
 1901. *Fasciolaria nodulosa* J. de Carle Sowerby sec. Noetling (*pars*), *Pal. Ind.*, new ser., Vol. I, part 3, p. 314, pl. xx, fig. 17 (non pl. xx, fig. 16, nec. pl. xxi, fig. 1 = *Lathyrus indicus*).

Minbu.



## CYRTOCHETUS (LOXOTAPHRUS) MINBUENSIS [Noetling].

1895. *Cassidaria minbuensis* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 28, pl. vi, fig. 4.  
 1901. *Oniscidia minbuensis* Noetling, *Pal. Ind.*, new ser., Vol. I, p. 296, pl. xix, figs. 18, 19.

Minbu.

## TRITONIDEA MARTINIANA [Noetling].

1895. *Nassa cautleyi* d'Archiac *sec.* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 32, pl. vii, figs. 2-4.  
 1901. *Cancellaria martiniana* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 332, pl. xxii, figs. 11-13.  
 1908. *Caniharus Martinianus* Noetling—Dal'on. *Quart. Journ. Geol. Soc.*, Vol. LXIV, pp. 619, 630, pl. iv, figs. 6, 7.

The figured specimens are from Minbu. The same species also occurs abundantly at Singu, and, according to Noetling, at Yenangyat.

## EBURNA LUTOSA Lamarck, var.

1790. *Eburna lutosa* Lamarck. *Encycl.*, pl. cocci, fig. 4.  
 1849. *Eburna lutosa* Lam.—Reeve, Monograph of the genus *Eburna*, pl. sp.  
 1881. *Eburna lutosa* Lam.—Tuyon. *Man. Conch.*, Vol. III, p. 211, pl. lxxxii, fig. 465.  
 1901. *Eburna protozeylanica* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 310, pl. xx, fig. 11.

Kama.

## MUREX (CHICOREUS) ARAKANENSIS Noetling.

1895. *Murex arrakanensis* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part I, p. 36, pl. viii, fig. 5.  
 1901. *Murex arrakanensis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 319, pl. xxi, fig. 7.

Minbu.

## MUREX (MURICANTHA) IRAVADICUS n. sp.

1901. *Murex (?) tchihatcheffi* d'Archiac and Haime *sec.* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 320, pl. xxi, fig. 9.

The figured specimen is from Yenangyat. The species also occurs at Minbu.

## MUREX IRAVADICUS var. YENANENSIS n. var. vel species distinguenda.

1895. *Murex tchihatcheffi* d'Archiac and Haime *sec.* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 36, pl. viii, fig. 5.  
 1901. *Murex (?) tchihatcheffi* d'Archiac and Haime *sec.* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 320, pl. xxi, fig. 8.

Yenangyat.

TRITONIUM (LAMPUSIA) DUBIUM [Noetling].

1895. *Cassidaria dubia* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 27, pl. vii, figs. 2, 3.

1901. *Semicassia protojaponica* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 295, pl. xix, fig. 15.

Minbu.

HINDSIA BIRMANICA n. sp.

1895. *Triton (Simpulum) davidsoni* d'Archiac and Haime sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 29, fig. 6.

1901. *Cancellaria davidsoni* d'Archiac and Haime sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 331, pl. xix, fig. 23, pl. xx, fig. 1.

Minbu.

HINDSIA NEASTRIATULA [Noetling].

1895. *Triton pardalis* Noetling (*pars*), *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 30, pl. vi, fig. 8a (*non* figs. 7, 8 = *Hindsia pardalis*).

1901. *Triton neastriatulus* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 301, pl. xx, figs. 2, 3.

The figured specimens are from Yenangyat. The species also occurs at Minbu.

HINDSIA PARDALIS [Noetling.]

1895. *Triton pardalis* Noetling (*pars*), *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 30, pl. vi, figs. 7, 8 = (*non* fig. 8a = *Hindsia neastriatula*).

1901. *Triton pardalis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 302, pl. xx, fig. 5.

Minbu.

The locality "Kama" mentioned by Noetling is founded on an erroneous identification of a specimen of *Hindsia neacolubrina*.

HINDSIA NEACOLUBRINA [Noetling.]

1901. *Triton neacolubrinus* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 304, pl. xx, fig. 4.

Kama.

RANELLA TUBERCULARIS Noetling.

1895. *Ranella tubercularis* "Lam."—Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, pl. vii, fig. 1.

1901. *Ranella prototubercularis* Noetling (*pars*), *Pal. Ind.*, new ser., Vol. I, part 3, p. 306, pl. xx, fig. 9 (*non* fig. 8 = *Ranella antiqua*).

Minbu.

Also in the Nari beds of Sind.

RANELLA ANTIQUA n. sp.

1901. *Ranella prototubercularis* Noetling (*pars*), *Pal. Ind.*, new ser., Vol. I, part 3, p. 306, pl. xx, fig. 8 (*non* fig. 9 = *Ranella tubercularis*).

Kama.

## RANELLA (PSEUDOBURSA) PROMENSIS n. sp.

1901. *Ranella elegans* Beck *sec.* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 309, pl. xx, fig. 10.

Kama.

## CASSIDEA BIRMANICA n. sp.

1895. *Cassis d'Archiaci* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 27, pl. vi, fig. 1.  
 1901. *Cassis d'Archiaci* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 294, pl. xix, fig. 14 (*non Cassis Archiaci* Bellardi, *Mem. Soc. Geol. Fr.*, 2nd ser., Vol. IV (1851), p. 224, pl. xiv, figs. 3, 5.

Minbu.

This species also occurs at Singu.

## CASSIDARIA ECHINOPHORA [Linn.] var. MONILIFERA Noetling.

1901. *Galeoda monilifera* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 297, pl. xix, fig. 16 (*non* fig. 17 = var. *promensis*).

Singu.

## CASSIDARIA ECHINOPHORA [Linn.] var. PROMENSIS n. var.

1901. *Galeoda monilifera* Noetling (*pars.*), *Pal. Ind.*, new ser., Vol. I, part 3, p. 297, pl. xix, fig. 17 (*non* fig. 16 = var. *monilifera*).

Kama.

## PIRULA CONDITA Brongniart.

1823. *Pirula condita* Brongniart, *Mem. terr. sed. sup. Vicentin*, p. 75, pl. vi, fig. 4.  
 1891. *Ficula condita* Brongn.—Sacco, *Moll. terr. terz. Piem. e Lig.*, VIII, p. 23, pl. i, figs. 27-32.  
 1895. *Ficula theobaldi* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 28, pl. vi, fig. 5.  
 1901. *Ficula theobaldi* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 298, pl. xix, fig. 21.

The figured specimen is from Yenangyat. The locality "Minbu" mentioned in Noetling's second monograph is doubtful. Amongst Noetling's specimens, the shells from Minbu referred by Noetling to "*Ficula Theobaldi*" belong to another species, *Pirula concinna* Beyrich, of which they constitute a local variety.

*Pirula condita* occurs in the Nari beds of Sind and Baluchistan, and is one of the commonest fossils of the oligocene and miocene of Europe.

## PIRULA CONDITA Brongn. var. SINGUENSIS n. var.

1901. *Ficula theobaldi* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 298, pl. xix, fig. 20.

Singu.

PIRULA PROMENSIS n. sp.

1901. *Ficula spec.* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 299, pl. xix, fig. 22, Kama.

CYPRÆA (BERNAYIA) SINGUENSIS n. sp.

1901. *Aricia humerosa* Sow. sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 291, pl. xix, fig. 11.

The figured specimen is from the so-called "Zone of *Aricia humerosa*," presumably from the neighbourhood of Thayetmyo. The same form occurs abundantly at Singu.

CYPRÆA (CYPRÆOTRIVIA) OPPENHEIMI n. sp.

1895. *Cypræa granti* d'Arch. sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 25, pl. v, fig. 12.  
1901. *Cypræa granti* d'Archiac and Haima sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 290, pl. xix, fig. 12.

The figured specimen is from Minbu. The species also occurs at Yenangyat.

TRIVIA NOETLINGI n. sp.

1895. *Trivium smithi* Martin sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 26, pl. v, fig. 13.  
1901. *Trivium smithi* Martin sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 293, pl. xix, fig. 13.

Yenangyat.

RIMELLA (DIENTOMOCHILUS) JAVANA Martin.

1879. *Rostellaria javana* Martin, *Tertiarschichten auf Java*, p. 50, pl. ix, fig. 7.  
1895. *Rostellaria javana* Martin, *Samml. des geol. Reichs-Mus. in Leiden*, Vol. V, pp. 57-59.  
1899. *Rostellaria (Rimella) javana* Martin, *Samml. des geol. Reichs-Mus. in Leiden*, new ser., Vol. I, p. 192, pl. xxx, figs. 445, 446.  
† 1899. *Rostellaria (Rimella) spinifera* Martin, *Samml. des geol. Reichs-Mus. in Leiden*, new ser., Vol. I, p. 192, pl. xxx, figs. 447, 448.  
1901. *Cancellaria neovolutella* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 328, pl. xxii, figs. 7, 8.

Kama.

RIMELLA (DIENTOMOCHILUS) PROMENSIS n. sp.

1901. *Rimella crispata* Sow. sec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 288, pl. xix, figs. 9, 10.

Kama.

## TURRITELLA ANGULATA J. de C. Sowerby.

1839. *Turritella angulata* J. de C. Sowerby, *Trans. Geol. Soc. Lond.*, 2nd ser., Vol. V, p. 328, pl. xxvi, fig. 7.
1854. *Turritella angulata* J. de C. Sow. *D'Archiac and Haime, Descr. an. foss. gr. numm. Inde*, p. 294, pl. xxvii, figs. 6-9.
1901. *Turritella angulata* J. de C. Sow. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 272, pl. xviii, figs. 13-15.
1901. *Turritella simplex* Jenk. *sec.* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 273, pl. xviii, figs. 1-4.
1901. *Turritella acuticarinata* Dunk. *sec.* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 274, pl. xviii, figs. 5-7.
- non *Turritella angulata* Sow. *sec.* Cossmann and Pissarro, *Pal. Ind.*, new ser., Vol. III, part 1, p. 59, pl. vi, figs. 3-5 (1909).

*Turritella angulata*, an extremely variable species, is one of the commonest fossils in the Gáj beds of Kachh, Sind and Kathiawar, where forms identical with those referred by Noetling to *T. simplex* and *T. acuticarinata* occur abundantly and are connected by every possible gradation with one another and with the typical form first described by Sowerby.

The lower eocene fossil from the Ranikot beds of Sind referred by Cossmann and Pissarro to *T. angulata* is specifically different, and may be distinguished as *T. Ranikoti*. It is much more elongate than the majority of specimens of *T. angulata* and is smaller and much less variable. The outline of the whorls posteriorly to the keel exhibits a double curvature which is never seen in *T. angulata*. The posterior slope, in the lower eocene form, always carries two conspicuous spiral threads which are invariably delicately granulated,<sup>1</sup> a character never observed in *T. angulata*.

Amongst the specimens figured by Noetling, those of which the locality is known are from Singu and from Kama.

## TURRITELLA NOETLINGI n. sp.

1901. *Turritella* spec. Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 277, pl. xvii, fig. 8.

Kama.

<sup>1</sup> This character is not well shown in the originally figured types because they are in a weathered condition.

TURRITELLA MAGNASPERULA SACCO.

1895. *Turritella (Haustator) magnasperula* Sacco, *Moll. terr. terz. Piem. e Lig.*, parte XIX, p. 18, pl. i, figs. 65, 66.  
 1895. *Turritella affinis* d'A. and H. sec. Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, pl. v, fig. 4.  
 1901. *Turritella affinisformis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 277, pl. xviii, fig. 9.

The specimen figured by Noetling is from Minbu. The species also occurs abundantly at Singu. It is also known from the oligocene beds of Balúchistán and of Liguria.

CALLIOSTOMA BLANFORDI Noetling.

1895. *Trochus blanfordi* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 16, pl. iv, figs. 3, 4.<sup>1</sup>  
 1901. *Calliostoma blanfordi* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 253, pl. xvii, figs. 6-8; (non fig. 5 = *C. singuënsis*).

Yenangyat, Minbu.

CALLIOSTOMA SINGUËNSE n. sp.

1901. *Calliostoma blanfordi* Noetling (*pars*), *Pal. Ind.*, new ser., Vol. I, part 3, p. 253, pl. xvii, fig. 5; (non figs. 6-8 = *C. blanfordi*).

Singu.

BATISSA CRAWFURDI Noetling.

1895. *Batissa crawfurdi* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 9, pl. ii, figs. 1-4, pl. III, fig. 1.  
 1895. *Batissa petrolei* Noetling, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 11, pl. ii, fig. 5, pl. iii, figs. 2, 3.  
 1901. *Cyrena (Batissa) crawfurdi* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 184, pl. xi, figs. 3-8.  
 1901. *Cyrena (Batissa) petrolei* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 188, pl. xi, figs. 9-11.

At the uppermost limit of the pre-Irrawadi beds in the southern part of the Yenangyoung anticline.

BATISSA KODOUNGENSIS Noetling.

1901. *Cyrena (Batissa) kodoungensis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 183, pl. xi, fig. 1.  
 1908. *Batissa kodoungensis* Noetling (*pars*).—Pascoe, *Rec. Geol. Surv. Ind.*, Vol. XXXVI, p. 144, pl. xix, figs. 1, 2, (non pl. xx, fig. 2 = *Batissa Selkouramae*).  
 ? 1908. *Batissa kodoungensis* Noetling.—Dalton, *Quart. Journ. Geol. Soc.*, Vol. LXIV, p. 624, pl. lvi, figs. 1, 2.

East of Khodaung, Yenangyoung anticline; also probably at an unknown locality in the region of the upper Yaw.

<sup>1</sup> Not figs. 1, 2, as erroneously recorded in the synonymy of Noetling's second monograph.

## OSTREA DIGITATA Eichwald var. ROHLFSII Fuchs.

1879. *Ostrea Rohlfssii* Fuchs, *Denkschr. d. k. Akad. d. W., m.-n. Cl.*, XLI, part 2, p. 106, pl. vi, figs. 5-8.
1883. *Ostrea digitalina* Eichw., var. *Rohlfssii* Fuchs, *Pal.* XXX, p. 44, pl. xii, figs. 3-6, p. 61, pl. xxii, figs. 1-3.
1901. *Ostrea promensis* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 109, pl. 88, fig. 3, pl. iii, figs. 1, 2.
1912. *Ostrea digitalina* Eichw., var. *Rohlfssii* Fuchs, Vredenburg, *Rec. Geol. Surv. Ind.*, Vol. XLI, p. 38, pl. vi, figs. 1-4.

Khayu Chaung (properly Keyu Chaung 17° 29', 96° 3') between the Pazwundaung Chaung and the Kenbati Chaung, southern Pegu Yoma.

Kenbati (properly Kinpadi 17° 30', 96° 1') coincides with the locality designated as "Keng-pa-dee" on the map attached to Theobald's geological description of Pegu in Volume X of the Memoirs of the Geological Survey of India. The locality of Theobald's specimens is therefore situated about 50 miles north by west of Rangoon.

The species is known to occur in the Akauktaung Series.

## OSTREA VIRLETI Deshayes.

1832. *Ostrea Virleti* Deshayes, *Exp. scient. Mor.*, III, part 1, p. 123, 2nd ser., Geol., pl. v, figs. 1, 2.
1879. *Ostrea Virleti* Desh.—Fuchs, *Denkschr. d. k. Akad. d. W., math.-nat. Cl.*, Vol. XLI, part 2, p. 106, pl. iv, figs. 1-9.
1879. *Ostrea hyotis* Linn. sec. Martin, *Tertiarsch. auf Java*, p. 125, pl. xxi, figs. 1, 2.
1883. *Ostrea Virleti* Desh.—Fuchs, *Pal.*, XXX, p. 43, pl. ix, figs. 1-6, pl. x, figs. 1-4; p. 61.
1901. *Ostrea peguensis* Noetling.—*Pal. Ind.*, new ser., Vol. I, part 3, p. 107, pl. ii, figs. 1, 2.

Probably from the same locality as *Ostrea digitata*. This species is also known to occur in the Akauktaung Series.

## IV.—STRATIGRAPHICAL LIST OF THE FOSSILS SPECIFICALLY IDENTIFIED AND CONCLUDING REMARKS.

We shall conclude this review with a tabular statement of the forms revised up to date, omitting only those that are specifically or generically undeterminable. The table shows the distribution of the several species in the four principal faunas dealt with in the preceding pages, namely those of Yenangyat, Minbu, Singu, and Kama, approximately coinciding, as already explained, respectively with the lower and upper Stampian, Chattian, and Aquitanian

stages. Separate columns are not given for the *Cytherea promensis* bed, the so-called "Zone of *Aricia humerosa*" and the zone of *Ostrea digitata* and *O. Virleti* on account of the small number of species recognized from those horizons. The so-called "zone of *Aricia humerosa*" is indicated in the column of "other occurrences" with the designation "Thayetmyo," the zone of *Ostrea digitata* and *O. Virleti* with the designation "Akauktaung horizon." The zone of *Cyrena Crawfurdi* of the Yenangyoung anticline is indicated with the designation "Yenangyoung."

Apart even from hitherto unpublished species, the list by no means exhausts the number of forms now identified from the Tertiary of Burma, especially amongst the Siphonostomata, and therefore conveys a very inadequate idea of the constitution of the Burmese Tertiary fauna which we hope to discuss more fully on some future occasion. Several of the species of the following list not recorded in the columns respectively assigned to the Minbu and Singu faunas are now known to occur at those localities. In preparing the following list, no specimens have been taken into account other than those in the collections dealt with by Noetling. The object of the present notice, as already stated, is to record the amendments that have been found necessary in Dr. Noetling's monograph so far as it has been critically examined. It is hoped that the publication of the results already arrived at may increase the usefulness of Dr. Noetling's work.

SYSTEMATIC LIST SHOWING THE DISTRIBUTION OF THE REVISED SPECIES.

	YENANGYAT (Stampian.)	MINBU (Upper Stampian.)	SINGU (Chattian.)	KAMA (Aquitanean.)	Other occurrences.
<i>Terebra (Duplicaria) protoduplicata</i> Noetl.					
<i>T. (Subula) Noetlingi</i> n. sp. . . .					
<i>T. (Noditerebra) samarangana</i> Mart.					



SYSTEMATIC LIST SHOWING THE DISTRIBUTION OF THE REVISED SPECIES—*contd.*

	YENANGYAF (Stampian.)	MIRBU (Upper Stampian.)	SINGU (Chattian.)	KAMA (Aquitanian)	Other Occurrences.
<i>T. (Myurella) protomyuros</i> Noetl. . .					
" <i>quetensis</i> . . .					Nari of Baluchistan.
<i>Clavatula protonodifera</i> Noetl. . .					
<i>C. (Ferrona) birmanica</i> n. sp. var. <i>singuensis</i>					
<i>C. (Ferrona) munga</i> Noetl. . . .					
<i>Surcula karnaica</i> [Noetl.] . . .					
<i>S. (Pleurofusua) Feddeni</i> Noetl. . .					
" <i>scala</i> n. sp. . . .					
<i>Pleurotoma (Hemipleurotoma) yena-</i> <i>nensis</i> Noetl.					Nari of Sind.
<i>Drillia protocincta</i> Noetl. . . .					
" <i>protointerrupta</i> Noetl. . . .					
<i>D. (Crassispira) kamaensis</i> n. sp. . .					
" <i>promensis</i> Noetl. . . .					
" <i>Cotteri</i> n. sp. . . .					
<i>Genotia iravadica</i> Noetl. . . .					
<i>Conus (Conospira) galensis</i> Noetl. . .					
<i>C. (Leptoconus) profurfurus</i> Noetl. . .					
" <i>vimineus</i> Reeve. . . .					Karikal and Mekran.
" <i>Bonneti</i> Gossm. . . .					Karikal.
" <i>hanza</i> Noetl. . . .					
" <i>Yuleianus</i> Noetl. . . .					? Thayetmyo.

SYSTEMATIC LIST SHOWING THE DISTRIBUTION OF THE REVISED SPECIES—contd.

	YENANGYAT (Stampian.)	MINBU (Upper Stampian.)	SINGU (Chattian.)	KAMA (Aquitanian.)	Other Occurrences.
<i>C. (Lithoconus) odengensis</i> Mart. . .					Gáj of Kachh.
" " var. <i>avaënsis</i> Noëtl.					? Thayetmyo.
" " var. <i>birmanica</i> n. var.					<i>Cytherea promensis</i> bed.
" <i>ineditus</i> Micht. . .					Nari of Sind, oligocene of Liguria.
" <i>Ickeï</i> Mart . . .					Thayetmyo.
<i>Merica pseudocancellata</i> [Noëtl.] . .					
<i>Olivella minbuensis</i> n. sp. . . .					
<i>Ancilla (Sparella) birmanica</i> n. sp. . .					<i>Cytherea promensis</i> bed.
<i>Athleta (Volutoepina) Jacobi</i> n. sp.					
<i>Volvaria birmanica</i> Noëtl. . . .					
<i>Clavilites seminudus</i> Noëtl. . . .					Thayetmyo.
<i>Lathyrus indicus</i> n. sp. . . . .					
<i>L. (Peristernia) Gautama</i> [Noëtl.] . .					
<i>Vasum basilicum</i> [Bell.] . . . . .					Oligocene of Liguria.
<i>Melongena pseudobucephala</i> Noëtl. . .					
<i>M. (Pugilina) praeponderosa</i> n. sp. . .					
<i>Siphonalia (Kelleia) Iravadica</i> . . .					<i>Cytherea promensis</i> bed.
<i>Cyrtochetus (Lozotaphrus) minbuensis</i> [Noëtl.]					
<i>Tritonidea Martiniana</i> [Noëtl.] . . .					

SYSTEMATIC LIST SHOWING THE DISTRIBUTION OF THE REVISED  
SPECIES—*contd.*

	YENANGYAT (Stampian.)	MINBU (Upper Stampian.)	SINGU (Chatian.)	KAMA (Aquitanian.)	Other Occurrences.
<i>Eburna lutosa</i> Lam. var. . . .					
<i>Murex</i> ( <i>Chicoreus</i> ) <i>arakanensis</i> Noetl.					
<i>M.</i> ( <i>Muricantha</i> ) <i>iravadicus</i> n. sp. .					
<i>M.</i> " " " var. <i>yenanensis</i> n. var					
<i>Tritonium</i> ( <i>Lampusia</i> ) <i>dubium</i> [Noetl.]					
<i>Hindsia birmanica</i> n. sp. . . .					
" <i>neastriatula</i> [Noetl.] . . .					
" <i>pardalis</i> [Noetl.] . . .					
" <i>neacolubrina</i> [Noetl.] . . .					Nari of Sind.
<i>Ranella tubercularis</i> Noetl. . . .					
" <i>antiqua</i> n. sp. . . .					
<i>R.</i> ( <i>Pseudobursa</i> ) <i>promensis</i> n. sp. .					
<i>Cassidea birmanica</i> n. sp. . . .					
<i>Cassidaria echinophora</i> [Linn.] var. <i>monilifera</i> Noetl.					
<i>Cassidaria echinophora</i> [Linn.] var. <i>promensis</i> n. var.					
<i>Pirula condita</i> Brongn. . . .					Nari of western India, oligocene and miocene of Europe.
" " var. <i>singuënsis</i> n. var.					
" <i>promensis</i> n. sp. . . .					
<i>Cypraea</i> ( <i>Bernayia</i> ) <i>singuënsis</i> n. sp.					Thayetmyo.

SYSTEMATIC LIST SHOWING THE DISTRIBUTION OF THE REVISED SPECIES—*concl'd.*

	YENANGYAT (Stampian.)	MINBU (Upper Stampian.)	SINGU (Chattian.)	KAMA (Aquitanian.)	Other Occurrences.
<i>C. (Cypraeotrivia) Oppenheimi</i> n. sp.					
<i>Trivia Noeltingi</i> n. sp. . . . .					
<i>Rimella (Dientomochilus) javana</i> Mart.					
<i>Rimella (Dientomochilus) promensis</i> n. sp.					
<i>Turritella angulata</i> Sow. . . . .					Gáj of western India.
" <i>Noeltingi</i> n. sp. . . . .					
" <i>magnasperula</i> Sacco.					Nari of Balúchistán.
<i>Calliostoma Blanfordi</i> Noetl. . . . .					
" <i>singuense</i> n. sp. . . . .					
<i>Batissa Crawfordi</i> Noetl. . . . .					Yenangyaung.
" <i>kodoungensis</i> Noetl. . . . .					Yenangyaung.
<i>Ostrea digitata</i> Eichw. var. <i>Rohlfsi</i> Fuchs.					Akauktaung horizon, Mekran beds.
<i>Ostrea Virleti</i> Desh . . . . .					Akauktaung horizon, Mekran beds.

Incomplete though it may be, the foregoing list illustrates some interesting features in the distribution of the species. The independence of the Kama fauna compared to the three other faunas, as had already been noticed by Dr. Stuart, is particularly evident. The Singu fauna, with 17 species, is intercalated between the Minbu and Kama faunas, including 27 species each, and therefore of equal relative importance; yet, it contains no less than 9 fully identical forms in common with the Minbu fauna, and only 2 in common with that of Kama, the latter figure rising to four if we also take varieties

into consideration. It has even more species in common with the Yenangyat fauna from which only 18 forms have been identified, than with the Kama fauna, the instances of full identity with Yenangyat amounting to 4, and with Kama, as already mentioned, to not more than 2. If, in addition to instances of full identity, we also take into account species represented by varietal modifications, the number of identical species in the Singu fauna rises to 4, as already mentioned, when compared with that of Kama, and 5, when compared with that of Yenangyat. The difference in the degree of relationship cannot altogether be attributed to differences of facies, for, while the Singu fauna certainly corresponds with shallower conditions of deposition than the deep-sea fauna of Kama, the bathymetric conditions of the Minbu and especially of the Yenangyat fauna do not widely differ from those of Kama.

The intermediate position of the Minbu fauna relatively to those of Yenangyat and Singu is indicated by the approximately equal proportion of common species on both sides: 10 with the Yenangyat fauna, 9 with that of Singu.

Amongst the forms dealt with by Noetling that have, so far, been examined, only one, *Clavalithes seminudus*, is common to the four faunas.

It may be noticed that out of 43 species constituting the aggregate fauna of Yenangyat, Minbu and Singu, there are six that occur also in the Nari beds of western India, which are known to be of oligocene age. Two of these, *Conus ineditus* and *Turritella magnasperula*, are characteristic oligocene fossils in Europe, while *Pirula condita* occurs abundantly in Europe, both in the oligocene and miocene. Another form, *Vasum basilicum*, not known in western India, also characterises the oligocene of Europe. These characteristic oligocene forms are fairly equally distributed through the three faunas of Yenangyat, Minbu and Singu. Attention may also be drawn to the genus *Volvaria*, not known in Europe in beds newer than oligocene.

The oligocene age of the Yenangyat-Minbu-Singu fauna cannot admit of any doubt.

Amongst the forms from the Yenangyat-Minbu-Singu fauna enumerated in the foregoing list, there is only one instance of full identity with a Gáj fossil, *Turritella angulata*, only found in the newest subdivision, the Singu stage. *Conus odengensis*, also a Gáj species, is represented at Minbu and Singu by a different variety.

Amongst the Kama fossils of the foregoing list, there are two instances of full identity with the Gáj fauna of western India: *Conus odengensis* and *Turritella angulata*. Four species, *Terebra samarangana*, *Drillia protocincta*, *Conus odengensis*, and *Rimella javana*, occur in the Tertiary beds of Java, either at the horizon of the Gáj in the Rembang and Njalindung Series, or at newer horizons. *Conus Bonneti* and *Conus vimineus* are known from the Upper Tertiary beds of Karikal, the latter being known also from the Mekran Series.

The foregoing list includes three species still living, *Conus vimineus*, *Eburna lutosa*, *Cassidaria echinophora*, all three of which are known in the Kama fauna, while the form last named is also known in the fauna of Singu. The proportions of living forms reckoned from a fauna represented only by a small number of species are apt to mislead, and a full discussion of the relationship of the fauna to that of the present day will best be deferred to a future occasion when fuller lists of species can be taken into consideration.

The present revision affords important data in support of the extremely interesting conclusions arrived at by Mr. Cotter regarding the gradual deepening, in a southern direction, of the basin in which were deposited the Tertiary strata of the Irrawadi region. This question has been ably discussed in several of Mr. Cotter's valuable contributions to the geology of Burma. (See especially: *Rec. Geol. Surv. Ind.*, Vol. XLIV, p. 166, Vol. XLVII, p. 63 and map, pl. i, *Journ. As. Soc. Beng.*, new ser., Vol. XIV, pp. 609 ff.). In whatever manner we may interpret the equivalence of the marine Akauktaung beds, their presence in Lower Burma constitutes a powerful argument in support of the conclusions established by Mr. Cotter, for, if they coincide with the stratigraphical gap below the Irrawadi Series of Upper Burma, they represent, in Lower Burma, the persistence of a marine basin when the region further north must have emerged; or, if, as is more probable, the marine Akauktaung beds are equivalent to the fresh-water Irrawadi Series, they obviously indicate, in southern Burma, a deeper lie of the earth's crust than further north during the period of their deposition.

The facts discussed in Parts I and II of the present study have demonstrated the contemporaneity of the estuarine *Batissa* beds of the petroliferous anticlines of Upper Burma with the marine beds of either the Kama or Pyalo stage further south. Mr. Cotter has already commented on the lateral variation of facies in a northerly

direction which affects "the Kama Clay, a formation which is represented by sands or conglomerates without well preserved fossils in Minbu." (*Journ. As. Soc. Beng.*, new ser., Vol. XIV, 1918, p. 414).

We wish particularly to draw attention to the fact that Mr. Cotter's conclusion regarding the emergence of the Arakan Yoma in eocene times (*Journ. As. Soc. Beng.*, new ser., Vol. XIV. p. 412), entirely corresponds with Dr. Tobler's conclusions regarding the period of upheaval of the Barissan Range which constitutes its southern extension in Sumatra. (*Tijdschr. van het koninkl. nederl. aardrijkskundig genootsch.*, Jaarg. 1906, p. 292, and concluding general tabular statement). At as early a period as the eocene, the great longitudinal depression constituted by the Irrawadi basin, the sea of Pegu, and the lowlands of East-Sumatra, already existed as an elongated area of subsidence between the two concentric orographic elements Naga-Arakan-Andaman-Nicobar-Barissan and Shan-Malacca-Banka, and was already more or less continuously separated from the Indian Ocean by the Arakan-Barissan line of upheaval.

NOTE ON THE MARINE FOSSILS COLLECTED BY MR.  
 PINFOLD IN THE GARO HILLS. BY E. VREDENBURG,  
*Superintendent, Geological Survey of India.* (With  
 Plates 8 and 9.)

## CONTENTS.

	PAGE.
INTRODUCTION . . . . .	303
DESCRIPTION OF FOSSILS . . . . .	304
AGE OF THE FAUNA . . . . .	321
1. Tertiary sequence in Burma . . . . .	321
2. Tertiary sequence in north-western India . . . . .	322
3. Tertiary sequence in Java . . . . .	326
4. Equivalence of the Garo Tertiary . . . . .	329
Other occurrences of newer tertiary fossils in north-eastern India . . . . .	330

## INTRODUCTION.

IN a previous communication (*Rec. Geol. Surv. Ind.*, Vol. L, p. 126), Mr. Pinfold has given the stratigraphical details regarding the occurrence of the interesting tertiary fossils which he has been so good as to place at my disposal for study.

The fossils collected by Mr. Pinfold were obtained from two localities of which the more easterly is near the banks of the Sumeswari river, one mile and a half south-west of the village of Bagmara, the more westerly, four miles north of the town of Dalu. The rock containing the fossils is of a blue colour weathering to yellowish green, and varies from a clay to an impure argillaceous and calcareous fine-grained sandstone, with minute grains of quartz and mica. The rock from Dalu is generally more arenaceous than that from Bagmara.

The organic remains are mostly those of mollusca with delicate shells, such as might have lived at a depth of some thirty fathoms. There are also shark's teeth and otoliths.

The shells are mostly fragmentary and include specifically undeterminable specimens of *Conus*, *Oliva*, *Murex*, *Natica*, *Solarium*, *Calyptraea*, *Arca*, *Pecten*, *Ostrea*, *Lucina*, *Dosinia*, *Venus*, *Tellina*,



in addition to which the following nine forms have been specifically identified :—

- Terebra protomyuros* Noetl.  
*Surcula promensis* n. sp., var. *silistrensis*.  
*Drillia protocincta* Noetl.  
 „ *tjemoroënsis* Mart. var.  
*Mitra chinensis* Gray, var. *subscrobiculata* d'Orb.  
*Siphonalia subspadicea* n. sp.  
*Turritella Pinfoldi* n. sp.  
 „ *angulata* Sow.  
*Calliostoma promense* n. sp.

#### DESCRIPTION OF FOSSILS.

The following notes are concerned with the species enumerated in the foregoing list.

Several of the forms obtained by Mr. Pinfold belong to species hitherto unpublished, which are described in detail below.

#### TEREBRA (MYURELLA) PROTOMYUROS Noetling.

1901. *Terebra protomyuros* Noetling.—*Pal. Ind.*, new ser., Vol. I, part 3, p. 335, pl. xxii, fig. 14.  
 1901. *Strioterebrum bicinctum* Mart. sec. Noetling.—*Pal. Ind.*, new ser., Vol. I, part 3, p. 337, pl. xxii, fig. 15.  
 non *Terebra bicincta* Hinds, 1843.  
 non *Terebra bicincta* Martin, 1879.

The Bagmara specimens correspond with the typical form from Burma. The fossil referred by Noetling to *Terebra bicincta* Martin belongs to the same species as the type of *T. protomyuros*, though the Javanese *T. bicincta* also exists in Burma, and may be distinguished as *Terebra Martin* its specific name being pre-empted.

*Occurrence*.—Bagmara.

#### SURCULA PROMENSIS n. sp.

Pl. VIII. figs. 1-3.

Both the localities explored by Mr. Pinfold have yielded specimens of a handsome *Surcula* which corresponds specifically with a fossil from the Kama horizon of Burma, although exhibiting some slight differences which may entitle it to rank as a variety. The Burmese

specimens are more complete than those from the Garo hills, and it will be convenient to describe them as representing the typical form.

*Description.*—Fairly large, ventricose, with broad conical spire measuring half the total height, and with broad body-whorl rapidly contracted anteriorly into a stem of medium length, rather tortuous at its extremity. The apex is missing in all the available specimens. The number of whorls following the protoconch should probably be ten. Their height is equal to two-fifths of their breadth, the maximum thickness being situated close to the anterior margin, or even, at the earliest stages of growth, coinciding with it. The linear, inconspicuous, finely wavy sutures, are surrounded by a moderately broad, moderately prominent raised band which, at the earliest stages of growth, is divided into two very unequal portions, of which the anterior one, which is the broader and more prominent, constitutes a torus-shaped spiral thread, while the narrower posterior portion fits tightly round the anterior margin of the preceding whorl, the ribs or nodosities of which account for the fine waviness of the sutures. With increasing growth the portion nearest the suture becomes divided by a groove, and fine spiral lines are developed on the anterior torus-shaped portion, which gradually widens till it separates into several narrow threads, the sub-divisions of the posterior portion also assuming the appearance of thin threads, till, in full-grown specimens, the entire circumsutural band assumes the appearance of a moderately broad, rather flat rim bearing six or seven contiguous spiral threads of irregularly alternating dimensions, amongst which the original disposition of the earlier whorls is no longer recognisable. Slight nodosities are observed on the circumsutural band of some specimens.

At the earliest stages of growth, the portion of the whorls situated between the circumsutural band and the anterior margin has the shape of a slightly quirked ogee (inverted when the shell is placed with apex upward); the concave and convex portions are about equal. With increasing growth the concave portion increases considerably in relative height at the expense of the anterior portion. At the same time, its degree of curvature decreases, and it assumes the appearance of a broad, slightly concave, conical shape. The anterior portion, now reduced to the condition of an anterior marginal swelling, becomes feebly convex, almost cylindrical, slightly contracted towards the anterior margin. Numerous thin, rod-like, short ribs, rather strongly oblique and anteriorly antecurrent, narrower

than the intervening spaces, decorate the anterior band. They have a tendency to swell at their posterior terminations along the margin of the concave band. On the last spire-whorl these swollen terminations tend to assume more definitely the appearance of distinct nodes, anteriorly to which the original ribs tend to lose their individuality through bifurcation. Delicate spiral threads, usually broader than the intervening spaces, or even quite contiguous and separated by mere linear furrows, cover the entire surface of the anterior marginal swelling and of the concave band. On the second spire-whorl beyond the protoconch, their number is four or five on the anterior marginal swelling, and about the same on the concave band. With increasing growth their relative number increases more on the concave band than on the anterior marginal swelling, in consequence of the alteration in the relative width of these two elements, until, on the last spire-whorl of full-grown specimens, there may be as many as eleven spiral threads on the anterior marginal swelling and fifteen on the concave band. In some specimens more than in others, they alternate more or less regularly in two sizes. Those decorating the anterior marginal swelling are always much broader than the intervals, while, in exceptional cases, they may become narrower than the intervals on the concave band at later stages of growth. All the spiral ornaments are elegantly decussated by the lines of growth which are steeply antecurrent or even, at later stages of growth, normal to the posterior suture, and which form, near the posterior margin of the concave band, a deep sinus, anteriorly to which they are very oblique and anteriorly antecurrent, curved with forwardly directed convexity, and reach the anterior margin antecurrently.

The large body-whorl measures five-sevenths of the total height. Anteriorly to the posterior part of the body-whorl which corresponds in shape with the spire-whorls, the base contracts rapidly with a very flat outline connected by a broad concavity with the terminal stem, which is of medium length, tapering in an anterior direction. It is terminated by a truncation oblique towards the right of the shell, the accretions to which constitute a steeply winding, slightly bulging zone in consequence of which the extremity of the stem is slightly deflected dorsally and towards the left of the shell. Over the posterior portion of the body-whorl, corresponding with the spire-whorls, the ornamentation is the same as on the last spire-whorl, the ribs being reduced to delicate oblique nodes along the

angulation that divides the posterior slightly concave slope from the anterior convexity. Anteriorly, from the level of the suture to the terminal zone of accretions, the whole surface is decorated with spiral threads alternating fairly regularly in three orders, those of the first order being always particularly conspicuous, the difference in the degree of prominence between them and the threads of the second order being much more marked than the difference between the threads of the second and third order. The two first principal threads anteriorly to the level of the suture are slightly more prominent than any of the other principal threads of the body-whorl. All the principal threads of the body-whorl are elegantly granulated by the intersections with the raised lines of growth. The lines of growth are antecurrent anteriorly as far as the more anterior of the two particularly prominent threads above mentioned, anteriorly to which they are vertical up to the margin of the terminal twisted zone. The terminal zone has a strongly scaly structure, which to a great extent confuses and obliterates the thin, crowded, raised spiral lines with which it is decorated.

The large aperture is broadly lanceolar, posteriorly angulated, anteriorly contracted into the oblique terminal canal. The columella is oblique, with a broad convex bend opposite the entrance to the canal, anteriorly to which it becomes still more oblique towards the left of the shell up to its termination. The columellar lip is extremely thin, rather ill-defined at its posterior termination. The outer lip, normal to the suture, is strongly prominent anteriorly to the rather broad sinus. The internal walls of the shell carry rather wide-spaced, delicate, sharply defined revolving liræ.

*Dimensions.*

	<b>mm.</b>
Height . . . . .	35
Thickness . . . . .	16
Height of spire . . . . .	18
Height of body-whorl . . . . .	24

*Occurrence.*—Kyaungon, Myaukmigon, Thanga.

*Comparison with other species.*—This is undoubtedly a premutation of *Surcula javana* Linn. (*S. nodifera* Lam.), of the eastern seas from Malacca to Japan, compared with which the Burmese fossil is somewhat smaller with a slightly broader spire. Its sinus band is decidedly broader, more distinctly concave, and not so sharply

marked off from the posterior circumsutural rim and the anterior circle of nodes. The Burmese fossil is further distinguished by the granulations of the body-whorl and by the internal liræ.

In several of its characters, such as the relatively feeble prominence of the anterior nodes, the granulations of the base, and the internal liræ, this shell agrees with some of the fossil varieties of *Surcula javana* described by Martin from Java (*Samml. des geol. R.-Mus. in Leiden*, new ser., Vol. I, p. 27, fig. 67), which represent therefore an intermediate link between the Burmese fossil and the living species.

The fossil specimen of *Surcula javana* described by Cossmann from Karikal (1900, *Journ. Conch.*, Vol. XLVIII, p. 33, pl. iii, fig. 8) agrees with the recent form in the absence of granulations from the base, though it still recalls the Burmese and Javanese fossils owing to the feeble prominence of the anterior nodes. It seems evident that a continuous history of the development of the recent species is recorded by these successive fossil occurrences.

#### SURCULA PROMENSIS VAR. SILISTRENSIS.

##### Pl. VIII, fig. 4.

Compared with the Burmese type, the Garo specimens are distinguished by a slightly narrower shape and slightly more crowded nodes along the anterior swelling of the whorls. In some specimens from both the localities explored by Mr. Pinfold, the nodes disappear entirely on the last spire-whorl and body-whorl, while the spiral threads over the entire surface of the last spire-whorl and the corresponding part of the body-whorl become very conspicuous and uniform; such specimens constituting a local race which might be distinguished as *dimorpha*. In some specimens the circumsutural swelling maintains its unsymmetrical bipartite disposition up to the termination of the spire, and even on the body-whorl where it constitutes an almost uniform, flat, band, with only some feeble threads or striations distributed over the original main divisions; this disposition being observed only in such specimens in which the anterior nodes remain well developed throughout the whole shell. In accordance with the peculiar smoothness of the circumsutural swelling, such specimens never exhibit any posterior nodes, while the circumsutural swelling is slightly nodular at early stages of growth in some specimens of the race *dimorpha*.

All the other characters described from the Burmese specimens are exactly reproduced in the shells from the Garo Hills. It should be noticed that, in the race *dimorpha*, in spite of the absence of nodes anteriorly to the sinus-band on the body-whorls the base is as distinctly granulated as in the other races or varieties. Owing to the friability of the Garo specimens, it is not possible to clear the interior of the shells of their rocky contents; fortunately one of the specimens exhibits, on the rocky infilling, a distinct internal cast of the inner walls of the body-whorl, showing that they are lirate just as in the Burmese specimens.

Owing to their slightly narrower shape, the Garo specimens approach *Surcula javana*, in general outline, more than the Burmese shells; this being counterbalanced by the complete disappearance of the nodes at later stages of growth in the race *dimorpha*, the ornamentation of which thereby differs from that of *Surcula javana* more than that of the Burmese form. The Garo form is a collateral development relatively to the Burmese species, and does not constitute an intermediate link between the Burmese form and *Surcula javana*.

*Dimensions.*—The following are the restored measurements of a specimen from the neighbourhood of Bagmara:—

Height	. . . . .	mm.
Thickness	. . . . .	50
Height of spire	. . . . .	18
Height of body-whorl	. . . . .	24
		32

*Occurrence.*—Bagmara, Dalu.

#### DRILLIA PROTOCINCTA Noetling.

1901. *Drillia protocincta* Noetling.—*Pal. Ind.*, new ser., Vol. I, part 3, p. 356, pl. xxiii, figs. 6, 7.  
 1906. *Pleurotoma (Drillia) madiumensis* Martin.—*Samml. des. geol. Reichsmus. in Leiden*, n. F., Vol. I, p. 296, pl. XLIII, fig. 707.

The specimens from the Garo hills are well preserved and strictly correspond with the Burmese and Javanese fossils.

*Occurrence.*—Dalu.

#### DRILLIA (BRACHYTOMA) TJEMOROENSIS Martin, var.

1906. *Pleurotoma (Drillia) tjemoroensis* Martin.—*Samml. des. geol. Reichsmus. in Leiden*, n. F., Bd. I, p. 295, pl. xliii, fig. 705.

This species is abundantly represented in Burma by a variety which differs from the solitary Javanese type owing to its slightly

less numerous ribs. It is also represented, in the collection from the Garo hills, by a specimen which agrees with the Burmese variety.

*Occurrence.*—Dalu.

MITRA CHINENSIS Gray, var. SUBSCROBICULATA, d'Orbigny.

1839. *Mitra chinensis* Gray.—Beechey's Voyage, p. 125, pl. xxxv, fig. 2.

1839. *Mitra scrobiculata* Brocchi?—J. de C. Sowerby, *Trans. Geol. Soc. Lond.*, 2nd ser., Vol. V, pl. xxvi, fig. 23.

1852. *Mitra subscrobiculata* d'Orbigny. *Prodr. Pal.* Vol. III, p. 54, No. 922.

Mr. Pinfold's collection contains a specimen of a *Mitra* identical with the above quoted fossil from Kachh, first described by Sowerby. Like the Kachh form, the specimen from the Garo hills differs from the living *Mitra chinensis* by the smaller size of the full-grown condition, and the more slender outline at equal dimensions.

*Occurrence.*—Bagmara.

SIPHONALIA (KELLETTIA) SUBSPADICEA n. sp.

Pl. IX, fig. 6.

Medium-size, moderately ventricose, with moderately broad conical spire, slightly contracted at the sutures, equal to nearly half the total height.

The protoconch is broken in the solitary available specimen. It is followed by five spire-whorls, the height of which is equal to two-fifths of their width, the maximum thickness being situated quite close to the anterior margin. They exhibit a continuous almost even convexity except quite close to the posterior margin where the outline is inflected, through a short concavity, into a short nearly vertical surface closely fitting round the anterior portion of the preceding whorl. There is sometimes a feeble angulation close to the anterior margin. The sutures are linear, inconspicuous, slightly wavy. The whorls are decorated with almost vertical ribs, the exact number of which cannot be ascertained on the first two whorls following the protoconch on account of the surface of the shell being weathered. On each of the three last spire-whorls, their number is eleven. They are convex and somewhat narrower than the intervening spaces. In addition to the axial ribs, the whorls carry, at first, seven well-defined spiral threads, narrower than the intervals. The most posterior thread encircles the posterior suture, the most anterior one almost coincides with

the anterior margin. The second thread, counting from the posterior margin, forms the anterior limit of the steep narrow circumsutural region. The sixth tread, that is, the second counting from the anterior margin, coincides with the slight anterior angulation of the convexity. On the penultimate spire-whorl, the number of spiral threads increases to ten on account of the development of intercalary threads of a second order, bisecting each of the three more anterior primary intervals, which are somewhat wider than the three posterior intervals. On the last spire-whorl, an intercalary thread also appears in the fourth interval counting from the anterior margin, thereby raising the total number of spiral threads to eleven. The lines of growth are crowded, evenly distributed, extremely delicate, antecurrent to the posterior suture, normal to the anterior margin.

The large body-whorl measures five-sevenths of the total height. The posterior portion of the body-whorl is similar in outline to the spire-whorls of which it forms the continuation. Anteriorly to the level of the suture, the surface contracts gradually with a moderate convexity continuous with that corresponding to the convex surface of the spire-whorls; the main portion of the body-whorl thereby acquiring a globose or ovoid outline, anteriorly connected, by means of a shallow concavity, with the anterior stem which is slightly tortuous in consequence of the steeply twisted zone of accretions of the terminal notch. The axial ribs, on the body-whorl, are much wider-spaced than on the spire-whorls, their total number amounting only to eight. In an anterior direction they disappear before reaching the concave zone of the base, with the exception of the last rib accompanying the aperture, which is more prominent than the others, and reaches the anterior stem. The two or three last ribs previous to the terminal rib exhibit a slight tendency to become spinose at the level of the angulation continued from the anterior portion of the spire-whorls. The spiral ornamentation of the last spire-whorl is continued, without any change, over the corresponding portion of the body-whorl. Anteriorly to the level of the suture, the whole of the convex portion of the base is ornamented with spiral threads regularly alternating in two orders of magnitude, and so distributed that, of the six primary intervals that separate the threads of the first order, the three most posterior ones are of the same width as the adjacent primary intervals continued from the spire-whorls, while the three more anterior ones are much wider.



The spacing again contracts on the concave zone, which carries three threads of the first order, with only very fine, indistinct raised lines bisecting the intervals. On the terminal stem, the alternation in two well-developed orders is once more resumed, with a total number of seven or eight threads as far as the terminal twisted zone, which only carries slightly scaly accretions of the terminal notch, without distinct spiral ornaments. The lines of growth, on the posterior portion of the body-whorl coinciding with the spire-whorls, are disposed in the same way as on the spire. Anteriorly to the level of the suture, they are vertical as far as the concave zone where they become anteriorly retrocurrent, the obliquity increasing on the anterior stem, till they become transverse on the terminal twisted zone which they cross with a shallow sinuosity corresponding to the anterior termination of the canal.

The aperture, greatly obscured in the solitary available specimen, by a rocky incrustation that cannot be safely removed, is oval-lanceolar, abruptly contracted anteriorly into a narrow canal steeply oblique anteriorly towards the left, slightly curved with concavity turned to the right, and slightly deflected dorsally. The columella exhibits a bend opposite the origin of the canal, anteriorly to which it shares the steep obliquity of the canal anteriorly towards the left, while, posteriorly to the bend it is at first steeply oblique in the opposite direction, and merges, by means of a gentle curvature, into the base of the penultimate whorl. The columellar lip is almost entirely concealed, but is evidently not thickened. The most posterior portion of the outer lip is antecurrent to the suture; the greater part of its course is straight and vertical, becoming anteriorly retrocurrent only on approaching the anterior termination of the shell. Externally it is thickened, almost throughout its entire length, by the prominent terminal rib. Its sharp margin is frilled by the terminations of the spiral ornaments, the lines of growth becoming slightly squamose in the immediate neighbourhood of the margin. The internal characters of the outer lip are entirely concealed.

*Dimensions.*

	mm.
Height . . . . .	28
Thickness . . . . .	14
Height of spire . . . . .	13
Height of body-whorl . . . . .	20

*Occurrence.*—Dalu.

*Comparison with other species.*—This shell belongs to a group of upper tertiary and recent eastern forms, all of which are very closely related to one another, including *Siphonalia nodulosa* [J. de C. Sow] from the miocene of Kachh, a very closely related mutation, as yet unpublished, from the upper miocene or pliocene of the Mekran, *S. tjibaliungensis* Martin, from the pliocene of Java, and the recent species *S. spadicea* [Reeve], from Japan, *S. fusoides* [Reeve] also from Japan, *S. modificata* [Reeve] from Japan and Lower California, and *S. varicosa* [Chemn.], of unknown habitat. Amongst all these species, the recent *S. spadicea* comes nearest to the above-described fossil which is practically identical in shape, but is distinguished by the increased spacing of the axial ribs on the body-whorl, while the spiral decoration of the base is finer and more crowded in the living form than in the fossil. The above-described fossil also resembles *Siphonalia nodulosa* from the miocene of Kachh, but it is more slender than the Kachh form, and its axial ribs are narrower relatively to the intervening spaces.

TURRITELLA PINFOLDI n. sp.

Pl. IX, figs. 9-11.

Medium size, very elongate. The spire is equal to five-sixths of the total height. The protoconch is missing in all the available specimens. The number of spire-whorls following the protoconch is about sixteen. Their height is equal to three-fifths of their thickness, the maximum width being situated close to the anterior margin. The general outline of each whorl expands with a steep conical surface from the posterior margin to the region of maximum width, beyond which the short remaining space as far as the anterior margin contracts also with a conical surface, opposed to the first, and of somewhat wider angle. Each whorl carries three narrow prominent keels, one of which coincides with the zone of maximum thickness. The linear sutures lie in the concave depression between the most anterior keel of one whorl and the most posterior keel of the next whorl. Of the intervals between the three keels the more anterior one is distinctly the widest in some specimens in which the more posterior interval is equal to the space between the posterior keel and the suture. In other specimens there is scarcely any difference between the two intervals, in which case the space between

the posterior keel and the suture is wider than the posterior interval. Along the anterior margin of each whorl is a thread much less prominent than the keels, half concealed by the posterior edge of the next following whorl. The concave surface in which lies the suture, and the concave intervals between the keels, are divided into a multitude of extremely fine threads, visible only with the aid of a lens, separated from one another by linear incisions. Amongst these minute threads, the one bisecting the space between the posterior keel and the suture, is often slightly more prominent than the remainder. A similar disposition, though less marked, may sometimes be observed also in the intervals between the keels. The lines of growth are oblique, slightly curved, with forwardly facing concavity; they are strongly antecurrent to the posterior suture, retrocurrent, though less obliquely, towards the anterior margin.

The body-whorl measures one-quarter of the total height. The portion forming the continuation of the spire exhibits the same outline as the spire-whorls and is followed by a short, rapidly contracted, broadly conical base. The ornamentation of the spire is continued over the portion corresponding with the spire-whorls. The anterior, half-concealed thread of the spire-whorls, on running free of the suture, circumscribes the base which carries some fine spiral threads.

The rounded aperture is incompletely preserved, the columella and columellar lip being broken in all the available specimens. The outer lip is very oblique, antecurrent to the suture.

*Dimensions.*—The following are the approximate restored measurements:—

	mm.
Height . . . . .	66
Thickness . . . . .	17
Height of spire . . . . .	54
Height of body-whorl . . . . .	14

*Occurrence.*—Bagmara, Dalu; Myaungu in Upper Burma.

*Variability.*—The specimens from the Garo hills mostly have the intervals between the keels distinctly unequal, while they are subequal in the specimens from Burma. The shells from both regions agree in all other characters.

*Comparison with other species.*—The only tertiary three-keeled forms that are as elongate, or even more elongate than the above-described shell, are *Turritella ægyptiaca* Mayer-Eymar, from the

Lower Lybian of Egypt, and *T. Hollandi* C. and P., from the lower eocene of Sind, which is perhaps the same species. These lower eocene shells are distinguished by their more evenly convex whorls, the maximum thickness of which coincides with the central keel, not, as in the Garo and Burma fossil with the anterior keel<sup>1</sup> *Turritella tricarinata* Brochi, fossil from the miocene and pliocene of Europe, living in the seas of Europe and West Africa, also has the whorls more evenly convex, while its general outline is somewhat less elongate than that of the shell above-described. The recent three-keeled species, *Turritella trisulcata* Lam. (Red Sea), *T. cingulata* Sow. (Valparaiso), *T. cornea* Lam. (Europe) are more broadly conical than the shell under consideration.

TURRITELLA ANGULATA J. de C. Sowerby.

1839. *Turritella angulata* J. de C. Sowerby.—*Trans. Geol. Soc. Lond.*, 2nd ser., Vol. V, pl. xxvi, fig. 7.
1854. *Turritella angulata* J. de C. Sow.—D'Archiac and Haime, *Descr. an. foss. gr. numm. Inde*, p. 294, pl. xxvii, figs. 6-9.
1901. *Turritella angulata* J. de C. Sow.—Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 272, pl. xviii, figs. 13-15.
1901. *Turritella simplex* Jenk. *sec.* Noetling, *Pal. Ind.*, new ser., Vol. I, part 3, p. 273, pl. xviii, figs. 1-4.
1901. *Turritella acuticarinata* Dunk. *sec.* Noetling *Pal. Ind.*, new ser., Vol. I, part 3, p. 274, pl. xviii, figs. 5-7.
- non *Turritella angulata* Sow., *sec.* Cossmann and Pissarro, *Pal. Ind.*, new ser., Vol. III, part 1, p. 59, pl. vi, figs. 3-5 (1909).

*Turritella angulata*, an extremely variable species, is one of the commonest fossils in the Gáj beds of Kachh, Sind and Kathiawar, where forms identical with these referred by Noetling to *T. simplex* and *T. acuticarinata* occur abundantly and are connected by every possible gradation with one another and with the typical form first described by Sowerby. Martin (*Samml. des Geol. R.-Mus. in Leiden*, new ser., Vol. I, p. 226) does not agree with Noetling's reference of one of the Burmese forms to *T. acuticarinata* which is apparently a smaller shell than *T. angulata*, but accepts the identification of the form referred to *T. simplex*. Whether or not Noetling's *T. simplex* may correspond with the Javanese type of this species, it is certainly identical with the Burmese form referred to

<sup>1</sup> In *Paleontographica*, Vol. XXX, part 3, Oppenheim has represented two specimens, Pl. xxii, fig. 29, and Pl. xxiii, fig. 14, which agree with Mayer-Eymar's diagnosis of *Turritella aegyptiaca*. There appears to have been some confusion as regards the specimen represented by fig. 15, pl. xxiii, also referred to the same species, but which is a broadly conical shell, perhaps a *Mesatia*.

*T. acuticarinata* with which it is connected by numerous intermediate forms, and, as already explained, both the Burmese forms are identical with *T. angulata*. That the Javanese *T. simplex* may also belong to the same variable species seems plausible, but this question has not been fully investigated. It is also doubtful whether *T. angulata* is truly distinct specifically from the living *T. duplicata* Linn., but this is also a question that needs further study.

As already mentioned (see above, page 292), the lower eocene fossil from the Ranikot beds of Sind referred by Cossmann and Pissarro to *T. angulata* is specifically different, and may be distinguished as *T. Ranikoti*.

Amongst the shells from the Garo hills, many specimens correspond with the typical *T. angulata*, while others assume the bicarinate disposition of the form which Noetling has referred to *T. acuticarinata*.

*Occurrence*.—Bagmara, Dalu.

In Burma the species occurs throughout the Singu, Kama, and Pyalo stages, and also probably at higher horizons. In Western India it abounds in the Gáj beds and perhaps occurs in the Mekran.

#### CALLIOSTOMA PROMENSE n. sp.

Pl. VIII, fig. 5. Pl. IX, figs. 7, 8.

Medium size, moderately broad, slightly extraconic.

The protoconch, broken in all the available specimens, is followed by eight spire-whorls, the height of which is equal to one-quarter of their width at later stages of growth, and somewhat more in the earlier part of the spire in consequence of its extraconic shape. Leaving out of consideration the raised spiral ornaments, the conical or sometimes very feebly convex outline of the whorls is practically continuous from one whorl to another. The sutures are linear, shallow, inconspicuous. The whorls are beautifully decorated with four equidistant granulated keels of which the first and last respectively correspond with the posterior and anterior margins, so that the marginal keels of successive whorls are directly in contact with one another, being separated merely by the shallow line of the suture. On the four or five earliest whorls following the protoconch, the first, third and fourth keels, counting from the posterior margin, are subequal, while the second one is slightly narrower. On the later spire-whorls, the anterior marginal keel becomes much broader and

much more prominent than the three others which are narrower than the intervening spaces; there scarcely remains any difference in width between the second keel and the first and third. On the first five whorls following the protoconch, the spaces between the keels carry delicate oblique ribs, posteriorly antecurrent, connecting the granules of adjacent keels. On the later spire-whorls, the intervals between the keels are smooth, with extremely fine, crowded, strongly oblique, straight lines of growth, antecurrent to the posterior suture, retrocurrent to the anterior margin.

The body-whorl consists of two portions, one of which constitutes the continuation of the spire-whorls, and is connected at a sharp angle with the nearly flat base, the outline of which remains quite straight up to the axis in the majority of specimens, while occasionally the surface is slightly hollowed towards the axis, though without the formation of an umbilicus, the axis being solid throughout. In the majority of specimens, the portion of the body-whorl forming the continuation of the spire corresponds exactly in shape and ornamentation with the last spire-whorl. In a few of the largest specimens, all the granulated keels, on approaching the aperture, decrease considerably in width and prominence; at the same time the posterior margin becomes relatively slightly contracted, so that the suture is no longer in immediate contact with the anterior keel of the preceding whorl. As, at the same time, the posterior keel of the body-whorl, in consequence of its contraction, leaves a narrow space between its posterior edge and the posterior margin, the suture, unlike what is observed on the spire, is separated, on both sides, by a small space, from the adjacent keels. The atrophy of the keels is accompanied by the appearance of some rudimentary, ill-defined spiral threads in the two posterior spaces, while the third keel may be duplicated by a narrow subsidiary granulated keel immediately contiguous to it on its anterior side.

In some specimens the anterior granulated keel of the body-whorl is separated from the base by a deep narrow furrow, followed, concentrically towards the axis, at close intervals by three more furrows; the marginal furrow and the next one being atrophied in some specimens, and sometimes the next furrow also, in which case there remains but the last furrow, separated from the circumference by a flat space. In every specimen, this is invariably followed, towards the axis, by five more furrows at subequal or gradually increasing intervals, the last furrow being deeper and broader than

the others, sometimes with a small spiral thread along its floor. A flat, broad spiral keel separates this last furrow from the axial portion. All these concentric furrows are crossed by a second set of radiating furrows, disposed at regular intervals, strongly curved, with forward facing concavity, with a truly radial direction where they cross the innermost keel, becoming more and more oblique towards the periphery where they seem almost tangential. As there are no intercalations in this radiating set, the spacing becomes very close towards the axis, the innermost keel thereby acquiring a granulated appearance. The lines of growth follow the same direction as the radiating furrows; across the narrow space between the innermost keel and the columella or columellar lip, they become strongly oblique and retrocurrent towards the axis. Spiral grooves separate the narrow space just mentioned, on one side from the granulated keel, on the other side from the axial callosity.

The very oblique aperture is oval, with the greater diameter extending from the axis of the shell to the angulation of the base. The flattened columella is separated by a shallow groove from the callosity that fills the axis of the shell. Its anterior termination, and therefore its junction with the outer lip is missing in all the available specimens. The outer lip is mostly straight and strongly oblique. The interior walls are not lirate. The inner layer of the shell is brilliantly iridescent.

#### *Dimensions.*

	mm.
Height . . . . .	20
Thickness . . . . .	19
Height of spire . . . . .	14
Height of body-whorl . . . . .	10

There are also larger specimens, up to 22mm. in diameter.

*Occurrence.*—Dalu; also in Lower Burma, at Kyudawon and Myauktin.

*Remark.*—This easily recognisable species is represented in the Garo collection by a single fragment, readily identifiable in spite of its imperfect condition. Its base is decorticated and has consequently lost the shallower grooves, though the innermost granulated keel is still recognisable, but the characteristic ornamentation of the spire is well preserved, the transition from the decoration of the earlier to that of the later whorls being particularly distinct. The

fragment is too incomplete for illustration, and the foregoing description has been based principally on the Burmese specimens.

*Comparison with other species.*—Amongst quadricarinate species of Trochidæ, the only one that might be related to the remarkably beautiful shell above-described, is *Trochus fragum* Philippi, of unknown habitat, if indeed it is a *Calliostoma* (Pilsbry suggests that it may be a *Thalotia*). The ornamentation of the spire decidedly resembles that above-described, but the ornamentation of the base is quite different. *Trochus australis* Broderip, from Australia, is more elongate than the form under consideration, and there appears to be a space between the posterior keel and the suture, so that the marginal keels of adjacent whorls do not come into contact as in the shell under consideration.

In both his monographs concerning the Tertiary fauna of Burma, Noetling has described and figured, under the name of *Trochus Blanfordi* or *Calliostoma Blanfordi*, certain fossils which bear some relation to the shell under consideration (1895, *Mem. Geol. Surv. Ind.*, p. 16, pl. iv, figs. 3, 4; 1901, *Pal. Ind.*, new ser., Vol. I, p. 253, pl. xvii, figs. 5-8). The figures representing these fossils in both monographs are inaccurate. The description in the first monograph is precise and accurate, that in the second monograph is inexact. The species was established in 1895 upon certain specimens from Minbu and Yenangyat. With these, in the second monograph, in 1901, was united a second form, occurring at a somewhat higher horizon, at Singu, represented in fig. 5, pl. xvii, (*loc. cit.*), which is possibly a mutation of the Minbu and Yenangyat form, but which differs so conspicuously that it cannot be conveniently included in the same species. It may be distinguished as *Calliostoma singuense*. In order to compare these fossils with the shell under consideration, it is necessary to indicate in what characters they differ from one another. Although the question has already been dealt with (see above, page 266), I here repeat the differential characters so as to avoid cross-references. *C. singuense* attains considerably larger dimensions than the genuine *C. Blanfordi*. The spire-whorls of *C. Blanfordi* are much more concave than those of *C. singuense*. At early stages of growth, both forms are quadricarinate; only, while the posterior marginal keel, in *C. Blanfordi*, as in *C. promense*, is immediately contiguous to the suture, there intervenes a small space in *C. singuense*. In both species, as in *C. promense*, the second keel is the feeblest, the fourth, the most prominent; not, as stated by



Noetling, the third, a statement contradicted by his own illustrations. On the later spire-whorls of *C. Blanfordi* there invariably appears a secondary granulated keel bisecting the posterior interval, and almost always a similar secondary keel similarly bisecting the next interval; so that the later spire-whorls nearly always exhibit as many as six keels, and never less than five. A similar change takes place in the later spire-whorls of *C. singuënsis*, but only in the posterior interval, so that there are never more than five keels, and the subsidiary keel is relatively much less prominent than in *C. Blanfordi*. Moreover, owing to the great difference in size between the two species, *C. singuënsis* still shows only four keels at a size equal to that of the full-grown specimens of *C. Blanfordi*. Noetling never detected the presence of a fifth keel in the Singu specimens. In 1895, when dealing with the genuine *Trochus Blanfordi*, from Yenangyat and Minbu, Noetling quite correctly stated that, in addition to the two anterior main keels, "there are from two to four revolving lines of very regular small round tubercles," (*loc. cit.*, p. 16), which correctly makes up a total varying according to the stage of growth, from four to six. In 1901, Noetling was perplexed at observing only four keels on the Singu shells, and amended his original description by stating that "at least a specimen from Yenangyat distinctly shows a larger number than four" (*loc. cit.*, p. 254).

The base is totally different in both the species figured by Noetling, and, in both of them totally differs from that of the shell from Kyudawon and Myauktin. In addition to a thick peripheral granulated keel, the base of *C. Blanfordi* exhibits an extremely beautiful ornamentation consisting of thirteen concentric granulated keels alternating in two sizes. On the base of *C. singuënsis*, there are ten concentric, smooth, flat bands, exhibiting an imbricated or stepped disposition, each band being separated from the next outer one by a small declivity facing outward.

It has been necessary to dwell at length upon the characters of these shells in order clearly to establish their distinctness from the Kyudawon and Myauktin fossil, this being one of the many unfortunate instances in which Noetling has based his conclusions upon material in a state of preservation totally unfit for study.

I may now observe that *C. Blanfordi* is distinguished from *C. promense* by its concave whorls; while, both in *C. Blanfordi* and *C. singuënsis* the spire-whorls are relatively taller, and therefore

fewer than in *C. promense*. Intercalary granulated keels are never developed in *C. promense*: the occasional duplication of the third keel on the body-whorl being caused, not by intercalation, but by the addition of a small contiguous band on the anterior side of the keel, therefore in the anterior space, precisely that which never carries any subsidiary ornaments, in either of the two other forms, not even in *C. Blanfordi*. The system of intersecting furrows on the base of *C. promense* differs so completely from the granulated keels of *C. Blanfordi* and from the imbricated smooth bands of *C. sin-guense*, as to need no further comparison.

## AGE OF THE FAUNA.

### 1. Tertiary sequence in Burma.

In attempting to define the age of the fossils above described, it is necessary briefly to summarise what is already known of the succession of Tertiary beds in the various provinces of the East-Indies.

The region nearest to the Garo hills in which a definite succession has been established is Burma. The succession of the post-eocene formations of Burma has already been discussed in the present volume (see principally page 243). By combining the sequence of post-eocene beds already discussed with the classification of the eocene established by Mr. Cotter (*Journ. As. Soc. Bengal*, new ser., Vol. XIV, p. 415), we obtain the following scheme:—

- |   |  |  |
|---|--|--|
| 12. Irrawadi Series, sandstones and clays, about 6,000 ft.  | Akaukaung series, probable marine equivalents of the Irrawadi Series, sandstones and shales, about 4,000 ft. | Pliocene and Pong-tian (? with Vindobonian). |
| 11. Pyalo stage, sandstones, pebble-beds, shales, about 1,500 ft. (perhaps a basal member of the Akaukaung series). |  | Approximately Burdigalian.                   |
| 10. Kama stage, shales and sandstones, about 1,500 to 2,000 ft.   |  | Approximately Aquitanian.                    |
| 9. Singu stage, sandstones and shales, about 1,500 ft.  |  | Approximately Chattian.                      |
| 8. Sitsayan stage, principally shales, with subordinate sandstones, 1,500 to 3,000 ft.                              |  | Approximately Staimpian.                     |
| 7. Shwezetau stage, mostly sandstone, about 3,000 ft.   |  | Approximately Lattorfian.                    |

- |   |                 |
|---|-----------------|
| 6. Yaw stage, largely shales, about 1,500 to 2,000 ft. . . .                      | } Upper eocene. |
| 5. Pondaung stage, principally sandstone, 3,000 ft. and more . . .                |                 |
| 4. Tabyin stage, principally shales, about 5,000 ft. . . .                        | } Eocene.       |
| 3. Tilin stage, principally sandstones, 2,000 to 5,000 ft. . . .                  |                 |
| 2. Laungshe stage, principally shales, 9,000 to 12,000 ft. . . .                  |                 |
| 1. Paunggyi or Swelegyin stage, principally pebble-beds, 2,000 to 4,000 ft. . . . |                 |

As I have already had occasion to notice (see, above, page 259), I wish again to draw attention to the disagreement between this list and a stratigraphical table which was published in these same "Records" ten years ago, for which I am largely responsible (Vol. XLI, p. 253). As already mentioned, the great advance of knowledge realised during the intervening years accounts for these discrepancies. In every branch of scientific research, we should always bear in mind the dictum so felicitously expressed by Professor Daly (*Igneous Rocks and their Origin*, 1914, page xxii): "Science is built on a long succession of mistakes."

## 2. Tertiary sequence in North-Western India.

The only other area in the East-Indies where the Tertiary has been classified with the same fulness of detail as in Burma, is the north-western region of India, including Kachh, Sind and Baluchistan. Throughout this region, the classification first established by Blanford in 1876 (*Rec. Geol. Surv. Ind.*, Vol. IX, p. 9) is applicable over a vast extent of country. The only amendment to Blanford's scheme that has seemed necessary is the intercalation of the Laki division between the Ranikot and Khirthar.

Owing to the absence of any observed direct stratigraphical continuity either with the other members of the marine succession or with the fresh-water Manchhar beds, the exact position of the Mekran beds remained uncertain in Blanford's scheme. These beds have yielded a rich fauna, the study of which is now far enough advanced to supply precise indications of their age.

The Mekran beds include a total thickness of several thousand feet of strata in which fossiliferous layers occur at many horizons. The stratigraphical investigations so far carried out are not sufficiently detailed to refer these various fossiliferous horizons to their relative levels respectively to one another. The isolated local faunas

are usually not sufficiently abundant to establish a distinct succession from faunistic considerations. Certain fossiliferous beds constituting the Gwádar peninsula undoubtedly belong to one of the highest horizons, while the lowest fossiliferous horizon so far recognised is that exposed at the northern end of the Talar pass, on the road from Kej to Gwádar, along the northern foot of the Talar mountains, some fifty miles north-east of Gwádar. This is, fortunately, the richest fauna at present available and is very useful, therefore, in affording a lower limit to the age of the Mekran Series. The Talar fauna can clearly be shown to coincide with the Odeng fauna of Java, not only on account of its containing identical species, one of which is the highly characteristic mutational form *Melongena ponderosa* Martin, a valuable zone-fossil, but also on account of the proportion of living species, which closely corresponds with that observed in the Odeng fauna when reckoned for an individual zoological group taken by itself. The entire molluscan fauna has not yet been critically examined, but, reckoning from what is already known of it, the proportion of living forms is probably not far from 40 *per cent.* The Odeng gastropoda examined by Martin up to the year 1900 gave a proportion of living species of 42 *per cent.* (*Samml. des geol. Reichsmus. in Leiden*, ser. 1, Vol. VI, p. 161). The Odeng beds are placed by Martin at the limit of miocene and pliocene, therefore at about the level of the Pontian. We may take it as sufficiently established that the Talar beds, the lowest fossiliferous beds at present known in the Mekran Series, are approximately of Pontian age.

The various local faunas other than the Talar fauna, are, as already mentioned, too scanty to furnish severally useful data for reckoning the age of the beds by means of the proportion of living forms; yet, taken together, the fossils from these various localities constitute a rich fauna, which, when united with the Talar fauna, give an aggregate proportion of living forms of 50 *per cent.* or more. As the Talar fauna considered by itself, does not contain more than 40 *per cent.* of living forms, it is clear that, in order to make up an average of 50 *per cent.*, some of the later Mekran beds must yield a fauna with even more than 50 *per cent.* of living forms, probably as much as 60 *per cent.* In accordance, therefore, with Blandford's original surmise, the Mekran Series undoubtedly contains pliocene beds. Indeed, the newest beds probably reach high into the pliocene.

Although, with the stratigraphical data at present available, I cannot draw exact lines of demarcation between the various zones of the Mekran Series, yet, for general purposes, I may conveniently distinguish two stages: a lower Talar stage, approximately coinciding with the Pontian, and an upper Gwádar stage generally representing the pliocene.

The Mekran Series consists almost entirely of alternations of shales and sandstones, with some pebble-beds at the upper horizons. This is also generally the constitution of the fresh-water Manchhar beds of Sind. The Upper Nari consists largely of sandstones. The lowest division of the eocene of Sind, the Lower Ranikot, also consists of shales and sandstones. All the other divisions, throughout a vast belt of territory extending through a portion of Baluchistan and Sind, known as the calcareous zone, consist chiefly of limestones and calcareous shales (*Rec. Geol. Surv. Ind.*, Vol. XXXVIII, p. 190). As in some parts of southern Java, we are evidently here in the presence of a region which, during a vast succession of ages, scarcely received any detrital sediments, and in which the sedimentary formations are almost entirely of organic origin (cf. Martin, *Samml. des geol. Reichsmus. in Leiden*, ser. 1, Vol. IX, p. 143). In other parts of Baluchistan, throughout the region in which the rocks assume the "flysch" character, sandstones become abundant at the various horizons represented chiefly by limestones in the calcareous zone. Owing to these lateral changes of facies, the lithological constitution of the various divisions has not been entered in the following list of formations, from which the thicknesses have also been omitted owing to their great range of variation:—

## TERTIARY SEQUENCE IN NORTH-WESTERN INDIA.

	Marine.	Fresh-water.	Approximate age.
7. MEKRAN SERIES.	Gwádar stage with abundant <i>Pecten Vasseli</i> .	Upper Manchhar coinciding with the Upper Siwalik.	Pliocene.
	Talar stage with <i>Melongena ponderosa</i> , <i>Ostrea digitata</i> , <i>O. Virleti</i> .	Middle Manchhar generally coinciding with the Middle Siwalik.	Pontian.
	(Representatives not observed).	Lower Manchhar coinciding generally with the Nahan.	Vindobonian.

Marine.	Fresh-water.	Approximate age.	
6 (b). Upper Gáj with <i>Ostrea latimarginata</i> .	Bugti beds, corresponding to part of the Murrees.	Burdigalian.	
<i>Chiefly marine.</i>			
6 (a). Lower Gáj with <i>Lepidocyclina marginata</i> .	.....	Aquitanian.	
5 (b). Upper Nari with <i>Lepidocyclina dilatata</i> .	.....	Chattian.	
5 (a). Lower Nari with <i>Lepidocyclina dilatata</i> and <i>Nummulites intermedius</i> .	.....	Stampian.	
4. Poorly fossiliferous massive limestones of the Mula pass; elsewhere a stratigraphical gap.	.....	Lower oligocene and upper eocene.	
3. Khirthar with large nummulites and large assilines.	.....	Lutetian.	
2. Laki with <i>Nummulites atacicus</i> and <i>Assilina tattensis</i> .	.....	Lybian.	
1 (b). UPPER RANIKOT.	Zone 4, with <i>Nummulites planulatus</i>	.....	Upper Cuisian.
	Zone 3, with small nummulites and small assilines.	.....	Lower Cuisian.
	Zone 2, with operculines.	}	London Clay.
	Zone 1, with <i>Calyptrophorus indicus</i> .		
1 (a). Lower Ranikot (fresh-water except at base).		Thanet sands.	

I wish once more to draw attention to the conclusion, already expressed on previous occasions (*Rec. Geol. Surv. Ind.*, Vol. XXXIV, pp. 86, 177) that a study of Indian Tertiary geology undoubtedly reveals the presence of a vastly developed intercalary stage, the Laki, intervening between the equivalents of the Cuisian and Lutetian, and corresponding with neither. It is equivalent to the Lybian stage of Egypt. In the Paris basin it corresponds to a

stratigraphical gap between the Cuisian and Lutetian, first recognised by Lemoine, who has given the name of "Laonnian" to the scanty fresh-water or brackish representative of the missing zone, occasionally occurring as discontinuous patches (1911, *Géologie du Bassin de Paris*, p. 220).

In Burma, the eocene divisions below the Pondaung stage have, as yet, yielded very few characteristic fossils, and their exact age is still uncertain. The equivalence of the post-eocene in Burma and in north-western India, in its main lines at least, is now established beyond any possible further doubt, and may be tabulated as follows:—

NORTH-WESTERN INDIA.		BURMA.		
UPPER MANCHHAR	} Mekran Series.	{ Gwádar stage.	Irrawadi Series, upper part.	Perhaps upper part of Akauk-taung Series.
MIDDLE CHHAR.		{ Talar stage .	Irrawadi Series, lower part.	Probably lower part of Akauk-taung Series.
	Lower Manchhar . . .		Not observed .	Part of Akauk-taung Series.
	Upper Gáj . . .		Pyalo stage .	
	Lower Gáj . . .		Kama stage	
	Upper Nari . . .		Singu stage.	
	Lower Nari . . .		Sitsayan stage	
	} Massive limestones of Mula pass.		Shwezetaw stage.	
			Yaw stage.	
			Pondaung stage.	

### 3. Tertiary sequence in Java.

Omitting the rather vaguely demarcated "Fossil-wood group" and the subsequently defined Irrawadi Series, Theobald's "Pegu

Group" essentially coincides with the post-eocene portion of the Tertiary of Burma. The corresponding beds in Java constitute Martin's "Java group" (*Samml. d. g. R.-M. in Leiden*, ser. 1, Vol. VI, p. 240). In the Java group, the "lower miocene," including the Rembang Series (1912, *Samml. des geol. Reichsmus. in Leiden*, ser. 1, Vol. 8, p. 153) and Njalingdun series (1911, *loc. cit.*, pp. 18, 22), corresponds with the Kama and Pyalo stages with both of which it has many species in common. The "upper miocene" includes the Tji Lanang series (1911, *loc. cit.*, pp. 44, 48) with the extraordinarily rich fauna collected by Junghuhn, which has become classical from Martin's first great monograph, "Die Tertiärschichten auf Java," in which a very large proportion of the described species belong to this stage.

The typical pliocene of Java is the Sondé series (*loc. cit.*, p. 194) which very closely corresponds, faunistically, with the Mekran beds of north-western India and with the rich fauna of Karikal so admirably described by Cossmann. The fauna of Odeng seems to represent a passage zone between the "upper miocene" and "pliocene" (*Samml. d. geol. Reichsmus. in Leiden*, ser. 1, Vol. VI, pp. 178, 190), corresponding approximately in age with the Pontian. As already remarked, the Odeng fauna closely corresponds with the Talar fauna of the Mekran.

Regarding the Kendeng beds which overlie the Sondé Series, and which have yielded remains of *Stegodon*, *Elephas*, and of the far-famed *Pithecanthropus*, there may be perhaps some slight uncertainty as to whether they might correspond with the uppermost zone of the Siwalik. The general consensus of opinion seems to be in favour of a true pleistocene age, and there is good reason for concluding that the Kendeng beds are approximately equivalent to the Narbada stage of India.

Fossiliferous equivalents of the oligocene have not been met with in Java. The "Java-Group" is underlaid by the Nanggulan Series of upper eocene age corresponding with the Yaw stage of Burma.

The following table indicates the approximate parallelism of the three most completely defined schemes of the later tertiary succession of the East-Indies, respectively in Burma, in Java, and in North-Western India.



	BURMA.	JAVA.	NORTH-WESTERN INDIA.
PLEISTOCENE . . . .	Plateau-gravel . . . . FRESH-WATER. MARINE.	Kendeng Series . . . .	Raised beaches and other equivalents of the Narbada Series. FRESH-WATER. MARINE.
PLIOCENE . . . .	Irrawadi Series, upper part. ?	Sondé Series . . . .	Upper Manchhar and Upper Siwalik. Gwádar stage.
PONTIAN . . . .	Irrawadi Series, lower part. Akauktaung Series (in part at least).	Odeng beds . . . .	Middle Manchhar and Middle Siwalik. Talar stage.
VINDOBONIAN . . . .	Not recognised or perhaps partly represented by the Akauktaung Series.	Tji Lanang Series . . . .	Lower Manchhar . Not known. or Nahan.
BURDIGALIAN . . . .	Pyalo stage . . . .	Njalingdun Series . . . .	Bugti beds corresponding to part of the Murrees. Upper Gáj.
AQUITANIAN . . . .	Kama stage . . . .	Rembang Series . . . .	Lower Gáj.
CHATTIAN . . . .	Singu stage . . . .	} Not identified . . . .	Upper Nari.
STAMPIAN . . . .	Sitsayan stage . . . .		Lower Nari.
LATTORFIAN . . . .	Shwezetau stage . . . .		} Massive limestones of the Mula pass.
UPPER EOCENE . . . .	Yaw stage . . . .	Nanggulan Series . . . .	

## 4. Equivalence of the Garo Tertiary.

Amongst the specifically recognisable fossils of the Garo hills, the following are known to occur also in other parts of the East-Indies:—

*Terebra protomyuros*,  
*Surcula promensis*,  
*Drillia protocincta*,  
 „ *tjemoroënsis* var.,  
*Mitra chinensis* var. *subscrobiculata*,  
*Turritella Pinfoldi*,  
 „ *angulata*,  
*Calliostoma promense*.

Amongst these eight species, *Terebra protomyuros*, *Surcula promensis*, and *Calliostoma promense* have hitherto been met with only in the Kama beds of Burma. *Surcula promensis* is represented, in the Garo hills, by the variety *silistrensis*, but, as already explained, this appears to be a collateral variety, not a mutation. *Drillia protocincta* occurs in the Kama beds of Burma and in the pliocene Sondé series of Java. *Drillia tjemoroënsis* var. characterises the Kama stage of Burma. The type is found in Java at Sangiran (Kali Tjemoro), in beds the exact horizon of which has not been recorded, but which may be pliocene; the Garo and Burma form representing, however, a separate variety. *Mitra chinensis* is the only undoubted living species recognised in the fauna of the Garo hills, where it is represented by the variety *subscrobiculata* characteristic of the Gáj of Kachh. *Turritella Pinfoldi*, at Myaungu (20° 31', 94° 21'), in the Minbu district of Burma, occurs in beds which contain *Ostrea latimarginata* and which, therefore, must be referable to the Pyalo stage. *Turritella angulata* occurs in the Singu, Kama, and Pyalo beds of Burma, perhaps also at higher horizons. In western India, it is found in the Gáj and perhaps in the Mekran series. As already mentioned, its specific distinctness from the living *Turritella duplicata* is not quite certain.

If we now analyse the evidence afforded by these fossils, *Turritella angulata* only indicates that the Garo fauna is newer tertiary. All the other species point to the Kama-Pyalo or Gáj as the age of the Garo fossils. One form, *Turritella Pinfoldi*, has, hitherto, been met with only in the Pyalo stage coinciding with the upper Gáj. The

absence of any undoubted oligocene forms, and the presence of *Drillia protocincta* which is known to extend into the pliocene, further suggest more particularly the Pyalo stage or the upper limit of the Gáj as the most probable horizon, which would be in keeping with the very likely supposition that the Karaibari exposure, described in 1821 by Scott and Colebrooke, is the western extension of the Sumeswari beds. One of the Karaibari mammalia, *Anthracotherium siliistrense*, probably occurs in the Lower Manchhar of Sind. The Kamliar horizon, at the base of the Manchhar, immediately resting on the Gáj, is regarded by Pilgrim as possibly synchronous with the Sansan fauna which de Lapparent places astride of the limit between Lower Miocene and Vindobonian, therefore just about the upper limit of the Gáj. We may therefore conclude that the age of the Sumeswari fauna is probably the same as that of the Pyalo beds, at the upper limit of the Gáj, at the upper limit therefore of the Lower Miocene.

Out of a total of nine recognisable species in the Garo fauna, one only, *Mitra chinensis* var. *subscrobiculata*, is considered certainly to be specifically identical with a living shell. This would give eleven *per cent.* as the proportion of living forms. On the supposition that *Turritella angulata* is identical with *T. duplicata*, the proportion would become twenty-two *per cent.* No precise signification can be attributed to figures derived from so small a total, though they are within the limits of the proportions observed for the lower miocene molluscan faunas of Burma, Java, and Western India, which, according to the horizon, facies, and generic constitution, vary from about 7 *per cent.* to about 25 *per cent.*

### Other occurrences of Tertiary Fossils in North-Eastern India.

The interesting collections obtained by Mr. Pinfold in the Garo hills constitute the first and only instance in which precise data have become available regarding the age of any of the later tertiary formations in the districts to the North of Burma, including Assam, the Sylhet region and the neighbouring countries. Indeed, with the exception of the neighbourhood of Cherra-Poonjee and Shillong, there is practically no spot where any of the rocks can be accurately dated. Fossils have been recorded only from a small number of localities, and have not been fully studied.

The nearest spot to the localities examined by Mr. Pinfold, from which newer tertiary fossils have been obtained, is along the Karaibari hills, between the western extremity of the Garo hills and the Brahmaputra.

A small thickness of horizontal or slightly undulating sandstones and clays which were exposed at low water along the banks of the Brahmaputra about a hundred years ago, but have not been observed since, yielded some littoral marine fossils together with mammalian remains (Colebrooke and Scott, *Trans. Geol. Soc. London*, 2nd ser., Vol. I, p. 132).

The mammalian remains have been studied by Pentland, Falconer and Cautley, Pomel, and Lydekker, and have been referred to two species which have been named *Anthracotherium silistrense* Pentland and *Chaeromeryx silistrensis* [Pentland]. Remains specifically identical with *Anthracotherium silistrense*, or at least very closely related, have been recorded from the Lower Manchhar of Sind, at a horizon therefore not very different from that of the Gáj beds. The species has an extensive vertical range, and, of itself, would not suffice to fix the date of the bed otherwise than as miocene. Nevertheless, the fact that the only other mammalian species recorded from the same bed is also an anthracotheroid, communicates a relatively ancient appearance to the fauna. The most conspicuous amongst the mollusca from Karaibari are large oyster-shells, now preserved at the British Museum, which, on a casual inspection, appeared to me to coincide with Gáj forms. Unfortunately, I did not take note of their characters. The small thickness of sandstone overlying the bed with littoral and mammalian remains is recorded to have yielded fossil wood.

There is reason to think that the Karaibari exposure, which is in the direct continuation of a line passing through the Bagmara and Dalu exposures, may be a western continuation of the strata studied by Mr. Pinfold, and, like them, may correspond with the Pyalo beds of Burma and the Upper Gáj beds of Sind, but the question needs further investigation.

In the Khasia hills, east of the region examined by Mr. Pinfold, the undulating stratification of the Garo hills gives place to a sharp flexure, north of which the strata are practically horizontal, while, south of the bend, they dip south at high angles. Identical horizons, when recognisable on both sides of the bend, are represented by a

much greater thickness of strata on the southern than on the northern side, indicating a rapid deepening of the basin of deposition in a southern direction. Amongst the horizontally stratified deposits of the plateau, on the northern side of the flexure, the undoubtedly eocene beds include two subdivisions, recognisable from their nummulites, and corresponding respectively with the Laki of Lybian age, and the Khirthar of Lutetian age, as developed in north-western India. The Sylhet limestone, on the southern side of the flexure, is a rock containing abundant large nummulites of Khirthar age.

Overlying the undoubted eocene of the plateau, is the Nongkulang Hill Series (Godwin-Austen, 1869, *Journ. As. Soc., Bengal*, Vol. XXXVIII, (2), p. 23) which must not be confounded with the Nanggulan Series of Java (see Martin, 1912, *Samml. des geol. Reichs-Mus. in Leiden*, ser., 1, Vol. IX, p. 111, with complete bibliography; also, 1914, *neue Folge*, Vol. II, part 4) though it is by no means impossible that both series may be contemporaneous.

The Nongkulang Hill Series of the Khasia hills is described by Godwin-Austen as consisting of marine strata unconformably overlying the eocene. The Nongkulang fossils were first examined by Stoliczka, who stated that "none of the species, so far as recognisable, appear to be identical with those known from the nummulitic beds of the same district" (*Rec. Geol. Surv. Ind.*, Vol. II, p. 10). The Nongkulang Hill Series, in the West Khasia hills, is overlaid by a considerable thickness of beds which Godwin-Austen attributes entirely to the Nahan; this same assimilation being extended to the entire succession of later Tertiary beds in the Garo hills, including even their uppermost strata; and also to the greater portion of the vast thickness of later Tertiary beds along the southern border of the Jaintia hills, with the exception of some uppermost irregularly bedded clays and conglomerates regarded by Godwin-Austen as perhaps the equivalents of the Siwalik proper (*loc. cit.*, p. 153). The fossils collected by Mr. Pinfold occur in the uppermost zones of the Tertiary beds in the Garo hills, and, since their palæontological characters indicate the age of the Upper Gáj or Pyalo beds, it follows that the entire succession of Upper Tertiary beds in the Garo hills must be, even at its upper limit, somewhat older than the Nahan; while as the horizon of the Nongkulang Hill fauna is separated from that of the Sumeswari fauna by a considerable thickness of

strata, we must also conclude that the Nongkulang Hill fauna cannot correspond with that discovered by Mr. Pinfold, and is probably older than the Gáj. The small collection of fossils obtained by Godwin-Austen from the Nongkulang Hill Series has lately been studied by Dr. E. Spengler. The full description has not yet been published, but, in a short preliminary note (*Centralblatt f. M., G., u. P.*, 1915, p. 623), Dr. Spengler mentions the occurrence of a new species of *Clypeaster* and of a *Euspatangus* related to *Euspatangus rostratus* d'Arch. The latter is a characteristic zone-fossil of the Nari of western India, and the comparison made by Dr. Spengler leads us therefore to believe that the Nongkulang Hill Series may be related to the Nari of western India, and that its age, therefore, may be oligocene. Still, the possibility is not yet excluded that it may be, after all, of upper eocene age, and, by a curious coincidence of terms, contemporaneous with the Nanggulan Series of Java.

Fossil palm-wood and dicotyledonous leaves are the only distinct organic remains so far recorded from the "teelah" ridges about Cachar. Between Cachar and the Bay of Bengal, the ranges in Hill-Tipperah and Chittagong include considerable thicknesses of strata regarded as upper tertiary in age. Fragmentary marine fossils have been obtained by Mr. P. N. Bose and other explorers. They are not specifically determinable, but include small clathrate valves of *Venus*, analogous to *V. bataviana* Martin, such as occur abundantly in the upper Tertiary of Java and in the Kama beds of Burma. The existence, in Hill-Tipperah and Chittagong, of equivalents of the Kama and Pyalo stages is probable.

In the North Cachar Hills, the strata, considerably disturbed, which apparently form the continuation of the Newer Tertiaries of the Jaintia hills, include two subdivisions, of which the lower one, with a maximum exposed thickness of 2,000 feet, is mainly shaly, while the upper one, with a maximum thickness of 3,000 feet, consists principally of sandstones.

The north-eastern extension of the Newer Tertiaries of Hill-Tipperah, of Cachar, and of the Jaintia hills, is to be sought in the Mikir hills, where the Mikir Shale Series (F. H. Smith, *Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 84), estimated at 800 feet in thickness, appears to be undoubtedly the continuation of the lower shaly beds of the North Cachar Hills. They contain oysters and other marine shells (Smith, *loc. cit.*, pp. 86, 87) which have not been identified.

They rest on eocene beds, and are overlaid by sandstones, apparently continuous with the upper arenaceous division of the North Cachar hills and containing fossil-wood.

The north-eastern continuation of the Tertiary zone of the Mikir Hills is in the Naga Hills, where Mallet recognised four principal stratigraphical divisions: the Disang series, mostly shaly, with an uppermost arenaceous subdivision, the Naogaon sandstone; overlaid by the coal-measures, principally shaly; the Tipám sandstones with fossil wood; and the locally developed Dihing conglomerates overlying the Tipám beds.

The structure, in the Naga hills, is complicated by faulting and overfolding, which increases the difficulties of classification. The Disang series appears to be partly cretaceous and may be heterogeneous. There is reason to believe that the coal-measures correspond, partly at least, with the coal-bearing Shwezetau stage of Burma of lower oligocene age. They have not yielded any distinct fossils. The Mikir Shale Series was regarded by Smith as approximately equivalent to the coal-measures. Fossil shells have been observed in the Tipám beds along the high road in the Diphupani gorge near Samaguting by R. D. Oldham who expressly states their identity with some of the Veneridæ from the strata near Prome (*Mem. Geol. Surv. Ind.*, Vol. XIX, p. 228), and, in the valley of the Dayang river, by Hayden (*Rec. Geol. Surv. Ind.*, Vol. XL, p. 291).

The evidence above reviewed reduces itself to this: fossils of the age of the Upper Gáj or Pyalo beds occur at the upper limit of the newer tertiary beds in the Garo hills; while the lower limit of these beds may safely be interpreted as post-eocene, since the Nongkulang Hill Series, whatever its exact age may be, intervenes between these Newer Tertiaries and the middle eocene. The Tipám sandstone is partly equivalent to the Pyalo stage, but we cannot state anything definite regarding its inferior limit. The next older rocks, the coal-measures, are probably, in part at least, of lower oligocene age, while the Sitsayan, Singu, or even Kama horizons, may be represented either by the lower portion of the Tipám beds, or, more probably perhaps, by the upper portion of the coal-measures. The upper limit of the Tipám beds is also indefinite.

With these important, but, at the same time, meagre data, the equivalence of the upper Tertiary beds throughout the vast territories of north-eastern India remains almost entirely conjectural as will be seen from the following tabular statement;—

	GARO, KHASIA, JAINTIA HILLS.	NORTH CACHAR, MIKIR.	UPPER ASSAM.	
UPPER SIWALIK, GWADAR.	Conglomeratic beds of the Jaintia hills.	.....	Dihing beds . . . .	UPPER IRRAWADI.
MIDDLE SIWALIK, TALAB.				LOWER IRRAWADI AKAUKTAUNG.
NAHAN . . . .				? AKAUKTAUNG in part.
	Fossil zone of Dalu, Bagmara and Karaibari.	(?) Sandstones of the North Cachar and Mikir Hills.		
UPPER GAJ, BUGTI	Sandstones and shales of the Garo, Khasia and Jaintia Hills.	Shales of the North Cachar and Mikir Shale Series.	Tipam sandstones . . . .	PYALO.
LOWER GAJ . . . .				KAMA.
UPPER NARI . . . .	Nongkulang Hill Series . . . .		Coal-measures . . . .	SINGU.
LOWER NARI . . . .				SITSAYAN.
MULA LIME-STONES.				SHWEZETAW.
				YAW.

PART 3.] VERDENBURG: Marine Fossils of the Garo Hills. 335



From the table it may be noticed that, even by partly referring the coal measures of Assam to as late an age as the oligocene, and even if we bring down the uppermost Jaintia conglomerates to an age as old as that of the Nahan, thereby compressing the sequence within the smallest probable range, yet the number of subdivisions established in Assam or in the neighbouring regions remains much smaller than those already defined, within the same range of time, in Burma, or in north-western India, or in Java; and, consequently, great difficulty is experienced in attempting to apportion the Assam strata to their respective equivalents in other regions. In consequence of the inaccessibility and unhealthiness of the north-eastern districts of India and also the scarcity of rock exposures in a forest-clad country, geological information regarding those regions is in a backward condition, and, until Mr. Pinfold's discovery, not a single horizon had been accurately fixed above the middle eocene. We must congratulate Mr. Pinfold on having for the first time established a definite stratigraphical zone, which will afford a most valuable fixed horizon in further unravelling the geology of this difficult region.

#### LIST OF ILLUSTRATIONS.

##### PLATE VIII.

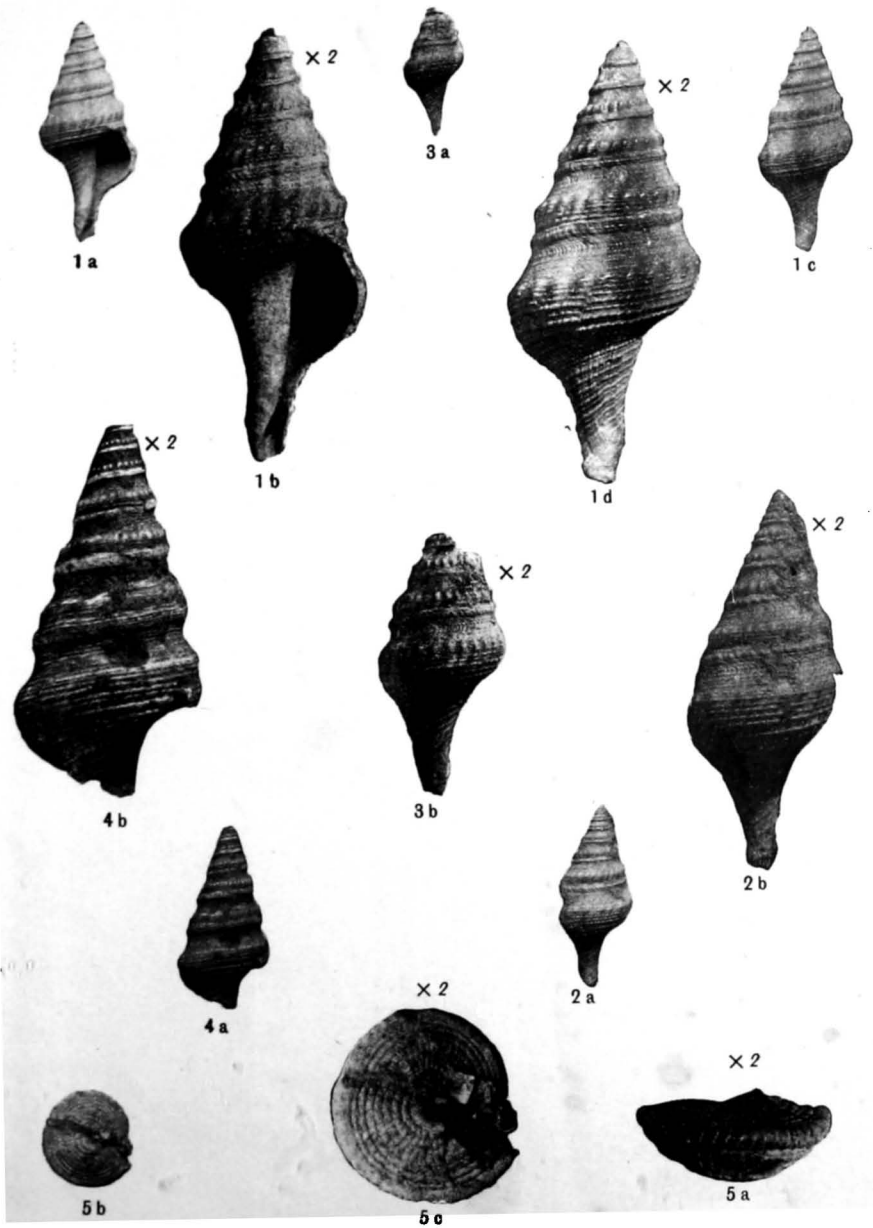
- FIG. 1.—*Surcula Promensis*. Myaukmigon, Burma; *a, b*, ventral aspect, natural size and enlarged 2/1; *c, d*, dorsal aspect, natural size and enlarged 2/1.
- FIGS. 2, 3.—*Surcula Promensis*. Kyaungon, Burma; *a, b*, dorsal aspect, natural size and enlarged 2/1.
- FIG. 4.—*Surcula Promensis* var. *Silistrensis*. Bagmara, Garo Hills; presented by the British Burma Petroleum Company; *a, b*, ventral aspect, natural size and enlarged 2/1.
- FIG. 5.—*Calliostoma Promense*. Kyudawon, Burma; presented by the Burma Oil Company; *a*, lateral view, natural size; *b, c*, base, natural size and enlarged 2/1.

##### PLATE IX.

- FIG. 6.—*Siphonalia subspadicea*. Dalu, Garo Hills; presented by the British Burma Petroleum Company; *a, b*, ventral view, natural size and enlarged 2/1; *c, d*, dorsal view, natural size and enlarged 2/1; *e, f*, side view, natural size and enlarged 2/1.
- FIG. 7.—*Calliostoma Promense*. Myauktin, Burma; *a*, ventral aspect, natural size; *b, c*, dorsal aspect, natural size and enlarged 2/1; *d, e*, base, natural size and enlarged 2/1.

- FIG. 8.—*Calliostoma Promense*. Myauktin, Burma; *a, b*, ventral aspect, natural size and enlarged 3/1.
- FIG. 9.—*Turritella Pinfeldi*. Bagmara, Garo Hills; presented by the British Burma Petroleum Company; natural size.
- FIGS. 10, 11.—*Turritella Pinfeldi* Myaungu, Burma; presented by the Burma Oil Company; 10, 11*b*, natural size; 11*a*, enlarged 2/1.

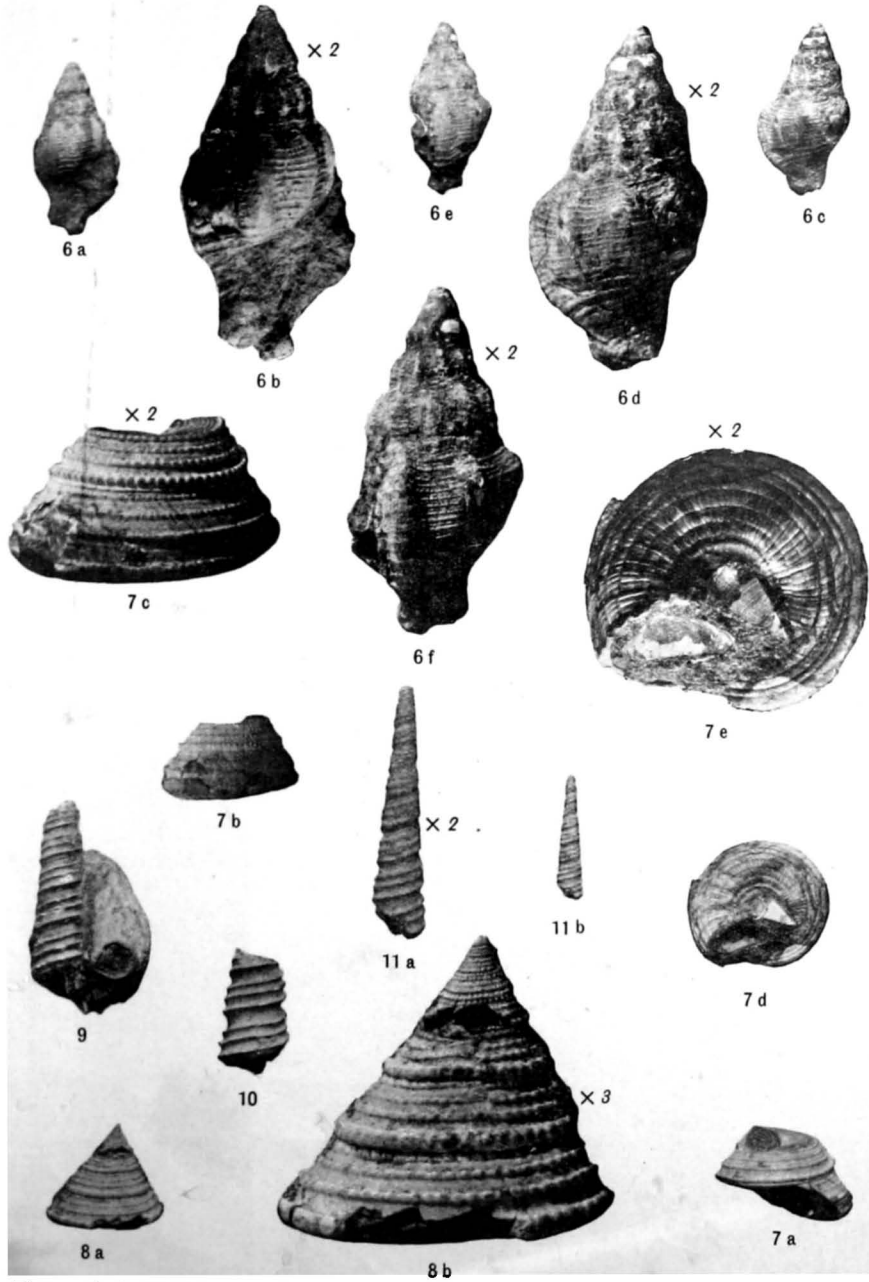
CALCUTTA  
SUPERINTENDENT GOVERNMENT PRINTING, INDIA  
8, HASTINGS STREET



Photographs by K. F. W. & S. R. Rau.

G. S. I. Calcutta

TERTIARY MOLLUSCA FROM THE GARO HILLS.



Photographs by K. F. W. & S. R. Rau.

G. S. I. Calcutta

TERTIARY MOLLUSCA FROM THE GARO HILLS.