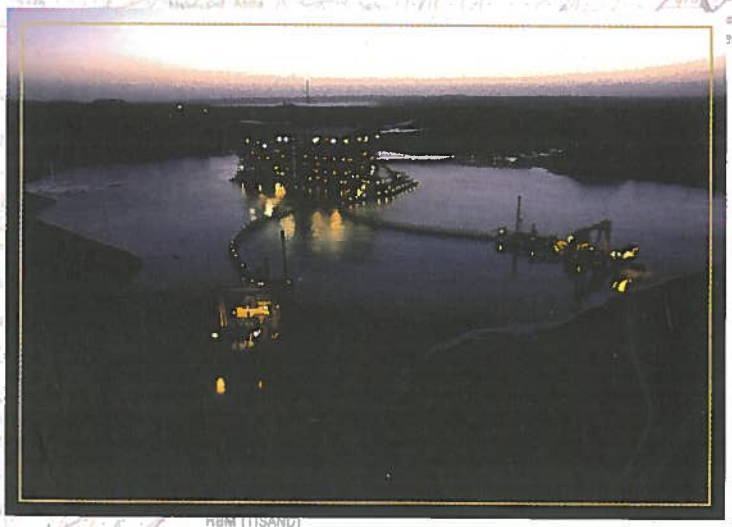
THE METALLOGENY OF THE RICHARDS BAY AREA

Representing the 2830 Dundee and
27½32 St Lucia Geological Series
1:250 000

by

H.G. Hira, H.L. King and D.L. Ehlers



EXPLANATION:
Metallogenic Map Sheet 2830
Scale: 1:250 000

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Cover: Mining plant E of Richards Bay Minerals at dusk, with two dredgers operational in the foreground. The slurry is pumped to the concentrator in the background, where the minerals are separated (photograph courtesy of Richards Bay Minerals).

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Abstract

The aim of this explanation is to compile the available information on the mineral deposits occurring within the borders of the 2830 Richards Bay 1:250 000 metallogenic map. The map area includes the 2830 Dundee and part of the 27½32 St Lucia geological maps. This explanation summarises information pertaining to the known mines, mineral deposits and occurrences in relation to their ages, lithologies and geological environments and thus serves as a guide to the metallogenic map.

The Richards Bay map sheet area contains a broad spectrum of mineral deposits in host rocks that range in age from 3.6 Ga Archaean to Recent. Mineralisation in the granite-greenstones consists of structurally hosted lode-gold deposits sharing many common characteristics with lode-gold deposits found in other granite-greenstone terranes. The Nondweni greenstones contain volcanic-related massive sulphide deposits, while the Pongola Supergroup is host to lode-gold and placer-gold mineralisation, occurrences that have been correlated with deposits found in the Witwatersrand basin.

The map area also includes the discontinuity-bounded tectonostratigraphic Tugela terrane of the Middle to Late Proterozoic Natal Metamorphic Province (NMP). The Tugela terrane has been interpreted as an ophiolite suite that was thrusted northwards onto the stable Archaean craton as nappe structures. The greenschist to amphibolite facies Tugela terrane has also been intruded by mafic-ultramafic complexes, alpine-type serpentinites (Sithilo and Sebenzani Complexes), plagiogranites and a number of alkaline to peralkaline granitoids (Ngoye, Wangu, Bulls Run). The metallogeny of the Tugela terrane can be described in relation to the various stages in the tectonic evolution of the belt. The initial rifting and extension-related stage was characterised by arc-related magmatism and volcanic-arc activity. Alkali basalt magmatism, resulting from hot-spot activity in an oceanic basin, in which the Tugela terrane initially accumulated, produced magmatic segregation deposits (Tugela Rand and Mambula Complexes) and volcanic-arc activity is responsible for the submarine-exhalative semi-massive sulphide mineralisation (i'Thuma River). Most of the mineralisation within the NMP is structurally related, where thrusts and shear zones probably created the paths necessary for the migration of mineralising fluids. The Alpine-type ophiolite deposits, were also emplaced along these structural zones. Epigenetic shear zone hosted gold mineralisation occurs within quartz veins (Ngubevu, Mfongosi, Nkunzana and Mpapala). Fluorspar deposits (Hlabisa) may represent a late-stage volatile-rich mineralising system active during the waning stages of the Lebombo volcanics.

No significantly large mineral deposit has yet been discovered in the Natal Metamorphic Province, possibly because of the relatively inaccessible mountainous terrain, deep weathering and dense vegetation. However potential mineralisation may also lie undiscovered beneath younger cover rocks of the Karoo Supergroup. Extensive coalfields (Klip River, Somkele, Nongoma) and smaller subeconomic coalfields (Qudeni, Nqutu, Mtunzini) occur within the map sheet area. KwaZulu-Natal is also host to most of South Africa's wetlands peat deposits. Other mineral occurrences in the map sheet area include dolomite, kyanite, iron, bauxite, phosphate, clay and aggregate.

The most extensive and economically exploited mineral deposits currently mined are heavy-mineral sand deposits in dune and beach sand occurring near Richards Bay and along the entire KwaZulu-Natal coastline. These sands contain economically significant concentrations of rutile, ilmenite and zircon, from which titanium and zirconium are extracted.

1 INTRODUCTION

Metallogenesis is the tendency of certain types and styles of mineralisation to occur in specific spatial, temporal and tectonic settings. Metallogeny serves to clarify the factors which result in these concentrations of deposits and commodities, and provides a basis for the development of exploration strategies.

The production of a metallogenic map involves two stages, namely an acquisition phase and a compilation phase.

During the acquisition phase all available information on the area is gathered from various sources, such as the in-house South African Mineral Deposits Database (SAMINDABA), external databases, literature, geological and topographic maps, aerial photographs, and field checking.

The visual format in which the data are presented during the compilation phase constitutes a simplified geological overlay, a tectonic environment overlay and a mineral deposit overlay, all of which are verified. Following this process, the explanation is compiled and linked to the metallogenic map via map deposit numbers.

The 1:250 000 metallogenic map of sheets 27½32 St Lucia and 2830 Dundee (1:250 000 geological series) summarises, in visual format, the known mineral deposits and occurrences of this part of KwaZulu-Natal in relation to the geology and the geological environment, thereby serving as a guide to the mineralisation of the area, and as a reconnaissance exploration tool. The genetic, spatial, temporal and tectonic aspects of the mineral deposits and occurrences are highlighted on the metallogenic map and the coal resource areas are outlined. The mineral deposits and occurrences are visually represented by symbols depicting the deposit sizes, morphologies, orientations, and locations. This explanation documents the more important mineral deposits occurring on the Dundee (2830) and St Lucia (27½32) sheets, hereafter referred to as the Richards Bay sheet.

The Richards Bay sheet contains a broad spectrum of mineral deposit types, including the important coal-bearing units of the Karoo Supergroup, more specifically the bottom and top seams and their correlates, the Gus and Alfred seams, the lode-gold and placer deposits of the Pongola Supergroup, the volcanogenic exhalative sulphide mineralisation, granite-related deposits, epigenetic precious metal deposits found in the Natal metamorphic province (NMP) and the heavy-mineral Quaternary sands.

Physiographically, the area is characterised by a variety of topographies, from the accessible grasslands and cultivated areas of the northern and western parts, to the relatively inaccessible mountainous and densely vegetated terranes in the south and east. The northeastern part of the area is drained by the Black and White Mfolozi Rivers, whilst the southern and western areas are drained by the Tugela–Buffalo River systems, and the central part by the Mhlatuze River (Linström, 1987a and b).

2 GEOLOGICAL SETTING AND ASSOCIATED MINERALISATION OF THE RICHARDS BAY SHEET AREA

The ore deposits in the 1:250 000 Richards Bay sheet area are classified according to their host units, for example: the gold mineralisation in the Archaean granite-greenstone terranes and the mineral occurrences in the Proterozoic rocks. Although this form of classification is constrictive, it allows a genetic overview of the ore deposits in relation to the tectonic evolution of the area.

The Richards Bay sheet incorporates many tectonic terranes of varying degrees of structural complexity and the geology is represented by rocks ranging in age from Swazian to Recent. The following brief overview of the geology covers the greater KwaZulu-Natal area and is given as an aid to understanding the mineralisation in its tectonic context and geological setting.

The oldest rocks in the KwaZulu-Natal belong to two major tectonic domains, the Archaean Kaapvaal craton and the Middle to Late Proterozoic Natal structural and metamorphic province (NMP). The southeastern portion of the Kaapvaal craton is exposed in the northern parts of KwaZulu-Natal as far south as the Natal thrust front as various inliers, and constitutes typical granite-greenstone terranes with measured ages of up to 3,64 Ga (Compston and Kröner, 1988). Each of these remnants is lithologically distinct and comprises volcanic rocks ranging in composition from komatiities to basalts, with greater or lesser amounts of clastic and chemical sediments. The granitoids, gneisses and deformed greenstone relicts are unconformably overlain by the volcanics and metasediments of the Pongola Supergroup, which were deposited during the Late Archaean cratonisation (Linström, 1987a & b). Lode-gold and copper-zinc mineralisation characterise the metallogeny of the greenstones terranes.

The Pongola Supergroup is one of the oldest stratigraphic units to have developed on the craton and is believed to be ± 2 900 Ma old (Beukes and Cairncross, 1991), thus serving to confirm the early stabilisation of this portion of the Kaapvaal craton. The Supergroup comprises volcanics of the Nsuze Group and overlying arenites, argillites and iron formations of the Mozaan Group. Studies by Matthews (1990) suggest that the Nsuze Group was deposited in response to rifting within an epicratonic basin, while the Mozaan Group is believed to have developed in a postrift, subsidence basin.

The Pongola Supergroup is host to both lode- and placer-gold mineralisation. The lode-gold mineralisation shows

many similarities to the deposits found in the underlying granite-greenstone terrane. The placer deposits have always held interest mainly because of their close resemblance and proximity to the richly mineralised lithologies of the Witwatersrand basin (Beukes and Cairncross, 1991).

Precambrian rocks to the south of the craton belong to the NMP, commonly known as the Natal mobile belt. They have been dated at between ± 1 250 and ± 950 Ma (Eglington *et al.*, 1989; Thomas and Eglington, 1990) and are proposed to be the eastern continuation of what has become known as the Namaqua-Natal mobile belt. This belt is postulated to extend from Namaqualand in the west to KwaZulu-Natal in the east (Thomas *et al.*, 1990, 1994). The NMP belongs to the northern frontal zone, the northernmost part of which is known as the Natal thrust belt. This is a 2–5 km-wide, east–west-trending belt comprised of the Ntingwe and Mfongosi Groups. The southern portion of the northern frontal zone comprises four flat-lying thrust sheets, collectively forming the Tugela Group. Southward, the thrust sheets move into intensely deformed, steeply dipping to vertical, strata which constitute the Matigulu Group* (Linström, 1987a).

The Natal sector of the Namaqua-Natal mobile belt has been divided into the following three distinct tectonostratigraphic terranes (Thomas, 1989): the Tugela (in the north), and the Mzumbe (central) and Margate terranes (in the south) (Table 1). These terranes are further subdivided by two major structural discontinuities, the Lilani–Matigulu shear zone, which separates the Tugela terrane from the Mzumbe terrane, and the Melville shear zone which separates the Mzumbe terrane from the Margate terrane. The Tugela terrane occupies the southern portion of the Richards Bay sheet area. Mineral deposits of the Mzumbe and Margate terranes are discussed in the explanation to the Durban and Port Shepstone sheets.

Aspects of the geology and evolution of the Namaqua-Natal metamorphic province have been analysed in great detail (Matthews, 1972, 1981, 1990; Matthews and Charlesworth, 1981; Thomas and Eglington, 1990; Jacobs *et al.*, 1993; Jacobs and Thomas, 1994; Thomas *et al.*, 1993, 1994, 1995). From this research there is general consensus that the evolution of the province can be related to a complete Wilson cycle model. Such a cycle involves an initial phase of extension and rifting, leading to fragmentation and the formation of an oceanic basin. This early phase is followed by plate convergence, obduction and, in this case, oblique collisional orogeny.

In the Natal sector, the Tugela Ocean is believed to have formed south of the Kaapvaal craton, with rising volcanic arcs (later to form the Mzumbe and Margate terranes) developing further south. Matthews (1972) interpreted the Tugela terrane as an ophiolitic assemblage that was deposited in this oceanic basin. Early northeast-directed thrusting and nappe emplacement, believed to be attributable to oblique arc-continent collision associated with the closure of the Tugela Ocean, led to the accretion of the three NMP terranes onto the southern margin of the Kaapvaal craton (Thomas *et al.*, 1994). Continued convergence is thought to have resulted in collision-induced crustal thickening and later ductile transcurrent shearing.

TABLE 1 – TECTONIC SUBDIVISION OF THE NATAL STRUCTURAL AND METAMORPHIC PROVINCE (NMP) (after Bullen *et al.*, 1992).

North Archaean Kaapvaal craton		
Mfongosi thrust		
Tugela terrane	Shallow-water shelf facies sediments	Ntingwe Group
	Greenschist facies metashales and lavas	Mfongosi Group
	Amphibolites	Tugela Group
Mapumulo thrust		
Mzumbe terrane	Amphibolite-grade gneisses and migmatites	Mapumulo Group
	Pre- and syntectonic I- and S-type granitoid gneisses, metabasites. Rapakivi granite-charnockite plutons	Oribi Gorge Granitoid Suite
Mellville shear zone		
Margate terrane	Granulite-grade gneisses	Mzimkulu Group
	Pre- & syntectonic granitoid gneisses and charnockites, rare metabasites. Rapakivi granite-charnockite plutons	Oribi Gorge Granitoid Suite
???		
Transkei terrane	Amphibolite-grade gneisses, pretectonic granite gneiss	
SOUTHERN CAPE CONDUCTIVE BELT SOUTH		

Four genetic groups of metalliferous deposits have been recognised within the NMP (Thomas *et al.*, 1994), and Table 2 indicates the known mineralisation within the Tugela terrane. These four genetic groupings are magmatic segregations, volcanogenic exhalative deposits, granite-related deposits and epigenetic precious metal deposits. The initial stages in the Wilson cycle of the NMP are believed to have been characterised by rifting and sea-floor spreading, volcanic arc activity and arc-related magmatism. The two main types of mineralisation that developed during this phase are the magmatic segregation deposits (confined to the Tugela terrane,

*Not yet approved by SACS

TABLE 2 – MINERALISATION STYLES WITHIN THE TUGELA TERRANE OF THE NMP (after Thomas *et al.*, 1990).

	Metal	Host lithology	Mineralisation type
Tugela terrane	Au, Ag, Pb, Cu, Zn	Mainly schists of the Mfongosi Group and amphibolites of the Tugela Group	Gold associated with quartz in shear zones
	Au, Ag, Cu, Pb, Zn	Amphibolites and schists of the Tuma Formation (Tugela Group)	Deformed, stratiform, sediment-hosted exhalative massive sulphide
	Cr, Fe, V, Ti, (Cu, Ni, Co)	Mafic and ultramafic rocks of the Sithilo Complex, the Sebenzani Complex**, the Mambulu Complex and the Tugela Rand Layered Suite	Vanadiferous & titaniferous magnetite layers and chromite-bearing pods in layered mafic/ ultramafic intrusions
	Zr, Nb	Syenitic and carbonate gneiss (Bulls Run Complex)	Local concentrations in gneissic carbonatite
	Nb, Zr, Y, REE	Peralkaline granitoid gneiss of the Ngoye Complex	Quartz-magnetite "blows"
	Zr, Nb, Zn, REE	Peralkaline gneiss in the Halambu Formation	Disseminated in peralkaline granitoid gneisses

such as the Tugela Rand Layered Suite) and volcanogenic exhalative deposits, such as the i'Thuma deposit. In addition, peralkaline granites were also generated during this phase, such as the Ngoye Complex. The supracrustal sequences of the NMP terranes are then believed to have been deformed and metamorphosed during a compressive accretionary event, which also affected the volcanogenic massive sulphide deposits. Afterwards, collision-related crustal thickening is thought to have resulted in the generation of syn- to late-tectonic granitic magmas. Magmatic fluids emanating from these magmas at shallow crustal levels may have resulted in the formation of pegmatites and epithermal vein deposits. Later isostatic adjustments of the terranes may have reactivated major shear zones which provided the conduits for late-mineralising fluids that formed precious metal vein deposits (Thomas *et al.*, 1994).

Overlying Phanerozoic rocks comprise the poorly mineralised sandstones of the Natal Group. The Carboniferous to Jurassic sediments (which host abundant coal deposits) and volcanics of the Karoo Supergroup unconformably overlie these older lithologies (De Wit *et al.*, 1992). The Vryheid and Emakwezini Formations of the Karoo Supergroup are very important coal-bearing horizons.

The Permo-Carboniferous Dwyka Group at the base of the Karoo Supergroup variably oversteps the older sandstones to lie directly on basement rocks in places. The Karoo Supergroup is most extensively developed in the western and northern parts of the province, whilst a thin strip is developed adjacent to the coast, in the central and southern areas. Quaternary sands interspersed with Cretaceous sediments (which host extensive heavy-mineral sand deposits) occupy the coastal belt along the eastern seaboard.

3 BRIEF DESCRIPTION OF THE STRATIGRAPHY

The following brief description of the stratigraphy of the Richards Bay sheet area, excluding the Nondweni Group, is based on the explanation of the geology of the old Dundee sheet by Linström (1987a).

3.1 THE NONDWENI GROUP

The Nondweni Group comprises a succession of dominantly metavolcanic rocks with minor metasedimentary rocks. It has been subdivided, in upwards succession, into the Magongolozi, Toggekry and Witkop Formations (Versfeld and Wilson, 1992).

The Magongolozi Formation, which forms the lowermost unit of the Nondweni Group, comprises a complex association of mafic and intermediate volcanic rocks in association with medium- to fine-grained layered diorites, gabbros and pyroxenites. The latter are an integral part of the succession, being high-level intrusions related to the emplacement of the volcanic rocks, or to the crystallisation of ponded lava lakes. Ultramafic and felsic volcanic rocks and komatiites are absent (Wilson and Versfeld, 1992a).

The Toggekry Formation, which overlies the Magongolozi Formation, comprises a succession of massive and foliated rhyolites and felsic schists with minor mafic volcanic and sedimentary rocks. This contrasts with the other formations of the Nondweni Group which are dominated by mafic pillow lavas and komatiites (Versfeld and Wilson, 1992b).

The Wikop Formation, which constitutes the uppermost formation of the Nondweni Group and which structurally overlies the felsic rocks of the Toggekry Formation, consists of a succession of dominantly spinifex-textured komatiites, pillowed basalts and komatiitic basalts, with minor sedimentary rocks (Wilson and Versfeld, 1992).

3.2 EMPANGENI METAMORPHIC SUITE*

The lower Lubana Formation* comprises melanocratic pyroxene-garnet-magnetite-quartz granoblastite interbanded with magnetite-orthopyroxene-quartz gneiss, garnet orthopyroxenite, clinopyroxene-garnet-plagioclase gneiss and garnet-biotite enderbitic granolite. The Lubana Formation has been subjected to granulite facies metamorphism.

The upper Ngweni Formation* is composed entirely of amphibolites. Their mineralogy comprises hornblende, hypersthene, diopside and minor plagioclase and opaque minerals.

*Not yet approved by SACS

3.3 THE PRE-PONGOLA GRANITES

These granitic units comprise the granitic basement complex which intruded the Nondweni Group and the Empangeni Metamorphic Suite. The granitic basement comprises granitic gneiss and homogeneous adamellitic granite.

The Nzimane inlier, exposed as several fault-bounded outcrops of the Archaean basement in the Hlbabisa area, consists of intrusive granitoids (Nzimane Granite) which contain remnants of the Wela Formation (Thomas *et al.*, 1999).

3.4 THE PONGOLA SUPERGROUP

The Pongola Supergroup comprises the lower Nsuze and the upper Mozaan Groups (Fig. 1). The Nsuze Group consists of six formations of alternating sedimentary and volcanic sequences. The six formations, in stratigraphic order from the base up, are the Bomvu Formation (orthoquartzitic sandstone), the Nhlebela Formation (amygdaloidal lava), the Thembeni Formation (intercalated mudstone, shale and siltstone), the Chobeni Formation (quartzite-dolomite), the Bivane Subgroup (amygdaloidal lava), and the Taka Formation (ferruginous shale and quartzite). The Mozaan Group unconformably overlies the Nsuze Group and comprises three formations. Conglomerate, iron formation, orthoquartzitic sandstone, shale and argillaceous sandstone comprise the lowermost Mandeva Formation, which is host to the Denny Dalton Mine auriferous mineralisation. The overlying Mpunga Formation consists of shale and intercalated quartzite, whilst the overlying Qwasha Formation, comprising ferruginous shale and intercalated quartzitic sandstone, caps the succession.

Ultramafic dykes, the layered Hlagothi Suite*, syenite bodies, and diabase sills and dykes have intruded into the Pongola Supergroup. The majority of the intrusives predate the deformational events which affected the Nsuze Group.

3.5 THE NATAL STRUCTURAL AND-METAMORPHIC PROVINCE

Roughly from north to south, the NMP comprises the Mfongosi (hornblende gneiss, amphibolite, schist, quartzite, iron formation), the Ntingwe (arkosic grit, conglomerate, mudstone, shale, limestone), Tugela, Matigulu and the Mapumulo Groups (banded hornblende-bearing gneiss, biotite gneiss, quartzo-feldspathic gneiss and migmatite). The Tugela Group consists of four thrust sheets. The lowermost thrust sheet, the Nkomo nappe, comprises the Bulls Run Complex and the Khomo, Woshane and Mtengu Formations, as well as the Halambu Gneiss, the Wangu Granite Gneiss, the Hlobane Complex and the Ngoye Complex. The overlying Madidima nappe comprises the Silambo, Zwaneni

Figure 1 – Stratigraphy of the Pongola Supergroup with respect to sheet 2830 Richards Bay.

and Endlovini* Formations, the Zidoni amphibolite, Gazeni mica-gneiss, Thawini Gneiss Formation, and the Mlalazi Complex. Above this, the Mandleni nappe comprises the Dondwana gneiss, Dulumbe Gneiss Formation, the Tondweni Gneissic Amphibolite Formation, the Wosi Amphibolite Formation, the Sithilo Serpentinite-Talc Complex, and the Mambulu Complex. The uppermost Tugela nappe itself is made up of the Tuma Formation, the Manyane Amphibolite Formation, the Kotongweni Tonalite, the Tugela Rand Layered Suite, the Mkondeni Diorite, the Dimane Granite and sheets of metagabbro.

Below the Tugela Group thrust sheets lies the steeply dipping Matigulu Group, which comprises the Thondo Amphibolite Formation, the Intuze Gneiss Formation, the Sequembi Amphibolite Formation, the Mpisi Gneiss Formation and Buhleni Gneiss.

3.6 THE NATAL GROUP

Above the rocks of the NMP are the fluvial sediments comprising a clastic wedge that forms the *Natal Group*. The base of the Group is marked by a conglomerate overlain by quartzose sandstone, occasional siltstone and shale.

3.7 THE KAROO SUPERGROUP

The Karoo Supergroup in this area comprises the Dwyka Group, the Ecca Group, itself made up of the Pietermaritzburg, Vryheid and Volksrust Formations, as well as the Normandien*, Emakwezini, Ntabene, Nyoka, Clarens, and Letaba Formations and intrusive Karoo dolerites.

3.8 QUATERNARY ROCKS

The Berea Formation consists largely of brown to red clayey, fine-grained, non-calcareous sands. The sands are comprised of quartz, with variable proportions of clay and minor volumes of heavy minerals, such as ilmenite, magnetite, rutile, and zircon.

The Port Dunford Formation is made up of a lower argillaceous member (mudstone, lignite and clay) separated from the upper arenaceous member by a lignite bed which is, on average, 1,3 m thick.

The interfluvial Masotcheni Formation comprises a thin unit and generally limited in outcrop to valley floors, hillsides and flood plains. The Formation consists of a basal boulder bed grading upwards into sandy clay and then topsoil.

*Not yet approved by SACS

4 ARCHAEAN MINERALISATION

4.1 GOLD

Archaean gold mineralisation in the NMP is hosted by granite-greenstone remnants and rocks of the late Archaean Pongola Supergroup. In section below, the various lode-gold and placer-gold deposits occurring in the Archaean terranes of the map area are documented (cf. Fig. 2).

4.1.1 Granite-greenstone terranes

4.1.1.1 Nondweni goldfield

The first gold to be discovered in the present-day KwaZulu-Natal was discovered at Golden Valley, 15 km south of Vryheid, in 1836. Within the Richards Bay sheet area, however, the "Nondweni goldfields" were the first to be discovered. By 1894 over 1 678 m of shafts had been sunk and three gold mining companies were active in the area. The bulk of the gold was produced from the Enterprise (91) and Sisters (93) Mines which, between them, produced over 90 kg of gold. Numerous other small prospects were also developed within the Nondweni granite-greenstone belt (Fig. 2). In these goldfields, the mineralisation is hosted by mafic to ultramafic rocks of the Witkop Formation. Gold-bearing quartz veins are hosted mainly within pillowed and komatiitic basalts and carbonatised komatiites (Versfeld, 1988). There are numerous small prospects, predominantly in the northern limb of the greenstone belt on outcrops of Witkop Formation metabasalt. These workings targeted the steeply dipping quartz veins in the pillowed and komatiitic basalts. The locations of these small workings are shown in Figure 3. Based on the sizes of excavations and dumps, very little production is assumed to have occurred from these prospects.

Sisters Mine (93)

The Sisters Mine deposit (93), situated some 6 km southeast of Nondweni on Lot 4, Nondweni 10634 (Fig. 3), is hosted by the Nondweni Group. The deposit was mined at the turn of the 20th century. Union Corporation prospected the area and one diamond drill hole was completed. However, it is believed that this drill hole missed the downplunge mineralisation of the mine workings. Anglo American reviewed the area, but no follow-up work was undertaken (Bekker, 1986). The mineralisation is hosted in a 50-m-thick calc-silicate unit enclosed by talc schists. The calc-silicates display remnant spinifex textures, implying that the unit represents highly altered spinifex-textured komatiite or komatiitic basalt. Mineralisation is concentrated in quartz veins and stringers which are situated below a 2-m-thick, north-dipping chert unit. Some of the old workings also

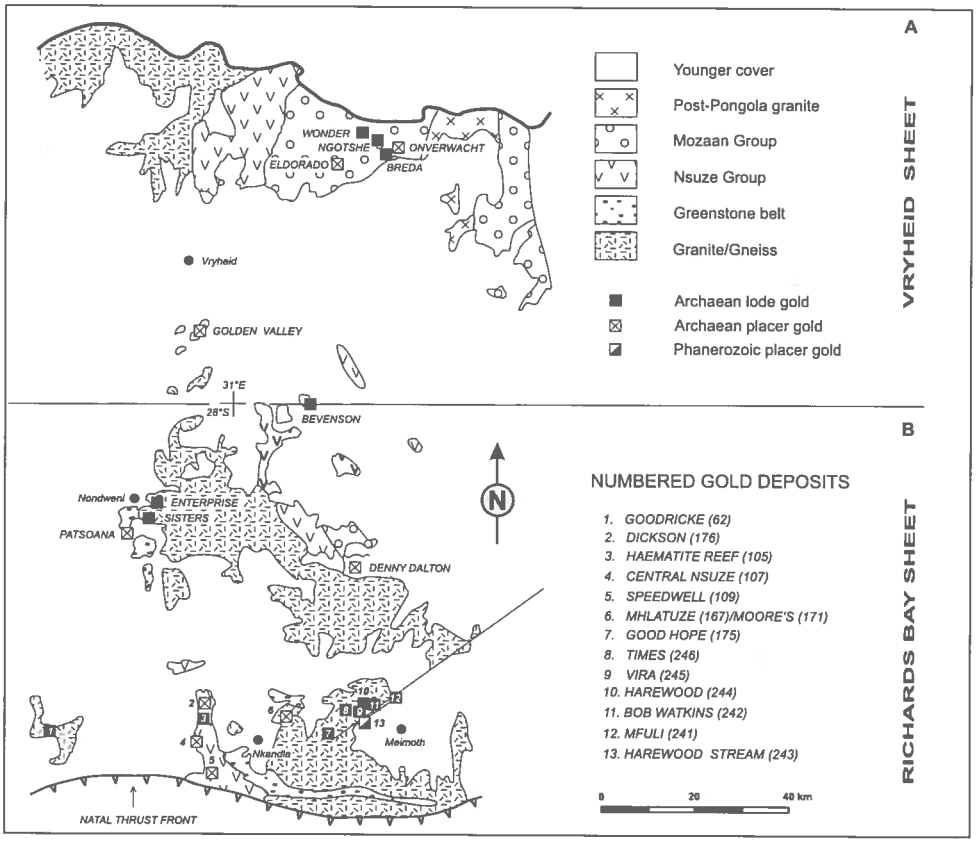

Figure 2 – Archaean gold occurrences of northern KwaZulu-Natal, south of the Pongola River (after Bullen *et al.*, 1994). Block A represents a portion of the Vryheid sheet, whilst block B represents a portion of the Richards Bay sheet.

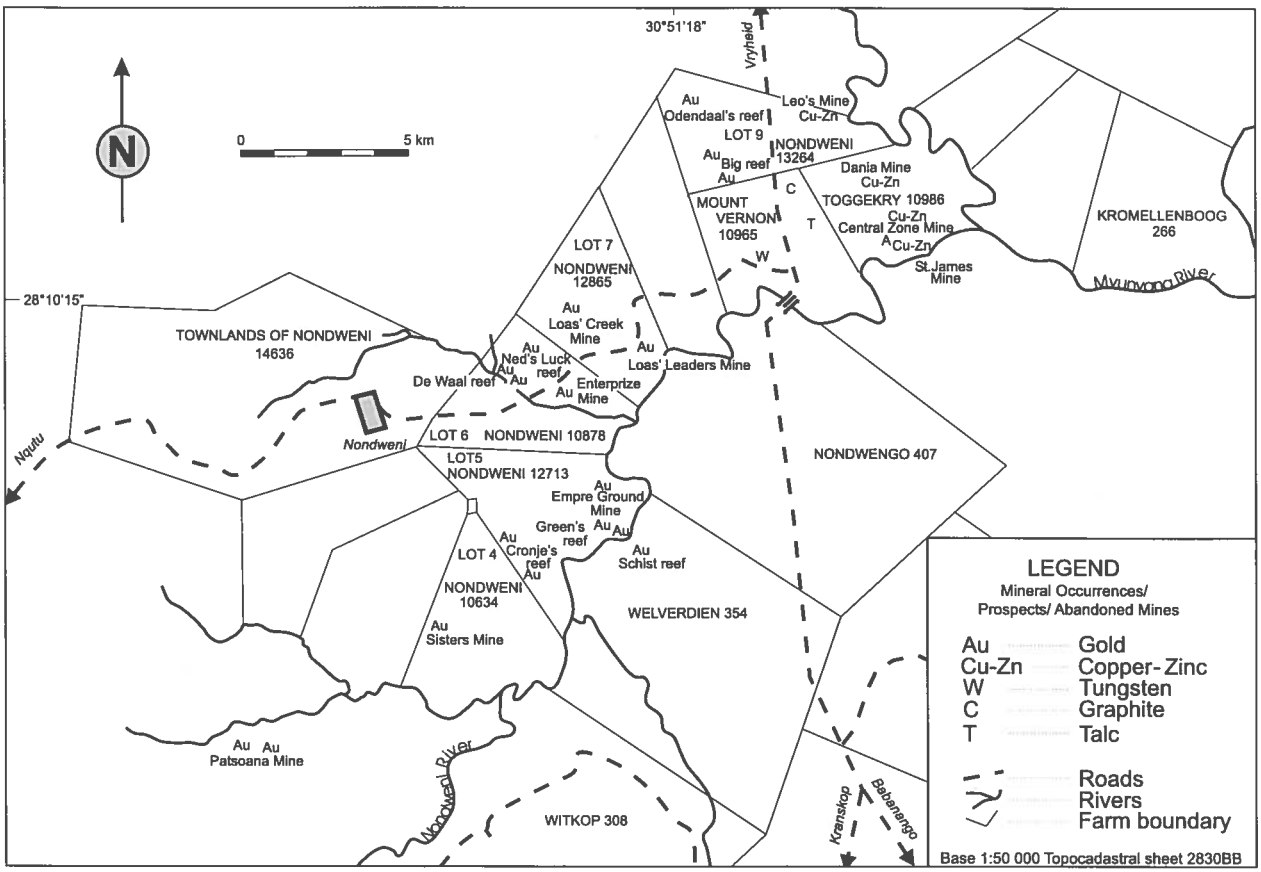

Figure 3 – Mineral occurrences in the vicinity of Nondweni, northern KwaZulu-Natal (after Versfeld, 1988).

exploited *en échelon* quartz-filled tension gash fractures (Versfeld, 1988). The quartz veins comprise an early generation of narrow stringers and veins which have been cross-cut by a second generation of coarser-grained veinlets.

There are no accurate records of past production at this mine. Channel sampling across the old excavations by Versfeld (1988) returned a maximum value of 1,3 g/t Au over 1 m, while sampling of diamond drill core gave a maximum value of 0,19 g/t Au. At the Sisters Mine (93), Versfeld (1988) proposed that gold had been leached from an earlier, relatively gold-enriched, carbonatised alteration envelope by CO_2- and H_2O-rich alkaline fluids, and concentrated in residual silica-rich fluids. These latter fluids precipitated within fractures in the carbonate rocks. Hydrothermal fluid/wall rock reactions are also thought to have influenced the selection of favourable sites for gold deposition. Investigations by the South African Development Trust Corporation Limited (STK) (De Klerk, 1987) revealed that the best gold grades were situated in the highly fractured and altered carbonate rocks. However, according to De Klerk, the mineralisation in this unit was probably the result of the intense fracturing which the mineralising fluids used as conduits en route to the final site of Au deposition, located stratigraphically higher in the volcanic pile, and which has subsequently been removed by erosion. De Klerk did not recommend further gold exploration at this site.

Enterprise Mine (91)

These workings, just north of the Sisters Mine (93) on Lot 6, Nondweni 10878 (Fig. 3), are found on a steeply dipping quartz vein which is up to 1 m thick, hosted in east–west-striking, subvertical, pillowed komatiitic basalt. No characteristic alteration envelope has been recognised in the host rocks over the 600 m strike length of this vein. Pyrite, pyrrhotite and minor chalcopyrite are present in vein quartz found in the old dumps. Versfeld (1988) proposed that the Enterprise and other minor gold vein deposits were formed by hydrothermal fluids leaching gold from lower levels in the greenstone succession and then precipitating it in dilational structures at higher levels in the more competent lithologies. No recent prospecting has been done in this area, which is now densely populated.

Goodricke's Workings (62)

These old workings occur some 45 km west of Nkandla near the Sifula inlier of the Nondweni Group. The workings are hosted in a granitic terrane along the southern extremity of the Kaapvaal craton on the Natal Thrust Front (Lynn, 1989). Cupriferous quartz veins, hosted in a mafic schist greenstone xenolith within the Archaean granitic terrane, were exploited at the turn of the 20th century (Lynn, 1989; Bullen *et al.*, 1994). The schistose lens is fine- to medium-grained and strikes east–west

with a steep northerly dip. Hosted by the schistose lens is a steeply dipping 75-cm-wide mineralised quartz vein, which has been mined down dip for 15 m (Fig. 4). The extent of the mining along strike could not be determined as the east–west developments had collapsed. Investigation by STK of the dumps above the inclined shaft, revealed galena, chalcopyrite, chalcocite, bornite and malachite mineralisation in association with vein quartz hosted by schists (Lynn, 1989). To the west of the greenstone remnant lies an ultramafic dyke. The dyke was extensively pitted, but no mineralisation was found (Lynn, 1989). To the south of the greenstone remnant, soil sampling by STK revealed a Cu, Zn and Pb anomaly, which may represent a larger xenolith or the southern extent of the mineralisation of the schistose greenstone remnant (Lynn, 1989). The soil sampling conducted by STK of the greenstone remnant and mafic dyke failed to reveal any gold mineralisation above 0,1 g/t. Analyses of dump samples revealed high Cu and Pb values and subeconomic gold values (Lynn, 1989).

At the Goodricke's Workings (62), Brown (1988b) identified four anomalous sulphide-bearing zones (Table 3), each of which contained trace amounts of gold, along with elevated base-metal (Cu, Zn, Co) and Ba concentrations. The highest gold value reported was 4,9 g/t in a quartz reef of limited strike length (40 m). Brown (1988b) concluded that the limited size of the deposit, coupled with its relative inaccessibility, militates against its economic potential Brown (1988b).

Melmoth granite-greenstone remnant

Six auriferous quartz vein deposits have been worked in this remnant. For production and grades, the reader is referred to Table 4. Bullen (1990, 1991) completed a detailed study on the mineralised part of this greenstone succession. Four phases of deformation and metamorphism were recognised in the greenstones, which comprise mainly mafic metalavas with minor serpentinite, talc schist, dacitic tuff, quartz-muscovite schist, quartzite and calc-silicate rocks. Syn-tectonic trondhjemitic gneisses, late-tectonic granodioritic gneisses and posttectonic granite dykes, form the main intrusive phases. The virtually inaccessible Times (246), Bob Watkins (242), Mfuli (241) and Good Hope (175) deposits have not been explored in detail; however Bullen's (1990) study included the Harewood (244) and Vira (245) workings.

The Harewood workings (244), on the farm Koningsberg 6147, are hosted by highly altered trondhjemite (now quartz-sericite schists), while at the Vira deposit (245), also on Koningsberg 6147, the workings are situated in mafic metalavas, just below the contact of the Natal Group sandstones. Mineralisation at both localities is confined to shear-zone-hosted, second-generation quartz veins, which cross-cut earlier, barren, and texturally different, quartz veins. The mineralised veins are composed of medium-grained, equigranular quartz, with minor tourmaline, specularite and sericite. Pyrrhotite, sphalerite and native gold occur in trace amounts. These quartz veins are confined to the centre of a major east–west-trending, brittle-ductile, steep, southerly dipping shear zone. This shear zone formed during the emplacement of a late-tectonic granodioritic pluton. Gold was concentrated in economic quantities (up to 5,6 ppm) in dilational sites which formed as the shear zone intersected lithologies of contrasting competencies. Quartz-infilled extension gashes also contain trace amounts of gold (Bullen 1990, 1991).

The Harewood and Vira deposits exhibit similar wall rock alteration features (for example — sericitisation and chloritisation) despite the fact that they are hosted in different rocks. This suggests that both deposits formed under similar conditions and that the mineralising fluids were of a uniform composition. From mineralogical studies, these fluids were considered to be of both magmatic and metamorphic origin. Magmatic fluids, believed to have been generated by the intruding granodiorite pluton, during pressure release and magma crystallisation, were oxidising by nature and deposited the silicate and oxide phases. The contact metamorphic effect of the pluton on the adjacent greenstones resulted in later, chemically reduced, metamorphic fluids, which deposited the sulphide phases and Au (Bullen, 1990).

Deposition of the gold was principally in response to fluid/wall rock interaction. Though similar wall rock alteration is present at both deposits, sericitisation dominates at Harewood (because of the original granitic host rocks), whereas chloritisation is more prevalent at Vira

TABLE 3 – CHARACTERISTICS OF THE SULPHIDE-BEARING ZONES AT GOODRICKE'S WORKINGS (after Brown 1988b).

Zone	Description	Highest element concentrations
A	Meta-argillaceous horizon with disseminated sulphides at the base underlain by layered, highly altered felsic volcanics	Cu: 75 ppm; Co: 400 ppm, Zn: 547 ppm
B	Banded iron formation containing disseminated sulphides which overlie an ultramafic unit that has been subsequently altered to talc	Cu: 351 ppm Zn: 1 183 ppm Co: 441 ppm
C	Intensely folded and altered felsic tuffs and meta-argillites containing a thin mineralised horizon with elevated Au values	Au: 300 ppb
D	Highly sheared ultramafics (with locally developed chrysotile) and meta-argillites which are enriched in sulphides along the shears	Cu: 1 246 ppm Low Au concentrations

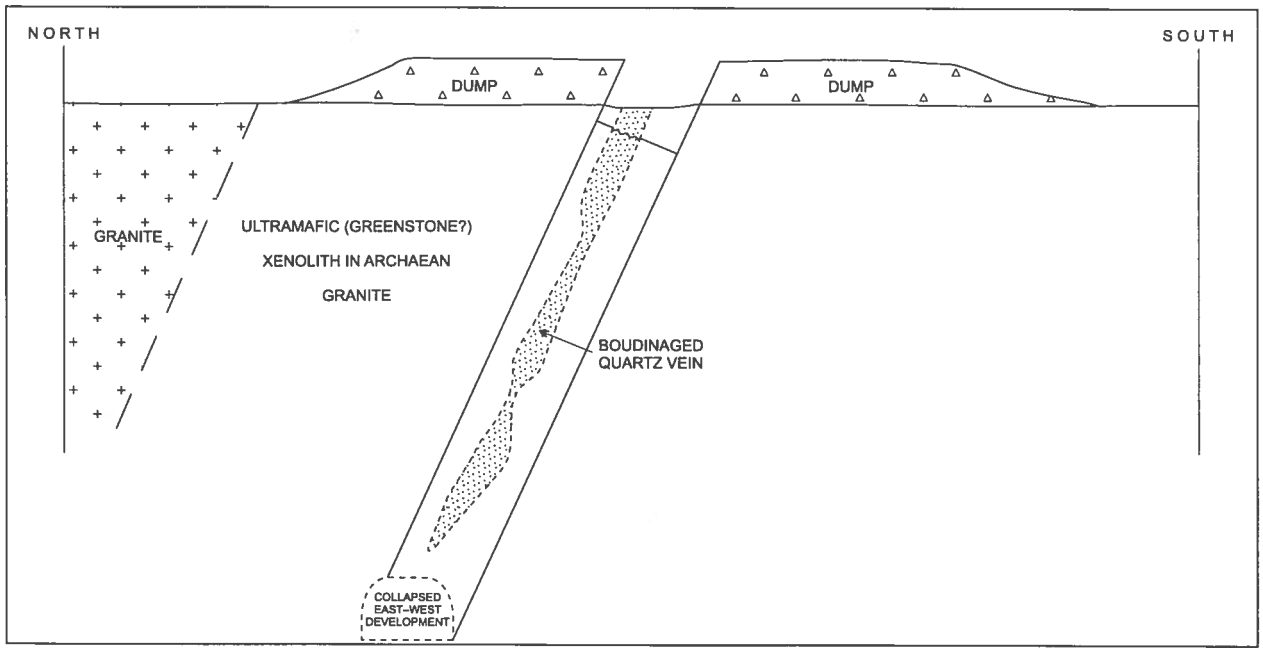

Figure 4 – Section of the inclined shaft at Goodricke's Gold Mine (62) (from Lynn, 1989).

owing to the mafic nature of the original lavas. Argillic alteration is pronounced immediately adjacent to the ore bodies, and this is surrounded by a wider halo of chloritic alteration (Bullen, 1990).

4.1.2 Pongola Supergroup

4.1.2.1 Placer-gold deposits

Archaean placer-gold deposits are restricted to the sedimentary lithologies of the Nsuze and Mozaan Groups of the Pongola Supergroup (Fig. 1). These deposits attracted attention mainly because of their stratigraphic and geological similarities with the richly mineralised Witwatersrand basin conglomerates. However, the complex fluviatile systems and hydrothermal activity that re-concentrated the mineralisation in the Witwatersrand basin appear to have been largely absent in this area (Dix, 1984), and extensive, high-grade gold deposits have not yet been located. Mineralisation is impersistent and all the old workings have been abandoned. Sulphide-bearing auriferous conglomerates hosted by the Nsuze Group are only located in the Nkandla area and are not evident in other localities. These conglomerates are totally absent in the White Mfolozi inlier to the north and the Piet Retief–Amsterdam area, where the auriferous conglomerates are confined to the Mozaan Group (Weilers, 1990). The Nsuze conglomerates in the Nkandla area have been extensively investigated by Gold Fields of South Africa, Anglo American Corporation of South Africa and the South African Development Trust Corporation Ltd.

There was renewed interest in these formations during the 1980s and early 1990s when Gold Fields of South Africa and Anglo American Corporation of South Africa conducted extensive diamond drilling in an effort to locate Witwatersrand-type mineralisation. U/Pb dating of single zircons carried out during this period confirmed similar ages for the strata and those of the Witwatersrand Supergroup (Beukes and Cairncross, 1991).

According to Beukes and Cairncross (1991), major horizontal tectonic disruption is likely to have occurred on the craton between 2 700 Ma and 2 800 Ma (De Wit and

TABLE 4 – SUMMARY OF AVAILABLE PRODUCTION STATISTICS FOR GREENSTONE-HOSTED LODE-GOLD DEPOSITS IN KWAZULU-NATAL.

Mine/Working name	Production period	Production	Average grade
Enterprise Mine (91) Sisters Mine (93)	1887–1899	90 kg	± 7 g/t (Hammerbeck, 1976a)
Harewood (244)	± 1894–1909	13 kg from 709 t	18,24 g/t
Vira (245)	as above	9,31 kg from 1222 t	7,63 g/t
Times (246)	as above	0.93 kg from 926 t	1,01 g/t
Bob Watkins (242)		3,79 kg	3,70 g/t

Roering, 1990), resulting in the juxtaposition of the Witwatersrand and Pongola depositional basins, and allowing lateral correlations. Studies by De Wit *et al.* (1992) revealed that the Witwatersrand basin had undergone at least two depositional cycles during its development. The first cycle, which produced the lower part of the basin, is likely to have formed on the continental platform of a passive continental margin that faced open-ocean conditions to the south and west, with sediments having been derived mainly from a northern provenance area. The Pongola basin, at the southern margin of the Kaapvaal craton, is of similar age (± 2 900 Ma) to the lower part (or West Rand Group) of the Witwatersrand basin. The southernmost outcrops of the Pongola Supergroup also show evidence of having been part of a passive continental margin facing open-ocean conditions to the south (Matthews, 1990).

The present distributions and close proximity of the Witwatersrand and Pongola basins is shown in Figure 5 and it has been proposed that the Pongola basin represents the erosional relic of a previously more extensive sedimentary basin (De Wit *et al.*, 1992).

Beukes and Cairncross (1991) found lithostratigraphic (similar facies types and vertical facies successions) and palaeoenvironmental (similar sedimentation styles and sequence stratigraphic evolution) correlations between the type profile of the Mozaan Group and that of the Witwatersrand Supergroup in the Heidelberg–South Rand goldfield area.

What has perplexed most workers is the lack of economic grades or concentrations of gold mineralisation in the Pongola Supergroup. Workers during the early 1980s suggested that the Mozaan auriferous conglomerates were correlates of the poorly mineralised, lower Witwatersrand, West Rand Group lithologies (Saager *et al.*, 1982, 1986; Weilers, 1990) and this was considered sufficient reason for the lack of economic gold mineralisation. However, Beukes and Cairncross (1991) found that only those conglomerates from the lower part of the Mozaan Group had been studied during the earlier investigations, whilst the stratigraphically higher Bongaspoort*–Ntanyana* Formations (a possible Central Rand Group correlate) had received little attention, and should be targeted for future investigations.

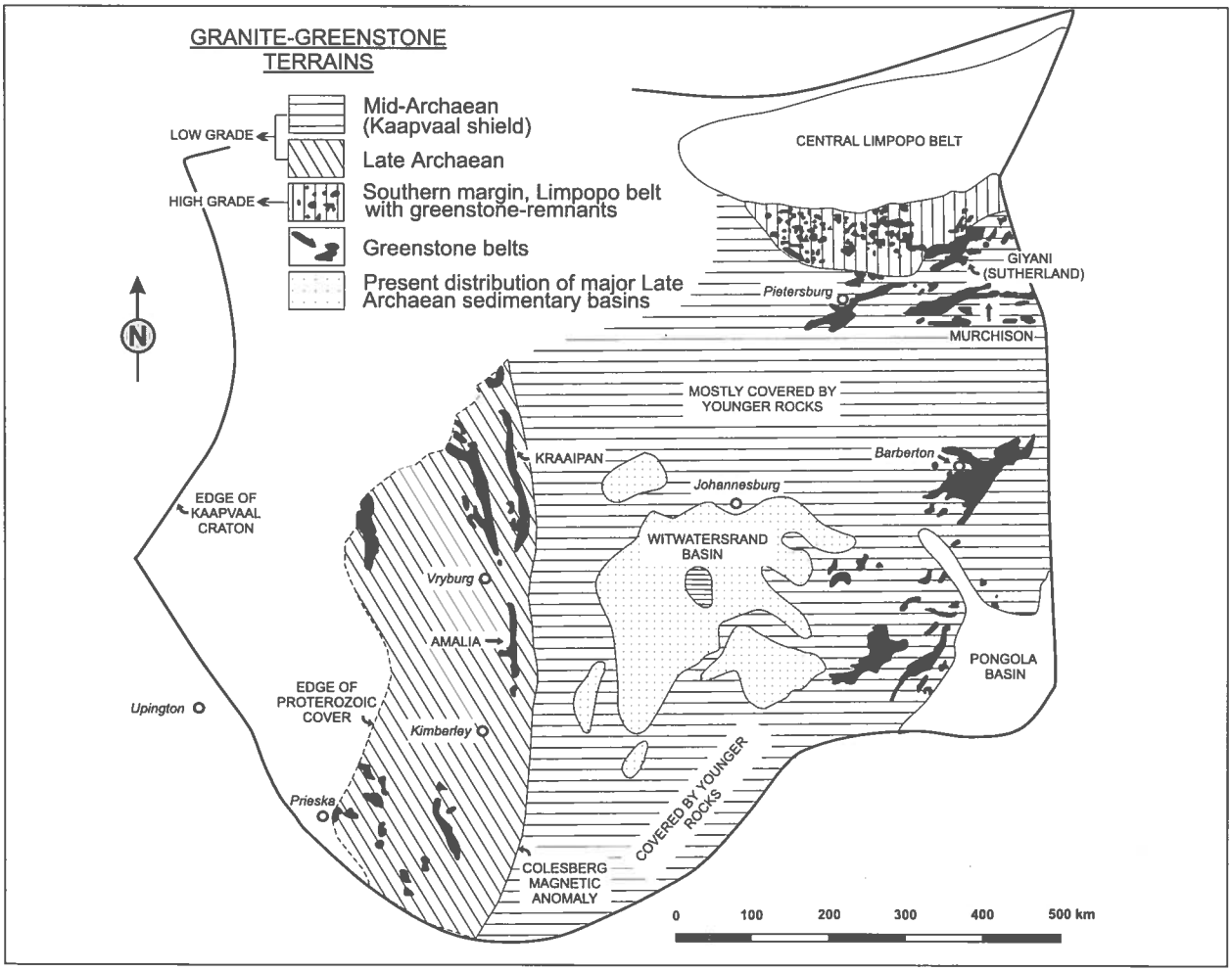

Figure 5 – Present-day extent of the Witwatersrand and Pongola basins on the Kaapvaal craton (after De Wit *et al.*, 1992).

*Not yet approved bySACS

When viewed on a broader scale, it is very likely that the two depositories were related in some way, as the distance between the southernmost Witwatersrand Supergroup outcrops and those of the Mozaan in the Amsterdam area is only 110 km. Beukes and Cairncross (1991) concluded that it seems highly unlikely that two such similar sequences could develop independently, in approximately the same time interval, such a short distance away from each other, on the same (i.e. Kaapvaal) craton.

Versfeld (1988) assumed the source of gold in the Nsuze Group to be the Nondweni greenstones, because the conglomerate clasts are dominated by greenstone lithologies. The low grade of mineralisation was attributed to the immature, matrix-supported nature of the conglomerates, which resulted in lower gold concentration factors.

Well-known Pongola placer deposits include the *Dickson (176)*, *Central Nsuze (107)*, *Speedwell (109)*, *Patsoana (95)* and *Denny Dalton (149, 234, 235)* Mines and occurrences.

The **Nsuze auriferous conglomerates**, which were worked in the early 1900s, are exposed in the Nsuze River gorge, some 12 km west of Nkandla. According to Groenewald (1982), three large synclines host the mineralised conglomerates, quartzites and phyllites of the Nsuze Group. The south and central Nsuze synclines plunge to the west at 30 to 40° and the North Nsuze syncline plunges to the east at 20°. The synclines are separated by thrust faults, so direct lateral correlation between the three synclines is impossible. Gold occurrences have been documented in each of the three synclines.

North syncline: Dickson Mine (176)

The Dickson Mine is located on the farm Qudeni 34 and the old workings consist of adits and trenches in two zones of steeply north-dipping, pyritic conglomerate. The deepest shaft was sunk to a depth of 30 m. The conglomerates comprise a series of seams; however, the Dickson Reef was the only conglomerate that was economically viable at the time of exploitation. The package of conglomerates strike east–west, dipping to the north at 77° (Weilers, 1990). The reefs, up to 35 cm thick, can be traced for 6 km along strike.

Total production recorded from this early venture was about 760 g Au at an average grade of 10 g/t (Hatch, 1910). Drilling carried out during the last exploration attempt in the area indicated that gold grades decreased with depth, from 9 g/t at surface to 1 g/t below the water table, which is suggestive of supergene enrichment (Bullen, *et al.*, 1994). The drilling also showed that the mineralised shoots had a limited lateral extent and the gold was very erratically distributed within them, suggesting that they would be subeconomic.

Central syncline: Central Nsuze (107)

These workings were mined in 1903/4 and consisted of 5 inclined shafts and 14 small adits (Weilers, 1990). The reef can be traced for 1 km along strike and contains a well-developed ore-shoot grading at 6,93 g/t Au over 87 cm (Winfield, 1982). This compares with assays by Hatch (1910) who reported a highest concentration of 6,2 g/t. The gold distribution at this deposit is, however, erratic and the projected reserves are small.

South syncline: Speedwell Mine (109)

These workings are situated near the village of Ntingwe on the farm Qudeni 25. Mining was carried out intermittently until the 1940s, and numerous adits and shafts are still visible over a width of 80 m. The reefs are steeply dipping and can only be traced for 600 m along strike, terminating against faults in the east and disappearing beneath younger cover rocks in the west (Bullen *et al.*, 1994). There are no production records for the old ventures; however Hatch (1910) analysed 10 conglomerate samples from this mine, which yielded an average of 3.1 g/t Au over a sampling width of 45 cm.

Randalhurst/Cooper's Claim (Store) gold occurrence (173)

This 1- to 4-m-thick auriferous Nsuze Group conglomerate layer crops out in the Mhlatuze River valley, south of the Nkandla–Melmoth road, some 10 km northeast of Nkandla. Most of the pits at Cooper's Claim have, however, caved in or have been in-filled (Thirion, 1979a). According to Saager *et al.*, (1986), the mineralised conglomerates are clast supported, with elongated pebbles and are well mineralised in parts. In addition, they contain detrital pyrite, pseudomorphic haematite and Fe-hydroxides. Up to 1910, 105 t of ore had been mined from several shafts and adits on the mineralised conglomerate zone, yielding ± 288 g of gold at an average grade of some 2,7 g/t (Hatch, 1910). As the general tenor of the reef was low, the workings were abandoned. Approximately 5,5 kg of gold were won from the Randalhurst occurrences with an average grade of 3 g/t (Weiler, 1990).

Moore's Claim (171, 172)

Moore's Claim is situated in the vicinity of Stanhope (Cooper's Store), some 10 km northeast of the Nkandla village. Approximately 5,5 kg of gold at an average grade of 3 g/t was won from the Moore's Claim workings (171).

In the early 1970s Messina (Tvl) Development Company Ltd investigated the prospect of copper and nickel mineralisation of the many irregular sill-like syenite intrusives and serpentinite bodies in the vicinity of the Cooper's Cu workings (161, 162, 164–166). They established that the average copper content of the syenites was between 0,03

and 0,05 per cent Cu, and that the nickel content of the serpentinites ranged between 0,2 and 0,3 per cent Ni. The nickel was, however, silicate bound and therefore not economically viable (Thirion, 1979a). The investigation indicated that the copper-bearing veins in the Mhlatuze River area are narrow (between 0,1 and 0,2 m) and of limited strike length, as well as having low assay values (~ 1,0 %, or less, Cu) (Thirion, 1979a).

Patsoana Prospect (95)

This prospect is situated some 10 km south of Nondweni on Reserve No.18 7638. The 2,5-m-thick conglomerate unit prospected here occurs near the base of the Nsuze Group and is overlain by cross-bedded quartzites and grits (Versfeld, 1988). The adits, pits and trenches were abandoned prior to 1900, as the workings were not profitable. Channel sampling by Versfeld (1988) indicated a peak assay value of 0,55 g/t in this matrix-supported conglomerate, and the clasts, mainly chert, quartzite and vein quartz, are considered to have been derived from the Nondweni Group.

4.1.2.2 Mozaan auriferous conglomerates

Denny Dalton workings (149, 234, 235)

The Denny Dalton workings, which operated intermittently between 1894 and 1926, are situated 38 km northwest of Melmoth on the farm Tusschenby 411 (Ward and Wilson, 1998). The mines are located within the White Mfolozi inlier. A total of approximately 14 kg of gold was produced from this mine, making it the largest placer-gold producer from the auriferous conglomeratic horizons of the Pongola basin. The average grade mined at Denny Dalton was roughly 4 g/t Au (Roberts, 1988).

The old mine workings, consisting of open pits and adits, are situated in a stream bed which has exposed the Mozaan contact reef (MCR). The highest grades (around 20 g/t) were reported from near-surface ore, which suggests supergene enrichment (Bullen *et al.*, 1994). Recent exploratory drilling revealed the maximum down-dip extent of the MCR to be less than 600 m from the local surface, which would not make this a viable mining venture. It is estimated that the remaining reserves have an average grade of ~1,4 g/t (Ward and Wilson, 1998). The uraniferous character of the conglomerates was established during reconnaissance exploration between 1974 and 1978 by Southern Sphere Uranium (Pty) Ltd. Drilling at Denny Dalton Mine has indicated potential reserves of approximately 235 kg gold and ~40 000 kg U_3O_8 (Weiler, 1990).

According to Saager *et al.* (1986), the basal conglomerate layer (MCR), which overlies a 30-m-thick quartzitic sandstone unit at the base of the Mozaan Group at Denny Dalton, constituted the prime target for mining, as it closely resembled the Witwatersrand ores, both with regard to mineralogy and texture. Dix (1984) noted some fluvial reworking of the conglomerates at Denny Dalton which, he believed, had been responsible for the local upgrading of the heavy-mineral content. However, this process did not seem as effective or long lasting here as it must have been in the Witwatersrand deposits.

The auriferous MCR is up to 7 m thick and contains large (up to 1 cm), rounded, compact pyrite grains, arsenopyrite and minor brannerite (Saager *et al.*, 1986). Economically exploitable mineralisation was only found in the lowermost 0,5 to 1,0 m of this reef, which dips at between 5 and 10° east-northeast and crops out intermittently over a strike length of 10–15 km (Bullen *et al.*, 1994; Weiler, 1990). The mineralisation occurs very erratically throughout the entire package. A second conglomeratic horizon overlies the MCR and is known as the hanging-wall reef (HWR), which is polymictic, consists of small- to medium-sized pebbles with pyrite and is lithologically similar to the MCR. The HWR is deemed potentially economically viable for uranium and gold exploitation (Weiler, 1990).

4.1.2.3 Lode-gold deposits

The quartz lode-gold deposits of the supracrustal Pongola Supergroup show many similarities to the lode-gold deposits in the underlying granite-greenstone terrane. The origin of these epigenetic lode-gold deposits is from deeply sourced hydrothermal fluids, the mineralisation being controlled by the structure in the areas concerned.

Haematite reef (105)

This occurrence (reported by Bullen *et al.*, 1994) was discovered in 1893 and is situated 12 km northeast of Nkandla (Fig. 2) on Reserve No.19 7638. The orebody is hosted in quartzite and phyllite of the Nsuze Group and mineralisation occurs in a 1-m-thick, bedding-parallel quartz reef which contains cubic pseudomorphs of haematite after pyrite, the haematite giving way to pyrite at depth. Some exceptionally rich pockets of ore with grades of up to 204 g/t gold, have been located. However, mineralisation is sporadic and apparently refractory at depth, which may cause beneficiation problems. These factors have led to the perception that the reef is subeconomic and no detailed prospecting has been reported since.

4.2 OTHER METALLIFEROUS DEPOSITS IN THE GREENSTONES

Few important metal occurrences (besides gold) exist within the various KwaZulu-Natal greenstones. The more important of these are described below, and the location of these, and other minor occurrences in the Nondweni area (Versfeld, 1988) are shown in Figure 3.

4.2.1 Copper-zinc deposits

Three base-metal sulphide occurrences are recorded from the Toggekry Formation of the Nondweni Group. Detailed descriptions of these deposits and analyses of samples taken from them are given by Versfeld (1988). The Toggekry Formation consists predominantly of quartz-feldspar-sericite schists (interpreted as reworked felsic tuffs), and also contains significant felsic volcanics, minor tuff beds and units believed to have been rhyolite flows (Versfeld, 1988). Distribution of the Toggekry Formation and location of the Dania (84) and St James workings (82) are shown in Figure 7 (Versfeld (1988) concluded that these massive Cu-Zn sulphide bodies within the Nondweni Group originated as syngenetic, chemically precipitated ores, that were deposited together with immature fine-grained sediments representing reworked felsic tuffs. The metals and sulphur are thought to have been convectively leached from the underlying volcanic pile of the Magongolozi Formation by circulating seawater. Thereafter, the hydrothermal fluids are believed to have been discharged along active fault lines and deposited in a trough with accumulating felsic tuffaceous sediments. Episodic mineralising events resulted in the deposition of sulphide ore at different stratigraphic levels. The sulphides were subsequently remobilised and concentrated in fold hinges, resulting in small, lensoidal, folded ore shoots which rarely exceed 4 m in width.

At the abandoned Gem Mine (106), northwest of Nkandla, malachite and chalcocite mineralisation are hosted in vuggy quartz veins which cross-cut a syenitic dyke. At the Buffels River deposit (64), west of Nkandla, the chalcopyrite, chalcocite and galena mineralisation is hosted by a quartz vein cross-cutting basic schist within granite.

Limited copper was produced at the turn of the 20th century using an experimental production plant at the Dania Mine (84) and the adjoining St Barbara Mine (Hatch, 1910). Initial development on the vein started in 1898 with a shaft been sunk down to 8 m by F. Cuber. The claim was then ceded to H. B. Marshall in 1899 and worked by F. Cuber to a depth of 37 m. From 1900–1904 it appears that no workings were undertaken, but from 1904, Messrs Hansen and Thornland deepened the inclined shaft to 46 m where the intercepted lode measured a width of 1,83 m and was hosted by chlorite and hornblende schist. In 1905 the claim was ceded to Mineral Exploration Syndicate Ltd of Johannesburg, who deepened the incline and vertical shafts. By June 1906, the Dania Mine had been abandoned (Robbins, 1974).

The deposit, whose underground workings have since collapsed, is located on the farm Toggekry 10986, 20 km northeast of Nondweni. A remnant gossan is observed at surface. The surface expression of the Dania deposit comprises a ferruginous gossan, with portions of the gossan stained green by copper silicates. According to Versfeld (1988), the sulphide orebody has a pinch-and-swell structure and is hosted in quartz-sericite schists of the Toggekry Formation. Within the old workings the pinch-and-swell structure of the ore body can be clearly seen — for example, at the 23 m level the lode swells to a maximum width of 4,57 m, whereas at the 30 m level, the width of the lode has decreased to 0,85 m, but swells again at the 52-m level to 5,8 m (Fig. 6) (Robbins, 1974).

The schist is intruded by granite, which cross-cuts the foliation of the schists and also intrudes the sulphide bodies. Minor shearing was noted at the granite-schist contact. The mineralisation is concentrated in the tight and isoclinal fold closures. Sulphide minerals identified in hand specimen by Versfeld (1988) include sphalerite, chalcopyrite and pyrrhotite, while ore in the dumps is stained by malachite, with rarer chrysocolla and azurite.

Recent diamond drilling at Dania (84) (Versfeld, 1988), indicated low grades and narrow intersection widths (generally less than 1 m), with a lack of continuity of the mineralisation between boreholes. The best values were obtained at depths of 30 to 50 m, and include intersections of 15 per cent Zn and 0,16 per cent Cu over a 5 m intersected width, and 0,9 per cent Zn, with 1,42 per cent Cu and 6 g/t Ag over an 11 m intersected width. Extensive drilling by major mining companies did not reveal significant ore reserves at depths of more than 100 m.

No production was ever recorded from the Central Zone Prospect (83), on the farm Toggekry 10986. However, there is evidence of earlier workings in the form of pits and trenches. The more recent prospecting included diamond drilling by ISCOR Limited in the early 1970s. Studies by Versfeld (1988) revealed that the sulphides are hosted in a recrystallised quartzite or chert member, between 2 and 20 m in thickness, which crops out over a strike length of 1,5 km. This member is isoclinally folded about an east–west striking axial plane and is hosted in schists of the Toggekry Formation. The schists adjacent to the quartzite member are reported to exhibit minor sulphide mineralisation in places. The Central Zone Prospect is intruded by granitoids and Karoo dolerites.

Gossanous material is exposed in the surface outcrops of the quartzites and is best developed in the hinge zones of folds (Versfeld, 1988). The highest values obtained from the sampling of diamond drill cores were 4,57 per cent Zn and 0,26 per cent Cu over 1,32 m and 16,4 per cent Zn over 1,06 m. However, the mineralised zones lack continuity along strike, indicating low tonnage potential. In addition, Ag values are insignificant and there appears to be no associated gold mineralisation (Versfeld, 1988).

The old workings at St James Mine (82) (Figs 7 and 8) comprise a filled-in shaft, which was sunk to a depth of 30 m, and a collapsed decline which lies roughly 25 m to

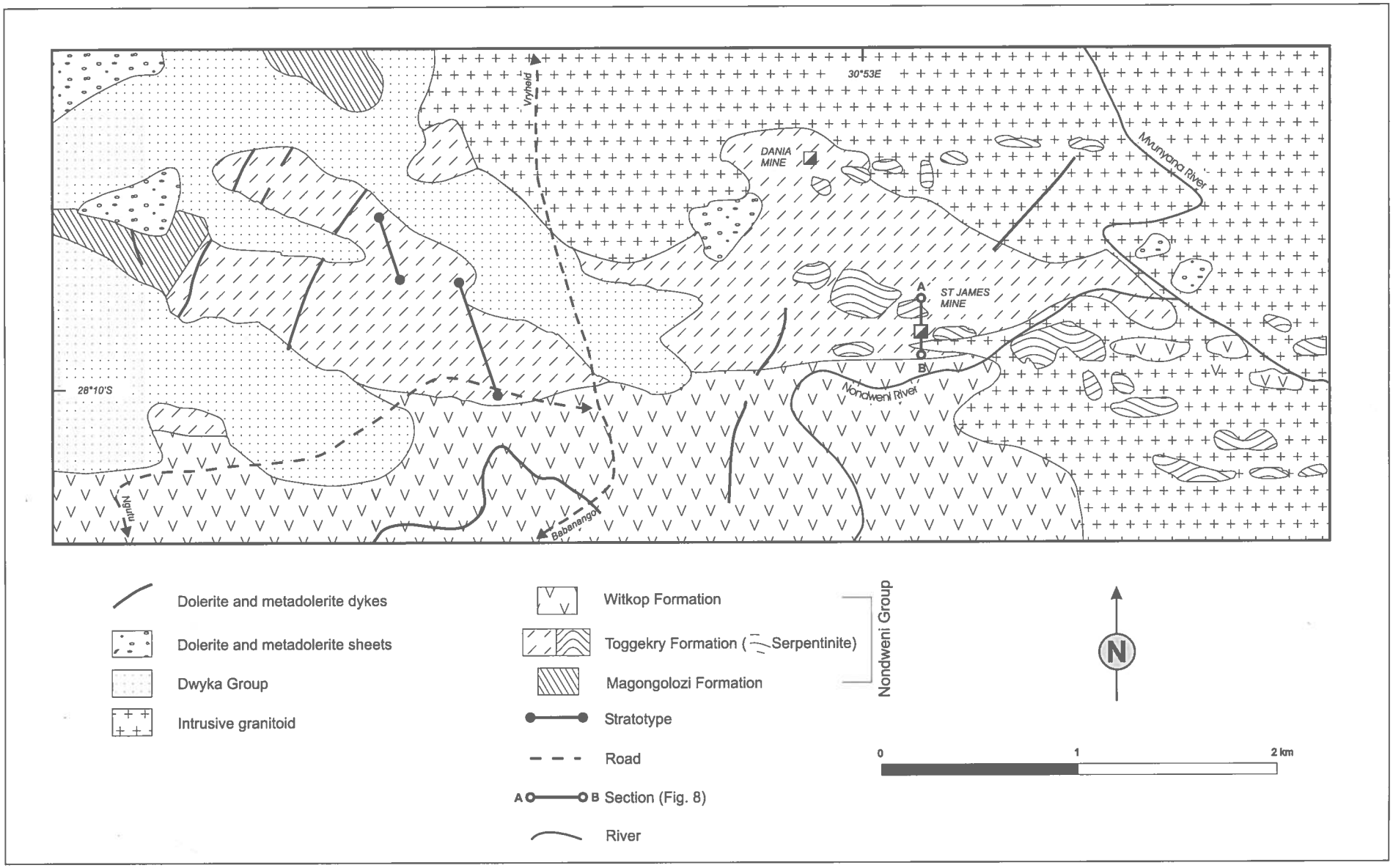

Figure 6 – Geology and distribution of the Toggekry Formation (Nondweni Group) and localities of the Dania Mine and St James Mine (after Wilson and Versfeld, 1994a).

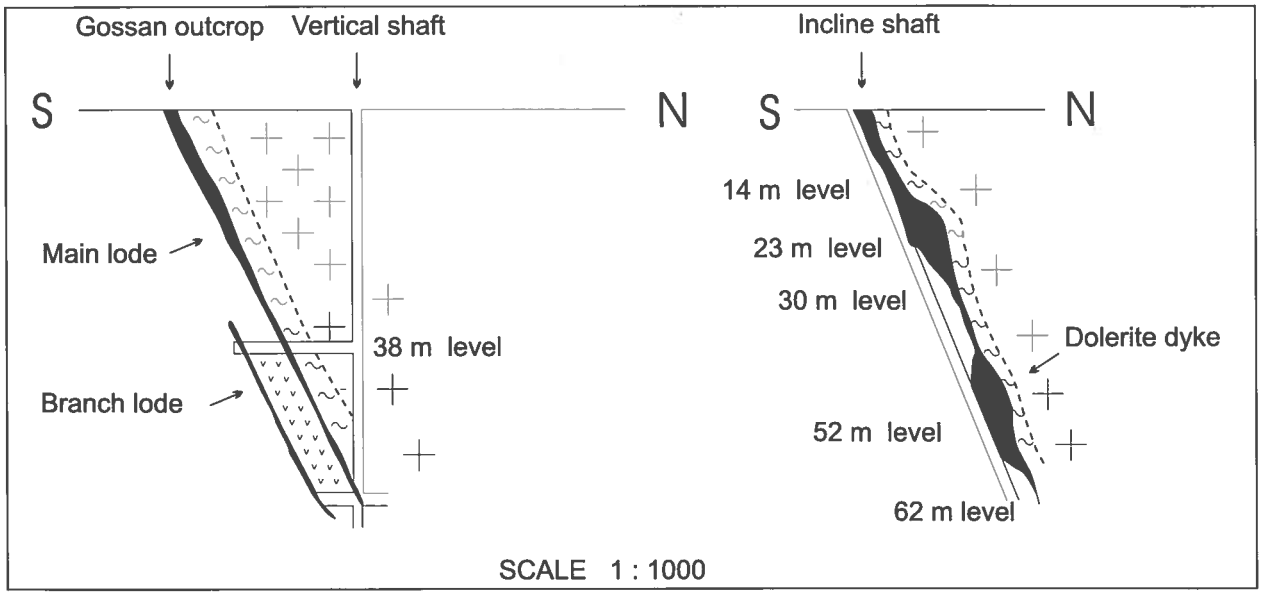

Figure 7 – Section through the Dania Mine workings (from Robbins, 1974).

the east of the vertical shaft, along with an adjacent small high-grade zinc dump, on the farm Toggekry 10986 (Robbins, 1974). Samples from the dump consist of high-grade secondary zinc mineralisation and boulders of massive sulphide containing pyrrhotite, sphalerite and chalcopyrite (Robbins, 1974).

According to Versfeld (1988), the ore occurs as stringers and pods of massive sulphide, hosted in schists of the Toggekry Formation. The mineralisation appears to be concentrated in the closures of minor folds occurring on the limb of a large-scale synclinorium which wraps around a serpentinite body. Diamond drilling also indicated massive sulphide ore in contact with granite that intrudes the serpentinite body. Core from the Toggekry Formation revealed that zones of ore grade mineralisation are bedded, and lie conformably within foliation planes of the quartz-sericite schist host rock. However, no significant tonnage of ore was proven, despite a number of high-grade intersections with mineralised zones.

Other copper workings in the Richards Bay sheet area mined in the early part of the 20th century include, east of Nondweni, the Magdalena Mine (145) on the farm Schoonuitzicht 385, the Subeni Mine (150) on Goud Hoek 498, the Northern Mine on Zandfontein 462 (80), Goodricke's Workings (62) 45 km west of Nkandla, and the quartz veins on Sweet Home (236) 6130 and Strijdplaats 63 (156), 20 km north of Melmoth (Wilson, 1998a).

4.2.2 Tungsten deposits

An occurrence of scheelite mineralisation (87), hosted by the Toggekry Formation, is located on the farm Mount Vernon 10965. Blebs of scheelite up to 4 mm in diameter are disseminated in a complex succession of silicified felsic tuffaceous sediments which are interlayered with highly silicified and deformed pillow basalts (Versfeld, 1988). Drilling in 1982 indicated significant tungsten mineralisation associated with minor quartz veins in a strongly mylonitised zone. Several quartz vein samples from the core revealed anomalous tungsten values ranging from 100 ppm to 0,30 per cent; however, indicated reserves were found to be low as the ore-bearing zones show little continuity. Further investigations by STK (Schutte, 1984), which included diamond drilling, concluded that the scheelite was very erratically distributed, as promising earlier results from prospecting by Anglo American could not be repeated. Ore reserves were calculated at 68 000 t with an average grade of 0,3 per cent WO_3, which was considered subeconomic. It is believed that this deposit is of hydrothermal origin (Versfeld, 1988).

4.2.3 Tin deposits

Tin and tungsten-bearing pegmatites were investigated in the Mtonjaneni area in 1908, at the confluence of the Mfuli and Ntunja Rivers (Fig. 9) by Premier Zululand Tin Ltd. During the same time period a large haematite body, the *Mtonjaneni iron body (281)*, was discovered in the same area (Ehlers, 1983).

Ehlers (1983) reported that the presence of such tin-bearing pegmatites may be indicative of an environment which is favourable for tin, tungsten, tantalum and niobium mineralisation, and that the mineralisation was probably derived from the amphibolite schists of the Mhlatuze Formation. The pegmatites are considered to have been "sweated out" from the amphibolites during a regional metamorphic event (Ehlers, 1983).

The irregular pegmatites in the Melmoth (Mtonjaneni) area vary in dip and strike, mineralisation, texture and mineral composition with respect to one another. The

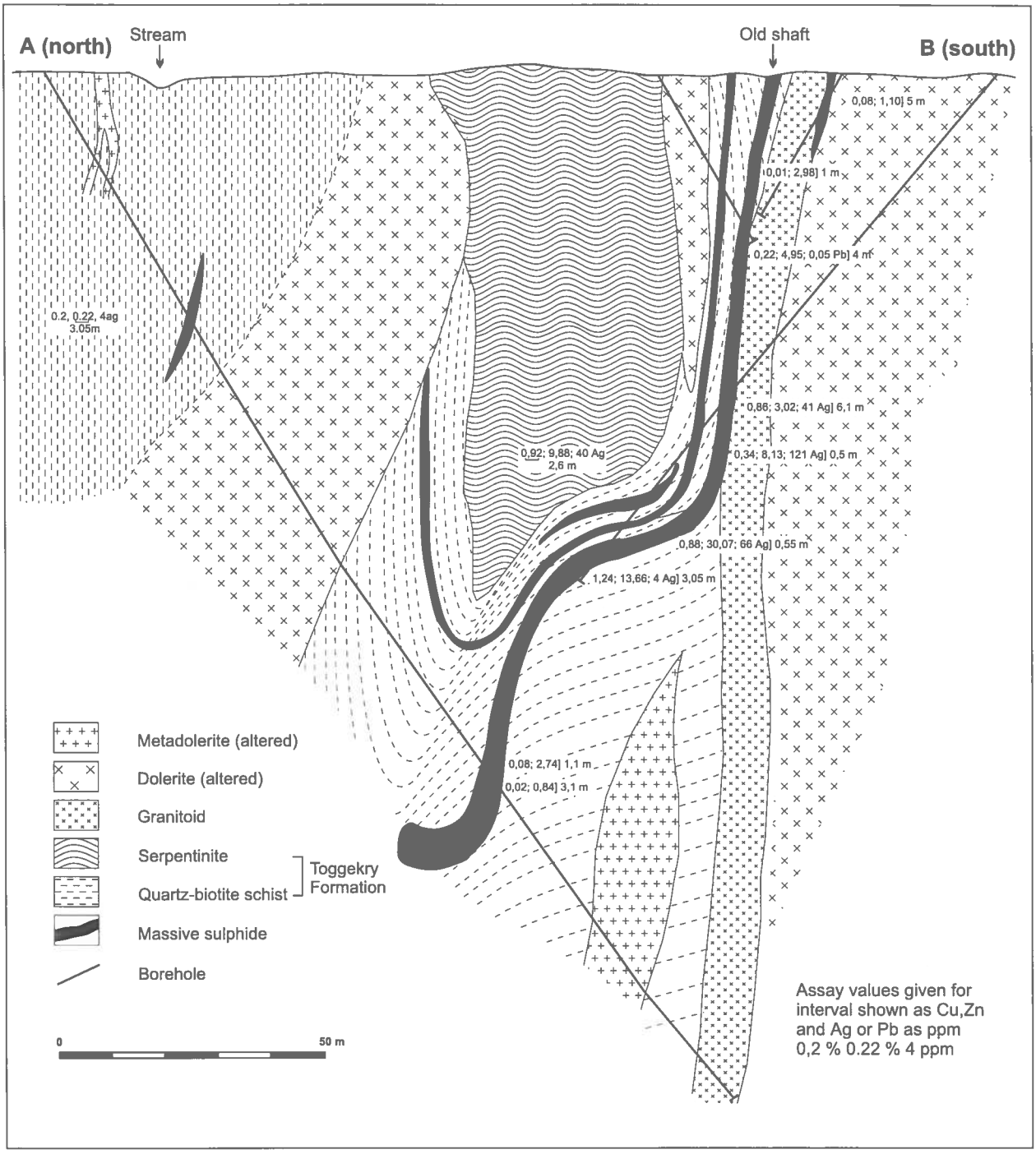

Figure 8 – Section through the St James Mine, interpreted from surface exposure and diamond drilling (from Wilson and Versfeld, 1994a).

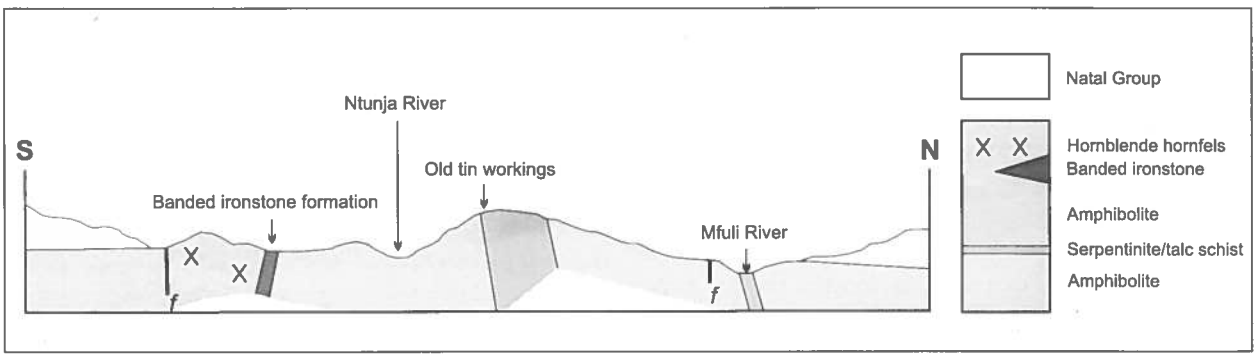

Figure 9 – Cross-section of the Melmoth tin area (from Ehlers, 1983).

majority of the pegmatites pinch and swell, and thus have a limited strike continuity. The pegmatite bodies intruded obliquely to the regional schistosity of the host rocks.

In 1908, the Premier Zululand Tin (Pty) Ltd Company undertook trenching and pitting on and around the pegmatite bodies, and one of the main pegmatite bodies assayed at 6,65 per cent tin and a minimum "proven" ore reserve of 36 000 t. Prospecting was soon abandoned at the site (Thirion, 1979b; Ehlers, 1983).

Union Carbide (Pros. S.A.) (Pty) Ltd undertook exploration in 1978–1979 on the banded iron formation on the Mtonjaneni property to establish the quality and the feasibility of extracting magnetite from the iron-bearing body, which is known as either the Mtonjaneni ironstone prospect or the Melmoth magnetite deposit (281) (Thirion, 1979b). They estimated a reserve of 25 000 000 t iron to a vertical depth of 200 m with an average iron content of 35 per cent (Ehlers, 1983). Unfortunately, approximately 40 per cent of the iron is contained in the non-magnetic mineral grunerite and feasibility studies indicated that the recoverable iron would be too low for the deposit to be economical (Ehlers, 1983). Unless better extraction and concentration of the magnetite can be achieved, exploitation of this magnetite iron ore occurrence is deemed uneco-nomical (Thirion, 1979b).

Stream-sediment sampling for Cu, Ni, Pb, Zn and Co in the Mtonjaneni area, undertaken by the Mining Corporation Ltd in 1983, gave discouraging results. The results revealed that the area lacks any economic concentration of these minerals and that there is a general lack of scheelite mineralisation (Ehlers, 1983).

Cassiterite-bearing pegmatite veins were mined in the early part of the 20th century from two prospects some 12 km east of Melmoth, in northern KwaZulu-Natal (Hatch, 1910). The pegmatites are intrusive into gneisses of the Nondweni Group. The first prospect, known as *Hazelhurst's Claims (280)*, assayed a maximum of 0,32 per cent Sn, but the pegmatite body is too small to be of economic significance. The *Premier (278)* prospect assayed a maximum value of 0,24 per cent Sn, and is also considered subeconomic, even though the dimensions of the pegmatite body are substantial.

4.3 INDUSTRIAL MINERAL DEPOSITS — GRANITE-GREENSTONE TERRANE

4.3.1 Talc

Abandoned talc workings were reported by Versfeld (1988) on the eastern part of the farms Mount Vernon 10965 (85) Toggekry 10986 and Kromellenboog 266 (81). The talc formed by the alteration of serpentinite near the contact with intrusive granites. A large body of talc developed in the alteration zone around the Sisters gold prospect (see Section 4.1.1.1) and its formation is ascribed to the hydrothermal alteration of komatiitic volcanic rocks. The talc was found to be highly impure owing to the presence of carbonate minerals, iron oxides and amphiboles. The deposit was never exploited (Versfeld, 1988).

4.3.2 Graphite

Subeconomic concentrations of graphite occur in schists exposed in old prospecting pits on the farm Mount Vernon 10965 (86) (Versfeld, 1988). Additional graphitic units were detected at depth using horizontal loop electromagnetic techniques and percussion drilling. These 1- to 5-m-thick bodies occur as conformable units within felsic tuffaceous sediments of the Toggekry Formation. Petrographic examinations revealed very finely divided flakes of graphite and these bodies were considered to be of limited economic significance (Versfeld, 1988).

4.3.3 Mica

At Ntumbeni (177), approximately 5 km east of Nkandla, sericite schist have been exploited from two north–south-striking quartzite-mica-schist zones, approximately 1 km in length and 150 m wide. A resource figure of 500 000 t was reported by Moore (1975).

Mica of little economic interest is also scattered through pegmatite veins in hornblende schist near the Mvusana River (200), northwest of Eshowe, and north of Melmoth (240) where books of muscovite up to 15 cm thick have been reported (Linström 1987a).

4.4 INDUSTRIAL MINERAL DEPOSITS — PONGOLA SUPERGROUP

4.4.1 Kyanite

Kyanite occurrences (181, 182, 183) on Reserve No. 19 7638, some 10 to 15 km south of Nkandla, are hosted by argillaceous sediments of the Nsuze Group (Meinster, 1978). The major bodies can be grouped into three deposits, two of which are situated on the Nomangci Ridge, whilst the third (Blue body) (181) is situated on the crest of Ndindindi (Marshall, 1964). Meinster's (1978) investigations in the area revealed two potentially mineable ore bodies, namely the High School body and the Blue body. Reserves at the High School body (182) was estimated at a minimum of 4,5 Mt of ore grading at an average of 40 per cent kyanite. Potgieter (1980), however, conservatively estimated the grade of the High School body as between 20–25 per cent kyanite, but also expressed the view that it may be as high as 45 per cent in places. The reserves of the Blue Body alone were estimated by Meinster (1978) to be in the order of 700 000 t, with an average grade of 45 per cent kyanite by volume. Regional metamorphism and localised contact metamorphism in the vicinity of granite intrusives resulted in alumina-rich sediments being altered to quartz-mica-kyanite schists (Blain *et al.*, 1976). The kyanite bodies are of limi-

5 THE PROTEROZOIC ROCKS OF KWAZULU-NATAL

An account of the known mineral occurrences in the Middle to Late Proterozoic rocks of the Tugela terrane of KwaZulu-Natal, is presented below, as this is the only terrane of the NMP that occurs within the map area.

No large mineral deposits have yet been discovered in the NMP, partly because of the relatively inaccessible terrain, deep weathering and dense vegetation of this subtropical area. Potential mineralisation may also lie undiscovered beneath the thick, younger cover rocks of the Karoo Supergroup. The low-grade metamorphosed Tugela terrane is host to much of the known mineralisation of the NMP (Fig. 10), with the number of occurrences decreasing in the higher-grade terranes to the south. Several informative papers have been published on various aspects of the mineralisation within the NMP by, for example, Thomas and Bullen (1992), Thomas *et al.* (1990, 1994) and Bullen *et al.* (1994).

5.1 THE TUGELA TERRANE

5.1.1 Shear-zone-hosted lode-gold deposits

As far as the NMP is concerned, this type of gold mineralisation is unique to the Tugela terrane. Shear-zone-hosted lode gold is present within the imbricate thrust front adjacent to the Kaapvaal craton and in the amphibolitic nappe zone to the south.

5.1.2 The thrust front — Ngubevu goldfield

Numerous small gold occurrences in this goldfield were prospected in the early 1900s, and of these, namely the HMS (65), Champions Reef (67), Golden Dove (66), Golden Eagle (68) and Buffalo River (64), five became small mines (Fig. 11, Table 5). This goldfield is situated in the westernmost part of the Natal thrust front. The gold mineralisation in the area occurs within quartz veins generally hosted by interlayered greenschist facies mafic lavas and schistose meta-pelites of the Mfongosi Group, and associated with locally developed graphitic schist horizons. These epigenetic gold-rich quartz veins and stringers (with grades up to 7 g/t having been recorded) are confined to westerly striking zones of intense shearing and carbonate alteration (Thomas *et al.*, 1990). Later-stage, undeformed carbonate-bearing quartz veins are generally very poorly mineralised, with values of around 20 ppb Au.

The graphitic schist horizons contain zones, up to several metres in thickness, of intense carbonate alteration, with associated quartz and sericite and abundant fine-grained tourmaline, the latter constituting up to 20 per cent of the rock (Thomas *et al.*, 1990). According to Thomas *et al.* (1990), the presence of such "tourmali-

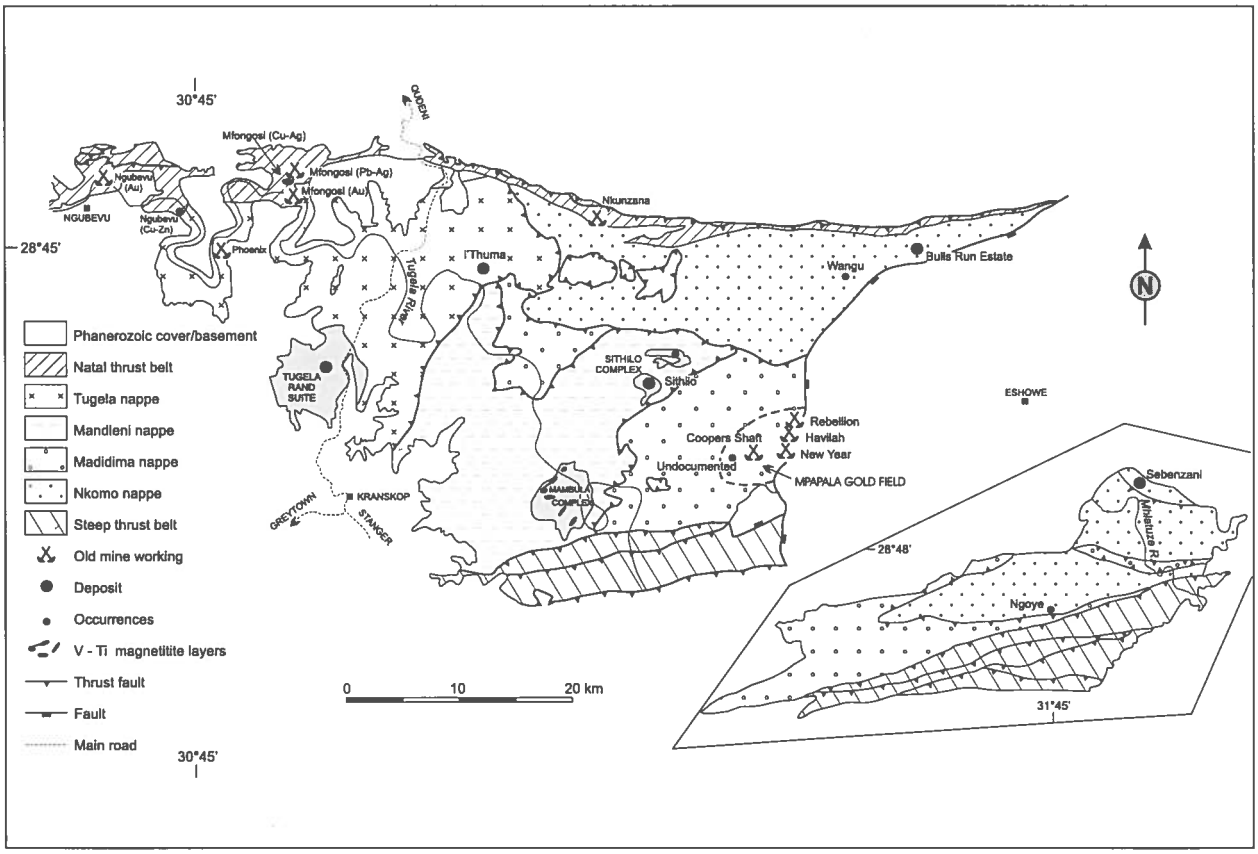

Figure 10 – Metalliferous mineral deposits within the Tugela Terrane (after Thomas *et al.*, 1990).

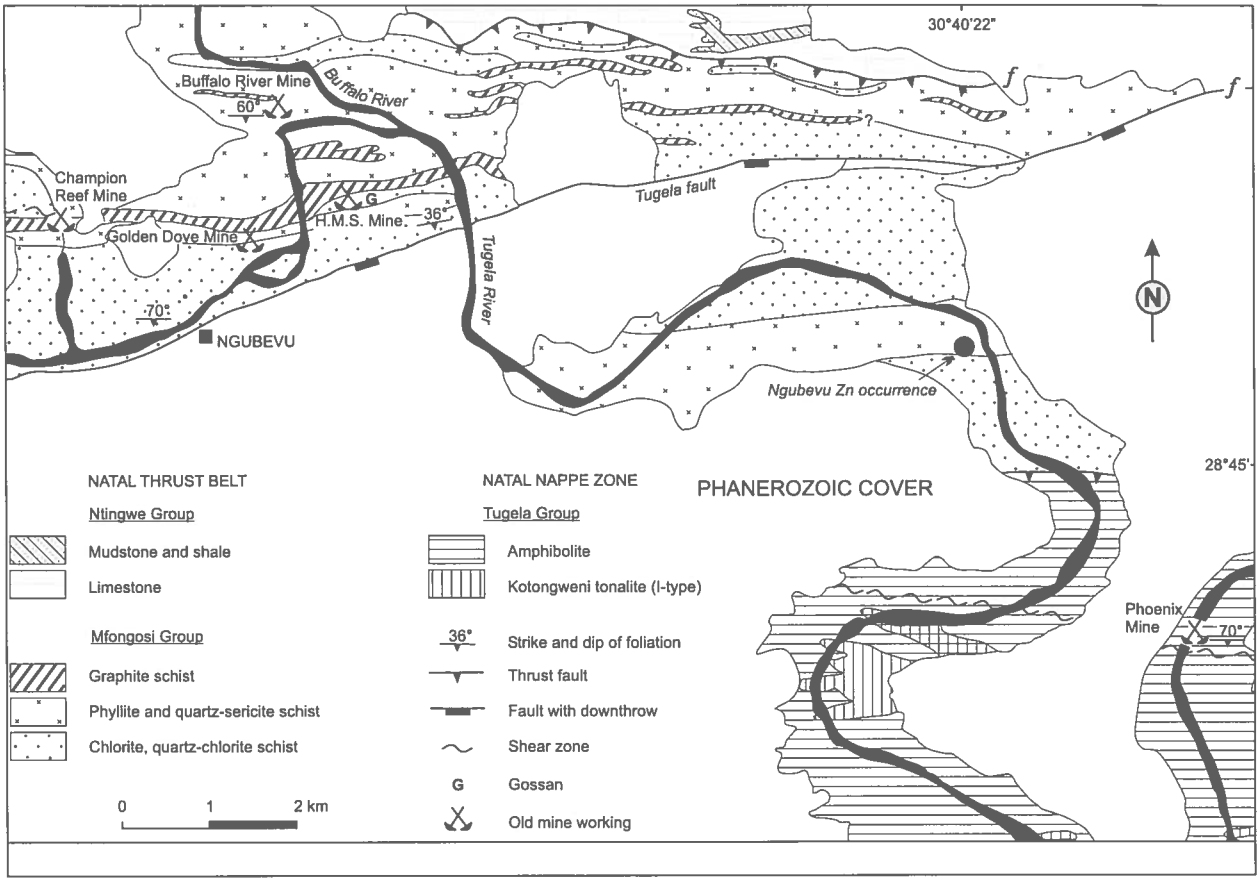

Figure 11 –Geology of the western part of the Natal thrust front, showing the Ngubevu mineral occurrences (after Thomas *et al.*, 1990).

TABLE 5 – CHARACTERISTICS OF THE NGUBEVU GOLD DEPOSITS (from Thomas *et al.*, 1990).

Mine name	Mfongosi Group lithology	Mineralisation/alteration	Structure of orebody	Known grade
H.M.S. (65)	Quartz sericite schist Quartz chlorite schist	Gold in quartz veinlets with disseminated pyrite Some carbonate alteration Pervasive silicification	Silicified shear zone dipping 63 °S	Highest of 5,2 g/t
Champion Reef (67)	Quartz sericite schist, associated graphite schist	Minor Au-bearing quartz veins in the shear. Minor pyrite. Intense late-stage sericite-calcite alteration. Prophylitic alteration around shear (epidote-albite-chlorite-sericite)	4-m-wide shear zone dipping 60 °S	5,4 g/t over 1,2 m (Hatch, 1910)
Golden Dove (66)	Chlorite and quartz-chlorite schist (metalavas)	Au in fine quartz veinlets Chlorite-calcite-sericite-pyrite alteration in shear zone Alteration halo not mineralised Late carbonatisation	Shear zone dips 55 °S	Quartz stringer: 7,1 g/t Shear zone rock: 45 ppm
Buffalo River (64)	Quartz-sericite schist and phyllite	Au associated with pyrite in gossanous enclaves in quartz veins with Cu, Pb, with Zn and Ni sulphides. Sideritic alteration	Steep south dipping, 70-cm-thick mineralised veins	Gossanous enclave: 1,6 g/t Au; 2.23 % Cu; 811 ppm Ni; 2 ppm Ag

nites" has important implications with regard to the genesis of the deposits, as they are often associated with, and genetically related to, stratabound base-metal sulphide, gold, tin and tungsten deposits, and result from submarine exhalative processes. These processes could possibly have formed the protores from which at least some of the epigenetic gold mineralisation is derived.

Thomas *et al.* (1990) considered the following sequence of events to be important to the genesis of the mineralisation at Ngubevu:

1. an early phase of barren quartz veins,
2. intense shearing, probably associated with northward-directed thrusting, which deformed the early veins,
3 mineralising hydrothermal fluids, which were channelled through shear zones, depositing gold in quartz veins during the metamorphic event that was synchronous with, or that possibly postdated, the last major deformation, and
4. the late generation of virtually barren carbonate-rich veining that is related to the late-stage influx of CO_2-rich fluids along shear zones, and which resulted in extensive carbonate alteration.

5.1.2.1 Mfongosi Gold Mine (115)

The mine is situated some 20 km east of Ngubevu on the north bank of the Tugela River. The mineralisation occurs as thin quartz stringers developed along the steep, southerly dipping foliation of the Mfongosi chlorite schist host rocks (Thomas *et al.*, 1990).

In 1909, approximately 1,3 kg of gold was produced from "Ayers reef" — a steep, west-pitching, poorly defined orebody up to 1,1 m thick, with an average grade of 5,2 g/t (Du Toit, 1931).

5.1.2.2 Nkunzana Gold Mine (189)

Given the intense deformation and alteration of the rocks along the Namaqua-Natal front, the rocks are considered favourable for the development of epithermal deposits, as is evidenced by the Nkunzana Mine. In the area around the Nkunzana Mine the rocks of interest form part of the Namaqua-Natal mobile belt and, the mineralisation is hosted by the Mfongosi Group schists (Ahrens, 1989).

The defunct Nkunzana Mine (189) workings are situated on both the east and west banks of the Nkunzana River, some 40 km northwest of Eshowe. Up to 1922, when the two workings were abandoned, about 24 kg of gold at a grade of between 2,8 g/t and 3,2 g/t had been produced (Du Toit, 1931). The mineralisation is hosted in sericite and chlorite schists of the Mfongosi Group of the Natal thrust belt (Fig. 12) (Scogings, 1988c). The intensely sheared schists display steep, southerly dipping, c- and s-planar fabrics, with steeply plunging stretching lineations and fold closures. The mineralisation is controlled largely by the lineation (Bullen *et al.*, 1994).

Two reefs at the western workings, namely the Buffel and Maltz Reefs, were sampled by STK in the late 1980s. Gold values in the order of 4.4 g/t across 1 m, were reported at Buffel Reef, whilst the Maltz open pit recorded a peak value of 1.6 g/t gold. The Buffel Reef has a pronounced As, Cu and Pb signature, whereas trends for the Maltz Reef indicate only a Pb, Cu and Zn association. The eastern workings appear to be characterised by a pronounced Cu-As signature, whereas the western workings are characterised by enhanced Pb and As (Scogings, 1988c).

It is believed that the auriferous lodes represent steeply plunging, pencil-like bodies, which were mined 70 m down plunge to the level of the Nkunzana River (Scogings, 1988c). Recent sampling of the adits by Thomas *et al.* (1990) has shown that elevated precious- and base-metal contents are localised within a ferruginous, highly oxidised reef zone. This zone is recognised principally by its ferruginous nature. The following maximum values were recorded over 1-m intersections: Au (4,4 g/t); Ag (0,9 g/t); Cu (235 ppm); Pb (1 260 ppm); Zn (370 ppm) and As (333 ppm). In addition, Ba, Y, Rb, and Co are enriched across the auriferous zone, relative to their concentrations in the surrounding schists. Sampling revealed that the eastern workings have a Cu-As signature, whereas the western workings are characterised by a Pb-As-Zn association (Thomas *et al.*, 1990).

The area around the Nkuzana Mine has subsequently been actively explored by numerous companies. For example, Eland Exploration (Pty) Ltd and JCI conducted stream sediment sampling, soil geochemistry, geological mapping and minor trenching in 1975 and 1981 respectively, and STK investigated the area from 1988 to 1989 (Ahrens, 1989). Sampling by the various companies confirmed the existence of coincident Cu/Pb anomalies with low gold in places (Ahrens, 1989). JCI reported that the Mfongosi schists to the northwest of the Nkunzana Mine yielded 1 200 ppm Cu and 230 ppm Zn, whilst STK reported Cu grades of 305 ppm, Pb up to 736 ppm, Zn up to 200 ppm, Co up to 92 ppm and As up to 204 ppm from the Mfongosi schists (Ahrens, 1989). Previous researchers had found no correlation between gold mineralisation and the intensity of quartz vein development at Nkunzana.

5.1.2.3 Golden Dove Mine (66)

The mine is located approximately 1 km northeast of Ngubevu on the north bank of the Tugela River. The quartz veins and minor sulphide-hosting reefs are hosted by chlorite schist country rocks, and the reefs vary in width from 0,5 to 3,0 m. Three reef zones were mined at Golden Dove, these being the Mitchell Reef, the Scottish

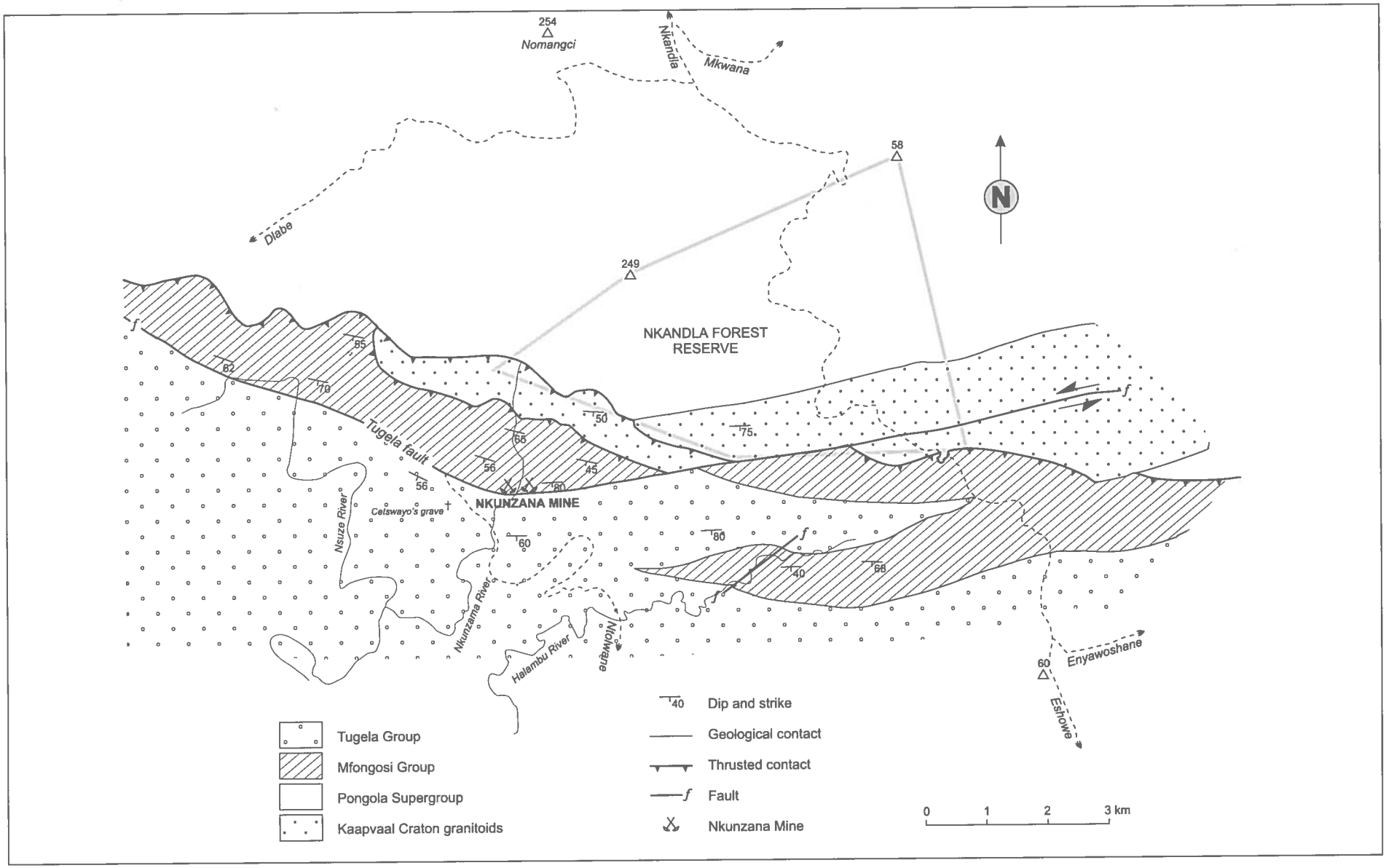

Figure 12 – Locality and geological plan of the Nkunzana Gold Mine (from Scogings, 1988c).

Reef and the Household's Reef. Mining activities at Golden Dove included many prospecting pits, trenches and vertical and inclined shafts. The old workings exploited the mineralisation for approximately 600 m along strike. Recent prospecting activities have failed to locate the strike extensions of the reefs. AAPS undertook sampling of the three reefs, recording the following values: Mitchell's Reef at 15 ppb across 190 cm, Scottish Reef at 5,8 g/t across 49 cm and 20 m length and 4,61 g/t across 80 cm along 19 m length, and Household's Reef at 9,8 g/t across 110 cm (Mann, 1984).

5.1.2.4 Champion Reef Mine (67)

Champion Reef Mine (67) is situated approximately 2 km west of Ngubevu and, like the Golden Dove workings (66), the mineralisation is hosted by chlorite schist. The old workings exploited the mineralisation for approximately 200 m along strike. Recent sampling of the Champion Reef returned values of 1,2 g/t across 50 cm, and surface pit and trench sampling returned values of 1,2 g/t across 100 cm (Mann, 1984).

5.1.2.5 Golden Eagle (68)

The Golden Eagle Mine (68) is situated opposite the Golden Dove Mine (66), on the western bank of the Ngubevu River. Three reefs were exploited at the old workings, these being the main reef, the south reef and the north reef. The main reef was the most worked of the three. It comprises numerous large quartz veins and the width of the reef varies from 1 to 3 m. Gossan zones, within and adjacent to the reefs, indicated the existence of mineralisation at Golden Eagle Mine (68). Recent sampling of the main reef reported the following value: 3,9 g/t Au across 38 m along 27-m strike length. The north reef assayed at 0,44 g/t Au across 100 cm and the south reef assayed at 0,62 g/t Au across 50 cm. Surface trenching reported the following values: main reef — 7,0 g/t Au across 71 cm along a 35-m horizontal length, north reef — 5,4 g/t Au across 100 cm (Mann, 1984).

5.1.2.6 HMS Mine (65)

The mineralisation at HMS Mine (65) is hosted by chlorite schist and black sulphide-rich phyllites. The strike length of the mineralisation is approximately 500 m. The workings are located roughly 2,5 km northeast of Ngubevu. This deposit appears not to have been stoped. The deposit grades between 3,7–4,7 g/t Au across 100 cm, with the highest values assaying at 2 g/t Au across 100 cm (Mann, 1984).

5.1.2.7 Buffalo River Mine (64)

The mine is situated on the south bank of the Buffalo River, approximately 2,5 km north of Ngubevu. The quartz vein mineralisation is hosted by chlorite schists, phyllites and carbonates. The anastomosing quartz veins comprise pyrite, chalcopyrite, malachite and siderite mineralisation. The approximate strike length of the old workings measures 150 m. Samples assayed at 0,1 g/t Au across 50 cm, with the maximum silver values totalling 3,1 g/t Ag across 50 cm (Mann, 1984).

5.1.3 The nappe zone

5.1.3.1 Phoenix Mine (75) (Tugela nappe)

Phoenix Mine (75) is located in the extremely rugged and poorly accessible "Umvoti goldfield" which is situated on the Tugela River, some 12 km east-southeast of Ngubevu, on Reserve No. 19 7638. The old workings consist of 4 adits driven into a hillside, where 90 t of ore was milled in 1907 at an average grade of 8,4 g/t (Hatch, 1910).

The mineralisation, in the form of quartz veins, is essentially confined to elongate lensoid bodies within the hanging wall of a pair of roughly parallel shears, which trend east–west and dip at 55–70° to the south. The orebody appears to be confined to these two shear zones, as other, more steeply dipping shear zones appear to be barren of any mineralisation. The quartz in the main mineralisation shears varies from stringers to veins with a width greater than 1 m. The quartz veins follow the attitude of the shear zone (McKay, 1990). A grade of 5,49 g/t gold over 60 cm, along a 50-m strike length, and patches of high-grade mineralisation were reported by Hatch (1910) in the main mineralisation area.

Theart (1987) recommended a detailed exploration programme in this area to locate possible extensions to the known mineralisation. The best grade obtained was from a pyrite-bearing quartz vein, which gave a value of 6 g/t over a width of 70 cm. Although recent investigations have revealed good grades in places, the workings have remained abandoned.

Duiker Exploration prospected the Phoenix Mine (75) area in the early 1990s. They found that the values quoted for the mine by Hatch (1910) (i.e. 47,3 g/t over 122 cm and 11,1 g/t over 76 cm in the adit and longest winze respectively) could not be repeated. Their sampling programme revealed only a few sporadic values exceeding 3 g/t, and the deposit was deemed to be economically unviable (McKay, 1990).

5.1.4 Madidima nappe — Mpapala goldfield

This goldfield is situated some 22 km west of Eshowe in the "Mbongolwana Flats" on Reserve No. 21 7638. Outcrop in this area is extremely poor and the mineralisation was initially discovered because it cropped out or was relatively near the surface (Evans, 1988). Four old workings, the Rebellion (264), New Year (266), Havilah (265) and Cooper's Shaft (220), were worked here in the early 1900s (Table 6). The gold is disseminated in quartz veins in amphibolites of the Silambo Formation of the Tugela Group as well as in a later, sheared aplitic dyke. Schurink

TABLE 6 – CHARACTERISTICS OF THE MPAPALA GOLDFIELD WORKINGS (from Thomas *et al.*, 1990; Evans, 1988).

Working	Tons crushed	Grade (g/t)	Known extent of orebody	Maximum width of orebody	Orientation of orebody	Recent grab sample assay (Evans, 1988)
Rebellion (264)	508	1,7	16,8 m strike; 15,9 m depth	1,7 m	045/80 SE	4,5 g/t Au; 580 ppm Cu; 58 ppm Zn
Havilah (265)	189	6,9	Strike unknown; 19,8 m depth	1,5 m	037/vertical	N/a
New Year (266)	436	5,2	Strike unknown; 11,0 m depth	5,5 m	037/vertical	3,2 g/t Au; 4 140 ppm Cu; 5100 ppm Pb
Cooper's Shaft (220)	1	40,5	450 m strike; 7,6 m depth	2,0 m	045/85 SE	N/a

(1986) reported anomalously high Au, Ag, Cu, Pb and As values. The quartz veins lie within narrow shear zones, one of which is continuous from the Rebellion to the New Year workings, a distance of over 2 km.. Thomas *et al.* (1990) concluded that the gold in the Mpapala goldfield is clearly of hydrothermal, epigenetic origin, related to high-grade metamorphic terranes, similar to those at Ngubevu. The model for these deposits is therefore a metamorphic replacement model, where the ore fluids were derived from devolatisation from the base of a volcanic pile in a high-grade metamorphic terrane (Schurink, 1986, p. 3). The gold was transported as H Au $(HS)_2$ complexes and deposited in favourable sites such as Fe-rich rocks (Schurink, 1986).

Evans (1988) considered the potential for finding mineralisation at depth in the area to be very promising — indeed, all the old workings were discovered because they cropped out or occurred near the surface. His sampling of some of the old workings indicated encouraging results (Table 6). However, detailed geological studies (mapping, trenching, geochemistry, geophysics, magnetic survey, resistivity and drilling) by Schurink (1986) on the old *Rebellion Mine (264)* revealed that the quartz veins have limited strike lengths and pinch out with depth. Diamond drilling and trenching revealed K-metasomatism and epidotisation as dominant alteration types, with traces of calcite and chlorite also evident. Pyrite and magnetite were evident in most samples, along with minor chalcopyrite.

In addition to these workings, Thomas *et al.* (1990) reported a new occurrence (219) in the area which yielded a grab sample with a grade of > 9 g/t. No further work is reported to have been done on this occurrence.

5.1.5 Gold-bearing massive to semi-massive sulphide deposits

5.1.5.1 i'Thuma volcanogenic sulphide deposit (124)

Stratiform, sulphide-rich volcanogenic rocks were discovered in the i'Thuma River area, 10 km east of Jamesons Drift (Fig. 13) in the early 1980s on Reserve No. 19 7638. According to Thomas *et al.* (1990), the orebody consists of a ± 2 m thick, fuchsitic, ferruginous, sulphide-rich unit with sheared margins in Tugela Group host rocks. Mineralisation is associated with amphibolitic metalavas and pelitic/psammitic metasediments. The orebody has been folded into a major, NE-plunging tight-to-isoclinal F_1 antiform, with both limbs dipping NW at about 40°. Shearing is most intense at the sulphide/host-rock interface, owing to the competency contrast between these rock types and the intensity of shearing decreasing towards the core of the sulphide unit.

Sulphides present include pyrite — which predominates (10–50 %), minor galena and sphalerite. Average gold and silver grades reported were 1,25 g/t and 27 g/t respectively, with elevated contents of Cu (0,3 %), Pb (0,32 %), Zn (0,18 %) and Ba (0,43 %), over a width of 1 m and along a 120-m strike length in the sulphide zone. Enhanced Ag and Au values were also obtained from the sheared sulphide rock and immediately adjacent host rocks (Thomas *et al.*, 1990).

The mica schist footwall contains abundant concordant pyrite-chalcopyrite segregations, up to several centimetres in length, along with a number of thin, phlogopite-rich, sulphide veinlets and magnetite quartzite layers. This interval, which also contains minor Au, tourmaline and andalusite, has been interpreted as a feeder zone for the overlying exhalative-type mineralisation (De Klerk, 1991). Silica was introduced by premetamorphic, exhalative, mineralising fluids, and formed medium-grained veins and segregations with associated sulphides. The observed biotite-chlorite-phlogopite-calcite-andalusite alteration is attributed to the effect of hydrothermal fluids passing through the footwall schist unit. Within the feeder zone concentrations of up to 230 ppb gold are present, which indicates that the mineralising fluids were also gold bearing. This implies that the Au mineralisation is most probably syngenetic in origin, and not the result of a late epigenetic event. Nevertheless, remobilisation and further concentration of the gold may have taken place during shearing (De Klerk, 1988).

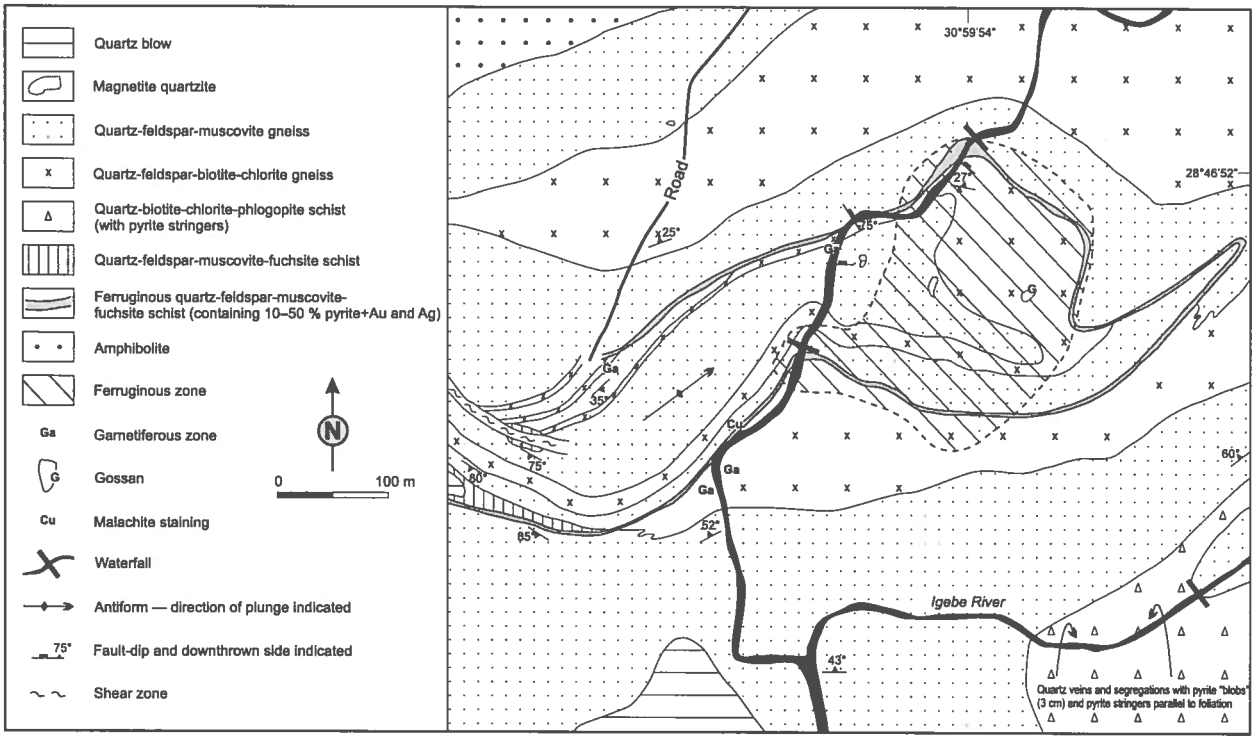

Figure 13 – Geology of the area surrounding the i'Thuma massive–semi-massive sulphide body (after Thomas *et al.*, 1990).

Thomas *et al.* (1990) related the i'Thuma deposit (124) to volcanogenic massive sulphide deposits in other parts of the world (for example the Australian deposits described by Large *et al.* (1988)), based largely on paragenetic associations. In both cases the Pb-Zn-Ag-Au association occurs in the massive to semi-massive sulphide body, with the footwall stringer zone consisting largely of pyrite and chalcopyrite. These authors therefore proposed that the i'Thuma River mineralisation represents an example of a syngenetic, sediment-hosted, volcanogenic, submarine exhalative, auriferous massive sulphide deposit, the first of its kind to be recognised in the NMP. The marginal grades and lack of infrastructure have thus far counted against the economic viability of this deposit.

5.1.6 Base-metal and other mineralisation

5.1.6.1 Ngubevu Cu-Zn mineralisation (70)

Several shear zone-hosted Cu-Zn showings were identified 6 km east of the Ngubevu goldfield, hosted in deformed, southerly dipping, quartz-mica schists and chlorite-epidote schists with quartz-calcite veins containing coarse-grained pyrite. Brown (1988a) noted relict textures in the rocks and suggested that the Mfongosi schists at this locality could represent highly deformed metalavas and tuffs and that the mineralisation was of submarine volcanogenic exhalative type, with a chloritised and carbonatised stringer zone to the south, and a stratigraphically higher, Cu-Zn sulphide zone to the north. Sampling of gossanous outcrops indicated grades of up to 0,85 per cent Cu and 1 per cent Zn.

A Zn-Cu-Ag anomalous volcanic assemblage was delineated by regional stream sediment sampling and diamond drilling by JCI in the early 1970s on a portion of Reserve 7638, between latitudes 28°42′, 28°46′ and longitudes 30°37′ and 30°44′. In the mid-1980s AAPS reexamined the anomaly by means of a detailed soil survey, limited geophysics and lithological sampling, and located a superior anomaly within the prospected area. However, they did not consider this occurrence to be a viable drilling target. In the late 1980s the South African Development Trust Corporation prospected the area for base metals, and after extensive investigations concluded that the occurrence was subeconomic owing to its short strike length and apparent limited down-dip extension of the gossanous horizon. ISCOR investigated the area in the early 1990s and intercepted an anomalous Zn-Cu-Ag volcanic assemblage during their drilling programme. The strike length of the anomaly was estimated at roughly 200 m with an approximate true thickness of 13 m (Clague *et al.*, 1991).

From the investigations conducted by ISCOR, the anomalous occurrence of Zn enrichment (roughly 0,23 % Zn) occurs, for the most part, in the quartz muscovite schist (acid tuff) of the Mfongosi Group. Associated with this Zn-enrichment zone is minor copper enrichment which, for the most part, occurs in two general zones, these being within the quartz muscovite schist with associated anomalous zinc values, or at the boundary between the quartz muscovite schist and the overlying chloritic quartz muscovite schist. The Cu values are, however, subeconomic. Silver is associated with both the zinc and copper values, but tends to be higher when associated with silver (Paizes, 1992).

Geochemical investigation of this anomaly suggests that the Zn-Cu-Ag values may represent the distal portion of a massive sulphide volcanic vent, which has either been eroded away or lies at great depth. The values intersected for Zn (0,23 % Zn across 13 m), Cu (0,18 % Cu across 4,3 m) and Ag (57 ppm across 8 m) are regarded as subeconomic, elevated metal background values (Paizes, 1992).

5.1.6.2 Mfongosi Pb-Ag workings (114)

Mfongosi chlorite schists host the mineralisation which is associated with a 1,7-m-thick south-dipping quartz vein in a shear zone. The orebody appears to be zoned, with Cu sulphides concentrated towards the hanging wall and pyrrhotite towards the footwall; however argentiferous galena was disseminated throughout (Hedges, 1909).

5.1.6.3 Mfongosi Cu-Ag occurrence (116)

This occurrence is situated 1 km northwest of the confluence of the Mfongosi and Tugela Rivers. Deformed mineralised granitoid in the form of concordant lenses (up to 5 m wide and 3 m thick) intrude the chlorite schists, magnetite quartzites and limestones of the Mfongosi Group. When analysed, grab samples of these extremely sodic granitoids revealed values of up to 1,6 per cent Cu and 9 ppm Ag (Thomas *et al.*, 1990). The mineralisation here is thought to be related to the intrusion of cupriferous sodic granite veins and dykes.

5.1.7 Magmatic ores

A number of east–west trending ultramafic bodies occur in the nappe zone of the Tugela terrane (Fig. 14), of which only the Sithilo Complex, Tugela Rand Layered Suite, and Ntulwane serpentinite body appear to have been prospected to any degree of certainty. The latter two deposits did not encourage further investigation after initial analyses indicated low Cr_2O_3 values and low Cr/Fe ratios (Wuth and Archer, 1986). The most significant deposits are described below.

5.1.7.1 Sithilo Complex — Chrome (208, -211)

The Sithilo Complex, which consists essentially of serpentinised dunite, is located on Reserve No. 21 7638, about 27 km west of Eshowe where it intrudes amphibolites of the Tugela Group. It is one of the larger ultramafic bodies in the area, with a strike length of approximately 3 km and a width varying from 0,5 to 1 km. According to early mining reports on the Natal Colony, attention was first focused on this deposit in 1904 when good-quality chrysotile asbestos veins were discovered. However, it was only in the early 1950s that exploration at Sithilo revealed four low-alumina chromite orebodies and during 1952–53 approximately 2000 t of high-grade chromite concentrates were produced from four adits driven into the northeastern flank of Sithilo Hill (Wuth and Archer, 1986).

The chrysotile is hosted by *en échelon* joint planes where it occurs in cross-fibre seams. The chrysotile occurrences tends to be sporadic (Gain, 1975).

The bulk of the Sithilo body is made up of dunite and olivine peridotite which have locally developed primary cumulate textures. Much of the economically exploited chromite mineralisation is hosted in dunite. Chromite occurs in numerous isolated pods, and as stringers, irregular stockworks and disseminations. In three of the old workings the chromitite occurs in lenticular bodies, whereas the fourth working is in a 15-m-diameter, southeast-pitching pipe-like chromitite body. The present setting of the chromite lenses can be ascribed to tectonic influence, as they are aligned *en échelon* and are parallel

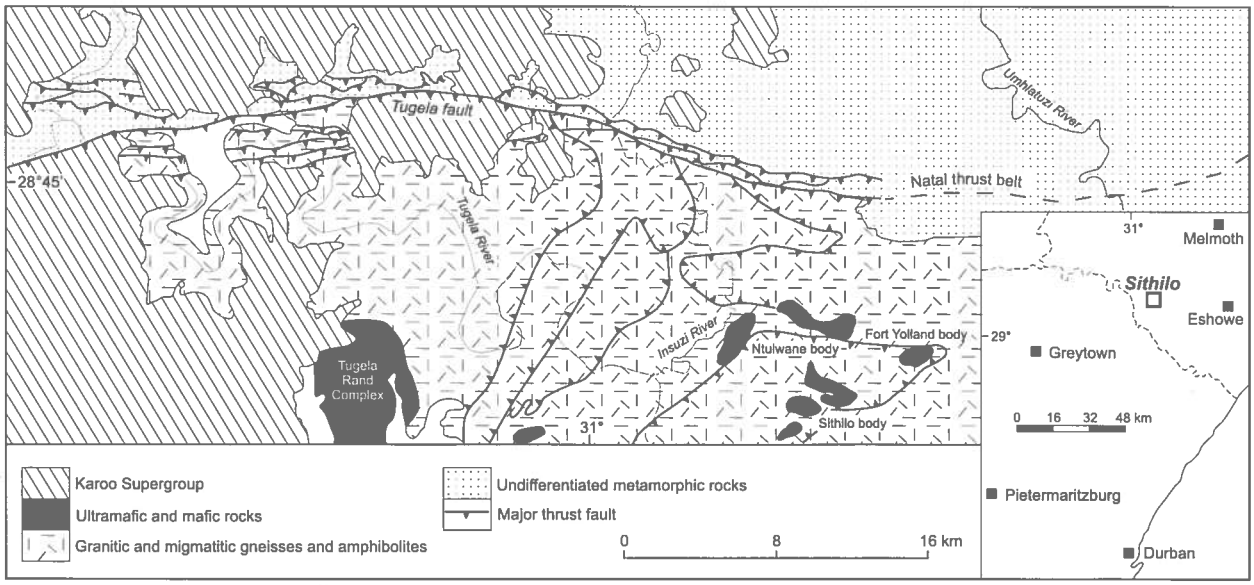

Figure 14 – Geological setting of the ultramafic bodies within the Tugela terrane (after Wuth and Archer, 1986).

to shears. Initial concentration however, was attributed to primary magmatic differentiation within the oceanic crust which initially localised and concentrated the mineralisation. Later faulting further limited the extent of the chromite orebodies (Wuth and Archer, 1986).

Wuth and Archer (1986) found that, in terms of lithology, structure and tectonic setting, the Sithilo body shows affinities with the ultramafic portions of typical chromite-bearing, alpine-type ultramafic complexes around the world, even though it has an incomplete ophiolite sequence (in other words, the pillow basalts, sheeted dykes and upper gabbros are missing). In addition, the textural and compositional character of the chromite is considered sufficient evidence to classify the mineralisation at Sithilo as a Precambrian equivalent of the considerably younger, alpine-type ophiolitic podiform chromite deposits such as those found in Turkey, Cyprus and the Phillippines. A comparison of ore grades from Sithilo with other alpine-type deposits shows a close correspondence, apart from the lower alumina contents (less than 5 % Al_2O_3) at Sithilo. Grades within the four workings range from 9 to 50 per cent Cr_2O_3 while Cr/Fe ratios are typically 1 in the lower grade ores, up to 3,3 in the highest-grade ores. Although the Sithilo Complex contains localised high-grade chromite with Cr/Fe ratios between 2,5 and 3, the chromite bodies are of limited lateral and down-dip extent and have a highly irregular shape, typical of Alpine-type chromite bodies, which has rendered the Complex subeconomic (Wuth and Archer, 1986).

5.1.7.2 The Tugela Rand Layered Suite — (127–132, Chrome 134, 135, 136)

This Suite is located on the farm Tugela Rand 1974, some 10 km north of Kranskop and forms a well-layered association of mafic and ultramafic rocks which intrude the amphibolitic gneisses of the Tugela nappe (Fig. 14). The Tugela Rand Layered Suite formed as a result of repeated, and sometimes long-lived, emplacement of magma into a chamber, which at the same time was undergoing crystallisation. Subsequent deformation is believed to have altered the original sheet-like form of the intrusion. The deformation caused the layering in the northern part of the body to have a shallow dip towards the south, while the southern part of the intrusion is more steeply dipping — being near vertical and overturned (Eales *et al.*, 1988).

Chromite occurs as impersistent layers associated with wehrlites and serpentinites and varies from massive chromitite to disseminated layers. The irregular chromite orebodies are of a limited size and are considered subeconomic.

Thomas *et al.* (1990) reported disseminated Cu, Ni and Co sulphides within the lowermost pyroxenitic and peridotitic rocks of the suite. Subeconomic peak values of 0,12 per cent Cu, 0,25 per cent Ni and 0, 027 per cent Co over 3,1 m were obtained from diamond drilling in the northeastern part of the Suite (Versfeld, 1981).

5.1.7.3 Sebenzani Cu-Ni sulphides (323)

An aerial magnetic anomaly, and the occurrence of gossans in the Sebenzani area some 8 km west of Empangeni, led to an intensive exploration programme for mineralisation here (Schutte and Schurink, 1986). The occurrence is situated south of the Natal thrust front, in the Nkomo nappe, within amphibolites, talc schists and actinolite schists which have been intruded by gabbros and ultramafics, the latter having been serpentinised. Sulphide minerals are mainly pyrrhotite, pyrite and chalcopyrite.

Drilling revealed sulphide intersections in all boreholes, with the following maximum values recorded over 5 m: Cu (0,6 %), Ni (0,8 %) and Co (1149 ppm). In addition, Schutte and Schurink (1986) noted that limited amounts of platinum group metals occur in association with the sulphides. Knoetze (1988, cited in Thomas *et al.*, 1990) suggested that this occurrence was also an ophiolite-type deposit, similar to the Sithilo body. He considered the potential for economic Cu-Ni mineralisation to be excellent and recommended further exploration in the area.

5.1.7.4 Mambulu Complex — Iron, titanium and vanadium (221–226)

The (layered mafic) Mambulu Complex, on Tugela Location 4674, crops out over an area of 25 km^2, about 20 km east of Kranskop, near the confluence of the Tugela and Mambulu Rivers. It comprises a succession of cyclic units of magnetite, anorthosite, gabbro and pyroxenite.

The Mambulu Complex intrudes amphibolites of the Tugela Group which forms part of the Tugela nappe. A broad saucer or funnel-like shape is envisaged for the body, due to centroclinally dipping contacts of the layering (Schulze-Hulbe, 1979). The Complex comprises medium-grained gabbro with lesser amounts of norite, websterite, anorthosite and vanadium-rich titaniferous magnetite layers. At least six magnetite-rich layers, each from 1 to 5 m in thickness, are recognised. Poor exposures have, however, prevented estimates being made of their extent or lateral continuity. These ores consist of up to 90 per cent V-Ti-magnetite, ilmenite and pleonaste, with trace amounts of the sulphides pyrrhotite, pentlandite, cubanite, chalcopyrite and pyrite also recorded. The titaniferous iron ores were first recognised and described by Du Toit (1918) and later by Wagner (1928).

Ore reserves, estimated by Luyt (1976), are of the order of 22 Mt at an average grade of 45,92 per cent Fe, 11,53 per cent TiO_2 and 0, 56 per cent V_2O_5. A detailed

ted extent and the potential of the kyanite-rich zones are further diminished by abundant, fine inclusions of quartz, ilmenite and secondary goethite which cause problems during the processing of the kyanite (Clarke, 1983).

Tests conducted on material from these sites suggested that kyanite could be successfully mined from the Blue body using open-cast methods. All workings in the area are currently abandoned. The High School kyanite body, one of the two potential bodies identified by Meinster (1978) and located on the Nomangci Ridge, is roughly 180 m wide and has a strike length of approximately 700 m. Beyond the limits of the body, the amount of visible kyanite decreases. The kyanite ore body is highly weathered at surface and it is believed that thin phyllite and/or kaolinite-rich layers may be intercalated with the kyanite ore zone.

4.4.2 Andalusite

Large andalusite crystals in the schists of the Mozaan Group have been documented in the northeastern part of KwaZulu-Natal (Linström, 1987b). These andalusite porphyroblasts are probably the result of the contact metamorphic effects resulting from the intrusion of the Spekboom granite (Weilers, 1990).

4.4.3 Corundum

Corundum-bearing aplite is hosted by irregular pegmatite veins which have intruded serpentinites of the Mozaan Group in northeastern KwaZulu-Natal (Linström, 1987b). Du Toit speculated in 1931 that small-scale exploitation of these deposits could be viable.

mineralogical assessment concluded by Reynolds (1986), found that, owing to the relatively coarse grain size of the ores, the presence of abundant granular ilmenite and simple grain boundary relationships, the ores would be amenable to beneficiation. He suggested that they would yield an ilmenite concentrate (50,4 to 53 per cent TiO_2) and a Ti-poor magnetite concentrate (3– 8 % TiO_2) containing approximately 1,1 per cent V_2O_5. The ores were found to be rarely pure and generally contain between 10 and 30 volume per cent of silicate minerals, largely plagioclase and clinopyroxene, with lesser amounts of hypersthene.

According to Reynolds (1986), the ores formed during the later stages of the fractional crystallisation sequence responsible for the formation of the Mambulu Complex. The more felsic and Fe-rich nature of the Complex suggests that it represents the higher level of a layered complex than the Tugela Rand Layered Suite (TRLS). However, in common with the TRLS, the Mambulu Complex was also affected by the tectonics and metamorphism during the NMP tectonic event. The Complex was subject to both amphibolite facies metamorphism, which modified the texture of the Fe-Ti oxide ores, and northward-directed thrusting.

The economic potential of the deposit is restricted by its remote locality, small size and moderately low TiO_2 and V_2O_5 contents. In addition, vast resources of these commodities occur in the Bushveld Complex, which can more economically supply the market for the foreseeable future.

The most recent investigations of the Mambulu Complex have concentrated on its Ni and PGM potential, this work being stimulated by the investigations carried out by STK (Steenekamp, 1990) which revealed a potentially mineralised troctolite unit in the northern part of the Complex. However, reconnaissance exploration (Anglo American Report, 1992) indicated that no significant base- or precious-metal mineralisation was developed and all prospecting was abandoned.

The granite gneisses and amphibolite surrounding the Mambulu Complex were prospected for scheelite by the South African Development Trust Corporation in the easly 1980s. Stream sediment sampling delineated areas of anomalous scheelite concentrations; however, the source of the scheelite was not located, and the majority of the anomalous concentrations occur below the flood line of the proposed Tugela River dam. In addition, the chert and quartz-feldspathic layers in the amphibolite schist were noted to contain isolated blebs of scheelite (Hannweg, 1982).

5.1.8 Alkaline complexes

The Wangu, Ngoye (330) and Bulls Run (250, 254–260) alkaline/peralkaline gneissic bodies occur near the north-eastern margin of the NMP and constitute the remnants of a tectonised and metamorphosed alkaline magmatic province. Subeconomic quantities of the various elements typically associated with alkaline and A-type granite complexes have been noted at each of these localities (Scogings, 1989a). The potential mineralisation in these bodies was investigated by Scogings (1983, 1986, 1988a, 1989a) and Scogings and Forster (1989). The exploitation potential of these deposits appears to be poor.

5.1.8.1 Wangu Granite Gneiss

Scogings (1989a) suggests that the Wangu gneisses represent deformed A-type peralkaline microgranitic or aplitic rocks. These rocks crop out in the Wangu Hills area, northwest of Eshowe. Analyses of these gneisses have shown marked enrichment in incompatible and large-ion lithophilic elements such as Zn, Nb, Zr, Th, Y and Rb (Scogings, 1988a). Of particular economic interest were samples that showed anomalously high concentrations of Nb (614 ppm), Y (514 ppm) and REE (2300 ppm). No discrete REE minerals occur in these rocks, and it was therefore suggested that the incompatible elements may be hosted in sodic minerals such as aegerine-augite (Scogings, 1989a).

The anomalous REE, Zr, Nb and Zn contents in the localised iron-rich, highly peralkaline siliceous gneisses within the Wangu gneisses, were interpreted by Scogings (1989a) as magmatically concentrated cumulate layers.

5.1.8.2 Bulls Run Complex (250, 254–260)

This alkaline complex, situated on the farm Bulls Run Estate 12987 on the north bank of the Mhlatuze River some 24 km from Eshowe, is essentially composed of syenite and nepheline-syenite gneisses with minor intrusive phases of carbonatite and peralkaline microsyenite (Scogings and Forster, 1989). These intrusive phases of carbonatite contain, apart from apatite, calcite and biotite, accessory phases of ilmenite, pyrite, pyrochlore and zircon. Samples of brown carbonate gneisses revealed values of up to 3993 ppm Nb and highly elevated Y, Sr and Ba values. Eluvial and alluvial occurrences of zircon, ilmenite and monazite were also reported by Von Backström (1962).

5.1.8.3 Ngoye Complex (290, 330, 331)

The Ngoye Complex is an elongate east–west trending body approximately 25 km long and up to 4 km wide, located just south of Empangeni (Fig. 15). The body is surrounded by felsic and amphibolitic gneisses of the NMP. The southern contact of the Ngoye granite gneiss and surrounding gneissic terrain was found to have potential for Nb, Ta, Sn, W and U mineralisation during an investigation of aeromagnetic and air-radiometric anomalies by the South African Development Trust Corporation (STK) (Scogings, 1983). Magnetite-rich

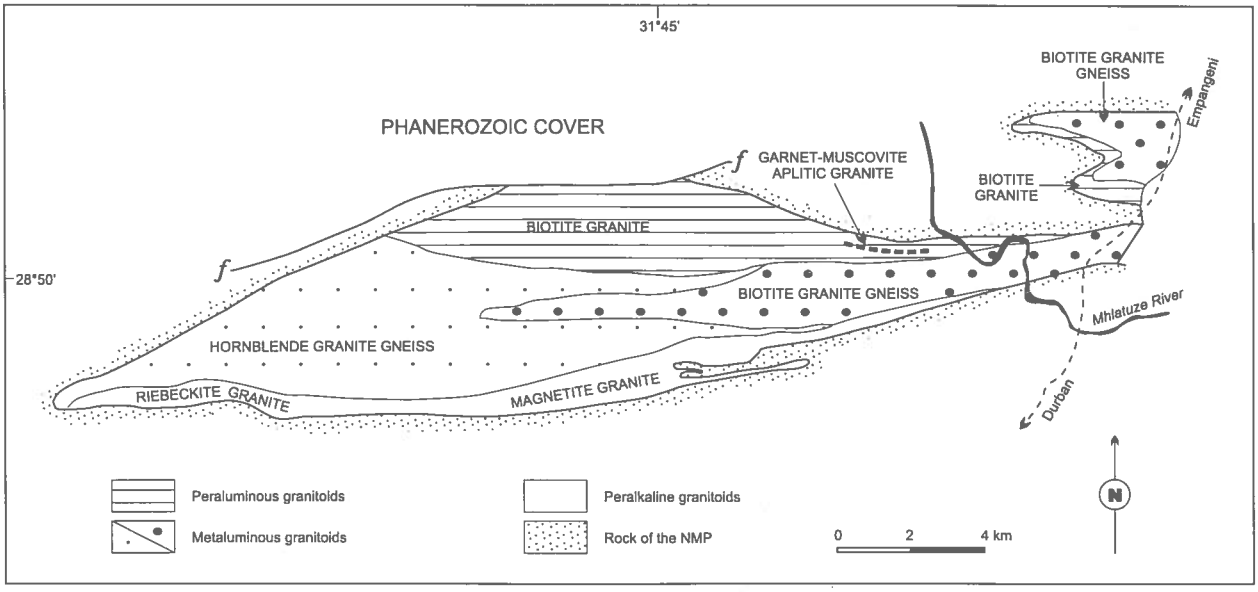

Figure 15 – Geological map of the Ngoye Complex, showing sample localities (after Bullen *et al.*, 1992).

rocks adjacent to the southern margin of the Ngoye body showing these anomalies were sampled and found to have anomalously high Nb, U, Th, Y, Zr and rare-earths with minor Sn, W and Ta values. A mafic intrusive body, also near the southern contact showed very high magnetic values. Targets were delineated using geophysics, soil and rock sampling and trenching to locate sites for drilling.

The target over the mafic body (330) was shown to have a high Ni content in soil and rock samples. Pyrrhotite, chalcopyrite and possibly pentlandite were macroscopically identified. Drilling revealed mineralisation restricted to the marginal and contact zones along the southern part of the Ngoye Complex. Magnetite-bearing pegmatites, also along the southern contact, were found to have elevated concentrations of Sn, W, Ta, Nb and U. However, the mineralised horizons are erratic, both in grade and width, as well as having short strike lengths. Widths are generally less than 3 m, and average 1 m. The two elements with the most consistently high concentrations occurring here, are Nb and U_3O_8.

Average grades calculated by Scogings (1983) are shown in Table 7.

TABLE 7 – MINERALISATION GRADES IN THE SOUTHERN PART OF THE NGOYE COMPLEX.

Element	Sn	W	Ta	Nb	U_3O_8
Grade	13 ppm	60 ppm	46 ppm	1 253 ppm	09 ppm

It was concluded that, owing to the complex nature of the mineralisation and low market values for the elements with high concentrations, this mineralisation was likely to be subeconomic. Also, there are abundant reserves of these elements elsewhere to sustain supplies for the foreseeable future.

5.1.8.4 Mlalazi Complex

The Mlalazi Complex, approximately 5 km east-north-east of Eshowe, measures roughly 3,5 km by 3 km and has intruded the Tugela Group gneiss in the Madidima nappe. The Complex comprises serpentinised dunites, gabbro-norites, pyroxenites and talc muscovite schists. The Complex is partially overlain by a thick soil cover and rocks of the Table Moutain sandstone, concealing, in places, the contacts between the various units. AAPS prospected the Complex in the early 1980s in an attempt to locate Cu, Ni and Co mineralisation. Pitting, trenching, and detailed mapping that were undertaken, revealed pronounced surface enrichments of copper, nickel, cobalt and chronium and slightly anomalous palladium values. However, percussion drilling revealed that, within a few metres of surface, the metal values fall to that of background for a dunite-wehrlite (Versfeld, 1982).

5.1.9 Industrial mineral deposits

5.1.9.1 Bulls Run Complex — mineral fluxes (250, 254–260)

Germiquet (1986a) recognised the Bulls Run Complex (Fig. 16) as a possible source of nepheline-based mineral fluxes for use in various industrial applications. Nepheline syenite is a nepheline-feldspar combination widely used as a source of alumina and alkalis for the manufacture of glass and ceramics, as well as for fillers/extenders in the paint, plastics rubber and adhesive industries. Exploration and beneficiation tests were undertaken by the STK on the Bulls Run Complex syenites in the late 1980s (Scogings, 1989b). Results indicated the presence of low-iron, glass-grade, nepheline syenite products equivalent to those produced in Canada, Norway and France. Comparisons with commercial nepheline syenite products from these countries are shown in Table 8, with sample localities from Bulls Run shown in Figure16.

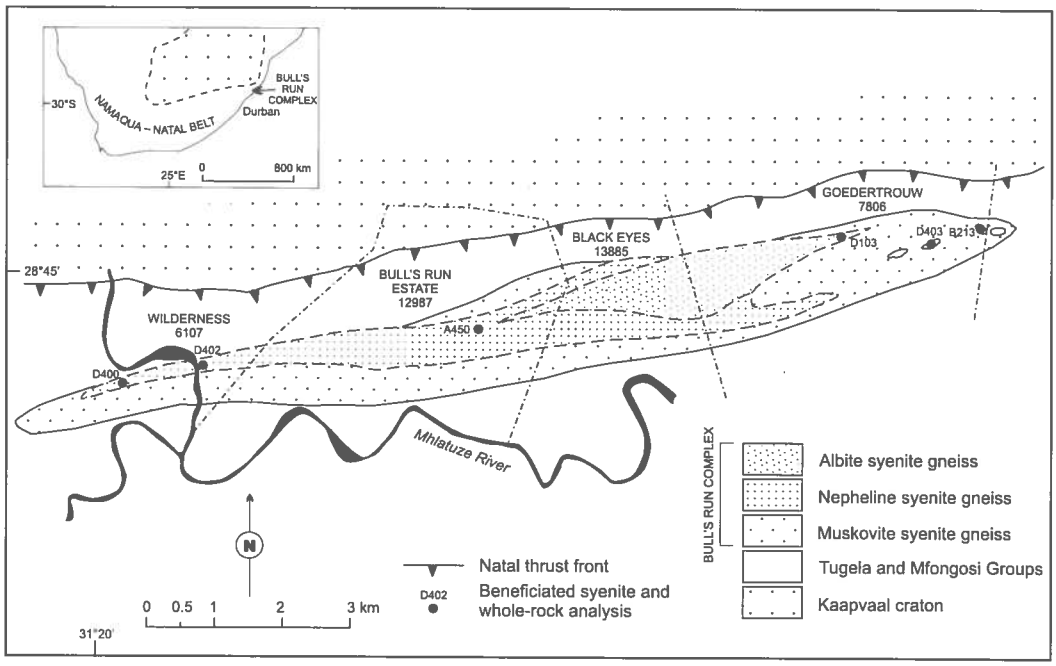

Figure 16 – Geology of the Bulls Run Complex, showing the localities for samples analysed in Table 8 (after Bullen *et al.*, 1992).

TABLE 8 – COMPARISON OF BULLS RUN MINERAL FLUXES WITH THOSE EXPLOITED OVERSEAS (from Scogings, 1989b).

	D400	D402	D403	B213	A450	Norway	Canada	France
SiO_2	62,40	56,80	55,71	55,70	59,34	55,70	60,30	59,80
Al_2O_3	20,00	23,56	23,45	21,30	23,06	23,90	23,70	20,65
Fe_2O_3	0,12	0,12	0,08	0,32	0,12	0,12	0,07	2,08
CaO	——	——	——	3,55	0,22	1,23	0,30	——
Na_2O	4,46	9,12	8,69	8,90	8,45	8,20	10,40	8,50
K_2O	10,80	7,54	7,25	5,39	7,75	8,57	5,00	6,25

Preliminary cost studies by Germiquet (1986b) indicated that the venture would be economically viable if product quality is acceptable to the local glass and ceramics industries and if sales of 2000 t/month were achieved.

The nepheline syenite crops out mainly on the Bulls Run Estate and access to the outcrops is poor. However, initial developers have targeted work on one of the several smaller plug-like nepheline syenite bodies, in the more accessible eastern end of the Bulls Run Complex. Potential reserves to a depth of 50 m were considered promising. Development of this site with respect to mining was, however, hampered by the fact that this area was to be proclaimed a nature reserve.

5.1.9.2 Ngoye Complex (quartz and feldspar aggregates for the glass industry)

An elongate, intrusive, sheet-like outcrop of peraluminous garnet-muscovite aplitic granite on the northern flank of the Ngoye Complex on Reserve No. 9 7638, was suggested as a suitable source of low-iron, non-magnetic quartz and feldspar aggregate for the glass industry (Scogings, 1989c). Beneficiation tests conducted by Mintek on two bulk samples of fresh material returned favourable results, with low Fe_2O_3 values important for the glass industry. On the basis of these initial beneficiation results it was recommended that a more detailed prospecting programme be implemented, to delineate reserves of suitable material.

5.1.10 Potentially exploitable and minor deposits

These deposits, described below and in Table 9, are other industrial mineral deposits occurring in the Tugela terrane (Fig. 17). Some have been worked in the past, while others have uncertain potential and require further investigation.

5.1.11 Talc

Extensive talc schist occurrences were first reported in the Tugela Valley by Du Toit (1931). More recent investigations by STK (Scogings, 1988b; Van Rensburg and Ahrens, 1989) delineated a number of potentially exploitable talc bodies in the eastern part of the Tugela Valley, all in the Middledrift–Sithilo–Khomo area, some 35 km west of Eshowe. Identified deposits and occurrences include those on Reserves Nos 19 (198) and 21 (205, 207, 212, 213), 7638 and in the Tugela Location 4674 (139, 214).

The regional geology of the area hosting these talc deposits is part of the Mandleni North tectonic unit, which forms part of the Tugela Group. The Tugela Group comprises predominantly hornblende-biotite gneiss and biotite-feldspar gneiss with associated serpentinites and serpentinite talc schist. The serpentinite and talc schists

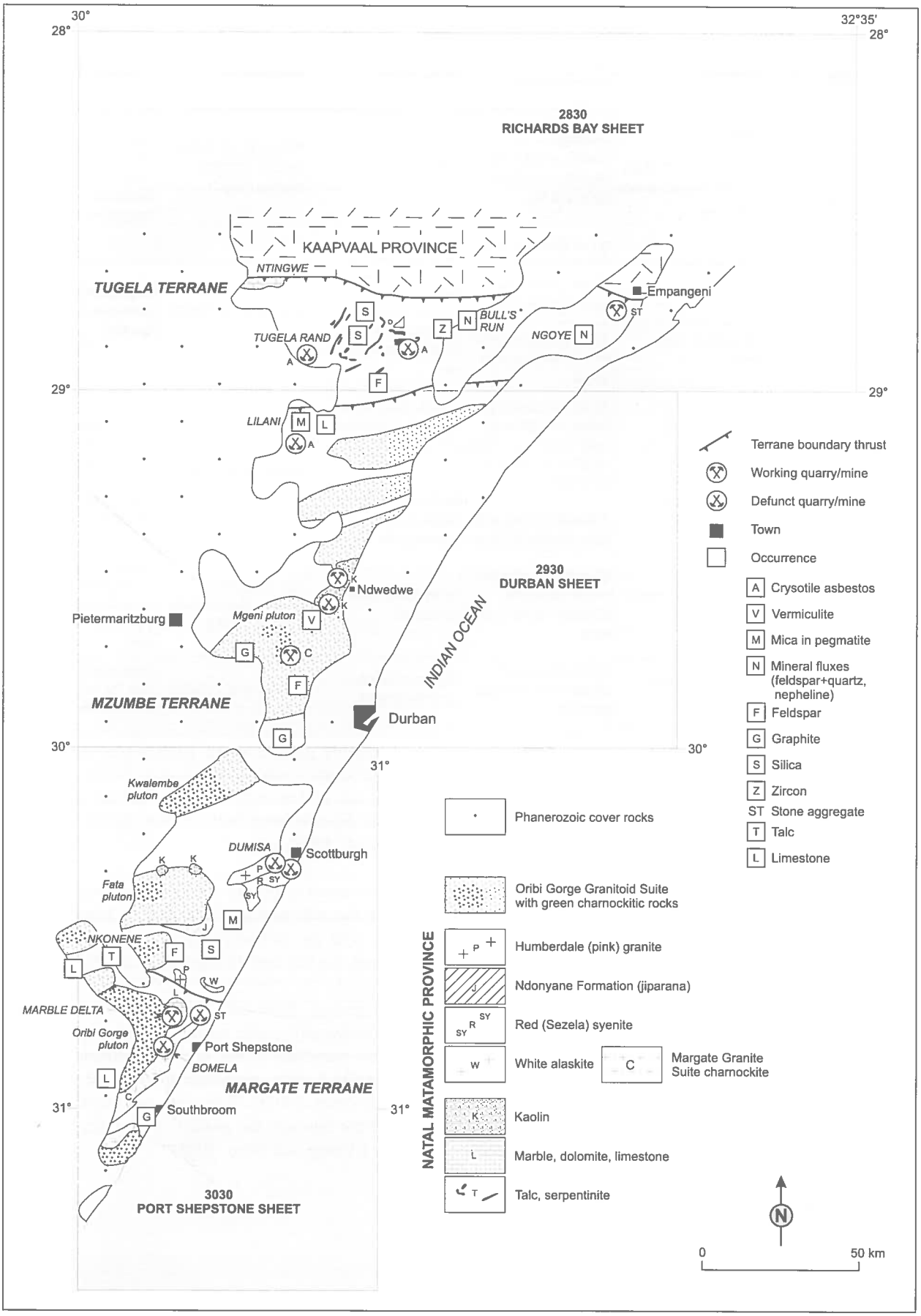

Figure 17 – Map of the Natal Metamorphic Province (NMP) showing industrial mineral occurrences, with talc occurrences shown in black (after Bullen *et al.*, 1992). The blocked portion at the top of the map represents a portion of the Richards Bay sheet.

TABLE 9 – POTENTIALLY EXPLOITABLE AND MINOR DEPOSITS WITHIN THE TUGELA TERRANE.

Commodity	Locality	Nature of mineralisation	Host rocks	References	Potential Reserves/uses and comments
Dolomite	Outcrops north of the Tugela River between the Buffalo and Mfongosi Rivers (63, 113)	Average $CaCO_3$ = 50,7 %, $MgCO_3$ = 37,3 %, SiO_2 = 9 %	Chlorite schist	Bullen *et al.*, (1992); Mackie (1986); Martini (1987)	Reserves > 100 Mt (estimated) Suitable for agricultural lime only, because of high magnesia content
Silica	i'Thuma River area (124) 1,5 km SSW of old Nkunzana Gold Mine	35 m diameter sub-circular quartz "blow", localised faint iron staining 400-m-long outcrop of 1-m-wide quartz veins	Mfongosi Group schists and gneisses Mfongosi Group schists and gneisses	Bullen *et al.* (1992)	High purity silica of potential electronics quality
Chrysotile Asbestos	Sithilo (Tugela Valley) (208–211) Tugela Rand (Tugela Valley) (127–132)	12 to 24 asbestos veins, of 120-mm total thickness. Fibre lengths between 6 to12 mm Asbestos veins with fibre lengths 3-18 m	Veins occur adjacent to a microgranite dyke Veins developed adjacent to microgranite sills	Bullen *et al.*, (1992)	Previously mined (opencast and underground) Poor quality as fibres are brittle
Zircon	Bulls Run Complex (250)	Eluvial and alluvial zircon deposits. Crystals up to 6 cm long	In decomposed gneisses	Von Backström (1962); Scogings & Forster (1989)	Grades of up to 0,66 % combined ilmenite, zircon and pyrochlore in eluvial soils
Stone aggregate	Ngoye Complex (290)	Medium-grained biotite-rich gneissic granites	Ngoye Complex granite-gneiss	Bullen *et al.*, (1992)	Aggregate production for local concrete industry

are believed to have been formed when ultramafic igneous intrusives, emplaced as sheets and pods along the soles of thrust planes in the nappe zone (Matthews, 1981) were altered to talc. The alteration has been attributed to hydration, resulting from retrograde metamorphism. According to Bullen *et al.* (1992), XRD analysis revealed that the predominant minerals present are talc, chlorite and anthophyllite, and this led them to propose the following reaction for the formation of the talc:

Olivine + orthopyroxene + H_2O talc + chlorite ± anthophyllite

Percussion drilling and pitting by STK (Van Rensburg and Ahrens, 1989) indicated that the talc bodies are massive, highly irregular and discontinuous. Where present, foliation within the talc bodies generally paralled the long axes of the deposits. The bodies themselves are also aligned roughly parallel to the general east–west strike of the host country rocks (Steenekamp, 1992b). Furthermore, the talc is generally off-white and no significant high-grade deposits were found during the investigation (Bullen *et al.*, 1992).

Initial investigation of the deposits revealed that the quality of the talc was not amenable to beneficiation. However, with the advent of acid-bleaching developed by Minemet, the talc met the minimum specifications for cosmetic-grade talc (Steenekamp, 1992a; Bullen *et al.*, 1992). In general, these talc occurrences are not considered economically viable owing to their limited size, insufficient quantities of talc schist, inconsistent thickness and strike length, spatial distribution and poor quality (Steenekamp, 1992b). Screening and magnetic separation did not increase the quality of these deposits significantly (Astrup and Horn, 1998).

6 POSTPROTEROZOIC MINERALISATION

The Karoo Supergroup lithologies crop out extensively in the area under investigation and contain a limited number of iron, fluorspar, bauxite and heavy-mineral sand occurrences. However, extensive coal deposits constituting the Klip River (1, 2) and Somkele (340) coalfields and a portion of the Nongoma coalfield, as well as small subeconomic coalfields, fall within the Richards Bay sheet area (see Appendix B).

Three collieries were operating in the 2830 Richards Bay sheet area in 1997, these being the Durban Navigation Collieries DURNACOL (1), the Zululand Anthracite Colliery (272) , and the Springlake Colliery (2) (Prevost, 1997) (Table 10). Subsequently, mining activities at the Zululand Anthracite Colliery have been suspended.

6.1 COAL DEPOSITS

6.1.1 Klip River coalfield

Coal has been commercially exploited in the Klip River (1,2) coalfield since 1865. Two seams are distinguished in this coalfield, namely the bottom and top seams, correlates of the Gus and Alfred seams respectively. The thicknesses of the two seams vary from north to south across the coalfield. The bottom seam averages 1,3 m in the northern portion of the coalfield, decreasing to 1,07 m in the central portion and 0,5 m in the southern section. The top seam has a maximum development of 3,3 m in the northern portion, decreasing to 0,5 m and less in the central portion but then increases to approximately 1,5 m in the southern portion of the coalfield (Snyman, 1998).

6.1.2 The Somkele coalfield (340), Hlabisa region

The Somkele coalfield (Figs 18 and 19), approximately 60 km north of Richards Bay and 20 km northwest of the town of Mtubatuba, started production in 1903 when two inclined shafts were sunk in the then-known Hlabisa coalfield. Approximately 515 t of coal was produced in 1903 and subsequent production figures do not appear to exist. The coalfield was discovered in the late 1880s and mining ceased in this area in 1909.

The Somkele coal is a high-ash anthracite and occurs in a structurally complex area in which major faults have subdivided the coalfield into five fault-bounded blocks. The fault-bounded coalfield contains four seams within the Late Permian Emakwezini Formation of the lower Beaufort Group, namely, the lower (A zone), main (B zone), upper seam 1 (C zone) and upper seam 2 (D zone), of which the main seam is the only seam of economic importance. The main seam has an average thickness of 10,6 m (Bekker and Hannweg, 1983; MacDonald, 1989; Snyman, 1998).

Until the 1960s only limited prospecting occurred in the coalfield (MacDonald, 1989; Snyman, 1998). JCI acquired an interest in the Somkele region in 1965. By 1986 they had drilled approximately 120 boreholes and taken a number of bulk samples from a 30-m prospect shaft. Their investigations revealed that although the anthracite is marketable, the structural complexity of the area would determine the feasibility of exploiting the seams rather than the reserves present and the quality of the coal (Cochran and Proctor, 1987).

Detailed prospecting of the eastern and western ore reserve blocks to the east of the ground belonging to JCI was undertaken in the 1970s and 1980s by the Mining Corporation Limited. The prospect area is approximately 30 km west of Mtubatuba, straddling the Mtubatuba–Nongoma road. A major upthrow strike fault separates the western and eastern blocks (Bekker and Hannweg, 1983).

The stratigraphy of the Somkele coalfield is that of the Karoo Supergroup. Five formations are recognisable in this region, namely the Pietermaritzburg, Vryheid, Volksrust, Emakwezini and Letaba Formations. The Vryheid Formation (deltaic environment) hosts all the major coal seams in northern Natal, yet in the Somkele coalfield there is a significant absence of coal seams in this Formation. This may be ascribed to the fact that the Somkele area represents a shallow-water marine/prodelta environment, that is, a paleo-environment that is deemed unsuitable for coal development (Bekker and Hannweg, 1983).

The Emakwezini Formation hosts all the major coal seams in the Somkele coalfield and, has a regional dip of

TABLE 10 – COLLIERIES OPERATING IN THE KLIP RIVER COALFIELD, IN THE RICHARDS BAY SHEET AREA, 1997 (from Prevost, 1997).

Colliery	Seam mined	Coal type	Production (kt)	Farm
Durban Navigation Collieries (1)	Top and bottom seams	Coking	1997– 786 kt 1996–1073 kt	Boyskraal 7793 Boyskraal 8945
Springlake Colliery (2)	Bottom seam	Anthracite	1996–550 kt 1997–300 kt	Lenteplaas 14432
Zululand Anthracite Colliery (272)	Main seam	Anthracite	1996–808 kt 1997–765 kt	Mahlabatini Trustland

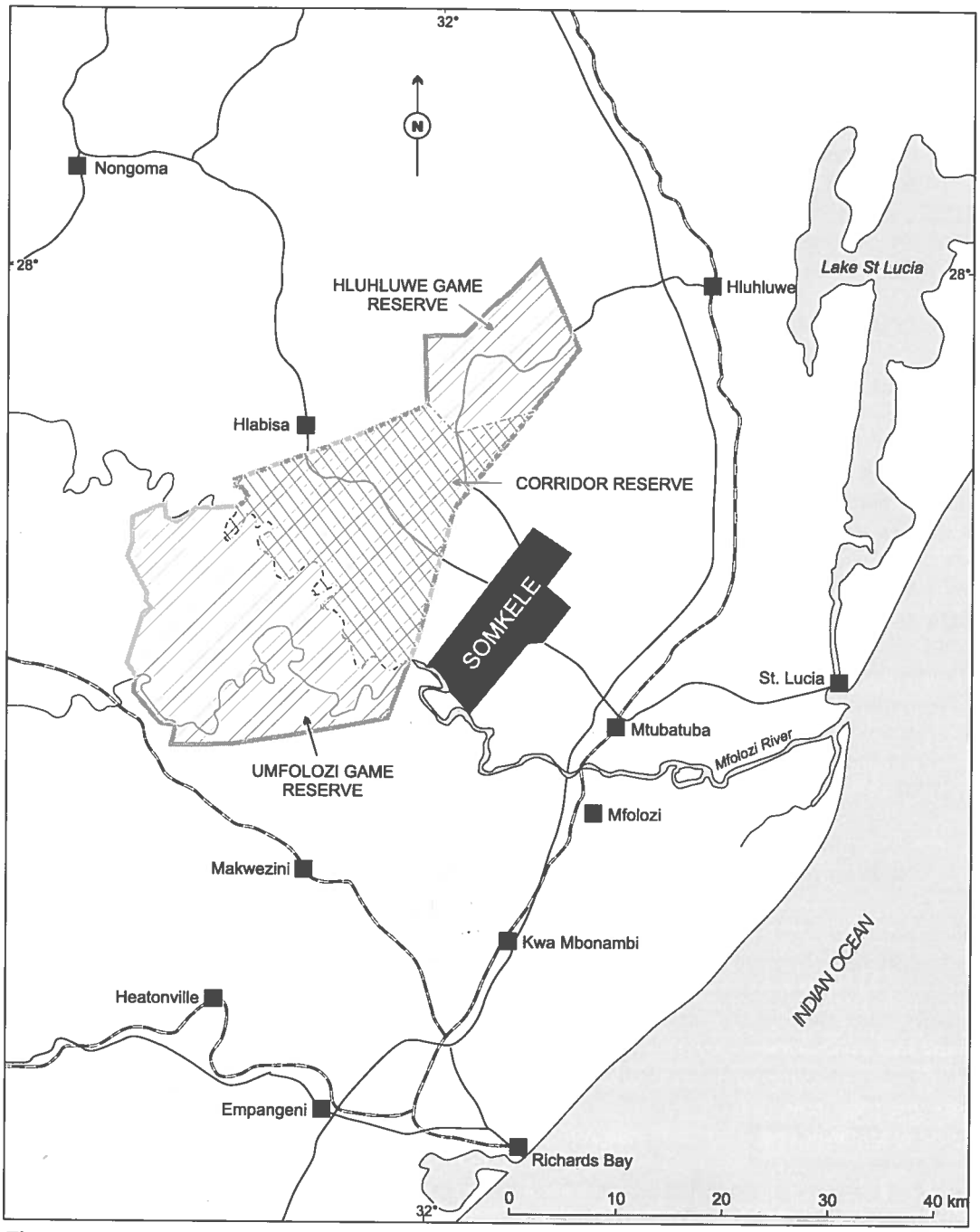

Figure 18 – Locality map of the Somkele coalfield (from Cochran and Proctor, 1987).

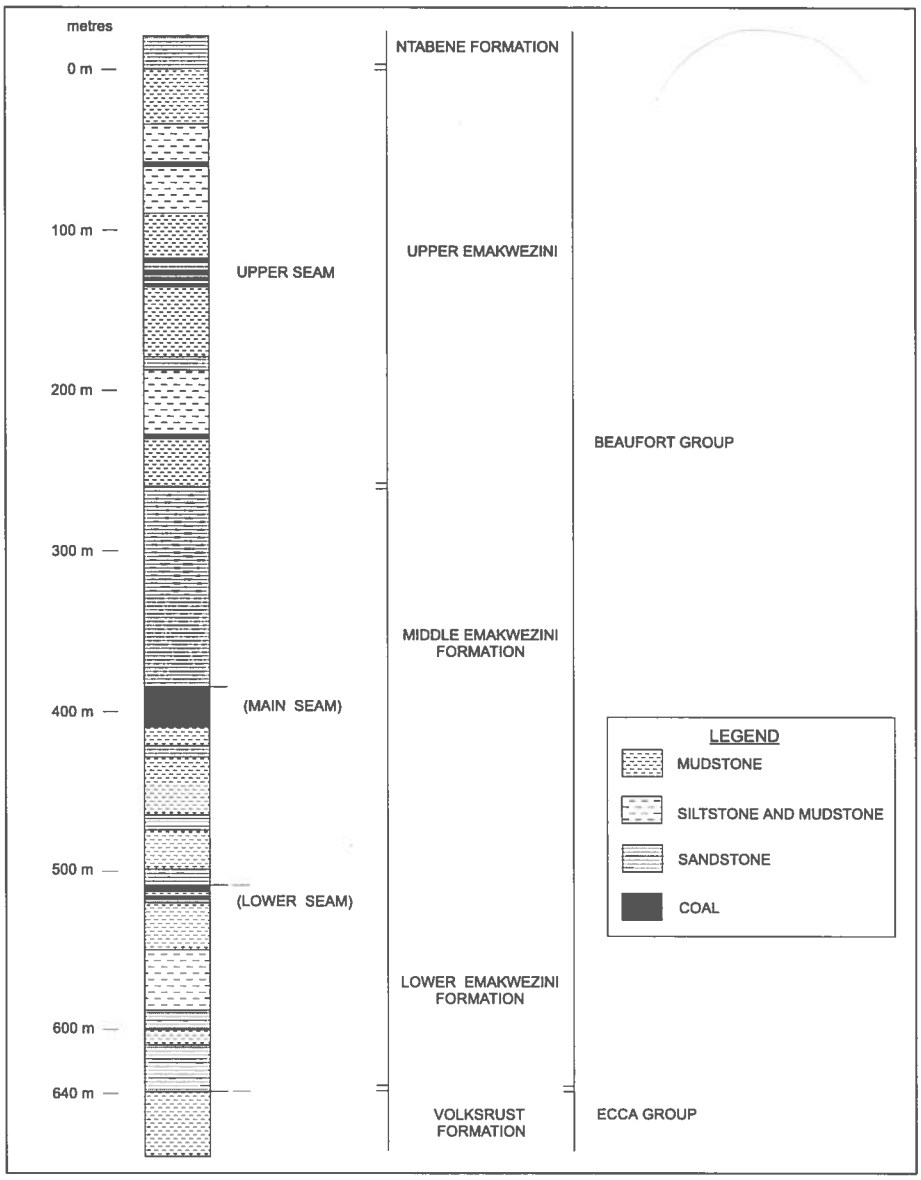

Figure 19 – Generalised stratigraphic column for the Emakwezini Formation in the Somkele coalfield (from Cochran and Proctor, 1987).

25° southeast. The Formation, comprising repeated sequences of shale and sandstone and four coal zones, represents a deltaic environment. The coal zones occur near the base of the Formation. The B (Main) zone is the most important of the four zones. The C and D zones are too thin and are thus deemed to be subeconomic, whilst the A seam is of inferior grade and small tonnage (Bekker and Hannweg, 1983).

The A zone is stratigraphically the lowest of the four seams and is separated from the B zone by a 60-m-thick succession of blue shale and black carbonaceous shale. In both ore reserve blocks the B zone anthracite comprises three coal seams, the B1, B2 and B3 seams, separated by mudstone and coal partings (Cochran and Proctor, 1987). The B zone is overlain by a 40- to 80-m succession of coarse feldspathic sandstone. The B seams have a high ash content, are low in sulphur, and friable (Bekker and Hannweg, 1983).

Dolerite has extensively intruded the area, affecting the economic potential of the coal seams to varying degrees. For instance, numerous small intrusions within the B zone have resulted in the burning of the anthracite, thereby complicating the extraction of the coal. In the vicinity of dolerite intrusions the coal is significantly devolatilised (1–2 % volatile matter).The burnt coal also has a significant increase in density, as well as having a very friable nature, which would result in a larger than normal loss of fines (Cochran and Proctor, 1987).

The mining potential of the Somkele area is further complicated by faulting, steep dips and roof and floor conditions. Disturbed ground (extensive jointing, small-scale faults and slickenslides) along the strike faults will affect the economic viability of the seams. Faulting has led to distinct changes in the dip of the coal seams across the faults. Mining of the B zone is further complicated by the weak floor rocks of the three B seams. The floor

rocks comprise mudstone, carbonaceous shale and poor-quality coal. The roof rocks to B1 and B2 would require extensive support, as the roof rocks comprise mudstone exhibiting fissility, carbonaceous shales and thin coal layers. The B3 seam is, however, overlain by a more competent coarse-grained sandstone and is therefore likely to form a stronger roof rock.

6.1.3 The Qudeni coalfield, Nkandla district

The Qudeni coalfield lies approximately 60 km from Nqutu on the road to Kranskop. Because of erosion of the landscape and extensive dolerite intrusion, the coal potential of the region has been limited to a 5 km² area (Fig. 20), containing coal resources estimated at 4,5 Mt (Ehlers, 1977a). In general, however, the coal potential of the Qudeni area is deemed subeconomic owing to the fact that the four coal seams are each less than 65 cm thick.

6.1.4 Nqutu (Langagazeberg and Telezeniberg) coalfield

The town of Nqutu lies approximately 50 km east of Dundee and 35 km south of the Blood River station. Three separate areas within this region were delineated and investigated by the Mining Corporation Ltd in the late 1970s for potential coal reserves (Fig. 21). At Langagazeberg an estimated *in situ* reserve of 4 Mt was calculated; at Telezeniberg the estimated reserves measured 1,5 Mt and an additional 7 Mt coal was found to occur in the Nqutu area (Ehlers, 1977c). Although the total coal resources of the Nqutu coalfield are estimated at 12,5 Mt it should be noted that the calculation was based on coal seams ranging in thickness from 15 to 58 cm, which cannot be commercially exploited, and therefore the entire coalfield is deemed uneconomical.

6.1.5 Mtunzini coalfield

The Mtunzini coalfield lies immediately north of the Nyezane River in the southern portion of Reserve 9, approximately 25 km south of Empangeni and roughly 11 km from the Gingindlovu siding (Fig. 22). Thin coal seams crop out in the area and are confined to a narrow belt which extends east–west. The potential economic area for coal in this area is approximately 15 by 2 km (Thirion, 1981). However, detailed exploration by the Mining Corporation Ltd in 1982 concluded that this coalfield represents a low-potential coal resource (Visagie, 1982).

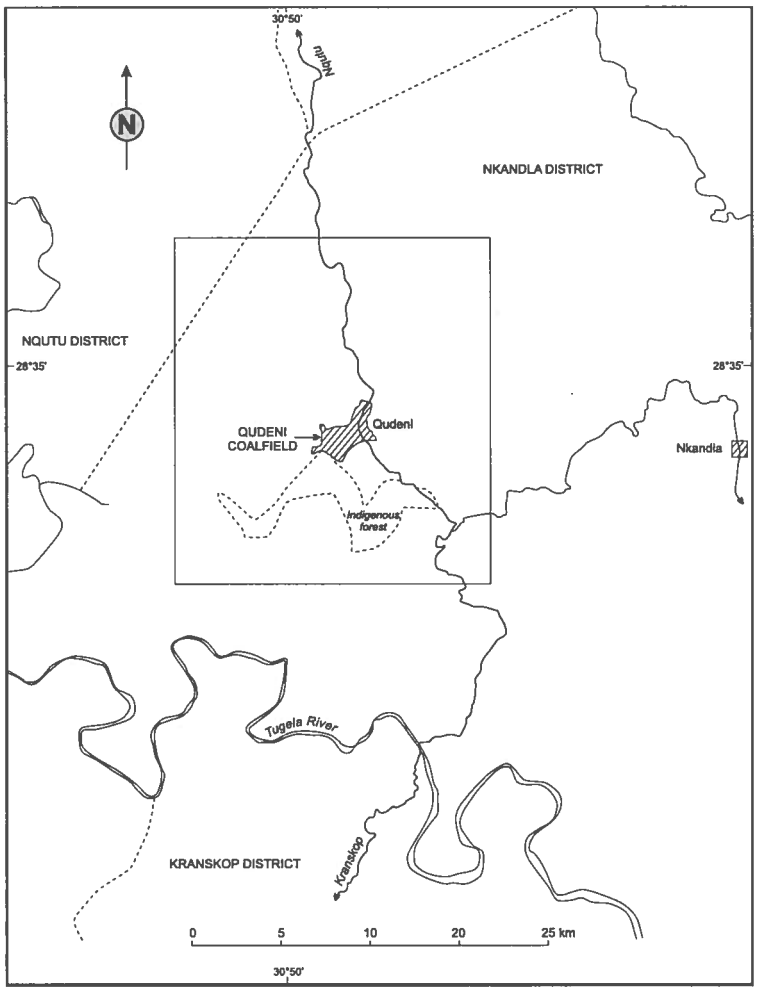

Figure 20 – Locality map of the Qudeni coalfield (from Ehlers, 1977a).

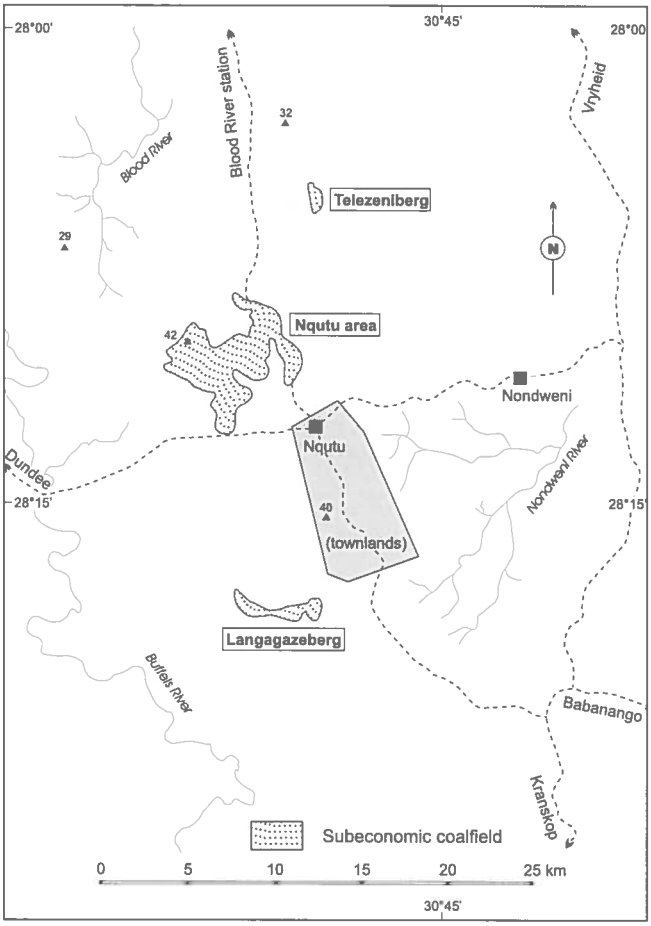

Figure 21 – Locality map of the Nqutu coalfield (from Ehlers, 1977c).

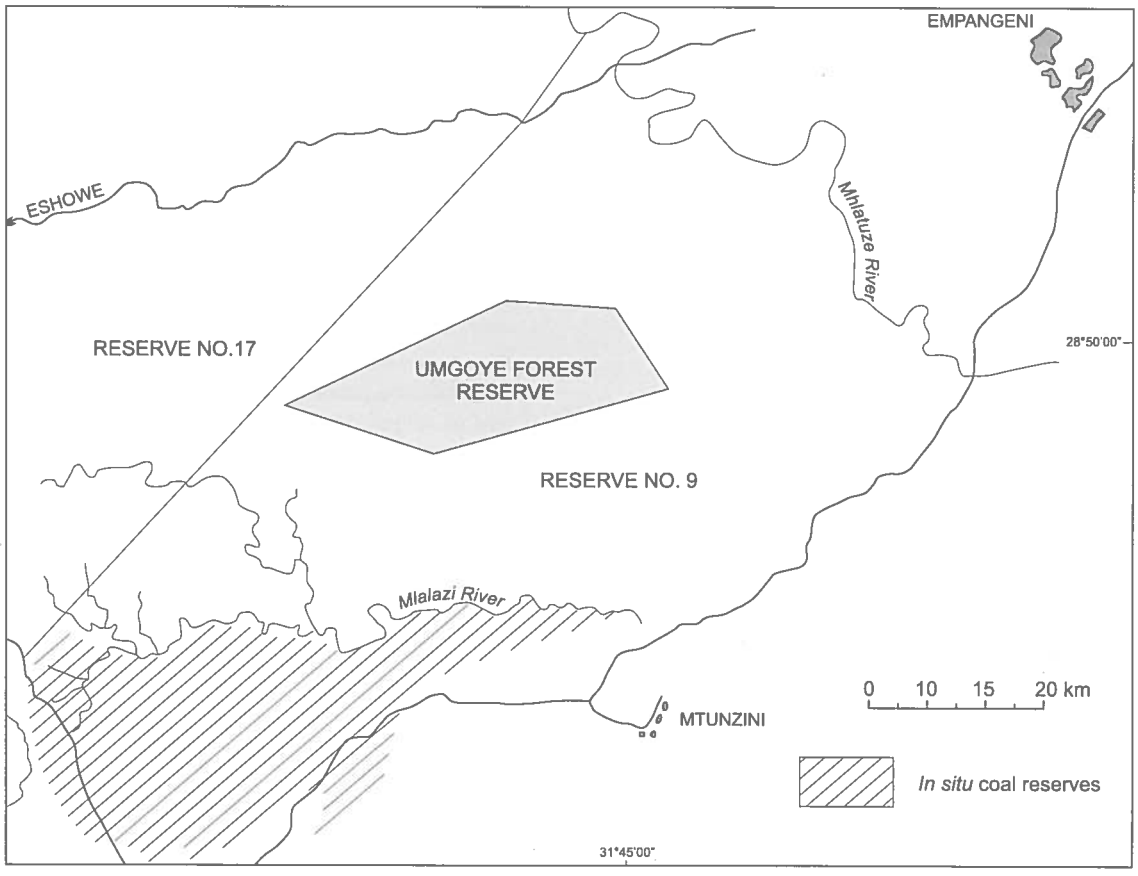

Figure 22 – Locality map of the Mtunzini coalfield (from Thirion, 1981).

This main coal-bearing sequence is exposed in a quarry face on the farm Bon Accord, portion 84, 10059 of Willow Hill. The total thickness of the coal-bearing interval on the farm Bon Accord is 2,12 m (Visagie, 1982).

6.1.6 The Eshowe and Empangeni area

In the area from Eshowe to Empangeni, eight coal seams at different localities have been reported. The coal seams in this region are hosted by sandstones of the Vryheid Formation and thicknesses range from 5 to 50 cm. The majority of the coal seams occur at depth and are deemed subeconomic. The area hosting the coal seams has been extensively intruded by dolerite, which has disrupted the stratigraphy of the area as well as the coal-bearing succession. Nonetheless, an area of 65 km^2 (Fig. 23) is deemed to be potentially economically viable, and hosts an estimated coal resource of 97 Mt. The thickness of the seams in this limited area measures approximately 100 cm (Ehlers, 1977b).

6.1.7 Hluhluwe area

The area approximately 20 km northwest of Hluhluwe was investigated in the early 1980s by the Mining Corporation Ltd to evaluate the potential for coal hosted by the Karoo sediments and base-metal mineralisation hosted by breccia dykes. The Karoo sediments in this area have been extensively intruded and metamorphosed by dolerite sills and dykes, and breccia dykes. The breccia dykes are essentially fine-grained and brecciated quartz-feldspar dykes, often containing haematite and limonite-bearing vugs. However, the volume percentage of the vugs is too low, indicating that economical sulphide mineralisation is absent. The breccia dykes were sampled; however, no anomalous metal values were recorded. For example, Ag assayed from chip samples at <1 and 1 g/t, whilst Au and Sn were extremely low. Although coal is present in this area, the area is deemed to have no economic potential in this regard (Bekker, 1982).

6.2 IRON DEPOSITS

Many small, isolated occurrences of non-oolitic iron formations are known in the northern interior of KwaZulu-Natal, and these are hosted mainly within the Ecca Group. All the known iron occurrences in the province were subject to detailed analyses by Wagner (1928). The ore is of variable character, the main types being sideritic and calcareous or dolomitic ironstone, haematite and goethite, and also as hard, dense magnetite. The latter is thought to have originated by contact metamorphism of the other varieties owing to the effects of Karoo dolerite intrusives. Wagner (1928) reported that the iron ore found in KwaZulu-Natal is of excellent quality, but of insignificant size when compared with other deposits found in South Africa.

The bulk of the iron that has been mined in KwaZulu-Natal has been extracted in the Dundee area, mainly as a

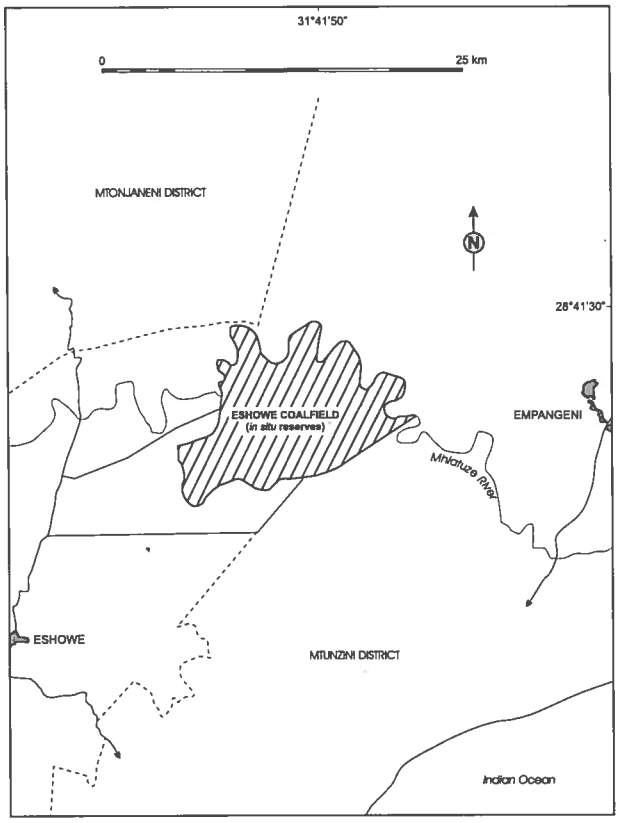

Figure 23 – Locality map of the coal-bearing area between Eshowe and Empangeni (from Ehlers, 1977b).

source of raw material for the Newcastle iron industry and for the pigment industry. Most of the bigger deposits have now been worked out and recent interest has focused mainly on small-scale ochre production (Hammerbeck *et al.*, 1976).

Ironstone exposed at Prestwick (28) 2415 was mined intermittently from before 1860 to 1953. The thin seams of ore average a thickness of 0,9 m and dip at 4° to the southwest. The ore zone is composed of siderite and subordinate black carbonaceous material, quartz and clay. The oxidised ore underwent enrichment, resulting in iron contents of 50 per cent, in comparison to the unweathered primary ore, which has an average iron content of 40 per cent. The ore horizon is overlain by a thin layer of carbonaceous shale hosting minor coal seams, which alone covered the costs of exploiting the iron ore.

Iron ore, similar to that occurring at Prestwick, was exploited at the Alleta Mine (3) on the farm Alletta 4350, from 1939 to 1953. Both deposits had similar original reserves of some 2 Mt. The same ore bed was also quarried at Davelsfontein (4) 4348 and Stanmore (29) 2412. Limonite was exploited on the farm Springfield (31) 9753. At Irondale (33) 6013, a haematite magnetite limonite seam of 0,9 m thickness was exploited. A quarry at Hazeldene 12649 supplied iron oxide for paint making. On the farm Brakfontein 155 (26, 27), fossiliferous and dolomitic ironstone was exploited, and although the iron content is low, the material is ideal for

smelting with siliceous iron ore (Hammerbeck *et al.*, 1976). In KwaZulu-Natal significant amounts of pig iron ore was produced as a by-product of the heavy-mineral sand and dune mining, at Richards Bay.

6.3 HEAVY-MINERAL SANDS

Palaeo-beach sands, rich in heavy minerals, occur in the vicinity of Muden (49–52) (Fig. 24) in northeastern KwaZulu-Natal (Ryan and Whitfield, 1979). These consolidated beach deposits occur predominantly within middle Ecca (Vryheid Formation) sandstones of the Karoo Supergroup. These sandstones are believed to represent mainly fluvio-deltaic deposits, which underwent significant shoreline reworking. Phelps Dodge of Africa Ltd investigated the Muden deposits and established that the deposits were tabular and had an average thickness of 1 to 2 m, whilst the lateral dimensions of the deposits measured 1,5 km by 750 m. The heavy-mineral component of the deposits was between 18–30 per cent and is hosted by ferruginous sandstones. Ilmenite is the most abundant heavy mineral, though significant amounts of zircon, monazite and garnet are also present. The deposits may contain trace amounts of tin and thorium. The deposits comprise a mixture of silica and haematite/goethite, with the matrix minerals replacing some of the detrital constituents (Germiquet, 1987). Behr (1986) reported that the ilmenite at Muden is highly altered (mainly to goethite), owing to weathering and postdepositional effects, and predicted that this would cause many difficulties during beneficiation of the ores. Tests conducted by Mintek indicated that the bulk of the material on magnetic separation reports to the middle fraction and would therefore cause beneficiation problems. In addition to the beneficiation problems, these heavy-mineral deposits are of limited extent (Germiquet, 1987).

Limited prospecting by mining companies has confirmed that these deposits do not have much economic potential and no ore reserves have been delineated. Nonetheless, there has recently been renewed interest in these types of deposits. The heavy-mineral sand deposits at Richards Bay are vast and are likely to supply all the country's needs for the near future, as well as allowing for significant exports.

6.4 FLUORSPAR

6.4.1 Hlabisa area (299–310)

The Hlabisa area, situated some 75 km north-northwest of Richards Bay in northern KwaZulu-Natal (Fig. 25), experienced intermittent mining activity from the early 1920s up to 1979. In the 1920s, when production started, approximately 4260 t of acid spar was exported. From 1932 to 1957 it is estimated that the sporadic production totalled 2 914 tons. From 1958 to 1960 approximately 4 261 t was mined. It has been suggested that the cessation of production was due to cave-ins and flooding of the workings and the increased competition from the "Bushveld granites" fluorspar deposits (Scogings, 1990). Crocker *et al.* (1988) estimated some 300 000 t CaF_2 in the more important deposits of the Hlabisa field, these figures being reflected in Table 9. These estimates were based on an average vein width of 0,9 m, were inferred to a depth of 30 m down dip and did not include all mineralised veins. The Hlabisa fluorspar, in general, is a high-quality acid-grade fluorspar with minor SiO_2 and $CaCO_3$ contamination (Scogings, 1990).

The Hlabisa fluorspar field is situated within a highly tectonised terrane. It has been suggested that the Hlabisa fluorspar mineralisation may represent a late-stage volatile-rich system that was active during the waning stages of the Lebombo magmatic cycle (Scogings, 1990). Scogings (1990) reported that the structure of the area is characterised by a series of step faults within a large uplifted fault block/horst. It is believed that the fluorspar mineralisation is closely linked to the complex structure of the area. A plot of all the known fluorspar deposits, together with the structures and major faults of the area (Fig. 26), indicates that the mineralisation was essentially confined to favourable trap sites caused by the intersection of cymoid structures and the boundary faults of the horst (Scogings, 1990).

Crocker *et al.* (1988) described, in detail, up to seven individual deposits in the area. The majority of the workings comprised narrow opencast pits along the strike of the quartz-fluorspar veins, most of which are hosted in diamictites of the Dwyka Group and sandstones of the Ecca Group. In some cases the veins cross-cut Karoo dolerites, Natal Group sandstones and Archaean granites. Most of the fluorspar forms the central filling of the coarsely crystalline veins which have exploited steep tensional fractures in the host rocks. These fractures are associated with sets of north to north-northeast-striking post-Karoo-aged normal faults. The fluorspar may also form a network interlayered with "cherty" quartz and fine-grained fluorspar (Scogings, 1990).

The veins average up to 1 m in thickness and generally tend to pinch out at a depth of 30 m, although some have been worked to a vertical depth of 50 m without decreasing in width. The association of veins in the northern parts of the field with dykes of rhyolite breccia suggests that mineralisation may persist to considerable depth in some places (Crocker *et al.*, 1988).

The Roadside Prospect, (305) hosted by the Dwyka Group tillite and shales, comprises several quartz veins which strike north to northeast. The old workings are 4 m wide by 2–3 m deep, but apparently depths of up to 20 m were mined here. Four veins were mined, amounting to a cumulative strike length of 2 km; however, the westernmost vein, which dips at 65° east, was the most productive. This vein is reported to have increased in width with depth — at surface the vein measured roughly 0,9 m, whereas at the base of the workings the width increased to 1,3 m (Scogings, 1990).

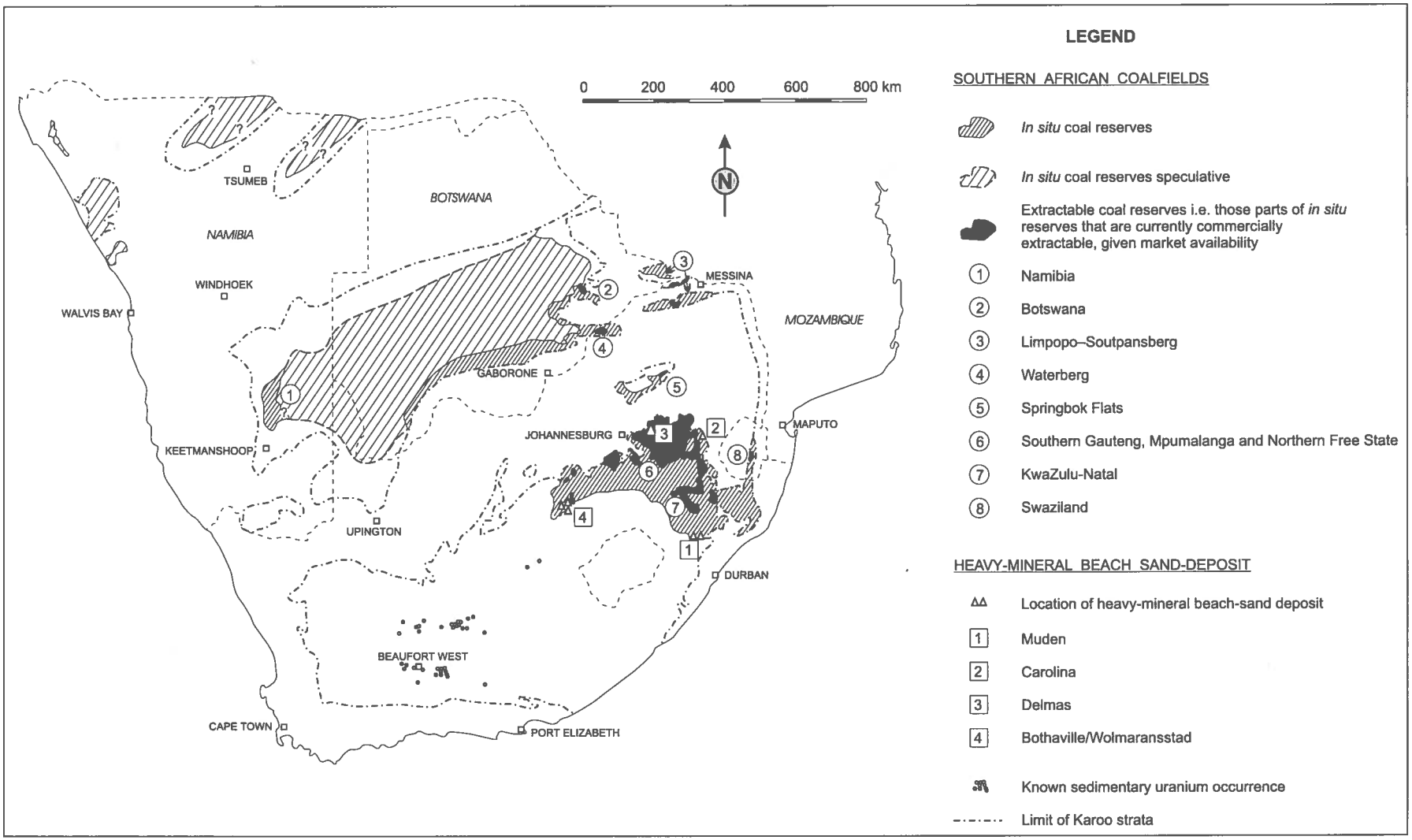

Figure 24 – Heavy-mineral placer deposits at Muden in relation to the distribution of coal deposits in Southern Africa (after Ryan and Whitfield, 1979).

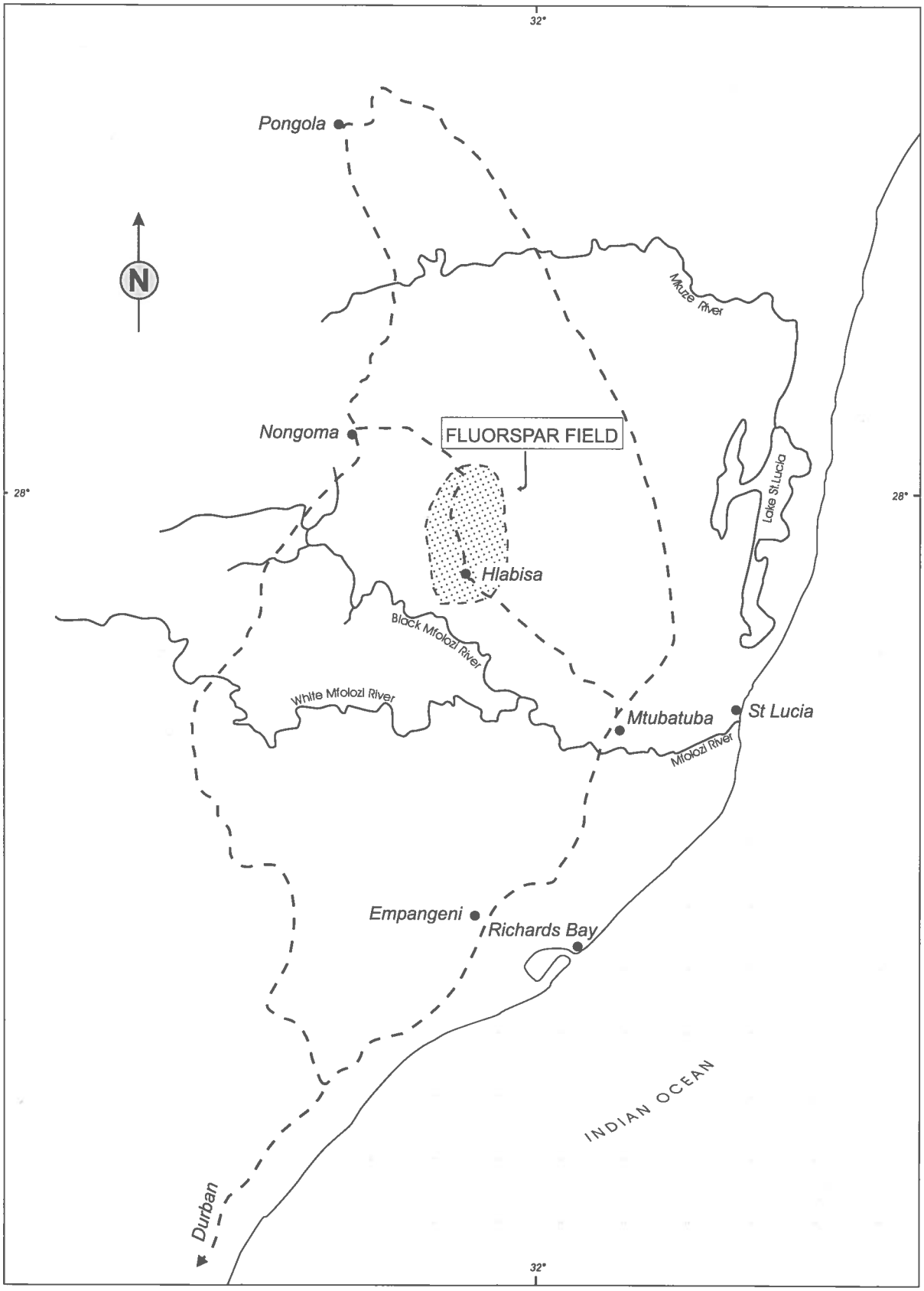

Figure 25 – Locality map of the Hlabisa fluorspar field (from Scogings, 1990).

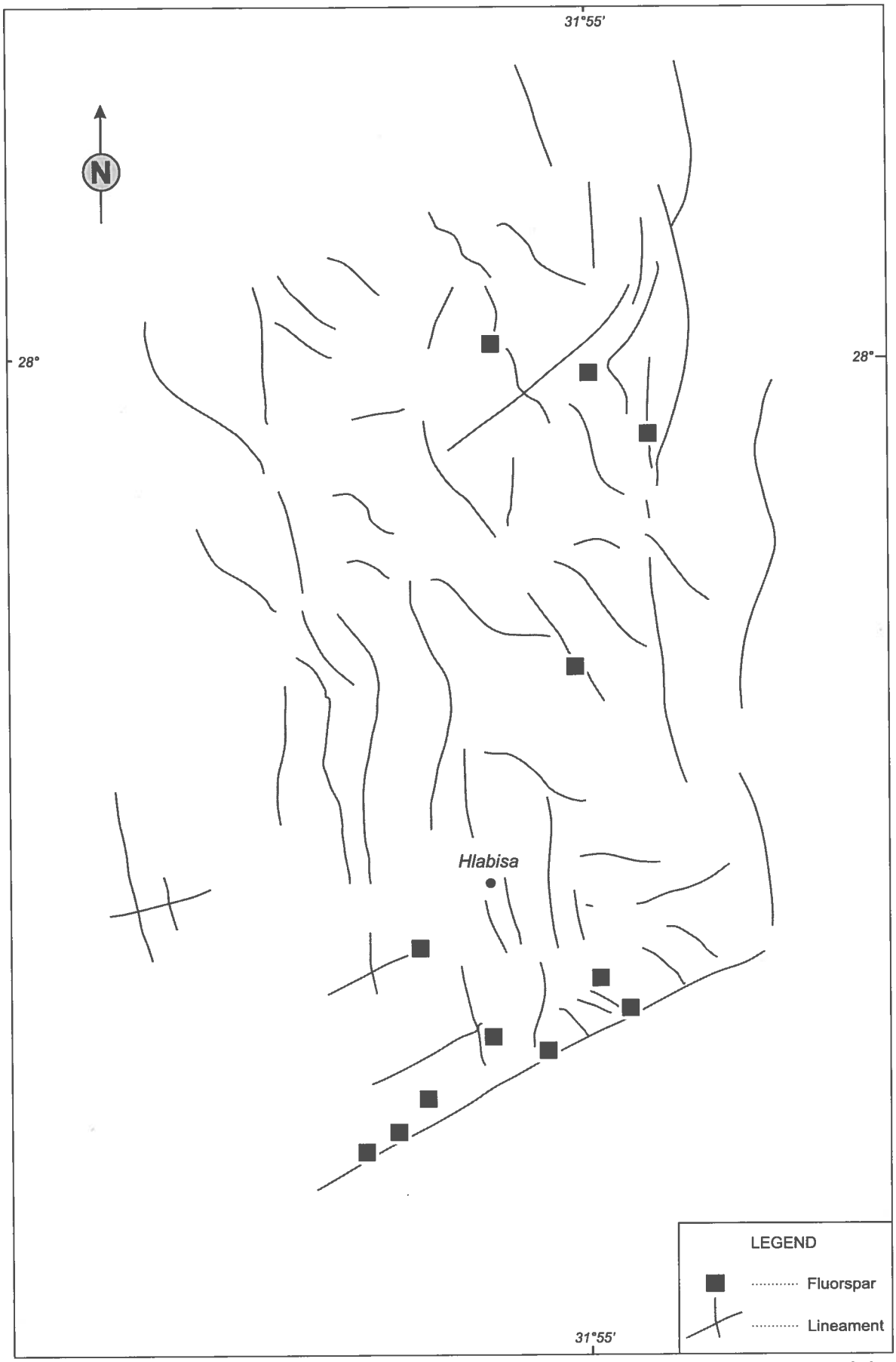

Figure 26 – Relationship between the known fluorspar deposits and the regional structure of the Hlabisa fluorspar field (from Scogings, 1990).

Workings at the Minnie Mine (306) exploited north–south-striking quartz-fluorspar veins hosted by altered Dwyka sandstone and tillite (Ahrens, 1990). The main workings at Minnie exploited the fluorspar veins to a depth of 33 m with a strike length of 200 m. A drilling programme in 1957 by ISCOR intersected two fluorspar veins below the main workings at a depth of between 30 and 40 m. Each of these veins has an approximate worth of 1 m (Scogings, 1990). At the Minnie workings, the veins displays little fluorspar on outcrop but they do display ferruginisation along strike.

At the Tainton workings (308, 309, 310), which were predominantly prospecting trenches, the fluorspar is surrounded by a brecciated quartz vein which obliquely cross-cuts an east–west dolerite dyke. The quartz-fluorspar veins at Tainton assay at roughly 50 per cent fluorspar, but platy quartz interleaved with the fluorspar resulted in grade problems (Scogings, 1990). The veins are surrounded by alteration zones, thereby supporting a hydrothermal origin for this mineralisation (Ahrens, 1990).

The Antoinette A (Rabe's Claim) (299) mine workings comprise a 90-m long by 34-m-deep opencast operation. Rock falls have rendered the underground operations inaccessible, and the shaft collar has been sealed. At Antoinette A (299), the ore body comprises a north-striking main vein, 0,5–1,5 m wide, and several parallel stringers cutting across Archaean granite and Jurassic dolerite (Ahrens, 1990). The mineralisation at Antoinette A (299) comprises an initial phase of pyrite and grey chalcedonic quartz within fractures which was subsequently brecciated, reopened and the vacant cavities filled by white chert and late-stage fluorspar (Ahrens, 1990; Scogings, 1990). The alteration envelope at Antoinette A (299) is extensive and thus supports a probable hydrothermal source for the fluorspar. Results from the chemical analyses of the Antoinette A (299) mineralisation indicates As levels of up to 300 ppm, minor base metals and gold assaying at 550 ppb (Ahrens, 1990; Ferrier, 1985). It is estimated that peak production in the 1950s at Antoinette A (299) amounted to roughly 2 000 t of ore per month (Ferrier, 1985). See Table 11 for reserves.

At Antoinette B (Prozeski's Claim) (300), the mineralisation comprises several interlayered fluorspar-quartz veins cross-cutting sandstones of the Natal and Dwyka Groups. The mineralisation has associated brecciation, but no alteration envelope. The workings at Antoinette B (300) consist of a number of open stopes over a distance of 300 m. Depths in excess of 10 m were stoped (Ahrens, 1990; Ferrier, 1985). Table 11 lists the reserves.

TABLE 11 – ORE RESERVE ESTIMATES FOR THE FOUR MAIN WORKINGS IN THE HLABISA FLUORSPAR FIELD (from Scogings, 1990).

Mine workings	Reserve	Strike length
Antoinette A (299)	7 560 t	over 150 m strike
Antoinette B (300)	4 200 t	over 100 m strike
Minnie (306)	25 200 t	over 150 m strike
Roadside (305)	10 080 t	over 200 m strike

At Antoinette C (297), the mineralisation comprises a quartz-fluorspar vein measuring 15–45 cm in width, hosted by the Dwyka Group. The vein has intruded across a fault (Ahrens, 1990).

The South African Development Trust Corporation initiated a project in the 1980s to investigate the fluospar deposits of the Hlabisa area and the possibility of precious-metal mineralisation associated with the hydrothermally altered zones, that is, epithermal gold-silver mineralisation associated with post-Karoo fracture systems. They proposed that, by integrating the geological data, the fluorspar mineralisation, the structural setting and the geophysical data, a model similar to that for Roxby Downs in Southern Australia may be applied to the Hlabisa fluorspar field (Ferrier, 1985; Ahrens, 1990).

A prominent magnetic anomaly to the north and north-east of Hlabisa was indicated by the aeromagnetic coverage undertaken by STK and was considered important for buried base and precious metals (Fig. 27).

The Hlabisa fluorspar field (Table 12) may be said to represent a multi-stage volatile-rich epithermal mineralisation system which was active in post-Karoo times. The mineralisation may be likened to the Roxby Downs and the Olympic Dam deposits. The large aeromagnetic anomaly at the centre of the Hlabisa mineralised field may represent a magmatically derived iron-rich ore body at depth which has the possibility of hosting both base and precious metals. This is akin to the Olympic Dam deposit. The Hlabisa fluorspar field is well suited to exploitation by small-scale mining (Scogings, 1990).

In addition to the fluorspar mined in this region, building stone was quarried at Sinkonkonko. Fuchsitic quartzites and muscovite schists have also been quarried on a limited scale in the area. There are showings of magnesite

TABLE 12 – ESTIMATED FLUORSPAR RESOURCES IN THE HLABISA AREA (after Crocker *et al.*, 1988).

Deposit name	Total strike (m)	CaF_2 (%)	Density (kg/m³)
Minnie *(306)*	5 640	30	2 780
Roadside *(305)*	1 070	50	2 840
Tainton No.2 *(308)*	460	30	2 780
Tainton No.3 *(309)*	610	40	2 810
Tainton No.4 *(310)*	300	20	2 760
Antoinette A *(299)*	4 750	30	2 780
Antoinette B *(300)*	760	30	2 780

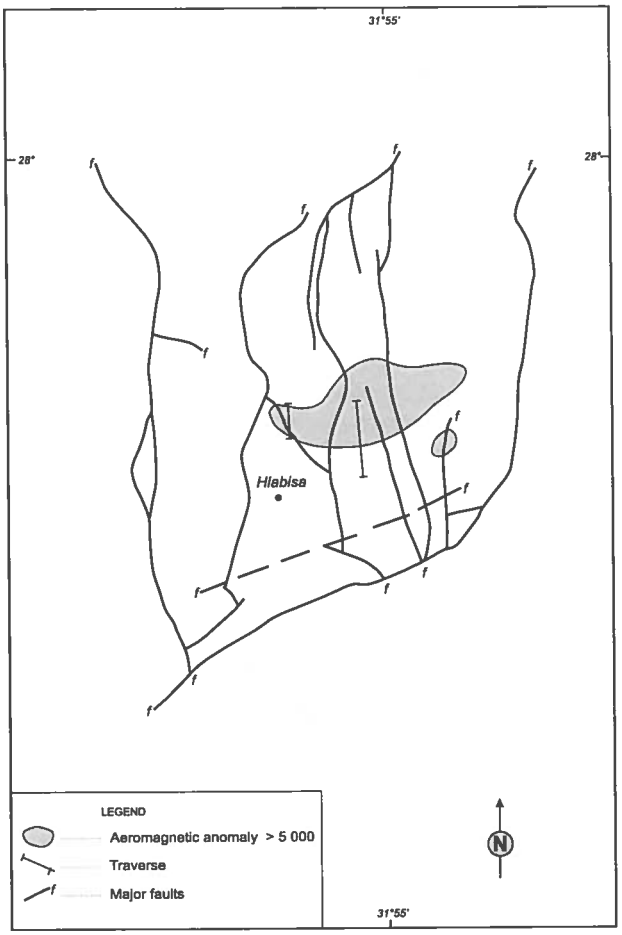

Figure 27 – Aeromagnetic anomaly in the centre of the Hlabisa fluorspar field (from Scogings, 1990).

developed on a few of the larger sills in this area (Sinkonkonko area). Within the area there are many small epithermal veins that are essentially comprised of quartz with minor iron staining, calcite and graphite. The graphite has typically been brecciated owing to the influx of later quartz (Ferrier, 1985).

6.5 BAUXITE DEPOSITS

Bauxite, an aluminous laterite, was discovered in KwaZulu-Natal during 1976 by Helmuth Redinger Exploration and Development (Pty) Ltd (Horn, 1983). These Karoo dolerite-derived, low-grade bauxite resources, were initially identified at Ngome in northern and Weza in southern KwaZulu-Natal. Subsequent to this discovery, the Geological Survey of South Africa (now known as the Council for Geoscience) initiated detailed investigations of target areas within the Province. Horn and Barnardo (1983) reported bauxite resources of some 23 Mt at a cut-off grade of 20 per cent alumina for the deposits in northern KwaZulu-Natal. The bauxite deposits are more extensively developed in the southern part of the KwaZulu-Natal and are described in detail in the explanation booklet accompanying the 2930 Durban and 3030 Port Shepstone metallogenic sheets.

The *Qudeni (110, 111, 112)* deposits, in the western portion of the Richards Bay sheet, were extensively mapped in the late 1970s by the Mining Corporation Limited. The latter investigation recorded values of approximately 35 per cent gibbsite to a depth of 1.5 m in the area between the Qudeni store and the Ekombe Hospital (Thirion, 1978). Later investigations of the area revealed reserves of 1 666 000 t of material with an average available Al_2O_3 content of 24 to 30 per cent, some 5–7 per cent reactive SiO_2 and 25–33 per cent Fe_2O_3. In addition, there is a 162 000 t indicated resource of bauxite with an Al_2O_3 content of 30 per cent, 7 per cent reactive SiO_2, and 33 per cent Fe_2O_3 (Barnardo, 1998).

6.6 DOLERITE (289)

Although the intrusion of dolerite sheets and dykes into the Karoo Supergroup has adversely affected many of the coal deposits of the region, it has been examined locally as a source of crushed stone. The dolerite deposit situated in Reserve No. 9, between Empangeni and Eshowe, was extensively investigated by Clydesdale (Transvaal) Collieries Ltd in 1967 as a source of stone aggregate. The quality of the stone is consistent and the estimated reserves for the deposit is approximately 23 410 000 cubic yards of crushed stone with the overburden varying between 12 to 41 inches. The dolerite sill strikes west-northwest and east-southeast. It is not known whether production occurred on this deposit (Bantu Mining Corporation, 1967).

6.7 GRAPHITE (336)

A graphite occurrence is situated approximately 30 km west of Hluhuwe, close to the southern extremity of the Hluhluwe Dam. It is presumed that the graphite was originally coal which was subsequently metamorphosed as a result of the intrusion of dolerites associated with Karoo volcanism. The graphite is weathered at surface, but becomes hard and slaty with depth. The graphite-coal seams of this deposit are approximately 3 m thick, strike approximately 20° W and dip at 45° to the east (Germiquet and Travias, 1977). Within the Sinkonkonko area, graphite was located in the late 1970s. The presumed origin of the graphite is believed to be devolatilisation of coal seams by dolerite intrusion. However, drilling of the area highlighted the fact that the outcrops are discontinuous and the drilling exercise failed to intersect any coal seams. No further work was conducted on these occurrences (Thompson, 1977).

6.8 CLAY (292)

A single occurrence of natural firing clay is located 5 km north-northeast of Gingindlovu in the Mtunzini area. The clay is covered by a black turf, which grades into a streaky ochre-grey material. This zone grades downwards into a more homogenous ochre-cream clay, and this, in turn, grades into carbonaceous shale of the Vryheid Formation.

The occurrence comprises a fine-grained clay which is chiefly composed of illite with minor quartz. On many occasions, the occurrence was sampled and analysed to determine its suitability in the manufacturing of earthernware pottery and bricks. It was established that the clay is suitable for ceramic purposes, but unsuitable for the manufacture of bricks, owing to its sensitivity to drying. The carbonaceous shale, however, is deemed suitable for brickmaking. A limiting factor on this occurrence may be its relatively small size, owing to extensive dolerite intrusion and faulting (Germiquet, 1982).

Prospecting in the Heatonville area (282–285) (northwest of Empangeni) revealed that portions of the Ntabeni Formation (Beaufort Group) are suitable for quarrying of material for brick-making purposes. The Ntabeni Formation comprises grey, purple red, silty mudstone interlayered with light-grey, medium- to coarse-grained sandstone. The material intersected by drilling indicated the presence of illite as a major constituent and kaolinite-montmorillonite as a lesser constituent. The material sampled proved suitable for brickmaking, given its good plasticity and dry and fired strength (Meissner, 1977).

7 RECENT DEPOSITS

7.1 HEAVY-MINERAL SANDS

Heavy-mineral-bearing sands have formed along much of the east coast of southern Africa and viable deposits are known in Kenya, Mozambique and South Africa. Important concentrations within KwaZulu-Natal have been reported from Isipingo, Hibberdene, Umkomaas and Umgababa on the south coast (Hammerbeck, 1976b). However, the Late Pleistocene–Holocene (Hugo, 1993) dunes on the north coast of the Province, in the vicinity of Richards Bay, are the only deposits currently being exploited. Exploitation was attempted at Umgababa on the south coast, but eventually ceased as a result of the environmental problems associated with bulk mining in a built-up area. The deposits in the vicinity of Richards Bay occur within the area under review and are described below.

7.1.1 Richards Bay (344)

These heavy-mineral sand deposits comprise part of the Recent age aeolian dunes which form a ± 17 km strip, 1 to 1,5 km wide, along the northern KwaZulu-Natal coast north of the Richards Bay Harbour (Fig. 28). This area is considered to host one of the largest placer deposits of heavy-mineral sands in South Africa, and has been mined since the late 1970s by Richards Bay Minerals (RBM). ISCOR has also shown interest either in mining heavy-mineral sand deposits from this heavy-mineral province or in flocculating the dune deposit.

According to Fockema (1986), coastal uplift during the early Holocene resulted in a complex series of dunes which formed on a previous erosional surface during a period of fluctuating sea levels. The local wind pattern then generated elongate "seif"-type dunes with an average height of 16 m and a maximum height of 60 m which formed parallel to the coast. According to Hugo (1993), the deposits occur either as individual dune cordons or as complexes containing dunes of different ages stacked one against the other. The modern dunes, which form high coastal dune ridges or cordons along the coastline generally host the more economically viable deposits. Prior to the final concentration of the heavy minerals in the aeolian dunes by wind sorting of these beach sands, fluctuating Pleistocene sea levels probably reworked and initially concentrated the beach and dune sands to produce an enhanced concentration of heavy minerals.

The complex suite of well-rounded heavy minerals includes ilmenite, hornblende, garnet (mostly pyrope with some almandine), pyroxene (mostly augite), magnetite, epidote, zircon, haematite, rutile, leucoxene, tourmaline, staurolite, kyanite, sphene, monazite and pyrite. However, the heavy minerals of economic interest are ilmenite, rutile, zircon and monazite. The ilmenite recovered by RBM contains between 46 and 50 per cent TiO_2, with a relatively high chrome fraction (0,2 to 0,3 % Cr_2O_3).

Fockema (1986) suggested that the Drakensburg volcanics and Karoo dolerite intrusives were the most likely source rocks of the ilmenite, while the rutile, zircon and

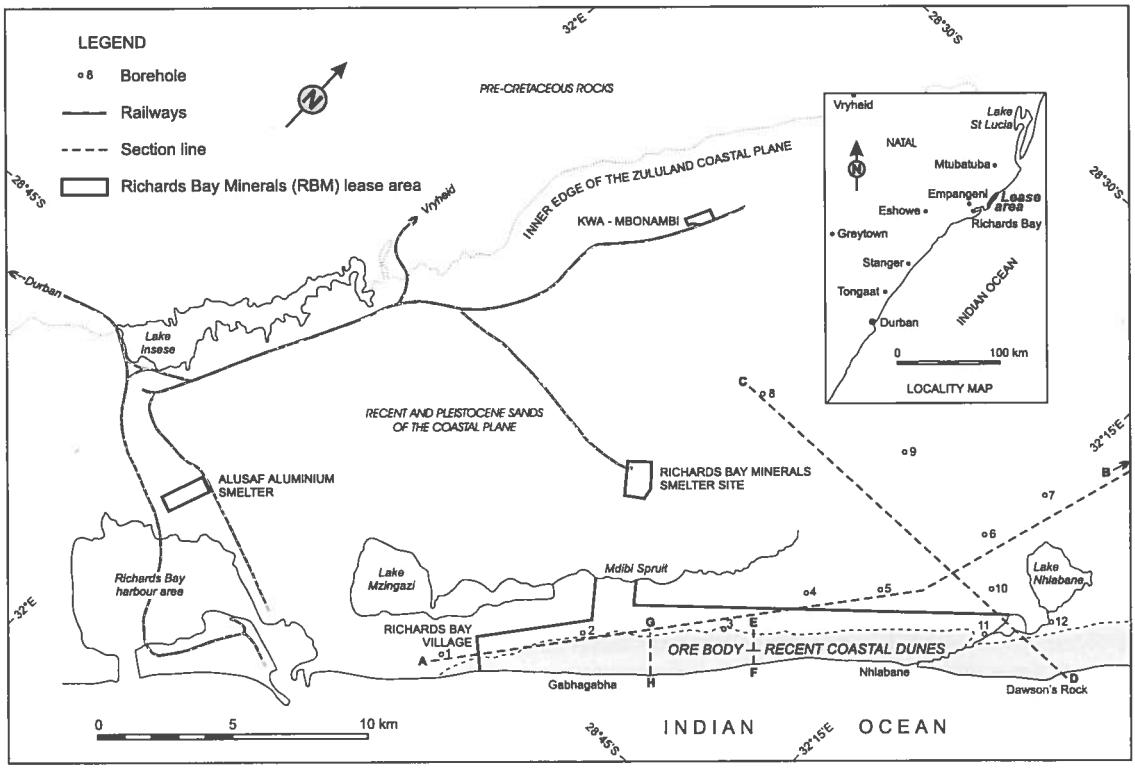

Figure 28 – Areas in the vicinity of Richards Bay exploited for heavy-mineral sands (after Fockema, 1986).

monazite were thought to be derived from the granites and gneisses of the NMP. Dunlevey (1991) considered this to be an oversimplification, in view of the many small heavy-mineral deposits in the Natal Group and Karoo Supergroup noted by Hammerbeck (1976b) and Behr (1986).

Hugo (1993) conducted a detailed investigation of the provenance areas of the minerals along the east coast of South Africa. His findings were in general agreement with those of previous workers, namely that the rocks of the Karoo igneous province and Precambrian basement lithologies (NMP and granite-greenstones of the Kaapvaal craton and their related intrusives) supplied the minerals and that the Karoo Supergroup sediments are considered to be intermediate source rocks.

However, chemical and petrographic data indicate that the predominant source for the heavy minerals in the northern parts of the province was derived mainly from the Precambrian basement lithologies. This is in contrast to the deposits of the Eastern Cape, where the heavy minerals were sourced mainly from rocks of Karoo age. Hugo (1993) suggests that the heavy minerals intermediately hosted in the Karoo Supergroup sediments (Beaufort and Ecca Groups) were transported to their present environments by the strong southerly Agulhas current.

At Richards Bay Minerals (344) (RBM), the mining techniques used to recover the heavy-mineral sands employ floating dredgers and concentrators (Figs 29 and 30), which produce a primary mineral concentrate of 82 to 85 per cent heavy minerals using gravity separation. This concentrate is then transported to a mineral separation plant where the individual minerals are separated. Further beneficiation occurs before the final product is sold to various industries. Pig iron is produced as a by-product of the heavy-mineral sands mining at Richards Bay.

Vast resources of heavy minerals have been identified along this northern coast. RBM have identified at least six deposits in their lease area, with total estimated reserves of over 3 600 Mt grading at a minimum of 2,24 per cent ilmenite. Ore grades generally decrease as one moves northwards from Richards Bay. Although offshore dune deposits with promising grades have been identified during the course of exploration, mining costs are prohibitive if current mining technology were to be used. Reserves could be even greater if extended over the St Lucia area (360, 366); however resistance from environmental bodies has ensured that this deposit will not be mined in the near future, if ever. Lake St Lucia was targeted as the next ore resource after the Richards Bay ore body was exhausted. With the decision of the South African government to preserve Lake St Lucia for ecotourism purposes only, RBM investigated the less attractive reserves to the south of Richards Bay, Reserve no. 10 (332) and in Reserve No. 4 (375) to the north. In their investigations, RBM was forced to consider ore

Figure 29 – The dredger at Mining Plant A of Richards Bay Minerals directs a powerful jet of water at the dune face, which causes it to slump. The slurry is then pumped to the concentrator (in the background), where the heavy minerals are separated. Photograph courtesy of Richards Bay Minerals.

that had previously been considered too low grade, too remote, and ore that was considered to have metallurgical problems, as well as fines that had not been extracted in the past, owing to poor extraction processes. The reassessment of the resources has led to an extension to the life of operations, which is estimated at 2020 at the current mining production. It is believed that once all the heavy-mineral sands have been exhausted in this area, concentrates will be imported from outside South Africa's borders and processed at Richards Bay (Wipplinger, 1998).

In 1999, Ticor Ltd. (TOR) started to exploit the Hillendale deposit (333) near Felixton, approximately 20 km southwest of Richards Bay. The heavy minerals form part of an older dune belt and have an estimated reserve of 73 Mt with a grade of 5,6 %. Although Iscor had already conducted a feasibility study by late 1997, new technology was required to deal with the main problem of disposing of slimes, aggravated by the high clay content of the soil in the disposal of the slimes.

Detailed attention is paid to the rehabilitation of the dunes. Prior to mining, vegetation cover is stripped and

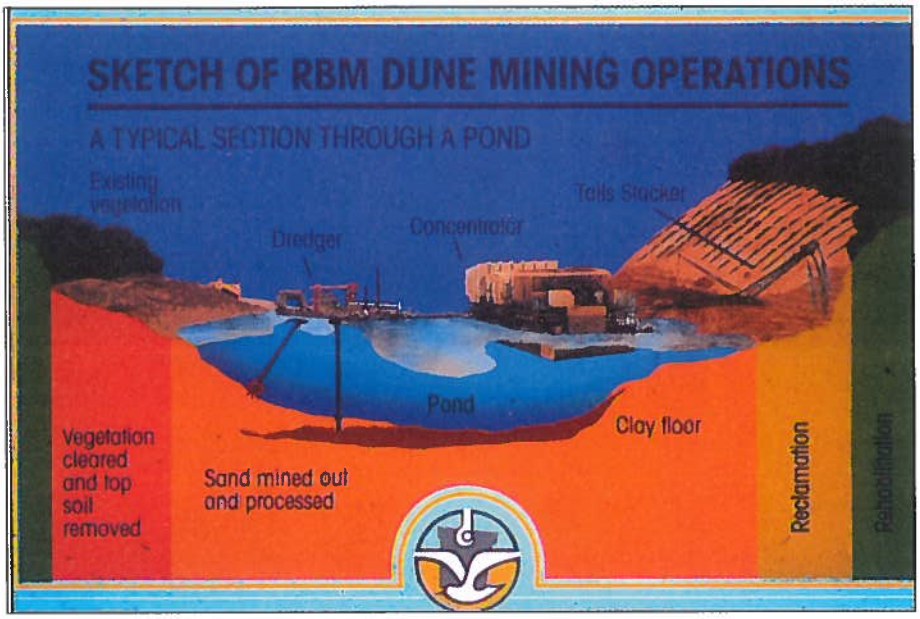

Figure 30 – Schematic representation of the dune mining operations of Richards Bay Minerals. Photograph courtesy of Richards Bay Minerals.

the topsoil is removed and stored for re-use during subsequent land reclamation. After mining, the dunes are revegetated with natural vegetation (Figs 31 and 32). RBM are acknowledged world leaders in this field (see the Chapter: *Mining in SA: Legislation and environmental considerations* in: Wilson, M.G.C. and Anhaeusser, C.R., 1998).

The existence of heavy-mineral sands (347) on the continental shelf off the KwaZulu/Natal north coast had already been confirmed in the early 1970s by an oceanographic survey. In 1997, AfriOre started exploration during their offshore Tugela Titanium Sand Project near Richards Bay.

7.2 GYPSUM DEPOSITS

Gypsum was mined on a limited scale near the confluence of the Tugela and Buffalo Rivers in the vicinity of Ngubevu (69), on Tugela Location 4674. Up to 1920, some 12 000 t of the material had been produced (Wasserstein, 1935). The lumps of gypsum are disseminated within clay intervals and because of the perennial nature of the Tugela River, further amounts of good-quality gypsum are expected to be found in the vicinity. No recent investigations have taken place in this rather rugged and remote area.

7.3 PHOSPHATE DEPOSITS

The phosphatic nodules of the Weenen area (17–20, 22), hosted by shales of the upper Ecca Group, were discovered in 1907. They are not confined to any stratigraphic position, but occur erratically through the upper 90 m of the Ecca Group shales and, within one horizon, the strike continuation of the phosphate may be very inconsistent. The nodules have a variety of forms, being principally nodular or "reef"like. The nodules vary from small spherical bodies to flattened bodies of approximately 1,2 m in length and 0,5 m in thickness. The average tricalcic phosphatic contents of the bodies is below 50 per cent. However, higher values have indeed been exploited. The phosphatic deposits occur as lenticular "reefs" of varying lengths but averaging between 9 and 45 m. The average thickness of such reefs is 0,2 m and the grades are generally very low, approximately 8,5 per cent $Ca_3P_2O_8$ (Wilson, 1998b; Coetzee *et al.*, 1976).

7.4 PEAT DEPOSITS

Peat has a wide variety of uses, namely as a fuel, a packing material in the horticultural industry, as an absorbent and disinfectant in the manufacture of ash bricks and insulating board (Grundling and Mazus, 1998), and forms an active part of the filter and storage capabilities of wetlands (Grundling *et al.*, 1998). Peat, a natural organic resource, comprises decaying organic matter which accumulates in moist, reducing and low-energy environments, such as swamps. KwaZulu-Natal is host to most of South Africa's peat deposits and extensive wetlands. It is to this purpose that the Council for Geoscience (CGS), in collaboration with the Department of Environmental Affairs and Tourism, conducted an extensive investigation on the KwaZulu-Natal peat deposits. The majority of the peat deposits in this province are situated in proclaimed conservation areas, and those outside such areas are used by the local communities as a source of water, horticulture and biomass. In the rural areas of KwaZulu-Natal, peat as a resource of clean drinking water supersedes its commercial exploitation aspect (Grundling *et al.*, 1998). Several samples (Table 13) were taken by the CGS during an investigation of the peat occurrences of KwaZulu-Natal.

Grundling *et al.*(1998) provide a detailed description of the KwaZulu-Natal peat- and wetlands.

Figure 31 – Once mining has been completed, windbreakers are erected at the start of the dune rehabilitation programme of Richards Bay Minerals. Photograph courtesy of Richards Bay Minerals.

Figure 32 – A ten-year-old rehabilitating forest, mined in 1978. Photograph courtesy of Richards Bay Minerals.

TABLE 13 – CHARACTERISTICS OF THE PEAT OCCURRENCES THAT FALL WITHIN THE RICHARDS BAY METALLOGENIC MAP AREA (from Grundling *et al.*, 1998).

Peatland name and map number	Locality	Peat thickness (m)	Wetland utilisation	Area (ha)	Volume (m^3) X 1 000
Kulaleni 1166 (351)	S28°02′40″ E32°31′15″	1,30	Conservation	75	56
Kulaleni 1168 (352)	S28°02′40″ E32°31′28″	1,00	Conservation	75	56
Kulaleni 1169 (353)	S28°02′49″ E32°31′47″	0,50	Conservation	75	28
Kulaleni 1170 (353)	S28°02′44″ E32°31′49″	1,30	Conservation	75	73
KwaDlembe 1156 (354)	S28°04′23″ E32°31′25″	2,25	Conservation	3	4
KwaDlembe 1152 (356)	S28°05′52″ E32°31′43″	1,50	Conservation	10	11
KwaDlembe 1150 (357)	S28°06′15″ E32°31′42″	2,00	Conservation	10	15
Sabhuku 1145 (355)	S28°05′28″ E32°30′50″	0,50	Conservation	75	28
Sabhuku 1129 (358)	S28°06′39″ E32°30′38″	1,30	Conservation	500	487
Mfabeni 1125 (359)	E32°31′30″ S28°09′02″	10,00	Water	7 000	35 000
Mkazana East 964 (361)	S28°12′55″ E32°29′20″	2,40	Conservation	80	128
St Lucia 789 (367)	S28°18′25″ E32°25′48″	1,20	Conservation/ plantation	80	101
St Lucia 1122	S28°22′55″ E32°24′50″	0,70	Conservation	37	17
St Lucia 928 (368)	S28°21′40″ E32°25′50″	0,40	Conservation	10	3
St Lucia 933 (370)	S28°23′01″ E32°24′49″	1,80	Conservation	100	120
Futululu 1251 (372)	S28°24N28″ E32°15N55″	6,50	Conservation	875	437
Dukuduku 1182 (369)	S28°22N35″ E32°22N22″	1,00	Conservation	50	33
Nyalazi 959 (362)	S28°14N33″ E32°22N52″	1,00	Plantation	30	20

7.5 LIMESTONE

A Tertiary limestone deposit occurs approximately 3 km west of the Mfekayi Station and south of the Hluhluwe River (363). The deposit was investigated by the Mining Corporation Limited in the late 1970s. Investigation of the deposit revealed that the limestone is highly siliceous, with the average $CaCO_3$ content measuring 62 per cent. The minimum estimated reserves for this deposit are approximately 5 Mt, but the deposit may be significantly larger. The average composition of the limestone deposit is as follows: 62 per cent $CaCO_3$, 37 per cent SiO_2, and 1 per cent $MgCO_3$ (Ehlers, 1978).

8 OTHER

8.1 ICELAND SPAR

A single reported occurrence of Iceland spar (194) was reported in 1943 to the Deputy Commissioner of Mines, Natal. The deposit is situated approximately 1 km to the north of the confluence of the Tugela and the Nsuze Rivers on Reserve No.19 and is hosted by the Tugela Group rocks of the Madidima nappe. The calcite vein can be followed along strike for approximately 100 m and has a more or less vertical attitude. The colour of the calcite varies from transparent to milky to yellow (Gain, 1975).

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APPENDIX A – COMMODITY AND LOCALITY DATA FOR ALL DEPOSITS AND OCCURRENCES IN THE 2830 RICHARDS BAY MAP SHEET AREA

MAP NO.	UQ REF NO.	FARM NAME AND NUMBER	COMMODITY 1	COMMODITY 2	COMMODITY 3	LAT.	LONG.
1	1178475	BOYSKRAAL 7709 DANNHAUSER	COAL			-280300	300100
2	1178484	BERGHEIM * *	COAL			-280300	300800
3	1120645	ALLETA 4350 KLIPRIVER	IRON			-280301	301423
4	1120647	DAVELSFONTEIN 4348 KLIPRIVER	IRON			-280309	301500
5	1120888	MORGENSTOND 3347 KLIPRIVER	IRON			-280414	301217
6	1120651	MORGENSTOND 3347 KLIPRIVER	IRON			-280426	301245
7	1203983	DUNDEE * NATAL	STONE AGGREGATE, GRAVEL			-280955	301202
8	1168874	UITHOEK 1335 KLIPRIVER	PSEUDOCOAL			-281359	300841
11	1168875	KUICKVLEI 12751 KLIPRIVER	PSEUDOCOAL			-282018	301039
14	1120745	ROOSDAL 2176 NATAL	PHOSPHATE			-283546	300044
17	1168735	KAFFIRS KRAAL 1309 WEENEN	PHOSPHATE			-284748	300523
18	1168737	WEENEN TOWN LANDS * WEENEN	PHOSPHATE			-285003	300630
19	1120744	WEENEN TOWN LANDS * WEENEN	PHOSPHATE			-285122	300621
20	1168730	BAVIAANS KRANTZ 1290 WEENEN	PHOSPHATE			-285121	300750
21	1120874	BAVIAANS KRANTZ 1290 WEENEN	LIMESTONE			-285019	300946
22	1168733	THE ALOES 6026 WEENEN	PHOSPHATE			-285527	301237
26	1120873	BRAKFONTEIN 155 UTRECHT	LIMESTONE			-280036	302528
27	1120797	BRAKFONTEIN 155 UTRECHT	IRON			-280109	302528
28	1120885	DAVELSFONTEIN 4348 KLIPRIVER	IRON			-280233	301738
29	1129377	MEYERS DEAL OF SCUUR RAND 7332 NATAL	IRON			-280200	301700
30	1203962	* 7442 NATAL	BUILDING SAND (Silica)			-280700	301603
31	1168725	SPRINGFIELD 9753 KLIPRIVER	IRON			-280743	301758
32	1203985	VAN ROOYEN 4252 NATAL	SILICA (General)			-280746	302041
33	1168727	B OF IRONDALE 6013 KLIPRIVER	IRON	MINERAL PIGMENT		-280927	302156
34	1168876	HAZELDENE 12649 KLIPRIVER	IRON			-280804	302505
35	1120886	HAZELDENE 12649 KLIPRIVER	IRON	MINERAL PIGMENT		-281003	302610
40	1120656	KNOSTROPE 3316 KLIPRIVER	ALUMINIUM (Bauxite)			-282337	302734
42	1120871	GOEDE KEUS 1066 NATAL	LIMESTONE			-282606	301641
43	1120667	GROOTE VLEI 5112 KLIPRIVER	ALUMINIUM (Bauxite)			-282802	302818
48	1120747	IMPAFANA LOCATION 4677 NATAL	TRAVERTINE (Dimension stone)		LIMESTONE	-284637	302617
49	1120706	NELS RUST 1857 UMVOTI	TITANIUM	THORIUM	URANIUM	-285743	302608
50	1120748	ERSKINE 2200 WEENEN	TITANIUM	THORIUM	URANIUM	-285812	301938
51	1120780	SUTHERLAND 2372 WEENEN	TITANIUM	THORIUM	URANIUM	-285844	302000
52	1120781	DALTON VALE 2205 WEENEN	TITANIUM	THORIUM	URANIUM	-285920	301926
60	1120836	KLIP RIVER LOCATION 4665 KLIPRIVER	TREMOLITE (Asbestos)			-283342	303430
61	1120837	KLIP RIVER LOCATION 4665 KLIPRIVER	TREMOLITE (Asbestos)			-283520	303538
62	1120838	KLIP RIVER LOCATION 4665 KLIPRIVER	COPPER	LEAD	GOLD	-283754	303747
63	1120661	RESERVE NO. 19 7638 NATAL	DOLOMITE			-284213	304042
64	1120910	KLIP RIVER LOCATION 4665 UMVOTI	GOLD	COPPER		-284303	303749
65	1120911	TUGELA LOCATION 4674 UMVOTI	GOLD			-284337	303822
66	1120912	KLIP RIVER LOCATION 4665 UMVOTI	GOLD			-284352	303742
67	1168739	KLIP RIVER LOCATION 4665 KLIPRIVER	GOLD			-284401	303637
68	1168741	KLIP RIVER LOCATION 4665 KLIPRIVER	GOLD			-284344	303556
69	1120909	TUGELA LOCATION 4674 UMVOTI	GYPSUM			-284450	303804
70	1120908	TUGELA LOCATION 4674 UMVOTI	ZINC	COPPER		-284422	304022

75	1168742	RESERVE NO. 19 7638 ZULULAND	GOLD			-284614	304443
76	1168871	TUGELA LOCATION * UMVOTI	GOLD			-284715	304453
77	1120689	VET SPRUIT 1888 UMVOTI	ALUMINIUM (Bauxite)			-285832	303923
80	1120859	ZANDFONTEIN 462 VRYHEID	COPPER			-280231	305346
81	1120858	KROMELLENBOOG 266 VRYHEID	TALC			-281010	305527
82	1120882	TOGGEKRY 10986 ZULULAND	COPPER	ZINC	LEAD	-280950	305313
83	1120881	TOGGECRY 10986 ZULULAND	COPPER	ZINC	SILVER	-280935	305311
84	1120880	TOGGEKRY 10986 ZULULAND	COPPER	ZINC	SILVER	-280919	305256
85	1168731	TOGGEKRY 10986 ZULULAND	TALC			-281002	305229
86	1120884	MOUNT VERNON 10965 ZULULAND	GRAPHITE			-280928	305210
87	1120879	MOUNT VERNON 10965 ZULULAND	TUNGSTEN			-280956	305153
88	1120878	NONDWENI FARM LOT 9 13264 NATAL	GOLD			-280910	305118
89	1120890	NONDWENI FARM NR 7 12865 NATAL	GOLD			-281016	304958
90	1120875	NONDWENI FARM LOT 6 10878 NATAL	GOLD			-281100	304935
91	1120803	NONDWENI FARM LOT 6 10878 ZULULAND	GOLD			-281106	304954
92	1120876	NONDWENI FARM LOT 5 12713 NATAL	GOLD			-281224	304935
93	1120877	NONDWENI FARM LOT 4 10634 ZULULAND	GOLD			-281301	304846
94	1203988	NONDWENI FARM NO. 2 12746 NATAL	LEAD			-281228	304744
95	1120802	RESERVE NO. 18 7638 ZULULAND	GOLD			-281356	304705
104	1120813	RESERVE NO. 19 7638 NATAL	GOLD			-283436	305925
105	1120819	RESERVE NO. 19 7638 ZULULAND	GOLD			-283436	305843
106	1120652	RESERVE NO. 18 7638 ZULULAND	COPPER			-283438	305816
107	1120810	RESERVE NO. 19 7638 ZULULAND	GOLD			-283734	305740
108	1168744	QUDENI LOT 25 14055 ZULULAND	COPPER			-284008	305936
109	1120789	QUDENI 25 14055 NATAL	GOLD			-284036	305955
110	1120666	QUEDENI FOREST RESERVE * ZULULAND	ALUMINIUM (Bauxite)			-283932	305210
111	1120664	QUEDENI 14 12401 ZULULAND	ALUMINIUM (Bauxite)			-283808	305210
112	1120665	UPTON 11146 ZULULAND	ALUMINIUM (Bauxite)			-283904	304836
113	1120660	RESERVE NO. 19 7638 NATAL	DOLOMITE			-284150	304709
114	1120905	RESERVE NO. 19 7638 ZULULAND	LEAD	SILVER		-284248	304837
115	1120784	RESERVE NO. 19 7638 NATAL	GOLD			-284358	304914
116	1120907	RESERVE NO. 19 7638 ZULULAND	COPPER	SILVER		-284334	304757
117	1120906	TUGELA LOCATION 4674 UMVOTI	COPPER	SILVER		-284358	304555
118	1120845	RESERVE NO. 19 7638 NATAL	GOLD			-284422	304511
124	1120662	RESERVE NO. 19 7638 ZULULAND	COPPER	LEAD	ZINC	-284652	305954
126	1120904	TUGELA LOCATION 4674 NATAL	NICKEL	COPPER	COBALT	-285058	305039
127	1120770	TUGELA LOCATION 4674 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285137	305045
128	1120771	TUGELA RAND 1974 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285202	305038
129	1120766	TUGELA RAND 1974 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285206	305024
130	1120767	TUGELA RAND 1974 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285150	305017
131	1120757	KAAL HOEK 1965 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285147	304919
132	1120756	THORN DALE 6217 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285157	304921
133	1120816	THORN DALE 6217 UMVOTI	BARYTES			-285310	304833
134	1120765	TUGELA RAND 1974 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285254	305048
135	1120772	TUGELA RAND 1974 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285306	305033
136	1120768	TUGELA RAND 1974 UMVOTI	CHRYSOTILE (Asbestos)	CHROME		-285324	305027
137	1120698	SPEKFONTEIN 1378 UMVOTI	STONE AGGREGATE, GRAVEL			-285546	305016
138	1120749	KRANSKOP 1376 UMVOTI	MANGANESE			-285826	305402

139	1168723	TUGELA LOCATION 4674 UMVOTI	CHRYSOTILE (Asbestos)	TALC	CORUNDUM	-285532	305914
144	1147903	MTOLO 14390 VRYHEID	GRAPHITE			-280835	311104
145	1120864	SCHOONVITZICHT 385 VRYHEID	COPPER			-281017	310548
146	1120872	LANGGEWACHT 235 VRYHEID	TALC	DOLOMITE		-281351	311008
149	1120868	TUSSCHENBY 411 VRYHEID	GOLD	URANIUM		-281648	311337
150	1120860	GOUD HOEK 498 VRYHEID	COPPER	GOLD	SILVER	-281715	310037
151	1120654	BABANANGO 17 VRYHEID	ALUMINIUM (Bauxite)			-282235	310146
152	1120658	SCHURWEBERG 192 VRYHEID	ALUMINIUM (Bauxite)			-282225	310636
153	1120659	ROOIPOORT 60 VRYHEID	ALUMINIUM (Bauxite)			-282351	310508
154	1120653	HARTSKAMP 160 VRYHEID	ALUMINIUM (Bauxite)			-282539	310249
155	1120657	DE WAAL 522 VRYHEID	ALUMINIUM (Bauxite)			-282446	310538
156	1120861	STRIJDPLAATS 63 VRYHEID	COPPER			-282628	310711
157	1120863	STRIJDPLAATS 63 VRYHEID	COPPER			-282655	310735
161	1120787	RESERVE NR. 19 7638 NATAL	COPPER			-283138	310541
162	1120774	RESERVE NO. 19 7638 ZULULAND	NICKEL			-283247	310658
163	1120700	RESERVE NO. 19 7638 NATAL	IRON			-283238	310716
164	1120790	RESERVE NO. 19 7638 ZULULAND	COPPER			-283233	310812
165	1120736	RESERVE NO. 19 7638 ZULULAND	IRON			-283244	310834
166	1120773	RESERVE NO. 19 7638 ZULULAND	NICKEL			-283300	310830
167	1120775	RESERVE NO. 19 7638 ZULULAND	IRON			-283250	310858
168	1120788	RESERVE NO. 19 7638 ZULULAND	COPPER			-283236	310907
169	1120701	RESERVE NO. 19 7638 ZULULAND	NICKEL			-283259	310933
170	1120699	NAAUWKLOOF 7431 VRYHEID	IRON			-283242	311017
171	1120792	NINEVE 6100 ZULULAND	GOLD			-283334	310958
172	1120786	NINEVE 6100 ZULULAND	GOLD			-283349	310955
173	1120783	RESERVE NO. 19 7638 ZULULAND	GOLD			-283353	310924
174	1120696	PROSPECT 6117 VRYHEID	IRON			-283308	311411
175	1120834	DIEPKLOOF 6118 NATAL	GOLD			-283436	311457
176	1120751	QUDENI LOT 34 10946 ZULULAND	GOLD	URANIUM		-283532	310141
177	1120776	THORN DALE 6217 UMVOTI	MICA			-283748	310843
178	1120777	RESERVE NO. 19 7638 ZULULAND	COPPER			-283835	310404
179	1120733	RESERVE NO. 19 7638 ZULULAND	COPPER			-283928	310452
180	1120769	RESERVE NO. 19 7638 ZULULAND	KYANITE			-283958	310454
181	1120727	RESERVE NO. 19 7638 ZULULAND	KYANITE			-284100	310409
182	1120707	RESERVE NO. 19 7638 ZULULAND	KYANITE			-284145	310634
183	1120708	RESERVE NO. 19 7638 ZULULAND	KYANITE			-284217	310818
184	1120703	RESERVE NO. 19 7638 ZULULAND	IRON			-284456	310957
189	1120778	RESERVE NO. 19 7638 ZULULAND	GOLD			-284512	310533
190	1120705	RESERVE NO. 19 7638 ZULULAND	IRON			-284559	310941
191	1120704	RESERVE NO. 19 7638 ZULULAND	IRON			-284607	310741
192	1120663	RESERVE NO. 19 7638 NATAL	COPPER	LEAD	ZINC	-284707	310001
193	1203984	WELVERDIEND 148 NATAL	STONE AGGREGATE, GRAVEL			-284959	310030
194	1120760	RESERVE NO. 19 7638 ZULULAND	ICELAND SPAR			-285118	310140
196	1120711	RESERVE NO. 19 7638 ZULULAND	CHRYSOTILE (Asbestos)			-284952	310541
197	1120732	RESERVE NO. 19 7638 ZULULAND	CHRYSOTILE (Asbestos)			-284953	310557
198	1120782	RESERVE NO. 19 7638 NATAL	TALC			-284928	310703
199	1120761	RESERVE NO. 19 7638 ZULULAND	CHRYSOTILE (Asbestos)	CORUNDUM		-284929	310736
200	1120702	RESERVE NO. 21 7638 ZULULAND	MICA			-284837	311355

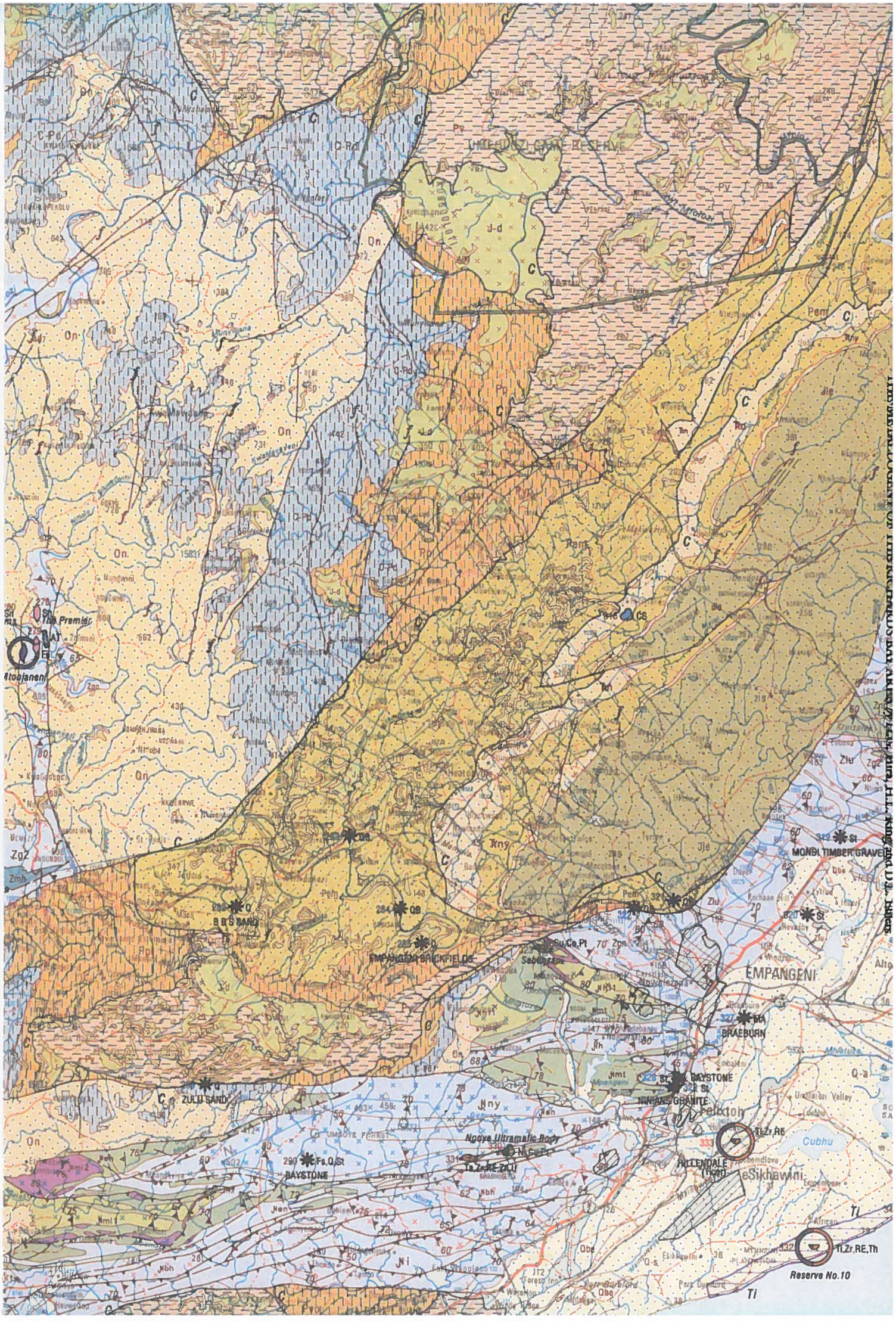
201	1120726	FORT YOLLAND 11091 ZULULAND	CHRYSOTILE (Asbestos)			-285101	311234
203	1120731	RESERVE NO. 21 7638 ZULULAND	TALC			-285124	310950
204	1120735	RESERVE NO. 21 7638 NATAL	CHRYSOTILE (Asbestos)			-285110	310936
205	1120734	RESERVE NO. 21 7638 ZULULAND	TALC			-285112	310858
207	1120729	RESERVE NO. 21 7638 ZULULAND	TALC			-285106	310827
208	1120764	RESERVE NO. 21 7638 ZULULAND	CHROME	CHRYSOTILE (Asbestos)	CORUNDUM	-285226	310800
209	1120763	RESERVE NO. 21 7638 ZULULAND	CHROME	CORUNDUM		-285237	310810
210	1120759	RESERVE NO. 21 7638 ZULULAND	CHROME			-285239	310827
211	1120762	RESERVE NO. 21 7638 ZULULAND	CHROME	CHRYSOTILE (Asbestos)	CORUNDUM	-285253	310846
212	1120755	RESERVE NO. 21 7638 ZULULAND	TALC			-285328	310726
213	1120779	RESERVE NO. 21 7638 ZULULAND	TALC			-285330	310805
214	1120753	TUGELA LOCATION 4674 UMVOTI	TALC			-285459	310108
215	1120758	TUGELA LOCATION 4674 UMVOTI	MAGNESITE			-285509	310111
216	1120650	RESERVE NO. 21 7638 ZULULAND	MAGNESITE			-285540	310800
217	1120862	RESERVE NO. 21 7638 ZULULAND	MAGNESITE			-285530	311100
218	1120728	RESERVE NO. 21 7638 ZULULAND	GOLD			-285541	311117
219	1120817	RESERVE NO. 21 7638 ZULULAND	GOLD			-285608	311229
220	1120821	RESERVE NO. 21. 7638 NATAL	GOLD			-285545	311326
221	1120742	BANTU RESERVE NO. 21 7638 NATAL	VANADIUM	TITANIUM	IRON	-285645	310404
222	1120741	RESERVE NO. 21 7638 ZULULAND	VANADIUM	TITANIUM	IRON	-285630	310335
223	1120739	TUGELA LOCATION 4674 UMVOTI	VANADIUM	TITANIUM	IRON	-285703	310300
224	1120738	TUGELA LOCATION 4674 UMVOTI	VANADIUM	TITANIUM	IRON	-285801	310233
225	1120740	TUGELA LOCATION 4674 UMVOTI	IRON	TITANIUM	VANADIUM	-285901	310308
226	1120737	TUGELA LOCATION 4674 UMVOTI	IRON	TITANIUM	VANADIUM	-285935	310403
231	1203751	OUWKLIP 8489 NATAL	SILICA (General)			-280208	312040
234	1120867	MOUNT SOPHIA 359 VRYHEID	GOLD	URANIUM		-281741	311630
235	1120866	HARDEARBEID 346 VRYHEID	GOLD	URANIUM		-281752	311727
236	1168817	SWEET HOME 6130 ZULULAND	COPPER			-282601	312152
240	1120832	IMFULI (MISSION STATION) 6154 ZULULAND	MICA			-283121	312249
241	1120835	IMFULI (MISSION STATION) 6154 NATAL	GOLD			-283135	312244
242	1120841	VERGELEGEN 6160 ZULULAND	GOLD			-283329	312035
243	1120842	KONINGSBERG 6147 NATAL	GOLD			-283337	312023
244	1120847	KONINGSBERG 6147 ZULULAND	GOLD			-283345	312011
245	1120855	KONINGSBERG 6147 ZULULAND	GOLD			-283350	311930
246	1120833	EIKENDAL 6134 ZULULAND	GOLD			-283355	311707
247	1120900	ALTENBURG 6105 ZULULAND	IRON			-284248	312134
248	1120901	EKUTULENI 6124 ZULULAND	IRON			-284254	312542
249	1120902	RESERVE NO. 11 7638 ZULULAND	IRON			-284313	312911
250	1120848	GOEDETROW 7806 ZULULAND	ZIRCONIUM	TANTALUM/NIOBIUM		-284440	312733
254	1120853	GOEDERTROW 7806 ZULULAND	NEPHELINE	FELDSPAR	MICA	-284504	312613
255	1120854	BLACK EYES 13885 ZULULAND	ZIRCONIUM	ZIRCON (Gemstone)	TITANIUM	-284504	312439
256	1120851	BLACK EYES 13885 ZULULAND	NEPHELINE	FELDSPAR	MICA	-284531	312439
257	1120849	BULL,S RUN ESTATE 12987 ZULULAND	NEPHELINE	FELDSPAR	MICA	-284544	312242
258	1120815	BULL'S RUN ESTATE 12987 ZULULAND	ZIRCONIUM	ZIRCON (Gemstone)	TITANIUM	-284615	312206
259	1120852	WILDERNESS 6107 ZULULAND	NEPHELINE	FELDSPAR	MICA	-284555	312103
260	1120850	RESERVE NO. 19 7638 ZULULAND	NEPHELINE	FELDSPAR	MICA	-284601	312001
261	1120655	RESERVE NO. 17 7638 ZULULAND	ALUMINIUM (Bauxite)			-285127	312008
262	1203915	PEN HARRY 14666 NATAL	KAOLIN (Clay)			-285232	312420

263	1203708	GRATTON 11482 NATAL	SILICA (General)			-285145	312849
264	1120820	RESERVE NO. 21 7638 ZULULAND	GOLD			-285426	311608
265	1120818	RESERVE NO. 21 7638 ZULULAND	GOLD			-285517	311521
266	1120812	RESERVE NO. 21 7638 ZULULAND	GOLD			-285532	311508
267	1203750	SUNNYSIDE 11374 NATAL	SILICA (General)			-285700	312500
272	1774684	RESERVE NO. 12 7639 ZULULAND	COAL			-281312	314045
278	1120840	RESERVE NO. 11 7638 NATAL	TIN			-283500	313106
279	1120822	RESERVE NO. 11 7638 NATAL	TREMOLITE (Asbestos)			-283547	313124
280	1120831	RESERVE NO. 11 7638 ZULULAND	TIN			-283558	313105
281	1120843	RESERVE NO. 11 7638 NATAL	IRON			-283610	313039
282	1203711	BOLTON 12785 NATAL	SILICA (General)			-284300	313800
283	1203917	* 13189 NATAL	BUILDING SAND (Silica)			-284130	314150
284	1203932	SHORRAGH 14265 NATAL	BUILDING SAND (Silica)			-284300	314335
285	1203707	RESERVE NO. 9 7638 NATAL	SILICA (General)			-284442	314419
289	1203709	RESERVE NO. 17 7638 NATAL	SILICA (General)			-284900	313700
290	1120814	RESERVE NO. 9 7638 NATAL	FELDSPAR	SILICA (General)	STONE AGGREGATE, GRAVEL	-285115	314031
291	1168820	* 10399 ZULULAND	MOLYBDENUM			-285614	313049
292	1203987	RESERVE NO. 9 7638 NATAL	REFRACTORY CLAY (Semi-Flint & Plastic)/FIRECLAY			-285900	313609
293	1203728	EMOYENI * NATAL	SILICA (General)			-285900	314000
297	1120798	RESERVE NO. 12 7639 ZULULAND	FLUORSPAR			-280019	315250
298	1168822	RESERVE NO. 12 7638 ZULULAND	GRAPHITE			-280104	315429
299	1120800	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-280118	315446
300	1120796	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-280210	315548
301	1120801	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-280512	315414
302	1120795	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-280814	315344
303	1120916	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-280935	315122
304	1120914	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-281043	315502
305	1120889	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-281124	315315
306	1168746	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-281114	315250
307	1120710	THE CORRIDOR 14418 NATAL	FLUORSPAR			-281151	315050
308	1120709	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-281208	315103
309	1120913	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-281213	315045
310	1120649	RESERVE NO. 12 7638 ZULULAND	FLUORSPAR			-281242	315007
318	1203990	RIVERLANDS 11896 NATAL	SHALE/BRICK CLAY			-283449	315111
319	1203754	EMPANGENE LOT 183 10638 NATAL	STONE AGGREGATE, GRAVEL			-284121	315835
320	1203947	SCHOONGEZICHT 11232 NATAL	STONE AGGREGATE, GRAVEL			-284342	315730
321	1203940	* 12418 NATAL	BUILDING SAND (Silica)			-284318	315254
322	1203944	* 11370 NATAL	BUILDING SAND (Silica)			-284333	315133
323	1120646	RESERVE NO. 5 7638 ZULULAND	NICKEL	COPPER	CORUNDUM	-284450	314827
327	1203717	UMHLATHZI (REM OF SUB 2 OF LAT 149) 14086 NATAL	GRANITE/QUARTZ-PORPHYRY/SYENITE (Dimension stone)			-284648	315523
328	1120898	* 13942 NATAL	STONE AGGREGATE, GRAVEL			-284841	315310
329	1203726	UMHLATUZI LOT 112 13942 NATAL	STONE AGGREGATE, GRAVEL			-284853	315300
330	1120857	RESERVE NO. 9 7638 ZULULAND	NICKEL	COPPER	PLATINUM	-285051	314723
331	1120856	RESERVE NO. 9 7638 ZULULAND	TANTALUM/NIOBIUM	ZIRCONIUM	RARE EARTHS	-285106	314602
332	1120897	RESERVE NO. 10 7638 ZULULAND	TITANIUM	ZIRCONIUM	RARE EARTHS	-285338	315755
333	1120897	RESERVE NO. 10 7638 ZULULAND	TITANIUM	ZIRCONIUM	RARE EARTHS	-285030	315510

336	1120793	MTOLO 14390 ZULULAND	GRAPHITE			-280832	321029
340	1774683	RES NO. 3 7638 NATAL	COAL			-281705	320604
343	1120870	* 12453 NATAL	SILICA (General)			-284028	320245
344	1120893	RESERVE NO. 4 7638 ZULIULAND	TITANIUM	ZIRCONIUM	RARE EARTHS	-284346	321057
347	1120896	LOCATED OFF SHORE * ZULULAND	TITANIUM	ZIRCONIUM	RARE EARTHS	-284523	321008
348	1168712	RESERVE NO. 10 7638 ZULULAND	LIGNITE			-285228	320105
351	1203991	CAPE VIDAL STATE FOREST (STATE LAND) * NATAL	PEAT			-280240	323115
352	1204016	CAPE VIDAL STATE FOREST (STATE LAND) * NATAL	PEAT			-280240	323128
353	1204000	CAPE VIDAL STATE FOREST (STATE LAND) * NATAL	PEAT			-280244	323149
354	1204002	CAPE VIDAL STATE FOREST (STATE LAND) * NATAL	PEAT			-280423	323125
355	1203993	CAPE VIDAL STATE FOREST (STATE LAND) * NATAL	PEAT			-280528	323050
356	1203995	CAPE VIDAL STATE FOREST (STATE LAND) * NATAL	PEAT			-280552	323143
357	1203994	CAPE VIDAL STATE FOREST (STATE LAND) * NATAL	PEAT			-280615	323142
358	1203992	CAPE VIDAL STATE FOREST (STATE LAND) * NATAL	PEAT			-280639	323038
359	1204005	EASTERN SHORES STATE FOREST (STATE LAND) * NATAL	PEAT			-280902	323130
360	1120891	GOVERNMENT GROUND, ST.LUCIA * ZULULAND	TITANIUM	ZIRCONIUM	RARE EARTHS	-281041	323148
361	1204006	ST LUCIA PARK (STATE LAND) * NATAL	PEAT			-281255	322920
362	1204012	THE NARROWS PLANTATION (STATE LAND) * NATAL	PEAT			-281433	322252
363	1203986	RESERVE NO. 3 7638 NATAL	LIMESTONE			-280931	321632
366	1120892	GOVERNMENT GROUND, ST.LUCIA * ZULULAND	TITANIUM	ZIRCONIUM	RARE EARTHS	-281731	322824
367	1204007	STATE LAND * NATAL	PEAT			-281825	322548
368	1204010	ST LUCIA LANDS 13702 NATAL	PEAT			-282140	322550
369	1204015	DUKUDUKU STATE FOREST (STATE LAND) * NATAL	PEAT			-282235	322222
370	1204011	ST LUCIA LANDS 13702 NATAL	PEAT			-282301	322449
371	1120894	RESERVE NO. 4 7638 NATAL	TITANIUM	ZIRCONIUM	RARE EARTHS	-282746	322451
372	1204017	U 195 NATAL	PEAT			-282428	321555
375	1168747	RESERVE NO. 4 7638 ZULULAND	TITANIUM	ZIRCONIUM	RARE EARTHS	-283507	322104

APPENDIX B – LIST OF OPERATING MINES AND PITS IN THE 2830 RICHARDS BAY MAP SHEET AREA

MAP NO.	UNIQ. REF. NO.	MINE NAME	COMMODITY MINED	DEP. STAT.	FARM NAME AND NUMBER	DISTRICT	LONG.	LAT.
1	1178475	DURBAN NAVIGATION COLLIERIES (DURNA)	COAL	CPR	BOYSKRAAL 7709	DANNHAUSER	300100	-280300
2	1178484	SPRINGLAKE COLLIERY	COAL	CPR	BERGHEIM *	*	300800	-280300
137	1120698		STONE AGGREGATE, GRAVEL	IPR	SPEKFONTEIN 1378	UMVOTI	305016	-285546
193	1203984		STONE AGGREGATE, GRAVEL	IPR	WELVERDIEND 148	NATAL	310030	-284959
231	1203751	B.B. TRANSPORT	SILICA (General)	IPR	OUWKLIP 8489	NATAL	312040	-280208
263	1203708	YARDLEY	SILICA (General)	IPR	GRATTON 11482	NATAL	312849	-285145
267	1203750	SAND	SILICA (General)	IPR	SUNNYSIDE 11374	NATAL	312500	-285700
282	1203711	B B S SAND	SILICA (General)	IPR	BOLTON 12785	NATAL	313800	-284300
285	1203707	EMPANGENI BRICKFIELDS	SILICA (General)	IPR	RESERVE NO. 9 7638	NATAL	314419	-284442
289	1203709	ZULU SAND	SILICA (General)	IPR	RESERVE NO. 17 7638	NATAL	313700	-284900
293	1203728	EMOYENI SAND	SILICA (General)	IPR	EMOYENI *	NATAL	314000	-285900
319	1203754	MONDI TIMBER GRAVEL	STONE AGGREGATE, GRAVEL	IPR	EMPANGENE LOT 183 10638	NATAL	315835	-284121
327	1203717	BRAEBURN	GRANITE/QUARTZPORPHYRY/ SYENITE (Dimension stone)	IPR	UMHLATHZI (REM OF SUB 2 OF LAT 149) 14086	NATAL	315523	-284648
329	1203726	NINIANS GRANITE	STONE AGGREGATE, GRAVEL	IPR	UMHLATUZI LOT 112 13942	NATAL	315300	-284853
333	1120897	HILLENDALE (TICOR)	TITANIUM, ZIRCONIUM	CPR	RESERVE NO. 10	MTUNZINI	315510	-285030
343	1120870	GRADED SANDS	SILICA (General)	CPR	* 12453	NATAL	320245	-284028
344	1120893	RBM (TISAND)	TITANIUM	CPR	RESERVE NO. 4 7638	ZULULAND	321057	-284346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