PALAEONTOLOGICAL HERITAGE REPORT: DESKTOP STUDY

Mineral prospecting on the Farm Stomp Oor 109 (Portion 3), Prieska District, Northern Cape Province

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1. EXECUTIVE SUMMARY

Alidabix (Pty) Ltd, Kimberley, has applied for a Prospecting Right covering a range of minerals over Portion 3 (a portion of Portion 1 – Stomp Oor A) of the Farm Stomp Oor 109, situated c. 45 km northwest of Copperton in the Prieska District, Northern Cape Province. Precambrian basement rocks of the Namaqua-Natal Province that underlie the Stomp Oor 109 study area at depth and that are a primary target of mineral prospecting are of no palaeontological heritage significance. Overlying Permo-Carboniferous glacial-related sediments of the Mbizane Formation (Dwyka Group) cropping out in the southern portion of the study area are - at most - of moderate palaeontological palaeosensitivity since they might contain plant remains and trace fossils. Most of the study area is mantled by superficial deposits of the Late Caenozoic Kalahari Group, including wind-blown sands, calcretes and alluvium along shallow water courses. These superficial sediments are generally of low palaeontological sensitivity in Bushmanland. However, important occurrences of fossil mammals have recently been recorded in association with stone artefacts within pan and alluvial gravel sediments near Copperton. Highly-fossiliferous crater lake deposits of Late Cretaceous age (*c*. 70 Ma = million years old) have been recorded on Farm Stomp Oor 109 and may be present at more than one site here, buried beneath the superficial sediment cover. A variety of terrestrial and freshwater fossil groups - including well-preserved pipoid frogs, galaxiid fish, rare dinosaur remains, insects, crustaceans, molluscs and plants – have been sampled from near-surface exposures as well as borehole cores. They provide a rare glimpse of extinct biotas of the subcontinental interior shortly before the catastrophic end-Cretaceous Mass Extinction Event. While fossiliferous sediments from the central part of the identified crater lake site are covered by over 40 m of sandy overburden, well-preserved fossils have also been recovered from marginal trenches and borehole cores penetrating only 1-3 m beneath the present land surface. The invasive phases of the proposed mineral prospecting programme (*viz*. percussion and core drilling) might have negative impacts of important fossil heritage preserved at or beneath the surface.

It is therefore recommended that a site visit by a professional palaeontologist be commissioned by the developer well before the commencement of the invasive phases of the prospecting programme. The resulting palaeontological heritage assessment report should make recommendations for any mitigation or monitoring measures to be following during siting, drilling and rehabilitation of the boreholes as well as for conservation of sedimentary borehole core material for future palaeontological analysis.

There are no objections on palaeontological grounds regarding the non-invasive phases of the proposed mineral prospecting programme on Farm Stomp Oor 109. The ECO responsible for the

mineral prospecting project should be aware of the potential for important fossil occurrences within near-surface or buried crater lake deposits and the necessity to conserve them for possible professional mitigation. A Chance Fossil Finds Procedure for the non-invasive phases of the prospecting programme is outlined in tabular form at the end of this report. Recommended mitigation of chance fossil finds involves safeguarding of the fossils (preferably *in situ*) by the responsible ECO and reporting of all significant finds to the South African Heritage Resources Agency, SAHRA (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 programme.

2. INTRODUCTION & BRIEF

The company Alidabix (Pty) Ltd, Kimberley, has applied for a Prospecting Right for Copper, Zinc, Gold, Silver, Diamond General, Diamond Alluvial, Diamond in Kimberlite, Molybdenum, Nickel and Platinum Group Metals over Portion 3 (a portion of Portion 1 – Stomp Oor A) of the Farm Stomp Oor 109, situated c. 45 km northwest of Copperton in the Prieska District, Northern Cape Province (Figs. 1 & 2).

The prospecting programme, as outlined in Background Information Document (BID) for the project compiled by M&S Consulting (May 2018), will involve ten phases spread over five years. Only phases 4, 6 and 8 involve invasive activities which include the development of 25 percussion boreholes and 15 core boreholes with a *c*.10 m^2 area disturbance around each hole as well as generating new access tracks. Borehole locations will only be finalised after initial non-invasive studies are completed (*cf* Conceptual Site Layout in Figure 3).

The following details for the percussion and core drilling are provided in the BID:

> ***Percussion drilling****:*
>
> *Twenty-five boreholes, on average 50 m deep each, are planned for phase 4. 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.*

Core drilling

Dependent on the results from the non-invasive prospecting activities, further confirmation and exploratory drilling may be required. Core drilling will only be used if mineralization has been found. The position of the boreholes is dependent on the results of the non-invasive activities.

Ten boreholes, planned 50
m depth each (can be more or less depending on results), are planned for phase 6 and five for phase 8. The collar position of all boreholes will be surveyed. All drilling will be short term and undertaken by a contractor using skid-mounted equipment.

Each drill site will be rehabilitated once completed. The boreholes will be covered with a metal plate and 1 m of previously stored topsoil. All drilling material, liquid spills and refuse will be cleared and transported to the relevant municipal landfill.

The following recommendations relevant to palaeontological heritage resources were made in the desktop heritage impact assessment report for the mineral prospecting project by Gaigher (2018):

Once the specific borehole sites have been determined, they must be subjected to a surface investigation to determine if any sites of heritage significance will be affected;
Due to the high palaeontological value of the area, it is suggested that a palaeontological study lead the placement of the boreholes to minimize their impact.

In response the SAHRA Archaeology, Palaeontology and Meteorites (APM) Unit has requested that a desktop Palaeontological Assessment be conducted as part of the BAR and EA Application due to the presence of significant palaeontological resources within the development area (SAHRA Interim Comment 25 October 2018, Case ID: 12973). The desktop assessment must be conducted by a qualified palaeontologist and must comply with the 2012 SAHRA Minimum Standards: Palaeontological Components of Heritage Impact Assessments.

The present desktop palaeontological heritage report has accordingly been commissioned by Alidabix (Pty) Ltd (Contact details: Hano Haman. Alidabix (Pty) Ltd. Address: 94 Central Road, Kimberley 8301. E-mail: hano@nayan.co.za).

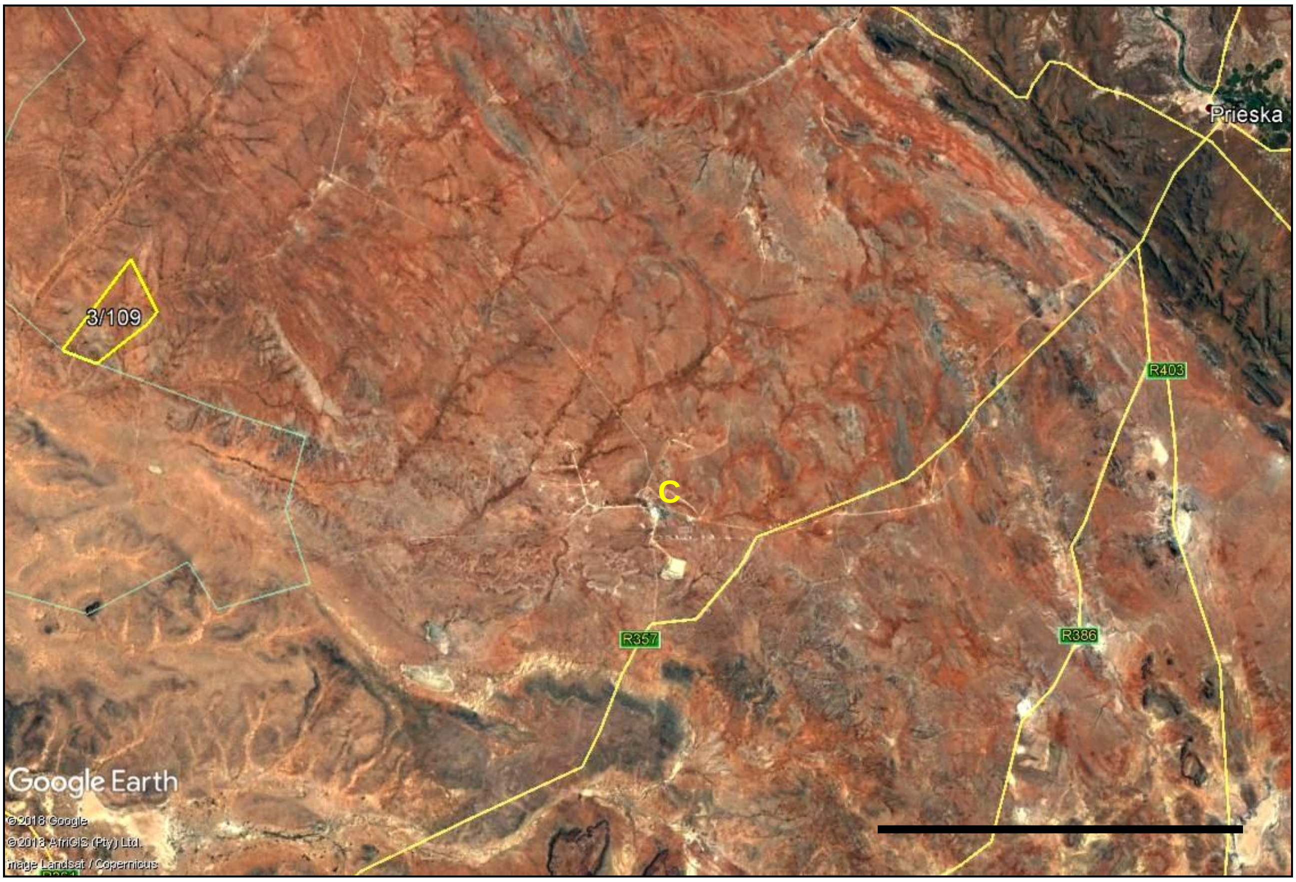

Figure 1. Google Earth© satellite image of the semi-arid Bushmanland region showing the location of the mineral prospecting study area on Portion 3 (a portion of Portion 1 – Stomp Oor A) of the Farm Stomp Oor 109, situated *c*. 45 km northwest of Copperton in the Prieska District, Northern Cape Province (yellow polygon). Scale bar = 30 km.

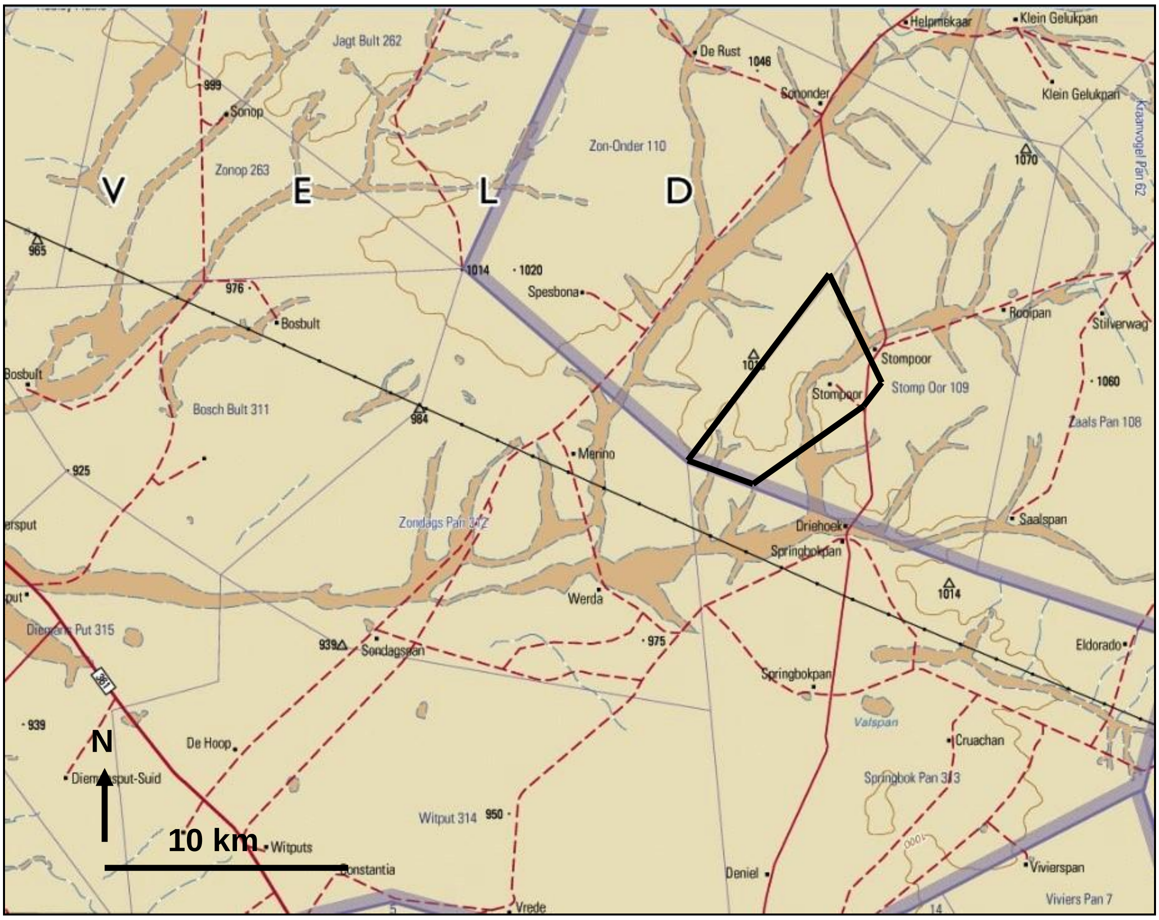

Figure 2. Extract from 1: 250 000 topographical sheet 2920 Kenhardt showing the mineral prospecting study area (black polygon) on Portion 3 of the Farm Stomp Oor 109, Prieska District, Northern Cape Province (Map courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray).

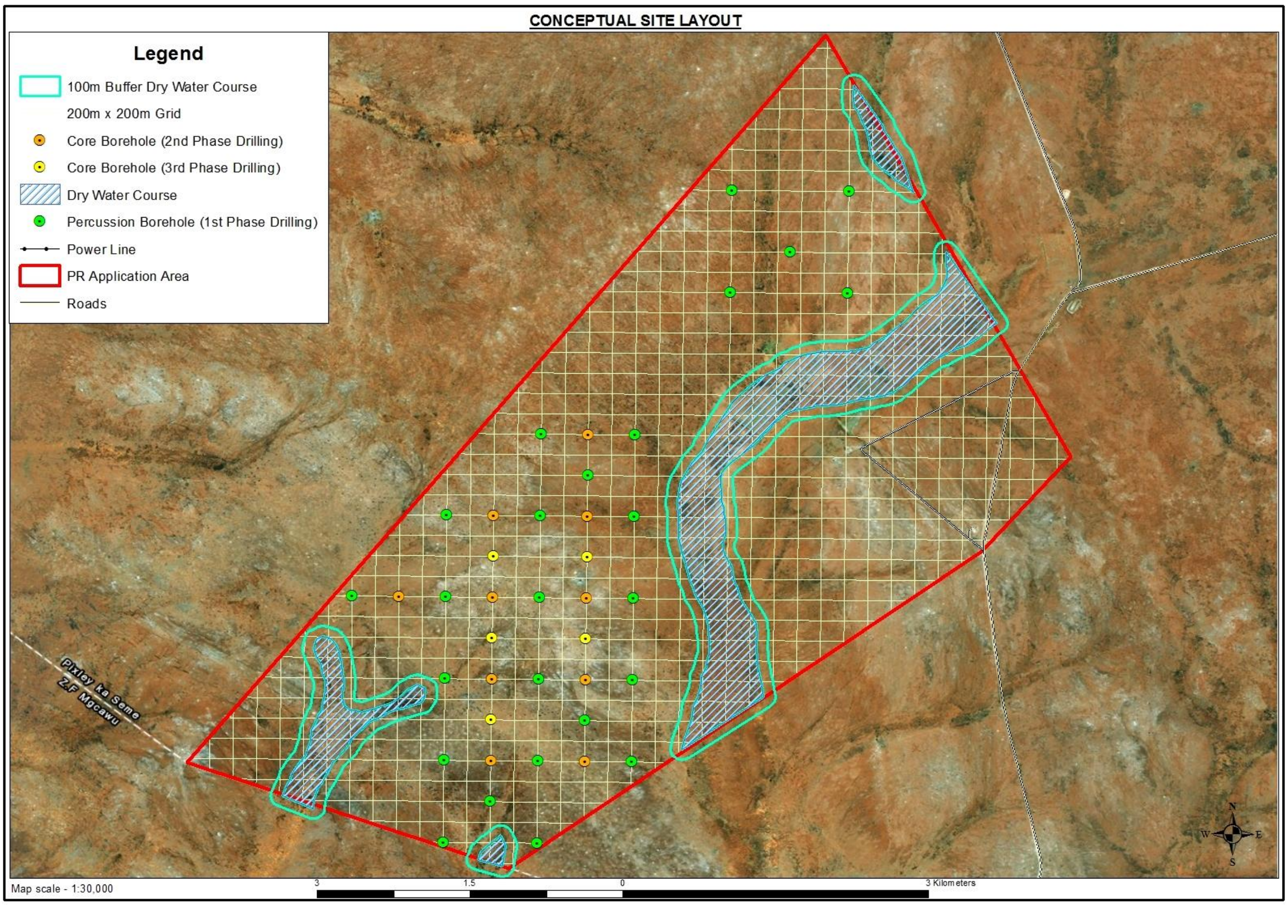

Figure 3. Conceptual Site Layout for the proposed mineral prospecting on Portion 3 of the Farm Stomp Oor 109 (Image abstracted from the Background Information Document compiled by M&S Consulting, May 2018). The final position of the boreholes is dependent on the results of the non-invasive prospecting activities.

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 South African Heritage Resources Agency, 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 (BID), maps, kmz files and supporting documents provided by Alidabix (Pty) Ltd;

2. A review of the relevant satellite images, topographical maps and scientific literature, including published geological maps and accompanying sheet explanations, as well as a previous desktop and field-based palaeontological assessment studies featuring comparable bedrocks in the Bushmanland region (*e.g.* Almond 2012, 2013a, 2013b, 2018).

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 on Farm Stompoor 109 near Prieska there is an extensive palaeontological literature relating to previous studies on borehole and surface material (See References). However, the precise geographical location of previous fossil finds is not specified in the published papers.

2.3. Legislative context for palaeontological assessment studies

The invasive phases of the proposed mineral prospecting project will be located in an area that is underlain in part by potentially fossiliferous sedimentary rocks of Permo-Carboniferous, Cretaceous and younger, Late Tertiary or Quaternary, age (Sections 3 and 4). The proposed development will entail shallow excavations into, or disturbance of, the superficial sediment cover and drilling of boreholes 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 present combined desktop and field-based palaeontological heritage study falls under the South African Heritage Resources Act (Act No. 25 of 1999). 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 National Heritage Resources Act include, among others:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have been published by SAHRA (2013).

3. GEOLOGICAL BACKGROUND

The mineral prospecting project area on Farm Stomp Oor 109 is situated in semi-arid, low-relief terrain between 990 and 1070 m amsl in the Kaiingveld region of Bushmanland, Northern Cape (Figs. 1 & 2). The area is drained towards the southwest by several shallow, intermittent-flowing tributaries of the Bastersputs se Leegte drainage system that eventually leads into Verneuk Pan. The geology of the study area near Copperton is shown on 1: 250 000 geological map 2920 Kenhardt for which a sheet explanation has been published by Slabbert *et al.* (1999) (Fig. 6).

- **Precambrian basement**

Precambrian granitoid or high-grade metamorphic rocks of the *circa* one billion year old **Namaqua-Natal Province** underlie the entire study area at depth but only appear at surface as a few small inliers (*e.g.* **Rok Optel Granite** of the **Keimoes Suite**, Mrk) (Cornell *et al.* 2006). These ancient (Mesoproterozoic) basement rocks are the primary target for mineral prospecting but will not be treated further here since they are of no palaeontological heritage significance (It is noted that some of the small areas mapped in red on the geological map Figure 6 might be Early Jurassic Karoo dolerite intrusions comparable to those occurring *c*. 10 km to the west).

- **Dwyka Group**

Permo-Carboniferous glacial sediments of the **Dwyka Group** (**C-Pd, Karoo Supergroup**) are mapped within the southern portion of the Farm Stomp Oor 109 study area. Similar glacial rocks probably underlie the Kalahari Group superficial sediments elsewhere where they may be intersected by deeper excavations or drilling during prospecting. The geology of the Dwyka Group has been summarized by Visser (1989), Visser *et al.* (1990) and Johnson *et al.* (2006), among others.

The Dwyka Group along the north-western margin of the Main Karoo Basin, including the Prieska Subbasin in particular, has been reviewed by Visser (1982, 1985). In Dwyka times the Prieska – Copperton area lay within a basement high region between the Sout River Valley in the west and the Prieska Basin in the east (Fig. 4). This area is referred to as the Kaiing Hills or Kaiing Veld Region by Visser and is characterized by a relatively thin Dwyka succession (normally < 50 m). This mainly comprises massive clast-rich diamictites and clast–poor argillaceous diamictites ("boulder shale") overlain by a thin zone of laminated dropstone argillite with outsized clasts composed mainly of quartzite and gneiss (Visser 1985). Ice transport directions initially towards the south and later towards the southwest are reconstructed by Visser (1985). The source area of many of the exotic boulder erratics (*e.g.* stromatolitic carbonates of Griqualand West succession, amygdaloidal lavas of the Ventersdorp Supergroup) seen in the Dwyka succession near Copperton, as well as the Prieska Basin to the east, is the elevated Ghaap Plateau to the north of Prieska (Visser 1982).

According to maps in Visser *et al.* (1990) and Von Brunn and Visser (1999) the Dwyka rocks in the Prieska-Copperton area close to the northern edge of the Main Karoo Basin belong to the **Mbizane Formation**. This is equivalent to the Northern (valley and inlet) Facies of Visser *et al*. (1990). The Mbizane Formation, up to 190 m thick, is recognized across the entire northern margin of the Main Karoo Basin where it may variously form the whole or (as here) only the *upper* part of the Dwyka succession. It is characterized by its extremely heterolithic nature, with marked vertical and horizontal facies variation (Von Brunn & Visser 1999). The proportion of diamictite and mudrock is often low, the former often confined to basement depressions. Orange-tinted sandstones (often structureless or displaying extensive soft-sediment deformation, amalgamation and mass flow processes) may dominate the succession. The Mbizane-type heterolithic successions characterize the thicker Dwyka of the ancient palaeovalleys cutting back into the northern basement rocks.

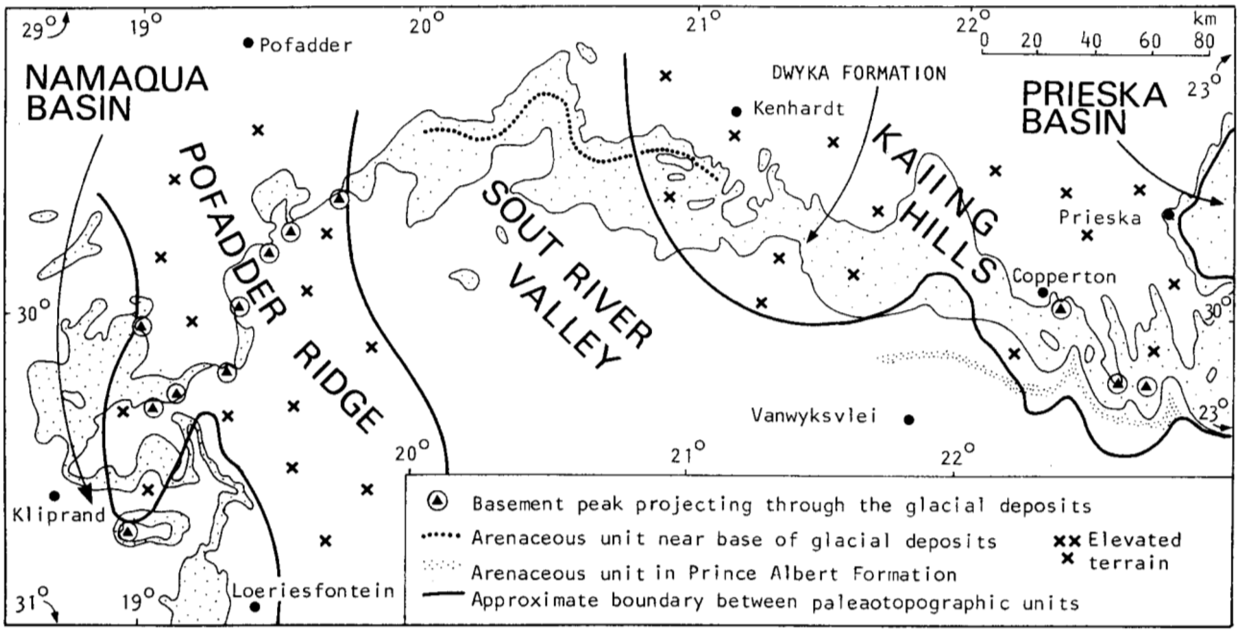

Figure 4. Reconstruction of the topography along the northern margin of the Karoo Basin in Dwyka times showing location of the Prieska-Copperton area on a basement high with scattered peaks of basement rock projecting through the Dwyka glacial sediment cover (From Visser 1985).

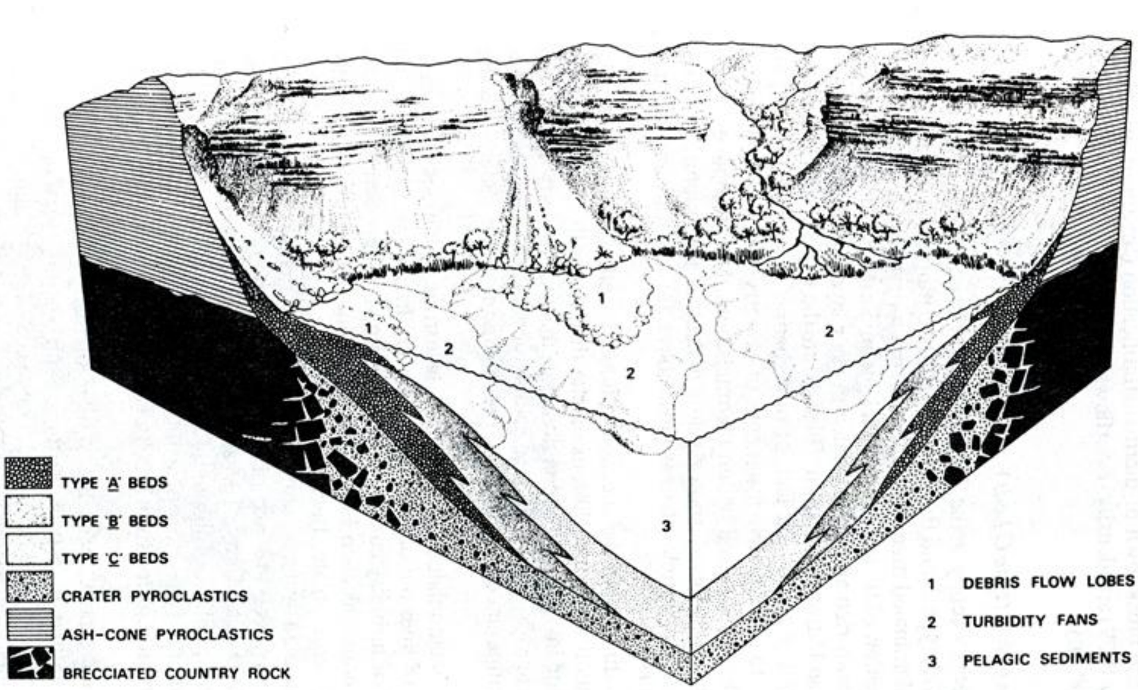

Figure 6. Palaeoenvironmental reconstruction of the Stompoor crater-lake during the Late Cretaceous. The original crater-lake is estimated to have been at least 1 km in diameter. Note the relationship between geomorphological features and geological facies. The contacts between the facies associations are grossly oversimplified and the hatching of ash-cone pyroclastics does not represent bedding

Figure 5. Reconstruction of the Stompoor Late Cretaceous epiclastic kimberlite pipe crater and enclosed crater lake (Smith 1986, 1988).

- **Late Cretaceous kimberlite pipes & crater deposits**

An important occurrence of Late Cretaceous (*c*. 70 Ma, Maastrichtian) epiclastic kimberlite deposits – including richly-fossiliferous crater lake sediments – has been studied in some detail from a sedimentological as well as palaeontological viewpoint on the Farm Stomp Oor 109 (Smith 1986a, 1986b, 1988, 1995). It constitutes one of the best known members of the Late Cretaceous to Paleogene **Bushmanland Pipe Swarm** (Verwoerd & De Beer 2006; Almond *in* Macey *et al.* 2011). Crater lake facies identified on the basis of borehole cores include marginal conglomeratic debris flow deposits, offshore, thinly-interbedded distal debris flows and turbidites as well as fine-grained laminated mudrocks deposited by suspension settling in the deepest parts of the lake (Fig. 5). It is possible that further kimberlite pipes and crater deposits occur in the subsurface within the study area and may be impacted by the proposed prospecting programme (*N.B.* The precise location of the known Stompoor pipe is not marked on the available maps. Several other kimberlite occurrences are shown on the Kenhardt 1: 250 000 sheet < 30 km NW of the present study area, however).

- **Kalahari Group**

The great majority of the Stomp Oor 109 study area is mantled by Late Caenozoic superficial deposits assigned to the **Kalahari Group**. The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), Thomas & Shaw 1991, Haddon (2000) and Partridge *et al.* (2006) (See Fig. 7 for an outline stratigraphy). The north-eastern sector of the area is largely mantled by unconsolidated orange-brown aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation** (Qg, red stippled area in Fig. 6) whose thickness in the study region is unclear but may range up to at least 40 m. Reworked sands as well as coarser, gravelly alluvial deposits are concentrated along drainage lines and within basement depressions. The Gordonia Formation dune sands are considered to range in age from the Late Pliocene / Early Pleistocene, dated in part from enclosed Middle to Late Stone Age stone tools (Dingle *et al*., 1983). Surface **calcrete** is mapped over large portions of the south-western half of the study area area (Tec, yellow in Fig. 6). These pedogenic calcretes may be locally quite thick (perhaps up to several meters) and are likely to underlie the Kalahari sands to the north. They may be provisionally assigned to the Plio-Pleistocene **Mokalanen Formation** of the Kalahari Group and reflect seasonally arid climates in the region over the last five or so million years. Elsewhere in the Northern Cape 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. In addition to aeolian sands and calcrete, the superficial sediments in the study area also include stream alluvium, colluvial deposits associated with small bedrock exposures as well as downwasted surface gravels. Concentrations of polymict cobbly to bouldery gravels characterise the Dwyka group outcrop area in the Northern Cape where they may be provisionally assigned to the **Obobogorop Formation** of the Kalahari Group (Fig. 7).

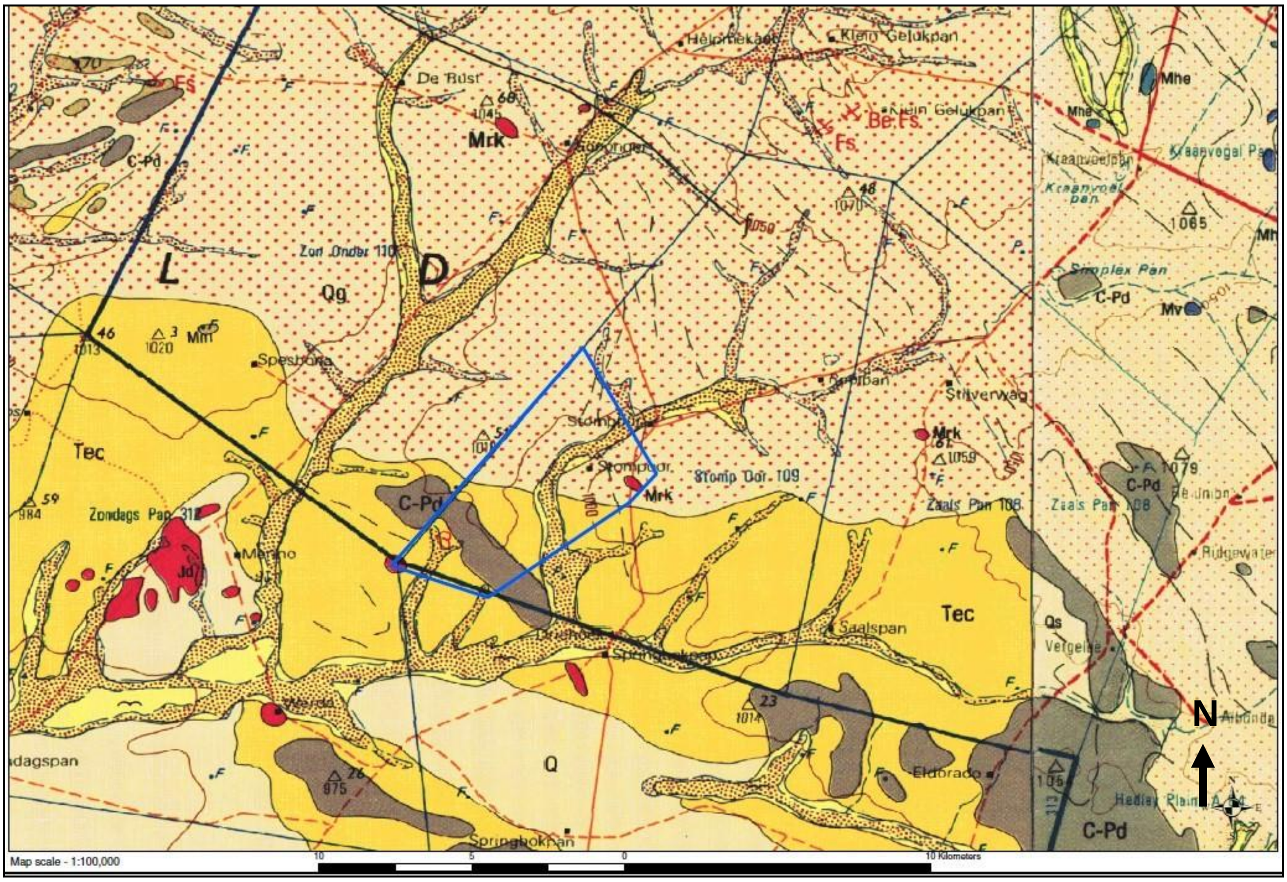

Figure 6. Extract from 1: 250 000 geological map 2920 Kenhardt (Council for Geoscience, Pretoria) showing the mineral prospecting study area on Farm Stomp Oor 109 (blue polygon) (Image provided by Alidabix (Pty) Ltd).

The following main rock units represented within the study area include:

1. Precambrian basement rocks (igneous / metamorphic) of the Keimoes Suite (Namaqua-Natal Metamorphic Province): Mrk (red) (*N.B.* Some small red areas might represent Early Jurassic dolerite which is mapped a few km to the west).
2. Karoo Supergroup sediments: grey (C-Pd) = Mbizane Formation (Dwyka Group)
3. Late Caenozoic (Quaternary to Recent) superficial deposits: dark yellow (Tec) = calcrete hardpans; pale yellow with red stipple (Qg) = Gordonia Formation aeolian sands (Kalahari Group); dense red stipple = alluvial deposits.

One or more Late Cretaceous kimberlite pipes are known in the region but are not indicated on the geological map of Stomp Oor 109 itself.

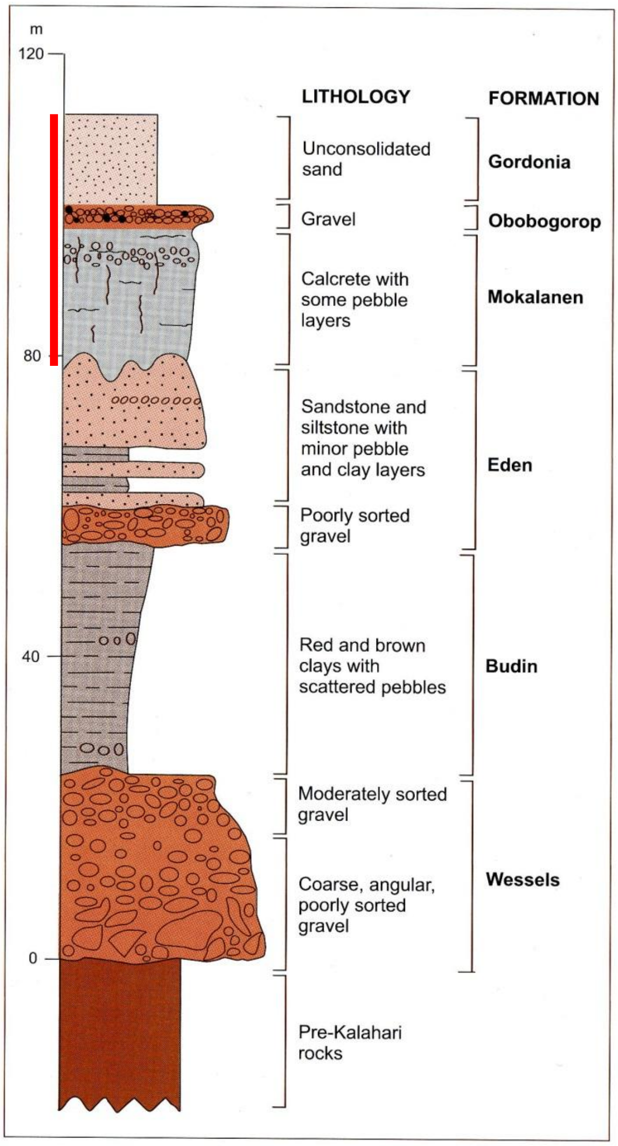

Figure 7. Generalised stratigraphy of the Late Cretaceous to Recent Kalahari Group (From Partridge *et al.* 2006). Only the upper units emphsized by the red line - Plio-Pleistocene subsurface calcretes (Mokalanen Formation), downwasted gravels (Obobogorop Formation) and overlying Pleistocene to Recent aeolian sands of the Gordonia Formation - are likely to be directly impacted by the proposed mineral prospecting activities on Farm Stomp Oor 109.

4. PALAEONTOLOGICAL HERITAGE

A brief account of known or potential fossil heritage preserved within the rock units represented on Farm Stomp Oor 109 is given in this section of the report (See also summary in Table 1).

Although they may originally have contained microfossils (*e.g.* ancient bacteria) the Mesoproterozoic basement metasedimentary rocks of the **Namaqua-Natal Metamorphic Province** that are a primary focus of mineral prospecting on Farm Stomp Oor 109 have been too intensely metamorphosed to preserve fossils, or they are igneous in origin.

The fossil record of the Permo-Carboniferous **Dwyka Group** is generally poor, as expected for a glacial sedimentary succession (McLachlan & Anderson 1973, Anderson & McLachlan 1976, Visser 1989, Visser *et al*., 1990, MacRae 1999, Visser 2003, Almond 2008, 2009, Almond & Pether 2008). A wide range of fossil groups is recorded from the **Dwyka Group** of the Northern Cape but recent field studies suggest that the glacially-related sediments are generally highly-weathered and calcretised near-surface in the Copperton region while well-preserved, potentially fossiliferous interglacial beds are not well-represented at surface in the area (*e.g.* Almond 2012, 2013a, 2013b). The only fossils recorded from the Dwyka rocks in the general region are small domical to columnar stromatolites preserved within bouldery erratics of grey carbonate (probably dolomite) have been reported from the farm Klipgats Pan by Almond (2013b). These erratics have probably been transported by ice movement from the Campbell Rand Subgroup (Ghaap Group) that crops out in the Ghaap Plateau to the north of Prieska. These reworked fossils are not of great palaeontological significance.

Thick successions (up to 300 m) of well-bedded crater lake deposits associated with post-Karoo volcanic pipes in southern Africa, including the **Bushmanland Pipe Swarm**, are known to be associated with rich fossil biotas of Late Cretaceous to Early Palaeogene age. Rare surface exposures as well as borehole core material from crater lake sediments has provided valuable evidence for environmental conditions and extinct biotas in the subcontinental interior around the time of the Cretaceous / Tertiary boundary. Closely comparable kimberlite crater lake biotas have been described from the Middle Cretaceous of Orapa in north-central Botswana (*c.* 95 Ma; Rayner & McKay 1986, Rayner *et al*. 1991, 1997, MacRae 1999), the Late Cretaceous or early Palaeocene Arnot Pipe at Banke near Platbakkies on the edge of the Bushmanland Plateau (*cf* Almond *in* Macey *et al.* 2011 and refs. therein) as well as from the Late Cretaceous of Stompoor near Prieska (*c* 70 Ma). Late Cretaceous dinosaur bones (the ornithischian *Kangnasaurus*) and ostracods have been recorded from coarse crater lake sediments from Kangnas near Goodhouse on the Orange River (Rogers 1913, Haughton 1915, Cooper 1985, De Wit *et al*. 1992).

The important Late Cretaceous (Maastrichtian) biota recorded from crater lake sediments on the Farm Stomp Oor 109 has been outlined, together with the sedimentological context and taphonomic analyses, in several well-illustrated papers by Smith (1986a, 1986b, 1988, 1995) (Fig. 8). The main fossil taxa involved are:

- The pipoid frog *Vulcanobatrachus* that is closely related to *Eoxenopoides* from the Arnot Pipe and modern platannas (Trueb *et al.* 2005);
- The galaxiid fish *Stompooria* (Anderson 1998) as well as disarticulated fish scales;
- A possible hollow bird bone as well as articulated vertebrae of an ornithopod dinosaur;
- Freshwater bivalves, gastropods, ostracods;
- Rare insect wings;
- Vascular plant remains including coalified wood, leaf impressions and an araucarian cone;

- Palynomorphs (spores and pollens) (Scholtz 1987).

It is noted that the crater lake deposits are mantled by over 40 m of Kalahari sands in the central portion of the diatreme while at its margins they lie only 1 m below the surface and so are accessible in shallow prospecting pits and boreholes (Trueb *et al.* 2005 p. 534).

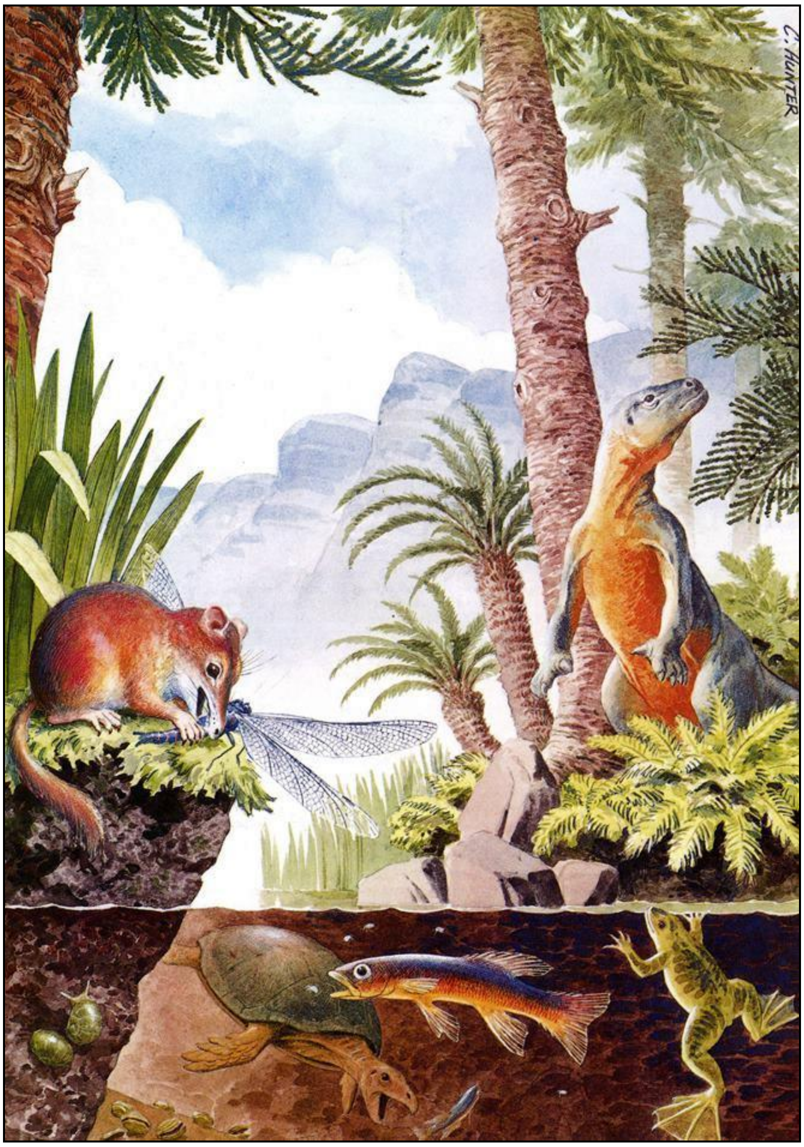

Figure 8. Artist's reconstruction of a Late Cretaceous (*c*. 70 Ma) crater lake and crater margin biota, based on the Stomp Oor 109 fossil site (From Smith 1986b).

The fossil record of the **Kalahari Group** that mantles most of the Bushmanland study area is also generally sparse and low in diversity. The **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying bedrocks (including, for example, dolerite) may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond 2008, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands. 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 of the **Mokolanen Formation**, as well as younger calcretes associated with modern pans and drainage lines, might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways.

Table 1: Summary of known or potential fossil heritage in the Stomp Oor 109 study area

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
KALAHARI GROUP ***plus*** **various unassigned superficial sediments of comparable age and origin**	Surface aeolian sands (Gordinia Formation), sandy and silty soils, calcrete hardpans (Mokolanen Fm), downwasted gravels, *plus* fluvial gravels, alluvium, freshwater pan deposits MAINLY PLEISTOCENE TO RECENT	Calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones & teeth, freshwater units associated with diatoms, molluscs, stromatolites *etc*	GENERALLY LOW BUT LOCALLY HIGH (*e.g.* concentrations of mammalian fossils, molluscs in pan and fluvial sediments)	Any substantial fossil finds (*e.g.* mammalian bones, teeth) to be reported by ECO to SAHRA for possible mitigation
BUSHMANLAND PIPE SWARM	Kimberlite pipes with epiclastic deposits incl. preserved crater lake sediments LATE CRETACEOUS - PALEOGENE	Bryophytes, vascular plants (leaves, wood, fruit, cones), fish, pipid frogs (adults, tadpoles), reptiles (tortoises, lizards), rare dinosaurs, birds (*e.g.* ratites), insects, ostracods, palynomorphs (bryophytes, ferns, gymnosperms, angiosperms) within crater lake sediments	VERY HIGH	Pre-construction field survey by professional palaeontologist to recommend mitigation and / or monitoring measures during development.
Mbizane Formation **DWYKA GROUP**	Tillites, interglacial mudrocks, deltaic & turbiditic sandstones, minor thin limestones LATE CARBONIFER-OUS – EARLY PERMIAN	Sparse petrified wood & other plant remains, palynomorphs, trace fossils (*e.g.* arthropod trackways, fish trails, U-burrows) possible stromatolites in limestones, fossiliferous erratics (*e.g.* stromatolitic limestones / dolomites)	MEDIUM	Pre-construction field survey by professional palaeontologist to recommend mitigation and / or monitoring measures during development.
Keimoes Suite **NAMAQIA-NATAL METAMORPHIC PROVINCE**	Small inliers of various granitic and high grade metamorphic rocks PRECAMBRIAN (MID - PROTEROZOIC)	NONE	N/A	None

Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient, **Plio-Pleistocene alluvial gravels**. Important fossil mammalian remains assigned to the Florisian Mammal Age (*c*. 300 000 – 12 000 BP; MacRae 1999) have been documented from stratigraphic units designated Group 4 to Group 6 (*i.e.* calcrete hardpan and below) at Bundu Pan, some 22 km northwest of Copperton (Kiberd 2006 and refs. therein). Orton (2012) recently recorded a single fossil equid tooth associated with a rich MSA artefact assemblage exposed in an erosion donga leading into the southern edge of a small quarry on the farm Hoekplaas (originally a pan area), near Copperton. It is possible that fossil bones and teeth of mammals are preserved within buried Pleistocene fluvial and pan sediments within the present study area, as seen at Bundu Pan. However, such fossil sites are likely to be sparsely distributed and their locations difficult to predict, given the extensive younger sedimentary cover.

5. SUMMARY & RECOMMENDATIONS

The Precambrian basement rocks of the Namaqua-Natal Province that underlie the Stomp Oor 109 study area at depth and that are a primary target of mineral prospecting are of no palaeontological heritage significance; they are either too old or too highly-metamorphosed to contain fossils, or they are igneous in origin. Overlying Permo-Carboniferous glacial-related sediments of the Mbizane Formation (Dwyka Group) cropping out in the southern portion of the study area are - at most - of moderate palaeontological palaeosensitivity since they might contain plant remains and trace fossils. Most of the study area is mantled by superficial deposits of the Late Caenozoic Kalahari Group, including wind-blown sands, calcretes and alluvium along shallow water courses. These superficial sediments are generally of low palaeontological sensitivity in Bushmanland. However, scientifically-important occurrences of fossil mammals have been recorded in association with stone artefacts within pan and alluvial gravel sediments near Copperton. Of particular note is the fact that highly-fossiliferous crater lake deposits of Late Cretaceous age (*c*. 70 Ma = million years old) have been recorded on Farm Stomp Oor 109 and may be present at more than one site here, buried beneath the superficial sediment cover. A variety of terrestrial and freshwater fossil groups - including well-preserved pipoid frogs, galaxiid fish, rare dinosaur remains, insects, crustaceans, molluscs and plants – have been sampled from near-surface exposures as well as borehole cores. They provide a rare glimpse of extinct biotas of the subcontinental interior shortly before the catastrophic end-Cretaceous Mass Extinction Event. While fossiliferous sediments from the central part of the identified crater lake site are covered by over 40 m of sandy overburden, well-preserved fossils have also been recovered from marginal trenches and borehole cores penetrating only 1-3 m beneath the present land surface. The invasive phases of the proposed mineral prospecting programme (*viz*. percussion and core drilling) might have negative impacts of important fossil heritage preserved at or beneath the surface.

It is therefore recommended that a site visit by a professional palaeontologist be commissioned by the developer well before the commencement of the invasive phases of the prospecting programme. The resulting palaeontological heritage assessment report should make recommendations for any mitigation or monitoring measures to be following during siting, drilling and rehabilitation of the boreholes as well as for conservation of sedimentary borehole core material for future palaeontological analysis.

There are no objections on palaeontological grounds to the non-invasive phases of the proposed mineral prospecting programme on Farm Stomp Oor 109. The ECO responsible for the mineral prospecting project should be aware of the potential for important fossil occurrences within near-surface or buried crater lake deposits and the necessity to conserve them for possible professional mitigation. A Chance Fossil Finds Procedure for the non-invasive phases of the prospecting programme is outlined in tabular form at the end of this report. Recommended mitigation of chance fossil finds involves safeguarding of the fossils (preferably *in situ*) by the responsible ECO and reporting of all significant finds to the South African Heritage Resources Agency, SAHRA (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 programme.

6. ACKNOWLEDGEMENTS

Mr Hano Haman of Alidabix (Pty) Ltd is thanked for commissioning this study and for providing the relevant background information. I am most grateful to Ms Claire Browning as well as Dr Thalassa Matthews of Iziko: South African Museums, Cape Town for assistance with obtaining relevant palaeontological literature.

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

Declaration of Independence

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

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

<table>
<tr><td colspan="3">CHANCE FOSSIL FINDS PROCEDURE: Mineral prospecting on Farm Stomp Oor 109 near Copperton</td></tr>
<tr><td>Province & region:</td><td colspan="2">NORTHERN CAPE, Prieska District</td></tr>
<tr><td>Responsible Heritage Management Authority</td><td colspan="2">SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Dwyka Group (Mbizane Formation) glacial-related sediments. Late Cretaceous crater lake sediments. Kalahari Group calcretes, aeolian sands, alluvium.</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Plant remains and trace fossils in Dwyka sediments. Well-preserved fossil frogs, fish, molluscs and plant remains, rare dinosaur bons in crater lake sediments. Bones, teeth, horn cores of mammals as well as calcretised burrows (e.g. termite nests, plant root and stem casts) , non-marine molluscs</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
• Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
• Context – describe position of fossils within stratigraphy (rock layering), depth below surface
• Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
• Alert Heritage Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation
• Ensure fossil site remains safeguarded until clearance is given by the Heritage Management Authority for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
• Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
• Photograph fossils against a plain, level background, with scale
• Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
• Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
• Alert Heritage Management Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Management Authority, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Management Authority</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Management Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Management Authority minimum standards.</td></tr>
</table>