PALAEONTOLOGICAL HERITAGE REPORT: DESKTOP STUDY

Proposed Transnet Sishen Railway Line Link Project in Gamagara Local Municipality, Northern Cape Province

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1. EXECUTIVE SUMMARY

Transnet is proposing to construct a *c.*1 km–long freight link line between two existing railway lines near the Assmang Khumani open-cast iron ore mine south of Sishen, Kuruman District, Northern Cape. The Precambrian bedrocks underlying the railway project area comprise terrestrial or submarine lavas (Ongeluk Formation, Postmasburg Group) as well as iron formation (Gamagara Formation, Elim Group) of Neoproterozoic age (*c*. 2 billion years old) that are completely unfossiliferous. The overlying thick Late Caenozoic superficial deposits – including calcretes, surface gravels and aeolian sands of the Kalahari Group – are, at most, sparsely fossiliferous and to a considerable extent already disturbed by mining-related activity. Low-diversity assemblages of trace fossils as well as non-marine molluscs (*e.g.* snails) and rare vertebrate remains (*e.g*. teeth, bones and horn cores of mammals) might occur within consolidated alluvial deposits along the Gamagara drainage line that is crossed by the proposed new rail link (See yellow dotted ellipse in Fig. 2a herein); important Pleistocene vertebrate and Stone Age archaeological remains are recorded from calcrete solution hollows at Kathu Pan, for example, less than 20 km north of the present study area. With the notable exception of the vertebrate remains, these Late Caenozoic fossils probably occur widely across the Kalahari region of the Northern Cape and are not considered to be of high conservation value.

Given (1) the comparatively small footprint of the proposed rail development, (2) the disturbed context, (3) the fact that there will be very little cut operations into the landscape since the new railway foundations would be placed on top of the natural ground level, as well as (4) the generally low palaeontological sensitivity of the bedrocks and superficial sediments in the study area, it is concluded that the proposed short rail link, including the associated construction camp and laydown area, is of overall LOW impact significance in terms of palaeontological heritage. Pending the discovery of significant new fossil remains before or during the construction phase, no further specialist palaeontological studies or mitigation are recommended for this development.

The Environmental Control Officer (ECO) responsible for the Transnet Sishen Railway Line Link Project project should be aware of the potential for important fossil fossil vertebrate finds within consolidated older alluvial deposits along the Gamagara drainage line and the necessity to conserve them for possible professional mitigation. A Chance Fossil Finds Procedure for this development is outlined in tabular form at the end of this report. Recommended mitigation of chance fossil finds during the construction phase of the proposed rail link involves safeguarding of the fossils (preferably *in situ*) by the responsible ECO and reporting of all significant finds to the South African Heritage Resources Agency (SAHRA). Where appropriate, judicious sampling and

recording of fossil material and associated geological data by a qualified palaeontologist, appointed by the developer, may be required. These recommendations should be included within the Environmental Management Programme (EMPr) for the proposed development.

2. INTRODUCTION & BRIEF

Transnet SOC Limited ("Transnet") is proposing to construct a freight link line, approximately one kilometre in length, between two existing railway lines near the Assmang Khumani open-cast iron ore mine south of Sishen, Kuruman District, Northern Cape (Figs. 1 & 2a). Slightly more than 300 m of the new line will traverse transformed land. Railway route options previously considered as well as the construction camp and laydown area are shown in Figure 2b.

Construction of the proposed new rail link may impact palaeontological heritage resources within the underlying bedrocks and superficial sediments of the Precambrian Transvaal and Keis Supergroups and the Late Caenozoic Kalahari Group. A desktop palaeontological heritage assessment for the development has therefore been requested by the SAHRA (Case ID: 11957, letter of 15 December 2017) in accordance with the requirements of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the NHRA include, among others:

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

The present report has accordingly been commissioned by AECOM SA (Pty Ltd) (AECOM), Centurion, as part of the Basic Assessment process for the Transnet Sishen Rail Link Project (Contact details: AECOM. 263A West Avenue, Centurion, Pretoria 0157. Tel: +27-12-421-3577).

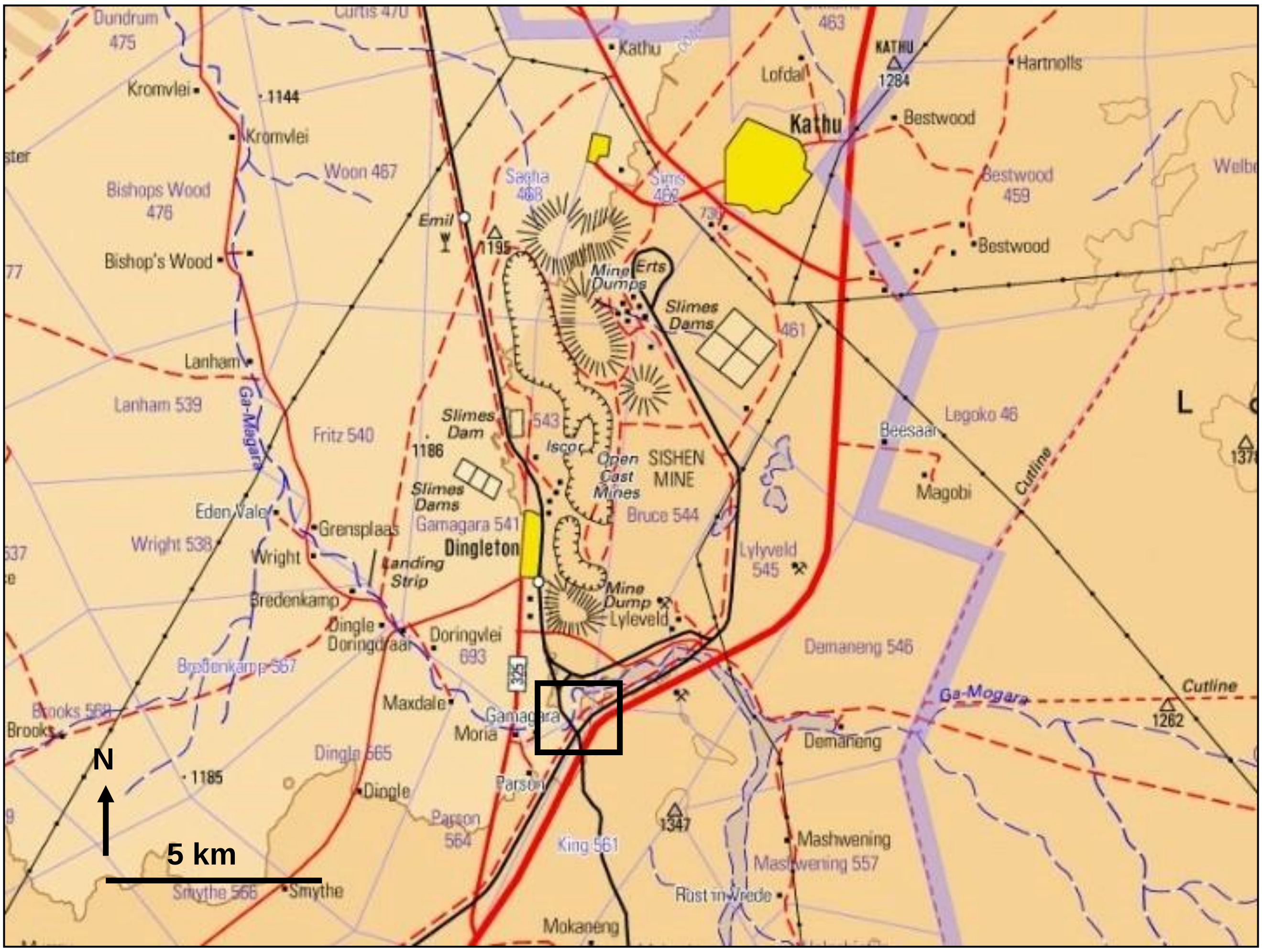

Fig. 1. Extract from 1: 250 000 topographical sheet 2722 Kuruman showing the study area (black rectangle) for the proposed Transnet Railway link on the western side of the N14 near the Assmang Khumani Mine, south of Sishen, Kuruman District, Northern Cape Province (Map courtesy of the Chief Directorate of Surveys & Mapping, Mowbray).

Fig. 2a. Google Earth© satellite image of the study area south of Sishen showing the proposed *c*. 1 km–long rail link (blue) between two existing railway lines (yellow). Brownish areas are underlain by iron formation while pale cream hues are associated with pedogenic calcrete. The new railway link will traverse the intermittent-flowing Gamagara drainage line (green vegetated zone). The Assmang Khumani open-cast iron ore mine (rusty brown area) is seen to the southeast. The most palaeontologically-sensitive sector of the new rail link is indicated by the yellow dotted ellipse; calcretised alluvium here *might* be associated with Quaternary mammalian fossils as well as trace fossils and Stone Age artefacts, as seen at Kathu Pan. Note that no substantial excavations into these alluvial deposits are planned.

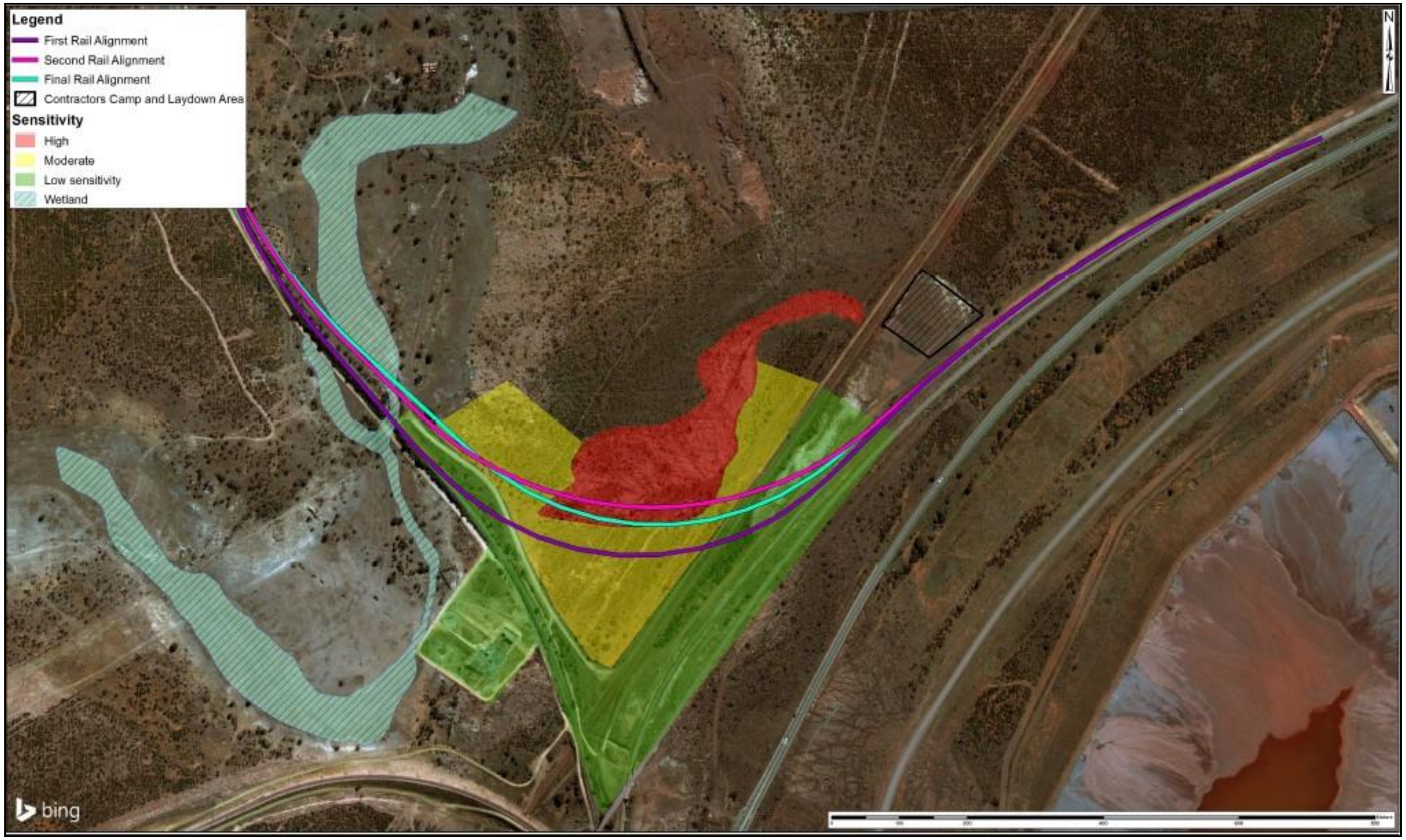

Fig. 2b. Satellite image of the Sishen Transnet Rail Link study area showing route alternatives considered, proposed location of the construction camp and laydown area as well as the current wetland area along the Gamagara River (Image supplied by AECOM).

3. APPROACH TO THE PALAEONTOLOGICAL HERITAGE STUDY

The approach to this palaeontological heritage study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images. 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. Based on this data, 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 and satellite images. 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 (Almond & Pether 2008). 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. 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 monitoring or 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 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 palaeontological collection permits from the relevant heritage management authorities, *i.e.* the SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). 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.

2.1. Information sources

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

1. A brief project descriptions, maps, kmz files and supporting documents provided by AECOM, Centurion;

2. A review of the relevant satellite images, topographical maps and scientific literature, including published geological maps and accompanying sheet explanations, as well as a previous desktop and field-based palaeontological assessment studies featuring comparable bedrocks in the Kathu - Sishen region (*e.g.* Almond 2010, 2013, 2014, 2015a, 2015b, Pether 2011).

3. The author's previous field experience with the formations concerned and their palaeontological heritage (Almond & Pether 2008);

2.2. 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 present study area near Sishen little is known about local fossil heritage resources on the basis of field studies, while the Kathu area to the north is better known. However, given (1) the comparatively small footprint of the proposed development, (2) the disturbed character of the context, as well as (3) the generally low palaeontological sensitivity of the study area, a desktop-level assessment of palaeontological heritage resources is considered appropriate here.

2.3. Legislative context for palaeontological assessment studies

The proposed railway project is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Precambrian and younger, Late Tertiary or Quaternary, age (Sections 3 and 4). The proposed development will entail excavations into the superficial sediment cover and locally into the underlying bedrock as well. Potentially this development might adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good. The decommissioning phase of the mine is unlikely to involve further adverse impacts on local palaeontological heritage.

The present combined desktop and field-based palaeontological heritage study falls under the NHRA. It will also inform the Environmental Management Programme (EMPr) for this railway project.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the NHRA 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 NHRA, 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) have been published by SAHRA (2013).

4. GEOLOGICAL BACKGROUND

The Transnet Sishen Railway LinkLine study area is situated in fairly flat, extensively-disturbed terrain at around 1200 m amsl between the Langberge in the west and the Kurumanheuwels in the east that falls within the semi-arid Southern Kalahari Geomorphic Province (Partridge *et al.* 2010). It lies *c*. 15 km SSW of Kathu town on the western side of the N14 tar road between Kathu and Postmasburg, close to the Sishen and Assmang Khumani opencast iron ore mines, Northern Cape (Figs. 1 & 2). This region is drained by the non-perennial Gamagara River which flows northwards into the Kuruman River to the north of Hotazel and whose shallow, shallow course is traversed by the rail link line footprint (See yellow ellipse in Fig. 2a).

The geology of the Sishen region is shown on the 1: 250 000 geological sheets 2722 Kuruman (Council for Geoscience, Pretoria) (Fig. 3 herein). This map is now out of print and is not supplied with a detailed sheet explanation (a brief explanation is printed on the map, however). Since this geological map was published, there have been considerable revisions to the stratigraphic subdivision and assignment of several of the Precambrian rock units represented within the study area. More recent stratigraphic accounts for the Transvaal Supergroup are given by Eriksson *et al.* (2006) and for the Olifantshoek Supergoup by Moen (2006), but correlations for all the subdivisions indicated on the older maps are not always clear. Simplified regional geological maps based on more recent scientific literature are provided by Cairncross and Beukes (2013) as well as Smith and Beukes (2016) (Figs. 4 & 5).

As shown on these recently published maps, the Sishen study area lies on the western side of a major N-S trending anticline within the Early Proterozoic bedrocks of the **Ghaap Group** (**Transvaal Supergroup**) known as the Maremane Dome. A major unconformity at the base of the Palaeoproterozoic **Elim Group** (basal **Keis Supergroup**), dated at approximately 2.2-2.0 Ga, truncates the gently folded Ghaap Group succession on the western side of the Maremane Dome - *viz.* Campbell Rand carbonates, Asbesheuwels BIF and Koegas quartzites and iron formation. This regional unconformity is associated with the major development of iron and manganese ores that are extensively exploited in the Sishen – Postmasburg region of Griqualand West. The metallic ores are associated with (1) the palaeokarst-related **Manganore Formation** overlying Campbell Rand Subgroup carbonates of the Maremane Dome as well as (2) the **Gamagara Formation** at the base of the Elim Group, previously included within the Olifantshoek Group (Schalkwyk 2005, Van Niekerk 2006, Da Silva 2011, Cairncross & Beukes 2013, Smith & Beukes 2016) (Fig. 6).

The Gamagara Formation unconformably overlies Late Archaean to Early Proterozoic Campbell Rand dolomites in the broader study region where it is represented by basal haematite pebble conglomerates of the **Doornfontein Member**. The Elim Group here is tectonically overlain by wedges of older Palaeoproterozoic sediments assigned to **Postmasburg Group**. These upper Transvaal Supergroup successions have been displaced eastwards onto the western flank of the Maremane Dome along multiple thrust planes constituting the Blackridge Thrust (*cf* Moen 2006, his Fig. 3). In the study area the Postmasburg Group is represented by basaltic to andesitic lavas of the **Ongeluk Formation** that are dated to 2.2 Ga and crop out to the south of the Gamagara River. The first part of this major flood basalt succession was extruded subaerially, but later lava flows show evidence of subaqueous extrusion (*e.g.* pillow lavas; Eriksson *et al.* 2006).

The subsurface stratigraphic succession in the Sishen Mine area is briefly outlined in the Sishen Iron Ore Mine Environmental Management Report (Sishen Iron Ore Mine 2002, 98 pp; data abstracted in Almond 2012; see also Smith & Beukes 2013). According to the same document the haematite ore mined at Sishen occurs in sedimentary rocks of both the Gamagara Formation (Elim

Group, previously assigned to the Olifantshoek Supergroup) and the Asbestos Hills Subgroup of the older Transvaal Supergroup. The ore deposit consists of ferruginous shale and conglomerates of the Gamagara Formation (Doornfontein Member), which unconformably overly the supergene-enriched iron formation of the Asbestos Hills Subgroup (Manganore Formation).

In the Sishen region the Precambrian bedrocks are extensively mantled by Late Cretaceous to Late Caenozoic (probably Quaternary) gravels, clays, calcretes and aeolian sands of the **Kalahari Group** (See stratigraphic column in Fig. 7).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).

Haddon (2005) reports a thickness of *about* 80 m of Kalahari Group sediments overlying the Precambrian bedrocks in the Sishen Iron Ore Mine located just north of the present study area. The earliest beds here are assigned to the **Wessels Formation** (basal gravels) and **Budin Formation** (calcareous clays) of probably Late Cretaceous age (Partridge *et al.* 2006); they lie too deeply below the surface to be directly impacted by the proposed rail development. The uppermost 15 m of the Kalahari sediments comprises well-indurated calcretised siltstones, pebbly horizons and clays with the development of solution hollows along joint surfaces within 10 m of the surface. Close to the surface calcretised silcretes showing *in situ* brecciation are also recognised. Thick to very thick pedogenic calcretes of the Plio-Pleistocene **Mokalanen Formation** are mapped to the west of the study area and also underlie Kalahari sands in the region. These 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 Boardman and Visser (1958). The surface limestones may reach thicknesses of over 20 m, 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.

Thick calcretes locally mantled with a veneer of Pleistocene Kalahari sands (**Gordonia Formation**) and downwasted surface gravels were described at the Transnet 16 MTPA Mangenese new loop study area near Sishen, only some 5 km NW of the present study area, by Almond (2013). A wide range of calcrete types is represented here, including gravelly, brecciated, silicified, honeycomb and karstified facies, the last with a network of partially sand- or gravel-infilled solution hollows.

Large areas of unconsolidated, reddish-brown aeolian (*i.e.* wind-blown) sands of the Quaternary Gordonia Formation are mapped in the Sishen region where their thickness is uncertain. 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.

Calcretised **older alluvial deposits** - comparable to those expected along the main Gamagara drainage line in the study area (yellow dotted ellipse in Fig. 2a) - have been described in association with a tributary of the Gamagara drainage system by Almond (2013) at the Transnet 16 MTPA new loop study area at Witloop, some 40 km north of Kathu. The considerable thickness of alluvial sediments encountered here includes calcretised polymict alluvial gravels, alluvial sands, silicified horizons with cherty concretions as well as wetland reedy swamp) deposits.

Judging from satellite images, ferruginous **downwasted surface gravels** dominated by clasts of iron formation mantle much of the study area. In many areas these superficial deposits are likely to be highly disturbed by mine-related activities.

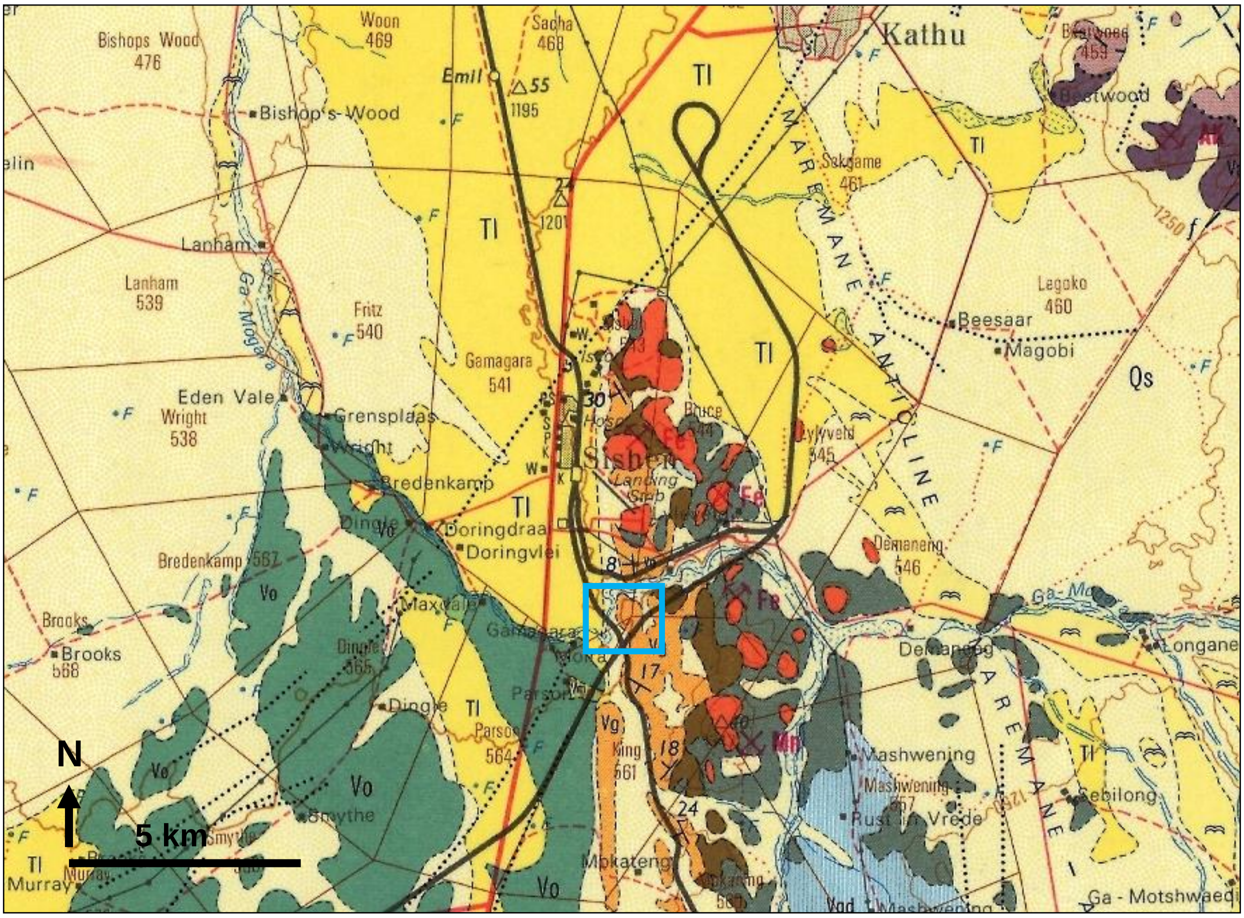

Fig. 3. Extract from 1: 250 000 geological map 2722 Kuruman (Council for Geoscience, Pretoria) showing the approximate location of the Transnet Rail Link study area near Sishen (blue rectangle) (Note that the geological mapping and lithostratigraphy shown here are now out-of-date). The following main rock units are represented within the broader Sishen study region: Vgd (pale blue) = Campbell Rand Subgroup; dark grey = Wolhaarkop chert breccia; red = Manganore Formation (Blinkklip breccia); Vg (orange) = Gamagara Formation with basal Doornfontein conglomerate (dark brown; Vo (blue-grey) = Ongeluk Formation lavas; Qs (pale yellow) = red Kalahari Group sands (Gordonia Formation).

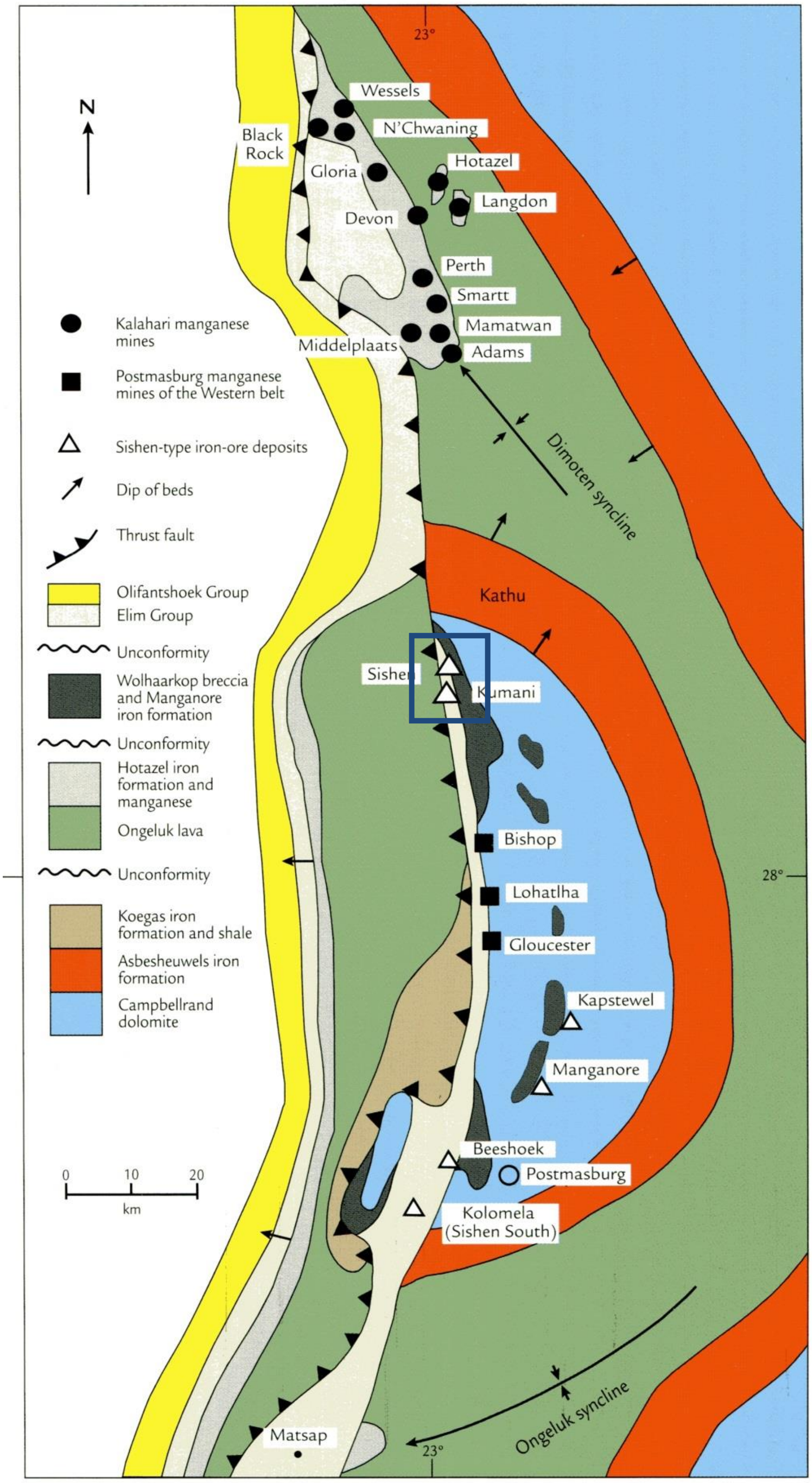

Fig. 4. Schematic geological map of the Griqualand West region, Northern Cape, showing the revised stratigraphic interpretation of the rock units represented in the Sishen – Assmang Khumani mine study region (dark blue square) (Map abstracted from Cairncross & Beukes 2013). The Ongeluk lava outcrop area (grey-green) also includes the Makganyene Formation diamictites that are not mapped in the present study area (See Fig. 5).

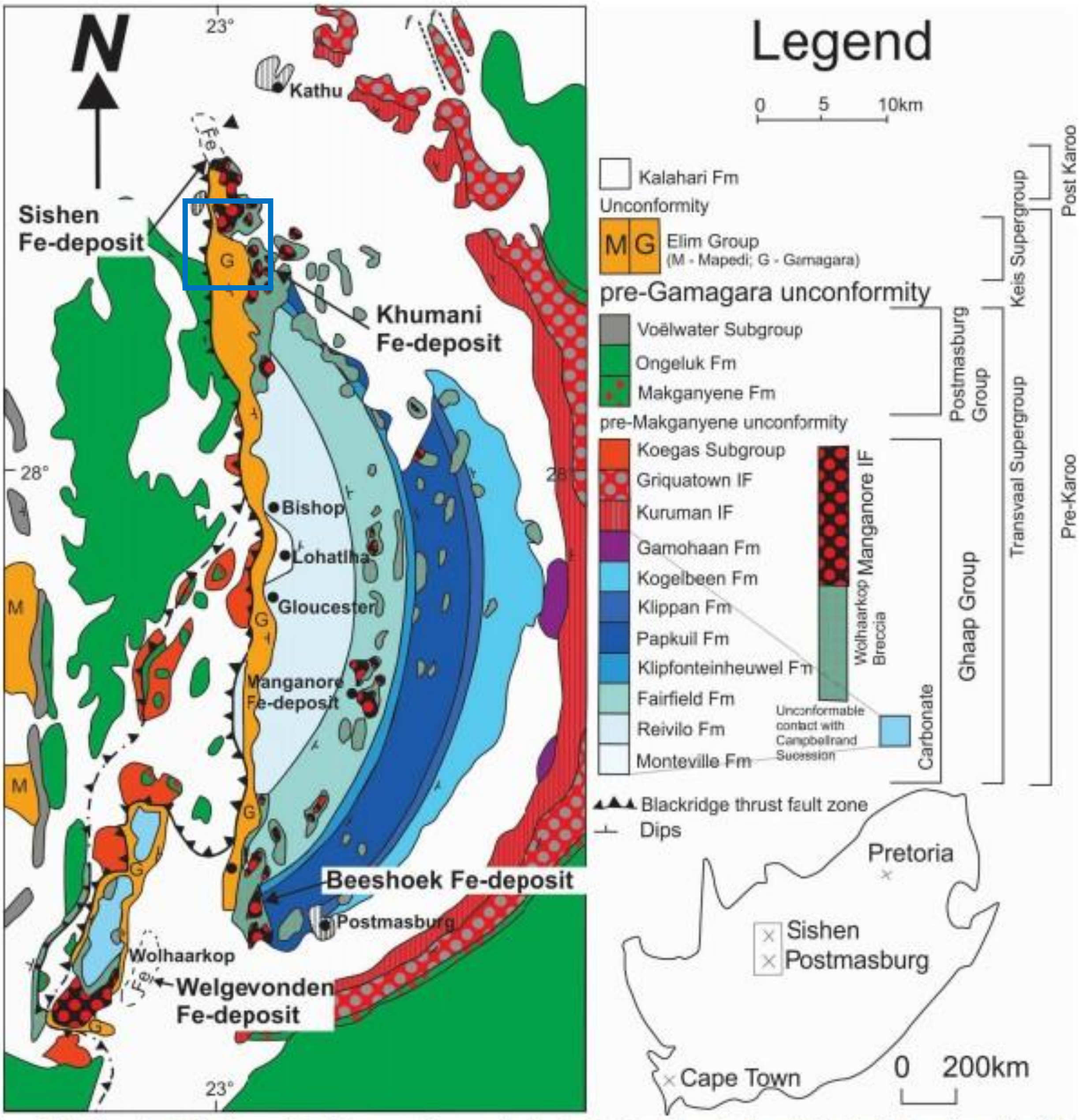

Figure 2: Regional geological map of the Maremane Dome region in the Northern Cape Province indicating the location of the Sishen, Khumani, Beeshoek and Sishen South iron ore deposits (modified after Van Schalkwyk and Beukes, 1986).

Fig. 5. Revised geological map and lithostratigraphy of the Maremane Dome area of Griqualand West (from Smith & Beukes 2016). The present study area close to the Sishen and Khumani opencast iron ore mines lies within the blue square. The Makganyene Formation outcrop area is shown in red with green spots (contrary to the legend).

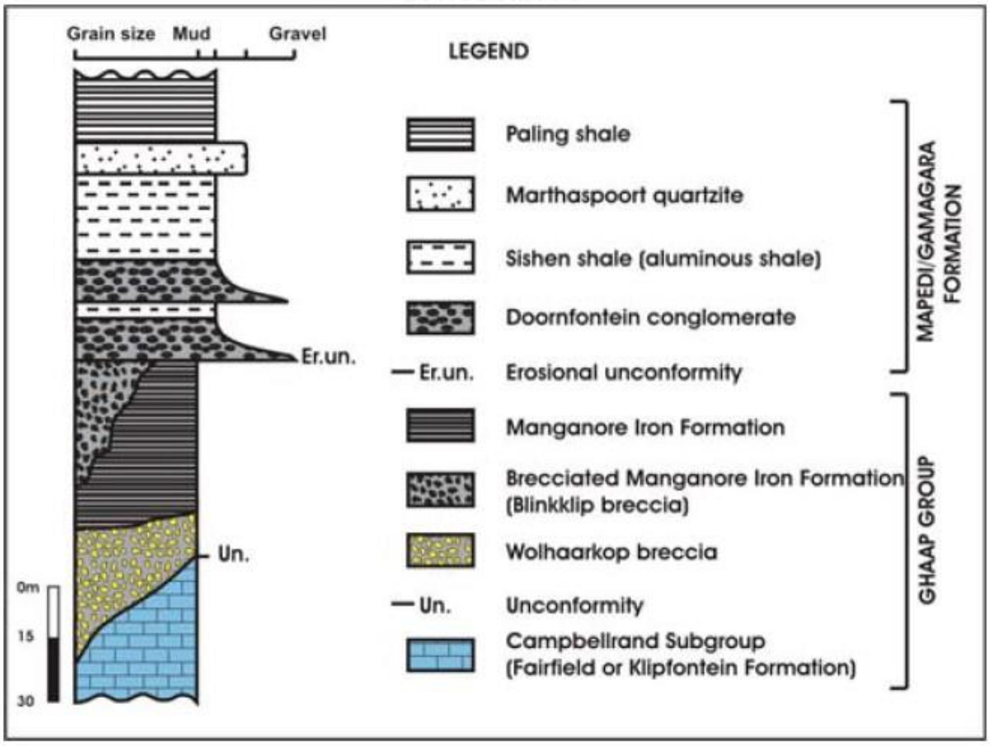

Fig. 6. Stratigraphic setting of the iron formations in the Sishen area (From Schalkwyk 2005). The present study area is underlain at depth by the Gamagara Formation with the ferruginous Doornfontein conglomerates its base. The Manganore Formation and underlying Wolhaarkop Breccia form part of a complex, supergene-enriched, lateritic weathering profile beneath the regional 2.2-2.0 Ga pre-Gamagara Unconformity, here associated with collapse of Asbestos Hills Subgroup BIF into karstic solution hollows on the Maremane Dome.

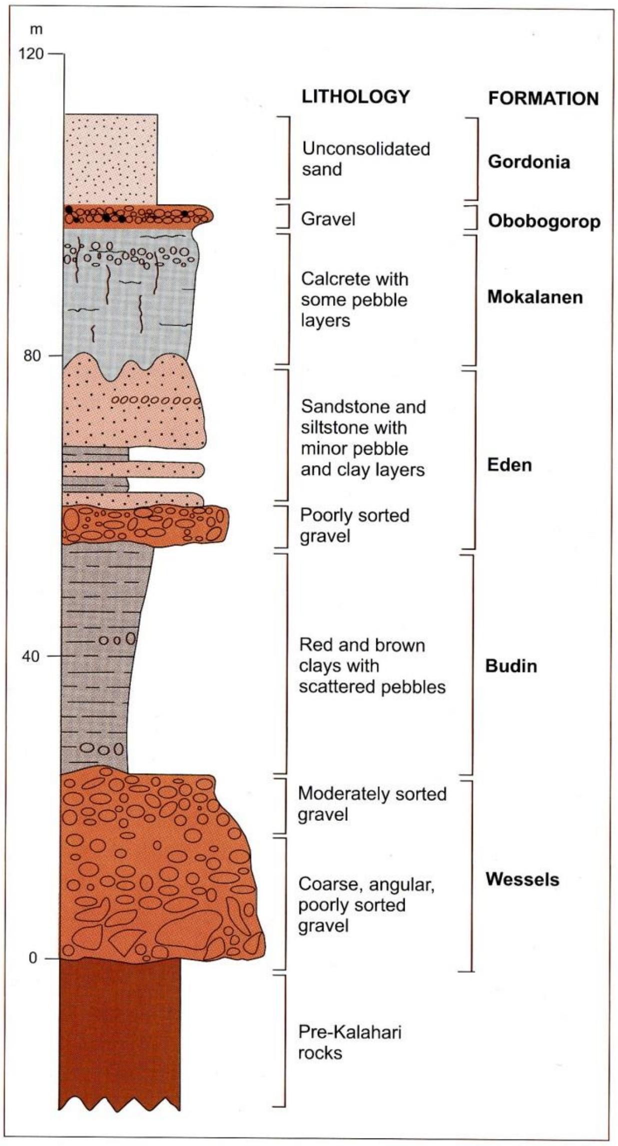

Fig. 7. Generalised stratigraphy of the Late Cretaceous to Recent Kalahari Group (From Partridge *et al.* 2006). Most or all of these rock units are represented within the Kathu – Sishen study region but only Plio-Pleistocene subsurface calcretes (Mokalanen Formation) and overlying Pleistocene to Recent aeolian sands of the Gordonia Formation are likely to be directly impacted by the proposed rail link project.

5. PALAEONTOLOGICAL HERITAGE

5.1. Fossils within the Precambrian bedrocks

Indirect evidence for photosynthetic life on land – but no body fossils - is provided by the *c.* 2.2 Ga lateritic palaeosols from the **Wolhaarkop palaeosol** underlying the Manganore Formation in Griqualand West and its stratigraphic equivalents (Hekpoort palaeosol in the Transvaal Basin). These resemble modern subtropical to tropical ferruginous soils that reflect an oxygen-rich atmosphere and the presence of abundant terrestrial biomass (Beukes *et al.* 2002). It is notable that small (< 2 mm long), urn-shaped microfossils named *Diskagma* which are recorded from the contemporary Hekpoort Formation palaeosol of the Transvaal Basin have been compared with lichenised actinobacteria or fungi (Retallack *et al.* 2013, Retallack 2014). These problematic fossils, which might represent the oldest-known eukaryotes and terrestrial organisms, may also be present within the co-eval Wolhaarkop palaeosol of the Griqualand West Basin of the Northern Cape.

The fossil record of the Postmasburg Group of the Transvaal Supergroup is very sparse. Stromatolitic bioherms up to 5 m long and 3 m thick that are made up of manganese-rich laminated carbonates are recorded from the glacially-influenced **Makganyene Formation** by Polteau *et al.* (2006). These carbonate rocks are interbedded with glacial diamictites in the Prieska Subbasin; the intimate association of warm-water carbonates and cold-water glacial deposits at low palaeolatitudes is of palaeoclimatic significance (See also Polteau 2000, 2005). The Makganyene Formation is not mapped within the present study area (Fig. 5) but might be present at depth beneath the Kalahari Group cover, however. There are contested records of possible trace fossils from contemporary 2.2 Ga sediments of the Postmasburg Group in the Transvaal Basin (Pretoria Group; Almond & Pether 2008). No fossils are recorded from the volcanic **Ongeluk Formation** that is mapped at surface just to the southwest of the study area.

5.2. Fossils within the Kalahari Group

The fossil record of the Kalahari Group is generally sparse and low in diversity. The lowermost Kalahari units of probable Late Cretaceous / Neogene age have yielded low-diversity trace fossil assemblages, such as the calcified rhizoliths recorded within lacustrine clays of the **Budin Formation** at Sishen (Partridge *et al.* 2006). These older Kalahari Group rocks are buried too deeply to be directly impacted by the proposed rail development to the south, however.

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 underlying lime-rich bedrocks 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*), tortoise remains 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 Gordonia Formation is therefore considered to be low. Underlying calcretes 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) may be expected occasionally expected within Kalahari Group sediments, including calcretes, notably those associated with ancient alluvial sands and gravels. Younger (Quaternary to Recent) surface gravels and colluvium are probably unfossiliferous.

Calcretised alluvial and wetland deposits along a tributary of the Gamagara drainage system at Witloop, to the north of Kathu, are associated with low-diversity trace fossil assemblages (Almond 2013). The traces include branching tubular burrows, possibly made by insects, dense tubular stem casts of reedy plants from swampy areas as well as sparse stone artefacts. Similar trace fossil assemblages may well be present within calcretised alluvial deposits along the Gamagara in the present study area. They are probably of widespread occurrence within the Kalahari Group and are not regarded as of high palaeontological significance. Well-consolidated, poorly-sorted calcrete gravel breccia and reddish-brown sands partially infilling solution hollows within thick karstified calcretes at the 16 MTPA manganese railway line loop study area near Sishen were searched, without success, for associated vertebrate bones and teeth or land snails by Almond (2013).

Important, taxonomically diverse Middle to Late Pleistocene mammalian macrofaunas as well as Stone Age artefacts have been recorded from multiple doline (solution hollow) infill sediments at Kathu Pan, *c*. 5.5. km NW of Kathu town (Beaumont 1990, Beaumont 2004, Beaumont *et al.* 1984; see also summary in Almond 2014). The fauna mainly consists of delicate, fragmentary tooth material (caps or shells or dental enamel) but also include some bones with at least one almost intact ungulate skeleton (Fig. 8). Most teeth and associated artefacts are covered with a distinctive shiny silicate patina. The fossils are assigned to the Cornelian Mammal Age (*c*. 1.6 Ma to 500 ka) and Florisian Mammal Age (*c*. 200 to 12 ka) that are associated with Acheulean and MSA stone artefact assemblages respectively (Klein 1984, 1988, Beaumont *et al.* 1984, Beaumont 1990, Beaumont 2004, Porat *et al.* 2010 and refs. therein; see also MacRae 1999). Interesting Cornelian mammal taxa found here include the extinct *Elephas recki* and *Hippopotamus gorgops* as well as various equids, white rhino and hartebeest / wildebeest-sized alcephalines. The dominance of grazers over browsers or mixed feeders among the Middle Pleistocene mammalian fauna suggests that the vegetation was grassy savannah at the time. Higher up in the succession the remains of typical Florisian forms such as *Pelorovis antiquus* the Giant Buffalo*, Megalotragus priscus* the Giant Hartebeest and *Equus capensis* the giant Cape Horse also occur (Fig. 9). Many of the tooth fragments as well as the associated MSA stone artefacts in this younger horizon are abraded, suggesting fluvial reworking of material into the doline together with the gravelly sand matrix. Additional fossil material of biostratigraphic and palaeoecological interest from the Kathu Pan doline infills include fossil pollens from well-developed peat horizons (Scott 2000), bird fossils, ostrich egg shell fragments and terrestrial gastropods. The mammalian remains may belong to animals attracted to permanent waterholes (*e.g.* spring eyes), especially during drier phases of the Pleistocene Epoch. The close association of large mammal fossils with abundant stone tools as well as occasional evidence for butchering suggests that human hunters or scavengers may also have played a role as concentration agents.

It is possible that solution cavities within calcretised alluvial sediments associated with the Gamagara drainage line south of Sishen might also contain important fossil vertebrate and Stone Age archaeological remains. The sector of the proposed rail link that crosses the Gamagara valley (See yellow dotted ellipse in Fig. 2a) is therefore potentially sensitive in palaeontological terms.

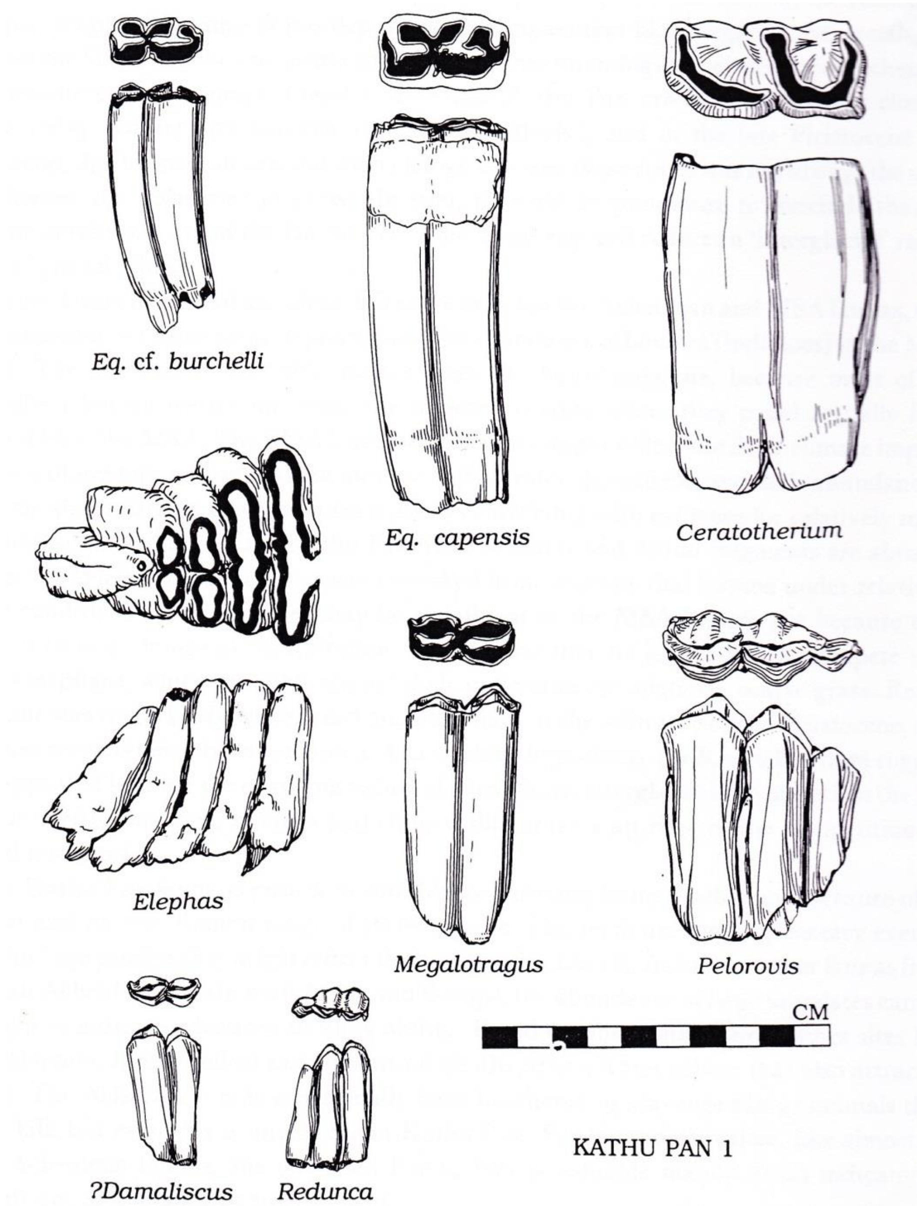

Fig. 8. Selection of Pleistocene large mammal teeth collected from solution cavity infills (dolines) at Kathu Pan, Northern Cape (From Klein 1988).

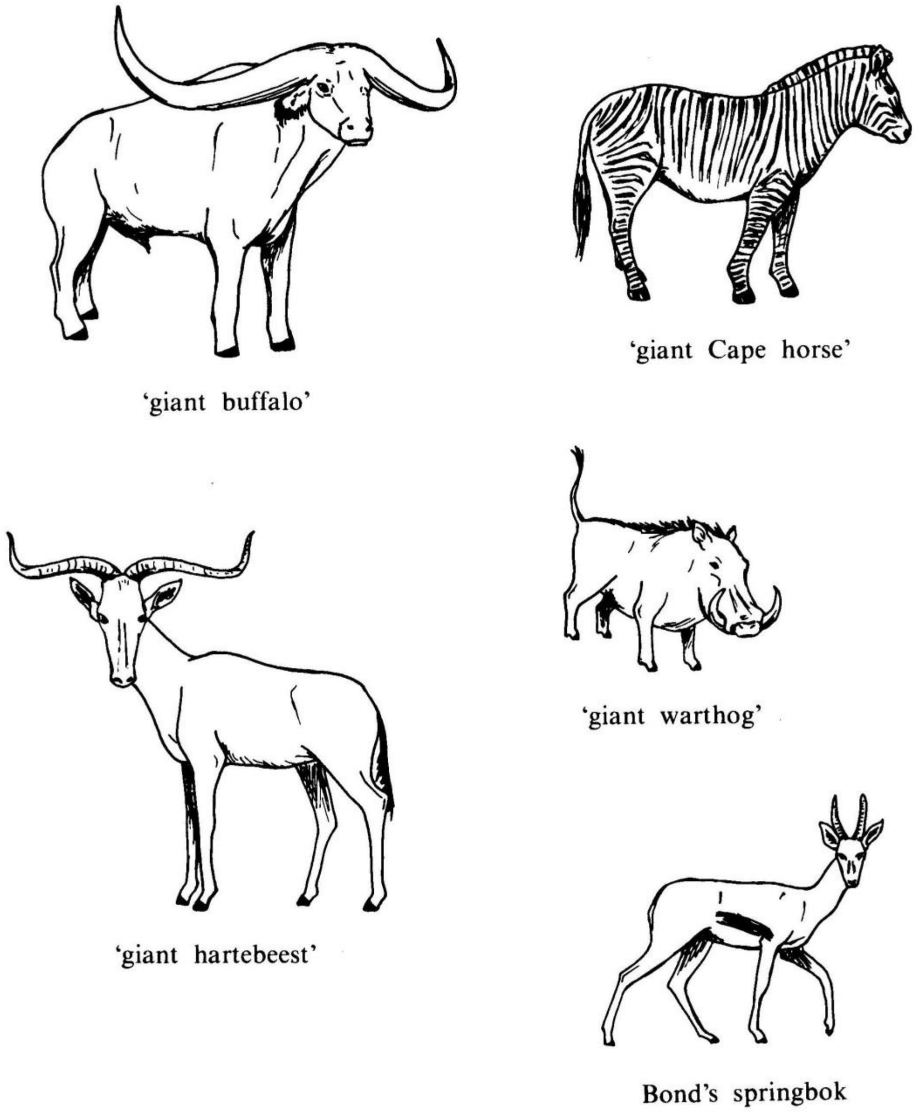

Fig. 9. Selection of extinct Pleistocene mammals of the Florisian Mammal Age, most of which are represented at Kathu Pan (From Klein 1984).

6. SUMMARY & RECOMMENDATIONS

The Precambrian bedrocks underlying the railway project area comprise terrestrial or submarine lavas (Ongeluk Formation, Postmasburg Group) as well as iron formation (Gamagara Formation, Elim Group) of Neoproterozoic age (*c*. 2 billion years old) that are completely unfossiliferous. The overlying thick Late Caenozoic superficial deposits – including calcretes, surface gravels and aeolian sands of the Kalahari Group – are, at most, sparsely fossiliferous and to a considerable extent already disturbed by mining-related activity. Low-diversity assemblages of trace fossils as well as non-marine molluscs (*e.g.* snails) and rare vertebrate remains (*e.g*. teeth, bones and horn cores of mammals) might occur within consolidated alluvial deposits along the Gamagara drainage line that is crossed by the proposed new rail link (See yellow dotted ellipse in Fig. 2a herein); important Pleistocene vertebrate and Stone Age archaeological remains are recorded from calcrete solution hollows at Kathu Pan, for example, less than 20 km north of the present study area. With the notable exception of the vertebrate remains, these Late Caenozoic fossils probably occur widely across the Kalahari region of the Northern Cape and are not considered to be of high conservation value.

Given (1) the comparatively small footprint of the proposed rail development, (2) the disturbed context, (3) the fact that there will be very little cut operations into the landscape since the new railway foundations would be placed on top of the natural ground level, as well as (4) the generally low palaeontological sensitivity of the bedrocks and superficial sediments in the study area, it is concluded that the proposed short rail link, including the associated construction camp and laydown area, is of overall LOW impact significance in terms of palaeontological heritage. Pending the discovery of significant new fossil remains before or during the construction phase, no further specialist palaeontological studies or mitigation are recommended for this development.

The ECO responsible for the Transnet Sishen Railway Line Link Project should be aware of the potential for important fossil fossil vertebrate finds within consolidated older alluvial deposits along the Gamagara drainage line (See yellow dotted ellipse in Fig. 2aa) and the necessity to conserve them for possible professional mitigation. A Chance Fossil Finds Procedure for this development is outlined in tabular form at the end of this report. Recommended mitigation of chance fossil finds during the construction phase of the proposed rail link involves safeguarding of the fossils (preferably *in situ*) by the responsible ECO and reporting of all significant finds to the SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). Where appropriate, judicious sampling and recording of fossil material and associated geological data by a qualified palaeontologist, appointed by the developer, may be required. Any fossil material collected should be curated within an approved repository (museum / university fossil collection).

These recommendations should be included within the Environmental Management Programme (EMPr) for the proposed railway development.

7. ACKNOWLEDGEMENTS

Mr Bharat Gordhan of AECOM, Centurion, is thanked for commissioning this study and for providing the relevant background information. I am grateful to Mr Gordhan and Ms Madelon Tusenius for handling the very substantial administrative documentation required for this desktop project.

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9. 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, Mpumalanga, Free State, Limpopo, Northwest and KwaZulu-Natal under the aegis of his Cape Town-based company *Natura Viva* cc. He has been 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 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.

Dr John E. Almond
Palaeontologist
***Natura Viva* cc**

<table>
<tr><td colspan="3">CHANCE FOSSIL FINDS PROCEDURE: Transnet Sishen Rail link line between two existing railway lines near Sishen</td></tr>
<tr><td>Province & region:</td><td colspan="2">NORTHERN CAPE, Kuruman District</td></tr>
<tr><td>Responsible Heritage Management Authority</td><td colspan="2">SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Kalahari Group, consolidated older alluvial deposits along the Gamagara River</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Bones, teeth, horn cores of mammals as well as calcretised burrows (e.g. termite nests, plant root and stem casts) , non-marine molluscs</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
• Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
• Context – describe position of fossils within stratigraphy (rock layering), depth below surface
• Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
• Alert Heritage Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation
• Ensure fossil site remains safeguarded until clearance is given by the Heritage Management Authority for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
• Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
• Photograph fossils against a plain, level background, with scale
• Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
• Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
• Alert Heritage Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Management Authority, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Management Authority</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Management Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Management Authority minimum standards.</td></tr>
</table>