A REPORT ON
SMALL-SCALE MICA MINING IN KODERMA REGION

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Abstract

Small-scale mining is prevalent in India and this study overviews the contribution of small mines to national mineral production. India is the major producer and exporter of sheet mica and various forms of mica products. This report highlights the major mica producing states in India and it examines the present and future of mica mineral in the Koderma region. It investigates the mica production, value of the mineral output, number of people engaged with this industry, development of mica pegmatites and it discuses about the types of mica control, structural aspects and prospecting of mica mineral in the region. It focuses on the various uses and specifications of different forms of mica and the present and future demand of scrap/ground mica. It also examines the impact of mining on women community and discusses the employment and social perspectives of women workers in this industry. It reviews the Indian Mines Act for employing female workers. Practices in small mining, barriers to technological upgrading and environmental management aspects are discussed. The report concludes that the socioeconomic significance of mica mining operations is often overlooked, and there is a need to protect its economic and social benefits. This sector has significant potential to contribute to the Indian economy and to generate employment;

Keywords: Pegmatite, micanet, lithological, socioeconomic, rural employment

1.0 Introduction

India is well known as the largest producer and exporter of mica in the world. Although mica pegmatite occurrences have been recorded in many states in India, mica is mainly produced from four states, namely Jharkhand, Bihar, Rajasthan and Andhra Pradesh. A small amount of production is reported from Tamil Nadu, West Bengal, Orissa and Madhya Pradesh. The location of major mica belts in India is shown in Figure 1. Pegmatites in general are regarded as an independent group of rocks of late magmatic origin. In fact pegmatites mark the concluding stages of magmatism (Smirnov 1965)· Silicates and oxides are the major constituents of pegmatites. Granitic pegmatites, originating and following the direct line, contain potash feldspar, quartz, plagioclase and biotitic. Besides these major pegmatite-forming minerals, muscovite, tourmaline, topaz, beryl, lepidolite, fluoride, apatite, rare earth minerals and radioactive minerals occur in pegmatite in varying proportions. Hybrid pegmatites formed by the assimilation of argillaceous rocks, might contain carbonates of calcium, magnesium and iron, hornblende, pyroxene, titanite, scapolite and other minerals

Valuable mica occurs in granitic pegmatites in which the constituent minerals crystallized on a large scale. This pegmatite occur as vein or dyke like masses and are found associated with mica schist, quartzites and other rocks of Archean Age. It is also observed that lenticular pegmatite bodies of irregular shape are found to include schists, generally along but sometimes across the folia (Holland 1902). The pegmatites generally occur in varying size and shape. It may be a few cm to more than a km in length and width from a few cm to more than 200m. Depending on the shape of pegmatite bodies observed in all the three belts, they are generally known as dykes, sheets, lensed and elliptical bodies. As per the shape of the pegmatite, they are called tabular, lenticular, branching and irregular. These are also pipe-like, cigar-shaped, accurate, trough-like and sinous pegmatics as well. In addition to the above shape and size of the pegmatites there are certain terminologies used to describe the pegmatics in different mica belts. These details have been delt separately while describing individual mica belt. Generally mica pegmatics are divided into homogeneous and heterogeneous. Zoned pegmatite units or the zoning in the pegmatites are the most important internal structural features. Zones in the pegmatite are successive shells, which commonly the shape of a pegmatite body. Commonly these are not developed with ideal symmetry. In general, zones nearest the walls of pegmatite bodies are more extensive and more continuous than zones nearest the core.

The criteria adopted for categorizing mines as small, medium and large scale, differ from country to country, and there exists no universal yardstick. In India, the mining and quarrying enterprises of industrial minerals and construction materials that occurs at subsistence level throughout the country i.e. operations producing relatively smaller quantities of mineral and employing relatively fewer persons, are termed as small mines (Rudra 2002). The maximum production capacity of 50,000 tonnes per annum has been accepted as the criterion to define Indian small-scale mines (Ghose 2003a). It is recognized that small-scale mining can make a significant contribution to development, which has been one of the principal motives for a persistent interest in the sector (Noetstaller 1994).

At present, the Indian mining industry comprehends almost the entire spectral of extractive and mineral products, including iron ore, coal, lignite, base and precious metals, building materials and gemstones. Operations range from small-scale mining through to some of the largest mining operations in the world. India ranks among the top ten mineral producing nations in the world, and its economy depends largely upon the revenues accrued from minerals output (Ghose 1986). Mineral distribution in the country is widespread; the prospective deposits occurring in areas, which include the fragile foothills of the Himalayas, deserts, arid and semi-arid regions, along vast coastlines, plains and rich forests (Srivastava 1987; Ghose and Kumar 1997a). Quite commonly, mineral deposits are worked in areas considered ecologically sensitive and/or rich in bio-diversity (Rai 1994;Ghose and Sen 2001). Various mining methods are used ranging from major opencast and strip mines, through underground long wall and hard rock ore mines, through dredging operations, soil and gravel extraction, to hand excavation of gemstones.

Women are involved in mining in three different ways – those who are working in the extractive process, those who are involved as workers in sorting and crushing of the preparation of minerals, and those who are working as clerks, peons secretaries, nurses etc. However, it is crucial to examine women as miners in the context of these women workers. . It is an area where women are usually disadvantage in mining as the contextual framework, which allows overtime and place in a very heterogeneous field (Chakrabarty 1989). Whereas it is true that women miners are indeed hidden from history and any attempt is made to recover the needs to conceptualize them within the problematic of mining history. In many instances the low profile of women miners takes on a particular quality due to contrasting high public profile of male miners.

2. 0 Contribution of small-scale mining to national mineral production in India

Small-scale mines represent a growing and important component of the mineral sector in terms of output value, contribution to the economy and employment. It has been estimated that small-scale mines worldwide contribute about one sixth of the value of global non-fuel mineral production (Argall 1978). In many developing countries, the output is significantly higher. In India, some 3000 small-scale mines account for about 5% of fuel mineral production (Ghose 2003b).A difficulty in studying small-scale mining in India is the absence of any nationally accepted criteria for identifying such mines. As a result, no statistical data are collected, maintained and published for proper appreciation of the role of small-scale mining in the country's economy. It has been reported (Chakraborty 2002) that such mines constitute about 90% of the total number of mines (about 3,700) and produce about 42% of the value of total output of non-fuel minerals and minor minerals taken together, and 6% of fuel mineral (coal) (Anon 2001a). If the production from non-reporting informal mines (500) is added up, all of which work on a small scale (mostly extracting minor minerals), the total contribution of the small-scale mining sector would be slightly higher.

Nevertheless, small-scale mining is more prevalent in India. Available facts and figures indicate that current small-scale mines in India will continue to be in operation for decades to come (Ghose 1990b). For the growth of the Indian mining industry, it is therefore essential to improve their techno-economic efficiency in all spheres of activity: from exploration to exploitation, including management and control (Chakraborty 2002). It is estimated that the share of Indian small mines in global small-scale production in certain minerals is significant, especially antimony (45%), calcium (50%), chromites (75%), clays (75%), feldspar (80%), fluorspar (90%), gypsum (70%), tungsten (80%) vermiculite (90%) (Table 1).

Out of some 80 minerals, including minor ores, being mined in India, around 70 of them are extracted by the small-scale sector (Table 2) (Ghose 1991). The number of small-scale mines contributing to the production of selected important minerals in India between 1985 and 1990 is given in Table 3. However, it is not easy to group these mines. In many mines, production is as low as tens of tonnes per day or even less, while some mines have a daily production of 150 to 200 tonnes. Investment and productivity in these mines also vary widely. While some of the mines are operated manually, some are considerably mechanized.

India could have derive a number of benefits from small-scale mining. It is the only alternative to exploit small deposits and can be undertaken with small capital input and a short gestation period. The sector has high employment potential and around 0.5 million people are currently employed in Indian small-scale mines (Carmen and Berger 1990). Unfortunately, the potential benefits are hardly realized in Indian small-scale mines (Cramer 1990). Each small-scale mining area has its own unique techno-economic and socio-cultural characteristics. To have a clear concept of the major problems common to the sector, one needs to know the geological, mining engineering and socio-economic circumstances within which each operates.

Women in Indian mining are indeed a nontraditional activity, and consequently there is a tendency to conceal the fact that women constitute an important segment of the work force. The socioeconomic characteristics of women as miners and the productive roles that these women play in mining tend to be overlooked. Mining is commonly seen as a masculine industries and it is commonly believed that Indian women play an insignificant role in it. In view of recent economic changes in industries, there is a need to review women's involvement in the industry and re-valuation of the prospects of women miners, and their work in the mines need to be examined . The objective of this investigation is to review the participation of women miners in Indian mica mineral industry and to ascertain the ways how this can be achieved with the provision of better and more training arrangements leading to capacity building, skill enhancement and improved safety in mines.

3.0 Investigations on Koderma region mica mines

India is the major producer and exporter of sheet mica and various forms of mica products. Presently, major mica producing states /districts are Jharkhand (Hazaribagh, Koderma and Giridh districts),Bihar (Nawada district), Andhra Pradesh (Nellore district) and Rajasthan (Bhilwara district). The Koderma mica belt lies between the latitudes $24^0 20^'$ and $24^0 45^'$ and longitudes $85^0 20^'$ and $86^0 15$ with a general trend of ENE-WSW extending for about 150 km length and 20 km with and covers an area of about 3000sq.km. The area runs along the nortern fringe of Chotonagpur pleatu,traveling the districts of Hazaribagh, Koderma, Nawada, Giridhi and Munger (Prassad 1980). Although in the past mica mining was carried out in all the parts of the belt in a scattered manner, at present the mining activities are confined mostly in the districts of Hazaribagh, Nawada and Giridhi. (Anon 1983)

Koderma region is situated in the in the southern portion of Koderma Reserve Forest and Khasmahal area of Koderma. The mica pragmatics found is generally small pipe type and lenses. The important mica mines are shown in Figure 2 . The mica in these areas is of ruby color, but green, white, silvery and brown colored mica are also found in some places. Mica occurs as varying generally from 15 to 30cm across but may extend up to 90cm or more. The average thickness of the blocks is 7.5cm to 10cm but may go up to 60cm and even more (Anon 1990). Occurrence of lepidolite mica are more reported as disseminated blocks as small segregated pockets in pneumatics near Bajayia. The geology of this belt have mainly been studied through granitic rocks and are divided into a broad types, i.e. (i)strongly to mildly foliated and lineated gneisses, porphyritic at places , but mostly non-porphyritic and occurring mostly as phacelithic sheets along the masses and limbs of the folds ; and (ii)massive equigranular types forming sub-elliptical boss-like bodies foliated along their margins with the country rocks. These granites and schists are again traversed by basic intrusives, pegmatite and quartz veins, and it is seen that these pegmatics are the sources of mica depending upon the rocks in which they are intruded (Mahadev and Maithani 1967).Two types of controls, i.e. lithological and structural, have been detected (Anon 1976)

An essential prerequisite for developing mica pegmatites is to carry out a systematic mining-geological study of a given mine and the adjoining areas . During the mining-geological studies, surface and underground geological plans and sections of its adjoining areas and mine are to be prepared. Structural set up in which the pegmatite is emplaced is to be clearly brought out. Internal units of the pegmatite body are to be studied. Concentration of commercial mica with respect to the structural set up and internal zoned units of the pegmatite are to be recorded.. All these information for the entire pegmatite body as revealed on the surface and the underground developments are to be processed and studied in detail with an analytical approach and thus certain conclusions are drawn in favor of locating promising mica zones in the pegmatite body. It can also provide clues for exploration and systematic development of the mica deposits in the particular mines or may serve as a guide for any other mine in the particular belt.

The mining of mica has been going on over 100years. Almost all the mica mines are started initially as opencast workings known as “Upper challa”. During the course of time as mica continued to persist in depth , the underground method of mining is adopted. The Indian mica industry has been flourishing up to 1950’s and the production of crude mica was about

30,000 tonnes per year from over 700 mines, which employed around 24,000 persons. However during the last five there is a continuous decline due to the closure of a number of mines. Mica is considered a strategic mineral...It has been reported that during the year 2001, the number of mica mines operating was Koderma region 32 (Anon 2001b) . Average daily employment below the ground was 342 persons , in opencast workings 82, above the ground 185 with a total employment of 609 persons only. Total quantity of mineral mica output during the year 2001 was 3,202,000 tonnes and the value of mineral output was INR 69(million rupees). This study reveals that for the collection of scrap mica about 20,000 people are engaged out of which fifty percent are women and child workers. Their average income is between INR60 to 100 per day.

Jharkhand is the largest producer of mica in India. During the year 2001, in Koderma region the number of mica mines submitted the returns was 3 , average daily employment was 102, production was 42,787 tonnes and value of mineral output was INR 1949,000.Production of scrap and waste mica from the Koderma region declines from 2,081 tonnes during 1975 to 1,872tonnes in 1976. However, it recovered slightly to 1,902 tonnes in 1977 and declined to 1,235 tonnes in 1980. During 1981 production recovered to 1,779 tonnes and rose to 2,266 tonnes and further 1,084 tonnes in 1988 Within the Koderma region of Jharkhand state operations inherently unsafe and are highly environmentally destructive. Technologies rarely extend beyond jackhammers, drills, and winches, although a small group of operations have winding system. Though mica is the major mineral mined in this region the statistics indicate that this industry is currently on the decline because of stiffer competition within the international mica market and recent developments of artificial substitutes of mica

In Koderma mica belt, a number mines have indicated the concentration of mica along and around the schist bodies. In Karitary mica mine(Prassad 1975a) of M/s Singho Mica Mining Co. the pegmatite has a strike length of 170m with a width of 2 to 10m. The pegmatite body strikes due NW-SE and dips 75^0 due west. Mica concentration is seen near the hanging wall schist and also observed all along the included thin layers of schist and mineralisation particularly rich in the eighth and ninth level.

The other important mine where the mica concentration seems to be fair to rich around schist patches is the Pananwa No3 mica mine (Ramanathan 1975; Prassad and Naik 1976) . In this mine two pegmatite bodies, A and B have been developed. The mine is developed for seven levels . the second level of this mine is developed in an NE-SW direction. The NNE portion drive, pegmatites A and B are seen divided by a parting schist of nearly 8 to 9m running in NNE direction. Good mica concentration of 100-150kg/m^3 has been noted in this region (Figure 2)

In Sethwa mica mine (Prassad et.al 1976; Ramanathan 1977a) mica mineralization is observed around a caught-up patch of schist. A number of pegmatites have been developed in this mine . The mine is developed for 22 levels . The 21st level has been developed to a length of 40m. The pegmatite shows pinching and swelling properties . in the southern part of the 21st level drive falling near the incline , a patch og caught-up schist of 2m by 0.5 is seen . The production rate in this part is of the order of 100-150 kg/m^3 . In other parts of the drive , the average production rate has is less than 100-150 kg/m^3 (Figure 3A,B)

Quartz bodies represent more important lithotomical control observed in zoned pegmatites. These bodies are mainly observed in zoned pegmatites where Quartz bodies occur as as a core around which mica concentration is found In the other types of pegmatites , these are known as quartz ponds. In Parbati No. 1 mica mine (Prassad 1976b) , 6here are two lentoid pegmatite bodies. The mine has been developed for four levels. Mineralisation in all the levels is seen around the core only. Level No. 2B is a good example of this type of mineralisation In this level, mica concentration is near the contact quartz core only.. Mica books are seen in the entire zone between quartz core and mica schist wall (Figure 4)

Another important mica mine in this region where the mica concentration around the quartz core and pods has been observed is Paisara (Prassad 1974;1977; Kumar 1968) mica mine. The mine is developed for eight levels . Mica concentration is seen around the quartz pods in third, fourth, sixth and seventh levels. In all these levels , the mica zone is found around quartz pods of varying dimensions (Figure 5) . Another good example of mica concentration around quartz pods is in the 19th level of Sethwa mine(Prassad et.al 1976) . The production of mica , here is reported to be 200kg/m^3 around quartz pods which is 3m long ang and 05m to 2m wide. Quartz is seen near grid S 8. In the strike direction , the mica zone nearly for 4m either side of the quartz pod(Figure 3).

Structural aspects also play a very important role in the concentration of mica in pegmatite. Pegmatite with good mica concentration is observed along the following structural locales , viz. either footwall or hanging wall or along the both the wall contracts, where there is change in strike and/or dip schists, along joint planes, slip planes, faults and fracture zones. In this region, mica mineralisation along the wall contacts has been found practically in all the mines and in this context mention can be made of Mohanaria mica mine (Sarker 1966) Pit No. 1 . Incline No. 1 in this mine has followed a pipe pegmatite , exposed in a shallow working. At the mouth of this incline , the pipe has roughly elliptical and shows thick quartz core surrounded by a comparatively thin layer of intermediate barren pegmatite. At the hang wall , the barren pegmatite zone is surrounded by a 0.4m wide fairly rich mica shoot. The maximum length of the shoot is about 9m in a roughly NW-SE direction and the maximum width across is about 2.4m(Figure 6)

In Parbati mica mine (Prassad 1975b)' mineralisation is seen along the hanging wall. In the first level, the mineralisation is found between the hanging wall schist and the quartz core, i.e. the hanging wall zone. Another important mine is the Salaya mica mine (Ramanathan 1977b) . In this mine , only one pegmatite has been developed. The pegmatite trends NE-SW with a dip towards NW varying between 60^0 to near vertical. The pegmatite has pinched out in the southwestern part in the third and the fourth levels. It has also been observed that the pegmatite shows attenuation and widening both along the dip and strike directions . The concentration of mica is good along the footwall contact of pegmatite with schists. The incidence of crude mica is of the order of 200-300kg/m^3 in mica shoots at the contacts in the fourth level. The other mineralized portions are near the quartz pod and caught-up patches of schist. But the concentration is seen only along footwall..

In a number of mica mines , good mica zones can be located from the presence or absence of certain minerals in pegmatite. Mica is seen concentrated or associated around or along with some minerals like quartz , feldspar, apatite, tourmaline, garnet etc. and these minerals are called indicator minerals. Grain size of the pegmatite is also an important factor. As observed , mica is generally associated with coarse and medium grain pegmatite. Mica mineralisation in Parabati No.1 mica mine is associated with the keolinised feldspar, smoky quartz and fine crystals of garnet. The concentration of the medium sized ruby mica books in the fourth level of Mine No.20, Pit No.64 is associated with smoky quartz and plagioclase feldspar in 60:40 ratio

Mica prospecting

It has been observed that the mica concentration in the pegmatites is peculiar and erratic due to which systematic mining has not been carried out and mica prospecting is still going on by trial and error methods. To overcome all the difficulties faced during the mica mining , an attempt has been made to evolve certain broad guidelines based on mining-geological studies for the prospecting and exploration of mica deposits. Although mica pegmatites are highly complex in nature , during mining-geological studies of mica mines, data pertaining lithological, structural and minerarological aspects for the concentration of mica at particular places in a pegmatite are collected .

4.0 Uses and specifications of mica

Mica is the group name for a number of complex hydrous aluminum silicate minerals that have a sheet or platy structure. Out of the seven important species of the mica group, muscovite and phlogopite are the two main commercial types. Among these two the muscovite is of major significance and accounts for the bulk of sheet mica production in the world. The world demand of sheet mica has been declining during the last three decades because of technological advances as well as development of substitutes.(Anon 1990) As a result of these developments, production of crude mica in the country has declined and was only 3,839 tonnes during 1988. However, the production of waste and scrap mica has remained steady, and rather has risen because of the increase in demand of this type of mica for export market.

Though India remains to be a major producer of mica in the world, its domestic consumption is very limited and as a result in continues to be a predominant exporter of various forms of mica and mica based products. However, there has been a declining trend in the exports of mica particularly of blocks and splittings. There has been an increase in the exports of scrap mica for use as a raw material for the manufacture of mica paper, which is a substitute for block mica, and splittings in most of their uses. The Government had canalized the exports of processed mica through Minerals & Metals Trading Corporation of India (MMTC) w.e.f. 24th January 1972. Subsequently, the MMTC set up a subsidiary organization, namely Mica Trading Corporation of India (MITCO) w.e.f. 1st June 1974. A Committee on mica industry/trade recently set up by the Ministry of Commerce has however recommended in its Report dated 24th February 1990, that the MITCO should b merged with MMTC and should function as a separate Division of MMTC, responsible for mica trading. While the production of mica and the labor employed in mica has been falling in the country, there is no study available regarding the actual status of demand of mica in India and in various markets of the world.

4.1 Uses of mica

Uses of natural sheet mica (blocks, films, splittings), manufactured sheet mica (micanite, mica paper), scrap mica/ground mica, and synthetic mica in different industrial applications are discussed .

Natural sheet mica

Natural sheet mica, either as blocks, splittings and films or as composite pieces in the built-up form also as micanite (made from mica splittings), is principally used in the electronic and electrical industry because of its unique electrical and thermal insulation properties and its mechanical properties which allow it to be cut, punched or stamped to close tolerances. There are a very large number of grades (represented by various sizes) and qualities of sheet mica

Block mica

Mica blocks are used as spacers in vacuum tubes for positioning and supporting the tube elements. The insulating properties of mica effectively separate the electrons surrounding the cathode from the positive charge carriers surrounded by anode. The major applications for vacuum tubes are in radio and television receiving sets. Earlier, end-uses accounted for the bulk consumption of block mica. But, the development of solid-state electronics and miniaturization in the electronic industry, transistors has replaced thermionic valves in radio and television receivers. This has resulted in the drastic decline in demand of mica in the vacuum tube industry. Mica blocks are used now only for specialty tubes for use in the production of professional electronic equipment and other strategic applications.

Block mica is also fabricated into washers of various sizes which act as insulators in electronic equipment. Electrical insulators of block mica are used in DC motors, generators, electric lamps, transformer coils, etc. Sizeable quantity of block mica is used in heating electrical elements industry and in auto electrical parts. Generally lower quality of block mica is used for these purposes. However, micanite and mica paper products are substituting block mica in most of the above applications. Block mica has a number of applications in guided missiles. The electrical, physical and heat endurance properties of natural mica combine to make it an excellent tool for the Missiles Engineer.

High quality block mica is also used for non-electrical and non-electronic uses like the lining of gauge glasses of high pressure steam boilers, diaphragm for oxygen-breathing equipment, market dials for navigation compasses, optical filters, retardation plates in heliumneon lasers, pyrometers, thermal regulators and stove windows. Transparency, flexibility, resistance to heat and chemical attack are the properties that make mica suitable for these applications. A process has been developed in the USA to coat sheets of high quality block mica with gold and silver specific patterns. These coated discs and stamped sheets are used in communication devices which take advantage of the dielectric and insulating properties of natural block mica for providing base for conductive circuits. Mica washers have gained extensive use in the computer industry. The small thin mica discs serve as gap separators in recording heads. Block mica is also used in microwave windows.

Mica films

Mica films are used extensively in all types of electronic condensers having an average dielectric constant of 7 and a dielectric strength at elevated temperatures that is greater than the other known insulting materials. Mica has been acknowledged as one of the most dependable insulations for all types of electronic capacitors. Earlier capacitors used entirely foil electrodes. In recent years, by a silk screening process, a layer of silver is deposited on the surface of the mica, which is used as an electrode. The excellent mechanical and electrical properties of natural mica films make it an ideal washer backing material for top and bottom of transistors mounting. High quality film mica is used for its dielectric property in electrical capacitors. Because of low power losses with alternating current, and extreme close tolerances of capacitance, mica capacitors assume importance in electronic circuits. Over the last 25 years, the capacitor industry has experienced numerous technological developments in conjunction with the replacement of some mica capacitors by cheaper ceramic plastic films and other materials. The demand of mica in the capacitor industry has also gone down. However, use of mica capacitors is expected to continue in the strategic uses like aircraft and missile equipment, and in industrial electronics.

Mica splittings

Mica splittings are ordinarily not used as such in end-use products. However, small-volume of splittings are used as the window in some types of Geiger counters. The unusual feature of this use is the extreme thinness to which the mica must be splited. Specifications call for thickness ranges of 0.00037 cm and 0.0005 –0.00075 cm. Some electrical motor manufacturers also use small quantities of book – form mica splittings as a base during the winding of mica tapes in end winding of conductors.

Micanite

Most of the mica splittings are used in the manufacture of built-up mica, often called micanite. This is made by partly overlapping irregularly arranged splittings, cemented together with a binder usually organic. Sheets are built-up of alternate layers of splittings and binder and pressed at elevated temperatures to form a raw material from which numerous shapes are milled, stamped, or cut. Important forms of built-up mica are segment plate, heater plate, molding plate, flexible or cold-forming plate, and composite built-up mica products. Built-up mica products can substitute for natural block mica in all applications that do not require transparency, extreme thinness, flexibility, very high dielectric strength, low power factor, or ability to withstand high temperatures.

The major properties and uses of different types of micanite are discussed below:

(i) Segment plate has a high mechanical strength, density and good thermal and electrical resistance. It has low compressibility and can be punched or cut to any determined size without cracking. The main application for segments plate is to separate and insulate copper commutator segments rings or bushings in direct current universal motors and generators. Small quantities are used to resist high working temperatures in the construction of control gear and apparatus for marine applications. Phlogopite built-up mica is preferred to muscovite mica as it wears at the same rate as copper segments. Muscovite has a greater resistance to wear, causing uneven ridges, which may interfere with the operation of the generator.

(ii) Moulding plate is made from mica splittings bounded with shellac, alky-vinyl or silicon resin. It has excellent insulating characteristics, high mechanical strength, heat and chemical resistance and excellent durability. When subjected to heat between 100 and 150°C it becomes soft and can be easily molded into different shapes without breaking and peeling. The main application is in V rings and cones for use in insulating the copper segments from the steel shaft at the ends of a commutator. Moulding plate is also fabricated into tubes and rings for insulation in transformers, armatures and motor starters.

(iii) Flexible plate is bounded with a special organic resin and has sufficient flexibility and adhesiveness to permit winding or wrapping into place without heating. Flexible plate has excellent durability and does not react with copper. It is used where a cold-forming insulation with high dielectric strength is needed. At high temperatures, flexible plate becomes stronger and becomes fully oil-resistant. Main applications are in armature slots, coils and cores of transformer magnets, in transformers and motor starters.

(iv) Flexible combination plate is built-up mica reinforced with paper, glass cloth or polyester film. This material is produced in wide continuous sheets that can be cut into ribbons or tapes. Flexible combination plate forms a wrapped insulation for coils and conductors of motors, transformers and other electrical equipment.

Manufactured sheet mica

Micanite and mica paper are the two most important manufactured sheet mica products. Micanite, which is manufactured from mica splittings, has already been discussed earlier. Mica paper is made from scrap/flake mica, which is even cheaper than mica splittings, and can substitute for most electrical and thermal use applications of block mica and micanite.Mica paper, while still maintaining the good inherent characteristics of mica, is a completely inorganic continuous laminated structure. In its untreated form mica paper has been found useful where extremes of temperature and pressure preclude the use of any organic material. It is also useful where thin sections are required which are not available in ceramics and for applications where mechanical shock would shatter vitreous materials.

The properties of mica paper such as uniformity in thickness and composition, resistance to thermal and mechanical shock and non-inflammability permit its use in high thermal applications (550^{o}C maximum continuous temperature and 1000^{o}C for short periods of time). Several grades of mica paper are produced depending on the end-use. These range from 50 to 3000 gsm (grams per sq.m.). These grades are used in electrical industry for the manufacture of mica paper based insulating products such as reinforced flexible tapes, reinforced flexible sheets, segment plates, hot forming micanites, heater plates, inorganic bonded laminates, etc. Thinner grades of mica paper are used in the electronic industry for the manufacture of mica paper capacitors, etc.

Both mica paper and mica splittings provide suitable insulation for high voltage electrical equipment. However, mica paper based insulation has the following advantages:

- High electric strength and corosion resistance
- Low dielectric loss even at higher temperatures

- Low values of power factor
- Independence of PF on the applied voltage
- Good aging stability
- Dimentional stability at operating temperatures
- Good mechanical strength
- High thermal conductivity
- Insensitivity to moisture
- Ease of application
- Adaptability to mechanical production
- Infusible and non-inflammable character and
- Relative inertness

For the same working voltage, the insulation thickness can be very much reduced. Consequently more space is available in the slots for active copper, which increases the output capacity of the machines. Due to these outstanding advantages there has been a trend all over the world to change over to mica paper based insulation. Mica paper is the basic constituent of the insulating materials for applications as class E,B,F,H and C insulation systems. Different types of insulating materials based on mica paper are available. These range from rigid curved plate for use as commutator segments and heater plate through hot forming and cold forming materials to reinforced flexible tapes, wrappers and slot tubes.

Mica paper is used in capacitors as dielectric with excellent results. It can replace the plastic dielectric film now being imported. Excellent performance under environmental extremes is a prime advantage of mica paper capacitors. They can operate well at elevated temperatures and they are particularly suitable in aircraft engines and gas turbines. Customs Electronics of USA are manufacturing electronic capacitors with mica paper on a large scale. It is believed that mica can very well substitute craft paper capacitors used in many electrical appliances such as fans, fluorescent lamps, power factor improvement capacitors etc. Higher dielectric constant and higher temperature capability are the decisive advantages. As the indigenous manufacture of mica paper has begun, it is desirable that the imported plastic film and kraft paper are replaced by mica paper in order to save foreign exchange and also to manufacture better capacitors.

Synthetic mica

Synthetic mica is a normal flur-phlogopite mica crystallized during the slow cooling of a melt of accurately proportioned raw materials. It is produced in the USA and Japan. Synthetic mica as produced commercially at present is randomly oriented flake mica. This is used for the manufacture of glass-bonded synthetic mica and other ceramic products. The various shapes and articles made from these are similar to those made from glass-bonded and phosphate bonded natural mica. Trade names for these products are: Synthetic mica, Thermica, Mykroy, Supramica, Mycalex, Micramic etc. These materials have excellent electrical, mechanical and thermal properties. Moulding and sheets made from glass-bonded mica have many applications, usually as small components in the following major industries:

a) Aircraft and automobile components,
b) Electrical distribution equipment, insulation and control gear, switch gear and cable attachments,
c) Electrical machinery components, armatures, commutators, fan housing and traction gear,
d) Radio & T. V. transmission equipment.
e) Printed circuits, computer components and business machines,
f) Telephone and telegraph apparatus, memory and encoding devices,
g) Domestic appliances, microwave components and
h) Welding arc and X-ray equipment.

Scrap mica/ground mica

Most of the scrap mica is used for different applications in the powder form. Major uses of different types of mica powder are given below:

Type	**End-uses**
Dry ground mica powder	a) Drilling mud, extender in cement, roofing etc. As dusting agent in electric cables. b) Dusting agent on electrodes for protection. c) Building product, joint cement, asphalt roofing.
Wet ground mica	a) As filler in paints, rubber and plastics. b) Wall paper for decorative effect.
Micronised mica powder	a) In paints for luster and anti-corrosion effect. b) For manufacture of reinforced plastics.

Scrap mica/ground mica constitutes more than 97% of the total world mica production. The uses of scrap/ground mica in different industries are discussed in detail in the following paragraphs.

Mica paper

It may be mentioned that the hi-tech use of processed scrap mica is in the manufacture of mica paper, which competes with the block mica and micanite. India is the sole producer in the world of factory scrap mica suitable for the manufacture of mica paper. So far only Indian ruby factory scrap mica has been used for the manufacture of mica paper, but the green mica scrap from Andhra Pradesh can also be used for this purpose to some extent. As the name implies, mica paper is actually a paper like material. However, it differs from ordinary paper in that it consists entirely of tiny flakes of mica without any organic additives. Instead of gaining its strength by the intertwining of fibrous material, mica paper is held together by a natural adhesive force between adjacent flakes. This natural force is unaffected by temperatures as high as 550^oC and is sufficient to give mica paper a tensile strength of the order $70kg/cm^2$ in lengthwise direction. Mica paper has excellent compression and shear strength, but without a binder its other mechanical properties are relatively poor. Mica paper is also known as reconstituted mica. High quality mica scrap is needed to make mica paper. Normally muscovite ruby mica is used for the manufacture of mica paper. Though there are several processes by which mica paper can be produced, two processes mostly followed are mechanical disintegration process and themo-chemical process.

Construction industry

The largest use of mica scrap/ground mica is reported to be in the construction industry. The major uses in the construction sector are in : (I) jointing cement for gypsum boards; (ii) asphalt roofings and damp proof seals; and (iii) insulation boards. The ground mica is used as a filler and extender to fill joints for the construction of gypsum plaster boards. Dry ground mica acts as a re-enforcement agent in joint cement by preventing cracking, peeling and by reducing shrinkage. Mica particles are insoluble and impenetrable to water and, therefore, protect the wall surface from moisture penetration. They also give a smooth edge and enhance the decorative effect of the wall surfaces.

Dry ground mica between 10 and 80 mesh is used as inert filler and the surface agent in roofing products. As a filler, mica is added to asphalt and bituminous composition to increase hardness and resistance to mechanical stress and weathering. The main market for mica is in molded asphaltic products, which is applied as a coating to asphalt roofing felt, shingles, or damp coarses. Mica prevents adjoining surfaces of the material sticking during manufacture and storage. Freshly made roofing felt because of the platy structure of mica does not absorb the coating. Mica has additional advantage of being resistant to weathering and to the acid in the asphalt. It also imparts a glistening appearance. The use of ground mica in building boards is a new development. It is expected that in a few years this use may gain significance. Ground mica acts as a reinforcing filler in plaster for textured coatings, the main function is to control shrinkage and cracking and maintain plasticity. These coatings are cheap and decorative, crack resistant and suitable for ceilings.

Refractories

Mica is used in insulation bricks, slabs and tiles because of its excellent thermal and insulating properties. Mica bricks can withstand temperatures up to 1000^{o}C, and by keeping heat loss to a minimum, can significantly reduce energy consumption. Use of mica bricks improves the efficiency of furnace by reducing operational cost and improving furnace room conditions. An additional advantage of mica bricks is their stability after long use. Adding a layer of mica bricks of around nine inch in depth can reduce the temperature immediately under the roof of a furnace by 15^{o}C. In addition to the muscovite scrap, the scrap of other inferior decomposed varieties of mica like vermiculite, sericite and suzorite are more widely used in the manufacture of insulation bricks for the general purpose heating insulation materials.

Paints

Use of mica as a filler and extender in paints is an important application. Mica acts both as a bulk and functional filler. This reduces consumption of expensive fillers and improves the optical and mechanical properties of paint. Mica is mainly used in four types of paints namely: (I) bituminous emulsions, (ii) exterior paints, (iii) fire retardant paints and (iv) pearlescent pigments. The insolubility of mica in water protects paint surfaces from water penetration, which makes this property of mica useful in emulsion or synthetic water paint. Owing to its excellent adhesive property, mica is also well suited to oil based primers.

Exterior paints are the main area of use for mica in paints because of its reinforcing properties. The platy structure of mica reinforces paint; it reduces peeling and cracking in the dry films, and prevents shrinkage and shearing of paint. These are industrial paints which are applied in severe conditions like chemical plants and off-shore drilling platforms etc. In aluminum, bronze and gold paints, mica acts both as an extender and as an agent to increase heat and fire resistance. Ground phlogopite mica is specially used in fire retardant paints because of its high heat insulation property.

The use of mica in perarlescent paints is a new development, though pearlescent pigments were already earlier used in the cosmetic industry. Pearlescent pigments rely upon light transmission, reflectance and interference to reproduce artificially a “mother of pearl” or nacreous effect. To achieve this optical interaction mica is used as a substrate upon which a thin coating of titanium dioxide (or other metal oxide) is laid. Both muscovite and phlogopite can be used for this purpose depending upon the effect required. Automobile industry is providing to be one of the most exciting markets for this pigment in USA, Japan and other European countries. This use is yet to be developed in India.

Oil well drilling

Drilling muds of fluids are an important market for ground mica, accounting for around 20% of the total world consumption of ground mica. Mica is added to drilling fluids to get off the lost circulation zones. The platy structure of mica facilitates the over lapping of particles to form a tight layer or wall, therby preventing further fluid loss. Mica also helps to keep solids in suspension. The particle size of mica should be larger than the particle size of solids normally suspended in the mud. Two forms of mica are used in drilling muds: Coarse flakes with a mesh size of 6 with density of 0.17 per kg/l and finer mica passing 30 mesh with density of 0.24 per kg/l. The powder is used when sealing agent needs to be smaller enough to allow the mud to pass through shaker screen. Low quality mica is consumed in oil well drilling as purity and color are not important.

Welding electrode

Dry ground 50 mesh mica is used in the flux coating for arc-welding electrodes, a core of steel wire is uniformly coated with flux containing 3 to 5% mica powder. Mica has the advantages of high heat resistance, excellent mechanical and thermal strength, low moisture absorption, and a high resistance to surface leakage and chemical attack. The mica coating protects welding electrodes in two ways: it helps to form a fusible slag and ensures a good seal at the fusion zone, and it protects the electrode from attack by heat and gas in the atmosphere. As mica also contains 10 to 12% potash, it helps to produce a stable arc, which is more suitable for welding with A/c current.

Rubber

Mica is used in the rubber industry in two main ways; (i) as a dusting agent, and (ii) inert filler in the production of rubber. The main application for mica in rubber industry is as a dusting agent in the production of rubber tyres. It can be applied as a powder in water or soap solution in conjunction with other minerals like steatite. Mica coating comes between inner rubbing and casing of rubber tyres. Mica prevents the inside of tyres from sticking to the mould during vulcanization and it prevents the movement of sulphur, while permitting air bubbles to escape.As a rubber filler mica improves the resilience and appearance of rubber products. Mica fillers increase the hardness, tensile strength and tear resistance of rubber articles. The strength imparted to rubber increases with fillers of small particle size and large surface area. Mica is suitable for use in both natural and specially colored rubber articles. Mica can also be used in electric cable insulating material, and in latex and foam rubber. However, so far mica has a small share of the market for rubber fillers.

Plastic

Mica is used in the plastic industry both as a bulk filler, to reduce the quantity of plastic resin needed, and as a functional filler, to impart desirable physical, electrical and processing properties to the plastic. Main use of mica is as a filler and reinforcer in thermo-plastics to improve their electrical properties, flexural strength and modulus, stiffness, heat deflection temperature, and heat resistance. Mica also absorbs up to 80% of incident ultraviolet radiation. Mica has the advantage of low specific gravity, is usually wetted by resins and dyes, and does not absorb moisture. With a hardness value of only 2.5 on Moh's scale, compared to 4.6 – 6.5 for glass fiber and 4.5 for wollastonite, mica does not have an abrasive effect on machinery. Mica is also inert to acids, alkalis and solvents. Mica is light in colour and retains this colour at elevated temperatures, and in presence of resins and chemicals. Both wet and dry ground mica can be used in plastic are made from refined grades of mica with other colour oxide deposits on mica. The use of mica is likely to gain more importance in the plastic industry.

Cosmetics

Small quantities of dry ground mica powder are used in cosmetic applications. Mica provides a pearly luster and glittering effect in nail, lipsticks, eye-shadows and barrier creams.

Mica has an advantage of high ultra-violet light stability, excellent lubricating, skin adhesion and compressibility. It is also resistant to heat, weather, and chemical attack. During the early 1980s, several pearlescent pigments including mica have been developed. The main area of growth lies in the use of titanium dioxide mica base pearlescent pigments which are less harmful to the skin than lead or bismuth mica base pearlescent pigments.

Wallpaper and other paper

Owing to mica's high resistance to the effects of the sun's rays, moisture, gases, water and other chemicals, small quantities of dry ground mica powder are used to improve the decorative coating and luster of wall-paper, printing and ceiling papers, greeting cards, and art finishes. As mica particles transmit and reflect light, the use of mica powder gives an attractive silvery sheen and enhances the decorative design on wallpapers. M/s. Boliden of Sweden is currently investigating the use of mica as a filler in mechanical printing paper (Newspaper and Magazines).

Agriculture

It has been claimed that a potential use for wet ground mica lies in spreading over crops and plants to control aphid infestation. Wet ground mica is used because the reflective properties of mica flakes are retained after grinding. Aphids see the reflection of the sky on the mica flakes, become disoriented and move elsewhere. Mica is almost as effective as the traditionally used aluminum flakes, and is much cheaper. There are also possibilities of using mica as a fertilizer for agriculture because of its 10% K_2O content.

Other uses

Small quantities of scrap mica/ground mica are also used in other industries like foundries as coating to foundry cores and moulds, as a dry lubricant to prevent hot bearings from seizing up, and incorporating into special greases to provide 'body' at high temperature, in leak-proof boiler and lagging compounds particularly when high heat resistance is required. It is reported that Kuraray Company of Japan is evaluating metal plated mica flakes as a new material for electro-magnetic interference shielding material.

4.2 Specifications of mica

Over the years, the Bureau of Indian Standards has realised the importance of mica and mica products, and has prepared standards for: (a0 Processed mica; (b) Fabricated mica; and (c) Mica-based products.

The BIS (formerly ISI) prepared as early as 1949 the following two specifications.

1) IS:13-1949 Methods for grading (by size) of processed mica,
2) IS:14-1949 Visual classification of processed muscovite mica.

Based on national and international experience and feed-back from industry and users these standards were subsequently revised twice. The latest Standards are:

1) IS: 1885 (Part-53)-1980 Electrotechnical Vocabulary Part 53 Mica,
2) IS:1175-1981: Methods for grading and classification of muscovite mica blocks, thins and films (first revision)

The document on vocabulary provides information on the terminology used in mica trade and provides means for effective communication. The latest version of IS:1175-1981 covers 13 grades based on area of useable rectangle, the largest being 645 sq. cm. and above (designated as size 630) and the smallest corresponding to area of useable rectangle between 4.8 to 6.4 sq. cm. and designated as size 5. In addition, this Standard provides 11 classifications of blocks and thins based on visual quality. Detailed description of each of the visual classification has been included.

Another important Standard relating to fabricated mica is IS:9502-1980 regarding muscovite mica components for electronic equipment.As is well known the quality of mica is generally evaluated visually on the basis of properties like colour, waviness, presence of stains and spots as specified in IS: 1175-1981 on methods for grading and classification of muscovite mica blocks, thins and films. Only better classes of ruby mica (based on visual examination) are thought to be suitable for precision type condensers. All qualities of mica classified 'below good stained or even below stained' are generally considered unsuitable for capacitor use even though there is no evidence contrary to their suitability for such purposes. Moreover, interpretation of visual standards varies from man to man. It has been found that some of the stained or spotted mica have power factor values much lower than expected on the basis of the visual examination and are therefore suitable for making radio condensers. Systematic studies of the properties of various grades (visual) of mica at the Central Glass and Ceramic Research Institute, Calcutta, have corroborated the fact that most of the samples of stained and visually lower classes mica have performance characteristics much superior to what is generally expected.

A number of studies carried out in India for the promotion of mica exports recommended preparation of an Indian Standard for classification of mica based on electrical properties. The studies indicated that foreign exchange earnings of India from mica exports would be increased manifold if the exports could be based on electrical classification. Noting the advantages of electrical classification over the visual classification currently adopted in mica trade and its possible effects on mica exports, the BIS took up the formulation of an Indian Standard on the subject. This Standard (IS:9455-1980) has since been published taking into consideration the views of technologists and concerned interests. The Committee which finalised this Standard had proposed that India should take the initiative for getting an ISO Standard prepared on the subject which would enable Indian exporters to negotiate orders based on the electrical classification.

The classification based on electrical property (power factor) comprises the following three grades:

a) Grade E_1 : Mica having a power factor of 0.040 per cent or lower, for use in tuning circuits and high frequency condensers;

b) Grade E_2 : Mica with power factor of 0.041 to 0.285 per cent, for general purposes application; and

c) Grade E_3 : Mica with power factor of 0.286 to 2 per cent, intended for blocking condensers.

Mica having power factor greater than 2 percent is not suitable for use as condenser and invariably used in domestic appliances. For determination of power factor as type test, the IS:4486-1967 recommends methods for determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies. However, for acceptance and routine tests, separate test methods have been specified for rapid determination of power factor: (a) perpendicular to lamination, and (b) parallel to cleavage plane. In view of the fact that dielectric loss parallel to cleavage plane is many times greater than in the perpendicular direction, determination of power factor parallel to the cleavage plane only would be adequate for acceptance and routine test.

For all the electrical and electronic applications of mica, other electrical properties, namely, dielectric strength, dielectric constant and insulation resistance vary very little from class to class, and even for the lower qualities (based on visual classification) the above properties are more than satisfactory. For the purposes of this classification the following electrical properties have been presumed to be applicable for all the three grades:

a) Dielectric constant - More than 6

b) Dielectric strength - More than 200 kV/mm, and

c) Specific resistance - More than 10^{14} ohm/cm.

Correlation between visual classification grades as given in IS: 1975-1981 and classification based on electrical properties has not been established so far. In view of the inherent advantage of electrical methods (the tests being scientific and directly related to the enduse) over the visual classification (the test are subjective and have no direct correlation with the end-use), adoption of electrical classification for mica trade is desirable.

Realizing that three is going to be large demand, both for indigenous consumption as well as for exports for built-up mica, an Indian Standard for built-up mica for electrical purposes was prepared as early as 1963. This Standard is currently under revision and a number of sections of the standard have already been brought out. Besides definitions, general requirements and methods of test, specific requirements in respect of the following have been laid down:

IS:9299 (Pt 3/sec 1) -1979-Rigid mica material for commutator separators.

IS:9299 (Pt 3/sec 2) - 1985-moulding mica materials for electrical purposes,

IS:9299 (Pt 3/sec 3)1982-Flexible mica flake tape for insulation of electrical machines,

IS:9299 (Pt 3/sec 4) - 1982-Rigid mica materials for heating equipment,

Doc: ETDC 63 (29/48) F – Flexible mica material in sheet form.

In addition Indian Standard on mica paper are under preparation at various stages of processing.

Standardization of mica

India took the initiative to take over the Secretariat of ISO/TC 56 Mica in order that the International Standards on the subject are laid down as early as possible to promote India's exports. Currently seven Standards have been brought out by ISO in relation to processed and fabricated mica. These Standards have been closely aligned with that prepared by ETDC 9 Mica Sectional Committee and listed in the earlier paragraphs. A number of Standards on mica based products have been prepared by IEC/TC 15 Insulating Material. Inspite of best efforts it has not been possible to prepare an ISO Standard corresponding to IS:9455-1980: Classification of muscovite mica blocks, thins and films based on electrical properties. Over the years the interest at the International level in standardization of processed and fabricated mica has considerably come down. The BIS has reported that at this stage it is difficult even to get a minimum of five countries to agree on undertaking International Standardization work in these areas. Accordingly there is a proposal that ISO/TC 56 may be dissolved and the work handed over to IEC/TC 15.

4.3 Internal demand of mica

Various types of mica are consumed in different end-uses. The reported consumption of various types of mica in different end-uses in India given in Table-IV shows that out of an average annual consumption of 3,772 tonnes over the period 1985-88, the onsumption of waste and scrap mica was the highest at an average of 1,930 tonnes, followed by 1,192 tonnes of ground mica, 375 tonnes of mica splittings, 265 tonnes of crude mica and 10 tonnes of processed block and film mica. The above consumption relates to around 50 reporting units in the organised sector industry and does not represent the total picture of the consumption of mica in the country. In addition to the reported consumption given in Table-IV, imported mica products to the extent of about 26 tonnes during 1985-86 valued at Rs.57 lakhs were also consumed in the organized sector of the industry. However, it is reported that the imports of mica products are more than the quantities reflected in the foreign trade statistics which may be due to mica forming an item of the composite insulation materials.

Due to the limitations mentioned above, an attempt has been made to arrive at the most realistic picture of the current, mica demand by ascertaining the consumption of various types of mica in the principal mica consuming units like BHEL, Railways, etc. and, other mica consuming industries such as electrical and electronics, welding electrodes, plastics, paints, insulation bricks manufacturing units etc. Efforts were also made to estimate the mica consumption in the electrical heating elements industry based on a study of selected units. Questionnaires were sent for collecting information and also spot visits were made to important centers of consumption for discussions and ascertaining the requirements of mica. An attempt was also made to obtain information on the sales of mica products by the producers of such products.

Sheet mica

Natural sheet mica (blocks, films and splittings) and manufactured sheet mica (micanite & mica paper0 are the principal sheet mica products used in electrical and electronics industries for various end-use applications such as in electrical machinery, heating elements, autoelectric and electronic components, besides for various other applications. There is substitution amongst the various sheet mica products for different end-uses and the degree of substitution varies from end-use to end-use. Clear cut trend in the substitution amongst the various sheet mica products is not discernible so far. The current status of the demand of various sheet mica products in different end-use industries is discussed below:

A. Electrical machines

In the electrical machinery manufacturing industry, sheet mica products are mainly used in the form of micanite and mica tapes out of natural mica splittings, mica paper based sheet and mica paper based tapes. The proportion of varius sheet mica products used as a product-mix varies from one type of electrical machinery to the other type of electrical machinery, and from one company to the other company.The Indian, Railways are consuming mica in the production of tractin motors, repairs/rewinding of traction motors and repair of smoothing reactors. Mica is used in the form of micanite and its products, mica wrappers, GMGS sheet and tapes and mica foilum. The present total requirement of Indian Railways is estimated approximately to be 70 tonnes per annum. The break-up of this requirement is as under:

i) Micanite and micanite products	:	35.9 tonnes
ii) Mica wrappers, GMGS sheets and tapes	:	33.6 tonnes
iii) Mica folium	:	0.5 tonnes

The requirement of the Railways for their direct use by 2000 A.D. is projected at around 90 tonnes per annum. This requirement does not include the mica used in electrical plant and machinery supplies made by vendors to the Railways such BHEL, New Government Electric Factory (NGEF) etc.The BHEL primarily uses mica in the form of mica tapes for insulating windings of electrical machines and in the form of flexible and moulding micanite for manufacturing various insulation applications in the manufacture and assembly of windings. The consumption of various mica products during 1988 is given below:

Types of Mica	1988
Mica paper based tapes	99 tonnes
Mica splittings based tapes	16 tonnes
Micanite/sheet	55 tonnes

The BHEL meet most of its requirements of micanite from its own micanite manufacturing unit at Bhopal. Besides it meets its requirements from supplies from other micanite suppliers in the country as well as from imports. The demand of mica paper products was mostly met so far from imports. Now substantial part of the demand of mica products is met from domestic suppliers. The import of different mica products by BHEL during 1988-89 was of the following order:

i)	Mica paper based tapes	40 tonnes
ii)	Mica splittings based tapes	5.5 tonnes
iii)	Micanite/sheet	3 tonnes

The BHEL's requirements in the next 5 to 10 years will be more or less at the present level. The future trend in consumption of various types of sheet mica products in BHEL units is likely to be as under:

i) In traction motors, mica paper tapes are replacing the mica splittings (which is termed as flakes by electrical industry) tapes and the trend would continue.

ii) With easy indigenous availability of mica paper tapes within the country ina few years, use of mica splittings based tapes for end-winding insulatin of motors and hydrogenerators would be replaced by mica paper tapes.

iii) For large capacity turbogenerators, use of mica splittings tapes has been introduced and shall continue further.

iv) In line with the production and use of large capacity turbo-generators anticipated for future years, there would be an overall increase in consumption of mica.

Information obtained from five other major manufacturers of electrical machines, shows that the main areas of applications of sheet mica are as:

i) Turn insulation and main insulation in form wound coils used in high voltage rotating machines;

ii) Slot insulation in rotating machines;

iii) Spacer in dry type transformers;

iv) Commutator separator (V-ring);

v) Rotar banding support;

vi) Mica folium insulation for Class-B motors, starter coil insulation;

vii) Glass mica resin system (GMRS mica paper based tapes) for starter coil insulation of 3.3 KV, 6.6 KV and 11 KV motors of Class-F;

viii) Electrical insulation in the form of tapes and sheets in low tension and high rotating electrical machines; and

ix) Electrical insulation in the form of mica tapes and micanite in D.C. and A. C. electric motors.

The level of current consumption of sheet mica products by these five companies is as follows:

a) Mica tapes : 30 tonnes

(i) Most of these tapes are based on mica paper, and contain about 45 to 50% mica content. About one tonne of the above quantity of mica tapes was based on natural mica splittings.

(ii) About 20 tonnes of the above mica tapes were imported into the country.

b) Micanite : 2 tonnes

The manufacturers of electrical motors and other machinery obtain some of the components like commutators, etc. from vendors. These components also contain mica based parts (micanite segments), which are not included in the direct consumption of mica indicated above for the different electrical machine manufacturers. There has been a general trend of increasing use of mica paper based tapes and mica sheets in electrical industry in recent years. Despite this trend it seems that mica splittings based on tapes and micanite have still good scope for use in the electrical industry especially in the Indian situation. Mica splittings based products are quite competitive, both from price point of view and the quality of insulation. As per a recent report, one reason for the increasing number of hydro-generator failures in the recent years is reported to be due to change from mica splittings based tapes to mica paper based tapes in mica insulation practice.

For estimation of the present demand of micanite and mica paper products in the domestic electrical machinery manufacturing industry, an appropriate method is to work out the supplies of micanite and mica paper products to the domestic consumers. It is estimated that out of about 400 tonnes of micanite produced per year in the country, approximately 100 tonnes are exported and the remaining 300 tonnes are supplied to the domestic market. The supplies of mica paper products to the domestic market is estimated to be of the order 200 tonnes per annum based on 100 tonnes each from domestic sources and imports. According to indications available from some of the principal electrical machinery manufacturers and taking note of the electric power generation/distribution programmers the country, a growth rate of 10% per annum has been assumed for arriving at the future demand of micanite and mica paper products in the country.

B. Repair of electrical machinery

It is reported that considerable quantities of sheet mica are consumed in the repair of old electric motors. According to the knowledgeable sources in the electrical industry, the consumption of sheet mica products in the electrical industry, the consumption of sheet mica products in the repairing of old electric motors is quite substantial, and may be of the order of 30% of the total sheet mica products for the entire electric industry Iron & Steel plants in India use various sheet mica products for repair of old electric motors in their plants.

C. Electrical heating elements

It is understood that substantial quantities of block mica are used in heating elements for domestic electric appliances like electric irons and toasters, electrical heaters etc. It is learnt from the reliable sources that about 75-80% of heating elements industrial elements

Electric irons

In conventional electric irons and toasters, the heating elements are made of raw mica, which provide support for the Nichrome wire and also serve as an insulator. Usually two supporting pieces of fabricated mica of dense/washer quality are used for winding of Nichrome wires and three to four pieces of better quality mica are used for insulating them from both sides. The size of heating elements varies according to wattage ranging from 250 to 1500 watts. In the standard and popular irons the wattage is rated at 750. In automatic irons, a small thick piece of washer mica is used for support at the junction of the thermostat with the mains connection. On an average 10 grams of mica are used for insulation and 20 grams for support in a heating element. Thus, a total of 30 grams of mica is used in a typical heating element.

Electric irons are notified under the small scale sector. Manufacture of electric irons is basically an assembling job which is carried on a cottage scale in and around Delhi. There are about 200 manufacturers of electric irons registered with the Small Scale Industry Directorate of

Delhi. Apart from these registered units, there are a large number of other units, at times operated by a single family as a house-hold job to manufacture irons. They procure different components from the market and after assembling, sell them in the market where it is distributed. However, companies in the organized sector market electric irons manufactured by these small scale industries to their specifications under their own brand name.

The total production of electric irons in Delhi is estimated at 400,000 to 500,000 pieces per month. This estimate is based on the information gathered from a few manufacturers of elelctric irons, Delhi Electric Appliances Manufacture Association and from the Product Manager of one of the principal companies marketing electric irons. Thus the number of heating elements for irons manufactured for the primary market is 400,000 to 500, 000 and about 300,000 elements are manufactured for replacement market. Assuming the norms of consumption of 30 gms of mica for each heating element, the total consumption of mica for production 800,000 heating elements per month for electric irons comes to around 24 tonnes per month.

In superior quality heating elements, better quality ruby variety of stained 'B' quality mica is used, whereas in the cheaper quality elements, washer and dense variety of mica preferably of Andhra and Rajasthan origin are used which are relatively cheaper than the Bihar ruby mica.

Toasters

Production of toasters in the country is limited. At present the total production is around 15,000 pieces per month in the country out of which about 8 to 10 thousand pieces are produced in and around Delhi. There are about 20 manufacturers of toasters in Delhi. The heating elements for toasters are presently based on mica which is used to provide support to the Nichrome wires. Of late a number of toasters have come up in the market which are automatic and incorporate latest design and technology. These toasters incorporate micanite as the base material for the nichrome wires. However, in and around Delhi at present no established manufacturer uses micanite.

In a two piece bread toaster, three pieces of fabricated mica each of about 25 square inch size are used. For the sake of economy and functional utility, the rectangular piece of 12.5 x 12.5 cms. is segmented into 2 to 4 pieces and joined together with the help of rivets which provide them support. However, in the case of automatic toasters where micanite is used, they do not require any riveting, as micanite is self-supporting. About 60 to 70 gms of mica by weight are used in a toster. Thus the consumption of mica in the manufacture of toasters works out to one tonne per month.

From the foregoing analysis, the consumption of mica blocks in electrical heating elements in and around Delhi comes to about 300 tonnes per annum. Assuming that the Delhi area accounts for about 75% of the total all-India production of heating elements the present consumption of block mica in the heating elements industry in India is estimated at 400 tonnes per year.Though the production of the heating elements in the country in future years is expected to increase sizeably, the demand of block mica is not likely to increase from the present level, primarily due to the possibility of use of micanite in place of fabricated block mica in the manufacture of irons and toasters, and the development of light weight electric irons incorporating tubular elements which do not require any mica.

Information on the price of micanite sheets, dimensional requirements of micanite sheets for manufacture of heating elements of different wattages, advantages and disadvantages of heater micanite sheets etc. is not available. Hence it has not been possible to analyses whether micanite sheets for heating elements can be substituted for fabricating mica used in the manufacture of heating elements. As already indicated earlier, majority of the market is for cheaper quality electric irons. Therefore, in this market segment, there seems to be little possibility of substitution of fabricated block mica by micanite sheets as the cost of micanite sheet will be high. Keeping in view the compulsory BIS certification scheme for electric irons introduced by the Government, it is anticipated that in future production of standard quality irons conforming to Indian Standards for the primary market is expected to pick up. Therefore, use of fabricated block mica may come down due to substitution by micanite heater plates.

Light weight electric irons had come in the market recently incorporating heating elements which are tubular in nature and do not use any mica. According to the industry sources, the demand for this type of electric irons is increasing fast and in about 2 to 3 years time they are likely to command about 50% of the total market. Thus increasing popularity of light weight electric irons based on tubular heating elements is also anticipated to result in the declining trend in the use of mica for these appliances. Discussions with the industry show that substantial quantities of heating elements are exported out of India. It is estimated that the block mica content in the heating elements exported is of the order of about 10 tonnes for 1988. It is reported that there is good demand for Indian heating elements in foreign countries and the exports may increase two-fold or more in the coming 5 to 10 years.

D. Sheet mica in auto electrical components

Discussions with mica industry circles revealed that some quantity of block mica is consumed in the manufacture of auto-electrical components in the country. The current demand of block mica in the manufacture of auto-electrical components in the country is estimated to be of the order of about 25 tonnes per annum. In view of the expanding automobile industry in the country, it is anticipated that the demand of mica based auto-electrical components will also increase. It is estimated that the demand of block mica for use in the manufacture of auto-electrical parts in the country may be of the order of 40 tonnes per year by 1994-95 and about 60 tonnes per year by 2000 A.D.

E. Sheet mica in electronics industry

Silvered mica condenser plates are manufactured from natural mica films. These condenser films are further used for the manufacture of silvered mica capacitors, which is turn are used in electronics industry. India exports mica condenser films, silvered mica plates, and silvered mica capacitors. Some quantities are also used in the domestic industry. Keeping in view the quantities of cut condenser mica films exported from the country (36 tonnes in 1985-86) and the production of silvered mica plates and capacitors in the country, it is estimated that about 150 tonnes of natural mica films are used for the manufacture of mica condenser films in the country. There are about a dozen manufacturers of silvered mica plates and capacitors in the country, whose annual production is about 1000 million pieces of silvered mica plates and 120 million pieces of silvered mica capacitors. Bulk of the silvered mica plates and capacitors produced in the country are exported. Consumption of silvered mica capacitors within the country may be of the order of 4 to 5 million pieces and goes into the production of various electronics products, viz. entertainment electronics, industrial electronics, communication electronics, defense electronics and space electronics, etc. It is expected that the demand of mica in these industries in the country may increase in the future years.

F. Mica based fire survival cables

The use of Samica glass fabric tapes for insulating fire survival cables for elevators is a new application. It is reported that in advanced countries, insulation of lift cables by mica tapes has been made compulsory. Information regarding the use of mica for insulating cables in India is not available. However, one cable manufacturing company has furnished information regarding the production of fire survival cables and consumption of mica tapes during 1986-87 to 1988-89 as follows:

Year	Production of Fire Survival Cable (In Line Kilometer)	Consumption of Mica Tape (In Meters Length)
1986-87	NIL	1,500
1987-88	1.4	21,500
1988-89	21.0	400,000

G. Sheet mica in non-electrical and non-electronics industry

The consumption of sheet mica in the non-electrical and non-electronics end-use industries like manufacture gauge glass, diagphragms and dials etc. is insignificant. It is estimated that the present level of consumption may be about one tonne per annum, and this may increase to about 1.5 tonnes by 1994-95, and 2 tonnes by 2000 A.D.

H. Sheet mica fabricated products for exports

As exports of fabricated mica products during the past years from the country have been fluctuating, it is difficult to anticipate the future level of exports. It is estimated that on an average about 200 tonnes of block mica are presently consumed per annum in the country by the mica fabrication industry for exports, and the same level is assumed for the future.

Total demand of sheet mica products

Based on the estimates reflected in the previous paragraphs, the present and future demands of sheet mica products in various end-use consuming industries are given below:

Scrap/ground mica

The scrap/ground mica is mostly consumed in a large number of industries like insulation bricks, mica paper, asphalt roofing felts and damp proof seals, various types of paints, welding electrodes; oil-well drilling, rubber tyres, plastics, jointing cements for gypsum boards and minor quantities for several other industries like cosmetics, wall paper etc. However, precise details of the consumption of scrap/ground mica in these industries are not available. Therefore, to have an idea of the present demand level, discussions were held with some of the important scrap/ground mica supplieres and consuming industries. These discussions revealed that the current level of consumption of scrap/ground mica in different industries in the country may be of the following order:-

Consumption of mica scrap in the insulation bricks industry is not likely to grow in the future because of the substitution by vermiculite which is relatively a cheaper material. Demand for scrap/ground mica is expected to grow in all other industries. The overall growth rate in these industries is anticipated to be between 7 and 8% per annum by 1994-95 and 2000 A.D. Based on this, the future demand of scrap/ground mica in the country is estimated to be as follows:

5.0 A perspective of the impact of mining on women community

India has a predominantly agrarian population that is dependent on the land and forests for its sustenance and social, cultural and economic lively hood. Rural and tribal women are primarily responsible for nurturing the family, colleting the forest products, and agricultural and livestock management. These women have a very intimate and symbiotic relationship with the ecology, as they are untenably linked to the natural resources. Governments and societies must recognize this link when they are conceptualizing development objectives and projects. Women are frequently alienate from development paradigms and their close association with the ecology receives even less recognition (Ghose 2004). In India exploitation of land and natural resources has a long history involving abuse and plunder. Most mining and mineral operations are found in forests regions, which are also habitat for tribal (indigenous) communities

Gender based discrimination and exploitation including female infanticide, dowry deaths, unequal wages, high levels of female illiteracy and morbidity, cast-based discrimination and other social evils, are wide spread in India. In India it has estimated that about 10 million people have been displaced due to mining projects. 75 % of people displaced have not yet been received any form of compensation or rehabilitation (Bhanumati 2002). In India, women have no legal rights over land or natural resources. The Land Acquisition Act is draconian obsolete., providing over-riding powers to the state to encroach onto people’s land for any public purpose including mining. To this day, the country does not have any relief and rehabilitation policy as a constitutional safeguard for its people. Local communities are not consulted about the acquisition of their land for projects and women are especially marginalized in the negotiation process. They are the last people to be informed about land acquisitions and their options and objections are rarely taken into account during decision-making. Testimonies from women living in coal mining areas show that displacement and loss of land are the most serious problems affecting their lives and livelihood, economic and social status, and health and security all depend land and forests. Mining has resulted in total destruction of traditional forms of livelihood and women's roles within subsistence communities. Women displaced by mining lose the right to cultivate traditional crops and due to forest destruction, are unable to collect forest produce for sale or consumption. As a result they are forced into menial and marginalized forms of labor and maids, servants, construction laborious or prostitutes –positions that are highly unorganized and socially humiliating.

Abundant medicinal plants are lost due to forest destruction, leaving women without a natural health support system. Often they are two poor to purchase medical services and medicines. Furthermore as the mining companies do not pay for the miners' medical expenses, employed men spend a large proportion of their wages on medicine, falling into a vicious cycle of indebtedness that drags the whole family into bonded labor. Historically, men have been the only recipients of rehabilitation program that provide their cash or employment to communities affected by mining. As a result , women have become completely 'idle' in the economic sphere. Often, when men get employment, women are forced to manage agricultural activities on their own. Displaced tribal communities that are not provided with compensation or rehabilitation, migrate to the bordering states in search of land and forests. They cut down vast stretches of forest for survival and face the harassment of the Forestry Department.

Displaced women are mostly absorbed into the small private or unorganized sector of mining related activities, where women are the first to be retraced, have no work safety measures, are susceptible to serious health hazards, and are exposed to sexual exploitation. The large-scale mines, which are increasingly technology dependent, have no space for women's participation as they are illiterate, lack of technical skills and face cultural prejudice. Whilst large-scale mining has limited space for women's employment, the small-scale sector absorbs women as contact or bonded labor under highly exploitative conditions Women's wages are always less than that of men, safety standards are non existent, paid holidays are not allowed even during pregnancy or childbirth. Un employed women living in mining communities eke out their livelihood by scavenging on the tailings and waste dumps, often illegally, and suffer from the constant harassment of the company guards, Mufia and the police. They are exposed to the physical and sexual exploitation of the mine owners, contactors and miners. They are at the mercy of local traders when selling their ores. In addition, women work with toxic, hazardous substances and suffer from several occupational illness including respiratory and reproductive problems, silicosis, tuberculosis, leukemia, and arthritis.

Most women working in mines have to leave their children at home, unattended, for the entire day. If they manage to take their children to mine-site, they expose them to high level of dust and noise pollution. In addition, the children are at risk of falling into the mine pits while playing and are susceptible to accidents from mine blasting. The living conditions of women displaced by mining have serious negative impacts on women. Tribal women's loss of economic status and the increase in non-tribal population in mining communities has resulted in degrading social customs. Social evils like wife beating, alcoholism, indebtedness, physical and sexual harassment, polygamy and desertion have emerged in many places. Human rights violations on female miners or women affected by mining have increased and are actively encouraged by state and corporate powers.

The lives of the women living in the gold mines of Kolar, Karnataka, provide stark evidence of exhaustible 'sustainability' of mining. The government has declared the mine bankrupt and exhausted, and is currently engaged in a legal battle with the union to ensure closure. As the laid-off men remain idle, women are forced out of their homes to eke out a living for their families. Within a span of one year since closure, there have been at least 35 deaths in this town due to stress and trauma. The government and the company have deliberately washed their hands off any responsibility towards the future of miners except offering a small compensation payment. The land is unfit for any use other than mining, women and communities haven left in despair.

Large multinational mining companies have only recently entered the industry and communities have not yet have experience dealing with such macro player. However, these companies have exhibited considerable influence when lobbying for changes in mining policies and legislation in the very short time since their entry into the market. The World Bank funded coalmine in Hazaribagh provides further evidence of mining based injustice and ecological destruction In addition to having use of contaminated water due to coal washeries, women are often harassed and assaulted when collecting wood, working, or when visiting neighboring villages. The women are too afraid of the 'Coal Mafia' to give testimonies of these of such incidents in public hearing or meetings. Although the Inspection Panel of the World Bank has been approached regarding these grievances, women are yet to experience justice.

6.0 Contribution to employment and social perspective

The increasing importance of small-scale mines in India, has led to increased employment and economic activity (Ghose 2003c). Because little is known of the extent of their production and their technical, and environmental implications, there is a need to obtain better information so that the promotion of small-scale mines can proceed in an effective manner. Information on employment; output; capital investment; revenue generated; and safety and health aspects is either inadequate or non-existent. In terms of government assistance to the sector, a case can be made for implementation of a straightforward reporting scheme, which would provide the data necessary for policy development and subsequent control of the sector, so that small-scale mines can make their best contribution to the economy and welfare of the country.

The employment effects of small-scale mining are considerable, especially in tribal and rural areas. A total workforce of about 500,000 is involved in this activity in India. Despite some drawbacks, small-scale mining has several benefits. These include the ability to operate in remote areas with little infrastructure, enabling the exploration of otherwise uneconomic resources, and a high degree of flexibility because of low overheads. Small-scale mining may also fit in well with existing social structures, particularly if seasonal operation is required to be compatible with agricultural production in the same area. The ability of small-scale mines to generate employment, income, and entrepreneurial skills in rural areas can act as restraint on migration to urban areas. In addition, because they are generally locally owned, small-scale mines can provide a larger net gain to the community and to the national economy than do larger, foreign-owned mines. On the other hand, small-scale mining can be inefficient, may suffer from poor working conditions, safety and health problems, and cause environmental degradation (Hickie and Wade, 1998). Much small-scale mining activity is carried out illegally and is thus difficult to monitor and control. Because of widespread smuggling, there can be considerable losses to the miners themselves and to the Government. In India, more than 50% of the total mining labor force can be engaged in small-scale mining. Thus, these enterprises, which make an essential contribution to economic growth, need to be integrated fully into their respective local economies.

7.0 Socioeconomic status of artisanal mining areas

Small-scale mining does contribute towards the improvement in the social environment around its locality, provided the sector is given some attention in the interest of the State and the workforce (Ghose 2003d). With regard to industrial status, small-scale mining is still considered an unorganized sector, receiving a stepmotherly treatment from both local and central government. Located in far-flung areas, isolated, disadvantaged by lack of power and infrastructure small-scale mines have always been considered as small-time investment and never have been considered as a continuous stream of income generation, both during and after mining. In sum, small-scale mining is unfortunately ill-supervised, neglected and viewed merely as a quick money-making proposition before leapfrogging into a new locale.

It contributes to some extend towards development of rural areas. Small mining operations help to create improved infrastructral facilities, like approach roads energy and water supply in a low scale. Small mining activities, being situated in economically backward areas, stimulate greater variety in income distribution and create new job positions. Consequently, the social and economic standard of living of the people in place starts rising further. Apparent contribution to government is the taxes and royalties from operators. But a significant contribution is fulfilling the social planning, the objectives of rural income generation, infrastructral development and stoppage of migration of rural labor.

8.0 Practices in small-scale mining

As compared to underground mines, Indian opencast workings are less complex in design, configuration, mechanization and operation, primarily because of more congenial environment and the ready availability of indigenous equipment. Small mines, particularly those producing minerals of low value, are not mechanized. Most of the operations are carried out manually in opencast workings. Generally, manual means are employed for both breaking and loading of the minerals. In case of very hard rocks, the rock is sometimes cracked by heating it and subsequently cooled with water, and sometimes explosives are used. Shot holes are drilled either manually using crow boards or mechanically using compressed air operated jack hammers to form a block and chisels are used or to extract the block. The workings are extended downwards, generally without formation of any bench, and as the depth increases, many a times ropes are used to go down to the floor of the quarry or to work on the sides on very small ledges.

Small-scale mining practices are as diverse as the minerals produced. At the low end of the industry, informal, micro-scale mining typically consists of the extraction of high value minerals, usually from alluvial liberalizations or outcrops, conducted by individuals or families, using purely manual techniques. By contrast, traditional and advanced small-scale mining comprises formal, organized mining activities carried out by small enterprises with limited capacity. Micro-scale mining is essentially confined to surface occurrences of minerals. Frequently, the only physical assets employed are the pick, the shovel, and the pan. Production and income are usually erratic and often marginal, due to the technical limitations. Unlicensed and unrecorded conduct of business is the rule rather than exception.

Micro-scale mining also has record of inadequate safety, poor social facilities, and environmental neglect. In some areas, the activity is associated with high incidence of malaria and other diseases. As a migrating form of mining it can contribute land degradation and deforestation. The next larger category of traditional small-scale mining consists of registered and licensed although non-mechanized or semi-mechanized mines, operated on a regular schedule by organized society members or entrepreneurs with the use of hired labour. Principal constraints faced by this category include lack of professional skills and capital required for mine planning, pre-production development, and mechanization. As a result, operations are usually limited to shallow portions of deposits and productivity is low.

Advanced small-scale mining encompasses small mineral properties using sophisticated mining and processing techniques based on professional expertise and state-of-the-art engineering design. Mines of this category play an important role in the mining sector, particularly in the field of industrial and construction materials. Operations are frequently privately owned, highly competitive, and in terms of financial performance, of superior to large-scale mines. Market orientation and continuous research and innovation, together with the enterprising spirit of the owners and engagement of skilled employees, are the key success factors. Mines in this category provide the most valuable evidence of ways and means as examples for successful small-scale mining. Necessarily, the classification of practices discussed is a simplification and numerous mines obviously exist in transitional areas are between the categories. The number of mines using, or on the way to introducing, advanced mining techniques is growing steadily. While these operations are largely competitive without outside assistance, both micro-scale mining and traditional small-scale mining will require supportive policies and programmes to improve working conditions and performance.

9.0 Indian policy on small mining

The small-scale mining sector in India does not have an appropriate place in policy statements. India has, however, a very special place for small-scale industries, but no corresponding place for small-scale mining (Anon 2000). Also, small-scale mining is not considered an industry for examining any benefit from the long least meant for SSI. In a way, it is a neglected sector in the Indian economy. This apparent neglect has led to the sector being developed in a haphazard manner so far, without guidance and support. But during the last 10 years or so, the small-scale mining sector has also, to some extent, been caught up indirectly in the vortex of globalization of India's economy. The better organized small-scale mines, in the upper range of production, in order to survive in the emerging competitive market, have been investing more and trying to adopt some advanced technology, involving methods to increase productivity and improve quality.

Although mineral wealth rests with the state government, the subject of regulation of mines and mineral development is covered by the constitution of India. By virtue of this, the Parliament has exclusive powers to make rules with respect to regulation of mines and mineral development, while rule-making powers in respect of minor minerals has been delegated to the state governments, under section 15 F of the mines and minerals regulation and development act of 1957. Thus, states have framed different rules under this provision. Mineral rights are granted in three ways: through leases, quarry licenses and permits.

The industrial policy resolutions of 1948 and 1956 recognized the important role of small-scale mining in the Indian economy.(Anon 1991) A significant aspect of this resolution was that it did not place any hindrance on the operation of small mines by privately owned enterprises, even for minerals envisaged under large-scale operations through the public sector. The problem of small-scale mining has since been taken into consideration in the recently declared national mineral policy. In paragraph 7.12 of the document, it is stated that small-scale mining with modest demand on capital expenditure and short lead time provides employment opportunities for the local population. Efforts will be made to promote small-scale mining of small deposits in a scientific and efficient manner while safeguarding vital environmental and ecological imperatives. It further states that preference should be given to scheduled tribes for mineral concessions for small deposits in scheduled areas. As regards size of operation, paragraph 7.2 of the mineral policy emphasizes conservation and development of scientific methods and states that tenure, size, shape, disposition with reference to geological boundaries, and other conditions should be such as to favorably predispose the lease areas to systematic and complete extraction of minerals. The issue of environmental management is being adequately addressed (Ghose 2001).

For a major group of small mines, producing minor minerals like building stones and sands, special provision has been made in the Mineral Conservation and Development Rules (MCDR) to relax the statutory qualifications. The recently amended MCDR provides for systematic planning of this type of deposit through a mine plan, and leaves the implementation to those with lesser qualifications. In the mines act, mines which do not go below the superjacent ground, opencast workings not extending more than 6m below the ground and where explosives are not used, and mines that do not employ more than 20 persons day are not considered under the purview of the act. While India's mineral policy clearly advocates leasing to local tribal people, it is an accepted fact that statutory provisions are generally phrased in complicated language, and require a good understanding of the implications of law on the part of the mine operator. Most of the members of scheduled tribes, for whose benefit the mineral policy has been designed, do not have the legal background required to be able to follow these provisions. All provisions of the mining law are not applicable in every case, depending on the location and extent of the deposit. Qualified mining and legal experts can prepare a systematic mining plan encompassing conservation, development, environment, and safety aspects. Local people, through representatives experienced in mining, can implement the annual action plan. Relaxation of legal provisions can be sought and granted by the statutory authority under the existing provisions of MCDR and MMR, but what is needed is a government agency to help local applicants get a lease through a single-window system. The government of Gujarat has taken steps in this direction through the Department of Industry after setting up an Industrial Extension Bureau.

10.0 Role of the Government

While there is a delicate balance to be achieved between control and encouragement, the provision of a legislative and regulatory framework that generates stability in the sector, will make it easier to improve safety and health conditions in small-scale mines, reduce wage exploitation, and improve working conditions. It is of equal importance that technical and management expertise are improved and that conditions are in place that encourage open sales of mining products. The Government has also an important role to play in providing training opportunities and in ensuring that safety and health regulations are appropriate and are observed.

A developing country like India will be required to strive for industrial development. This will call for increased minerals production, while due regard to safety, conservation and environmental management are strictly observed (Ghose 1997). States, being the first owners of a mineral property and the receivers of royalty and 'dead rent' from mineral exploration, should enter into appropriate agreements with entrepreneurs, before the commencement of any development of mineral prospects, on the following basic principles:

- Ease of processing and timely granting of the mining lease.
- Assurance from the developer/entrepreneur through regional EIA and EMP for cluster of mines in the area, that the development will not pose a threat of irreparable environmental damage (Sen and Ghose 1997a; 1997b).
- Provision of basic infrastructure services, such as approach road, power, water, community market etc, in areas where a large number of small mines are expected be opened, without over-legislating basic educational facilities (a minimum of high school level) should be available nearby, where the mineral properties are located.
- Opportunities should be given to local people, which is very important as, after all, they have lived on the land from time immemorial.
- Provision for employment-oriented training and the widest possible opportunity of employment for so trained local people.
- Small-scale ancillary industries should be developed surrounding the project.
- Emphasis should be given to the development of mineral resources in rural areas. This in turn, would mean the development of the rural area itself, which will contribute directly to the development of the local rural economy, a responsibility of the State.

There is a need to educate mine owners and workers, and the statutory authorities may consider arranging free dialogue/workshops between legislators and miners to ensure that legal provisions are fully understood. This would go a long way towards improving observation of rules, particularly by owners of small mines. Such training should focus on strengthening the capacity for a participatory process in decision-making in order to provide incentives for local initiatives and enhance local management capacity. The strategy envisioned is to focus on specific problems in mineral resources management and capitalize on existing databases, maps, and available environmental and socio-economic studies.

The specific training objectives should be:

- To provide the necessary tools techniques and methods that will assist local and national agencies in the assessment of environmental and socio-economic impacts of alternative strategies of resource management, and enable other interests, including, in particular, local communities, to formulate their concerns in way that can be integrated into the decision-making process.
- To provide training in the application of management tools.

Adequate training infrastructure should also be created so that eco-friendly mining, an integral aspect, would also be covered. The following steps should be implemented in a sequential manner for sustainable development of artisanal mining areas:

- Establish a committee/working group of administrative personnel with delegative powers to remove policy bottlenecks (for example, demarcation of forest land, Panchayat land & mining lease area etc.) and social issues (such as alternate employment).
- Establish a community task force to raise awareness of the advantages of environmental preservation and encouraging people to enlighten others. (This may be undertaken by NGOs).
- Prepare regional maps and location plans for each mining pit (area wise and zone wise).
- Prepare regional environmental management plans (carrying capacity study) for each cluster of small mines in a given area by a scientific organization and work out the modules for environmental protection (Kundu and Ghose, 1994; 1997).
- Invite experts/expert organization to solve various problems identified in earlier steps periodically and as a regular practice.
- Adopt and implement suggestions into actual practice and fix future strategy.

11.0 New configuration of small-scale mining

There is a need to ensure the existence of an adequate economic and social infrastructure at the remote sites where small-scale mining is often carried out. In this regard, government has to establish special small-scale mining agencies in order to create the means to commercialize and legalize artisanal mine production and to raise living standards and employment opportunities in rural areas. The creation of mining cooperatives has been one of the more successful ways in stimulating small-scale mining. Cooperatives have two significant advantages. Through their greater financial power and long-term viability, they have facilitated access to mining and processing equipment. This increases output and therefore income. Also, a wider ownership structure gives stability to the operation, and helps it weather the boom and bust cycles that are common in small-scale mines. Profit flows can be, and have been, used to create social services, such as medical services for workers and their families, as well as for expending production capacity. Encouraging the creation of central processing and transport facilities, including through cooperatives would help informal mining operations to be more efficient and productive.

Small-scale mining has earned the dubious distinction of being the springboard for people centered development (Ghose, 1994). The very same sector of small-scale mining may engender a paradigm shift towards a new development approach that could be ecologically and economically self-sustaining, as well as equitable. The sector holds the potential to eradicate poverty by creating employment; generating income from mineral exports; and perhaps also to provide social stability in the coming decades. A thriving small-scale mining sector, besides offering direct employment and real income to unskilled rural population also helps stem rural urban migration flows, enabling people to remain in their native communities practicing complementary agricultural and seasonal trades (Ghose, 1991).

In the recent past, the role of minerals and metals in economic development in India has received much attention (Ghose, 1986, 1990a). Characterized by low and middle income economics, India faces a major challenge in terms of economic revival and has emerged as a variable global problematic. The technological level of the informal small-scale mining sector needs to be upgraded to help it become more self-reliant, viable and sustainable. Economic viability depends upon its ability to produce cost-effectively and market its products, either within the local economy or for export. The need to strengthen the technological capacity is thus inescapable and for each type of small-scale mining activity, from micro-scale family-owned operations to more traditional small-scale mining, appropriate technological inputs have to be identified and deposit-specific models of small-scale mining developed.

The idea of a new technological configuration is expanded on here in terms of a hypothetical example from India. Currently, a small gold rush is taking place at Bandwan Block in South Purulia District of the state of West Bengal, where extensive gold panning operations have been undertaken along the river valleys to Totko, Jamuna, Kumari, and Sona, by an estimated work force of 2000. The gold miners earn a pittance of about Rs.20 per day (less than half a U.S. dollar) and eke out a miserable existence. An incremental advance in technology could be made possible by providing the workers with a batea rather than a pata, to help improve recovery. However, if a group of workers could be provided with simple hand concentrators, such as 'Mighty Miner' (marketed by David Mathieson & Associates Pty. Ltd., of Australia and priced at US$500), which uses a 44 gallon drum and special sieves, throughput could be raised to 3t/day or more, with improved recovery of micro fine gold and concomitant higher earnings. If the deposit conditions allow it, a Terraprobe may identify prospective areas and different scales of operation for washing the alluvial may be devised. For example, one could use the Prospector (from Goldfield Engineering, Provo, USA, which can wash 2-4 yards per hour) or a heavier transportable gold washing plant (for example, Alaskan Models 10, 25, and 35 manufactured by the same company which may cost US$ 12,000-30,000) as the operation gets organized either by an entrepreneur or through a cooperative to raise appropriate capital.

Essentially, therefore, finding a new configuration boils depends on raising the production through simple means, to a partial and finally a full mechanization appropriate to the scale of operations. There is need for tools and artifacts and modules of mechanized equipment complement, which should be simple, maintenance free, and at the same time environment-friendly. For each level of small-scale operation, the appropriate technology must be identified, the criteria for which have been discussed by McDivitt (1990).

At the other end of the spectrum, the new configuration will seek to promote reasonably capital-intensive but environmentally compatible mining systems, which could exploit small deposit through a mining 'circus' in a mineralized district. The industrial minerals sector could rightly be targeted for a massive input of such new technological options for small-scale but profitable operations. In the case of dimension stone/construction material particularly, significant quantities will continue to be required in the development process of most developing countries. We may be witnessing the emergence of a new stone age as consumption of construction materials has now reached a level of over 10t per capita in developed countries and some 1-2t per capita in developing countries. Be it as a basic raw material, like limestone or dolomite, construction stone, crushed aggregate, or dimension stone, the sheer volume of the operations calls for major technological input in appropriate modules. The material, after being quarried, needs to be trimmed to specified sizes and shapes, which as a downstream processing operation can also provide employment. Stone extraction and processing, which hitherto had a local rather than an international character, has undergone a profound change with the rising demand of high unit value dimension stone. The reassessment of stone extraction technology has currently focused on energy considerations and environment-friendliness; and new types of equipment must increasingly be used – both in the quarry and the processing plant – such as new types of rock splitters, new extraction technology using expansive cements, and improved rock-breaking devices.

The transition to new technological modules in the small-scale sector should be matched by appropriate and supportive promotional policies, legislation, and technical and processing services. Such a new configuration, even cosmetic changes, can only be possible trough a massive organized effort on the part of organizations such as FADEMIN, which will focus on financing, technical services, and administrative and environmental control. The use of machinery pool and of regional processing facilities is also envisaged. An organized small-scale mining sector may be better able to take advantage of the opportunity.

Therefore, the new configuration of small-scale mining in developing countries will lead to a metamorphosis of the current do-it-yourself type of artisanal mining. Given an enabling environment with increasing intervention by government and non-governmental organizations, an organized sector with much greater input of technology may emerge viable, self-reliant, and better able to move up the gradient from artisanal to high-tech mining. Using deposits-specific and mineral-specific exploitation plans and environmental control measures, we can foresee increasing proliferation of such small-scale mining activity, supported by promotional policies of the state.

The attributes of the modular mining systems for small-scale operations should include:

- Appropriateness to the level of operations, including skills profile of the workers, low maintenance requirements, and user-friendliness;
- Low energy requirements, preferably using regenerative energy supply; and
- Mobility or transportability for use in different mine sites.

A wide range of modular systems could be envisaged, but the focus must primarily be on cost-effectiveness and environmental compatibility.

For the dimension stone industry, for instance, one could adopt the rock mass, subdividing the blocks into smaller blocks, equating by dress drilling, and finally squaring the blocks for customer requirements. A range of methods – from expansive cements to flame jet cutting- could be conceived for each scale of operation. For the new configuration of ore mines, one could select appropriate capacity of caravan mills, which are essentially reassembled concentrating plants on trailers. Such compact, easily transported units for crushing, grinding, separation, dewatering, and power supply can serve for a group of small-scale operations in a mining region (e.g., Sala Caravan Mill).

12.0 Barriers to technological upgrading

Major barriers to technological upgrading, especially of incremental innovations, in the small-scale mining sector will be the problems of technology diffusion and resistance to change. The progression from any incremental technological change to innovative systems and then on to the stage of imitation or diffusion can be painstakingly slow, especially due to the lack of effective communication and exchange of ideas in the small-scale sector. While a technology can improve and develop during the diffusion process itself, in the small-scale mining environment for any new technology to be successful, it has first to be implemented and then learnt by use (Ghose 1997a). Another impediment is that any equipment or technique is exploitable if, and only if, the recipient has attained a certain technological level. Technologies for small-scale mining are not just blueprints or artifacts; they require skills, some know-how, and proficiencies on the part of the work force at various levels of involvement. Since any technical change in the small-scale sector may be perceived as a quantum jump in uncertainty, this may encounter stiff resistance from the miners. Infusion of new technology in the small-scale mining sector will therefore call for a major effort at training in specific fields, the key concept being that of learning. The major effort at training in specific fields, the key concept being that of learning. The major difference between technological systems in the developed and developing world relates to the very different manpower, training, work ethic, and employment traditions. For the rapid implementation of new techniques in the small-scale mining sector, involvement and attitudinal change will have to be emphasized.

In a triplicate meeting organized by the International Labor Organization (ILO, 1990), the question of small-scale mines was discussed by participants from 22 countries, including India. The meeting concluded that good safety and health measures should not be neglected in this type of mines. To that end, public authorities should promote training of mine inspectors with the task, among others, of providing the employers and workers concerned with information and advice so that regulations on working and living conditions in the mines be observed. Jobs that are created in small-scale mines should confirm to national and international labor standards and be subject to inspection. Small-scale mines should be made to adhere to the relevant standards. Because they are invariably labor intensive, it is important that they should be included in statistical surveys and be subject to ongoing monitoring. Despite action taken by the Government of India to develop small-scale mines and improve their profitability, price fluctuations and unstable markets are major sources of income and employment problems in the sector. The ILO is already involved in technical cooperation in India to improve safety and health of in mines. Training programmes for mine inspectors, operators, and rescue teams and mine owners are underway. In several cases, the projects are geared towards small-scale mines. Experienced mine personnel are serving as chief technical advisers. In addition, the ILO has prepared and published several codes of practice that are relevant to the mining industry, including small-scale mines.

Thus it is obvious that irrespective of location, size and type of the mine, there is much scope of application of science and technology for techno-economic improvement of the Indian small-scale mining sector to render it more self-reliant, economically viable, and sustainable. There is a wrong notion that application of any technology is always a capital-intensive affair (Rathore et.al 2000). On the contrary, a technology is said to be successful only when it suits a given condition and yields positive economic results. From the Indian socio-economic perspective, it would be irrational to think of high-tech, capital-intensive small mining ventures like those in advanced countries. Thus, for instance, the Ankele opencast dolomite mine in Finland, a highly mechanised mine with automation, produced 82,408 tonnes of mineral in 1989, with only two miners working for 3763 hours in the year (Matikainen and Pukkila 1990). But it would be irrational to plan for such mines in today's India.

Obviously, Indian small mines should basically be a labour-intensive industry, to make use of the huge reserves of manpower readily and economically available in the country. Moreover, deployment of larger manpower reduces the capital requirement of any project. In turn, it would promote the regional socio-economic development. At the same time, to optimise the economic benefit of any small-scale mining venture within its given limits of infrastructural facilities and resources, necessary operational support should be provided by appropriate technology. Appropriate technology does not mean any particular level of technology. It may be conventional, even primitive, or sophisticated and ultramodern. The only criterion for any technology to be appropriate is that it fits the system and purpose in question.

While conventional or indigenous but costly machinery may not be appropriate for many Indian small mines, the use of sophisticated computer based techniques may be most appropriate for planning and designing those same mines by external agencies. For overall improvement of the Indian small-scale mining sector, it is most essential to adopt a pragmatic approach at all levels. It is evident that small-scale mining has much in common with industries such as construction and agriculture. Many of its processes are simple and direct, involving earthmoving, breaking and sorting of materials, drainage, water and power supply, and transportation of bulk materials over short distances. So far as gaps in equipment availability are concerned, larger and more sophisticated units have presently replaced much of the rather simple equipment, which was used in the past. But, slightly upgraded versions of this early equipment can be of much use in small-scale mining sector even today.

For technological upgrading of Indian small-scale mines through mechanisation, the criteria for equipment must be in tune with the socio-economic and technological backdrop of the country.

Thus, equipment for small-scale mines should:

- Require small amounts of capital;
- Emphasise locally available materials;
- Be relatively labour-intensive, but more productive than many traditional technologies;
- Be small enough in scale to be affordable to local groups;
- Be easy to underground, operate and maintain by local people without high level training;
- Be of simple design to be produced in local workshops;
- Be flexible and adaptable to local circumstances;
- Be in harmony with local needs, traditions and environment;
- Extend human labour and skills rather than replace or eliminate them;
- Place emphasis on self-reliance to meet local needs; qne

- Minimise the impacts of infrastructure limitations and shortage of trained manpower.

These criteria emphasising simplicity and self-reliance are difficult to build into the programme of large organisations, but are well suited to projects carried out by small groups.

13.0 Environmental management

India, however, is not a unique case, as it is a well-known fact that most small-scale mining adversely impacts the environment. Several countries have adopted different strategies for tackling pressing environmental problems of the industry. The following sections describe how India is working to address some of this.

It is mandatory to draft an environmental management plan (EMP) before commencing any mining project in India (Ghose 2001). The socioeconomic environment has been considered as one of the most important parameters in an EMP report and even international funding agencies, such as the World Bank, emphasize this aspect (Ghose and Lal, 1998; 2001). A number of NGOs are also working in this sector and coordination is being made with social experts and technocrats (Ghose and Kumar 1997b). An EMP helps to ensure that the potential environmental impacts of a project are assessed and incorporated at an early stage of development planning. The procedure of preparing an EMP has been accepted as a statutory requirement for granting a permit from the environmental angle (Ghose 1997b). In India, the Public Investment Board requires an environmental clearance from the Department of Environment (DOE), Ministry of Environment and Forests, Govt. of India, to sanction funding for all major projects. All mining projects need to be cleared by DOE to ensure that effective safeguards are in place to prevent environmental hazards (Sen and Ghose, 1997). DOE has issued guidelines for the preparation of an EMP report for mining projects. Finally, the Environmental Appraisal Committee for mining project (EAC-M) formed by DOE examines the EMP report before granting clearance for the project.

Presently all new mining projects and those undergoing reorganization involving more than 5 ha of land are required to obtain environmental clearance from the Central Government. The policy relating to the promotion of environmental improvement, hence, cleaner production in the small-scale mining sector in India is governed by respective state governments. The mineral (environmental) policies do not vary from state to state. As all the states in India are working under the umbrella of the national policy, implemented by respective state governments.

14.0 Conclusion

India will be required to strive to attain increased production of minerals. Small-scale mica mining provides a wealth of socio-economic benefits to rural inhabitants, generates employment, income, fits in well with existing infrastructure, and can to restrain migration to urban areas. It also makes a significant contribution to development objectives, however there is no nationally accepted criterion for this. Nevertheless, the sector is still considered an unorganized sector and it does not figure prominently in government policy statements. The socio-economic significance of small-scale mining operations is often overlooked, and there is a need to protect its economic and social benefits. The creation of mining cooperatives can be one of the more successful ways in stimulating small-scale mining. There is a need to educate mine owners and workers with establishment of mining centre consisting of shared mining and processing facilities plus a practical mining advisory service. Thus, the operations, which make an essential contribution to economic growth and social benefit, need to be integrated fully into their respective economics. This report suggests certain ways in which more involvement of female miners in the industry can be achieved.

Recommendations

In order to be prosperous and safe, mica mining needs to be raised from its condition as an unorganized unsupervised industry to one that is modernized, monitored, organized, and supported so that specific goals can be set and met. In recognition of the need for state support for small-scale mining, government is implementing programmes to foster it. These are also making small-scale mining more attractive to private sector involvement. Reasons for promoting small-scale mines include: the creation job opportunities in rural areas for unskilled labor in mining; diversity is dependence or imports of basic commodities successful artisanal mining will also encourage locals to participate more fully in private sector activities. Making mica mines, thereby making them better recognized and accountable for their labor practices and safety conditions will help to secure improvements in the lives of rural people.

The tax regime and the conditions of purchase of mine output can be very important. The involvement of Government in purchasing arrangements, plus the means to ensure the deposit of material for sale, can not only reduced illegal dealings, but also stimulated additional mining activity. The second step to be taken by the Government is to provide social and technical assistance. This can often be accomplished more easily through mining cooperatives than for individual or small groups of miners, often widely dispersed geographically. The presence of a regional assay office can help miners to determine a viable search strategy. Simple but effective analytical facilities, which can operate in the field without the need for electricity, can be set up for about US$25,000. Lack of equipment is a major constraint to the operation of artisanal mica mines. Without explosives, output is low. Unless pumps are available, mining operations often have to cease once the water table has been reached. The lack of ventilation in underground operations quickly leads to physiologically difficult working conditions. Overall, life is very much is at risk in artisanal underground mines. However working conditions can be improved through fairly basic technical support and the provision of appropriate equipment.

India needs to establish mining centres based on shared mining and processing facilities plus a practical mining advisory service, that would provide information and training. Mica miners in the region could thus obtain free technical advice from resident mining engineers; drilling and blasting services; and access to a custom milling plant to process ore at a competitive price. A major factor that can inhibit the successful economic development of small-scale mines is the processing of ore. Artisanal miners need to receive technical training and advice on the assessment of ore grade and on mining practices so that the output of processable mineral can be increased.

Another important task of the Government is to create the geological base necessary to provide mica miners with information to assist their prospecting. This includes the need to train the miners in prospecting techniques.

References

Anon (1976) *Mica Pegmetites—A literature Survey, Mica Pegmatites of India* , Geological Survey of India, Bulletin No. 5, April,pp49

Anon (1983) *Mining and Geological Studies : An Aid to Mica Mining* Indian Bureau of Mines, Nagpur , India

Anon (1990) Mica—A Market Survey, Indian Bureau of Mines, Nagpur

Anon (1991) *The Mines Act* 1952, Gyan-Khan Prokashan Dhanbad, pp1-108

Anon (2000) *Indian Minerals Yearbook*, MGMI Publication, Calcutta, India

Anon (2001a) *Statistical Profile of Minerals*, Indian Bureau of Mines, Nagpur, India.

Anon (2001b) Statistics of Mines in India, (Non-coal), *Directorate General of Mines Safety,* Dhanbad.

Argall, G.O.Jr. (1978) Future of small-scale mining- important for the future, *Conference UNITAR* New York, USA.

Bhanumati, K.(2002), The status of women affected by mining in India, *Tunnel Vision: Women, Mining and Communities* , Australia, pp20-25

Carman, J.S. and Berger, A.R. (1990) Small-scale mining: a general review, In:. *Small-scale Mining: A Guide to Appropriate Equipment*, McDivitt, J.F. Intermediate Technology Publication, London. pp ix-xi.

Chakrabarty,D. (1989)Rethinking working-class history: Bengal 1890-1940, New Jersey,pp219-230.

Chakraborty, M.K. (2002) Issues and problems of Indian small-scale mines, *National Seminar on Policies, Statutes & Legislation*, January, CMRI, Dhanbad, India

Cramer, S. (1990) The legal battle of small-scale mining, *Appropriate Technology*, **17**(2) pp5-7.

Ghose, Achyuta K.(1997a) Scope of mechanization and application of appropriate technology in Indian small-scale mines, *Minetech*, 18(1&2) pp32-36.

Ghose, A.K.(1986) Mineral development in LDCs-constraints and challenges , In: Strategies for Exploitation of Mineral Resources in Developing Countries. Ghose, A.K.(Ed)Oxford & IBH Publishing Co. New Delhi, pp49-58.

Ghose, A.K.(1990a) Minerals , metals and developing countries-a forward look, *Proc. 14th Congress of CMMI*, Edinburgh, Institution of Mining &Metallurgy,London,pp249-255.

Ghose, A.K.(1990b) Technology trends and policies for solid energy materials in developing countries by 2001, Proc. 14th World Mining Congress, Beijing, Weitang, F.(Ed.) Pergamon Press,pp66-76.

Ghose, A.K (1991) Towards an integrated plan for socio-economic development-the small-scale route, *Jr. of Mines Metals and Fuels*, March, pp7.

Ghose, A.K. (1994) New configuration of small-scale mining for developing countries, In: *Small-scale Mining – A Global Overview*, Ghose, A.K.(Ed)Oxford & IBH Publishing Co. New Delhi, pp29-42.

Ghose M.K. (1997b) Environmental management for disposal of spoils and tailings from the mines, , *Environment and Ecology*, **15**(1) pp. 206-210

Ghose, M.K.(2001) Management of topsoil for geo-environmental reclamation of coal mining areas, *Environmental Geology*, **40** (11/12) pp1405-1410 (2001).

Ghose, Mrinal K.(2002) Environmental management in small-scale mining in Indian context, *TERI Information Digest and Energy Management,* **1**(4) pp629-636)

Ghose, M.K.(2003a)Promoting cleaner production in the Indian small-scale mining Industry, *Jr. Cleaner Production* ,**11,**pp159-165..

Ghose, M.K.(2003b) Indian small-scale mining with special emphasis on environmental management, *Jr. Cleaner Production* , **11,**pp167-174.

Ghose, Mrinal K.(2003c)Environmental impacts of Indian small-scale mining industry- an overview, *Minerals and Energy*, **18,**pp24-33

Ghose, Mrinal K. (2003d) A perspective of small-scale mining in India, In: *The Socio-economic Aspects of Artisanal and Small scale Mining*, Gavin M.Hilson (Ed.), A. Balkema Publishers, The Netherlands, pp449-457.

Ghose , Mrinal K. (2004) Impact of mining on female community: a perspective of female miners in the Indian context, *Minerals and Energy*, **4,**pp16-24.

Ghose, M.K. and Lal, Giradhari (1998). Assessment of socio-economic impacts due to a coal washery project, *Jr.of the Indian Association of Environmental Management*, **25** (3) pp. 136-140.

Ghose, M.K. and Lal, Giradhari (2001). Impact assessment of coal washery projects on socio-economic environment-an Indian case study, *Jr. of Environmental Studies and Policy,* TERI, **4** (1) pp35-44

Ghose M.K. and Kumar, A. (1997a) Management of the spoils and tailings from coal washery and mineral beneficiation plants, *Jr. Indian Association of Environmental Managemen*t,, **24,** pp. 63-67(1997).

Ghose, M.K. and Kumar, Y. (1997b) Impacts on socio-economic environment due to a large opencast coal project -. *Jr. of the Institution of Public Health Engineers*, (1) pp. 53-54

Ghose M.K. and. Sen P.K (2001) Characteristics of iron ore tailing slimes in India and its test for required pond size, *Environmental Monitoring and Assessment*, **68**, pp51-61

Hickie, D.and Wade, M. (1998) Development of guidelines for improving the effectiveness of environmental assessment, *Environmental Impact Assessment Review*, **18,** pp267-287.

Holland, T.H. (1902) *The Mica Deposits of India* , Memorandum, Geological Survey of India, **34,**

Kumar, A. (1968) *A Report on the Mining –Geological Study of Paisara Mica Mine* of M/s S.K.Dev Mica Mining Co. Indian Bureau of Mines.

Kundu, N.K. and Ghose, M.K. (1994) Studies on the topsoil of an underground coal mining project, *Environmental Conservation*, **21** (2) pp. 126-132

Kundu, N.K. and Ghose, M.K. (1997) Shelf life of stock-piled topsoil of an opencast coal mine, *Environmental Conservation*. **24**(1), pp. 24-30

Mahadevan, T.M. and Maithini, J.B.P. (1967) *Geology and Petrology of the Mica Pegmatites in Pars of the Bihar Mica belt*, Chapter III, Geology of the Area , Memoirs of the Geological Survey of India, **93.**

Matikinen, R. and Pukkila, J (1990) *Mining in Finland*, Helsinki Institute of Technology, Helsinki, Finland.

McDivitt, J.F. (1990) *Small-scale Mining: A Guide to Appropriate Equipment*, Intermediate Technology Publication, London.

Noetstaller, R (1994) Small-scale mining, practices, policies, perspectives, In: *Small-scale Mining – A Global Overview*, Ghose, A.K.(Ed)Oxford & IBH Publishing Co. New Delhi, pp3-10.

Prassad, S.M. (1974) *A Report on the Mining –Geological Study of Paisara Mica Mine* of M/s E.M.M.Ltd. Indian Bureau of Mines.

Prassad, S.M. (1975a) *A Report on the Mining –Geological Study of Karatory Mica Mine* of M/s Singho Mica Mining Co. P.O.Koderma, Indian Bureau of Mines.

Prassad, S.M. (1975b) *A Report on the Mining –Geological Study of Parabati No.1 Mica Mine* of M/s B.R.Modi Mica Mining Co. P.O.Koderma, Indian Bureau of Mines.

Prassad, S.M. (1977) *A Report on the Mining –Geological Study of Paisara Mica Mine* of M/s Nanda and Samont Co. (P) Ltd., Indian Bureau of Mines.

Prassad, S.M. (1980) A critical study of pegmatites of Bihar mica belt, *The Indian Mining and Engineering Journal*, **XIX** (4)

Prassad , S.M. and Naik, A. (1976) *A Report on the Mining –Geological Study of Pananwa No.3 Mica Mine* of M/sC.D.Ltd, Indian Bureau of Mines

Prassad, S.M. Singh K.C.P. and Verma, V.S.(1976) *A Report on the Mining-Geological Study of Sethwa Mica Mine* of M/s Chatturam Dharshanram , Indian Bureau of Mines

Rai, K.L (1994) Geological and geo-environmental constrain in small-scale mining in Himalayan mineral deposits-selected case studies, In: *Small-scale Mining-A Global Overview*, Ghose, A.K.(Ed)Oxford & IBH Publishing Co. New Delhi, pp51-64.

Rathore, S.S. Bhardwaj, G.S. and Jain, S.C. (2000) *Diamond Stone Technology*, Himansu Publications, Udaipur, India, pp239-242.

Ramanathan, N.(1975) *A Report on the Mining –Geological of Pananwa Mica Mine* of M/s Chatturam and Dharshanram , Indian Bureau of Mines

Ramanathan, R.(1977a)*A Report on the Mining-Geological Study of Sethwa No.2 Mica Mine* of M/s Chatturam Darshanram, Indian Bureau of Mines.

Ramanathan, R.(1977b)*A Report on the Mining-Geological Study of Salaiya Mica Mine* of M/s Goenka Mica Co. Indian Bureau of Mines.

Rudra, A.K. (2002) Policies, statues and legislation in small and medium mines, *National Seminar on Policies, Statutes & Legislation*, January, CMRI, Dhanbad, India

Sarkar, U.N. (1966) *Mining –Geological Study of Salaya Mica Mine Pit No.10* of M/s Nund and Samont Co.(P) Ltd. , Indian Bureau of Mines.

Sen, P.K. and. Ghose, M.K (1997a) Siting of tailing pond for the safe disposal of tailings from iron ore beneficiation plants - a case study, *Minetech* Vol. 18 (1 & 2), pp. 63 - 67, (1997).

Sen, P.K. and. Ghose, M.K (1997b) Management of copper tailings for its safe disposal, *Minetech*. **18** (4), pp. 41-45 .

Shrivastava, R.K.(1987)Problems of exploration and exploitation of magnesite deposits of Jhiroli in Almora District, U.P. *Indian Ceramics*, **30**(8)pp157-161.

Smrinov, V.I (1965) *Geology of Economic Mineral Deposits*, Izd-vo Nedra, Mosco

Table 1 Contribution and position of India in world production of the principal minerals and metals during 1998-99

Commodity	World	India	Contribution(%)	Rank
1.Mineral fuels (Million tonnes)				
(i) Coal and lignite	4598	315.6	6.8	3rd
(ii)Petroleum	3355	32.7	1.0	26th
2.Metallic minerals (Thousand tonnes)				
(i) Bauxite	125500	6609.5	5.2	6th
(ii) Chromite	13200	1418.8.1	10.7	3rd
(iii)Iron ore	1111000	72230.0	6.5	6th
(iv) Manganese ore	23300	1537.7	6.6	6th
3.Industrial materials (thousand tonnes)				
(i) Barytes	62000	660.8	10.6	7th
(ii)Kyanite, Andhausite &Sillimanite	360	18.2	5.1	3rd
(iii) Magnasite	18500	349.8	1.9	13th
(iv)Apatite &Rock phosphate	135000	127.6	0.9	13th
(v) Tac/ Steatite Pyrophyllite	7600	573.4	7.5	4th
(vi) Mica (Tonnes)	3000000	1484.0	0.5	1st *
4.Metals/Alloys (Thousand tonnes)				
(i) Aluminum	22700	543.4	2.4	11th
(ii) Copper (refined)	14000	148.8**	1.1	20th
(ii) Steel (crude)	776000	23333^+	3.0	5th
(iii) Lead (primary & secondary)	6000	47.9	0.8	21st
(iii) Zinc (primary)	8000	173	2.1	21st

*World data relating to mica blocks and splitting is not available for 1998. As such India's ranking in the mica blocks and splitting production is not known. However, it would descend to the 9th rank, if all forms are considered. Indian production in the table relates to crude mica only.

** Relates to copper production of primary.

$^+$ Relates to steel ingots only

Table 2 Mineral reserves in India (Thousand tonne of recoverable reserves as on 1.4.1995)

Mineral	Proved	Probable	Possible	Total
1.Andaluside*	--	--	18450	18450
2.Antimony				
(i) Ore (t)	--	--	10588	10588
(ii) Metal(t)	--	--	174	174
3. Apatite	655	10268	2721	13644
4. Asbestos(t)	2659874	2620188	4102776	9382838
5.Ballclay	7329	7960	22238	37527
6.Barytes.	52705	27780	6577	87062
7.Bauxite	768216	586427	1107788	2462431
8. Bentonite	37200	108766	219523	365489
9.Borax*(t)	--	--	74204	74204
10.China clay	45833	301615	695020	1042468
11.Chromite	25734	30775	29720	86229
12.Cobalt ore*(Mt)	30.63	2.00	7.28	39.91
13. Copper				
(i) Ore	165648	151712	99450	416810
(ii) Metal	1722	1611	1041	4374
14.Corundurn (t)	793	673	26871	28337
15.Diamond (carats)	851156	--	130359	981515
16.Dispore (t)	497101	482635	453531	1433267
17.Diatomite	--	--	2008	2008
18.Dolomite	515979	705356	3085520	4386855
19.Feldspar (t)	4468664	6298998	20518327	31285989
20.Fire clay	64296	46017	407820	518133
21. Fluorite	1503	1000	448	2951
22.Fuller's earth	--	763	227567	228330
23.Garnet	104	9734	41878	51716
24. Gold				
(i) Ore (t)	4178910	10003179	3605886	17747975
(ii) Metal (t)	21.1	36.0	10.8	67.9
25.Granite ('000m^3)	11114	332457	683850	1027421
26.Graphite (t)	792637	1236719	2550120	4579476
27.Gypsum	26247	31380	179974	297601
28. Iron ore				
(i)Hematite (Mt)	5106	2367	2577	10052
(ii) Magnetite (Mt)	1530	781	1097	3408
29.Kyanite	322	1570	925	2817
30.Lead & Zinc				
(i) Ore	71287	47801	60044	179132
(ii) Lead metal	879	642	801	2322
(ii) Zinc metal	4660	2554	2864	10078

31. Limestone	12061132	16705201	46912557	75678890
32. Magnesite	48775	145829	50537	245141
33.Marble	3294	120292	701038	824624
34.Mica (t)	--	--	59980	59980
33.Manganese ore	40075	49401	77833	16730
34. Molybdenum				
(i) Ore (t)	--	36000	800090	8036900
(ii)Contained Mo S_2 (t)	--	62	2764	2826
35.Nickel ore* (Mt)	51.54	73.68	58.26	183.48
36.Ochre	3431	8009	15924	27364
37. Phosphorite	88646	16843	39885	145374
38. Quartz/ Silica sand	323381	602994	1475806	2402181
39.Quatrzite	9516	49877	245684	305077
40. Rock salt	2010	1540	--	3550
41.Ruby (kg)	79.45	220.00	170.00	469.45
42.Sillimanite	69	38683	12868	51620
43. Silver				
(i) Ore (t)	80240326	41132313	37423435	158796074
(ii) Metal(t)	2117.57	1575.51	1181.71	4874.79
44.Sulphur*	--	--	210	210
45.Talc/Stearite/Soapstone	7123	41862	100559	213704
46. Tin				
(i) Ore(t)	561325	--	28346000	28904325
(ii) Metal (t)	226	--	3046	3272
47. Titanium minerals				
(i) Ilmenite	15734	55094	19349	90146
(ii) Rulite	1657	3901	910	6468
(iii) Leucoxene	74	--	--	74
(iv) Titaneferrous magnetite	2170	1392	8737	12299
48. Tungsten				
(i) Ore	4250000	11153489	22707471	38110960
(ii) WO_3 (t)	4549	12564	69419	86532
49.Vanadium				
(i) Ore (t)	3033875	4032000	4460920	11526795
(ii) Metal (t)	6530	5670	51403	63603
50.Vermiculite	56732	28949	136901	222582
51.Wollastonite	1519	2769	2007	6295
52. Zircon	1506	193	--	1699

* Conditional resources

Table 3 Number of small-scale mines of some selected important minerals in India (1985 - 1990)

Minerals	No. of small mines (up to 50,000 t/annum)					Percentage of total No. of mines				
	1986	1987	1988	1989	1990	1986	1987	1988	1989	1990
Asbestos	82	82	87	74	76	100	100	100	100	100
Bauxite	154	195	182	186	183	93	94	94	94	93
Baryte	52	46	51	51	45	100	100	100	100	100
Chromite	22	23	22	22	23	100	100	100	100	100
Coal	48	49	56	41	54	9	9	10	8	11
Dolomite	137	133	132	134	120	95	95	95	95	94
Feldspar	138	138	116	117	120	100	100	100	100	100
Fire clay	247	263	239	232	212	100	100	100	100	100
Graphite	31	40	51	51	50	100	100	100	100	100
Iron Ore	243	259	237	238	206	71	72	73	73	68
Kaolin	180	198	182	183	170	100	100	100	100	100
Kyanite	13	15	15	10	9	100	100	100	100	100
Lime stone	486	563	569	525	546	77	79	79	76	77
Manganese Ore	199	207	199	199	185	97	97	97	97	96
Mica	165	181	150	045	148	100	100	100	100	100
Ochre	93	113	91	87	91	100	100	100	100	100
Pyrophilite	40	45	43	44	44	100	100	100	100	100
Quartz	206	229	198	198	205	100	100	100	100	100
Silica sand	257	275	272	3012	274	100	100	100	100	100
Steatite	278	258	252	252	239	100	100	100	100	100