Orissa, a major state of India has enormous mineral potential and is rich in mineral resources. Many of the minerals are known to be in abandon supply, while many are least known in this state. Orissa produces enormous minerals including non-metallic, metallic and fuel minerals. Orissa stood one of major producer of Chromite, Nickel, Iron, Manganese, Tin, Graphite, Bauxite, Lead and Zinc in India. Among the fuel minerals, coal of Ib-River and Talcher coalfields continues to play a dominant role among the domestic energy resources in this state. In terms of geographical distribution of mineral resources of India, about 10-14 % of mineral production comes from the state of Orissa. Let us discuss the mineral potential of the state one by one briefly.

**BAUXITE ORE**

**Introduction**

Bauxite is a heterogeneous ore of aluminium. It is derived from Khondalite and Charnockite consists of Gibbsite, Goethite and Kaolinite in varying proportion with some Garnet, Hematite, and Ilmenite as accessory minerals.

Although Bauxite is the main source of aluminium, it is the second abundant metal element in the earth's crust after silicon. Bauxite is mined for production of alumina by the Bayer's process.

**Occurrences**

The main Bauxite deposits of Orissa are associated with the Eastern Ghats Super Group of rocks and form the major component of the East Coast Bauxite (ECB) deposits. All the East Coast Bauxite cappings over Khondalite in Orissa sector e.g., Ballada, Maliparbat, Panchpatmali, Kodingamali, Karnapadikonda, Bapulimali, Sijimali, Lanjigarh etc. of Koraput and Kalahandi districts occur in a single planation surface (+900m above MSL).

Bauxite caps the Gandharmardan plateau over Khondalite on the Border of Bolangir-Sambalpur districts. It occurs at an elevation of 940-1000 above MSL.

Bauxite occurs in the Kandhamal hills overlying the Vindhyan shale at an elevation of 960m above MSL.

Small and isolated bauxite cappings occur over BIF (shale) formation at elevations of 610-671m above MSL around Kusumdihi in Sundargarh District.

Bauxite with intercalated laterite caps over metavolcanics on the flat-topped hill namely Dholkata Pahar and Kanjipani range of Keonjhar District. These areas range from 727 to 848m above MSL with intervening valleys around 600m above MSL.
All the hill ranges west of Nawana and east of Similipal Garh and Bakua of Similipal Complex (Mayurbhanj), laterites are observed around 1000m above MSL (Das and Mohanty, 1998).

**COAL**

**Introduction:**

Out of 57 Gondwana and 14 tertiary coalfields considered for the national inventory of coal, Orissa state has only two. They are Ib-River coalfield and Talcher Coalfield. Yet its share in the reserve so far established in the country amounts to 23.6%.

**Occurrences:**

The Ib-River Coalfield is named after a tributary of the Mahanadi. The coalfield is located in the southeastern part of Mahanadi Master Basin and occupies an area 1460 sq. km. The coalfield is bounded by latitudes 21°30' and 22°14'N and longitudes 83°32' and 84°10'E. It covers parts of Sundargarh, Jharsuguda and Sambalpur districts. It embraces the Hingir Sub-basin in the north and the Rampur Sub-basin in the south.

The Talcher Coalfield constitutes the southeastern most member of the Lower Gondwana Mahanadi Master Basin and occupies an area of over 1813 sq km. The coalfield is bounded by latitudes 20°50' and 21°15' N and longitudes 84°09' and 85°33' E. This basin mainly occupies the Brahmani River Valley. It covers parts of Dhenkanal and Angul districts along with a small portion of the adjoining Sambalpur District.

<table>
<thead>
<tr>
<th>Coalfields</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Districts</th>
<th>Basinal area in sq. Km.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ib-River</td>
<td>21°31'</td>
<td>83°32'</td>
<td>Jharsuguda, Sundargarh &amp; Sambalpur</td>
<td>1460</td>
</tr>
<tr>
<td>Coalfield</td>
<td>22°14'</td>
<td>84°10'</td>
<td>Dhenkanal, Angul &amp; Sambalpur</td>
<td>1813</td>
</tr>
</tbody>
</table>

The major parts of the Talcher and Ib-River Coalfields are covered by the Talchir, Karharbari, Barakar, Barren Measures, Lower Kamthi (Raniganj) and Upper Kamthi sediments. Among them only Barakar, Karharbari and to some extent Lower Kamthi (Raniganj) sediments are coaliferous (Manjrekar et al, 1998).

**CHINA CLAY**

**Introduction:**

China clay is also a clay like material comprising mostly mineral Kaolinite (Al₂O₃, 2SiO₂, 2H₂O) where Al₂O₃, SiO₂ and H₂O% are 39.5%, 46.56% and 13.94% respectively. It has a specific gravity of 2.6 and a fusion point of 1.785°C.

Kaolin deposits have been formed by decomposition of feldspathic granite. Kaolin occurs in form of pockets or lenses within the main mass of granite.

**Occurrences:**

China clay is found to occur in a long belt stretching from southern Singhbhum to Mayurbhanj Granite belt. Badampahar-Joshipur, Karanjia- Ramchandrapur belt with a number of deposits on either side of NH-6 is the most important china clay producing area of the state.

Besides these, there are a few occurrences in Keonjhar, Sambalpur, Koraput, Sundargarh and Dhenkanal districts.

The important deposits in Mayurbhanj District are found near Joshipur, Dumuria, Jamba,
Kadodiha, Jamkeswar and Thakurmunda. The china clay found in Joshipur area of the Maurbhanj District is pale cream to yellow in colour (Mohanty, 1998).

**CHROMITE**

**Introduction:**

Chromium is indispensable for industrial complexes including aerospace, steel and special alloys. Chromite is the only economic source of chromium. Chromite belongs to the spinel group and has the basic formula $R^{+}R^{+++}O_4$, where $R^{+}=$Mg, Fe with traces of Mn and Ni and $R^{+++}=$Cr, Al, Fe with traces of Ti and V. It has five major components viz., MgO, FeO, Cr$_2$O$_3$, Al$_2$O$_3$ and Fe$_2$O$_3$, whose proportions are greatly controlled by the composition of the magma from which the primary silicates and chrome spinel crystallized. Pure chromite contains 67.9% by weight of Chromic Oxide (Cr$_2$O$_3$) or 46.5% by weight of Chromium.

**Occurrence:** In Orissa chromites are confined to three areas.

(a) Boula-Nuasahi in Keonjhar district. The chromite deposits occur at and around Bidyadharpur barrage, Nuasahi and Agarpura.

(b) Sukinda in Jajpur district. The main deposits of Chromite and Nickel of Sukinda are present in the area Kamardah, Saruabil, Kaliapani, Kathpal, Maruabil, Bhimtangar etc.

(c) Bhalukasuni in Balasore district. The main deposits of this area are Bhalukasuni village of Nilgiri Sub-division.

(d) In Similipal ultramafic complex of Mayurbhanj District, probable reserve of 27 million tonnes of laterite Nickel ore has been estimated by GSI (Sahoo, 1998).

**NICKEL ORE**

Annual consumption of nickel in the country is about 15000 tonnes and almost the entire quantity is met through imports. Hence Sukinda ultramafic complex, the only indigenous resources of Nickel ore of India, should be utilized.

The Sukinda ultramafic body is stratiform in nature and comprises inter-layered nickel and chrome rich rocks (dunite-peridotite and orthopyroxenite). The serpentinitised dunite-peridotite members have been subjected to intense chemical weathering resulting in the formation of a nickel rich limonite cover. Thus the lateritic nickel ore is of secondary origin (Sahoo, 1998).

**PLATINUM GROUP OF ELEMENTS**

Platinum Group of Elements i.e. Platinum (Pt), Palladium (Pd), Rhodium (Rh), Ruthenium (Ru), Osmium (Os) and Iridium (Ir) are the rarest of precious metals in the earth's crust. In India, only a minor amount of Palladium is recovered as a byproduct from Singhbhum Copper belt, Jharkhand. Besides, no other Platinum Group Elements mine production is known in India.

Moreover, on the basis of geological criteria such as rock association, age, tectonic setting, depositional environment, geochemical association and abundances, the principal terrains for identification and delineation of Platinum targets are: 1. Baula-Nuasahi, Keonjhar District 2. Sukinda area, Jajpur District, 3. Singhbhum-Orissa Craton and 4. Amjori Hill, Keonjhar District (Mukherjee, 1998).

**IRON ORE**

**Introduction:**

Iron is a very important element comprising about 5% of the earth's crust. It is rarely found in native condition except in the meteorites and eruptive rocks in association with Cobalt and Nickel.
The source minerals from which iron is being extracted on commercial scale are only a few, like Hematite, Magnetite, Goethite, Siderite.

**Occurrence:**

The iron ore deposits of the state occur in five distinct zones.

(a) **Bonai (Sundargarh District) Kendujhar (Keonjhar District) Bett**

(b) **Gandhamardhan of Keonjhar District.**

(c) **Tomka-Daitari of Jajpur District.**

(d) **Gorumahisani-Badampahar of Mayurbhanj District.**

(e) **Hirapur of Nawarangpur District (Mohanty, 1998).**

**FIRECLAY**

**Introduction:**

The term fireclay has been commonly applied to refractory clays, which can withstand of 1500°C or higher temperature. It is basically Kaolinite.

On the basis of plasticity, fireclay is classified as plastic, semiplastic and non-plastic. An important parameter of fireclay in refractoriness expressed in terms of pyrometric cone equivalent (PCE).

**Occurrence:**

In Orissa fireclay are confined to three geographical belts.

(a) **Talcher Coalfield in Dhenkanal and Angul:**

In Talcher Coalfield, fireclay has been encountered in the following locations.

* Jagannath Colliery
* South Balanda Colliery
* Near Kaniha Village
* Near Ghantikhal Village

(b) **Ib-River Coalfield:** The occurrences of this area have been recorded near Jurabaga, Darlipali, Rampur, Kuropal, Bariapahar, Khinda, Lukopali, Kulda, Siarmal etc.

(c) **Athgarh Basin:** Clays of Talabasta area belongs to Athgarh formation of upper Gondwana of Cuttack district (Nanda and Bhol, 1998).

**BASE METAL DEPOSITS**

**Introduction:**

Though Orissa is not a rich state in terms of the base metal ore deposits (Cu, Pb and Zn), it has three small deposits to its credit, at various stages of exploration and development.

**Occurrences:**

There are three occurrences of base metal deposits in Orissa.

(a) **Adash Copper ore deposits:** It belongs to Sambalpur district. The copper prospect (21°23’05”latitude 84°37’45”) is situated at a distance of 120 km from Sambalpur Railway Station and can also be approached from Reamal on the Deogarh -Angul NH-6, 30km. Here Graphite is produced as co-product.

(b) **Kesarpur Copper deposits:** The villages of Mayurbhanj like Kesarpur, Dudhiasal and Madansahi encompassing the copper ore deposit are located between latitudes 22°04’ and longitude 22°07’. The chief minerals of the ore are pyrite, pyrhotite and chalcopyrite, with minor amount of Nickel and Molybdenum.

(c) **Sargipalli Lead ore deposits:** Sargipalli deposit lies between the village Lokdega (22°02’ : 83°55’) and Bharatpur (22°03’ : 83°56’) in Sundargarh district. The common primary minerals of the deposits are galena, chalcopyrite and sphalerite (Patnaik et al, 1998).
GRAPHITE

Introduction:-

Natural graphite is an allotrope of elemental carbon, which crystallises in the hexagonal system. It is a soft and opaque black mineral with a metallic luster, greasy feel, hardness of 1 to 2 in Moh's scale, specific gravity of 2.09 to 2.93.

Occurrence :-

The major graphite zone of Orissa is coincident with the migmatized quartz- garnet - sillimanite - graphite schists of khondalite suite and its contact with medium - grained granite gneiss. The important graphite belts of the state are -

(a) Sargipali belt: (21°00'-22°22':83°15'-83°40')

Sargipali belt contains more than 150 occurrences, which belongs to the deposits of Sargipali, Dangachancha, Darhamunda, Sapmuna, Rengali, Mohanilah, Raju-Nagphena etc of Bargarh, Bolangir and Kalahandi districts.

(b) Titilagarh belt: (20°06'-21°24':83°00'-83°45')

Titilagarh belt contains more than 120 occurrences which belongs to the deposits of Titilagarh, Boroni, Malisira, Singharan, Loitora of Bolangir and Kalahandi districts.

(c) Tumudibandh belt: (18°45'-20°00':83°00'-83°45')

Tumudibandh belt contains more than 50 occurrences, which belongs to the deposits of Tumudibandh, Lakhajorna, Palur, Raisil, Ambaguda of Phulbani, Rayagada and Gajapati districts.

(d) Dandatopa belt: (20°37'-21°00': 84°15'-84°45')

Dandatopa belt contains more then 22 occurrences, which belongs to the deposits of Dandatopa, Adeswar, Kamalpur, Akharkata and Girida of Dhenkanal and Angul districts (Mishra et al, 1998).

MANGANESE ORE

Introduction:

It was recognised as an element in 1774 by Swedish chemist Scheele, whose fellow countryman, Ghan isolated the metal in the same year. The average crustal abundance of manganese is slightly less than 1% (950 PPM).

Manganese deposits are widespread in the world's land areas. The common primary minerals of Manganese deposits of Orissa are pyrolusite, Rhodonite, Manganite, Jacobsite and Psilomelane.

Occurrence:

Manganese ore deposits of Orissa occur in three distinct geological set-up

(a) Bonai-Keonjhar :- Bonai-Keonjhar belt constitutes the most important manganese ore producing region of the country.

(b) South Orissa: - The manganese ore deposits of south Orissa comprising parts of Rayagada, Kalahandi and Bolangir districts are associated with Khondalite suit of rocks belonging to the Eastern Ghats Super Group.

(c) Ghoriajhor area of Sundargarh District - Manganese bearing gondite of Ghoriajhor formation is the youngest horizon occurring in the core of Gangpur synclinoriun and confined to the central part of the Gangpur group of meta-sedimentaries (Sarangi and Mohanty, 1998).

VANADIUM

Introduction :-

Vanadium is an important alloying element. Addition of small amount often less than 0.1% to steel and cast iron can significantly increase their
strength, toughness and ductility. In Orissa vanadium is confined to the by-product sludge of Alumina plants.

Magnetite associated with gabbro-anorthosite suite of rocks contain Vanadium and Titanium, occur at several locations in Mayurbhanj District. Vanadium bearing magnetites had also been recorded near Boula in Keonjhar district and Godasahi and Rangamatia in Balasore district. The Magnetite and Ilmenite form the bulk composition of the ore. The mineral Coulsonite $(FeV)_3O_4$ is responsible for the vanadium content of the ore.

**Occurrences :-**

In Orissa Vanadium bearing magnetite is confined to five geographical belts.

a) Rairangpur -Bisoi :-It includes deposits at Kumardubi, Betjharan, Amdabeda, Gargari, Kunjakocha, Bhangapahar, Hatichar.

b) Bisoi -Joshipur :-It includes deposits at Mayurbeka, Kesham, Dhulabeda, Sialnoi, Bariadihi, Kundabari.

c) Baripada -Podadiha :-It includes deposits at Bahalda, Andipur, Chitrabania.

d) Rangamatia (Betei) Godasahi :-Deposits at Rangamatia and Godasahi.


**BEACH SAND MINERALS**

**Introduction :-**

The term "Beach Sand Minerals" also called Heavy minerals is usually associated with a group of industrial minerals comprising mainly Ilmenite, Rutile, Zircon, Monazite, Garnet and Sillimanite. The major gangue mineral in the beach sand deposits is quartz. The specifications of these minerals are given in the Table 1.

**Occurrence :-**

The resources of beach sand mineral in India are confined to the states of Kerala, Tamilnadu, Orissa, Andhra Pradesh and Maharashtra. In Orissa, Atomic Minerals Division has explored a stretch of about 50 km from south of Mahanadi mouth to Orissa-Andhra Pradesh Border and identified a number of potential deposits ranging in grade from 5% to 30% heavy mineral. Ganjam coast is most important from the point of view of reserve and grade. The Indian Rare Earths Limited (IREL) leasehold extends for a length of 18 kms along Chhatrapur coast between Rusikulya River confluence in the NE and Gopalpur on the south-west. The different identified blocks of this deposit are Pedalaxmipuram- Ramayapatna, Ramayapatna-Markandi, Niladipur- Kantiagarh, NE of Kantiagarh, East of Jhatiapadar, SE of Arunpur (Siddiqui, 1998).

**DIMENSION AND DECORATIVE STONES**

**Introduction :**

Any natural stone irrespective of composition and origin, which can be cut, sized and shaped to suit the fancy and specification of the builders, designers and architects are marketed as Dimension stones. The various rocks, which are quarried as dimension stones, include granite, marble, sandstone, limestone, slate, laterite and khondalite.

**Granite:**

The suitability of granites for utilization as dimension stones depends to a large extent on their physical, chemical and mineralogical properties. The dimension stones under the "Granite" category can be broadly divided into two types viz., acidic (composed of quartz, orthoclase, perthite, biotite, muscovite, garnet etc)
and basic rocks (composed dominantly of clino-
pyroxene and plagioclase).

**Marble:**

The term Marble is derived from Latin word "Maarmor" which itself comes from Greek root, meaning a shining stone. It is the recrystallised limestone. Commercially, marble is crystalline rock composed of calcite, dolomite or serpentine, which can take polish.

**Sandstone:**

Sandstone has been used in construction, rough slabs, tiles etc. The cementing material of these sedimentary rocks determines the degree of compaction, colour and thus ultimately the quality of these stones as dimension stones. The Vindhyan formations constitute an excellent storehouse of this category.

**Limestone:**

The limestones, generally used as dimension stones, comprise dolomitic limestone which are usually hard, argillaceous and siliceous in nature. The state of Orissa, though a potential store house of limestone has yet no record of utilization of this material as dimension stone.

**Slate:**

The metamorphism of shales under pressure produce slates, which are characterized by presence of close set planes along which they can be easily split into sheets.

**Laterite:**

It is a porous, pitted and clay like rock with a hard limonitic protective crust containing a large quantity of iron in form of red and yellow ochre. In Orissa, these are used for building purpose as substitute of bricks in the districts of Cuttack, Nayagarh, Khurda, Puri and Ganjam.

**Khondalite:**

Khondalites are a typical constituent of the Eastern Ghats. It is quartz feldspathic garnetiferous sillimanite schist/gneiss. These have been used for construction of temples and are presently being used in the form of tiles for exterior decoration and also for sculptural purposes.

**Occurrences:**

In Orissa, the Archeans which constitute about two-third of the landmass of the state host a variety of dimension stones like Granite, Khondalite etc. In particular, the following geological terrains are important.

a) Chhotnagpur -Singhbhum- Bonai :- Granites and gneisses of many types, dolerite, anorthosite, gabbro etc.

b) Eastern Ghats-Charnockite, khondalite, leptynite, anorthosite, pyroxene granulite, nepheline, syenite etc. (Sarangi, 1998).

**TIN ORE**

**Introduction:**

Tin is the major ingredient of solder and tinplate. Generally it is not used in its pure form. Mostly it is used as either alloyed with another metal or coated upon another metal. Cassiterite (SnO₂) is the only mineral of commercial importance as a source of tin, which contain 78.6% of tin and 21.4% of oxygen. Usually it is dark brown or black in colour with an adamantine luster. Cassiterite is a high temperature product of magmatic crystallization. It has a specific gravity of 7. The most of the World's tin is produced from placer deposits and richest placers are found in stream deposits. In India tin occurrences are confined to Bastar region of Chhattisgarh State and Malkangiri District of Orissa.
**Occurrences :-**

a) Malkangiri District is the main source/reservoir of tin ore in Orissa. Occurrence of tin (Cassiterites) was first located in Mundaguda-Salimi area of Malkangiri District by the State Directorate of Mining and Geology during 1974. The area surrounded by Bhimsen River in the west, Sarangpalli village in the east, Kolab river flowing westwards in the south, Lokti and Tulsidongar in the north.

b) Confluence of Ong and Mahanadi: Pegmatites and vein quartz emplaced in granitoid foliation contain tin values of up to 0.5%.

c) Confluence of Tel and Mahanadi: Pegmatites within the granite have gemstones along with tin, tungsten in dispersed manner.

d) The area in between Amuda and Manmunda; Bamunda and Karunapalli of Boudh District are also bearing the pegmatites which contain tin (Sn) along with Nb, Ta and W (Mohapatra and Mishra, 1998).

**GEM STONES**

**Introduction :-**

The stones having the qualities like natural origin, beauty, durability, uniqueness, rarity, hardnes and chemical resistance are characterised as gemstones. Diamond because of high value is treated as an exclusive species of gemstone. The gemstones whose occurrence have been recorded in Orissa include emerald, aquamarine, heliodor, chrysoberyl, alexandrite, tourmaline, ruby, sapphire, cat's eye, zircon, topaz, moonstone, quartz, garnet etc. Properties and characteristics of few common gemstones are given in Table 2.

**Occurrence :-**

The gemstone occurrences of Orissa are localised in

1. Eastern Ghats Granulite belt.
2. High grade supra-crustal rocks.
4. Alkali syenite.
5. Quaternary sediments and gravel beds.

The gemstones and their associated rocks and the location in the state are presented in the Tables 3, 4 (Mishra and Mohanty, 1998).

**LIMESTONE AND DOLOMITE**

**Introduction :-**

Limestone is a calcareous sedimentary rock composed of mineral calcite (CaCO$_3$), which on calcination yields lime (CaO) for a wide range of industrial uses. In its purest form, limestone should contain 56% CaO and 44% CO$_2$.

Dolomite is a double carbonate of calcium and magnesium containing 30.4% CaO, 21.7% MgO & 47.9% CO$_2$ in its purest form. Both limestone and dolomite also contain silica, alumina, iron oxides, alkalies, Phosphorous, Sulphur etc.

**Occurrence :-**

Orissa has vast resources of limestone occurring in three distinct geological settings, namely Gangpur group, Vindhya and Eastern Ghats, where as dolomite is mostly confined to Gangpur and Vindhyan Groups. These deposits are confined to following districts.

**District** | **Areas**
---|---
Sundargarh | Biramitrapur, Lanjiberna, Hatibari, Pumapani, Gatinagar, Gomardih.
Bargad | Dungri, Banjipali, Jampali.
Koraput | Umpavalli, Tummiguda (Sunki valley).
Malkangiri | Kottameta, Nandiveda, Uskalvagu (Rath and Rath, 1998).
GOLD

Introduction and Probable Occurrence:-

Based on the existing concepts of space-time relationship of various gold deposits all over the globe and more importantly on empirical geological criteria such as rock association, age, tectonic setting, depositional environment, geochemical association and abundances, the principal terrains for identification and delineation of gold targets are:

1. Badampahar - Gorumahisani belt.
2. Tomka-Daitari to further north-west upto south of Jamda-Koir valley.
3. Possible Archean greenstone in Bonai craton.
4. Bengpal Group, granitoids and the contact zone with Eastern Ghat granulite.

OTHER MINERALS

The other minerals and ores which occur in the state and some of which are being mined include pyrophyllite, quartz, quartzite, kyanite and steatite etc.

Pyrophyllite

Introduction :-

It is a hydrous aluminium silicate used mainly in refractories making. Pyrophyllite occurs in the form of quartz-pyrophyllite schist associated with granite and also quartz reef.

Occurrences :-

The occurrences of the state are associated with Singhbhum-Bonai granite. The major deposits are Anjor, Balabhadrapur, Nitigotha, Madrangajodi, Roduan, Rampakot, Dalimpur of Keonjhar District. Joshipur and Manada of Mayurbhanj and Lahunipada in Sundargarh District.

Kyanite, Sillimanite & Andalusite :-

Introduction: These are anhydrous aluminum silicate minerals. This group of minerals is believed to be products of anhydrous metamorphism of argillaceous sedimentary rocks.

Occurrences: Refractory grade kyanite confined to Panijia in Mayurbhanj District. Occurrence of quartz bearing kyanite are confined to Magarmuhan, Torodanali, Jhili, Golagadia, Paliaharra, Kamakhyanagar of Angul & Dhenkanal districts.

Soap Stone, Steatite and Talc :-

Introduction: These are soft hydrous magnesium silicate with chemical composition $3\text{MgO}_{4}\text{SiO}_2\text{H}_2\text{O}$.

Occurrence :- These deposits are confined to Mayurbhanj, Sambalpur, Sundargarh, Ganjam & Dhenkanal districts. Mayurbhanj district is contributing about 95% of the total production.

Quartz & Quartzite

Introduction: The use of quartz and quartzite depend upon its silica content. Quartzite and quartz are used in the manufacture of silicon refractories, as a flux in iron and steel and ferroalloy industries, abrasive industry and also for manufacture of silicon alloys, glass and sodium silicate.

Occurrences: Generally these are found in almost all the districts of the state except in the coastal planes (Mohanty, 1998).

Conclusion:

Now we doubt that the continuing degradation of the natural environment by exploring above-mentioned minerals poses one of the greatest challenges to modern societies. In particular all mining activities create a burden on
the environment although paradoxically at the same
time the revenues gained from these activities
create the basis for our well-being. Major
problems include global warming, loss of
biodiversity, water and air pollution, releases of
persistent organic pollutants and other toxic
substances and land degradation. There is an
intimate relationship between mine workers and
people of near by surroundings and the potential
exposure to toxic substances, pollutants and
wastes. Air pollution, surface water pollution,
ground water contamination, devegetation and
defacing of landscape, subsidence of land,
occupational health hazards etc. are the major
impact of mining leading to various environmental
damages. Mining operations may be categorized
as either surface or underground. Surface mining
may be broadly defined to encompass open pit,
open cast, quarry, strip, dredging and placer
(hydraulic) mining. Underground methods include
pillar-and-stope, shrinkage stope, block caving
and longwall mining. Most mining operations
(whether surface or underground) share a number
of common stages or activities, each of which have
potentially adverse impacts on the natural
environment, social and cultural conditions, or the
health and safety of mine workers.

Expansion within the mining and
metallurgical sector leads to the development and
economic growth of our country. The products
of the sector (including metallic and non-metallic
minerals, construction materials) are not only
essential for construction activities and many
industrial processes, but are also often a valuable
source of foreign exchange earnings. However,
mapping operations frequently involve a high degree
of environmental disturbance, which can extend
well beyond the extent of mineralized areas. The
environmental impacts of a mining operation
commence with exploration activities, extend
through extraction and processing of minerals, and
may continue post-closure of the operation. The
social and environmental issues associated with
mining and mineral processing operations are both
highly significant and complex to manage. The
fixed location of the mineralized zone of interest
imposes constraints on all aspects of mining
developments including the method of mining,
location of mine facilities, requirements for new
infrastructure and services and the suitability of
waste management or disposal methods. This in
turn profoundly influences the environmental,
social and health impacts of mining developments,
as well as the economic viability of developing a
given mineralized zone. The challenges with
Environment Assessment of mining projects are
twofold--- firstly, to ensure that environmental,
social and health impacts of mining developments,
and the economic viability and acceptability of the project; and secondly to
ensure that adequate mitigation or protection
measures are incorporated into project design.
This requires both effective environmental
legislations and enforcement by regulatory
institutions, and sound environmental management
practices by private and public sector mine
operators. In order to minimize the adverse
impacts of mining it is desirable to adopt eco-
friendly mining technology. Restoration of mined
areas by re-vegetating them with appropriate
plant species, stabilization of the mined lands,
graudal restoration of flora, prevention of toxic
drainage discharge and conforming to the
standards of the air emissions are essential for
minimizing environmental impacts of mining in such
a state like Orissa having enormous mineral
potential.
### Table 1: Specification of Beach Sand Minerals and their application (Siddiqui, 1998)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Chemical composition</th>
<th>Specific gravity</th>
<th>Major applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilmenite</td>
<td>FeO.TiO$_2$</td>
<td>4.67</td>
<td>Manufacture of titanium dioxide, production of synthetic rutile and Ferro-titanium alloys.</td>
</tr>
<tr>
<td>Rutile</td>
<td>TiO$_2$</td>
<td>4.1</td>
<td>Coating of welding electrodes, titanium dioxide pigment, production of titanium sponge and metal.</td>
</tr>
<tr>
<td>Zircon</td>
<td>ZrO$_2$SiO$_2$</td>
<td>4.68</td>
<td>Foundries, ceramics and refractories, manufacture of Zirconium metals and chemicals.</td>
</tr>
<tr>
<td>Sillimanite</td>
<td>Al$_2$O$_3$SiO$_2$</td>
<td>3.24</td>
<td>Manufacture of high temperature refractories.</td>
</tr>
<tr>
<td>Garnet</td>
<td>3RO.R$_2$O$_3$.3SiO$_2$</td>
<td>4.68</td>
<td>Manufacture of abrasives, for polishing glass/T.V tubes, wood for sand blasting and water filtration.</td>
</tr>
<tr>
<td>Monazite</td>
<td>Phosphate of the Rare Earths with variable amounts of thorium.</td>
<td>5.10</td>
<td>Production of rare earth compounds, Thorium, Uranium, Helium etc.</td>
</tr>
</tbody>
</table>

### Table 2: Properties and characteristics of some common gemstones (Mishra and Mohanty, 1998)

<table>
<thead>
<tr>
<th>Name</th>
<th>Composition</th>
<th>Colour</th>
<th>Moh's hardness</th>
<th>Specific gravity</th>
<th>Refractive Index (RI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amethyst</td>
<td>Silica</td>
<td>Purple</td>
<td>7.0</td>
<td>2.65</td>
<td>1.56</td>
</tr>
<tr>
<td>Beryl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquamarine</td>
<td>Beryllium, Aluminium, silicate</td>
<td>Blue green to light blue</td>
<td>7.5-8.0</td>
<td>2.63-3.80</td>
<td>1.58</td>
</tr>
<tr>
<td>Heliodor</td>
<td>-do-</td>
<td>Yellowish green</td>
<td>7.5</td>
<td>2.63-3.80</td>
<td>1.58</td>
</tr>
<tr>
<td>Corundum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ruby</td>
<td>Aluminium oxide</td>
<td>Rose to deep purplish red</td>
<td>9.0</td>
<td>3.95-4.10</td>
<td>1.78</td>
</tr>
<tr>
<td>Sapphire</td>
<td>-do-</td>
<td>Blue, Light Yellow</td>
<td>9.0</td>
<td>3.95-4.10</td>
<td>1.78</td>
</tr>
<tr>
<td>Diamond</td>
<td>Carbon</td>
<td>white, blue, white, pink yellow, brown, green</td>
<td>10.0</td>
<td>3.5</td>
<td>2.42</td>
</tr>
<tr>
<td>Gemstone</td>
<td>Host Rocks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Iolite   | Al, Mg silicate with Iron  
Gray, light or dark blue, violet  
7-7.5  
2.53-2.65  
2.54 |
| Chrysoberyl | Beryllium aluminates  
Green by day and red by artificial light  
8.5  
3.5-3.84  
1.75 |
| Alexandrite | Beryllium aluminates  
Green by day and red by artificial light  
8.5  
3.5-3.84  
1.75 |
| Cat’s eye | -do-  
Greenish to brownish  
8.5  
3.5-3.84  
1.75 |
| Feldspar | Moonstone  
Alkali aluminium silicate  
White  
6.0-6.5  
2.77  
1.52-1.54 |
| Garnet | Complex silicate  
Brown, black, yellow, green, ruby red, orange  
6.5-7.5  
3.15-4.30  
1.79-1.98 |
| Topaz | -do-  
White, blue, green  
8.0  
3.4-3.6  
1.62 |
| Tourmaline | -do-  
All including mixed  
7.0-7.5  
2.98-3.20  
1.63 |
| Zircon | Zirconium silicate  
White, blue, brown, yellow, green  
6.0-7.5  
4.0-4.8  
1.79-1.98 |

Table 3: Gemstone and their associated rock (Mishra and Mohanty, 1998)

<table>
<thead>
<tr>
<th>Name of the Gem Stone</th>
<th>Host Rocks</th>
</tr>
</thead>
</table>
| 1. Ruby and sapphire. | a. Contact of pegmatite and ultramafic rocks.  
b. High grade pelitic (kyanite-sillimanite) schists  
c. Nepheline syenite  
d. Cordierite-sillimanite-garnet schists and Paragneisses. |
| 2. Emerald and Aquamarine. | Contact of beryl bearing pegmatite with ultramafic rocks. |
| 3. Alexandrite and Chrysoberyl cat's eye. | Pegmatites in Khondalite suite of rocks. |
| 4. Rhodolite, almandine and uvarovite garnets; fibrolite cat's eye iolite. | High-grade pelitic schists. |
| 5. Amethyst, topaz, aquamarine, heliodor, tourmaline, moonstone, labradorite, microcline. | Pegmatite. |
Table 4: Gemstones and their district wise location in Orissa, India
(Mishra and Mohanty, 1998)

<table>
<thead>
<tr>
<th>Location</th>
<th>Gem stone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angul District</td>
<td>Quartz, Garnet</td>
</tr>
<tr>
<td>Magarmuhan - Jhilli Nuagan</td>
<td>Aquamarine, heliodor</td>
</tr>
<tr>
<td>Sambalpur District</td>
<td>Aquamarine, garnets</td>
</tr>
<tr>
<td>Chabhati-Beldihi</td>
<td>Garnet, green tourmaline, aquamarine</td>
</tr>
<tr>
<td>Bagdhapa- Tabloi</td>
<td>Hessonite</td>
</tr>
<tr>
<td>Meghpal-Ranchipada</td>
<td>Green tourmaline</td>
</tr>
<tr>
<td>Deogarh District</td>
<td>Emerald, topaz, heliodor and aquamarine</td>
</tr>
<tr>
<td>Sambalpur District</td>
<td>Chrysoberyl and Cat's eye</td>
</tr>
<tr>
<td>Jharsuguda District</td>
<td>Orange, brown and yellow colour zircons, topaz and amethyst</td>
</tr>
<tr>
<td>Meghpal-Ranchipada</td>
<td>Green beryl, aquamarine, heliodor and amethyst.</td>
</tr>
<tr>
<td>Bolangir District</td>
<td>Rhodolite garnets.</td>
</tr>
<tr>
<td>Ghuchepali-Antarla</td>
<td>Greenish blue to sea blue aquamarine</td>
</tr>
<tr>
<td>Ghumsar-Dehli</td>
<td>Garnets, topaz, Cat's eye</td>
</tr>
<tr>
<td>Muribahal- Tentelkhunti</td>
<td>Cat's eye, topaz, zircon, moonstone, agate, diamond.</td>
</tr>
<tr>
<td>Saraibahal-Suklimuri</td>
<td>Garnets, topaz, iolite, tourmaline and diamond.</td>
</tr>
<tr>
<td>Naktamunda-Siali</td>
<td>Ruby</td>
</tr>
<tr>
<td>Subarnapur District</td>
<td>Hessonite garnet and zircon</td>
</tr>
<tr>
<td>Badmal-Mursundi</td>
<td>Blue opaque corundum, apatite, aquamarine</td>
</tr>
<tr>
<td>Binika-Sonepur</td>
<td>Blue iolite and fibrolite</td>
</tr>
<tr>
<td>Boudh District</td>
<td>Yellow sapphire.</td>
</tr>
<tr>
<td>Boudh-Ramgarh</td>
<td>Almandine garnets, iolite</td>
</tr>
<tr>
<td>Kantamal-Manmunda</td>
<td>Cat's eye</td>
</tr>
<tr>
<td>Kantamal District</td>
<td>Cat's eye</td>
</tr>
<tr>
<td>Jilingdhar-Hinjilibahal</td>
<td>Sillimanite Cat's eye</td>
</tr>
<tr>
<td>Orhabahala-Urharanga</td>
<td>Chrysoberyl.</td>
</tr>
<tr>
<td>Ghatalpara-Singiharan</td>
<td>Almandine garnets, iolite</td>
</tr>
<tr>
<td>Sirjapali-Tundla</td>
<td>Hessonite garnet and zircon</td>
</tr>
<tr>
<td>Banjipadar-Sargiguda</td>
<td>Blue opaque corundum, apatite, aquamarine</td>
</tr>
<tr>
<td>Nawapada District</td>
<td>Cat's eye</td>
</tr>
<tr>
<td>Sardhapur-Patialpada</td>
<td>Yellow sapphire.</td>
</tr>
<tr>
<td>Katamal-Babebir-Amera</td>
<td>Almandine garnets, iolite</td>
</tr>
<tr>
<td>Damjhar-Burhapa-Mantritarai</td>
<td>Black opaques, iolite</td>
</tr>
<tr>
<td>Rayagada District</td>
<td>Tourmaline.</td>
</tr>
<tr>
<td>Paikdakulguda-Hatamuniguda</td>
<td>Cat's eye</td>
</tr>
<tr>
<td>Irkubadi-Tarhama</td>
<td>Sillimanite Cat's eye</td>
</tr>
<tr>
<td>Karlaghati-Karanigurha</td>
<td>Chrysoberyl.</td>
</tr>
<tr>
<td>Phulbani District</td>
<td>Cat's eye</td>
</tr>
<tr>
<td>Bargochha</td>
<td>Cat's eye</td>
</tr>
<tr>
<td>Belghar</td>
<td>Cat's eye</td>
</tr>
</tbody>
</table>
References:


Rakesh Kumar Satapathy and Shreerup Goswami are working in the P.G. Department of Environmental Science, Fakir Mohan University, Vyasa Vihar, Balasore.