Gamsberg Zinc Mine and Associated Infrastructure, Northern Cape

Khâi-Ma Local Municipality, Namakwa District Municipality, Northern Cape Province

Farm: Portions 1 Bloemhoek 61, Portion 1 and 4 Gams 60, Aroams 57

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***Palaeontological Impact Assessment: Desktop Study***

Facilitated by: APelser Archaeological Consulting cc

833B St Bernard Street, Garstfontein, 0081

Tel: 083 459 3091

2022/03/02

Ref: Pending

**B. Executive summary**

Outline of the development project: APelser Archaeological Consulting cc has facilitated the appointment of Dr H. Fourie, a palaeontologist, to undertake a Palaeontological Impact Assessment (PIA), Phase 1: Field Study of the Gamsberg Zinc Mine and Associated Infrastructure, Northern Cape in the Khâi-Ma Local Municipality, Namakwa District Municipality on Farm: Portions 1 Bloemhoek 61, Portion 1 and 4 Gams 60, Aroams 57.

The applicant, Black Mountain Mining (Pty) Ltd. Gamsberg Mine currently requires further environmental related applications to authorise additional activities that are required for ongoing operations and which were not included in the previous authorisations, and authorise changes required in infrastructure layout as a result of optimised planning..

The Project includes one locality Option (see Figure 1):
Alternative 1: An area indicated with infrastructure in colour with the town of Aggenys to the northwest.

**Legal requirements:-**

The **National Heritage Resources Act (Act No. 25 of 1999) (NHRA)** requires that all heritage resources, that is, all places or objects of aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance are protected. The Republic of South Africa (RSA) has a remarkably rich fossil record that stretches back in time for some 3.5 billion years and must be protected for its scientific value. Fossil heritage of national and international significance is found within all provinces of the RSA. South Africa's unique and non-renewable palaeontological heritage is protected in terms of the National Heritage Resources Act. According to this act, palaeontological resources may not be excavated, damaged, destroyed or otherwise impacted by any development without prior assessment and without a permit from the relevant heritage resources authority.

The main aim of the assessment process is to document resources in the development area and identify both the negative and positive impacts that the development brings to the receiving environment. The PIA therefore identifies palaeontological resources in the area to be developed and makes recommendations for protection or mitigation of these resources.

"palaeontological" means any fossilised remains or fossil trace of animals or plants which lived in the geological

past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or traces.

For this study, resources such as geological maps, scientific literature, institutional fossil collections, satellite images, aerial maps and topographical maps were used. It provides an assessment of the observed or inferred palaeontological heritage within the study area, with recommendations (if any) for further specialist palaeontological input where this is considered necessary.

A Palaeontological Impact Assessment is generally warranted where rock units of **LOW** to **VERY HIGH** palaeontological sensitivity are concerned, levels of bedrock exposure within the study area are adequate; large scale projects with high potential heritage impact are planned; and where the distribution and nature of fossil remains in the proposed area is unknown. The specialist will inform whether further monitoring and mitigation are necessary.

Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):
(i) (i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens.

This report adheres to the guidelines of Section 38 (1) of the National Heritage Resources Act (Act No. 25 of 1999). Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as (a) the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length; (b) the construction of a bridge or similar structure exceeding 50 m in length; (c) any development or other activity which will change the character of a site (see Section 38); (d) the re-zoning of a site exceeding 10 000 m² in extent; (e) or any other category of development provided for in regulations by SAHRA or a PHRA authority.

This report aims (**1c)** to provide comment and recommendations on the potential impacts that the proposed development could have on the fossil heritage of the area and to state if any mitigation or conservation measures are necessary.

Outline of the geology and the palaeontology:

The geology was obtained from map 1:100 000, Geology of the Republic of South Africa (Visser 1984) and the 1:250 000 geological map of Pofadder 2918 (Agenbacht and Praelkelt 2001).

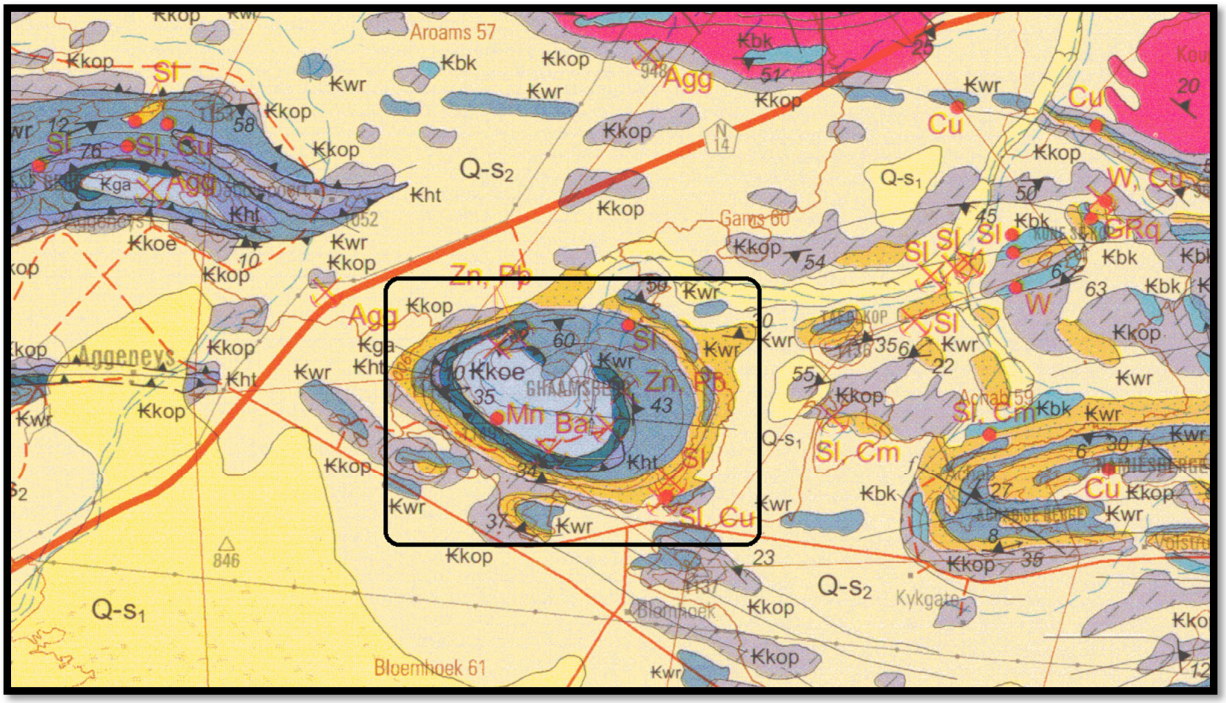



**Figure:** The geology of the development area.

*Legend to Figure and short explanation.*

Q-s1 – Red wind-blown sand and dunes (dark yellow). Gordonia Formation, Kalahari Group. Quaternary.

Q-s2 – Sand, scree, rubble, sandy soil (yellow). Unnamed. Quaternary.

Namaqua Metamorphic Province:

Nsm – Yellow-brown to- grey-weathering biotite-hornblende augen gneiss (red). Swartmodder gneiss.

Bushmanland Group:

Kkoe – Brown-weathering psammitic schist, conglomerate, amphibolite and quartzite.

Kga – Sulphide-bearing magnetite-grunerite-garnet-pyroxene rocks, cordierite fels, sillimanite schist and quartzite.

Kht – Rhythmically layered quartzite, quarts-feldspar-biotite gneiss ± sillimanite nodules, quartz-biotite-sillimanite schist.

Kwr – Layered sequence of mainly medium- to thick-bedded, white quartzite and pelitic schist (▒) with interbedded sillimanite bodies. Minor lenticular quartzite, biotite gneiss and massive amphibolite/calc-silicate gneiss.
Kbk – Fine- to medium-grained, massive to finely layered calc-silicate gneiss, amphibolite, biotite gneiss and marble (‡).
Gladkop Metamorphic Suite:
Kkop – Red-brown-weathering, medium- to coarse-grained leucogneiss, in places biotite-rich with abundant augen.
---f--- – (black) Fault.
……. – Undifferentiated linear structure.
□ – Approximate position of expansion (in black on figure).

Mining Activities in study area on Figure above
Zn – Zinc ore.

Summary of findings: The Palaeontological Impact Assessment: Phase 1: Field Study was undertaken in February 2022 in a wet summer with hot conditions (Appendix 6 of Act, **1(d)**) during the official Level 1 lockdown of the Covid-19 virus. The following is reported:

The development is taking place over several geological formations.

Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary, are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Inland deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous. Some of these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980).

The Kalahari deposits extend in age down to at least the Late and probably the Early Tertiary (65 million years ago). Fossils are scarce, and are of terrestrial plants and animals with close affinity to living forms. Included in the Kalahari Group are the Quaternary alluvium, terrace gravels, surface limestone, silcrete, and aeolian sand. Four major types of sands have been delineated (Kent 1980, Visser 1989). The Kalahari Group is underlain by the Uitenhage and Zululand Groups (McCarthy and Rubidge 2005).

The rocks of the Namaqua Metamorphic Province are mostly gneissic in character. It is present along the Orange River from Prieska in the east to the Atlantic Ocean. The radiometric age vary from 1 350 to 2 000 Ma. The Koperberg Suite is at the top as an intrusive, followed by the Spektakel Suite, Keimoes Suite, Hoogoor Suite, Little Namaqualand Suite, Gladkop Suite, Vioolsdrif Suite, underlain by the metasedimentary and volcanic rocks of the Orange River Group, Okiep Group, Bushmanland Group, Korannaland Sequence and at the bottom, the Marydale and Kaaien Groups (Kent 1980).

The Bushmanland Group comprises the pregranitic succession in Bushmanland. Subgroups present are the Pella (Swartmodder Gneiss), Gaudom, Hom, Aggeneys (Namies Schist and Gams formations) (now Wortel, Witputs, Skelmpoort, T'hammaberg, Hotson, Koeris). Outcrops are mostly present as inselberge with an age of 1 305 – 1 415 Ma (Kent 1980, Visser 1989, Cornell *et al.* 2006).

The Gladkop Metamorphic Suite derives its name from a hill or inselberg consisting of the Steinkopf Gneiss, Brandewynsbank Gneiss near Springbok and intrusive in the Steinkopf Gneiss, and the Noenoemaasberg Gneiss intrusive into the Brandewynsbank Gneiss near Ratelpoort (Kent 1980).

*Palaeontology* - Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, the palaeontological sensitivity can generally be **LOW** to **VERY HIGH**, and here in the development **LOW** and **VERY LOW** (SG 2.2 SAHRA APMHOB, 2012) (Almond and Pether 2009).

The more recent Phanerozoic deposits (Cenozoic) are of importance in the study of life during the last 300 million years. Large areas in the western part of the Northern Cape Province are underlain by Cenozoic (Tertiary, Quaternary) deposits of the Kalahari Group. The palaeontology of the Kalahari Group in the Northern Cape is poorly studied, but palynomorphs, root casts (rhizomorphs), burrows, rare vertebrate remains (mammals, fish, ostrich egg shell), diatom-rich limestones, freshwater stromatolites, freshwater and terrestrial shells (gastropods, bivalves), ostracods, and charophytes may occur (Almond and Pether 2009).

The Budin Formation may contain numerous calcified root casts, as can be seen at Sishen Ore Mine. Fossils such as numerous ostracods, bivalves, gastropods, as well as diatoms are present in the Lonely Formation (Partridge *et al.* 2006).

Recommendation:
The impact of the proposed additional infrastructure and activities on the fossil heritage is **LOW**. A Phase 1 Palaeontological Impact Assessment: Field Study was done. A Phase 2: Mitigation is recommended if fossils are found during excavating, drilling, clearing or blasting (according to SAHRA protocol).

**Table 2:** Criteria used (Fossil Heritage Layer Browser/SAHRA):

| Rock Unit | Significance/vulnerability | Recommended Action |
|---|---|---|
| Kalahari | **Low** | Desktop study not required, however protocol for chance finds is |
| Namaqua Metamorphic | **Very Low** | No action required |
| Bushmanland Group | **Low** | Desktop study not required, however protocol for chance finds is |

The Project includes one locality Option (see Figure 1):
Alternative 1: An area indicated with infrastructure in colour with the town of Aggenys to the northwest.

The PIA done by Pether 2013 is relevant.

The mining of the zinc ore will take place in the unfossiliferous Bushmanland Group with a **LOW** sensitivity.

Concerns/threats to be added to the EMPr (**1k,l,m**):

1. The overburden and inter-burden must always be surveyed for fossils. Special care must be taken during the clearing, digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden not to intrude fossiliferous layers (probably not relevant for this project).
2. Threats are earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction, the sealing-in, disturbance, damage or destruction of the fossils by development, vehicle traffic, prospecting, mining, and human disturbance.

The recommendations are (**1g)**:

1. Mitigation is needed if fossils are found, permission needed from SAHRA.
2. No consultation with parties was necessary.

3. The development may go ahead with caution, but the ECO must survey for fossils before or after blasting or excavating in line with the legally binding Environmental Management Programme (EMPr) this must be updated to include the involvement of a palaeontologist/ archaeozoologist when necessary.
4. The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction activities. The protocol is to immediately cease all construction activities if a fossil is unearthed, construct a 30 m no-go barrier, and contact SAHRA for further investigation.

Stakeholders: Developer – Black Mountain Mining (Pty) Ltd. Gamsberg Mine
Environmental – APelser Archaeological Consulting cc. 833B St Bernard Street, Garstfontein, 0081, Tel: 083 459 3091.
Landowner – Black Mountain Mining (Pty) Ltd.

**C. Table of Contents**



**D. Background information on the project**

Report

This report is part of the environmental impact assessment process under the National Environmental Management Act, as amended (Act No. 107 of 1998) (NEMA) and includes Appendix 6 (GN R38282 of 4 December 2014) of the Environmental Impact Assessment Regulations (see Appendix 1). It is also in compliance with SG 2.2 SAHRA APMHOB Guidelines, 2012. Minimum standards for palaeontological components of Heritage Impact Assessment Reports, Pp 1-15 (**2)**.

Outline of development

This report discusses and aims to provide the developer with information regarding the location of palaeontological material that will be impacted by the development. In the pre-mining phase it may be necessary for the developer to apply for the relevant permit from the South African Heritage Resources Agency depending on the presence or absence of fossils (SAHRA / PHRA).

The applicant, Black Mountain Mining (Pty) Ltd. Gamsberg Mine currently requires further environmental related applications to authorise additional activities that are required for ongoing operations and which were not included in the previous authorisations, and authorise changes required in infrastructure layout as a result of optimised planning.

They currently mine zinc, lead, copper and silver at an opencast mine near Aggeneys. The Gamsberg inselberg is being mined via upperground operations. An estimated 1.5 billion tons of waste rock will be generated during the Life of Mine. The haul trucks transport the waste material to the edge of the inselberg where it is tipped over the edge to form a waste rock dump expected to cover 490 hectares.

Local benefits of the proposed development include benefits to the local economy, job creation and social development for the community.

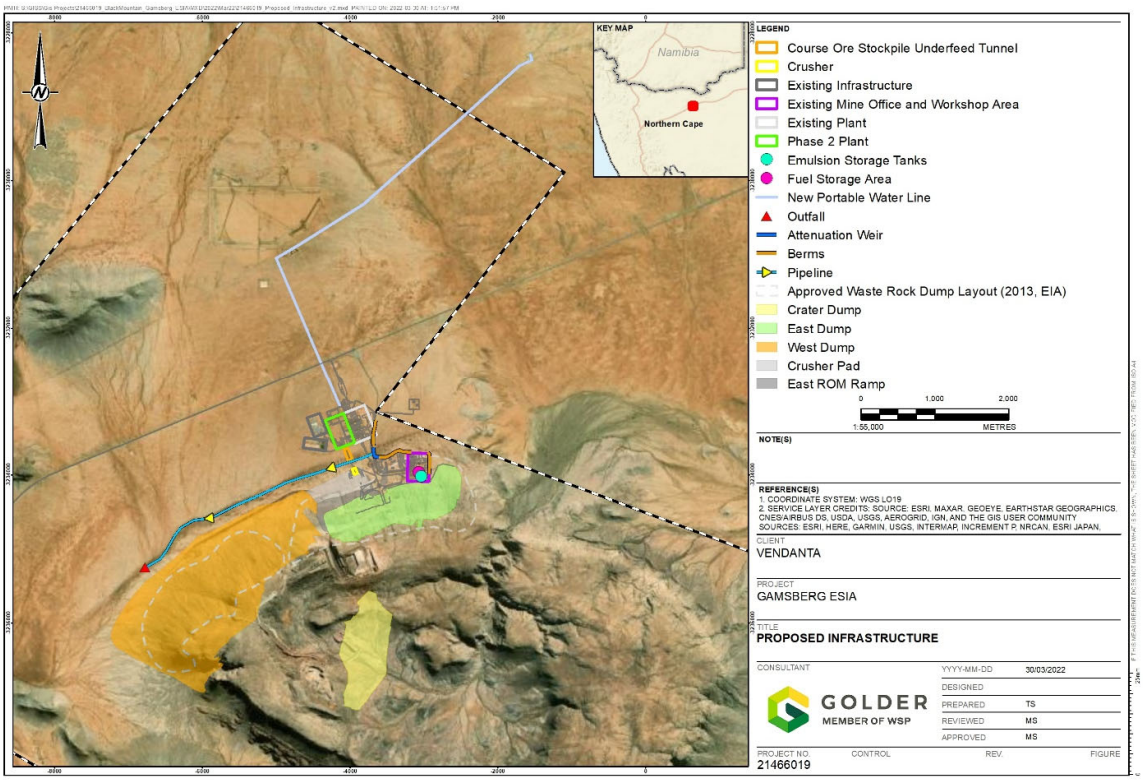



**Figure 1:** Map showing planned infrastructure (Golder).

The following infrastructure is anticipated (± 746.89 hectares):

1. New potable water pipeline
2. Expansion of dangerous goods storage facilities
3. River diversion
4. Redefined layout for the waste rock dump and quartzite rock dump/berm
5. Defined layout for the crusher and coarse ore stockpile for the 2nd phase of the concentrator plant.

The Project includes one locality Option (see Figure 1):
Alternative 1: An area indicated with infrastructure in colour with the town of Aggenys to the northwest.

Rezoning/ and or subdivision of land: No.
Name of Developer and Consultant: Black Mountain Mining (Pty) Ltd. Gamsberg Mine and APelser Archaeological Consulting cc.

Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a palaeontological impact assessment to ascertain if any palaeontological sensitive material is present in the development area. This study will advise on the impact on fossil heritage mitigation or conservation necessary, if any.

*Short Curriculum vitae (**1ai,ii**):* Dr Fourie obtained a Ph.D from the Bernard Price Institute for Palaeontological Research (now ESI), University of the Witwatersrand. Her undergraduate degree is in Geology and Zoology. She specialises in vertebrate morphology and function concentrating on the Therapsid Therocephalia. For the past 15 years she carried out field work in the Eastern Cape, Limpopo, Mpumalanga, Gauteng, Free State and Kwazulu Natal Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 26 years.

Legislative requirements: South African Heritage Resources Agency (SAHRA) for issue of permits if necessary. National Heritage Resources Act (Act No. 25 of 1
999). An electronic copy of this report must be supplied to SAHRA.

**E. Description of property or affected environment**

Location and depth:

The Gamsberg Zinc Mine and associated infrastructure is situated in the Khâi-Ma Local Municipality, Namakwa District Municipality, Northern Cape, on portion 1 of farm Bloemhoek 61, portion 1 of farm Gams 60 and remainder of farm Aroams 57.

Depth is determined by the related infrastructure, such as the foundations to be developed and the thickness of the formation. Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to determine due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot. Geological maps do not provide depth or superficial cover it only provides mappable surface outcrops.

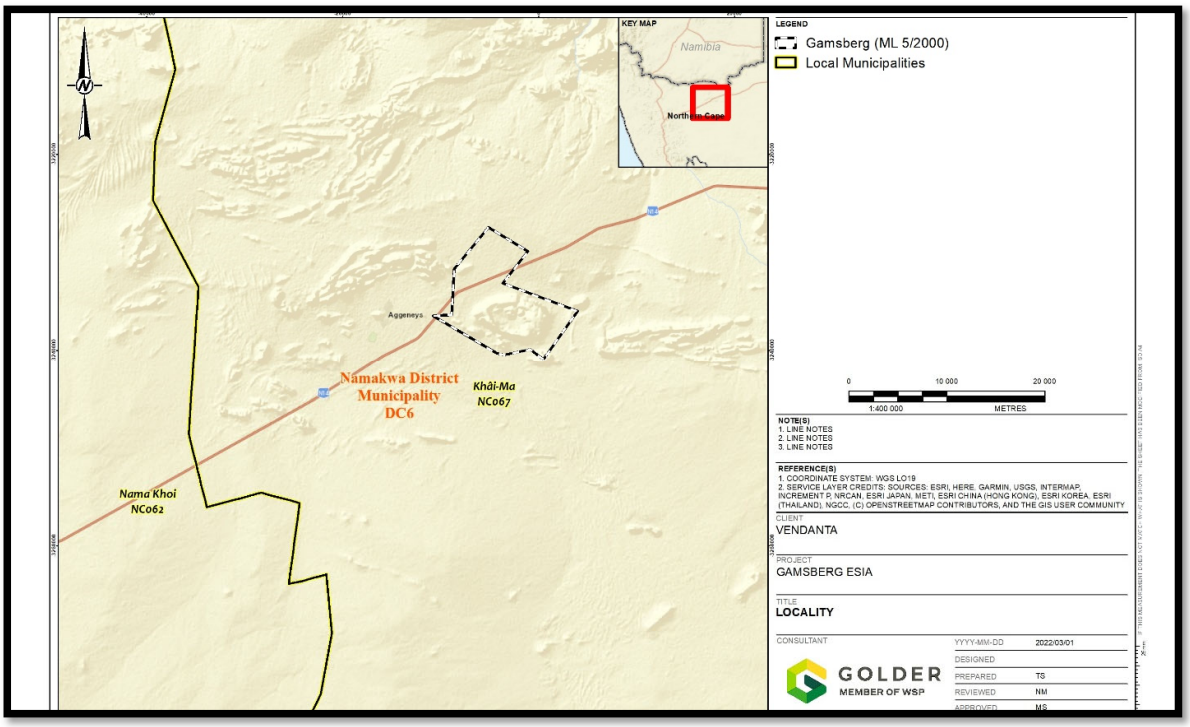



**Figure 2:** Location map Google Earth (Golder).

**F. Description of the Geological Setting**

Description of the rock units:

Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary, are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Inland deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous. Some of these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996). A thick cover of Kalahari reddish sand blankets most outcrops and is dominated by the typical Kalahari thornveld (Norman and Whitfield 2006).

The Kalahari deposits extend in age down to at least the Late and probably the Early Tertiary (65 million years ago). Fossils are scarce, and are of terrestrial plants and animals with close affinity to living forms. Included in the Kalahari Group are the Quaternary alluvium, terrace gravels, surface limestone, silcrete, and aeolian sand. Four major types of sands have been delineated (Kent 1980, Visser 1989). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996). A thick cover of Kalahari reddish sand blankets most outcrops and is dominated by the typical Kalahari thornveld (Norman and Whitfield 2006). The Kalahari Group is underlain by the Uitenhage and Zululand Groups (McCarthy and Rubidge 2005).

The Kalahari Group consists of the Wessels Formation at the base, followed by the Budin Formation, the Eden Formation, Mokalanen Formation, Obobogorop Formation and the Gordonia Formation at the top. The Lonely Formation is also present (Partridge *et al.* 2006).

The Gordonia Formation (Qg) is of Late Pliocene / Pleistocene to Recent in age (the well-known "Kalahari Sands"). It can be up to 30 m thick and form part of a vast dune sea or erg that stretches northwards to the equator and beyond (Almond and Pether 2009).

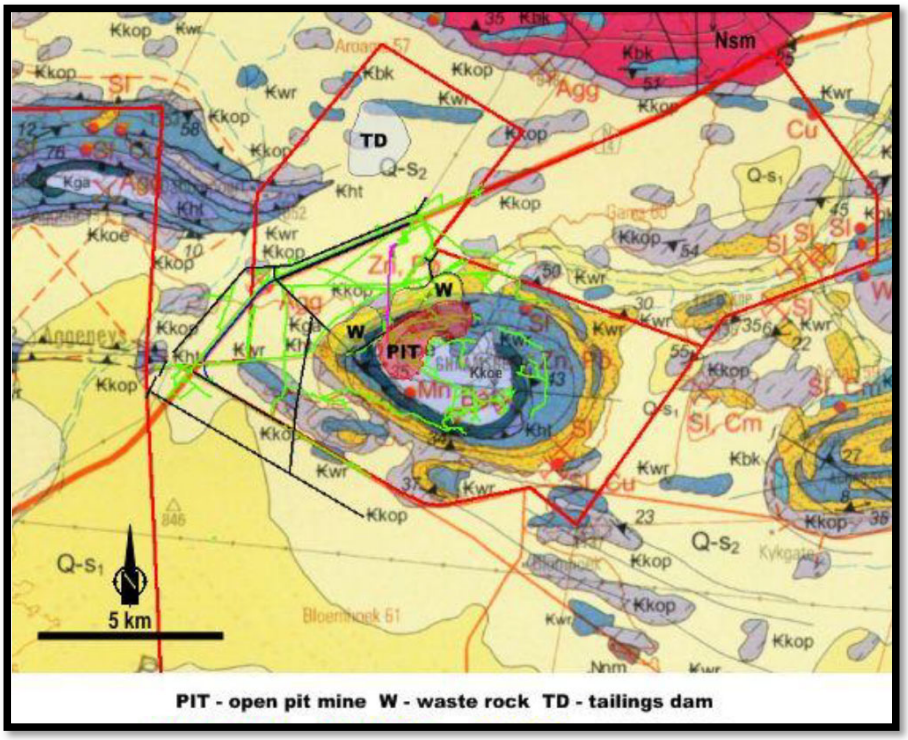
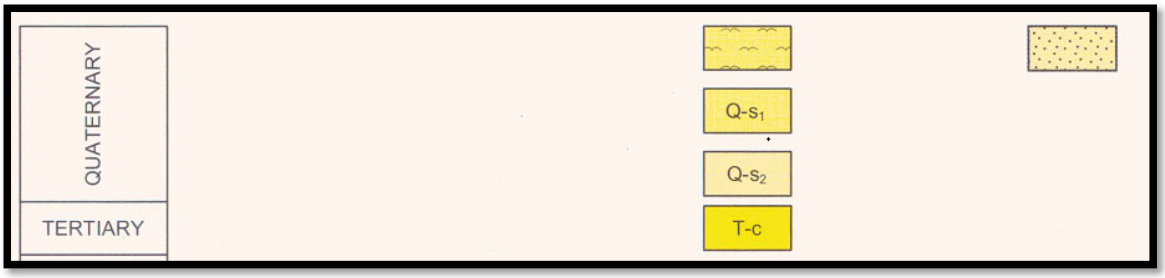



**Figure 3:** Geology of the area (Agenbacht and Praekelt 2001) (Pether 2013) (**1h**).
*Legend to Figure and short explanation.*

Kalahari Group:

Q-s1 – Red wind-blown sand and dunes (dark yellow). Gordonia Formation, Kalahari Group. Quaternary.

Q-s2 – Sand, scree, rubble, sandy soil (yellow). Unnamed. Quaternary.

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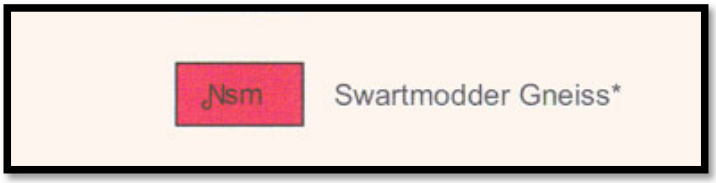


Bushmanland Group:

Kkoe – Brown-weathering psammitic schist, conglomerate, amphibolite and quartzite.

Kga – Sulphide-bearing magnetite-grunerite-garnet-pyroxene rocks, cordierite fels, sillimanite schist and quartzite.

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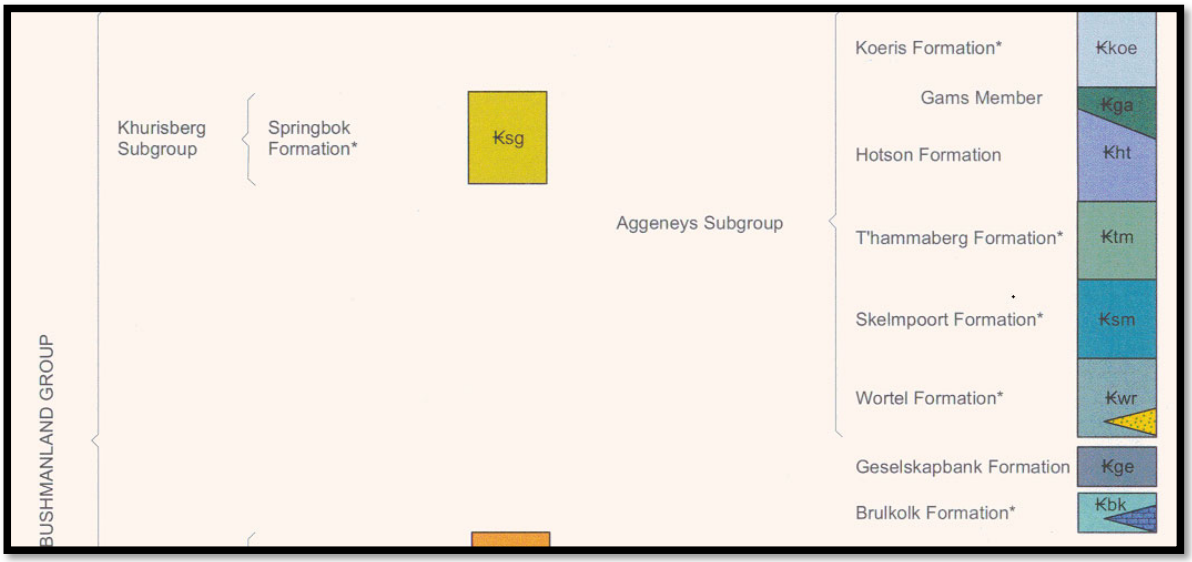


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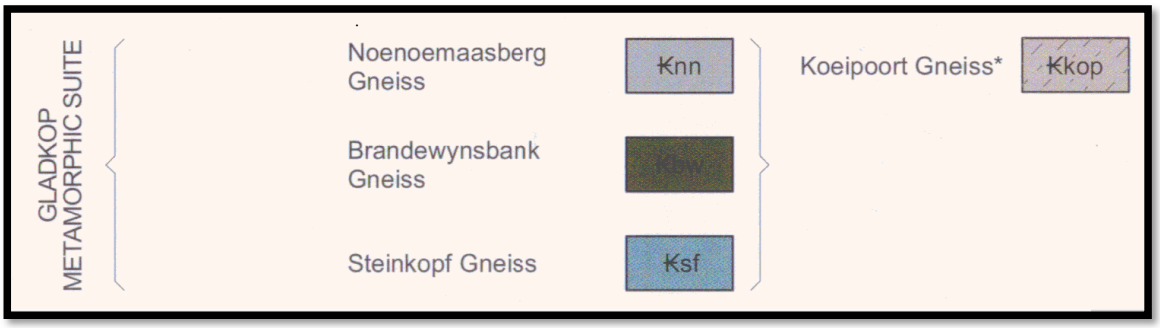


---f--- – (black) Fault.
……. – Undifferentiated linear structure.
□ – Approximate position of mining right (in black on figure).

Mining Activities in study area on Figure above

Agg – Aggregate Ba – Barytes Mn – Manganiferous iron ore Pb – Lead
Sl – Sillimanite Zn - Zinc.

The mining past and present has an influence on this development.

The rocks of the Namaqua Metamorphic Province are mostly gneissic in character. It is present along the Orange River from Prieska in the east to the Atlantic Ocean. The radiometric age varies from 1 350 to 2 000 Ma. The Koperberg Suite is at the top as an intrusive, followed by the Spektakel Suite, Keimoes Suite, Hoogoor Suite, Little Namaqualand Suite, Gladkop Suite, Vioolsdrif Suite, underlain by the metasedimentary and volcanic rocks of the Orange River Group, Okiep Group, Bushmanland Group, Korannaland Sequence and at the bottom, the Marydale and Kaaien Groups (Kent 1980).

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Aggeneys is situated near the N14 National Road with the plains covered by thick Kalahari deposits, including numerous stabilised red sand dunes and thick calcrete. The Gamsberg orebody is low grade, but large (Norman and Whitfield 2006).

*Field Observation* – Access on this mine is controlled therefore one cannot move around freely to observe the site.


**Figure 4:** Present waste rock dump area.


**Figure 5:** Another view of the waste rock dump area – V cut area.


**Figure 6:** Area to the left of the V-cut area.


**Figure 7:** View of opencast area.


**Figure 8:** Another view of the open pit area.


**Figure 9:** View of middle section of the open pit area.


**G. Background to Palaeontology of the area**

Summary: When rock units of moderate to very high palaeontological sensitivity are present within the development footprint, a desk top and or field scoping (survey) study by a professional palaeontologist is usually warranted. The main purpose of a field scoping (survey) study would be to identify any areas within the development footprint where specialist palaeontological mitigation during the construction phase may be required (SG 2.2 SAHRA AMPHOB, 2012).

'Algal microfossils' have been reported from shales and are probably of diagenetic origin (Eriksson 1999), these may be present here. Stromatolites are significant indicators of palaeoenvironments and provide evidence of algal growth between 2640 and 2432 million years ago. Significant fossil remains of Cenozoic aged terrestrial organisms have been recorded from the sedimentary rocks of the Kalahari Group. These fossils are rarely found and are allocated a **HIGH** palaeontological sensitivity as they are important indicators of palaeo-environmental conditions (Groenewald and Groenewald 2014).

The palaeontology of the Kalahari Group in the Northern Cape is poorly studied, but palynomorphs, root casts (rhizomorphs), burrows, rare vertebrate remains (mammals, fish, ostrich eggshell), diatom-rich limestones, freshwater stromatolites, freshwater and terrestrial shells (gastropods, bivalves), ostracods, and charophytes may occur (Almond and Pether 2009). The more recent Phanerozoic deposits (Cenozoic) are of importance in the study of life during the last 300 million years. Large areas in the western part of the Northern Cape Province are underlain by Cenozoic (Tertiary, Quaternary) deposits of the Kalahari Group.

The Gamoep Suite near Platbakkies yielded pollen flora, leaves, wood, frogs, and insects. The teeth and bones of the dinosaur *Kangnasaurus* were found at the farm Kangnas 77 (Pether 2013). The Kao Valley has yielded fossils of *Gomphotherium*, bovids, giraffids, a rhinocerotid, tortoises, rodents, crocodile teeth, and catfish. At Areb, teeth of the extinct horse *Hipparion* were found (Pether 2013) just to mention a few fossil localities in the greater area.

**Figure 11:** Example of a Stromatolite (Photograph: E. Butler).

**Table 1:** Taken from Palaeotechnical Report (Almond and Pether 2009) **(1cA, 1cB)**.

| | | | |
|---|---|---|---|
| **18. KALAHARI GROUP**<br><br>**Wessels (Tw), Budin (Tb), Eden (Te), Mokalanen (T-Qm), Obobogorop, Gordonia (Qg) and Lonely Formations** | Fluvial gravels, sands, lacustrine and pan mudrocks, diatomites and diatomaceous limestones, evaporites, consolidated to unconsolidated aeolian sands, pedocretes (especially calcrete)<br><br>Late Cretaceous to Recent<br><90 Ma → 0 Ma | Palynomorphs, root casts (rhizomorphs / rhizoliths) and burrows (*eg* termitaria), rare vertebrate remains (mammals, fish, ostrich egg shell *etc*), diatoms, freshwater stromatolites, freshwater and terrestrial shells (gastropods, bivalves), ostracods, charophytes | Fossils mainly associated with ancient pans, lakes and river systems<br><br>Palaeontology poorly studied. Basal Late Cretaceous gravels and lacustrine clays probably fossiliferous (bones, teeth, petrified wood, palynomorphs?) but v. rarely exposed. |
| **4. NAMAQUA METAMORPHIC PROVINCE**<br>**large number of subunits (M*….)** | Igneous and metamorphic rocks (including high grade metasediments)<br>Early to Mid Proterozoic (Mokolian)<br>*c.* 2-1 Ga | NO FOSSILS RECORDED | |

Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, if there is the presence of Karoo Supergroup strata the palaeontological sensitivity is generally **LOW** to **VERY HIGH**.

**Table 2:** Criteria used (Fossil Heritage Layer Browser/SAHRA):

| Rock Unit | Significance/vulnerability | Recommended Action |
|---|---|---|
| Kalahari | **Low** | Desktop study is not required, but protocol for chance find |
| Namaqua Metamorphic | **Very Low** | No action required |
| Bushmanland Group | **Low** | Desktop study is not required, but protocol for chance find |

Databases and collections: Ditsong: National Museum of Natural History.

Impact: **LOW** for the Kalahari age sediments and for the Bushmanland Group. There are significant fossil resources that may be impacted by the development and if destroyed are no longer available for scientific research or other public good.

The Project includes one locality option (Figure 1) (**1f,j)** with a **LOW** palaeontological sensitivity.
Alternative 1: An area indicated with infrastructure in colour with the town of Aggenys to the northwest. The approximate size of the waste rock dump is 250 hectares.

All the land involved in the development was assessed **(ni,nii)** and none of the property is unsuitable for development (see Recommendation B).

**H. Description of the Methodology (1e)**
The palaeontological impact assessment: desktop study was undertaken in February 2022. A Phase 1: Field Study will entail a walkthrough of the affected portion with photographs (in 20 mega pixels) taken of the site with a digital camera (Canon PowerShot SX620HS). A Global Positioning System (GPS (Garmin eTrex 10) can be used to record the outcrops. A literature survey is included and the study relied on literature, geological maps, google.maps and google.earth images.

Assumptions and Limitations **1(i)**:-
The accuracy and reliability of the report **may be** limited by the following constraints:

1. Most development areas have never been surveyed by a palaeontologist or geophysicist.
2. Variable accuracy of geological maps and associated information.
3. Poor locality information on sheet explanations for geological maps.
4. Lack of published data.
5. Lack of rocky outcrops.
6. Inaccessibility of site.
7. Insufficient data from developer and exact lay-out plan for all structures.

**A Phase 1 Palaeontological Impact Assessment: Field Study will include:**

1. Recommendations for the future of the site.
2. Background information on the project.
3. Description of the property of affected environment with details of the study area.
4. Description of the geological setting and field observations.
5. Background to palaeontology of the area.
6. Field Rating.
7. Stating of Significance (Heritage Value).

**A Phase 2 Palaeontological Impact Assessment: Mitigation will include**:

1. Recommendations for the future of the site.
2. Description of work done (including number of people and their responsibilities).
3. A written assessment of the work done, fossils excavated, not removed or collected and observed.
4. Conclusion reached regarding the fossil material.
5. A detailed site plan.
6. Possible declaration as a heritage site or Site Management Plan.

**The National Heritage Resources Act No. 25 of 1999 further prescribes:**

Act No. 25 of 1999. National Heritage Resources Act, 1999.
National Estate: 3 (2) (f) archaeological and palaeontological sites,
(i)(1) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens,
Heritage assessment criteria and grading: (a) Grade 1: Heritage resources with qualities so exceptional that they are of special national significance;
(b) Grade 11: Heritage resources which, although forming part of the national estate, can be considered to have special qualities which make them significant within the context of a province or a region; and (c) Grade 111: Other heritage resources worthy of conservation.
SAHRA is responsible for the identification and management of Grade 1 heritage resources.
Provincial Heritage Resources Authority (PHRA) identifies and manages Grade 11 heritage resources.
Local authorities identify and manage Grade 111 heritage resources.

No person may damage, deface, excavate, alter, remove from its original position, subdivide or change the planning status of a provincially protected place or object without a permit issued by a heritage resources authority or local authority responsible for the provincial protection.
Archaeology, palaeontology and meteorites: Section 35.
(2) Subject to the provisions of subsection (8) (a), 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.

Mitigation involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or excavation, recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before a Phase 2 may be implemented.

The Mitigation is done in order to rescue representative fossil material from the study area to allow and record the nature of each locality and establish its age before it is destroyed and to make samples accessible for future research. It also interprets the evidence recovered to allow for education of the public and promotion of palaeontological heritage.

Should further fossil material be discovered during the course of the development (*e. g.* during bedrock excavations), this must be safeguarded, where feasible *in situ,* and reported to a palaeontologist or to the Heritage Resources authority. In situations where the area is considered palaeontologically sensitive (*e. g.* Karoo Supergroup Formations, ancient marine deposits in the interior or along the coast) the palaeontologist might need to monitor all newly excavated bedrock. The developer needs to give the palaeontologist sufficient time to assess and document the finds and, if necessary, to rescue a representative sample.

When a Phase 2 palaeontological impact study is recommended, permission for the development to proceed can be given only once the heritage resources authority has received and approved a Phase 2 report and is satisfied that (a) the palaeontological resources under threat have been adequately recorded and sampled, and (b) adequate development on fossil heritage, including, where necessary, *in situ* conservation of heritage of high significance. Careful planning, including early consultation with a palaeontologist and heritage management

authorities, can minimise the impact of palaeontological surveys on development projects by selecting options that cause the least amount of inconvenience and delay.

Three types of permits are available; Mitigation, Destruction and Interpretation. The specialist will apply for the permit at the beginning of the process (SAHRA 2012).

**I. Description of significant fossil occurrences**

Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to determine due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot.

'Algal microfossils' have been reported from shales and are probably of diagenetic origin (Eriksson 1999), these are present here. Stromatolites are significant indicators of palaeoenvironments and provide evidence of algal growth between 2640 and 2432 million years ago. Significant fossil remains of Cenozoic aged terrestrial organisms have been recorded from the sedimentary rocks of the Kalahari Group. These fossils are rarely found and are allocated a **HIGH** palaeontological sensitivity as they are important indicators of palaeo-environmental conditions (Groenewald and Groenewald 2014).

The Budin Formation may contain numerous calcified root casts, as can be seen at Sishen Ore Mine. Fossils such as numerous ostracods, bivalves, gastropods, as well as diatoms are present in the Lonely Formation (Partridge *et al.* 2006).

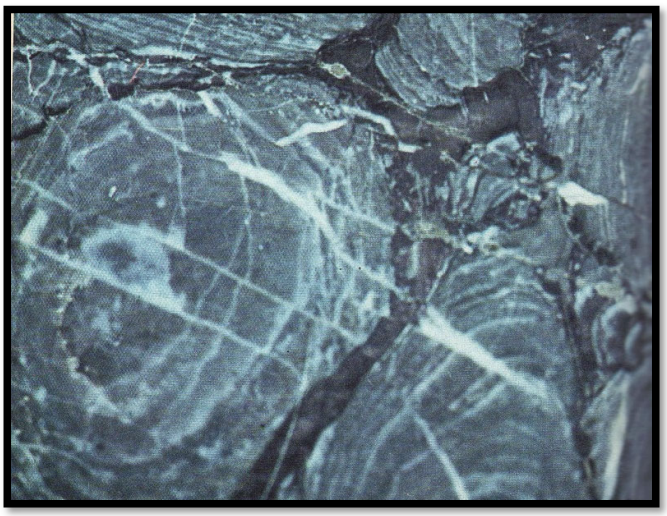

**Figure 12**: Thin section of a stromatolite (De Zanche and Mietto 1977).

The Quaternary Formation to Holocene may contain fossils. A very wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms, and other micro fossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens, within calc tufa. Stromatolite structures range from a centimetre to several tens of metres in size (Groenewald and Groenewald 2014).

The threats are:

- Earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction,

- The sealing-in or destruction of fossils by development, vehicle traffic, clearing, prospecting, mining, and human disturbance. See Description of the Geological Setting (F) above.

**J. Recommendation (1o,p,q)**

a. There is no objection (see Recommendation B) to the development, it was necessary to request a Phase 1: Palaeontological Impact Assessment: Field Study and if fossils are found during excavating, clearing, drilling, or blasting a Phase 2: Mitigation will be necessary. The palaeontological sensitivity is **LOW,** but fossils (stromatolites) may be present.
b. This project may benefit the economy, the growth of the community and social development in general.
c. Preferred choice: Only one locality option is presented and possible.
d. Care must be taken during the grading of roads, digging of foundations and removing topsoil, subsoil and overburden (see Executive Summary) or blasting of bedrock. The following should be conserved: if any palaeontological material is exposed during digging, excavating, drilling or blasting SAHRA must be notified. All construction activities must be stopped, a 30 m no-go barrier constructed and a palaeontologist should be called in to determine proper mitigation measures.
e. No consultation with parties was necessary (**1o,p,q).**
f. This report must be submitted to SAHRA/PHRA together with the Heritage Impact Assessment (Archaeological).

Sampling and collecting:
Wherefore a permit is needed from the South African Heritage Resources Agency (SAHRA / PHRA).

a. Objections: Cautious. See heritage value and recommendation.
b. Conditions of development: See Recommendation.
c. Areas that may need a permit: Yes.
d. Permits for mitigation: Needed from SAHRA/PHRA if fossils are found.

**K. Conclusions**

a. All the land involved in the development was assessed and none of the property is unsuitable for development (see Recommendation B).
b. All information needed for the Palaeontological Impact Assessment Study was provided by the Consultant. All technical information was provided by APelser Archaeological Consulting cc.
c. Areas that would involve mitigation and may need a permit from the South African Heritage Resources Agency are discussed.
d. The following should be conserved: if any palaeontological material is exposed during digging, excavating, drilling or blasting, SAHRA must be notified. All development activities must be stopped, a 30 m no-go barrier constructed, and a palaeontologist should be called in to determine proper mitigation measures, for example, shallow caves.
e. Condition in which development may proceed: It is further suggested that a Section 37(2) agreement of the Occupational, Health and Safety Act 85 of 1993 is signed with the relevant contractors to protect the environment (fossils) and adjacent areas as well as for safety and security reasons.

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**Acknowledgement:** To staff of the mine that assisted with the signing in (Pieter Venter) and for driving us (Neil) and showing us the different aspects of the development a huge thank you.

**Declaration (Disclaimer) (1b)**

I, Heidi Fourie, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project for which I was appointed to do a palaeontological assessment. There are no circumstances that compromise the objectivity of me performing such work.

I accept no liability, and the client, by receiving this document, indemnifies me against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by the use of the information contained in this document.

It may be possible that the Desktop Study may have missed palaeontological resources in the project area as the presence of outcrops are not known or visible due to vegetation while others may lie below the overburden of earth and may only be found once development commences.

This report may not be altered in any way and any parts drawn from this report must make reference to this report.

POPI Act 2013 Statement

It provides that everyone has the right to privacy and includes a right to protection against the unlawful collection, retention dissemination and use of personal information contained in this document and pertains to the phone and contact details, signature and contents.

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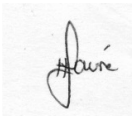

Heidi Fourie
2022/03/02

Appendix 1: Mammal fossils that may be present (MacRae 1999).

Silhouette representation of the larger vertebrates whose remains are represented in Members 1-3 of the Swartkrans site on the outskirts of the town of Krugersdorp. Numbers after each taxon comprise minimum numbers of individuals represented in the remains of the lower bank (Member 1), hanging remnant (Member 1), Member 2 and Member 3 respectively.
Courtesy of Dr C.K. Brain.
Museum of Natural History, Pretoria

**FAUNA FROM MEMBERS 1 - 3, SWARTKRANS (Makapanian Mammal Age)**
**Courtesy Dr B. Brain, - Museum of Natural History, Pretoria**

**1**: *Homo erectus* (man) 1,3,2,0. **2**: *Australopithecus robustus* (robust apeman) 13,87,17,9. **3**: *Parapapio jonesi* 0,8,0,0. **4**: *Cercopithecoides* sp. 1,0,0,0. **5**: *Papio hamadryas robinsoni* 6,38,8,11. **6**: *Theropithecus oswaldi danieli* 1,17,1,14. **7**: *Dinopithecus ingens* 1,26,0,0. **8**: *Panthera pardus* (leopard) 4,12,2,5. **9**: *Dinofelis* sp. (false sabre-toothed cat) 0,1,0,0. **10**: *Megantereon* sp. (dirk-toothed cat) 0,1,0,1. **11**: *Acinonyx jubatus* (cheetah) 0,1,0,1. **12**: *Felis caracal* (caracal) 1,0,0,0. **13**: *Felis lybica* (African wild cat) 0,0,0,1. **14**: *Felis serval* (serval) 1,0,0,0. **15**: *Panthera leo* (lion) 1,1,0,0. **16**: *Hyaena brunnea* (brown hyaena) 1,4,2,3. **17**: *Chasmaporthetes nitidula* (hunting hyaena) 2,8,1,2. **18**:*Crocuta crocuta* (spotted hyaena) 0,2,1,1. **19**: *Proteles* sp. (large fossil aardwolf) 1,1,0,1. **20**: *Vulpes* sp. (fox) 0,2,0,3. **21**: *Canis mesomelas* (black-backed jackal) 3,4,4,5. **22**: Large canid gen. and sp. indet. 0,0,1,1. **23**: *Aonyx capensis* (Cape clawless otter) 2,0,1,2. **24**: *Atilax* sp. (water mongoose) 0,0,1,1. **25**: *Cynictis penicillata* (yellow mongoose) 0,0,1,1. **26**: *Herpestes ichneumon* (large grey mongoose) 1,0,0,0. **27**: *Suricata suricatta* (suricate) 0,0,2,1. **28**: *Genetta tigrina* (large-spotted genet) 0,0,0,1. **29**: *Manis* sp. (pangolin) 0,0,0,1. **30**: *Orycteropus afer* (antbear) 1,0,1,1. **31**: cf. *Elphas* sp. 2,0,0,1. **32**: *Procavia transvaalensis* (large fossil dassie) 3,8,3,5. **33**: *Procavia antiqua* (fossil dassie) 17,16,10,11. **34**: *Hipparion lybicum steytleri* (three-toed horse) 1,1,1,1. **35**: *Equus capensis* (giant Cape horse) 2,6,3,5. **36**: *Equus burchelli* (Burchell's zebra) 0,0,0,1. **37**: *Phacochoerus* sp. (warthog) 1,0,3,1. **38**: cf. *Tapinochoerus meadowsi* (large fossil pig) 1,7,1,1. **39**: *Hippopotamus* sp. (hippopotamus) 1,0,0,1. **40**: Giraffid 0,1,1,1. **41**: *Megalotragus* sp. (giant hartebeest) 0,3,1,3. **42**: *Connochaetes* sp. (wildebeest) 7,19,7,7. **43**: Medium alcelaphine: *Alcelaphus* sp. or *Beatragus* sp. (hartebeest) 3,22,3,6. **44**: *Rabaticerus porrocornutus* 0,2,0,0. **45**: *Damaliscus* sp. (blesbok) 2,4,6,6. **46**: *Antidorcas marsupialis australis* (springbok) 11,0,10,18. **47**: *Antidorcas recki* 0,6,2,1. **48**: cf. *Gazella* sp. (gazelle) 5,6,5,14. **49**: *Oreotragus oreotragus* (klipspringer) 1,0,0,1. **50**: *Oreotragus major* (fossil klipspringer) 0,1,0,0. **51**: *Raphicerus campestris* (steenbok) 1,0,1,3. **52**: *Makapania* sp. (musk ox) 0,3,0,0. **53**: *Syncerus* sp. (buffalo) 2,3,2,3. **54**: *Taurotragus oryx* (eland) 0,0,1,1. **55**: *Tragelaphus strepsiceros* (kudu) 0,4,0,1. **56**: *Hippotragus* cf. *niger* (sable) 0,0,1,3. **57**: *Pelea* sp. (rhebck) 0,2,0,2. **58**: *Redunca arundinum* (reedbuck) 0,1,0,0. **59**: Lagomorph gen. and sp. indet. (hare) 9,0,4,7. **60**: *Pedetes* sp. (springhare) 1,0,1,1. **61**: *Hystrix africaeaustralis* (porcupine) 2,2,1,2. **62**: *Chelonia* indet. (tortoise) 1,0,2,2.





**Left**: Teeth of the white rhino *Ceratotherium simum* from Makapansgat. **Right**: View from above shows the sharp cutting edges of the tooth row of this predominant grazer. Specimen 170 mm long.
In the collection of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg.
Photograph C.S. MacRae

Appendix 2: **Table 3:** Listing points in Appendix 6 of the Act and position in Report (in bold).

| Section in Report | Point in Act | Requirement |
|---|---|---|
| B | 1(c) | Scope and purpose of report |
| B | 1(d) | Duration, date and season |
| B | 1(g) | Areas to be avoided |
| D | 1(ai) | Specialist who prepared report |
| D | 1(aii) | Expertise of the specialist |
| F Figure 3 | 1(h) | Map |
| F | 1(ni) | Authorisation |

| | | |
|---|---|---|
| F | 1(nii) | Avoidance, management, mitigation and closure plan |
| G Table 1 | 1(cA) | Quality and age of base data |
| G Table 2 | 1(cB) | Existing and cumulative impacts |
| G | 1(f) | Details or activities of assessment |
| G | 1(j) | Description of findings |
| H | 1(e) | Description of methodology |
| H | 1(i) | Assumptions |
| J | 1(o) | Consultation |
| J | 1(p) | Copies of comments during consultation |
| J | 1(q) | Information requested by authority |
| Declaration | 1(b) | Independent declaration |
| Appendix 2 | 1(k) | Mitigation included in EMPr |
| Appendix 2 | 1(l) | Conditions included in EMPr |
| Appendix 2 | 1(m) | Monitoring included in EMPr |
| D | 2 | Protocol or minimum standard |

Appendix 3: Management Plan and Protocol for Chance Finds (**1k,l,m)**.

This section covers the recommended protocol for a Phase 2 Mitigation process as well as for reports where the Palaeontological Sensitivity is **LOW**; this process guides the palaeontologist / palaeobotanist on site and should not be attempted by the layman / developer. As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to oversee the construction activities in line with the legally binding Environmental Management Programme (EMPr) so that when a fossil is unearthed they can notify the relevant department and specialist to further investigate. Therefore, the EMPr must be updated to include the involvement of a palaeontologist during the digging and excavation (ground breaking) phase of the development.

The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction activities.

- When a fossil is found the area must be fenced-off with a 30 m barrier and the construction workers must be informed that this is a no-go area.
- If fossils have already been found they must be kept in a safe place for further inspection.
- The ECO should familiarise him- or herself with the formations and its fossils. A site visit after blasting, drilling, clearing or excavating is recommended and the keeping of a photographic record when feasible.
- Most museums and universities have good examples of fossils.
- The developer must survey the areas affected by the development and indicate on plan where the construction / development / mining will take place. Trenches have to be dug to ascertain how deep the sediments are above the bedrock (can be a few hundred metres). This will give an indication of the depth of the topsoil, subsoil, and overburden, if need be trenches should be dug deeper to expose the interburden.

Mitigation will involve recording, rescue and judicious sampling of the fossil material present in the layers sandwiched between the geological / coal layers. It must include information on number of taxa, fossil abundance, preservational style, and taphonomy. This can only be done during mining or excavations. In order for this to happen, in case of coal mining operations, the process will have to be closely scrutinised by a professional palaeontologist / palaeobotanist to ensure that only the coal layers are mined and the interlayers (siltstone and mudstone) are surveyed for fossils or representative sampling of fossils are taking place.

The palaeontological impact assessment process presents an opportunity for identification, access and possibly salvage of fossils and add to the few good plant localities. Mitigation can provide valuable onsite research that can benefit both the community and the palaeontological fraternity.

A Phase 2 study is very often the last opportunity we will ever have to record the fossil heritage within the development area. Fossils excavated will be stored at a National Repository.

**A Phase 2 Palaeontological Impact Assessment: Mitigation will include (SAHRA) -**

1. Recommendations for the future of the site.
2. Description and purpose of work done (including number of people and their responsibilities).
3. A written assessment of the work done, fossils excavated, not removed or collected and observed.
4. Conclusion reached regarding the fossil material.
5. A detailed site plan and map.
6. Possible declaration as a heritage site or Site Management Plan.
7. Stakeholders.
8. Detailed report including the Desktop and Phase 1 study information.
9. Annual interim or progress Phase 2 permit reports as well as the final report.
10. Methodology used.

Three types of permits are available; Mitigation, Destruction and Interpretation. The specialist will apply for the permit at the beginning of the process (SAHRA 2012).

The Palaeontological Society of South Africa (PSSA) does not have guidelines on excavating or collecting, but the following is suggested:

1. The developer needs to clearly stake or peg-out (survey) the areas affected by the mining/ construction/ development operations and dig representative trenches and if possible supply geological borehole data.
2. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work.
3. A Palaeobotanist / palaeontologist (contact SAHRIS for list) must then inspect the affected areas and trenches for fossiliferous outcrops / layers. The contractor / developer may be asked to move structures, and put the development on hold.
4. If the palaeontologist / palaeobotanist is satisfied that no fossils will be destroyed or have removed the fossils, development and removing of the topsoil can continue.
5. After this process the same palaeontologist / palaeobotanist will have to inspect and offer advice through the Phase 2 Mitigation Process. Bedrock excavations for footings may expose, damage or destroy previously buried fossil material and must be inspected.
6. When permission for the development is granted, the next layer can be removed, if this is part of a fossiliferous layer, then with the removal of each layer of sediment, the palaeontologist / palaeobotanist must do an investigation (a minimum of once a week).
7. At this stage the palaeontologist / palaeobotanist in consultation with the developer / mining company must ensure that a further working protocol and schedule is in place. Onsite training should take place, followed by an annual visit by the palaeontologist / palaeobotanist.

**Fossil excavation, if necessary, during Phase 2:**

1. Photography of fossil / fossil layer and surrounding strata.
2. Once a fossil has been identified as such, the task of extraction begins.

3. It usually entails the taking of a GPS reading and recording lithostratigraphic, biostratigraphic, date, collector and locality information.
4. Use Paraloid (B-72) as an adhesive and protective glue, parts of the fossil can be kept together (not necessarily applicable to plant fossils).
5. Slowly chipping away of matrix surrounding the fossil using a geological pick, brushes and chisels.
6. Once the full extent of the fossil / fossils is visible, it can be covered with a plaster jacket (not necessarily applicable to plant fossils).
7. Chipping away sides to loosen underside.
8. Splitting of the rock containing palaeobotanical material should reveal any fossils sandwiched between the layers.

***SAHRA Documents***:
Guidelines to Palaeontological Permitting Policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.
Palaeotechnical Reports for all the Provinces.

Appendix 4: Impact Statement

The development footprint is situated on a geological layer with a low palaeontological sensitivity. The nature of the impact is the destruction of Fossil Heritage. Loss of fossil heritage will have a negative impact. The extent of the impact only extends in the region of the development activity footprint and may include transport routes. The expected duration of the impact is assessed as potentially permanent. The intensity/magnitude of the impact is moderate as it may continue in a modified way. The probability of the impact occurring is improbable with a low likelihood.

Mitigation procedures (should fossil material be present within the affected area) will not be necessary. The loss of resources occurs but natural cultural and social processes continue, albeit in a modified manner. The cumulative impact is low. Impacts on palaeontological heritage during the construction and preconstruction phase will potentially not occur. The significance of the impact occurring will be S= (2+5+8)2

S = 30 Moderate (30-60).