PALAEONTOLOGICAL HERITAGE REPORT: DESKTOP STUDY

Proposed mineral prospecting on the farms Spitz Kop 168, Bingap 184 and Cairnpoint 195 near Groblershoop, Hay Magisterial District, Northern Cape Province

John E. Almond PhD (Cantab.)
***Natura Viva* cc,**
PO Box 12410 Mill Street,
Cape Town 8010, RSA
naturaviva@universe.co.za

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1. EXECUTIVE SUMMARY

Blue Lounge Trading 107 (Pty) Ltd, Kimberley, is proposing to undertake prospecting for iron and manganese ores located on two sites on the farms Spitzkop 168, Bingap 184 & Cairnpoint 195, *c.* 50 km east of the town of Groblershoop in the Hay Magisterial District, Northern Cape Province. The proposed prospecting activities will be conducted in seven phases over a period of three years. Twenty-four boreholes, each approximately 50 m deep (can be more or less depending on results) are planned for Phase 3 while fifteen boreholes are planned for Phase 5. The percussion boreholes will have a 10 m x 10 m surface disturbance around each hole. 500 m long and 3 m wide access tracks will be constructed.

The Precambrian (Palaeoproterozoic) iron and manganese ores of the Koegas Subgroup and Elim Group that are the primary targets of the proposed prospecting activities east of Groblershoop are unfossiliferous, with the possible exception of – hitherto unrecorded - microfossil assemblages within less altered ironstone facies, comparable to those known from the older Kuruman Formation banded ironstones of the Ghaap Group. Minor carbonate-rich horizons within the Heynskop Formation (Koegas Subgroup) and Lucknow Formation (Elim Group) might contain stromatolites (fossil microbial mounds) but these would probably 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 at surface are considered unlikely within the Blue Lounge prospecting areas, although borehole cores might yield sections through identifiable stromatolites; if encountered, these would be of considerable scientific interest.

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 usually, at most, sparsely fossiliferous. Direct impacts on potentially-fossiliferous calcretised alluvium and terrace gravels along the Soutloop drainage line during the prospecting phases are unlikely since they lie largely or entirely outside the provisional borehole core 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, access roads 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, vertebrate bones and teeth in calcretised alluvium) 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. However, s*hould invasive prospecting or mining activities (percussion coring, construction of access roads) extend into the outcrop area of calcretised alluvial deposits along the Soutloop (pale grey areas on satellite images such as Figure 2 herein), a pre-construction palaeontological specialist site visit is recommended.*

The ECO responsible for the Blue Lounge mineral prospecting programme near Groblershoop should be aware of the potential for exposure of well-preserved stromatolites within 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 Blue Lounge Trading 107 (Pty) Ltd, Kimberley, is proposing to undertake prospecting for iron and manganese ores on two sites (total area 9127.3034 Ha) which are situated either side of the N8 trunk road and some 50 km east of the town of Groblershoop in the Hay Magisterial District, Northern Cape Province (Fig. 1). The land parcels concerned are as follows: Remaining Extent of the Farm Spitzkop 168; Portion 1 (Annex Trapeze) of the Farm Spitzkop 168; Portion 2 of the Farm Spitzkop 168; Remaining Extent of the Farm Bingap 184; Remaining Extent of Portion 1 (Gelukshoek) of the Farm Bingap 184; Portion 3 (a portion of Portion 1) of the Farm Bingap 184; Remaining Extent of the Farm Cairnpoint 195; and Portion 1 of the Farm Cairnpoint 195 (Figs. 2 & 3).

The proposed prospecting activities will be conducted in seven phases over a period of three years. Invasive prospecting in the form of percussion drilling will take place in Phases 3 and 5, as outlined in the draft Basic Assessment Report prepared by M and S Consulting (Pty) Ltd., Kimberley:

> Percussion drilling will be used 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-four boreholes, approximately 50 m deep each (can be more or less depending on results) are planned for Phase 3 while fifteen boreholes are planned for Phase 5. The percussion boreholes will have a 10 m x 10 m surface disturbance around each hole. 500 m long and 3 m wide access tracks will be constructed. Existing roads will be used as far as possible. 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.

Each drill site will be rehabilitated. The boreholes will be filled with drill chips and covered with topsoil. No offices and storerooms will be established at the site as Blue Lounge Trading 107 (Pty) Ltd will make use of facilities in the towns of Griekwastad or Groblershoop.

The proposed mineral prospecting activities might impact palaeontological heritage resources within the underlying bedrocks of the Precambrian Transvaal and Keis Supergroups and as well as overlying sediments of the Late Caenozoic Kalahari Group. 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 bedrocks are probably not exposed at surface within the Blue Lounge project areas (based on published 1: 250 000 geological maps and satellite imagery), only a desktop assessment of the proposed mineral prospecting activities is presented here. This study will contribute to the Basic Assessment Report as well as the Environmental Management Programme for the proposed development.

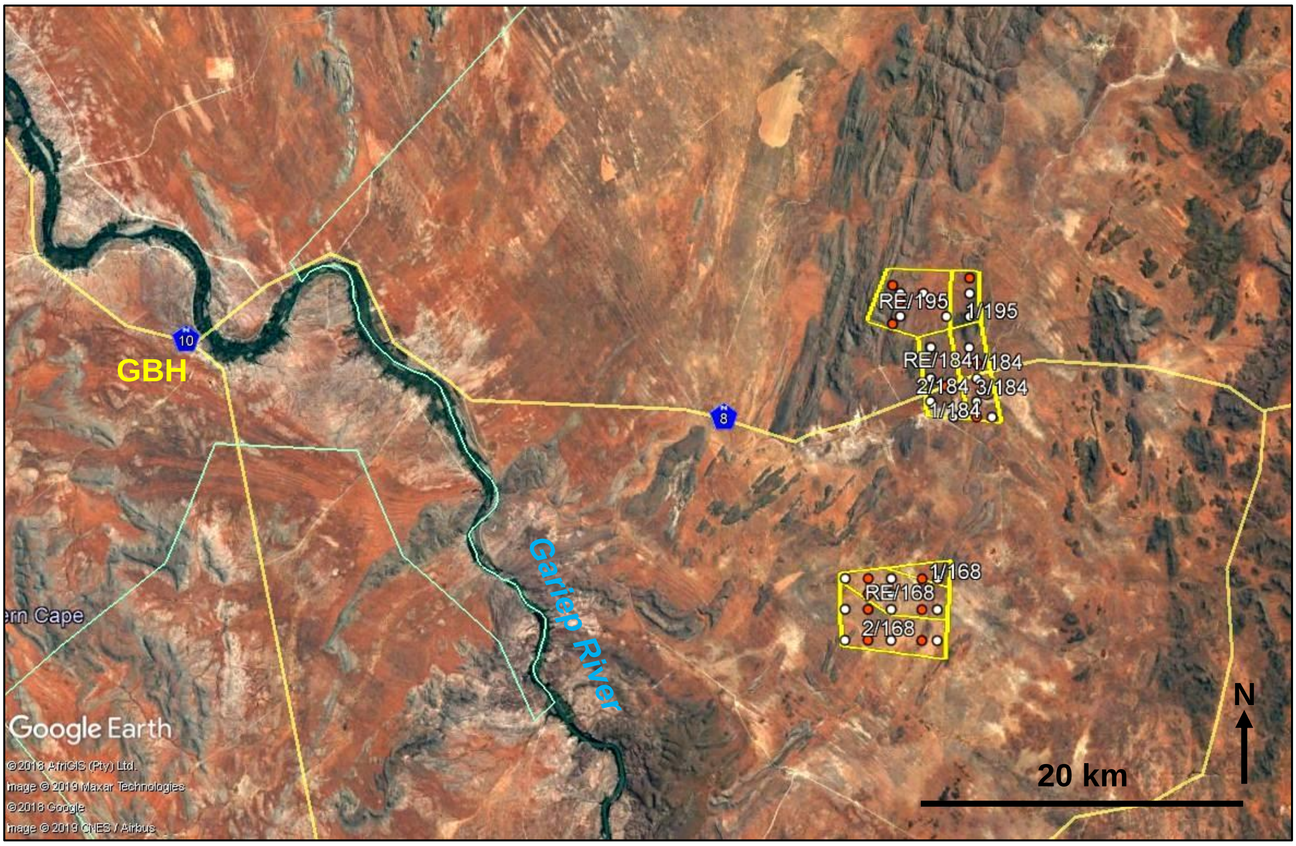

Figure 1: Google Earth© satellite image of the area east of Groblershoop (GBH), Northern Cape, showing the two Blue Lounge mineral prospecting areas (yellow polygons) located in desert terrain to the NE of the Gariep River, both north and south of the N8 trunk road to Kimberley. See Figures 2 and 3 below for more detail.

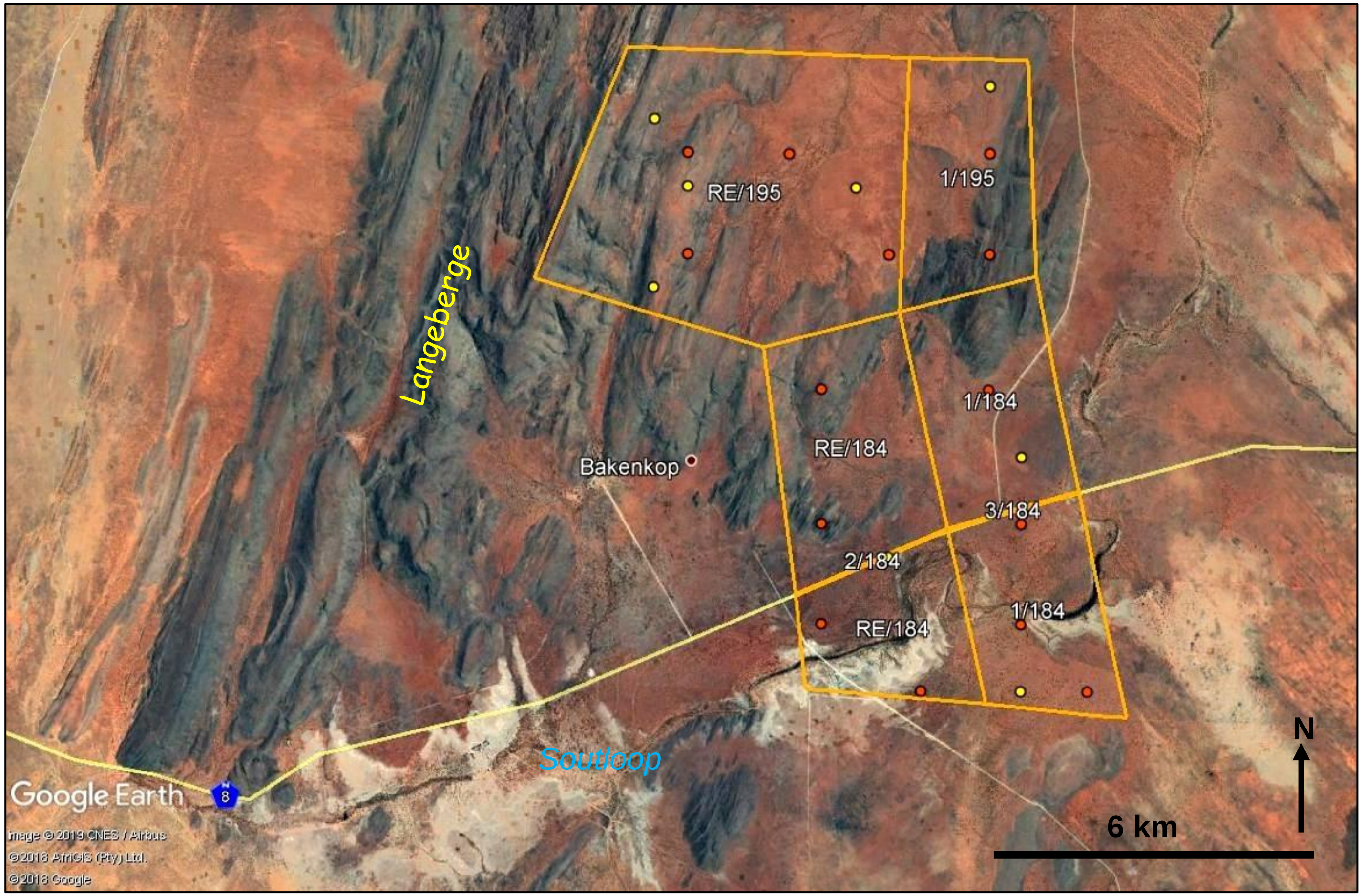

Figure 2: Google Earth© satellite image of the northern mineral prospecting area showing the land parcels concerned (orange polygons). Potential sites for the two phases of percussion drilling are shown in orange and yellow. The NNE-SSW trending grey ridges of the Langeberge Range are largely built of Precambrian quartzitic braided river to shallow shelf sediments of the Olifantshoek Group (Keis Supergroup). Reddish-brown lowland areas are largely mantled by Quaternary to Holocene aeolian sands and alluvium of the Kalahari Group. Pale areas along the meandering Soutloop drainage line are probably calcretised older alluvial sediments that *might* be associated with Quaternary mammalian fossils as well as trace fossils and Stone Age artefacts, as seen for example at Kathu Pan.

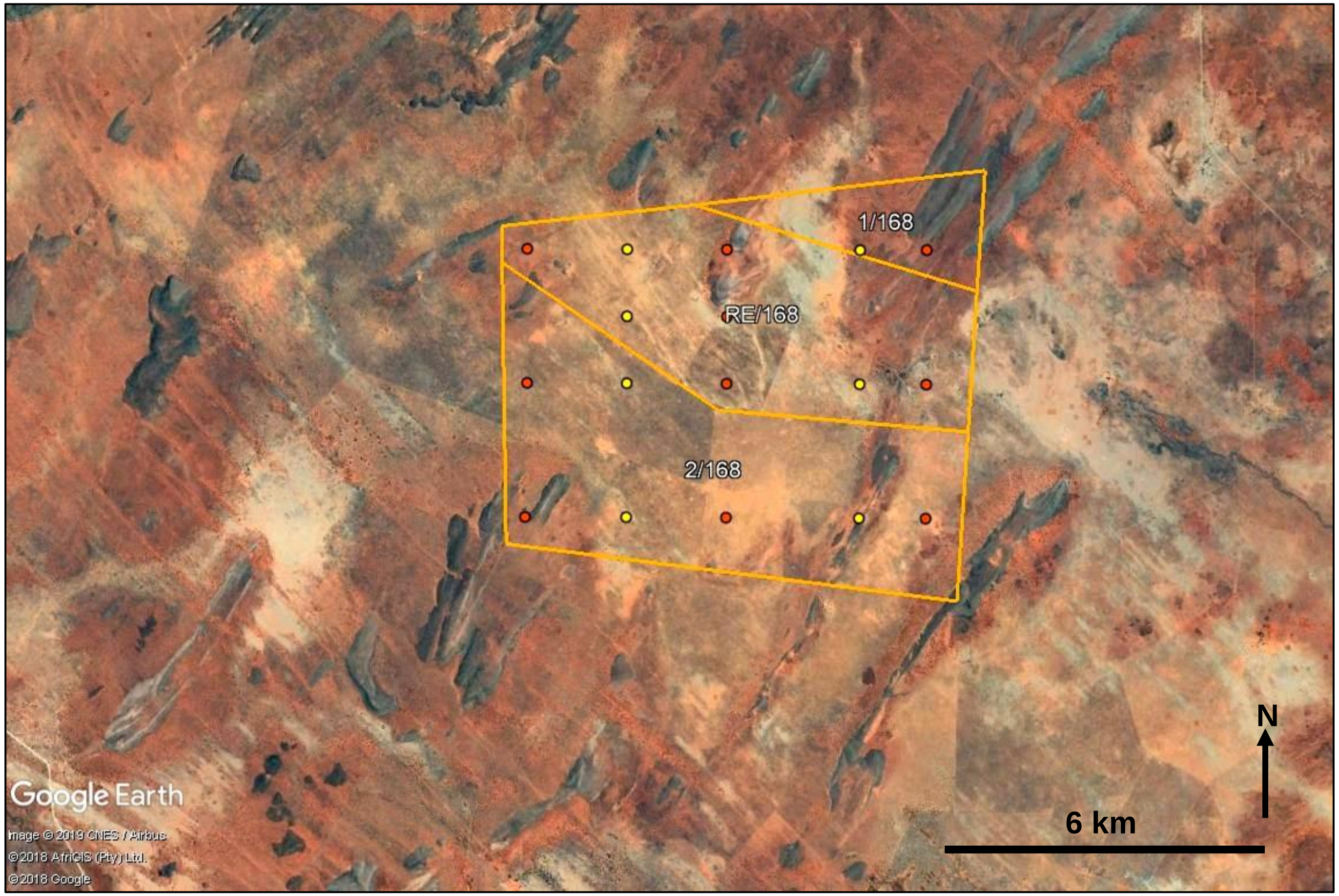

Figure 3: Google Earth© satellite image of the southern mineral prospecting area showing the land parcels concerned (orange polygons). Potential sites for the two phases of percussion drilling are shown in orange and yellow. The grey NNW-SSE trending ridges have been mapped as Lucknow / Mapedi Formations of the Mokolian Elim Group. Reddish-brown lowland areas are largely mantled by Quaternary to Holocene aeolian sands and alluvium of the Kalahari Group.

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 BA 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 Postmasburg – Olifantshoek region (*e.g.* Almond 2017).

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 Groblershoop very little is known about local fossil heritage resources on the basis of palaeontological field studies, including field-based palaeontological assessment reports (See References under Almond). It is noted that so far palaeontological assessment reports have not been submitted for the numerous mineral prospecting studies proposed in the broader study region (SAHRIS website). 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 more northern of the Blue Lounge prospecting areas, located on Farms Cairnpoint 195 and Bingap 184 (Figs. 1 & 2), is situated in arid, sandy to rocky terrain on the south-eastern flanks of the Langeberge Range, some 50 km east of Groblershoop and 30 km northeast of the Orange River (Gariep). Much of the area, which spans the N8 trunk road between Groblershoop and Kimberley, is dominated by low, NNE-SSE trending rocky ridges of the Olifantshoek Group or “Matsap Beds” which reach elevations of *c*. 1500 m amsl at Balenkop in the west and 1290 m amsl Grootkop in the east. The intervening sandy plains at elevations of between 1000 to 1150 m amsl are traversed in the southern sector of the study area by the winding course of the non-perennial Soutloop drainage line and its various small tributaries. This drainage system cuts westwards through the Langeberge and eventually joints the Gariep River near the Boegoeberg, some 30 km to the west of the study area. Pale grey areas along the margins of the Soutloop system on satellite images probably reflect calcretised alluvial deposits (sands and gravels).

The more southern of the two Blue Lounge prospecting areas, located on Farm Spitz Kop 168, lies in low relief (*c*. 1000 -1100 m amsl), desert terrain to the south of the N8 trunk road and some 20 km NE of the Gariep River (Figs. 1 & 3). Based on satellite imagery, most of the area is mantled by sandy to gravelly superficial sediments, including NW-SE trending sandy ridges, with several scattered, low NNE-SSW ridges of basement quartzites, reaching 1170 m amsl in the NE corner of the area at Bakenkop. There are no major drainage lines in the area.

The following account of the geology of the target iron and manganese ore deposits within the Blue Lounge prospecting area near Groblershoop is provided in the Draft BA Report:

> *The target area encompasses rocks of the Griqualand West Sequence consisting of quartzite and subgraywacke of the Matsap Formation and banded ironstone and quartzite of the Koegas Formation. The target iron and manganese enrichment zones are found within the general banded ironstone assemblage. These rocks consist of alternating thin layers, of average width of the order of 5mm, of chert, magnetite, the iron silicates stilpnomelane and minnesotaite, the more complex sodium silicate riebeckite, and carbonate. Seams of crocidolite asbestos occur in certain zone of the banded ironstone. Numerous splays of the Blackridge thrust system are found in the target area, complicating the structural geology of the area.*
>
> *Further north from the application area 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 on the application area 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 ore 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.*
>
> *Recrystallization of the dusty hematite pigment into clusters of microplaty hematite or specularite on the application area has been interpreted as a low-temperature hydro-thermal product. This area has been substantially disrupted by late Namaqua faults. A hydrothermal origin has been demonstrated for the manganese ore found in the area.*

The geology of the study region to the east of Groblershoop is shown on adjoining 1: 250 000 geology sheets 2822 Postmasburg and 2922 Prieska (Council for Geoscience (CGS), Pretoria) (Figs. 4 & 5), neither of which is accompanied by a detailed sheet explanation. Since these two maps were published in 1977 and 1995 respectively, the geology, stratigraphy and structure of the Precambrian (Palaeoproterozoic) bedrocks here have all been radically revised (*e.g.* Eriksson *et al.* 2006, Moen 2006, Van Niekerk 2006, Schröder *et al.* 2011, Da Silva 2011). Eastwards displacement and tectonic reduplication of various Proterozoic successions has probably occurred along the complex Blackridge Thrust Zone in this region (*cf* Moen 2006, fig. 3, Da Silva 2011, Fig. 5.2) (Figs. 6 & 7 herein).

Unspecified subunits of the Palaeoproterozoic **Koegas Subgroup** (Ghaap Group, Transvaal Supergroup) have apparently been recognised within the Blue Lounge project area (see above), probaly as a consequence of thrusting. They are not mapped by the CGS and may be only or largely present in the subsurface. The Koegas beds include a range of siliciclastic and ironstone facies that have been briefly described by Eriksson *et al.* (2006) (*N.B.* at the time they were assigned to the Postmasburg Group), and subsequently in much more detail by Schröder *et al.* (2011). The Koegas succession comprises several thin, upward-shoaling marine packages within which offshore ferruginous muds pass up into pale shoreface quartzites (Fig. 8). The subgroup is capped by banded ironstones of the **Roinekke Formation** which is typically 20-45 m thick and has been dated to *c.* 2.4 Ga (Schröder *et al.* 2011). These last beds are erosionally overlain by the basal Makganyene diamictites of the Postmasburg Group *sensu stricto*.

The oldest bedrocks mapped at surface by the CGS within the Blue Lounge project area comprise undifferentiated outcrops of Lucknow and/or Mapedi Formations in the southern sector (Ml in Fig. 5). These sediments were included within the base of the Olifantshoek Supergroup by Moen (2006) but have now been assigned to the **Elim Group** which is unconformably overlain by the revised Olifantshoek Group *sensu stricto*. Due to the major regional unconformity dated at approximately 2.2-2.0 Ga that is recognised between the Elim beds and the Transvaal Supergroup, and locally associated with iron formation, the Elim and Olifantshoek Groups have been incorporated into a separate **Kheis Supergroup** (Da Silva 2011) (Fig. 7).

Details of the **Elim Group** beds mapped within the present project area, or present in the subsurface, are not available. According to Moen (2006) and Van Niekerk (2006) the **Mapedi / Gamagara Formation** at the bottom of the Elim succession comprises a basal ironstone pebble conglomerate (Doornfontein conglomerate) followed by several thin, mudrock-to-quartzite shoaling cycles and minor mafic volcanics. The overlying **Lucknow Formation** also includes several mudrock-to-quartzite shoaling cycles of marine shelf sediments, locally capped by quartz-rich dolomite. The unconformably overlying, tough-weathering, quartzite-dominated “Matsap Beds” of earlier authors that build the Langeberge Range are now assigned to the **Olifantshoek Group** ss. Their stratigraphy and sedimentology have been described by Jansen (1983), Van Niekerk (2002), Moen (2006) and Da Silva (2011), among others. The various quartzitic and conglomeratic subunits of the “Matsap Beds” mapped in the northern Blue Lounge project area are now incorporated within the **Volop Formation** and are broadly interpreted as braided river deposits. This early continental red bed succession has been correlated with the 2.0-1.8 Ga Waterberg Group of Limpopo Province. Basal Olifantshoek conglomerates of the **Neylan Formation** and 1.9 Ga subaerial volcanics (basalts, tuffs with red sandstone interbeds) of the **Hartley Formation** that lie stratigraphically between the Lucknow and Volop Formations may also be present in the subsurface within the Blue Lounge study areas.

As seen in the published 1: 250 000 geology maps as well as satellite images, most of the lower-lying sectors of the Blue Lounge project areas are mantled by Late Cretaceous to Late Caenozoic 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). Large areas of unconsolidated, reddish-brown aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation** are mapped in the area east of Groblershoop where their thickness is uncertain. NW-SE trending linear sand dunes are visible on satellite images within and close to the project area. 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. **Older (pre-Holocene) alluvial sediments** such as terrace gravels are mapped along the meandering course of the Soutloop drainage line; the pale appearance of these deposits on satellite images suggests that they are probably extensively calcretised (Fig. 2). Other unmapped Late Caenozoic sediments are likely to include unconsolidated younger alluvium (sands, gravels), downwasted surface gravels, scree gravels (colluvium), sheetwash deposits, various soils and possibly also small pans.

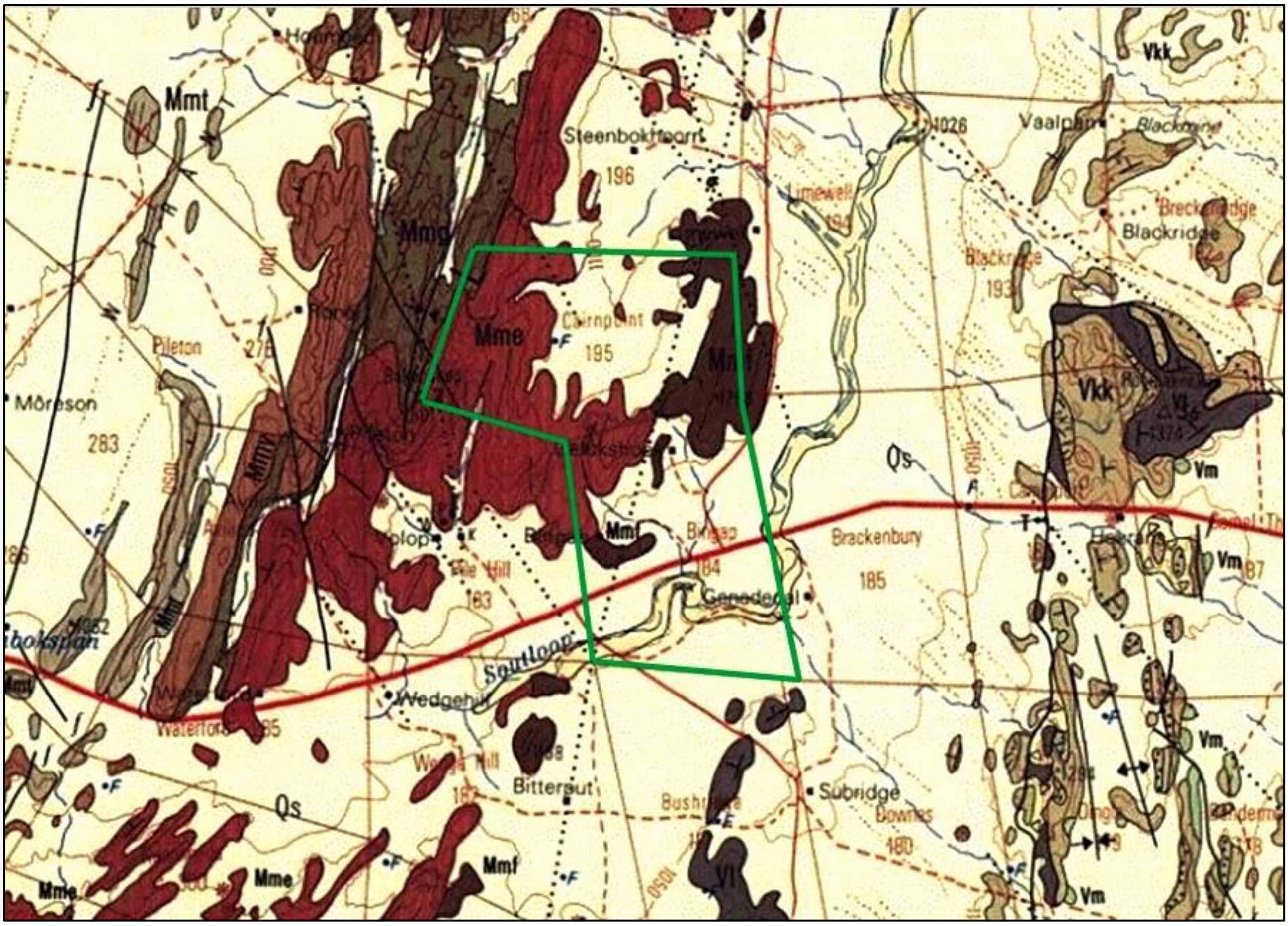

Figure 4: Extract from 1: 250 000 geology map 2822 Postmasburg (Council for Geoscience, Pretoria) showing the northern Blue Lounge prospecting area on farms Cairnpoint 195 and Bongap 184 (green polygon). The rock units mapped here include:
Mmf (dark brown) = Fuller Member, Volop Formation (Olifantshoek Group "Matsap Beds")
Mme (pale brown) = Ellie's Rust Member, Volop Formation (Olifantshoek Group "Matsap Beds")
Mmg (middle brown) = Glen Lyon Member, Volop Formation (Olifantshoek Group "Matsap Beds")
Older alluvium (darker yellow with double flying bird symbol) along Soutloop drainage line
Qs (pale yellow) = Quaternary to Holocene aeolian sands of the Gordonia Formation (Kalahari Group)
Note that the subsurface geology of this region is complicated by extensive Late Precambrian faulting related to the Blackridge Thrust Zone. The stratigraphy of the Precambrian bedrocks has also been extensively revised since this map was published in 1977. Target ironstones of the Koegas Subgroup (Ghaap Group) are not mapped at surface here.

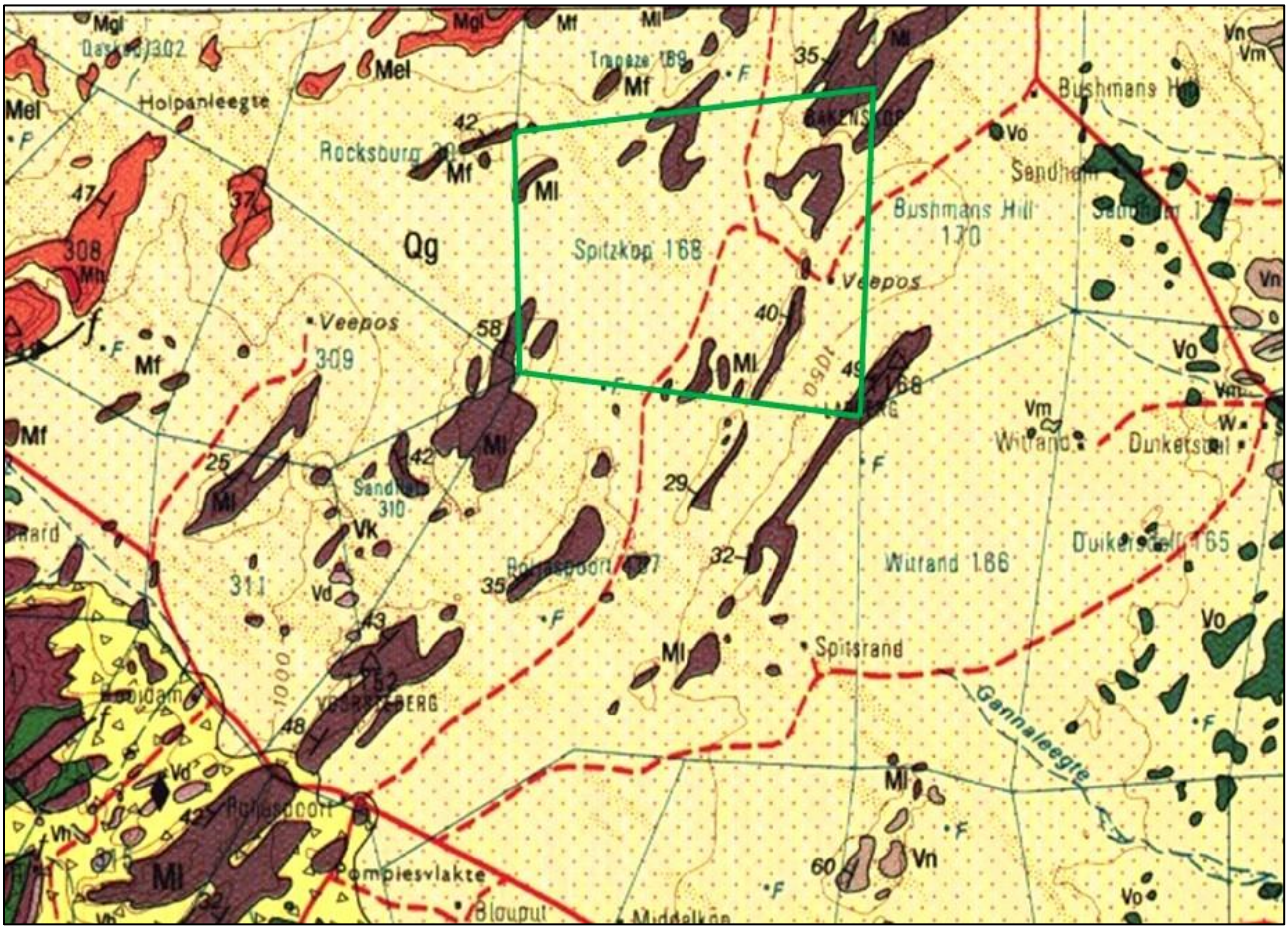

Figure 5: Extract from 1: 250 000 geology map 2922 Prieska (Council for Geoscience, Pretoria) showing the southern Blue Lounge prospecting area on the farm Spitzkop 168 (green polygon). The rock units mapped here include:
Ml (purple-brown) = Lucknow / Mapedi Formations of the Mokolian Elim Group
Qg (yellow with brown stipple) = Quaternary to Recent aeolian sands of the Gordonia Formation (Kalahari Group).
Note that the subsurface geology of this region is complicated by extensive Late Precambrian faulting related to the Blackridge Thrust Zone. The stratigraphy of the Precambrian bedrocks has also been extensively revised since this map was published in 1977.

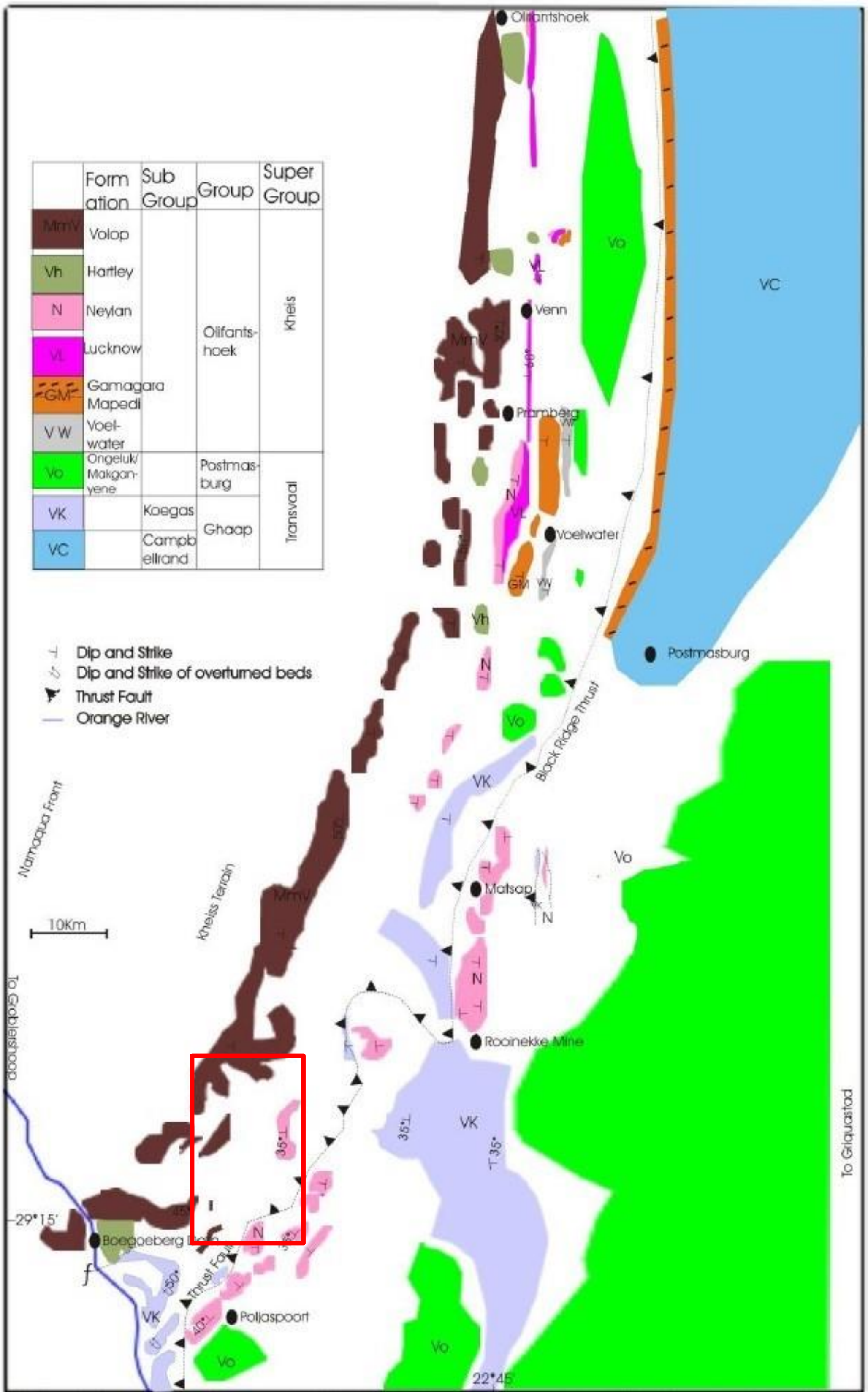

Figure 6: Revised mapping of Palaeoproterozoic quartzite units to the SW of Postmasburg (From Da Silva 2011). In some areas quartzites previously mapped as Lucknow Formation (Elim Group) have been re-assigned to the Neylan Formation (Olifantshoek Group). The present study area lies within the red rectangle.

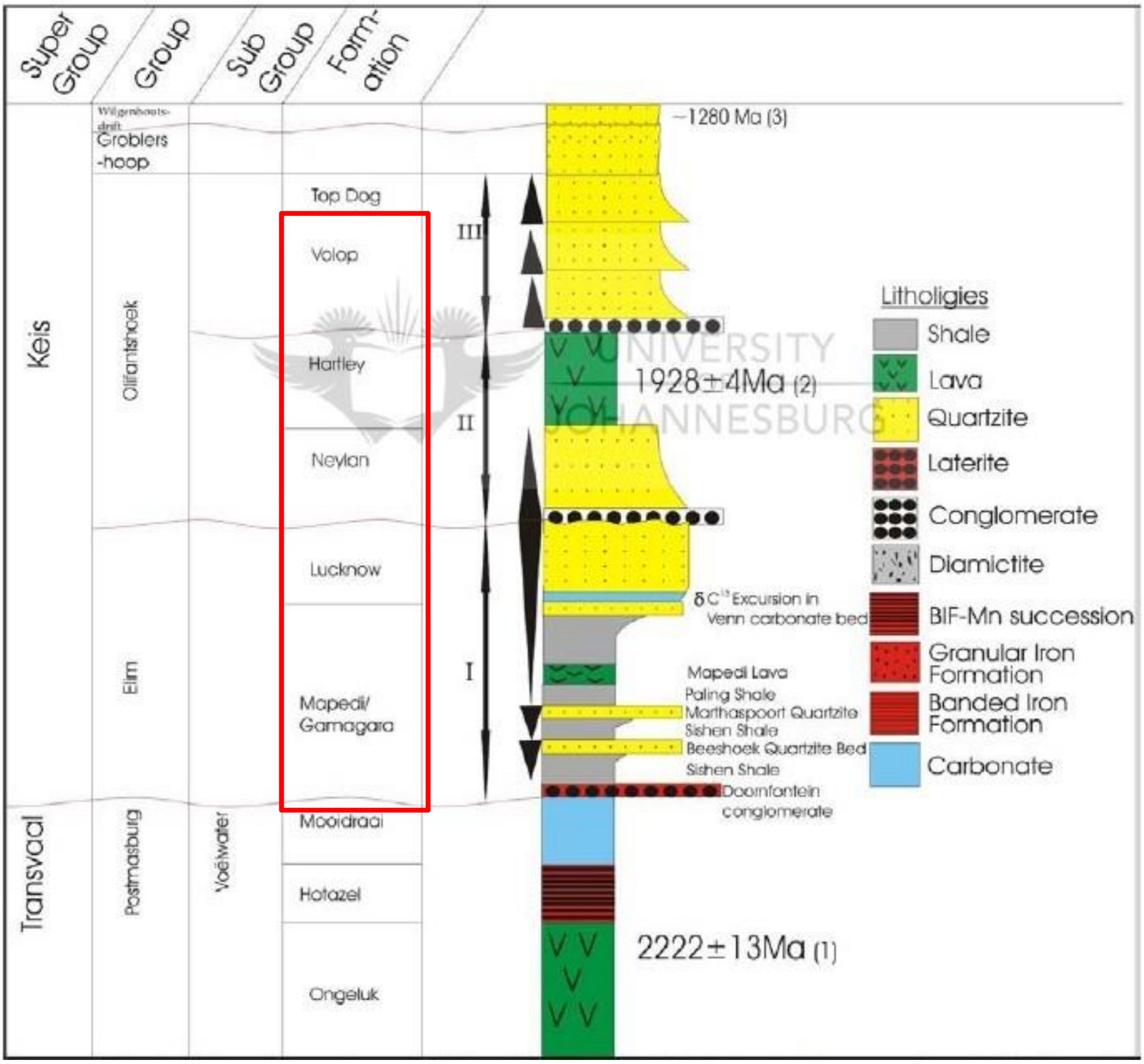

Figure 7: Revised stratigraphy of the Early Proterozoic (Mokolian) Elim and Olifantshoek successions of the Northern Cape (From Da Silva 2011). The red rectangle emphasises rock successions that may be represented at or below the surface within the Blue Lounge project areas.

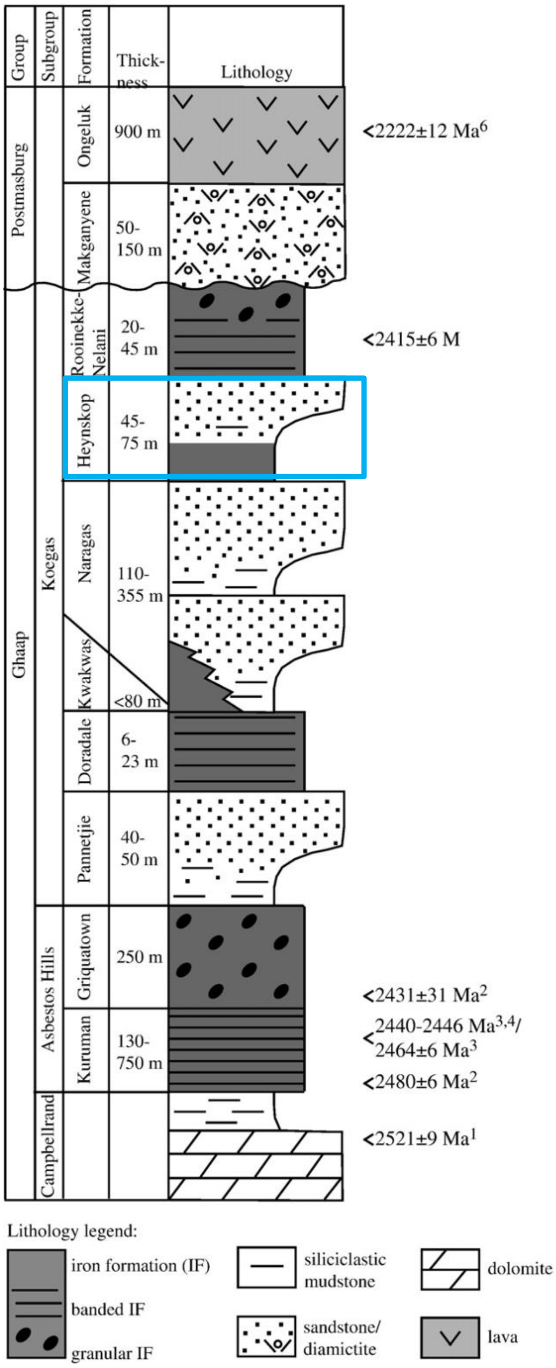

Figure 8: Stratigraphy of the Koegas Subgroup (Ghaap Group) of the Griqualand West Basin (From Schröder *et al.* 2011). Stromatolitic carbonates, including large bioherms, are recorded within the Heynskop Formation (blue rectangle).

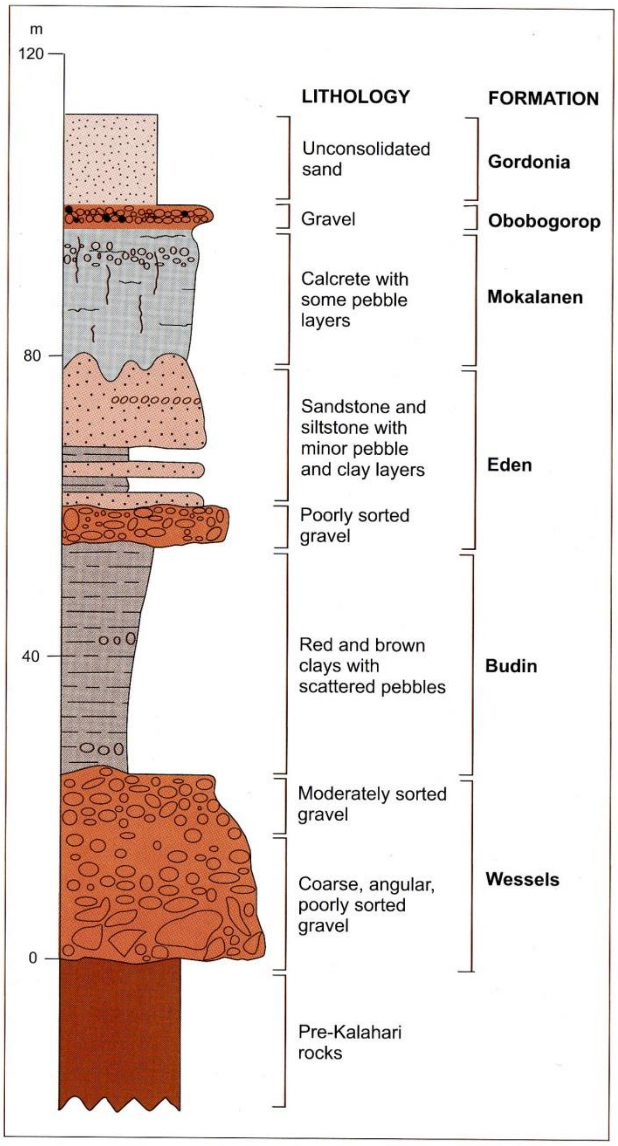

Figure 9: Generalised stratigraphy of the Late Cretaceous to Recent Kalahari Group (From Partridge *et al.* 2006). Only the uppermost rock units – such as Plio-Pleistocene subsurface calcretes (Mokalanen Formation), Obobogorop gravels and Pleistocene to Recent aeolian sands of the Gordonia Formation - are likely to be directly impacted by the proposed mineral prospecting programme.

4. PALAEONTOLOGICAL HERITAGE

4.1. Fossils within the Precambrian bedrocks

According to Beukes (1978) and Schröder *et al.* (2011) the Heynskop Formation of the **Koegas Subgroup** (**Ghaap Group**) contains stromatolitic carbonates that locally build large (up to 100 m diameter, 40 m thick) bioherms within the upper part of the succession. Smaller-scale stromatolitic columns are illustrated by Schröder *et al.* 2011 (Fig. 10). The biohermal carbonates pass laterally and upwards into iron formation and deep-water mudrocks, and were interpreted by Beukes (1983) as building a barrier separating foreshore clastics and offshore iron formations. The bioherms mainly occur in the more distal outcrop areas of the Koegas Subgroup (*e.g.* Naragas and Roinekke areas near Prieska) and are closely associated with deeper-water facies, perhaps because clastic influx into the basin (inhibiting stromatolite growth) was restricted during periods of transgression.

Precambrian bedrocks of the **Elim** and **Olifantshoek Groups** indicated on the published 1: 250 000 geological maps of the Blue Lounge project areas (Figs. 4 and 5) are not known to be fossiliferous. Microfossil assemblages may be preserved within less altered ironstone facies, comparable to those known from the older Kuruman Formation banded ironstones of the Ghaap Group, but have not been recorded hitherto from these younger post- Ghaap Group successions.

To the author's knowledge, stromatolites or other fossil remains have not been recorded from the quartzitic dolomites of the **Lucknow Formation** (Elim Group). The *c*. 1.9 Ga "Matsap" quartzites and pebbly conglomerates (**Volop Formation**, Olifantshoek Group) are interpreted as continental, braided fluvial deposits and are unlikely to contain fossils. However, rare finer-grained intervals might yield bio-sedimentary structures attributable to lacustrine microbial mats, such as those recorded from the broadly co-eval Waterberg Group. Some of the earliest known (1.8 Ga) terrestrial cyanobacterial mats have been recorded from playa lake deposits of the Makgabeng Formation within the Waterberg Group outcrop area on the Makgabeng Plateau, west of Soutpansberg, Limpopo Province (Eriksson *et al.* 2000, Eriksson *et al.* 2008).

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.

Calcretised **older alluvial sediments**, including terrace gravels associated with the Soutloop drainage line, are possibly Pleistocene or older. They might contain important fossil vertebrates (*e.g.* mammalian bones, teeth and horncores), trace fossils and rhizoliths and non-marine molluscs as well as Stone Age archaeological remains such as recorded elsewhere in the Northern Cape, such as the Kathu area (Beaumont 1990, Beaumont 2004, Beaumont *et al.* 1984; *cf* summary in Almond 2014). However, satellite images suggest that these deposits lie largely or entirely outside the footprint of the proposed prospecting activities (Fig. 8) and direct impacts on local fossil heritage are therefore considered unlikely.

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.

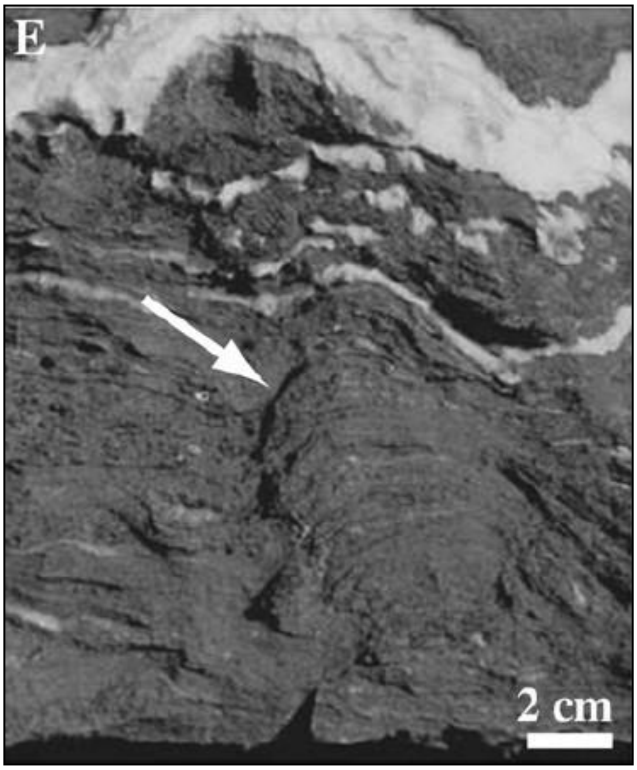

Figure 10: Small scale stromatolitic column (arrowed) within carbonates of the Heynskop Formation, Koegas Subgroup near Rooinekke (Illustration from Schröder *et al.* 2011).

5. SUMMARY & RECOMMENDATIONS

The Precambrian (Palaeoproterozoic) iron and manganese ores of the Koegas Subgroup and Elim Group that are the primary targets of the proposed prospecting activities east of Groblershoop are unfossiliferous, with the possible exception of – hitherto unrecorded - microfossil assemblages within less altered ironstone facies, comparable to those known from the older Kuruman Formation banded ironstones of the Ghaap Group. Minor carbonate-rich horizons within the Heynskop Formation (Koegas Subgroup) and Lucknow Formation (Elim Group) might contain stromatolites (fossil microbial mounds) but these would probably 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 at surface are considered unlikely within the Blue Lounge prospecting areas, although borehole cores might yield sections through identifiable stromatolites; if encountered, these would be of considerable scientific interest.

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 usually, at most, sparsely fossiliferous. Direct impacts on potentially-fossiliferous calcretised alluvium and terrace gravels along the Soutloop drainage line during the prospecting phases are unlikely since they lie largely or entirely outside the provisional borehole core 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, access roads 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, vertebrate bones and teeth in calcretised alluvium) 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. However, s*hould invasive prospecting or mining activities (percussion coring, construction of access roads) extend into the outcrop area of calcretised alluvial deposits along the Soutloop (pale grey areas on satellite images such as Figure 2 herein), a pre-construction palaeontological specialist site visit is recommended.*

The ECO responsible for the Blue Lounge mineral prospecting programme near Groblershoop should be aware of the potential for exposure of well-preserved stromatolites within 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

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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.

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

<table>
<tr><th colspan="3">CHANCE FOSSIL FINDS PROCEDURE: Mineral prospecting on the farms Spitzkop 168, Bingap 184 & Cairnpoint 195</th></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">Proterozoic bedrocks of the Koegas Subgroup, Elim and Olifantshoek Groups.
Kalahari Group, consolidated older alluvial deposits associated with the Soutloop drainage line.</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Well-preserved stromatolitic horizons within Precambrian carbonate bedrocks (possibly exposed in 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 within older calcretised alluvium.</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>
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