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U. P., LUCKNOW

MINERALS OF UTTAR PRADESH

by

Ravi Prakash

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MINERALS OF UTTAR PRADESH

INTRODUCTION

1.1 OUR PAST

Uttar Pradesh has a long and interesting history of mining of minerals, which dates back to ancient times when base-metals, (copper-lead), alluvial gold and iron ores were mined and refined from parts of our Himalayas, the Bundelkhand and the south-eastern districts. Prior to the 1900^s, records also show the interest of Cexnish miners in Garhwal, when efforts for the mining of copper were intensified. The development of modern technology which helped with bulk production of metals with a consequent decline of prices, controls on the use of fuel wood, the development of communications, as well as, political unstability were perhaps some factors that led to the decline of the small scale metal mines and refining centres within the State. Since then, exploration geologists have been surveying the ground for deposits of both industrial and metallic minerals, which could be developed in the State in relation to the present day technology and economic factors. Excellent accounts of the ancient workings are compiled in Records of the Geological Survey of India, the Himalayan and district Gazetteers, and the old maps and records of the Survey of India.

The early and middle 1900 saw Uttar Pradesh as an extremely backward State with respect to minerals. This was the period of emphasis on deposits in the country's coastal and neighbouring regions, where tremendous activity led to the development of the iron and steel industry, coal and copper, apparently with a view for the export of these essential commodities abroad. Geologically important regions in the up-country remained neglected. The post-independence period brought forth recognition for the need for geological exploration in these

neglected parts, including Uttar Pradesh, where intensive, large scale surveys were then planned. The 1950^s saw the expansion of the Geological Survey of India and the creation of a U.P. Circle, the deployment of teams from the Indian Bureau of Mines, the setting up of the Oil & Natural Gas Commission with their headquarters at Dehradun, and the creation of the State Directorate of Geology & Mining in 1955, with the main object of exploration of industrial minerals in Uttar Pradesh. At this time, the State witnessed a spurt in mining with the development of high grade limestone deposits around Dehradun and the setting up of the Government Cement Factory at Churk in Mirzapur district. The deposits of silica-sand near Shankargarh in Allahabad, developed earlier through the private sector, were mined for the increasing needs of the glass industry and for iron foundries. The State's traditional mines were for building stones derived from the vast Vindhyan sandstone formations of Mirzapur, Varanasi, Allahabad, Banda, Jhansi and Agra districts.

Looking back at the stage during 1950-1960, when building stones, silica sand and limestone were the principal minerals mined, it is a matter of some satisfaction to record the development of new minerals, magnesite, diaspore and pyrophyllite, bauxite, rock phosphate, talc, gypsum, dolomite, baryte, and most importantly, coal in the southwestern parts of Mirzapur district. The small investments made on exploration during the last two decades certainly encourage us for more intensive efforts. While the above are minerals under development for the industry, the recent efforts have also outlined certain potential mineral belts in the State. Discoveries of uranium-copper-lead-zinc-gold and nickel indications in a complex geological environment occurring near Sonrai and adjoining areas of Balitpur district in southwestern Bundelkhand, of baryte-lead-zinc findings in Allahabad and Banda district, lead-zinc-copper ores near Askote in Pithoragarh district, the possibility of similar metals and diamonds in Mirzapur show that so little was known about the mineral potential of our State. These finds merely suggest the need for painstaking efforts that the exploration geologist will have to make in the State's interior and backward districts.

1.2 THE STATUS OF MINING, PAST AND PRESENT:

The value of mineral production in Uttar Pradesh has been estimated to have grown from Rs. 99,682,000 in 1963 to Rs. 133,604,000 in 1967 (Indian Minerals Yearbook, 1976), indicating an increase of about 13.4% in four years, though it formed only about 4.2% of the total value of minerals produced in the country. The following table gives a mineral-wise production from 1964-65 to 1971-72 (Source: Directorate of Geology & Mining):

Table I

MINERAL PRODUCTION IN UTTAR PRADESH

Name of minerals	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72
Silica-sand	Nil	Nil	Nil	Nil	5928.40	35438.500	134391.00	188829.00
Soapstone	Nil	Nil	154.00	124.00	385.00	285.250	289.550	N.A.
Ochre	Nil	Nil	Nil	Nil	1586.44	1876.570	2118.00	2087.00
Bauxite	1190.00	6655.00	2394.40	2716.00	50928.40	26549.400	13161.400	6103.50
Limestone (Major)	175285.33	194021.62	169204.01	116758.97	135237.72	179791.325	647753.661	1353022.12
Limestone (Minor)	-	-	-	-	-	17484.573	54805.00	50985.430
Marble	-	-	-	-	-	4195.296	8698.425	6842.567
Gypsum	1070.90	1127.54	1340.32	530.30	1069.79	726.800	2632.635	1425.00
Pyrophyllite	1699.27	3915.17	2678.00	752.00	319.00	4381.00	2451.00	3238.00
Uraspore	1180.41	1713.45	2493.02	1063.56	525.00	2753.00	3263.00	2402.00
Dolomite	-	23638.06	46718.90	61978.201	50665.41	29339.800	21797.590	16638.405

(Rock phosphate, Magnesite and other minerals mentioned in the text are presently under development)

(Source: Directorate of Geology & Mining, Uttar Pradesh)

The development of mines and minerals in the State can further be judged from the following figures of accrued income (through royalty from major and minor minerals) to the State from 1962-1963 to 1973-74:

TABLE II
INCOME FROM MAJOR & MINOR MINERALS

Financial Year	Total revenue
1963-64	Rs. 7,61,244.00
1964-65	Rs. 9,67,970.00
1965-66	Rs. 15,25,569.00
1966-67	Rs. 9,67,273.00
1967-68	Rs. 17,34,435.00
1968-69	Rs. 19,85,657.00
1969-70	Rs. 36,35,966.00
1970-71	Rs. 49,56,632.00
1971-72	Rs. 54,04,019.00
1972-73	Rs. 56,21,272.00
1973-74	Rs. 71,76,622.00

As against a total of 26 major and no minor minerals leases granted in 1963, the figure rose to 59 major and 13 minor in 1967 and 154 major and 45 minor mineral concessions are operational in the State today through the private sector along with a few concessions in the public sector as well.

The statements of mineral production and income indicate that while its growth was low and erratic in the early 60^s, it was only from 1966-67 onwards did it show an appreciable rise when it stood 6th in the all India list, but contributed only 4.3% of the country's total production. Bihar was the leading State contributing 33.3% of the total for the country, followed by West Bengal and Madhya Pradesh with 18.7% and 15.4% respectively. Most of our State's production, however, came from minor minerals like limestone, sandstone and other building stones, sand, saltpeter, marble etc. It was only in the post 1965

that important mines for major minerals developed, including those for steatite which was exported to foreign countries. From 1966-67 to 1973-74, the income figures indicate an increase of over 70% or a growth rate of approximately 10% per annum. From the production statement further, an increase of 54% is evident when the total figures of major minerals produced in 1964-65 are compared with these for 1971-72. All these figures would give some justification to the efforts planned and implemented in the State since the 1950^s for exploration.

1.3 GEOLOGY:

Uttar Pradesh has a land area of 2.9 lakh square kilometres of which approximately 46,000 square kilometres is covered by the Himalayan tract, 2.00 lakh square kilometres by the central plains and about 42,000 square kilometres by the southern rocky belt comprising some of the oldest rocks in the sub-continent.

Geologically, the northern part of the State comprising the HIMALAYA is sub-divided into tectonic zones (i) an outer (southern) Siwalik belt comprising sedimentary rocks of the Tertiary era (mid Miocene to Upper Pliocene), (ii) a narrow strip of low grade meta-sedimentary rocks of possible Pre-Cambrian age (Simla) with intricately deformed zones of the marine, early Tertiary sediments (th Numulitics), which appear to have been faulted against the younger Siwaliks; (iii) a fairly wide, en-echelon disposed series of synclines underlain by sedimentary rocks of the Jaunsar, Blaini, Krol and Tal formations considered to have formed in localised outer basins preferentially negative over periods of time. These are thrust over (ii) separated by what is named as the Krol thrust. (iv) A mid Himalayan geanticline comprised of the calc. zone of Tejam overlain by quartzites, a group of old (possibly Rhiphaean) sedimentary rocks which are cut by basic lavas and granodiorites. These rocks along with parts of (iii) are capped by (v) thrust sheets of older meta-sedimentary rocks which are considered to have been derived from what are now the inner Himalayas.

(iv) The inner, high region represents rocks of the main Tethyan basin, within which, the two youngest mountain belts of the world, the Himalaya and the Alps, developed. It is comprised of a complete sequence from Pre-Cambrian (> 600 m. years) meta-sediments to sedimentary rocks of the Cretaceous, which are capped by Exotic blocks of the Indo-Tibetan border in the Kumaon Himalayas. The Map I gives a schematic picture of the geology of the Himalayas (Source: Gansser, 1964).

The PLAINS forming the central part of the State are comprised of an extensive Quaternary foreland cover, which prevents any direct observation as to the relationships of the northern Himalayan rocks with those of the southern basement. The Map II is a compilation of the basement structure and depths, giving further the regional aspects of geology of the southern rocky block, (Source: Mathur & Kohli, ONGC, 1963). The plains, including the their northern border with the Himalayas, are an important target for the search for oil and natural gas.

The SOUTHERN tract which runs roughly parallel and south of the Yamuna river and the Ganga between Allahabad and upto east of Varanasi is comprised of the northern extension of the Indian shield. It is underlain by the complex Archaean crystalline rocks of the Bundelkhand (> 2600 m.years), which are overlain by sequences of the platform cover, the Bijawar sediments and meta-sedimentary rocks underlain by older meta-sediments of Berwar (Lalitpur) and possibly the jungles of Mirzapur district; the vast Vindhyan sediments which form a characteristic plateau in the Mirzapur-Allahabad-Varanasi-Banda and Lalitpur districts. The youngest rocks in this belt are the coal bearing Gondwana which form in isolation in the south-western corner of Mirzapur, and the basic traps which cover parts of the Vindhyan plateau in Lalitpur district. The table III give geological successions of rocks units in the three main physiographic parts of our State, and against whom important mineral deposits are indicated.

TABLE III

GEOLOGY & MINERALS (indicated & known) OF UTTAR PRADESH

The Himalayas and the Siwalik belt		The Plains		Southern-Rocky Tract	
Geologic tectonic zones	Minerals	Geologic zones	Minerals	Geological zones	Minerals
Quaternary piedmont deposits of south flank	Boulder, shingle ballast, lacustrine clay, and calc-tuffa.	Newer Alluvium	Sand, Morrum, Shingle, Ballast, Marls	Gondwana	Coal, non-plastic fine clay.
Siwalik belt, comprising middle and upper units	Oil & gas prospects. Low grade iron ores. Low grade coal.			Vindhyan	Recently indicated lead-zinc-copper-barite mineralisation; bauxite, ochre, clay-lithomarge; limestone and dolomite; building stone ballast; pyrite, mineralisation silica-sand.
Outer-Autochthon	Selenite occurrences and possible pyrite.			Bijawar	Indicated copper, lead, zinc, uranium, low grade iron ores; Marble, limestone & dolomite.
Krol Synclines of the Outer Himalaya	Sandy limestone, dolomite, phosphorite, marble, high calcium limestone, gypsum, barite-lead; showings of copper lead; small, low grade iron ore.	Older Alluvium	Kankar, Reh, Salt-petre, clays & brick-earth, quaternary boulder & stone; ballast. Calc.-tuffa.	Bojwar Jungel	Indicated gold-uranium; magnetic iron ores.
Geanticline of middle Himalaya	Magnesite, talc-steatite, lead-zinc-copper workings; uranium showing in quartzites; limestone-dolomite, slate.			Archaeon basement	Diaspore-pyrophyllite; indicated graphite, copper-lead-nickel, alluvial gold, Mica, clays. Selenite.
Crystalline thrust zone	Mica, graphite, copper-lead-zinc of Askote & Pekhri; building stones. Uranium & antimony showings in Chameli dist.; Amphibole asbestos; Sulphur.				
Inner Himalaya	Kyanite, garnet, marble. Arsenic and antimony.				

1.4 AGENCIES EXPLORING MINERALS IN UTTAR PRADESH.

The following is a list of agencies which are presently engaged with the exploration and development of minerals in Uttar Pradesh:

1. The Geological Survey of India
2. The Indian Bureau of Mines
3. The Directorate General of Mines Safety.
4. The Atomic Minerals Division of the Government of India
5. The Oil & Natural Gas Commission
6. The National Coal Development Corporation
7. M/S Pyrites, Phosphates & Chemicals Ltd.
8. The State Directorate of Geology & Mining, U.P.
9. M/S Almora Magnesite Limited
10. The U.P. State Cement Corporation
11. The U.P. State Bundelkhand Vikas Nigam
12. The U.P. State Mineral Development Corporation Ltd.
13. The Mineral Exploration Corporation of India.

The above agencies have been assisted on particular projects by the National Geophysical Research Institute, Hyderabad; the Central Glass & Ceramic Research Institute, Calcutta; the National Metallurgical Laboratories, Jamshedpur, the Department of Exploration Geophysics, Osmania University, Hyderabad; the Central Electrical Research Institute, Karaikudi; the Central Building Research Institute, Roorkee, and the State Universities having departments for geology and geophysics.

2. MINERAL RESOURCES

The earlier Chapter has shown that while the State in ancient times supported metal mines for conventionally important minerals such as copper-lead, alluvial gold and iron ores, with technological development and the opening up of large mines and processing plants, the small operators, as those in our Himalayas, could not economically continue their workings. Since then, from the early 1900^s, isolated efforts for finding economically viable mines have continued with little success in the base metal field. Such programmes intensified in the mid 1900, however, led to discoveries of important industrial minerals like limestone, gypsum, marble, silica-sands and magnesite, most of whom have since been developed.

The early field geologist traversed known trails using a compass and topographical maps of the Survey of India. The lack of good communication made the work necessarily slow and painstaking. The situation was considerably changed after 1960 when roads were built to connect the remote parts of our State. The development of such infra-structure saw the advent of modern exploration methods when apart from routine mapping and mineral survey programmes, sophisticated geochemical and geophysical methods, as integrated tools with geology, were applied for the search for ore deposits. Recently, in 1973-74, air-borne geophysical surveys using magnetic, electro-magnetic and radiometric methods were deployed in a small part of our State in the Bundelkhand, as well as, bore hole geophysics using resistivity, gamma-gamma-ray logging, radiometric and induced-polarisation were used with some success.

In today's context of economic mineral deposits, standards relating to size and shape of ore bodies, their location and grade are extremely stringent. Furthermore, our country with its vast population, and with a past history of

prospecting and mining, through old records had already a large volume of data, relating to conventional minerals which were visible on the surface. The ground had been extensively "walked over", and a fair idea of the deposits found by our ancient ancestors could be had by re-opening the old workings. Most of today's large operating mines in the country are those which had been found much earlier, but needed detailed evaluation before they could be re-opened. This factory, in the author's opinion, has been to our disadvantage, as well as, it perhaps showed down a possible effort towards intensive exploration of large areas selected on the basis of known geological relationships, rather than the existence of ancient workings. Mineral deposits today, are viewed "as integral parts of complex geological environments and geological theory is, therefore, an essential guide to successful exploration". Such thinking needs to be applied on a large scale in the country and our State, specially now when the search has to be geared for finding completely "hidden deposits" which lie well below the surface. The new, sophisticated methodology developed so rapidly in the western countries will need to be adopted with modifications for our special technical problems, such as those that may relate to tropical weathering of the rocks and sulphide minerals, or to those created through extensive agriculture and ground pollution through the use of fertilizers!

Advanced technology, integrated large area surveys, developing suitable methodology that would be effective in particular areas and on special problems, and the need to change our attitude from "walking the beaten trails" to looking for "new pastures" will require intensive efforts, both in terms of manpower and finance. Any curtailment of exploration today will require twice the input tomorrow, and the existing gestation period before a mine can be opened and the mineral won for a profit would merely increase at agonising rates. In our State, almost all the existing mines were developed through prospecting in recent times. The application of modern technology, in which we are late in starting by at least two to three decades in this

State, has already led further to the discovery of mineral belts that were hitherto unknown. This would suggest that much wealth lies concealed below the ground that needs to be found. Investments here are, therefore, of long term significance, which must be increased now for meeting our requirements, say at the turn of this century.

2.1 MINERALS OF THE U.P. HIMALAYAS:

Studies of geological and mineralogical relations in the Himalayas reveal that ore minerals developed clearly in close connection with the various phases of evolution, of initially the complex basin in which the sediments accumulated in varied environments and later the great movements that eventually gave rise to the world's highest mountain chain. During such an overall evolution, metals brought in during sedimentation and later processes of injection through volcanic and related activity were re-distributed in typical assemblages, each of whom are today recognised within distinct tectonic zones. For instance, the starved outer-basins which controlled sedimentary Krol carbonate sequences are today the site for mining some of the purest limestone and dolomite deposits. Similarly, the middle Himalaya of restricted, perhaps only Proterozoic deposition, was the site for preferred shallow carbonate-black shale-volcanic association, and which afterwards appears to have remained an area free from younger sedimentation. This is known for unique, perhaps metamorphic magnesite and talc deposits within carbonates, and the base-metals in the more complex associations within this belt. These concepts are merely beginning to take shape, but would depend heavily upon the availability of basic data on local and regional distribution of facies; their structural order and the regional migration and distribution of associated elements. The effort towards compiling such regional data has so far been much below the pressing need. Further, the basic tool, the geological map on say 1:50,000 scale is not freely available on account of restrictions imposed on their distribution. The following is a brief zone-wise description of mineral deposits investigated so far.

2.2 THE SIWALIK BELT:

The Siwaliks are considered as a belt of young sedimentary rocks of the Miocene-Pliocene times, and within which are buried fossil mammals indicating the stage of evolution of life. They formed along the southern front of the Himalayan chain through accumulation of sediments along longitudinal basins that parallel the Himalayan trend. They are generally comprised of a lower sand-clay-red bed association which is gradually overlain by coarse elastics, possibly related to activation of the mountain front. The Siwaliks unconformably cover marine Tertiary rocks of the outer-Himalaya which are considered to be the main source for OIL AND NATURAL GAS in India. The Siwaliks themselves merely provide structural traps for the accumulation of oil and gas. Such structures known from Mehand in Dehradun and the Saryn valley region near Tanakpur may well extend below the alluvium, where they are being investigated by the Oil & Natural Gas Commission.

ALLUVIAL GOLD was panned in early 1900^s from streams draining the Siwalik hills in Bijnor district, and accumulations have been recorded in 'relict' stream channels in the same region. This shows a possible primary source within Siwalik sediments. Reported uranium from Siwalik beds elsewhere suggest a possible gold-uranium association which needs to be investigated within our State.

PEAT and LIGNITE lenses are further reported from Siwalik sandstones. These are not considered to be of any commercial value at present.

LOW GRADE HEMATITE bearing sandstones (iron ores) of Kaladhungi in Nainital district were mined and processed for implements in the 18th and 19th century. The deposits were mined from near Kaladhungi-Dechauri, where ancient remnants of a processing plant are still to be seen. Very preliminary data on the grade or reserves is available from records of the Geological Survey of India.

SIWALIK SAND deposits, which are in the form of loose boulders of friable sandstone, were exploited from near Rajpur in Dehradun district. The boulders occur above the Siwalik sandstones contained within the northerly trending hillock immediately west of Rajpur. A small glass making unit was in existence in the early years near Devi Temple which was based on these deposits.

GYPNUM as small lenticular bodies is found in the belt, within quaternary conglomerates where it apparently formed as a result of alteration of carbonate debris through action of naturally formed acids. Preliminary investigations show the presence of the following types:

TABLE IV
ANALYSIS OF GYPNUM FROM THE
NIHAL VALLEY, NAINITAL DISTRICT

Contents	Variety	
	Pink	White
1. Water & volatiles	15.80%	20.81%
2. CaO	35.41%	33.50%
3. So ₃	49.27%	46.47%

(Analysis of selected samples only;
Source: Geology & Mining, U.P.)

Minor minerals, BOULDER & SHINGLE, which form the basic raw material for roads, railways, irrigation canals and other engineering works are available as large deposits within lower reaches of the Yamuna, Tons, Ganga, and other smaller rivers draining out into the plains from Garhwal and Nainital districts. These deposits mined, usually by private lessees, are a good source of income to the State. Small industries for making pre-stressed concrete blocks and poles could be planned on these deposits.

2.3 THE AUTOCTHON & THE KROL BELT

The belt comprises the outer chain of mountains, clearly distinguished from their physiography and the type of forest growth that they support. On aerial photographs, one can clearly observe the sharp line that divides the belt from the Siwalik range occurring to the south and usually characterised by dense jungles in the Dehradun, Tehri, Pauri and Nainital districts.

Very generally speaking, while the basal parts of this belt comprising older sediments contain evidence of vein type mineralisation, with indications of copper-lead-zinc-baryte, the younger rocks contain important, commercially workable deposits of limestone, marble, dolomite, gypsum and rock-phosphate. Within the rock-phosphate zone, detailed tests also show the presence of uranium, copper, nickel, molybdenum and vanadium. Since the earlier surveys of J.B. Auden of the Geological Survey of India in the 1930^s when limestone was considered as the only important mineral, more intensive investigations have led to new discoveries in this belt. This paper only describes deposits of minerals that are of known importance within this belt.

LIMESTONE

Extensive deposits of limestone investigated occur within what is known as Krol C stage member of the Krol Group, from parts of the Blaini formations, the Mandhali which forms a part of the Jaunsar group of sediments, and from Tal formations in the Dehradun, Tehri, Pauri and Naini Tal districts. The following is a brief account of the quality and reserves as are known so far through investigations done by the Geological Survey of India and the State Directorate of Geology & Mining, U.P. :

TABLE V
GRADE AND RESERVES OF LIMESTONE
IN THE KROL BELT

Name & location of deposit	Reserves (in million tonnes)	Chemical analysis (Average)		
		CaO%	MgO%	SiO ₂ %
MANDHALI LIMESTONE NEAR MANDARSU- KALSI, DEHRADUN	66.6	45-50	1%	6-11%
BARKOT-KUTIA, KROL C LIMESTONE DEHRADUN	38.2	50%	2-4%	1%
KROL C STAGE MUSSOORIE - SON VALLEY (Source (G.S.I.))	1. 146.4 2. 254.5 3. 6.5	50% 45% 54%	2-4% 3-10% 1%	1% 2% 1%
LAMBIDHAR AND H. TIPAN, MUSSOORIE CHEMICAL GRADE)	7.00	53%	2%	1%
JAUHASI NEAR KHAIRNA, NAINITAL	10.00	44%	2-3%	7-8%
TAL LIMESTONE NILKANTH, GARHWAL	50	34-36%	1.0%	20, 30%

Total estimated reserves: 579.20 - Potential areas in Lansdown & Nainital are further to be assessed.

INDUSTRIAL POTENTIAL

(a) The deposits in this belt can be classified as (a) those ~~which are~~ suitable for dolomitic and building lime, and possibly also for cement after blending, estimated at over 350 million tonnes; (b) approximately 100 million tonnes being available from the Mussoorie belt for the sugar and paper industries and (c) about 10 million tonnes being available for special chemicals, such as precipitated and activated chalk, bleaching powder and calcium carbide. Tests done recently on the purest category show that it is marginally suitable

for carbide, an essential source for acetylene and P.V.C., as well as, for white cement. The high calcium limestone is further suitable for use in the steel melting shop.

Sites for cement plants have been located on the basis of orders of magnitude or detailed feasibility studies, and recommendations have been made for setting up a 4.00 lakh tonnes/annum plant at Rishikesh, and a similar capacity unit near Kalsi. The area is capable of sustaining, on the basis of present surveys, a total cement capacity of 12-16 lakh tonnes per annum. With the availability of power, a 50 tonnes per day carbide plant can further be planned.

Presently, the deposits around Dehradun sustain a lime production of 30,000 tonnes per annum, and three units of 6-15 tonnes per day have been set up for manufacturing precipitated and activated chalk. About 4.00 lakh tonnes of high grade limestone is mined from the area for feeding the requirements of chemical, paper and sugar industries in U.P. and the adjoining States.

MARBLE

The Krol C stage in its upper parts contains lenticular bands of marble, of cryptocrystalline texture and white to light grey or cream shades. The marble may either be high calcium in composition or dolomite, with MgO exceeding 19%. The deposits in the Kiarkuli-Bhatta-Arni Gad areas in Dehradun are being mined for the production of marble chips for flooring in luxurious buildings. The dolomitic marble is not being used at present.

In addition, black cryptocrystalline marbles are being exploited as high grade limestone in the chemical industry. The reserves and grade of this type are compiled in the table VI, under category 1 of the Krol C stage limestone of Mussoorie. The following table gives a break-up of the deposits in Dehradun district:

TABLE VI
MARBLE DEPOSITS IN THE KROL BELT

NAME & LOCATION OF DEPOSITS	RESERVES (in million tonnes)	CHEMICAL ANALYSIS (AVERAGE)		
		CaO	MgO	SiO ₂
Hatipaon-Cloud End Lambidhar (Mussoorie)	10.11	53%	<1%	<1%
Kiarkuli-Bhatta (Mussoorie)	3.00	53%	<1%	<1%
Dolomitic marble of Ghorapitti, Dehradun	2.00	28%	19-21%	<1%

The high calcium white marble extensively used today for making marble chips needs to be considered for more useful purposes in national interests. In view of the grade of this marble, it needs to be conserved for the production of calcium carbide, which is likely to become a strategic commodity for plastics in the near future.

DOLOMITE

Extensive deposits of high grade dolomite are known from the Krol belt, a very small part of it having been assessed so far. High grade dolomite finds an important use in the iron and steel industry where it is used as a flux, as well as, for refractories and metal magnesium through the newly developed vacuum-metallurgy.

The deposits are mainly distributed within the Krol E stage, and forms south facing scarps overlooking the Dehradun valley, and the plains south of Naini Tal. The deposits could be proved for mining from those occurring east and west of Mussoorie, the Song river valley and Ghoran in Dehradun, from Narendra Nagar in Tehri; from near Dogadda in Pauri and from the Khurpa-Tal - Nainital region in the outer Kumaon Himalaya.

The total potential available is likely to be well over 100 million tonnes.

The deposits at Ghoran hill are estimated at over 10 million tonnes, having MgO above 20%, SiO₂ < 2% and combined Al₂O₃ + Fe₂O₃ at less than 1%.

ROCK PHOSPHATE

Though the discovery of rock phosphate deposits in the Krol belt of Mussoorie goes back to early 1900 when the mineral was reported by Rev. Parsons from near Woodstock, intensive investigations undertaken by the Geological Survey of India in collaboration with the U.S. AID in middle 1960 revealed extensive low grade deposits in both limbs of the Mussoorie syncline, covering parts of Dehradun and Tehri-Garhwal districts. A small part of these deposits are being mined today by M/S Pyrites, Phosphates & Chemicals Limited, a Government of India undertaking, from near Maldeota in the Bandal river valley, approximately 18 kilometres from Dehradun.

The rock phosphate occurs as a sedimentary horizon within possibly Mesozoic black shales of the Tal Formations, immediately above the Krol E stage dolomites. Its extent could be determined easily due to the association of uranium minerals, which are detected with the help of scintillation counters. The mineralised beds, particularly in the south limb contain appreciable amounts of nickel, copper, molybdenum, vanadium and uranium, some of the metals being present as organic compounds. Detailed laboratory investigations are necessary to determine if these metals, along with carbonates or oxides of calcium could be recovered as by-products during the course of processing of the phosphate.

The consumption of rock phosphate in the country, mainly for fertilizers, during 1971-72 was over one million tonnes, out of which only about 20% of our requirements were met from indigenous resources. The foreign exchange requirement for the import of rock phosphate was around Rs. 13.00 crores. This

was expected to rise to around Rs. 20.00 crores at the beginning of the Vth plan, with our needs increasing to around 1.5 million tonnes. With the discovery and development of deposits in our Mussoorie belt and in Rajasthan, it is expected that our dependance on imported ores is likely to be reduced substantially.

The table VII gives briefly the estimated reserves and grade of the phosphorite in accordance with presently acquired data (Source: Open files of M/S Pyrites, Phosphates & Chemicals Ltd.; reports of the Geological Survey of India and the National Mineral Development Corporation):

TABLE VII
GRADE & RESERVES OF ROCK PHOSPHATE AROUND MUSSOORIE

SL. NO.	BLOCK & LOCATION	AVERAGE THICKNESS	RESERVES (In mill. tonnes)	AVERAGE GRADE (P ₂ O ₅ %)
1.	DURWALA, 18 KMS. EAST OF MUSSOORIE	5 metres	5.29	19.60%
2.	MALDEOTA, 18 KMS. east northeast of Dehradun	2 metres	7.25	19.60%
3.	MATHET, DUBRA & CHIPALDI, west & east of Maldeota	1 metres	1.51	20-25%
4.	PARTIBBA CHAMASARI Just south of east Mussoorie.	1-3.50 metres	2.79	17.00%-31.2%
5.	KIMOJ MASRANA, 11 kms. east of Mussoorie	0.5-3 metres	1.59	11.4-15%
6.	BHUSTI JHAMTALGAON 20 kms. from Maldeota	1.10 metres	0.51	25%
7.	JALIKHAL M. THLANGAON	1-3.46 metres	4.26	20-26%
8.	NAGINI, CHAMBA, KUMALI, north of Narendramagar.	1-6	0.63	13-15%

The table VII suggests that from the presently available data, we could consider a potential reserve of about 17 million tonnes, with an average grade ranging from 16-20% P_2O_5 . The present data, however, is from preliminary surveys and shallow drill hole intersections. Intensive detailed work is planned by the Pyrites, Phosphates & Chemicals Ltd. through the State Directorate and the Mineral Exploration Corporation of India.

The low grade run of mine rock phosphate is finding an extensive use directly for the treatment of acidic soils in our hills, and in other rocky parts of the country. In addition, ground rock phosphate is used for making mixed N.P.K. fertilizers. Plans are further being drawn for setting up beneficiation plants for upgrading the rock and then for utilising the same for the manufacture of fertilizers. This is an important step keeping in view the fast rising cost of high grade imported phosphate rock and our increasing needs for phosphatic fertilizer. The production of elemental phosphorous directly from the low grade Mussoorie rock phosphate can be considered with increased availability of cheap power.

The Mussoorie rock phosphate belt is considered a potential source for the State and our country's needs for fertilizer for the future. The need is for proper evaluation of the type of soils that need to be treated and then for conserving and planning the production of phosphatic fertilizers for meeting our long term requirements. Any planning and production in isolation may be of immediate advantage to a particular area, but not necessarily so in the long term interests of the country.

GYPSUM

Gypsum deposits in the belt are confined to the Krol red shales (possible ancient evaporites), and the Krol D stage limestone and pyriteous shales. The mineral is considered to have formed either by direct precipitation from sea waters, or by metasomatic replacement of the lime-carbonates by action of acidic waters generated from the pyrite bearing beds. The deposits are in

the form of small lenses within the red shales, the best concentrations seen upstream of the river Ganga near Lachuanjhula, or as small replacement deposits within carbonate rocks near Sahastradhara, and in the Song valley in Dehra Dun and Tehri Garhwal.

The deposits have been assessed in a very preliminary fashion, and the following tables are compilations of the grades and reserves as known so far.

TABLE VIII
CHEMICAL ANALYSIS & RESERVES OF GYPSUM
FROM DIFFERENT LOCALITIES IN THE BELT

Locality	Analysis (Average)			Reserves (estimated in mill. tonnes)
	Combined water	CaO	Sulphuric anhydrate (SO ₃)	
Sahastradhara	20.85%	33%	45%	Exhausted
Mahipur-Sera	20.9%	33.94%	45.6%	35,000
Lachuanjhula	21.00%	33.7%	44-45%	80,000 (approx.)

The reserve estimates are for surface exposures that are already under mining through private parties, who are mainly meeting the requirements for the manufacture of plaster of paris. The potential reserves that could possibly be developed through mechanised open-cast or underground methods are perhaps much larger.

The deposits of this belt have not been able to find a market in the State's cement industry so far on account of erratic and small quantities mined by private lessees. After a proper assessment through detailed geological mapping and drilling, they could be considered for this industry, as well as, for making sulphur through new processes using mollasses, developed by the B.K.G.M., France.

BARYTE - LEAD

Lenticular veins of baryte ($BaSO_4$) associated with galena (lead) and copper sulphide ores were discovered recently in fissures cutting Blaini and Naghat formations in the Krol belt, between Dehradun and Rishikesh. In the Song valley region itself, approximately 40 veins were found with poor surface extentions, however, their association with major, large scale structures, such as the Krol thrust, suggests that larger sub-surface deposits may be located.

Several samples of baryte were analysed in the laboratories of the State Directorate, and they showed a variation from 73.10% $BaSO_4$ to 88.90% $BaSO_4$. The total mineralised area is about 5.5 sq. kilometres immediately south of the Song-Bandal river confluence in Dehra Dun district. Approximately 5000 metric tonnes of ore is estimated from the small veins here.

OTHER MINERALS

Occurrences of copper-lead mineralisation are reported from the lower and upper sections of the Jaunsar formations in the Chakrata division. Small deposits of iron ores similarly are reported from near Nagthat, west of the river Yamuna. Generally speaking, geological work in the belt has shown a relationship of deeper tectonics with mineralisation in this belt. The Jaunsar sections, therefore, need to be probed in detail for metallic mineralisation.

SULPHUR SPRING: Three important sulphur springs (cold) are reported from Manjhera, Sahastradhara in the Baldi river valley, and from near Sera in the Song river valley. The spring at Sahastradhara provide a tourist attraction. It was investigated several years ago, and was classified as "Medicinal water" by P.K. Ghose, due to the presence of sulphates of sodium and magnesium, bicarbonates, chlorides of alkalies and alkaline earths. The following tables give details of the Sahastradhara spring waters:

TABLE IX

SULPHUR SPRING - SAHASTRADHARA,
DEHRADUN

(Geology & Mining, U.P.)

Date of sample collection: 27th July, 1957

Temperature of spring water: 21.5°C

Temperature of Baldi river water: 23.0°C

Transparency - clear, white flaky deposit on standing for a few days. White crystalline precipitate on keeping for a few days with an electrolyte (NaCl), presumably through precipitation of SiO₂ and S.

Chemical constituents	Sample No.		
	1	2	(P.K.Ghose) 3
Temperature	In parts 21.5°C	per million 21.5°C	23°C
SiO ₂	14	14	16
Fe
Al	7	6.89	4
Ca	528.5	528.9	591.5
Mg	108.4	108.2	12.3
Na	35.4	35.4	314.7
K	-	-	-
Cl	3.2	3.7	5.0
So ₄	1371	1371	1580
HCO ₃	16	273	179
S	16	16	15.2
H ₂ S	Present	Present	Present
CO ₂
Total ions	2356.7	2667.6	2915

The Krol belt of the outer Himalaya is, therefore, potential for industrial minerals, some of which are likely to meet our requirements for cement, chemicals and fertilizer for a long time to come.

2.4 THE DEOBAN-TEJAM-CHAMOLI BELT:

The belt follows the entire middle Himalaya in Uttar Pradesh. While its relationships with the older rocks of the Krol belt are yet a matter of controversy, in the Bhagirathi section, the rocks of this belt apparently underlie the rocks of the Jaunsar-Morar Chakrata region. The belt is comprised of two major formations classified under the Deoban-Tejam Group. These are a basal carbonate - black shale to calc. shales which are overlain, often discordantly, by massive Chamoli quartzites. In the eastern sector, the quartzites appear to be overlain by dark shale-carbonate beds.

The belt appears to represent an inerrantly stable part of the ancient Himalayan marine basin, the more negative parts of which flanked this high both to the south and north. Since the development of the formations, the stratigraphic record would suggest that the belt remained a high ground where no major sediments accumulated after perhaps the Pre-Cambrian-Rephaean (600 m.years). However, the belt must contain evidence of earth movements that gave rise to sediments over a pulsating sea floor, which was later effected by vertical uplifts. Further, the sedimentation in this ancient palaeobasin must have been influenced by an environment usually related to stable platforms, in which shallow seas, often confined, caused the enrichment of certain metals, particularly lead and zinc. It is in this overall context of complex geological environment that this belt is to be viewed. The belt is important for commercial deposits of Talc & Steatite, and magnesite. It is urgently being searched for copper-lead-zinc and even uranium. The belt sustained our ancient copper mines all along its length from Pithoragarh to Uttarkashi.

The Deoban-Tejam zone forms as a complex ge-anticline which has a general plunge towards the northwest. It essentially follows three parallel antiform axes, all three being evident in Pithoragarh-Sirdang, only two in Almora and Chamoli, the entire structure plunging out in north Dehradun and westwards. Most mineral deposits of promise, however, are so far located along the southern and central axes in Pithoragarh, Almora, Chamoli; Pauri and Uttarkashi districts. The following is an account of the important minerals found in this belt.

MAGNESITE

Magnesite is today perhaps the most important mineral of our Himalayas, due to its need for our iron and steel industry. The only other sources for magnesite are in Tamil Nadu and Mysore States. It is used for making dead burnt magnesite, the name "dead burnt" indicating the degree of burning or calcination of magnesium carbonate to extremely stable oxides, and as "pea" magnesite for direct use as a basic refractory. The dead burned product is further used for making straight and chrom magnesite refractory bricks. In the Uttar Pradesh Himalayas, the first unit for dead burned magnesite has been established near Kafligarh-Matela, about 50 kilometres north of Almora. The unit of 100 tonnes per day capacity is managed by M/S Almora Magnesite Limited, a Government undertaking and a joint sector company formed by the participation of the U.P. State Industrial Development Corporation and M/S Belpahar Refractories (a subsidiary of the Tata Iron & Steel Co. Ltd.). The mineral can further be used for making lightly calcined magnesite, basic magnesium carbonate and other chemicals, magnesite straw boards for insulation, and sordel cement. Such ancillaries are now planned.

Magnesite deposits occur as small lenses within massive dolomite of the calc zone of Tejam. It is considered to have formed in geological structures, where the dolomite (CaMgCO_3) was

preferentially converted to coarsely crystalline magnesite through natural solutions. Some workers, however, regard these as basically direct precipitates from large ephimeral ancient marine basins. The ores mined usually contain impurities such as calcite, dolomite, siderite and talc which have to be sorted manually for making dead burned magnesite.

The deposits have been investigated principally from Pithoragarh, Almora and Chamoli districts, though parts of Garhwal and Tehri may also be potential areas. In Pithoragarh, significant deposits occur between Chandak and Bisabajar, in the Ram Ganga valley near Thal and Tejan, and from around Dewal Thal. In Almora district, the deposits are in three large groups, in the Someshwar (Girichchina) - Dewaldhar-Pagna-Nail sector following the southern axes of the geanticline, in the Pungar valley and the Lahor valley, following generally the southern limb of the northern anticlinal axis. The Jhiroli deposits in the Dewaldhar group are presently being mined at the rate of about 225 tonnes per day. These are estimated at 4.00 million tonnes.

In Chamoli district, the deposits occur in two groups, one in the Pipalkoti - Hilang region south of Joshimath, and the second in the Mandakini river valley from near the villages Ghuni and Rauri, about 17 miles upstream from Nandprayag.

For purposes of exploitation and expansion of the basic refractories and dead burnt magnesite units in the U.P. Hinalayas, the Pithoragarh district is likely to contain over 20-30 million tonnes, out of which over 3 million tonnes near Chandak have been proved for a new 100 T.P.D. venture to be set up at Pithoragarh in the private sector. In Almora, the expected reserves are around 20 million tonnes. In case underground mining for magnesite is proved to be economically

viable, the reserves would then substantially increase. The following table describes some salient features of some of the important magnesite deposits known from the belt:

TABLE X
STATEMENT DESCRIBING SOME SALIENT
FEATURES OF THE MAGNESITE DEPOSITS

Name of deposit	Thickness of mineralisation	Average		Composition		Extent/Reserves
		MgO	CaO	SiO ₂	Fe ₂ O ₃	
Dewaldhar	Ranging between 50-115 ft. av. thickness 70 feet.	43.95 to 41.19	2.31 to 0.30	4.62 to 1.90	3.35 to 1.33	Exposed strike length 7797 ft. Estimated reserves 7.9 m. tonnes with overburden 1:1, without overburden 3.3 m. tonnes.
Agar-Girichchina	Varying between 83 to 30 ft.	43.22 to 38.13	5.78 to 2.14	4.20 to 1.58	3.02 to 2.21	Exposed strike length 3120 ft. Estimated reserves upto 5200 level are 3.48 m. tonnes. Without overburden 1 million tons.
Chhani	10-15 ft.	43.25	2.88	0.63		300-400 ft. length
Nail	20-25 ft.	40.63	5.43	0.82		300 feet
Bhurgaon	Average	42.85	1.93	1.72	4.80	Several scattered outcrop between Pagnakhol and Bhurgaon.
Bauri	Sufficiently thick					Exposed in several zones. One such zone measures 1200x400 ft. and another 100x50 feet
Asaun	Average					Two deposits, one of them measuring 1200x400 feet.

Harap

Name of deposit	Thickness of mineralisation	Mgo	Average		Composition		Extent/Reserves
			CaO		SiO ₂	Fe ₂ O ₃	
Naini- Doup	Average	Quality variable in different parts of deposits					Scattered deposits associated with dolomite & Tale.
Trap	40 feet	42.13	1.05	4.90	4.30	Deposits measuring ½ mile.	
Munapani	100 feet	43.09	1.22	5.18	2.61	Two furlongs exposure.	
Jakh- Harbar	50 feet	43.59	1.24	2.82	3.73	Several discontinuous deposits between Jakh-Harbar.	
Upper	40-50 feet	41.70	1.42	8.44	3.66	Mineralisation traced for 2000 feet.	
Muna	Sufficiently thick	42.13	2.07	2.90	4.07	Exposed strike length 300 ft. Another deposit north of Pungar measuring 1500x700 ft.	
Karauli	Average	42.17	1.17	7.20	2.61	Extensive deposits occurring between Karauli & Mahatgaon. Twelve known deposits occurring in close proximity, constitutes an extensive deposit. The deposits at Dewalthal, Chandog, Satsilang & Tadiari are among the largest group of deposits. Two deposits exposed for half a mile, one is 75 ft. thick and the other 200 feet.	
Lang- Duari	Sufficiently thick					Several deposits in close proximity large deposits measuring over 500x300 ft.	
Belakuchi group	Sufficiently thick deposits upto 80 feet.					Extensive deposits covering large areas. Outcrop traced upto 500 feet.	
Chuni	Approximate 30 feet	43.51	0.28	3.72	3.57		

TALC

Talc is the softest common mineral on the Moh's scale of hardness, and is a hydrated silicate of magnesium. It is commonly found as lenticular deposits within dolomites, magnesite or basic rocks. The more massive varieties are often termed soapstone, due to the soapy feel of the mineral, or as steatite. Apart from its common usage in cosmetics it is of considerable importance as a filler in paints, textile and paper industries, and in the manufacture of ceramics, roofing felts, insecticide powders and soaps. It is also used as a polishing, dusting or lubricating agent in the rubber, foundry and grain food industries. Small deposits of the mineral are mined by private groups from parts of Almora and Pithoragarh districts. "Lava grade" talc is further exported to the U.K. and Europe, and there is scope for expanding exports to other foreign countries as well.

In the Deoban-Tejam belt, the deposits are considered to have formed by the alteration of siliceous dolomites and magnesite. In Pithoragarh district, deposits of talc occur in association with the principal magnesite deposits described earlier, and are mined from near Dewal Thal. In Almora, the best deposits occur north, east and northwest of Bageshwar, mainly along with north flank of the Pungar-Lahore river axis. In Chauoli, the deposits were mined earlier from north of Pipalkoti. The following tables give some of the main characteristics of the deposits in the Lahore and Pungar valleys of Almora district.

BASE METALS

The base-metals, copper-lead and zinc were extensively mined from this belt in ancient times, the most important centres of mining being Dewal Thal and adjoining areas in Pithoragarh, from around Shishkahn-Bageshar in Almora; the Dhanpur-Dobri-Guar, south of the Alaknanda in Pauri Garhwal, and from near Kunet and adjoining parts in Tehri Garhwal district. Isolated workings within the calc-zone are also reported from the Bhilangana valley in Uttarkashi, and from Chamoli district. The metal belt follows closely the deposits of talc and magnesite described earlier. The common site of copper utensils used by the villagers today is evidence to the flourishing industry which existed in the past.

Detailed exploration for copper is in hand through the Geological Survey of India near Dhanpur in Pauri where large scale mineralisation and mines are seen, and by the State Directorate in parts of Almora (Bageshwar) and Pithoragarh districts. Commonly, the mineralisation zones appear to be associated with massive siliceous to talcose dolomites, which may in turn overlie or underlie black shale beds. Virtually all the old mines were located within "zones of oxidation" where the sulphides of copper have broken down into carbonates or oxides. In certain areas, however, localised enrichment through the replacement of iron sulphides (pyrite) by chalcocite-bornite-chalcopyrite-sulphides of copper or copper-iron, is evident, but not persistent in depth. For the ancient miner, this situation was ideal as it gave the possibility for mining and concentrating soft copper ores through the use of hand tools.

Most of the copper occurrences within this belt are perhaps derived through the mobilisation of primary metal in black shales and the siliceous carbonates, and which was subsequently weathered into copper-carbonates within extremely erratic

oxidation zones. Their search, therefore, within shale-carbonate rock association involves the identification of complex geological environments. While the oxidation zone at Dhan pur is apparently very deep, as seen from adits located between 3000-2300 metres above sea level, at Osail in Pithoragarh district, it is extremely shallow and within a vertical zone of + 30 metres.

The author, from present knowledge, would like to conclude that within this belt, while the best showings are within massive carbonate rocks, in the present context, search would need to be intensified in more primary environments, such as the black shales themselves or the shale-carbonate-granodiorite rock association.

SHISHKHANI LEAD: The lead (often associated with zinc and silver) deposit of Shishkhani near Bageshwar is presently the only one that may be commercially exploitable. According to reports of the Geological Survey of India, the deposit is over 300 metres long with total metal values ranging between 1-5%. Detailed work is in hand with the Mineral Exploration Corporation of the Government of India for proving its grade and extent. Lead mineralisation is further reported from near Guar, and from black shale sequences of Pithoragarh.

The Deoban-Tejam belt, covering the entire middle Himalaya in U.P. is a potential zone for the future discovery and mining of these essential metals. It calls for an integrated surveys effort using a multi-discipline approach.

URANIUM

Uranium showings are reported from the belt from near Nagarasu, within what are probably the extension of the Chamoli quartzites, and from near Berinag, from within the same quartzites in the Almora-Pithoragarh districts. The minerals occur as dark, brown to black inclusions and veins of pitch blende with possibly some uraninite as well.

LIMESTONE

In the calc zone of Tejam, deposits of limestone were searched, within the generally dolomitised terrain, on the basis of physical characteristics of the carbonate sediments, in particular their grain size and bedding. In general, these ancient possibly Pre-Cambrian carbonate sediments have undergone various degrees of dolomitisation, only the finer thinly bedded ones having partially escaped this process, possibly owing to their having been lithified more readily after their deposition in the shallow marine basins.

Cement grade limestone deposits were located principally in three areas, near BHULGAON east of Someshwar, near JHIROLI-MATELA where they underlie the magnesite deposits in Almora district, and by the Geological Survey of India from near GANGOLIGHAT in Pithoragarh district. The following table compiles the grade and reserves of the above mentioned deposits:

TABLE XII
CEMENT GRADE LIMESTONE DEPOSITS IN THE CALC ZONE
OF TEJAM

Name of deposit	Chemical Analysis % (Average)			Estimated reserves (in Million Tonnes)
	CaO	MgO	SiO ₂	
BHULGAON	43.50	2	7-18	10.00
MATELA	43.12	1	10-11	4.00
GANGOLIGHAT	50.00	1	8.4	22.7

Since it may be difficult to transport coal in large bulks to the above sites in the middle Himalaya for the production of Portland cement, small rotary or vertical shaft kilns of 100-300 tonnes per day capacity are under consideration.

Within the same belt, deposits of white to light grey crystalline, often dolomitic MARBLE are known to occur. Some good occurrences are reported from the valley of the Birahi Ganga in Chamoli district.

Apart from the above named limestone and marble deposits known in the belt, several other occurrences no doubt must exist. Their search would be fruitful when a techno-economic feasibility for the manufacture of lime, cement and chemicals could be established in these areas.

SLATE, which is a low grade regionally metamorphosed argillaceous rock, forms certain excellent deposits within the belt. It is used extensively for roofing or paving, and has potentialities for export to other consuming areas within the country. Good deposits are mined from near Bageshwar, and potential deposits are reported from near Karas in Almora district. No systematic investigations for examining their extent or physical properties have yet been undertaken.

The calc. zone of Tejam, in view of its potentiality for metals is presently given a high priority for geological investigations.

2.5 THE CRYSTALLINE THRUST SHEET AND THE ROCK ZONE

Without going into any controversy, the rocks of the Thrust Sheet may simply be described as crystalline meta-sediments that cap the Krol and the Deoban-Tejam sequences in the outer and middle Himalaya, and are preserved within major synclines or "Klippen", with the Deoban-Tejam rocks often forming a "Fenster" or a window. In the outer Himalayas, the thrust bound rocks are exposed in what are termed Satengal, Banali, Amri-Lansdown synclines, and they form the outer mountain chain in Naini Tal and Pithoragarh districts east of Nainital. At Lansdown and near Amritpur (Naini Tal) they contain intrusive granites. In the middle Himalaya, the crystalline

metamorphic rocks occur along synclinal axes of Almora, Dwarshat, Dudatoli-Thaliesen where again muscovite-felspar granites and the mica bearing pegmatites, often with Tourmaline are associated. Within the calc. zone of Tejam, they occur as isolated Klippe, or within major synclines, as that of Bageshwar-Baijnath-Nandprayag but without the granite. The Bageshwar axes joins up west and north west of Nandprayag with the north plunging axis of the meta-sediments in the root zone. The persistence of metamorphic rocks over sediments and their map continuity into probable source areas in the inner Himalaya clearly suggest stupendous earth movements which brought the older crystalline rocks, which must have formed at great depths under high temperatures and pressures, to rest over sedimentary rock that were not buried so deeply. The continuity of these rocks into the inner Himalaya, where they form a normal sequence being overlain by sediments, would suggest that the inner Himalaya was the "Root Zone" or the source from where at least some of the thrust sheets were derived by gravity slides over a basement of varied sedimentary rocks.

Some characteristics of these rocks are that the grade of metamorphism apparently increases up section, though the grades are actually controlled by isograds that are oblique to the foliation of these rocks; that the southern sections are characterised by arenaceous-argillaceous sequences with granite, whereas in the mid-Himalaya and particularly in Chamoli the sequences contain carbonate interbeds within the siliceous-meta-shaly sequences and without the granite; the highest metamorphic grades (upto Kyanite-garnet) are seen only in the inner Himalaya, where in the Harsil-Gangotri region even the granites, considered to have formed through melting or anatexis of the sediments, also occur. Mineral deposits are controlled within this zone broadly in accordance with the above mentioned characteristics of this belt, and are now described briefly.

ASBESTONS

Asbestos, which is a fibrous variety of several distinct species of silicate minerals, generally related to the Amphiboles or Serpentine. It can be felted or woven as any other fibre, the resulting product being fireproof. It is used widely for making insulators, liners, acid and heat resistant sheets, asbestos-cement sheets, etc; the tensile strength and length of the natural fibre determining its suitability. Small deposits of the mineral are known from Kandhara, Jalai, Kund, Bamoori near Chandrapuri-Okhimath in the Mandakini valley in Chamoli district.

The deposits are associated with low grade calc. silicate rocks, with the SILKY TREMOLITE short fibre asbestos forming long fibred veins within crystalline marbles. as at Kandhara, and the long fibred veins of possibly AMOSITE type associated with crystalline ankerite sideritic carbonate rocks of Jalai, Kund and Bamoori. The deposits are suitable for making acid and fire resistant sheets, brake-band linings and insulating materials, however, cannot perhaps be considered for asbestos cement.

SULPHUR

Old sulphur mines are reported from the Mandakini I & II forest divisions of the old Garhwal district, now Chamoli district, in the Roopganaga valley near Sutol, about 50 kilometres east of Mandprayag. The deposits form as incrustations within quartzites. One sample analysed gave the following results:

SiO_2 -83.7%, R_2O_3 -2.85%, S - 7.10%. No detailed investigations have yet been carried out.

MICA

Mica pegmatites of small dimensions, form en-echelon, tectonically controlled bodies within biotite schists of the Thalisen region. Twelve such bodies are reported from near Jallu, Badni Khal, Gadoli, Kunet and Ghuri villages in Pauri-Garhwal district. Muscovite mica books of 10x7 cms. to 10x8 cms were collected from surface exposures. Old mica mines are also reported in this area.

The geological setting for Mica pegmatites is one of medium grade metamorphism, within which the pegmatites are emplaced. The mica-pegmatites diminish in areas of higher grade metamorphism. Detailed tests and trials are in hand on samples collected from the area. Ilmenite bearing schists occur in association near Jallu, the crystals assaying 48.2% TiO_2 .

GRAPHITE

Deposits of usually amorphous to crystalline graphite are reported from near Thaliasen-Kaprauli in Garhwal, from the Kalimitti hill and Barihhina north of Almora and from near Munshiari in Pithoragarh district. No detailed data is yet available and the deposits are generally considered to be of low grade.

URANIUM & BASE METALS

The meta-calcareous-argillaceous sequences of Chamoli in the POKHARI-DANDAKHANI (MOHANKHAL)-MACHKUNDI-JAJAI region in Chamoli district contain several old mines for copper. This appears to have been an important centre for copper mining in our ancient past. The mines near Pokhri were revived during the last 1800^s and early present century by Cornish miners, who after reportedly mining rich ores at shallow depths ran into lean bodies below.

Associated with the Pokhri-Mohankhal belt are radio-active minerals which are under investigation through the Atomic Minerals Division of the Government of India. The uranium bearing zones are reportedly of moderate to high grade (+0.05% U_3O_8), of fair lateral extent but rapidly dying out in depth. Within the uranium-copper belt, some small lenticular bodies of stibnite (antimony sulphide) ores were also found by the Geological Survey of India.

The carbonate-argillaceous-quartzitic sequences of Pokhri-Gkhimath-Tungnath are considered to be extremely important for searching the above mentioned metals. While uranium is likely to be confined to low grade meta-sedimentary sequences, copper and other base metal ores may be found in wider geological setting.

ASKOTE POLYMETALLIC ORES: Detailed investigations in hand with the Geological Survey of India near Askote in Pithoragarh district have proved the presence of a moderate to small sized ore body within the crystalline syncline overlying the calc. zone rocks. Ore mineralisation comprises galena, sphalerite, chalcopyrite (lead-zinc-copper) within a structure over 300-400 metres long, about 2 metres wide, and assaying total metal contents of 2-5%. The deposits are in their final stages of evaluation and hopefully would sustain the first modern base-metal mine in the U.P. Himalayas.

The search for metals in the crystalline belt is perhaps to be rewarding in the Himalayas, and the need is for large scale integrated surveys using stream-sediment geochemistry and geological methods.

OTHER INDUSTRIAL MINERALS

GARNET & KYANITE, which are of use in the abrasive and refractory products occur extensively within the root zone crystalline rocks, near Suki in the Bhagirathi valley in Uttarkashi, and in the northern sections of the Kali river valley in Pithoragarh district. **MARBLE** and associated calc. silicate rocks occur lower down in section between Gangnani and Suki, near Badrinath Ji

and were mined for use in the construction of Shri Badrinath temple. ANTIMONY & ARSENIC minerals are further reported from the glacial debris in the Shunkalpa glacier.

SULPHUR & HOT SPRINGS occur in the inner Himalaya within the southern to central parts of the root zone section. Important springs of hot water are reported from Gangani (Bhagirathi valley) -Mandakini valley-Alaknanda at Shree Badrinathji-Tabpban near Joshimath - Dar in the Dhauli valley in Pithoragarh. The axis suggests the presence of a HOT LINEAMENT in the Himalayas, which could be a potential source for GEOTHERMAL POWER, or for minerals contained in the hot waters of possible deep seated origin. The encrustations from the hot spring waters of Dar in Pithoragarh were analysed and showed the following contents (in gms/100 cc):

Residue after evaporation	.. 0.1872
Silica + Insolubles	.. 0.0924
Sesquioxide - R_2O_3	.. 0.0115
CaO	.. 0.0103
MgO	.. 0.0062
Chloride	.. 0.0040
Sulphur	.. 0.06975
	or 3.168 gms per gallon

(Source: D.G.M. reports)

Modern research suggests the need for detailed investigations in such hot spots, which can be potential areas of metallic mineralisation, sulphur and other minerals as well. The remote and inaccessible nature of the belt has handicapped large scale intensive surveys.

2.6 THE TETHYAN ZONE

The name Tethyan zone is derived from the name TETHYS given by geologists to the ancient sea that separated the southern GONDWANA LAND from the norther ANGARA LAND. The zone is comprised of a normal sequence of low-grade meta-sedimentary and sedimentary rocks of marine origin, within which the rich

fossil fauna is evidence to the evolution life from the early Cambrian (less than 600 million years) to the late Mesozoic (less than 135 million years). The highest mountain peaks in U.P. are underlain by these sequences or the underlying Pre-Cambrian crystalline rocks. In view of the rugged mountain country which follows this belt, investigations so far have been more with the object of understanding the sequence in terms of its broad lithology and fauna, and its overall structure. Minerals are merely reported occurrences so far within the belt. The belt, therefore, offers a vast, extremely rugged terrain with high relief, as a challenge to the present and future geologists in Uttar Pradesh.

The earlier figures in plate I show the divergent lithology, which is perhaps interesting for non-metallies, limestone, dolomite, phosphorite, as well as primary metallic minerals. The belt requires a tremendous deployment of man-power that could operate during May-September each year, detailed photo-interpretation of structures and rocks through multi-channel scanning, air-borne geophysics, and to start with regional stream sediment geochemistry with one sample per square kilometre. Such a coverage necessarily involves tremendous financial inputs, and hopefully these can be found in the near future.

The foregoing paragraphs would show that the Himalayan belt in U.P. contains a vast potential for exploiting limestone, dolomite, magnesite, rock phosphate, gypsum, mica, base-metals and possibly also asbestos and uranium. The deep understanding so urgently needed is lacking from want of detailed, even 1:50,000 geological maps. At the present rate, it is doubtful if a co-ordinated picture of the Himalayas would emerge in the next few decades. The author makes the plea for giving our Himalayas the importance that is due so that man-power and finance, in vastly increased terms, could be utilised for their assesment.

2.7 THE CENTRAL PLAINS

The central plains, which provide some of the most fertile tracts of land in our country, are comprised of Quaternary peidmont and alluvium which relate to the Holocene and Recent times. Structurally, the plains have formed in a fore-deep which parallels the Himalayan chain to the north, and which generally follows the Arravalli-Vindhyan-Archaen axis west and south of the Yamuna - Ganga lineaments. While several views have been expressed by famous people, such as E. Suess, S. Burrard on the origin of the fore-deep, more recently it was considered to have formed as a sag in the earths crust, between the north drifting Indian continent and the comparatively soft sediments accumulated in the Tethyan basin, which were later upheaved into a mountain chain.

The central plains contain unconsolidated sediments, mainly sands, silts and clays with eccassional gravel beds and lenses of peaty organic matter. The alluvium is sub-divided into (a) OLDER ALLUVIUM, and (b) NEWAR ALLUVIUM, of mid to upper Pliestocene (2-01 million years) and upper Pliestocene to Recent age.

The OLDER Alluvium, called Bhangar in the Ganga valley, is comprised of dark alluvium generally rich in concretions and nodules of KANKAR, impure calcium carbonate. It contains remains of extinct species of animals including Rhinoceros, and other mammals. It forms slightly elevated terraces, generally above the present day flood levels, the present rivers having cut through to lower levels.

The NEWER ALLUVIUM, called Khadar in Punjab is light coloured, more sandy and poor in calcareous matter. It contains fossils of living species.

The plains and the alluvium mainly contain what are known as "Minor Minerals", which are of great importance from the revenue point of view to our State. In addition, the plains contain abundant GROUND WATER which provides vast areas for their needs of irrigation. Geologists further expect the presence of marine Tertiary rocks to form folded belts below

the alluvium, and such a speculation is of importance for searching OIL & NATURAL GAS below the alluvial cover. The discovery of these structures below the Bhramaputra alluvium in Upper Assam raises the belief that similar structures may be found elsewhere as well in this great alluvial basin. The following is a description of some of the important minor minerals exploited from our plains.

BRICK EARTH is a minor mineral of great importance to our State. It supports over 5000 brick kilns in the central and southern parts of our State, each producing 10-50 lakh bricks per annum, and from which a minimum royalty of about Rs. 70,00,000 per annum is expected on the basis of a royalty of Rs. 1.50 per 1000 bricks manufactured.

SAND & MORRUM is excavated from the newer alluvium of the present day channel of the Yamuna near Okhla in Bulandshar, and from Bhognipur near Kalpi where extensive coarse sand deposits from older deposits formed under a presumably more turbulent ancient Yamuna. These deposits are mined even through underground methods. It comprises some of the finest quality sand available in the State. Sand is also mined extensively from the beds of the Yamuna, Betwa and Ken rivers in Hamirpur and Banda, and good quality coarse morrum is available from the bed of the Son river in Mirzapur. To give an idea of the value of sand and morrum, small areas near Okhla are auctioned for over Rs. 16,00,000 for periods of two years.

Deposits of KANKAR & MARL have been mined for lime burning in the Allahabad, Lucknow and Gorakhpur divisions. Extensive deposits of Kankar are known from the older alluvial tracts all over the central parts of the plains.

SALTPETRE, which forms as encrustations over older alluvium in Mathura, Aligarh and adjoining districts, is formed through the deposition of nitrates and chlorides of potassium and sodium. Scrapings of these natural salts are extensively processed through large factories for the production of potassium nitrate. A common site around several villages in Mathura, where this is a flourishing industry, is the concentration of these

salts in large iron pans through solution, filtration and evaporation. The concentrates are then processed in the factories located within Mathura town.

BALLAST, which is in demand for concrete, is extensively mined from river beds as they are traced from the Himalayas into the plains. Mining areas are granted through auctions, permits or through minor mineral leases.

REH, the common white efflorescence in western and central U.P., is formed as a result of accumulation, in poorly drained water-logged areas of soils, through concentration of disseminated salts in the subsurface. These are mainly chlorides, sulphates and carbonate of sodium, which contribute towards the formation of Usar Soils.

So far, no systematic investigations have been undertaken for qualitative or quantitative assessment of the minor minerals. This is now becoming a pressing need with sophistication of specifications by the consumers, and the need for standardising works in which these may be used.

2.3 THE SOUTHERN TRACT

The southern rocky belt of our State is comprised of (a) an ARCHAEN basement complex, over which (b) linear zones of sedimentary rocks developed in the Pre-Cambrian-Proterozoic-Cambrian, and in the Mesozoic times. (c) The Deccan traps, which represent a late Mesozoic-early Tertiary phase of vast basic lava flows form the youngest rocks in the belt. Basically, these rocks are distributed in two tectonic districts, the Jhansi-Lalitpur-Banda, and the Allahabad - Mirzapur which contain similar geological elements. Such tectonic settings, particularly the Archaen-Pre Cambrian boundaries, are extremely important areas of mineralogeny. In Uttar Pradesh, more and more intensive geological investigations bring forth the realisation for recognising and understanding the ancient environment within which the Archaen and the later rocks of the Platform cover rocks formed. These environments in turn suggest mineral assemblages which need to be searched.

The Archaean basement complex in the Jhansi-Lalitpur region is classified into two tectonic sub-blocks, a northern granitised complex which is the site for mining of Diaspore & Pyrophyllite and a southern gniessic complex with large suites of ultrabasic to acidic intrusive rocks, potential for nickel and associated base-metals. Each sub-block differs in its geotectonic, activation, magmatic and minerogenetic aspects. While this block comprises an area of about 160x280 kms in the Jhansi region, it is exposed south of the Vindhyan range in Mirzapur where only the gniessic elements of the south Jhansi sub-block are apparent. This sub-block, was the preferred site for the later sedimentation-deformation and igneous activity during BIJAWAR, VINDHYAN & GONDWANA times, which witnessed the development of linear marine and fresh water basins. A transitional set of formations, termed BERWAR in Lalitpur and JUNGEL in Mirzapur form a distinct suit of meta-sediments below the Bijawar's in both districts. The following table lists the geology and minerals in the distinct sedimentary tectonic groups in southern Uttar Pradesh:

TABLE XIII

GEOLOGY & MINERALS IN THE SOUTHERN ROCKY TRACT OF UTTAR PRADESH

ERA & AGE	GROUP FORMATIONS	MINERALS
GONDWANA-MESOZOIC 280-Less than 100 million year	LOWER GONDWANA OF Mirzapur district	Non-plastic fire-clay & coal deposits in the Bansi-Binda areas.
PRE-CAMBRIAN -CAMBRIAN Less than 2400 million years to less than perhaps 600 million years.	VINDHYAN SUPER GROUP	Bauxite & laterite; lithomarge, clays & ochres.
	REWA GROUP	Silica sandstones, indications of copper-lead-zinc-baryte mineralisation. Pyrite in Bijaigarh shales Bauxite & laterite.
	KALMOR GROUP	Rohtas limestone, dolomite, lead mineralisation; kajrahat limestone S.S.G. grade dolomite; laterite & clay.
PRE-CAMBRIAN 2400 million years	BIJAWAR GROUP	Ningha marble, copper-lead-zinc-uranium-gold in the Sonrai formations; Solda & Obra banded hematit quartzites (low grade iron ores). Andalusite, calcite.
ARCHAIC 2400 to over 2600 million years METHONI BUNDELKHAND COMPLEX	MADARA FORMATIONS; BUNDELKHAND GRANITE COMPLEX BERHAR JUNGLE FORMATIONS AJAUL FORMATION & BASEMENT GNESSES COMPLEX OF METHONI JHANSI & MIRZAPUR	Nickel-copper-lead-zinc indications pyrophyllite-diaspore, ceramic pegmatites; Ancient placer & mobilised gold, possible uranium; Banded magnetite-quartzites (iron ores); Molybdenum; Graphite mineralisation. Possible Jungel diamond pipes.

The following are brief descriptions of the important minerals investigated so far in this tract.

2.9 THE GONDWANA BELT

The Gondwanas form a large outcrop in the south-western corner of Mirzapur district. The conglomerates, sandstones and shales of the Barakar formations contain a potential of over 900 million tonnes of grade III coal presently under development.

through the National Coal Development Corporation, and over two million tonnes of fire clay suitable for certain types of refractories.

COAL

Coal deposits of Mirzapur district are mainly confined to the Barkar stage of the Lower Gondwana Group. The coal seams investigated by the G.S.I. and the N.C.D.C. are classified as the PUREWA top and bottom seams, TURRA seam and the KOTA coal seam. The following table summarises the salient characteristics of the seams investigated:

TABLE XIV
SALIENT FEATURES OF THE PUREWA, TURRA
& KOTA COAL SEAMS

Name of seam	Purewa Top	Purewa bottom	Turra	Kota
Thickness (metres)	6-9	10-14	14-21	2.3-4.4
Moisture%	6.5-7.5	6.2-8.6	7.5-9	-
Ash %	25-38	6.2-8.6	17-24	-
Volatyle matter%	26.5-28	30-31	28-29	-
Fixed carbon %	60	36-39	44-47	-
C.V. K.cal./kg	-	4830-5145	5495-5735	-
K.cal/kg including bands	23-4200	3700-400	4270-5420	-
H.G.I.	-	-	75-70 in Gorbi	-
Softening temperature (°C)	1200-1400	1400	230-1400	-
Hemispherical temperature (°C)	1300-1400	1400	1400	-

The first mining venture within Uttar Pradesh recently commenced at Bina, with the commencement of stripping of overburden for exposing the Turra seam, ^{The seam is} estimated to have a thickness of 18 metres, and proved reserves 60 million tonnes. The production programme is likely to commence from 1976-77 with a target of 0.5 million tonnes per annum, to be pushed upto 2.00 million

tonnes per annum by 1980-81. The seam is assessed to contain at Bina, 7-7 3% moisture, 23.6-28.3% Ash having a C.V.K Cal. per Kilogram varying from 4660 to 4850. The production from U.P. collieries is likely to meet the increased demands for power generation, and for setting up coal based fertilizer, low temperature carbonisation and producer gas units.

FIKE CLAY

The Barakar clay was investigated by the Directorate in 1965 from deposits occurring at Bansi, Misra and Makhri Khoh in Mirzapur district. The clay beds in the three localities average a thickness of little over 2m. Thin intercalations of burnt carbonaceous material are present in the clay beds indicating dehydration of the clay. Undehydrated clay was noted in only one trench in the Bansk area. The reserves of clay in the three area is given in Table XV.

TABLE XV

Area	Sector	Estimated reserves (in lakh tons)
Bansi	1. Gaurbotha Sector	4.06)
	2. Charkakur Sector	3.36)
	3. Sui Chattan Sector	9.73)
	1. Isolated Hillocks	2.06)
	2. West of Baskatwa nala	0.88)
	1. East of ChunahwanaJala	1.34)
	2. West of ChunahwenaJala	10.76)
	Total Reserves	32.19 Lakh tons

Samples of clay from the three areas has been tested and have shown that these alone are not suitable for any industrial purpose due to their non-plastic nature and due to high porosity of the material prepared. The clay could, however, be used for making IS: 6 standar fire-bricks after blending with suitable plastic clay. Actual tests after such blending have not so far been carried out. The properties of the clays as determined by C.G.CR.I. are summarised.

TABLE xvi
 PROPERTIES OF BANSI, MISRA AND MAKRI KHOH
 CLAYS, DISTRICT MIRZAPUR

	Loss in ignition	Plastic limit	P.C.E. (orton cones)
Bansi Clay	2.67 to 10.59	Nil to 29.4	30-31 to 31-32
Misra Clay	3.22 to 6.86	Nil	28-30 to 31-32
Makri Khoh Clay.	3.74 to 10.0	Nil to V. low	26-28 to 31-32

Several tests of the Bansi clay samples did not give the desired improvement in porosity and P.C.E., neither by decreasing the proportion of low fusible clay nor by using finer grog and firing to a temperature of 1400°C. It was therefore concluded that this clay alone can not be used for making IS: 6 fire-bricks and a suitable plastic fire-clay having P.C.E. of at least Orton Cone 28 will have to be blended. Clays from Misra and Makri Khoh areas are generally low in refractoriness than the Bansi clay and therefore a plastic clay with refractoriness of orton cone 30 will need to be blended with these clays for making IS:6 quality fire-bricks.

2.10 THE VINDHYAN SUPER-GROUP

The Vindhyan Supre-Group in Uttar Pradesh generally follows the vast Plateau in the Mirzapur, Varanasi, Allahabad Band and Lalitpur districts, as well as, forms linear outcrops of the Semri in the Son river valley of Mirzapur district. It is comprised of a basal group of marine sedimentary carbonate formations and and pyroclastic-volcanic rocks called the SEMRI GROUP, which is overlain by unconformable sequences of mainly arenaceous or sandy rocks classified as the KAIMUR AND REWA Groups. The following is a description of the important minerals found in this belt.

LIMESTONE

Extensive deposits of limestone suitable for portland cement manufacture were reported by the G.S.I. from the Kajrahat and Rohtas stages of the Son valley Vindhya in Mirzapur district. Detailed investigations of these two belts have been continuously in hand with the U.P. Directorate since the year 1958.

Kajrahat Belt: The belt extends from Obra in the west to Kota in the east along a strike length of about 18 km. The stratigraphic thickness of the Kajrahat stage limestone and dolomite sequence varies between 400 to 600 m. The belt is sub-divided into members 1 to 12, of which the members 1 to 4 have been generally found to be below 3.2% MgO and of the grade suitable for cement manufacture. The deposit has been divided into seven blocks numbered from east towards west. Proving of the reserves of Block IV was carried out for the requirements of the Government Cement Factory at Daila. This factory is at present producing 1200 tonnes of cement per day and all the supplies of limestone are mined from Block IV. Table XVII gives the proved and estimated reserves of limestone from the seven blocks, along with the average quality.

TABLE XVII
QUALITY AND RESERVES OF LIMESTONE FROM
KAJRAHAT BELT, DISTRICT MIRZAPUR

Block	Average quality			Reserves. (Million tonnes)
	Ca% CaO%	MgO%	SiO ₂ %	
I	45.	2.56	11.3	13.19 (estimated)
II	43.5	2.68	11.9	2.78 (estimated)
III	42.9	3.07	13.0	12.9 (estimated)
IV	43.5	2.85	12.4	45.9 (Proved)
V	42.1	3.10	13.2	12.45 (estimated)
VI				
VII	43.0	3.39	12.3	20.00 (tentative)
TOTAL				107.23 (estimated)

The highest grade of limestone is found in the eastern part of the deposit in the Kanhar river valley, where a considerable quantity of low silica high calcium material is available. The MgO and silica content tend to increase gradually towards west in the Blocks VI to VII, where MgO exceeds the permitted limit of 3.2%. This limestone will, however, be suitable for cement after blending with high grade limestone.

Rohtas Belt: This belt runs through the entire width of the Mirzapur district from the M.P. border in the west to the Bihar border in the east along a strike length of about 90 km. Out of this length 30 km of the western part is either intimately intercalated with shales or is not exposed and is not suitable for large scale industrial purposes. The remaining part of the deposit has been investigated in some detail, and has been divided into four sectors. The estimated reserves and quality is given in Table XVIII.

TABLE XVIII
QUALITY AND RESERVES OF LIMESTONE FROM
ROHTAS BELT, DISTRICT MIRZAPUR

Sector	CaO%	Average quality		Reserves (Million tonnes)
		MgO%	SiO ₂ %	
1. Gurma- Pataudh	38.1 to 48.5	0.4 to 3.0	6.8 to 17.9	48.90
2. Kanach- Susnai	42.0 to 45.0	2.5 to 3.0	11.0 to 14.5	35.00
3. Susnai- Lahona	42.0 to 43.0	2.0 to 2.5	12.0 to 14.0	26.00
4. Chandni- Basuhari	43.0 to 44.0	1.5 to 2.0	11.0 to 13.0	70.90
			TOTAL	180.80

Out of the above mentioned reserves, 23 million tonnes have been proved in the Ghaghar valley area of the first sector by Dalela (1969) of U.P. Directorate. Detailed investigations in the Sectors (2) and (4) and surface investigations in Sector (3) are now in hand.

Uses: The limestone deposits of Mirzapur district are being used for cement manufacture by the U.P. State Cement Corporation Ltd. One cement factory at Churk operating on Sector (1) of the Rohtas limestone is producing 1400 tonnes of cement per day. The other factory located at Dalla is using the limestone from Block IV of the Kajrahat belt and is producing 1200 tonnes of cement per day.

Besides, a new cement factory of 1200 tonnes per day capacity is proposed in the private sector based on the Chandni-Basuhari sector of Rohtas belt. The total requirement of limestone for these three factories will be 70, 60 and 30 million tonnes respectively and the total annual production of cement from Mirzapur district is thus likely to be 1.68 million tonnes.

The limestone from the two belts is also used for burning lime and about a dozen lime kilns are operating in the Chopan-Salkhan area. The supplies of limestone are drawn mainly from Pataudh area (Satnarwa) of the Rohtas belt. Some of the lime produced is pure enough for use by Messrs Kanoria Chemicals for various chemical purposes. Considerable reserves of dolomitic limestone are available in members 7 to 10 of the Kajrahat belt, which could be used as ballast material and for dimensional stone blocks. Thin bands of S.M.S. grade limestone are also available in Block I of this belt.

DOLOMITE

Two deposits of dolomite from southern Uttar Pradesh have been investigated by the Directorate, one of high grade material discovered in the Kajrahat belt of Mirzapur district and the other of blast furnace grade dolomite from the Lower Vindhyan, Tirohan stage of Banda district.

Mirzapur dolomite: The deposit occurs as a more or less persistent band of variable thickness as member 11 of the Kajrahat Formation and has been traced as discontinuous outcrops along a strike length of approximately 8 km between south-east of Bari toward north-west up to Chopan through Bagmanwan hill. The variation in thickness and chemical composition, as shown by surface sampling and drilling of 3 holes is given below.

<u>Chopan</u>	<u>Bagmanwan</u>	<u>South of Bari Village</u>
Thickness: 10 to 15 m.	Thickness: 6 to 10 m	Thickness: 7 m.
Insolubles: 2 to 2.5%	Insolubles: N.A.	Insolubles: 1.7 to 2.5%
MgO: 19 to 20%	MgO : N.A.	MgO: 19 to 20%

The low insoluble (3%) and high MgO contents make the dolomite eminently suitable for steel melting shop, as a flux material. The dolomite is massive, fine grained having a light grey colour. Total reserves are estimated at 6 million tonnes, which need to be proved by systematic drilling.

Banda Dolomite: The main exposure of Tirohan stage dolomite runs along a strike length of about 16 km from Gehra nala in the south-west of Khoh-Rihutia villages in the north-east. The thickness of the exposed dolomite is over 30 m. Nineteen surface sample lines placed at an interval of 500 m were run across the dolomite band. The following range of composition was established by chemical analysis.

MgO.: 18.06 to 19.62%; CaP: 26.81% to 28.41%
 SiO₂ 5.89% to 11.29%;
 R₂O₃: 1.90% to 2.83%

Mineable reserves of nearly 10 millions of this dolomite are estimated from the belt. Major part of the deposit appears to be suitable for blast furnace in the steel industry where the upper permissible limit for silica is 7%.

CLAY AND LATERITE

Small deposits of clay form pockets over the Kajrahat shales east of the Kanhar river near Hardi, and laterite cappings over the Kajrahat dolomites are mined from the east of the Obra road near Billi-Bari for mixing with limestone for the production of cement.

PYRITE MINERALISATION

Disseminations of pyrite (iron sulphide) along with traces of lead and zinc are found within the black shales of the Bijaigarh formations, immediately north of the Ghaghar valley in Mirzapur. Detailed investigations are in hand .

SILICA SAND

Regional investigation of the glass sand deposits of parts of Uttar Pradesh in Allahabad and Banda districts show that the Kaimur quartzite formation exposed in these districts can be divided into (i) Pratapur Member (ii) Shankergarh Member and (iii) Manduri-Hindoldandi Member, from base to top. Largest mines of silica-sand are situated in the Pratapur Member in the Derabari, Kolahi, Bhainshahi, Pardwan, Kanchanpur areas along the nala beds, where the thickness of the glass sand has been found to extend up to 30 m. A wide variation in the friability of this member has been noted from one area to another. Next in order of importance for glass sand production is the Shankergarh Member which forms the Shankergarh-Bargan plateau. A 2 to 3 m thick sub-member within this middle member is generally friable and extensive areas of the same are being mined. The Manduri-Hindoldandi member occurs as small outliers in Bhainshahi, Derabari, Manduri and Hindoldandi areas and generally the entire exposed thickness of this member is friable. The reserves are, however, limited and the maximum thickness exposed is 16 m.

The friable silica sands have developed within distinct members as a result of weathering through acidic waters and their action either in zones with pre-existing carbonate and sulphides, or in linear zones of shearing. The friable zones so thus produced through natural processes, are extremely erratic in terms of grade or thickness. Their evaluation, therefore, requires systematic painstaking geological methods.

Uses and specifications: Silica-sands are mainly used in the manufacture of a number of varieties of glass, both coloured and clear. Their other important use is as foundry moulding sands for making moulds in casting industry, besides many other small uses.

For glass making sands a uniform grain size is an essential requirement, besides low iron and titanium contents. Over size or fines in the sand tend to result in variations in the glass melt. At least 70% of the sand should consist of grains between 0.25 mm and 0.5 mm in diameter, in other words most of the sand should have -20+120 mesh B.S.S. size. Iron oxide should be less than 0.06% for clear glass and less than 1.2% for coloured glass. TiO_2 should always be less than 0.1% and silica 96% to 99%.

Sand required for foundry should have (i) sufficient cohesiveness when moist (ii) sufficient refractoriness to withstand heat (iii) sufficient strength to resist pressure (iv) enough permeability and (v) proper texture and composition so that the mould will produce a smooth surface on casting. The texture of the sand, largely depending on the shape and size of individual grains and amount and distribution of clay material is very significant. Silica percentage should vary between 90 to 98 and alumina from 1 to 5.

Mechanical analysis of 55 samples of silica sand collected from the three members from various areas has shown that in all the samples 80% to 95% material is of the size - 30 + 120, B.S.S. mesh. Chemical analysis of insitu samples has shown a variation of SiO_2 between 94 and 97.4% while iron oxide varies from 0.04% to 1.1%. Representative samples drawn from the stacks in the important quarrying areas showed a variation in silica from 94% to 98.7% and in iron oxide from 0.01% to 0.93% in the Shankargarh Member and 0.09% to 0.49% in Pratapur Member. A wide range of chemical composition is obvious from these results. It appears that on account of this reason the Planning Commission had noted in their development programme for the Fifth Plan period, that the glass industry lacks an adequate supply of standardised raw materials and the factories should be supplied with graded sands from Allahabad-Banda districts.

It has been generally concluded that the sands can be used for moulding purposes by preparing synthetic sand mixtures with certain percentages of Bihar bentonite and Dextrine at various moisture contents. In view of good green strength, refractoriness and

permeability values obtained, the sands may be successfully used in light to medium steel cast iron and non-ferrous foundries with suitable addition of binders.

Market for U.P. Sands: The reported production of silica sand from the country for glass industry during the year 1972 was 387,685 tonnes, out of which U.P.'s contribution was 167,967 tonnes according to official figures. The above figures do not include the sand for moulding purposes but probably includes considerable quantities consumed in industries other than glass. The Planning Commission has estimated that the Indian glass industry alone will require 400,000 tonnes of silica sand by 1978-9 to achieve a production level of approximately 500,000 tonnes of glass and glass-ware. The annual growth rate of silica-sand consumption is 10%.

In 1972, it was estimated that the additional capacities required for various glass products by 1978-9 would be as follows:

<u>Item</u>	<u>Annual capacity.</u>
(i) Flat glass	100,000 tonnes
(ii) Bottles	210,000 tonnes
(iii) Glass shells for electric lamps	13,500 tonnes
(iv) Glass wool and fibre glass	3,700 tonnes
(v) Optical and ophthalmic glass	680 tonnes.

In 1970, fifteen of the largest glass plants in Uttar Pradesh consumed just over 40,000 tonnes of silica sand. Two new sheet glass plants are to be established in the State in the next 2 or 3 years and both will require about 18,000 tonnes of sand annually. It is also understood that one or two new bottle plants will be coming into production soon. With the additional capacity planned for U.P. and making allowance for expansion of existing units, the total demand for glass sands by factories consuming in excess of 1,000 tonnes per year will be at least 75,000 tonnes by 1975.

In West Bengal, twelve glass factories are registered with DGTD. Out of these, four glass works consume over 60,000 tonnes per year. Assuming an average consumption of 2,500 tonnes by each of the other 8 factories, the potential market in West Bengal is at least 80,000 tonnes per year. It has become already clear that there is a good

scope of producing additional quantities of sand from the Allahabad and Banda districts, which will need to be processed and graded. Accordingly the U.P. State Mineral Development Corporation is planning to set up mines and a processing plant in the area.

BAUXITE & LITHOMARGE-CLAY-CONCRETE

Deposits of bauxite were discovered by the Directorate at Rajahuan, district, Banda, in the year 1965, and detailed investigations commenced in 1967.

The deposits of Banda are spread over an area of about 2.5 sq. kms. in isolated hillocks on the upper Vindhyan plateau bordering Madhya Pradesh. Considerable area of bauxitisation is also available in Madhya Pradesh where prospecting has been undertaken by the G.S.I.

Within profiles of irregular thickness that reach a maximum of 60 m., the bauxite member is generally 2 to 3 m thick, but an unusual thickness of 28 m is achieved in the central part.

Bauxite is occasionally overlain by small and thin outliers of pisolitic laterite and is underlain by aluminous laterite. The bauxite along with the aluminous laterite has been classified in the following three grades :

A Grade	:	Al_2O_3	above 50%
B Grade	:	Al_2O_3	between 45% and 50%
C Grade	:	Al_2O_3	between 40% and 45%

Blockwise figures of reserves for the above grades is given in Table XIX.

TABLE XIX

RESERVES OF VARIOUS GRADES OF BAUXITE
IN RAJAHUAN, BANDA DISTRICT

Block	Grade	Average		Composition		Reserves (Million Tonnes)
		Al_2O_3 %		SiO_2 %		
I	A	50.28	to 61.6	0.5	to 7.5	1.55 (Proved)
	B	45.21	to 49.98	0.59	to 5.83	0.75 (Proved)
	C	40.13	to 44.80	1.20	to 9.60	1.43 (Proved)
II	A	50.34	to 54.41	2.42	to 8.41	1.65 (estimated)
	B	45.07	to 49.62	2.20	to 18.33	1.60 (estimated)
	C	40.07	to 44.88	4.38	to 19.38 (generally 9%)	
III	A	Note: Major part comprises of only laterites, detailed work not done. Isolated bauxite outcrops estimated by preliminary examination.				0.15 (estimated)
	-					0.2 (estimated)
IV	A	50.0	to 59.00	0.78	to 4.54	0.086 (Proved)+0.15
	B	45.03	to 49.93	0.74	to 19.95	0.073 (estimated)
	C			(generally 6%)		
	C	40.02	to 44.76	1.32	to 12.60	1.48 (estimated)
V	A	50.66	to 59.82	0.95	to 2.72	2.5 (estimated)
	B	45.31	to 49.28	3.55	to 3.70	2.00 (estimated)
	C	Note: This block has not been prospected in detail.				
VI	A	51.12	to 59.22	0.96	to 1.76	
	B	-		-		1.5 (estimated)
	C	-		-		1.5 (estimated)

Total reserves of A and B grade = 8.4 million tonnes

Total reserves of C grade = 8.2 million tonnes

Uses of Specifications: The main use of bauxite is in the production of alumina for aluminium. Messrs Hindustan Aluminium Corporation Limited, Renukote, District Mirzapur are using this bauxite as well for metal production.

Other important uses of bauxite are in refractories and abrasives. The Rajahuan bauxite appears to be suitable for abrasives, and only very selected parts of the deposit may be suitable for refractories on account of the high titanium content in the A grade ore. TiO_2 in the bauxite ranges from 7% to 18%, however, no economical method has so far been evolved to separate titania from the red mud or the bauxite.

The basal member of the laterite profile in the Rajahuan area comprises of a clay lithomarge whose thickness varies between 3 to 30 m. The clay found in the lithomarge contains up to 6% Fe_2O_3 but the material may be suitable for making sanitary pipes. Testing is to be done in case the results are encouraging, suitable areas for open cast mining will have to be searched. The lithomarge also contains layers of yellow ochre and in the Geodhin hill a small underground mine is operating to produce yellow ochre. This is used in the paint industry. Any large scale plans for mining of yellow ochre do not appear to be possible due to limited reserves.

Varanasi Bauxite: The G.S.I. have discovered a bauxite deposit in Chandraprabha area of district Varanasi where nearly 1.5 million tonnes of metal grade ore is reported. Similar small deposits occur as float filling depressions in Allahabad district.

BASE METALS

Recent diamond drilling undertaken in the lower (basal) silica sand bearing member in the Shankergarh area has revealed the presence of carbonates, oxides and relict sulphides of lead and zinc below zones of friable sands. Galena-baryte mineralisation further has been reported from calc. sandstones forming the upper beds of the Kaimur sandstone near Manikpur. These finds open up an entirely new ground for base metals.

BUILDING STONES

The red, spotted or the cream - white sandstones mined from Upper Vindhyan horizons have been the traditional source for building stones. The red sandstone used at Agra and Delhi in famous

historical buildings was derived from mines in Agra. It is also extensively mined from Lalitpur, Banda, Allahabad, Mirzapur and Varanasi districts.

2.11 THE BIJAWAR GROUP

The group comprised of sedimentary and meta-sedimentary (low grade) rocks unconformably underlies the Semri Group of the Vindhyan in Mirzapur and Lalitpur districts. It consists of shallow water marine sediments, parts of whom are suspected to have been deposited in lagoonal-deltaic environments. The group is basically comprised of basal carbonate rudite beds which are overlain by banded hematitic iron ores. These are in turn overlain by argillaceous rocks. The Bijawar's contain intrusives of basic and some possibly ultrabasic rocks, which are cut by young, often pegmatitic granites. The following are some important mineral occurrences of the Bijawars.

COPPER-LEAD-ZINC MINERALISATION

Extensive mineralisation of copper in linear zones of weathering and strata-bound lead-zinc has been investigated in the lower members of the Bijawar group near Sonrai in Lalitpur district. The following table summarises the extent and grade found so far:

TABLE XX

Locality	Metal	Extent	Grade	Structure
Sonrai	Copper	+ 400 metres 1.5-3 metres wide	0.5 - 1%	Oxidation zones in cross faults and decollement within sheared carbonates.
Pisnari	Copper	+ 1 km 1-2 metres wide	0.5 - 0.8%	Weins in fractured parts of Bandai sandstone.
West Sonrai	Lead- zinc	+ 1 km. 1-3 metres zones	0.5 - 1%	Disseminations in Rohini carbonate beds with laminae.

Detailed investigations are in hand for following up the discovered and other possible environments within the same belt.

URANIUM: Uranium in the form of the mineral coffinite occurs with hard bitumin within zones of decollement, as well as, the brecciated parts of Bandai sandstone, where copper-lead-zinc sulphides are also associated. The preliminary work done so far shows widespread mineralisation within these structures along a strike length of over 6 kilometres. The best zone intersected so far assays over 0.06% U_3O_8 in 2.5 metres, along with 0.5% Cu and over 1% Pb-Zn. The association of uranium with copper within the basal beds of the Bijawar in Sonrai shows promise for the discovery of multi-metal ores in Lalitpur district. The investigations are in hand by the Directorate in collaboration with U.N. Mineral Surveys in Uttar Pradesh. GOLD mineralisation has further been discovered in the belt, and it occurs along the faulted margin of the Bijawars with the basement complex. Preliminary assays show gold values from 0.2 - 1.5 grams per tonne in zones of 2 metres and more. The discoveries of complex Cu-Pb-Zn-U-Au mineralisation in the Bijawar's of Lalitpur raise hopes for finding one or two of these metals in economically exploitable quantities. Anomalous nickel values were recorded from the same belt in Mirzapur district by the Geological Survey of India.

MARBLE

White medium to finely crystalline marble occurs at Ningha, within a dome shaped anticlinal structure in the basal Bijawar carbonates of Mirzapur. It was previously mined in a small way for producing marble chips. The deposits are estimated at over 7 million tonnes upto 30 metre depth from surface, and the following table shows their grade-wise reserves:

TABLE XXI
CHEMICAL GRADING OF NINGHA MARBLE DEPOSIT
DISTRICT MIRZAPUR

GRADE	COMPOSITION	RESERVES
A	CaO : 48.5 % to 51.55% MgO : 0.45% to 1.94% SiO ₂ : 5.44% to 8.76%	4.8 million tonnes
B	CaO : 48.12% to 49.32% MgO : 2.32% to 3.32% SiO ₂ : 4.19% to 7.33%	2.4 million tonnes

Silica content is on the high side as regards the use of this marble in the chemical industry, however, some low silica bands (below 3% silica) are reported from the eastern part of the deposit. This marble, therefore, is generally suitable for the cement industry alone for purposes of up-grading the cement raw materials.

The marble is medium to fine grained, predominantly white coloured with occasional light grey and rarely pink shades. Light grey bands upto 1 cm thickness are sometimes present, showing flow folds. Laminations and beds of quartzite are commonly present in the marble and are generally found near its contact with the overlying quartzite member. Exploratory mining for detecting the presence of unfractured marble, suitable for making marble slabs, was carried out in the year 1973 by a private company who are seeking collaboration with the U.P. State Cement Corporation for setting up a marble mine. The marble was not found to be free from fractures upto a depth of two meters. It is, however, believed that in greater depth the marble should be free from fractures, as unbroken core samples upto 8 feet in length were taken out during drilling carried out by the Directorate in 1966-67. It has been decided that the U.P. State Cement Corporation will first mine out marble upto a reasonable depths before attempts to test the marble for finding unfractured blocks is made again.

ANDALUSITE

The G.S.I. have investigated deposits of andalusite found over an extensive area near Wyndhamganj, Mirzapur district. Crystals of andalusite of an average size of 1 to 2 cm length are found distributed in the country rock of Bijawar phyllites in close proximity of intrusive granites and in the quartz veins and pegmatites traversing the phyllites. Andalusite also occurs as placer deposit near Mahwaria over an area of 1.5 sq. km.

More samples will therefore need to be tested to see if some simple method of beneficiation could be adopted to scrap and wash out the impurities. Possibly calcined andalusite could perhaps be used for spark plug insulators, and for laboratory porcelain and thermo-couple protection tubes.

LOW GRADE IRON ORES

Large deposits of banded hematite-quartzites form a middle member within the Bijawars of Mirzapur and Lalitpur districts, where they are found south of Obra and near Solda respectively. The low grade ores contain small pockets of enriched secondary crystalline hematite which was mined in the early years from near Solda in Lalitpur, and was supplied to the steel industry in Kanpur many years ago.

Preliminary work done on the low grade ores in Mirzapur showed while most of it contains iron between 25-35%, SiO_2 varies between 25-40%. The higher grade pockets contain rich ores with over 62-65% Fe. These are, however, extremely small to merit exploitation.

CALCITE

An occurrence of calcite within the Bijawars is located to the NNE of village Farsoi, district Mirzapur. Since the continuity of the deposit in depth is not ascertained, reserves were calculated only upto 5 feet depth and nearly 5,000 tonnes of calcite are estimated. The mineral is usually of white colour with ferruginous staining, however, the quality improves in the north-western part of the deposit where it is translucent to transparent. Table XXII gives the chemical analysis results of trench samples collected.

CHEMICAL ANALYSIS RESULTS OF CALCITE
FROM PARSOI, DISTRICT MIRZAPUR

Sample No. Contents	1 %	2 %	3 %
SiO ₂ + Insol.	0.66	1.63	1.54
Before washing	0.74	1.63	1.61
B ₂ O ₃ After washing	0.6013	1.064	0.839
CaO	54.63	54.37	53.81
MgO	0.20	0.43	0.41
Loss	43.24	42.43	42.43
Total CaO ₃	97.50	97.06	96.05

2.12 THE BERWAR FORMATIONS - JUNGLE

The group of meta-sediments and possible pyroclastic rocks that occur below the Bijawars in Lalitpur, and possibly also in Mirzapur are given this name. They are comprised basal quartz conglomerates, shloritic and black shales with quartzites and banded magnetite quartzites. The formations are being searched for gold in zones of alternation and within the conglomerates where low surface values (below 1.5 gms per tonne) have been found. The only mineral so far of possible economic value are the magnetic iron ores which are not described.

IRON ORES

Banded magnetite quartzites form a chain of east-northeast trending hillocks in the Berwar-Girar area, west of the Dhasan river in Lalitpur. The deposits are estimated at over 30 million tonnes with +28% Fe. Detailed evaluation is in hand for examining the possibility of concentrating the ore for making sponge iron.

2.13 THE BASEMENT COMPLEX

The basement Archaean complex, comprised of the elements described briefly earlier has given indications of base-metals, nickel, molybdenum, and mica in pegmatites. However, the only economic minerals in this belt are deposits of pyrophyllite and diaspore ceramic pegmatites and graphite which are described briefly.

PYROPHYLLITE-DIASPORE

Numerous deposits of varying dimensions have become known in the Jhansi and Hamirpur districts, associated with quartz reefs and the Basement Complex. The earliest discoveries made by Misra (1944 & 1953) in Balar, Bijri, Dhankua areas of district Jhansi and Gaurahri deposit of district Hamirpur are presently held under mining lease by private parties. Mining of these minerals started in the year 1964 for industrial utilisation, prior to which only pyrophyllite was being used on cottage industry scale for making of pots and vases by the local men. The following grades of pyrophyllite and diaspore are being produced by Messrs Eastern Minerals (Private) Limited in Jhansi district. Diaspore is generally found in the form of geodes and veins in the pyrophyllite.

1. Pyrophyllite

Grade - 1 :	Al ₂ O ₃	33%,	Fe ₂ O ₃	1%
Grade - 2 :	Al ₂ O ₃	30%,	Fe ₂ O ₃	3% (powdered)

2. Diaspore

D - 1 Grade:	Al ₂ O ₃	65%,	Fe ₂ O ₃	1%
D - 2 Grade:	Al ₂ O ₃	65%,	Fe ₂ O ₃	3%
D - 3 Grade:	Al ₂ O ₃	60 to 65%,	Fe ₂ O ₃	3%
D - 4 Grade:	Al ₂ O ₃	55 to 60%,	Fe ₂ O ₃	5% (only in powder form)

The company has installed a crushing and pulverising plant in Jhansi. Besides, despatching of lump sized pyrophyllite and

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diaspore for better grades to various consumers in the refractory and ceramic industry in the country, the company utilises the second grade pyrophyllite powder for making pesticides, while diasporé powder of D-4 grade and having the size of +30 mesh 10% and -30 mesh 90% material, is dispatched to the leading high alumina refractory manufacturers of the country.

On the basis of investigations carried out later by the U.P. Directorate, the reserves of pyrophyllite and diasporé estimated from various deposits of Jhansi district are given in Table XXIV. The quantity of diasporé normally available varies from 7% to 10% of the pyrophyllite, with exception of Bijri deposit where the percentage of diasporé is almost zero. The deposits of Hamirpur district located in Gaurahri, Pahari-Garhi, Tori and Turra Mohan have not been investigated so far.

TABLE XXIV
TENTATIVE RESERVES OF PYROPHYLLITE AND DIASPORÉ
IN JHANSI DISTRICT

Name of Deposit	Leased to/vacant	Estimated Reserves (Tonnes)	
		Pyrophyllite	Diasporé
1. Palar-Garhari	Eastern Minerals	21,600	2,400
2. Bijri	Eastern Minerals	48,000	2,000
3. Dhankua	Ishwar Industries	9,000	5,000
4. Mailar	Eastern Minerals	30,600	3,600
5. Bawal-Tanda	" (Partially)	13,600	1,300
6. North Dhankua	Vacant	10,800	1,200
7. Tori-Bar	Vacant	90,000	10,000
8. Patha	Vacant	7,000	1,000
9. Larwari	Sri Lal Chand Chaddha	Very small	X
10. Harpura	Vacant	N.A.	N.A.

Results of Testing: The deposit Tori-Bar found and investigated by the Directorate in detail has shown the presence of following grades of the two minerals:

	<u>Quality</u>	<u>Reserves</u>
Pyrophyllite	Al ₂ O ₃ : 28.11% to 35.4%	90,000 tonnes
	Fe ₂ O ₃ : 3.2% to 10.0%	
Diaspore	Al ₂ O ₃ : 50.40% to 56.7%	10,000 tonnes
	Fe ₂ O ₃ : 1.5% to 6.80%	

In this area diaspore is not found in the form of geodes or veins but is present in thick lenticular bodies in which diaspore and pyrophyllite occur having an intimate intergrowth, or as disseminations of diaspore in pyrophyllite. This has resulted in the lowering of the quality of diaspore. A sample of this low grade diaspore was tested at the Warren Spring Laboratories, England for finding a method of upgrading the ore. The sample contained 56.7% Al₂O₃ and approximately 50% diaspore.

Heavy liquid analysis showed that the 3.2 sp. gr. sink product had an assay of 79.3% Al₂O₃ and the 3.0 sp. gr. sink product an assay of 75.6%. 93.9% of the diaspore was present as 3.0 sp. gr. sink product (85.1% allowing for slime loss) and this will represent the maximum potential recovery of the diaspore at the 85% passing 100 mesh grind. In flotation studies the preliminary bench peal tests comprising of eight tests showed that some of the pyrophyllite was readily floatable using amine or frother - collector systems at acid PH. Best grade of diaspore was, however, restricted to a 75% sink content even when a coarser deslime was used. Microscopic examination of the diaspore product showed it to contain coarse pyrophyllite which was proving difficult to float. The main series of floatation test work included eleven tests in which it was decided to float out the fine pyrophyllite and then float the diaspore subsequently using sodium oleate collector. Generally the results of this series were very satisfactory and in terms of heavy liquid analysis the final diaspore concentrate consistently had a 3.0 sp. gr. sink content of 95% and frequently 95%. Recovery of the 3.0 sp.gr. sink material to the diaspore products varied from 61 to 84%, the best result being achieved in a test where an 83.4% recovery was obtained to a combined diaspore

concentrate (including cleaner tailing) containing 92% sink material. The Al_2O_3 content of this product was 67.0%. This is lower than envisaged from the heavy liquid analysis but is still at an acceptable level. Weight recovery to this concentrate was 52.5% on deslimed feed or 39.9% on head ore.

Flootation could be achieved in soft or hard water and the best conditions for pyrophyllite floatation were using stage additions of Dow 250 (total .033 kg/tonne) as collector frother at pH 3. The standard oleate addition for diasporite floatation was 0.55 kg/tonne and pH was maintained in the range 6-6.5.

It was recommended that batch test work should be done on larger representative samples to be followed by continuous pilot plant testing to provide data for process costing.

A plan for setting up a high alumina refractory plant in the Jhansi district is under consideration. An annual capacity of producing 4,000 tonnes of high alumina bricks from diasporite is being proposed for the first about four-five years after which the diasporite reserves are likely to be exhausted and bricks would be manufactured from pyrophyllite.

CERAMIC PEGMATITES

Felspar predominant pegmatites have been found by the U.P. Directorate near Bijoli railway station, district Jhansi over an area of about one square kilometer in the Basement Complex. The felspar generally contains intergrown quartz, however, pure felspar is commonly present. A potential reserve of about 200,000 tonnes of felspar of mixed grade is estimated out of which nearly half the quantity could be of the grade acceptable for ceramic industry.

Surface samples distributed over one outcrop area of 20,000 sq. m were analysed for their alkali content. The results are given in table. XXV. Preliminary tests carried out by the Government Potteries Centre, Lalitpur have shown promising results, for use of the felspar in ceramics.

TABLE XXV

ANALYSIS RESULTS OF FELSPAR SAMPLES FROM
BIJOLI, JHANSI DISTRICT (BY FLAME PHOTOMETER)

Sample No.	% Na ₂ O	% K ₂ O	% Total Alkalies
1.	4.99	10.96	15.95
2.	3.19	7.48	10.67
3.	3.07	12.37	15.44
4.	3.34	11.37	14.71
5.	4.21	8.17	12.38
6.	2.81	11.32	14.13
7.	3.36	10.81	14.17
8.	3.70	11.05	14.75
9.	1.39	12.46	13.85
10.	1.40	12.51	13.91
11.	2.73	10.39	13.12

Uses: The acceptable grade of felspar should have total alkalies above 12% out of which K₂O should be above 10%. At the present, the requirement of all the pottery industry in the State is met by material brought from Rajasthan. The total annual requirement is of about 20,000 tonnes and can be met by the Bijoli deposits, in case they are found of acceptable grade after testing, for several years.

GRAPHITE

A lenticular body of graphite occurs, possibly as a xenolith in the Basement Complex of Bundelkhand near Pathanauri village in Birma river section, Hamirpur district. Graphitisation is parallel to the E.W. foliation of the gneiss - schists country rock, and has been observed over a width of three meters. Strike extension is not seen on account of alluvial cover on both the banks of Birma. A preliminary geophysical survey by E.M., Magnetometer and s.P. method has been conducted to test the strike extension of graphite. The results of this survey are awaited.

Fine inclusions of siliceous country rock are present in the graphite zone, however, it may be expected that the rock will yield about 50% graphite. Processing of the ore will be necessary before it can be used for industrial purposes. Detailed work is in hand.

3. MINERAL BASED INDUSTRIES - PRESENT AND FUTURE POSSIBILITIES

Geological exploration in Uttar Pradesh has led to the development of cement, refractory and glass industry. Aluminium industry, which was earlier established in Mirzapur district on the basis of availability of cheap power, can now be expanded on new bauxite deposits located within the State. In addition, several small units are in production for ceramics, and more recently mini-steel plants have developed in various parts of the State. On a smaller scale, lime and chemicals from limestone are produced from areas having vast resources of limestone. Mention may be made here also of the several brick kilns which are in operation throughout the State and which utilise our minor mineral - brick earth. While all the existing mineral based industrial units can be expanded in the near future, there are possibilities for setting up others and which are now to be pursued through the newly established U.P. State Mineral Development Corporation. Therefore, in addition to the efforts through the private sector, the Central and State Corporations are now to play a vital role in the development of mineral based industries in Uttar Pradesh.

The following is a brief account of the existing, as well as, those mineral based units which are likely to be considered in the coming future, and hopefully would develop by the turn of the present century.

3.1 ALUMINA & ALUMINIUM

The aluminium industry at Renukoot, Mirzapur is perhaps the largest single unit based on minerals. The 80,000 tonnes per annum smelter installed by M/S Hindustan Aluminium Corporation, as licensed earlier, is proposed to expand to a total capacity of 1.20 lac tonnes per annum of aluminium metal. While the present capacity of the plant is based on bauxite mines owned by the Company elsewhere in the country, the

expansion project was considered to be feasible on the basis of new reserves discovered in the Allahabad, Banda and Varanasi districts described earlier.

The industry is presently faced with acute power shortage which would hopefully be overcome and which would enable it to expand to produce approximately 2.40 lac tonnes of alumina and about 1.20 lac tonnes of metal. In addition, technology needs to be developed for utilising low grade bauxite ores, as well as, for recovering important by-products such as iron, titanium, vanadium and others which are today wasted in the red mud produced during the processing of various types of abuxite.

3.2 BASE AND OTHER METALS

Under this paragraph mention is merely to be made on deposits of lead-zinc-copper-uranium and gold which have since become known in the State, particularly in our districts Lalitpur and Pithoragarh. The development of concentrating plants or smelter for producing the above mentioned metals would depend upon the size of the ore bodies eventually proved in terms of their grade and tonnage. While detailed work is already in hand through the State Directorate and Geological Survey of India, this needs to be stepped up with a view to quickly outlining the deposits and then planning processing plants based on those that may be found feasible.

3.3 CEMENT

The cement industry in Uttar Pradesh is entirely in the hands of the public sector. The newly formed U.P. State Cement Corporation is operating two cement plants of 1400 and 1200 tonnes per day capacity at Churk and Dalla in Mirzapur districts. The two plants draw their requirements of limestone from reserves available in the Rohtas and Kajrahat limestone belts.

As a result of investigations completed so far, the U.P. State Cement Corporation are now committed to large scale expansion. Two new kilns of 1200 tonnes per day capacity for making portland cement, as well as, an integrated plant for manufacturing blast furnace slag-cement at Chunar are under way. The expanded units are going to draw their requirements of additional limestone from the Kajrahat limestone belt which was earlier proved to contain suitable quantities and grades of limestone.

The cement industry needs to be developed in Uttar Pradesh in a big way, specially since most of our requirements along with those of northern parts of our country have depended upon production from this part. With the increasing difficulties of traffic movement through railways, it is imperative that these be overcome so that cement would be developed on a larger scale here for our needs, as well as, those of our neighbouring States. With this objective, detailed investigations done already show the possibility of tapping an additional 130 million tonnes of limestone from the Rohtas belt in Mirzapur district which could sustain a cement production of over 15 lac tonnes per annum, as well as, for developing atleast two lac tonne units around Dehradun based on deposits of Mandhali limestone near Kalsi, and those of high silica limestone near Rishikesh.

For the development of our backward Himalayas, cement is likely to provide necessary incentive and infra-structure. In view of the shortage of space and the cost of transport of coal in large quantities to these difficult areas, it is not possible to consider ^{conventional} economically feasible large rotary kilns in our Himalayas. Accordingly, the possibility of setting up 200 tonnes per day vertical shaft kilns for portland cement in parts of Almora, Pithoragarh, Garhwal and other hill districts is being investigated. Research towards attaining this goal

is a must and it is hoped that financial aid would be available for meeting this objective.

3.4 GLASS AND CERAMICS

Uttar Pradesh is perhaps the founder of the glass industry in our country. Traditionally this industry developed on the basis of large, high quality silica-sand deposits, found in parts of Allahabad and Banda districts, south of the river Yamuna. The deposits which are worked mainly in the private sector feed the major requirements of the industry located in different parts in our country.

The description of silica-sand deposits, given earlier, contains also data on the types of glass manufacturing units that have been developed in the State and outside, along with projections for present and future demands for silica-sands. In view of the central location of our deposits in terms of the movement of sand and the finished products to several parts of the country, there is scope for enlarging the existing glass industry within Uttar Pradesh. New areas found are now being proved and the urgent need is for developing large plants that could process these sands for removing impurities and for supplying consistent grades for the increasing needs of the industry. Such a project is being planned by our Mineral Development Corporation. Hopefully, with the setting up of mines and processing units, plants for the manufacture of several glass wares and allied products, including those for television tubes and screens would also be set up near Shankergarh in Allahabad or Banda districts.

The ceramic industry so far in the State is on a small scale developed in areas around Khurja and other centres. This industry has been seeking its requirements of felspar, quartz and clay from neighbouring States. With a view to developing

this industry further it is necessary to investigate the State's own resources of clay, felspar and quartz and for developing mines on the same.

The town of Ferozabad is famous for the glass industry that is developed there. The industry is traditional and depends on the several thousand highly skilled workers for the manufacture of various types of glass-wares. It is necessary to give all assistance to such traditional industry. Detailed studies are necessary to determine their present difficulties and then to ameliorate the same. It is possible that steps like those for setting up a low temperature carbonisation plant be considered here which could help the industry with its urgent requirements for suitable fuel.

3.5 FERTILIZERS

In recent years, geological investigations have proved the presence of extensive deposits of rock phosphate around Dehradun. The deposits found are of low grade and therefore, unsuitable for direct use in the manufacture of phosphatic fertilizers. However, ground rock phosphate from Dehradun is suitable for for the treatment of acidic soils, as well as, for making mixed fertilizers with nitrogen and potash.

M/S Pyrites, Phosphates & Chemicals Ltd. are proposing to set up a beneficiation plant for upgrading the low grade rock phosphate at Dehradun. With the development of this plant it should be possible to consider setting up units for the manufacture of phosphatic fertilizers as well.

ELEMENTAL PHOSPHOROUS: The low grade rock phosphate deposits are suitable for the manufacture of elemental phosphorus. This, when produced, can be the basic material for several major industries. Such an industry is necessarily power intensive and would, therefore, need to await the availability of additional and cheap power in the northern parts of our State.

3.6 LIME AND CHEMICALS

Lime industry, manufacturing mainly building and chemical lime is located in parts of our Mirzapur and Dehradun districts. Smaller kilns utilising kankar or marl are further distributed in other central parts of the State. With the scarcity of cement and the need for making available suitable building materials such as lime or lime pozzolana to the towns and villages within Uttar Pradesh, there is considerable scope for expanding this industry through sophisticated modern kilns. At the same time better qualities of lime are needed for our sugar and other chemical industries, and there is scope for manufacturing other types of lime, such as hydrated lime.

The Central Building Research Institute, Roorkee is in the process of developing methodology for producing lime pozzolana, as well as, other lime mixtures and plasters which would be suitable for building purposes.

High grade limestone is also the basic raw material for the production of certain urgently needed chemicals, such as precipitated and activated chalk and calcium carbide. The Dehradun deposits, which are perhaps some of the purest found in the country, are eminently suitable for feeding the requirements of such chemical industry. So far three units for precipitated calcium carbonate have been set up in the Dehradun region and more are planned in the future. CALCIUM CARBIDE units can not perhaps presently be considered since they require large quantities of cheap power. With the necessity of producing calcium carbide ~~wixx~~ for our needs of acetylene gas and subsequently also for plastics, large units producing calcium carbide will have to be considered in the country and particularly in regions like Dehradun where the raw material is readily available.

3.7 IRON AND STEEL

With the need for increasing steel production and distributing new manufacturing units all over the country, mini-steel plants have come up in our State in Jhansi, Kanpur and certain north-western districts. At present, Uttar Pradesh has an installed capacity of over 200,000 tonnes of steel per annum. These plants are entirely based on scrap iron, which has so far been readily available.

In view of the possible future difficulty in getting adequate quantity of scrap iron for these plants, the Government of India is seriously considering to set up large plants for sponge iron, which could replace scrap iron in mini-plants in various parts of the country. Since the raw materials for sponge iron, iron ores and coal, would need to be transported from the existing high grade ore mines in Bihar -Orissa, it is advisable to consider low grade iron-ore deposits which are scattered all over the country, as in our Mirzapur and Lalitpur districts. The processing of low grade magnetic ores is well known to the western world. Technology needs to be developed for utilising such ores having low iron contents in our country as well. Detailed test work has been undertaken at the National Metallurgical Laboratory, Jamshedpur, and depending upon the technical and economic feasibility, it should be possible to consider mines and concentrating plants based on low grade iron ores, which could in turn feed the requirements of sponge iron units.

3.8 PETROLEUM AND NATURAL GAS

The investigations done by the Oil & Natural Gas Commission in Dehradun and other parts of the State have not been successful so far. However, work done recently suggests the possibility of new discoveries in case more intensive

investigations are undertaken in the Pilibhit - Tanakpur region, as well as, in other areas where hidden structures are likely to be located. This activity naturally requires to be given priority in the country's interest involving large inputs of funds.

3.9 REFRACTORIES

The setting up of the 100 tonnes per day dead burnt magnesite project in Almora district through M/S Almora Magnesite Limited is the first major step that the State has taken for the development of the refractory industry. The plant is based on reserves of magnesite located in the Dewaldhar-Jhiroli area near Bageshwar.

Apart from certain southern States in the country, Uttar Pradesh has deposits of magnesite which will have to be developed on a much larger scale for meeting the increasing requirements of basic refractories for the iron and steel industry. The present capacity of 30,000 tonnes is likely to be doubled in the near future through the private sector through a new plant in Pithoragarh district. Moderate reserves of magnesite are known and under investigation in various parts of Almora, Chamoli and Pithoragarh districts, and hopefully U.P. could provide the answer to our country's needs of the future.

For the further development of basic refractories, our State lacks deposits of chromite ore. With the increasing demand of basic bricks in our mini-steel plants, it is necessary to consider setting up units on the basis of import of chrome ore from Orissa. Straight magnesite bricks, however, do have a good market and units for this await larger production of dead burnt magnesite.

In addition to magnesite, Uttar Pradesh has large reserves of other refractory minerals, namely, clay, andalusite, diaspore

and pyrophyllite. Our bauxite is perhaps not suitable for high alumina refractories. In addition, the State has vast reserves of high grade dolomite which could be utilised for manufacturing dead burnt dolomite, as well as, for mining and transporting dolomite as a flux for the steel industry.

On the basis of reserves of clay, diaspore and pyrophyllite available in Mirzapur and Bundelkhand, plans are under way for setting up units for the manufacture of different grades of alumina-silicate refractories, the demand for which is likely to rise manifold in the near future. A problem that needs investigation through research is that for processing of our low grade ores which occur in abundance and which are today mainly wasted. Tests are in hand, for instance, to determine if intimate mixtures of diaspore-pyrophyllite ores can be treated for the recovery of diaspore, and then used for making refractory bricks having high alumina contents.

In addition to the above deposits, graphite may be discussed under this para. Promising deposits have recently been located in parts of Hamirpur and lower grade ores are known from various parts of our Himalaya. Manufacture of graphite crucibles and electrodes can be considered, therefore, in the near future provided economically viable mining ventures could be developed on deposits that are now under investigation.

3.10 TALC BASED UNITS

Uttar Pradesh is producing some of the finest quality talc from Alnora district. Though deposits of this mineral are extremely scattered and irregular in nature, there are large occurrences that require careful investigation and development. Talc is presently exported for the manufacture of cosmetics, including talcum powder, and can also be used for manufacturing insulators needed in the electronic industry.

3.11 BUILDING STONES

The State has been important for building stones that were used in ancient historically important constructions. Blocks and large slabs of white to cream, speckled or spotted and red sandstone is still mined from deposits of the Vindhyan formations in Varanasi, Mirzapur, Allahabad, Banda, Lalitpur and Agra districts.

With the increase in the price of coal needed for making bricks, and the growing demand for sandstone in houses and large buildings, the development of sandstone mines along modern lines need to be considered. The markets also appear to be promising for slate and granite which occur in Almora and southern, U.P. The marble deposits of Ningsha, Mirzapur and of Dehradun are suitable for making chips for floorings, however, further experimentation is necessary for producing tiles and mosaics, as well as, for mining large slabs and blocks from Ningsha.

The building stone mines are labour intensive. Given an economic incentive, the existing mines could be modernised for better recovery less waste, and more acceptable products prepared after processing through cutting and polishing machines. The traditional art of making ornamental blocks with chiseled designs could also perhaps be encouraged.

4. GENERAL REMARKS

The paper is compiled at the instance of the Gandhian Institute of Studies, who are conducting the Second Uttar Pradesh Study. The author was called upon for briefly compiling data on the State's mineral resources, and the foregoing paragraphs show that the past impression of the State being extremely poor in minerals needs now to be revised. The paragraphs have also shown that with the deployment of finance and equipment, several new minerals have been found within the last two decades, and which promise the development of mineral based industries in U.P. While we are endowed with several types of industrial minerals which pose a challenge for investigation, as well as, for their use after detailed research, the author would like to express the feeling that given the required resources, many new metallic minerals would also be found, and those under discovery stage at present would be developed for the needs of our country.

While an effort is in hand and which needs to be intensified for geological exploration, it is extremely necessary to develop facilities for research, which needs to be oriented towards the utilisation of various grades and types of ores and industrial minerals. The gestation period for the development of mines and mineral processing plants is already an extremely long one. This is further increased due to lack of research facilities needed for exhaustive tests on industrial minerals and rocks, or natural products which are not "tailor made" for industrial utilisation. Deposits that may be found, quite often remain unutilised over long periods for want of the requisite research leading to solutions for their use. The author pleads for the development of this facility urgently.

It has also been brought out in the earlier paragraphs that exploration has been done somewhat in isolation, and that

there is an urgent need for integrated intensive surveys. To start with, our need is for properly compiling all known data on the varied aspects of geology and mineral occurrences, as well as, of published geological maps with critical information, all of which needs to be put together for concluding on potential mineral belts. The belts so selected can systematically be taken up for investigation.

While efforts are already in hand to integrate information, the next natural step would be to undertake large areas for surveys using the well established and sophisticated methods of exploration. This requires coordination not only at the national level, but also with foreign Universities or Institutions where new methodology is being developed at a very fast rate. Recently the use of satellites has resulted in the production of photographs and other data which is of immense value in mineral exploration. The need is for collaborating with agencies for obtaining and utilising this vital data.

A definite policy for mineral exploration and particularly development needs are to be clearly evolved. So far the exploring agencies have been guided by papers published by the Planning Commission, which have indicated immediate priority programmes. In the field of mineral exploration, while the country's requirements of particular minerals certainly needs to be given the due priority, investigations on an integrated scale must be undertaken now so that, at the turn of the century, the State can be ready to deploy its resources on particular minerals or metals that may be indicated through such surveys. In fact, exploration with back up research facilities need to be given priority in the overall context of economic development.

While the need for research on industrial minerals, for the development of mineral based industry, as well as, for

fully utilising wastes through the development of methodology for recovering by-products has been indicated, there is a similar need for systematic scientific investigations on our minor minerals. As an example, the vast occurrences of ballast and sand needed by the industry are mined from various parts of the State and are of various grades and utility. There is a need to make detailed inventories of all such minor mineral deposits, so that their use could be scientifically controlled. While ground water is not within the scope of this paper, the common belief that the State has abundant supplies should not stand in way for systematic investigations of this most needed resource over the years to come. Unscientific exploitation of ground water leads to several problems, and it is necessary to consider detailed investigations so that its future use could be properly controlled over the years in the future.

Mineral development, specially since it relates to backward and interior areas of our State, cannot be stepped up through an intensification of exploration alone. Infra-structure, in the shape of transport and communications, power, water, development of land and even financial subsidies are often necessary before viable projects on minerals can evolve. Intensive exploration programmes are also handicapped for want of such requirements, specially of road networks in parts of our Himalayas. While it would not be possible to discuss the infra-structure requirements of each project or mineral bearing region, certain general recommendations are made here for consideration.

The lack of power, specially in our Himalayas, is perhaps the most important factor handicapping mineral development. The existing industry, may that be Aluminium, Steel, basic Refractories or Cement suffers today from the lack of

uninterrupted and constant power supply. The development of our coal-fields in Mirzapur and setting up super thermal power stations is perhaps one answer for this need. The State further is planning hydro-electric schemes in our southern and northern parts, and the Ganga grid when completed, is likely to provide a large potential. However, the author would like to make the plea that in the Hinalayas, small scale generation, by tapping high gradient hill streams should be considered, which could later be hooked on the main grids. Such small units can not only perhaps help with rural development and water pumping, but could also encourage small scale quarries, and even perhaps wood sawing and processing units. Such schemes could be planned and integrated with village development schemes.

For power intensive mineral based industry, such as aluminium, elemental phosphorous or carbide, suitable subsidies on power tarriff need to be considered in national interests. The award of a similar subsidy on transport has already gone a long way with helping industry to develop in difficult terrains.

Bulk transport of ore or finished products still largely depends on our railways. Generally speaking, the bottle-necks in this region appear to be confined to the eastern and southeastern sectors, where movement of cement and coal is becoming more and more difficult. The development of the State, northern and northwestern parts of our country in the future would depend a lot on smooth movement of the above mentioned commodities. The existing links through Mughalsarai or Gharwa Road (via Pipri) are likely to become saturated, specially after the presently proposed expansion of the cement industry and the development of coal mines near Bina in Mirzapur. Since cement and coal requirements need further

to be stepped up for up-country needs, additional links, such as that between Dehri-on-Son in Bihar and Robertsganj need urgent consideration. Similarly, for movement westwards, rail connections between Singrauli and Lalitpur through links skirting the U.P. - M.P. border are desirable.

In the northern region, the Dehradun - Rishikesh area is already showing signs of congestion. Further, areas east of Dehra Dun are merely connected with small gauge lines. An inter-connection of this system on broad gauge is necessary. In addition, certain bold ventures are further proposed and which need to be phased. Railway into the interior Himalaya can perhaps be considered along the Ganga-Alaknanda system, and along the Kali-Saryu system for connecting Rishikesh with Chamoli district, and Tanakpur with Bageshwar. These can open up large mineral tracts, and perhaps make small scale metal mines for copper-lead-zinc along with those for magnesite, soapstone, dolomite, limestone and slate feasible in the middle and inner Himalaya. An alternative route from Saharanpur into the Dun valley would help with the development of fertilizer and chemical industries based on carbonate rocks and rock phosphate.

The road net-work in the State is helpful, however, the need is for widening and strengthening the existing system so that faster and heavier traffic becomes possible. The usual class B loads allowed on hill roads do not permit economic transport of ores or their finished products. These need strengthening and a reclassification so that at least 10 tonne trucks could ply. While the above should be given priority, the forest roads available need investments for conversion into all weather roads, in the south, as well as, in north U.P. with a view to developing specific roads for connecting mineral deposits, the Government once considered sanction of special funds. Our needs in Dehra Dun, Tehri, Almora, and in the southern districts for mineral development are well known. Since these roads serve specific objectives, funds need to be allocated separately for

the same.

Within this discussion, the author would like to mention the several taxes that transporters have to pay on minerals moved by road. The problem is aggravated on account of individual rates charged in the different areas, particularly by Forest and Urban authorities. These need to be rationalised in the interest of development.

The above discussion outlines certain problems of power and communications. In addition to these requirements, the problems of the small mine owners in the private sector need also to be considered. Since mines form an integrated part of a large industry, in national interests, the State should consider maximum exploitation with minimum wastage of these depleting assets. The State, therefore, needs an agency for assisting the small lessee with technical know-how and equipment, along with facilities for proving the resource in individual mines so that its exploitation could be done scientifically. The small lessees neither have the know-how or the finance for this important cause. Such assistance could be subsidised, and part of money spent recovered from production, and phased over periods of time. Small mining ventures are usually not mechanised but are often labour intensive, and, therefore, to the State's advantage. They further generate ancillary groups, such as those for transport or processing and marketing of ores. These, therefore, could be encouraged and helped.

Lastly, perhaps an important infra-structure that would help with mineral development, relates to the creation of an industrial discipline amongst the workers, and for making available trained technicians for jobs involved in workshops, in mines or in other mineral processing plants. In the author's view, one way would be for the Government to subsidise and create

training facilities to willing workers, not necessarily educated, on projects wherever they may be set up. Even the small lessees would be asked to provide training facilities, to willing candidates of his choice, and which may be partially subsidised by the State.

Mineral development in Uttar Pradesh will need to be an integrated programme of exploration for which priority needs to be given. With such programmes, special inputs are necessary in related fields without which viable ventures cannot develop. A closing thought further, since mines lead to destruction of lands and forests which are perhaps equally important for our largely populated country, inputs on research are necessary now to determine the best ways that these problems can be minimised, as well as, that of silting and pollution through extensive mining.

The author would like to conclude by thanking the State Government with whose permission the paper was written, and by expressing his gratitude to his friends and colleagues for helpful discussions. In particular, thanks are due to Sri G.S. Srivastava who typed the draft and the final paper, and to Sri D.K. Mukerji for drafting the maps and sections.