GEOLOGY AND MINERAL RESOURCES OF HIMACHAL PRADESH

Miscellaneous Publication No. 30 : Part - XVII
(Second Revised Edition)

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2012
GEOLOGY AND MINERAL RESOURCES OF THE STATES OF INDIA

HIMACHAL PRADESH

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Since time immemorial metal constituted an integral part of human development. Exploration and exploitation of mineral wealth form a vital parameter of development and modernization of a nation, where particularly, Geology plays the pivotal role. Realising this, the Geological Survey of India, since its inception has been the torch-bearer by constantly and ceaselessly providing basic geoscientific inputs and attributes required for the sustainable harnessing of mineral wealth. The Miscellaneous Publication No. 30 series is meant for updating and revisioning of existing geoscientific database. The present volume is the second revised edition, with updated available information pertaining to geology and mineral occurrences of Himachal Pradesh.

The state is adorned with lofty mountains covers an area of 55,673 sq km and is bounded by 30° 20' and 33° 15' N latitudes and 75° 45' and 79° 00' E longitudes. Physiographically, the state is bounded in the north and northwest by Jammu and Kashmir, in the east by Tibet (China), in the southeast by Uttarakhand, in the south by Haryana and in the southwest by Punjab. Himachal Pradesh was made a full-fledged State on 25th January, 1971. There are total 12 districts in the state namely Bilaspur, Chamba, Hamirpur, Kangra, Kinnaur, Kullu, Lahul and Spiti, Mandi, Shimla, Sirmaur, Solan and Una.

The geological history of this state so far established is mainly due to the protracted geological investigations and mapping carried out by the geologists of the Geological Survey of India. Medlicott (1864) was the pioneer worker, who provided a broad base for the future geological work; Oldham (1887, 1888) and McMahon (1883) also provided new and noteworthy information. Modern structural concepts were introduced in the Simla Hill by Pilgrim and West (1928) while Auden (1934) established new standard of mapping in the Lesser Himalaya. In the Higher Himalaya notable contributions were made by Griesbach (1891), Stoliczka (1865) and Lyddeker (1879). However, it was Hayden (1904) who provided a lucid and detailed synthesis of the Spiti Geology, which became a basis for all subsequent studies in the Tethyan Basin.


Among the different kinds of mineral occurrences, limestone represents the major mineral deposit of Himachal Pradesh. Muktinath (1949), Vohra et al., (1976), Sharma (1983), Prashra (1977), Bhandari (1977), Chandra Shekhar (1983 & 1984) and Singh (1988) were involved in investigating the limestone resources. Baryte, occurring next in abundance, has been investigated by Muktinath (1957), stibnite by Dutt and Ahmad (1957) and Srikantia and Padhi (1964). Base metals in the Garsah valley were investigated by Sharma (1966) and Banerjee and Naidu (1985) and in the Tons valley by Sharma (1976) and Parimoo (1983). Gold as neo-placer occurrence was examined by Saxena et al. (1985) and Sharma (1988).

Acknowledgements

The task of compilation is always challenging and a daunting one. A combined effort by the officers of GSI, Chandigarh office made it possible and the present revised volume is prepared with renewed and updated information related to geology and mineral resources of Himachal Pradesh. The task has been accomplished under the watchful supervision of Shri R.S. Rana, Director, Technical Coordination-1, SU: PH&HP. Compilers wish to thank him for critically going through the manuscript. Help rendered by S/Shri P.C. Sethi, Sr. Geologist and Rakesh Kumar, Steno is thankfully acknowledged. Compilers feel grateful to Shri D.R.V. Ramana Murty, Dy. Director General & HOD, Northern Region for rendering every possible help and support along with providing his valuable suggestions required for publishing this volume. Compilers also wish to extend thanks and gratefulness to the Director and officers of the Publication Division, Northern Region and also to all those who lent active support in finalizing and publishing this work.
Physiography

Essentially being a hilly terrain the state of Himachal Pradesh displays prominent features characterized by lofty mountain ranges incised by deeply dissected valleys carved out in slopes of various descriptions. The elevation above mean sea level varies from 320m in Una District, to 6975 m at Leo Pargil Peak of Kinnaur District. Physiographically, the State can be divided into five distinct parallel zones. From south to north these are:

1. Alluvial Plain: A limited zone of nearly flat plain developed at the foot hills of Siwalik Range in the vicinity of Indo-Gangetic Alluvium in the southwestern and southeastern fringes of the state with an average altitude of 375m.

2. Siwalik Foothills: It is also known as Sub-Himalaya and is the outermost mountainous zone of Himachal Himalaya, separating the state from the plains of Punjab and Haryana. It is 8 km - 50 km wide zone, with altitude ranging from 345m to 1500m. This zone contains many prominent longitudinal valleys viz. Una, Sirsa and Poanta duns.

3. Lesser Himalayan Zone: It is a 65km to 80km wide zone between Sub-Himalaya and Central Himalaya. The altitude of this zone rarely exceeds 3000m.

4. Central Himalayan/Great Himalayan Zone: It comprises a zone of snow-capped peaks ranging in height from 4000m to 5000m. It separates the Lesser Himalayan zone from the Trans-Himalayan zone.

5. Trans Himalayan/Higher Himalayan Zone: It is mainly a rain shadow area, having an average width of 40km and height varying from 3000m to 6000m. The mountain ranges in general trend in NW-SE direction.

There is a network of perennial rivers in Himachal Pradesh, which have glaciers as their sources. Majority of the drainage of the State belongs to Indus River System. The Satluj, Beas, Ravi, Chenab, Spiti, Parbati, Pabbar, Tons and Giri are the main rivers of Himachal Pradesh. Of these, the Satluj, which rises in the highlands of Tibet, is an antecedent river. Most of the rivers flow following the trend of the main structural grain of the region.

Nearly 17% of the total area of Himachal Pradesh is covered by glaciers. A recent study in 2004 has documented 2,554 glaciers in the state, which are the source of fresh water to the rivers of North India. Bara Shigri is the largest glacier in the State, which is located in the Chandra valley of Lahaul and feeds the Chenab River. The glacier is more than 25km long and about 3km wide. Chandra Nahani, Bhadali, Bhaga, the Lady of Keylong, Mukkila and Hamata are other major glaciers in the state. There are many fresh water lakes in Himachal Pradesh. The Chandra Tal, Suraj Tal, Yonam Tso and Nako Lake are the lakes formed due to damming of glaciers, while the Riwalas and Renuka lakes are due to damming of river/stream courses. Besides, Gobindsagar, Pong and Pandoh are the artificial lakes in the state formed due to the construction of dams across Satluj and Beas rivers.
The state of Himachal Pradesh is covered by the rocks ranging in age from Precambrian to Recent. The normal order of super-position of the rocks in the Lesser Himalaya has been affected by later events of thrusting. Owing to its complex tectonism and geological evolution, establishing an unanimously-accepted geology and stratigraphy of Himalaya remained mired with debate and controversy- posing a natural deterrent. With this backdrop, effort is made hereunder to present a generlised view.

<table>
<thead>
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<th>AGE</th>
<th>GROUP</th>
<th>FORMATION</th>
<th>LITHOLOGY</th>
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<tbody>
<tr>
<td>HOLOCENE</td>
<td>NEWER ALLUVIUM</td>
<td>Channel Alluvium*</td>
<td>Fine to coarse, micaceous, sand-silt and clay</td>
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<tr>
<td></td>
<td></td>
<td>Terrace Alluvium*</td>
<td>Grey sand and grit with pebbles of sandstone and lenses of clay</td>
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<td></td>
<td></td>
<td>Fan Alluvium*/Bhangal</td>
<td>Brownish grey clay, sand and gravel with boulders</td>
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<td>MIDDLE TO UPPER PLEISTOCENE</td>
<td>OLDER ALLUVIUM</td>
<td>Older Alluvium*/Dun Gravels</td>
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<td>Plio-Pleistocene</td>
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<td>Upper Siwalik</td>
<td>Coarse sandstone, grit and conglomerate with local clay beds</td>
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<td>Mio-Pliocene</td>
<td>SIWALIK</td>
<td>Middle Siwalik</td>
<td>Coarse micaceous sandstone with interbeds of earthy clay</td>
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<td>Miocene</td>
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<td>Sandstone - clay alternation</td>
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<td>Eocene-Miocene</td>
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<td>LILANG</td>
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<td>Nunuluka</td>
<td>Sandstone, limestone and shale</td>
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<td>Alaror</td>
<td>Shale limestone, dolomite and sandstone</td>
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<td>Hangrang</td>
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<td>Shale, limestone, dolomite and siltstone</td>
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<td>Chomule</td>
<td>Grey dolomite, shale and marl</td>
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<td>Kaga</td>
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<td>Gechang</td>
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<td>Po</td>
<td>Quartzarenite, siltstone, sandstone, and shale</td>
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<td>SANUGBA</td>
<td>Takche</td>
<td>Limestone, dolomite, shale, siltstone, and sandstone</td>
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<tr>
<td>SILURIAN</td>
<td>Takche</td>
<td>Limestone, dolomite, shale, siltstone, and sandstone</td>
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<td>ORDOVICIAN</td>
<td>Thango</td>
<td>Purple quartzite and shale</td>
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<td>HAIMANTA#</td>
<td>Kunzam La</td>
<td>Siltstone, shale slate, quartzite, sandstone and dolomite</td>
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<td>Quartzarenite, shale, arkosic sandstone and limestone</td>
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<td>Sankholi = Tal B</td>
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<td>Shaliyana = Tal A</td>
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<td>KAMTRAM#</td>
<td>Thango</td>
<td>Purple quartzite and shale</td>
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<td>TAL</td>
<td>Sankholi  = Tal B</td>
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<tr>
<td>HAIMANTA#</td>
<td>Kauriyala / Krol C, D and E</td>
<td>Dolomite, cherty limestone, shale, sandstone, quartz arenite, calcilutite</td>
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<td>Mahi / Krol A</td>
<td>Dolomite, oolitic limestone, shale</td>
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<td>Chambaghat (=Krol Sandstone)</td>
<td>Quartzarenite and friable sandstone</td>
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<td>BALIANA</td>
<td>Infra Krol</td>
<td>Black shale and slate, slaty quartzite</td>
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<td></td>
<td>Blaini</td>
<td>Diamicite shale and dolomitic limestone</td>
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<td>Katarigali</td>
<td>Carbonaceous slate and phylite with interbeds of quartzite</td>
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<td></td>
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<td>Diamicite with sandstone and intercalated argillites</td>
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<tr>
<td>NEOPROTEROZOIC</td>
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<td>Batal, Phylite, grey quartzite and carbonaceous phylite</td>
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<tr>
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<td>Sanjauli</td>
<td>Sandstone, greywacke conglomerate</td>
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<td></td>
<td>Chhaosa</td>
<td>Shale, siltstone and greywacke</td>
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<td></td>
<td>Kunihar</td>
<td>Stromatolitic limestone and shale</td>
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<td></td>
<td>Basantpur</td>
<td>Argillite and siltstone with bands of limestone and dolomite</td>
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<tr>
<td>JAUNSAR</td>
<td>Naghat</td>
<td>Quartzarenite, grit, conglomerate, shale, slate phylite</td>
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<td></td>
<td>Chandpur</td>
<td>Shale, slate, phylite, quartzite</td>
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<td></td>
<td>Mandhali</td>
<td>Limestone, argillite, arenite and conglomerate</td>
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<td></td>
<td>Guma</td>
<td>Shale, salt, grit and dolomite</td>
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<td></td>
<td>Darla-Tattapani (=Peontra Volcanics)</td>
<td>Quartzite, slate and basic flow</td>
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<tr>
<td>MESOPROTEROZOIC</td>
<td>LARJI</td>
<td>Auf, Stromatolitic limestone</td>
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<td></td>
<td>Hurla</td>
<td>Quartzarenite with subordinate shale and argillites</td>
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<tr>
<td>SHALI = DEOBAN</td>
<td>Bandla</td>
<td>Shale, slate, siltstone</td>
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<td></td>
<td>Parmali</td>
<td>Dolomite, limestone</td>
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<td></td>
<td>Makri</td>
<td>Shale, limestone, dolomite</td>
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<td>Tattapani</td>
<td>Cherty dolomite, shale</td>
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<td>Sorghwari</td>
<td>Limestone</td>
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<td></td>
<td>Khatpul</td>
<td>Dolomite, quartzarenite and shale</td>
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<td></td>
<td>Khaira</td>
<td>Quartzarenite</td>
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<td>Ropri</td>
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<td>PALAEOPROTERO-ZOIC</td>
<td>RAMPUR</td>
<td>Manikan Quartzite, Quartzite with bands of metabasalt</td>
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<td>NARAUL</td>
<td>Banjar, Metabasalt, quartzite, phylite</td>
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<td>SUNDERNAG AR</td>
<td>Bhalan, Slate, phylite, quartzite</td>
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<td>Maloh, Purple quartz arenite, shale, slate phylite</td>
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<td>Mandi Volcanics</td>
<td>Basaltic and andesitic flows</td>
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<td>KULU</td>
<td>Khokhan</td>
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<td></td>
<td>Gahr</td>
<td>Gneiss, minor quartzite, phylite</td>
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<td>Kharmada</td>
<td>Carb-phylite, limestone, quartzite</td>
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</table>
The reconstructed stratigraphy of the rocks in Himachal Pradesh is given below.

Era wise description of various groups/formations exposed in the Himachal Pradesh is as follows;

**PROTEROZOIC**

Proterozoic rocks represented by Jutogh Group and Vaikrita Group mostly constitute the Lesser Himalayan terrain in Himachal Pradesh. The Jutogh Group comprises Panjerli, Manal, Bhotli, Khirkhi, Taradevi, Kanda, Naura, Badrol, Rohru, Chirgaon and Jaknoti Formations in ascending order. The Panjerli, Manal, Bhotli Formations comprise carb-phylite, quartzite, carbonaceous limestone, and schist whereas, Khirkhi and Kanda Formations comprise mainly quartzite. Taradevi Formation has variable lithology comprising phylite and schist that are often carbonaceous. Garnetiferous/staurolite/graphite schist, sillimanite gneiss, quartzite, marble and amphibolite comprise the Naura Formation. Badrol and Rohru formations comprise mainly quartzite, schist and quartz schist. The topmost Chirgaon and Jaknoti formations consist of schist, quartzite, amphibolite and gneiss. Vaikrita Group is divided into Kharo, Morang, Shiasu and Chamba Formations. Kharo Formation comprises sillimanite/kyanite schist, quartzite and gneiss, which are argillo-arenaceous towards base, feldspathic in the middle and migmatized at the contact with Rakcham Granite. The Rohtang Gneissic Complex represents the Kharo Formation in Higher Himalaya of Lahual and Kulu areas. Morang Formation comprises schist and quartzite with rare calc silicate and marble bands. Shiasu Formation consists of grey green and purple quartzite with minor bands of biotite-chlorite schist and hornblende-schist. Chamba Formation mainly comprises slate and phyllite with minor quartzite.

**Palaeoproterozoic**

Rocks of Jeori-Wangtu Banded Gneissic Complex and of other Groups namely Kulu and Rampur (=Naraul = Sundernagar) represent the Palaeoproterozoic period in the State. The Jeori-Wangtu Granitoid Gneiss
is strongly foliated with well-developed augen-gneiss, mylonitic gneiss and porphyroblastic biotite gneiss with non-foliated granitoids in the central part. These are the oldest rocks exposed in Himachal Pradesh forming basement for the Rampur Group. However, some units of Bandal Granitoids show cross cutting relationship with Rampur Group of rocks. The Kulu Group comprises Khamrada, Gahr and Khokan formations. The Khamrada Formation forms the basal unit of Kulu Group and is characterized by carbonaceous and graphitic phyllite-schist with bands of limestone. The Gahr Formation consists of quartzose, banded and streaky gneisses with alternate beds of schist and quartzite. The Khokan Formation comprises mainly quartzite, quartz schists, chlorite-quartz schist, slate and garnetiferous schist. The Kulu Group is one of the three principal crystalline nappes of Himachal Pradesh. The Naraul Group consists of quartzarenite phyllite, slate, and diamictite whereas Sundernagar Group comprises dominantly of purple coloured arenaceous sediments with argillites and characterized by interstratified basic lava flows of the Mandi-Darla Volcanics. The Rampur Group presents an association of metabasalts and metasediments dominated by clastics. It is divisible into three Formations: Bhalan, Banjar and Manikaran. The Bhalan Formation consists of slate, greenish phyllite and schist with inter-beds of flaggy quartz arenite and subordinate metabasics. The Banjar Formation comprises a thick sequence of dark green phyllite representing metabasalts. The Manikaran Formation comprises quartzarenite/quartzite with occasional bands of metabasic rocks.

Mesoproterozoic

The Mesoproterozoic rocks in the Himachal Himalaya are classified into two stratigraphic Groups; Shali (Deoban) and Larji. The Shali Group has been divided into eight formations namely Ropri, Khaira, Khapatpul, Sorgharwari, Tattapani, Makri, Parmali and Bandla. The Ropri Formation, the basal unit consists of red shale, siltstone, dolomite and limestone. The Khaira Formation comprises cross-bedded quartz arenite and purple shale. The Khapatpul Formation comprises massive dolomite, cherty stromatolitic dolomite ad quartzarenite. The Sorgharwari Formation consists of pink, purple limestone and purple, green shale. The Tattapani Formation is predominantly made up of massive stromatolitic dolomite. The Makri Formation is represented by inter-bedded sequence of shale, slate, siltstone, quartzarenite and dolomitic limestone. The Parmali Formation comprises cherty, stromatolitic dolomite and subordinate quartzarenite. The Bandla Formation consists of green and purple shale, siltstone, sandstone, and cherty breccia. The Shali Group represents a shallow stable platformal type of sedimentation substantiated by the presence of stromatolites, sedimentary structures like mud cracks and oscillation ripple marks. The Deoban Group, which is exposed in the southwestern fringes of the State bordering Uttarakhand, is divided into three formations. The basal, Atal/Dharagad Formation comprises limestone, quartzite, slate and basic flows. Minas Formation is represented by buff colored limestone with slate partings, tuffaceous slate and dolomite. Bajmara Formation consists of slate and stromatolitic limestone. The Larji Group comprises a sequence of slate, quartzarenite and diamictite overlain by quartzarenite and carbonate rocks and is best exposed in Beas valley, Kulu area. The Hurla Formation forming basal part of Larji Group comprises quartzarenite with subordinate shale and argillites. The overlying Aut Formation is characterized by carbonate rocks rich in stromatolites. The upper part of Mesoproterozoic is represented by Guma and Darla-Tattapani (Peontra volcanics) Formations. The Guma Formation in the Mandi area comprises shale, salt grit, purple grits and dolomite whereas, Darla-Tattapani Formation is represented by quartzite, slate and basic flows.

Neoproterozoic

The Neoproterozoic sequence in the State has been divided into the Lower and the Upper Neoproterozoic divisions. The Jaunsar Group, Simla Group and Batal Formation of Haimanta Group represent the Lower Neoproterozoic division. The Jaunsar Group is typically developed in the Deoban structural belt where it has an autochthonous development. It is divisible into three formations namely Mandhali, Chandpur and Naghat. Mandhali Formation is characterized by a lithological association of limestone, argillite, arenite and conglomerate. The Chandpur Formation is characterized by the occurrence
of alternate sequence of argillite and arenite. It comprises a thick rhythmic sequence of shale, siltstone and greywacke sandstone. The Nagthat Formation comprises sandstone, arkose, quartz, arenite, grit, conglomerate, grey, purple and green shale, slate and phyllite. In the Pabbar Valley, a huge outcrop of granitoid gneiss (Kharsali Granitoid Gneiss) is concordant and is mainly seen close to the contact between the Mandhali and Chandpur formations.

The Simla Group is divisible into four formations viz. Basantpur, Kunihar, Chhaosa and Sanjauli. The Basantpur Formation is characterized by the abundant interbeds of limestone and dolomite within argillite and siltstone whereas Kunihar Formation comprises lenticular interbeds of stromatolite-bearing limestone with fissile shales. The Chhaosa Formation is characterized by a thick rhythmic sequence of shale, siltstone and greywacke. The Sanjauli Formation is divisible into Lower and Upper Members, on the basis of characteristic lithological associations. Lower member is characterized by an association of coarse gritty sandstone and greywacke. The Upper Sanjauli Member comprises conglomerate and arkosic arenite exposed on the Kandaghat-Chail road.

The Batal Formation represents the upper part of Lower Neoproterozoic and comprises grey-green phyllite, grey quartzite and carbonaceous phyllite in the lower part, quartzite alternating with pyritous carbonaceous phyllite in the middle and green chlorite phyllite, carbonaceous phyllite, quartzose phyllite with interbeds of pale white to grey quartzite in the upper part.

The upper Neoproterozoic era in the State is represented by Manjir Formation, Katarigali Formation, Baliana Group and Krol Group. The Manjir Formation in the Chamba area comprises lenticular thick bedded or massive diamicite with subordinate sandstone and intercalated argillites. The matrix of the diamicite shows variation from sand, silt to clay. The Katarigali Formation comprises dark grey, carbonaceous slate and phyllite with interbeds of quartzite. The Blaini and Infra-Krol Formations constitute the Baliana Group. The Blaini Formation rests unconformably over the Simla and Jaunsar group of rocks. It is divisible into four members A, B, C and D in ascending order.

Member A comprises diamicites consisting of poorly sorted clasts of various rock types in a sandy to argillaceous matrix. Member B comprises shale and argillite whereas Member C consists of diamicite with poorly sorted clasts embedded in a matrix of variable composition. The Member D comprises dolomitic limestone and siltly-pelite purple and green shale partings. The overlying Infra-Krol consists dominantly of argillaceous association of black and grey shale, slate and phyllite interbedded with thin buff coloured slaty quartzite.

The Infra-Krol Formation passes into the Krol Group with occurrence of Chambaghat Formation (=Krol Sandstone Formation) at the base comprising quartzarenite and friable sandstone followed by Mahi, Jarasi and Kauriyala Formations. The erstwhile Krol A Formation has been re-designated as Mahi Formation, which comprises alternation of greenish grey calcareous shale and argillaceous limestone with variable gradation. The Jarasi Formation (erstwhile Krol B Formation) is characterized by thinner laminated purple to red shale with green shale intercalations and thin interbeds of dolomite and chert limestone. The upper Kauriyala Formation encompasses erstwhile Krol C, D and E Formations and re-designated as members C, D and E. The Member C is represented by dolomite, cherty limestone and shale, Member D comprises an alternation of cherty limestone and shale whereas Member E is the topmost lithostratigraphic unit with a dominant banded grey and pale cream white calcite-limestone with a rugged appearance. Litho units of Krol Group have yielded algae, acritarchs, stromatolites and oncolites referable to Neoproterozoic.

**PALAEozoic**

**Cambrian**

The Tal Group represents the Lower Cambrian sequence in the Lesser Himalaya. It occurs in the core of Nigali Dhar and Korgai synclines. The Tal Group is divisible into three formations namely Shaliyana, Sankhol and Koti Dhaman. The Shalihana Formation comprises a sequence of earthy siltstone, chert and carbonaceous shale, minor limestone and phosphorite. The Sankhol Formation is made up of alternate bands of grey to olive green, fine to medium grained
arenaceous and argillaceous beds. Koti Dhaman Formation is characterized by medium to coarse-grained arenaceous sediments comprising quartzarenite, arkosic sandstone and limestone.

In the Spiti / Kinnaur and Higher Himalayas, Cambrian rocks are represented by Kunzam La Formation of Haimanta Group. The Kunzam La Formation is made up of greenish grey siltstone, shale/slate, quartzite, sandstone, dolomite, and local pebble beds. The Kunzam La Formation in its basal part encloses the trace fossils of *Phycodes*, *Pedum*, *Plagiogmus*, *Rusophycus*, *Diplichnites*, *Skolithos*, *Planolites* & *Gordia*. In the upper part trilobites *Psychoparia*, *Oryctocephalus*, *Lingulella haimantensis*, *Redlichia noetlingi*, *Olenus haimantensis* of Middle Cambrian age are found.

**Ordovician**

The Sanugba Group represents the Ordovician-Division suite of rocks in the Spiti area. It is divisible into Thango, Takche and Muth Formations each representing different geological periods. The Thango Formation representing Ordovician in the State unconformably overlies the Kunzam La Formation. It largely consists of massive to bedded purple quartzite and shale. The Thango sequence is characterized by herringbone, festoon and planar cross-bedding, rare low angle cross bedding, ripple marks, mud cracks and current crescents indicating shallow tidal sea environment. The body fossils present include *Raphistoma*, *Favosites*, *Halysites*, *Catenularia*, *H. wallichi*, *H. spitiensis* (Reed), *H. spitiensis* (Reed), *H. spitiensis* (Reed), *Halysites Catenuaria*, *H. wallichi*, *Halysites Catenuaria*, *H. wallichi*, brachiopods: *Orthis*, *Pentamerus oblongus*, *Chonetes*; gastropods: *Pleurotomaria*, *Bellerophon* sp., *Euomphalus* cf. *triquetus*; trilobite: *Calymene*; bryozoa: *Hallopora fistuliporid*; algae: *Girvanella*, *Apidium indicum*, *Vermiporella*. Presence of *Vermiporella*? *Girvanella* and *Vermiporella* indicate a back reef, partly organic and foreslope facies environment.

**Devonian**

Devonian period in Himachal Himalaya is represented by Muth Formation, which is constituted of compact to granular, medium to fine grained white to mottled, locally grey quartzarenite. Gradually dolomite beds of significant thickness appear. At places, olive green shales are associated with dolomite and sporadic conglomerate lenses. The white quartz arenite contains 95% quartz and has bimodal grain size distribution. Low angle cross bedding, trough sets, festoon and herringbone cross bedding, ripple bedding, channel fills and mud cracks are the characteristic attributes of this formation. Total absence of body fossils and general absence of trace fossils together with aforementioned bedding features are indicative of transgressive upper shore facies to beach environment.

**Carboniferous**

The Carboniferous rocks in Himachal Pradesh are classified as Kanawar Group. These rocks are exposed in the Spiti Basin and have been divided in to Lipak, Po and Ganmachidam Formations. The Lipak Formation comprises dark grey to black limestone and dolomite, grey shale and pink limestone and lenticular snow-white and powdery gypsum beds in the upper part. The presence of limestone, dolomite and gypsum in the Lipak Formation suggests an evaporite basin. The environment of sedimentation varies from subtidal to intertidal with acquisition of supratidal conditions in the terminal part to form an evaporite basin when gypsum was precipitated. It also contains important fossils like *Syringothyris cuspidata*, *Syringothyris lydekkeri*, *Neospirifer bambadhurensis*, *Productus* and *Buxtonia* sp.

The Po Formation comprises thick sequence of white to grey, medium-grained quartzarenite, siltstone, sandstone and grey, black, locally pale green shale.
with rare cherty partings. In the basal part of this formation plant fossils Rhacopteris ovata and Sphenopteridium furcillatum have been recorded. The upper part contains a rich assemblage of bryozoan Fenestella. Other fossils include Productus lineatus, Dielastra, Reticulania lineata, Protoretepora ampla. Asteriacites, Aulichnites, Phycodes, Planolites and Skolithos are common trace fossils.

The Ganmachidam Formation has a gradational contact with the underlying Po Formation and comprises pebbly mudstone, pebbly siltstone, pebbly sandstone, conglomeratic sandstone and black shale alternations. The clasts in the conglomerate vary in size from granule to pebble, with rare cobbles. These are moderately sorted, sub-angular to sub-rounded, locally well rounded and are composed of sandstone, limestone, shale, vein quartz and rare granite.

**Permian**

The Permian in Himachal Pradesh is represented by Kuling Group in the Spiti / Kinnaur, Kukti Formation of Tandi Group in Lahaul and Salooni Formation and Panjal Volcanics in Chamba whereas, the Phirsephu Formation of Lahaul-Zanskar area represents the Permo-Triassic sequence of the State. The andesitic and basaltic flows of Panjal Volcanics of the Chamba area, bordering Jammu and Kashmir represent the volcanic phase that erupted during Permian. The Kuling Group is divisible into Gechang and Gungri formations. The Gechang Formation has a highly variable thickness and comprises brown to grey, pale grey, coarse-grained weakly bioturbated, cross bedded, calcareous sandstone with local conglomerate and / or shell lag at base containing Skolithos, Laevicyclus and Zoophycos trace fossils known from this formation. Euredesma cordatum, Deltopecten, E.hasdaniensis, E.mahendragarhensis, Waagenophyllum and Neospirifer have been reported from this formation. The Gungri Formation comprises black shale, calcareous silty shale, phosphatic, cherty and calcareous nodules and thin limestone. Some of the nodules enclose fossil shells. Zoophycos is a common trace fossil. Fossils present include Marginifera himalayensis Dien, Productus gangeticus Dien, Chonetes cf. lisarensis Dien, Spiriferella rajah, Xenaspis carbonaria, Cyclobus oldhamii.

In Chamba area Salooni Formation that overlies Panjal Volcanics comprises black shale, slate, calcareous slate and lenticels of limestone. Modiola lidarensis, Spiriferella rajah, Productus sp. etc. are the some of the important fossils. In Lahaul area, the Kukti Formation, the basal part of Tandi Group represents the Permian sequence. It comprises carbonaceous phyllite, bluish grey to greyish white; thinly bedded to bedded limestone interbeds of calcareous slate, inter bands of cross-bedded calcarenite and intraformational diamictite at the base. This formation, which rests over the litho units of the Neoproterozoic Batal Formation of Haimanta Group, has yielded Michelina salinaria, Waagenophyllum indicum and Wentezellella cf. salinaria. The later report of cycloclobus oldhamii is the most significant discovery confirming its assigned Permian age. The Phirsephu Formation comprising pyritiferous and crinoidal limestone overlying undifferentiated Kuling Group represents Permo-Triassic sequence in Lahaul-Zanskar area.

**MESOZOIC**

**Triassic**

Kalhel / Tandi Formation of Tandi Group and Lilang Group represent the Triassic period in the state. The Kalhel/ Tandi Formation in Chamba- Lahaul area normally overlies the Salooni Formation and comprises mainly grayish blue, grey and yellow limestone and dolomite with interbedded grey quartzite in the upper part. Limestone contains ossicles of crinoids in the lower part. The Salooni and Kalhel Formations represent the major Permo - Trias marine transgressive event in the Himalaya. In Spiti Valley, Triassic is represented by Lilang Group that lies over the Kuling Group. The Lilang Group has been divided into eight Formations namely Mikin, Kaga, Chomule, Sanglung, Hangrang, Alaror, Nunuluka and Kioto. The Mikin Formation is made up of dark grey to grey, locally cherty dolomite and shale lenses repeated in cycles of carbonate-shale units. This formation includes Otoceras beds, Ophiceras beds, Meekoceras zones, Hedenstroemia beds, Basal Muschelkak, Nodular Limestone, Lower Muschelkak and Upper Muschelkak. Its age ranges from Scythian to Anisian.
Kaga Formation rests conformably over the Mikin Formation and consists of light to dark grey, green, calcareous shale, local abundant thin shelled pelagic DAonella and carbonate with filamentous wackestone indicating bathyal to subtidal environment of deposition for this formation.

Chomule Formation rests conformably over the Kaga Formation and is constituted of evenly bedded light grey dolomite in basal part and dark grey dolomite in the upper part with local subordinate calcareous shale and marl. Sanglung Formation is divisible into three members and is made up of grey shale, limestone, dolomite and siltstone repeated in a cyclic order in the Member A. Member B consists of bedded, grey limestone, locally cherty dolomite, minor shale, siltstone and cross-bedded sandstone repeated vertically in a cyclic pattern with carbonate at the base and shale /siltstone / sandstone towards top. Member C is made up of shale, ferruginous cross-bedded sandstone, and syn-sedimentary breccia.

Hangrang Formation is constituted of light to dark grey, massive dolomite. Coral Thecosmilia in growth positions occurs with chain and solitary coral, hydrozoan, tabulzoan, sponges, algae, brachiopod, lamellibranch, gastropod and ostracod.

Alaror Formation has a conformable contact with the underlying Hangrang Formation and the overlying Nunuluka Formation and is made up of dark grey to brownish shale with subordinate limestone, dolomite and cross-bedded sandstone. Lamellibranch Monotis and trace fossil Rhizocorallium are common in this formation. The environment of deposition of the Alaror Formation seems to vary from platform edge to lagoon. Nunuluka Formation consists of gritty pale while cross-bedded and ripple marked sandstone, limestone and shale with rare pebbles arranged in cycles, commencing with limestone and ending in sandstone / shale. The lithology and microfacies suggest deposition varying from mud /tidal flat to coastal area. Kioto Formation is divisible into Para and Tangling members. The lower Para Member represents Triassic sequence whereas, the upper Tangling Member falls under Jurassic. The Para Member consists of grey, pale, creamish, sporadically cherty thick-bedded dolomite and limestone. Limestone contains Megalodon ladakhensis Bittner, and Dicerocardium himalayense.

Jurassic

The Tagling Member of Kioto Formation (Liang Group) and Spiti Formation (Lagudarsi Group) form part of Jurassic era in Spiti and Kinnaur area. The Tangling Member is made up of dark grey to blue, fine-grained, cherty dolomite, lenticular conglomerate, arenaceous limestone. Numerous fossils of belemnites, bivalves and gastropods are found in this member.

Spiti Formation comprises black shale tending to be splinthery, fine-grained sandstone and siltstone with profusion of nodules of granule to boulder size, many of these enclosing fossils in some sections. This formation is rich in fossils, which include Epimayites lemoinei, Prograyiceras grayi, Grayiceras koeneni, Mayaites waageni, Belemnopis gerardi, Inoceramus ef. Sularum, Lima melaancholica. Oxfordian to Tithonian age has been assigned to this formation.

Cretaceous

The Lagudarsi Group represents the Cretaceous period in Himachal Himalaya and is divisible into two formations namely Giumal and Chikkim. Giumal Formation is constituted of sandstone, siltstone, silty shale, shale and local conglomerate lenses. The sandstone beds in basal part are calcareous and rich in body and trace fossils. The clasts and matrix in conglomerate are mainly composed of quartzite. Some of the important fossils found in the Giumal Formation are - Cardium giumalense, Ostrea sp., Gryphaea aff. bayleri, Pecten sp., Tellina cf. strigata, Pseudomonotis, Perisphinctes. Giumal Formation is assigned an age from Berriasian to uppermost Aptian.

The Chikkim Formation is divisible into basal Limestone Member and upper Shale Member. The Limestone Member is made up of grey to bluish grey limestone, dolomitic limestone with alternation of marl and shale in the upper part. The Limestone member includes Globotruncana and radiolarians. The important fauna from this member include Lenticulina sp., Dentalina sp., Nodosaria sp., Palmula rugosa, Lagena sp., Pseudotextularia cf. elegans, Globotruncana appeuninca. The Limestone Member is assigned Carnomanian to Turonian age. The shale member comprises grey, ash grey, silty shale, shaly limestone / marl and fine siltstone bands. The shale Member contains a rich foraminiferal assemblage like
Globotruncana gansseri dicarinata, G. stuarti stuartiformis, G. tricarinata, Textularia sp.. It is considered to be a Campanian to Maastrichtian age.

**CENOZOIC**

**Palaeocene - Eocene - Oligocene**

In Lesser Himalayan Tectogen, Kakra Formation and Subathu Formation represent the Palaeocene - Eocene sedimentary sequence, mostly occurring as outliers over diverse pre-Palaeogene formations viz. Mandi Darla Volcanics, Shali Group, Deoban Group, Simla Group, Blaini Formation, Krol Group and Tal Group. Whereas, Dagshai Formation (= Lower Dharamshala Formation), has been assigned Late Eocene to Oligocene age.

The Kakra Formation comprises a basal pisolithic laterite, followed by a sequence of quartzarenite, variegated shales and massive to thin bedded limestone. It has been assigned a Thanetian to Early Ypresian age on the basis of its fossil content. Important fossils recorded are Ranikothalia, Rotalia trochidiformis, Daviesina sp. Fish Galeocerda latidens, Dasyatis sp., Myliobatis sp., and several species of Pycondus. The fauna suggests an open marine to shallow marine brackish water basinal condition.

Sedimentation in Eocene in Himachal Pradesh is represented by the Subathu Formation. In most part, the base of this formation is not exposed. This formation is divisible into A and B members. Member ‘A’ comprises green shale, foraminiferal limestone, oyster marls, quartzarenite, local carbonaceous shale, and calcareous sandstone. Member ‘B’ consists of red, green and blue mudstone, shale and quartzite. The Dagshai Formation (=Lower Dharamshala Formation) overlies the Subathu Formation with a gradational contact. The rocks of the Dagshai are characterized by the presence of purple sandstone and clays with pink clay conglomerate and grey sandstone. The Dagshai Formation is sparsely fossiliferous, consisting mainly of plant impressions, imperfectly preserved plant stems and trace fossils of worm tracks and burrows. The important plant fossils are Poaites sp., Milletta asymmetrica, Buhinia sp., Ficus Kumarhattiensis, Ficus spp., Carpolithus sp.

**Oligocene - Lower Miocene**

From the Dagshai to Kasauli the lithological contact is normal and transitional. The rocks of the Kasauli Formation(=Upper Dharamshala Formation) are hard, grey and green, compact, massive sandstone with minor proportion of grey to purple claystone with subordinate shale. The sandstone is coarse, micaceous and at times feldspathic with garnet as the common heavy mineral. The fossils include plant remains (Sabal major, S. microphylla, Mesua tertiaria, Dalbergia daphotaensis, Cassia dayalii, Carpolithus spp., Lamellibranch (Unio). Kasauli flora indicate moist to dry tropical forest environment. Based on Unio and Palm leaves an Early Miocene age has been assigned to Kasauli Formation.

**Middle Miocene – Middle Pleistocene**

This period is represented by the rocks of Siwalik Supergroup, extending from Potwar basin in NW to the foothills of Arunachal Pradesh in SE. The Siwalik Supergroup is divisible into three groups viz. Lower, Middle and Upper on the basis of lithostratigraphy.

The Lower Siwalik Group consists essentially of a sandstone - clay alternation and has yielded a rich mammalian fauna which includes Amphicyon sp., Conophyus sp., Telmatodon sp., Hippiophorion sp., Giraffoid genera., Crocodilus sp. and Cheloniceras sp.

The Middle Siwalik Group comprises a thick succession of coarse micaceous sandstone with interbeds of earthy clay. It normally succeeds the Lower Siwalik with a gradational contact. The vertebrate fossils present in these rocks include Bramapithecus sivalensis Lewis, Dryopithecus punjabicus Pilgrim, Ramapithecus brevirostris Lewis, Sivapithecus sivalensis Lydekker, Sugrivapithecus sarmantus Lewis. Other fossils include Rodentia, Carnivora, Perissodactyla, Artiodactyla, Proboscidea. Some of these include Hipparion theobaldi, Stegodon cautleyi, Hippopotamus sp., Girrafokeryx sp.

At the end of the Middle Siwalik period the strata were uplifted and eroded before the deposition of Upper Siwalik commenced. The Upper Siwalik consists of thick coarse sandstone, grit and conglomerate with local clay beds. The Upper Siwaliks have yielded following faunal assemblages. Stegodon ganesa, Hyselphas sp., Equus cautleyi, Hexaprotodon sp., Rhinoceros platyrhinus, Hemibos triqueticornis,
Leptobos sp., and Hippopotamus sp., Crocodylus biporcatus and Gavialis browni. The fresh water Siwalik rocks were deposited in the fore deep formed in front of the Himalayan range.

**Upper Pleistocene - Recent**

Thick pile of fluvial, fluvio-glacial, glacial, lacustrine and gravitational sediments exposed in Beas, Banganga, Soan-Sohan, Spiti, Giri –Yamuna, Satluj and Sunder Nagar valleys of Kangra, Mandi, Kulu, Spiti, Shimla and Sirmaur districts represent post Siwalik Quaternary deposits, which are divided into Older Alluvium and Newer Alluvium formations. The Older Alluvium Formation comprising multi cyclic sequence of brown to grey silt, sand with kankar and reddish brown to grey micaceous sand with pebbles. In Poanta Saheb area of Sirmaur district, bordering Uttarakhand and Haryana states, the Older Alluvium is represented by Dun Gravel. It is also exposed in NW-SE trending Soan-Sohan valley of Una District and plains of Beas in Kangra District where the Older Alluvium Formation represents fluvio-lacustrine sediments comprising thick multi-cyclic sequence of sand silt, clay, with occasional pebble bed strewn with kankar. Newer Alluvium has been subdivided into Fan Alluvium, Terrace Alluvium and Channel Alluvium. The Fan Alluvium comprising brownish grey sand, silt and gravel sequence, lies disconformably over Older alluvium within a narrow zone immediately to the south of Siwalik hills. The Terrace Alluvium exposed as depositional terraces of all main rivers flowing through the state, is composed of cyclic sequence of grey, micaceous, fine to coarse-grained sand, silt and clays. The Channel Alluvium exposed as point bar/channel bars within the active channels is composed of grey, fine to coarse micaceous sand and silts.

In Banganga valley of Kangra District, the fluvioglacial and fluvial deposits represent a part of Newer Alluvium Group and divisible into three formations, namely Bhangal Formation (= Fan Alluvium), Terrace Alluvium and Channel Alluvium. The Bhangal Formation comprises poorly sorted detritus of boulder, cobble, and pebble set in sandy or silty matrix whereas Terrace Alluvium consists of multiple fill cyclic sequence of medium to coarse-grained grey sand and grit with pebbles of sandstone and lenses of clay. Channel Alluvium comprises grey, micaceous, fine to coarse, sand-silt and clay. There are extensive exposures of undifferentiated Quaternary sediments in the state whose stratigraphy is yet to be established. The undifferentiated Quaternary deposits of Spiti valley have been classified into glacialic, glacio-fluvial, lacustrine and mass wasting deposits. The lacustrine deposits are bluish grey buff to yellowish white silt/mud with variable aerial extent with more than 200m thickness. The carbonaceous materials embedded in lacustrine deposits of Spiti have yielded radiocarbon age of 3929 ± 4 Ybp to 5369 ± 36 Ybp (Jamwal, 2008). Whereas, the fluviolacustrine deposits of Giri River Basin have yielded Quartz OSL age from 9.9 ± 0.7 to 52.5 ± 3 Ka (Jamwal and Sethi, 2010).

**GRANITOIDS**

A number of granitic rocks ranging in age from Proterozoic to Tertiary are widely exposed in the Himachal Pradesh. Based on their tectonic setting, these can be broadly classified into three groups.

(i) Those occurring as window and forming the basement viz. Jeori-Wangtu and Bandal.

(ii) Those occurring along the thrust sheets overlying the above window (a) Associated with Kulu Crystallines viz. Baragaon and (b) Associated with the Jutogh Group of rocks viz. Chor, Kainchwa and Pabbar Granitoid Gneiss.

(iii) Those associated with the Vaikrita viz. Dalhousie, Dhauladhar, Mandi, Karsog, Rakcham, Jispa, Ratilaman, Barashigri and Nako.

The geochronological dates of some of these granites mostly carried out by various institutions (other than GSI) are as follows;

(i) Early Proterozoic Granitoids: These include Bandal Granite (1840 ± 70 Ma, Frank, 1975 and 1905 ± 72 Frank et al. 1977) and Wangtu Granite 2030 ± 150 Ma Bhanot et al. 1976 and 2025 ± 86 Ma Kwatra et al. 1986.)

(ii) Middle Proterozoic Granitoids: These include Baragaon Gneisses (1430±150 Ma, Bhanot et al. 1979), younger phases in the Bandal Granite (1229 ± 40 Ma, Bhanot et al. 1976), Chor Granite (1000 Ma) and older phase in the Rohtang Gneissic Complex (1962 Ma), Powell et al. 1979).

(iii) Late Proterozoic - Lower Palaeozoic Granites: These include various intrusive phases in the Rohtang Gneissic Complex viz. 612 ± 100Ma (Bhanot et al. 1979), 581 ± 9 Ma and 500 ± 8 Ma (Mehta 1977) and 476 ± 50 Ma (Powell et al. 1979); Mandi Granite (500 ± 100 Ma, Jager et al.
1971 and 545 ± 12 Ma, Mehta, 1977); Dalhousie Granite (456 ± 50 Ma, and 350 ± 50 Ma, Bhanot et al. 1974), Jispa Granite 496 ± 16 Ma Frank et al 1977; North of Manikaran Granite (467 ± 45 Ma, Bhanot et al. 1979) and Rakcham Granite (500 and 350 Ma).

(iv) Tertiary Granite: The Nako Granite of Lower Spiti Valley has been dated 108± 17 Ma (Sharma 1987). However, it crosscuts the mega F2 folds in the Vaikrita rocks and is interpreted to be of Tertiary age.

Besides, Kwatra et al. (1986) provided a Rb-Sr whole rock age of 530+40 Ma for the Chor Granite. Singh (1993) derived an age of 910 +23 Ma by TIMS for the undeformed variant of the Chor Granite. Singh et al. (2003) reported a SHRIMP U-Pb age of 823+5 Ma of zircon from the deformed Chor Granite.

Based on these available geochronological dates, granites of Himachal Pradesh have been emplaced during four different geological periods. The Jeori – Wangtu and Bandal granites (1840±70Ma) are the oldest granites belonging to Palaeoproterozoic age followed by Mesoproterozoic Granitoids viz. Baragaon Gneisses (1430± 150 Ma), Bandal Granite, Chor and Kainchwa Granite and Rohtang Gneissic Complex.

The Dhauladhar-Mandi-Dalhousie, Rakcham, Ratlamán, Jispa granites, an equivalent of Pan-African granitoids represent early Palaeozoic granites whereas, Nako Granite represents Tertiary. The Proterozoic Granitoids represent a complex suite of rocks with varied texture and mineral composition and mostly show well developed gneissic structure. The early Palaeozoic granitoids are mostly coarse grained, porphyritic and two mica granites. These granitoids range in age from 450Ma to 550Ma. Mineralogical, petrochemical, and geochronological studies of Mandi, Kulu, Akpa and Chor granitoids indicate that these granitoids fall into granite to granodiorite modal composition with garnet as common mineral and preponderance of muscovite over biotite. Chemical dating of monazite and magmatic allanite hosted in these granitoids has yielded ages of 485 ± 59 Ma for Kulu granite, 470 ± 60 Ma for Akpa Granite, 500 ± 41 Ma for Chor Granite and 514 ± 49 Ma for Mandi granite (Kundu and Sundararaman 2009). Chemical monazite age of 486 ± 66 Ma for the andalusite bearing contact aureole of Mandi Granite and 466 ± 38 Ma for monazite from restite strongly confirm the intrusive age of the granite. The geochemical signatures of Bandal and Chor granitoids denote ‘S’ type granite affinity and signature of Continental Collision Granite (CCG) and Continental Arc Granite (CAG) type granites (Jamwal and Sethi 2011). The Nako Granite is massive, non-foliated, biotite, tourmaline bearing leucogranite. It is the youngest granitoid intruded into Morang Formation and has been dated 108 ± 70 Ma.

BASIC VOLCANIC ROCKS

Basic volcanic rocks of different ages have been reported from several localities in Himachal Pradesh. These can be broadly grouped as

(a) Basic volcanic rocks associated with the Shali (Mandi-Darla Volcanic), Larji and Deoban Formations: Mandi-Darla Volcanics are associated with Sundernagar Group and are contemporaneous lava flows interstratified with quartzarenite, slate and phyllite. The volcanics are lavas of basaltic composition and are greenish and greyish green. Three main types of lavas can be recognized; (1) massive non-vesicular (2) amygdaloidal and (3) metamorphosed. Metamorphosed lava predominates over the other two types. The massive, non-vesicular lavas are generally fresh, greenish and well-jointed, containing epidote, which stands out prominently on the weathered surface. The amygdaloidal lava is susceptible to weathering. The vesicles are filled with the zeolites, calcite and silica.

(b) Basic volcanic rocks of Manikaran - Rampur area: It consists of massive traps, green basic schist, which at places contains quartzite bands. The massive traps are vesicular and amygdaloidal in nature and have undergone extensive epidotization and chloritization and have attained feeble schistosity.

(c) The Panjal Traps of Chamba area: The occurrence of basic volcanic rocks underlying Salooni Formation has been reported from Chamba District. These volcanic rocks have been correlated with the Panjal Traps.
The rocks of Himachal Pradesh have been subjected to intense deformation, which, at many places, has disrupted the original stratigraphic position of the various formations.

1. **Siwalik Autochthonous to Parautochthonous Belt:** The Siwalik lithology is folded in open upright to overturned folds. Along the southern limit, the Siwalik has, at places, moved over the alluvium along a thrust, while along the northern boundary it is thrust over by the Lower Tertiary belt. The thrust between the Lower Tertiary and Siwalik is known as the Main Boundary Fault.

2. **Lower Tertiary Parautochthonous Belt with Subsidiary Belt of Shali:** The Lower Tertiary belt is thrust over the Siwalik. On the northeastern side, the Krol, Simla and Shali rocks are thrust over the Lower Tertiary belt. Along the trace of the Main Boundary Fault, between Khadli and Sataun, this also occurs as a linear belt of the Shali in the form of a tectonically truncated anticline.

3. **The Simla Group Belt:** Folded in a major synform and an antiform, it occurs as a superficial nappe over the Shali belt. The Lower Tertiary sediments have been involved in a complicated folding in the Bakhlag-Bugher area.

4. **The Outer Krol Belt Superficial Nappe:** Bounded by the Krol-Giri synformally folded thrusts, rocks of the Blaini, Infra-Krol, Krol and Subathu occur as superficial nappe over the isotropic zones of the Lower Tertiary and Simla Group. A major fault at Kandaghat dislocates the Giri Thrust and brings the Simla Group of rocks to rest over the Infra Krol. The Subathu rocks, exposed as window within the Infra Krol near Solan, are cited as evidence in favour of allochthonous nature of the Krol Belt.

5. **The Jaunsar and Inner Krol Belt Superficial Nappe:** Bounded by the synformally folded Chail-Tons Thrust, it rests over the Simla and Deoban belts.

6. **Rampur Belt:** The Rampur Group, folded into a complex antiform, rests over the Larji Formation and below the Kulu Crystallines along the thrusts. It is exposed in Kulu-Rampur stretch as a window.

7. **Larji Belt:** Highly folded Larji rocks are exposed as a window within the Rampur window.

8. **The Crystalline Thrust Sheet of Kulu:** In between the Jaunsar Group (Superficial nappe) and the Jutogh Thrust Sheets, occurs the thrust sheet of the crystalline of Kulu. From NW to SE along its western contact, it tectonically rests over the Siwalik, Subathu, Shali, Simla and Jaunsar groups and along its eastern contact over the Rampur Group and Larji Group of rocks. Southeast of Kadiiali, this thrust sheet is tectonically overlapped by the Jutogh Thrust Sheet.

9. **Jutogh Thrust Sheet:** The Jutogh Thrust Sheet rests along the folded Jutogh Thrust over the Blaini Formation, Simla Group, Jaunsar Group and Kulu Group. In the Simla area it rests over the Jaunsar Group as a klippe.

As the higher and metamorphic rocks occupy the physical top, the structure of the Jutogh (Pilgrim and West 1928) was interpreted as major recumbent anticline whose normal limbs have been eroded.

10. **Vaikrita Thrust Sheet:** The presence of kyanite and sillimanite at the base of the Vaikrita sequence marks the Vaikrita Thrust. From the Satluj Valley it skirts around the northern limit of the Rampur-Larji Window. Towards Karsog, folded into a synform, it swings towards north and
possibly links up with the Panjal Thrust. The Chamba, Manjir, Katarigali, Salooni and Spiti Basin rocks rest above the Vaikrita rocks.

Four principal deformations in the Kulu Crystalline have been identified in the rocks of the Himachal Pradesh, viz.

1. Thrusting and development of $S_1$ foliation and $F_1$ appressed folds.
2. Selective development of the $S_2$ plane and $F_2$ upright folds.
3. Development of $F_2$ cross folds with selective development of crude $S_3$ fracture planes.

Evidences of Holocene tectonic activity are known from various parts. This activity in the Trans-Himalaya of Lahaul and Spiti has affected the river courses and created lakes. In the Lesser Himalaya the tectonic activity is responsible for translating the Siwaliks along a thrust over the alluvium.
Due to difference in relief, geological and tectonic set up and weathering processes, Himachal Pradesh exhibits unique topography encompassing different landforms of diverse origins and magnitudes. These landforms with appropriate climatic conditions and drainage network have developed varied thickness of soil horizons. Availability of good soil and water has controlled human settlements, forest growth, agricultural activity, and land use pattern.

**Climate:** There is a great variation in the climatic conditions of Himachal Pradesh due to extreme variations in elevation. The climate varies from hot and sub-humid tropical in the southern tracts to cold, alpine and freezing in the northern and eastern mountain ranges with greater elevation. Broadly the state experiences three marked seasons; hot weather season, cold weather season and rainy season. Evaporation generally exceeds rainfall over a period of six months during October to December and April to mid-June. Summer lasts from mid-April till the end of June and most parts become very hot (except in alpine zone which experience mild summer) with average temperature ranging from 28°C (82 °F) to 32°C (90 °F). July to September is marked by rainy season when monsoon is vigorous in the state. Winter lasts from late November till mid-March when temperature plummets sub zero. The average rainfall in Himachal Pradesh is 1,111 mm, varying from 450mm in Lahaul and Spiti to over 3,400mm in Dharamshala, the headquarters of Kangra District. Precipitation declines from west to the east, and south to the north. Winter precipitation occurs as snow at elevations above 1800m. An average of three meters of snow is experienced between December and March.

**Landuse pattern:** As per the statistical outline HP 2007, bulk area (62.51%) of the Himachal Pradesh is under wasteland and water bodies. Only 22.49% is covered under forestland and 7% under agricultural land whereas, the built-up land constitutes 7.97% of the total area of the state. Out of the total waste land and water bodies, 25.76% is covered under pasture and grazing land, culturable waste land amount to 2.21% and rest is under barren/rocky and water bodies. As the state falls under unique agro-climatic region of the country, bulk of the area under agricultural land is being used both for agricultural and horticultural activities making the state the largest producer of apple in the country.

**Environmental hazard:** Due to varied topography, relief and climatic conditions with intervention of anthropogenic activities, a number of environmental problems in form of hazards have arisen in the state. Some of these problems are actively operative and others are potential in nature. Important natural and anthropogenic hazards in the state are described below.

**Soil erosion:** Soil erosion/mass wasting is a widespread phenomenon and most common environmental hazard. Its topography, poor physical characters of soils, climatic condition and anthropogenic intervention are the main causes for soil erosion/mass wasting. Excessive frost weathering/ scree-talus menace is prevalent in high altitude tribal areas of Kinnaur, Lahaul and Spiti and Chamba districts.

**Landslide:** Landslide is the main environmental hazard of entire Kinnaur and Kullu districts, Lahaul division of Lahaul and Spiti district, tribal areas of Chamba district and parts/sections of Kangra, Mandi, Shimla and Sirmour districts of the state.

**Seismic hazard:** Some major earthquakes that took place during last one century have affected the state. The State falls under Zone IV and V of Macro Level Seismic Zones of India. These earthquakes include Kangra (M=8) 1905, Sundernagar (M=7.5) 1906, Mandi (M=5.5) 1930, Chamba (M= 6.5, 6.2 and 5.5) 1945, 1947 and 1950; Kinnaur 1975 (Magnitude 6.2) and Dharamshala (M=5) 1978, (M=5.7) 1986. Barring Kangra-Chamba belt, which forms a part of active seismic Zone V, the entire state falls in Zone IV indicating moderately prone to seismic hazard.
Snow avalanche: Lahaul and Spiti District and parts of Kinnaur and Chamba districts and Marhi-Rohtang pass section of Kullu district are prone to snow avalanche.

Flash flood/cloud burst/out wash melt water surge: Parts of Satluj Valley of Kinnaur and Shimla Districts, parts of Pabbar valley, Shimla District, Beas valley of Kullu District and Spiti block of Lahaul and Spiti District of the state are prone to either flash flood/cloud burst and or out wash melt water surges. Water scarcity, water toxicity, and water logging are the other geo-hazards of the state.

Anthropogenic hazard: Owing to the ongoing developmental activities, laying of communication network, and expansion of inhabitation due to population exodus, the anthropogenic hazards have resulted in aggravating natural hazards resulting in instability of slopes triggering mass movements, excessive removal and active erosion of soils, disruption of water regimes, increase in rate of run and removal of vegetative cover. The discernible anthropogenic hazards which are responsible for the degradation of the environment in the state are quarrying and mining of construction material in Kangra, Una, Kulu and Shimla Districts; deforestation and encroachment to the forest land in Shimla, Kinnaur, Solan, Sirmaur, Chamba and Kulu Districts; hydro electric projects in Kinnaur and Mandi Districts; industry and industrial effluents in industrial townships of Mehatpur (Una), Baddi, Parwanu and Nalagarh (Solan); brick kilns in Una District; tourist inflow and garbage disposal in tourist places of Kullu, Shimla and Kangra Districts and laying of communication network in entire state.
The state of Himachal Pradesh with numerous glaciers, a large network of perennial streams/rivers, extensive vegetative cover has following natural resources. Nearly the entire area of Himachal Pradesh has been covered by systematic geological mapping with the reported occurrence of a number of non-metallic, metallic and other minerals. A variety of minerals are known from the state but for limestone/dolomite, baryte and gypsum, all others are of academic significance. The following is the list of mineral occurrences in the state.

**ASBESTOS**

**Kangra District**
Small occurrence of asbestos of uneconomic nature occurs in a nala south east of Kami village (32° 12': 78° 07').

**Mandi District**
The highly weathered basaltic rocks of Darla Volcanics exposed along the right bank of a small nala flowing between Ardhi and Badsar contain very thin fibres of asbestos.

**Shimla District**
Chrysotile asbestos was observed by Captain Palmer in association with a dolerite dyke on the Shali ridge, north of Shimla. The fibres reach upto a length of 3.5 cm.

**BARYTE**

**Kinnaur District**
(i) Snow white, massive to cryptocrystalline baryte occurs as epigenetic hydrothermal veins and quartz-baryte lenses in the light grey quartzite of Tiwari Formation near Arsomang (31°18'38'': 78°43'00''), Alingdar (31°26'30'': 78°38'30'') and Mangla Thach. Near Arsomang, three such veins are noticed, the central, being the largest, is over 60 m long and has an average width of 40cm.

(ii) One metre thick vein of massive snow white barytes has been reported in the purple quartzite of Yamrang La Formation (Thango Formation: east of Gekod Thach (31°37'00'': 78° 47'45''). The exposed extension is over 8m.

**Lahaul and Spiti District**
Lenses and bands of baryte in the purple quartzite and shale have been reported from area NW of Tarikhango pass.

**Shimla District**
Thin veins of barite are found associated with limestone at Naldera near Shimla.

**Sirmaur District**
The baryte occurs as epigenetic veins in Krol E Formation of the Krol Group at Kanti (30°03' 45'': 77°38'45''), Tatyana (30°38'15'': 77°38'25'') Batewari (30°40'00'': 77°36'15'') and Kheel (30°36'30'': 77°37'30''). At Kanti, Tatyana and Kheel baryte occurs in the cherty limestone at the contact of Krol D & E, whereas at Batewari, it occurs near the Krol- Tal contact.

The Kanti baryte deposit is the largest and was estimated to have reserves of 15,000 tonnes. Chemical analysis indicates 99% BaSO\(_4\). The occurrences around Tatyana consist of several small, thin veins with probable reserves of 300 tonnes of baryte. One sample has analysed 96.56% BaSO\(_4\).
At Kheel the baryte vein is 9m long with a width of 2.80m. One sample has analysed 55.57% $\text{BaSO}_4$. The estimated reserves upto 3m depths are of the order of 300 tonnes. The baryte occurrence at Batewari is reported as vem in Kundari nala, which is about 8m long and 1m thick. One sample has analysed 98.99% $\text{BaSO}_4$. The probable reserves are of the order of 100 tonnes. Most of the baryte deposits in Sirmaur District have been fully exploited.

**Solan District**

Lenticular bands of baryte have also been reported near Subathu (30°58': 76°59') Haripur (31°01': 76°59') and Sair (31°05': 77°03').

**BAUXITE**

**Shimla District**

(i) Occurrence of boehmite bauxite has been reported about one kilometre northeast of village Deharu (30°49': 77°39'). The bauxite forms basal part of the Subathu Formation (Eocene). It occurs at a number of places as localised pockets, which range in thickness from 1m to 3m but generally do not extend laterally beyond 10m. The bauxite is earthy pale-grey and brownish and is characterised by well-developed pisolitic texture. Chemical analysis indicated the presence of $\text{Al}_2\text{O}_3$ 55.10% $\text{SiO}_2$ 24.97%, $\text{Fe}_2\text{O}_3$ 1.20% $\text{TiO}_2$ 5%.

(ii) In Chapla area (31°03': 77°01'), the bauxite deposit occurs mostly as lateritised rocks at the base of the Kakra Formation. Thickness and length of the zones vary from 1m to 5m and 1-5 km respectively. The deposit is low in alumina and high in silica content.

**Sirmour District**

In Bench area (30°47': 77°37'), bauxite occurs in isolated patches at the base of Kakra and Subathu Formations. The deposit contains low alumina and high silica. During early ninth century a specimen of high quality bauxite at Nahan (30°33': 77°16') was examined by Crookshank.

**Solan District**

In Deothal area (30°51': 77°10'), bauxite occurs as pisolitic ore having a thickness of 1-5m and traceable for about 1.5 km.

**BERYL**

**Chamba District**

(i) Beryl bearing pegmatites have been located in Kilar Gneiss around Haksu bridge (33°05': 76°23').

(ii) Pegmatite bodies with beryl have been found within gneisses of Kilar Formation. The pale yellow to light bluish-green beryl occurs at about 1km east of Dehda nala bridge (33°05'10": 76°22'30") and about 1.5 km south of Jules (33°05'35": 76°23'15\degree). The visual estimate of beryl in pegmatite is less than 0.5%.

**Kinnaur District**

(i) Pale blue beryl has been reported from the Wangtu bridge (31°32': 78°15') and for some distance up the Satluj and Shipki Pass (31°49': 78°45').

(ii) Beryl associated with pegmatite has been reported from near Riuni village (78°04'20": 31°04'16") and Nalgan Ghatti (31°19'20": 78°12'15")

(iii) Sporadic, bluish translucent hexagonal crystals of beryl are noticed in the pegmatites, intrusive into the schistose rocks of the Vaikrita Group in Morang (31°36'00: 78°26'30") Tirung (31°34'30": 78°27'00") area.

(iv) Greenish blue beryl is found in the pegmatite along its contact with the country rocks near Ribba (31°35'15": 78°26'30") and near the confluence of Kashanj Khad and Satluj River.

(v) Small crystals of beryl within pegmatite veins traversing the Rakcham Granite have been reported from the area between Pangi (31°36': 78°21') and Akpa (31°35'00": 78°22'45').

**Kulu District**

(i) Beryl bearing pegmatites intrusive into schist and granites have been reported from Sara Umga Thach (32°10': 77°29') and northeast of Pando Seo Thach (31°56'30": 77°40'30")

(ii) Sporadically beryl is found associated with pegmatites in Mantalai (31°51'45": 77°47'15") area and in Tanang Khol (31°57": 70°33')

(iii) Crystals of beryl measuring upto 8cm in length are found associated with the pegmatites at Munni
Thach (31°59'45":77°39'45") and Piaignonirum Thach (32°14'30":77°18'30").

**CLAY**

**Kangra District**

(i) Yellow coloured clay has been reported from 3 km west of Shahnur (32°13':76°12').

(ii) Light grey to whitish grey clay bands varying in thickness from 0.5-3 m and having 90% clay content have been reported from Middle and Upper Siwaliks at Kaajan (32°19'30":75°54'05"), Indpur (32°09'30":75°44'00"), Paliana (32°09'00":75°54'30") Koithar (32°04'34":75°52'10") and Hatli (32°05'05":75°50'50") in Nurpur Tehsil.

Reserves of white clay of Koithar area are of the order of 15,000 tonnes. The clay is composed of mонтmorillonite, kaolin, quartz, carbonate and Fe-oxide.

**Kinnuar District**

China clay occurs as alteration product of granite, gneiss and pegmatite, east of Lipa (31°39':78°24'). Lacustrine clays occur at Shalkar, Chango and Ganfa along the Spiti River.

**Kulu District**

China clay occurrence has been reported from near Bathua (31°28:77°32) which is locally used for white washing.

**Lahaul & Spiti District**

Two lacustrine clay pockets have been reported at Kioto (32°56':77°55") and Atragoo (32°07':78°10'). The first one is about 500 m in length with a maximum width of 80 m while the latter one is 250 m in length with a maximum thickness of 15 m.

**Mandi District**

Small irregular pockets and lenses of clay are found within the weathered muscovite granite, tourmaline – muscovite granite, porphyrocline granite and pegmatite of Mandi – Karsog Granite Complex at Mohi (31°35':76°55'20"), Seri Chak (31°06'54":76°55'45"), Seul (31°40'36":76°55'36"), Saul Khad (31°40'28":76°53'27"), Dhalar (31°35'24":76°55'30"), Batala Beli (31°15'50":77°13'20"), Karsog (31°23'00":77°12'00"), Chichot (31°33'00":77°01'00"), Garaich (31°24'30":77°14'45"), Negi Nal (31°26'00":77°11'00"), Bashaich (31°26'15":77°13'30"), Phaiash (31°27'00":77°05'15"), Tarai (31°35'09":76°59'56"), Dophna (31°31'33":77°01'22"), Nid (31°32'20":77°01'00"), Dangthar (31°32'37":77°06'15"), Seri (31°36'55":77°00'06"), Raiji (31°37'34":77°00'03"), Burahata (31°36'09":77°01'59"), Balha (31°39'03":77°17°30"), Tarapur (31°38'00":76°59'37"), Kohlu, Dalikar (31°37'38":77°01'00") and Rackchui (31°39'05":76°59'43").

The clay pockets in the above areas range in length from 10-220 m, the clay pocket at Phaiash extends for 1 km. The width of the clay pockets varies from 1-1045 m.

Physical tests on the clay samples from Garaich and Negi Nal have revealed that the clay is suitable for the manufacture of stoneware.

The cumulative reserves of clay pockets at Karsog, Chichot Batala Beli Garaich, Negi Nal, Bashaich and Phaiash have been estimated at 1,05,336 tonnes. The tentative reserves of the clay pockets at Tarai, Dophna and Nid are of the order of 5, 14, 404, 17, 172, 02 and 17,714.02 tonnes, respectively.

The clay from all the aforementioned pockets is used by the local inhabitants for white washing and plastering of their houses.

**Shimla District**

Pottery clays resulting from the decompositin of limestone associated with carbonaceous slates occur on the spurs of the hills running north of Simla (31°08":77°10"). They have been used for the manufacture of bricks, tiles and coarse pottery.

**Sirmour District**

Brick – clay of fluvial origin occurs at and around Sirmur Tal (30°32'30":77°39'20"), 16 km north of Paonta Sahib. Similar clay also occurs along the Nimba-ka-Khala. The occurrence extends for 500 m with an average width of 80 m. The average thickness is 3.38 m with an overburden, 1.2 m thick.

Other occurrences of this type of clay are at Rati Kharak (30°31'00":77°32'10") Kalidhang (30°36'30":77°39'30"). At Rati Kharak the clay occurs...
in an area, 480m in length and 120m in width, having a thickness of 2m. In Kalidhang area, the clay occurs on both sides of Khasuda Ka Khala. The deposit is 540m in length and 180m in width. Its thickness varies from 20m to 30m. The deposit contains clay bands of varying colours, which are interlayered with bands of gravel, pebbles and sandy loamy soil. The varved nature of the clay deposit indicates that the clay is of lacustrine origin. The reserves of the clay around Kalidhang are about 2.63 million tonnes up to a depth of 20m.

A few clay pockets occurring within the weathered rocks of Chor Granite Complex have been reported at Kanda (30°50’30’’: 77°24’15’’), Roundi (30°49’30’’: 77°27’00’’) Kotliyan (30°49’08’’:77°27’15’’) and Gudag (30°46’30’’:77°29’15’’). The clay is sticky when wet and powdery when dry. The length, width and thickness of these pockets vary from 3 to 22m, 0.5–2m and 0.5–5m respectively.

An occurrence of China clay is known from one kilometre north of Rajpur (30°35’: 77°44’).

COAL

Kanga District

Coal occurs near Dera Gopipur (31°53’: 76°83’) in the Pinjor sand rock of the Upper Siwalik Group and in the Nahan Sandstone. The coal occurrence from this locality was based on two very small lenticular pockets and a few stringers of lignite in the northeastern cliff off Beas River. The first pocket contains a few lenticular remains of carbonised weed. The thickness of second occurrence varies from 1cm to 7cm with maximum length of about 30 cm.

Mandi District

A carbonaceous coal horizon is traceable for about 90m near Mansai (31°34’: 76°51’’). There is another 91cm thick seam traceable for 45m, 750m to the south of the earlier one.

A coal seam near Dehar (31°25’: 76°49’) crops out in and near the steep right bank of Satluj River about 280m upstream of the suspension bridge. The carbonaceous horizon is interbedded with limestone with almost vertical dips. Two carbonaceous seams, 180cm and 90cm thick could be traced for a distance of about 90m.

Small discontinuous patches of coal outcrops are noted near Kaphai (31°32’: 76°51’’). An outcrop of coal is seen on the right bank of a small stream about 600m southeast of Arthi (31°32’: 76°52’’). The coal is sheared and stained dull greyish yellow, rusty on the surface.

COPPER

Chamba District

(i) Malachite encrustations are reported in the Manchhap nala (31°00’: 76°25’30’’) wooden bridge and within vein quartz at Chue Padder (32°54’00’’: 76°28’00’’).

Kinnaur District

(i) Malachite encrustations are reported in the Manchhap nala (31°25’30’’: 78°33’30’’) section.

(ii) Few specks of pyrite and chalcopyrite with malachite stains have been noted in quartz veins near Mangsula (31°22’30’’: 78°30’30’’). These veins are more frequent at the contact of Granite and Batal Formation.

(iii) A few malachite stains have been noticed in the phyllite of the Batal Formation near Lippa (31°39’: 76°38’15’’).

(iv) Two small old workings for copper are observed near Rangbar (32°49’: 78°24’) in the Ropa valley. It consists mainly of malachite and azurite coatings along the joint planes and fissures of banded quartzite in the Kunzam La Formation.

An old working of copper is reported near Sangnam (31°47’: 78°28’). Chemical analysis shows 550 ppm Cu values.

(v) Sparsely disseminated pyrite occurs in quartzite and phyllite north east of Sangnam. In a nala north of Giabong, malachite and azurite stains are seen in phyllite.

Kulu District

(i) Malachite sains and sparse disseminations of chalcopryite have been reported in the massive
quartzite belonging to Bhallan Formation of the Rampur Group at Seond (31°54': 77°13'). The copper values vary from 0.1% to 0.22%. The mineralisation is restricted to very limited area of about 60m on a road cutting.

(ii) Stains of malachite are observed in quartz veins traversing chloritized schist near Shatnala bridge. Sample from Shatgar (31°58': 77°12') gave copper value as 1.21%. The mineralisation comprises stains of malachite with spare dissemination of chalcopyrite and pyrite.

(iii) In Maol (Mahul) (31°55': 77°07') area, the mineralized zone has an average width of 0.50m and a strike length of about 5m. Copper values near village Bihachang in Maol khad vary from 0.55% to 0.90%. One sample has analysed 2.9% lead, 0.35% zinc and 30 ppm silver.

(iv) In Garsha Valley, i.e., the area lying between Kurala Nal in the north and the Sainj khad in the south, and to the east of Beas River, the copper mineralisation is manifested by numerous surfaces showing stains and encrustations of malachite and azurite, covering an area of about 9km x 6km. Besides, a number of old workings bear testimony to the fact that copper mining activity was extensive in the past. Amongst the old workings the prominent are Naraul (31°49'40": 77°13'45"), Gobha (31°50': 77°15"), Lalgi (31°49': 77°14"), Kalpna (31°50': 77°15"), Danala (31°48': 77°15"), Sib (31°42': 77°01") Shallash (31°48': 77°28") and Dudhu (31°48': 77°15"). The mineralisation generally occurs as disseminations, specks and thin stringers of chalcopyrite, covellite and pyrite. The general trend of mineralisation is NW-SE. The host rock for mineralisation is calcareous quartzite and conglomeratic quartzite.

The old working at Lalgi is quite extensive with wide stopes and covers a strike length of 55m. At places 'Cobalt bloom' is found in the oxidized portions of this mine. Encouraging copper and cobalt values have been obtained from this working.

The effective strike length of promising mineralized zones between Gobha in the north and Danala in the south is about 4.5 km. From the available information the mineralised zone of about 12m width and grade of the order of 1% is anticipated.

(v) In Sainj Valley, a zone containing malachite stains and very sparse dissemination of chalcopyrite occurs in a massive quartzite about six km form Larji. This zone occurs in strike continuity of the Garsha mineralisation.

Lahaul & Spiti District
Malachite staining is occasionally noticed in association with quartz veins in Chandra Tal (32°39': 77°37') and Sarchhu (32°42'30": 77°32') areas.

Copper mineralisation in the form of chalcopyrite, malachite and azurite is seen along brecciated zones and within quartz veins associated with limestone of the Kunzam La Formation in the area between Chandra Tal and Bara lacha pass (32°44': 77°26').

Sirmaur District
At Sataun (31°33': 77°38'), copper mineralisation occurs in the carbonaceous shale and quartzite of the Blaini Formation. The mineralisation zone is 25m wide along a road section and consists of stringers and disseminations of pyrite and chalcopyrite. Copper values range from 0.13% to 4.40%. One zone has analysed 2.27% Cu along 1.30 (m true) width.

Solan District
An old copper mine exists near Solan (30°55': 77°07').

FLOURSPAR

Kinnaur District
Rare occurrence of light green crystals of flourspar has been reported in the pegmatite veins at Wangtu Bridge (31°22': 78°04').

Sirmaur District
A few flourspar veins have been located in the Krol 'E' Formation of the Krol Group.

GARNET

Kulu District
(i) Small garnet crystals have been reported to occur in the Sarkani (31°43': 77°16') area.
(ii) Garnet crystals in the gneiss and schist have been reported around Sara Umga Glacier (32°10’; 77°31’).

Sirmaur District

Large size crystals of garnet, often transluscent, have profusely developed around the Chaur area.

GLASS SAND

(Quartzite pebbles/cobbles/boulders)

Bilaspur District

Soft white quartzite near Sirha (31°21’: 76°47’), Aruali (31°18’: 76°47’), Banda (31°19’: 76°47’) and Solag (31°21’: 76°50’) might be suitable for glass industry.

Kangra District

Soft quartzite boulders, which yield good glass sand on crushing, occur near Barhwain (31°48’: 76°08’) and on the Bastram ridge. Smaller deposits also occur in the Khads near Bhadroa (32°15’: 75°41’).

Una District

Glass sand deposits in the form of quartzite pebbles and cobbles in the gravel bed occur along the upper stretch of Jaijon-di-Khad. The pebbles and cobbles of the size of 5-15cm predominate in the area. The analytical results have indicated that the pure white quartzite pebbles and boulders (Grade ‘A’) contain on an average 97.44% SiO$_2$ and 0.22% Fe$_2$O$_3$ and those with greenish and greyish tinge (Grade ‘B’) contains 95.7% SiO$_2$ and 0.59% Fe$_2$O$_3$.

Total reserves of Grade ‘A’ in three blocks have been estimated at 59,309 tonnes while the total reserves of Grade ‘B’ in these blocks are of the order of 39,019 tonnes.

In Bathri village (31°18’30”: 76°17’30”), Kum Khad a gravel bed containing glass sand yielding quartzite pebbles, cobbles and boulders of Grade ‘A’, ‘B’ and ‘C’ is exposed along the Garshankar-Nangal road. The analytical results indicate 98.89%, 98.40% and 98.78% SiO$_2$ in quartzite fragments of grade, ‘A’, ‘B’ and ‘C’, respectively. The Fe$_2$O$_3$ values in the quartzite fragments of these grades are 0.068% 0.264% and 0.92%, respectively.

The total reserves (of Grade ‘A’, ‘B’ & ‘C’) down to a depth of 2m have been estimated at 8,42,570 tonnes. The inferred reserves for an extra depth of 3m are of the order of 12,63,854 tonnes. The glass sand of the above deposits can be used for manufacture of ordinary glass.

In addition the white quartzite belonging to Rampur Group exposed in Sunda (77°38’52½:31°26’36½) and Darshai (77°41’00½; 31°27’30½) area of Shimla District with an aerial extent of 1.5 sq km and 2 sq km respectively have yielded more than 95% silica. These quartzite deposits have been assessed for their suitability for glass sand and allied purposes.

GOLD

Bilaspur District

Placer gold is recorded from the nala sands towards the north east of Ghamarwin (31°27’: 76°42’), the source being the boulder beds of Siwalik.

Kangra District

Gold washing in the Beas River at Rai (32°10’: 75°55’) and downstream has been recorded by Abbot. The yield is said to be at the rate of about 73 grains to the cubic yard.

Kinnaur District

Small quantities of gold are obtained from the sand bars along the Satluj River between Morang (32°36’: 78°28’) and Wangtu (31°32’: 78°04’)

Kulu District

Calvert mentions gold washing at Samsi (32°53’: 77°12’) in the river sands of Beas River.

Mandi District

Colebrook reported small quantities of gold in the bed of Satluj River at Jauri (31°19’: 77°02’). Poor concentration of gold has been found in placers between Hukkal (31°46’: 76°44’) and Dharampur (31°48’: 76°46’). Recent work carried out in Dharampur-Sarkaghat area has revealed the presence of Au content < 6 ppb to < 20 ppb in stream sediments and < 6 ppb to 100 ppb in bedrock.

Sirmaur District

Placer gold has been reported from the Siwalik rocks in different parts of this district. The gold content
varies from < 20 ppb to 160 ppb, both in the stream sediments as well as bedrock.

**GYPSUM**

**Kinnaur District**

Large deposits of gypsum occur associated with the Lipak Formation between Liwa Thach (31°55': 78°55') and Kapusa (32°04': 78°34') especially in the Yulang Valley, North of Chango (31°59': 78°36') and in the Yangthang (31°53': 78°37') area. A small area around Shalkar (32°00': 78°34') was covered by detailed mapping and reserves of 1.25 million tonnes were inferred up to 25m down depth extension. The total in situ reserves in this belt, however, may be over 100 million tonnes. Small occurrences of gypsum are known from similar beds exposed near Tari-Khango Pass. The gypsum is mostly of alabaster type soft, white, granular, with common large pockets of anhydrite and small selenite zones. It is considered to be of evaporitic origin.

Thin bands of white granular gypsum associated with the maroon shales of Yamaranjha Formation occur near Bayulkhona Thach (31°24': 78°40').

**Lahaul & Spiti District**

Gypsum associated with the Lipak Formation occurs on the right bank of Spiti River, east of Losar (32°25': 77°45') along the right bank between Hurling (32°04': 78°31') and Sumdo (32°04': 78°36'), in Gyundi Valley (32°16': 77°50') and at Dhuma Dangse (32°25': 77°40'). The occurrence between Hurling and Sumdo is quite extensive. Anhydrite and selenite are locally associated with gypsum in this stretch.

Elongated crystals of translucent gypsum are present in the Spiti Formation, east of Lamayuru (32°52': 77°44':15').

**Sirmaur District**

Gypsum occurs as thin bands and lenses in the red and green shales as well as in the dolomitic limestone of Krol 'B' Formation in Bharii (30°33': 77°45') and Korga (30°35': 77°45'). The chemical analysis in Bharii has given CaSO\(_4\) 60% and above, in the estimated reserves of 85,000 tonnes and in Korga CaSO\(_4\) 42% in the estimated reserves of 5, 56,000 tonnes. The deposit is suitable for utilisation in the cement industry. Small deposit of gypsum of inferior quality occurs at about 1.5 km southwest of Shilorna (30°36': 77°37').

**Solan District**

Gypsum occurs in Eocene rocks about 3km southeast of Subathu (30°58': 76°59'). Pockets of gypsum occur in the area and in the nalas draining into Kuthar River from the western ridge about 5km southwest of Subathu.

The purple indurated clay of Dagshai near Dabughat contains pockets of gypsum along the Bhaklag (30°00': 76°57') – Dhondhan (30°14': 75°54') road.

**IRON**

**Kangra District**

Iron ores have been worked in the neighbourhood of Dharamshala (32°14': 76°23'). These occur as magnetite particles disseminated in the talcose schist and require concentration by washing before being smelted. Iron-ore was reported to occur near Bir (32°03': 76°47') and Kohad (30°05': 76°52').

**Kinnaur District**

Magnetite is reported from Mangru La (31°22': 78°30'). Small scale smelting had also been carried out. The magnetite occurs as profuse disseminations as octahedral crystals in volcanogenic sediments, which show very low grade metamorphism and are grouped with the Kunzam La Formation.

**Kulu District**

Bands of haematite-quartzite about three to six centimetres thick and about two metres long have been reported from Serajpet Resever Forest and north of Roshal (32°02': 77°18') village. Old workings of iron ore are reported from Gargi (32°02': 77°20') and south of Garaham (31°58': 77°20').

**Lahaul & Spiti District**

Hayden (1904) recorded the occurrence of a band of red haematite in the Thango Formation about 5km south east of Muth (31°57': 77°00').

Lenticular haematite quartzite occurrences in the Thango Formation have been reported at Thango.
(32°02'30":77°57'00") and Shitekar (32°26'30":77°40'30"). The main band at Thango is 1.5 - 2.5m thick and extends for 130m along strike. The chemical analysis of a few samples indicate the presence of Cr 1000 ppm (in one sample), Ni 100ppm to 200ppm (in two samples), Ba 200ppm to 500ppm (in all samples), Zr 100 to 300 ppm (in 3 samples), Ta, 1000ppm (in two grab samples), W, 300 ppm (in two grab samples) and Ce 300 ppm (in two grab samples).

Mandi District

Magnetite associated with hematite occurs in schist and phyllite in a belt extending intermittently from Rama Bhet (31°35':77°06') upto the vicinity of Sangalwaro (31°30':77°13'). Sparsely disseminated magnetite and hematite occur around Jhungi (31°25':77°06') in the phyllites.

Magnetite occurs as disseminated grains in quartzite and as concentration in thin bands near Kohar Khas (32°06':76°48'). The iron bearing quartzite has been traced from about 1.5km north of Baragoran (32°05':76°00') to Multhan (31°03':76°50').

Shimla District

Haematite is found as bands and lenses in the Rohru tehsil. Alternating bands of iron ore with biotite-schist were encountered at Shil (31°09':77°40'). The bands are 2.5 cm thick. More important occurrences are distributed in the Banoti Valley around Narain (31°12':77°39') and Shekal (31°11':77°39'). Two old workings of haematite are located at Soom, south of Pujari (31°11'30':77°40'). The old workings are within the haematite quartzite band (Jutogh Group) measuring about 50m x 10m.

Sirmaur District

Magnetite occurs as lenticles in quartzite of Jutogh Group at Kanhari (30°47':77°21'). The deposit was worked for some time about a century back and used in a blast furnace at Nahan (30°34':77°21').

Small pockets, lenses, veins and disseminations of magnetite associated with some pyrite have also been reported from lana Chetta (30°47':77°22') in the Jutogh Group.

KYANITE

Kinnear District

Kyanite blades measuring 8cm - 15cm in length in kyanite-staurolite schist of Maldi Formation have been reported from Morang (31°36':78°26'30") Tirung (31°34':30":78°27'00") area.

Kulu District

(i) Kyanite has been reported in the rocks of Central Gneiss and Schist Formation around Bershani (31°06':77°26') Khir Ganga Thach (32°00':77°31') and Tanti Thach (31°57':77°30').

(ii) Fairly long blades of kyanite are found in the schist and gneiss to the south of Tapru Thach (31°58'00":77°32'30"), 2km upstream of Ori Age Thach (31°57'15":77°33'00") in the Tang Khol (31°57'00":77°33'00'), Chini Gohru Thach (31°58'00":77°34'30") and in Bakar Kiara Khol (31°58'00":77°32'30"). The blades vary in length from minute crystals to about 20cm. The occurrences are of sporadic nature.

(iii) Bluish translucent blades of kyanite associated with gneiss are noticed in Bakerbihal Khol (31°46'00":77°41'00") Bhagon Thach (31°58'00":77°36'30") Ratiruni Thach (32°00'30":77°40'30") and several other places. The individual blades at times exceed 10cm in length.

(iv) Kyanite blades occur in quartz-mica schist of the Central Gneiss Formation east of Khirganga Thach (31°59'40":77°30'30") east of Kalga Thach (31°59'45":77°27'0") Bhalingach Thach (31°59'00":77°29'00") and Tunda Bhuj Thach (31°58'00":77°35'00")

Schistote xenoliths occurring in granite contain kyanite blades upto 5cm in length north of Ratiruni Thach and east of Mantalai. However, these occurrences have no economic significance.

Lahaul & Spiti District

Significant kyanite mineralisation associated with metasediments of the Batal Formation has been reported from the Thanppattan (32°56'00":76°54'30") area of Miyar Valley. The main zone rich in mineralisation is 40m thick and traceable for over 1km.
LEAD

**Kinnaur District**

(i) Specks of galena have also been noticed along thin quartz veins in the gneisses near Nalgan ghati (31°19′ 20″: 78°12′ 50″).

(ii) A few specks of galena are observed in a minor shear zone exposed east of Alingdar (31°25′ 30″: 78°38′ 30″).

**Kulu District**

(i) A few specks of galena have been observed in the quartz veins a chlorite-schist at Sangthan (31°58′: 77°15′). Lead values range from 100 to 240 ppm. Three samples have analysed zinc values varying from 200 to 470 ppm.

(ii) Minor disseminated specks of sulphide are observed in quartzose phyllite east of Komand (Mot Kandi) (31°53′: 77°14′). One sample on chemical analysis has shown 400 ppm lead.

(iii) In Khanor Khad area near Manikaran (31°02′: 77°27′) the ore and gossan together yielded lead, gold and copper. At Uchich (31°01′: 77°23′) the lode is over 60 cm in width and contains lead, gold and silver.

(iv) At Chong (31°77′: 77°11′) the ore contains lead, and silver. A small stringer of galena associated with quartz vein has also been reported from near Garona (31°50′: 77°14′). Occurrences of lead ore have also been reported from north/east of Behal (31°45′: 77°15′).

**Lahaul & Spiti District**

The occurrence of galena has been noticed in small quartz vein infiltrated along a fault plane in upper Triassic limestone between Po (32°03′: 78°23′) and Dankhar (32°05′: 78°16′) section in the Spiti valley. Galena associated with vein quartz occurs in the quartzite of the Po Formation near Tabo.

Specks of galena are associated with Muth Quartzite in the Chandra Tal area. A 12 cm thick E-W trending quartz vein, intrusive within the quartzite of the Tandi Formation contains galena in the form of thin stringers and specks along the road section between Tandi (32°34′: 77°59′) and Sissu (32°29′: 77°58′).

**Shimla District**

Lead in the form of vein occurs in schist and gneiss of Jutogh Group at Darkoti (31°07′: 77°36′). Lead values vary from 0.73% to 12.00% at different localities.

Lead ore is found in the form of some galena pebbles of varying size at Tal (31°10′: 76°53′) in the Ark Tehsil. A ferruginous limestone band, north of Tal has indicated 1.2% Zn and 0.29% Pb over an average width of 7.5 m.

**Sirmaur District**

(i) Massive lode of a minor deposit comprising galena and sphalerite has been reported at Anyar (30°44′: 77°44′). The samples from old working have indicated lead 0.75% and zinc 0.21%. Another sample gave 10% zinc content.

(ii) Strata-bound synsedimentary, polymetallic sulphide mineralisation occurs within an interbedded slate – limestone sequence near the Deoban–Shimla Group contact in Dathyari (30°41′ 32″: 77°45″) Chamri (30°43′: 77°44′) – Auri (30°42′ 03″: 77°44′ 40″) area. Three mineralised lodes, 20 cm to 150 cm thick ranging in length from 75 m to 80 m have been delineated over a strike length of nearly 340 m. The sulphide mineralisation mostly comprises marcasite with galena, sphalerite, pyrite and chalcopyrite. An old working exists in Chamri (30°53′: 71°15′) area.

Small lenses and veins of quartz with galena are observed in slate and phyllite exposed in the Amba area (30°38′: 77°27′). Large pebbles with rich galena mineralisation are a common sight all along the Amba Nala.

Small gossanised band measuring 4 m x 1 m occurs in sandstone and shale of Subathu Formation, 1 km east of Chapla (30°58′: 77°00′) in Dabur God. Lead value varies from 0.9% to 0.38%. Old workings of lead ore have been reported at Danheri (31°00′: 77°00′) and Panuh (30°50′: 77°08′).

The Pb-Zn mineralization in Ambota area (77°41′30″; 30°46′00″) is associated with dark grey basal dolomitic limestone of Deoban Group overlying argillaceous-arenaceous sequence of Simla Group. The mineralization comprising sphalerite and
subordinate galena along with pyrite in the area occurs in the form of stringers, specks, disseminations, fracture-filled veins and veinlets along NW-SE and NW trending cross joints/shears. Three zones of mineralization with strike length of 260m to 500m and width of 10m to 37m have been established based on drilling of three boreholes upto 95m depth. The analytical results of first borehole have yielded Zn values ranging from 19ppm to 5% and two stray Pb values of 2.8% and 4.5%. The weighted average calculated from first borehole for Zn mineralization in seven demarcated zones varies from 0.22% to 1.87% whereas in third borehole the weighted calculated average varies from 0.062% to 0.65%.

Solan District

In Motipur – Narag area, lead-zinc mineralization is confined to fractured and brecciated limonitised quartzite of Sanjauli Formation of Simla Group along 2.1 km NW-SE trending shear zone with 42m to 50m width. Galena, sphalerite and pyrite occur as disseminates, fracture fillings along later stage quartz veins within the brecciated quartzite.

LIMESTONE AND DOLOMITE

Bilaspur District

Large reserves of limestone (both dolomitic and non-dolomitic) occur amongst the Pre tertiary rocks near Jamthal (31°24': 76°52') Aur or Gagal-Hill (31°20': 76°51'), Chhabiawae (31°23': 76°52') and Darobn (31°21': 76°51'). The limestone is suitable for cement manufacture. In Gagal-Burmana area, the reserves of cement grade limestone have been estimated at 117.1 million tonnes. The Gagal limestone deposit contains CaO 45.20% to 47.80% and MgO 0.91%. The Burmana limestone deposit contains CaO 47.62% and MgO 1.47%.

Occurrence of dolomite has been reported from a locality 1.5km west of Lohrda (31°15': 76°00') and 800m east of Bhajun (31°14': 76°49'). The analyses show that the dolomite may find use as flux.

Occurrences of calcareous tufa has been recorded at Lathwin (31°31': 76°41') and near Thakurdwars (31°26': 76°31').
Kulu District

Several thick bands of pink, cream and purple limestone interbedded with dolomite occur in the Aut Formation of Larji Group near Hurla (31°50': 77°11'), Tharas (31°50': 77°11'), Dalasni (31°47': 77°12') and Larji (31°43': 77°13').

Several thick bands of grey dolomite interbedded with limestone in Larji Group occur as tectonic window in the southern parts of the Kulu valley. A dolomite band is well exposed on the ridge east of the Beas River between Hurla (31°50': 77°11'15") and south of Larji (31°46': 77°14') and also in the Hurla – Garsah and Larji – Behali sections in the Garsha Valley and Sainj Valley respectively.

Mandi District

Cement grade limestone, belonging to the Sorgharwari Formation of Shali Group has been reported between Alsindi (31°17'45": 77°07'45") in Mandi district in the west and Jaunrog (31°18'00": 77°20'30") in Shimla District in the east. The limestone was investigated along a strike length of 15km. It is pink to grey and contains thin shale partings. The CaO contents in limestone vary from 34.40 to 52.00% and MgO varies from trace amount to 9.80%. The estimated reserves are of the order of 550 million tonnes.

Dolomitic limestone occurs at Talwana (31°26': 76°52') and Baned (31°30': 76°53'). An occurrence of dolomite has been reported from Harabagh (31°59': 76°50'), 5km from Jogindernagar.

Thinly bedded Pre-tertiary limestone occurs near Thalat (31°42': 77°50') along the Beas River.

Calcareous tufa has been reported below the Krol limestone at Bir (31°42': 77°50') along the Beas River, at Kulaira (31°31': 76°54') and Paloti (10 kilometres from Mandi). The CaO, MgO percentages and the reserves of these occurrences are as under:

<table>
<thead>
<tr>
<th>Location</th>
<th>CaO%</th>
<th>MgO%</th>
<th>Tentative Reserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bair</td>
<td>43.56 to 54.56</td>
<td>1.22 to 2.92</td>
<td>12,000 tonnes</td>
</tr>
<tr>
<td>Kulaira</td>
<td>50.92 to 52.32</td>
<td>0.84 to 1.52</td>
<td>5,000 tonnes</td>
</tr>
<tr>
<td>Paloti</td>
<td>41.36</td>
<td>1.85</td>
<td>1,250 tonnes</td>
</tr>
</tbody>
</table>

Shimla District

Limestone deposits of Deoban/Shali Group and Mandhali Formation occur in different parts of this district. The predominant limestone sequence of the Deoban varies in thickness from 120m to 600 m and extends over 30km west of the Tons River. The limestone in the Mandhali Formation is comparatively less consistent. It shows maximum development in the western part of the area where its thickness ranges from 40m to 195m that is traceable for about 15km. In part of the area, tentative quarriable reserves of about 1020 million tonnes have been estimated. Chemical analysis shows that the limestone falls within the specification of cement, flux and chemical grades. Cement grade limestone deposits belonging to Sorghawari Formation of the Shali Group have been reported in (i) Drawal-Kariali (ii) Jalog – Thench (iii) Jalog – Suma (iv) Chamba nulla – Thirku and Shali Sainthal blocks.

The estimated reserves and quality of the limestone in these blocks are as under:

(i) Drawal (31°14'00": 77°14'12") Kariali (31°14'00": 77°14'30") Block. The total inferred reserves of grade limestone as calculated upto ground level are of the order of 80.43 million tonnes. The limestone contains on an average 44.50% CaO and 1.95% MgO.

(ii) Jalog (31°15'10": 77°16'30") – Thench (31°15'25": 77°15'30") Block: The probable reserves of cement grade limestone calculated upto 30m depth and strike extension of 30m on either side of the sampling line are 3.185 million tonnes.

(iii) Jalog-Suma Block: Total inferred reserves of cement grade limestone are 255 million tonnes. The limestone contains on average 46.3% CaO and 1.88% MgO.

(iv) Chamba nullah (31°15'05": 77°15'40") – Thirku Block: Total inferred reserves of cement grade limestone are 224 million tonnes. The limestone contains on average 44.8% CaO, 1.54% MgO, 1.4% R₂O₃, 0.73% Fe₂O₃ and 1.2% Al₂O₃.

(v) Shali (31°02'00": 77°10'00")-Sainthal (31°15'05": 77°17'30") Block: Total inferred reserves of cement grade limestone are 146 million tonnes. The
limestone contains an average 45.25% CaO and 2.25% MgO.

Chemical grade, flux grade and high-grade limestones occur in different parts of Shimla District in the Stromatolitic Limestone Member of Deoban Group. It is generally grey, greyish white, very fine-grained, massive and dense in nature. This limestone has been investigated in Guma Block and its NW and SE extensions.

The estimated reserves and quality in these blocks are:

<table>
<thead>
<tr>
<th>Block</th>
<th>Reserve Details</th>
<th>CaO</th>
<th>MgO</th>
<th>R₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guma Block: (30° 48' 10&quot;: 77° 43' 45&quot;)</td>
<td>Inferred reserves up to a depth of 10m from the surface.</td>
<td>64.88%</td>
<td>2.25%</td>
<td>0.77%</td>
</tr>
<tr>
<td>NW Extension of Guma Block:</td>
<td>Inferred reserves up to a depth of 10m from the surface.</td>
<td>12.72%</td>
<td>4.44%</td>
<td>0.19%</td>
</tr>
<tr>
<td>SW Extension of Guma Block:</td>
<td>Inferred reserves up to a depth of 20m from the surface.</td>
<td>12.72%</td>
<td>4.44%</td>
<td>0.19%</td>
</tr>
</tbody>
</table>

The limestone contains an average 53.11% CaO, 0.44% MgO and 0.77% R₂O₃.

Sirmaur District

The chemical grade, cement grade and dolomitic grade deposits occur in different parts of this district.

(a) Chemical grade limestone: The limestone occurs as large lensoid bodies within the mica-schist associated with streaky gneiss and amphibolites of the Jutogh Group. It is generally white to snow white, at places light pink to greyish black, hard, compact and coarse grained. At many places it has been recrystallized into marble.

The limestone has been investigated in (i) Datwardi – Chunvi Block (ii) Hathana – Olana Block, (near Nohraghat) (iii) Dida – Bhanra Block. The estimated reserves in these blocks are as under:

(A) Datwardi (31° 46’ 45": 77° 28’00") – Chunvi (30° 46’30": 77° 24’10") Block:

<table>
<thead>
<tr>
<th>Type of Reserve</th>
<th>Reserve Details</th>
<th>CaO</th>
<th>MgO</th>
<th>R₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential reserves</td>
<td>101.36 million tonnes</td>
<td>53.93%</td>
<td>0.61%</td>
<td>0.84%</td>
</tr>
<tr>
<td>Inferred reserves</td>
<td>21.44 million tonnes</td>
<td>53.90%</td>
<td>0.66%</td>
<td>0.19%</td>
</tr>
<tr>
<td>Inferred reserves up to a depth of 10m along dip direction.</td>
<td>8.80 million tonnes</td>
<td>53.90%</td>
<td>0.66%</td>
<td>0.19%</td>
</tr>
</tbody>
</table>

(B) Hathana (30°48’00": 77°25’15") – Olana (37°48’00": 77°26’00") Block:

Probable reserves up to 1900m RL have been estimated as 29.87 million tonnes. The limestone contains on an average 53.9% CaO, 0.66% MgO, 0.19% Fe₂O₃ and 0.22% Al₂O₃.

(C) Dida (30°46’45": 77°26’20”) – Bhanra (30°46’15": 77°26’00”) Shangoli (30°46’ 40": 77°26’45”) Block:

<table>
<thead>
<tr>
<th>Type of Reserve</th>
<th>Reserve Details</th>
<th>CaO</th>
<th>MgO</th>
<th>Fe₂O₃</th>
<th>Al₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserves without overburden</td>
<td>16.29 million tonnes</td>
<td>53.22%</td>
<td>14.1%</td>
<td>1.17%</td>
<td></td>
</tr>
<tr>
<td>Reserves with 1:1 overburden</td>
<td>33.93 million tonnes</td>
<td>54.12%</td>
<td>14.1%</td>
<td>0.19%</td>
<td></td>
</tr>
<tr>
<td>Reserves up to 30m depth</td>
<td>14.31 million tonnes</td>
<td>53.90%</td>
<td>0.66%</td>
<td>0.19%</td>
<td></td>
</tr>
<tr>
<td>Reserves up to 60m depth</td>
<td>23.31 million tonnes</td>
<td>53.90%</td>
<td>0.66%</td>
<td>0.19%</td>
<td></td>
</tr>
<tr>
<td>Reserves up to 100m depth</td>
<td>34.56 million tonnes</td>
<td>53.90%</td>
<td>0.66%</td>
<td>0.19%</td>
<td></td>
</tr>
</tbody>
</table>

The limestone contains an average 53.22% CaO, 14.1% MgO and 1.17% R₂O₃.

(D) Nohra (30°49’00": 77°25’30”) – Hindga (30° 48’40": 77°23’30”) Block:

<table>
<thead>
<tr>
<th>Type of Reserve</th>
<th>Reserve Details</th>
<th>CaO</th>
<th>MgO</th>
<th>Fe₂O₃</th>
<th>Al₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserves without overburden</td>
<td>4.64 million tonnes</td>
<td>53.22%</td>
<td>14.1%</td>
<td>1.17%</td>
<td></td>
</tr>
<tr>
<td>Reserves up to 30m depth</td>
<td>3.95 million tonnes</td>
<td>53.22%</td>
<td>14.1%</td>
<td>1.17%</td>
<td></td>
</tr>
<tr>
<td>Reserves up to 60m depth</td>
<td>6.26 million tonnes</td>
<td>53.22%</td>
<td>14.1%</td>
<td>1.17%</td>
<td></td>
</tr>
</tbody>
</table>
The limestone contains on an average CaO 53.95%, MgO 0.88%, R$_2$O$_3$ 0.81% with phosphorous and sulphur in traces.

(E) Bulain Dhar Block (30°47'10": 77°24'10") :
(a) Reserves without overburden 1.31 million tonnes
(b) Reserves upto 30m depth 1.65 million tonnes.
(c) Reserves upto 60m depth 1.94 million tonnes.

The limestone contains on an average 53.60% CaO, 0.95% MgO, 1.21% R$_2$O$_3$ with phosphorous and sulphur in traces.

The chemical analyses of the limestones from the above block indicate that it can be used as such or after calcining in chemical industry, manufacture of cement, alkalis, glass, calcium carbide, sugar refining, as a flux in iron and steel industry and as filler.

(b) Cement grade limestone : Cement grade limestone occurs as discontinuous lensoid bodies in between the Nahan (Lower Siwalik) and the Subathu (Eocene) along the Main Boundary Fault (Nahan Thrust) at Sataun (30°33'30": 77°38'30") and adjoining areas. The limestone is traceable for a stretch of 18km from Bhatrog (30°32'45": 77°38'53") in the east to Baila (30°34": 77°28") in the west. The limestone is fine to medium grained, white to dark grey and brown and has high CaO content, low magnesia and silica thus making it suitable for the manufacture of portland cement.

A total reserve of 48.84 million tonnes of good quality limestone has been proved between Bhatrog (30°32'45": 77°38'53") and Pedua (30°34'05": 77°36') along 7 km stretch. The limestone contains on an average 50% CaO, 1% MgO, 4 to 5% SiO$_2$, 1.5% Al$_2$O$_3$ and 1% Fe$_2$O$_3$.

The limestone occurs along the same strike continuation as discrete lenticular bodies all along the Nahan Thrust. The major limestone patches occur at Sataun (30°33'30": 77°38'00") Manal (30°34": 77°37'), Pedua (30°34'05": 77°36'), Kyari (30°34": 77°34'30"), Bharli (30°33": 77°45'), Paonta (30°26'00": 77°37'00"), Detar (30°34": 77°33'), Bakun (30°34": 77°31'45"), Bharog (30°33'37": 77°31'10"), Khair (30°33'54": 77°30'10"), Kansar (30°33'34": 77°28'45") and Roj (30°33'24": 77°23'24"). Of these, the largest lens stretches for more than 4km in an East – West direction from Manal to Kyari.

The tentative reserves of the Kansar limestone occurrence are estimated to be 6.88 million tonnes. The limestone on an average 50% CaO and <1% MgO and is suitable in the manufacture of portland cement.

Good quality limestone belonging to Subathu Formation was reported in the Ja-Muse-ka-Khala stream section north of Barthal (30°33": 77°26'). The limestone is exposed over a length of 1,100m with a thickness varying between 8m and 45m. It grades into dolomite in the central portion. The reserves of limestone are estimated to be 3.7 million tonnes. Another band of limestone varying in thickness between 2m and 7.5m has been reported from about 300m north of Tina (30°33": 77°24').

Limestone of Krol ‘C’ Formation of the Krol Group with considerable thickness is reported from Kewal Khal (30°41": 77°11") and Sangrah (Kalth – Bagrath). The chemical analysis of a few grab samples from this occurrence indicates an average content of 52% CaO in 8 samples with a maximum of 55.5% CaO in five samples.

(c) Dolomitic magnesian limestone : The limestone occurrence at Roj (30°33'24": 77°23'24") west of Kansar is a Mg-rich dolomitic limestone with 30% CaO and 20% MgO. The tentative reserves are of the order of 4.55 million tonnes. This limestone can be used in mortar and as a base coat for plastering.

The Mandhali Limestone between Sataun and Kamrao is high in silica and magnesia. The reserves of this limestone near Poka (30°33: 77°40' have been estimated to be several million tones. Dolomite free from silica occurs at Salyoni (30°34": 77°23'). Dolomitic
limestone occurs in the Krol Group at Kalth – Bagrath block and Bagrath – Raucha Block.

(i) Kalth – Bagrath Block (30°39'30": 77°26'00") :
Reserves without overburden-388.1 million tonnes
Reserves upto 30m depth. 446.3 million tonnes.
The limestone contains on an average 30.73% CaO, 20.01% MgO, 1.31% Al₂O₃ and 3.92% R₂O₃.

(ii) Bagrath-Raucha Block (30°40'15": 77°25'25") :
Reserve upto 10m depth 375 million tonnes.
Limestone contains on an average 42.28% CaO and 13.33% MgO.
An occurrence of calcareous tufa is reported from Shatdwara (30°52': 77°12')

Solan District
Occurences of thick lenticular bodies of grey to dirty white dolomitic limestone of Shali Group form the rugged topography of the Badhaloag limestone deposit. The grey to dirty white limestone bands show an average CaO content of 47%, which is considered as fertilizer grade.

LITHIUM
Kinnau District
Lithium bearing granite pegmatite veins that have intruded into the country rocks comprising metasediments of the Vaikrita Group and Lipak Formation (Kanawar Group),in the Yangthang area (31°53': 78°37') have shown Li content varies from 300-1000 ppm.

MAGNESITE
Chamba District
(i) Lenses of magnesite occur in the Katarigali Formation near the confluence of Muchetar nala and the Ravi River (32°23'00": 76°39'00"). The main magnesite band is exposed in a vertical cliff face on the left side of Muchetar nala and extends towards WNW to the ridge top. It is a lensoid band varying in size between 30m x 3m and 350m x 10m. On an average, its thickness varies between 4m and 9m. The estimated reserves, calculated upto five metres depth, are of the order of 55,620 tonnes. The chemical analysis indicates that the magnesite contains, on an average 39% MgO. The CaO content varies from 0.87 to 27.54%.

About 500m down stream of the confluence of Muchetar nala and Ravi River, occur several small lenses of magnesite varying in size between 2m x 0.5m and 10m x 2m.

(ii) In Duner (32°02': 76°19') magnesite is associated with dolomite interbedded with slate and carbonaceous shale of upper part of Katarigali Formation. Chemical analysis of samples has revealed 38.19% MgO and 1.40% CaO content.

(iii) A lensoid band of magnesite about 3m thick with a strike length of 700m is recorded in Katarigali Formation at Tundah (32°30'6": 77°28'14"). Chemical analysis of one sample revealed 37.15% MgO and 6.02% CaO content. Some irregular patches and small pockets of varying size of megnesite occur in the dolomite bands southwest of Kao (30°28'09": 76°35'24"). Chemical analysis of one specimen has revealed 36.50% MgO and 3.13% CaO content.

(iv) Small pockets of magnesite associated with a limestone band of Katarigali Formation occur near Pasan Got area (32°43'50": 76°21'30"). Chemical analysis of one specimen has revealed 36.50% MgO and 3.13% CaO.

(v) In the area north of Bhajund (32°45'15": 76°26'25") pockets and lenses of magnesite (2m x 0.7m) have been noticed from 3m thick dolomitic limestone band which marks the contact between the Katarigali and Manjir Formations. Magnesite gradually grades into dolomitic limestone.

(vi) Magnesite lenses along with limestone varying in thickness from 1m-7m over a strike length of 75m are seen in Suni area.

(vii) In Kala (32°23'45": 76°38'30") area, magnesite bands varying in thickness from a few metres to 20m have been located.

(viii) Magnesite bands ranging in thickness from 1m to 10m have been reported from Panglod nala (32°48'30": 76°21'30").
Geology and Mineral Resources of Himachal Pradesh

(ix) Lenticular magnesite bands ranging in thickness from a few metres to 20m have been reported at a number of places south of Manimahesh (32°23'45" : 76°38'30").

(x) Lenticular bands of magnesite associated with dolomite/limestone in Katarigali Formation occur in Chanota (32°22'30" : 76°27'50") areas. The size of the magnesite bands at Chanota varies between 30m x 3m and 350m x 10m with thickness varying between 4m and 9m. Chemical analyses of a few samples has revealed 45.15% MgO. In Gharola area the size of the magnesite lenses varies between 10cm x 2m and 1 m x 20cm.

(xi) Magnesite bodies ranging in thickness from 1m to 5m with strike extension for 50m have been found in the lower horizon of Dunai Formation, about 0.5km north of Keh Got (32°58'30": 76°22'30") and about 1km north of Riali Got.

MINERAL WATER

Bilaspur District
At Bhasra (31°14': 76°47") the water is strongly saline and has a slightly aperient quality. It is said to be efficacious in cases of scrofula, dropsy and rheumatism.

Kangra District
(i) At Jawalamuki (31°52': 76°23') water is saline and is being used as a cure for goitre. The amount of salt and iodine in the water of six springs situated in Jawalamukhi valley in 1000 parts is as follows:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Location</th>
<th>Salt</th>
<th>Iodine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kipera Spring</td>
<td>22.0</td>
<td>0.0799</td>
</tr>
<tr>
<td>2.</td>
<td>Jwala Spring</td>
<td>26.30</td>
<td>0.09324</td>
</tr>
<tr>
<td>3.</td>
<td>Jwala 2nd</td>
<td>24.0</td>
<td>0.0799</td>
</tr>
<tr>
<td>4.</td>
<td>Jwalamukhi</td>
<td>22.80</td>
<td>0.0799</td>
</tr>
<tr>
<td>5.</td>
<td>Nagia Spring</td>
<td>22.20</td>
<td>0.09324</td>
</tr>
<tr>
<td>6.</td>
<td>Kangra Basa</td>
<td>23.0</td>
<td>0.09324</td>
</tr>
</tbody>
</table>

(ii) At Lausa (30°23': 76°05') water is sulphurous at a temperature of 22 C. It resembles that of Bareges, Haute, and Pyrenees and contains 0.159 Na₂SO₄, 0.74 NaCl, 2.600 Na₂CO₃ and 0.0040 CaCO₃ (in 1,000 parts). It is used to cure goitre.

(iii) At Tatwani (32°07': 76°46') there is a spring in the bed of the Lum, a tributary of the Birmi River. The temperature of water is 49 C. Water is limpid with a saline taste and slightly alkaline. Residue contains 9.233% NaCl with small quantities of chloride, sulphate and carbonate of lime, also 0.012 parts of sodium bromide in 1,000.

(iv) At Tira Jiva, (30°08': 76°14') a saline spring occurs with 42.2 C from seven or eight small vents within a space of 20m. It is strongly charged with H₂S and leaves saline encrustations. Hot spring is also reported from Skiba, Thopan, Karcham, Tapri, and Roura Thach areas.

(v) At Manikaran (32°02': 77°25') there are as many as fourteen springs. Temperature of water varies from 71.4 C to 94.4 C (boiling point at this elevation). Discharge of water is exceedingly copious. Sulphuretted hydrogen is emitted, but the water is clear and palatable, containing 3.2 parts of saline matter in 10,000. It has deposited large quantities of ferruginous travertine.

Shimla District
Ten springs occur on the right bank of the Satluj River, opposite Suni village (31°14': 77°11'). The temperature of water is 57 C and is strongly sulphurous with a strong distasteful salinity. It contains chloride and sulphate of soda.

Solan District
There are five springs at Jaoni (31°32': 77°50'). The temperature of water is 55 C with a disagreeable saline taste and its deposits are found to be of ferruginous nature.

NICKEL AND COBALT

Kulu District
Traces of nickel and cobalt have been reported from the copper ore occurring in quartzite in the Naraul (31°49'40":77°13'45") – Danala (31° 47' 30": 77° 15") area of Garsha Valley. The mineralisation comprises chalcopyrite, covellite, pyrite and cobalt-nickel bloom.
OCHRE
Lahaul & Spiti District

Hayden (1904) mentioned the occurrence of large quantities of yellow ochre in recent deposits near Dauksa camping ground on the Ratang River (32°13' 78°05') that was initially reported by Griesbach.

PYRITE
Chamba District

Sporadic cubes of pyrite occur in Kamli Got area along joint planes in slates and phyllite in 2-5m thick zones traceable for a length of 150cm, at 800m southwest of Mawa (32°46' 76°18'). Such mineralisation was also seen two kilometres east of Kamli Got (32°46' 78°20') in the debris of quartzitic slates of the right bank of Lanj nala. The pyrite associated with pyrrhotite is not considered to be un-economic. Pyrite has been recorded in highly crushed carbonaceous slates of Katarigali Formation near the Chakoli Bridge (32°45'30'' 76°00'00''). In Bharaura where pyrite veins vary in thickness from a millimetre to 4.5cm, it occurs as disseminated cubes, veins, stringers and fine-grained impregnation.

Lahaul & Spiti District

Dissemination and stringers of pyrite were observed in the Shatul Gneiss near Dulgi Ghati (31°26' 78°05') and in the rocks of Jutogh Group, west of Brandy Khagau (31°26' 78°06').

Shimla District

A zone of pyrite dissemination associated with chalcopyrite and arsenopyrite is recorded in the phyllite and schist of the Jaunsar Group near Matiana (31°13' 77°24'). The mineralisation is associated with impersistent veins of white quartz, the longest vein being 2m long and 8cm wide. Small veinlets are about 40cm to 50cm long and 1cm to 2cm wide. The mineralisation zone is exposed in the road cutting. It runs for about 2km of which the second kilometre is a zone of sparsely disseminated pyrite. Chemical analysis shows pyrite contains 0.5% to 5.8% sulphur. Pyrite occurrences have also been reported from near Bhuin (31°07' 77°27') on the Theog (31°07' 77°32') Mothkai road. Small cubes of pyrite are disseminated in the carbonaceous schist of Jutogh Group over an area of about 3 sq m along the road cutting, east of Rohru (31°12' 76°45').

The occurrence of 70cm wide zone of pyrite disseminations in a band of carbonaceous phyllite has been recorded north of the Sungri Rest House (31°23' 77°42'). The band is traceable for a distance of about 3km along the strike with an average width of about 240 cm. Several lenticular seams of pyrite of variable thickness occurring within the Jutogh Group are found in the upper reaches of the Ashmi River, east of the Tara devi (31°00' 77°05') to the south of Shimla. The pyrite seams are generally upto 60 cm thick. The principal localities where the pyrite is found are Badhaighat nala (31°05' 77°08'), Kyari (Shamri) nala (31°05' 77°09'), north of Rehana (31°04' 77°10') etc. The average sulphur content ranges between 35% and 40% and Al₂O₃ 0.02%.

Pyrite occurrence is also found at Chirgaon (31°32' 78°06') and Purbani (31°36'30'' 78°18').

Sirmaur District

An occurrence of pyrite in the form of lenses and veins in limestone and slate was recorded at Sayasu (30°41' 77°45') and Diyandon (30°43' 77°43'). The steeply dipping vein at Sayasu is exposed in Tons River bed, for a distance of 150m with a thickness varying between 50 cm and 1.2m. On analysis, one sample yielded 30% sulphur with arsenic in traces.

RADIOACTIVE MINERALS
Kinnur District

Anomalous radioactivity value is observed near Ropar village (31°48.78'26") in the black slates of the Batal Formation. The yellowish encrustations along fracture planes in the Wangu Granite are reported to be carnotite.

Kulu District

Radioactive minerals occur in massive upper quartzite of the Banjar Formation, Manikaran Formation near Chhinjra, Jari in Parbati Valley and near Thela (31°51' 77°16') in Garsha Valley. A good value above background radioactivity has been noted in the Manikaran Quartzite east of Pingrang and on the Tharang Dhar.
Hamirpur district
Radioactive minerals are reported from the rocks of Siwaliks in the district.

Shimla District
Uranium mineralisation was located by the Atomic Mineral Division in the Manikaran Quartzite of the Rampur Group in Kasha (31°24'30": 77°50'15") Pat (31°24':77°50') area. The mineralisation in the form of yellow brown encrustation is visible in the weathered surface near Pat.

ROCK PHOSPHATE
Chamba District
Phosphatic nodules varying in size from 1.5cm to 7cm in diameter and containing 20%-30% P2O5 occur in the black carbonaceous slate of Salooni Formation at Tarota (32°42'50": 77°05'25"), Dhandi Nala (32°45'30": 76°00'00") Dhanot (32°43'30": 76°05'20") Dhulan (32°39': 76°09") Tiloga (32°45'40": 76°00'00") Thamiru (32°48'40": 75°57'00") Dantal (32°45'40": 76°00'00") and Bhatinund (32°43': 76°04').

Kinnaur District
Black cherty nodules in the shale of Kuling Formation contain 21% P2O5. The phosphatic horizon is about 20m thick. However, the percentage of the nodules is very low.

Lahaul & Spiti District
Phosphatic nodules ranging in size from 4cm to 10cm from the Spiti Shale have analysed 5%-15% P2O5.

Mandi District
Shale pockets of the Khatpul Formation and dolomite of the Tatapani Formation, Shali Group are mildly phosphatic at Kandi (31°19': 76°44'). In Katti Jau area, the phosphate occurring as pellets is confined to the green facies of the Subathu Formation. The phosphatic nodules are 10cm x 12 cm in size.

Shimla District
In Kalor (30°52'15": 77°10'30") area, the sandstone alongwith limestone of Krol 'A' Formation (Krol Group) is found to be phosphatic. The P2O5 content varies from 8% to 10% over a strike length of more than 5km in the Rajgarh area.

Sirmaur District
Sparsely distributed phosphatic nodules containing 30% P2O5 occur in the grey and yellowish shales in Balia – Kansar (30°34': 77°28') and Birileh (30°34': 77°26') areas. In Nigali (30°34'40": 77°43'25") – Sharmiaya (30°33'30": 77°43'30") area, rock phosphate is generally found in the lower Tal only.

Besides, pockets of phosphatic chert occur in Krol dolomite. Cherty pebbles in conglomerate of Upper Tals are also mildly phosphatic at Charang Dhar. The cherty pebbles vary in size from less than one cm to 10cm with 20.25% P2O5.

Solan District
Rock phosphate in Dati Deeb (31°12'30": 76°56'30") occurs as pellets in the green facies rocks of Subathu Formation. The sandstone and limestone of Krol 'A' Formation of the Krol Group are found to be phosphatic in Deoria (30°50'30": 77°11'15") area. In Pata (31°21'45": 76°55'45") and Rakhalong Deedo (31°10'00": 76°56'40") areas phosphatic nodules occur in the brown shales of Subathu Formation. The nodules, vary in size upto 26cm and contain 32% P2O5.

ROCK SALT
Mandi District
The rock salt occurs in Guma (31°58': 76°51') and Drang (31°46': 76°56') areas. The total reserves of the rock salt are 7.552 million tones. Chemical analysis indicates on average insoluble impurities 21%, KCl, 3% NaCl about 70.40% and the rest consisting of CaO, CaSO4 and MgO. Detailed geological work and drilling has been carried out to assess the grade and reserves. Drilling data show that except for minor intercalation of non productive beds (clay, quartzite, etc.) the cores are composed of salt throughout the area investigated. Chemical analyses show that the average salt content is over 70% and with depth no regular change in the salt content is indicated.

Besides Drang, saline grits occur intermittently in discontinuous patches over a linear distance of 180km northwest of Mandi. The important occurrences
of salt grit are: Megal (31° 45': 76° 57'), Drang, Herkalan (31° 56': 76° 52'), Guma (31° 56': 76° 51'), Dewalkhas (32° 05': 76° 40') and Kandbari (32° 07': 75° 35').

Kangra District

Thin white, saline encrustation forms on the surface of pebbles and rocks near Behna (31° 22': 77° 23').

RUBIDIUM

Kinnaur District

The pegmatite veins intrusive into the Carboniferous rocks in the Yangthang (31° 53': 78° 37') area contain up to 350ppm of rubidium.

SILVER

Sirmaur District

Silver has been reported 3km east of Chiargaon. The samples, however, gave a value of only 10ppm of Ag.

Kinnaur District

The galena boulders in Amba (30° 38': 77° 27') area contain up to 250ppm Ag.

Kulu District

Calvert and Henwood reported several lodes of argentiferous galena in the neighbourhood of Manikaran, which are as under:

(i) Khenor khad: Three mineralized zones have been reported from this place. First zone has yielded silver, second zone lead, gold, silver and copper, and the third zone, several centimeters thick, has yielded lead, gold and silver.

(ii) Uchich (32° 01': 77° 23'): About 69cm wide, lode had been reported from here. The ore samples show gold and silver mineralization.

(iii) Chong (37° 57': 77° 11'): One lode reported at this place is about 15cm thick. The ore contains lead and silver.

Calvert has also mentioned a 75cm wide lode of galena containing silver at Komand on the eastern side of the Kot Kandi (31° 55': 77° 16').

SLATE

Chamba District

Good deposits of slate, suitable for roofing, paving and fencing purposes occur in Chamba and Katarigali Formations in different parts of Chamba district.

In the Chamba Formation, the slate is confined to its middle part. Good deposits of slate suitable for roofing, paving and fencing purposes occur in a zone nearly 7km in length extending from near Talai (32° 21'55": 76° 04'30") to northwest of Makotsu (32° 24'50": 76° 01'10''). The slate belt attains its maximum thickness of 884m in Chikki nala and minimum thickness of 200m near Makotsu.

The following are the important slate occurrences:

(i) Rupaina (31° 22' 00": 76° 03'35") Nargal (32° 22'15": 76° 02'25") area: The slate belt in this area is 240m thick and extends over a strike length of about 800m. The probable reserves estimated are of the order of 5,18,400 tonnes.

(ii) Bhora (32° 23' 05": 76° 02' 50") Bela (32° 22'40": 76° 02' 15") area: The slate horizon in this area is about 560m thick extending over a strike length of about 900m. The probable reserves are of the order of 1,360,800 tonnes.

(iii) Chaunda Devi (32° 24' 40": 76° 01' 50") area: The slate deposit is 320m thick and extends over a strike length of about 700m. The probable reserves are of the order of 6,04,800 tonnes.

(iv) Renda (32° 24' 40": 76° 01' 15") area: The slate horizon in this area is 160m thick and extends over a strike length of 400m. The probable reserves are of the order of 1,72,800 tonnes.

In Chuari (32° 25'50": 76° 01'00") Dhalhousie (32° 34': 75° 58') area, five horizons of slate have been recorded in Kulu Formation. Out of these, the two topmost horizons contain good quality slate.

The following are the slate bearing localities in this area:

Khotri (32° 25' 55": 76° 02' 10''), Chamari (32°26'00": 76°01'15''), Debrera (32°27' 0": 76°00'10''), Dabriara (32°28'55": 76°00'25''), Kophru (32°59'00": 76°00'20'').
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The total reserves of cleavable slates occurring in the area, between Kalm Nadi in the southeast and near Sapri (32°33'25": 75°58'35"), in the northwest have been estimated to be of the order of 11,505,000 cu m. The reserves have been calculated up to a depth of 15m.

In the Chamba Formation, fairly good deposits of slate occur in its middle and upper parts in the area north and northeast of Rakh. This formation, in fact, is the main source of slate produced in the Chamba and Barmaur tehsils of this district. The important slate bearing localities are Dulara (32°29'05": 76°14'35"), Dhanara (32°26'25": 76°14'45"), Se (32°29'40": 76°14'30"), and Panthal (32°28'55": 76°14'30"). The investigation carried out in the slate belt in the area between Sajhot (32°30'05": 76°13'55"), to near Dudiana (32°28'50": 76°15'20"), has revealed the probable reserves of the order of 18.4 million tonnes.

In the Katarigali Formation, a zone of dark grey black shale/slate has been traced from near Kandail in the northwest to near Gharola (32°26'10": 76°27'15"), in the southwest.

Kangra District

A more or less continuous slate belt of variable width and thickness occur over a strike extension of about 7km from a little west of Bhagsunath (32°14'40": 76°20'00"), in the southeast to near Chamba Pass (32°17'04": 76°15'10"), in the northwest.

The belt comprises two slate horizons of variable widths occurring at different stratigraphic levels within the Kulu Formation. One of the horizons, occurring at the base of streaky and gneissic quartzite is about 75m wide and has an average width of about 120m. The important slate occurrences are as under:

1. Dharmkot (32°15'05": 76°19'15") area: Here the slate horizon is 210m thick extending over a strike length of 1750m. The probable estimated reserves are of the order of 9,92,250 tonnes.

2. Ab Got (32°16'50": 76°17'35") area: The slate horizon in this area is 40m thick and extends over a strike length of 200m. The probable estimated reserves are of the order of 21,600 tonnes.

3. Area north of Bhatti (32°16'45": 76°15'15") : The 60m thick slate belt extends over a strike length of 100m. The probable reserves are of the order of 1,62,000 tonnes.

STIBNITE

Lahaul & Spiti District

Stibnite occurs as small veins in the granitic rocks of Bara Shigri (32°17':77°36') area. According to the Indian Bureau of Mines (IBM), the minimum anticipated reserves are 10,568.20 tonnes with 1.65% Sb. The mineralization is associated with cervantite and kermesite with traces of copper, zinc and arsenic.

TALC/STEATITE

Shimla District

An occurrence of talc has been reported from near Asrau (31°29': 78°20') upto Idpa (31°39': 78°24'). The rocks consist of talc schists.

Sirmaur District

Steatite of good quality occurs at Nahan (30°33': 77°17').

TOURMALINE

Kinnaur District

(i) Tourmaline has been reported in the pegmatites traversing the gneisses and granites around Rakcham (31°23': 78°26') and Chhitkul (31°21'20": 78°26'25').

(ii) In Khokpea nala, a small lens of tourmaline rich graphite schist is exposed within the Vaikrita Group. Similar concentration is noticed in quartzite about a kilometer south east of Shangi (31°33'15": 78°29'00").

Kulu District

(i) Tourmaline bearing pegmatites intrusive into gneisses and granites have been reported around
Umga Thach (32°10': 77°27') and Samsi Thach (32°07': 77°29').

(ii) Black crystals of tourmaline, 5cm in length and over 1cm in width, are present in pegmatites around Sara Umga Thach (32°10': 77°29') and Pando-Seo Thach (31°56'30": 77°40'30').

**ZINC**

**Lahaul & Spiti District**

Zinc blende is sparingly disseminated through the gangue of the antimony ore at Bukkanbudi in the Tarikere taluk (31°42': 75°49').

**Sirmaur District**

Zinc blende is found associated with galena and pyrite at Anyar (30°44': 77°44') and Chamri (30°43': 77°45'). Chemical analyses of samples collected from old workings at Anyar, has yeilded 1.5% Zn and 0.21% Pb. Another sample has given 10% Zn. At Chamri the zone contains 3.01% Zn and 3.01% Pb.

**FOREST**

As per Forest Survey of India (2007), an area of 14,353 sq km of state is under forest cover of which 1,093 sq km, 7,883 sq km and 5,377 sq km area constituted by very dense, moderately dense and open forests respectively. These forests vary from Tropical Dry Deciduous Forests type to Sub-Tropical Dry Ever Green Forests and Himalayan Moist Temperate Forests type to Sub-Alpine and Alpine Forests. In these forests different species viz Deodar cover 811 km², Kail (Blue Pine) 809 km², Chil (Pine) 1436 km², Fir/spruce 1343 km², Sal 183 km² and Ban (Oak) covers 540 km² of the total area of the state. Forest wealth of Himachal Pradesh is estimated at over Rs. 1,00,000 crore.

**SOILS**

The soils of the State can broadly be divided into nine groups on the basis of their development and physico-chemical properties. These are: (i) alluvial soils, (ii) brown hill soil, (iii) brown earth, (iv) brown forests soils, (v) grey wooded or podzolic soils, (vi) grey brown podzolic soils, (vii) planosolic soils, (viii) humus and iron podzols (ix) alpine humus mountain speletal soils. The soil found in the districts of Mandi, Kangra, Bilaspur, Una, Solan, Hamirpur and Sirmaur is generally brown, alluvial and grey brown podzolic, Kullu and Shimla have greywooded podzolic soils, while Kinnaur, Lahaul and Spiti and some parts of Chamba district have humus mountain speletal soils.

**HYDRO ELECTRIC RESOURCE**

Himachal Pradesh, abode of numerous glaciers and network of perennial streams with availbbility of high hydraulic heads, has immense hydropower potential. Out of India's total 80,000 MW hydroelectric potential 20,000 MW lies in Himachal Pradesh. The state has nearly exploited the half of the acquired hydroelectric potential and the work on exploiting the rest of the potential is in progress. The major hydroelectric projects of the state which have been commissioned or likely to be commissioned soon are Bhakra dam project (1200MW), Nathpa Jhakri HEP (1500 MW), Beas Satluj link project (990MW), Pong Dam HEP (360MW), Chamera HEP stage I (540 MW), Baspa HEP I & II (510 MW), Karcham-Wangtu HEP (1000MW), Rampur HEP (430MW), Kol Dam HEP (800MW) and Parvati HEP (1000MW).
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### Errata

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<td>Page, 6; para, 1; The reconstructed stratigraphy of the rocks in Himachal Pradesh is given below.</td>
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