

ananjayarao Gadgil Library



JIPE-PUNE-006696

~~263 FT~~

6696

Kesashantung

SERVANTS
SOCI
POO

A. S. New 6/2/99

THE GEOLOGY
OF
BARODA STATE

BY

R. BRUCE FOOTE, F.G.S., C.F.E.G.S.,

*Fellow of the University of Madras; Superintendent,
Geological Survey of India, Retired; and lately State Geologist, Baroda.*

PUBLISHED BY ORDER OF HIS HIGHNESS

THE GAEKWAR.

PART I.—The Divisions of the State in Gujarat Proper.

PART II.—The Divisions of the State in the Kathiawar
Peninsula.

PART III.—Appendix and Glossary.

Madras:

Printed by ADDISON & CO., Mount Road.

1898.

H. 23182

C8

6696

PREFACE.

THE duty of making a Geological Survey of the Baroda State was entrusted to me early in October 1891 and occupied me during the working seasons of 1892, 1893 and 1894. During those three years I visited carefully and examined closely all the minurally important regions lying within the limits of the State both in Gujarat and Kathiawar. The completion of this memoir has unfortunately been much delayed by long-continued ill-health contracted in the service of the State and by difficulties connected with the preparation of the maps and plates requisite to illustrate the memoir, the work required being of such a nature that all the most important parts had to be done by myself and did not admit of my being appreciably assisted by anyone else.

CONTENTS.

PART I.

Geological Features of the State in Gujarat Proper.

CHAPTER I.

GEOGRAPHY AND PHYSIOGRAPHY.

Subdivisions of the State into Prants or Districts.—The Nausari Prant, 1; the Baroda Prant, 2; the Kari Prant, 2; *Physiography of the State; Orology.* The Alluvial flat, 3; hills in the Kari Prant, 3; in the Vejapur Mahal, 4; in Waghoria Taluq, 5; in Sankheda Taluq, 5; in the Amroli Mahal, 8; in Velachha Taluq, 8; in Kamrej Taluq, 9; in Songad Taluq, 9, 10 and 11; in Vyara Taluq, 11; in Moha Taluq, 11; in Gandevis Taluq, 12. *Hydrology:* The principal rivers and their tributaries; the Sábarmati, 13; the Mahi, 13; the Dadhar, 13; the Narbadda, 13; the Kim, 13; the Mindhola, 14; the Purna, 14; the Ambika, 13. *Climate.*—Rainfall, 14; Temperature, 14; Transparency of Atmosphere, 15.

CHAPTER II.

SUCCESSION OF ROCKS.

Their distribution, 17; VIb. *Subaerial formations*, 17; VIa. *Old Alluvia of the great rivers*, 17; V. *The Eocene (Nummulitic) System*, 17; IV. *The Deccan Trap (Cretaceous) and Intertrappean rocks*, 17; III. *The Bagh Beds (Marine Cretaceous)*, 17; II. *The Champanir System (Transition or Submetamorphic Series)*, 17; I. *The Archæan rocks or Crystalline Series*, 17; their respective extent, 18.

PREVIOUS OBSERVERS :—Dr. Lush, 1836, 18; Lieut. Fulljames, 1838, 18; Mr. John Vanpell, 1839, 19; Mr. A. B. Wynne, 1868, 20; Mr. W. T. Blanford, 1869, 20; Dr. T. Oldham, 1882, 20; Mr. F. A. H. Elliott, 1883 (The Baroda Gazetteer), 21; Maps of Baroda State, 21.

CHAPTER III.

I. THE ARCHÆAN ROCKS.

The principal areas; a. *The Virpur Granite Area*, 22; b. *The Orsang river area*, 22; c. *the Unch river area*, 23; inliers at Wadeli, Vidvaswami hill, Deroli, east of Lachharas hill and Bodeli, 23; the Orsang area, 24; section in the Orsang river bed, 24; rocks seen in the Motipura nullah, 25; crystalline limestones south of the Railway bridge, 25; Motipura marble bed, 26; Harikua marble beds, 25; Wadeli marble bed, 25; gneissic beds of Bhadrali and Jhojwa, 25; the Bodeli inlier, 27; the Unch river inlier, 27. *Intrusive rocks in the Archæan areas:*—Trap dykes, 28; Quartz runs, 28; Brecciated quartz runs, 28; Pegmatite veins in the Virpur area, 29.

CHAPTER IV.

THE CHAMPANIR SERIES—TRANSITION ROCKS.

Quartzites of Gugulpur, hill, 30; quartzites of the Achali ridge, 30; inliers in valley of the Heran, 30; the Karali inlier, 31; the Partapura inlier, 32; the Ghora hill inlier, 32; Lachharas hill, 33; inlier No. 5, 34; Dudhpura inlier, 34; Sandara inlier and its marble beds, 34—36; Sigam inlier, 36, Chloritic schists with auriferous quartz veins, 37; assay of the quartz, 37; Sigam Kanbi inlier, 37; Songir river bed inlier, 38; inliers north of the Songir quarry ridge, 38; the Padwan inlier, 38; the Lonadra inlier, 39; the Sihadra inlier, 39; the Punpawa Mata inlier, 40; inliers 18, 19 and 20, 41; inliers at Naswari, 41; the Sandia Breccia rocks, 41.

CHAPTER V.

THE BAGH BEDS (MARINE CRETACEOUS SERIES.)

In Sankheda Taluq :—In the Heran and Men valleys, 42; the Songir inlier, 43; the Ghantoli inlier, 44; the Watershed inlier, 44; the Kurwa Naddi Section, 45; the three inliers at Lachharras, 46; the Dev river inlier, 47; the Dantaj inlier, 47; the western inlier, 48; the Sándásál inlier, 48; the Karichla inlier, 49; the Kun river inlier, 49; fossils, 50; Infraposition to the Deccan, 50.

CHAPTER VI.

THE DECCAN TRAP SERIES.

- A. *In Dehgam Taluq* :—Trap rocks in the Watrak and its tributaries, 51; relations of the Trap and laterite at Paori Moti, 52.
- B. *In Sauli Taluq* :—Trap rocks in the Mahi river bed, 53; Tufaceous agglomerate, 53.
- C. *In Waghoria Taluq* :—Sections in and S. of the Vishvamitri river, 54; Trap in the Deo river, 55; on Bairapur rise, 55.
- D. *In Sankheda Taluq* :—In the Heran valley, 56; in the Aswan valley, 56; in the Men valley, 56.
- E. *In Velachha Taluq* :—Calcite veins, 57.
- F. *In Kamrej Taluq* :—Exposure east of south end of Naroli Nahani laterite ridge, 58.
- G. *In Vyara Taluq* :—58. In the Tapti, 59; Porphyritic trap, 59; Dykes, 60.
- H. *In Songad Taluq* :—60. The Nanchal hills dome; Songad hill and Fort, 61; Formation of the western highlands (gháts).
- I. *In Moha (Mahuva) Taluq* :—Section in the Parna above Moha, 64.
- J. *In Palsana Taluq* :—Amygdaloid bed in the bed of the Mindhola river, 64.
- K. *In Gandevi Taluq* :—Basaltic ridge at Wangri, 64.

CHAPTER VII.

THE NUMMULITIC SERIES.

Laterite formations, 65; in the Sábarmati valley at Virpur, 65; Jawanpura section, 65; hard grit bed at Virpur, 66; the Jer waterfall, 65; springs, 66; laterite beds in the sandstone series, 67; Phudera sandstones, 67; the Cañon section, 67; Pedhamli cliff section, 68; the Upper Gorge, 68; the Lower Gorge, 68; absence of fossils, 69; Paori Moti section, 69; laterite at Thalpura, 69

laterite and nummulitic rocks in Velachha taluq, 70; other rocks, 70; flaggy sandstone at Hathuran, 70; gravel beds W. and E. of Kosamba railway station, 70; inliers in the Kim valley, 71; calcite veins, 71; river sections S. W. of Velachha, 71; nummulitic limestone at Chhamusal, 71; laterite N. and E. of Mangrol, 72; the basement laterite bed, 72; limestone (shelly) near Nogama, 73; the agate gravels, 73; limestone S. W. of Naroli Nahani, 74; the nummulitic limestone, 74; limestone outcrops in Kamrej taluq, 74; agate gravel, 75; younger laterite, 75; basement laterite, 75; sections N. and N. E. of Karjan, 75; section at the mouth of the Rhén, 76; Dhantwa section, 78; fossil wood, 78; Dungra section, 78; Karjam section; the Pàroli-Dolan section; Dungar laterite hill, 81; hæmatitic laterite gravel in Palsana taluq, 81; laterite at Kuree Moha taluq, 81; Kuree high level laterite, 82; laterite in Gandevi taluq, 82.

CHAPTER VIII.

THE ALLUVIAL AND SUBAERIAL FORMATIONS.

Older Regur deposits, 85; well-like quagmires, 85.

- A. THE RIVER AND COAST ALLUVIA; human remains; palæolithic implements, 86; palæolithic implements in Sadolia section, 87; in Pedhamli section, 88; the gully systems of the great river banks, 88; section of the alluvium of the Sábarmati at Saroli, 90; gravels in the alluvium of the Sábarmati, 91; reaches of the Sábarmati, 91; Madhaoghát section, 91; shingle beds in the Sábarmati, 92; present action of the rivers reaches of the Sábarmati, 92; Mahuri alluvial cliffs, 93; note on the Bokh valley, 93; reaches above Mahuri, 94; reaches of the Watrak, 94; relative ages of the Sábarmati and its tributaries, 94; alluvium of the Mahi valley, 95; the Dadhar and its tributaries, 95; the Nerbudda, 95; the Orsang, Unch and Heran, 95; the Aswan and Mea, 96; boulder shingle at Amroli, 96; prevalence of gully systems, 96; the Kim, 96; the Tapti, 97; the Kamrej section of the Tapti alluvium, 97; the Mindhola alluvium, 97; the Purna alluvium, 97; the Tokarwa alluvium, 98; the Ambika and Kaveri alluvia, 98; the coastal fluviomarine alluvium, 98; the Umrat marine sandstone, 99.
- B. THE SUBAERIAL FORMATIONS, 99; *the Loam, or Loess, Formations*, 99; Loess hills, 99; wherein the loess hills differ from ordinary dunes, 101; inundation lakes, 102; blown loam hills of brown colour, 103; absence of fossils, 103; *Sand dunes, or blown sands*, 103; dunes of blackish sand at Kamrej, 104; coast dunes Neolithic remains on the tops of blown loam hills, 104; human bones imbedded in a loess hill.

CHAPTER IX.

ECONOMIC GEOLOGY.

Absence of road making materials leading to want of roads, 105; non-navigation of the rivers, 107; carriage of road metal and building stones by river navigation, 108; hindrances to traffic caused by the gully systems, 108; great destruction of river side land susceptible of check, 109; gain of land by warping, 109.

MINERAL RESOURCES:—Classification into five groups: A. Metals, B. Building materials, C. Road making materials, D. Ceramic and glass-making materials, E. Decorative stones.

- A. METALS; Iron and iron ores;** Iron industries in the Kari Prant at Phudera and Vijapur and at Atarsumba and Dehgam, 110; old iron smelting works at Samdhi, Sankheda Taluq, 111; at Vasravi in Velachha Taluq, 112; iron ore in the basement laterite bed at Naroli Nahani, 112; magnetic iron sand in the Tapti river, 113; possibility of establishing a charcoal iron industry to work it, 113; old iron industry at Galha in Kamrej Taluq, 114; *Gold*; auriferous quartz at Sigam in rocks of Champanir age, 115; assay of the quartz, 115.
- B. BUILDING MATERIALS.** Geological systems from which derived: 1. the Archæan system; 2. the Champanir system; 3. the (Marine Cretaceous Bagh Beds,) System; 4. the Deccan Trap series; 5. the Eocene (Nummulitic) system; 6. the Fluvialite alluvia; 7. the Marine alluvium, 116.
1. *The Archæan system*; Virpur granite, 117; the Orsang granite area, 118; green and pink granite at Motipura, 118; Bodeli granite inlier, 118; Bhadradi gneiss, 118; crystalline limestones, 119; Motipura green marble, 119; Harikua marble beds, 119; marble beds north of Motipura, 120; Wadeli marble, 120; quartz, 120.
 2. *The Champanir System*: Limestones in the Heran valley (Sándara inlier, 121.) The quartzites of Achali ridge, 122; of Lachharas hill, 123; of Sihadra knoll, 123; The slates of the Heran valley at Songir and Lonadra, 123; The Sandia breccia, 123.
 3. *The Marine Cretaceous Series*: (*The Bagh beds.*) The Songir sandstone quarries, wasteful quarrying, 123; large reserves of sandstone in Sankheda taluq, 127; the gritty beds of Nawagam, Dantaj, 127; Karachla and the Kun river, 127; gritty limestones, and cherty bands, 127.
 4. *The Deccan Trap Series*: Reasons for little use of Trappean rocks as building stones, 128; paucity of quarries, 128; porphyritic trap; the majority of the dykes, basaltic, 129; granular trap rock, 129; Amygdaloid traps, 129; Amygdaloid traps unsuitable for building stone, 129; Amygdaloid traps only an indirect source of supply of agates, 130; absence of Basaltic columns,
 5. *The Eocene System (Nummulitic)*: Phudera sandstones, 130; Virpur grit bed, 130; Hathuran sandstone, 130; clayey calcareous sandstones at Velachha, 130; Dhamrod and Boridra sandstones, 131; Dhantwa and Karjan sandstones, 131; limestones, shelly and nummulitic, of Tarkeshwar, Lindiad, Limodra, the Natu Pir tank, Nogama and Dhinod, 131; laterite rock of Paori Moti, 131; of Dungar, 132; of Kurel and Gandevi, 132; The "Cement Stones" at Velachha, a possible source of hydraulic lime, 132; clay beds N.E. and N. of Karjan, 133; great clay bed in the Pardi-Dholan section, 133.
 6. *The Alluvial Formations*:—
 - a. *Fluvialite Alluvia*: Tufaceous limestone or kankar, 133; sand, 134; brick earth, 134; soils, 134; shingle beds in the Mahi, &c., 135; rarity of good agates, 135; the Derda Paori Agate, 135; jasper shingle, 135; sandstones,
 - b. *Marine Alluvia*: The Umrat shelly ragstone, 136.
- C. ROAD MAKING MATERIALS.** Basaltic shingle in the Mahi river, 136; Basaltic rocks in the Deo river, and on Bairapur hill, 137; in the Sankheda taluq, 137; in Velachha and Kamrej taluqs, 137; in Songad Vyara, Nausari and Gandevi taluqs, 137; in the Northern taluqs, 137.
- D. CERAMIC AND GLASS MAKING MATERIALS.** The Patan Pottery, 138; The Mandwa glass industry, 138; Bad selection of materials, 139; good sand where procurable, 139; pure white quartz of Vidwaswami Mita hill, 139.
- E. DECORATIVE STONES.** Lapidaries' work in Baroda, 139; processes there followed, 140.

PART II.

Sketch of the Geology of the Gaekwari Districts in the Kathiawar Peninsula.

CHAPTER I.

GEOGRAPHY AND PHYSIOGRAPHY.

Subdivision into six taluqs, 141; *Orology*, 142; the Gir Forest, 142; the Sarkala group, 142; the Rojmal group, 142; the Chakrosar group, 143; the Nandivela group, 143; the Lepala group, 143; the Jhar hills, 143; hills in Kodinar Mahal, 143; hills in Okhamandal, 143; want of forests, 144; *Hydrology*, 144; of Amreli Mahal, 144; of Dhari Mahal, 144; of Kodinar Mahal, 144; of Damnagar Mahal, 144; of Shihanagar Mahal, 144; the Coastline of Kodinar Mahal, 145; Diu Head, 145; Mul Dwarka, 145; the Okhamandal Coast and Rann, 145; Dwarka cliffs, 146; Aramra Bay, 146; Beyt-harbour and Shankodar Island, 146; Coast line W. & S. of Positra, 147; Deleterious action of W. wind on vegetation, 147.

CHAPTER II.

THE SUCCESSION OF ROCKS—PREVIOUS OBSERVERS.

A. The Succession of Rocks, 148; B. Previous observers, 148.

CHAPTER III.

THE DECCAN TRAP SERIES.

Want of good sections, 150; Position of the trap flows, 150; Absence of intertrappean formations, &c., 151; Basic and Acidic Trap-dykes, 151; the acidic dykes series, 152; the Sakhpur dyke, 152; dykes S. of Damnagar, 153; the Nigala and Kakhbhai dykes, 154; the Dalkhania dyke, 154; the Basic dyke series, 154; Dykes in the Damnagar Mahal, 156; the Dhrupnia dyke, 156; the Karkolia dykes, 156; the Ambaldi dyke, 156; Dykes in the Amreli Mahal, 156; the Versara dyke, 156; the Katma dyke, 157; the Akkadia mota dykes, 157; the Jhalia dyke, 157; the Gaodka dyke, 157; Dykes in the Dhari Mahal, 157; non-trappean dykes, 157; *Calcite veins*, 158; the Daragni veins, 158; the Jikiali and Kotada veins, 159; the Pipalwa "marble" vein, 159; *Variolitic Chert veins*, 160; the Kotada vein, 160; the Dalkhania vein, 160; the Shemardi vein, 160; *Jaspery Chert veins*, 161; the Khamba vein, 161; the Nigala vein, 161.

CHAPTER IV.

TERTIARY FORMATION: GAJ AND DWARKA BEDS.

The Gaj beds, 162; Fossils in the Gaj beds, 162; the *Dwarka beds*, 163; Brecciated Limestones of Rajpura Bandar, 163; Beyt Island, 164; Gypsiferous clays of Kuranga, 164; Bardia Limestones, 164; the Dwarka shelly sandstones, 165.

CHAPTER V.

POST TERTIARY FORMATIONS: 1. THE MILIOLITE; 2. THE ALLUVIAL DEPOSITS; 3. THE SUBAERIAL DEPOSITS.

1. *The Miliolite Formation*, 166; Miliolite hills, 166; Thickness of the formation, 167; Coralloid weathering, 167; the Sakhpur section, 167; the Ghantwar section, 168; the Chachar canon of the Singaora river, 168; the brown limestone at Shedaya, 169; 2. *Alluvial deposits*, 169; Alluvium of the Shatranji, 169;

The Fotel bara creek alluvium, 170; the Okhamandal Rann, 170; the Gomt creek flat, 170; the Aramra alluvial flat, 170; the raised coral reef, 170; 3 *Subaërial deposits*, 171; Black soil spreads, 171; Red soils, 171; White alkaline soils, 171.

CHAPTER VI.

ECONOMIC GEOLOGY.

Absence of metals, 172; Building stones, 172; Road materials, 172; Basaltic rocks, 172; Diorite, 173; Rupavati diorite, 173; Marble, 173; Calcite, 173; Pipalwa "Marble" vein, 174; White siliceous sinter, 174; coloured jaspersy Chert, 174; Variolitic Chert, 175; Stones of the acidic dykes, 175; Miliolite, or Porbandar stone, 175; Kodinar Miliolite as good as Porbander stone, 176; Proposal to export the Miliolite, 176; Velan Bandar harbour and breakwater, 176; stone for the breakwater, 177; Brown limestone of Shedaya, 177; Mode of quarrying the Miliolite, 178; Okhamandal limestones and calcareous grits, 179; Rajpura Breccia limestone, 179; Limestones at Positra, 180; South of Bardia, 180; Lime, 180; Iron ore, 180; Marl, 180; Gypsum, 180.

APPENDIX I.

THE AGATE (AKIK STONE) MINES OF RATANPUR.

Relative situations geologically of the Ratanpura beds and those at Naroli Nahani and Galha, 182; My visit to the mines, 181; Mr. Ginwalla, the Akikstone contractor, 181; list of varieties recognized, 182; character of the Pits at Ratanpur, 182; Treatment of the stones raised, 182; Description of the Cornelian (Agate) mines at Ratanpur by John Copland, Esq., of the Bombay Medical Establishment, 183.

APPENDIX II.

GLOSSARY OF THE TECHNICAL TERMS AND NAMES USED IN THE MEMOIR. •

APPENDIX No. 1.

THE AGATE MINES OF RATTANPUR.

The circumstances under which the Agate beds occur in the south of Velachha and the north of Kamrej Taluqs are rather dissimilar to those in which the famous Rattanpur beds are met with in the Narbadda valley, east of Broach. In the former case the beds occur close to the bottom of the nummulitic series and rest directly on the laterite which forms the actual basement bed. Whereas at Rattanpur the agatiferous beds lie considerably above the base of the series and are underlaid by other gravel beds of considerable but uncertain thickness.

The agate gravels near Naroli Nahani in Velachha Taluq are so greatly obscured by the overlying cotton soil that it was impossible to form any idea of their surface appearance, but they are in all probability like the agate gravels further south near Galha, unconsolidated or only half consolidated beds of coarse gravel, with much small gravel or sand intermixed. The Rattanpur gravels on the contrary are much less coarse and more generally consolidated than the Galha beds. The latter contain a much larger number of large pebbles of agate heliotrope and coloured cherts than the Rattanpur beds, and would for that reason be, in all probability, far more valuable if these larger stones were exported to Europe, where such large stones would be far more appreciated than they are by the Cambay lapidaries, who are intent only on working up the common small agates for the China market.

I do not think the Naroli Nahani or Galha beds would need to be mined by pits as at Rattanpur; they could be worked by simple digging. Whether the smaller grey agates occurring in the beds would be improved by burning would have to be ascertained experimentally. Mr. Ginwalla, the present contractor for the Rattanpur mines, had visited the Galha beds and formed a bad opinion of their value from the comparative paucity of the small grey agates so largely found at Rattanpur, but I think they were far too little exposed to form a reliable estimate of their value by mere cursory inspection, and he did not seem to have perceived the far greater richness of these gravel beds in large agates, heliotropes (bloodstones) and richly coloured cherts. The beds should not, I think, be offered by public auction, but be worked by the State, and the valuable stones collected be offered for sale at intervals, subject to the superintendence of the Chief Engineer of the State.

In order to gain a better idea of the economic value of the agate gravel beds of Naroli Nahani and Galha, I visited the famous agate mines at Rattanpur in Rajpipla State with the approval of His Excellency the Dewan. The information gained was interesting but not conclusive, as so much of the value of the agates depends upon the fancy of the Cambay lapidaries, and this, in its turn, is founded upon the China market, which takes the greater part of the whole outturn.

The stones dug out at Rattanpura and most highly valued at Cambay are not those which would rank highest in the estimation of European Collectors and mineralogists, but very much smaller stones which I should intuitively have set down as of fourth or fifth grade.

I visited the mines out of which the desired kinds of agates are dug in the company of Mr. Ruttonji Nowroji Ginwalla, the Akik contractor, who was most courteous and obliging and showed me everything connected with the raising of

the "Akik" stones and their preparation for the Cambay market. He also kindly furnished me with a list of the names and descriptions of the principal varieties, twelve in number, of agates recognized by the dealers and lapidaries, which list I give in the note below :—

List of varieties recognized.

- | | | |
|------------------|-----|--|
| 1. Jerda | } | Thin skins (outer crusts) a very bright colour, very rare. |
| 2. Maddaya | } | |
| 3. Mactária | ... | White and bluish. |
| 4. Lambi dunghi. | | Good colour, red. |
| 5. Rodi damli | ... | Do. do. small. |
| 6. Moti damli | ... | The common kind. |
| 7. Asli | } | White to yellowish after baking. |
| 8. Baman | } | |
| 9. Devna pug. | | |
| 10. Datára | ... | White. |
| 11. Bimpor | ... | Large agates, rare. |
| 12. Pipodra | ... | Poor stones. |

Unfortunately I was unable to see Mr. Ginwalla again after receiving this list from him and to ask him some questions about it, but I give it at length, as it may possibly prove useful to the officials who may have to deal with agate dealers.

The pits sunk to reach the gravel bed containing the desired class of stones are simple shafts from 25 to 30 feet in depth, but rarely more. The shafts are rarely more than $2\frac{1}{2}$ feet in diameter, and the miners descend by means of holes in the sides 3 to 4 inches deep, into which they thrust their feet and hands. No ladders were in use in those I saw, which were rather numerous and scattered without plan through the thin small tree jungle. Like the old Deneholes, or chalkmines in Sussex and Essex, the shafts are at their base expanded into small chambers whose size varies according to the firmness of the gravel bed reached.

The whole process looks rude and dangerous, but Mr. Ginwalla told me that accidents are of very rare occurrence, as the gravel beds are very fairly consolidated by a rather ferruginous sandy matrix.

The stones raised were carried from the pits in baskets by coolies to Mr. Ginwalla's bungalow at Limodara, where they were sorted and underwent a process of slight baking in open earthenware pots covered with small fires of dry cowdung, after which they would be sorted again finally and slightly chipped to see what had been the effect of the baking. The general action of the firing appears to be an intensification of the internal colouring of the stones especially in respect of red tints.

I would very gladly have made a careful examination into the lapidary's industry at Cambay, but no opportunity for doing this presented itself.

An elaborate account of it is, I believe, given in the volume of the *Bombay Gazetteer*, in which the State of Cambay is described, but I have been unable to get sight of it. I cannot help thinking that there must be some lapidaries at Cambay capable of turning out much better work than what was produced by the Baroda workshop which I referred to at page 140 of the first part of this Memoir. If not, it is very hard to understand how the industry acquired the reputation which it undoubtedly enjoys at present.

The first published account of these interesting mines is that given by Mr. John Copland in the *Transaction of the Literary Society of Bombay* (Vol. I., p. 289, 1819), from which I give some extracts of interest, as he noted several facts which did not come under my observation, or else some things connected with the mines must have changed in the long interval of nearly 80 years which intervened between our respective visits. His remarks as to the colours of the stones found and the changes they undergo are quite in agreement with my later observations, but among the stones collected I noticed nothing but agates,

to heliotropes,¹ mocha stones or jaspers, all of which occur commonly in the argate gravels in Velachha and Kamrej Taluqs. But other pits may very probably produce these as well, though I happened to see none, and was much struck by their absence. No mention was made to me by Mr. Ginwalla of the presence of "fire damp" in the pits, nor of accumulations of foul air rendering them unsafe for the mines, and I certainly think that the testimony of (although negative) of an educated and very intelligent man like him should be preferred to the mere assertion of an ignorant man as in all probability was Mr. Copland's guide, whom he describes merely as a miner.

I had not seen Mr. Copland's paper before my visit to the mines, or should certainly have made very special enquiries on this point. In the absence of carbonaceous matter in the gravels, it is most improbable that either fire-damp or choke damp should accumulate in the pits.

Account of the Cornelian mines in the neighbourhood of Baroach in a letter to the Secretary from John Copland, Esq., of the Bombay Medical Establishment:—

EXTRACT.

"On account of the tigers with which the country abounds, no human habitations were found nearer the mines than Rutunpoor, which is seven miles off. The miners reside at Neemoodra, where alone the stones are burnt. The mines are in the wildest part of the jungle, and are very numerous; they are shafts working perpetually downwards, about four feet wide: the deepest we saw was 50 feet; some extend in a horizontal direction at the bottom, but in consequence of the earliness of the season few had reached a depth sufficient to render this turn necessary, and in those that had it was not carried many feet. In using the term 'earliness of the season,' it is proper to mention that the nature of the pits is such as to prevent their being worked a second year on account of the heavy rains which cause the banks to fall in, so that new ones are opened at the commencement of every fair season. We arrived at the mines about seven o'clock A.M., when none of the workmen had come except one, who accompanied us as a guide from Neemoodra. We were informed that the fire-damp (hydrogen gas) was not uncommon in the mines, and that the miners did not descend till the sun had risen sufficiently to dispel the vapours. We went to the bottom of one pit, about 30 feet deep, without any assistance from ropes, or ladders, by means of small niches for the feet and hands on opposite sides of the pit, but understood that the miners always made use of a rope to hold by, of which we could not avail ourselves, as the workmen at the close of their labour carry to their homes the simple instruments of their vocation, together with the stones which the day's labour has acquired. The soil is gravelly, consisting chiefly of quartz sand reddened by iron and a little clay. The nodules may weigh from a few ounces to two or even three pounds, and lie very close to each other; but for the most part distinct not in strata but scattered through the mass and in the greatest abundance. I saw none of a red colour at the mines; some were blackish-olive like common dark flints, others somewhat lighter, and others lighter still with a slight milky tinge. The first our guide informed us would be black when burnt, the second red, and the third white. In this he may have been correct; but I doubt the fact as to the first, which we found in a proportion inconsistent with the well-known rarity of a black cornelian. I sent specimens of each to Captain Hall of the Royal Navy, whose zeal in all scientific researches I doubt not has settled this point. I confess myself of opinion that there can be no precise rules drawn from the appearance of the stones before, for that which they will assume after burning, because it depends partly on the degree of heat they undergo.

"A red cornelian by an intense heat will become white; but as far as my observations go, no stone of the former colour is found so in the mines (excepting jaspers), although a large proportion of them assume it at Neemoodra. Many also, after having been burnt, show both colours sometimes distinct and sometimes mixed, and of a pinky blue; while the colour was uniform, or very nearly so, in all which I remarked at the

¹ Copland mentions Hæmatites chiefly of the brown and green (with red spots) varieties, which was doubtless a slip for heliotropes, as was pointed out already by Dr. H. J. Carter in his summary of the Geology of India when speaking of the "Cornelian Conglomerates" (p. 751).

“ mines. The lightest-coloured stones came out of the fire of a much more delicate and transparent white than before, and often surrounded by a cortex of red, but without any distinct line separating the colours. We were unfortunate in the time of visiting Neemootra, for all the good stones had been removed and only a few heaps of refuse left. I saw none imbedded in rocks as flints are in chalk; some nodules on being broken showed a mixture of quartz and agate, and others in a crust of quartz minutely crystallized on the inner surface contained a black oxide of iron of a powdery appearance, many pieces of which we found by themselves in the gravel. Hematites chiefly of the brown and green (with red spots) varieties, mocha stones and jaspers of various colours are very common here; indeed the last was found in almost every part of the province we visited on our route; each stone is chipped in the mine to discover its quality, and those which are approved separated from the refuse, heaps of which lay at the mouth of every pit which had been worked.

“ I shall now attempt to give an account of the mode in which the cornelians undergo the action of fire, as derived from the testimony of a respectable native attached to the adawlut at Baroach, who was formerly in the cornelian trade, and had himself superintended the process at Neemootra; his account is corroborated by our personal observation, and by what we learned on the spot.

“ The stones are brought to this village every evening, spread on the ground, exposed to the sun to prepare them for the further process, and turned every fifteenth day till the time of burning, which is only once a year, one month before the commencement of the monsoon. They are then put into round earthen pots about fourteen inches in diameter, the bottom of which have been taken out, and the pots inverted (mouth downward); the pieces taken from the bottoms are put inside and placed over the mouths to prevent the stones falling out; in this state the pots are placed side by side in a trench of indefinite length, but of which the depth and breadth are about two feet having a layer of five or six inches of dry goat's dung below, and the same above the pots.

“ This is set on fire about eight o'clock in the evening. All the fuel is consumed before daybreak, when the pots are removed from the trench to the open air for the stones to cool which requires about three hours; after this they are taken out of the pots piled in heaps and again chipped for the same purpose as when taken from the mines, and are finally thrown into a pit where they remain till called for (more to be out of the way of thieves than as constituting any part of the operation). From Neemootra the cornelians are carried to Cambay by the merchants who come from thence, where they are cut and formed into the beautiful and much sought after ornaments peculiar to the place.

“ I ought to mention that the miners do not forsake a pit on meeting with a spring, but merely change the direction—the water never rising to any great height.”

APPENDIX No. II.

GLOSSARY

OF TECHNICAL TERMS AND NAMES USED IN THE MEMOIR.

As this Memoir will doubtless be placed in the hands of many who have not done any previous geological reading, a glossary of the technical terms and names which have been unavoidably used can hardly fail to be valuable.

Acicular—(*Acicula*, a little needle). Needle-like, long and fine; a term applied to crystals.

Agate—(Derivation said to be from the river Achates in Sicily). A variegated form of silica, banded with different colours, or with opaque and translucent layers alternating. It is commonly found lining cavities in basalt and other volcanic rocks. Called *Akik* by Indian lapidaries.

Agglomerate—Ejected, blocks of volcanic rock cemented together into a *breccia* rarely into a conglomerate.

Albite—(*Albus*, white). A kind of felspar, usually of a white or grey colour, and differing from orthoclase or common felspar in containing soda instead of potash, and in crystallizing in the triclinic, or anorthic, system.

Alluvium—(*Alluo*, I wash against). Clay, silt, sand, and gravel deposited from water. The term is usually restricted to deposits from rivers, lakes, and seas, still existing, or which existed in very late geological times; and it is especially applied to the deposits formed by rivers when overflowing their banks.

Allumina—An earth; the sesquioxide of the metal aluminium, containing two equivalents of the metal and three of oxygen. Alumina combined with silica is the basis of all clays.

Amethyst—(*ἀμέθυστος*). Quartz or rock crystal, of a pink or purple colour, the colour being due to the presence of manganese or iron.

Amorphous—(a privative, and *μορφή* form). A term applied to such mineral substances as present no appearance of crystallization.

Amygdaloid—(*αμυγδαλον* almond; *εἶδος* form). A volcanic rock containing nodules (generally small) of quartz, felspar, zeolite, or some other mineral. These minerals have been deposited in cavities which were originally, in most cases, air-bubbles in molten rock.

Analcime—(*ἀνάγκις*, weak; in allusion to its weak electric power when rubbed). A zeolite composed chiefly of silica, alumina, and soda, and crystallizing in the cubical or monometric system. The ordinary form is a rhombohedron.

Anamesite—(*αναμεσος*, intermediate). A fine-grained variety of dolerite or basalt, in which the constituent minerals are so minutely crystallized, that the rock appears homogeneous, except under the microscope.

Andesite—A variety of trachyte, first described from the Andes, consists of Andesin felspar, glassy felspar and hornblende disseminated through a dark coloured base.

Anticlinal—(*ἀντί*, opposite, and *κλίω* I incline). The curvature of strata in a ridge-like form, the convexity or salient angle being upward.

Anticlinal axis—A line drawn along the summit ridge of an anticlinal curve.

Apophyllite—(*αποφυλλίζω*, I exfoliate). A hydrous silicate of lime and potash, with some fluorine; allied to the zeolites, and occurring in the same manner as zeolites in volcanic rocks. It crystallizes in the tetragonal, or pyramidal system.

Aqueous rocks—(*aqua*, water). Rocks deposited by water, in contradistinction to igneous rocks, the formation of which has been due to heat.

Arenaceous—(*arena*, sand). Sandy, or composed of sand.

Argillaceous—(*argilla*, clay). Composed of clay, or containing a large proportion of it.

Arkose—A detrital rock, composed of the materials of decayed granite in angular fragments quartz, felspar, and mica, and forming a gritty rock often hard to distinguish at first sight from weathered granite.

Ash, Volcanic—A general name applied to fragments of rock and dust (lappillæ, scorix, etc.) ejected from volcanoes. When consolidated, the mass forms a breccia, consisting of larger and smaller masses of various igneous rocks, such as basalt or trachyte, &c., in a finer matrix.

Augite—(*ἀυγή*, lustre). A mineral known also as pyroxene; one of the principal constituents of lavas, and especially of dolerite. It is composed of silica combined with lime, magnesia, iron, and other basis in varying proportions. Augite differs but little in composition from hornblende, and both crystallize in the same system, the oblique or monoclinic, but the angles differ.

Azoic—(*ἄ* privative; *ζωή*, life). A term applied to the oldest rocks in which no organic remains have hitherto been discovered.

Basalt—(*basaltes* Gr. Lat.) An igneous rock, composed of augite and labradorite, and often with olivine in disseminated grains. The term is chiefly applied to the hard black crystalline form of dolerite, and especially to that variety of the rock which exhibits prismatic structure.

Basin—A defined area composed of strata, dipping in a concave form from the circumference towards the interior.

Basset or Basset-edge—A miner's term for the outcrop of a bed.

Bed—A single definite layer of a sedimentary rock, irrespective of thickness.

Botryoidal—(*βότρυς*, a bunch of grapes; *εἶδος*, form). Minerals and rocks are thus termed when, owing to concretionary structure, the surface is raised into numerous convex projections resembling grapes.

Boulder—A mass of rock transported by water action too large to be classed as a pebble.

Breccia—(Italian). A rock composed of angular fragments cemented together.

Calcareous—(*Calx*, lime). Composed of lime, or containing a considerable quantity of it.

Calcite—(*Calx*, lime). Mineral carbonate of lime, crystallizing in the hexagonal system.

- Cañon**—(Spanish). A narrow river gorge with high precipitous sides.
- Chalcedony or Calcedony**—(Derived from the town of Chalcedon). A variety of uncrystallized silica with a waxy lustre, and either transparent translucent; generally bluish white or white in colour.
- Chert**—Impure silica, or flinty portions of rocks.
- Chlorite**—(χλωρός, green) a hydrated silica of alumina, iron and magnesia, resembling mica, but of green colour and very soft; occurs chiefly in scales of small crystals in metamorphic rocks. Forms a large constituent of chlorite schist.
- Cleavage**—A fissile structure, not due to the original bedding of a rock, but, as a rule coincident with it. Cleavage is characteristic of true slates, and has been shown to be due to pressure exercised at right angles to the cleavage planes.
- Conformable**—Beds having their satisfaction planes perfectly parallel, and in which the lower has not been eroded before the deposition of the upper.
- Conglomerate**—(Con, together, and *glomero*, I collect). Rocks composed of rounded pebbles cemented together, or imbedded in a sandy argillaceous calcareous or ferruginous matrix.
- Coralline**—(κοράλλιον). A general term for the calcareous structure secreted by Anthozoa and Hydrozoa.
- Coral reef**—A shoal or low island formed by the growth of corals, and the accumulation and consolidation of their débris. In many tropical seas, archipelagoes of great extent are entirely formed of coral reefs. These reefs have been shown to have been built upon submerged land, the reef-building animals which can only at certain moderate depths, having gradually built up the island as the base sank.
- Cretaceous**—(Creta, chalk) a system of rocks called after the chalk formation which is one of its most important members.
- Crop**—Crop out. To appear at the surface. See "Outcrop."
- Crystal**—(κρυσταλλος, ice). A mineral or salt having regular polyhedral structure. All crystalline forms known are divided into six systems: the cubic or isometric; the pyramidal, dimetric, or tetragonal; the prismatic, orthometric, or orthorhombic; the hexagonal or rhombohedral; the monoclinic or oblique; and the triclinic or anorthic.
- Debris**—(French). A huge rush of water caused by the sudden giving way of some dam whether natural or artificial.
- Débris**—(Débris, fragments of wreck). An accumulation of loose material derived from the waste of rocks.
- Degradation**—The wasting and wearing away of rocks by atmospheric and aqueous action.
- Delta**—The alluvial land near the mouth of a river. The name was originally given to the triangular tract near the mouth of the Nile, and was derived from the resemblance of this area in form to the Greek letter Δ.
- Denudation**—(Denudo, I lay bare). The removal of the superficial crust of the earth by the agency of the atmosphere and water.
- Deposit**—(Depono, I lay down). Any substance originally suspended and dissolved in water and precipitated therefrom.

Detritus—(*Detero*, I rub off). Material removed by disintegration and other agencies from the surface of rocks.

Diaphanous—Transparent.

Diorite—(*διοραω*, I distinguish). A rock, naturally fine-grained, of a dark-green colour, and consisting of felspar (not orthoclase) and hornblende.

Dolerite—(*δολος*, a trick or deceit). A rock of volcanic origin, composed of labradorite and pyroxene, and distinguished from trachyte and its allies by the much larger proportion of bases to silica.

Dune—(French). A sand-hill raised by wind action.

Dyke—A rough stone wall. Volcanic or plutonic rock (trap), filling a longitudinal fissure in a pre-existing formation.

Eocene—(*ἠώς*, dawn; *καινος*, recent). The lowest great sub-division of tertiary strata.

Eolian—(*Eolus*, god of the winds). A term applied to wind-carried formations, such as blown sands.

Erosion—(Eating or gnawing away). Refers to the action of moving water.

Escarpment—An inland cliff, usually produced by the outcrop of a hard stratum.

False bedding—Oblique lamination; the arrangement of sand and other materials of which a bed is composed in laminæ not parallel with the planes of bedding. False bedding is especially common in beds of sandstone deposited by running water, as by a river, or by tidal currents in the sea.

Fault—A miner's term for any break in the continuity of a coal seam or mineral vein, however caused. In geology, the name is only applied where fracture of any rocks has taken place, accompanied by the shifting, either vertical or horizontal, of the opposite faces of the crack.

Felspar or Feldspar—(The latter spelling is correct, the word being derived from the German *feldspath*). A very important group of minerals, one or the other species being a principal constituent of almost all igneous rocks. Orthoclase, albite, oligoclase, and labradorite are felspars: all consist of double silicates of alumina and one or more alkalies or alkaline earths, and crystallize in the oblique or anorthic system.

Felsite or Felstone—A rock of compact texture, usually pale coloured, but sometimes black or brown, weathering white, composed chiefly of felspar with some quartz. Felsite is the matrix of most porphyries.

Ferruginous—(*Ferrugo*, iron rust). Impregnated with iron oxide.

Flag or Flagstone.—Hard laminated, or fissile stone, especially hard sandstone in thin slabs.

Flint—Silicious concretions, usually translucent and tolerably homogeneous, occurring in chalk or lime-stone.

Foliation—The arrangement in alternating laminæ of different minerals, occurring commonly in gneiss and other metamorphic rocks.

Foraminifera—(Foramen, a small opening; *fero*, I bear). A group of *Rhizopoda* living in hollow perforated shells, frequently chambered. Globigerina, Alveolites and nummulites are examples.—See *Rhizopoda*.

Formation—An assemblage of rocks of similar origin, connected by mineral characters, by organic remains, or by being of the same geological age.

Fossil—(*Fossilis*, dug out of the earth). Originally, this term applied to all mineral substances; now, it is restricted to organic remains, animal or vegetable, imbedded in rocks.

Freestone—A stone, usually a sandstone, easily cut and dressed.

Gabbro—(Italian). A rock composed of labradorite and diallage, or fersthenite (bronzite). It is frequently associated with serpentine.

Garnet—(*Granatus*, like a grain). A mineral crystallizing in the isometric or cubical system, and composed of silicate of alumina and lime, or iron; the alumina often replaced by sesquioxide of iron, and the lime by magnesia or some other oxide.

Gastropod—A family of mollusca or shell fish that walk upon the extended edge of the foot.

Ghat—(Hindi). A landing-place, ford, or pass. The term "ghâts" is usually applied to the passes through the mountain-ranges that run parallel, or nearly so, to the coasts of the peninsula, has now been transferred to the ranges themselves.

Gneiss—(A German miner's term). A highly foliated rock, composed of quartz, felspar, and mica in crystals. The mica is sometimes replaced by hornblende, and garnets, or other minerals are imbedded. Gneiss passes through sensible gradations into granite.

Granite—A plutonic rock, rich in silica, and composed of felspar, quartz, and mica. The felspar is almost always orthoclase; a second felspar, usually oligoclase, being frequently present also. In some forms of granite mica is absent (aplite or pegmatite).

Gravel—Loose pebbles, with or without sand.

Green-earth—A hydrous silicate of iron and potash, found chiefly in basalt and other eruptive rocks.

Greenstone—A general name for igneous rocks, composed principally of felspar and hornblende. By some writers certain plutonic rocks containing mica are also called greenstones.

Grit—A coarse sandstone, or, according to some writers, a sandstone in which the grains of quartz are angular. The term is applied somewhat loosely.

Group—An association of beds agreeing in mineral character, or varying slightly amongst themselves in mineral character, but containing the same fossils. The terms "group" and "series" are frequently used by geologists as equivalent terms.

Gypsum—(*γύψος*, lime or chalk). Hydrated sulphate of lime crystallizing in the oblique system.

Hamatite—(Greek *αἷμα*, blood). Native iron oxide in a massive form, either crystalline or amorphous. The crystalline variety, known as specular hematite, crystallizes in the hexagonal system.

Hornblende—A silicate of various bases, usually lime, magnesia, or iron, in combination with each other, part of the silica being often replaced by alumina. The crystallization is oblique. Hornblende is an important constituent of many igneous rocks, such as syenite, diorite, etc.

Hornstone—A variety of flint or chert, resembling horn in appearance.

Hylogene—(Greek *ὑπό*, below; *γίνομαι*, I am made). A term proposed by Lyell for the metamorphosed sedimentary formations formerly known as

primary. The term is extended to express the idea that the beds in question has been transformed from below.

Igneous—(Latin, *ignis*, fire). A term applied to all geological phenomena supposed to be due to the action of the heat. Igneous rocks are such as are believed to have undergone fusion. Particular igneous rocks were formerly supposed to be characteristic of different geological epochs, and some foreign geologists still believe in the distinction, which has, however, been entirely abandoned by all the best English writers.

Inlier—An exposure of an underlying rock through the overlying stratum.

In situ—(Latin, *in place*). A term applied to a rock or fossil when still in the exact position in relation to the matrix or surrounding rocks in which it was formed or deposited.

Ironstone—Any ore of iron; but generally the name is employed for carbonates, especially the argillaceous carbonate of iron so common in the coal-measures, and generally known as "clay ironstone."

Jasper—Impure opaque coloured quartz, often of a bright red colour, or striped red and black or white.

Jhil—(Hindi). A marsh or shallow lake.

Laterite—A cellular ferruginous clay, either of sedimentary origin, or formed by subaerial weathering of ferruginous rocks.

Lava—(Italian). The molten rock that flows from a volcano in eruption. Lavas have the same composition as intrusive volcanic rocks, and are divided into two great sections, (1) doleritic, or basic, consisting largely of pyroxene, and not containing more than 45 to 55 per cent. of silica; and (2) trachytic, or acidic rocks, with 60 to 80 per cent. of silica, and composed mainly of felspar.

Limestone—Indurated carbonate of lime.

Loam—A soil composed of clay and fine sand.

Loess—(German) A term applied to a very fine unstratified or imperfectly stratified formation, composed of clay, very fine sand, and some carbonate of lime, occurring in the Rhine valley. Similar beds of great thickness have been found in China and other parts of Central Asia, and shown to have been probably formed of fine dust transported by the wind.

Lydian stone—A black siliceous rock, either a kind of jasper, or an altered very fine grained siliceous shale.

Magnetite—Magnetic iron ore. An ore of iron composed of one equivalent of sesquioxide and one of protoxide, or of three equivalents of iron and four of oxygen. It crystallizes in the isometric or cubical system, and is usually found in octohedra.

Marble—Properly this term is only applied to the finer and more crystalline forms of limestone. Commonly, however, all rocks capable of being polished are thus called.

Metamorphic rocks—(Greek *μετά* after; *μορφή* form). Rocks which have undergone a change of structure and become crystalline. The term is especially applied to sedimentary formations, which, through the agency of heat or chemical action, have acquired crystalline structure.

Mica—(Latin, *mico*, I shine). A group of minerals, distinguished by being easily split into thin elastic plates, composed of silicates of alumina and various earths and alkalies, and largely developed in crystalline rocks. "Abrak," is the best known Indian name for this mineral.

- Mica schist**—A metamorphic foliated rock composed of mica and quartz.
- Miliolite**—A finely oolitic limestone composed in great part of the tests of foraminifera.
- Nodule**—An aggregation of a mineral, such as carbonate of lime, or silica, around a nucleus, or central point.
- Nummulite**—(Latin, *nummus*, a coin). A genus of Foraminifera, consisting of lenticular shells composed of chambers arranged in a spiral. Nummulites are so abundant in eocene beds as to be characteristic.
- Obsidian**—A lava that has cooled rapidly and is consequently vitreous like glass or slag. The term is especially applied to vitreous acidic or trachytic lavas, composed mainly of felspar.
- Oligoclase**—(Greek, ὀλίγος, little; κλάω, I cleave). A species of felspar, chiefly a silicate of alumina and soda with some lime and potash, crystallizing in the anorthic or triclinic system, and commonly found in granite and other plutonic rocks.
- Olivine**—A tribasic silicate of magnesia and iron, usually of a greenish (olive green) colour and translucent, crystallizing in the prismatic system. The transparent form is known as chrysolite. Olivine is common in basalt, and usually occurs in imbedded grains of a dark yellowish green colour.
- Oolite**—(Greek ὄον, egg; λίθος, stone). Limestone composed of small rounded concretionary particles. From the prevalence of such limestones in the middle secondary rocks, the term "oolite" has been applied to the system of beds underlying the cretaceous.
- Orthoclase**—(Greek, ὀρθός, straight; κλαω, I cleave). Common felspar, essentially a silicate of alumina and potash, crystallizing in the oblique or monoclinic system, and forming an important ingredient of granite, gneiss, and many other rocks.
- Ossiferous**—(Latin, *os*, a bone; *fero*, I bear). Bone-bearing: applied to beds yielding bones of Vertebrata.
- Outcrop**—The edge or surface of a bed, where it appears on the surface of the ground.
- Outlier**—A portion of a bed detached from the main area by denudation.
- Palæontology**—(Greek, παλαιός, ancient; ὄν, being; λόγος, discourse). The science of ancient forms of life found fossil in the rocks.
- Pegmatite**—(Greek, πῆγμα, anything fastened together). Usually, a binary granite, composed of quartz and felspar without mica. By some German geologists, the name is applied to a granite containing orthoclase, quartz, and white mica.
- Period**—A subdivision of geological time.
- Petrology**—(Greek, πέτρος, rock; λόγος, discourse). The science treating of rocks, their structure and composition.
- Pisolite**—(Latin, *pisum*, a pea). A concretionary limestone similar to oolite, but of coarser texture, the concretions being larger.
- Pitchstone**—A vitreous, dark-coloured rock of igneous origin allied to obsidian, but less glassy, of resinous lustre, and frequently containing small crystals, and grains of quartz, felspar, etc
- Plutonic**—(*Pluto*, god of the infernal regions). Igneous rocks formed beneath the surface of the earth and not erupted, but exposed by elevatory movements of the earth's crust.
- Porphyry**—(Greek, πορφύρεος, purple). An igneous rock composed of

compact finely crystalline mass in which large crystals of felspar are imbedded.

Prehnite—(Named after the discoverer). A hydrous silicate of alumina and lime, crystallizing in the prismatic system, but usually occurring in reniform crystalline masses associated with zeolites.

Pumice—A kind of volcanic froth, the mass of air bubbles from the surface of lava consolidated, and forming a spongy rock, allied to obsidian in composition, but so light as to float upon water.

Pyrites—(Greek, *πυρίτες*, from *πῦρ*, fire). Iron pyrites; bisulphide of iron, crystallizing in the cubical system.

Quaquaversal—(Latin, *quaque*, wheresoever; *verto*, I turn). Dipping on every side; applied to strata which dip in all directions towards or from a common centre.

Quartz—(German) A miner's term for pure silica, crystallizing in the hexagonal system.

Quartzite—A metamorphic rock composed entirely, or almost entirely, of silica. An altered sandstone.

Quartz-reef—A vein of silica traversing other formations.

Quartenary—A term used by some geologists for post-tertiary and recent formations.

Recent—In geology, the present epoch; the period during which no important change has taken place in the plants and animals inhabiting the earth.

Reh—Impure salt efflorescing on the surface of swampy soils, or in dry river beds. Called oos (ús) in Gujarat.

Rock—In geological writings, this word is understood to mean any mineral substance occurring in large masses. Sand and clay in large quantities form rocks, as well as limestone or granite.

Rhyolite—(Greek, from *ρῥομαι*, I protect). A rock allied to trachyte and felsite in composition.

Saccharoid—(*σακχαρ*, sugar; *εἶδος*, form). A granular structure resembling that of loaf-sugar.

Sandstone—A rock composed of sand cemented together.

Scarp—A steep face of rock bounding a bed. The precipitous side of any rising ground.

Scoria—(Lat. *slag*). The vesicular portions of a lava flow, or the equally vesicular fragments ejected from volcanoes during eruption. The term is sometimes used as synonymous with volcanic ash, which is, however, of more general application.

Section—(Latin *seco*, I cut). A face of rocks exposed, or cut by nature or art, or represented in a drawing.

Sediment—Earthy deposit from mechanical suspension in water.

Sedimentary rocks—Rocks formed by the deposition of sediment, in seas, lakes or river beds.

Series—A collection of beds comprising several groups, connected by stratigraphical relations or by similarity of organic remains. See "group."

Shale—A consolidated and well-laminated argillaceous or clayey rock.

Shingle—Loose pebbles, especially those on the sea-shore. A coarse form of gravel.

Silica—(Latin, *silex*, a flint). Silicic acid, a compound of the elements silicon and oxygen. Quartz is the same as silica.

Siliceous—Composed partly or wholly of silica or quartz.

Silt—Fine sediment from water, especially from rivers.

Sinter—(German). a mineral formed by hot or cold springs; the former producing a siliceous, the latter a calcareous, deposit.

Slate—A fissile non-crystalline argillaceous rock, the planes of separation which are not due to bedding, but to cleavage. This is the true geological definition; but the term is often applied to hardened shales, which are bedded, not cleaved, and to schists, which are crystalline.

Stalactite—(Greek, *σταλασσα*, I drop) Earthy matter forming icicle-like projections, and separated from solution in water, through the evaporation of the latter, whilst trickling down cliffs, or dropping from the roofs of caves. The material is commonly carbonate of lime, less frequently alcedony or some other mineral.

Stratum—Pl. Strata. (Latin *stratus*, spread.) A bed or layer of a sedimentary rock.

Strike—A line drawn along a bed at right angles to the dip, being the intersection between the plane formed by the bed and the earth's surface, horizontal. The line of outcrop of any stratum on level ground.

Sub-metamorphic—Partially or imperfectly metamorphic. A term applicable to transition rocks such as the Champanir series which are sometimes crystalline but more frequently unaltered.

Synclinal—(*συν*, together; *κλίω*, I incline). The curvature of strata into a trough or valley-like form.

Synclinal axis—A line drawn along the lowest portion of a synclinal curve.

System—A term applied in geology to the whole series of beds representing a sub-division of geological time, as the carboniferous system or the cretaceous system.

Talus—(Latin). The loose detritus accumulated by falling from the face of a cliff, precipice or slope, and not re-arranged by water.

Tertiary—The third or upper great division of geological time, including all formations above the cretaceous and below the deposits of the glacial epoch. The name is synonymous with Cænozoic.

Trachyte—(Greek, *τραχυς*, rough). A volcanic rock, usually of a pale colour, and mainly composed of felspar; a rough mass, frequently with unbedded crystals of sanidine (glassy felspar, a variety of orthoclase). Some hornblende or augite (generally, in acicular crystals) and dark-coloured mica are also present in most trachytes.

Transition—(Latin, *transeo*, I go over). The rocks forming a passage from the crystalline gneiss and schists to the fossiliferous sedimentary rocks.

Trap—(Swedish, *trappa*, a stair; *treppe*, German). A name originally applied to tabular greenstone and basaltic rocks, from their frequently occurring in hills with step-like terraces on the sides. The name should be restricted to stratified lavas, (flows) whether basaltic or a trachytic, and to intrusive dykes and masses of basalt, greenstone, trachyte, or similar rocks. The term is too generally used to be abandoned; and for the ancient bedded lavas, which in vast flows cover so enormous an area in India, no term equally expressive exists.

Trapdyke—An injected vein of trap rock.

Travertine—(Tiburinus, from the river Tibur, near Rome). Calcareous tufa deposited from the water of springs holding lime in solution.

Tufa—(Italian). Any porous vesicular rock. The term is generally restricted to calcareous deposits from springs.

Tuff—A volcanic formation, an agglomerate, composed of loose material scoriae, lapilli, etc., cemented together. The term is especially applied to subaqueous volcanic accumulations.

Unconformity, Unconformable—Strata are unconformable to each other when the lower has suffered from denudation before the deposition of the upper, or, in a minor degree, when the upper overlaps the lower. As a general rule, the planes of deposition in unconformable strata are not parallel to each other, but there are exceptions for instance, the lower bed may have been partially denuded whilst still perfectly horizontal, and a second horizontal bed may be deposited on the denuded surface of the first, without the latter having been disturbed. In this case the bedding planes in both continue parallel, although the two are quite unconformable.

Unstratified—Rocks which do not occur in layers or strata.

Variolitic—A rock structure in which a compact matrix includes many pea-like globular bodies.

Vein—In geology, a fissure filled with some mineral substance differing from that of the rock around, which is by miners technically called the "country rock."

Volcanic—(Latin, *Vulcanus*, god of fire). Igneous action at the surface of the earth, in contradistinction to plutonic action, which takes place beneath the surface.

Volcanic ash—See "Ash."

Warping—An artificial process of elevating the surface of low alluvial land by allowing turbid tidal or river waters to flow over it and deposit their burden of sediment before draining them away, and repeating the operation frequently. The same process is frequently followed by nature in lowlying delta lands.

Zeolite—(Greek, ζέω, I boil). A group of minerals, hydrous silicates of alumina and various earths and alkalies, all characterized by intumescence before the blowpipe. Several of the species are common in amygdaloidal volcanic rocks, filling the cavities.



C U T C H

L I T T L E R A N

INDEX.

- RECENT & SUBAERIAL MILIOLITE.
- DWARKA SERIES.
- GAU SERIES.
- TERTIARY
- DECCAN TRAP SERIES, CRETACEOUS.
- BASIC TRAP DYKES.
- ACIDIC TRAP DYKES.
- CALCITE & QUARTZ VEINS.

The very pale tints of red and green are given to connect the outlying (dark-tinted) patches of Baroda territory.

Map OF KATHIWAR

Scale, 8 Miles = 1 Inch.

GEOLGY FROM A SURVEY BY R. BRUCE FOOTE, F.G.S. F.U.M.
REFERENCE STATE GEOLOGIST, BARODA.

<ul style="list-style-type: none"> ● Tahsil Office ■ Market Town ■ Tahsil Office & Market Town ○ Place of Pilgrimage & Fair ○ Railway Station ▲ Traveller's Bungalow ○ District ○ Sea Port ○ Jetty ○ States 	<ul style="list-style-type: none"> Population over 20,000 do do 10,000 do do 5,000 do do 2,500 do do 1,000 do do 500 do do under 500 Thana Chitris
---	---

- 1 Jhalavad
- 2 Halal
- 3 Sorath
- 4 Cochevad
- Baroda
- Ahmedabad Col.

Note: Approximate Boundaries shown thus.....

Photocopy of Geol. Photo. Office, Baroda, 1927

MADRAS IN 1733.

Enlarged from Talboys Wheeler's Map, and corrected from other sources.








Scale of Yards



GEOLOGICAL MAP OF SANKHEDA TALUKA

BY
R. BRUCE FOOTE
F.G.S. F.U.M. & C.

INDEX

-  POST-TERTIARY
Subaerial and Alluvial
-  CRETACEOUS
Deccan Trap Series
-  MARINE CRETACEOUS
Bagh Beds
-  SUB-METAMORPHIC
Champaur Series
-  CRYSTALLINE
Archaean Granites and Gneisses
-  Crystalline Limestones
-  Crush Breccia
Dip and Strike

