South Africa

Total population (2001 estimate): 43,586,097
Area: 1,219,912 km²
Annual population growth rate (2001 est.): 0.26%
Life expectancy at birth (2001): 48.09 years
People not expected to survive to age 40 (1998): 25.9% of the total population
GDP per capita (2000 est.): US $8,500
The landscape of South Africa is characterized by an extensive central inland plateau, mountainous areas in the east and northeast of the country, and gentle and ‘table mountain’ landscapes in the Cape Province. The climatic conditions differ in the various parts of the country. While in the eastern parts of the country, specifically along the coast, humid, subtropical conditions prevail, the west of the country is dry with semi-arid to arid conditions.

The wealth of South Africa is largely based on its natural resources sector, specifically mining and farming, and its developed industrial sector. South Africa is a relatively developed country in terms of modern mining and farming practices. Over many decades, however, the country has been divided by unequal distribution and access to land, mineral and other resources. In both the mining and farming sector there are gradual changes taking place that have the goal of a non-discriminatory, equitable and profitable sharing of resources.

The mining industry of South Africa, one of the best developed in the world, forms a crucial part of South Africa’s economy. Sales of minerals and mineral products contribute about 16% of the GDP. The mining sector directly employs approximately 550,000 people. Indirectly, the mining sector involves many more people. It is estimated that approximately 10 million people, a third of South Africa’s population, rely on the mining sector. Mineral production is dominated by gold, diamonds, platinum-group metals, chromium, manganese, vanadium and other metals as well as coal and industrial minerals. Mineral exports made up about 37% of all exports from South Africa. Most of these resources are developed by large national and trans-national companies. Only in recent years has the government encouraged small-scale mining.

The agricultural sector, including the government, farmers, agribusiness and national and international organizations expressed the common commitment to a more equitable partnership for a united globally competitive profitable and sustainable agricultural sector. Although the primary agricultural sector accounts for only 4.5% of the GDP, the larger agri-food sector accounts for another 9%. The farming sector consists of about 50,000 large commercial farms with a labour force of about 1 million workers. The small-scale farming sector provides livelihoods to more than 1 million persons, and occasional employment for another half-million persons. Another 3 million farmers live in ‘communal areas,’ primarily producing food for their own families. Unused productive soils are rare in South Africa and expansion is limited. Therefore the agricultural sector has to increase output per unit of land. Soil degradation is a major concern to the farming community.

The agriculture of South Africa is largely based on the production of maize, but is also diversified in many producing and value-added agro-based industries. Other crops include wheat, oats, sugar cane and sunflower. South Africa is well known for its deciduous fruits and grapes.

Only about 13% of the surface area of South Africa can be used for crop production but large areas of the country are used for grazing. The soils of much of South Africa are nutrient deficient.

**Geological outline**

Large parts of South Africa are underlain by Precambrian rocks, including:
- the Archean granite/greenstone terrain, including the Barberton and Murchison belts
- the Archean Limpopo mobile belt,
- the Archean Witwatersrand Supergroup with its extensive gold deposits,
- the Paleoproterozoic Transvaal Supergroup,
- the Bushveld Complex with platinum, chromium and vanadium deposits,
- the Vredefort Dome, one of the earth’s largest meteorite impact structures,
- the Paleoproterozoic (Mokolian) Waterberg Supergroup,
- the Mesoproterozoic Namaqualand Metamorphic Province.
The lower Paleozoic is characterized by sediments and granites that were folded into the Cape Fold Belt in the southwestern part of the country. Approximately two-thirds of South Africa’s surface is covered by rocks of the Paleozoic to Mesozoic Karoo Supergroup, comprising several thousand meters of mainly clastic sediments and volcanics. The rocks of the Karoo Supergroup (300-140 million years in age) include glacial sediments of the Dwyka Group, coal-bearing strata of the Ecca Group, thick sandstone formations (Beaufort Group) and extensive, up to 1,400 m thick, sequences of basaltic lavas. Cenozoic terrestrial and fresh-water sediments, mainly sands, of the Kalahari Group cover large parts of northwest South Africa along the borders with Botswana and Namibia.

Several alkaline complexes, carbonatites and kimberlites (some of them diamond bearing) have intruded the Precambrian and the Karoo.

**AGROMINERALS**

**Phosphates**

South Africa has a highly-developed domestic and export oriented phosphate industry. There are several types of phosphate rocks in South Africa, the main source being of igneous origin (currently mined at Phalaborwa), as well as sedimentary and biogenic resources. The latter two types are however not mined at present. Large resources of phosphate-rich sediments are located offshore.

**Igneous phosphates**

**Phalaborwa**

The largest igneous phosphate deposit in Africa is that of Phalaborwa (old name Palabora) in the low veld of the Northern Province of South Africa, adjacent to the Kruger National Park. The Phalaborwa Complex, about 2,050 million years old, is an igneous intrusion composed of three vertical pipes that continue, according to gravity data, to depths of more than 5 km. The central feeder pipe is composed of copper-bearing carbonatite and serpentinitized olivine-apatite-magnetite rock, (named foskorite after the company Foskor) set in a large body of pyroxenites and syenites. The total complex occupies an area of about 20 km². Pyroxenites occupy about 95% of the surface area (excluding the syenites), 3% are coarse-grained foskorites, 2% are carbonatite rocks. Apatite is not distributed equally. It is almost absent in the central part of the northern pyroxenite, but is enriched in foskorite and apatite-rich pyroxenite and glimmerite, a rock type with apatite and more than 75% phlogopite. Typical grades are: carbonatite 1-8.5% P₂O₅, massive pyroxenite 6% P₂O₅, glimmerite 9% P₂O₅ and foskorite 10% P₂O₅.

Palabora Mining Company (PMC) Ltd., a subsidiary of Rio Tinto, shares the mining area of the Phalaborwa Complex with Foskor Ltd., a wholly owned subsidiary of the state owned Industrial Development Corporation (IDC). While PMC focuses on the production of copper from the central carbonatite of the Phalaborwa Complex, Foskor Ltd. is primarily a phosphate mining company. However, until recently Foskor also produced the zirconium mineral baddeleyite.

Foskor Ltd. receives phosphate ore from 3 different sources of Phalaborwa mining operations:

- Foskor’s own pyroxenite ore from the open pit (20%).
- Foskorite ore mined by PMC on Foskor claims (40%).
- High grade phosphate tailings from PMC’s copper operation (40%).

The average feed grades from foskorite are 8% P₂O₅, from PMC tailings 9% P₂O₅, and from the pyroxenite 7.5 % P₂O₅ (de Jager 1989). They are then concentrated by various methods into high grade phosphate concentrates (36-40% P₂O₅). These three sources of PR supply Foskor Ltd. with about 2.9
million tonnes of phosphate concentrate per year. The apatite concentrate is traded under the name Palfos (Palfos 80 = 36.5% P₂O₅, and Palfos 86 = 39.5% P₂O₅). Some 900,000 tonnes are exported directly, 1,000,000 are sold for domestic fertilizer consumption, and the remaining 1 million tonnes are converted by local phosphoric acid producers and exported (Sims 1999). As a result of the changes at PMC, which produced 80,000 tonnes per day of copper ore and will change in 2002 into a 30,000 tonnes per day underground mining operation, Foskor plans to expand its direct mining operation and generate a total of 3,650,000 tonnes of phosphate concentrate per year (Sims 1999). A large amount of PR from Foskor is converted to phosphoric acid and fertilizer products by Indian Ocean Fertilizers (IOF), a wholly owned subsidiary of Foskor Ltd., at its Richards Bay facility and exported, largely to Asian markets.

Drill-proven and stockpiled phosphate ore reserves exceed 300 million tonnes at an average grade of 7.45% P₂O₅ (Wilson 1998). The total in-situ resources of PR at Phalaborwa, to a depth of 600 m, are estimated at 13,000 million tonnes with an average grade of 6.8% P₂O₅ (de Jager 1989).

Agronomically, the phosphate rock from Phalaborwa is not suitable for direct application because the main phosphate mineral is a fluor-apatite with very low reactivity.

Glenover

Phosphate mineralization at the Glenover Carbonatite Complex, located in the Northern Province, is associated with a breccia zone along the carbonatite-pyroxenite contact. The whole ovoid-shaped complex is 4.7 km long and 3.5 km wide. The iron- and apatite-rich breccia body occurs near the centre of the Glenover complex. Between 1962 and 1983 the high grade (> 30% P₂O₅) central portion of the 10-million tonne ore body was mined by Goldfields of South Africa (GFSA) producing some 1,445,000 tonnes of 36% P₂O₅ concentrate. The ore consisted of 75-95% apatite, the rest being hematite, martite, limonite and clay (Wilson 1998). Considerable ore resources grading 20-25% P₂O₅ remain in situ below the open cast floor in the northwestern section of the mine. Approximately 2.5 million tonnes of residues finer than 12 mm (from crushing and screening) were left on dumps. Plans are underway by the company Fer-Min-Ore Ltd. to leach these fines (P₂O₅ 20-37%) to produce phosphoric acid for animal feed products.

Schiel

The Schiel Complex, also located in the Northern Province is a large syenitic complex with subordinate carbonatite, foskorite, and syeno-gabbro. With an age of 2,095 ± 36 million years, it is almost the same age as Phalaborwa (Wilson 1998). The deposit of apatite, associated with magnetite and vermiculite was discovered in 1953. Subsequent exploration revealed ore reserves of 36 million tonnes at 5.1% P₂O₅ in the weathered zone to a depth of 39.6 m (Verwoord 1986).

Spitskop

The Spitskop Complex in the Northern Province, emplaced 1,341 ± 41 million years ago, consists of a ring complex with pyroxenite, ijolite, nepheline-syenite and carbonatite. The whole complex is about 14 km across. Three concentric apatite-rich zones occur in the complex as ring zones 27-37 m wide and 400 m in diameter. The average grade is 7.5% P₂O₅ (Wilson 1998). The apatite is finely intergrown with iron-oxides, and attempts to produce a phosphate concentrate with more than 20% P₂O₅ proved difficult (Wilson 1998).
Other small igneous phosphate occurrences

Small apatite enrichments of igneous origin are those of Kruidfontein, 40 km east of Pilansberg in the Rustenburg District, and the Bandolier Kop in the Northern Province. While the apatite mineralization in the Kruidfontein area occurs in a carbonatite, the apatite of Bandolier Kop occurs in veins and lenses in pegmatites. The occurrences are of no economic value.

Sedimentary phosphates

Several types of sedimentary phosphates are described from offshore and onshore South Africa. The largest sedimentary phosphate resources are the replacement deposits offshore west and south of South Africa. On the western margin of South Africa, phosphorite pellets are found not only offshore, but are also abundant on the adjacent coastal terraces on land. Small occurrences are associated with Upper Tertiary sediments in the coastal area of KwaZulu and Upper Dwyka Shales and Upper Ecca Shales of the Karoo Supergroup.

Offshore sedimentary phosphate resources

Extremely large diagenetic replacement phosphate resources occur as near-continuous ‘pavements’ or cappings of limestones offshore between Cape Agulhas and Cape Recife on the continental shelf. The Agulhas Bank deposits consist of boulders and cobbles of phosphatized limestone, in a matrix of glauconite, microfossils and quartz sand. Goethite-rich apatite cement and replacement of limestone by phosphate indicate diagenetic formation. The age of these phosphates is considered Neogene (between Miocene and 0.61 million years ago) (Birch 1990). Samples from the Agulhas Bank range from 10-25% P₂O₅. With an area of 35,000 million m², an average thickness of 0.5 m, and an average grade of 16% P₂O₅ the Agulhas Bank offshore phosphate deposits would contain about 5,000 million t P₂O₅ (Birch 1990). However, on technical and economic grounds they are not considered for mining at present.

The authigenic pelletal phosphorites along the western coast of South Africa, south of the Orange River are extensions of the rich marine offshore deposits of Namibia. These offshore resources contain approximately 3,500 million tonnes of P₂O₅ (Birch 1990).

Onshore sedimentary phosphate resources

Part of the major sedimentary phosphate province that stretches along the western coast of South Africa into Namibia is the onshore phosphorite deposits of the Saldanha embayment in the Langebaan area in the Sandveld region of the Western Cape Province. Here, several types of phosphates occur, from guano-derived Al-rich phosphates to unconsolidated pelletal and consolidated crust type (phoscrete) deposits. The phosphatic sediments are of Miocene to Pliocene age (Hendey and Dingle 1989). It is thought that the phosphorites in the Saldanha area were formed in an estuary adjacent to a region with upwelling and high biological productivity (Birch 1990).

Some of the phosphorites have been mined in the past, others are, for various reasons, not developed. Among the Ca-phosphate occurrences and deposits in the Saldanha area is the Varswater deposit, the mined out phosphorites from the Baards Quarry and Old Varswater Quarry, as well as Sandheuvel, Paternoster and Duyker Eiland. The main phosphates at Varswater consist of pelletal sands of francolitic composition with ‘collophane’ cement (Hendey and Dingle 1989). The average thickness of the mineable layer is 10 m at 10% P₂O₅. The Varswater deposit at Langeberg near Langebaanweg has 49 million tonnes of reserves at 10% P₂O₅. Mining started in 1965. By 1970 production of phosphate concentrate was at 163,300 tonnes annually.
The deposit at Sandheuvel (23.6 million tonnes at 6% P₂O₅) is unexploited. Also the Paternoster ore body is unexploited. It contains unconsolidated low-grade ore, at Pelgrimsrust 10 million tonnes at 5% P₂O₅ and at Noodhulp 2.7 million tonnes at 4% P₂O₅. The Varswater deposit on the farm Langeberg 188 near Langebaanweg produced about 24 million tonnes before it closed in 1992. Some 25 million tonnes of ore at a grade of 8.5% P₂O₅ remain as proven reserves. The ore was concentrated to 29-30% P₂O₅ and sold as ‘Langfos’ fertilizer. The apatite from Langebaan was chemically and mineralogically analyzed and proved a carbonate-substitutedapatite with a unit-cell a-value of 9.364 Å. This a-cell value is considered ‘intermediate’ with marginal value for direct application on agricultural soils (Thibaud et al. 1992). Agronomic evaluation by Thibaud et al. (1992) showed that Langebaan PR (Langfos) was not an effective substitute for superphosphate. In a further study they showed that the relative agronomic effectiveness of a superphosphate-Langfos blend increased in close association with an increase in the proportion of the superphosphate (Thibaud et al. 1993).

Uloa

Frankel (1966) described a small bed of nodular phosphate in Miocene beds in the Uloa area along the lower reaches of the Umfolosi River in coastal northern KwaZulu-Natal. The nodular bed with francolitic composition (refractive index 1.622) varies from 30-100 cm in thickness but is of importance as it is one of only a few Tertiary sedimentary phosphate occurrences along the eastern coast of Africa. In the northerly extension from Uloa, in southern Mozambique, the extensive glauconite-bearing Eocene Cheringoma Formation with fossil fish and teeth beds is seen as an excellent potential source rock for phosphorites.

Karoo phosphates

Small phosphate occurrences are described from shales of the Upper Dwyka Group in the Western Cape Province (east of Matjiesfontein). Concretions, up to 6 m long and 0.3 m thick occur in shales directly overlying tillites (Wilson 1998). The resources are very small and of no economic value. Very thin phosphorite beds have also been found in Dwyka Group sediments overlying the Dwyka diamictite near Stanger, north-east of Durban in coastal northern KwaZulu-Natal (Buehmann and Buehmann 1987).

Phosphatic nodules in the Ecca Group have been known for a long time from the Weenen area, north-northwest of Pietermaritzburg in KwaZulu-Natal Province. The flattened nodules, up to 1.2 m long and 0.5 m thick, are confined to small localized areas in the Upper Ecca Group shale horizons. Local low-grade lenticular phosphate ‘reefs’ have also been encountered, but have no economic potential.

Guano deposits

Several small island guano deposits were mined at the beginning of the 20th century off the coast of South Africa, north of Cape Town (Hutchinson 1950). For example, some 771 tonnes were produced in 1919 from Dassen Island (Hutchinson 1950). The islands are part of a chain that is inhabited by seabirds feeding on the fish in the nutrient-rich upwelling zone of the Benguela Current.

A small aluminum phosphate deposit with a grade of 15% P₂O₅ was mined in the early 1900s on the farm Klipfontein in the Hoedjes Bay area on the Atlantic coast, near Saldanha Bay. The Hoedjes Bay deposit (also referred to as Kreeftebaai and Klipvlei) was formed from the reaction of sea-bird excretions and granite (Atkinson and Hale 1993). The small operation ceased shortly after World War I. Another guano-derived Al-phosphate mineralization that has been mined is that of Constable Hill, with an average grade of 22.48% P₂O₅. The ore was processed to yield aluminum sulphate and feed-grade calcium-phosphate (Wilson 1998).
K-silicates

There are no known evaporite-related potash deposits reported in South Africa. The only K sources of significance are K-silicates, specifically feldspar, phlogopite from the Phalaborwa igneous complex and, in small amounts, glauconite. The feldspar resources from pegmatites are considerable, but are of little use for agricultural purposes. Most researchers found that the solubility of feldspar is too low to warrant direct application of this K source. A better source from the point of K-release is that of phlogopite and glauconite. While glauconite resources are very small (glauconitic sandstone pebbles reported by Frankel 1966) phlogopite resources are extensive, forming large portions of the pyroxenite complex of Phalaborwa.

Phlogopite is also found in foskorite (or phoscorite) and in the carbonatite of Phalaborwa. Large parts of this complex are rich in phlogopite: the phlogopite pyroxenite contains 25-50% phlogopite, the pyroxenitic glimmerite 50-75% phlogopite and the glimmerite more than 75% phlogopite (de Jager 1989). The chemical composition of glimmerites averages about 8.2% K$_2$O and 7-24% MgO and various amounts of CaO and SiO$_2$ (Fourie and de Jager 1986). Electron microprobe analyses of phlogopite show a narrow range of K$_2$O from 9.3% to 10.4%, and MgO from 23.1 to 26.5% (Erickson 1989). In the weathering zone the phlogopite is altered into vermiculite. The total phlogopite resources in the Phalaborwa complex exceed 1,500 million tonnes. Up to 1.5 million tonnes of phlogopite are discarded every year. In the late 1990s this ‘waste resource’ was studied by the Industrial Development Corporation (IDC) of South Africa and Foskor on their viability as a source of alumina, magnesia and potassium sulphates. However, similar efforts using inorganic acidulation techniques on an industrial scale were unsuccessful in Finland (at the Siilinjaervi carbonatite complex). On a smaller scale, acidulated phlogopite showed some promising agronomic results in Sri Lanka (Weerasuriya et al. 1993). Whether there have been attempts to extract K and Mg from phlogopite, for example, through biological means (bioprocessing or through plants like rye grass), is unknown.

Liming material

Limestone and dolomite resources occur in several different forms in South Africa. A large proportion of the 178 sedimentary, igneous, calcrete and travertine limestone and dolomite occurrences and deposits reported by Gwosdz (1996) are of Precambrian age, including more than 14 of Archean age and 61 of Proterozoic age. Many of the Archean limestone/dolomite resources occur in the form of marble. The Proterozoic limestone and dolomite resources occur largely as compact, fine-grained dolomitic limestones. Many of these resources are used for dimension stone purposes, for metallurgical uses and in agricultural applications. Due to their relatively high Mg content, they are generally not used in the cement industry. In contrast to the hard sedimentary carbonates, the Cretaceous to Recent carbonates that occur intermittently along the coast from Saldanha Bay to East London are called ‘soft’ carbonates (Martini and Wilson 1998). Much of these soft carbonates are suitable for agricultural purposes. Some soft limestones containing oyster shells have been mined for use as poultry grit and as additive in animal feed.

In addition, Gwosdz (1996) described the calcitic and dolomitic resources in 7 carbonatite complexes, Phalaborwa, Spitskop, Glenover, Goudin, and the carbonatites near Kruidfontein, Tweerivier-Bulhoek, Nooitgedacht, Kruidfontein. Ca-carbonatites (soevites) containing 1.7% P$_2$O$_5$ have been mined for agricultural purposes by a local development corporation from the Spitskop alkaline complex, between Pietersburg and Middelburg.

Calcrete deposits are numerous in South Africa. Calcretes occur in nodular form and as caprocks with variable thicknesses, from nodules a few centimetres across to 30 m thick beds. They are often used as local sources for building material, for road construction and for agriculture. Gwosdz (1996) described the location and composition of the main 48 calcrete occurrences, several of which are mined for agricultural
purposes. Extensive deposits of this kind are exposed and mined as agricultural liming materials in the Zeerust-Dwaalboom area near the border with Botswana (Martini and Wilson 1998). The 18 occurrences of travertine in South Africa reported by Gwosdz (1996) are mostly small and are high-Ca and low-Mg limestones. Exceptions are the travertine deposits along the 250 km long escarpment north of Kimberley, and the 20-30 m thick travertine layer at Ulco, some 70 km northeast of Kimberley (Martini and Wilson 1998).

Agricultural applications made up about 5.9% of the total limestone sold in South Africa in 1987 (Griffiths 1989). The major producers of agricultural limestone are Aglime Ltd. at Riversdale, Bontebok Limeworks Ltd., Coetzee Limeworks Ltd., and Leo Dolomite Quarry at Potgietersrus, Bryttynymyn Ltd. at Bloemhof, Buhrmannsdrifmyn Ltd. at Groot Marico, Marine Lime Ltd. at Vredenburg near Saldanha, and Spitskalk Ltd. at Nebo (Griffiths 1989).

Limestone fines from ‘wastes’ include limestone fines from slimes dams in Groot Marico excavated by Maricomyn. The fines from the AMCOR slime ponds at Droogegrond, Lyttelton, south of Pretoria planned to be marketed as dolomitic agricultural limestone (Gwosdz 1996).

Hiqualime Ltd. produces agricultural lime from ‘waste’ material at Highveld Steel (Griffiths 1989). The dolomitic residue from a fluorspar mine south of Zeerust was pumped to slimes dumps and is currently reworked and sold as magnesium-rich agricultural lime (Martini and Wilson 1998).

In 1994 the sales statistics of unburnt limestone in South Africa included 726,406 tonnes of agricultural lime, out of a total of 15,006,064 tonnes (Skillen 1995).

**Sulphur, pyrite and gypsum**

There are no commercial natural resources of elemental sulphur in South Africa. Sulphur is solely won as by-product from the oil refineries (35,000-40,000 tonnes), and 140,000 tonnes sulphur are extracted from coal during the synthetic-fuel process (Boelema and Ehlers 1998).

Pyrite is a common by-product from the gold mining and the coal industry. While large resources of pyrite are extracted by flotation and converted into sulphuric acid from the gold mines in the Witwatersrand Basin, the pyrites from gold deposits in various Archean greenstone belts are unsuitable for sulphuric acid production because of their relatively high arsenic concentrations.

Sulphuric acid is also extracted as by-product from smelter gases, for example from processing of copper ores from Phalaborwa. Sulphuric acid is used for many purposes including the production of superphosphate fertilizers. Once lower SO2 emission standards are enforced, substantial more quantities of sulphuric acid will become available.

Most of South Africa’s natural gypsum deposits formed in surficial terrestrial arid to semi-arid environments. Extensive surface to near surface deposits are located in the Northern Cape Province and the northern part of the Western Cape Province. Smaller deposits and occurrences are found in the Eastern Cape Province and in the KwaZulu-Natal Province (Oosterhuis 1998). Gypsum formed in the upper portion of the weathering profile in shales of the Ecca Group of the Karoo Supergroup and in salt pans. These types of deposits form in areas where evaporation rates are high and precipitation rates are low. Gypsum precipitates largely in clay layers.

The richest gypsum fields in South Africa are located in the so-called Bushmanland, west of Van Wyksvlei in the Northern Cape Province. The gypsum deposits consist of several different types, from high-grade powdery gypsum (90% gypsum) to gypsum mixed with clay (65-85% gypsum). The deposit is
approximately 3 m thick. Total reserves are in excess of 30 million tonnes (Oosterhuis 1998). The deposits at Vanrhynsdorp, West Coast and Steytlerville-Jansenville are all comparatively small in size.

By-product gypsum resources form strong competition to natural gypsum deposits. High-grade gypsum by-product is generated during the salt recovery from seawater near Port Elizabeth. Other sources of inexpensive by-product gypsum are phospho-gypsum, a by-product from phosphate fertilizer and phosphoric acid manufacture (Griffiths 1989).

The agricultural sector consumed some 41,000 tonnes of gypsum in 1987, which is 12% of the total gypsum consumption in South Africa (Griffiths 1989).

**Vermiculite**

Palabora Mining Company (PMC) Ltd. is the world’s largest producer of vermiculite. With an annual capacity of 230,000 tonnes per year, PMC is more than double the size of any other vermiculite producer in the world. In 1998, PMC accounted for 43% of the world’s vermiculite production and 87% of the export market (Ellicott 2000). The vermiculite deposit at the Phalaborwa complex has been mined since 1940 and is currently operated by the Vermiculite Operations Department (VOD) of the Palabora Mining Company Ltd.

From the start of vermiculite mining until 1993 the VOD has produced more than 4.9 million tonnes of 90% pure vermiculite concentrate (Wilson 1998). The Vermiculite Operations Department extracts vermiculite from three separate sources: the VOD open pit in the north of the Phalaborwa complex, the so-called PP&V (Palabora Phosphate and Vermiculite Company) pit in the southern part of the complex, and various rock and tailings dumps. At present the PP&V deposit is being mined together with the reclamation of tailings dumps created from earlier mining of the VOD deposit.

The vermiculite deposit at Phalaborwa was formed by surface weathering of phlogopite. Commonly the deposit is confined to the upper 50 m from the surface, although in some areas the vermiculitization of phlogopite goes deeper than 50 m. The VOD extracts about 8,500 tonnes of ore per day at a head grade of 22% and a cut-off grade of 15%. The flake size is extremely variable, resulting in 6 commercial grades after winnowing: Premium, large, medium, fine, superfine and micron. All materials are sold in the unexfoliated form. About 75% of the materials pass through the harbour of Richards Bay as bulk, the remainder is shipped in containers via Durban.

The quality of the Phalaborwa vermiculite is very good, it has one of the highest expansion coefficients of any vermiculite in the world, 26 times its original volume compared to 10-18 times for US material.

Other vermiculite occurrences are found in the eastern section of the Schiel alkaline complex, at the Glenover complex and a few other places with small amounts and various grades.

**Zeolites**

Zeolite occurrences have been reported from two principal areas of South Africa, the Heidelberg-Riversdale area in the Western Cape Province (approximately 250 km east of Cape Town, and the Nkwala Estate near the Mkuze Game Reserve of the Lebombo Mountains in northern KwaZulu-Natal (Wipplinger and Horn 1998).

The up to 75% pure zeolite beds (clinoptilolite-heulandite and mordenite) of the Heidelberg-Riversdale area occur in altered tuff beds overlying bentonite-rich horizons of the Upper Mesozoic Uitenhage Group. The zeolite beds are several metres thick and can be followed intermittently over a distance of 30 km.
They are located in an agricultural area and should be investigated for their potential application as animal feed, odour control, ammonium capture from manures, and as soil amendments.

The zeolite occurrences in the Lebombo Mountains of northern KwaZulu-Natal occur in association with perlite in chill zones of rhyolitic ashflows and other volcanic and volcaniclastic rock suites of the Lebombo Group (Karoo Supergroup). Mineable ore reserves are 1 million tonnes (Griffiths 1989). The zeolite deposits, consisting of 85-90% clinoptilolite and mordenite, have been extracted at the rate of 7,000 tonnes per year by Pratley Perlite Mining Co Ltd. Potential applications of the zeolites from Natal include removal of ammonium from mine waters of gold mines, and the use of ammonium-charged zeolites for mine tailings reclamation (Griffiths 1989). A portion of the zeolite product is also sold as animal feed under the trade name ‘Clinomix’ (Skillen 1995).

**Perlites**

Small amounts of perlites are mined from the deposits in an area close to the Mkuze Game Reserve of KwaZulu-Natal (Strydom 1998). The perlite deposits occur as lenses of irregular shape associated with rhyolitic lavas of the Lebombo Group (Karoo Supergroup). Perlite is extracted by selective mining techniques by Pratley Perlite Mining Co Ltd. and then crushed and expanded at their Krugersdorp plant for use in horticultural and construction industries. Annual production from this resource is approximately 1,200 tonnes (Skillen 1995) from a resource base of 3 million tonnes. The other company in South Africa that produces expanded perlite is Chemserve Perlite Ltd., which imported 10,000 tonnes of crude perlite in 1997 (Strydom 1998).

**Rock and mineral wastes**

There are large resources of ‘wastes’ from diamond, vermiculite, phosphate and various industrial mineral operations stored in tailings. Examples are the tailings at Phalaborwa (containing among other things, phlogopite, apatite fines and carbonates), the phosphate fines at Glenover and the magnesium-rich reprocessed kimberlite fines. In addition, there are large amounts of ‘by-products,’ that can be used for agricultural application, for example, flue gas desulphurization (gypsum) products, fly ash, slags from the steel industry, as well as ‘wastes’ from building and cement industries. Organic wastes could be used together with mineral wastes, or as a medium to increase nutrient release from minerals. Organic wastes that need to be investigated include those from sugar cane, pineapple and fruit processing industries.

**Agromineral potential**

The potential for development of agromineral resources in South Africa is good. The indigenous fertilizer industry is well developed to provide processed P-fertilizers for modern farming practices. However, the potential to develop alternative, low-cost fertilizers for smallholder farmers and subsistence farmers in high-population density, low-income areas has not been investigated. As a first step, areas have to be identified where low-cost mineral amendments are available, where nutrient and crop needs are defined, and where poverty is widespread. Soils in these areas have to be investigated for their deficiencies, and nutrient replenishing strategies have to be tailored for the different soils and crops.

In addition, a systematic survey of nutrient containing ‘waste’ materials, both inorganic-mineral and organic for use on nutrient deficient soils in high-density population areas needs to be undertaken.

The major phosphate mine in the country, Phalaborwa, produces inexpensive PR concentrates. The closed Glenover phosphate mine has substantial ‘fines’ as potential P resources. These concentrates should be tested on their potential for development of low-cost, agronomically effective phosphate blends for communal and small-scale farmers. Experiences from Kenya and Zimbabwe indicate that PR concentrate
and phosphate fines currently discarded as ‘wastes,’ can be pelletized or compacted with acidifying superphosphates or with other nutrients and nutrient-containing ‘waste products’ to form low-cost alternative fertilizers and soil amendments.

Alternative uses of mineral wastes should also focus on crops with high K and Mg requirements and trees. For example, the K-Mg silicate phlogopite in combination with various locally available N- and P-supplying materials should be agronomically tested on local soils in rural areas close to Phalaborwa. Biological processing techniques using organic ‘wastes’ should be tested on locally available silicate and phosphate rocks. Strong collaboration with scientists of the Agricultural Research Council or universities is recommended.

References:


