PALAEONTOLOGICAL HERITAGE REPORT: DESKTOP STUDY

Proposed mineral prospecting on the Remaining Extent and Portion 1 of the Farm Demaneng 546, Gamagara Local Municipality, Kuruman Magisterial District, Northern Cape Province

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September 2019

1. EXECUTIVE SUMMARY

Ditukus Projects (Pty) Ltd, Northriding, is applying for Environmental Authorisation and Prospecting Rights (PR) for mineral prospecting (iron and manganese ores) on the Remaining Extent and Portion 1 of the farm Demaneng 546, situated some 10 km southeast of the town of Kathu in the Kuruman Magisterial District, Northern Cape Province. The proposed prospecting activities and associated infrastructure will include 20 boreholes with blasting, bulk sampling from 10 trenches, ablution facilities, diesel tanks, generator site, offices, workshop, processing plants, roads, salvage yard, stockpile area, washbay, waste rock dumps, water tank, weighbridge and control room over an area of 2 073 ha.

The Precambrian (Neoproterozoic) iron and manganese ores of the Manganore Formation and Wolhaarkop breccia that are the targets of the proposed prospecting activities are unfossiliferous, with the possible exception of – hitherto unrecorded - microfossil assemblages within less altered ironstone facies, comparable to those known from the Kuruman Formation banded ironstones of the Ghaap Group. The host carbonates of the Campbellrand Subgroup may contain stromatolites (fossil microbial mounds) but these would only be encountered in the subsurface where they are likely to be secondarily mineralised and karstified. Scientifically useful exposures of intact, well-preserved stromatolitic horizons during surface trenching are considered unlikely, although borehole cores might yield sections through identifiable stromatolites. The Late Caenozoic superficial deposits overlying the Precambrian bedrocks within the project footprint – including calcretes, surface gravels and aeolian sands of the Kalahari Group – are, at most, sparsely fossiliferous. Direct impacts on potentially-fossiliferous calcretised alluvium and terrace gravels along the Ga-Mogara drainage line are unlikely since this lies well to the north of the project footprint.

Given (1) the comparatively small footprint of the proposed prospecting activities as well as (2) the generally low palaeontological sensitivity of the bedrocks and superficial sediments in the study area, it is concluded that the proposed development, including boreholes, trenches, plant and associated infrastructure, is of overall LOW impact significance in terms of palaeontological heritage. Pending the potential discovery of significant new fossil remains (*e.g.* well-preserved stromatolite horizons) during the invasive prospecting phases, no further specialist palaeontological studies or mitigation are recommended here and there are no objections on palaeontological heritage grounds to authorisation of this project.

The ECO responsible for the mineral prospecting programme on Demaneng 546 should be aware of the potential for exposure of well-preserved stromatolites through trenching and in borehole cores. 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 prospecting 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 mineral prospecting project.

2. INTRODUCTION & BRIEF

The company Ditukus Projects (Pty) Ltd, Northriding, is applying for Environmental Authorisation and Prospecting Rights (PR) for mineral prospecting (iron and manganese ores) on the Remaining Extent and Portion 1 of the farm Demaneng 546, situated some 10 km southeast of the town of Kathu in the Kuruman Magisterial District, Northern Cape Province (Figs. 1 & 2). The proposed prospecting activities and associated infrastructure will include 20 boreholes with blasting, bulk sampling in the form of 10 trenches, ablution facilities, diesel tanks, generator site, offices, workshop, processing plants, roads, salvage yard, stockpile area, washbay, waste rock dumps, water tank, weighbridge and control room over an area of 2 073 ha (Fig. 3).

Phases 2 and 4 of the proposed prospecting programme will be invasive and are outlined as follows in the Draft Environmental Impact Assessment Report and Environmental Management Programme Report prepared by M and S Consulting (Pty) Ltd., Kimberley (See also Fig. 3):

- Phase 2: Percussion drilling

Percussion drilling will be used initially to identify the position of a suspected base metal deposit. The position of the boreholes is dependent on the results of the review of historical activities, geological mapping, desktop study and geophysical survey.
Twenty boreholes, each 50 m deep (can be more or less depending on results), are planned. The collar position of all boreholes will be surveyed. All drilling will be short term and undertaken by a contractor using truck-mounted equipment.
Angled percussion holes are planned to locate and intersect the mineralization. A traverse line or grid drilling is used to identify and define the extent of any mineralization. The sizes of the boreholes drilled will be determined by such factors as cost, proposed sampling, availability of drilling machines and the volume of sample required, among others.

- Phase 4: Bulk sampling

Bulk sampling will be conducted during phase 4 of the prospecting period for a period of 19 months. Ditukus plans to bulk sample a total volume of 47 500 m³ of ore. For exploration purposes 23 750 m³ of iron ore will be bulk sampled and 23 750 m³ of manganese ore will be bulk sampled. Bulk sampling will be conducted at a rate of 10 000 tonnes of final (sellable) tonnes per month.

With the 1:1 stripping ratio the total tonnes excavated per month calculates to 20 000 tonnes. 20 000 tonnes / month x 19 months = 380 000 tonnes total excavated for the prospecting period of which 190 000 tonnes will be final (sellable) ore. The bulk sampling will be conducted with a yellow fleet consisting of: 1 x 80T Excavator, 1 x 30T Excavator, 3 x ADT, 2 X Front End Loader and 2 x Mobile Crushing & Screening Plants (1 for iron ore & 1 for manganese ore).

The proposed mineral prospecting activities might impact palaeontological heritage resources within the underlying bedrocks and superficial sediments of the Precambrian Transvaal Supergroup and the Late Caenozoic Kalahari Group respectively. The SAHRA Archaeology, Palaeontology and Meteorites (APM) Unit have therefore requested that:

> *A Palaeontological Impact Assessment (PIA) inclusive of a field visit be conducted during the EIA phase of the EA process as the proposed footprint for the prospecting activities is located within an area of very high palaeontological sensitivity as per the SAHRIS PalaeoSensitivity map. The PIA must be conducted by a qualified palaeontologist and the report must comply with the SAHRA 2012 Minimum Standards: Palaeontological Components of Heritage Impact Assessments (*SAHRA Case ID: 14119, Interim Comment dated Monday August 26, 2019).

The present palaeontological heritage specialist report has accordingly been commissioned on behalf of the proponent by M and S Consulting (Pty) Ltd, Kimberley (Contact details: Ms Tanja Jooste. M and S Consulting (Pty) Ltd, 36 William Street, Kestellhof, Kimberley, 8301. Tel No: 053 861 1765. Fax No: 086 636 0731. E-Mail address: ms.consulting@vodamail.co.za). Since potentially fossiliferous carbonate bedrocks of the Campbellrand Subgroup are not exposed within the Demaneng project area (based on published 1: 250 000 geological maps and satellite imagery), only a desktop assessment of the proposed mineral prospecting is presented here.

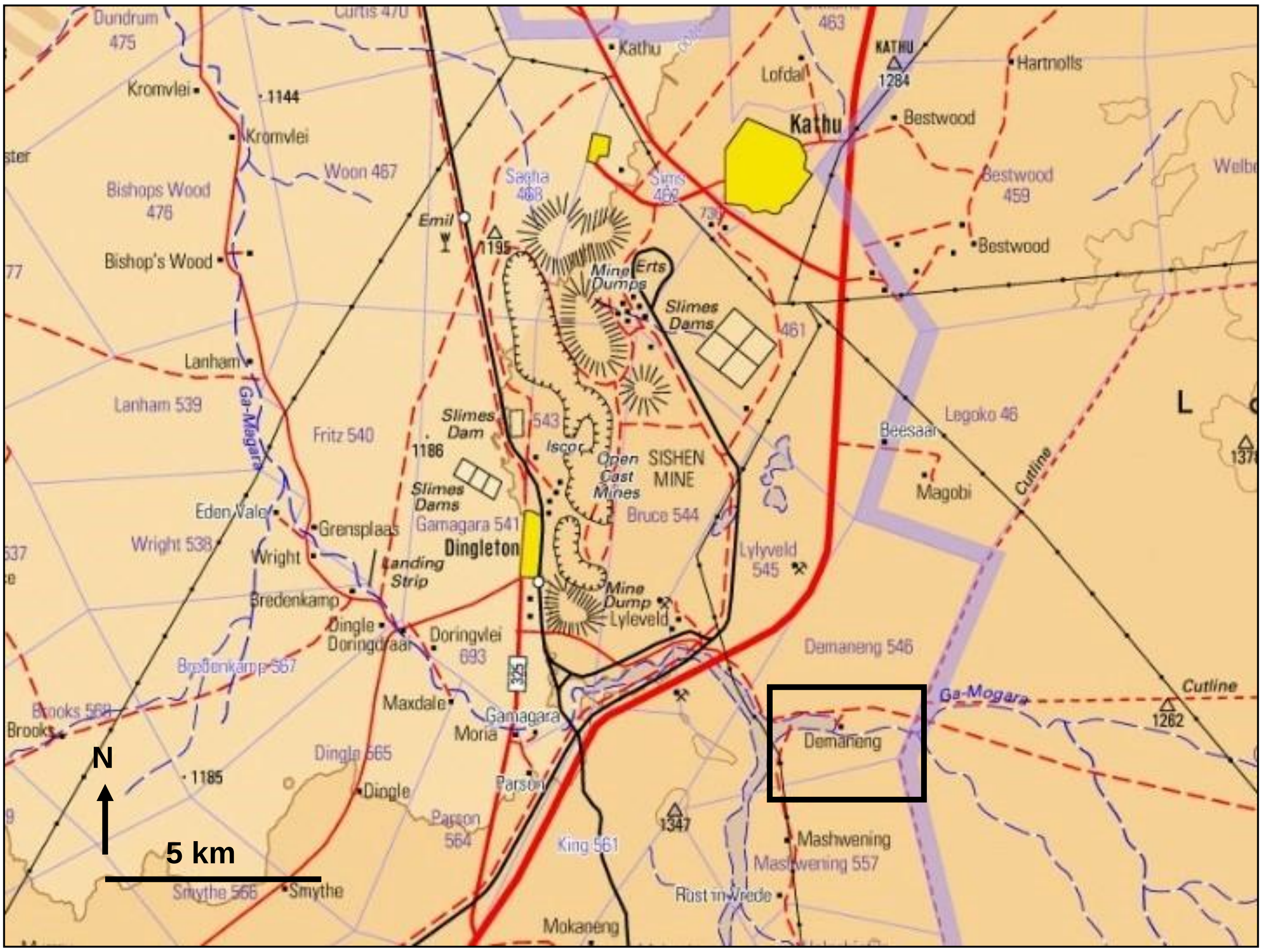

Figure 1: Extract from 1: 250 000 topographical sheet 2722 Kuruman showing the *approximate* location of the proposed mineral prospecting activities on the Remaining Extent of the Farm Demaneng 546 and Portion 1 of the Farm Demaneng 546 (black rectangle). The site lies on the eastern side of the N14 Postmasburg – Kathu tar road and south of the Ga-Mogara River, some 10 km SE of the town of Kathu in the Kuruman District, Northern Cape Province (Map courtesy of the Chief Directorate of Surveys & Mapping, Mowbray).

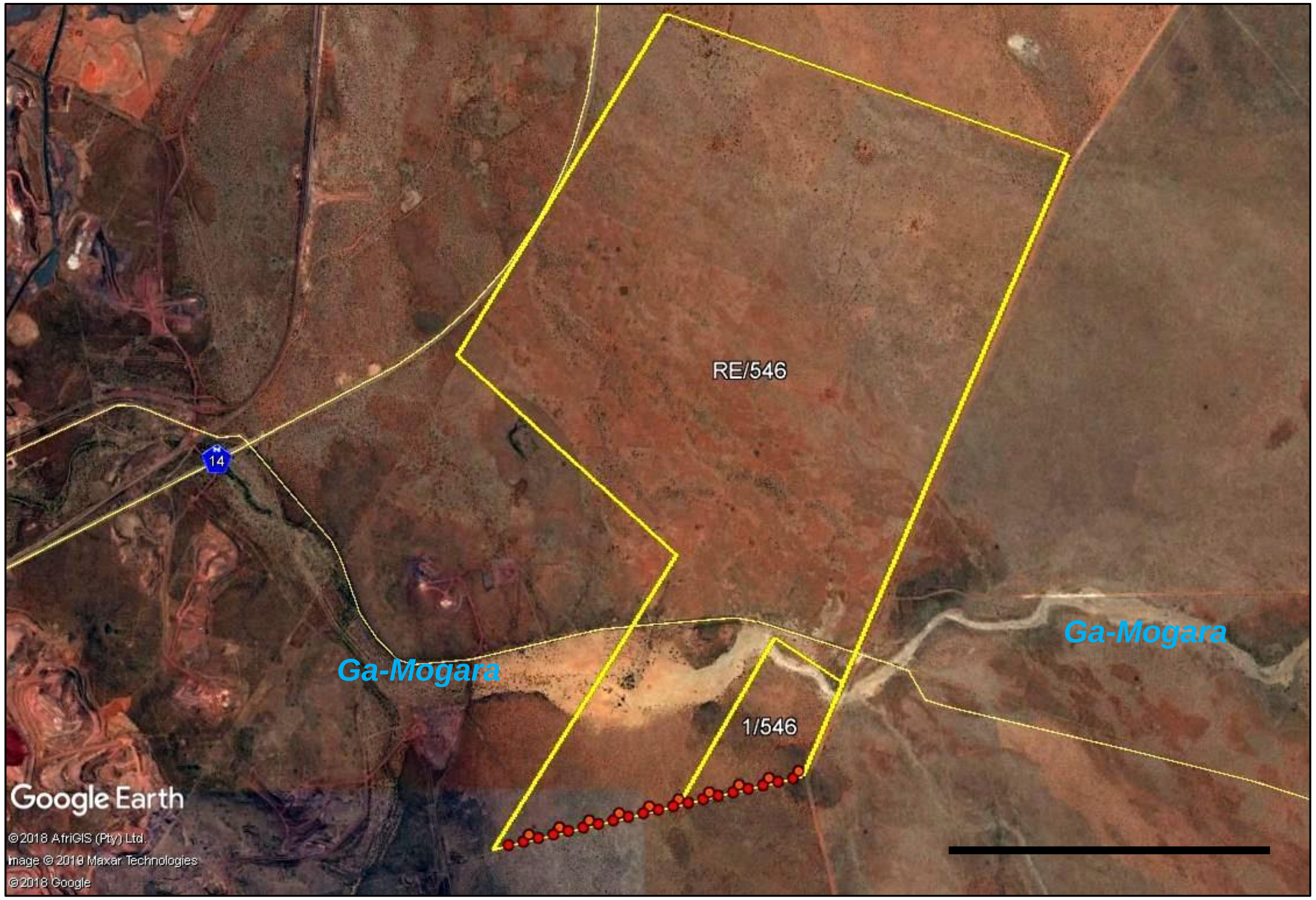

Figure 2: Google Earth© satellite image of the mineral prospecting area southeast of Kathu showing the Remaining Extent of the Farm Demaneng 546 and Portion 1 of the Farm Demaneng 546 (yellow polygons). Proposed borehole sites are indicated in red and trenches in orange (See Figure 3 for more detail). Carbonate bedrocks of the Campbellrand Subgroup are not mapped near-surface in the prospecting area. Most of the area is mantled by orange-hued Quaternary to Recent Kalahari sands. Darker brown areas are underlain by iron formation (Manganore Formation / Wolhaarkop chert breccia) while pale cream hues are associated with calcrete along the Ga-Mogara drainage line. 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 the consolidated older alluvial deposits are planned, including alluvial terrace gravels mapped along the Ga-Mogara to the north and east of the project footprint. Scale bar = 3 km. N towards the top of the image.

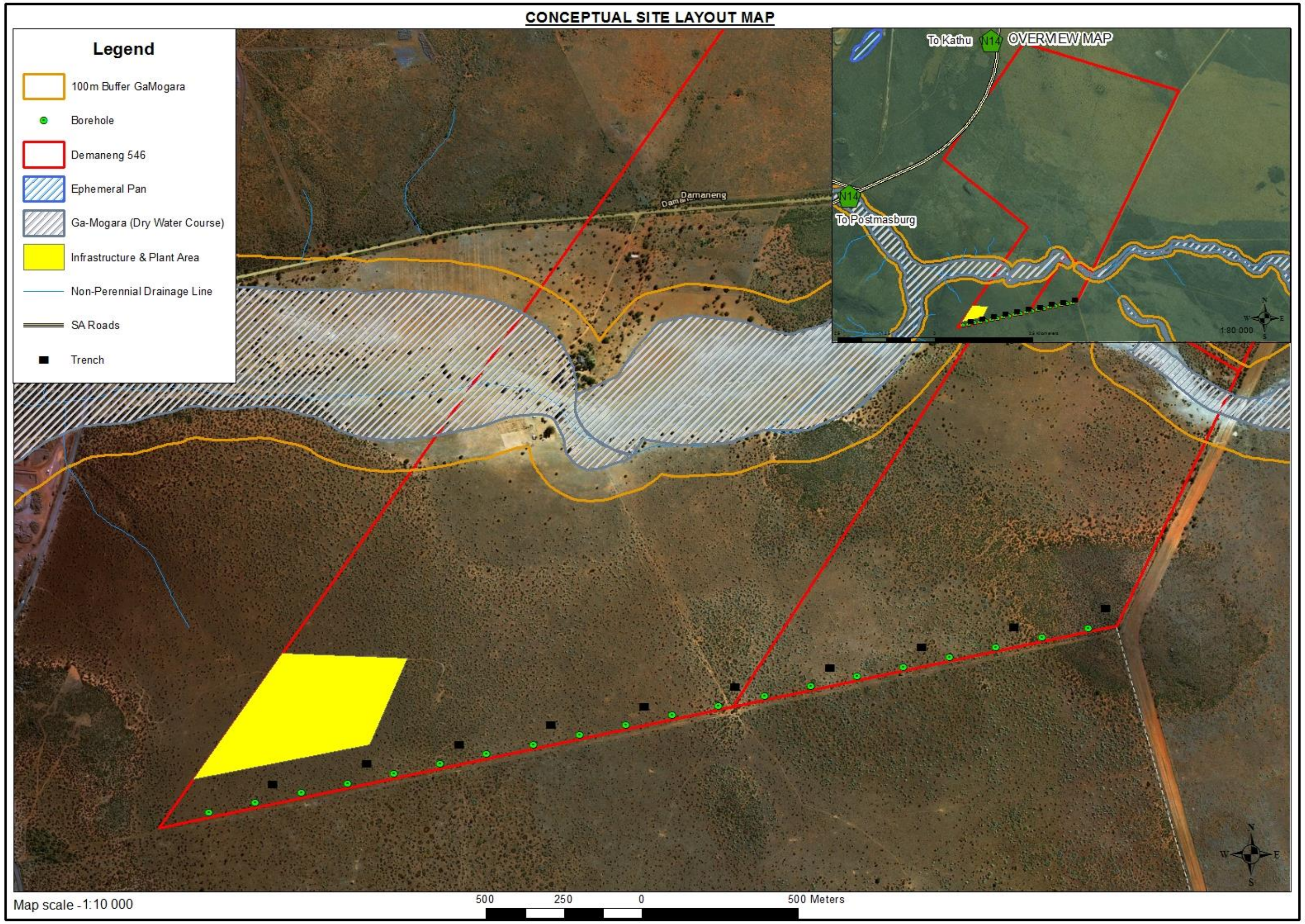

Figure 3: Conceptual site layout map for the proposed mineral prospecting activities on the Remaining Extent of the Farm Demaneng 546 and Portion 1 of the Farm Demaneng 546 (Image abstracted from the Draft EIA Report prepared by M and S Consulting (Pty) Ltd). The project footprint lies well away from potentially-sensitive older alluvial deposits (terrace gravels, calcretes *etc*) along the Ga-Mogara drainage line.

2. 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 description, maps, kmz files, Draft EIA Report and supporting documents provided by M&S Consulting Pty (Ltd), Kimberley;

2. A review of the relevant satellite images, topographical maps and scientific literature, including published geological maps and accompanying sheet explanations, as well as previous desktop and field-based palaeontological assessment studies featuring comparable bedrocks in the Kathu - Sishen region (*e.g.* Almond 2010, 2013, 2014, 2015a, 2015b, 2018a, 2018b, 2018c, 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 Kathu little is known about local fossil heritage resources on the basis of palaeontological field studies apart from a few field-based palaeontological assessment reports (See References under Almond). However, given (1) the comparatively small footprint of the proposed development, (2) the lack of bedrock exposure here 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 mineral prospecting project is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Precambrian and younger, mainly 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 mining project is unlikely to involve further adverse impacts on local palaeontological heritage.

The present combined desktop and field-based palaeontological heritage study will contribute to the EIA for the project and falls under the National Heritage Resources Act, 1999 (NHRA). It will also inform the Environmental Management Programme (EMPr) for this 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).

3. GEOLOGICAL BACKGROUND

The Ditukus Projects (Pty) Ltd mineral prospecting study area on the Remaining Extent of the Farm Demaneng 546 and Portion 1 of the Farm Demaneng 546 is situated in fairly flat-lying terrain at around 1220-1250 m amsl. It lies between the Langberge in the west and the Kurumanheuwels in the east and falls within the semi-arid Southern Kalahari Geomorphic Province (Partridge *et al.* 2010). It is located *c*. 10 km SE of Kathu on the eastern side of the N14 tar road between Kathu and Postmasburg, close to the Sishen opencast iron ore mine, Northern Cape (Figs. 1 to 3). This region is drained by the shallow, non-perennial Ga-Mogara drainage line which runs 800 to 1500 m to the north of the project footprint and when in flood flows into the Kuruman River to the north of Hotazel.

The geology of the Kathu - Sishen region is shown on the 1: 250 000 geological sheet 2722 Kuruman (Council for Geoscience, Pretoria) (Fig. 4 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. 5 & 6).

As shown on these recently published maps, the Kathu-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. The host rocks for the target mineral ores on Demaneng 546 are shallow marine carbonates of the **Campbell Rand Subgroup** (Vgd in Fig. 4) of the Ghaap Group - previously included within the “Ghaapplato Formation” in older literature. This is a very thick (1.6 - 2.5 km) carbonate platform succession of dolostones, dolomitic limestones and cherts with minor tuffs and siliciclastic rocks. It 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 2005). A range of shallow water facies, often forming depositional cycles reflecting sea level changes, are represented here, including stromatolitic limestones and dolostones, oolites, oncolites, laminated calcilutites, cherts and marls, with subordinate siliclastics (shales, siltstones) and minor tuffs (Beukes 1980, Beukes 1986, Sumner 2002, Eriksson *et al.* 2006, Sumner & Beukes 2006). The Campbellrand carbonate bedrocks within the project area are karstified and do not appear to be exposed at surface (*cf* Figs. 2 & 4) but are likely to be encountered during borehole and trenching operations.

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. 7).

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 broader Sishen region 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. 8).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 northwest 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); these older Kalahari beds are unlikely to be represented within the present study area, however. 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 along the Ga-Mogara drainage line 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 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. Calcretised **older alluvial deposits** have been described in association with a tributary of the Ga-Mogara 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. Older terrace gravels are mapped along the banks of the Ga-Mogara drainage line to the north and east of the present study area. However, none of these older alluvial deposits lies within the footprint of the mineral prospecting project.

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.

The following useful account of the geology of the target iron and manganese ore deposits within the Ditukus prospecting area on the Remaining Extent of the Farm Demaneng 546 and Portion 1 of the Farm Demaneng 546 is provided in the Draft EIA Report:

The Postmasburg iron & manganese field is situated on the Maremane Anticline dome, which is located within the Kaapvaal Craton, although close to its western margin. The country rocks are Palaeoproterozoic metasediments of the Transvaal Supergroup. Two arcuate belts of deposits extend from Postmasburg in the south to Sishen in the north. Two major ore types are present. The ferruginous type of ore is composed mainly of braunite, partidgeite and bixbyite and occurs along the center of the Gamagara Ridge, or Western Belt. The siliceous type of ore consists of braunite, quartz and minor partidgeite and occurs in deposits along the Klipfontein Hills (or Eastern Belt) and the northern and southern extremities of the Gamagara Ridge. Dolomites of the Campbellrand Group form the basement rock for these deposits and are overlain by the Manganore Iron-Formation and the Gamagara Formation. The dolomite palaeosurface is karstified, leading to collapse structures where iron and manganese formation has fallen into karst cavities to form the well-known Wolhaarkop Breccia body. Geological and geochemical evidence suggest that the manganese ores represent weakly metamorphosed wad deposits that accumulated in karst depressions during a period of lateritic weathering and karstification in a supergene, terrestrial environment during the Late Paleoproterozoic period. The dolomites of the Campellrand Group of the Transvaal Supergroup are host and source for the wad accumulations. The ore at Demaneng originated as pods and lenses of wad in chert breccia that accumulated in a karst cave system capped by the hematitized Manganore iron-formation of the Transvaal Supergroup. The cave system finally collapsed and the hematitized iron-formation slumped into the sinkhole structures. The manganese ores were affected by diagenesis and lower greenschist facies metamorphism. Evidence for renewed subaerial exposure of the ore and their host rocks can be seen in the secondary karstification and supergene weathering.

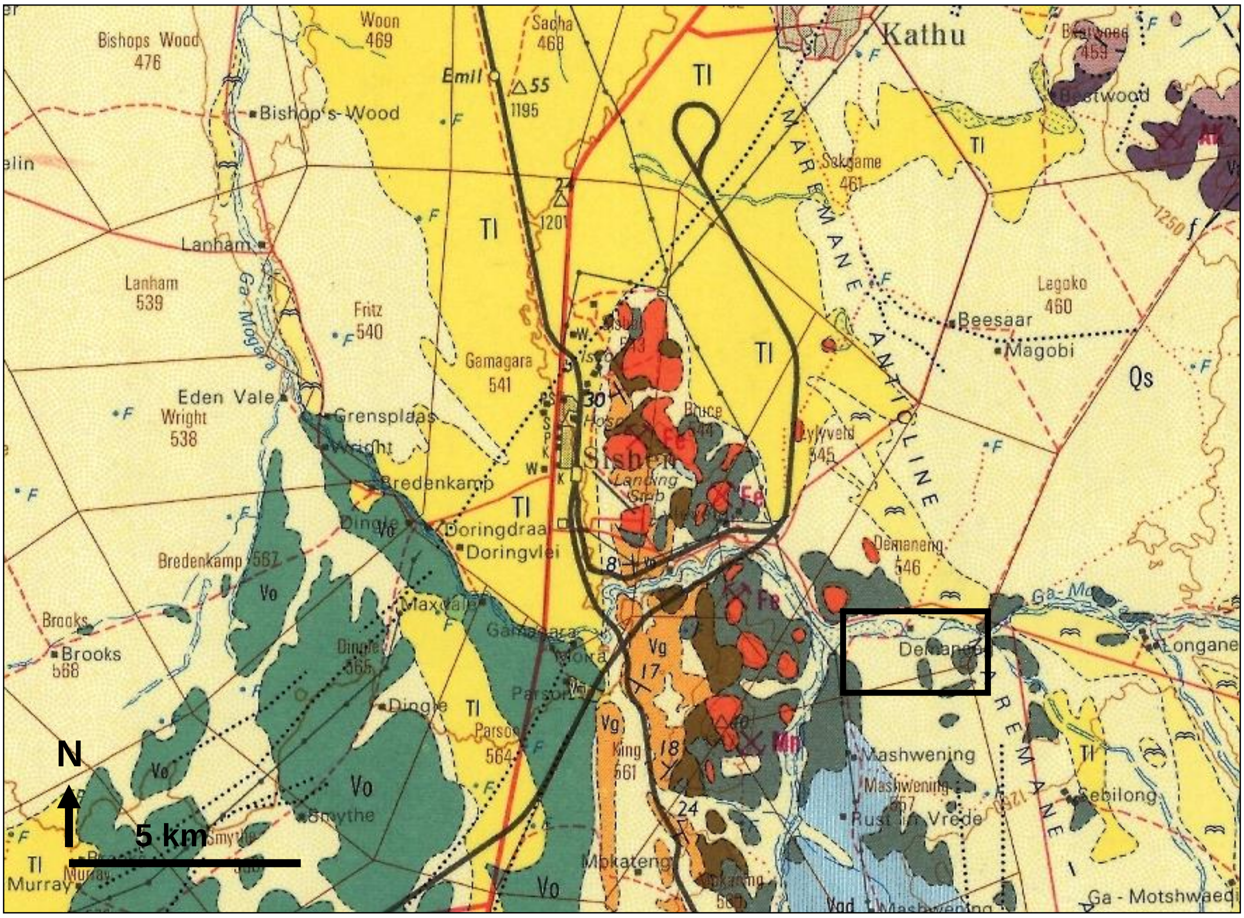

Figure 4: Extract from 1: 250 000 geological map 2722 Kuruman (Council for Geoscience, Pretoria) showing the approximate location of the mineral prospecting study area on the Remaining Extent of the Farm Demaneng 546 and Portion 1 of the Farm Demaneng 546 near Kathu and Sishen (black rectangle) (Note 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; Tl (dark yellow) = Kalahari calcretes; Qs (pale yellow) = red Kalahari Group sands (Gordonia Formation). ***N.B.*** **Older terrace gravels (yellow with double flying bird symbol) are mapped along the banks of the Ga-Mogara drainage line to the north and east of the present study area.**

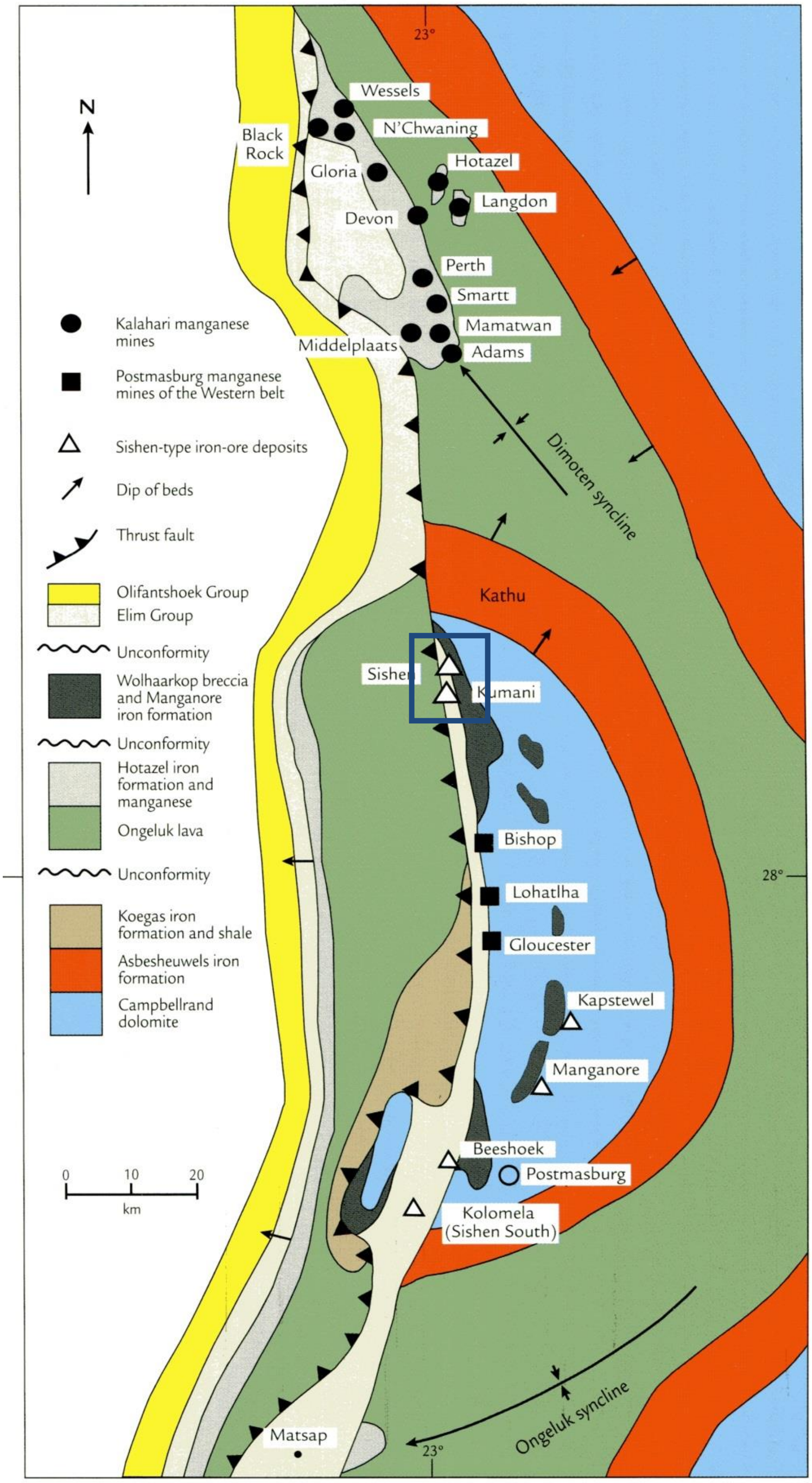

Figure 5: Schematic geological map of the Griqualand West region, Northern Cape, showing the revised stratigraphic interpretation of the rock units represented in the Sishen – Kathu study region (dark blue square) (Map abstracted from Cairncross & Beukes 2013). The Ongeluk lava outcrop area (grey-green) also includes the Makganyene Formation diamictites that are not mapped in the present study area (See Fig. 6).

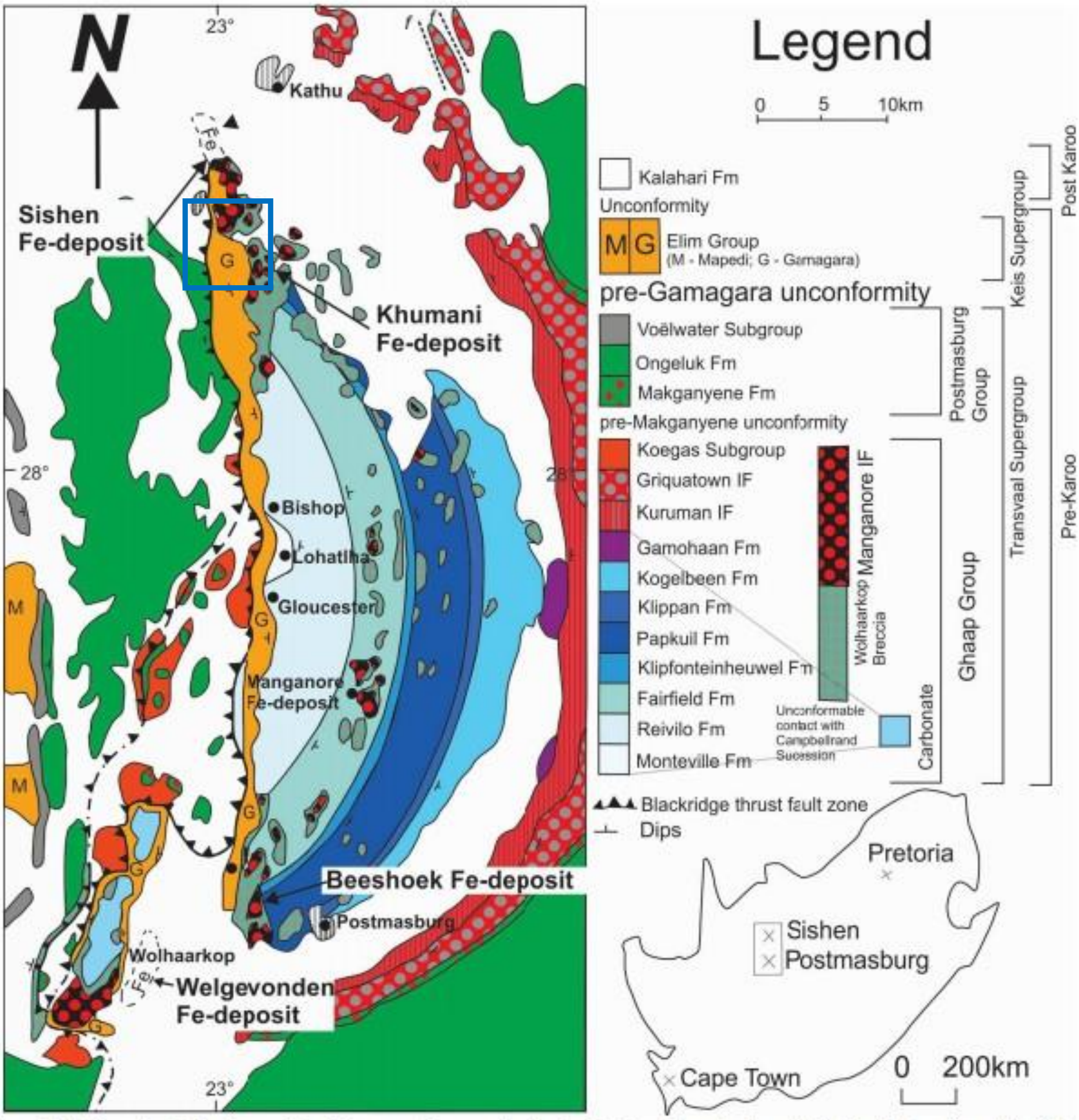

Figure 2: Regional geological map of the Maremane Dome region in the Northern Cape Province indicating the location of the Sishen, Khumani, Beeshoek and Sishen South iron ore deposits (modified after Van Schalkwyk and Beukes, 1986).

Figure 6: 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 opencast iron ore mine lies within the blue square. The Makganyene Formation outcrop area is shown in orange with green spots (contrary to the legend).

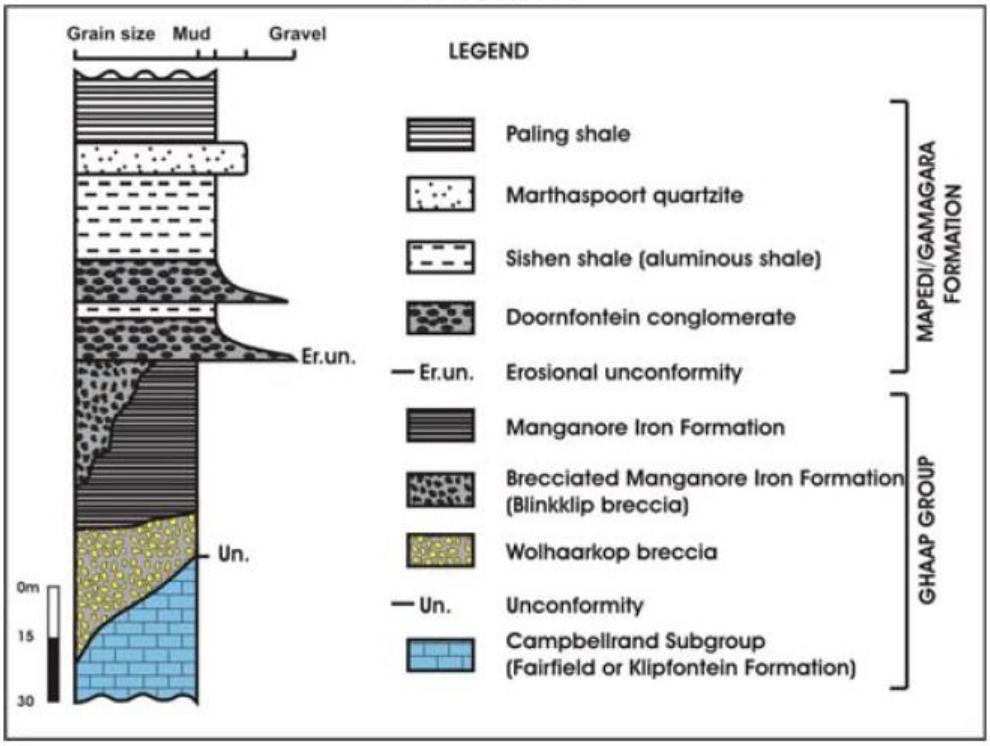

Figure 7: Stratigraphic setting of the iron formations in the Sishen area (From Schalkwyk 2005). The Gamagara Formation with the ferruginous Doornfontein conglomerates its base forms the unconformable local base of the Elim Group (Kheis Supergroup). The Manganore Formation and underlying Wolhaarkop Breccia 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. These iron and manganese ores are the targets for the present mineral prospecting project.

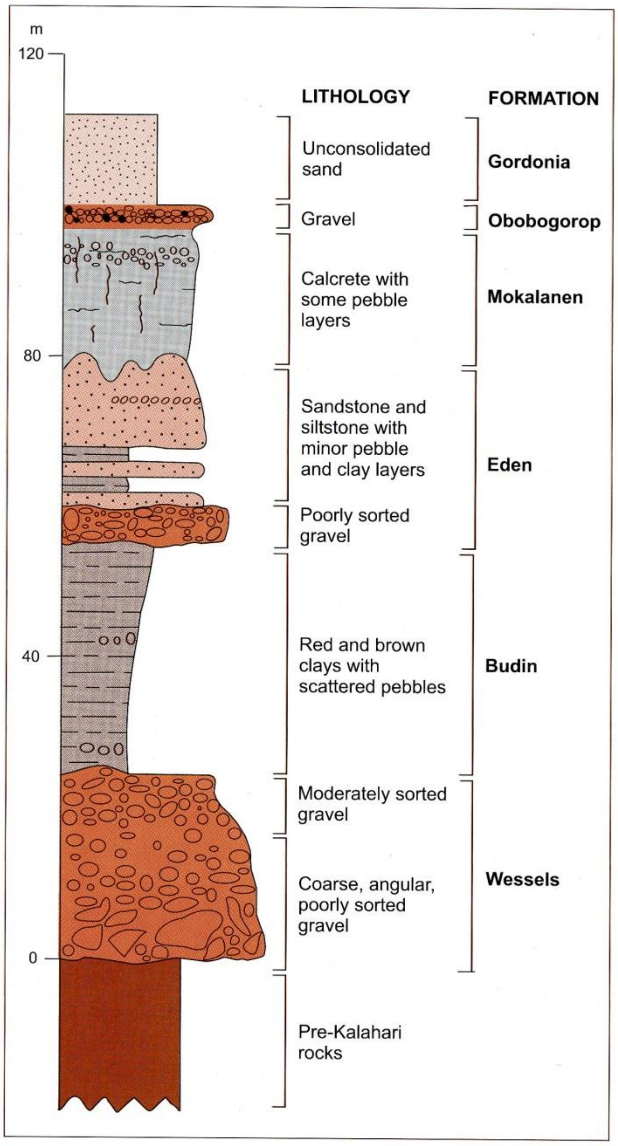

Figure 8: Generalised stratigraphy of the Late Cretaceous to Recent Kalahari Group (From Partridge *et al.* 2006). Most or all of these rock units are represented within the Kathu – Sishen study region but only Plio-Pleistocene subsurface calcretes (Mokalanen Formation) and overlying Pleistocene to Recent aeolian sands of the Gordonia Formation are likely to be directly impacted by the proposed mineral prospecting programme.

4. PALAEONTOLOGICAL HERITAGE

4.1. Fossils within the Precambrian bedrocks

Potentially stromatolitic shallow marine carbonates of the **Campbellrand Subgroup** (Ghaap Group) are not mapped at surface within the present study area on Demaneng 546, although they can be expected to be present in the subsurface where they are likely to be extensively karstified. The Campbell Rand carbonates in the Griqualand West Subbasin are well known for their rich fossil biota of *stromatolites* or microbially-generated, finely-laminated sheets, mounds, domes, columns 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 and several subsequent papers), Beukes (1980, 1983), Eriksson & Truswell (1974), Eriksson & Altermann (1998), Eriksson *et al* (2006), Altermann and Herbig (1991), Altermann and Wotherspoon (1995), and Sumner (2002). The oldest, Archaean stromatolite occurrences from the Ghaap Group have been reviewed by Schopf (2006, with full references therein).

The **Manganore Formation** ironstones have not yielded any macrofossils or macroscopic biosedimentary structures such as stromatolites; the latter are generally associated with shallower water deposits within the photic zone. However, it is possible that less altered Manganore sediments may contain microfossil assemblages comparable to those reported from cherty facies within the Kuruman Formation of the Ghaap Group (*cf* MacRae 1999, Tankard *et al.* 1982 and refs. therein). *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.

4.2. Fossils within the Kalahari Group

The fossil record of the Kalahari Group is generally sparse and low in diversity. This applies to the Mokalanen calcretes and Gordonia dune sands that overlie the Precambrian bedrocks within the present study area.

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 Ga-Moggara 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 Ga-Mogara 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. 9). 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. 10). 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 Ga-Mogara drainage line southeast of Sishen might also contain important fossil vertebrate and Stone Age archaeological remains. However, the available geological maps indicate that these deposits lie outside the footprint of the present prospecting project (Fig. 3).

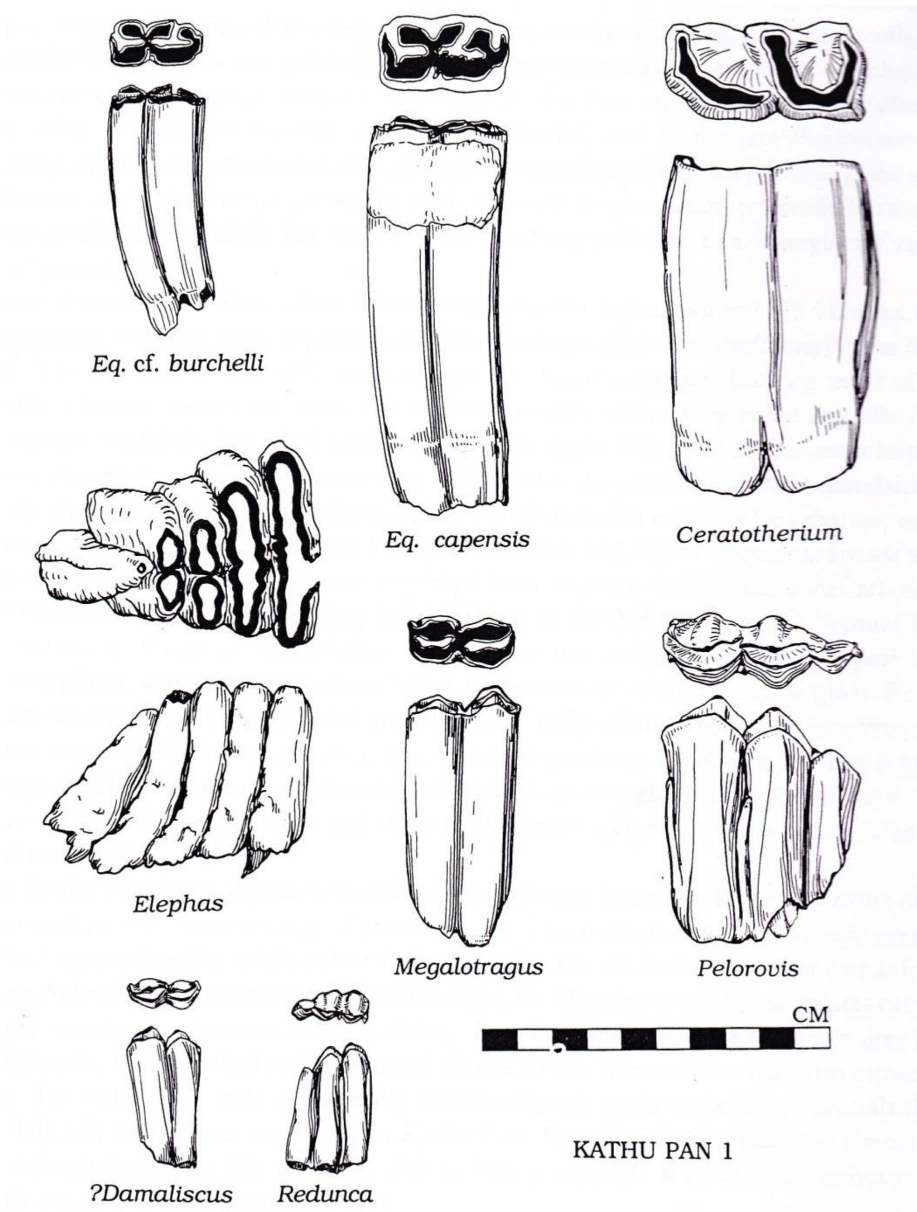

Figure 9: Selection of Pleistocene large mammal teeth collected from solution cavity infills (dolines) at Kathu Pan, Northern Cape (From Klein 1988).

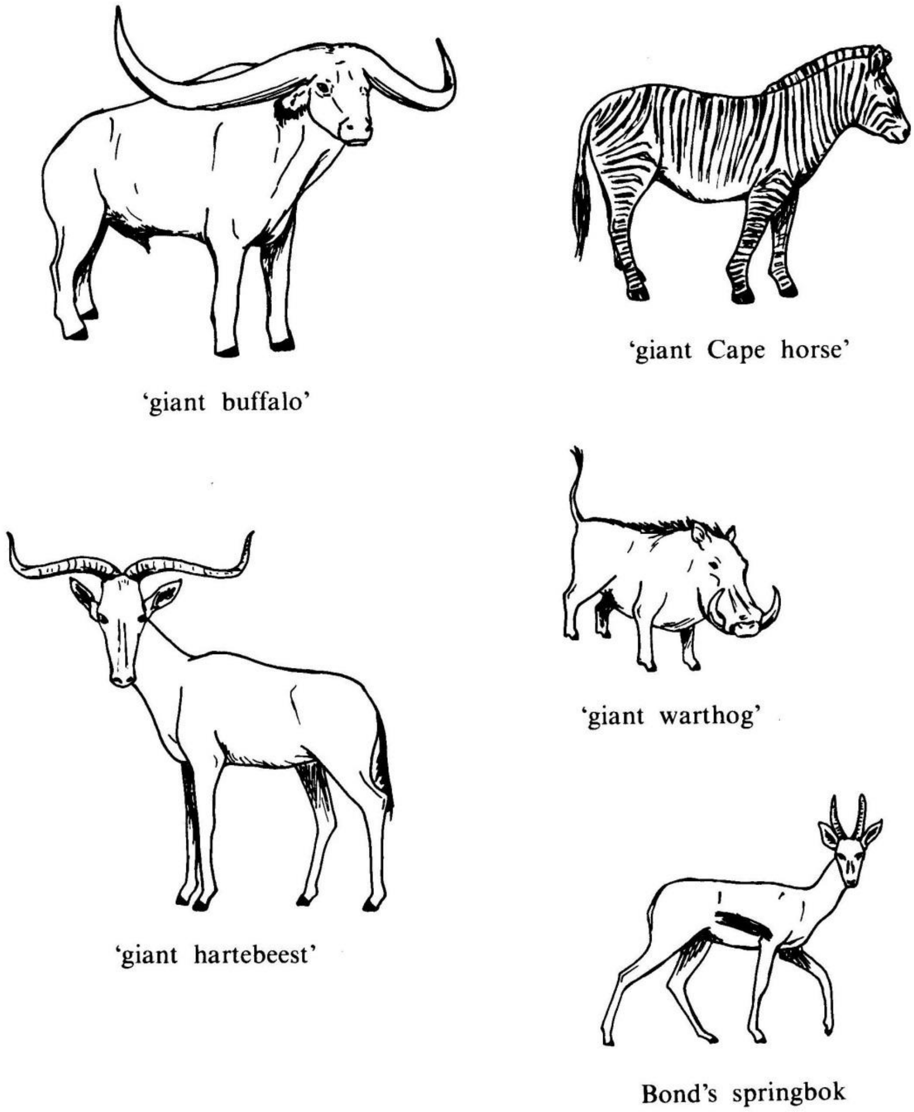

Figure 10: Selection of extinct Pleistocene mammals of the Florisian Mammal Age, most of which are represented at Kathu Pan (From Klein 1984).

5. SUMMARY & RECOMMENDATIONS

The Precambrian (Neoproterozoic) iron and manganese ores of the Manganore Formation and Wolhaarkop breccia that are the targets of the proposed prospecting activities on Demaneng 546 near Kathu are unfossiliferous, with the possible exception of – hitherto unrecorded - microfossil assemblages within less altered ironstone facies, comparable to those known from the Kuruman Formation banded ironstones of the Ghaap Group. The host carbonates of the Campbellrand Subgroup may contain stromatolites (fossil microbial mounds) but these would only be encountered in the subsurface where they are likely to be secondarily mineralised and karstified. Scientifically useful exposures of intact, well-preserved stromatolitic horizons during surface trenching are considered unlikely, although borehole cores might yield sections through identifiable stromatolites.

The Late Caenozoic superficial deposits overlying the Precambrian bedrocks within the project footprint – including calcretes, surface gravels and aeolian sands of the Kalahari Group – are, at most, sparsely fossiliferous. Direct impacts on potentially-fossiliferous calcretised alluvium and terrace gravels along the Ga-Mogara drainage line are unlikely since this lies well to the north of the project footprint.

Given (1) the comparatively small footprint of the proposed prospecting activities as well as (2) the generally low palaeontological sensitivity of the bedrocks and superficial sediments in the study area, it is concluded that the proposed development, including boreholes, trenches, plant and associated infrastructure, is of overall LOW impact significance in terms of palaeontological heritage. Pending the potential discovery of significant new fossil remains (*e.g.* well-preserved stromatolite horizons) during the invasive prospecting phases, no further specialist palaeontological studies or mitigation are recommended here and there are no objections on palaeontological heritage grounds to authorisation of this project.

The ECO responsible for the mineral prospecting programme on Demaneng 546 should be aware of the potential for exposure of well-preserved stromatolites through trenching and in borehole cores. 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 prospecting 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 mineral prospecting project.

6. ACKNOWLEDGEMENTS

Ms Tanja Jooste of M and S Consulting (Pty) Ltd, Kimberley, is thanked for commissioning this desktop study as well as for providing the necessary background information.

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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, Mpumalanga, Free State, Limpopo, Northwest, Gauteng 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.

John E. Almond

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

<table>
<tr><td colspan="3">CHANCE FOSSIL FINDS PROCEDURE: Mineral prospecting on Remaining Extent & Portion 1 of Farm Demaneng 546 near Kathu</td></tr>
<tr><td>Province & region:</td><td colspan="2">NORTHERN CAPE, Kuruman District</td></tr>
<tr><td>Responsible Heritage Resources 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">Campbellrand Subgroup carbonate bedrocks.
Kalahari Group, consolidated older alluvial deposits associated with the Ga-Mogara drainage line.</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Well-preserved stromatolitic horizons within the carbonate bedrocks (exposed in trenches / borehole cores)
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 Resources 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 Resources 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 Resources Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources 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 Resources 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 Resources Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Authority minimum standards.</td></tr>
</table>