The distribution of the economic mineral resource potential in the Western Cape Province

AUTHORS:
Luncedo Ngcofe[1]
Doug I.Cole[1]

AFFILIATION:
[1]Council for Geoscience, Cape Town, South Africa

CORRESPONDENCE TO:
Luncedo Ngcofe

EMAIL:
lngcofe@geoscience.org.za

POSTAL ADDRESS:
Council for Geoscience, PO Box 572, Bellville 7535, South Africa

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South Africa is blessed with vast mineral resources. The formal exploitation of mineral resources in South Africa started with copper mining in Namaqualand (near Springbok in the Northern Cape Province) in the mid-1800s. The discovery of diamonds near Kimberley in 1867 and gold on the Witwatersrand in 1886 led to the significant growth of the mining industry in South Africa. In 1995, it was reported that approximately 57 different minerals were sourced from 816 mines and quarries,[1] with the most important mining provinces being the North West (as a large producer of platinum group metals and gold); Gauteng (gold); Mpumalanga (coal) and the Free State (gold). Although the Western Cape is classified as being the least productive in terms of mineral resources,[1] it has a large potential for the exploitation of industrial minerals. These often neglected resources comprise a highly diverse group of vitally important minerals that are used in a variety of applications ranging from everyday products to highly sophisticated materials. Here we describe economic or potentially economic minerals occurring in the Western Cape in terms of their geological setting.

Geology

The occurrence of a mineral resource is always determined by the geological setting of a region. In the Western Cape Province, the oldest rocks are gneisses and granites of the Mokolian Namaqua-Natal Metamorphic Province (~1100 million years old) exposed north of Vredendal. These rocks are overlain by the Gariep Supergroup rocks, which are approximately 650 million years old, and similar-aged rocks of the Malmesbury Group. The Kaaimans and Cango Groups occur in the southwestern and southern parts of the province, respectively (Figure 1). The Malmesbury and Kaaimans Groups are intruded by the 550–510-million-year-old Cape Granite Suite. The slightly younger Vanrhynsdorp Group occurs in the northwestern part and the Klipheuwel Group in the southwestern part of the province. The rocks of the Table Mountain, Bokkeveld and Witteberg Groups of the Cape Supergroup follow unconformably upon the older rocks described above. The younger Dwyka, Ecca and Beaufort Groups of the Karoo Supergroup were deposited from 300 to 255 million years ago in the northeastern part of the province (Figure 1). Rocks of the Karoo Supergroup and older strata were tectonically deformed during the Cape Orogeny, which finished about 215 million years ago and was followed by uplift and intrusion of a vast network of dykes and sills of the Karoo Dolerite Suite into the Karoo rocks some 180 million years ago. Fluvial sandstone and gravel overlaid by lacustrine clay of the ~145 million year old Uitenhage Group occupy small fault-bounded basins between Worcester and Plettenberg Bay. The youngest geological sequence is the Cenozoic sediments, which consist of fluvial, marine and predominantly windblown sandy deposits. They are assigned to the Sandveld Group on the western coastal plain and the Bredasdorp Group on the southern coastal plain.

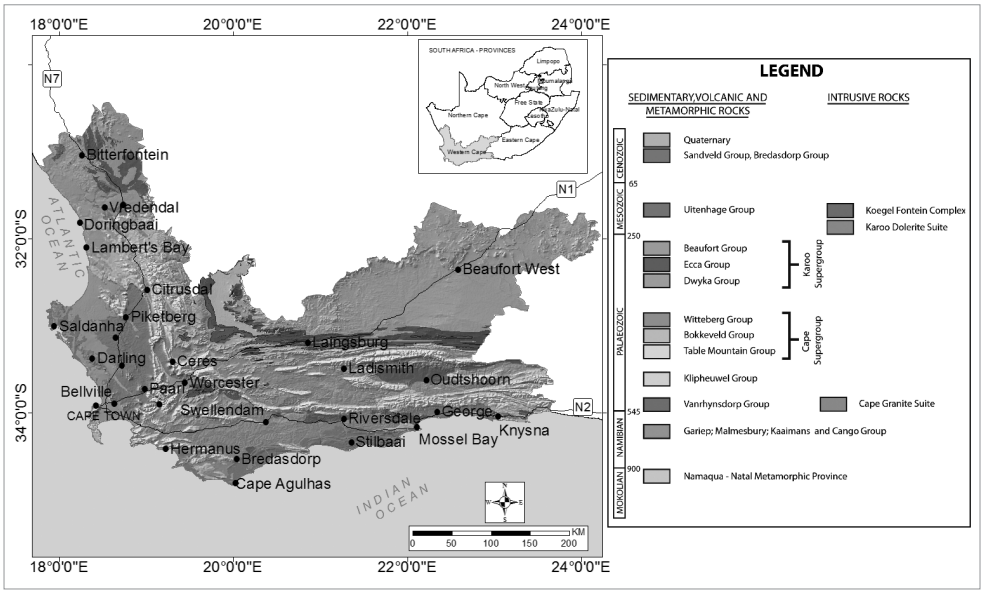

Figure 1: Geological map of the Western Cape Province.

Mineral occurrences

A total of 26 mineral commodities with economic or potential economic variability for exploitation have been delineated in the Western Cape Province.[2] In approximate order of economic importance and present status these comprise: stone aggregate, brick clay, building sand, limestone, dolomite, diamonds, heavy minerals, gypsum, uranium, bentonite, dimension stone (granite, sandstone, marble), rare earth elements, silica sand, plastic clay, salt, phosphate, gravel, kaolin, industrial sand, shale gas, tungsten, mineral pigment, lignite and manganese. Only the first 11 minerals are discussed here. Figure 2 shows the distribution of the discussed eleven minerals in the Western Cape Province. The information about each mineral was derived from the South African Minerals Database (SAMINDABA), metallogenic maps of the region and through field identification and verification processes. Our findings will be used to update the SAMINDABA database.

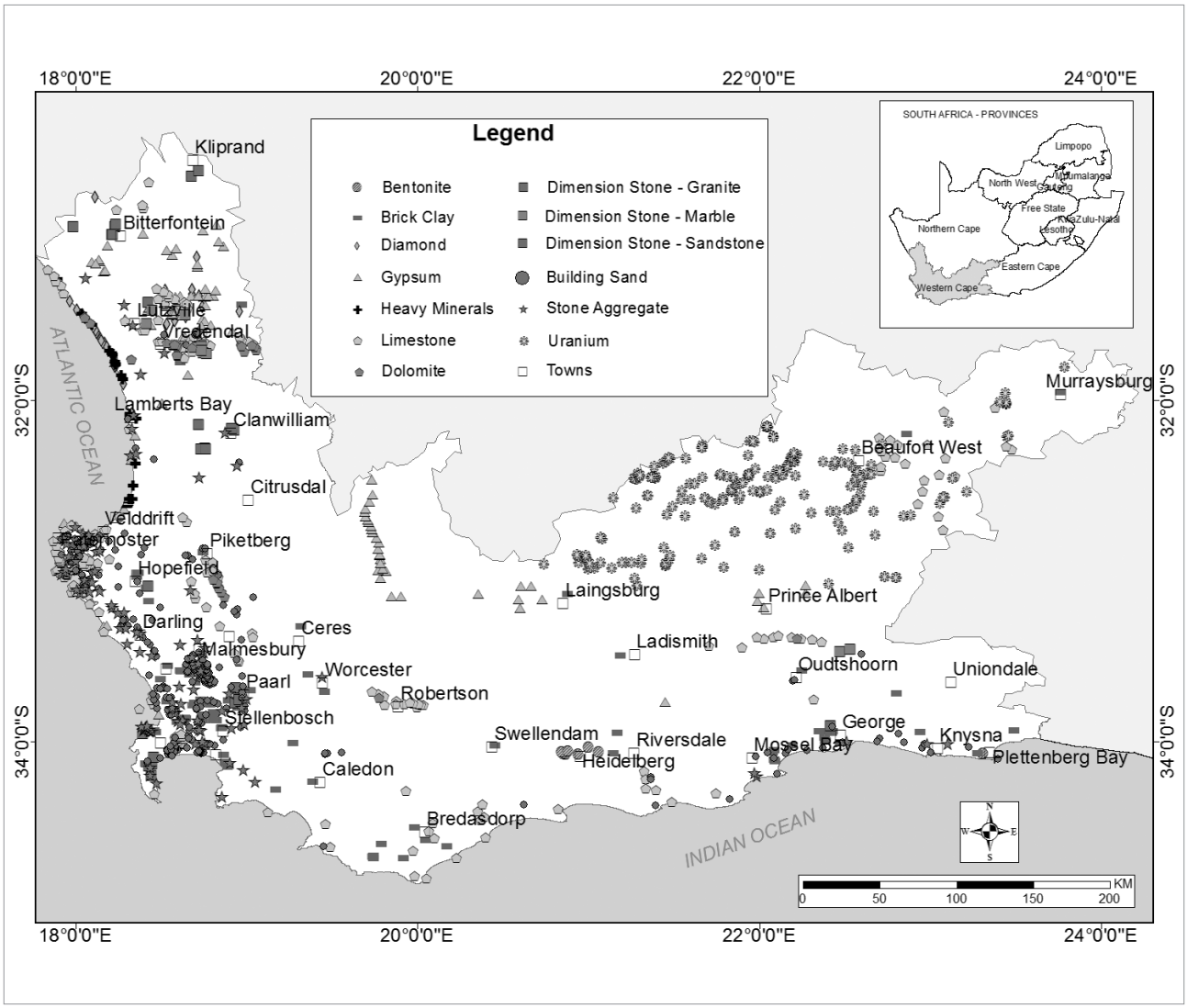

Figure 2: Map of the mineral potential of the Western Cape Province.

Stone aggregate

Stone aggregate is a crushed rock generally coarser than 6.7 mm, largely used for road, concrete and other pavement construction.[3] Quartz-rich rocks produce a good-quality aggregate. In the Western Cape, these rocks are sourced from the quartzitic sandstone of the Piekenierskloof, Peninsula and Skurweberg Formations of the Table Mountain Group,[3,4] granite of the Pan-African Cape Granite Suite and hornfels of the Malmesbury Group.

Brick clay

The short supply of wood and natural building stone led to the use of brick clay as an alternative building material. Today, brick clay is the most predominant building material. Clays suitable for brick-making material must contain the minerals kaolinite, quartz and illite.[5,6] Van Strijp[7] concurs, reporting that kaolinite has a good sintering effect while quartz acts as a stabiliser and illite provides plasticity. In the Western Cape, clays meeting these requirements comprise residual clay of the Malmesbury Group shale of Cape Town, Ceres and Hopefield; residual clay of the Gifberg Group (Gariep Supergroup) schist near Klawer; residual clay of the Saasveld Formation (Kaaimans Group) schist and phyllite in the George area[8,9] and residual clay of the Kirkwood Formation (Uitenhage Group) mudstone near Oudtshoorn and Swellendam.[2]

Building sand

Sand mining is normally short to medium term in duration, creating relatively few job opportunities. However, it contributes significantly to the local and regional economy. Building sand is commonly used for the manufacture of plaster, mortar and concrete.[9] Building sand is distributed over most of the province but is generally absent in areas underlain by Karoo Supergoup sedimentary rocks and dolerite between Laingsburg, Beaufort West and Murraysburg. In the Greater Cape Town area, plaster and mortar sands are obtained from hairpin parabolic dunes of the Holocene Witzand Formation in the Philippi and Macassar regions. Concrete sand is obtained from hillwash deposits in the zones southwest of Malmesbury and northwest of Darling.[2] In the Saldanha and Vredenburg urban area, all three types of building sand are sourced from colluvial and hillwash sands. In the southern part of the province east of Port Beaufort (Figure 2), enormous resources of mortar and plaster grade building sand are derived from coast-parallel dunes, up to 54 m high, of the Strandveld and Wankoe Formations (Bredasdorp Group).[10] Concrete grade sand in the same area is exploited from hillwash, colluvial and alluvial sands.

Limestone/dolomite

Limestone is used for several applications, including cement manufacture, metallurgical flux, paper coating, water purification, steel production and

as a neutraliser of acid soils.[2,11,12] Pure limestone is composed entirely of calcium carbonate; when it contains variable amounts of magnesium, it is called dolomite.[11] Limestone and dolomite are discussed together because they form in similar geological environments and are often associated in the field. To a certain extent they have similar uses, although limestone is the more valuable material. Limestone occurs in the western and southern portion of the province and can be divided into high-grade and low-grade categories. The high-grade limestone occurs in the Cango Group north of Oudtshoorn, in the Malmesbury Group in the southwestern part of the province and in the Gifberg and Vanrhynsdorp Groups in the vicinity of Vanrhynsdorp and Vredendal. Low-grade limestone occurs in the De Hoopvlei, Wankoe and Waenhuiskrans Formations of the Bredasdorp Group between Stanford and Mossel Bay and in the Langebaan and Velddrif Formations of the Strandveld Group between Cape Town and Velddrif. Dolomite occurs in the Malmesbury Group near Robertson and in the area southeast of Piketberg and in the Vanrhynsdrop Group in the region of Vredendal and Vanrhynsdorp.

Diamonds

Diamonds are only present in the northwestern part of the province and are hosted by both alluvial and marine placers. Alluvial placers occur in fluvial deposits of the middle Pliocene Quagga's Kop Formation in the Knersvlakte and in fluvial terrace gravels in the Olifants and Hol River valleys.[2] Marine placers occur along the coast northwest of Donkin's Bay in gravels that overlie Pliocene to Pleistocene wave-cut terraces and in gravel within recent offshore gulleys and potholes.[13] The diamonds were derived from an inland kimberlite source via a late Cretaceous 'Karoo River' that connected the diamondiferous kimberlite region of central South Africa to the Knersvlakte and mouth of the Olifants River.[14] The diamonds of alluvium placers are of low grade and no longer exploited.[15] Present mining of the marine placers is concentrated on the diamondiferous gravel that fills gullies, joints and potholes in bedrock on the seafloor.[2,15,16]

Heavy minerals

Heavy minerals provide a source of both titanium, which is hosted in the minerals ilmenite and rutile, and zirconium, in the mineral zircon. Other heavy minerals such as magnetite, monazite, garnet, tourmaline and hematite are commonly present but are not processed. In the Western Cape Province, heavy mineral bearing sands are present along the west coast, north of Dwarskersbos within Quaternary beach and aeolian placers.[17] A total of 16 placers have been discovered but only 2 are economically viable, the others being small or of low grade.[17-19] The largest is Namakwa Sands hosted by aeolian sand some 52 km northwest of Lutzville (Figure 2).

Gypsum

Gypsum occurs in the northwestern part of the province. It is hosted by clay and occurs in the form of selenite crystal aggregate, powder, alabaster and satin spar veins.[2] The gypsum-bearing clay is derived from underlying bedrock of the Namaqua-Natal Metamorphic Province, Gariep Supergoup, Vanrhynsdorp Group and Whitehill Formation. The clay has an average thickness of 1 m but can attain thicknesses of up to 4 m. In the region northwest of Vanrhynsdorp, approximately 4.5 million tons of gypsum has been mined since the 1930s, leaving remaining resources of 13 million tons.[20] Given the rate of production of gypsum, the province will have an adequate supply for the next 100 years. The applications of gypsum are largely in the building industry, as cement retarder, in plaster and ceiling boards, and as a soil conditioner in the agriculture industry.

Uranium

The Western Cape Province has deposits of uranium with economic potential hosted by sandstone of the Beaufort Group between Laingsburg, Beaufort West and Murraysburg, which have never been exploited. During the period between 1976 and 1979 when the price of uranium reached USD110/lb U_3O_8, extensive exploration occurred in the Laingsburg and Beaufort West regions, but the exploration stopped when the price dropped.[2] Currently, the price ranges between USD40 and USD55/lb U_3O_8 and it is presumed that should the price rise to sustainable levels – above USD80/lb U_3O_8 – exploration of this resource might occur again.[15]

Bentonite

Bentonite is a clay-rich mineral consisting mainly of montmorillonite. It is used for a variety of applications, for example, as a wine and fruit juice decolourant, as a binder in foundry sands and as a soil sealant.[5] It occurs in five rift-related basins of the Late Jurassic to Early Cretaceous age in the Cape Fold Belt between Robertson and Plettenberg Bay:

1. Robertson and Swellendam basin – bentonite occurs in the Kirkwood Formation but no prospecting has been carried out.[2]
2. Heidelberg–Riversdale basin – bentonite in the Kirkwood Formation is divided into two units: an upper multicoloured, pale greyish yellow and reddish sandstone and mudstone unit and a lower zone comprising olive-green and greenish grey mudstone and sandstone beds.[5] The lower zone is up to 10 m thick and hosts several bentonite horizons.
3. Mossel Bay basin – bentonite has been prospected with insignificant results.
4. Plettenberg Bay basin – bentonite occurs in lenticular- to pod-like bodies that vary in thickness from 0.15 m to 2.5 m and were mined between 1993 and 2004.[5]
5. Oudtshoorn basin – bentonite occurs in the Uitenhage Group but exploration has not been undertaken.[2]

Dimension stone

Dimension stone is a collective term for various natural stones used for structural or decorative purposes in construction and monument applications. There are three types of dimension stone that occur in the Western Cape Province: granite, sandstone and marble. These stones are used for building construction, tiles, cladding and memorial art (tombstone). There are two types of granites mined in the province: a light grey, medium-grained granite (known as Paarl Grey), which occurs on the eastern side of the Paarl Pluton, and a light green, charnokitic granite (known as Green Granite) which is located in the northwest part of the province around Bitterfontein.[15] Although no longer popular, sandstone was formerly exploited from the Peninsula Formation (Table Mountain Group) near Cape Town, Piketberg and Vanrhynsdorp, from the Robberg Formation at Mossel Bay and from the Kirkwood Formation at Oudtshoorn for local building stone.[2,21] The marble in the province is a result of the metamorphism of limestone during the Pan African Orogeny.[13] The marble resources are found in the Widouw Formation (Gariep Supergroup) in the northwestern part of the province near Vanrhynsdorp and in the Cango Group in the De Rust area.

Conclusion

The status of the selected resources in term of deposits, working mines and former mines is shown in Figure 3. There are still a number of deposits to be exploited. The extent of former mines does not necessarily relate to the depletion of resources, but is driven rather by market value and demand. The resources of building sand in the Greater Cape Town area are limited and new resources from other regions or crushed sand from the Table Mountain Group sandstone east of this area will have to be utilised. The other construction materials – stone aggregate, brick clay and limestone (for use in cement manufacture) – are in abundant supply. There are approximately 20 000 tons of uranium in the identified resource category, but the uranium price must rise to higher sustainable levels before exploitation becomes viable. The current updated distribution of mineral resources in the Western Cape Province will be vital to town and rural planners, as well as to conservation organisations such as CapeNature, for the delineation of nature reserves so as to avoid sterilisation of economic important mineral commodities.

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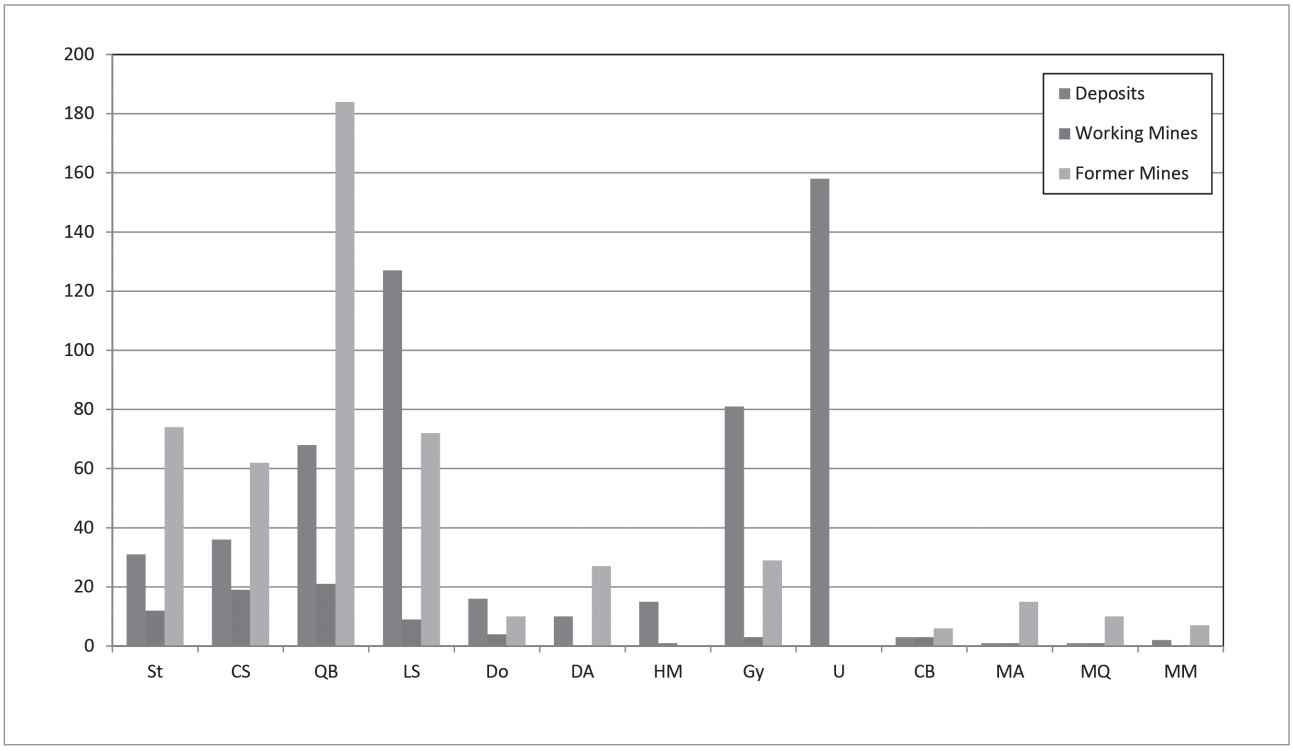

St, stone aggregate; CS, brick clay; QB, building sand; LS, limestone; Do, dolomite; DA, diamonds; HM, heavy minerals; Gy, gypsum; U, uranium; CB, bentonite; MA, granite (dimension stone); MQ, sandstone (dimension stone); MM, marble (dimension stone).

Figure 3: The status of potentially economic minerals of the Western Cape Province.

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