REPORT R44/2004

THE SILICA INDUSTRY IN

THE REPUBLIC OF SOUTH AFRICA

2004

DIRECTORATE: MINERAL ECONOMICS

Washed silica sand

the dme

Department:
Minerals and Energy
REPUBLIC OF SOUTH AFRICA

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Silica

Executive Summary

Quartz is extremely resistant to weathering and is the second most common mineral in the earth's crust.

Excellent recovery rates, extensive mineral reserves and LOM plans, selective mining, minimal over-burden, good product specs, exact blending, low effluent discharge and the lack of tailings dumps epitomize the silica industry. Discards and fines are either reworked or used as construction material.

The location of silica deposits/ producers to manu-facturers and end-user markets is of crucial importance – 87% of silica producers and millers are within 65 kilometres of their major clients. There is much competition [locally] in the lower-end product ranges; the converse is true for the purer, finer grades and speciality silicas.

Silica consumption is a good indicator of growth in steel, construction, GFCF and the macro-economy. Over the last 10 years, the silica industry and its associated industries have been characterized by consolidation, contraction and the discovery of new niche markets. E.g. the mothballing/ closure of five mines and B&E Silica's recent mine acquisitions.

Major markets are metallurgical, glass and construction, accounting for 92.6% of total sales. The metallurgical sector can be subdivided into foundry sands and steel applications, fluxing (non-ferrous), refractories and silicon manufacture. Major markets for fume silica are construction (cement and concrete additives); whilst the ceramic industry is the largest consumer of milled silica.

Over the last 10 years, foundry sand consumption has decreased substantially, due to substitution, e.g. the use of chromitic and chemically bonded sands, and an improvement in spent sand recovery rates.

Over the last three years, producers have shifted their focus to the finished, tailored product – this includes packaging, quality assurance, expedient delivery and customer support. Value addition (i.e. fine sizing, washing, classifying and blending) is a necessity, rather than an exception to the rule. Silica sizing of -100um is a definite prerequisite in the export market.

The industrial sector is moving towards the regeneration and re-use of spent products. This includes the re-use of foundry sands, silica fines and fume silica in construction – as a supplemental cover material at landfill sites, and as an additive in concrete, cement and asphalt paving mixes.

In the construction industry, tile cement, grouting and cement manufacture are niche markets showing tremendous growth potential. Other growing markets include recreational and filter media applications, container glass manufacture and aggregate uses.

In the speciality silica market, international competition is intense. Product differentiation, price, consistency, purity, exchange rate fluctuations, turnaround times and ISO compliancy are crucial success factors in this industry. Inter-product substitutes, international regulations and company consolidations are threats to the Industry.

Fume silica sales are governed by both local and global changes in the chemical, refractories, steel, electronics and civil markets. New niche markets include speciality glass fibres, fuel cell technologies and pigment modifiers. Global fume silica demand has been projected at 30% y-o-y for the next 3 years.

In the silicon industry, electronics and rubber applications are expected to record the fastest gains, spurred by a rebound in the semiconductor market and industrial manufacturing.

Manufacturers and millers focusing on "in-house production" through mine acquisitions (lowering their input costs) and silica producers focusing on downstream beneficiation and products (to improve profit margins) may forespell radical new developments in years to come.

Expected growth in the industry has been forecast at 2,9% (in line with macro-economic growth), however silica exports continue to grow at a phenomenal rate of 36% y-o-y over the last 9 years.

Should the Rand reach the R9,00/$ mark, this may open up large export markets for milled, graded and fume products. Most companies view ISO compliancy as too expensive; but those that have adhered to these criteria have had tremendous success when tendering for contracts both locally, in the SADEC region and internationally.

Untapped markets include the local manufacture of silica gels and sols, fused silica and synthetic silica, which should be significantly cheaper to produce than imported products currently available.

ISHE, 'About Face' and NOSA certification have forced many role players to implement and adhere to stringent health, safety and environmental measures. Silicosis remains a contentious issue in the silica industry.

Black economic empowerment initiatives are set to increase significantly in the next 5 years – particularly around pit operations, material handling, logistical/ transport services and partnerships/JV's.

Importance

Share of industrial minerals sector '02	
Production	3.9%
Revenue	2.9%
Export Value	0.1%
Employment	6.3%
Remuneration	9.1%

Fundamentals

Key Indicators '03	
Market Cap. (R Mil.)	600
Reserve Base (Mt)	550
Production (Mt)	2.8
Capacity (Mt)	3.8
Total Sales (Mt)	2.7
Total Sales (R Mill.) *	200
Exports (kt)	<40
Average LOM	46
Average mine age	28.0
Growth (y-o-y), 2006	3.5%
Growth (y-o-y), 2009	4.0%

Markets '03

Silica (2.7 Mt)		
1	Metallurgical	53.6%
2	Glass	19.6%
3	Construction	19.4%
4	Filter media	3.6%
5	Recreational	2.5%
6	Ceramics	0.9%
7	Other	0.3%

Milled & Fume Silica (72 kt)		
1	Construction	55.2%
2	Ceramics	25.5%
3	Fillers	9.8%
4	Glass	5.2%
5	Refractories	3.6%
6	Other	0.7%

* Excludes fume silica

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Abbreviations

ASTM	American Society for Testing Materials
BEE	Black Economic Empowerment
EMP	Environmental Management Programme
FFS	Foskor Fume Silica
FOB	Free on board
FOR	Free on rail
GFCF	Gross Fixed Capital Formation
kbar	1000 bar
kt	Kiloton (1000 tons)
L	Litre
LOM	Life of Mine
Mt	Megaton (1 000 000 tons)
Nm	Nanometre (1x 10^{-9} metres)
PMC	Palabora Mining Company
PROD.	Production
R/t	Rands per ton (in ZAR)
R&D	Research and development
S.A.	South Africa
SiO_2	Silicon dioxide
Spec	Specifications
t	Tons (1 000 kg)
TiO_2	Titanium Dioxide
µm	Micron (1 x 10^{-6} metres)
y-o-y	Year-on-year
ZTS	Zirconium Titanium Silicate
°C	Degrees Celsius
#	Mesh

Definitions

Brownfield projects include expansions and exploration done on site or in close proximity to current infrastructure.

Greenfield projects include exploration and infrastructural projects located some distance away from the mine and/or plant perimeter.

Silica (SiO_2) occurs naturally as the mineral quartz and exists in any of these five forms: sand, silcrete, quartzites and sandstones, massive quartz derived from veins or pegmatites and quartz crystals from vugs or cavities, and is the principal source of silicon. Microcrystalline varieties of silica include flint, opal, tripoli, chalcedony and kieselguhr.

Silica sand is defined as a material consisting of a minimum 95% quartz grains or particles, of which these particles would contain a silica content greater than 98%. According to ASTM standards, sand is defined as naturally occurring, poorly consolidated silica particles that pass through a 4# and are retained by a 200# US standard sieve

Silicon (Si) can be classified as a metalloid as it shares properties with both metals and non-metals. The atomic weight is 28,6 and the relative density 2,33 at 25°C. Silicon has a grey to metallic lustre, is brittle and has a melting point of 1420°C. Silicon alloys includes ferrosilicon and silicomanganese.

Sol is a colloidal solution or suspension, i.e. a colloid that has a continuous liquid phase.

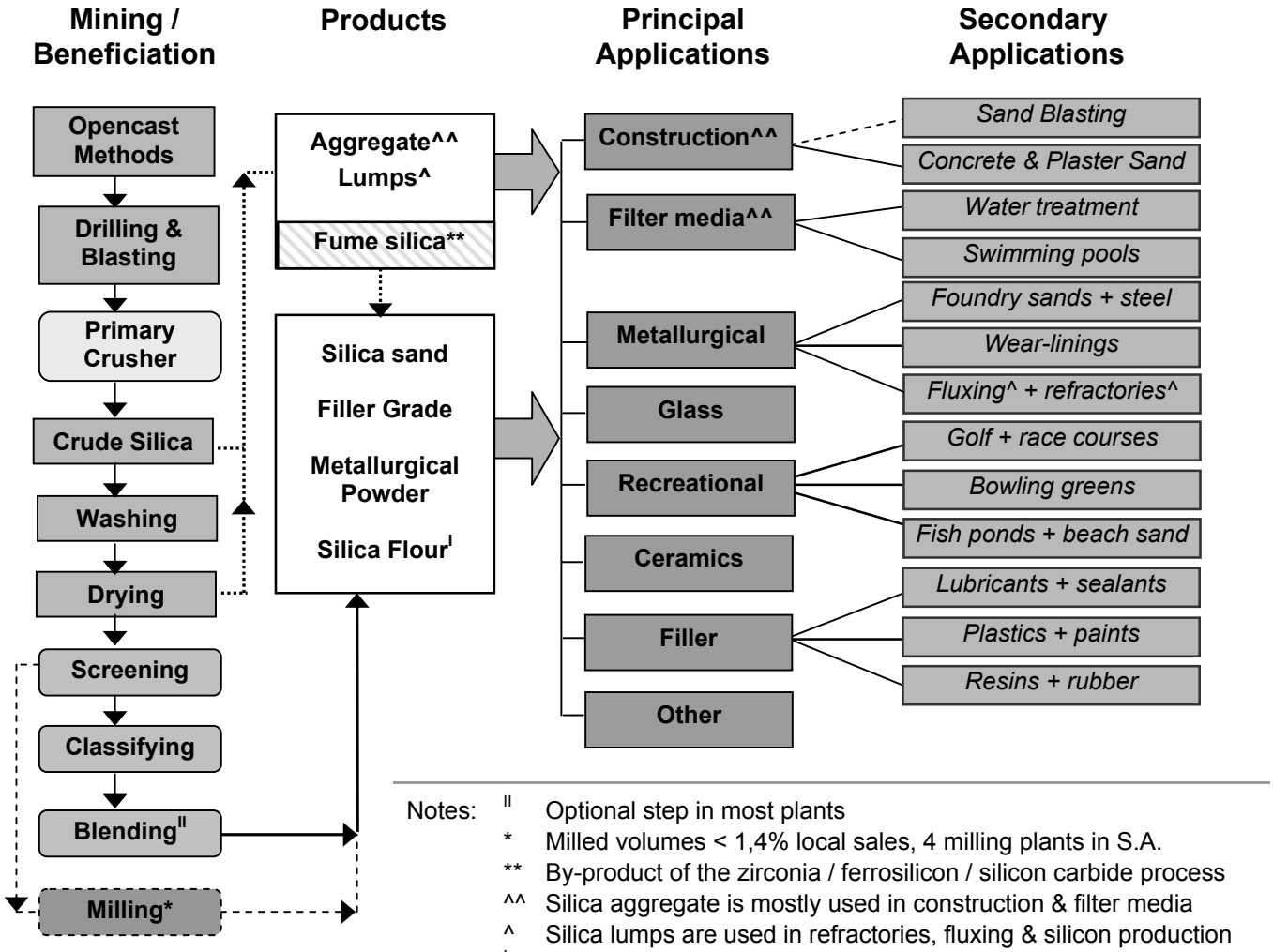
Stucco is a weather-resistant mixture of dehydrated lime, glue and powdered marble or pure silica sand, used in decorative mouldings on buildings.

1. Introduction

Quartz is the second most common mineral in the earth's crust, feldspar being the most common. The mineral quartz forms in a variety of geologic environments, these include crystallization in magmatic rocks (granites); authigenic crystals in sedimentary carbonate rocks; hydrothermal fluid in-filling of veins and fractures; the dissolving and reordering of silica in metamorphic rocks, and deposits from water-based solutions in pockets, voids and breccia cavities.

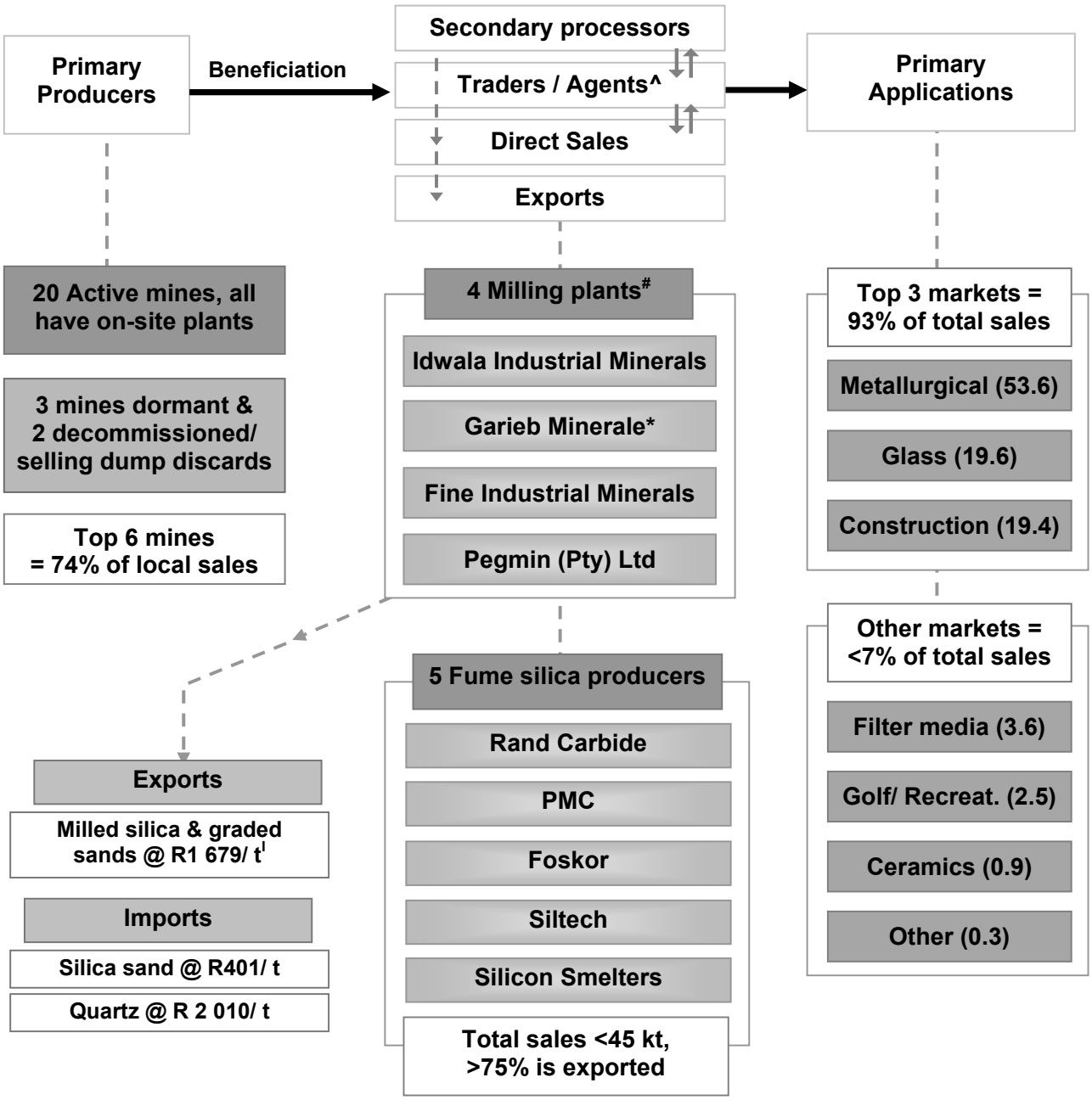
In 2003, there were 20 South African producers of silica (all with on-site plants), 3 dormant mines, 2 decommissioned mines and 5 fume silica producers. Silica is mined by opencast methods and extracted as silica sand or as lumps from pegmatites (frequently as a co-product of feldspar and mica), quartz massifs, veins or quartzites. Silica is produced synthetically, as a by-product of the zirconia fusion process and zirconium basic sulphate process. Silica lumps are first crushed and sized to cobbles, pebbles and finer grades; it is sold in various crude or processed forms and generally has a purity greater than 98% SiO_2. Processed silica is defined as silica beneficiated after primary crushing, which includes washing, drying and screening (i.e. the removal of iron, opaque inclusions and clay). Major markets (in descending order of magnitude) are metallurgical applications, glass, construction, filter media, recreational/ golf sands and ceramics.

2. Industry Flowchart



Notes:
- [II] Optional step in most plants
- * Milled volumes < 1,4% local sales, 4 milling plants in S.A.
- ** By-product of the zirconia / ferrosilicon / silicon carbide process
- ^^ Silica aggregate is mostly used in construction & filter media
- ^ Silica lumps are used in refractories, fluxing & silicon production
- [I] Flour is used in enamel coatings, pottery flint, abrasives & fillers

3. Industry and company structure[II]

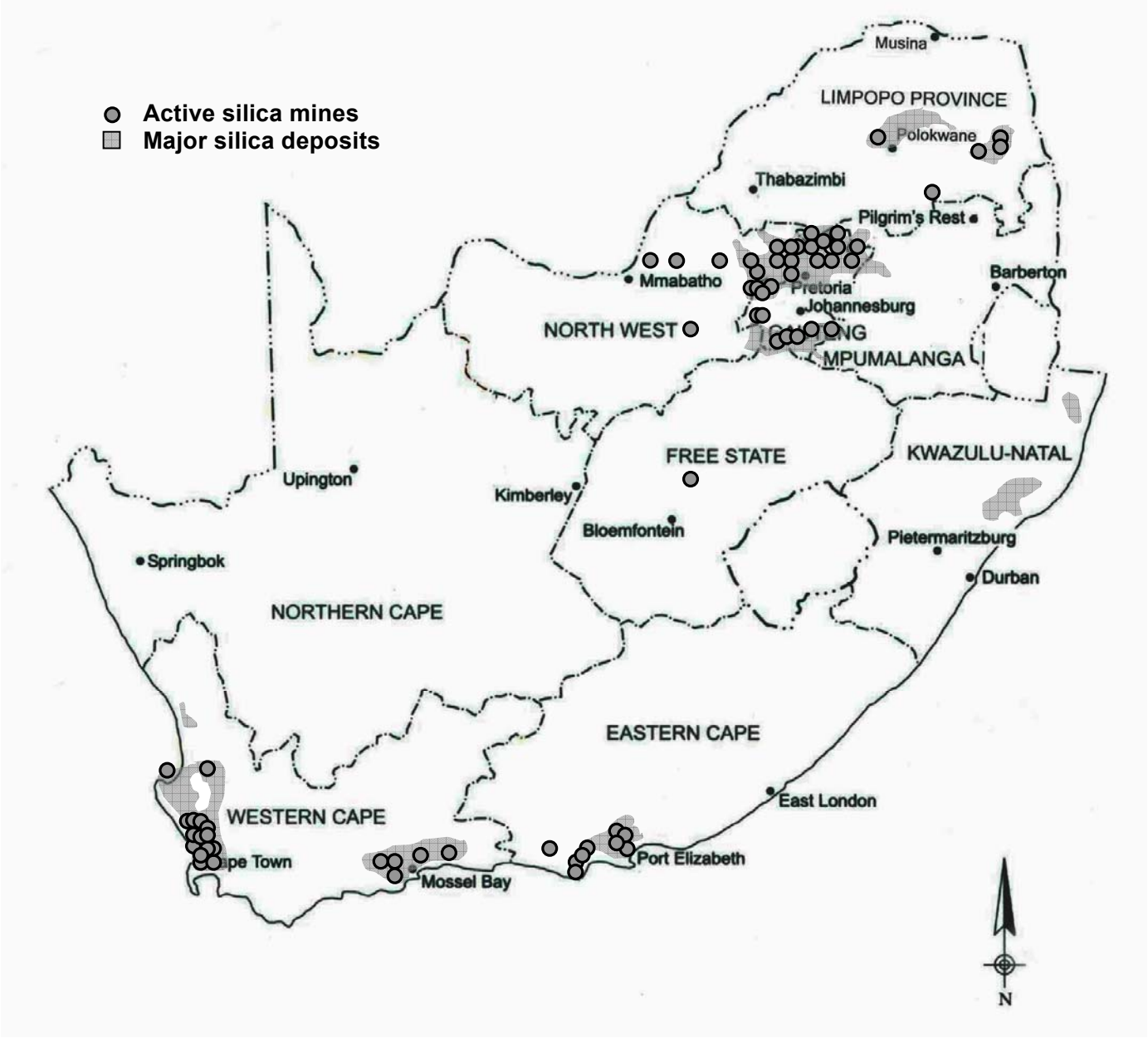


Notes:
- [II] As at 31 December 2003
- # Plants which produce fine, milled grades of silica (75-200µm)
- ^ Sells silica without any value addition or further beneficiation – no accurate information is available
- * Silica production line shut down temporarily
- [I] FOB prices

4. Raw Material

Quality sand deposits, proximally located to the construction, foundry and glass industries in the Western Cape have encouraged the exploration and extraction of silica in this region (Diagram 1). Similarly, quality quartzitic deposits in the Mpumalanga and Gauteng regions have provided a large reserve base for nearby glass, ceramic, foundry and steel, refractory and construction industries.

DIAGRAM 1: Simplified map of South Africa's major silica mines and deposits



Adapted, Council for Geoscience map

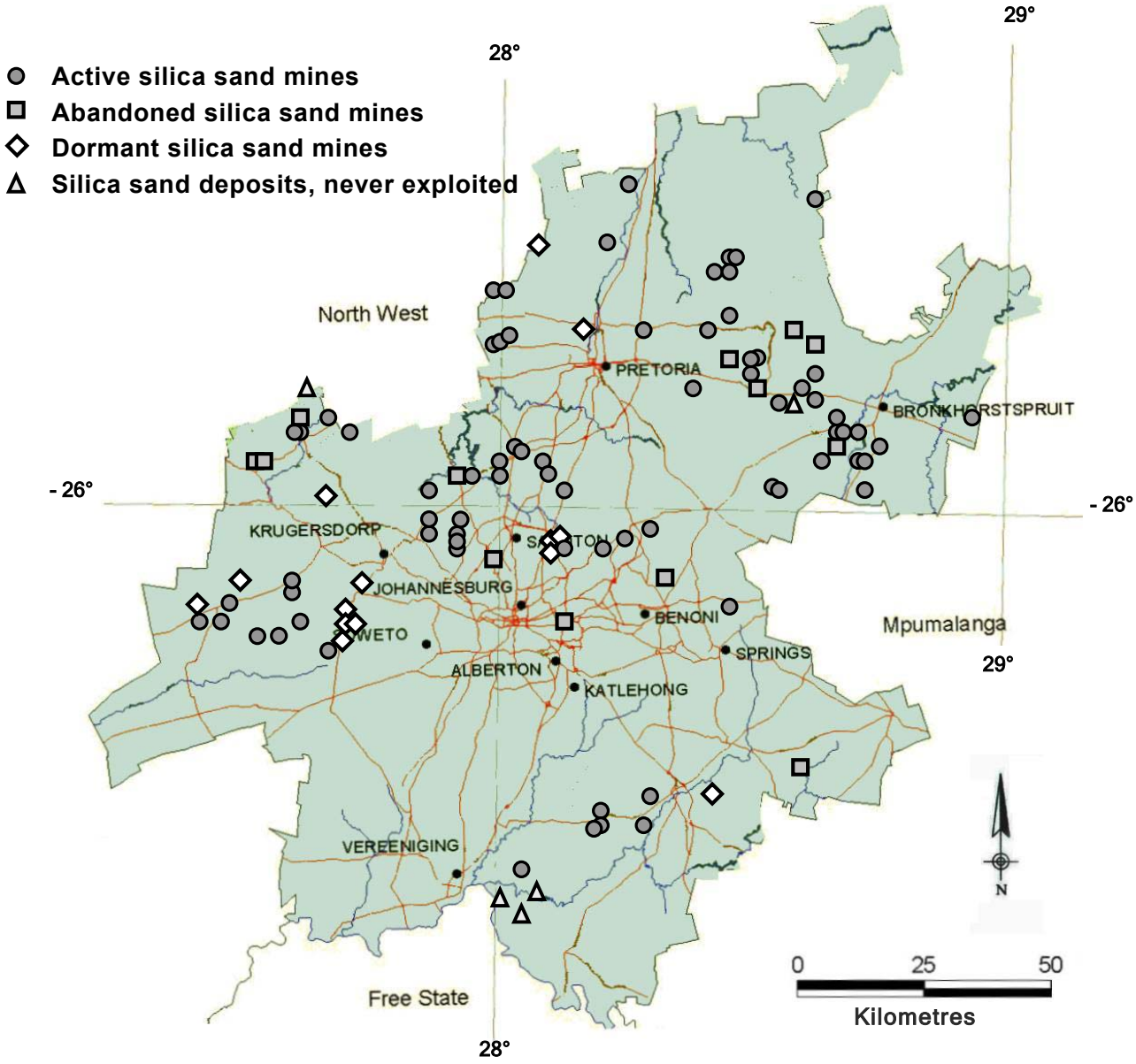
4.1 Silica sand

Industrial sand and gravel, often called "silica," "silica sand," and "quartz sand," includes sands consisting of a minimum 95% quartz grains or particles, each of >98% silica.

Silica sands are generally low in clay, iron and chrome content; and consist of sub-rounded grains. Sands are first washed to remove clay, then sized to separate coarse from fine-grained materials. Further beneficiation may entail removal of iron, opaque inclusions and other accessory minerals.

In the Gauteng region, medium-sized deposits exist in the north and westerly areas around Pretoria, but have either been exhausted, or built up by sprawling urban developments (Diagram 2). Most of the high-grade silica sand that is used by glass factories, occurs in the Western Cape, particularly in the Pinelands-Philippi-Strandfontein district.

DIAGRAM 2: Simplified map of Gauteng's silica sand mines and deposits



Other high-quality deposits in the Cape Peninsula include the Brackenfell-Faure, Vishoek-Noordhoek, Hopefield-Elands Bay, Atlantis and Kleinmond areas. Silica-sand deposits of variable grade include those near Kwa-Nibela and Mmbazwana, Fernwood and Mtubatuba in the Lower Umfolozi District (KwaZulu-Natal); Barkely Bridge and Nahoon deposits (Eastern Cape); near Ottoshoop in the Lichtenburg district (North West province); to the east of Potgietersrus as well as near the Nylstroom Townlands (Limpopo province).

4.2 Silcrete

Silcrete consists of a mixture of crystalline and amorphous silica, comprising a dense, yellowish rock containing up to 98,4% SiO_2, with up to 3,4% TiO_2 as the main impurity. Two major profile types in South Africa are the weathering profile type (e.g. silcretes of the Cape coastal zone) and the non-weathering profile type (e.g. silicified calcretes and evaporite pans). Silcrete from the Mossel Bay and Riversdale Districts were once used for the manufacture of silica refractories.

4.3 Quartzites, Massive quartz and Quartz crystals

Quartzites are classified as either orthoquartzites – sedimentary, quartz sands derived from secondary silification; or metaquartzites – metamorphic rock consisting mainly of quartz, formed by the recrystallization of sandstone or chert. Massive quartz occurs in hydrothermal veins and in pegmatites.

High-quality deposits are found in the Mica district (quartz pods and cobbles) near Phalaborwa, whilst pegmatites, quartz veins and cobbles are found in a band stretching between Polokwane-Tzaneen-Phalaborwa. Other significant deposits include those in the Sangqhu River Valley (near Port Shepstone), quartzite bands in the Nababeep area (near Springbok); in the Magaliesberg Formation between Silkaatsnek and Breedtsnek (North West), east of Pretoria on the farm Donkerhoek, as well as in the Delmas, Bronkhorstspruit, Belfast and Steelpoort areas.

4.4 Fume silica

Fume silica (or micro-silica) is a by-product of the zirconia electro-fusion process at Foskor Ltd. The primary feedstock, zircon sand and silica, are fused at >2 800°C to produce various grade of fused zirconia. The by-product, silica-rich fume vapours, are cooled, condensed and silica recovered via the baghouse extraction system.

Fume silica is also a by-product in the production of silicon and ferrosilicon alloys, as at Rand Carbide, Silicon Smelters and Silicon Technologies (Siltech). High-purity quartzite is reduced with coal and char at very high temperatures; the furnace gases are then cooled and filtered; the filtered product being fume silica.

4.5 Zirconium titanium silicate (ZTS)

ZTS is a by-product of the Zirconium Basic Sulphate process at PMC. Zircon sand and silica are used as raw materials. Previously, PMC supplied the market with baddeleyite, but with the switch from opencast to underground mining, declining baddeleyite grade and lower tonnages being handled, the company replaced its baddeleyite products with zirconium sulphate. Zircon concentrate is now purchased for this purpose.

4.6 Synthetic silica

In recent times, synthetic crystals have replaced naturally occurring quartz crystals. Large, synthetic crystals can be grown under hydrothermal conditions, using a solution of soluble quartz at

temperatures of 400°C and a pressure of 1,6 kbar. The basic raw materials for synthetic silica production are: 1) high purity silica sand and 2) aluminium tri-hydrate, as sources of silicon dioxide and alumina respectively. Four other important components used in the process are sodium carbonate, sodium and potassium hydroxide and sulphuric acid.

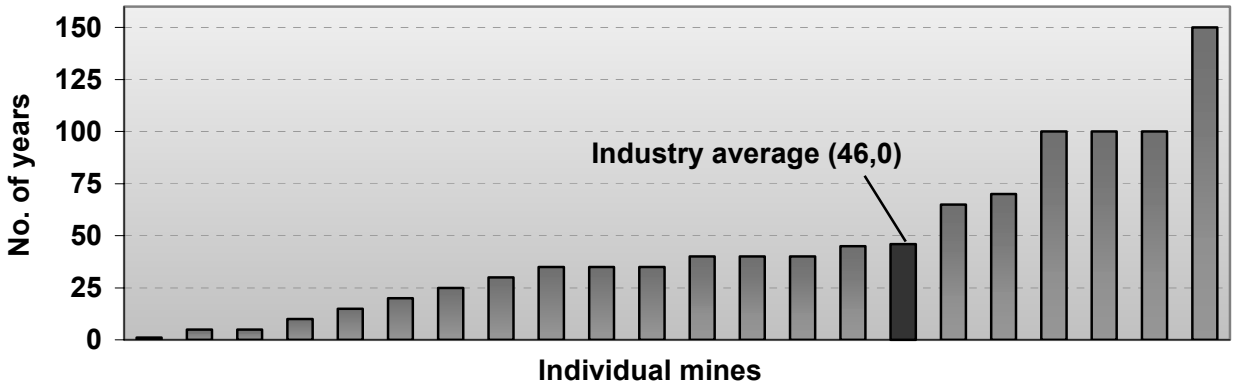
Silicon dioxide is formed by the polymerisation of a sodium silicate solution. Two primary manufacturing processes are 1) silica gels made from a sol under acidic conditions, and 2) precipitated silicas produced in alkaline media using stirred reactors.

5. Reserves and Resources

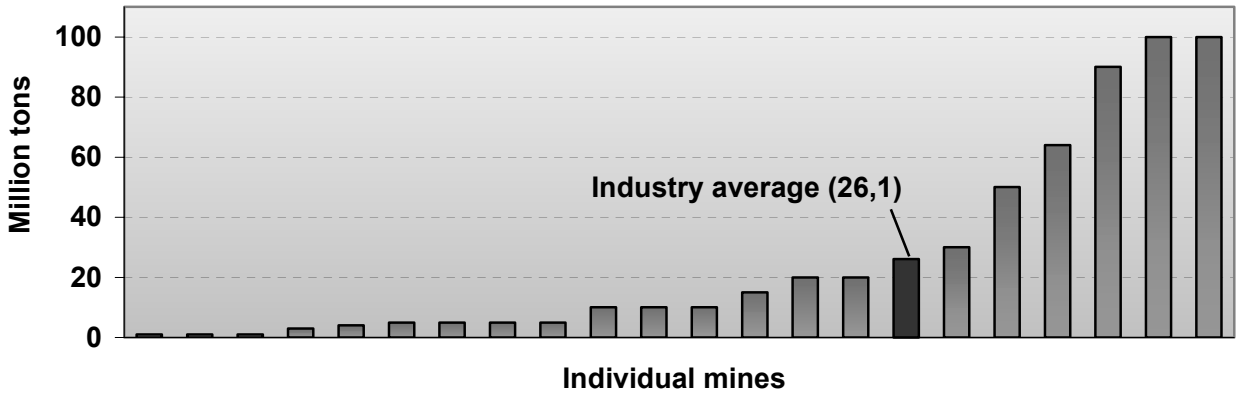
The industry is epitomized by a high rate of ore recovery – close to 95%, with lengthy LOM plans and large reserve bases. Some LOM plans are in excess of 90 years at a y-o-y growth rate of 15% (Graph 1). Commercial reserves, based on mine estimates, have been calculated at 550 Mt, averaging 26,1 Mt per mine (Graph 2). The industry average for LOM plans is 46,0 years.

Two producers mine at least 4 pits concurrently – quarry to primary crusher distances varying from 1-40 km, depending on the LOM and quality of the individual deposit. Selective mining is practised throughout the industry, especially regarding overburden disposal and iron content in vertical layering, e.g. At Samquarz, orebody characterization is important: vast tracts of chert overburden are stripped, crushed and graded, producing a saleable, aggregate mix that can be used in metallurgical applications; purer, individual layers are exploited for specific markets – metallurgical, amber- and clear glass grades.

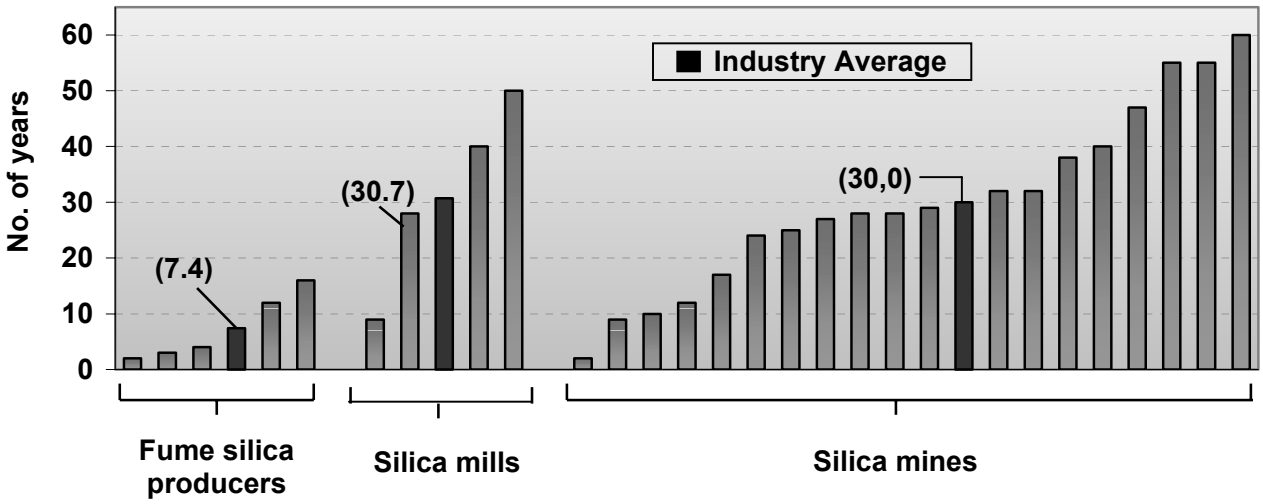
GRAPH 1: LOM of silica mines, 2003



GRAPH 2: Commercial reserves of silica (based on mine estimates), 2003



GRAPH 3: Average age of silica mines, mills and fume plants in South Africa, 2003



The average age of all silica mines, mills and plants in South Africa is 26,2 years. In Graph 3, fume silica producers are the newest entrants to the speciality silicas market, the average age being 7,4 years (range: 1 - 16 years). The average age of silica mills in the industry is 30,7 (range: 9 - 50); whilst that of silica mines is 30,0 (range: 9 - 60).

6. Pit and Plant Processing

Beneficiation includes processes that produce a finer silica fraction, higher purity and minimal residue.

The type of deposit prescribes the mining method used, i.e. a solid quartzitic rock formation may require drilling and blasting, whereas Consol's silica deposit at Philippi is mined using dredging methods. Other silica sand deposits are exploited by means of conventional earthmoving equipment. Processing includes primary and secondary crushing, washing, drying, screening, classifying and possibly blending. Three mines use hydro jet-sizing and spiral concentrating in their beneficiation process. Milling is an additional step, although there are only four millers in South Africa.

The damage on chutes, wear-linings and pipes is more pronounced with deposits containing sub-angular to angular quartz grains; additionally, finer fractions are needed when transporting this particular product in slurry form in and around the quarry or plant area.

Very few producers have entered the milling arena as a) it is costly due to the abrasive nature of silica; b) the market is too small to justify any new entrants; c) wet milling (which improves dust suppression), requires large water reserves and capex.

Small-scale operators rely on labour-intensive hand-sorting techniques to extract silica (usually from pegmatites and veins) – of the finest grades are extracted in this way. Two producers have found these labour intensive processes unprofitable, but cannot upgrade, as capital costs are too high. Some producers have resorted to drying their final product by replacing cooling cylinders with wind-cooling systems or solar evaporation.

There has been a distinct need for mechanisation, from slurry feeds in the mine pit to bagging and handling systems, e.g. the installation of automated bagging machines has improved bagging efficiencies at B&E Silica by 110%. Automated bagging is not only safer, but also reduces the human handling error.

On-site laboratories and thorough quality control checks (both internally and externally) are standard in the industry. At several plants routine quality checks are done every 1-2 hours; the other extreme being once a day. Storage limitations have been critically reviewed and revamped by at least 4 producers in the last year – this includes elevated, divisional walls and protective covers (fixed roof structures and/ or tarpaulins) in storage sheds or zones. These added features have allowed producers to maintain accurate specs, minimize contamination and reduce airborne loss of graded products.

Almost all plants operate on a 24hr basis, whilst pit operations work a 12-18hr day, normally divided into 2 or 3 shifts. Fourteen out of 17 mine managers interviewed have stressed that they would like to run a 24hr pit and plant operation within the next 1-2 years.

Environmental problems have been reduced significantly through dust control management and prevention – wetting of pit roads and the use of scrubbers and dust collectors in final stage processing. Conveying techniques have also improved dramatically – the use of slurries (larger fractions) and vacuum pumps (finer fractions) have reduced the human handling error and significantly improved efficiencies.

The use of water as a cleansing agent, most often in a closed water circuit, is commonplace in the industry. Water as a carrier (in a slurry) is receiving marked attention. Two companies have contracted out their R & D and ten companies do in-house R&D. Nonetheless, most silica producers do not actively pursue new ventures or niche markets.

At B&E Silica's Groenfontein Quarry, the crushers have been overhauled recently, boosting capacities by 33%. B&E Silica has also bought the Bronx Mine (formerly owned by Ecca Holdings) and Spitzkop Silica (formerly owned by Highveld Steel), in October 2003 and January 2004 respectively. It is one of the top 3 silica producers in South Africa, and is part BEE-owned.

Samquarz (Delmas) has invested R100 million in its plant over the last three years, of which R39 million was acquired through donor funds from Germany. Upgrading included an overhaul of the primary crusher, buffers, secondary crusher, screening and classifier plant. The commercial lifespan of the mine is 45 years.

In-depth Industry Description

7. Product Overview and Applications

Particle sizing, uniform grain size, purity (above 98,0% silica) and low alumina, lime, iron, and magnesia contents are important in feedstock composition. Average particle size range for lumpy silica is +16 to -100mm, silica sand 4mm to -0,3mm and silica flour -75µm.

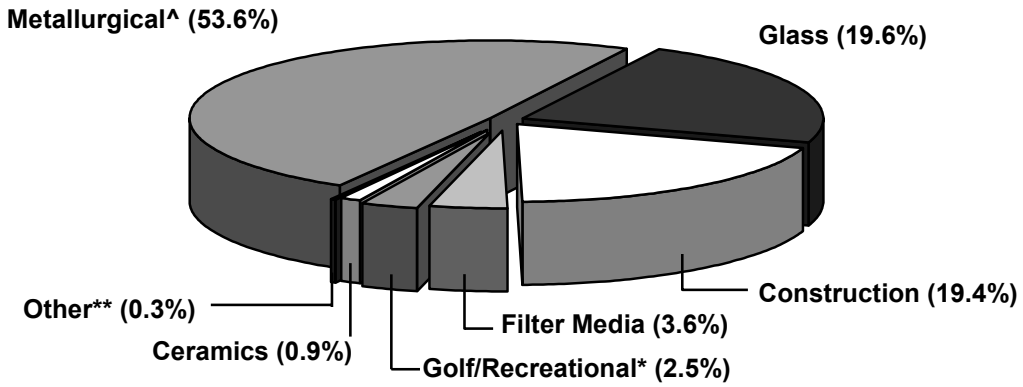
The inherent whiteness, abrasion resistance, heat resistance, angularity, strength and inertness of silica has proved it to be an excellent product in filter media, compost manufacture, fillers and extenders, cement and concrete applications, soaps, general abrasives, glass and fibreglass, ceramics, adhesives and sandblasting.

Most pegmatite-mining companies focus on feldspar extraction (higher profit margins), silica being more a contaminant than a saleable product. Pegmatite miners, small-scale miners and fume silica producers, generally sell less than two or three silica grades. Silica sand product ranges are far more extensive – some have up to 50 different product grades available.

Lumpy silica producers generally sell less than 6 products, though most steel and fluxing applications require large silica cobbles ranging from +16 to -150mm. Flexibility is important too – three producers have noted that they are prepared to make a specific product (which may be out of their spec range), on condition that the clients purchase at least 30 tons per week for a predetermined period.

GRAPH 4: Primary markets, by volume, for all silica products in 2003

Total: 2.73 Mt



Notes:
- ^ Includes fluxing applications, foundry sands, refractories and silicon manufacture
- * Includes stadium and school fields, bowling greens and race courses
- ** Includes fillers, extenders and sandblasting applications

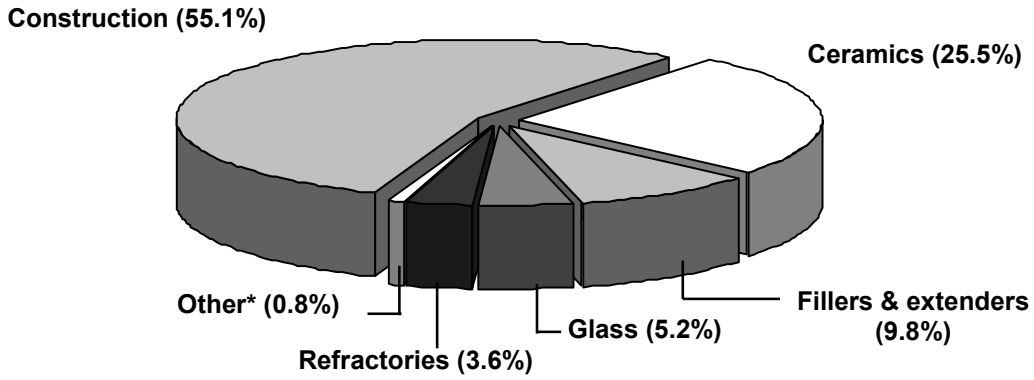
Graph 4 shows the metallurgical industry to be the main consumer of silica (53,6%). This comprises:

- Foundry sands and steel manufacture (29,7%)
- Silicon and ferrosilicon production (12,2%)
- Non-ferrous fluxing applications (8,7%)
- Refractories (2,9%)

The glass industry (2nd largest silica consumer) has increased its market share marginally from about 18% in 1991 to 19,6% at present. The construction industry (which includes tile grouting and adhesives, plastering, cement and aggregate) is the 3rd largest consumer market (19,4%). Applications for filter media and recreational sands have grown from marginal to major markets in the last 10 years.

GRAPH 5: Primary markets, by volume, for milled & speciality silicas (<200 µm), 2003

Total: 72.0 kt



Notes: * Includes fluxing, chemical and golf/recreational sand applications
II Filler applications include rubber, plastics and paint

Graph 5 shows the biggest consumers of milled and speciality silicas to be the construction industry (55,2%), followed by ceramics (25,5%), fillers and extenders (9,8%) and glass (5,2%).

7.1 Metallurgical industry

Over the last 20 years, there has been a significant change in market consumption and applications. The shift has been most pronounced in foundry sand consumption – some companies recording a gradual reduction of up to 50% in their foundry market sales.

An improvement in spent sand recovery; the changeover to chemically-bonded resins, chromitic sand substitution, less steel being produced per capita and composites replacing steel in some applications, have had a detrimental effect on foundry sand sales. This has been partly offset by increased demand for foundry sand for castings from the automobile industry; a result of impressive export initiatives in this industry.

7.1.1 Foundry and casting

In the foundry industry, silica products are traded under certain prerequisites: a) consistent supply of feedstock, b) accurate specs and c) ambient temperatures below 35°C. ***Silica lumps*** are used:

- as a flux in the manufacture of silicon, charge chrome, steel and ferrosilicon,
- in the manufacture of silica bricks for high-temperature refractory furnace linings, and
- as linings in ball and tube mills.

As a flux, silica removes impurities in the smelting of base metal ores. Iron and basic oxides react with silica, becoming calcium magnesium-iron silicates (slag).

TABLE 1: Average/ typical chemical composition of local silica products*

Chemical composition	Local producers** / mines													
	B & E Silica, Delmas Mine	Bronx Mine, amber glass	Consol Limited Glass sand	Donkerhoek Quartzite	Eggo Sand B3	Fine Industrial Minerals	Garieb Minerale, Silica 325[l]	B & E Silica, Spitskop Mine	Idwala Industrial Minerals	Silicon Smelters (Invensil)	Noel Lancaster Sands – dry	Pegmin – Milled, 200 mesh	Samquarz, D13 28/ 310	Container glass SiO_2 specs
SiO_2	99.1	99.2	99.7	98.1	99.6	98.5	99.2	97.4	99.8	99.5	97.8	99.3	99.5	>99.5
Al_2O_3	0.4	0.2	<0.1	0.9	0.0	0.8	0.1	0.9	<0.1	<0.1	0.8	0.3	<0.1	<0.1
Fe_2O_3	0.5	<0.1	<0.1	0.2	<0.1	0.1	0.1	0.5	<0.1	<0.1	0.4	<0.1	<0.1	<0.1
CaO	<0.1	0.1	<0.1	0.0	<0.1	<0.1	0.1	0.0	<0.1	<0.1	0.2	<0.1	<0.1	0.1
Na_2O	<0.1	0.0	na	0.0	0.0	<0.1	0.1	0.2	<0.1	na	na	<0.1	<0.1	<0.1
MnO	<0.1	<0.1	na	0.0	0.0	0.0	<0.1	na	<0.1	<0.1	na	na	<0.1	<0.1
MgO	<0.1	0.0	<0.1	0.2	0.0	<0.1	0.0	<0.1	<0.1	<0.1	0.1	na	<0.1	0.1
Moisture	na	na	<0.1	na	na	<0.3	0.0	na	na	na	0.5	na	5	na
LOI	<0.1	0.2	0.2	na	0.1	0.3	0.3	na	<0.1	na	0.8	0.2	<0.1	<0.3

Notes:
- * Silica product details from Sullwald Transport (part of PMC), Okiep Copper and Tubatse Quartzite have been excluded, as all silica material is sold or transferred internally; Atlantis Sand Sales' chemical analysis not available
- ** Public listings and details of controlling companies details have been omitted
- na Not available
- [l] Garieb Minerale's silica production line has been temporarily suspended
- Typical values, rounded off

Foundry sands are used to make both ferrous (iron and steel) and nonferrous (copper, aluminium, brass) metal castings. The most common casting processes used in the foundry industry are green sand casting and chemically-bonded (resin-bonded) casting. Large-scale plants producing bulk, low value castings rely almost exclusively on the green sands casting process.

Chemically bonded casting is favoured for high value, low volume precision castings, as it is about $1/10^{th}$ the capex cost of green sand casting. Operating costs are significantly higher and recovery of spent sand much lower (<80%) in chemical-bonded casting, whilst recoveries in green sand casting can be up to 98%.

Feedstock for the green sand process consists of high-quality silica sand; about 10% bentonite clay (as binder), 2 - 5% water and about 5% coal dust or starch (which improves the casting finish). The type of metal being cast determines which additives and what gradation of sand is used.

Chemically bonded sand cast systems require one or more organic binders (usually proprietary) in conjunction with catalysts and have different hardening/setting procedures. Typically, about 1 ton of foundry sand is required for each ton of iron or steel casting produced.

The grain size distribution of foundry sand is very uniform, with approximately 85 to 95% of the material in the 0,6 to 0,15 mm size range; and 5 to 12% smaller than 0,075mm. The particle shape is typically sub-angular to angular. The use of fine sand improves the smoothness and the dimensional accuracy of the casting's surface. However, fine sands dramatically reduce mould permeability, thus increasing 'blowout' and cracking.

Moulding sand is sand used for making moulds – these sands are not designed for permanent use in constructions. ***Core sands*** are sands used to fill the cores or hollow spaces in castings. Chemically bonded systems are most often used for "cores" (used to produce cavities that are not practical to produce by normal moulding operations) and for moulds for nonferrous castings.

7.1.2 Chrome, copper and silicon alloys

In chrome beneficiation, lumpy silica varying in size from 80 - 150 mm is added to chrome slag for four reasons: a) it forms the acidic component of the slag, b) improves fluidity, c) it lowers and allows for better control of liquidus temperatures and d) it naturally binds or coalesces slag impurities. The final product, charge chrome, may have a chrome content of about 50% and a silica content of up to 3%. In copper beneficiation at PMC, lumpy silica is used as a flux. In silicon manufacturing, smaller silica fractions improve surface area (promoting faster reaction times) and quickly isolate impurities in the silica itself.

Silicon metal is produced from lumpy silica that is carbo-thermically reduced in arc-furnaces at high temperatures. The feedstock must be exceptionally high in purity and low in alkalis (especially potassium). The three principal uses of silicon metal are in the metallurgical, chemical and electronics industries. Silicon is a common additive in aluminium casting alloys, as it enhances fluidity, increases resistance to hot-cracking and improves pressure tightness.

Silicon metal is also used to produce silane chemicals from which more than 1 000 silicone resins, lubricants, anti-foaming agents, plastomers and water-repellent compounds are derived. Electronic applications and specialty applications include photovoltaic cells for solar energy conversion and semiconductors, superconductors and integrated circuit technologies (silicon chips). The semi-conductor and chemicals industry has shown significant growth with silicon metal consumption increasing at an annual rate of 5-8%.

TABLE 2: Raw material volumes required to produce 1 ton of silicon and ferrosilicon

Silicon	(in t)	Ferrosilicon (FeSi 75)	(in t)
Silica (lumpy quartz)	2.6	Quartz	1.8 - 2.0
Wood chips	1.5 – 2.0	Iron turnings	0.23 – 0.26
Petroleum coke	0.5	Carbon	0.7 – 0.9
Low ash coal	0.37	Soderberg paste	0.055 – 0.07
Charcoal	0.25	Electrical energy (kWh)	8 500 – 10 000
Pre-baked electrodes	0.1		
Electrical energy (kWh)	13 000		

Ferrosilicon and ***ferrosilicomanganese***, alloys produced from silicon, are used principally in steel-making (Table 2). Ferrosilicon is most effective in the deoxidation of molten metal, the transfer of elements (such as chromium) from the slag and as a source of energy through exothermic reactions. In steel manufacturing, silicon alloys increase the tensile strength and electrical properties of steel and improve resistance to corrosion and high temperature oxidation. Further, it

acts as a graphitising agent in the production of grey and ductile iron used in foundry applications. ***Copper-silicon*** and ***aluminium-silicon*** alloys are important for strength, malleability and corrosion resistance in steel-making applications.

Demand for silicon metal depends largely on the international markets for aluminium castings and for silicon chemicals. Demand for ferrosilicon is closely allied to developments in the global steel industry. South Africa is a minor role-player supplying in the region of 5,5 percent to both these world markets. Silicon metal prices are dependant on the purity of/or contained silica. For every ton of steel produced, about 2,5-5kg of ferrosilicon is needed.

Companies involved in the proposed Saldanha silicon smelter project (worth about R440 million), include: Novamet (Italy), Industrial Development Corporation (IDC), Pyromet (SA smelting technology experts) and Eskom. Using quartz mined near Van Rhynsdorp, approximately 160km north of Saldanha, the smelter will produce silicon metal. Initial production capacity would be about 23 kt per year with a maximum capacity of 50 kt per year.

7.2 Glass industry

All South Africa's glass-sand demand is met with:

a) high-purity crushed quartzite from the Delmas-Bronkhorstspruit area and
b) Consol's sand deposits in the Western Cape.

The increase in soft-drink, wine, spirit-cooler, fruit juice and beer consumption (which is also highly seasonal) has had a knock-on effect in glass manufacture and silica requirements. Spirit-coolers, bottled fruit juice and the fashionable "drinking out a bottle" trend have boosted glass sales tremendously.

This has been slightly offset by recycling, substitution and lightweight containers – the same bottle can be used up to 30 times before it is replaced/ remelted; whilst 1,25L returnable bottles can be re-used up to 40 times before recycling. Nonetheless, glass substitution through plastics (especially polyethylene terephthalate) is rapidly gaining consumer acceptance.

Lightweight containers, requiring less silica per bottle produced, have eased pressures on silica feedstock orders. The iron content of silica for flintware products (wine, spirits, spirit-coolers and food containers) should be less than 0,025%, but ideally between 0,015 – 0,020%. Green and amber containers require silica with an iron content of 0,012% or lower.

Major container glass producers in South Africa are Consol (with 4 plants, Wadeville, Pretoria Olifantsfontein and Bellville), Nampak (1 plant in Germiston) and Metalbox. Flat glass producers include Pilkington Flat Glass and minor role players, Kempton Clear Glass and Royal Kempton Glass.

In South Africa about 600 kt of container glass is produced per year; of this, about 19% (115 kt) is recycled or removed from the waste stream. This compares favourably to countries such as Britain (25%), but is significantly less than that of Germany (88%) and the Netherlands (90%). Regarding flat glass, about 170 kt is produced a year, of which approximately 15% is recycled. The iron content of silica feedstock for flat glass should be less than 0,03%.

The use of cullet* as feedstock has not affected silica consumption in the flat glass industry; nonetheless, the container glass industry has benefited from recycling and re-use, which in turn has reduced production costs and marginally lessened demand for silica feedstock.

Consol are expanding their glass factory output, at a cost of R200-240 million. This is a brownfields capacity-expansion project near Wadeville. Glass production capacity increase of 15% is to be expected, with growth mainly focused on the soft-drink market.

One of Consol's long-term greenfield projects includes the relocation of its Philippi operation, and the further delineation of silica reserves in under-developed parts of the Western Cape.

A new technique in effluent water treatment has been developed in Japan, using glass bead bubbles, with a high TiO_2 content, which float on water. The photo-catalytic properties of the TiO_2 break down organic pollutants and bacteria in water. This technology can treat wastewater for about 10% of the cost of conventional methods.

Note: * Cullet is broken or whole scrap glass in a form suitable for remelting. Unprocessed cullet varieties include flint (clear), amber (brown), and green (emerald).

7.3 Construction industry

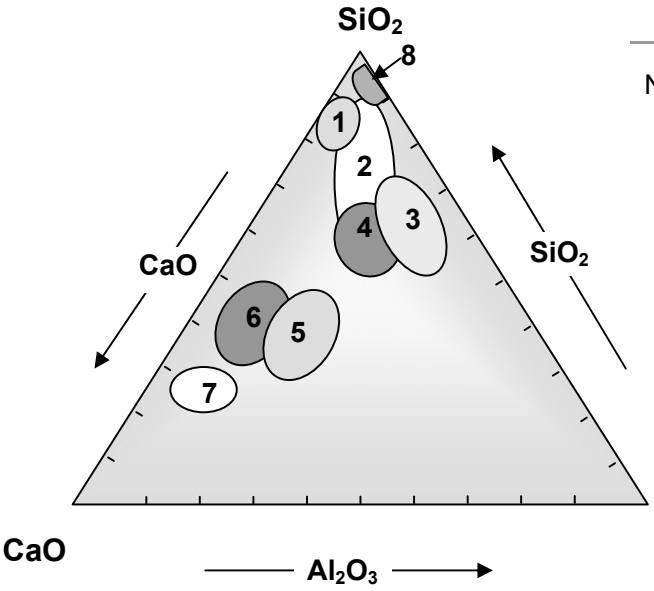
The boom in the construction industry has seen indirect increases in silica consumption as:

- a filler in grouting, plastering, paint, cement and concrete,
- a sealant in roof tile coatings and acid-proof flooring,
- an aggregate

In the last 5 years, silica sand and fume silica, as a cement additive or pozzolanic material, have become increasingly popular in speciality- and high-strength cement applications (Diagram 3).

Crude silica, sold as an aggregate, has also shown strong sales increases, especially in urban developments and road construction around Midrand, Pretoria-East and Randburg, as well as in 'aggregate-deficient' areas, e.g. the northern extremities of the Limpopo and Northern Cape Province.

DIAGRAM 3: Representation of the principal cementitious materials in a ternary diagram



Notes:
1 Glass
2 Natural pozzolanic
3 Class F fly ash
4 Clays
5 Class C fly ash
6 Slag
7 Portland Cement
8 Fume silica (Si and Si Fe compounds)

New value-added products include sanded tile grout – a blend of Portland cement, silica sand, colorfast pigments, and organic and inorganic chemicals. Important characteristics of tile grout include ease of workability and clean-up, rapid curing, high bonding, low shrinkage and uniform color control.

In the building industry, downstream product ranges that require silica sand and -flour include traction-, paver sands, self-levelling floor resurfacers, fibreglass reinforced stucco and waterproofing applications (such as glass block mortar). Glass block mortars are a blend of white sand, cement, lime and special additives designed to provide a decorative, waterproof joint. Industrial sealants and bonding mortars are a blend of Portland cement, fibreglass fibres and special additives. Heavy-duty sealants and surface bonding mortars are used underground:

- To seal air leakages,
- As a structural coating on mortarless walls, and
- To construct mortarless walls for strength and air routing.

Example: QUIKRETE GUN-ite MS™ is a dry process shot-creting material containing fume silica, and is specially designed for repairing above- or below-grade concrete and mortar. Distinctive features of this gunite are its high strength, high adhesion, low permeability, low rebound and low sag. It can also be made with alkali-resistant glass fibre or other types of fibre-reinforcement.

7.4 Silica flour

Silica flour is a natural, milled, crystalline silica, used in the ceramic industry for enamel and pottery flint. It is also used as inert filler in rubber, abrasive soaps and powders, paints and glass.

After many stagnant years, the ceramics industry has recently shown tempered growth – this has been attributed to ceramic import substitution, good marketing and world-class ceramic and sanitaryware production plants coming on-stream. Nanoscale silica (finely divided silica, less than 0,1 - 0,02µm) is finding increasing market acceptance. Double-digit growth, though off a low base, is expected in this industry in the medium and long term.

Barring ceramic-grade silica increases, milled silica demand has tapered off in the last 8 years and little growth is expected in the medium and long term – this is associated with the capped market for fine silica in ceramics, high energy costs incurred, the use of other fillers and extenders and the substitution of fine silica for cheaper, coarser silica grades. Variable growth is expected in niche markets such as paint and glass.

7.5 Fume silica

Fume silica is a fine, solid, white to grey pozzolanic powder (<75µm) containing non-porous particles of amorphous silica. Bulk densities vary between 180-800 kg/m^3 for densified, semi-densified and undensified products; with an average particle size of 4-8 µm and surface area of 13-20 m²/g. Carbon content is generally below 5%.

Fume silica is used in the production of silicone, sealants, elastomers, carbon-black substitution in tyres, technical rubber articles, emulsion paints and chemicals, in refractories, cements and masonry applications.

The large surface area, low density ratios and high silica, carbon and zirconium content of fume silica make it ideal for high-strength applications, such as construction, reinforced fibreglass and composite plastics. Accelerated growth is expected in fume silica sales in the construction sector, where it is used as a modifier in the production of fibre-cement, concrete and ferro-concrete articles.

The addition of fume silica in cement and concrete:

- Prevents high temperature strength retrogression,
- Acts as a buffer to volatile components forming, and
- Promotes quicker setting rates.

Fume silica sales are governed by both local and global changes in the chemical, refractories, steel, electronics and civil markets. In South Africa, fume silica exports generally vary between 50-85% of individual companies fume production.

It is expected that more advanced civil applications will be developed for fume silica in the near future. While still in the R&D phase, markets such as fuel cell technologies, speciality glass fibres and pigment modifiers, may show exceptional growth in the near future.

Composite plastics/ glass-reinforced plastics are gaining market acceptance in tough operational, mining environments. Glass-reinforced plastics are used because of their high quality, versatility and endurance in corrosive conditions – they do not rust, rot or chip. Current trends suggest that more densified fume silicas are replacing lighter or undensified fume products.

TABLE 3: Average/ typical chemical composition of fume silica products

Chemical composition	Local producers** / mines						
	Siltech SIL FS	Rand Carbide Fume	SS^ - densified	FFS[I] – Refractory B	FFS[I] – Civil C	FFS[I] – Chemical D	PMC ZTS[X]
SiO_2	91.5	91.0	92.7	88	87	86	37.5
Al_2O_3	0.9	0.7	<0.1	0.3	0.3	0.3	na
Fe_2O_3	2.4	3.2	<0.1	0.5	0.5	0.5	na
CaO	0.6	2.0	<0.4	1.8	2.5	3.0	na
ZrO_2	na	na	na	7.5	8.0	8.0	23.0
TiO_2	<0.1	na	na	na	na	na	<0.1
LOI	2.8	3.0	3.8	0.7	0.7	0.7	na

Notes:
- ** Public listings and controlling companies' details have been omitted
- [I] Foskor Fume Silica
- ^ Silicon Smelters (Invensil), densified product
- [X] Palabora Mining Co.'s zirconium titanium silicate, chemical analysis before drying
- na Not available
- Typical values, rounded off

7.6 Silica sand

Silica sand is used in the manufacture of glass and fibreglass, silicon carbide production, in foundry castings, the manufacture of sodium silicate and other chemicals, sandblasting, the manufacture of abrasive papers, recreational uses including golf and bunker sands and as filter media in water purification, industrial filtration, sewage treatment.

Growing markets for silica sand include recreational and filter media applications, construction and glass manufacture. Recreational sand markets include golf courses, bowling greens, race courses, stadium and school fields, playpen sands, Zen gardens, fishponds and beach sand manufacturing – these markets are generally associated with a higher or improved standard of living, with some bagged products selling for more than R1 000/t.

Filter-media applications overlap with recreational uses, but are more focused on swimming pool filter systems, municipal sewage and water treatment. The industry has shifted to improved, effective filtering systems, meaning that spent sand is replaced on a regular basis (every 4-10 years and not at 20-year intervals).

Two producers have changed their material packaging to suit their customer's needs as well as selling 'pre-mixes' for specific clients and markets. Certain niche markets have shown exceptional growth through knowledge distribution – public awareness campaigns, expos and smart advertising.

7.7 Fused quartz and high purity crystalline silica

The production of fused quartz or silica entails heating cristobalite, a polymorph of quartz, to melting point (1 710°C) and then cooling it rapidly. Fused quartz and high-purity crystalline silica are used in the piezoelectric, optical and glass industries – these applications include lamp tubing, fibre optics, photovoltaic cells, semi-conductors, pressure gauges, oscillators, resonators and wave stabilizers. Quartz' ability to rotate the plane of polarized light, as well as its transparency in ultraviolet rays make it an ideal component in heat-ray lamps, prisms and spectrographic lenses.

7.8 Semi-precious gemstones

Semi-precious varieties of quartz include amethyst, citrine, rose quartz and smoky quartz. Cryptocrystalline forms include agate, jasper and onyx.

7.9 Synthetic sands

Synthetic sands are an artificial mixture of sand with fine clay or bentonite. Properties of synthetic sands include: no electrical and optical twinning, no cracks, fractures and dislocations and minimal inclusions.

7.10 Silica gel

Silica gel is amorphous silica, prepared in formation with water. Removal of the liquid creates xerogels and further treatment with alcohol creates aerogels. Silica gels are used as drying agents and viscosity modifiers. Synthetic silica manufacture, using sol-gel technologies and citric acid as a catalyst, is in an advanced state of research.

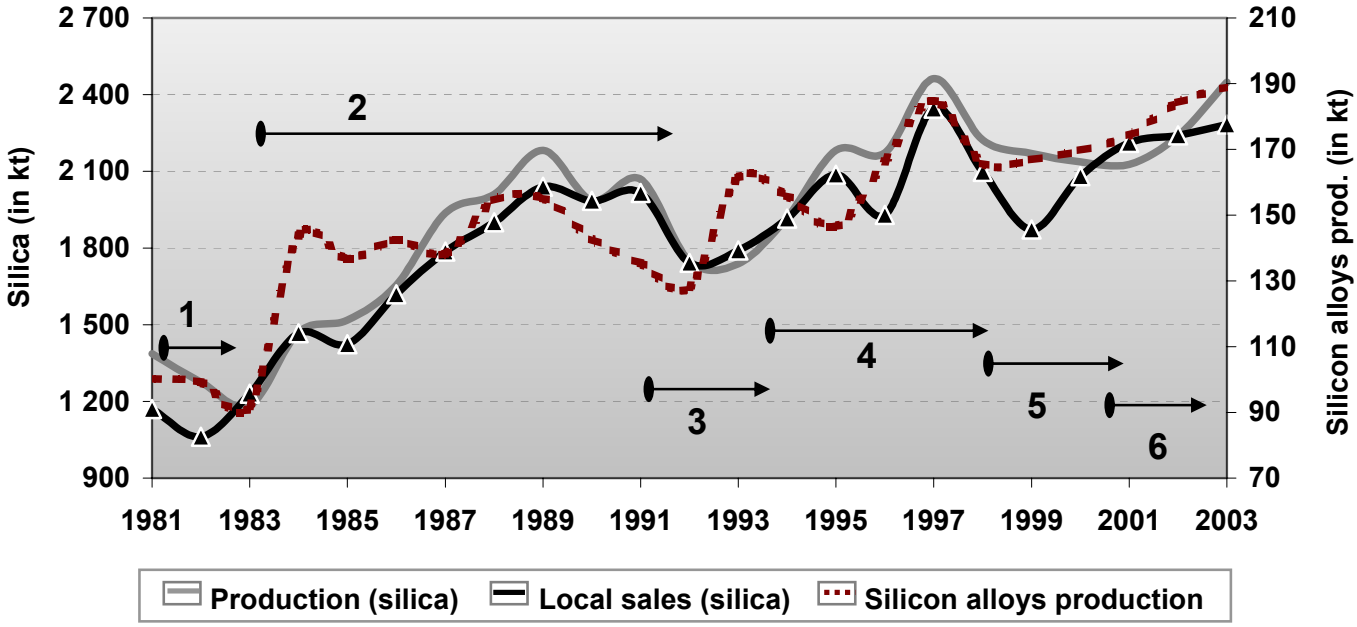
8. Supply and Demand

8.1 Supply

There is a good balance between supply and demand in the industry. Where demand is lacking, excesses are stored or graded further, e.g. in the late 1980's and the period between 1995-2000, there was a significant oversupply in the market (Graph 6). These trends were quickly reversed and stability maintained in subsequent years (1990-1994 and 2001).

In 2003, the top six companies contributed 74,2% to local sales, whilst the Delmas-Cullinan-Bronkhorstspruit area alone, contributed 61,2% to gross local sales. In 2003, production, local sales value and silica prices (FOR) increased by at least 8,5%. Local sales volumes increased moderately by 1,9% (see *Addendums:* Tables). Two producers have been able to generate export revenue even at R6,00/US$, whilst the majority believe that exports can only be considered at R9,50/US$. South Africa exports graded sands, fume and milled silica.

GRAPH 6: Production and local sales of silica and silicon alloys (in kt), 1981 – 2003



Notes:
1 Global recession
2 Strong growth in construction, GFCF & steel sectors
3 Reduced public sector spending, change in government, Gulf War & global recession
4 Renewed growth in construction, private sector spending & steel exports
5 Asian stock market collapse, high interest rates & stockpiling of raw silica
6 Closure of several mines, improved sales in glass feedstock, construction and metallurgical applications (associated with exports of steel & castings). There was a moderate oversupply of silica in 2003.

Two producers have reported production levels as low as 20-25 % of installed capacity, although the industry average is about 73%. Both Bronx Mining and Donkerhoek Silica have indicated that their production will at least double over the next year – mostly attributed to new management, more

effective use of available capacities and strategic upgrades. Most producers have chosen not to diversify into other niche markets, but to rather boost their core business dealings.

At least five producers have targeted stepping up production and utilizing 100% of available capacity as their primary targets for the next two years. Two extremes exist in the industry – those with large capex plans and realistic upgrades; and those characterized by a lack of adequate planning and capex implementation, resulting in cash flow and product delivery problems. In the last ten years there has been a significant decrease in fly-by-night operators, especially in the foundry sands industry, as consumers are prepared to pay a premium for accurate specs and reliability.

One fume silica producer will be increasing capacity by 35% within the next year. Other producers are expected to follow suit in within the next 3 years. Supply and demand for milled silica will remain balanced for the next few years, and no additional capacities have been planned for the near future.

8.2 Demand

Silica demand is set to grow at similar levels to that of the macro-economy, at about 2,9% year-on-year. Global markets, the forex rate and direct foreign investments will determine future growth of South Africa's metallurgical industry. Internationally, principal drivers in this end-user market are steel, silicone chemicals and aluminium industries. Locally, principal drivers for growth would be steel and automobile exports. Additional import duties on S.A. steel products, particularly in the USA may dampen export growth.

Container glass demand is expected to grow significantly in the near future, whilst flat glass growth may be realised through an expanding local consumer base and automobile exports (Table 4). Growth in the construction sector has a knock on effect on steel consumption, foundry castings and glass consumption. Low interest rates, buoyant property prices and rapid development of certain industrial and urban areas in Gauteng, will affect growth positively.

Fume silica demand is set to increase significantly (projected growth globally is 30% y-o-y), but the expected influx of cheap, imported material remains a problem for local producers. Fume silica is finding increased market acceptance amongst producers of cement, concrete and refractories. Some fume silica producers export up to 85% of their total production. It is hoped that once some of the R&D projects are commercially viable, strong demand will be seen in the electronics, fibre optics and speciality glass sectors.

TABLE 4: Medium and long-term demand/ market prospects for all silica types.

Strong growth (>4%)
Filter media
Nanoscale uses
Tile cement & grouting
Construction [aggregate]
Fibre-glass additives [fume silica]
Glass-reinforced plastics
Castings in automobile industry
Recreational and golf sand
Cement-additives [fume silica]

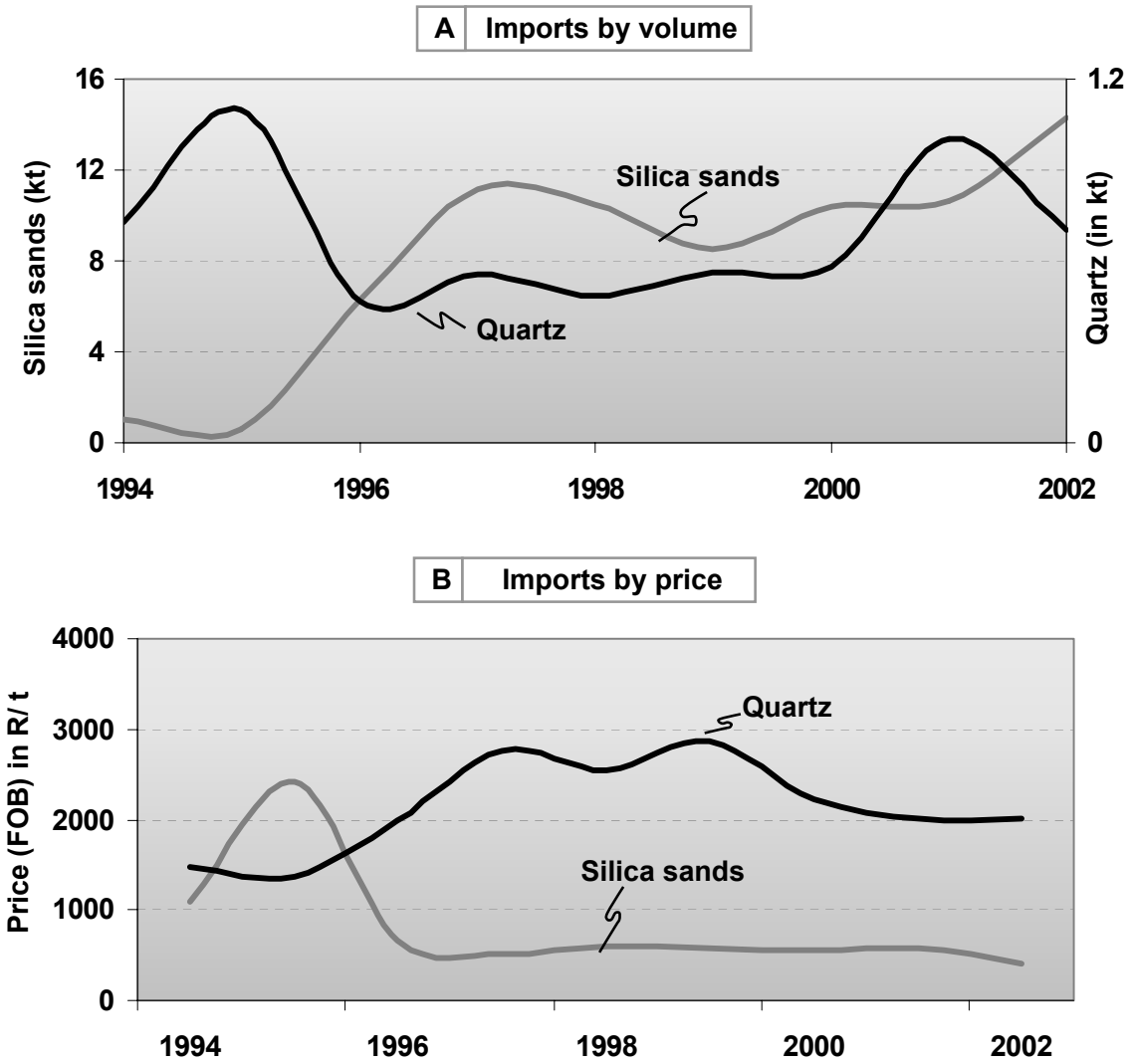
Moderate growth (2 - 4%)
Ceramics
Container glass manufacture
Refractories [fume silica]
Paint & glass [milled silica]

Marginal growth (0 - 2%)
Fluxing [milled silica]
Fillers and extenders
Refractories [normal silica grades]
Sandblasting

8.3 Imports

Imports of silica products have never exceeded 17 kt p.a. over the last 10 years (equivalent to 0,7% of local sales). In the last three yeas, prices for silica sand and quartz have remained stable at R500/t and R2 000/t respectively (Graph 7).

GRAPH 7: Imports of silica, 1994 – 2002



8.4 Sphere of influence

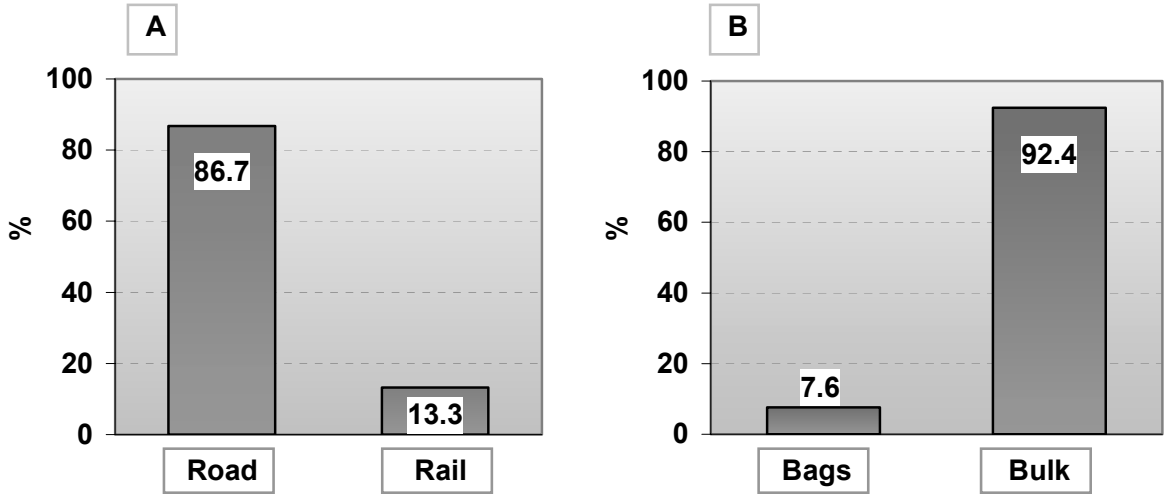
Silica sand used in construction, must be proximally located to urban or industrial centres to be economic (50-100 km). Industry sources have stressed that transport costs have kept some companies out of lucrative markets (glass). High-value, high-purity products are generally less bulky than construction sand, and can compete on national and international markets.

9. Logistics and Transport

Turnaround* times have improved from a week down to 24 - 48 hours. This has led to the creation of marketing and logistics divisions by various companies to deal specifically with the placement of orders, order tracking, client problems and logistical/ transport arrangements – private contractors are used where silica producers cannot deliver the product themselves.

Transport costs have become an important factor in price determination – up to 50% of the consumer price may be transport-related. Several companies have increased profit margins using their own transport lines, although this does increase risk. Most companies have contracted out transport, albeit it at a lower profit mark-up and risk. Location and transport costs have barred many producers from large contracts with the glass and metallurgical industries.

GRAPH 8: Road/ rail split (A) and bags/ bulk split (B), 2003



Road transport is the favoured mode of transport. The 13,3% rail transport figure is misleading: only 3 producers use rail, of which Samquarz accounts for more than 85% of the total (Graph 8). Bulk transport is the dominant mode of transport by far (92,4%); bagged volumes are generally associated with speciality silicas and high-value, graded sands.

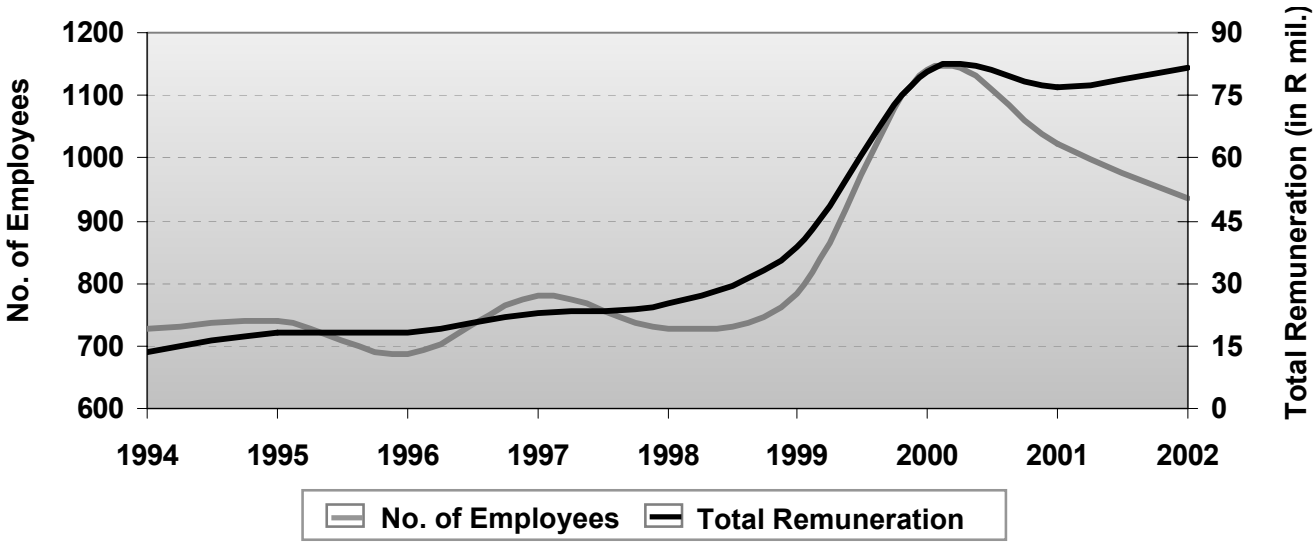
Lack of reliability and slow delivery by Transnet has seen road transport increase dramatically over the past 7 years. Road transport guarantees a quick turnaround time – within 24 to 48 hours a product can be despatched and delivered, anywhere in the country. Conversely, rail transport needs to be booked 7 to 9 days in advance, collection is unreliable and delivery slow.

Note: * Time taken for a specific order, from the time of ordering to the time it's received by the client.

10. Employment and Remuneration

There has been a steady decrease in employee numbers since early 2000 (Graph 9). This has been attributed to mechanisation, cost cutting exercises, the temporary closure of two mines and the decommissioning of 3 mines. Employee remuneration in the silica sector is of the highest in the industrial sector – though revenue generation is 2,9% of industrial mineral totals, employment is well over 6,0% and remuneration at 9,1%.

GRAPH 9: Number of employees and total remuneration, 1994 - 2002



11. Environmental Concerns and Human Safety

All employees must wear hard hats and masks in mining and processing areas. Most companies have regular/monthly health checks, annual thorough physicals and annual/ biannual chest X-rays. The use of advanced baghouses, densifiers, dust hoods, scrubbers, dust collectors and other forms of dust suppression have minimized silica dust pollution significantly in production plants.

Recent fatalities in the silica industry have put renewed pressure on several mines to invest (both time and money) in more visible, stringent safety measures. The ISHE, Opencast Blast Mining, and 'About Face' EMP certification (all ASPASA endorsed), as well as NOSA accreditation, have assisted major role players in overall health and safety and proper environmental management.

12. Threats, Problems and Risk in the Industry

Power cuts have affected the industry severely, particularly in the Bronkhorstspruit-Cullinan-Delmas area (which accounts for 75% of South Africa's silica sales). Inconsistent power supply has led to major disruptions in processing (drying, conveying, hoisting and slurry pumps), quality assurance, turnaround times and to a lesser extent data loss and storage. Eskom is addressing these problems and early warning systems have already been installed.

Barriers for new entrants to silica production and sales are high start-up costs, continued capital expenditure from day one, finding receptive markets, technical know-how regarding processing and a proper understanding of an orebody. Prospective entrants must have acute product- and industry knowledge. Currently, there is a definite skills shortage in South Africa regarding milling and processing of silica. In the milling industry, factors that must be considered are energy costs, mill lining replacements and the capped market for fine silica.

Industry risk is low to moderate. Factors that have ensured stability in the industry include:

- Extensive LOM plans,
- Substantial, high-quality ore reserves,
- A lack of competitively priced substitutes,
- A good balance between bulk and high-value producers,
- Relatively stable supply and demand market forces, and
- Similar growth patterns in silica consumption and the macro-economy.

In a well-balanced market a new entrant needs a technological advantage in order to be able to take the market share from established producers. In such a situation it is generally easier to purchase an existing operation, or an interest in one, than start a new operation.

13. Conclusions/ Summary

Over the last three years, producers have focused on the finished, tailored product – this includes packaging, quality assurance, expedient delivery and customer support. The Industry's greatest challenges are to maintain a balance between cost-efficiencies and product pricing, whilst producing consistent, better silica specs. Value addition is an absolute necessity.

In the construction industry, tile cement, grouting and cement manufacture are markets showing excellent growth potential. At present, recreational and filter media applications are showing strong growth. Moderate growth is to be expected in foundry sands consumption, steel-making and container glass manufacture, although this is dependent on downstream upgrades/ plant capacity increases. New niche markets include composite plastics and nanoscale applications.

The industrial sector is moving towards the recycling, regenerating and re-use of spent products; especially in applications such as construction, landfill sites, concrete, Portland cement and asphalt paving mixes. Possible new product developments may include precipitated silica and silica gels (both are imported), and further import replacement of fume silica products.

Competition in the lower-end product ranges is set to increase; though there is little competition, locally, for the purer, finer grades and speciality silicas. Manufacturers and millers focusing on "in-house production" through mine acquisitions (lowering their input costs) and silica producers focusing on downstream beneficiation and products (to improve profit margins) may forespell radical new developments in years to come.

In the speciality silica market, strong international competition is expected in the immediate future. Chinese exports, product differentiation, price and inter-product substitutes are threats to local producers. Fume silica sales follow both local and global trends in the metallurgical, computer and construction industries. The use of fume silica in high-strength cement and concrete manufacture is expected to grow significantly in the near future. Strong growth is anticipated in new markets that include speciality glass fibres, fuel cell technologies and pigment modifiers. Global fume silica demand has been projected at 30% y-o-y for the next 3 years.

In the silicon industry, electronics and rubber applications are expected to record the fastest gains, spurred by a rebound in the semiconductor market and industrial manufacturing. The demand for ferrosilicon will continue to track the cyclical growth patterns of the iron and steel industries. Future increases in ferrosilicon demand are likely to be linked to economic growth, and not expected to exceed 1,5-2% per year for the next decade.

Further consolidation is anticipated in the silica industry, with several producers taking competitor's market share. Expected growth in the industry has been forecast at 2,9 % (in line with the macro-economy), though silica exports continue to grow at a rate of 36% over the last 9 years.

Tendering for silica contracts/ orders in the SADEC region and internationally is expected to increase – although market penetration is intrinsically linked to forex rates and resource deficiencies in those countries. For most companies, ISO compliancy is not an option, although new environmental legislation may make ISO compliancy more attractive. Visible, enforced safety, health and environmental measures, such as those stipulated in ISHE, 'About Face' (both ASPASA endorsed) and NOSA accreditation, will become the norm in the next two years.

Black economic empowerment initiatives are set to increase drastically in the next 5 years – particularly around pit operations and silica extraction, material handling and logistical/ transport services. Silicosis remains a contentious issue in the silica industry.

14. Addendums

14.1 TABLES

TABLE 5: Applications requiring silica additives

Abrasives	Detergents	Pharmaceuticals
Acid-proof Flooring	Edible Oil Refining	Plastics
Acid-resistant cement	Effluent & Waste Treatment	Powders
Animal Feed	Electrodes	Polyolefins
Anti-Caking Agent	Fillers & Extenders	Polyols
Biocide Delivery	Film Coatings	Printing Inks
Brewing	Fluidised bed media	Pulp & Paper Bleaching
Ceramics	Foundries	Refractories
Chemicals [Inorganic Oil]	Glass & Fibreglass	Rubber
Chemicals [Gas]	Insecticides	Sand Blasting
Coal Washeries	Mineral Processing	Textile Bleaching
Computer chips	Moisture Protection	Thermal Insulators
Civil Engineering	Nuclear Waste Minimisation	TiO_2 Extenders
Construction & Cements	Paints & Lacquers	Tunnelling
Desiccants	Pigments	Water Treatment
Dental hygiene	Paper Fillers & Coatings	Welding

TABLE 6: South Africa's production, local sales and exports of silica, 1981 – 2003

Year	Prod.	Local sales			Export sales			Total sales	
		Mass	Value (FOR)		Mass	Value (FOB)		Mass	Value
	kt	kt	R '000	R/t	kt	R'000	R/t	kt	R '000
1981	1 387	1 171	15 727	13	0.6	303	483	1 171	16 031
1982	1 276	1 062	15 779	15	0.6	307	542	1 063	16 086
1983	1 184	1 230	18 541	15	0.3	129	394	1 231	18 670
1984	1 471	1 467	23 718	16	0.7	272	384	1 467	23 990
1985	1 518	1 424	23 841	17	0.4	28	77	1 424	23 869
1986	1 655	1 619	29 497	18	0.7	40	54	1 619	29 537
1987	1 937	1 786	36 973	21	1.1	47	45	1 787	37 020
1988	2 011	1 901	45 933	24	0.3	33	109	1 901	45 966
1989	2 182	2 040	57 140	28	0.2	15	95	2 040	57 155
1990	1 986	1 985	65 559	33	0.1	21	152	1 985	65 580
1991	2 068	2 015	76 424	38	0.2	39	173	2 015	76 463
1992	1 750	1 742	71 715	41	0.8	144	178	1 743	71 859
1993	1 738	1 791	68 411	38	0.7	104	139	1 792	68 515
1994	1 920	1 916	72 878	38	1.3	327	245	1 917	73 205
1995	2 182	2 087	89 319	43	0.7	150	227	2 088	89 469
1996	2 173	1 929	90 195	47	1.3	456	352	1 931	90 651
1997	2 463	2 345	112 578	48	0.9	298	320	2 346	112 876
1998	2 223	2 097	114 224	54	2.2	1 375	627	2 100	115 599
1999	2 170	1 872	107 776	58	3	731	286	1 875	108 507
2000	2 137	2 080	119 284	57	1	591	822	2 081	119 875
2001	2 127	2 211	130 650	59	0.5	636	1 320	2 211	131 286
2002	2 239	2 241	158 622	71	1.0	1 742	1 679	2 242	160 364
2003	2 448	2 283	176 817	77	1.1	1 214	1 085	2 284	178 031

TABLE 7: Employment and remuneration, 1995 – 2002

Year	Employees	Total Remuneration R'000
1995	740	18 218
1996	686	18 206
1997	780	22 822
1998	726	25 317
1999	783	38 866
2000	1 141	80 472
2001	1 022	76 789
2002	937	81 667

Note * Table 6 & 7 totals exclude 4 active mines added to the registry in October 2003. All other stats include these mines.

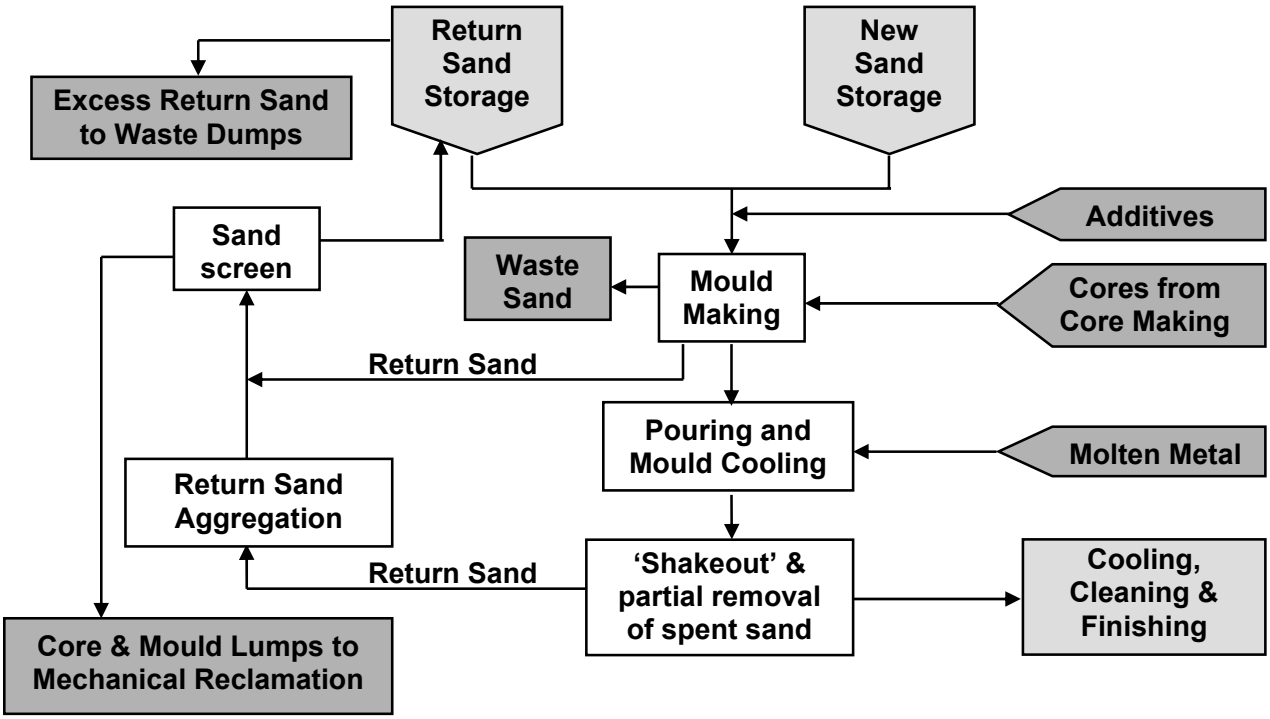
TABLE 8: Siliceous material imports, 1994 – 2002

Year	Silica and quartz sands (25.05.10)			Quartz (25.06)		
	Mass	Value (FOB)		Mass	Value (FOB)	
	T	R	R/t	T	R	R/t
1994	993	1 086 174	1094	727	1 072 955	1 476
1995	587	1 416 142	2 412	1 098	1 496 968	1 364
1996	6 310	4 177 723	662	469	937 566	1 999
1997	11 129	5 692 116	512	554	1 530 936	2 763
1998	10 467	6 143 814	589	485	1 239 654	2 556
1999	8 512	4 939 817	580	560	1 608 662	2 872
2000	10 413	5 877 343	564	579	1 290 097	2 228
2001	10 640	6 169 402	579	1 003	2 025 293	2 019
2002	14 330	5 741 149	401	704	1 415 357	2 010

Source: RSA, Commissioner for South African Revenue Service, 1996 - 2002
Notes: Codes in brackets refer to sub-chapters of the Harmonised System

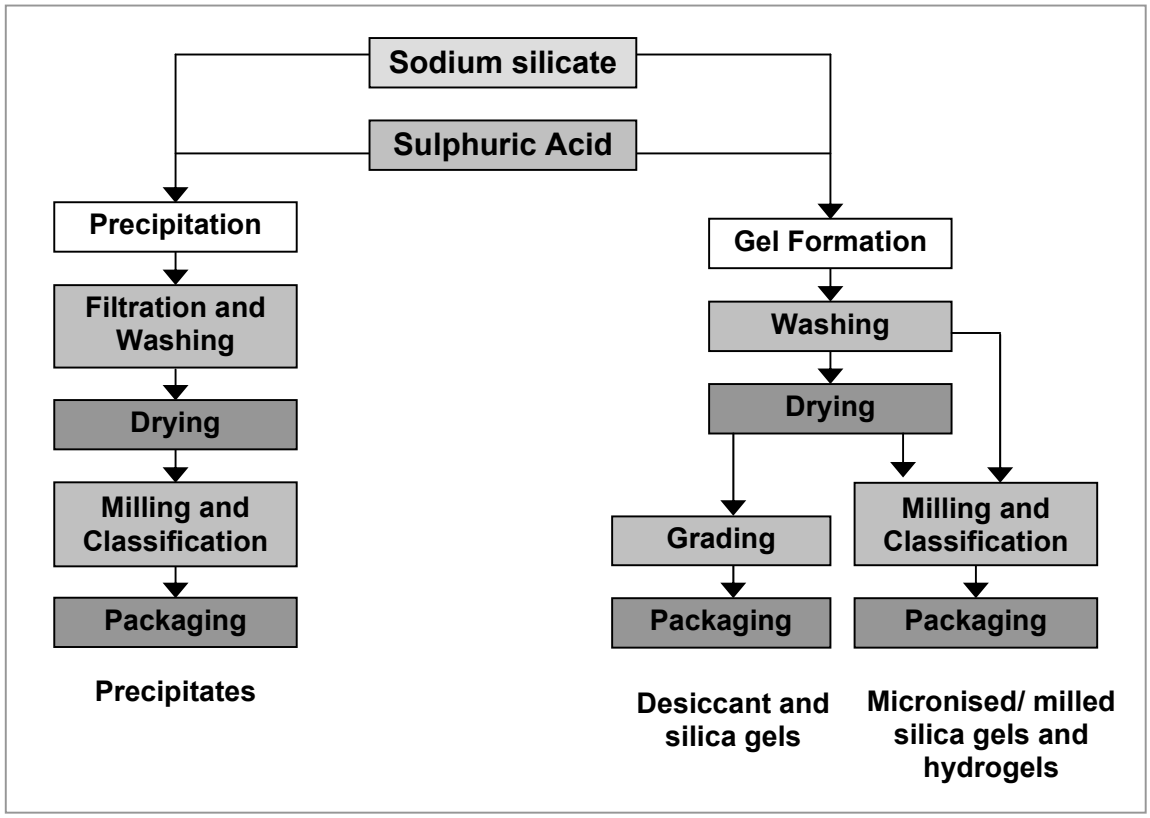
14.2 PROCESS FLOW DIAGRAMS

DIAGRAM 4: The green sand mould system



Note: Some new sand and binder is typically added to maintain the quality of the casting and to make up for sand lost during normal operations.

DIAGRAM 5: Synthetic amorphous silica production

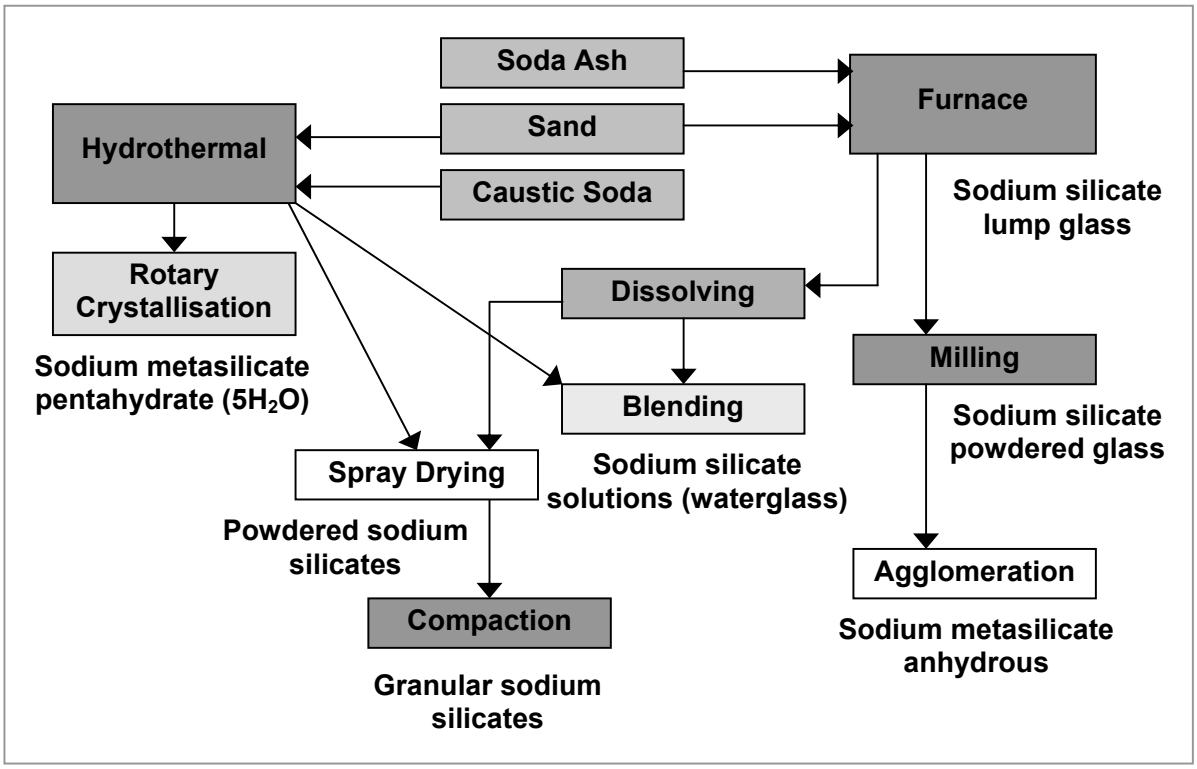


The two basic raw materials for synthetic silica production are high-purity silica sand and aluminium tri-hydrate, as sources of silicon dioxide and alumina respectively. Four other important components are sodium carbonate, sodium and potassium hydroxide and sulphuric acid.

Silicon dioxide is formed by the polymerisation of a sodium silicate solution. Two primary manufacturing processes are: 1) silica gels made from a sol under acidic conditions, and 2) precipitated silicas produced in alkaline media using stirred reactors. The final dried materials are aggregates of fine silicon dioxide particles, which have controlled morphology – this includes porosity, surface area, pore size distribution, density and surface chemistry. Once the silica microstructure has formed through controlled aggregation, it is important to control the final, particle size and size distribution by micronisation or by other particle modification techniques.

Generally speaking, synthetic silicas are chemically inert, meet the purity and safety standards required for contact with food, and have tailored particle sizes. These silicas have surface modification capabilities for use in waxes, silanes and catalytic materials. Additional applications include additives for plastics, matting agents, desiccants, liquid carrying, toothpaste, rubber filling, speciality catalysts, beer stabilization and edible oil refining.

DIAGRAM 6: Soluble silicates manufacturing process



The primary process is the conversion of crystalline silicon dioxide (sand), with low levels of impurity, into a water soluble form through reaction with alkali. In practice, selected sand is either fused with sodium carbonate in a furnace, or dissolved directly in sodium or potassium hydroxide. These processes produce a range of 'water glasses' or silicates, differentiated by the relative proportions of silicon dioxide and alkali present in solution.

These solutions contain oligomers of silicon dioxide, and can be dried and/or granulated to produce amorphous silicate powders and granules. Silicate solutions are valuable in their own right in detergents, where they act as formulation stabilisers and water softeners. They are an important component in construction and civil engineering applications such as soil consolidation, cavity grouting and sprayed concrete, and in the manufacture of various building and refractory products. They are widely used to stabilise peroxide in the bleaching of pulp, paper and textiles and form the basis of specialist adhesives for paper converting applications.

The mining, mineral processing and extractive industries rely on silicates for agglomeration, beneficiation and shale stabilisation in oil drilling operations. Powdered and granulated silicates form the basis for industrial cleaning and domestic dish wash applications.

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Alpha Stone – Polokwane	Multi-sand (Pty) Ltd
B & E Silica (Pty) Ltd	Noel Lancaster Sands (Pty) Ltd
Catnis (Pty) Ltd	Okiep Copper Company
Consol Limited IMD	Palabora Mining Company Ltd
Donkerhoek Quartzite (Pty) Ltd	Pegmin (Pty) Ltd
Eggo Sand (Pty) Ltd	PFG Building Glass (Pty) Ltd
Fine Industrial Minerals CC	Rand Carbide Ferroalloys Plant
Foskor Ltd	Samancor Ltd - Tubatse Quartzite
Garieb Minerale (Pty) Ltd	Samquarz (Pty) Ltd
Gelletich Mining Industries	Sandhawk (Pty) Ltd
Highveld Steel & Vanadium Corp. Ltd	Siltech (Pty) Ltd
Idwala Industrial Minerals (Pty) Ltd	Sterkfontein Crushers (Pty) Ltd

Comments & Queries

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