

Palaeontological specialist assessment: desktop study

PROPOSED 16 MTPA EXPANSION OF TRANSNET'S EXISTING MANGANESE ORE EXPORT RAILWAY LINE & ASSOCIATED INFRASTRUCTURE BETWEEN HOTAZEL AND THE PORT OF NGQURA, NORTHERN & EASTERN CAPE.

Part 1: Hotazel to Kimberley, Northern Cape

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EXECUTIVE SUMMARY

Transnet SOC Limited is planning to expand the capacity of the existing manganese ore export railway line between Hotazel (Northern Cape) and the Port of Ngqura (Coega IDZ, Eastern Cape) from the originally envisaged 12 Mtpa to 16 Mtpa. An additional fourteen rail loops that were not part of the previous EIA for the 12 Mtpa proposal will be extended and one new loop will be constructed close to Sishen in the Northern Cape. The 16 Mtpa expansion will require two rail compilation yards that are located at Mamathwane, Northern Cape, and the Coega IDZ in the Eastern Cape. Refurbishment of the second rail is required between Kimberley and De Aar in the Northern Cape. The present desktop report forms part of the Basic Assessment of ten railway loop developments along the manganese ore railway line between Hotazel and Kimberley in the Northern Cape.

The construction phase of the proposed new and extended railway loops along the Transnet Hotazel to Kimberley manganese ore railway may entail several substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. These excavations may disturb, damage or destroy scientifically valuable fossil heritage exposed at the surface or buried below ground. Other infrastructure components (e.g. laydown areas) may seal-in buried fossil heritage. However, most of the direct impacts will occur within the existing railway reserve, which is already highly disturbed, while palaeontologically highly sensitive rock units along the route, such as the lower Ecca Group and the Vaal River Gravels, will not be directly affected by the loop construction programme. The operational and decommissioning phases of the 16 Mtpa railway line are unlikely to involve significant adverse impacts on palaeontological heritage.

The extended loop development at Gong Gong is underlain by unfossiliferous lavas of the Early Precambrian Allanridge Formation (Ventersdorp Group) and no palaeontological impacts are therefore anticipated here.

Four of the proposed loop developments (Glosam, Postmasburg, Tsantsabane and Trewil) are underlain by Early Precambrian (2.6-2.5 billion year old) marine carbonate rocks of the Campbell Rand Subgroup (Ghaap Group, Transvaal Supergroup) that are known for their prolific fossil record of stromatolites, *i.e.* laminated microbial reefs constructed by cyanobacteria, in some cases associated with well-preserved microfossils.

The proposed loop developments at Wincanton, Sishen and Ulco are underlain by Late Caenozoic (probably Plio-Pleistocene) calcretes or pedogenic limestones, at least some of which may be attributed to the Mokalanen Formation of the Kalahari Group. The proposed new loop at Witloop and the Fieldsview loop extension overlie Pleistocene aeolian (wind-blown) sands of the Gordonia Formation, Kalahari Group. While a wide spectrum of vertebrate remains, invertebrates, trace fossils, plant fossils and microfossils have been recorded from these Kalahari Group sediments, in general they are of low palaeontological sensitivity and of considerable lateral extent so impacts on fossil heritage here are likely to be of low significance.

It is recommended that a brief palaeontological field assessment of the sedimentary rock units exposed along the Hotazel to Kimberley sector of the Transnet manganese ore export railway be undertaken before construction commences to assess impacts of the proposed loop developments on local fossil heritage and to make recommendations for any further specialist palaeontological studies or mitigation that should take place before or during the construction phase. These recommendations should also be incorporated into the Environmental Management Plan for the proposed railway developments.

1. INTRODUCTION AND BRIEF

Manganese ore mined in the Hotazel area near Kuruman (Kalahari Manganese Field) in the Northern Cape is transported by rail to a bulk minerals handling terminal at Port Elizabeth, where it is unloaded and placed on stockpiles before being loaded onto ships for export. Transnet SOC Limited is planning to expand the capacity of the existing manganese ore export railway line between Hotazel (Northern Cape) and the Port of Ngqura (Coega IDZ, Eastern Cape) from the originally envisaged 12 Mtpa to 16 Mtpa. Twelve project areas involved were originally assessed when the recent 12 Mtpa Environmental Impact Assessment was completed. An additional fourteen rail loops that were not part of the previous EIA will be extended and one new loop will be constructed close to Sishen in the Northern Cape (Table 1). The 16 Mtpa expansion will require two rail compilation yards that are located at Mamathwane Northern Cape and Coega IDZ in the Eastern Cape. Refurbishment of the second rail is required between Kimberley and De Aar in the Northern Cape.

Table 1: List of new loops or loop extensions forming part of the 16 Mtpa expansion of the Hotazel to Port of Ngqura manganese ore railway line (From BID kindly provided by ERM). The present report covers the Northern Cape loops listed here between Hotazel and Kimberley.

Northern Cape	
Witloop	New loop
Wincanton	Loop extension
Sishen	Loop extension
Glosam	Loop extension
Postmasburg	Loop extension
Tsantsabane	Loop extension
Trewil	Loop extension
Ulco	Loop extension
Gong Gong	Loop extension
Fieldsview	Loop extension
Eastern Cape	
Drennan	Loop extension
Thorngrove	Loop extension
Cookhouse-Golden Valley	Loop extension
Ripon-Kommadagga	Loop extension

1.1. Legislative context for palaeontological assessment studies

ERM Southern Africa (Pty) Ltd (Block A, Silverwood House, Silverwood Close, Steenberg Office Park, Cape Town 7945, South Africa; tel: +27 21 702 9100) has been appointed as the Independent Environmental Assessment Practitioners to undertake a Basic Assessment of an additional fourteen railway loops between Hotazel and Ngqura as well as an Environmental Impact Assessment of the proposed new compilation yard at Mamathwane in terms of the National Environmental Management Act (NEMA) (Act 107 of 1998, amended in 2008).

The present desktop study forms part of the Basic Assessment of ten of the fourteen additional loops, located between Hotazel and Kimberley in the Northern Cape, and is to be followed by a brief field-based palaeontological assessment by the author. A list of the loops under consideration is given in Table 1 and these are also shown on the map in Fig. 1 (kindly provided by ERM). The present palaeontological heritage report also falls under Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the Environmental Management Plan for this project.

The proposed railway line developments are located in areas that are underlain by potentially fossil-rich sedimentary rocks of Precambrian and younger, Tertiary or Quaternary age (Sections 2 and 3). The construction phase of the developments may entail substantial excavations into the superficial

sediment cover as well as locally into the underlying bedrock. In addition, substantial areas of bedrock may be sealed-in or sterilized by railway infrastructure, lay-down areas as well as new gravel roads. All these developments may adversely affect potential fossil heritage at or beneath the surface of the ground within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good. Once constructed, the operational and decommissioning phases of the railway developments are unlikely to involve further adverse impacts on palaeontological heritage, however.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance;
- palaeontological sites;
- palaeontological objects and material, meteorites and rare geological specimens.

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(4) No person may, without a permit issued by the responsible heritage resources authority—

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph (a) to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) are currently being developed by SAHRA. The latest version of the SAHRA draft guidelines was circulated for comment in November 2011.

1.2. Scope and brief for the desktop study

This desktop palaeontological specialist report provides an assessment of the observed or inferred palaeontological heritage within the ten proposed loop study areas within the Northern Cape between Hotazel and Kimberley (Fig. 1, Tables 1 & 2), with recommendations for further specialist palaeontological studies and / or mitigation where this is considered necessary.

The report has been commissioned by ERM Southern Africa (Pty) Ltd (Block A, Silverwood House, Silverwood Close, Steenberg Office Park, Cape Town 7945, South Africa; tel: +27 21 702 9100). It contributes to the Basic Assessment for the proposed 16 Mtpa railway developments and it will also inform the Environmental Management Plan for the project. The scope of work for this desktop study, as defined by ERM, is as follows:

The Contractor's role involves generating a Paleontological Baseline Report and a Paleontological Assessment Report. The findings will be based on one extended field trip (10 days) covering both the Northern Cape and Eastern Cape.

1.3. Approach to the palaeontological heritage Basic Assessment study

The approach to this palaeontological heritage Basic Assessment study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images (Figs. 3 to 8). Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database (Table 3). Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the

development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (e.g. sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (e.g. SAHRA for the Northern Cape). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.4. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.
2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant (“mappable”) bedrock units as well as major areas of superficial “drift” deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.
3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information;
4. The extensive relevant palaeontological “grey literature” - in the form of unpublished university theses, impact studies and other reports (e.g. of commercial mining companies) - that is not readily available for desktop studies;
5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous “drift” (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the case of the Transnet 16 Mtpa study areas a major limitation for fossil heritage studies is the low level of exposure of potentially fossiliferous bedrocks such as the Karoo Supergroup, as well as the paucity of previous specialist palaeontological studies in the Northern Cape region as a whole.

1.5. Information sources

The information used in this desktop study was based on the following:

1. A short project outline provided by ERM;
2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations as well as several desktop and field-based palaeontological assessment studies in the broader Hotazel to Kimberley region by the author (*e.g.* Almond 2010a, 2010b, 2011a, 2011b, 2012a, 2012b, among others).
3. The author's previous field experience with the formations concerned and their palaeontological heritage (See also review of Northern Cape fossil heritage by Almond & Pether 2008).

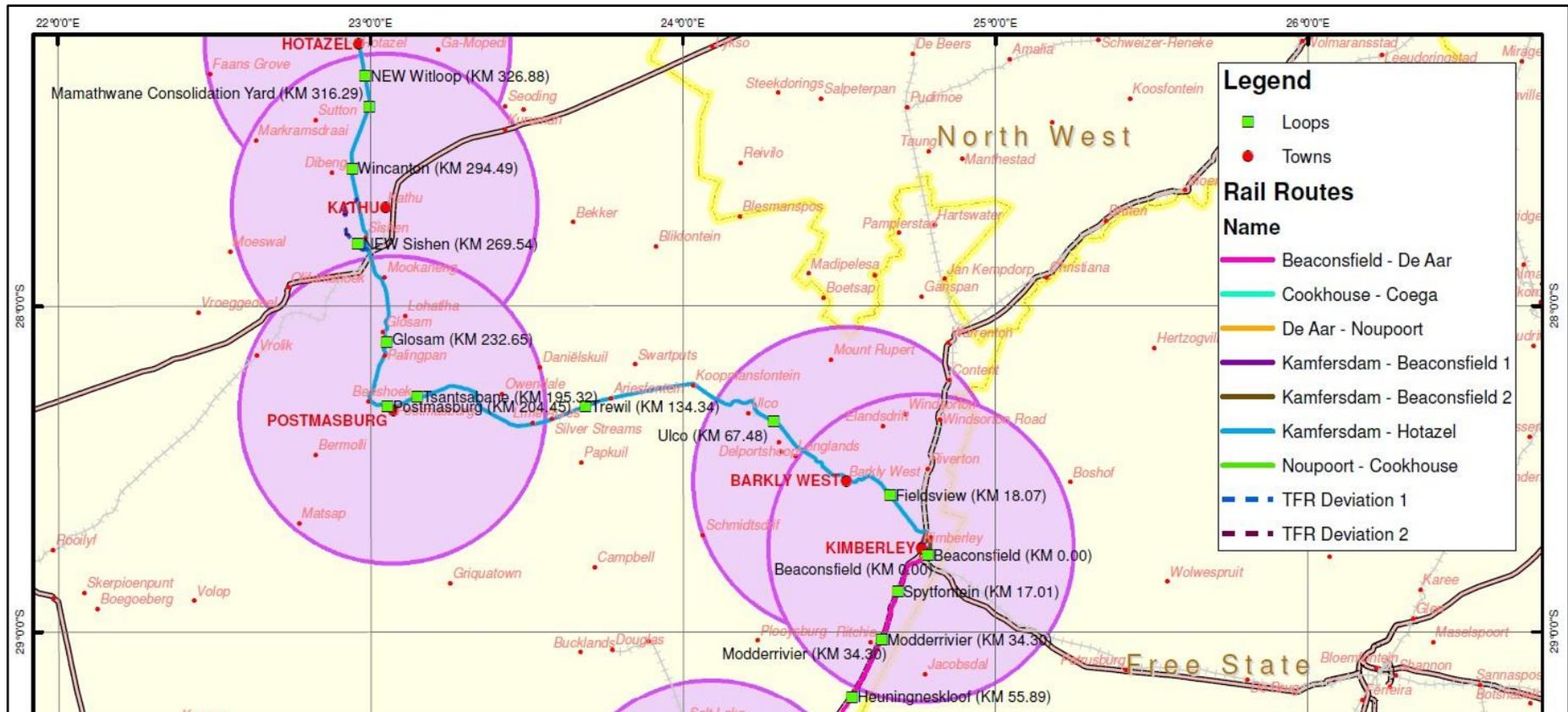


Fig. 1. Map of the Hotazel to Kimberley sector of the Transnet manganese ore export railway line, Northern Cape, showing the ten railway loops covered by the present desktop Basic Assessment report as well as the location of the Mamathwane Compilation Yard (green squares) (Map modified from image kindly provided by ERM).

Table 2. Summary of geology and palaeontological sensitivity of the 10 railway loop study sites between Hotazel and Kimberley

LOOP	LOCATION	PROJECT	GEOLOGY	PALAEONTOLOGICAL HERITAGE SENSITIVITY	RECOMMENDATION
1. WITLOOP (km 326.88)	27° 17' 54.4" S 23° 00' 59.05" E	New loop	Gordonia Formation (Kalahari Group)	LOW	Brief field assessment of loop development footprints and representative bedrock exposures in the region to assess likely palaeontological impacts based on levels of bedrock exposure, degree of weathering and deformation, and presence of near-surface fossils.
2. WINCANTON (km 294.49)	27° 34' 48.1" S 22° 56' 27.02" E	Loop extension	Calcrete	LOW	
3. SISHEN (km 269.54)	27° 48' 31.52" S 22° 57' 26.9" E	Loop extension	Calcrete	LOW	
4. GLOSAM (km 232.65)	28° 06' 40.09" S 23° 02' 58.22" E	Loop extension	Campbell Rand Subgroup dolomites	MEDIUM	
5. POSTMASBURG (km 204.45)	28° 18' 26.63" S 23° 03' 08.92" E	Loop extension	Campbell Rand Subgroup dolomites	MEDIUM	
6. TSANTSABANE (km 195.32)	28° 16' 45.12" S 23° 08' 51.78" E	Loop extension	Campbell Rand Subgroup dolomites	MEDIUM	
7. TREWIL (km 134.34)	28° 18' 25.01" S 23° 41' 10.45" E	Loop extension	Campbell Rand Subgroup dolomites	MEDIUM	
8. ULCO (km 67.48)	28° 21' 15.12" S 24° 17' 20.11" E	Loop extension	Calcrete	LOW	
9. GONG GONG	c. 28° 28' 27.99" S c. 24° 25' 31.61" E	Loop extension	Allanridge Formation (Ventersdorp Group)	ZERO	
10. FIELDSVIEW (km 18.07)	28° 34' 48.76" S 24° 39' 40.98" E	Loop extension	Gordonia Formation (Kalahari Group)	LOW	

2. GEOLOGICAL OUTLINE OF THE STUDY AREA

The existing Transnet manganese ore export railway line between Hotazel and Kimberley, Northern Cape, crosses several different physiographic regions of the RSA (Visser *et al.* 1989, their Fig. 2.1.). The initial stretch between Hotazel southwards to Dingleton traverses flat-lying, sandy semi-desert terrain at c. 1100-1200 m amsl of the southern Kalahari Region lying between the Korannaberg in the west and the Kurumanheuwels in the East. This region is drained by the Ga-Mogara River (a southern tributary of the Kuruman River) and its tributaries, and bedrock exposure is extremely limited. Between Dingleton, Postmasburg and east to Lime Acres the line runs through the slightly higher-lying (1300-1400m amsl), more rocky terrain of the Griqua Fold Belt Region on the western side of the Ghaap Plateau. This region is characterised by north-south trending rocky ridges and megafolds of Precambrian bedrocks, including the Maremane Anticline in the west and the Asbesberge to the east. From Lime Acres (south of Daniëlskuil) east to Ulco the railway crosses the southern part of the extensive, flat-lying Ghaap Plateau Region (c. 1200-1400m amsl) that is underlain by great thicknesses of Precambrian carbonate sediments (limestones, dolomites). The railway line then descends from the eastern edge of the Ghaap Plateau into the western portion of the Upper Karoo Region drained by the Harts and Vaal Rivers. This lower-lying region (c. 1100-1200m amsl) includes the sector all the way to Barclay West and Kimberley, situated between the Vaal and Orange Rivers.

The geology of the study area between Hotazel and Kimberley is covered by three adjacent 1: 250 000 scale geological maps, 2722 Kuruman (brief sheet explanation printed on map), 2822 Postmasburg (brief sheet explanation printed on map) and 2824 Kimberley (sheet explanation by Bosch 1993). Relevant extracts from these sheets are provided in Figs. 3 to 8 below. A more regional geological map at 1: 1 000 000 scale is also available (sheet explanation by Visser 1989) but differs in several respects from the more detailed 1: 250 000 maps that form the preferred basis for the present desktop study (*e.g.* regarding the outcrop area of the Dwyka Group).

All major rock units mapped along the railway line between Hotazel and Kimberley are listed in Table 3, together with a brief summary of their geology, age, known fossil heritage and inferred palaeontological sensitivity (largely based on Almond & Pether 2008). The location of these rock units within the stratigraphic column for South Africa is shown in Fig. 2. They include a wide range of sedimentary and igneous rocks ranging in age from Late Archaean (2.7 Ga = billion years old) to Recent. The igneous rocks (*e.g.* lavas, dolerite intrusions) are entirely unfossiliferous and a high proportion of the sedimentary rocks are of low palaeontological sensitivity. The main exceptions are fossiliferous marine shelf carbonates of the Ghaap Group (Vryburg Formation, Campbell Rand Subgroup), interglacial to post-glacial sediments of the Dwyka and Ecca Groups (Karoo Supergroup) and Late Tertiary (Neogene) to Pleistocene alluvial gravels along the Vaal River.

For the purposes of the present Basic Assessment of the proposed new railway loops and loop extensions only those rock units that are mapped within the development footprint (as shown on 1: 250 000 geological maps, Figs. 3 to 8) will be considered further here. As seen in Table 2, the Gong Gong study area is underlain by Late Archaean lavas of the **Allanridge Formation (Ventersdorp Subgroup)**, the Glosam, Postmasburg, Tsantsabane and Trewil sites by Late Archaean shelf carbonates of the **Campbell Rand Subgroup (Transvaal Supergroup)**, the Wincanton, Sishen and Ulco sites by Late Caenozoic (probably Plio-Pleistocene) **calcretes** or pedogenic limestones, while the Witloop and Fieldsview sites overlie Pleistocene to Recent aeolian sands of the **Gordonia Formation (Kalahari Group)**. A short review of the geology of these rock units is given below, while details of their known fossil heritage are given in Section 3.

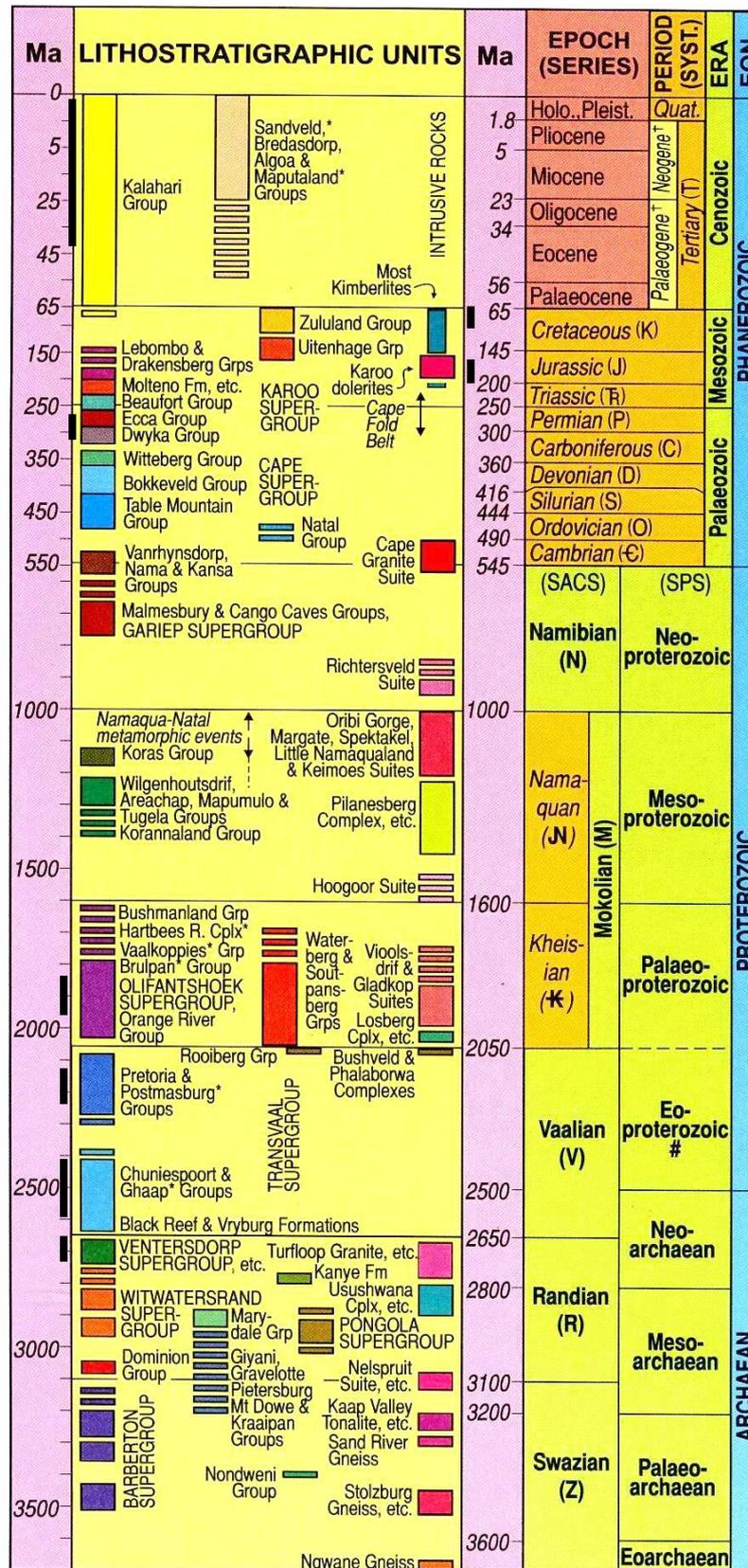


Fig. 2. Stratigraphic column for southern Africa showing the main rock units represented along the manganese ore export line railway between Hotazel and Kimberley, Northern Cape (thick vertical black lines) (See also Table 3).

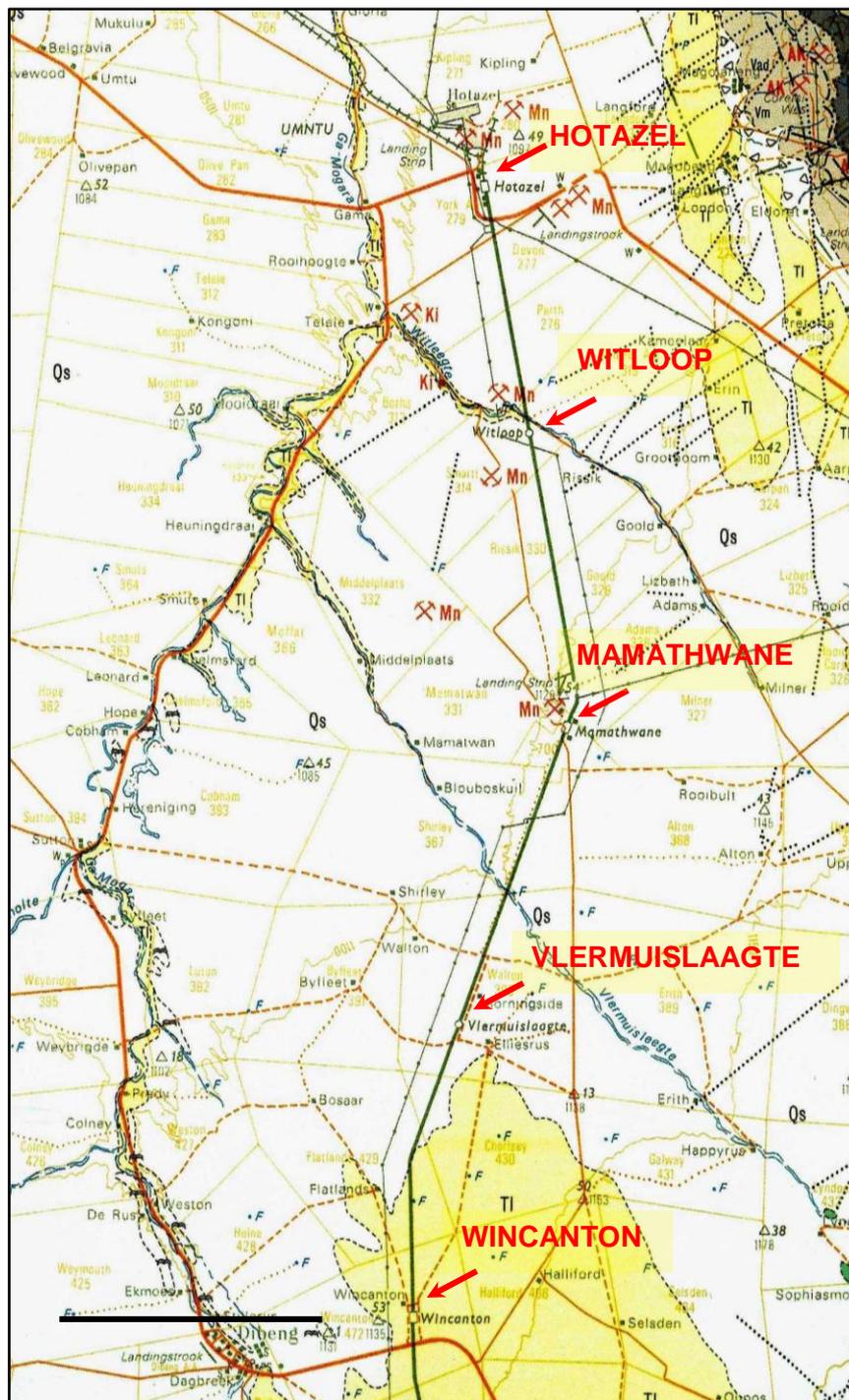


Fig. 3. Extract from 1: 250 000 geology map 2722 Kuruman (Council for Geoscience, Pretoria) showing location of the proposed new rail loop at Witloop (underlain by aeolian sands of the Gordonia Formation, Qs) and the loop extension at Wincanton (underlain by surface calcrete, TI). Note also the position of the proposed new compilation yard at Mamathwane and Vlermuislaagte Substation that is due to be upgraded. Both these additional sites are also underlain by Gordonia Formation aeolian sands. See Table 3 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = c. 10 km.

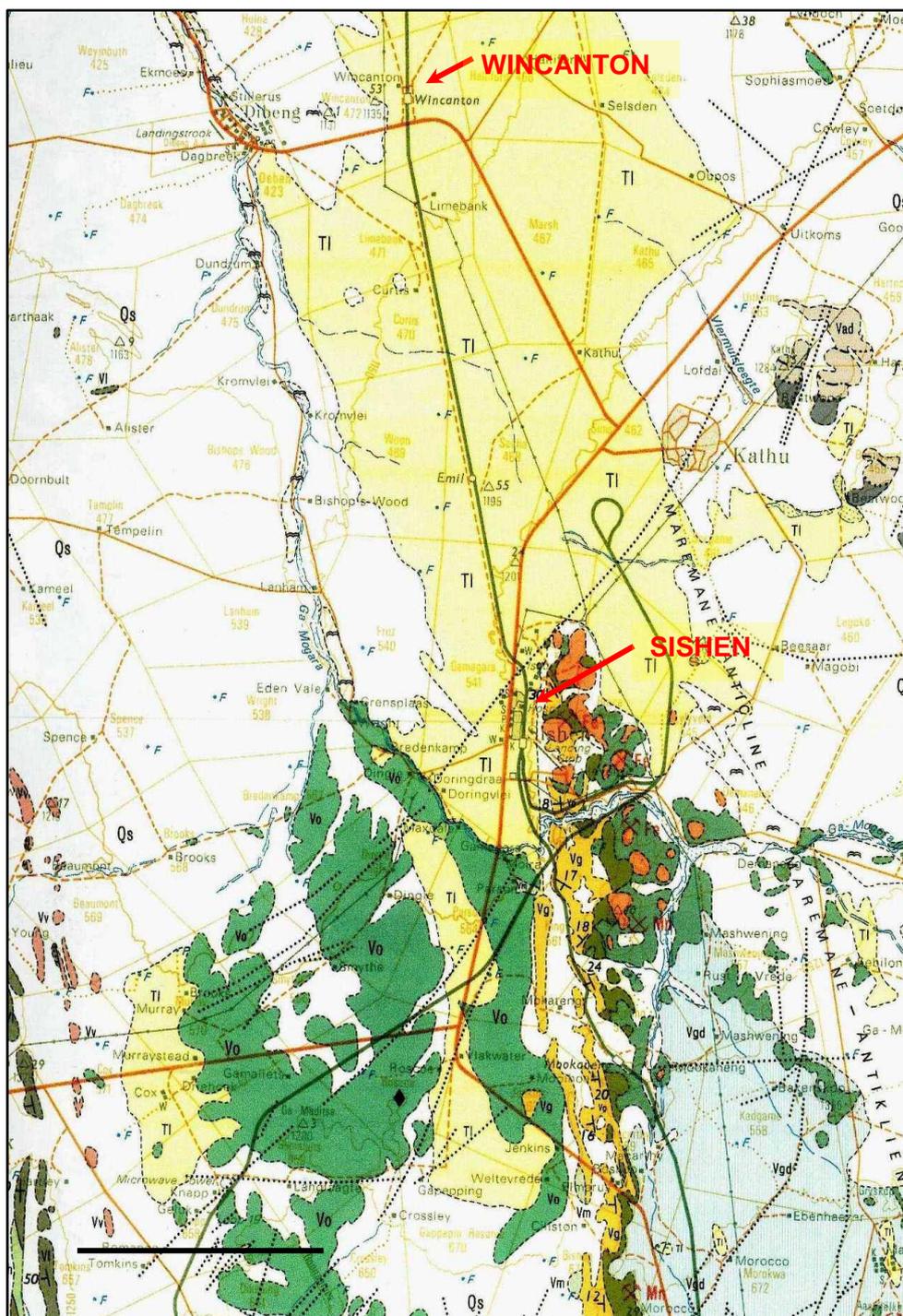


Fig. 4. Extract from 1: 250 000 geology map 2722 Kuruman (Council for Geoscience, Pretoria) showing location of the proposed new loop extensions at Wincanton and Sishen (both underlain by surface calcrete, TI). See Table 3 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = c. 10 km.

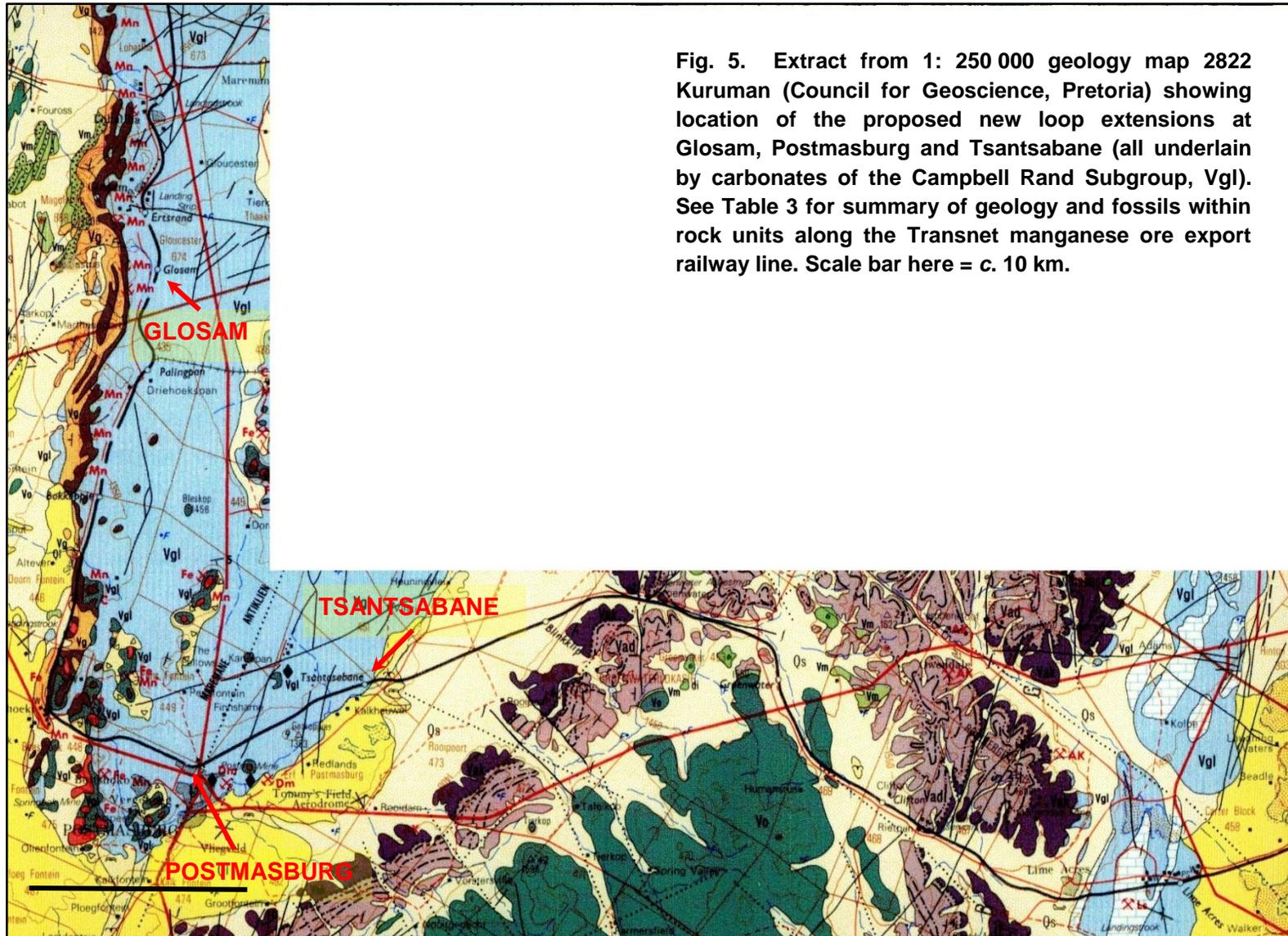


Fig. 5. Extract from 1: 250 000 geology map 2822 Kuruman (Council for Geoscience, Pretoria) showing location of the proposed new loop extensions at Glosam, Postmasburg and Tsantsabane (all underlain by carbonates of the Campbell Rand Subgroup, Vgl). See Table 3 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = c. 10 km.



Fig. 6. Extract from 1: 250 000 geology map 2822 Kuruman (Council for Geoscience, Pretoria) showing location of the proposed new loop extension at Trewil (underlain by carbonates of the Campbell Rand Subgroup, Vgl). See Table 3 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = c. 10 km.

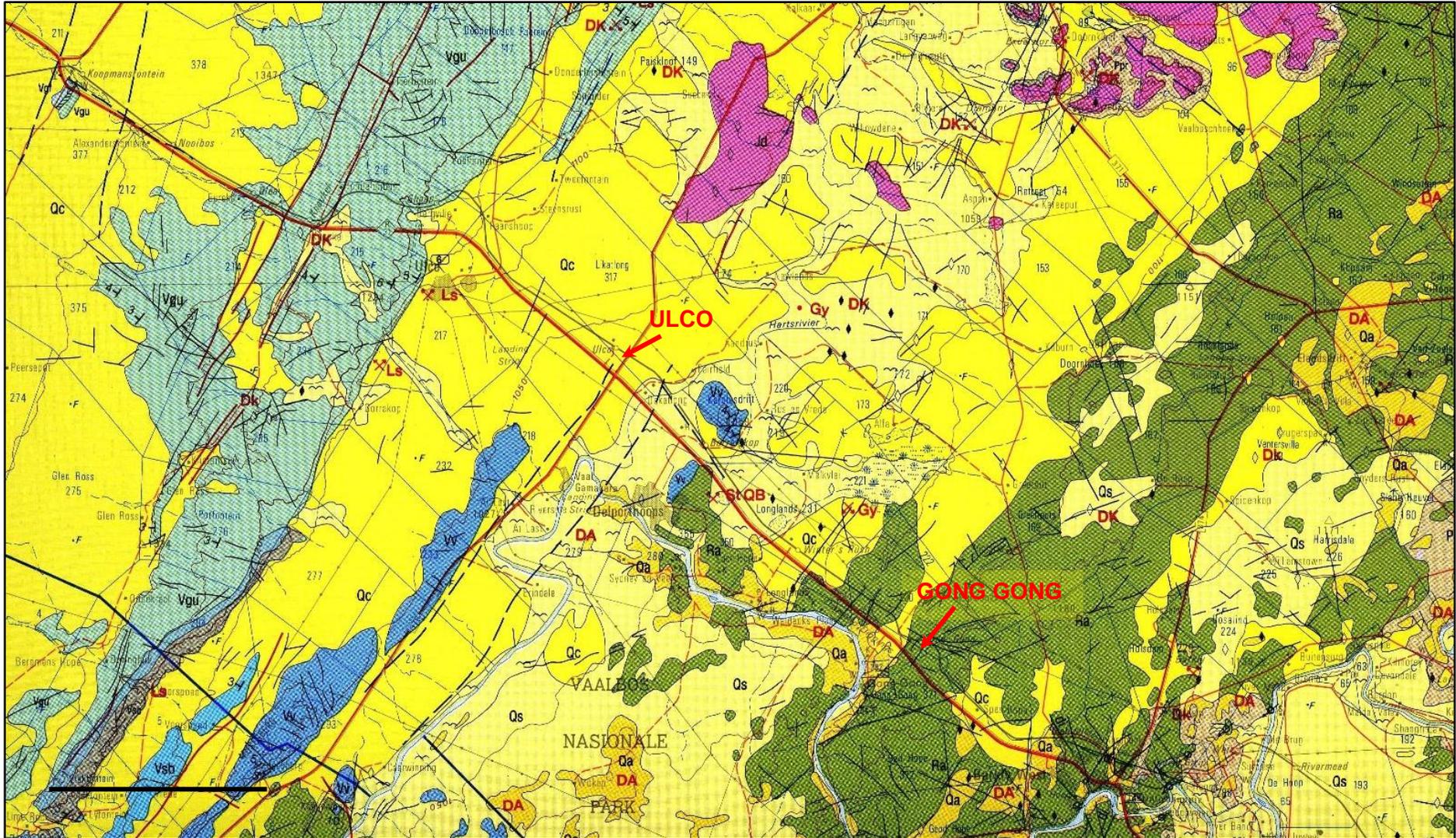


Fig. 7. Extract from 1: 250 000 geology map 2824 Kimberley (Council for Geoscience, Pretoria) showing location of the proposed new loop extensions at Ulco (underlain by surface calcrete, Qc) and Gong Gong (underlain by Allanridge Formation lavas, Ra). See Table 3 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = c. 10 km.

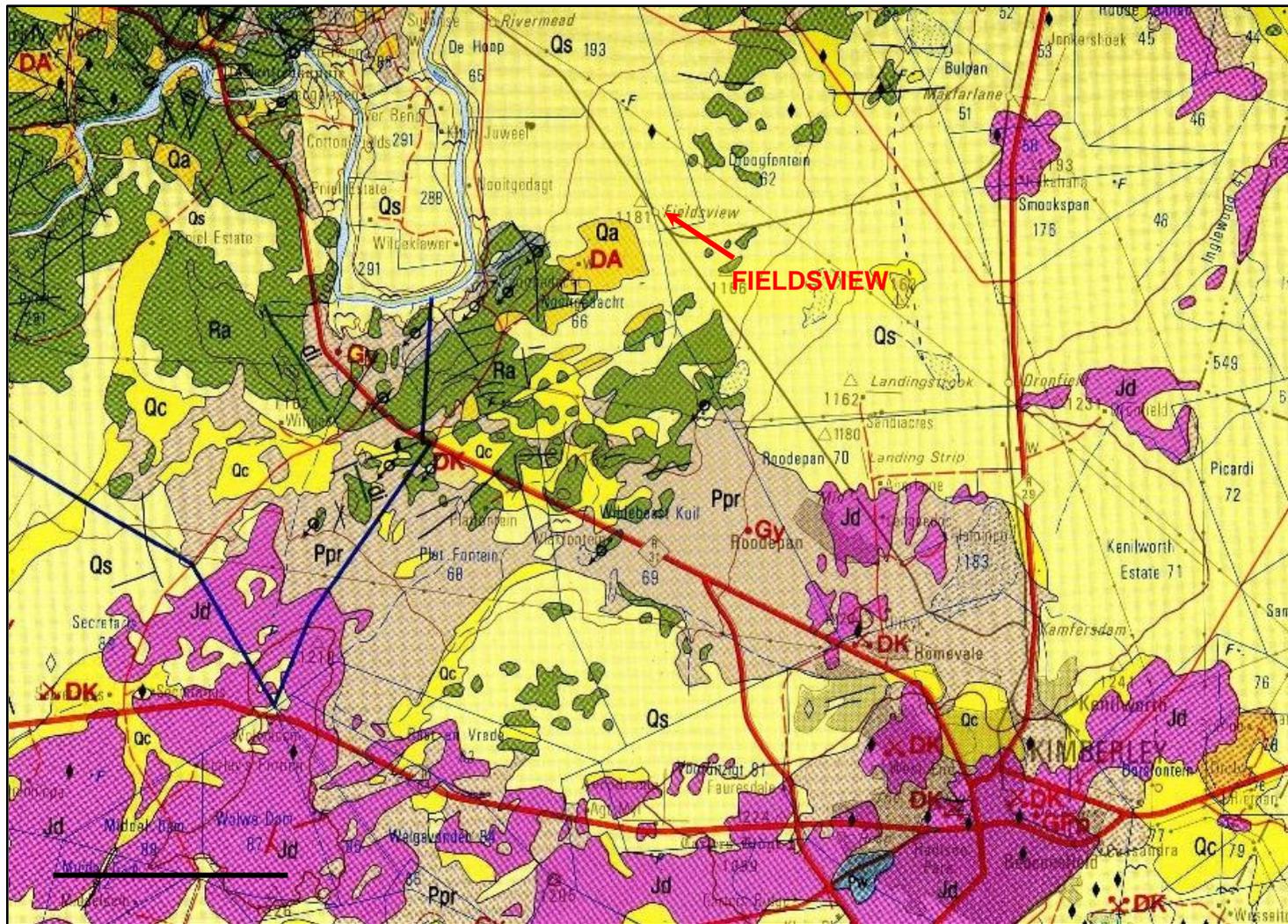


Fig. 8. Extract from 1: 250 000 geology map 2824 Kimberley (Council for Geoscience, Pretoria) showing location of the proposed new loop extension at Fieldsview (underlain by Gordonia Formation aeolian sands, Qs). See Table 3 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = c. 10 km.

2.1. Allanridge Formation (Ventersdorp Supergroup)

The **Ventersdorp Supergroup** represents a major episode of igneous extrusion (LIP = Large Igneous Province) that is associated with fracturing of the Kaapvaal Craton some 2.7 Ga (billion years) ago. The basal lava pile termed the Klipriviersberg Group - mainly basaltic lavas welling up in fissure eruptions, totalling up to two kilometres thick and 100 000 km² in extent - accumulated over a comparatively short period of some six million years (McCarthy & Rubidge 2005). The overlying Platberg Group comprises a range of felsic to mafic volcanic rocks, including lavas and pyroclastics, such as the porphyritic felsites and pyroclastic flows of the Makwassie Formation near Kimberley (Bosch 1993, Van der Westhuizen *et al.* 2006). These igneous rocks are associated with rift-related sediments, including colluvial, alluvial fan and lacustrine deposits, and are overlain by fluvial polymict conglomerates and quartzites of the Bothaville Formation. At the top of the Ventersdorp succession are the greyish-green amygdaloidal and porphyritic lavas - mainly basaltic andesites - of the **Allanridge Formation**. Here can be recognised lava flows up to 14m thick with vesicular tops, pipe-like structures due to lava degassing, and pillow structures formed during subaqueous eruptions (Bosch 1993). Gas vesicles within the amygdaloidal lavas are infilled with a range of secondary minerals including reddish chalcedony, quartz, calcite, chlorite and epidote. A thin lenticular succession of conglomerate and cross-bedded quartzites occurs locally just above the base of the succession.

A broad NE-SW trending outcrop area of resistant-weathering Allanridge Formation lavas is mapped to the northwest of Kimberley, including the Gong Gong loop extension study area (Fig. 7). A rusty-brown to metallic (desert varnish) surface weathering patina has developed on many surface boulders; this patina has been exploited locally by Later Stone Age rock engravers (*e.g.* Wildebeest Kuil rock art centre near Kimberley). A number of glacial pavements - glacially-striated and eroded bedrocks - of Dwyka age (*i.e.* Permo-Carboniferous, *c.* 300 Ma) are mapped within the Allanridge Formation outcrop area in the same region. These features, which here indicate consistent ice transport directions to the southwest, are of geological conservation significance (Almond 2012c).

2.2. Campbell Rand Subgroup (Ghaap Group, Transvaal Supergroup)

According to the 1: 250 000 geology maps (Figs. 5 to 7) the majority of the manganese ore railway line between Sishen to just east of Ulco is underlain by Early Precambrian (Late Archaean to Early Proterozoic) marine sediments of the **Transvaal Supergroup**, and in particular by the **Ghaap Group** of the Griqualand West Basin, Ghaap Plateau Subbasin. Useful reviews of the stratigraphy and sedimentology of these Transvaal Supergroup rocks have been given by Moore *et al.* (2001), Eriksson and Altermann (1998) as well as Eriksson *et al.* (1993, 1995, 2006). The Ghaap Group represents some 200 Ma of chemical sedimentation - notably iron and manganese ores, cherts and carbonates - within the Griqualand West Basin that was situated towards the western edge of the Kaapvaal Craton (See also fig. 4.19 in McCarthy & Rubidge 2005).

The **Campbell Rand Subgroup** (previously included within the Ghaapplatto Formation) of the Ghaap Group is a very thick (1.6-2.5 km) carbonate platform succession of dolomites, dolomitic limestones and cherts with minor tuffs that was deposited on the shallow submerged shelf of the Kaapvaal Craton roughly 2.6 to 2.5 Ga (billion years ago; see the readable general account by McCarthy & Rubidge, pp. 112-118 and Fig. 4.10 therein). A range of shallow water facies, often forming depositional cycles reflecting sea level changes, are represented here, including stromatolitic limestones and dolomites, oolites, oncolites, laminated calcilutites, cherts and marls, with subordinate siliclastics (shales, siltstones) and minor tuffs (Eriksson *et al.* 2006). Due to their solubility and low resistance to weathering, exposure levels of these rocks are often very low. The outcrop area of chert-rich subunits is often largely covered in downwasted, siliceous rock rubble (*e.g.* Postmasburg sheet area).

Carbonates of the "Ghaapplatto Formation" underlie the loop study areas at Glosam, Postmasburg, Tsantsabane and Trewil (Figs. 5 & 6). Note that since the 1: 250 000 geological maps were produced, the Campbell Rand succession has been subdivided into a series of formations, some of which were previously included within the older Schmidtsdrift Formation or Subgroup (Beukes 1980, 1986, Eriksson *et al.* 2006). It is unclear exactly which of these newer carbonate-dominated units are

represented in the Transnet railway study areas. However, this level of stratigraphic resolution is not critical for the current baseline report.

2.3. Late Caenozoic superficial sediments (calcretes, aeolian sands)

Large sections of the Transnet manganese ore export railway line study area are mantled by a range of **superficial sediments** of probable Late Caenozoic (*i.e.* Late Tertiary or Neogene to Recent) age, many of which are assigned to the **Kalahari Group**. The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), Thomas & Shaw 1991, Haddon (2000) and Partridge *et al.* (2006). Other superficial sediments whose outcrop areas are often not indicated on geological maps include colluvial or slope deposits (scree, hillwash, debris flows *etc*), sandy, gravelly and bouldery river alluvium, surface gravels of various origins, as well as spring and pan sediments. The colluvial and alluvial deposits may be extensively calcretised (*i.e.* cemented with pedogenic limestone), especially in the neighbourhood of dolerite intrusions.

Mappable exposures of **calcrete** or **surface limestone (QI / Qc)** occur in the southern Kalahari Region (Wincanton and Sishen loop study areas), also to the east of Postmasburg, as well as covering large portions of the Ghaap Group carbonates of the Ghaap Plateau (Ulco loop study area). These pedogenic limestone deposits reflect seasonally arid climates in the region over the last five or so million years and are briefly described by Truter *et al.* (1938) as well as Visser (1958) and Bosch (1993). The surface limestones may reach thicknesses of over 20m, but are often much thinner, and are locally conglomeratic with clasts of reworked calcrete as well as exotic pebbles. The limestones may be secondarily silicified and incorporate blocks of the underlying Precambrian carbonate rocks. The older, Pliocene - Pleistocene calcretes in the broader Kalahari region, including sandy limestones and calcretised conglomerates, have been assigned to the **Mokalanen Formation** of the **Kalahari Group** and are possibly related to a globally arid time period between 2.8 and 2.6 million years ago, *i.e.* late Pliocene (Partridge *et al.* 2006). Thick deposits of calc-tufa ("*kranskalk*") occur along the margins of the Ghaap Plateau, as at Ulco, where lime-rich groundwaters reach the ground surface (Bosch 1993).

Large areas of unconsolidated, reddish-brown to grey aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation (Kalahari Group; Qs** in Figs. 3 to 8) are mapped in the Transnet manganese ore railway study region, including the Witloop and Fieldsviepw loop study areas. According to Bosch (1993) the Gordonia sands in the Kimberley area reach thicknesses of up to eight meters and consist of up to 85% quartz associated with minor feldspar, mica and a range of heavy minerals. The Gordonia dune sands are considered to range in age from the Late Pliocene / Early Pleistocene to Recent, dated in part from enclosed Middle to Later Stone Age stone tools (Dingle *et al.*, 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8Ma back to 2.588 Ma would place the Gordonia Formation almost entirely within the Pleistocene Epoch.

3. PALAEOLOGICAL HERITAGE WITHIN THE STUDY AREA

Fossil biotas recorded from each of the main rock units mapped along the Transnet manganese ore export railway line are briefly reviewed in Table 3 (Based largely on Almond & Pether 2008 and references therein), where an indication of the palaeontological sensitivity of each rock unit is also given. The quality of fossil preservation may be compromised in some areas due to intense tectonic deformation, while extensive dolerite intrusion has compromised fossil heritage in portions of the Karoo Supergroup sediments (e.g. Eccca Group) due to resulting thermal metamorphism. In addition, pervasive calcretisation and chemical weathering of many near-surface bedrocks in the Northern Cape has further compromised their original fossil heritage in many areas (e.g. Eccca Group outcrop). The fossil record of the rock units underlying the proposed railway loop developments between Hotazel and Kimberly are reviewed in more detail below.

3.3. Fossils within the Ventersdorp Supergroup

Domical stromatolites are recorded from shallow water lacustrine calcarenites within the volcano-sedimentary succession of the Rietgat Formation at the top of the Platberg Group (Schopf 2006, Van der Westhuizen *et al.* 2006). The overlying predominantly siliciclastic Bothaville Formation contains conical stromatolites (Schopf 2006). Carbonate sediments are not reported in association with the Allanridge Formation lavas at the top of the Ventersdorp Supergroup, however.

3.2. Fossils within the Campbell Rand Subgroup

The shallow shelf and intertidal sediments of the carbonate-dominated lower part of the **Ghaap Group** (*i.e.* **Schmidtsdrif** and **Campbell Rand Subgroups**) are well known for their rich fossil biota of *stromatolites* or microbially-generated, finely-laminated sheets, mounds and branching structures. Some stromatolite occurrences on the Ghaap Plateau of the Northern Cape are spectacularly well-preserved (e.g. Boetsap locality northeast of Daniëlskuil figured by McCarthy & Rubidge 2005, Eriksson *et al.* 2006). Detailed studies of these 2.6-2.5 Ga carbonate sediments and their stromatolitic biotas have been presented by Young (1932), Beukes (1980, 1983), Eriksson & Truswell (1974), Eriksson & Altermann (1998), Eriksson *et al.* (2006), Altermann and Herbig (1991), and Altermann and Wotherspoon (1995). Some of the oldest known (2.6 Ga) fossil microbial assemblages with filaments and coccoids have been recorded from stromatolitic cherty limestones of the Lime Acres Member, Kogelbeen Formation at Lime Acres (Altermann & Schopf 1995). The oldest, Archaean stromatolite occurrences from the Ghaap Group have been reviewed by Schopf (2006, with full references therein). The Tsineng Formation at the top of the Campbell Rand carbonate succession has yielded both stromatolites (previously assigned to the Tsineng Member of the Gamohaam Formation) as well as filamentous microfossils named *Siphonophycus* (Klein *et al.* 1987, Altermann & Schopf 1995).

3.3. Fossils within the Kalahari Group

The fossil record of the **Kalahari Group** is generally sparse and low in diversity. The **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying bedrocks (including, for example, dolerite) may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized

rhizoliths (root casts) and termitaria (e.g. *Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (e.g. *Trigonephrus*) (Almond 2008, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (e.g. *Corbula*, *Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al.*, 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonina Formation is therefore considered to be low. Underlying calcretes of the **Mokolane Formation** might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient, Plio-Pleistocene alluvial gravels.

Table 3. Fossil heritage of rock units cropping out along the Hotazel to Kimberley sector of the Transnet manganese ore export railway line

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONTOLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
<p>OTHER LATE CAENOZOIC TERRESTRIAL DEPOSITS OF THE INTERIOR</p> <p>(Most too small to be indicated on 1: 250 000 geological maps)</p>	<p>fluvial, pan, lake and terrestrial sediments, including diatomite (diatom deposits), pedocretes, spring tufa / travertine, cave deposits, peats, colluvium, soils, surface gravels including downwasted rubble</p> <p>MOSTLY QUATERNARY TO HOLOCENE</p> <p>(Possible peak formation 2.6-2.5 Ma)</p>	<p>bones and teeth of wide range of mammals (e.g. mastodont proboscideans, rhinos, bovids, horses, micromammals), reptiles (crocodiles, tortoises), ostrich egg shells, fish, freshwater and terrestrial molluscs (unionid bivalves, gastropods), crabs, trace fossils (e.g. termitaria, horizontal invertebrate burrows, stone artefacts), petrified wood, leaves, rhizoliths, diatom floras, peats and palynomorphs.</p> <p>calcareous tufas at edge of Ghaap Escarpment might be highly fossiliferous (cf Taung in NW Province – abundant Makapanian Mammal Age vertebrate remains, including australopithecines)</p>	<p>LOW</p> <p>Scattered records, many poorly studied and of uncertain age</p>	<p>any substantial fossil finds to be reported by ECO to SAHRA</p>
<p>Gordonia Formation (Qs)</p> <p>KALAHARI GROUP</p> <p>plus</p> <p>SURFACE CALCCRETES (TI / Qc)</p>	<p>mainly aeolian sands plus minor fluvial gravels, freshwater pan deposits, calcretes</p> <p>PLEISTOCENE to RECENT</p>	<p>calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (e.g. tortoise) bones, teeth</p> <p>freshwater units associated with diatoms, molluscs, stromatolites etc</p>	<p>LOW</p>	<p>any substantial fossil finds to be reported by ECO to SAHRA</p>
<p>Windsorton & Rietputs Formations</p> <p>HIGH LEVEL ALLUVIAL GRAVELS (Qa)</p> <p>Miocene to Pleistocene</p>	<p>ancient alluvial gravels, locally diamondiferous and calcretised</p>	<p>sparse Tertiary vertebrates in older gravels. Rich Pleistocene mammalian fauna (bones, teeth) in younger gravels (e.g. equids, elephants, hippo) associated with Acheulian stone artefacts</p>	<p>HIGH</p>	<p>pre-construction field assessment by professional palaeontologist</p>
<p>KIMBERLITE INTRUSIONS</p> <p>(diamond symbol)</p>	<p>Kimberlite / olivine melilitite / carbonatite volcanic pipes and related intrusions (fissure fills), sometime diamondiferous.</p> <p>JURASSIC, CRETACEOUS TO PALAEOCENE</p> <p>c. 200-60 Ma</p>	<p>Rare fossiliferous xenoliths of country rocks (e.g. Beaufort Group sediments with fossil fish). Bryophytes, vascular plants (leaves, wood, fruit), fish, pipid frogs (adults, tadpoles), reptiles (tortoises, lizards), rare dinosaurs, birds (ratites), insects, ostracods, palynomorphs (bryophytes, ferns, gymnosperms, angiosperms) within crater lake sediments</p>	<p>LOW</p>	<p>none</p>

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONTOLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
KAROO DOLERITE SUITE (Jd)	intrusive dolerites (dykes, sills), associated diatremes EARLY JURASSIC (182-183 Ma)	no fossils recorded	ZERO (also cause baking of adjacent fossiliferous sediments)	none
Prince Albert Formation (Ppr; locally mapped within C-Pd) ECCA GROUP	basinal mudrocks with calcareous concretions EARLY PERMIAN	marine invertebrates (esp. molluscs, brachiopods), coprolites, palaeoniscoid fish & sharks, trace fossils, various microfossils, petrified wood	HIGH IN KIMBERLEY - DOUGLAS REGION	pre-construction field assessment by professional palaeontologist
Mbizane Formation (C-Pd) DWAYKA GROUP	tillites, interglacial mudrocks, deltaic & turbiditic sandstones, minor thin limestones LATE CARBONIFEROUS – EARLY PERMIAN	sparse petrified wood & other plant remains, palynomorphs, trace fossils (e.g. arthropod trackways, fish trails, U-burrows) possible stromatolites in limestones	LOW TO MODERATE (N.B. stratotype section in the Douglas area)	pre-construction field assessment by professional palaeontologist
Gamagara Formation (Vga / Vg) OLIFANTSHOEK SUPERGROUP	continental red beds (shales, sandstones, conglomerates), lateritic palaeosols EARLY PROTEROZOIC (1.9 Ga or older)	lateritic palaeosols reflect terrestrial biomass	LOW	none recommended
Ongeluk Formation (Vo) Makganyene Formation (Vm) POSTMASBURG GROUP	lavas glacial diamictites <i>plus</i> carbonates EARLY PROTEROZOIC (2.2-2.3 Ga)	none stromatolitic domes within carbonate facies	LOW TO MODERATE	recording & sampling of any newly exposed stromatolites by palaeontologist
Daniëlskuil Formation (Vad) Kuruman Formation (Vak) Asbestos Hills Subgroup (Va) GHAAP GROUP	BIF (banded iron formations) with cherty bands EARLY PROTEROZOIC (c. 2.5-2.4 Ga)	important early microfossil biotas	LOW	none recommended

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONTOLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
Campbell Rand Subgroup (Vca / Vgl, Vgu, Vgd etc) GHAAP GROUP	shallow marine to intertidal limestones / dolomites, siliceous breccias ("Manganese Marker") LATE ARCHAEOAN (c. 2.6-2.5 Ga)	rich stromatolite assemblages (stratiform, domical, columnar), important early microfossil biotas	MODERATE TO HIGH	recording & sampling of any newly exposed stromatolites in development footprint
Vryburg Formation (Vv) GHAAP GROUP	lavas, siliciclastics, carbonates LATE ARCHAEOAN 2.64 Ga	stromatolites in carbonates	MODERATE	recording & sampling of any newly exposed stromatolites in development footprint
Allanridge Formation (Ra / Ral) VENTERSDORP SUPERGROUP	lavas and volcaniclastic sediments LATE ARCHAEOAN 2.7 Ga	no fossils recorded	LOW	none recommended any substantial fossil finds to be reported by ECO to SAHRA

5. CONCLUSIONS AND RECOMMENDATIONS

The construction phase of the proposed new and extended railway loops along the Transnet Hotazel to Kimberley manganese ore railway may entail several substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. These excavations may disturb, damage or destroy scientifically valuable fossil heritage exposed at the surface or buried below ground. Other infrastructure components (e.g. laydown areas) may seal-in buried fossil heritage. However, most of the direct impacts will occur within the existing railway reserve, which is already highly disturbed, while palaeontologically highly sensitive rock units along the route, such as the lower Ecca Group and the Vaal River Gravels, will not be directly affected by the loop construction programme. The operational and decommissioning phases of the 16 Mtpa railway line are unlikely to involve significant adverse impacts on palaeontological heritage.

The extended loop development at Gong Gong is underlain by unfossiliferous lavas of the Early Precambrian Allanridge Formation (Ventersdorp Group) and no palaeontological impacts are therefore anticipated here.

Four of the proposed loop developments (Glosam, Postmasburg, Tsantsabane and Trewil) are underlain by Early Precambrian (2.6-2.5 billion year old) marine carbonate rocks of the Campbell Rand Subgroup (Ghaap Group, Transvaal Supergroup) that are known for their prolific fossil record of stromatolites, *i.e.* laminated microbial reefs constructed by cyanobacteria, in some cases associated with well-preserved microfossils.

The proposed loop developments at Wincanton, Sishen and Ulco are underlain by Late Caenozoic (probably Plio-Pleistocene) calcretes or pedogenic limestones, at least some of which may be attributed to the Mokalanen Formation of the Kalahari Group. The proposed new loop at Witloop and

the Fieldsview loop extension overlies Pleistocene aeolian (wind-blown) sands of the Gordonia Formation, Kalahari Group. While a wide spectrum of vertebrate remains, invertebrates, trace fossils, plant fossils and microfossils have been recorded from these Kalahari Group sediments, in general they are of low palaeontological sensitivity and of considerable lateral extent so impacts on fossil heritage here are likely to be of low significance.

It is recommended that a brief palaeontological field assessment of the sedimentary rock units exposed along the Hotazel to Kimberley sector of the Transnet manganese ore export railway be undertaken before construction commences to assess impacts of the proposed loop developments on local fossil heritage and to make recommendations for any further specialist palaeontological studies or mitigation that should take place before or during the construction phase. These recommendations should also be incorporated into the Environmental Management Plan for the proposed railway developments.

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8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed railway project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.



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