Report for proposed Mafube LifeX Road Realignment Project

Nkangala District Municipality, Steve Tshwete Local Municipality, Mpumalanga Province

Farms: Roodepoort 418 JS, Panplaats 395 JS, Belfast

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Palaeontological Impact Assessment: Phase 1 Field Study

Commissioned by: Golder Associates Africa (Pty)

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2017/10/30

Project Ref: 1776031

B. Executive summary

Outline of the development project: Golder Associates Africa (Pty) facilitated the appointed of Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA): Phase 1 Field Study of the suitability for the proposed Mafube Road Realignment project.

The applicant, Mafube Coal Mining (Pty) Ltd is currently undertaking the Mafube Life Expansion project (Mafube LifeX), which included the mining operations at Nooitgedacht and Wildfontein in the Mpumalanga Province. This authorisation was granted, but it was found that sections of district road D684 and district road D1048 traverse the Nooitgedacht Coal Reserve and their closure and/or realignment will be required.

The new proposed road realignment will be situated on Nooitgedacht 417 JS and Panplaats 395 JS, 40 km east of the town of Middelburg via the R104 regional road, and 30 km west of Belfast, in the Mpumalanga Province.

This development includes one approved Alternative (see Locality Map) (Figure 1).
Alternative F – Approved route will transect Panplaats 395-JS in a northerly direction and then the route will turn west through Nooitgedacht 395-JS.

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.

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) 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) (NHRA).
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 50m 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 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 mitigations or conservation measures are necessary.

Outline of the geology and the palaeontology:
The geology was obtained from the Geological Map of the Republic of South Africa, 1:100 000 (Visser, 1984) and 2528 Pretoria, 1:250 000 (Walraven 1978).
Legend to Map and short explanation (Figure 1).
Pe – Shale, shaly sandstone, grit, sandstone, conglomerate, coal in places near base and top (brown). Vryheid Formation, Ecca Group, Karoo Supergroup.
Mr – Granophyre, pseudogranophyre (orange). Rashoop Granophyre Suite, Bushveld Complex.
Vu – Ferrogabbro, ferrodiorite, diorite [=] (green). Upper Zone, Rustenburg Layered Suite, Bushveld Complex.
Vdr – Glassy amygdaloidal pseudospherulitic and porphyritic black rhyolite; black rhyolite, leptite [=] (pink). Damwal Formation, Rooiberg Group, Transvaal Supergroup.
Alt F– Proposed Route Alternative.

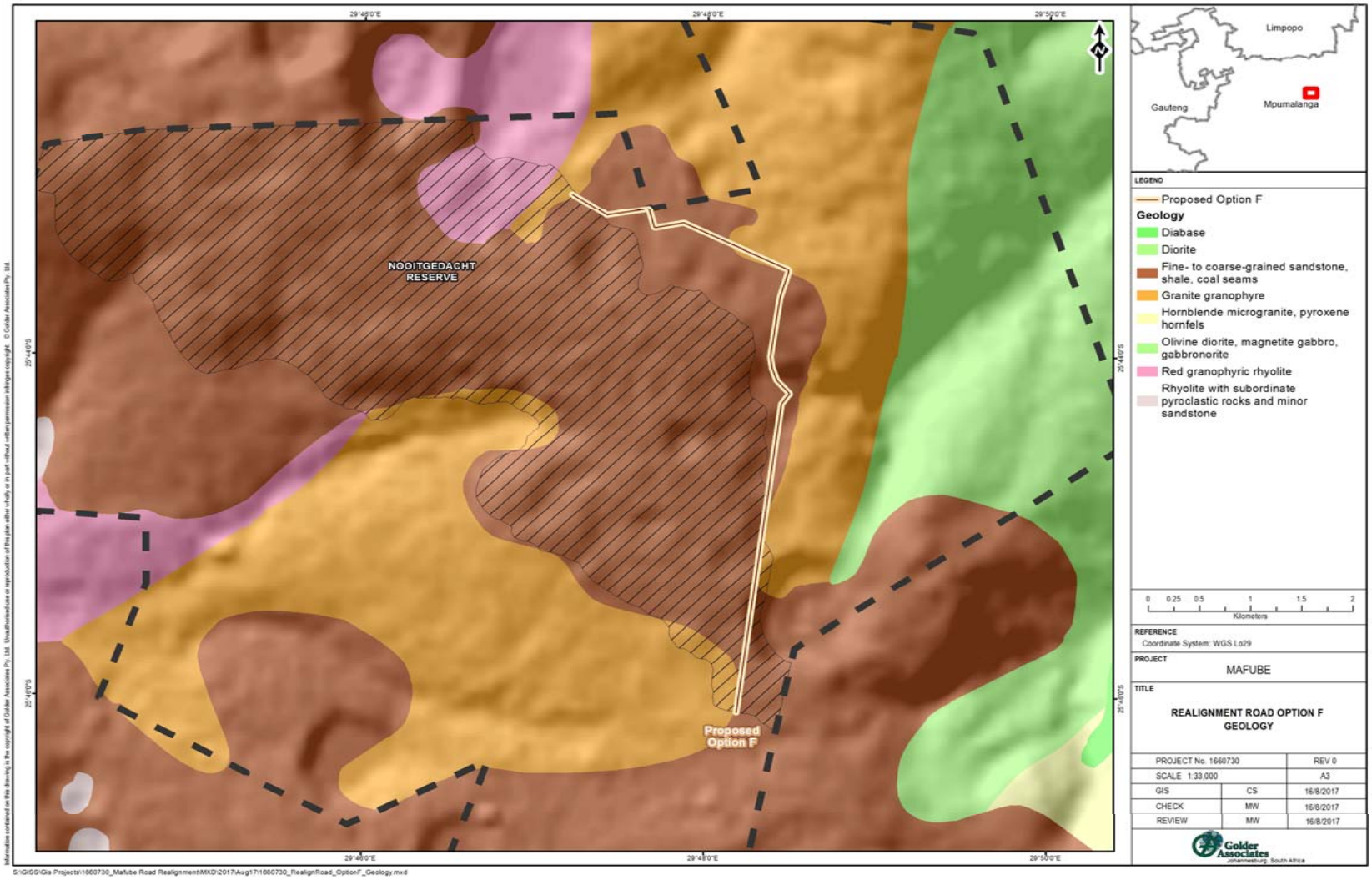
Mining activities:
Presently coal.
Summary of findings (1d): The Desktop PIA was undertaken during February 2017, it was summer, the Phase 1 Field Study was undertaken in October 2017 in the summer in hot and dry conditions and the following is reported:

The formations present are mainly the Rustenburg Layered Suite (Mr, Vu) of the Bushveld Complex, Transvaal Supergroup (Vdr) and the Vryheid Formation, Karoo Supergroup (Pe).

The proposed development and associated structures will be developed on the Vryheid Formation. It is Permian in age. The area is covered with corn fields, vegetation and grassland.

The Vryheid Formation (Pe,Pv), Ecca Group is rich in plant fossils such as the Glossopteris flora represented by stumps, leaves, pollen and fructifications. This formation is early to mid-Permian (Palaeozoic) in age and consists of sandstone, shaly sandstone, grit, conglomerate, coal and shale. Coal seams are present in the Vryheid Formation within the sandstone and shale layers. Fossils are mainly present in the grey shale which is interlayered between the coal seams (Kent 1980, Visser 1989). Borehole logs in the coalfields show the following layers; soil, shale and sandstone, shale and sandstone interbedded, sandstone, coal, conglomerate reworked diamictite, Dwyka Tillite, and the Pre-Karoo Basement.

Figure 1: The geology of the development area (Golder Associates).



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, but here locally **VERY HIGH** for the Vryheid Formation (SG 2.2 SAHRA APMHOB, 2012).

Recommendation: The impact of the development on fossil heritage is **VERY HIGH** and therefore mitigation or conservation measures were necessary for this development. A Phase 1 Palaeontological Assessment was recommended. The topsoil, subsoil, overburden, inter-burden and bedrock may have to be surveyed for fossiliferous outcrops. Protocol and Management Plan is attached (Appendix 3). No fossils were found during the walk through.

There is no objection to the development.

Concerns/threats to be added to the EMPr (1g,1ni,1nii,1o,1p):

1) Threats are earth moving equipment / machinery (for example haul trucks, front end loaders, excavators, graders, dozers) during construction, the sealing-in or destruction of the fossils by development, vehicle traffic, mining activities, and human disturbance.
2) Special care must be taken during construction of the road as a site visit may have missed a fossiliferous outcrop. An appropriate Protocol and Management plan is attached for the Environmental Control Officer (Appendix 2).

The Recommendations are:

1) No consultation with parties was necessary. The Environmental Control Officer (ECO) must familiarise him- or herself with the Vryheid Formation fossils.
2) Mitigation may be needed if fossils are found.
3) The development may go ahead with caution, but the ECO must survey for fossils before or after excavation in line with the legally binding Environmental Management Programme (EMPr). This must be updated to include the involvement of a palaeontologist if any fossils are uncovered.

Stakeholders:
Developer – Mafube Coal Mining (Pty) Ltd, Mafube Colliery, Springboklaagte, Anglo Operations Limited and Exxaro, B. van Stelten, Tel. 013 246 9410.
Environmental – Golder Associates Africa (Pty), P.O. Box 6001, Halfway House, 1685. Tel. 011 254 4800.
Mineral Rights Holder – Mafube Coal Mining (Pty) Ltd.

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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 contained in GN R982 of 04 December 2010.

Outline of development

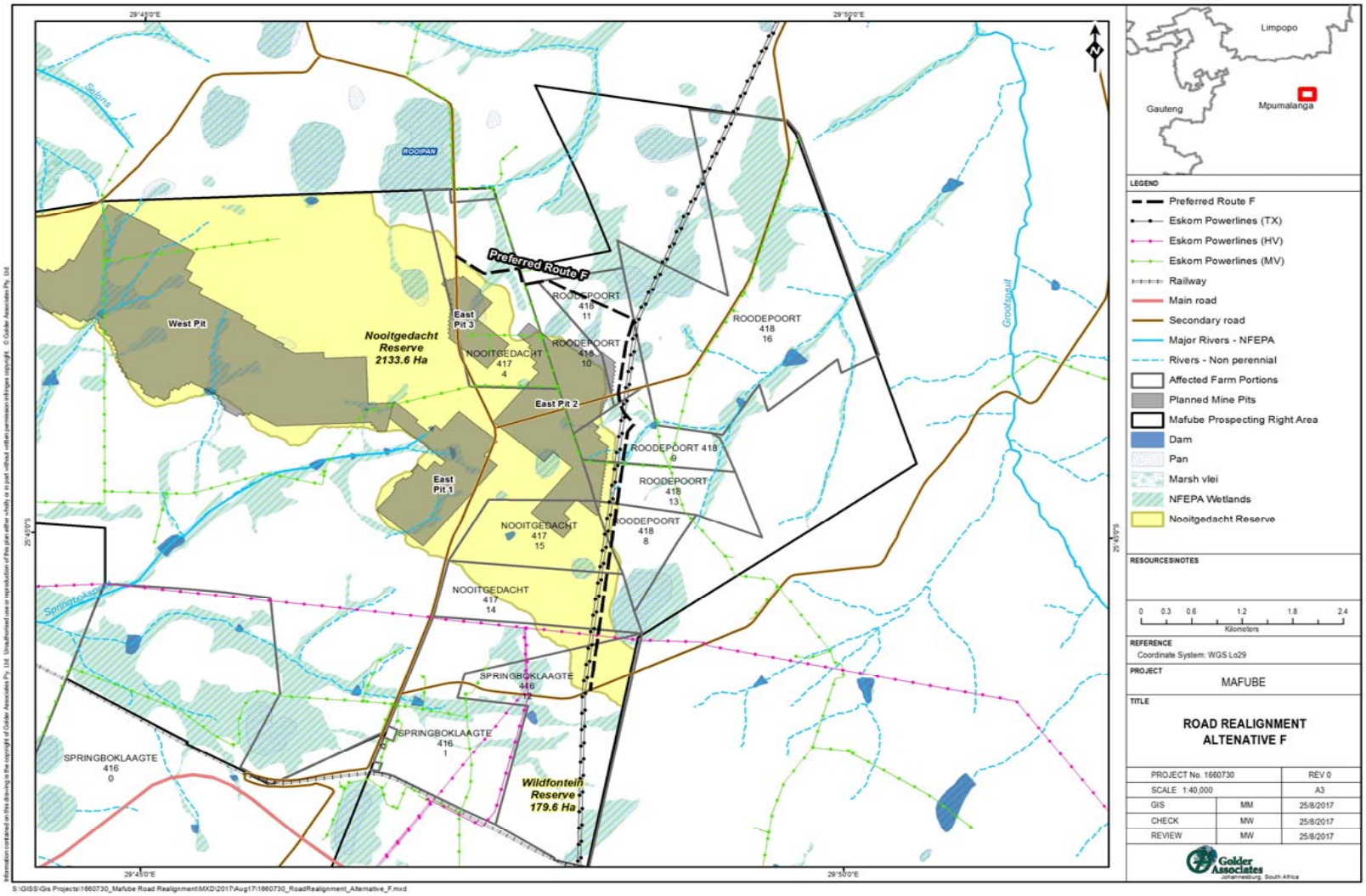
This report discusses and aims to provide the developer with information regarding the location of palaeontological material that will be impacted by the development. In the pre-construction phase, if the palaeontological sensitivity is VERY HIGH or LOW, it may be necessary for the developer to apply for the relevant permit from the South African Heritage Resources Agency (SAHRA) and follow protocol.

The applicant, Mafube Coal Mining (Pty) Ltd is currently undertaking the Mafube Life Expansion project (Mafube LifeX), which included the mining operations at Nooitgedacht and Wildfontein in the Mpumalanga Province. This authorisation was granted, but it was found that sections of district road D684 and district road D1048 traverse the Nooitgedacht Coal Reserve and their closure and/or realignment will be required.

Road D684 is an unpaved road, approximately 8 m in width. It is located in a rural area that consists predominantly of farming and some coal mining. It provides access to the Sikhululiwe Village that is located adjacent to the road reserve. It is proposed to close this road over a distance of approximately 8.0 km from the T-junction with road D1574 in the south to the change in a western direction in the north. The closure of road D1048 is also proposed over a distance of 2.5 km.

This development includes one approved Alternative (see Locality Map) (Figure 2).
Alternative F – Approved route will transect Panplaats 395-JS in a northerly direction and then the route will turn west through Nooitgedacht 395-JS.

Figure 2: Map indicating surface infrastructure (Golder Associates)



Rezoning/ and or subdivision of land: No.
Name of developer and consultant: Mafube Coal Mining (Pty) Ltd and Golder Associates Africa (Pty).
Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a Desktop PIA 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.

Dr Fourie obtained a Ph.D from the Bernard Price Institute for Palaeontological Research, 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 nine years she carried out field work in the Eastern Cape Province, Gauteng Province, Free State Province and Mpumalanga Province. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 23 years.
Legislative requirements: SAHRA / Provincial Heritage Resources Agency (PHRA) for issue of permits if necessary. The National Heritage Resources Act (NHRA). An electronic copy of this report must be supplied to SAHRA/PHRA.

E. Description of property or affected environment
Location and depth:
The new proposed road realignment will be situated on Nooitgedacht 419-JS and Panplaats 395-JS, 40 km east of the town of Middelburg via the R104 regional road, and 30 km west of Belfast, in the Mpumalanga Province.

Depth is determined by the road construction. The thickness of the grey shale can vary and this is interlayered with the also variable yellow sandstone and coal seams.

F. Description of the Geological Setting
Description of the rock units:
The development is taking place in an area covered by the Vryheid Formation (Figure 1).

The Bushveld Complex (surrounding area) is a massive body of igneous origin and it is intrusive in the Transvaal Supergroup (Kent, 1980). It covers an area of 65 000 km² and is chrome and platinum rich (Visser, 1989). The age is Vaalian (2,100 – 1,920 Ma). The Rustenburg Layered Suite is so termed as it is intrusive in origin and the term is to be equivalent to a ‘group’. It consists of mafic and ultramafic rocks and is rich in platinum, chrome and vanadium. The layered rocks of the Bushveld Complex are generally believed to be the result of crystals settling out of magma during slow cooling. The magmatic events petrogenetically related to and generally considered part of the whole magmatic evolution of the Complex are, the diabase sills and the Rooiberg Group. The Complex consists of three main units or suites of which the Rustenburg Layered Suite is one (Kent, 1980), the other two are the Rashoop and Lebowa Granite Suites (Visser, 1989). This region is covered by the ‘Bushveld’ vegetation.

The Bushveld Complex rocks are classified mafic and ultramafic because of the iron and magnesium (and/or calcium) rich content, such as norite, gabbro and pyroxenite. The heaviest minerals, such as olivine and pyroxene, and any sulphide minerals (like magnetite and chromite) concentrate towards the base of each layer. Lighter minerals, such as feldspar and quartz, tend to form at the top (Norman and Whitfield, 2006).

It is believed that the Bushveld Complex looked like the Yellowstone National Park in the States of Wyoming, Idaho and Montana, United States of America, when it formed. The Rustenburg Layered Suite formed first. Erosion caused the Bushveld Complex to shrink in size. The Complex crops out at surface in three very long arcs, from Thabazimbi to Pretoria in the west, from Mokopane to Middelburg in the east, and north of Mokopane (McCarthy and Rubidge, 2005).

The Bushveld Complex is economically very important. By far the most important metal mined from the Rustenburg Layered Suite is platinum. Gold is also present, other minerals are nickel, copper, chrome, vanadium, tin, fluorspar and cobalt. Quarries provide dimension stone and granite (Visser, 1989).

The Transvaal Supergroup fills an east-west elongated basin in the south-central part of the old Transvaal (now North – West, Gauteng and Mpumalanga Provinces) as far south as Potchefstroom. It is Vaalian in age, approximately 2600 Ma to 2100 Ma. A maximum thickness of the Transvaal Supergroup reaches 2000 m in the north-eastern section. An east-west elongated basin is filled with clastic, volcanic and chemical sedimentary rocks. Three groups based on lithological differences have been established: they are the Rooiberg, Chuniespoort, and Pretoria Groups as well as other smaller groups (Kent 1980). It is the Bushveld Complex that is responsible for the tilting of the Transvaal sediments and the heat of its intrusion having created andalusite crystals (Norman and Whitfield 2006). This Supergroup is underlain by the Ventersdorp, Witwatersrand and Pongola Supergroups, and the Dominion Group. The Rooiberg Group is divided into the Formations Damwal and Selonsrivier in the Loskop dam area (Visser 1989).

The Vryheid Formation present is part of the Karoo Supergroup. The Karoo Supergroup is renowned for its fossil wealth. The Vryheid Formation (Pe,Pv), Ecca Group is rich in plant fossils such as the *Glossopteris* flora represented by stumps, leaves, pollen and fructifications. This formation is early to mid-Permian (Palaeozoic) in age and consists of sandstone, shaly sandstone, grit, conglomerate, coal and shale. Coal seams are present in the Vryheid Formation within the sandstone and shale layers. Fossils are mainly present in the grey shale which is interlayered between the coal seams (Kent 1980, Visser 1989). Borehole logs in the coalfields show the following layers; soil, shale and sandstone, shale and sandstone interbedded, sandstone, coal, conglomerate reworked diamictite, Dwyka Tillite, and the Pre-Karoo Basement (Figure 3).

The Vryheid Formation is named after the type area of Vryheid-Volksrust. In the north-eastern part of the basin the Vryheid Formation thins and eventually wedges out towards the south, southwest and west with increasing distance from its source area to the east and northeast (Johnson 2009). The Vryheid Formation consists essentially of sandstone, shale, and subordinate coal beds, and has a maximum total thickness of 500 m. It forms part of the Middle Ecca (Kent 1980). This formation has the largest coal reserves in South Africa. The pro-delta sediments are characterised by trace and plants fossils (Snyman 1996).

This development includes one approved Alternative (see Location Map) (Figure 2).
Alternative F – Approved route will transect Panplaats 395-JS in a northerly direction and then the route will turn west through Nooitgedacht 395-JS.

Ecca rocks are stable and lend themselves well to developments. It is only unstable in or directly above mining activities (Snyman 1996). The site itself is situated on the flat-lying Vryheid Formation, Ecca Group, Karoo Supergroup. Dolerite dykes do occur throughout the Karoo Supergroup. Structural geological features such as dykes and faults can have a measurable influence on ground water flow and mass transport.

The typical colours for the Vryheid Formation are grey and yellow for the sediments and black for the coal seam. The thickness of the grey shale can vary and this is interlayered with the also variable yellow sandstone and coal seams.

Field Observations

Figure 3: Overview of site.

The road will follow the route of the power lines

Area mostly covered in corn fields

G. Background to Palaeontology of the area

Summary: When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a desktop 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).

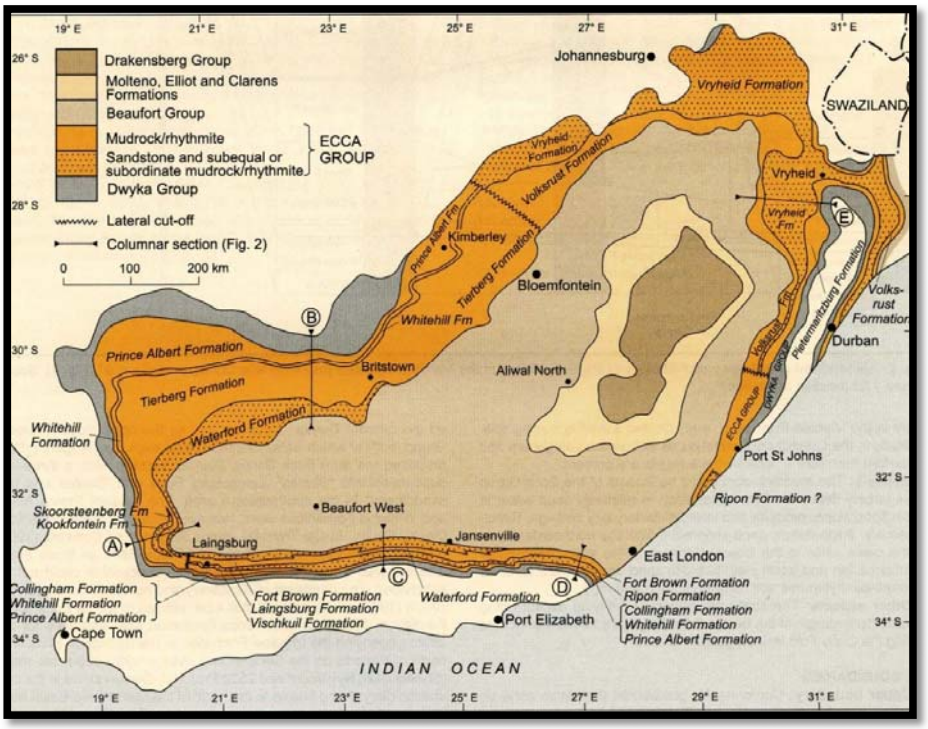


Figure 4: Map to show extent of the Ecca Group (Johnson 2009).

The Ecca Group may contain fossils of diverse non-marine trace, *Glossopteris* flora, mesosaurid reptiles, palaeoniscid fish, marine invertebrates, insects, and crustaceans (Johnson 2009). *Glossopteris* trees rapidly colonised the large deltas along the northern margin of the Karoo Sea. Dead vegetation accumulated faster than it could decay, and thick accumulations of peat formed, which were ultimately converted to coal. It is only in the northern part of the Karoo Basin that the glossopterids and cordaitales, ferns, clubmosses and horsetails thrived (McCarthy and Rubidge 2005).

The *Glossopteris* flora is thought to have been the major contributor to the coal beds of the Ecca. These are found in Karoo-age rocks across Africa, South America, Antarctica, Australia and India. This was one of the early clues to the theory of a former unified Gondwana landmass (Norman and Whitfield 2006).

Table 1: Criteria used (Fossil Heritage Layer Browser/SAHRA).

Rock unit	Significance/vulnerability	Recommended action
Vryheid Formation	Very High	Field assessment and protocol for finds is required
Bushveld Complex	Insignificant or zero	No palaeontological studies are required.
Rooiberg Group	Low	No palaeontological studies are required however a protocol for finds is required

Table 2: Taken form palaeotechnical report (Groenewald and Groenewald 2014).

Subgroup / Supergroup	Group	Formation	Fossil Heritage	Comment
Karoo Supergroup	Ecca	Vryheid	Rich fossil plant assemblages of the Permian Glossopteris flora, rare fossil wood, diverse palynomorphs. Abundant low diversity trace fossils, rare insects, possible conchostracans, non-marine bivalves, fish scales	Globally important and under collected

Databases and collections: Ditsong: National Museum of Natural History.
Impact: **VERY HIGH.** There are some fossil resources that may be impacted by the development.

H. Description of the Methodology (1e)

The Desktop PIA was undertaken during February 2017. This Phase 1 Field Study was undertaken in October 2017. The walk through of the affected portion was done and photographs (in 20 mega pixels) were taken of the site with a digital Canon camera (PowerShot SX620HS). It was not necessary to use a Global Positioning System (GPS) (Garmin eTrex 10) to record outcrops if not covered with topsoil, subsoil, overburden, and vegetation. The walk through and drive through did identify the Vryheid Formation. A literature survey is included.

Assumptions and Limitations (1i):-
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. A site visit was not conducted.
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. Heritage 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.
> The National Estate as: 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 used: (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 paleontologically 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 (Heritage value) (1f)
All Karoo Supergroup geological formations are ranked LOW to VERY HIGH, but here the impact is potentially **VERY HIGH,** for the Vryheid Formation, Ecca Group. Rocks of Permian age in South Africa are particularly rich in fossil plants (Rayner and Coventry 1985). The fossils are present in the grey shale interlayered with the coal seams. The fossils are not very rare and also occur in other parts of the

Karoo stratigraphy. The pollen of the Greenside Colliery also on the Vryheid formation was the focus of a Ph.D study. It is often difficult to spot the greyish fossils as they are the same colour as the grey shale in which they are present as these coalified compressions have been weathered to leave surface replicas on the enclosing shale matrix. A locality close to Ermelo, also Vryheid Formation, has yielded *Scutum, Glossopteris* leaves, *Neoggerathiopsis* leaves, the lycopod *Cyclodendron leslii,* and various seeds and scale leaves (Prevec 2011).

Fossils likely to be found are mostly plants (Appendix 1) such as '*Glossopteris* flora' of the Vryheid Formation. The aquatic reptile *Mesosaurus* and fossil fish may also occur with marine invertebrates, arthropods and insects. Trace fossils can also be present. The marine bivalve *Megadesmus* is found in the upper part of the Volksrust Formation near Newcastle (Johnson 2009).

During storms a great variety of leaves, fructifications and twigs accumulated and because they were sandwiched between thin films of mud, they were preserved to bear record of the wealth and the density of the vegetation around the pools. They make it possible to reconstruct the plant life in these areas and wherever they are found, they constitute most valuable palaeobotanical records (Plumstead 1963) and can be used in palaeoenvironmental reconstructions.

Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to be determined due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot. The vast coal mining industry provides palaeontologists with fantastic access to coal-associated plant fossils, while simultaneously resulting in the destruction of important National palaeontological heritage.

Fossils likely to be found are mostly plants (Appendix 1) such as '*Glossopteris* flora' of the Vryheid Formation. The aquatic reptile *Mesosaurus* and fossil fish may also occur with marine invertebrates, arthropods and insects. Trace fossils can also be present. The marine bivalve *Megadesmus* is found in the upper part of the Volksrust Formation near Newcastle (Johnson 2009).

The threats are:- earth moving equipment/machinery (for example haul trucks, front end loaders, excavators, graders, dozers) during construction, the sealing-in or destruction of fossils by development, vehicle traffic, mining activities, and human disturbance. See Description of the Geological Setting (F) above.

J. Recommendation (1j,1l)

a. There is no objection to the development, but it was necessary to complete this Phase 1 PIA to determine whether the development will affect fossiliferous outcrops as the palaeontological sensitivity is **VERY HIGH** for the Vryheid Formation. A Phase 2 Palaeontological Mitigation would only have been required if the Phase 1 Palaeontological Assessment found fossiliferous outcrops, which was not the case.
b. This project will benefit the economy, the growth of the community and social development in general.
c. Preferred choice: By developer Alternative F.
d. The following should be conserved: if any palaeontological material is exposed during excavating SAHRA/PRHA must be notified. All construction activities must be stopped and a palaeontologist should be called in to determine proper mitigation measures.

Sampling and collecting (1m,1k):
Wherefore a permit may be needed from the SAHRA/PHRA.

a) Objections: None.
b) Conditions of development: See Recommendation.
c) Areas that may need a permit: Yes if fossils are found.
d) Permits for mitigation - needed from SAHRA / PHRA: **Yes**.

K. Conclusions

a) All the land involved in the development was assessed and none of the property is unsuitable for development.
b) All information needed for the Phase 1: Field Scope was provided by Golder Associates Africa (Pty).
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, SAHRA/PHRA must be notified. All development activities must be stopped and a palaeontologist should be called in to determine proper mitigation measures.
e) Condition in which development may proceed: It is further suggested that Occupational, Health and Safety Act is adhered to for safety and security reasons.

L. Bibliography

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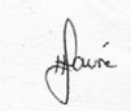
Declaration / disclaimer (1b)

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 scope. 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 Phase 1 PIA Field Study may have missed palaeontological resources in the project area as outcrops are not always present or visible due to vegetation while others may lie below the overburden of earth and may only be present 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.



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Heidi Fourie
2017/10/30

Appendix 1: Examples of Vryheid Formation Fossils.

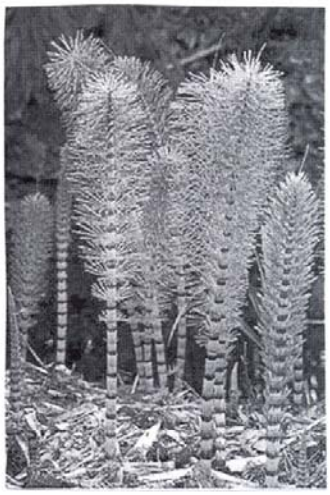
Ecca Group

Vryheid Formation

Glossopteris

Ferns

Horsetails



Clubmosses

Appendix 2:

Table 1: Listing points in Appendix 6 of the Act and position in Report.

Section in report	Point in Act	Heading
B	1(c)	Outline of development project
	1(d)	Summary of findings
	1(g)	Concerns/threats:
	1(n)i	“
	1(n)ii	“
	1(o)	“
	1(p)	“
D	1(h)	Figures
	1(a)i	Terms of reference
H	1(e)	Description of Methodology
	1(i)	Assumptions and Limitations
I	1(f)	Heritage value
J	1(j)	Recommendation
	1(l)	“
	1(m)	Sampling and collecting
	1(k)	“
Declaration	1(b)	Declaration
Appendix 2	1(k)	Protocol for finds
	1(m)	“
	1(q)	“

Appendix 3: Examples of Vryheid Formation Fossils (Horsetail fern stem, *Glossopteris* leave).

Appendix 4:

Protocol for Finds and Management Plan

This protocol is to be used for all Phase 2 Mitigation processes as well as for reports where the Palaeontological Sensitivity is **LOW**; this process guides the palaeontologist on site and should not be attempted by the layman. As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to oversee the construction / mining 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. When a fossil is found the area must be fenced-off and the construction workers must be informed that this is a no-go area. Therefore the EMPr must be updated to include the involvement of a palaeontologist (site visit once a month or training for the ECO) during the digging and excavation (ground breaking) phase of the development.

The EMPr already covers the conservation of heritage and palaeontological artefacts that may be exposed during construction activities. The ECO should familiarise him- or herself with the Ecca Group formations and its fossils. The Evolutionary Studies Institute, University of the Witwatersrand has good examples of Ecca Group Fossils.

The developer must survey the areas affected by the development and then 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 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 excavations. In order for this to happen, in case of 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.

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) -

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

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).

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. Fossils likely to occur are for example the fossil plants from the Vryheid Formation, these are present in the grey shale.
3. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work.
4. A Palaeontologist / Palaeobotanist (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.
5. If the Palaeontologist / Palaeobotanist is satisfied that no fossils will be destroyed or have removed fossils, development and removing of the topsoil can continue.
6. 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.
7. When permission for the development is granted, the next layer can be removed, if this is part of the Vryheid Formation, then with the removal of each layer of sediment, the Palaeontologist / Palaeobotanist must do an investigation (a minimum of once every two weeks).
8. 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. Using 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 will reveal any fossils sandwiched between the layers.

SAHRA Documents:

Guidelines to Palaeontological Permiting policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.
Palaeotechnical Reports for the nine Provinces.