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MINOR MINERALS

30.20 QUARTZ & OTHER SILICA MINERALS
[MOULDING SAND (MAJOR)]

(FINAL RELEASE)

GOVERNMENT OF INDIA
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30-20 Quartz & Other Silica Minerals

The term 'quartz' is often referred to as a synonym for silica. Silica (SiO_2) is one of the ubiquitous materials in the earth's crust. Quartz, quartz crystals, quartzite, silica sand, sand (others) and moulding sand are all coined together in one generic name 'silica minerals'. This is because all these commodities are essentially crystalline silicon dioxide (SiO_2) with variations mostly related to their crystalline structure and presence of minor or trace impurities. Silica occurs in several forms giving rise to different varieties.

Crystalline Varieties

The important varieties of crystalline quartz are vein quartz (massive crystalline quartz); milky quartz (white, translucent to opaque); ferruginous quartz (containing brown limonite and red haematite and almost opaque); aventurine quartz (containing glistening flakes of mica or haematite); cat's eye (opalescent greenish quartz with fibrous structure); rock crystal (clear, colourless, well-crystallised transparent quartz); amethyst (clear-purple or violet-blue), transparent quartz; rose quartz; smoky quartz; etc. Occurrences of massive crystalline quartz in veins or pegmatites have been recorded in almost all the states.

Clastic or Granular Varieties

These varieties include sand consisting largely of unconsolidated quartzose grains (0.06 mm to 2 mm diameter), gravel consisting largely of unconsolidated coarse quartzose grains or pebbles (2 mm to 8 mm in diameter), sandstone and quartzite. Quartzite is a granulose metamorphic rock consisting essentially of quartz and sandstone cemented by silica which has grown in optical continuity around each grain. Occurrences are reported from Andhra Pradesh, Bihar, Delhi, Haryana, Karnataka, Kerala, Madhya Pradesh, Rajasthan,Tamil Nadu, Uttar Pradesh, etc. The silica sand from Naini area in Allahabad district, Uttar Pradesh is of a very high quality.

Cryptocrystalline Varieties

This group includes chalcedony, agate, jasper, onyx, flint and chert. These varieties appear non-crystalline (amorphous) in hand specimens, but under microscope show double refraction which reveals their concealed crystalline nature. These varieties are reported from Gujarat, Uttar Pradesh, Tamil Nadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Karnataka and Punjab. The most important occurrences of agate are in Ratnapur, Rajpipla area and further west between Tapi and Narmada rivers in Bharuch district, Gujarat, where it is found as pebbles in varying sizes associated with clay washed down by the river flow. Other occurrences of economic importance are reported from Amravati, Aurangabad, Buldhana, Chandrapur, Nashik and Pune districts in Maharashtra; beds of Krishna and Godavari rivers in Andhra Pradesh; Dumka district in Jharkhand; Dhar, Mandsaur, Sihore and Shahdol districts in Madhya Pradesh; and Kachchh district in Gujarat.

As per Govt. of India Gazette Notification S.O 423 (E), dated 10th February 2015, the 31 minerals declared as minor minerals. Out of these 31 minor minerals, Agate, Fuschite quartzite, Jasper, Quartz, Quartzite, Sand (others) and Silica sand come under the different veriety of silica minerals. Minor minerals come under the purview of respective state governments and they frame the rules for minor minerals.

RESERVES/RESOURCES

As per the NMI database, based on UNFC system as on 1.4.2015, the total reserves/ resources of quartz and silica sand in the country have been estimated at 3,907.95 million tonnes out of which 647.53 million tonnes (17%) are placed under Reserves category and 3,260.42 million tonnes (83%) are placed under Remaining Resources category. Resources by grades reflect foundry & moulding grade at 735.59 million tonnes (19%), glass at 649.77 million tonnes (17%), ceramic & pottery grade at 438.44 million tonnes (11%) and ferro-silicon grade at 183.96 million tonnes (5%). The abrasive, sodium silicate, others, unclassified and not-known grades at 1,900.18 million tonnes (48%) of the total resources. State-wise Haryana alone accounts for 1,653.65 million tonnes (42%) resources, followed by Rajasthan at 740.46 million tonnes (19%), Andhra Pradesh 236.69 million tonnes (6%), Tamil Nadu 201.49 million tonnes (5%), Maharashtra 179.72 million tonnes (4.60%), Jharkhand 151.19 million tonnes (4%), Uttar Pradesh 140.72 million tonnes (3.60%), Gujarat 132.42 million tonnes (3.39%), Kerala 128.48 million tonnes (3.28%), Karnataka 95 million tonnes (2.43%), Telangana 80.07 million tonnes (2.05%) etc. (Table-1).

Similarly the total reserves/resources of quartzite in the country as per NMI database, based on UNFC system as on 1.4.2015 have been estimated at 1,658.80 million tonnes out of which reserves are placed at 83.47 million tonnes (5%) and the remaining resources at 1,575.32 million tonnes (95%). Statewise bulk resources of about 884.18 million tonnes are located in Haryana (53%) followed by Bihar 277.82 million tonnes (17%), Odisha 140.55 million tonnes (8.47%), Maharashtra 90.70 million tonnes (5.46%), Punjab 81.91 million tonnes (5%) and Jharkhand at 40.70 million tonnes (2.45%). Gradewise resources of refractory grade-I & II are estimated at 579.45 million tonnes (35%), ceramic & pottery grade at 215.91 million tonnes (13%), BF grades at 66.50 million tonnes (4%) and the remaining resources at 796.92 million tonnes (48%) are of ferro-silicon, low, unclassified, others & not-known grades (Table-2).

EXPLORATION & DEVELOPMENT

The exploration & development details, if any, are given in the review on "Exploration & Development" in "General Reviews".

PRODUCTION & STOCKS

QUARTZ/SILICA SAND/QUARTZITE/ SAND (Others)/ AGATE

As per the Govt. of India Notification S.O. 423(E), dated 10th February 2015, 'Quartz/Silica Sand/Quartzite/Sand (others)/Agate' have been declared as 'Minor Mineral'. Hence the production data is not available with IBM.

MOULDING SAND

The production of moulding sand was 27,686 tonnes valued at ` 61.46 lakh in 2016-17. All the production was reported from 4 private sector deposits n Chhattisgarh. The production of moulding sand was at 25,852 tonnes in 2015-16 increased by 305% during the year as compared to that in the previous year.

There were three reporting mines in both the year 2014-15 and 2015-16. The production of moulding sand was reported only from Chhattisgarh during the year. Three principal producers of moulding sand accounted for the entire production in 2015-16 (Tables- 3 to 6).

Mine-head closing stocks of moulding sand in the year 2015-16 were 1,148 tonnes as against 411 tonnes in 2014-15.

The average daily employment of labour in 2015-16 was 35 as against 29 in the preceding year.

Table – 1 : Reserves/Resources of Quartz & Silica Sand as on 1.4.2015
(By Grades/States)

(In '000 tonnes)

Grade/State	Reserves				Remaining resources								Total Resources (A+B)
	Proved STD111	Probable		Total (A)	Feasibility STD211	Pre-feasibility		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
		STD121	STD122			STD221	STD222						
All India: Total	**433014**	**93339**	**121169**	**647522**	**354566**	**368217**	**362128**	**36872**	**219180**	**1897899**	**21436**	**3260297**	**3907819**
By Grades													
Glass	205934	24780	19173	249886	83708	46000	54870	3268	5506	194962	11505	399820	649706
Ferro-silicon	10385	170	6729	17283	14199	15950	15194	106	65173	55878	179	166679	183963
Sodium silicate	2385	80	1911	4376	840	1422	5313	195	325	30869	11	38976	43351
Ceramic and Pottery	35142	8883	23348	67373	98139	24681	68351	7553	13022	159035	289	371070	438443
Foundry and Moulding	115324	4946	9898	130167	71962	47190	121130	19234	37977	300257	7672	605421	735589
Abrasive	48	-	-	48	2253	256	1984	22	21	3508	-	8043	8091
Others	20911	8067	2026	31004	44667	65197	27456	1185	873	866706	541	1006625	1037629
Unclassified	42010	45825	56370	144204	28474	161250	48346	4747	1976	150383	679	395855	540060
Not-known	875	590	1715	3180	10323	6270	19485	563	94307	136301	560	267808	270988
By States													
Andhra Pradesh	94483	3429	13687	111599	32690	4039	17329	7081	6691	45661	11599	125090	236690
Assam	-	-	-	-	-	-	-	-	-	1790	-	1790	1790
Bihar	-	-	-	-	-	-	-	-	-	25755	-	25755	25755
Chhattisgarh	501	479	800	1780	389	282	789	56	26	642	7672	9856	11636
Goa	-	-	-	-	-	20	1736	-	-	18248	-	20004	20004
Gujarat	27892	5617	15260	48769	26742	6681	17809	2932	3371	26099	21	83656	132425
Haryana	-	-	-	-	35553	247695	186475	886	642	1182400	-	1653650	1653650
Himachal Pradesh	1	-	7	8	99	-	-	-	-	2928	-	3027	3035
Jammu & Kashmir	-	-	-	-	-	-	-	-	-	3110	-	3110	3110
Jharkhand	-	-	1070	1070	534	985	4533	137	766	143053	112	150122	151192
Karnataka	7975	417	1807	101991	15904	6695	9448	94	52	52077	525	84794	94993
Kerala	221	33	136	389	179	1985	3588	14611	30241	77489	-	128092	128481
Madhya Pradesh	129	30	1781	1940	516	-	920	791	316	2717	-	5261	7201
Maharashtra	15188	93	9984	25265	33039	15455	48535	-	355	57077	-	154461	179726
Meghalaya	-	-	-	-	-	-	-	-	177	6906	-	7083	7083
Odisha	567	109	725	1401	344	2038	2918	93	63308	3944	179	72824	74225
Punjab	-	-	-	-	-	-	-	-	-	3927	-	3927	3927
Rajasthan	239131	58049	51713	348894	160210	34587	50216	5464	8001	131753	1098	391439	740333
Tamil Nadu	25086	3493	1199	29778	28196	15176	2191	3387	95837	26931	-	171718	201496
Telangana	18541	1367	6916	26824	10334	2414	8365	159	3107	28642	230	53250	80074
Tripura	-	-	-	-	-	-	-	225	-	264	-	490	490
Uttar Pradesh	445	19825	15144	35413	9415	30013	7048	957	6290	51590	-	105314	140727
West Bengal	2853	400	939	4193	310	151	229	-	-	4896	-	5586	9779

Figures rounded off

Table – 2 : Reserves/Resources of Quartzite as on 1.4.2015
(By Grades/States)

(In '000 tonnes)

Grades/States	Reserves				Remaining resources								Total Resources (A+B)
	Proved STD111	Probable		Total (A)	Feasibility STD211	Pre-feasibility		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
		STD121	STD122			STD221	STD222						
All India : Total	**47758**	**2016**	**33698**	**83472**	**120723**	**141437**	**160355**	**119953**	**152715**	**868850**	**11293**	**1575325**	**1658798**
By Grades													
Refractory Grade-I	29574	831	19192	49597	50814	10512	31337	1032	1067	293813	2906	391482	441079
Refractory Grade-II	1038	303	42	1384	1666	3220	497	3183	21075	99849	7497	136987	138371
Ceramic / Pottery	112	49	16	177	18499	37356	58442	-	3599	97772	72	215741	215918
Low	249	35	-	284	2139	3764	73	-	23	8791	-	14789	15073
Ferro-silicon	-	-	-	-	169	8392	3034	-	376	461	523	12955	12955
B.F.	-	-	-	-	-	848	2067	197	275	62822	295	66503	66503
Others	9713	68	175	9956	35277	15920	2093	309	251	44895	-	98745	180701
Unclassified	5572	672	12938	19182	12158	55006	60718	94298	94799	226394	-	543373	562555
Not-known	1500	58	1334	2892	-	6418	2094	20935	31250	34053	-	94750	97642
By States													
Andhra Pradesh	16001	-	1389	17390	2103	8357	6418	-	3975	24797	1256	46905	64295
Arunachal Pradesh	-	-	-	-	-	-	-	-	-	5270	-	5270	5270
Bihar	-	282	12260	12542	390	959	8090	5490	22822	227531	-	265282	277824
Chhattisgarh	605	1524	1567	3696	575	7035	1856	-	-	15404	-	24870	28566
Haryana	-	-	-	-	50751	118056	116686	113902	124458	360335	-	884188	884188
Himachal Pradesh	25	-	16	41	16	-	-	-	-	-	-	16	57
Jammu & Kashmir	1500	58	-	1558	-	-	-	-	120	9100	7380	16600	18158
Jharkhand	181	-	-	181	763	49	390	197	275	38854	-	40527	40708
Karnataka	231	-	-	231	69	48	592	-	-	4914	1730	7353	7584
Madhya Pradesh	-	-	-	-	-	-	-	-	-	832	-	832	832
Maharashtra	9026	-	-	9026	49172	-	21156	-	-	11344	-	81671	90697
Odisha	20050	151	18381	38582	16861	6914	5128	364	274	71503	927	101971	140554
Punjab	-	-	-	-	-	-	-	-	116	81796	-	81912	81912
Rajasthan	140	-	86	226	-	18	18	-	-	706	-	742	968
Sikkim	-	-	-	-	-	-	-	-	675	16444	-	17119	17119
West Bengal	-	-	-	-	24	-	21	-	-	21	-	66	66

Figures rounded off

Table - 3 : Principal Producers of Moulding Sand, 2015-16

Name and address of producer	Location of mine	
	State	District
Mahendra Kumar Seksaria, 271, Ramdev Mandir, Ward-35, Ganjpara, Durg-491 001, Chhattisgarh.	Chhattisgarh	Durg
Deepak Kumar Gupta, 97-A, Plot 10-11, Nehru Nagar (East), Bhilai, Durg- 490 020, Chhattisgarh.	Chhattisgarh	Durg
Smt. Archana Das, 44, Vardhaman Nagar, Jain School Road, Rajnandgaon-491 441, Chhattisgarh.	Chhattisgarh	Rajnandgaon

Table –4: Production of Moulding Sand , 2016-17 (By States/Sector)

(Qty in tonnes; Value in `'000)

State	No. of Mines	Quantity	Value
India/Private Sector	**4**	**27686**	**6416**
Chhattisgarh	4	27686	6416

Table –5: Production of Moulding Sand , 2013-14 to 2015-16 (By States)

(Qty in tonnes; Value in `'000)

State	2013-14		2014-15		2015-16 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**29963**	**4877**	**6383**	**1671**	**25852**	**6068**
Chhattisgarh	29323	4675	6383	1671	25852	6068
Gujarat	150	68	-	-	-	-
West Bengal	490	134	-	-	-	-

Table – 6 : Production of Moulding Sand, 2014-15 & 2015-16 (By Sector/States/Districts)

(Qty in tonnes; Value in `'000)

State/District	2014-15			2015-16 (P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
India	**3**	**6383**	**1671**	**3**	**25852**	**6068**
Private sector	3	6383	1671	3	25852	6068
Chhattisgarh	**3**	**6383**	**1671**	**3**	**25852**	**6068**
Durg	2	5953	1459	2	24992	5638
Rajnandgaon	1	430	212	1	860	430

Table-7: Production of Flint Stone , 2016-17
(By States/Sector)

(Qty in tonnes; Value in `'000)

State	No. of Mines	Quantity	Value
India/Private Sector	**1**	**26**	**8**
Jharkhand	1	26	8

Table – 8 : Production of Flint Stone, 2013-14 to 2015-16
(By State)

(Qty in tonnes; Value in `'000)

State	2013-14		2014-15		2015-16 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India/Jharkhand	**459**	**136**	**244**	**79**	**253**	**76**

Table – 9 : Production of Flint Stone, 2014-15 & 2015-16
(By Sector/State/District)

(Qty in tonnes; Value in `'000)

State/District	2014-15			2015-16 (P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
India/Private Sector	**2**	**244**	**79**	**1**	**253**	**76**
Jharkhand/ Sahibganj	2	244	79	1	253	76

FLINT STONE

The production of flint stone was only 26 tonnes valued at ` 8000 in 2016-17. The production was reported from only one private sector deposit in Jharkhand.

The production of flint stone at 253 tonnes in 2015-16 increased by 4% during the year as compared to that in the previous year.

There was one reporting mine in 2015-16 as against two in the previous year. The entire production of flint stone was reported from Jharkhand (Tables - 7 to 9).

There were no mine-head closing stocks of flint stone in 2015-16 as well as in 2014-15 .

The average daily employment of labour in 2015-16 was 2 as against 7 in the preceding year.

MINING

Mining for silica minerals is carried out by manual opencast method. Quartz produced in the form of lump along with other associated minerals is invariably hammered to pieces and manually sorted before it is despatched to the consuming industries.It is sometimes crushed and marketed. Glass sand is generally screened and washed to remove all the deleterious constituents for its use in glass industry.

APMDC owns two crushing plants located at Mahabubnagar district in Andhra Pradesh with crushing capacity of 45 tonnes and 1000 tonnes a month, respectively. Besides, Maharashtra Minerals Corp. Ltd is having a 50,000 tonnes per year beneficiation plant at Phondaghat in Sindhudurg district. The plant has advanced technology in washing both by water and chemicals and further grading it in required fractions.

HEALTH HAZARDS

Respirable silica is still a cause of major concern to miners and consumers since many minerals, especially industrial sand and gravel contain crystalline silica. There is a potential threat of workers getting subjected to "silicosis" in quartz, silica sand

and gravel mines. Occupational safety measures & regulations to monitor the levels of crystalline silica in these mines are mandatory. In the USA, the Occupational Safety and Health Administration (OSHA) listed "crystalline silica" as one of their top five priorities for formulation of necessary rules. The OSHA, on the basis of significant information put out by International Agency for Research on Evaluation of Cancer has declared that any material containing more than 0.1% crystalline silica should indicate its carcinogenic hazard.

USES

Quartz, quartzite and silica sand are used in various industries like glass, refractory, foundry, ceramic, cosmetic, electrical, abrasives, paints, etc. The primary use of silica is in the manufacture of virtually all types of glasswares, ceramics and ceramic glazes. Other major uses are in metallurgy, (where silica is used as a refractory, foundry mould, fluxes and as a source of silicon for the production of silicon metal and ferro-silicon and other ferro-alloys), silicon carbide manufacture, chemical & construction sectors and as a natural abrasive. Known for its piezoelectric properties, high quality quartz crystal is used in electronic devices, multiple telephone lines, depth-sounding devices, range finders, chronometers, etc.

Sand is also used as a fireproofing material, for sandstowing in mines, soundproofing material and as a filler. Silica sand is also used to maintain or increase the permeability of oil and gas-bearing formations; its application as a filler in acid proof cements, putty, paints, epoxy & polyester resins is inevitable. Besides, it is widely used in horticulture as a filtration medium, and for ornamental purposes as well. Silica flour is used as a filler in plastic and rubber products.

Flint and chert are used in abrasives and tube-mill lining. Besides, chert is used in crushed form as aggregate for concrete and road surfacing. Rounded pebbles of chalcedony are used as balls in ball mill for finer crushing and grinding felspar, calcite and barytes. The different cryptocrystalline varieties of transparent and translucent chalcedony are valued as semiprecious stones and are carved out into a variety of ornaments and used for making different ornamental wares or articles of decoration. Agate pieces after cutting and polishing are sold as semiprecious stones. Big pieces are used in making mortars and pestles for laboratory use. Agate cut into requisite shapes is also used as fulcra of scientific balances and in making edges, planes and bearings of precision instruments.

INDUSTRY & SPECIFICATIONS

In India, quartz, quartzite and silica sand are used mainly in glass, foundry, ferro-alloys and refractory industries and also as building materials. According to its suitability for different purposes, it may be named as building sand, paving sand, moulding or foundry sand, refractory sand or furnace sand, filter sand, glass sand and grinding & polishing sand.

Glass

Main use of silica minerals is in the manufacture of different types of glasses, i.e. glass containers, bottles, amber glass containers, clear flint glass, vacuum bottles and other glasswares.

The natural silica sand is the preferred material in glass industry, but in some cases where the glass plants are located far away from silica deposits, crushed quartz is also used. For use in glass industry, the silica sand must be uniform in chemical composition, size and shape of grains. Uniform grain size promotes even melting in the glass tank. The sand should not be coarser than 20 or 30 mesh and finer than 100 to 120 mesh. As a general rule, the grains should be angular rather than rounded, because angular grains melt more readily than the rounded ones.

For glass manufacturing, the silica sand should be fairly free from contaminations of clay materials, pebbles, etc. Silica sand usually contains iron oxide, calcium oxide, potassium oxide and sodium oxide in small amounts. Iron is the most objectionable impurity because it imparts colouration to the glass.

The common permissible limits of iron oxide in silica sand for use in the manufacture of different types of glass are as follows:

Glass type	Fe_2O_3 %
Optical glass	0.005-0.008
Flint or soda-lime glass	0.02-0.05
Plate glass	0.1-0.2
White bottles or window glass	0.2-0.5
Dark bottle glass	0.5-0.7

BIS has laid down specifications for glass making sands vide IS:488-1980 (Second Revision, Reaffirmed 2008 & 2013).

Chromium compounds, alumina, lime and magnesia are the other deleterious impurities. Chromium compounds are undesirable because these compounds impart more colouration to the glass than iron. Alumina tends to decrease transparency and makes the batch more difficult to melt. The maximum quantity of alumina permissible in sand is 1.5 percent. The maximum permissible limit for lime and magnesia is about 0.05% and for alkalies, it is 0.01% or less.

Ceramic

Ceramic whiteware 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 to dry easily and provides compatability between the body and the glass to prevent crazing or peeling. Main source of silica for this application is silica sand. In addition, silica flour is used in formulation of ceramic body for enamels and frits. Silica flour produced by fine grinding of quartzite, sandstone or lump quartz is used in enamels. The silica flour normally contains more than 97.5% SiO_2, less than 0.55% Al_2O_3 and less than 0.2% Fe_2O_3. Purity and small particle size (BS mesh-200) are fundamentally important for silica in manufacture of ceramics. BIS has prescribed the specifications of quartz for ceramic industry vide IS: 11464-2011 (First Revision).

Foundry

Silica sand is used in both foundry cores and moulds because of its resistance to thermal shock. Silica content of 85% is used in iron casting. In steel foundries, silica content should be at least 95%. BIS has laid down specifications of high silica sand for use in foundries vide IS: 1987-2002 (Second Revision, Reaffirmed 2007).

Natural moulding sand contains variable amount of clay which acts as a 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 more 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 sub-angular to rounded shape. As far as possible, the sand shall be free from gravel. As per IS:3343-1965 (Reaffirmed 2008), 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

Refractoriness of the natural moulding sand based on sintering temperature range should be as follows:

Grade A - 1350 to 1450 °C

Grade B - 1200 to 1350 °C

Grade C - 1100 to 1200 °C

Washed sand grains are required to be sub-angular to rounded shape.

Silica flour is particularly used in the steel foundry in dressing for moulds & cores and also as essential ingredient in the moulding sand mixtures. It is also used to obtain elevated temperature strength, high density and resistance to metal penetration in cores. Silica flour is produced by crushing, washing and

grading high-grade quartz/quartzite rocks or white silica sand or other deposits sufficiently pure to get the desired material. BIS has laid down specifications of silica flour for use in foundries vide IS: 3339-1975 (Reaffirmed 2008 & 2014).

Refractory

Quartz and quartzite are used in the manufacture of refractory silica bricks. For the manufacture of refractory bricks, silica mineral should be free from aluminosilicates (felspar, mica, etc.) as they adversely affect refractoriness of the bricks. Silica rock (raw material) should be hard, having high bulk density and low porosity.

Fluxes

Massive quartz, quartzite, sandstone and unconsolidated sands are the main sources of silica that get used as flux in smelting base metal ores where iron and basic oxides are slagged as silicates. Silica is also used to balance the lime and silica ratio of the blast furnace mix. The silica content for this purpose must be as high as 90% with minor amounts of impurities like iron and alumina up to 1.5% maximum. BIS has laid down IS: 13676-1993 (Reaffirmed 2008 & 2014) for quartzite for iron making in blast furnace.

Ferro-silicon and Other Alloys

Ferro-silicon contains about 75-90% silicon and minor amounts of iron, carbon, etc. It is estimated that for the manufacture of one tonne ferro-silicon of 70-75% grade, about 1.78 tonnes quartz is required besides other raw materials like coke, iron scrap, etc. Quartz is the major source of silica in the manufacture of ferro-silicon. Occasionally, quartzite is also used. However, 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 from 3/4 to 5 inches is generally preferred. Ferro-silicon is produced by smelting a mixture of quartz, metallic iron (steel scrap and turnings) and a reducing agent like coke, charcoal or wood chips.

Quartz, suitable for ferro-silicon production should have more than 98% SiO_2, less than 0.4% Al_2O_3 and not more than 0.2% each of Fe_2O_3,CaO and MgO. Phosphorus or arsenic should not be present in quartz. If Al_2O_3 is more than the prescribed limit, it affects reduction in the electric furnace. Alkali has a tendency to promote a sticky slag which contaminates the products. If higher iron (more than 0.3%) is present in quartz, the fusion in the furnace takes place at lower temperature and affects reduction process. Another important factor is that quartz should have good thermal stability at 1200 °C or more. BIS has laid down IS: 13054-1991 (Reaffirmed 2008) for use of quartz/ quartzite for production of ferro-alloys.

Silico-manganese, a combination of 60-70% manganese, 16-28% silicon and 1.5 to 2.5% carbon is used as a more effective deoxidizing agent than high carbon ferromanganese in the production of various types of steels. The production of silico-manganese (including medium carbon & low carbon silico-manganese) which was about 249.69 thousand tonnes in 2014-15 increased to 269.92 thousand tonnes in 2015-16. The details of silicon ferro-alloys are also discussed in the review on Ferro-Alloys'.

Silicon Metal

A high purity quartz containing about 99.80% 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 percent. For production of one tonne of silicon metal, about 2.6 tonnes silica is consumed.

CONSUMPTION

The quartz and silica sand consuming industries are glass , cement, ferro-alloys, Iron & Steel, foundry and fertilizer. Other industries such as ceramic, alloy steel, insecticide, refractory, abrasive also consume quartz and silica sand.

POLICY

Foreign Trade Policy (FTP) for 2015-2020, the imports of silica sands (processed (white), processed (brown) & other) will subject to Plant quarantine (Regulation of imports into India) Order, 2003. Quartz

(lump & powder), quartzite (lump & powder) & flint are free as per import policy 2015-20. The export of silica sand (processed (white), processed (brown) & other) permitted under licence. However, the exports of river sand to Maldives under bilateral agreements between Government of India and Government of the Republic of Maldives are permitted, subject to 'No Objection Certificate' by CAPEXIL within the annual ceiling of 2, 2.5 & 3 lakh metric tonnes for the years 2014-15, 2015-16 and 2016-17, respectively.

SUBSTITUTION

In order to reduce the potential threat of "silicosis", a variety of materials are used as substitutes for silica. Basic and neutral refractories (including magnesite, mag-chrome, dolomite and high alumina bricks) have replaced silica in a large number of applications. Chromite, olivine and zircon are alternatives to foundry sands. Garnet and to a lesser extent, olivine are used in sand blasting to avoid the risk of silicosis. Wollastonite is more favoured than free silicon for use in the ceramic industry, again due to the risk of silicosis. In electronic industry, replacement of natural quartz crystal by cultured quartz crystal is increasing steadily. It has been estimated that about 10 billion quartz crystals and oscillators per year are manufactured and installed world wide in all types of electronic devices.

FUTURE OUTLOOK

According to its suitability for different purposes, quartz & silica minerals are named as building sand, paving sand, moulding or foundry sand, refractory sand or furnace sand and glass sand, etc. The future market demand of quartz and silica minerals will depend on its application. However, the main use of silica minerals is in manufacture of different types of glasses, natural silica sand being the preferred material in the glass industry. In India, quartz, quartzite and silica sand are used mainly in glass, foundry, ferro-alloys, refractory industries and also as building materials. Silica sand is used in the oil industry for the hydraulic fracturing process as it helps in the extraction of gases. The market demand of silica minerals may be very high due to horizontal well drilling by oil companies.

The demand for quartz, silica sand, moulding sand and quartzite is increasing over the years to cater to the requirement of ferro-silicon, silico-manganese, silico-chrome, silica refractories, glass and for moulding and casting purposes. The requirements of these products are linked up directly with iron and steel industry including alloy steel production. Further, setting up foundries and enhancing their capacities are also linked with metallurgical industry.

The consumption of ferro-silicon, quartzite, quartz/silica sand showed increase trend from 2013-14 to 2015-16. It may continue in future due to rise in production in steel sector, infrastructure development, foundry etc.

As per the report of the Sub-Group on 12th Plan, Planning Commission of India, the domestic demand of quartz and silica minerals was estimated at 3.15 million tonnes by 2011-12 and at 4.85 million tonnes by 2016-17 at 9% growth rate.

As on 01.04.2015, the total resources of quartz-silica sand is 3,908 million tonnes and quartzite is 1,659 million tonnes. There are very good prospects of increasing the production and also the export of quartz and silica minerals to the neighbouring countries.