QUARTZ & SILICA SAND

Bulletin No. 25

PUBLICATION CELL

Training, Mining Research

& Publication Division

INDIAN BUREAU OF MINES

Ministry of Mines

NAGPUR

भारत सरकार
GOVERNMENT OF INDIA
खान मंत्रालय
MINISTRY OF MINES
भारतीय खान ब्यूरो
INDIAN BUREAU OF MINES

प्रशिक्षण, खनन अनुसंधान और प्रकाशन प्रभाग
Training, Mining Research & Publication Division

BULLETIN No. 25

QUARTZ & SILICA SAND

ISSUED BY
CONTROLLER - GENERAL
INDIAN BUREAU OF MINES
NAGPUR

May 1993

Price : (Inland) Rs. 55.00; (Foreign) £ 6.41 or $ 19.80

Printed at IBM Press, 6/1993/72/250

INDIAN BUREAU OF MINES

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PREFACE

Silica minerals, comprising quartz, silica sand, quartzite, etc., are the most abundantly available minerals in the earth's crust. Although silica preponderance in earth's crust is unrivalled, only a relatively small percentage is of commercial significance.

Silica minerals have wide industrial applications. Rock crystal is one of the most important precious stones. Amethyst, rose quartz, smoky quartz, etc. are the other varieties of gemstones. Quartz crystals are also much sought-after for their application in electronic industry.

India is endowed with sufficiently large reserves of silica minerals. It is estimated that the total reserves of silica minerals are in the order of 1,350 million tonnes. Precious and semi-precious rock crystal deposits also occur in different parts of the country.

This bulletin describes the geological set-up of silica mineral occurrences, various forms of gems and semi-precious stones, geographical distribution pattern, mining, beneficiation, various industrial uses with specifications, problems and prospects. It also highlights the future applications of silicon ceramics in automobiles, disposal of radioactive wastes, in the manufacture of optical fibre, etc.

Co-operation extended by various State Government departments responding to our questionnaires is thankfully acknowledged.

The information obtained from Industrial Minerals, published by Metal Bulletin Journals Ltd., U.K., is also thankfully acknowledged.

The officers associated in the preparation of this bulletin are S/Shri C. Pal, Senior Mining Geologist, A. Basu, Deputy Controller of Mines, S.Thirunavukkarasu, Assistant Mining Geologist and Smt. M.N. Gaikwad, Assistant Ore Dressing Officer.

It is hoped that the information contained in this bulletin will be useful to silica sand producers, user industries, etc.

S.K.CHOUDHURI

Nagpur — *Controller General*

24th April,1992 — Indian Bureau of Mines

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Chapter 1 INTRODUCTION

1.1 HISTORICAL BACKGROUND

Minerals are indispensable to man. In all stages of human advancement, from the primitive to the most sophisticated,man had to look for minerals for his subsistence, decoratives, festivities, etc.

Utilitarian value of minerals and the mineral substances which so abundantly occurred in nature had motivated the primitive man towards purposeful utilisation of minerals. In his efforts to hunt for food as well as for self protection, he might have used hard rocks and minerals. Hard rock like quartzite and hard minerals like quartz, flint, chert, etc. had been commonly used by man in Palaeolithic Age as weapons. In the Neolithic or New Stone Age,man appears to have learnt the art of grinding, grooving and polishing stones like flint, quartz, chert, etc.which resulted in improved types of stone implements[2].

In India, both in the pre-Vedic and Vedic times, precious and semi-precious stones had been much in use. The finds of Mohenjodaro and Harappa testify this; we find the ornaments made of such semiprecious stones, viz. agate, amethyst, rock crystal, jasper, bloodstone, etc[2].

Of all non-metallic minerals, silica sand has the most diversified use. This is because of its common occurrence around the world, distinctive physical characteristics such as hardness, chemical and heat resistance as well as low price. Silica bearing rocks and minerals such as quartz, quartzite, silica sand, together with other varieties of silica like agate, amethyst, jasper,flint, etc. are now being used in a host of industries like glass, ceramics, foundries, ferro-alloys, abrasives, refractories, ornamentation, etc. One of the first industries to use silica sand was the glass industry. At least 4,000 years ago, long before the iron was smelted, glass-making was already a known craft. The oldest known specimens of glass are from Babylon (2600 B.C.) and from Egypt (2500 B.C.) where the industry was well established by around 1500 B.C

1.2 GENERAL

Silicon (Si) does not occur in a free state in nature, but its compounds are extraordinarily abundant and constitute about 28 percent of the earth's crust[1]. The oxide quartz and the 'Great Group' of silicates are the most important rock forming minerals. Silica (SiO_2) occurs in the form of quartz (crystalline form); chalcedony, agate, flint and jasper (cryptocrystalline form); and opal (the hydrous form); sandstone, essentially composed of small grains of quartz, is the most widely occurring sedimentary deposit while quartzite is the metamorphosed derivative of sandstone. 'Silica sand' is the trade name of weathered sandstone or quartzite enriched in silica. Agate, chalcedony, rock crystal, amethyst, opal, etc. are the residual pockety deposits having sporadic occurrences.

1.3 COMPOSITION

The fundamental unit in building the silicate minerals is SiO_4–tetrahedron in which silicon atom (or more strictly, cation) is situated at the centre of a tetrahedron whose corners are occupied by four oxygen atoms[1]. Distribution geometry of SiO_4-tetrahedron determines the formation of various silicate minerals. The following table gives an idea of the various silicates and their composition and structure :

TABLE- 1

Type of structure	Composition	Mineral
Separate SiO_4 group	SiO_4	Neo-silicates - Olivine
Double SiO_4 group	Si_2O_7	Soro-silicates - Melilite
Ring structures	Si_6O_{18}	Cyclo-silicates - Beryl
Single chain	Si_2O_6	Ino-silicates - Pyroxenes
Double chain	Si_4O_{11}	Ino-silicates - Amphiboles
Sheet	Si_4O_{10}	Phyllo-silicates - Micas
Framework	$(Al,Si)_nO_{2n}$	Tecto-silicates - Feldspars
-do-	SiO_2	--------- - Quartz

Quartz is silicon dioxide (SiO_2) and it is in crystalline form. The crystal structure is like a framework where the SiO_4 -tetrahedron is linked by all four corners to make the three-dimensional form. The hexagonal prisms are the usual crystal form of quartz.

1.4 VARIETIES

1.4.1 Crystalline Silica[1]

Rock crystal is the purest and most transparent form of quartz. It is sometimes used in jewellery and for making optical glass.Untwined, clear variety of rock crystals possesses piezoelectric properties used in telecommunication and hence is of strategic importance. Amethyst is a purple to violet coloured transparent form of quartz, owing its colour perhaps to the presence of manganese in traces. It is used in jewellery. Rose Quartz is a pale pink or rose coloured variety of quartz. Cairngorm, and Smoky Quartz are varieties of quartz of a fine smoky brown colour, while Morion is a nearly black variety.

Milky Quartz is a common variety of a milk-white colour. The milkiness is due to the presence of a multitude of very small air cavities. When the milkiness is superficial, such crystals are known as 'quartz-en-chemise'. 'Cat's Eye' is quartz with minute fibrous structure. When cut suitably, it exhibits a peculiar opalescent play of light. 'Adventurine Quartz' is a variety containing spangles of mica, hematite etc. 'Ferruginous Quartz' contains iron oxides which impart a reddish or brownish colour to the mineral.

1.4.2 Crystalline

1. **Chalcedonic silica** - It includes three varieties, viz. (a) Chalcedony, (b) Flint and (c) Jasper.

(a) **Chalcedony** : has a great number of sub varieties such as:

(i) **Carnelian** : is a well-known translucent variety of a reddish or yellowish red colour and Sard is a brownish variety, both being used for signet rings and similar work.

(ii) **Parse** : is a translucent, dull leek-green variety of chalcedony.

(iii) **Plasma** : is a sub-translucent bright green variety, speckled with white.

(iv) **Blood-stone or Heliotrope** : this is similar to plasma but speckled with red.

(v) **Chrysoparse** : is an apple-green variety of chalcedony.

(vi) **Agate** : is a variegated chalcedony composed of different colour bands, sometimes with sharp lines and sometimes with shading off imperceptibly one into another. Agates are cut and polished for broaches, snuff-boxes, mortar & pestle, etc.

(vii) **Moss Agate or Mocha Stone**: this variety is a chalcedony containing small dendrites (tree-like growths) constituting iron oxide.

(b) **Flint** : is a compact cryptocrystalline silica of a black colour or various shades of grey. Flint breaks with well marked conchoidal fracture and affords sharp cutting edges. Pre-historic man used flint for fabricating of weapons, chisels, hatches, etc. Flint was used for gunflints and for igniting tinder before the invention of percussion-locks or matches. Flint is also used in tube mills and calcined flint is used in pottery industry. Hornstone or Chert is grey to black opaque form of cryptocrystalline silica.

(c) **Jasper** : is an impure form of cryptocrystalline silica, usually red, brown and yellow in colour.It is opaque even on the thinnest edges.Some varieties, such as Egyptian or Ribbon Jasper are beautifully banded with different shades of brown.

1.4.3 Cryptocrystalline Silica-Hydrous

(a) **Opal** : is a hydrous silica, compact but sometimes reniform or stalactitic. It displays beautiful internal reflections and opalescence on rotation.

(b) **Precious Opal** : is the gem variety exhibiting opalescence and a brilliant play of colours. Hydrophane, hyalite and Wood Opal are the other varieties of opal.

1.5 PROPERTIES

Quartz is colourless, transparent and resistant to weathering and alterations. Devoid of cleavage, it breaks with irregular fracture.The lusture is vitreous and occasionally resinous. Hardness is 7 in Moh's scale and specific gravity is about 2.65. Quartz crystals of pure, untwined, clear and transparent varieties possess piezoelectric properties. Coloured varieties like Amethyst, Cairngorm and Plasma are in demand as semiprecious stones.

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Chapter 2 GEOLOGY

The range of silica raw materials occurring in nature is quite extensive. This includes pure form of the mineral such as Rock Crystal and Vein Quartz which are primarily associated with acid igneous bodies and the SiO_2 in the form of unconsolidated sands such as the river sands, beach sands and sand dunes. The secondary or residual products consist of the consolidated rocks such as quartzites,the metamorphosed form and the sandstones,the sedimentary form.

In India, quartz and silica sand or industrial sand deposits are associated with various geological formations ranging in age from Archaeans to Recent. Silica sands are known to occur in many stratigraphic units belonging to Archaeans, Dharwars, Aravalli, Delhi, Vindhyans and Gondwana Super Group. The Deccan Traps abounding in Geodes filled with Agate and other forms of crypto crystalline silica, Rock Crystals and Amethystine Quartz contribute significantly to production of rare variety of silica minerals e.g. Rock Crystals, Amethyst,Agate, etc.

Quartzite formations belonging to Dharwars, Aravalli, Delhi, and Cuddapah Super Group gave rise to many important and extensive deposits of silica sand. The sandstones and the felspathic sandstones belonging to Vindhyan and Gondwana Super Group gave rise to massive deposits of silica sand, moulding sand and other varieties of industrial sands.

The intrusive veins/reefs of quartz associated with various geological formations are the major sources of Rock Crystals and other varieties of silica minerals. The Cuddalore sandstones followed by Pleistocene to Recent deposits gave rise to mammoth occurrences of sands in deltaic region, coastal sands, sand dunes, etc.

The generalised geological sequence showing major geological formations which contain workable sand deposits is given below:-

Recent to Pleistocene	:	Sands in deltaic region, coastal dunes, etc.

Pliocene to Upper Miocene	:	Cuddalore sand stone (Rajamundry).
Oligocene	:	Burdwan formation / Bengal Basin, Durgapur Beds, etc.
Early Miocene to Late Cretaceous	:	Deccan Traps
Middle Cretaceous to Upper Carboniferous	:	Gondwana Group (Rajmahal Traps).
Pre-Cambrian	:	Cuddapah, Vindhyan Super Groups.
Archaeans	:	Dharwar, Aravalli, Delhi Super- Groups - Various Gneisses, etc.

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Chapter 3 OCCURRENCE

3.1 INDIAN OCCURRENCE (RARE VARIETY)

3.1.1 Crystalline Variety

(i) QUARTZ CRYSTAL

Quartz a crystalline form of SiO_2, belongs to hexagonal system and occurs in well developed prismatic crystals. Quartz crystal has piezo-electric properties which allow it to be used for accurate electronic frequency control and also in electronic circuitry. Quartz occurs as an original constituent of the acidic rocks such as granite, rhyolite and quartz-felsite. Quartz is also a common constituent of metamorphic rocks and a prominent vein stone. Ever since the piezo-electric properties of quartz crystal became apparent, the mineral became widely sought after. High quality quartz crystal deposits are wide spread in India. The prominent deposits are in Bihar, Rajasthan and Andhra Pradesh. Crystalline quartz commonly occurs in large trap-covered areas of Maharashtra, Andhra Pradesh and Madhya Pradesh. Transparent crystals of quartz occur in pegmatites of Ajmer and Tonk districts of Rajasthan. Transparent quartz crystals in pegmatites near Mirijra Kundi (23°18′ : 87°01′) and Balidumdumi (23°18′ : 87°0′) have also been reported in Bankura district of West Bengal. Quartz crystals of great variety and beauty and of every size have also been reported from Rajmahal Traps of Bihar.

Among the countries in world, Brazil has been regarded as major source of electronic grade quartz crystals. In Brazil, quartz is found to occur in the form of veins, pipes and small pockets[9]. The deposits of quartz are located in the state of Minas Gerais, Santa-Catarina,Parana and Bahia. Of these, the deposits in Minas Gerais are the richest[3].

High purity quartz crystal deposits are reported from Arkansas state in U.S.A. A major quantity of the large clear quartz specimen produced in U.S.A. is sold for museum specimen and only a very small quantum goes for crystal unit manufacture.

Angola produces Grade-A quartz crystals suitable for electronic industry. The operational area is situated in the West Central part of the country.

In Madagascar, electronic grade quartz crystal deposits are found in Fianarantsoa. Other countries producing high quality quartz crystals are South Korea, Turkey and Malagasy Republic. Fine crystals come from Cumbria and Cornwall. Large crystalline forms of quartz are found in joints in Alps, erstwhile USSR (Urals)[8].

(ii) AMETHYST

Amethyst is found as vein-filling and cavity-filling associated with quartz reefs in Bundelkhand granites near Andar (25°32′ : 78°06′) and near Bagaund (22°05′ : 75°53′). Amethyst occurring as blocks are also recorded along the western slopes of Dirohara Hill (21°30′:78°50′) in Chhindwara district. Small amethysts occurring in Deccan trap geodes are being collected from the bed of Narmada river near Jabalpur. A few crystals of amethyst have also been found in association with sapphires of Zanskar in Kashmir.

Geodes of quartz, lined with crystals of amethyst, sometimes measuring several inches in length have been reported to occur in a bed of chalcedony in Punch Pahar near Burhait in Santhal Paraganas (Bihar).

Occurrences of several veins of amethystine quartz have been reported in and around Shansabad, Palment, Nagunpally and Bekonenpett in Hyderabad. Occurrence of amethyst has also been reported from bed of Godavari as placer in Warangal district. Small occurrences of amethyst have also been reported from Kangayam (11°0′ : 77 °34′) in Coimbatore district, Tamil Nadu.

Small occurrence of amethystine rock has been reported around Mysore. Similar smaller occurrences of amethyst near Chaital (26°07′ : 78°39′), Gangari (25°36′ : 78°28′) and Chandeva (25°42′ : 78°32′) around Panna district, as secondary veins in Panna formation, have also been reported.

Occurrence of amethystine rock have been reported from Rondiel (27°14′ : 75°53′) and Samod (27°21′:75°48′)in Udaipur and Jaipur districts respectively in Rajasthan.

(iii) ROSE QUARTZ

The meta-sedimentary rocks of Bankura, West Bengal containing veins of quartz and pegmatite are reported to have some stray occurrences of rose quartz. Similarly, occurrences of rose-quartz have also been reported from Hazaribagh district, Bihar. Several veins containing sparse mineralisation of rose quartz are also found in many parts of Hyderabad district. Rose quartz has also been reported from Warangal district, Andhra Pradesh. In Maharashtra, rose-quartz, occurring as vein near Khairi (21°32′ : 78°50′) has been reported.

(iv) SMOKY QUARTZ, CAIRNGORM

Smoky Quartz, cairngorm crystals are collected from stream sediments near Vallam (10°43′ : 79°03′) in Tanjore district in Tamil Nadu that drain the grits of Cuddalore sandstone. The Trappean rocks of Rajmahal are reported to contain smoky quartz in abundance. Smoky quartz is also reported from Hazaribagh district from the igneous terrain.

(v) MILKY QUARTZ

Occurrence of milky quartz has been reported from the Trappean rocks of Rajmahal.

(vi) CAT'S EYE

Cat's eye, as placer deposit, is found in the bed of Krishna river in Paland and Guntur districts, in Andhra Pradseh Cat's eye is also found on the Bowa Gorse and Bowa Abbas Hills, near Ratanpur in Rajpipla in Maharashtra. Sporadic occurrence of cat's eye along Malabar coast has also been reported. Sparse occurrence of cat s eye has been observed in the pegmatites in the Nilgiri Hills. Sporadic occurrences of cat's eye in the neighbourhood of Tamil Nadu have also been reported.

3.1.2 Cryptocrystalline Varieties

Agate and its varieties carnelian, onyx, etc. are of common occurrence in the amygdalodial flows of the Deccan and Rajmahal traps. The chief sources of supply are the rivers that drain the areas covered by the rocks and the adjoining plains. Large quantities of agate, jasper and carnelian pebbles are collected from bed of Godavari river near Rajahmundry in East Godavari district. Chalcedony and agate are common near Pungadi (17°01′ : 81°30′) in West Godawari in Andhra Pradesh. Nodules of agate as amygdules derived from basalt which overlie the Gondwana coal measures are found in abundance among the Rajmahal Hills (25°03′ : 87°50′). In the centre of hills near Burhait (24°53′ : 87°36′), a mile-long bed of agate nodule was reported by Sherwill, W.S. In Palamau district, the bed of the Sone river is reported to yield large quantity of good variety of agate.

Occurrence of agate, as pebbles, in the plains of Bijapur (16°50′ : 75°43′) has been reported. Good quality and highly priced agate is reported to occur in and around Kapadganj (23°21′ : 73°04′) and also in the bed of Majan river between

Mandra and Amliyara (23°13′ : 73°04′). These agates are of almond- shaped balls, weighing about 1 to 5 kg. Occurrences of agate have also been reported from Ratanpura (21°43′ : 73°11′), Damlai (21°42′ : 73°13′), Dholkuva, Vasna (21°39′: 73°12′) and other villages. The river beds where agates occur in abundance are Karad, Kaveri and Amravati and the streams near Amed.

The Trappean regions in particularly near Paithan (19°28′ : 75°23′) are reported to yield large quantity of agate. According to Ain-i-Akbari, Ballarpur (19°51′ : 79°20′) about 10 km. north of Chandrapur on the Wardha river was at one time famous for producing agate pebbles. Although agate pebbles are known to be very abundant in the debris from the trappean rocks, it is believed to afford one source from which lapidaries of Jabalpur obtained material for their ornamental stone work. Hand specimens of agate are said to have been obtained perhaps from Narmada river bed. Agate has been reported in Bhamanghati sub-division of Mayurbhanj district, Orissa.

In Rajasthan, fragments of agate and nodules of agate are reported from Banas river bed. The other reported occurrences of agate are near Bina (26°54′ : 77°17′), Buneerah near Udaipur as well as plains of Banswara and Dungarpur districts. In Gujarat, occurrences of extensive beds of agate and chalcedony conglomerate forming the river terraces near Veratia (22°23′ : 70°26′) have been reported. Agate bearing conglomerates are recorded from Leukhana (21°31′ : 72°17′), Badi (21° 36′ : 73°13′), Chaya (20°30′ : 72°12′) and Ranpur in Bharnagar. In Junagadh, occurrences of agate and milk white chalcedony in geodes near Khamba (21°09′ : 71°17′) and Sakhra (20°52′ : 71°19′) have been reported.

In Uttar Pradesh, the Bunda district is well known for agate occurrence. Some small quantity of agate in Mirzapur district has also been reported.

Occurrences of other varieties of cryptocrystalline silica, namely moss agate, jaspar, carnelian and onyx are very sporadic. Some of the reported occurrences of these varieties are mentioned here. In Andhra Pradesh, large quantities of jasper and carnelian pebbles are collected from the bed of Godavari river near Rajahmundry.Onyx is reported and Carnelian occurs in druses in traps of Rajmahal near Bombay and Ratanpur. Carnelian has also been reported from the trappean region of Hyderabad while in Rajasthan, carnelian is reported from river bed of Banas.

Moss-agate is reported from the beds of Krishna, Godavari,Bhima and Narmada rivers. Moss-agate is also reported from Tankara (22°40′ : 70°48′) in Saurashtra, and Bunda district in Uttar Pradesh. Chalcedony of white, yellow, green and blue colours is said to occur near Biana (26°54′ : 77°17′) in Rajasthan.

Chalcedony conglomerate forming the river terrace near Varatia (22°23′ : 70°20′) in Saurashtra is also reported. Chalcedony of white, yellow and blue colours is reported, to occur in Bangalore district, Karnataka. Milky white chalcedony in geodes is also reported from Khamba (21°09′ : 71°17′) in Junagadh. Chalcedony of white, yellow, green & blue colours has also been reported from Nilgiri Hills.

3.1.3 Cryptocrystalline-hydrous

Common opal is wide in distribution. In India, it is found mostly in Rajasthan, Andhra Pradesh, Maharashtra, Madhya Pradesh, Tamil Nadu, Bihar, Orissa, Jammu and Kashmir and Union Territory of Andaman[4].

In Rajasthan, massive milky white opal is reported from the base of the hills near Srinagar in Ajmer. In Andhra Pradesh, good occurrence of opal is found at Kodur (18°16′ : 83°34′) and Kotakarra (18°22′ : 83°31′). Opal is common in geodes in traps near Pungadi in West Godavari. The occurrence of numerous and very fine specimens of milky white opal with a flame colour irridescence is reported from the beds of Sina river between Andargaon(18°02′ : 75°35′) and Paula (18°16′ : 75°31′).

Opal is reported in geodes in Deccan Traps near Kandri (21°24′ : 78°58′) and near Gavilgarh (20°22′ : 77°20′) in Amravati district in Maharashtra. Wood opal and Milky white opal are found replacing tree stems near Alundalipur and Malvay near Ariyalur, Tiruchirapalli district in Tamil Nadu.

Minor occurrences of opal are reported from Boirani (19°35′ : 84°45′) in Ganjam district in Orissa; Rajmahal Hills in Bihar; near Pusa at Rupshu in Kashmir and in serpentine rocks in Rutland Island (11°25′ : 92°40′) in the Andamans.

3.2 INDIAN OCCURRENCE - COMMON VARIETY

3.2.1 Quartz

Quartz is an oxide of silicon. It is one of the common minerals in the earth's crust forming greater part of sandstone and quartzite as well as sand of the sea shore and river valleys. It may be found in nature as a hydrothermal deposit in veins and fissures in all types of acid igneous rocks.

The deposits occur in the states of Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Rajasthan, Tamil Nadu and West Bengal. Andhra Pradesh was the leading quartz producing state contributing about 31% to the all-India production during the year 1989-90 followed by Karnataka (28%), Rajasthan (20%) and Tamil Nadu (5%). The remaining percentage was shared by Bihar,Gujarat, Haryana and Madhya Pradesh[17].

(1) ANDHRA PRADESH

In Andhra Pradesh, the deposits of quartz reefs/veins occur as intrusions in the Archaean granite, granitic complex and pegmatite group of rocks. The important deposits of quartz are located in Khammam, Mehboobnagar, Medak, Nellore, Prakasam and Ranga Reddy districts. Minor deposits occur in Anantapur, Chittoor and Cuddapah districts. The total reserves in the state are estimated at 9 million tonnes.

(a) Khammam district

Vein type of quartz deposits occurring in Khammam district, associated with granitic complex, are located around Tadlapalle, Brahmalkunta, Belhampudi and Rallapadu in Yelandu taluka, and Usirikaya Palli reserve forest in Tellandu taluka in the eastern part of the district near Singareni. The total reserves are placed at 1.02 million tonnes.

(b) Mehboobnagar district

The quartz deposits occurring as veins are located in Chowlapalle and Vithal areas and around Annepuram village north of Mehboobnagar town in the central part of the district. The total reserves of quartz are estimated to be around 4 lakh tonnes.

(c) Medak district

The quartz veins occur as intrusions in granite complex around Mallepalle and Tarpole in Sange Reddy taluks north-west of Hyderabad, Naraspur and Khondpur, in Narsapur taluka north of Hyderabad. The total reserves are estimated at 3.25 million tonnes of which 2.09 million tonnes are of glass grade.

(d) Nellore district

Pure vein-quartz associated with the pegmatites occurs in Podelakur taluka and around Talupur, Giddalur and Orupalli Rajupalan in Rapur taluk, south of Nellore. The total reserves are placed around 1.21 lakh tonnes.

(e) Prakasam district

Quartz deposits occur as veins and reefs in Archaean granites at Bomireddipalle area near Giddalur in the Velikonda hill range. Quartz occurrences are also noticed at Komarolu, Tatireddipalle, Gobrapalle, Nallaguntla and Gundareddipalle in Kurnool district. The reserves in Bomineddipalle area are estimated at 2 million tonnes. The production of quartz is very less.

(f) Ranga Reddy district

In this district, quartz reefs occur as intrusions in Archaean granite. Deposits of quartz occur around Bajpalli, Bhorumpet, Bahadurpalli in Medchal talukas, Domar,Hydernagar and Rallaguda in Hyderabad (West) taluka and Kothwalguda in Shamshabad taluka. The areas are located north of Hyderabad. The total reserves of quartz in the district are estimated at 1.95 million tonnes of which 1.52 million tonnes are of glass grade.

(g) Other minor occurrences

Other minor occurrences are from Gadsingpur near Shadnagar south of Hyderabad in Hyderabad district; Karlanaparla and Pullajpeta near Garividi in Vizianagaram district; Nemakkal north of Anantapur in Anantapur district;Kambakkam reserved forest in Kalahasti taluka of Chittoor district; Pagadalpalli and Gaganganpalli in Cuddapah district; Timmapuram area in Visakhapatnam and also in Godavari West, Guntur, Krishna, Srikakulam and Warangal districts.

(2) ASSAM

In Assam, the quartz deposits are reported in Nowgon and Karbi Anglon districts. Quartz in pegmatites analysing 97.98 to 98.92 percent SiO_2 content occur at Hahim in Assam. The reserves are estimated at 19,570 tonnes.

(3) BIHAR

In Bihar, deposits of quartz occurrences are reported from Santhal Parganas Mungher and Giridih districts[19].

(a) Santhal Parganas district

In Santhal Parganas district, quartz occurs as intrusion in granite gneisses in most of the areas.Deposits of quartz occurrences are at.

(i) Herla-Dhobni area
(toposheet No: 72 L/2, Lat.-24°41′)

Long 86°33′. An area of 3.34 sq.km. was mapped and reserves of quartz are estimated at around 1,03,950 tonnes by Department of Mines & Geology (DGM), Bihar.

(ii) Sugapahari area

(toposheet No:72 L/11, Lat.24°16′15″, Long. 86°34′20″)

An area of 0.12 sq.km. was mapped and reserves of quartz are estimated at around 4,288 tonnes by DGM, Bihar.

(iii) Dhutla area

(toposheet No : 72 L/16)

An area of 0.28 sq.km. was mapped and total reserves of quartz are estimated at around 25,770 tonnes by DGM, Bihar.

(iv) Tamjor area

(toposheet No : 72 L / 16, Lat. / 24°00′00″ Long.- 86°52′25″)

An area of 0.18 sq.km. was mapped and total possible reserves of quartz are estimated at around 15,037 tonnes.

(b) Mungher district

In Mungher district, investigation of quartz occurrence was carried out by DGM, Bihar. The deposits are confined to Mallepur, Batia and Simultala areas. In Mallepur area, milky white quartz of considerable size containing 97% SiO_2 is located in Manjhipur Morwa area in Batia and Simultala areas, the hillocks of quartzite and vein quartz are exposed in meta-sedimentary formation of Pre-cambrian Age. The quartz deposits are located at Karyasair, Jirbuliaputni, Batia, Cheharghat, Chhata-Kauam, Panari, Bijaianosahi, Lewa, Asathua, Belataur, Mahugaon, Karijhal, Tarakhar, Lodhma, etc. in Batia area and in Kathranala, Pathalchapti, Hiraraidih and Kenhumar in Simultala area.

(c) Giridih district

In Giridih district sizeable deposits of quartz are found by DGM, Bihar at 19 localities i.e.Gando, Ratburdih, Sathibad, Jondritanur, Mohandih, Kasidih, Telaiwana, Gaganpur, Pipjatol,Naiyadih, Daradmara,Dumardiha, Phuljori, Bhimal, Banjha, Gande,Ghorajori,Gurnia and Jogidih.

(d) Other deposits

Veins of quartz occurring as intrusions in rocks of different ages are found in a number of places in Singhbhum, Ranchi, and Dhanbad districts. The pegmatites of Bihar mica belt are also good sources of quartz.

(4) GUJARAT

In Gujarat, quartz deposits generally occur in the form of veins, lenses or reefs associated with pegmatites.The deposits are in Kutch, Panchmahal, Sabarkantha, Surendranagar, Kheda and Vadodara districts. However, the deposits in Panchmahal district only are important. Besides, numerous veins of quartz intruding into the Aravalli rocks are noticed in Godhra, Jhalod, Dohad and Lunawads areas[20].

(a) Panchmahal district

Quartz deposits in Panchmahal district occur around Asyadi near Sant Road Station, Sajora,Pavalki Chenpur, Dangaria, Degwada, Nathuadik and Vechvanpiplod in DevgarhBaria taluka; at Virany, Jolha, Navamuvada, Bhuval, Charelmoti, Bhanpura, Sattalao, Shero and Limbodra in Lunawada taluk on the northern part of the district; at Dhabudi, Mechalai, Rasulpur Kasanpur, Timba, Khatta, Natapur and Gajipur in Godhra taluka in the eastern part of the district at Chalvad, Duma, Javan Keva, Kothirav, Vav, Pipiya and Lafni in Jamoughoda taluka, and at Aroda, Machhelai and Dhabudi in Limkheda taluka. The quartz generally occurs as veins within the quartzites. It is associated with pegmatites also. The total reserves of quartz are estimated to be around 7.55 million tonnes.

(b) Other occurrences

Quartz occurrences are also reported from Chilyavant, Piplej, Ambala, Gabadiya and Tundwa villages in Chota Udepur taluka of Vadodara district; Virpur village in Balasinor taluka of Kheda district; Ingrols village in Khamoha taluka of Amreli district; and Pyaka village in Mandvi taluka of Kutch district.

(5) KARNATAKA

Karnataka is reported as the second major quartz producing state in India. The deposits are reported from Bellary, Shimoga, Tumkur,Hasan, Bangalore, Chitradurga, South Karnataka and Raichur districts[2].

(a) Bellary district

In Karnataka, the major production of quartz comes from Bellary district. The deposits of quartz are located at Harvanhalli and Harayanhalli in Hospet taluka; Belegal in Bellary taluk;and Ubalagundi, Veranhelly in Sandur taluka. The total reserves in the district are placed at 6.03 million tonnes and is mostly of silicon alloy grade.

(b) Shimoga district

Quartz deposits are located at Hinusekatte in the central part of the district. The total reserves which are of silicon alloy grade are estimated to be around 3.5 million tonnes.

(c) Tumkur district

Deposits of quartz occur at Ganganhalli in Koratageya taluka; Veerapur in Nittur taluka; and Choudanahalli in Tiptur taluka. Quartz occurs as floats. The total reserves of quartz in the district are estimated at around 3.93 million tonnes of which 1.39 million tonnes are of glass grade.

(d) Hasan district

Quartz occurs as veins in peninsula gneisses and granites of all ages. Quartz deposits occur in Rayasamudrakaval in Channavayapatna taluka. It occurs as veins in chlorite schist. The total reserves, which are mostly of glass grade, are estimated around 1.08 lakh tonnes.

(e) Bangalore district

In Bangalore district, quartz occurs as veins in Peninsular gneissic rock and granites of all ages. Large deposits of pure white quartz are located at Hulikunte and Doddamanakhalla in Doddaballapan taluka; and at Siddapur in Kanakpura taluka south of Bangalore in the southern part of the district.

The quartz also occurs as discontinuous lenses and pockets in pegmatites. The total reserves are estimated at 94,000 tonnes.

(f) Chitradurga district

Quartz occurs as vein/reef associated with Chitradurga group or Dharwar Super Group rocks and Chitradurga Granite. Quartz deposits occur at Bilaspur and Nandigavi in Harihar taluka; Ghattihosahalli and Kumminagatta in Holankera taluka as well as Kangunalli and Ramajjanahalli in Hosadurgh taluka.

(g) South Karnataka district

Quartz occurs as vein/reef in Peninsular gneisses at Bada, Hejamadi, Kapupadu, Kadavoo, Katapadi, Mathu, Mulur, Nadusol, Pongola,Parampally, Tenkanidiyur, Tenka, Udayawar and Uliyagoli in Udipi taluka; Chitrapu, Kulai and Suratkal in Mangalore taluka; Bejadi, Thekkatte and Kode in Coondapur taluka as well as Iddaya in Mangalore taluka.

(h) Raichur district

Quartz deposits occur at Siddapuram in Raichur taluka. A number of white quartz veins have also been located at Sultanpur, Jogarkal, Mallapur, Volkomndinne, Bichal, Yedakanur, Uddinhal, Sangalpur and Indavasi areas.

(i) Other occurrence

Pure white quartz is found in Mysore district near Khanpur. In Belgaum district, numerous quartz veins are associated with schists and granite rocks in Kolar district.

3.2.2 Silica Sand

Silica sand is an assemblage of individual silica grains in the size range up to 2 mm. A sand can be formed in nature by natural weathering of sandstone and quartzite, or mechanically by crushing a sandstone/quartzite, or by a process of flotation whereby the various constituents in a pegmatite or kaolin mixture are separated[7].

Silica sand occurrences in the country are widespread and extensive. Important silica sand deposits are in Andhra Pradesh, Bihar, Goa, Gujarat, Haryana, Karnataka,Kerala,Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Uttar Pradesh. In 1991, Haryana was the leading silica sand producing state contributing 39% production, followed by Rajasthan (12%),Uttar Pradesh (11%), Maharashtra (10%), Karnataka (8%) and Gujarat (7%). The remaining 13% was accounted together by Andhra Pradesh, Bihar, Kerala, Madhya Pradesh, Tamil Nadu, etc.[17]. Some minor deposits also occur in Assam, Himachal Pradesh, Jammu and Kashmir, Meghalaya, Orissa, Punjab, Tripura and West Bengal.

(1) ANDHRA PRADESH

In Andhra Pradesh, the silica sand deposits are in Nellore,Kurnool and Prakasam districts.

(a) Nellore district

Nellore district is an important silica producing district of Andhra Pradesh. The deposits of silica sand (moulding sand type) are located around Atakanithippa, Perumallapadu and Pannamgudu in Sulurpet taluk; and Momidi, Chintavaram, Yerur, Ballavolu and Thamminapatnam in Gudur taluk in the south part of the district. The total reserves are estimated at around 9 million tonnes. Monidi area is the most important deposit of the district.

(b) Kurnool district

The silica sand deposits are associated with quartzite and shale at Puricherla in Kurnool taluk and Orvakalmandalan in Orvakal taluk.

(c) Prakasam district

The deposits of silica sand occur at old Chirala,Pandillapalli, Epurupalem and Kadavakudury in Chirala taluk and at Chakicherla in Singarayakonda taluk.

(d) Other occurrence

Silica sand deposits occur in Magnurs & Varkur in Mekthal taluk and Kommireddipalli,Ponakal,Kundur and Shakepur in Addakalmandakam taluk of Mahboobnagar district.

(2) BIHAR

The silica sand deposits occur in Santhal Parganas district. However, a small production is also reported from Singhbhum and Nalanda districts. The reserves are estimated to be around 150 million tonnes[19].

(a) Santhal Parganas district

The deposits of silica sand are located around Bejanpahar in Doda taluk and Raibazar, Jainbad, Kaba and Mangathat areas near Rajmahal.

(3) GOA

In Goa, the silica sand deposits occur in Arrosim Utorda belt and Benanlim-Varca belt of South Goa, Belgaum and Bijapur districts. The total reserves of silica sand are estimated to be around 6.52 million tonnes.

(a) South Goa district

In South Goa district, deposits of silica sand occur at Varch, Benavlim, Utorda, Cavelassim and Orrosim in Salcete taluk and Basapur, Vadalged, Maldani, Kundargi and Markandi in Gokak taluk. The deposits are associated with sea sand.

(b) Belgaum district

In Belgaum district, deposits of silica sand occur at Akrali, Sathnali, Mantharga, Kapoli and Hishal in Khanapur taluk..

(c) Bijapur district

In Bijapur district, occurrences of silica sand deposits are reported at Parvati in Badmai taluk.

(4) GUJARAT

In this state, significant silica sand deposits are reported in Surendranagar, Kutch, Sabarkantha and Broch districts. The deposits of silica sand of moulding sand type are reported in Bhavnagar, Jamnagar, Rajkot, Bharuch and Surat districts[20].

(a) Surendranagar district

Silica sand deposits occur in the western part of the district around Gautamagarh, Kumbharpara, Kukada, Jamwani, Bhaduk and Dharmeivdra in Muli taluk; Bhaduka and Dheduki in Sayala taluk; Devsar, Gungaliyang, Jamwali, Vavdi, Chotila, Umrade, Surajdeval, Godavari and Rampura villages in Chitola taluk; Kondh in Dhrangadhara taluk and Negra in Wadwan taluk. The reserves are estimated to be around 5 lakh tonnes[2].

(b) Kutch district

The deposits occur in and around Anjar, Sapeda, Nagalpur, Ratatalav, Sinogra and Ingorela in Anjar taluk, Chopadwa in Bhachau talulk in the south-eastern part of the district and at Netra in Nakhatrana taluk in western part of the district.

(c) Sabarkantha district

Silica sand occurs around Illol, Kadoli, Khedawada, Pethapur, Parabanda and Himatnagar villages in Himatnagar taluk. The deposits are associated with hard sand stone. The total reserves are estimated to be around 65,000 tonnes.

(d) Bharuch district

Pocket type silica sand deposits are found around Bhimpur, Amod, Imlai, Dhamalaiamod, Padel and Bhuri villages in Jagadia taluk. The deposits are associated with clay, claystone, sandstone and ferrugenous shale.

(e) Other deposits

The other deposits of silica sands occur at Roswad village of Mandavi taluk in Surat district. The Moulding sand type silica sand deposits occur around Malanke in Bhavnagar district; Gadechi in Okhamandal taluk of Jamnagar district; Jogeshwar in Wagra taluk of Broach district; Rampura in Chotila taluk and Memka in Wed-hawan taluk of Surendranagar district and in some parts of Rajkot district.

(5) HARYANA

Haryana is the leading silica sand producing state in India[17]. The deposits are in Bhiwani, Faridabad, Gurgaon and Mahendragarh districts. The total reserves of silica sand in the state are estimated to be 22.6 million tonnes. Out of which, about 15 million tonnes are in Faridabad district alone.

(a) Bhiwani district

In Bhiwani district, silica sand deposits occur around Atela, south of Bhiwani in Charukhidadri taluk. Silica sand beds occur in the country rock of quartzites.

(b) Faridabad district

Major silica sand deposits of Haryana state occur in Faridabad district. The deposits are found around Mangar, Pali, Anangpur, Mohbtabad and Sadkhal in Ballabgarh taluk. The silica sand comprises Delhi Quartzite of Alwar Series of the Delhi System. The reserves have been estimated at 14.82 million tonnes.

(c) Gurgaon district

In Gurgaon district, occurrences of silica sand deposits are reported at Rangalla in Nuh taluk, Ghairatpurbas in Gurgaon taluk and Rozka-Gujjar in Sohna taluk.

(d) Mahendragarh district

In Mahendragarh district, silica sand occurs in and around Ruparsarai, 28 km. south of Narnaul, in Narnaul taluk. The reserves have been estimated at 7.3 million tonnes.

(6) KARNATAKA

In Karnataka, the important silica sand deposits of moulding sand type occur in Bijapur and South Kanara districts. Other less important deposits occur in Belgaum, Dharwar, Gulbarga, North Kanara and Raichur districts.

(a) Bijapur district

Deposits of silica sand are located at Parvati, north of Badan in south eastern part of the district. Fine grained sandstone of Kaladgi Age is the source of silica sand. The reserves are estimated at 5.6 million tonnes.

(b) South Kanara district

Deposits of silica sand of moulding sand type occur along the coastal belt of the district from Mangalore to Udipi at Uliyargol, Udayawara and Tenke in Udipi taluk as well as Thekkette in Coondapur taluk.

(c) Other deposits

Other deposits of silica sand of moulding sand type occur in Belgaum, Dharwar, Gulbarga (at Ramasamudrakaval village in Yadgiri taluk), North Kanara (at Holangaddesgude, Angadi, and Devangiri villages in Kumta taluk and at Bengre village in Bhatkal taluk) and Raichur districts (at Siddapuram in Raichur taluk).

(7) KERALA

In Kerala, silica sand deposits occur in Allappuzha and Kollam districts in the coastal belt. The total reserves in the state are estimated at 105 million tonnes of which most of the silica production comes from Allappuzha district[2].

(a) Allappuzha district

Deposits of silica sand occur in area from Allappuzha to Pallipuram and over a linear stretch of 35 km along Venbanad lake. The important producing places are Panavally, Pallipuram, Thycuttusery and Kokkathamangalam in Shertally taluk. The total reserves estimated in the district are 103 million tonnes[2].

(b) Kollam district

Silica sand deposits occur in Ambalapuzha and Ananthdam areas of the Kollam district. The reserves are estimated at 2.45 million tonnes .

(8) MADHYA PRADESH

The occurrences of silica sand deposits are reported from Dewas, Jabalpur, Morena, Rewa, Raisen and Gwalior districts. Total reserves have been estimated at 12.24 million tonnes by Indian Bureau of Mines.

(a) Dewas district

Silica sand deposit is located at Mirzapur in Bagli taluk in the central part of the district. It occurs in loose form as soft friable sandstone.

(b) Jabalpur district

Silica sand deposits occur in Jotpur, 2 km. west of Jabalpur on Itarsi road. Other deposits are reported from Chhurhaitona area, associated with the Lameta sand stones. The reserves are estimated to be around 15,000 tonnes.

(c) Morena district

The deposits occur in the area around Dhanela, Pahadi, Sherpur, Pancholi, Lohabani and Jakhoda villages near Noorabad in the southern part of the district. Silica sand occurs in patches within friable quartzites of the Vindhyan System. The reserves are placed at 1.65 lakh tonnes.

(d) Rewa district

The deposits occur near village Ghateha in Teonthar taluk and Maziani, Kolpara and Pakhra villages around Dubhara as a weathered product of Dhandraul Quartzite of Kaimur Series of Vindhyan System.

(e) Raisen district

Silica sand deposits occur around Nagori, Pagneshwar, Kanakhara and Pohra villages. The area is located at a distance of 15 km. from Raisen. The reserves of about 3 million tonnes have been estimated by the state authorities.

(f) Gwalior district

Silica sand deposits occur around Tighra locality which is situated at about 12 km from Gwalior. Silica sand has been formed due to weathering of sandstone and quartzites. The reserves of about 1.4 million tonnes of silica sand have been estimated in the area by state authorities.

(9) MAHARASHTRA

In Maharashtra, silica sand deposits are in Kolhapur, Ratnagiri and Sindhudurg districts. However, only the Phondaghat deposits in Sindhudurg district is important from the point of reserves and production. The total reserves of silica sand are estimated at 59 million tonnes.

(a) Kolhapur district

In Kolhapur, silica sand deposits are found in Radhanagari, Paneri and Bhande areas in south western parts of the district. The reserves are estimated to be around 5.5 lakh tonnes.

(b) Ratnagiri district

In Ratnagiri district, silica sand deposits occur at Oni, Tiware, Manrul, Watul and Barthade in Rajapur taluk. The total reserves in the district are placed at 2.75 million tonnes.

(c) Sindhudurg district

In Sindhudurg district, important silica sand deposits occur around Phondaghat, Kasarda,Karkul and Wagheri in Kankavli taluk; Tendoli and Walawal in Kudal taluk; Math, Kasarde, Shiroda-Arawali, Ubhadana, Vetora,Modhemud,Tulus- Hodwada and Shiroda in Vengurla taluk. The total reserves in the district are estimated at 55.34 million tonnes.

(10) RAJASTHAN

In Rajasthan, silica sand occurrences are reported from the Pre- Vindhyan formation in and around Jaipur and Tonk districts. The chief rock contributing silica sand is the various quartzites occurring in the Delhi Super Group of the Pre-Cambrian formation[15]. The deposits occur in Bundi, Jaipur, Kota, Bharatpur, Sawai-Madhopur, Tonk and Bikaner districts. Banskhon, Jhir Jamwa and Ramgarh hills are the main sources of silica sand in the district, for which about 2.8 million tonnes of reserves have been indicated.

(a) Bundi district

Silica sand deposits are located at about 1.5 km south of Barodiya village in Hindoli taluk. This area lies 10 km. northwest of Bundi. Silica sand occurs as altered product of the Vindhyan Sandstone. The reserves in the area are estimated to be around 14.09 million tonnes.

(b) Jaipur district

In Jaipur district, the deposits of silica sand are derived from the quartzites belonging to Alwar Group. The deposits occur in four areas : (i) Around Jaipur in-Banshkho, Jomwa, Dhula, Jhir (Bassi-taluk), Manota (Jaipur taluk) and Ramgarh villages, (ii) Sanod area in Chomu taluk in north-western part of the district, (iii)

Kundal Bhankhari in the eastern part of the district and (iv) Girota in Sikarai taluk. The reserves are estimated at 4.45 million tonnes. The Jaipur district is the second major producing district of Rajasthan.

(c) Kota district

In Kota district, silica sand is associated with the traps between Sirbu shales and the trap boulders. The silica sand deposits are located near Kundi in Atru taluk and Chhabra town. The reserves in the area are estimated to be around 4.0 million tonnes.

(d) Bharatpur district

In Bharatpur district, the silica sand is obtained from quartzite ridges mainly composed of the ferruginous and white massive quartzite of Ajabgarh group. The silica sand deposits occur in Gothara, Navali, Gudhakar and Keladevi localities. The total reserves are estimated to be 0.76 million tonnes.

(e) Sawai Madhopur district

In this district, silica sand occurs as the altered product of quartzites. The deposits are located near Gangpur and Hindaun areas in the northern part of the district. The reserves have been estimated to be around 7 lakh tonnes.

(f) Tonk district

In Tonk district, silica sand occurs as the altered product of quartzites and is found in Nahata and Barthal areas north east of Tonk. The reserves are estimated to be around 3 lakh tonnes.

(g) Bikaner district

In Bikaner district silica sand occurs near Mash and Mudh areas. The reserves are estimated to be around 1.6 lakh tonnes.

(11) TAMIL NADU

Tamil Nadu is a rich source of silica sand occurrence in isolated patches along the Bay of Bengal coast, between Ennore in Chengalpattu district and Vedaranyam in Thanjavur district covering a stretch of about 200 km.

(a) Chengai-MGR district(Chengalpattu district)

Silica sands have been known along the coastal tracts in Chengai-MGR district. The DGM has carried out investigations near Agaram R.F. At present, the

Tamil Nadu Minerals Ltd. are working on these deposits. In between Thiruvanmiyur and Palar river, a good horizon of silica sand with potable water has been investigated by the GSI. Therefore, mining of these silica sand deposits has been banned as the water contained in these deposits is being supplied to Madras city for drinking purposes.

(b) South Arcot district

Silica sand occurrences are reported along the Bay of Bengal coast. Silica sand is known to occur along the peninsula coast from Orissa down to Tamil Nadu in the east and in Kerala in the west. The oldest rocks belonging to Archaeans are followed by the Upper Cretaceous and Mio-Pliocene Cuddalore formation, Tertiary laterite, Sub-recent white sands, Sub-recent and Recent coastal sand, alluvium and soil. Silica sand of high quality occurs as distinct layers at depth of 2.5 to 3.0 metres below brown sand in the east coast right from Madras to Marakanam in this district. The total inferred reserves are about 7.5 million tonnes.

The total estimated reserves of good grade silica sand in the Chengai-MGR district and South Arcot district have been estimated by DGM, Tamil Nadu at about 15 million tonnes, sufficient to last for several decades.

(c) Thanjavur district

In this district, the silica sands are of Recent to Sub-recent age. There are two locations of silica sands in this district, one near Kariyapattanam and another near Thillavilagam. The silica sand stretches over lengths from 1.5 to 2.5 km. widths from 1.00 to 1.5 km., and thicknesses from 0.70 to 2.25 m.

The total area of occurrence is 2.7 sq.km. and the total indicated reserves of silica sand available works out to 6.6 million tonnes. In addition to this, occurrence of silica sand deposit at Chettipulam-Kariyapattanam village is under investigation.

(12) UTTAR PRADESH

India's best quality silica sand deposits occur in Allahabad and Banda districts [17].

(a) Allahabad district

In Allahabad district, silica sand occurrences are reported at Golahiya, Lalapur, Janwa, Laundkhurd, Kolahi, Janwa, Aswan, Bankipur, Bhandwa, Bhansai; Bargarhi, and Bankipura villages in Bara taluk; Purabaldu, Aswan, Derabari, Lakhnautibari, Sunderpur, Bhita, Bankipur, Chatehra, Deoria and Nibi villages in Karchana taluk; Chitehra and Garheta villages in Lohgara taluk. The silica sand occurs as an altered product of quartzites belonging to the Dhandraul stage of Kaimur Series of Vindhyan System.

(b) Banda district

In Banda district, silica sand occurs in patches within hard quartzites of Dhandraul Stage of Upper Kaimur Series of Vindhyan System. The deposits are in Misra- Pahari,Arwari, Naudiha,Kurmian, Semra, Murka and Bargarh areas Guiya-Kalan, Barhakotra, Pardwan, Goiyakhurd, Kalchhiaha, Murka, Semra and Kolenazra village in Mau taluk.

MINOR OCCURRENCE

(1) ASSAM

In Assam, the deposits occur at Tanjuri in Nowgong and Karbi Anglong districts.This area is located at about 40 km from Nowgong, Gauhati. The total reserves of silica sand have been estimated at 1.79 million tonnes.

(2) DELHI

In Delhi, the silica sand is reported from Badarpur and Bhatti mines area on the south-eastern border of the Union Territory of Delhi. The silica sand is obtained from the quartzites belonging to Alwar Series of Delhi System.

(3) HIMACHAL PRADESH

In Himachal Pradesh, silica sand deposits occur at Itri in Una district. Itri is located on Dharamkot road 18 km. from Una . The silica sand occurs as fragmentation of soft boulder beds of upper Siwalik formation. The total reserves of silica sand are estimated to be 2.5 million tonnes.

(4) JAMMU & KASHMIR

In Jammu and Kashmir, silica sand is derived from the quartzites belonging to the Muth quartzites of Devonian Age. The deposits are found in Anantnag, Rajouri,Poonch, Doda, Udhampur and Jammu districts. The reserves of silica sand in the state are placed at 3.11 million tonnes.

(a) Anantnag district

Silica sand occurs in the area between Gugaldar and Hapatnar, about 88 km. south of Srinagar. The reserves are estimated at around 2 million tonnes.

(b) Rajouri, Poonch and Doda districts

Silica sand deposits occur around Chhamba-Dattigala and Kishtwar areas in these districts. The reserves in these districts are estimated to be around 1.03 million tonnes.

(c) Udhampur and Jammu districts

In these districts, quartzites yielding silica sand have been reported from various places in Tawi bed near Jammu. Reserves of silica sand are estimated to be around 80,000 tonnes.

(5) MEGHALAYA

In Meghalaya, silica sand deposits are associated with the current bedded quartzite of Shillong Series of Eocene Age. Silica sand deposits are located at Krait near Mawphlang, 17 km. south west of Shillong and at Umstew in the East Khasi Hills district, at Laithryngew and Cherrapunji in the southern part of Khasi Hills district and at Tura in Garo Hills district. The reserves are estimated at 5 lakh tonnes.

(6) ORISSA

In Orissa, foundry grade silica sand deposits are located at Khadapur in Kalahandi district. The reserves are estimated at 50,000 tonnes.

(7) PUNJAB

In Punjab, silica sand deposits are reported in Gurudaspur and Hoshiyarpur districts. The reserves are placed at 18.12 million tonnes.

(a) Gurudaspur district

In Gurudaspur district, silica sand deposits are reported from Batala and Dharamkot. Silica sand occurs as sand dunes formed due to wind action. The reserves are estimated to be around 9 million tonnes.

(b) Hoshiyarpur district

In Hoshiyarpur district, silica sand deposits occur in Barapur-Sadarpur-Khaba-Dikhad-Maira, Nadedola, Dikhad-Jaijan-Gaggar belt near Garshankar in the south- eastern part of the district. Silica sand occurs as loose fragments in an intermixture of Siwalik sand; gravel and boulders in stream beds and slopes. The reserves have been estimated to be 9.12 million tonnes.

(8) TRIPURA

In Tripura, silica sand deposits are reported from Bisramganj, Purba and Chamanpura localities near old Agartala. The sand is derived from Dupitola sediments of Recent to Sub-recent Age. The reserves are estimated at 2.11 lakh tonnes.

(9) WEST BENGAL

In West Bengal, silica sand deposits are found at Kalesota and Mahisnadi in Neturia block of Purulia district. Silica sand is derived from Barakar sand stones of Lower Gondwana Age. The reserves have been estimated to be around 3 million tonnes.

3.2.3 Quartzite

A large portion of quartz occurs in the form of quartzite, a metamorphosed detrital sedimentary rock in which the constituent grains, largely quartz, recrystallise and develop an interlocked mosaic texture. Deposits of quartzite are reported from the states of Bihar, Madhya Pradesh, Orissa, Rajasthan and Jammu and Kashmir[2]. Orissa was the leading quartzite producing state contributing 50% production followed by Madhya Pradesh (34%) and Rajasthan (2%) in 1991.

(1) BIHAR

White friable quartzites belonging to the Upper Kaimur Stage occur in Sahabad and Singhbhum districts. The reserves are estimated to be around 18.00 million tonnes.

(a) Singhbhum district

The quartzite deposits occur at Khakripara and Jamjore near Tatanagar; at Kendadih, 12 km from Ghatsila and Chiriburu near Lotapahar. Of these, the deposits at Kendadih and Chiriburu are important with 1.08 million tonnes and 13.70 million tonnes of reserves respectively.

(b) Monghyr district

The quartzite deposits occur at Mirzapur and Raunakabad in Monghyr sub-division. It occurs in a north-south trending hill and is massive in nature.

(2) MADHYA PRADESH

In Madhya Pradesh, the deposits of quartzite are in Durg, Sehore, Raigarh and Rewa districts. The total reserves of quartzites are estimated at 9.5 million tonnes.

(a) Durg district

The quartzite deposits of Durg district are located at Danitola and Kalkasa near Balod. These deposits occur in a bedded form. The reserves of these deposits are 3.21 and 2.37 million tonnes respectively.

(b) Sehore district

Quartzite deposits occur in Mallajpur village near Rehiti in Narsullaganj taluk. Milky white to reddish quarzite of Vindhyan Age is exposed in the area. The reserves have been estimated at 3.0 million tonnes.

(c) Raigarh district

Quartzite deposits occur in Urdana and Rampur reserved forest nearly 3 km from Raigarh. The quartzite in Urdana and Rampur belongs to lower part of Chandrapur Series of lower Vindhyan System.

(d) Rewa district

The quartzite deposits are found in Ghuman (25°07′ : 84°24′), Suti (25°08′ : 81°05′) and Bargah, (25°08′ : 81°27′) areas.

(4) ORISSA

In Orissa, the quartzite deposits are in Bolangir, Dhenkanal, Kalahandi, Mayurbhanj, Sambalpur and Sundergarh districts. The total reserves of quartzite in the state are estimated to be around 17.5 million tonnes.

(a) Bolangir district

The quarzite deposits occur in the district at Nuapara. The total reserves have been estimated to be around 5 million tonnes.

(b) Dhenkanal district

The quartzite deposits occur in the district at Karande near Hindol. The reserves are estimated to be around 4,020 tonnes.

(c) Kalahandi district

In Kalahandi district, the deposits of quartzite occur at Amjore near Bandigaon in Jaipalna taluk. The reserves are estimated to be around 7 lakh tonnes. The quartzites occur in the core of Pegmatites.

(d) Keonjhar district

Quartzite deposits occur in Keonjhar district at Pancham in Keonjhar sub-division and at Barpada and Barang in Anandpur sub-division. The quartzite deposit occur in association with granite gneiss and serpentine dolerites. The total reserves in the district are estimated at 14.14 million tonnes.

(e) Mayurbhanj district

In Mayurbhanj district, the deposits of quartzite occur at Dubulabera. The reserves are estimated in the district at 30,000 tonnes.

(f) Sambalpur district

In this district, the quartzite deposits occur at Kanjhiharan. The reserve estimated is 39,420 tonnes.

(g) Sundergarh district

In this district, the quartzite deposits occur at Altaghat, Bhabulatha, Gobira and Suedi in Panposh sub-division; at Barsuam in Burra taluk; and at Jharbeda, Kulijhar,Navaloli, Ramjori and Sonparbat in Kharmunda taluk. The total reserves are estimated at 2.57 million tonnes.

(5) RAJASTHAN

In Rajasthan, the quartzite deposits occur in Ajmer, Alwar, and Bundi districts.

(a) Ajmer district

The quartzite deposits occur at Chosla and Balapura in Arani taluk; Jalia Pithawas and Nagroo in Pinagarh taluk and Jangia, Piproli and Bardana. The reserves are estimated to be around 92,109 tonnes.

(b) Alwar district

The quartzite deposits occur near Tatarpur in Mundowan taluk. The estimated reserve is around 10,000 tonnes.

(c) Sawai Madhopur district

In Sawai Madhopur district, quartzite deposits occur at Bagoli in Bonli taluk.

(d) Jhunjhunu district

In Jhunjhunu district, quartzite deposits are reported from Banwasa in Khetri taluk.

(6) ANDHRA PRADESH

In Andhra Pradesh, the quartzite deposits occur in Guntur district.

(a) Guntur district

White Quartzites are noticed near Kotturu ($16^{o}42' : 79^{o}47'$) and Nakerikal ($16^{o} 30' : 79^{o}15'$).

(7) JAMMU &KASHMIR

In Jammu &Kashmir, the quartzite deposits occur in Anantnag and Poonch districts.

(a) Anantnag district

Two quartzite bands belonging to the Muth Quartzite Series of Devonian Age occur in the Gugalder ($35^{o}50' 45'' : 75^{o}21'$) and Hapatnar ($33^{o}49' 45'' : 75^{o}21'$) areas. The deposits are situated around 88 km. south-east of Srinagar and is connected with Aishnugam, a town on Srinagar-Pahalgam road.

(b) Poonch district

The quartzite deposits in this district are at Batla Hill area between Chhanbar ($33^{o}51'15'' : 74^{o}15'15''$) and Dattigala ($33^{o}51'30'' : 74^{o}16'15''$) areas. The quartzite is friable and of snow white to flesh in colour. The quartzite band extends over a strike length of 600 m with an average thickness of 167 m.

3.3 WORLD OCCURRENCES (RARE VARIETY)[13]

(i) *Rock Crystals*

Fine crystals come from Cumbria and Cornwall. Large crystalline forms are found in joints in Alps, former USSR (Urals), Brazil, Madagascar and other localities.

(ii) *Amethyst*

Some of the important areas, where good crystals of amethyst are found, are Austria (Tyrol), Brazil, Uruguay and Madagascar.

(iii) *Smoky quartz*

A variety known as Cairngorm is common in Scotland and found in the Cairngorm mountains. This variety is also in the Alps, Brazil & Madagascar.

(iv) *Rose quartz*

Major producers of rose quartz are Japan (Yoshima), Burma (Magok), Finland, Brazil (Minas-Gerais, Bahia), Madagascar, USA (Maine, Colorado, California, South Dakota), former USSR (Urals) & South-west Africa.

(v) *Cat's eye*

Major occurrences are in South-west Africa, western Australia,Burma and USA (California).

(vi) *Moss agate*

Moss agate is found in China and USA (Colorado,Michigan).

3.4 WORLD OCCURRENCES (COMMON VARIETY)

Silica sand occurrences have been reported from all over the world. The major producers of silica sand in the world together with the related geological set-up are discussed in this chapter.

(1) United Kingdom[6]

The process for casting glass was invented in the 17th century in France. Later, England began to make flint glass making the beginning of modern glass technology.

Silica sand deposits in U.K. are found in various geological formations, besides large deposits of aeolian sand.

The Pleistocene Chelford Formation

Near Chelford, there are three principal horizons of sand. The middle layer of white sand is bounded above and below by red sand horizons. This is one of the largest silica sand producing areas. The Chelford deposits produce three standard grades of foundry sand and four grades of glass sand. Other formation containing silica sand beds is carboniferous sand stone horizon near leven seat.

Carboniferous Mill stone Grit

Formation near Oakamoor in English Midlands also contains workable sands. It produces two standard glass grades with silica content 98 to 98.4% and iron content 0.03 to 0.085%.

The Folkstone Beds at Reighate produces silica sand for glass, foundry and building industry. Its flintgrade is very low in iron (0.035%).

The Morvern peninsula in Scotland produces sands from underground mine located at Loch Aline. The mining method adopted is room & pillar.

At Aline mine, currently two grades i.e. B & C grade material are produced. The B grade product contains Fe_2O_3 of 0.013% together with low levels of alumina and alkalies. The C-grade sand has a Fe_2O_3 specification of 0.03%. Silica content in both grades averages 99.8%. Mostly, the Loch Aline sand is used in tableware glass and container glass, etc.

(2) Belgium

In Belgium, silica sand producing centres are located at MOL, Lommel and Maasmechelelen[6]. In the production of silica sand MOL and Lommel account for approx. 45% each, with Maasmechelen providing around 10%.

Quartz sand deposits at MOL and Maasmechelen possess favourable granulometry, typically 200 microns with SiO_2 of about 99.5 % iron & alumina level of 0.025 and 0.2% respectively. The silica sand is primarily used in foundry & glass industries.

(3) West Germany

The upper cretaceous sand stones are being exploited around Haltern & Dulmen. The tertiary sands are being worked near Cologne, to the south of French and at Herzogenrath, the German-Dutch border[6]. Near Hirschau area, superior quality sands are being exploited from the Middle Jurassic formation. Felspathic silica sands are also produced from pegmatite bodies near Bavaria in West Germany. Sands produced in this country are suitable for glass due to their excellent fusibility and proper granulometry (0.02- 0.25 mm). Iron content of these sands is about 0.007 per cent.

(4) France

Paris-Basin and Aquitine Basin contain about 90% of silica sand reserves of France[6]. France produces about 6 million tonnes of silica sand annually. The Fontainebleayu sand has SiO_2 content of 99.6% and Fe_2O_3 & Al_2O_3 levels of 0.63% and 0.46% respectively. Sand deposits associated with granite are found in Drome basin in south-eastern France. Silica sand from this deposits is produced as a co-product of kaolin extraction. The other major source of silica sand is the Saint Gobain conglomerate formation at Moru and Rozet, etc.

(5) South Africa

Delmas deposit is one of the largest deposits of silica sand in the Republic of South Africa.

(6) Australia

The Cape York mine is the largest silica sand mine in Australia and has an extensive reserves of about 200 million tonnes. The mine is located on Cape York Peninsula about 60 km. north of Cooktown in Queen'sland. In Victoria, near Ballarat at Allendale, quartz cobbles excavated during gold mining is being used as raw feed for production of silica flour.

(7) United States of America

Glass making was probably the first industry to be transplanted from Europe to North America, first to Mexico[16]. The first glass factory was established at James town in United States in 1608. In 1989, 29.2m tonnes of silica sands were produced in the United States for a variety of uses of which, 12.3 million tonnes were for glass making. In United States, silica sands or industrial sand deposits are associated with various geological formations ranging in age from late Pre-Cambrian to Mid-Tertiary. It is reported that silica sands are known to occur in 70 stratigraphic units. Lithologically, these deposits ranged from quartzites, sandstone with different degrees of cementation, quartz-conglomerates, chert-beds, quartz-pegmatites to terrace sands & gravels and sand-dunes.

The important deposits which produce high quality sands are Oriskany sandstone bed belonging to Ridgeley formation of Early Devonian age, the St. Peter sandstone of Middle Devonian age and Jordan sandstone of upper Carboniferous age. Minnesota and Wisconsin, are a primary source of hydraulic fracturing sand. The Hickory sandstone of Cambrian age produces mostly hydraulic facturing sand. Tuscarora quartzite formation of lower Silurian age in Pennsylvania and Virginia produces refractory brick grade sands. In the west, Lone formation of Eocene age, in northern California and Eureka and quartzite of middle Devonian age in central California are also some of the important deposits of sands.

(8) Lebanon

Glass making in Lebanon is known since antiquity, with the Phoenicians in 3000 BC, through Roman, Byzanthian, Arabian and Ottoman rules coming down to the present times.

The major silica sand deposits in Lebanon are within the Basal cretaceous sandstone formation. It is a sedimentary deposit[12]. The sandstone formation is extending from Jezzine to south of Lebanon where it is about 250 metres thick. It goes from north through Chouf (250 metres thick) to Central Mount Lebanon at Baskinta where it is about 350-m. thick. The white silica sand zone makes about 5-10 % of the total thickness of the sandstone formation.

(9) Brazil

Brazil possesses the world's largest commercial deposits of high quality quartz crystal[9]. It is the chief source of electronic grade quartz crystals. The quartz deposits which produce the electronic grade crystals occur in the form of veins, pipes and small pockets. Most of the quartz is milky quartz and as such is unsuitable for electronic application. However, the bulk of the marketable quartz occurs as clear termination to the milky quartz which is comparatively rare. The ratio of clear commercial grade crystal to total excavation varies from 1:1000 to 1:100,000. The deposits of quartz are located in the States of Minas Gerais, Santa-Catarina, Sao-Paulo, Parana, Bahia and Rio-de-Janeiro. Of these, the deposit at Minas-Gerais is the richest. It has reserves of 2,490,322 tonnes proved; 2,718,262 tonnes indicated; and 3,147,869 tonnes inferred.

(10) Angola

Quartz deposits in Angola are located 50 km. south of Gabela in the west central part of the country. It produces about 1,500 tonnes of quartz annually of which about 25 tonnes are of Grade-A suitable for electronic use.

(11) Madagascar

Madagascar produces about 500 kg. of electronic grade quartz per year. The source of quartz is in the Fianarantsoa area.

(12) Tuekey[6]

Turkey has a large reserve of good colour silica sand with low feldspar content. Deposits often occur below 5-20 metres of overburden cover. The major deposit is located around Edirne- Kirklareli-Tekirdag in European Turkey. Sands have typical grain of 0.1-0.5 mm and contain low iron.

(13) Hungary

There are three major producing centres of silica sand, viz. Fehervaresurgo, Soskut and Kisors. The Fehervaresurgo silica sand is produced as a co-product of bauxite mining. Dry mining technology together with flotation and magnetic separation accomplished will have an annual output of 400,000-450,000 tonnes. The Soskut deposits produce different grades of sands and about 3 grades of foundry sands. Besides, other industrial and constructional grade of sands are also produced. The Kisore deposits is the major source for foundry sands for Hungarian heavy industry.

The other countries which produce sands are Portugal, Middle East, Philippines and Pakistan.

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Chapter 4 USES & SPECIFICATIONS

Mineralogy, chemistry and physical properties are the three characteristics which govern the application of silica in any industry. Different forms of silica which are used in various industrial applications are given below :

4.1 USES

The different uses of silica, silica sand, quartz and quartzite are as below :

(i) Lump Silica

(a) **Flux** : Massive quartz, quartzite, sandstone and unconsolidated sands.

(b) **Silica, Ferro-silicon & Silicon Alloys :** Lump quartz, quartzite, and well cemented sandstone.

(c) **Silica bricks** : Quartz and Quartzite.

(d) **Aggregate** : Quartz and quartzite.

(e) Material in ball and tube mills, lining and packing for acid towers and grinding pebbles.

(ii) Silica Sand

Glass and glass fibre
Silicon carbide
Hydraulic fracturing
Foundry sand
Sodium silicate
Sand blasting and sand paper
Filter media in water treatment
Portland cement manufacture
Silicon alloys & metals

(iii) Silica Flour

Ceramic, enamels, frits, pottery, flint

Filler, rubber, asbestos cement

Extender in paints

Abrasive in soap & scouring pads

Autoclave-cured concrete products

(iv) Quartz Crystal

Electronic for its piezo-electric properties.

4.2 SPECIFICATIONS

The various criteria which govern the selection of silica raw material for use in the specific industry are described below:

4.2.1 Glass

In the manufacture of glass, all the three attributes, viz. chemical, mineralogical and physical properties are of importance in determining the suitability of silica sand[5]. Chemistry will dictate the minimum acceptable silica level and maximum permissible impurity level. Mineralogy will help in understanding whether the undesirable elements present with silica are an integral part of silica or they are present as separate minerals. Finally, the physical size of the silica is critical to the manufacturing processes used in the production of different types of glasses.

For the bulk of glass production, silica sand is the main raw material used. This can be derived from naturally occurring unconsolidated sand or from consolidated sandstones or quartzites which can be crushed and ground to generate appropriate sizes. Silica sand constitutes about 60% of the glass composition. A typical Batch Composition of some varieties of glass is given below :

Typical Batch Composition (%)

	Flat Glass	Container Glass
Silica sand	60.0	59.60
High calcium limestone	4.0	14.18
Dolomitic limestone	15.0	-
Soda ash	20.0	19.00
Salt cake (sulphate)	0.5	1.00
Alumina	-	4.50
Rouge (others)	0.5	-

The various types of glass produced in the country are (1) Glass bottle, (2) Sheet glass, (3) Wired and figured glass, (4) Vacuum flasks, (5) Laboratory glass, (6) Glass shells and (7) Fibre glass. Flint glass and opthalmic glass are also produced in addition to bangles and glass beeds.

4.2.1.1 FLAT GLASS[5]

The minimum SiO_2 level of 99% is generally stipulated for flat glass manufacture, but values as low as 96% are also acceptable provided the variation does not exceed 0.3% of the mean value. Sands should have a low iron content with a preferred maximum of 0.1% Fe_2O_3. Usually, sand containing Fe_2O_3 between 0.02 and 0.1% are used. The high Fe_2O_3 content will give rise to coloration in the glass and as such is unacceptable. Alumina content should be in the range of 0.2 - 1.6% (Al_2O_3).Refractory minerals such as Kyanite, Sillimanite and Andalusite, coarser than 0.4mm is undesirable. Chromite minerals, if present, should not be coarser than 0.2mm. Sand particles are preferred in the range of 125 microns to 1 mm with a mean of about 250 microns. The particle size should be such as to ensure uniform melting. Too fine particle size is generally avoided to prevent carry over into the exhaust system where cyclic furnaces are used and to prevent corrosion. Fine particle size does not melt readily but balls up and causes 'seeds' and similar imperfection in the glass. Angular particles are preferred as it melts more readily than rounded particles. Moisture content up to 5% is desirable as it prevents segregation and is cheaper to buy.

SPECIFICATIONS FOR SILICA SAND USED IN FLAT GLASS

(i)Chemical

Constituent	Critical control limit
SiO_2	99.5% min.
Fe_2O_3	0.04% max.
Al_2O_3	0.30% max.
TiO_2	0.1% max.
Cr_2O_3	2 ppm max.
Co_3O_4	2 ppm max.
MnO_2	2 ppm max.

(ii) Physical

Size	Cumulative retention
16 mesh	none
20 mesh	0.01% max.
40 mesh	0.10% max.
140 mesh	92.0% min.
200 mesh	99.5% min.

The table summarises the control limits and acceptable variation for silica sand as issued by Flat glass producers.

4.2.1.2 FLINT GLASS

(a) For manufacture of flint glass, the American Ceramic Society, USA, has specified that the first grade optical glass should contain 99.8% SiO_2, a maximum of 0.1% Al_2O_3 and 0.02% Fe_2O_3. The third quality flint may contain as little as 95% SiO_2 with alumina contents up to 4%. In U.K., the B. S. 2975 has outlined the specifications for sands for the manufacture of colourless glass. There are three grades of sand[5] :

Grade A : for fine grade optical glassware.

Grade B : for high grade domestic & decorative glassware.

Grade C : for general colourless glassware including containerglass.

Chemical specifications of sand for manufacture of glass are given as under :

(In percentage)

	Gr.A	Gr.B	Gr.C
Minimum SiO_2	99.5	99.5	98.5
Maximum Fe_2O_3	0.008	0.013	0.03*
Maximum TiO_2	0.03	N.A.	N.A.
Maximum Chromium, Cr_2O_3	0.0002	0.0002	0.0006

(* For grade C sand with a Cr_2O_3 content less than 0.0002%, the Fe_2O_3 content may be greater than 0.03% but less than 0.035%)

(b) The physical specifications, as set by American Ceramic Society, USA are given below :

"All sand should pass through 20 mesh screen, 40-60% should be retained on a No.60 screen, between 10% and 20% retained on a No.80 screen and not more than 5% should pass a No.100 screen".

4.2.1.3 COLOURED CONTAINER GLASS

For coloured glass, permissible level of iron content can be relaxed but it should not be more than 0.3% Fe_2O_3 for green glass. In the manufacture of amber and brown glass, Fe_2O_3 content as high as 1% is acceptable[5]. The maximum level of alumina and alkali content may be negotiable but the important need is for the consistency. The refractory minerals such as chrome, corundum, zircon, nepheline, etc. must be sufficiently fine to avoid visible stones in the finished glass.

4.2.1.4 FIBRE GLASS

For manufacture of fibre glass insulation (glass wool), fine sands or more commonly silica flour, with 20% reject on a 60 mesh screen, is used to promote easy melting. Though optical clarity is not a requirement in glass fibre, yet iron content should not be too high which may affect heat transfer in the furnace. The prime concern in glass fibre manufacturing is a minimal number of breaks per hour. It is therefore important to eliminate any unmelted material which would cause stoppage. For this purpose, silica sand containing Fe_2O_3 up to 1% may be used.

4.2.1.5 OPHTHALMIC GLASS

Ophthalmic glass for use in spectacles is produced from silica sand. The essential requirements are high silica content coupled with low levels of iron and aluminium oxides.

4.3 The standard specifications

The standard specifications for glass sands prescribed by different standard organisations in India, USA and UK are given below :

4.3.1 Indian Standard Specifications

The Indian Standard (IS : 488-1980) prescribes the specifications of 4 grades of glass making sands as follows :

(a) Chemical Specifications :

Special Grade : For the manufacture of high grade colourless glass, such as crystal glass tableware and decorated ware.

Grade-1 : For the manufacture of decolourised glassware such as container ware, lamp ware, etc.

Grade-2 :For the manufacture of glass ware where a slight tint is permissible, and

Grade-3 : For the manufacture of non-colourised and some coloured glasses.

The chemical composition of the 4 grades of sand shall be as follows. This does not cover silica sand used for optical and other special glasses which is given separately.

(In percentage)

Component	Special Grade	Grade I	Grade 2	Grade 3
L.O.I(Max)	0.5	0.5	0.5	0.5
SiO_2(min)	99.0	98.5	98.0	97.0
Fe_2O_3(max)	0.020	0.04	0.06	0.10
Al_2O_3(max)	*	*	*	1.50
TiO_2 (max)	0.10	0.10	0.10	*
MnO }				*
CuO }		To pass the test prescribed		*
Cr_2O_3 }				*

*These requirements shall be as per agreement between the purchaser and the supplier.

(b)Physical Specifications

The requirements of size grading : When tested according to the method prescribed, the sizes of the grains constituting the material shall be within the following limits :

	Percentage by weight
1. Retained on 1 mm IS sieve	Nil
2. Retained on 600 microns IS sieve (max)	1.0%
3. Passing through 600 microns IS sieve but retained on 300 microns IS sieve (max)	50.0%
4. Passing through 125 microns IS sieve (max)	5.0%

The physical specifictions of silica sand specify that it shall be fairly free from contamination like clay material, pebbles and other extraneous matters. The sand should not contain more than 4% moisture.

4.3.2 U.S. Bureau of Standards Specification

Specifications of glass sands formulated by the American Ceramic Society and the U.S.Bureau of Standards provide a good idea of permissible variations in sand for making different types of glasses.

US Bureau of Standards

(In Percentage)

Quality of glass	SiO_2 Min	Al_2O_3 Max	Fe_2O_3 Max.	CaO+ MgO Max.
First quality optical glass	99.8±0.1	0.1±0.05	0.02±0.005	0.1±0.05
Second quality Flint glass, containers and tableware glass.	98.5±0.5	0.5±0.1	0.035±0.005	0.2±0.05
Third quality flint glass	95.0±1.0	4.0±0.5	0.035±0.005	0.5±0.1
Fourth quality sheet glass, rolled and polished plate	98.5±0.5	0.5±0.1	0.06±0.005	0.5±0.1
Fifth quality sheet glass, rolled and polished plate	95.0±1.0	4.0±0.5	0.06±0.005	0.5±0.1
Sixth quality green glass, containers and window glass	98.0±1.0	0.5±0.5	0.3±0.05	0.5±0.1

4.3.3 British Standard Specifications (B.S. 2975 : 1958)

The B.S. Specifications for making colourless glasses were drafted in co-operation with the Society of Glass Technology. The proportions of grains of different sizes present in the sand, after drying at 110°C must be between the following limits :

BRITISH SIEVE NO	PERCENT
1. Residue on No.16 B.S. Sieve	Nil
2. Residue on No. 25 B.S.Sieve	Not more than 2
3. Residue on No.36 B.S.Sieve	Not more than 10
4. Material Passing No.100 B.S. sieve, including material passing No.120	Not more than 10
5. Material passing No.120 B.S. Sieve	Not more than 5
6. When the larger particles are friable aggregates, the above limits may be extended as follows :	
(a) Residue on No.25 B.S.Sieve	Not over 6
(b) Residue on No.36 B.S.Sieve including the residue on No.25	Not over 15

The limits for chemical composition of sand for colourless glasses are as follows: (B.S. 2975 : 1958)

(in percentage)

Type of glass	SiO_2 (min)	Fe_2O_3 (max)	TiO_2 (max)	Cr_2O_3 (max)
Fine grade optical glassware	99.5	0.008	0.030	0.0002
High grade domestic and decorative glass ware	99.5	0.013	*	0.0002
General colourless glassware including containers	98.5	0.030	*	0.0006

*No maximum limits are specified.

Cobalt content must be absent and all other colouring oxides shall not exceed 0.01%. For Al_2O_3, maximum limit is to be agreed between the buyer and the vendor.

4.4 CERAMICS

Whiteware ceramic body contains about 40% silica besides other constituents except for bone-china in which it is not used at all. The silica serves to provide whiteness, renders the ceramic body easy-to-dry and provides compatability between the body and the glass to prevent crazing or peeling. Main sources of silica in this application are silica sand, calcined silica sand and calcined flint. In addition, silica flour is also used in the formulation of ceramic body for enamels and frits. Silica flours produced by fine grinding of quartzite, sand stone or lump quartz are used in enamels. The silica flour should contain more than 97.5% silica, less than 0.55% alumina and less than 0.2% Fe_2O_3. Purity and small particle size (BS mesh 200) are fundamentally important for silica in the manufacture of ceramics. Sometimes cristobalite is used to increase the thermal expansion capability. The silica sand should be less in alumina content. Of late, ceramics manufacturers are tending towards incorporation of quartz/cristobalite mixes which have the same thermal expansion characteristics as flint or to silica sand/flint mixes which have the benefit of higher whiteness than silica alone. Lately, use of dry ground silica in ceramics is becoming popular.

4.5 FOUNDRY

Silica sand is used in both foundry cores and moulds because of its resistance to thermal shock. Physical properties rather than chemical composition are important in foundry industry. Silica content of 85% is used in iron casting while in steel foundries, the content should be at least 95%. Silica particle size distribution and grain shape are some of the important factors which govern the utilisation of silica sand in foundry[5].

A coarser sand will have a low surface area, thus requiring less binder than a finer sand. Rounded grains also consume less binder than angular particles with a higher surface area. Binder being the most expensive component, its cost could be reduced by optimising the sand size and shape. Rounded grains also have an added advantage. It allows maximum escape of gas during casting. However, the foundry sand should have the following properties:

i) It should possess sufficient cohesiveness to hold together the core or mould when moist.

ii) It should be refractory to withstand the high temperature of the molten metal.

iii) It should have the strength to resist the weight of the metal.

iv) It should be permeable to escape gases generated during cooling of the metal.

v) It should possess the right texture and composition to produce a smooth casting that will not react with the metal.

Silica is not suitable for all types of casting. Silica sand could not be used in Hadfield manganese steel (austentic manga nese steel) which contains about 14% Mn. In silica sand mould, silica reacts with melt and causes vigorous metal-mould reaction, resulting in a pock-marked surface on the steel. In such cases, more refractory sand,e.g. olivine, chromite, zircon, etc. are used.

Silica sand containing sufficient clay to provide mould strength occurs sometimes in nature. As such, these sands are used with out addition of binding agent.

Most of the foundry units in India use the moulding sand having 40 to 65 A.F.S.(American Foundry Men's Society) numbers. The SiO_2 content of 90-95% are used in foundry industry. Clay content should not be more than 1%. However, occasionally clay content upto 2% is acceptable. Steel foundry sands should preferably contain 97% or above SiO_2.

The quality of silica sand required for moulding purposes, expressed as a multiple of weight of casting, varies widely. The requirements of sand for core making in the foundry industry depend on the degree of coring in any particular casting and vary from 4 to 5% of the weight of the casting. The norm of consumption is also dependent on the binding materials used and the amount of reclaimed sand. In the individual foundry units this norm varies from 0.5 to 5 tonnes of silica. The average norms of consumption of silica mineral as a whole, for various types of casting, are estimated at 1.2 tonnes for iron casting, 1.8 tonnes for steel, 1.1 tonnes for malleable iron, 1.0 tonne for SG Iron and 0.9 tonne for non-ferrous metal casting.

There are three types of Indian standards for natural moulding sand, high silica sand and silica flour used in the foundry industry.

1) Indian Standards (IS 3343-1965) Specification for Natural Moulding Sand for use in Foundries

Natural moulding sands contain variable amount of clay which acts as bond between the sand grains. These sands, therefore, possess strength, plasticity and refractoriness to varying extent depending upon the clay minerals present. When it contains a greater amount of clay, it is blended with river sand which is relatively clay-free so as to get the optimum properties desired in the sand mixture.

Washed grains shall be mostly of sub-angular to rounded shape. As far as possible, the sand shall be free from gravel. Natural moulding sand for use in foundries shall be of three main grades, namely A, B and C with respect to clay content.

Grade	Clay (%)
A	5 to 10
B	10 to 15
C	15 to 20

According to the grain size of moulding sand, each main grade shall be divided into II sub-grades, as indicated below:

Grain Size Distribution of Moulding Sand

Grade	Fraction retained on I.S.Sieve Designation Micron	%Minimum
850/425	850, 600 and 425	60
600/300	600, 425 and 300	60
425/212	425, 300 and 212	60
300/150	300, 212 and 150	60
212/106	212, 150 and 106	60
150/75	150, 106 and 75	60
850/300	850, 600, 425 and 300	60
600/212	600, 425, 300 and 212	60
425/150	425, 300, 212 and 150	60
300/106	300, 212, 150 and 106	60
212/75	212, 150, 106 and 75	60

For example, natural moulding sand falling under grade 'A' with respect to clay content and grade 850/425 according to its grain size distribution shall be designated as Grade A 850/425.

The refractoriness of different grades of natural moulding sand is as follows:

Grade	'A' Sintering temperature range
A	1350 to 1450°C
B	1200 to 1350°C
C	1100 to 1200°C

(ii) Indian Standards (IS : 1987-1974) Specification for High Silica Sand for use in foundries

High silica sand for use in foundries is different from that used in glass and refractory industries. Sand for foundry purposes should have well developed grading, preferred shape and size, besides meeting the requirements of chemical composition, sand should be essentially free from mica content. The grain size, shape and its distribution ultimately affect the moulding characteristics of the sand mixture. This standard covers the requirements for both natural and crushed sands.

High silica sand for use in foundries shall be of 3 grades, namely A,B and C with respect to clay content of the sand and 6 sub-grades, namely grades 850/425, 600/300, 425/212, 300/150, 212/106 and 150/75 based on the distribution of sand grains. High silica sand is designated with a symbol which should be a combination of gradation according to clay content and grain distribution.

For example, high silica sand falling under Grade A with respect to clay content and grade 425/212 according to its grain distribution shall be designated as A 425/212. Specifications regarding clay content, chemical composition, sintering temperature and grain fineness for different grades are discussed below:

Clay content : Clay content for Grade 'A' shall not exceed 1.0% and for Grades 'B' and 'C', it shall not be more than 2%. If required, clay content for Grade 'A' may be accepted upto 2% subject to agreement between the supplier and the purchaser.

Chemical composition : High silica sand after washing off the clay matter shall conform to the requirements given in the table given below :

CHEMICAL COMPOSITION OF HIGH SILICA SAND

Grade	Requirements, percent				
	SiO_2	Al_2O_3 (max)	Fe_2O_3 (max)	CaO & MgO (max)	Alkalies (max)
A	Over 98	1.0	1.0	1.0	0.5
B	Over 95 upto 98	1.5	1.0	1.0	0.5
C	Over 90 upto 95	5.0	1.5	2.0	1.5

Sintering temperature : The sintering temperature range for Grade A high silica sand shall be 1685 - 1710^{o}C.

Grain shape : Washed sand grains shall be mostly of sub-angular to rounded shape.

Grain fineness : High silica sand for foundry purposes shall have a well-defined grading with 70% and above of the sand grains retained by 3 adjacent sieves.

Sorting co-efficient for washed and graded sands shall range from 1.14 to 1.40 while for naturally bonded sands it should be between 1.40 and 2.50. The fineness (grain distribution) of different grades of silica sand shall conform to the requirements as specified below :

GRAIN FINENESS OF SILICA SAND

Grade	Main fraction	Percent (min)	Coarse fraction	Percent (max)	Fine fraction	Percent max
850/425	850, 600 and 425 micron	70	3.35 mm	2	212 micron and finer	10
600/300	600, 425 and 300 micron	70	3.35 and 1.70 mm	4	150 micron and finer	8
425/212	425, 300 and 212 micron	70	1.70 mm and 850 micron	4	106 micron and finer	6
300/150	300, 212 and 150 micron	70	850 and 600 micron	4	75 micron and finer	4
212/106	212, 150 and 106 micron	70	850, 600 and 425 micron	10	53 micron and finer	5
150/75	150, 106 and 75 micron	70	600, 425 and 300 micron	1 2	53 micron and finer	7

(iii) Indian Standards (IS : 3339 - 1975)specifications for Silica Flour for use in Foundries (first revision)

Silica flour is a good refractory material for moulding work. It is used particularly in the steel foundry as dressing for moulds and cores and also for adding to moulding sand mixtures. Silica flour is also used to obtain elevated temperature strength, high density and resistance to metal penetration in cores. Silica flour shall be produced by crushing, washing and grading the high grade quartz and quartzite rocks or from white silica sand or other deposits sufficiently pure to get the desired material.

Chemical composition : The silica flour, when analysed, shall conform to the following requirements :

Characteristics	Requirements
Silica percent by wt., min.	98.0
Moisture percent by wt., max.	1.0

Fusion point : The fusion temperature of silica flour shall not be below 1700°C.

Grain fineness : 100% of silica flour shall pass through 150 micron I.S. sieve and at least 95% shall pass through 75 micron I.S. sieve. If required, silica flour of coarser variety may also be supplied subject to the agreement between the purchaser and the supplier.

The Institute of Indian Foundrymen has brought out guidelines for selection of base silica sand for use in ferrous castings. The details of the guidelines are given below :

SELECTION OF BASE SILICA SAND FOR DIFFERENT CASTING AND BINDER PROCESSES

1) Base Sand for Different Castings in Iron and Steel

Cast metal and size	SiO_2 content desirable	Suggested Sand sources by region			
		West	North	East	South
1) Small to medium iron castings(upto 1 ton)	90% and above	Goa,Ratnagiri, Saurashtra, Vengurla Walaval	Allahabad, Rajasthan,	Barakar (Washed), Allahabad	Chirala, Cochin, Gudur, Mangalore,Tunga bhadra.

(Contd.)

Cast metal and size	SiO_2 content desirable	Suggested Sand sources by region			
		West	North	East	South
2) Heavy iron castings	95% and above	Phondaghat, Ratnagiri, Vengurla	Allahabad, Rajasthan	Rajamahal	Cochin, Hyderabad (Quartz), Mangalore.
3) Steel castings (all sizes)	97 to 99%	Ratnagiri, Vengurla	Allahabad, Rajasthan.	Rajamahal	Cochin, Hyderabad (Quartz), Manga lore.

2) **Base Sand Depending on Binder Process**

Binder Process	Important Properties of base sand & desirable values for these properties		
1) Silicate-CO_2	AFS Clay	:	Preferably below 1%
	ADV	:	Not critical
	Grain fineness No	:	50 to 60 (AFS)
2) Shell process and hot box process	AFS Clay	:	0.5% and below
	ADV	:	Less than 3 ml
	Grain fineness No	:	55 to 70 (AFS)
	Moisture	:	below 0.5%
3) Phenolic cold set & other acid cured resin binders.	AFS Clay	:	Below 0.5%
	ADV	:	Less than 3 ml
	Grain fineness No	:	50 to 65 (AFS)
	Moisture	:	below 0.5%
4) Other moulding and core making processes (general category)	AFS Clay	:	Below 1%
	ADV	:	Not critical
	Grain fineness No	:	50 to 65

Note :The silica content required should be chosen according to the cast metal and casting size.
AFS :American Foundrymen's Society.
ADV :Acid Demand Value.
Source :Guidelines for selection of base silica sand for use in ferrous foundries : Standardisation Committee, the Institute of Indian Foundrymen, Pune, 1984.

4.5 HYDRAULIC FRACTURING

Hydraulic fracturing is a process used in oil and natural gas wells to stimulate production. A fluid with sand in suspension is pumped under high pressure into the pay zone of the well. The fluid/sand suspension serves to enlarge the existing openings/pores and also creates new voids through which the oil or gas can move more freely. The sand remains to hold the fractures open, acting as a proppant, even when the fluid is withdrawn.

For hydraulic fracturing, the sand grains should be well rounded with high degree of sphericity which will allow easy placement in the formulation and provide maximum permeability. The sand should also have a high compressive strength. It should be dry and non-agglomerated, unfractured, clean and free from contaminants like feldspar, clay and calcite. Silica sand should contain SiO_2 more than 98%, the most common size fraction being 20-40 mesh. Acid solubles should be less than 0.3%.

SUMMARY OF END USERS SPECIFICATION FOR 'PROPPING' AGENT[5]

SiO_2	98%, min.
Silt and soft particles	1%, max.
HCL solubility	0.3%, max.
Roundness (Krumbien factor)	0.6, max.
Appearance	Clean, washed and dried.

Grade	Sieve No.	Allowable % passing
20-40	18	100
	20	95, min.
	30	70, max.(50 preferred)
	40	10, max.
	45	5, max.
	50	0.5, max

4.6 FLUXES

Massive quartz, quartzite, sandstone and unconsolidated sands are the chief sources of silica. These are used as a flux in smelting base metal ores where iron and basic oxides are slagged as silicates. Silica is also used to balance the lime-silica ratio of the blast furnace mix. Free silica is the active slagging agent. The silica content should be as high as 90% with minor amounts of impurities like iron and alumina upto a max. of 1.5%. Lump silica in the size range of plus 5/16 inch to minus 1 inch is used.

Silica, as a fluxing agent in more specialised field e.g. welding flux, is used in the form of flour. For coated electrodes, the particle size must be such as to provide a sufficiently tough coating which will withstand the mechanical damage. It should also produce a pore structure for immediate drying. Generally, the particle size in electrode fluxing manufacture should not exceed 250 microns with an average of about 60 microns. The chemical specification stipulates that phosphorus and sulphur content should be nil as they cause cracking, while lead, zinc, arsenic, antimony, boron, cadmium and vanadium are also undesirable since they affect the fluiditity of the slag and reduce ductility of the weld metal.

4.7 REFRACTORY INDUSTRY (SILICA BRICK)

Quartz and quartzite are used in the manufacture of refractory silica bricks. Presently, however, these bricks are being replaced by basic linings of magnesite, dolomite or natural types such as bauxite, etc. in L.D., basic oxygen and electric furnace. Silica reacts readily with basic slag and therefore is unsuitable in the basic steel making process. Nevertheless, silica bricks continue to be used in coke-ovens, ceramic kilns, glass tank crowns and as blast furnace chequers in some steel mills. Silica bricks have excellent load resistance capacity at high temperature.

The primary requirements for the raw materials required in refractory bricks are that they should maintain the designed degree of physical and chemical identity at high temperature. They should exhibit resistance to abrasion, impact, thermal shock and a high load level. The silica sand should be free from alumino- silicates, such as felspar and mica, as they adversely affect refractoriness of the bricks. Silica rock raw material should be hard, consisting of sand grains cemented by chalcedonic silica to give a high bulk density with low porosity. Porosity can be controlled by particle size. It also determines the effectiveness of the bricks. Less porous bricks generally have 45% coarse (0.5 - 3.35 mm), 10% medium (0.18-0.5 mm) and 45% fine flour (0.18 mm) material.

To prevent expansion, the bricks are fired in batch kilns at a temperature above the conversion temperature of 1470^{o}C for long periods to attain densities of 2.3 - 2.35. For rapid conversion of quartz to cristobolite or tridymite and to reduce energy consumption, chalcedonic silica can be added.

Super-duty silica bricks produced are capable to withstand load of 50 psi at 1650°C - 1700°C. They exhibit good thermal shock reistance above 600°C and show relatively high resitance to attack by iron oxide and alkalies.

The chemical specifications for silica used in refractory bricks are :-

SiO_2	-	97% min. but preferably more than 98%
Al_2O_3	-	less than 1% but preferably less than 0.5%
Total alkalies		less than 0.2%

4.8 FERRO-SILICON

Quartz is the major source of silica in the manufacture of ferro-silicon. Occasionally, quartzite is also used. Quartz/quartzite after crushing, yields strong and competent lumps and particles in which the individual grains and crystals are sufficiently well bonded to withstand electric furnace smelting without thermal or physical decomposition or break-down above the arc reduction zone. Use of quartzite is restricted as it contains higher alumina and iron and more likely that it would break down in the furnace. Lump silica in the size range of 3/4 to 5 inches are generally preferred. A larger fraction feed also ensures the porosity of the mix.

Ferro-silicon is produced by smelting a mixture of quartz, metallic iron (generally in the form of steel scrap and turnings) and a reducing agent like coke, charcoal or wood chips.

A typical furnace charge for the production of 50% grade ferro-silicon contains 50% quartz, 25% metallic iron and 25% reducing agent. Ferro-silicon produced in six grades contain between 25% and 95% silicon.

Quartzite containing high iron is not desirable as it poses difficulty in controlling the addition of metallic iron in the feed. In addition, a high iron content silica sand usually also indicates a high alumina content which is undesirable. A typical specification of silica sand used in ferro-silicon manufacture is : 98% SiO_2, 0.2% max.,Fe_2O_3 0.4% max.,Al_2O_3 CaO and MgO each less than 0.2% and a maximum of 0.1% phosphorus. TiO_2 level of 0.002% is specified. About 1.85 tonnes of silica is required for production of 1 tonne of 75% ferro-silicon.

4.9 SILICON METAL

A high purity quartz containing about 99.8% SiO_2 without any other contaminant is used in the production of silicon metal. The production of silicon metal is similar to that for ferro- silicon except that no iron is added. The alumina and iron contents are specified to be below 0.1% each with calcium and phosphorus contents each restricted to 0.005%. Silicon metal is graded according to iron content. A higher grade silicon metal will contain around 0.1% Fe_2O_3. For production of 1 tonne of silicon metal, about 2.6 tonnes of silica is consumed.

4.10 FILLER AND EXTENDER

The finest form of silica, as silicon flour and micro-silica, is used for reinforcement as filler and extender in many industries. The particle size and the surface area of the silica are two important parameters. The silica raw material should have a high purity, averaging about 98.99% SiO_2, 0.01-1% Fe_2O_3[5].

4.10.1 Paint Industry

Silica sand powder and quartz powder are used as filler and extender in paint formulations. The addition of silica flour or tripoli (a micro-crystalline silica) in paint formulation makes the paint more resistant to chemicals because of its acid resistance. Because of its hardness, scrubbing and wear resistance of surface films are also enhanced. The addition of silica also adds to tint retention, durability and flowability of the paint.

The IS specifications (IS:67-1979) which give specifications of silica used as an extender in paint industry are as below:

Characteristics	Requirements		
	Type (1)		Type (2)
	Grade (i)	Grade (ii)	
1. Volatile matter Percent by mass (max)	0.5	0.5	0.5
2. Residue on sieve, percent by mass (max.)	0.5 on 63 micron IS sieve	0.5 on 45 micron IS sieve	0.5 on 63 micron IS sieve
3. Oil absorption	18 to 20	18 to 20	18 to 20
4. Matter soluble in water, percent by mass (max.)	0.5	0.5	0.5
5. L.O.I,Percent,max.	0.5	0.5	0.5
6. pH of aqueous	7±1	7±1	7±1

4.10.2 Rubber

Ultra-fine particle size silica is extensively used in both industrial and silicon rubber manufacture. The silica is incor porated for its reinforcement qualities (this is believed to be because of its ability to form net work structure), and as replacement for carbon black in applications which require a colour other than black. Silica offers superior adhesion, tear resistance and heat ageing property in tyre manufacture. In synthetic soling and rubber footware, silica adds abrasion resistance, stiffness and translucence to the product. Generally, silica flour containing above 98% SiO_2 and metallic contaminants less than 0.1% is preferred.

4.10.3 Plastic

In the manufacture of plastic, silica in the form of flour or tripoli is used. It imparts flexural and compressive strength to plastics. In addition, their low oil absorption, wettability and rapid dispersion allow high loading in most compounds. The addition of tripoli improves the dimensional stability and resistance to thermal shock. The excellent di-electric properties of tripoli also make it suitable for plastics used to encapsulate electronic components.

TYPICAL ANALYSIS OF TRIPOLI (SOUTHERN ILLINOIS)

Chemical		Percent	Physical	
SiO_2	:	99.5+0.5	Specific gravity	2.65
Fe_2O_3	:	0.025	Bulking value (gal/ 100 lbs)	4.531
Al_2O_3	:	0.009	Refractive index	1.5-1.55
TiO_2	:	0.005	Specific resistance (Ohms)	25,700
CaO	:	0.15	GE brightness (%)	84-91
			Ph	7
			Melting point (°C)	1,722

4.11 CEMENT[5]

The addition of flour in asbestos cement mixes is designed to adjust the lime : silica ratio of the cement to ensure optimum curing. During autoclaving, the silica and cement react to form a semi-crystalline silicate hydrate. The optimum ratio used for this application is 5 parts cement and 3 parts silica. The important specifications for silica are reasonably high silica content, particle size and a compatable surface area. The other impurities that need to be avoided are high soluble alkalis which can promote a false early set, while iron, chromium and nickel cause staining.

Micro-silica, a silica spheres, is obtained as a primary product from silica sand in the manufacture of silicon and ferro-silicon. Micro-silica offers a number of beneficial effects to concrete mixes. The major beneficial effects which micro-silica can offer include : total supression of alkali silica reaction, reduction of permeability, sulphate resistance, reduced chloride-ion penetration from 50% to 100%, corrosion inhibition, reduced carbonation, greatly improved freeze-thaw durability, improved workability and pumpability, increased chemical and abrasion resistance and increased compressive flexural and tensile strengths.

4.12 POLYMER APPLICATION

Micro-silica particles function as effective reinforcing fillers in many polymer products. It serves to improve their impact resistance and stiffness. Special micro-silica products with suitable chemical additives are also produced which contribute to a smoother production process and increased productivity.

4.13 GRINDING AND ABRASION

Quartz silica is widely used in grinding and abrasive industries. It has a hardness of 7 in Moh's scale and conchoidal fracture when broken. Generally, the angular particle shape with sharp cutting edge and purity are the essential requirements of the industry. In marble cutting, average particle size requirement is 0.19 - 0.7 mm. Silica sand is also used as an abrasive grit in sand blasting and sand paper. Silica flour is used as an abrasive agent in soap and scouring pads. Some of Tripoli sands are used in buffing and polishing compounds, scouring abrasives and tooth polishes because individual grains lack sharp edges.

4.14 LININGS

Crystalline silica stones having silica content more than 96% are used as linings for ball and pebble mills. The degrees of interlocking of crystals and crystal size are major factors which govern the use of the rock. The various materials used in these industries are chert which consists of extremely fine-grained and tough chalcedonic silica. Quartzite, free from contaminating materials such as mica can also be used. Silica is a natural selection for lining and packing for acid towers.

4.15 WATER FILTRATION

Sand and gravel are usually used as filter media for filtration of water. The Indian Standard Specifications (IS: 8419-1977) for filter sand and gravel sand used in the filtration of water are as follows :

Effective size : The particle diameter shall correspond to 10% finer on the grain size curve. The uniformity co-efficient ratio shall be D60/D10 where D60 is the particle diameter corresponding to 60% finer on the grain size curve andD10 is the particle diameter corresponding to 10% finer on the grain size curve.

(i) Filter sand : Rounded grains are preferable to angular ones for removal of turbidity. It shall consist of hard and durable grains of silica sand and shall have a specific gravity not less than 2.5. All grains of sand shall preferably be water worn. The minimum SiO_2 content in sand shall be 90% and impurities like clay, loam, silt, etc.shall not exceed more than 5% by volume. The acid soluble matter in sand shall not be more than 5% and the loss of ignition shall not exceed 0.7%.

(ii) Filter gravel : It shall consist of hard and preferably rounded stones with an average specific gravity of not lessthan 2.5. It shall be free from clay, sand, loam and organic impurities of any kind. The gravel shall contain not more than 2% by mass of thin, flat or elongated pieces determined by hand picking. The acid solubility for gravel sizes 10mm or larger should not exceed 10% and for sizes smaller than 10 mm, it should be less than 5%. Gravel should be free from excessive amount of limestone or shells.

4.16 ACTUAL USER'S SPECIFICATIONS IN INDIA

The specifications adopted by the different acutal user industries in India are given in the following table :-

ACTUAL USER'S SPECIFICATIONS IN INDIA

Specifications Of Silica Minerals Consumed in Different Industries

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
A) GLASS INDUSTRY									
1.	Alembic Glass Industries Ltd.	Baroda Gujarat	Silica sand, quartz	Glass & Glassware	-30 +80 -30 +80	96.7 99.6	2.50 0.22	0.10 0.04	- -
2.	Travancore Ogale Glass Manufacturing Co. Ltd.	Kalamserry, Distt. Ernakulam, Kerala	-	Glass & glassware	-40 +60	99	-	-	-
3.	Excell Glass Limited	Alleppey, Kerala	Silica sand	Glassware	-30 +80	99	-	0.01 (max.)	Colour-Pure white
4.	Paliwal Glass Works	Shikohabad, Distt. Mainpu,r Uttar Pradesh	Silica sand	Glassware	Retained on I.S. Sieves on 600 micron passing through 125 micron I.S. sieve	98.5	-	0.04 to 0.07	TiO_2-0.1% (max.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
5.	Associated Glass Industries Ltd.	Kukatpally Ranga Reddy, Andhra Pradesh	Quartz sand	Glass bottles	-20 +100	99.0	0.97	0.063	Colour-white
6.	Krishna Silicate and Glass Works Limited.	Jadhavpur & Burnpur, West Bengal	Silica sand	Glass bottles	-30 +80	96.5	0.2	0.06	TiO_2-0.1%
7.	Vitrum Glass Co. Ltd.	Bombay, Maharashtra	Silica sand	Amber glass bottles	-30 +80	98.5	1.0	0.15	-
8.	Bharat Glass Works	Bombay, Maharashtra	Silica sand	White bottles	-	98 to 99.5	0.07	0.3 to 0.7	-
9.	Hindustan National Glass Industries Limited.	Bahadurgarh, Distt. Rohtak, Haryana	Silica sand	Glass bottles & tumblers	-30 +80	98.5	0.1 (max.)	0.05 (max.)	-
10.	Apar Private Ltd.	Nadiad, Distt. Kheda, Gujarat	Silica sand	Glass shells, tubes.	-100 mesh	99	0.96	0.4	-
11.	Borosil Glass Works Ltd.	Bombay, Maharashtra	Silica Sand	Laboratory ware	-50 +150	-	0.03	0.03	150 mesh 3% (Max)
12.	Chetan Gentha & Co. Ltd.	Mathura, Distt. Faridabad Haryana	Silica sand, Quartz	Automobile, lenses	-30 +80	99.8	-	0.03	Cr_2O_3:0.004%

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
13.	F.G.P. Ltd.	Naupada, Thane, Maharashtra	Silica sand & fine silica	Glass wool staple tissue	-30 +80 Quartz Powder: 300	99.0	-	0.5	TiO_2 :0.5%
14.	Hindustan vacuum Glass Ltd.	Faridabad, Haryana	Silica sand	Vacuum flasks	-30 +80	98	-	0.06 (max.)	-
15.	Hindusthan Pilkington Glass Works Ltd.	Asansol, Distt. Burdwan, West Bengal	Silica sand	Sheet glass	- 98.5	0.9	0.06	-	-
16.	Shree Vallabh Glass Works Ltd.	Anand, Kaira Gujarat	Silica sand, Quartz	Sheet glass, figured glass, processed glass	-30 mesh	98.0	1.00	0.08	Colour-white, Moisture:4%
17.	Shree Vallabh Glass Ltd.	Baiser, Distt. Thane, Maharashtra	Quartz/ Silica sand	Sheet glass	-30 +80	99	0.51	-	-
18.	Vazir Glass Works Ltd.	Bombay, Maharashtra.	Quartz/ Silica sand	Glass Containers	-30 +80 -50 +100	98.5	-	0.05	-
19.	Haldyn Glass Works Limited	Bombay Maharashtra	Silica sand Quartz	-	-30 +80 mesh	99.8	0.05 (max.)	0.03 (max.)	-

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
B) FOUNDRY INDUSTRY									
1.	A.C.C. Babcock Limited.	Shahabad, Distt.Hyderabad Andhra Pradesh	Silica sand Quartz	G.I. Castings Iron alloys	-	80 to 98	2 (max)	-	CaO:4%(max.)
2.	Bhartia Electric & Steel Co.Ltd.	Calcutta, West Bengal.	Silica sand	Castings	8 to 10:Nil 16 to 30:10-15% 40 to 100:70% 150:6%	96	-	-	-
3.	Binny Ltd.	Meenambakkam, Distt. Chingle-put, T.N.	Silica sand	G.I. castings	AFS Fineness 40 to 60	92	-	-	Moisture : 5% (max.), LOI:1% (max.) AFS Clay : 1%
4.	Burn Standard Co. Ltd.	Howrah, West Bengal	Silica sand	-	AFS fineness	96.8	2.5	-	-
5.	Etex Super Castings Ltd.	Gudalur, Distt.Coim-batore, T.N.	Silica sand	Malleable castings	AFS Fineness : 60	98	-	-	Clay:0.5%(max.)

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
6.	Ennore Foundries Ltd.	Ennore, Distt. Madras Tamil Nadu	Silica sand	G.I. & Aluminium castings	B.S.S. Mesh +44:10% -44+72: 50 to 70% -72+150: 15 to 40% & -150 : 5%	95	-	-	CaO+MgO: 1.5% (max.)
7.	Howrah Iron & Steel Works Ltd.	Howrah West Bengal	Silica sand moulding sand	-	60to80	94 to 97	2.0 max.	-	-
					40 to 50	70 to 80	5.0 max.	-	-
8.	IISCO Stanton Pipes & Foundry	Ujjain, Madhya Pradesh	Silica sand	C.I. pipe	-30:10% -30+44:30% -44+60:30% -60+100:20% -100:10%	94-96	0.5 max.	-	CaO+MgO 0.5% (max.) Na_2O+K_2O:1% (max.).
9.	Mysore Kirloskar Ltd.	Harihar, Distt. Chitradurga, Karnataka	Silica sand	C.I. & SGI castings	ASTM Mesh % 50 - Nil 70 - 20 100 - 50 to 54 140 - 20 to 25 Fines - 5	98.0 min.	1.5	-	CaO+MgO 0.5%
10.	Shah Malleable Castings Ltd.	Chitalasar, Distt.Thane, Maharashtra	Silica sand	Malleable & G.I. Castings	AFS Fineness 50-70	96 to 98.5	-	-	Shape-Round to Sub-angular

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
11.	Tata Engineering and Locomotive Co. Limited.	Jamshedpur Distt. Singhbhum	Silica sand Quartzite	Automotive castings	-	97 (min.)	-	-	Colour-Pale Yellow. Free from any contamination. Clay:3%(max.) OAFS Clay content 0.2%
12.	Tata Engineering and Locomotive Co. Ltd.	Pune Maharashtra	Silica sand	Automotive castings	AFS Fines 48 - 52 68 -72	98 (min.)	1	Traces	Shape-rounded to Sub-angular Free from quartzite etc. R_2O_3:1%(max.)
13.	The Indian Hume Pipe Co.Ltd.	Bombay, Maharashtra	Quartzite	Arc welding	-	98 to 99	-	0.5 (max.)	-
C)	**FERRO-SILICON INDUSTRY**								
1.	Industrial Development Corpn. of Orissa Ltd.	Cuttack, Orissa.	Quartzite	Silico-chrome low & high carbon ferro-chrome	75 to 125 mm	96	-	-	-
2.	Tata Engineering & Locomotive Co.	Keonjhar Orissa	Quartzite	-	1.5 to 2.5 cm	97 - 98	1	-	-

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
3.	Visvesvaraya Iron & Steel Ltd.	Bhadravati Distt. Shimoga Karnataka	Quartz, sea sand,coarse sand, fine sand	Ferro-silico-manganese silico-chrome	70 - 120mm	98 quartz	0.5-0.6	1-1.2	
						98 sea sand	-	-	
						90-95 Coarse sand	1-2	1-1.5	CaO:1- 1.5% MgO:0.5-1.00%
						80-85 fine sand	8-10	1.5-3	CaO:1-2% MgO:1-1.5%
D) REFRACTORY INDUSTRY									
1.	Allied Refractories Pvt.Ltd.	Amaghata Distt. Dhanbad, Bihar.	Quartzite	Silica refractories	-	98.5	0.6	0.6	-
2.	Associated Cement Co. Ltd.	Katni, Distt. Jabalpur Madhya Pradesh	Quartz	-	-	95	-	0.5	-
3.	Bharat Refractories Ltd.	Marauda, Distt.Durg Madhya Pradesh	Quartzite	Silica refractories	-	97.5 (min.)	1 (max.)	1 (max.)	Shape-Crypto-crystalline, Free from Ferruginous impurities.

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
4.	Bharat Refractories Ltd.	Bhandaridah Distt.Giridih Bihar	Silica sand	Mortar & & fire clay bricks	-30 +70	97	-	-	Refractoriness PCE : 32
5.	Burn Standard Co.	Jabalpur Madhya Pradesh	Silica sand	-	16-20		95	-	- -
6.	Kumardhubi Fireclay & Silica Works	Kumardhubi Distt.Dhanbad Bihar	Silica sand Quartzite	Fire, silica & aluminium silica bricks	-	99.5	1	-	Refractoriness Orton cone, PCE-Not less than 32.5
7.	Orissa Industries Limited.	i) Laticata, Distt. Sundergarh, Orissa ii) Barang, Distt.Cuttack, Orissa.	Quartzite	Fireclay and high aluminium silica bricks.	-	96-97	0.2	0.2	LOI : 8%
8.	Tata Iron & Steel Co.Ltd.	Jamshedpur, Distt.Singhbhum, Bihar	Quartzite Silica Sand	Silico-morter	Quartzite : 3 mm Silica:2mm sand	96	-	-	Alkalies : 2%
E) CEMENT INDUSTRY									
1.	Cement Corpn. of India Ltd.	Rajban Distt.Sirmur, Himachal Pradesh	Sandstone	Portland cement	-	75-82	7-9	3-5	CaO : 2-4% MgO : 0.7%

(Contd.)

Sl. No.	Name of Consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufac-tured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
2.	Tamil Nadu Cement Corpn.	Ariyalur Distt. Trichy Tamil Nadu	Sand	Portland Cement	-	64.48	3.56	2.40	BD:1.2, CaO : 14.3% MgO : 1.2% LOI : 13.06%
3.	The Travancore Cements Ltd.	Nattakom, Distt. Kottayam Kerala	Silica sand	White Cement	-	98	-	0.1	-
F. CERAMICS INDUSTRY									
1.	Bharat Heavy Electricals Ltd.	Bangalore Karnataka	Silica sand, quartz	Insulators	-	99	-	0.1	-
2.	Dalmia Ceramic Industries Ltd.	Dalmia-puram, Distt. Trichy Tamil Nadu	River sand	Stoneware pipes	20 to 150 mesh	80-85	-	-	Colour-Light brown, Impuri-ties:15- 20%
3.	Hindustan Potte-ries	Lilloh, Distt. Howrah West Bengal	Quartz	Porcelain goods	100 to 350 in liquid ship	99	-	-	TiO_2:2 to 3% Other impuri-ties 0.7%
4.	H & R Jhonson (India) Ltd.	Bangalore, Karnataka	Quartz	-	-200 mesh	Quartz: 97 Silica sand: 99.5	-	0.5 (max.)	–

Sl. No.	Name of Consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
5.	W.S.Insulators of India Ltd.	Porur Distt. Chingleput, Tamil Nadu	Quartz	Insulators Lighting assess	Lumpy	99.5	1	0.05	Colour:White
G)ASBESTOS INDUSTRY									
1.	Shree Digvijay Cement Company Limited	Digvijayanagar Distt.Ahmedabad Gujarat	Silica Shells	A.C.Pipes & Sheets	Fine powder	97.5	-	0.8	Colour : colourless. Insoluble in water LOI : 0.5-1.2% CaO:1.5%
H)ABRASIVE INDUSTRY									
1.	Abrasive Industry	Mora Distt.Raigad, Maharashtra	-	Grinding wheels	-	99	-	-	-
2.	Carborundum Universal Ltd.	Tiruvottiyur	Quartz	Bonded Abrasive	Retention in 240	80	-	-	-
3.	Grindwell Norton Limited	Bangalore, Karnataka	Quartz	Silicon carbide grains	4"Lumps	99.5	0.04 (max)	0.1 (max)	-
4.	Grindwell Norton Limited	Karakambadi Distt.Chittor Andhra Pradesh	Quartz	Silicon Carbide grains	100 to 150mm	99 - 99.75	-	0.05 (max)	Free from surface impurities CaO:0.10%

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
5.	Regmal Mills Ltd. The Straw board Mfg.Co.Ltd.	Ambala Road Distt. Saharanpur, U.P.	Quartz	Flint Paper coated abrasive	-	99.5	-	Nil	-
I.	**IRON & STEEL INDUSTRY**								
1.	Bhilai Steel Plant	Bhilai Distt., Durg, Madhya Pradesh	Silica sand, Quartzite	-	50 to 80 mm	92	2.0	-	Refractoriness: 17°C. Alkalies:0.5% (max.)
2.	Bokaro Steel Plant	Bokaro, Distt. Dhanbad,	Quartzite	Pig iron ingot steel	600, 425, 300	96-98	0.5 (max.)	1.5 (max.)	Shape-Rounded grain Moisture:1.5%
3.	Durgapur Steel Plant	Durgapur, Distt. Burdwan, West Bengal.	Banded hematite quartzite	-	50 to 125	35	1 (max.)	-	Fe : 35%:1% (max)
4.	The Tata Iron and Steel Ltd.	Jamshedpur Distt. Singhbhum Bihar	Quartzite	Pig iron	-	94 to 96.50	0.5 to	- 1.2	-
5.	Visvesvaraya Iron and Steel Ltd.	Bhadravati Distt.Shimoga, Karnataka	Quartz	Pig Iron	10 to 15 mm	98	0.5 to 0.6	1 to 1.2	-

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
J) CHEMICAL INDUSTRY									
1.	Mineral and Chemical Products	Kendposi Distt. Singhbhum, Bihar.	Silica sand	Ultramarine blue	-	99	-	-	Free from iron
K) INSECTICIDE INDUSTRY									
1.	Rallies India Ltd.	Thana Maharashtra	Silica sand (granular)	-	16 to 30	90	-	-	-
L) ELECTRODE INDUSTRY									
1.	Graphite India Limited	White field, Distt.Bangalore Karnataka	Silica sand	Welding electrode	14 mesh 5% (max) 35 mesh : 90% (min.) 350 mesh:30% (max.).	95	-	-	Moisture : 2% (max.)
2.	Indian Oxygen Ltd.	Kardah, 24 Parganas West Bengal	Quartz	Vortile ferroweld	B.S: 60 mesh:Nil 120 mesh: 10% (max.) 200 mesh: 30% (max.)	97	-	-	Moisture : 2% (max.)

(Contd.)

Sl. No.	Name of consumer	Location Village/ District/ State	Name of Silica Mineral Consumed	Name of Product Manufactured	SPECIFICATIONS PHYSICAL Size	CHEMICAL (%) SiO_2	Al_2O_3	Fe_2O_3	REMARKS
	M) RUBBER INDUSTRY								
1.	Apollo Tyres Ltd.	Trichur, Kerala	Silica powder	-	325 mesh	87	-	-	-
2.	Inarco Ltd.	Bombay Maharashtra	Silica	Rubber	-	98	-	-	Sp.Gr.:1 to 2
3.	Synthetics and Chemicals Ltd.	Fatehganj, Distt. Rai Bareli, Uttar Pradesh.	Quartz chips	Synthetic rubber	1/4" to 3/4"	99	-	-	Metallic impurities:1% (max.)

Chapter - 5*

MINING AND PRODUCTION

5.1 INTRODUCTION

The deposits of silica sand and quartz in India are widespread and extensive. Haryana is the leading producer of silica sand followed by Rajasthan, Uttar Pradesh, Maharashtra, Karnataka and Gujarat. Other producing states are Andhra Pradesh, Bihar, Kerala, Madhya Pradesh and Tamil Nadu. Andhra Pradesh is the leading producer of quartz followed by Karnataka, Rajasthan, Maharashtra and Tamil Nadu, the other producing states are Bihar, Gujarat, Haryana and Madhya Pradesh.

5.2 LEASE AREA, MINES AND PRODUCTION[1]

Total leasehold area held in the country for silica sand is 41,126 Ha and 24,764 Ha for quartz. The total all-India production for silica sand in 1990-91 was 1.318 million tonnes from 264 mines and 2.32 million tonnes in 1991-92 from 252 mines. For quartz the corresponding figures are about 0.2 million tonnes from 204 mines in 1990-91 and about 0.16 million tonnes from 170 mines in 1991-92. For statewise break-up production during 1990- 91 and 1991-92, refer Table 5.1.

5.1 Statewise Production of Silica Sand Quartz and Quartzite During 1990-91 & 1991-92

Mineral/State	1990-91		1991-92	
	Production (Quantity) (tonnes)	No.of working mines	Production (Quantity) (tonnes)	No.of working mines
SILICA SAND				
India	**1317631**	**264**	**23242285**	**252**
Andhra Pradesh	80946	18	90450	22
Bihar	79815	2	69246	2

(Contd.)

* Reference Nos 1 to 4 cited under this chapter are listed on page 84.

Table - 5.1 (Concld.)

Mineral/State	1990-91 Production (Quantity) (tonnes)	1990-91 No.of working mines	1991-92 Production (Quantity) (tonnes)	1991-92 No.of working mines
Gujarat	82264	50	124965	45
Haryana	352156	10	1260358	9
Karnataka	119113	36	132083	35
Kerala	68968	17	85941	17
Madhya Pradesh	4904	4	5987	3
Maharashtra	208069	34	244628	32
Rajasthan	191539	61	220452	58
Tamil Nadu	150	1	5324	2
Uttar Pradesh	129698	31	84851	27
QUARTZ				
India	**212218**	**204**	**164473**	**170**
Andhra Pradesh	68380	49	61108	43
Bihar	3461	7	1156	3
Gujarat	3694	6	3439	6
Haryana	127	3	-	-
Karnataka	70150	5	43878	6
Maharashtra	5724	4	5269	3
Rajasthan	51061	112	40617	95
Tamil Nadu	9621	18	9006	14
QUARTZITE				
India	**86603**	**27**	**89661**	**21**
Bihar	22040	6	12920	5
Madhya Pradesh	35454	5	42523	4
Orissa	23490	15	24490	11
Rajasthan	5619	1	9728	1

5.3 MINING METHOD

5.3.1 Silica Sand

Most of the silica sand deposits are worked manually by opencast method using hand tools like pickaxes, crow-bars, hammers and shovels.

Drilling and blasting is carried out, only when hard formation is encountered. While very few mines are semi-mechanised, one mine in Rajasthan has deployed heavy mining machinery for removal of overburden and ore.

The method of mining in some of the important mines in the leading states of Haryana & Rajasthan is given here, which may be considered as representative for the whole country.

HARYANA[2]

In Haryana there are three silica sand mines producing more than one lakh tonnes/year. Description of some of the mines is given below :

(i) Gothra Mohabatabad Silica Sand Mine

This is the largest producing mine in India. Production of silica sand in 1990-91 was 3,39,310 tonnes and the total production including ordinary sand was 9,79,330 tonnes. A number of pits have been opened in the lease area. Out of these only 5 pits are working. The length of the pits varies from 80 to 100 m, width 50 to 100 m, and depth 15 to 30 m. In the lease area the yellow and white silica sand is overladen by red/ordinary sand 5 m thick, morrum 3 m thick and Top soil 3 m thick, respectively. Silica sand is mined manually with crow-bars and spades. The height of the benches is 3 - 4 m. The silica sand is transported on mules from pit bottom to surface and then loaded into trucks and despatched to the consuming units. Recently the lessee has started using hydraulic excavators for removal of overburden.

(ii) Pali Silica Sand Mine of M/s P.K. Sethi, Dist. Faridabad, Haryana

It is a labour-intensive opencast mine. The production in 1990- 91 was 1,64,970 tonnes inclusive of ordinary sand (see Table 5.2) with average daily employment of 325.

As many as 30 pits have been developed in the area, depth of pits varying from 8m to 10m. The dimensions of one working pit are, length 50 m, width about

20 m and depth 15 m. Drilling and blasting are carried out wherever required in quartzite patches, both in overburden and silica sand zones. For drilling of holes, Jackhammer drills are used. The sand produced is usable as it is; no treatment is required. Sand to overburden ratio is 6.7:1.

(iii) Pali Silica Sand Mine of M/s Goodwill Mineral Corporation Dist. Faridabad, Haryana

The production from the mine in 1990-91 was 9,33,020 tonnes inclusive of ordinary sand with average daily labour employment of 244. Overburden is removed by two hydraulic backhoes. The silica sand and ordinary sand is excavated manually so that they do not get mixed with overburden. The bench height is around 1.5 m. At present, silica sand from the mine is transported on mules to the stacking yard. To dispense with mule transportation, in the statutory 'mining plan', the management has proposed the construction of a haul road 6 m wide at 1 in 16 gradient and accordingly the work has been in progress. The r.o.m. sand is marketed without any further processing. There is no sub-grade mineral. It is planned to work the deposit to further depth till the mineral to overburden ratio reaches 4.5:1.

(iv) Pali Silica Sand Mine (Plot No.1) of M/s Sahi Ram Dist.Faridabad, Haryana

The mine produces both silica sand and ordinary sand, the total production during 1990-91 being 4,60,980 tonnes with average daily labour employment of about 117. The deposit is worked manually using crowbars, spades, etc. A number of pits have been opened up in the area. The length of the pits varies from 35 to 100 m, width from 15 to 50 m and depth from 10 to 35 m. The pits are not benched properly.

(v) Badkhal Silica Sand Mine - Dist.Faridabad, Haryana

Production of silica sand in 1990-91 was 1,89,563 tonnes with average daily labour employment of 310. It is a labour-intensive mine. Mining is carried out manually. The thickness of the overburden varies from 2 to 4 m. Overburden comprising alluvium soil is scraped manually. The small quartzite boulders in over burden are broken with the help of hammers. In case of big boulders drilling and blasting is done for breaking them to convenient size for handling and removal. The sand is excavated manually and transported on mules from the pit-bottom to the pit top. From pit-top, the sand is loaded into trucks and transported to the consuming centres. The r.o.m. sand is marketable as it requires no treatment.

RAJASTHAN[3]

(i) Barodia Silica Sand Mine,
Dist Bundi, Rajasthan

It is a mechanised opencast mine. The production in 1990-91 was 28,516 tonnes, with average daily labour of 110. The mine does not produce any ordinary sand.

The rock formation in the area consists of : (i) top portion of 30-40 m of hard quartzite, (ii) intermediate portion of 10 m of semi-altered quartzite, and (iii) bottom portion of white silica sand. For removing the overburden, i.e quartzite, deep hole drilling is done. Both burden and spacing of holes are kept at 3 m. Blast holes of 11 m. depth and 100 mm. dia are drilled with Halco down-the-hole drill. While drilling in the intermediate zone of semi-altered quartzite, the burden and spacing of holes are kept at 4 m., depth of holes being 11 m. In silica sand zone, drilling with jack hammer is carried out. The deep holes in OB are charged with ANFO explosive and spl. gelatine and blasted with Cordex detonating fuse with ordinary detonators. In silica sand zone, the holes are charged with 80% spl. gelatine and blasted. The waste is dumped in the area earmarked for it. The reddish silica sand occurring in the intermediate zone and the white silica sand in the bottom zone are stacked separately near the beneficiation plant for treatment.

While the overburden is loaded with a Pocklain shovel (0.9 m^3) capacity into dumpers (8 tonnes) for transporting to the dumping place, the silica sand is transported in mini-trucks of 3.5 tonnes capacity. Two benches have been developed in the overburden with height and width of 8 m each. In silica sand zone, 3 benches have been formed, with height and width of 4 m each. The mine has deployed the following equipment.

1. Shovel (Pocklain) 0.9 cu.m.	...	1
2. Dumpers-8 tonne	...	4
3. Mini-trucks 3.5 tonne	...	3
4. Compressor (diesel)		
Broomwade 110 cft	...	1
Khosla 400 cft	...	1
5. Halco		
Down-the-hole drill (100 mm dia)	...	1
6. Jack hammers	...	3
7. Electric pumps 10.5 H.P.	...	5

(ii) Jhir Silica Sand Mine,
Dist. Jaipur Rajasthan

It is a semi-mechanised opencast mine, production during 1990-91 being 29,233 tonnes with average daily employment of 44. The silica sand in this area is overlain by a 2 m layer of alluvium and quartzite followed by another layer of 9 - 12 m unweathered quartzite. Till 1989-90, mining was being carried out manually. From 1990-91, excavators have been deployed for removal of hard overburden. However, the layer of top soil mixed with quartzite being friable and soft, it is still excavated manually with simple hand tools.

The lower layer of overburden i.e. unweathered quartzite being hard and compact, it is removed by drilling and blasting and loaded by excavators as well as manually into trucks. After removing the overburden, the loose silica sand, is excavated manually. The loading is however done manually and also by mechanised loader. Both the overburden and silica sand are loaded into tractor trailors for transporting to waste dumps or to treatment site, as the case may be. Five pits have been opened up, but ther major production is from pit 2 & pit 3 only, as discussed below.

Pit No.2 : The dimensions of the pit are 205 m x 67 m x 16 m. There are in all 16 benches. The top bench is at 470 mRL and bottom bench at 356 mRL. The pit slope is less than 45^{o}. The bench height varies from 2.5 m to 10 m. While the friable and loose silica sand benches collapse during summer, due to wind the overburden benches are stable and safe.

Pit No.3 : The dimensions of the pit are 120 m x 90 m x 35 m. Three benches have been developed. The RL of top and bottom benches are 435 m and 400 m respectively and the slope of the pit is about 45^{o}. The silica sand is hard and stable.

To improve the mine environment, a Plantation Programme has been taken up in the lease area. After crushing and screening, the silica sand mined is directly saleable. About 15% of the production comprising poor grade stone and +14 mesh material however, goes to waste.

(iii) Girota Silica Sand Mine,
Dist. Jaipur, Rajasthan.

The deposit is worked manually by opencast method. The production during 1990-91 was 10,984 tonnes with average daily labour of 31. Two pits, No.1 & 2, are being worked. In pit No.1, benches have been formed in overburden and silica sand. Overburden and interburden comprise quartzite, unweathered boulders of quartzite and sandstone. It is excavated by simple hand tools. Drilling and blasting is carried out when hard formation is encountered. Holes are drilled with jack hammer to a depth of 0.75 to 1.5m. The holes are charged with ANFO and 80% spl gelatine and blasted with ordinary detonators and safety fuse. Overburden is loaded manually into camel carts and dumped on the eastern side of the mine on the slope of the hillock. The dumps have been secured by stone walls.

Silica sand is also mined manually. Loose silica sand is screened directly through 16 mesh sieves. The hard lumps of silica sand are however, crushed in a 16 HP disintegrator before screening through 16 mesh sieves. The -16 mesh silica sand is stacked separately and despatched to the consuming industries. The over size (+16 mesh material) is also stacked separately. It is reported that semi-weathered quartzite boulders comprising about 15% of ROM ore are found in silica sand zone. Although these boulders may yield silica sand by grinding in a disintegrator, at this mine these are not sorted out. Instead, it is treated as waste.

(iv) Nimora Silica Sand Mine,
Dist.Jaipur, Rajasthan

The deposit is worked manually by opencast method. The production in 1990-91 was 10,793 tonnes with average daily employment of 22. The silica sand deposit in the area is massive and occurs over a considerable length on the hill. The overburden consists of alluvium and unweathered quartzite boulders, varying in thickness upto 8 m.

In overburden as well as in silica zone simple tools like pick- axe, crowbar, etc., are used for removing soft and fractured zones, whereas in hard formation, Jack hammer drilling is done. The holes are charged with spl. gelatine or ANFO and blasted with ordinary detonators and safety fuse.

Loading of overburden and mineral is done manually into truck and tractor trolley for transporting to the dump yard or to the crushing yard as the case may be. The mineral is crushed and screened through 16 mesh screens. The -16 mesh product is despatched to the consuming industry by trucks. The +16 mesh material is further crushed and screened. About 10% of the ROM ore comprising hard uncrushed material forms the reject. There are two operating pits which are described below :

Pit No.1 : It is the main producing pit. The size of the pit is about 190 m x 80 m x 20 to 50 m in depth. Four benches have been developed in the pit, height of the bench varying from 3m to 10 m in both overburden and silica sand. The width of the working benches varies from 5 to 8 m.

Pit No.2 : It is located at a distance of 400 m SW of pit No.1. The size of the pit is 70 m x 30 m x 20 m (depth along slope).

The silica sand from pit No.1 is white and massive. It is marketed after crushing and screening to -16 mesh. But in case of pit No.2, silica sand is fine-grained and contaminated with clay. It is not marketable, as such. It is blended with the silica sand of pit No.1 in the ratio of 1:3 and marketed.

Table 5.2 : Mine-wise Production of Silica Sand(1990-91) from Important Mines[1,2]

State District	Name of the mine	Production of Silica sand (tonnes)	Production inclusive of ordinary sand (tonnes)
HARYANA			
Faridabad	Pali (P.K.Sethi)	9,980	1,64,970
"	Pali (Good will Mineral Corporation)	1,33,900	9,33,020
"	Pali (Plot No.1, Sahi Ram)	82,960	4,60,980
"	Manger(Plot No.10)	64,991	2,58,805
"	Badkhal	1,89,563	4,62,867
"	Anangpur (Mohan Ram)	51,010	1,46,307
"	Manger (Plot No.9, Shri Rattan)	2,740	1,81,094
"	Gothra Mohabatabad	3,39,310	9,79,330
"	Pali Somprakash Sethi	25,310	73,035
"	Manger (Plot No.4) (Om Prakash)	87,020	3,15,261
"	Anangpur (Som Prakash Sethi)	45,180	1,23,365
"	Manger (Haryana Minerals Ltd.)	2,284	2,28,064

(Contd.)

Table - 5.2 (Contd.)

State District	Name of the mine	Production of Silica sand (tonnes)	Production inclusive of ordinary sand (tonnes
RAJASTHAN			
Jaipur	Jhir		29,233
"	Nimora		10,793
"	Girota		10,984
Bundi	Barodia		28,516
Sawaimadhopur	Manjhora- I		11,097
BIHAR			
Sahebganj	Mangalhat		45,717
"	Raibazar		23,850
ANDHRA PRADESH			
Nellore	Momidi		18,570
"	Southern		16,510
"	Vengamamba		15,270
KARNATAKA			
Dakshin Kannad	M.L. 1872		25,585
"	Kumbashi		18,670
"	Tekkattee		13,070
KERALA			
Alleppey	Kumpail		13,038
"	Geepee		12,024
MAHARASHTRA			
Sindhudurg	Shiroda Arvali		40,069
"	Pondaghat (MMC)		15,075
"	Pondaghat (A. R. Patwardhan)		14,614
"	Ubhadanda		14,211

(Contd.)

Table -5.2 (Concld.)

State District	Name of the mine	Production of Silica sand (tonnes)	Production inclusive of ordinary sand (tonnes)
MAHARASHTRA (Concld)			
Sindhudurg	Gogte		12,923
"	Aravali (No.3)		10,481
UTTAR PRADESH			
Allahabad	Janwan		28,416
"	Kothai		10,192
GUJARAT			
Rajkot	Hasanpur		14,330

5.3.2 Quartz

Quartz deposits are worked manually by simple opencast method, by making pits in the area using pickaxes, crowbars, hammers and chisels. Drilling and blasting is carried out when hard formation in OB or mineral is encountered. A list of important quartz and quartzite mines of the country is given below.(Table 5.3 and 5.4)[1].

Table 5.3 : Mine-wise Production of Quartz from Important Mines in 1990-91

State District	Name of the mine	Production (Quantity in tonnes)
ANDHRA PRADESH		
Nalgonda	Agraharaka charim	11,840
Prakasham	Chandulurm	7,000
Medak	Andde	6,673
Ranga Raddy	Pohampalli	4,700
"	Bachapalli	4,700

(Contd.)

Table - 5.3 (Concld)

State District	Name of the mine	Production in tonnes
ANDHRA PRADESH (Concld.)		
Medak	R.Mallepalli	3,392
Ranga Raddy	Hydernagar	3,898
"	Hafeezpeth	2,580
"	Kothwalaguda	2,400
KARNATAKA		
Shimoga	Bilikalbetta	32,578
Bellary	Yemanahalli	14,617
"	Hemavanahalli	10,149
MAHARASHTRA		
Bhandara	Jogiwada	2,807
TAMIL NADU		
Salem	Thindamargalorm	2,718
Tiruchira-ppalli	Pungambody	2,260
RAJASTHAN		
Ajmer	Banboria	3,042
"	Dholpura	2,961
"	Uarkhura	2,811

Table 5.4 : Mine-wise production of quartzite from important mines in 1990-91

State District	Name of the mine	Production in tonnes
BIHAR		
Singhbhum	Daraimach	12,810
Munger	Baisa	5,400

(Contd.)

Table - 5.4 (Concld.)

State District	Name of the mine	Production in tonnes
BIHAR (Concld.)		
Munger	Pattam	2,640
"	Mirzapur-Bardha	1,020
MADHYA PRADESH		
Durg	Donitolu	12,747
Raigarh	Urdana-Rampura	12,600
"	Chirapani	6,803
Durg	Kalkera	1,746
ORISSA		
Mayurbhanj	Kuldiha	14,809
Sundargarh	Gobira	2,480
Kalahandi	Kadolibhal	1,803
Bolangir	Naupara I	1,531
RAJASTHAN		
Sawai- madhopur	Bagdolikalan	5,619

5.4 SILICA SAND IN COASTAL BELTS

5.4.1 Mining

1. DAKSHIN KANNAD DISTRICT - KARNATAKA[4]

Silica sand of moulding type occurs along the coastal belt of the district from Mangalore to Udipi. It is devoid of impurities and is snow-white to dull-white in colour. The sand particles are uniformly fine-grained and subrounded to angular. The sand from this area is used in foundry and sodium silicate industries.

2. SINDHUDURG DISTRICT - MAHARASHTRA[4]

Mochemud - Ubhadanda area : Silica sand occurs in the form of sand dunes formed due to Arabian Sea waves and wind action which together have been active in disintegration of the sandstones and forming sand dunes. The top layer of 0.5 m thickness in these sand dunes contains impurities like shell, roots, and dry leaves. The sand below this layer is pure and is of foundry grade. Mining of silica sand from these sand dunes is carried out manually by scooping with spades, and also by mechanical means.

5.4.2 Limitation on Mining in Coastal Zones

Recently, the Government of India has issued a Notification dt.19.2.91 under section 3(1) and section 3(2)(v) of Environment (Protection) Act 1986 and Rule 5(3)(d) of Environment (Protection) Rules, 1986 which has put limitations on mining activities within Coastal Regulation Zones (CRZ).

The Notification has restricted setting up and expansion of industries, operations or processes, etc., in coastal regulation zone (CRZ). The coastal stretches upto 500 metres from High Tide Line (HTL) and land between Low Tide Line (LTL) and HTL are covered under Coastal Regulation Zone. Under this provision, it is now prohibited to carry out mining of sands, rocks, and other sub-strata materials within this CRZ, except those rare materials not available outside the CRZ.

BIBLIOGRAPHY

1. Information and data - Mineral Statistics Division, IBM.

2. Inspection Reports under MCDR - from the Regional Office of IBM - Dehra Dun, 1991 and 1992.

3. Inspection Reports under MCDR from the Regional Office, IBM - Ajmer, 1991 and 1992.

4. Silica Minerals - A Market Survey, Mineral Economics Division,IBM - 1989.

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Chapter-6 PROCESSING AND BENEFICIATION

6.1 PROCESSING OF QUARTZ

Quartz is utilised in various industries such as glass, foundry, sodium, silicate, silicon alloys, iron and steel as well as refractory and ceramic in the form of powder of different meshes.

Natural quartz is too hard to be crushed easily. The quartz lumps are calcined to make them friable and easy to crush. The 'rom' quartz lumps are broken into maximum size of 25 cm and the ferrugenous stains on quartz grains are removed by chipping. These pieces of quartz are loaded in a kiln with alternate layers of coal. The loading pattern adopted is one layer of quartz (35 cm) followed by a layer of coal (5 cm). The kiln has a granite base with walls of refractory bricks. Normally, one tonne of coal is required for calcination of 8 tonnes of quartz. The quartz- coal charge is ignited and left to burn for 24 hours. After calcination, the quartz is removed from the kiln and broken into small chips upto 2.5 cm size. These calcined chips are crushed in a crusher and sieved to the required mesh size for use in the industry.

6.2 PROCESSING OF SILICA SAND

The main impurities in silica sand are iron oxide and clayey matter. The iron oxides occur as thin coating or as inclusions within the sand grains. The samples from the mine are tested in laboratory to decide the beneficiation method to be adopted.

Beneficiation Methods

For beneficiation, different types of ore dressing techniques are applied depending on the type of deposit, its mineralogy, chemistry and impurities present therein. The methods of beneficiation are as follows :-

A. Comminution

(i) Crushing, (ii) Grinding and (iii) Screening.

B. Wet Process

(i) Washing by agitation, if required, (ii) Hydrosizing,

(iii) Cycloning, (iv) Classification and (v) Flotation.

C. Cold Chemical Treatment

(i) Attrition scrubbing and (ii) Chemical treatment.

D. Hot Chemical Treatment

E. Physical Process

(i) Magnetic separation, (ii) Tabling, (iii) Jigging, (iv) Spiral classification and (v) Froth flotation.

The main aim of beneficiation is to remove the impurities and obtain a product of the desired mesh. The methods generally adopted are (i) Screening, (ii) Scrubbing, (iii) Chemical treatment and (iv) Electromagnetic separation.

(i) Screening

Screening of the raw sand is done to remove the dust and clayey matter. This is done by sieving the sand through fine mesh sieve (0.15 mm). Large size particles are undesirable in the manufacure of glass because these take more time to dissolve in the glass melt. Normally, screening is done mechanically. There are two types of screening : (a) dry screening and (b) wet screening.

(a) Dry Screening

The dry screening is adopted by the Gujarat Mineral Development Corporation (GMDC) in their silica sand crushing plant at Surajdeval in Surendranagar district.

(b) Wet Screening

The wet screening is adopted by Maharashtra Mineral Corporation (MMC), Bombay in their silica sand washing plant at Phondaghat in Sindhudurg district. By this process, stones, wooden chips and sand particles of size larger than specified are removed. The sand slurry obtained by wet screening is further subjected to attrrition.

(ii) Scrubbing

Scrubbing is carried out by attrition machines. Sand slurry is fed to these machines by gravity. The scrubbed sand slurry is deslimed by subjecting the slurry to centrifugal forces in a cyclone chamber where the slimes are rejected. The deslimed sand is then graded in a gradiator which works on the principle of hindered settling. The flow of water from the overhead tank to the individual compartments of the gradiator is controlled in such a way that the particular mesh size of the sand particles having greater settling velocity owing to weight settle down against the rising current of water. Subsequently the washed sand is dried by special machines using either hot gases or steam.

(iii) Chemical Treatment

The sand may be subjected to further scrubbbing with use of chemicals like sodium hydroxide, sodium carbonate, etc. to reduce the iron content.

(iv) Electromagnetic Separation

When the iron content is not within acceptable limits, still the sand may be subjected to magnetic separation.

6.3 BENEFICIATION INVESTIGATIONS BY INDIAN BUREAU OF MINES ON SILICA SAND

(i) Two silica sand samples from Vavdi Mines of Gujarat Mineral Development Corporation, Surendranagar, were subjected to beneficiation. Methods of attrition, screening and scrubbing were adopted. The samples assayed (97.5 % SiO_2, 0.2% Fe_2O_3) and (96.68% SiO_2, 0.3 % Fe_2O_3) which on beneficiation assayed (99.58% SiO_2, 0.036% Fe_2O_3) and (99.49% SiO_2, 0.06 % Fe_2O_3), respectively. The grain size was within the limits of -30+80 mesh. This size is suitable for use in glass, foundry and ceramic industries.

(ii) The IBM has successfully carried out sand scrubbing with use of chemicals NaOH and Na_2CO_3 to reduce the iron content. If the iron content is still not reduced to acceptable limits, it is subjected to magnetic separation. The beneficiated products fulfill the I.S. Specifications for making grade I and grade II glass. Two samples from Lalpur area of Allahabad district received from U.P. State

Mineral Development Corporation were beneficiated by the above method. The process devised by IBM is likely to be commercially adoptd by UPSMDC in their proposed project.

(iii) Silica sand from Bhatti group of mines was beneficiated by the IBM laboratory at Ajmer. The feed sample contained 98.05% SiO_2, 1.15% Al_2O_3 and 0.16% Fe_2O_3 which was upgraded by attrition and scrubbing. The upgraded sample contained 99.56% SiO_2,0.27 % Al_2O_3 and 0.06 % Fe_2O_3.

6.4 BENEFICIATION INVESTIGATIONS BY NATIONAL METALLURGICAL LABORATORY (NML), JAMSHEDPUR ON SILICA SAND AND QUARTZITE

The NML has been successful in reducing the iron content in various quartz, quartzite, and silica sand samples by adopting methods of screening, washing and magnetic separation.

(i) Silica Sand : Iron content in three silica sand samples from Allahabad area could be reduced from the original level of 0.35 %, 0.71% and 0.57 % to 0.036%, 0.036% and 0.081 % by adopting screening, washing, magnetic separation and leaching.

(ii) Quartzite : Three samples of quartzite were upgraded and the silica content raised from the original 94.44%,92.48% and 88.91% to 98.1 %, 97.53% and 91%, respectively, by adopting grinding, classification and magnetic separation process.

6.5 BENEFICIATION IN FOREIGN COUNTRIES FOR SILICA SAND

The beneficiation methods adopted in some foreign countries are given below :

Country	Location of plant	Beneficiation method
United Kingdom	King's Lynn deposit	a) Washed, treated (cold acid leaching) and froth floated using petroleum sulphonate as collector for glass sand.

(Contd.)

Country	Location of plant	Beneficiation method
United Kingdom (Contd.)		b) Washing and classification for foundry sand.
Austria	Quarzwerke Ges,MBH	Washed and sieved, passed through attrition scrubbers, floated, classified in upward current classifiers & dried.
Finland	Lohja Corporation, Nilsia	Crushed, ground and deslimed, flotation for iron-bearing silicate, magnetic separation and washing.
Australia	a) Melbourne, Victoria	Flotation and Hindered settling.
	b) New South Wales	White sand processed through spiral concentrator and high intensity magnetic separator.
South Africa	Industrial Sand & Engg. Co. Ltd.	Dry high intensity magnetic separation.

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Chapter-7 RESEARCH, PROBLEMS AND PROSPECTS

7.1 RESEARCH

Continued research in many fronts on industrial silica sands has opened up new areas of applications. Some important areas where innovations and improvements have been made are:

The use of silicon nitrate (Si_3N_4) a ceramic for engine components is a new area for silica minerals. The Si_3N_4 - components have begun to replace traditional metals in engine, turbo- charger, rotors, valves and ball bearings. The advantage of Si_4N_4 includes improved durability, lower wear and friction, increased fuel efficiency and greater impact resistance. As materials and production cost is less, use of Si_3N_4 and other materials such as silicon carbide could become common place.

COMPARISON OF PHYSICAL PROPERTIES

Material	Strength (M Pa)	Temperature use limit	Thermal shock	Hardoors Brinels/ knoop
Cast iron	260	1,100°C	-	240
Steel	590	1,100°C	-	550
Aluminium	150	650°C	-	120
Silicon Nitride	840	1,000°C	700°C	1,800
Silicon Carbide	460	1,400°C	400°C	2,800

* In glass melting technology, use of oxygen in place of air has improved efficiency of furnace.Oxygen raises the flame tempera ture and minimizes heat losses to the flue.

* Use of seg-melt, the segregated furnace improves the thermal efficiency. According to reports, this method will cut down cost of container glass by about 11%.

* Department of Energy's (DOE) USA effort to use a vetrification process to secure radioactive liquid plutonium waste is yet another new area for silica sand application.

The radioactive waste will be fused with waste of borosilicate particles to form glass to be poured into stainless steel containers, sealed and stored in the DOE's permanent underground waste storage at YUCCA Mountain, N.V. The project is scheduled to commence in 1992 and will continue for 20 years.

* International Agency for Research on Cancer (IARC) has stated in its findings that there is limited evidence that silica is carcinogenic. Silicosis is also known to be a non-cancerous lung disease. MSHA, the Mine Safety & Health Administration, USA recommends that producers should label the products and train their employees about proper handling of silica.

* Research for silica mining industry has resulted in increased productivity with reduced cost. Equipment manufacturers and Government agencies have been working constantly on improving exploration,mining and processing plant technology, etc. In USA,significant development in processing plant technology has resulted in maintaining adequate production at relatively stable cost.

* The use of computerized system in plant operation and quality control together with improved mining & processing units have permitted recovery of saleable fractions of silica sand which were earlier considered uneconomical.

IBM has carried out beneficiation studies on a number of silica sand samples from Uttar Pradesh, Gujarat, Delhi, Maharashtra, etc.and has been successful in producing glass grade concentrate. The main problem with silica is reduction of iron content. This problem was tackled by acid/alkali scrubbing and magnetic separation. Felspar was taken care of by flotation.

7.2 PROBLEMS

* Ministry of Environment & Forest Notification under section 3(1) and section 3(2)(v) of the Environment (Protection) Act,1986 and Rule 5(3)(d) of Environment Protection Rules, 1986, declared coastal stretches as 'Coastal Regulation Zone'(CRZ) and have regulated activities in the CRZ- 19th Feb.1991. The above notification prohibits following activities in the coastal zone:

  (i) Mining of sands, rocks and other sub-strata material (except those rare minerals not available outside CRZ), within the 500 m from High Tide Level.

  (ii) Dressing or altering of sand-dunes, natural features including landscape changes for beautification, recreational and other such purposes except as permissible under this notification.

  As a result, mining activity in coastal areas of Goa, Maharashtra, Karnataka, Kerala, Tamil Nadu and Orissa region covering iron ore, silica sand, mineral sands, etc. has been affect ed.

* In the international scenario, the growing use of finer feeds, demand for purer materials and recycling of silica becoming apparent which may have effect on mining activities.

* Glass industry, particularly the container glass is competing head to head with polyethylene teraphthalate (PET) and aluminium cans. Gradual switch over to cans for beer and 2 and 3 litre 'PET' bottles for soft drinks has created negative influence on glass container industry.

* Flat glass industry is being adversely affected by the continued economic recession and is expected to continue as long as large inventories of office & hotel space remain unoccupied and cars and trucks remain rooted to sale room floors.

7.3 PROSPECTS

* With stringent requirements being imposed on water quality, requirements of sand for filtration media may boost up steadily.

* Increasing environmental awareness and disposal problem posed by the plastic container favours the container glass sector. This has an annual growth rate currently of 1%, but is expected to boost up greatly.

* Fibre glass output is on the increase with ever increasing use of fibre glass materials. This should give a big boost to the silica sand production.

* There are increasing demands for quartz crystal in communication system (specially cordless telephones), electronic time pieces, personal computers, micro-processors, colour television, etc. Rising demand of quartz crystals in automobile industry is also expected.

* Turmoil in oil industry and increase in prices would stimulate drilling and extraction from new and old oil deposit in the oil producing countries. This will increase the demands of hydraulic fracturing sands to a great extent.

* A 10 million dollar project to manufacture silicon metal has been taken up jointly by DOW Corning Corp and Manitoba Energy Authority (MEA) by Canada Government. The process contemplates manufacturing of silicon metal through plasma technology using local high quality silica sand. The first stage of the project, which has made good progress since November, 1988, concerned with testing and evaluation of raw materials. Silica sand and charcoal are put to electrical heating utilising plasma technology, an efficient method to convert electricity to heat in manufacture of silicon metal. The silica sand obtained from Black Island deposits, in lake Winnings, Manitoba, Canada, contain SiO_2 99.558 % and iron oxide 0.020 %.

7.4 WORLD NEWS

7.4.1 Quartz Beneficiation Plant for former USSR

KHD Humboldt Wedag AG of cologene is to deliver essential equipment for a Quartz sand preparation plant for former USSR. In the plant, a high grade quartz concentrate will be produced from quartz sand of grain sizes of 0.4 - 0.1 mm. It is planned to obtain 1 tonne of final product from a feed of 1.2 tph. Quartz sand preparation process will comprise the following stages in sequence, e.g.wet magnetic separation, flotation, chemical treatment, drying and cooling, and packing.

After the first flotation, the material is to be fed into a Jones/type wet high-intensity magnetic separator. Mica and felspar will be separated by subsequent flotation process. For complete separation of magnetic material, the material is to be fed into the magnetic separator system again. The non-magnetic fraction will then be treated with acid and later separated by filtering. The quartz sand will be neutralised by adding water on filter. Further, the quartz sand will be de-ionised with water and filtered again.

The product, in the form of cake, is obtained from vacuum filter. This product then passed through belt weight meter and fluidised bed drier, where drying takes place at a temperature of about 180°C. From drier, the product is conveyed to fluidised bed cooler and the final product is discharged at a temperature of about 40°C. The dried and cooled product is bagged in 40 kg. paper or plastic bag. All the items of equipment in the quartz preparation plant are designed for continuous operation during 24 hrs./day for 305 days per year.

7.4.2 U.S. Technology for China's First Silica Plant

The Chinese Government has awarded a contract to PPG Industries Inc., the largest US producer of precipitated silica to provide technology and equipment for China's first commercial silica plant.

The plant was scheduled for completion by the end of 1988 and will have a capacity of 10,000 tpa. The plant is located in Nanchang, approx.800 km. south of Beijing in Jiangxi Province. The process involved melting of a mixture of silica sand and alkali (soda ash or caustic soda) to produce sodium silicate glass. This sodium silicate glass is then subjected to acid environment when silica component of the glass will be precipitated in spherical particles of approximately 6/8 microns diameter. Precipitated silica has been known to be primarily used as reinforcing agent in shoe soles, tyres, mechanical rubber goods, etc.This promotes extra durability and a more efficient friction action.

7.4.3 U.K. - Reopening of Langholme Sand Quarry

Langholme sand quarry in Humberside, U.K. was lying closed for several years. However, a company, P & R Sand Ltd., has been able to re-establish sand extraction and processing method based on existing planning permission, granted some 25 years ago, as below:

(1) Sand horizon occurs below the water table which is about 1m. below ground level. The sand will be won by using a suction cutter dredge operating to a depth of 10 metres. The capacity of the dredge is about 60 tph. The dredged sand is to be fed to a 3 mm trash screen before it is transferred to a Floatex classifier which will remove the plus 650 micron material. The undersized material will further pass through a Foatex Separator and a product in the minus 650 micron plus 125 micron size range will be produced.

A high intensity magnetic seperator unit is proposed to be installed in order to reduce iron level from 0.5% Fe_2O_3 to 0.3% or better. The installed capacity of the plant is 40 tph.

7.4.4 Australia-Queensland Silica Sand- Environment Halts Mining

A 500 sq.km. silica sand dunes adjacent to Great Barrier Reef Off Cape York at Shelburne, Bay has been prevented from extracting on environmental consideration.

BIBLIOGRAPHY

(Chapters 1,2,3,4 & 7)

1. Rutley's Elements of Mineralogy by H.H. Read F.R.S.
2. Silica Minerals - A Market Survey - April, 1989 by IBM.
3. Indian Mineral Resource - By S.Krishnaswamy.
4. GSI Bulletin No.10 - Indian Precious Stone - Iyer L.A.N.
5. Industrial Minerals, April, 1987.
6. Industrial Minerals, July, 1989.
7. Industrial Minerals, June, 1976.
8. Industrial Minerals, May, 1979.
9. Industrial Minerals, August, 1984.
10. Industrial Minerals, April, 1989.
11. Industrial Minerals, July, 1991.
12. Industrial Minerals, Sept., 1989.
13. Minerals and Rocks - Chatto Nature Guide - Chatto & Windus London.
14. Mineral & Mining World, April, 1991.
15. Mineral & Mining World, May-June, 1991.
16. USBM - Yearbook 1991.
17. Indian Minerals Yearbook, 1991, IBM.
18. National Mineral Inventory as on 1.4.1990.

19. Communication from Department of Mines and Geology, Patna, Bihar, August, 1991.

20. Communication from Directorate of Geology and Mining, Ahmedabad, Gujarat, August, 1991.

21. Communication from Department of Geology and Mining, Madras, Tamil Nadu, October, 1991.

22. Communication from Directorate of Mines & Minerals, Calcutta, West Bengal, October, 1991.

23. GSI Miscellaneous Publication No.30 Part I to IX.

24. Mineral Facts and Problems - Bureau of Mines - Bulletin 667, US Department of the Interior.

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