Proposed Turfvlakte Open Pit Mining near Lephalale, Limpopo Province

Lephalale Municipality, Waterberg District Municipality, Limpopo Province

Farm: Daarby 458, Appelvlakte 448, Grootestryd 465, Nelsonskop 464, Turfvlakte 463-LQ

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Palaeontological Impact Assessment: Phase 1 Field Study

Commissioned by: Golder Associates

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Johannesburg

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Ref: Pending

2018/02/27

B. Executive summary

Outline of the development project: Golder Associates has facilitated the appointed of Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA), Phase 1 Field Study of the suitability of the Proposed Turfvlakte Open Pit Mining on the Farms Daarby 458, Portion 0 and 1 of Appelvlakte 448, Portion 0 and 1 of Enkelbult 462, Portion 3 of Grootestryd 465, Portion 1 of Nelsonskop, 464 and Turfvlakte 463-LQ near Lephalale in the Waterberg District Municipality, Lephalale Local Municipality within the Limpopo Province.

The Farm Turfvlakte 463-LQ lies on the south-eastern border of the Grootegeluk Mine Rights Area. Due to faulting in the area, Benches 9A and B and Bench 11 protrude quite shallow on this farm compared to the rest of the Grootegeluk Mine Area. High quality coal can be mined in this area at a stripping ratio of 2.8 tonnes on average. Exxaro is planning to develop this mine and if possible beneficiate the coal at the current Grootegeluk beneficiation facilities.

The Project includes several site layout alternatives (Figure 1):
All alternatives will have the same impact.

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.

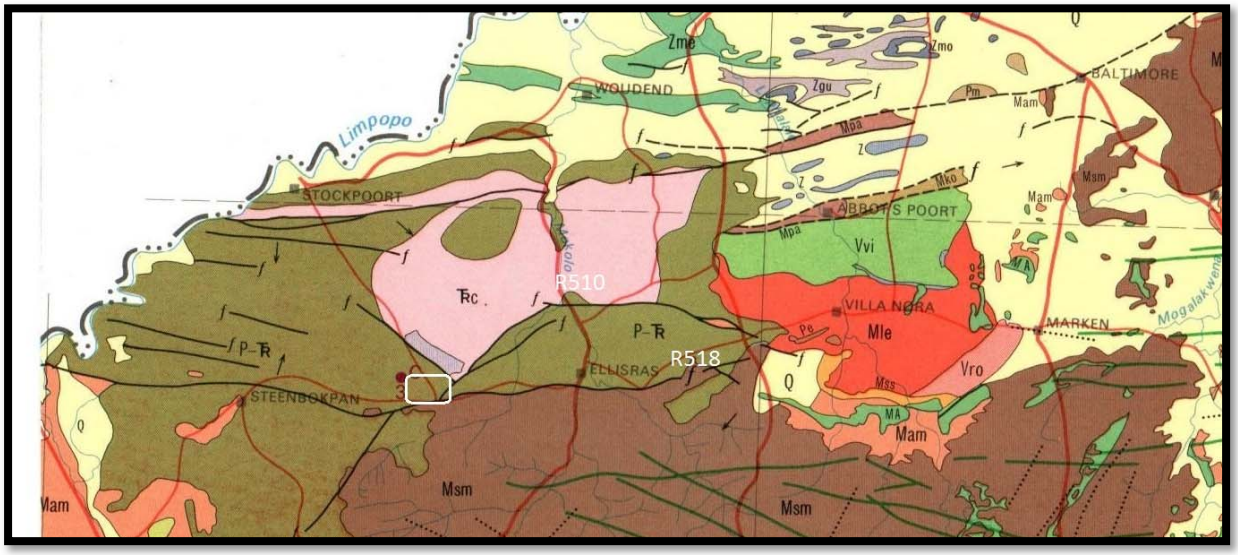
Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):
(i) (i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens.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

Figure 3: The geology of the development area.



Legend to map and short explanation.
TRc – (pink) Sandstone, siltstone. Clarens Formation, Stormberg Group, Karoo Supergroup. Triassic.
P-TR – (khaki) Sandstone, shale, mudstone, coal. Grootegeluk Formation, Ecca Group, Karoo Supergroup. Permian.
Msm – (brown) Sandstone, conglomerate. Sandriviersberg & Mogalakwena Formation, Subgroup Kransberg, Waterberg Supergroup. Mokolian.
…… – (black) Lineament (Landsat, aeromagnetic).
------ - Concealed geological boundary.
--f--- - Fault.
□ - Pointing to two farms where mining development will take place.

Mining Activities:
C – Coal.

Summary of findings (1d): The Phase 1 PIA Field Study was undertaken towards the middle of December 2017 in the summer in hot and dry conditions and the following is reported:

The development will be situated on the Grootegeluk Formation close to Lephalale.
The Karoo Supergroup is renowned for its fossil wealth. It is marked as Undifferentiated strata of the Karoo Supergroup, but correlates with the Vryheid Formation (Pe,Pv), Ecca Group and the Grootgeluk Formation which is rich in plant fossils such as the *Glossopteris* flora represented by stumps, leaves, pollen and fructifications (Appendix 1). 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 Grootegeluk Formation within the sandstone and shale layers of the horsts and grabens. 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.

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 can generally be LOW to VERY HIGH, and here locally VERY HIGH for the Grootegeluk Formation (SG 2.2 SAHRA APMHOB, 2012).

Recommendation:
The potential impact of the development on fossil heritage is VERY HIGH and therefore a field survey or further mitigation or conservation measures were necessary for this development (according to SAHRA protocol). A Phase 2 PIA and or mitigation are only recommended if the Phase 1: Field study finds fossils (plant remains).

During the survey, it was found that the site is directly underlain by shale and sandstone of the Grootegeluk Formation and that coal is present. Recent structures for mining activities are present. It is located on a relatively flat topography. Part of the area is being mined and very disturbed.

The survey was done in summer towards the middle of December 2017, conditions were hot and dry and the area is covered by overburden, vegetation, natural grassland and other land uses include big and small game farming, roads and mine structures. The development will take place on the Grootegeluk Formation known for its plant fossils. The development will benefit the community. There are several site layout alternatives with a very high heritage impact, fossils were not found during the walk through and drive through.

The Project includes several site layout alternatives (Figure 1):
All alternatives will have the same impact.

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

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 the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden 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. Mitigation may be needed (Appendix 2) if fossils are found.
2. No consultation with parties was necessary. The Environmental Control Officer must familiarise him- or herself with the Grootegeluk Formation and its fossils by completing a theoretical and practical training session with a professional palaeontologist on site (minimum 2 days).
3. The development may go ahead with caution, but the ECO together with the mine geologist 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 when necessary.
4. The EMPr already covers the conservation of heritage and palaeontological artefacts that may be exposed during construction activities. The protocol is to immediately cease all construction activities if a fossil is unearthed and contact SAHRA for further investigation. It is recommended that the EMPr be updated to include the involvement of a palaeontologist (to provide training) during the digging and excavation phase of the development either for training or a site visit once a month during construction.

Stakeholders: Developer – Exxaro Resource Limited, Grootegeluk Coal Mine, P.O. Box 178, 0555.
Environmental – Golder Associates, P.O. Box 6001, Halfway House, 1685, Tel. 011 254 4970.
Landowner – Exxaro Resource Limited, Grootegeluk Coal Mine, P.O. Box 178, 0555.

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 R326 of 7 April 2017) of the Environmental Impact Assessment Regulations (see Appendix 3).

Outline of development

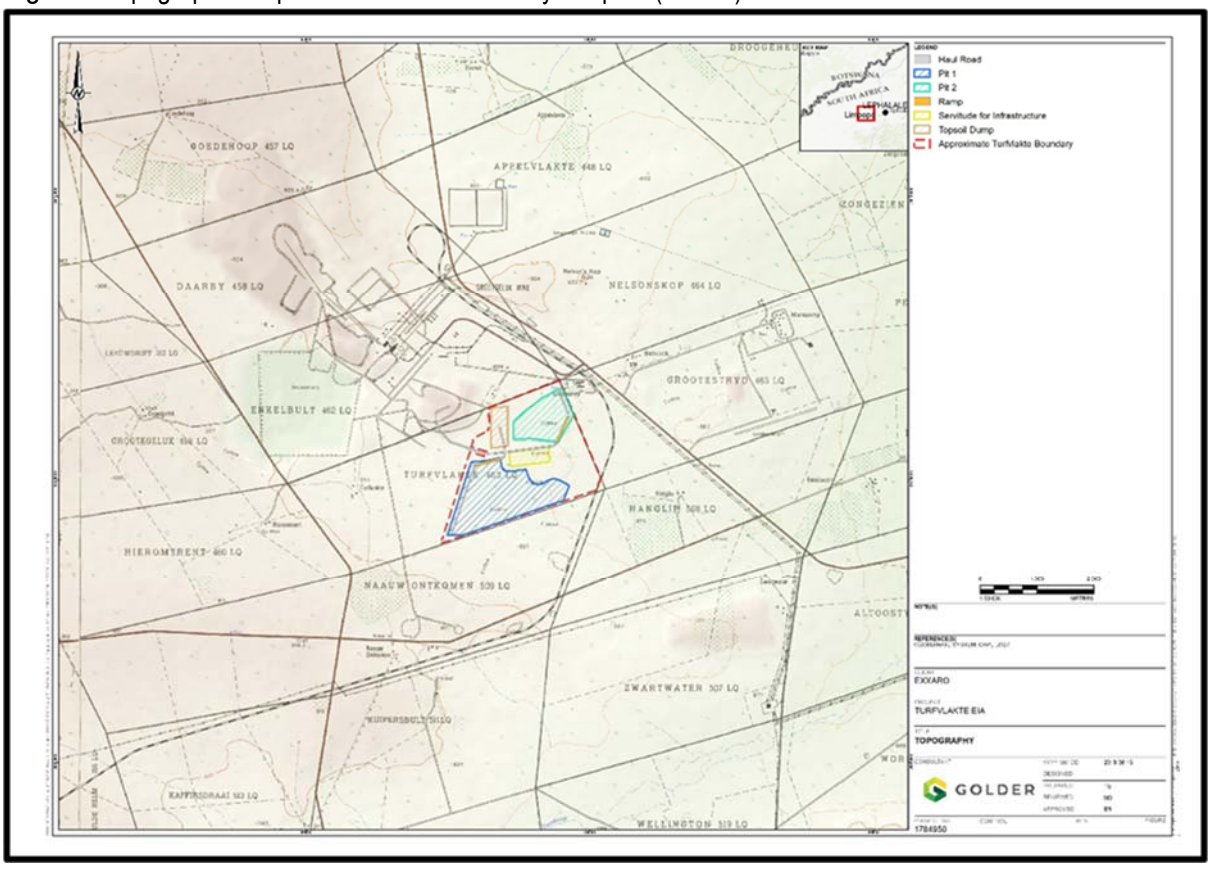
This report discusses and aims to provide the applicant with information regarding the location of palaeontological material that will be impacted by the development. In the construction phase, it may be necessary for the applicant to apply for the relevant permit from the South African Heritage Resources Agency (SAHRA / PHRA) if a fossil is unearthed.

The development is necessary as the available coal reserves within the Grootegeluk Mine Right area will be mined. Access routes, pipelines and power lines will run through the remaining Grootegeluk Mining Rights area so as to link up to the existing mine infrastructure.

Related infrastructure:

1. Open Pits,
2. Construction and use of Access and Haul Roads,
3. Stockpile for backfill,
4. Contractor lay-down area and refuelling,
5. Coal supply Conveyor belt,
6. Storm water management,
7. Crush, tip and screen facility,
8. Wash facilities,
9. Discard dump,
10. Reclamation activities at the Co-disposal facilities,
11. New 8 MVA power line required.

Figure 1: topographic map to show location and lay-out plan (Golder).



The Project includes several site layout alternatives (Figure 1):

All alternatives will have the same impact.

Rezoning/ and or subdivision of land: No.
Name of developer and consultant: Exxaro Resource Limited, Grootegeluk Coal Mine and Golder Associates.
Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a palaeontological impact assessment: field study 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 (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 ten years she carried out field work in the Eastern Cape, Free State, Gauteng, Limpopo and Mpumalanga Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 23 years.
Legislative requirements: South African Heritage Resources Agency (SAHRA) for issue of permits if necessary. National Heritage Resources Act (Act No. 25 of 1999). An electronic copy of this report must be supplied to SAHRA.

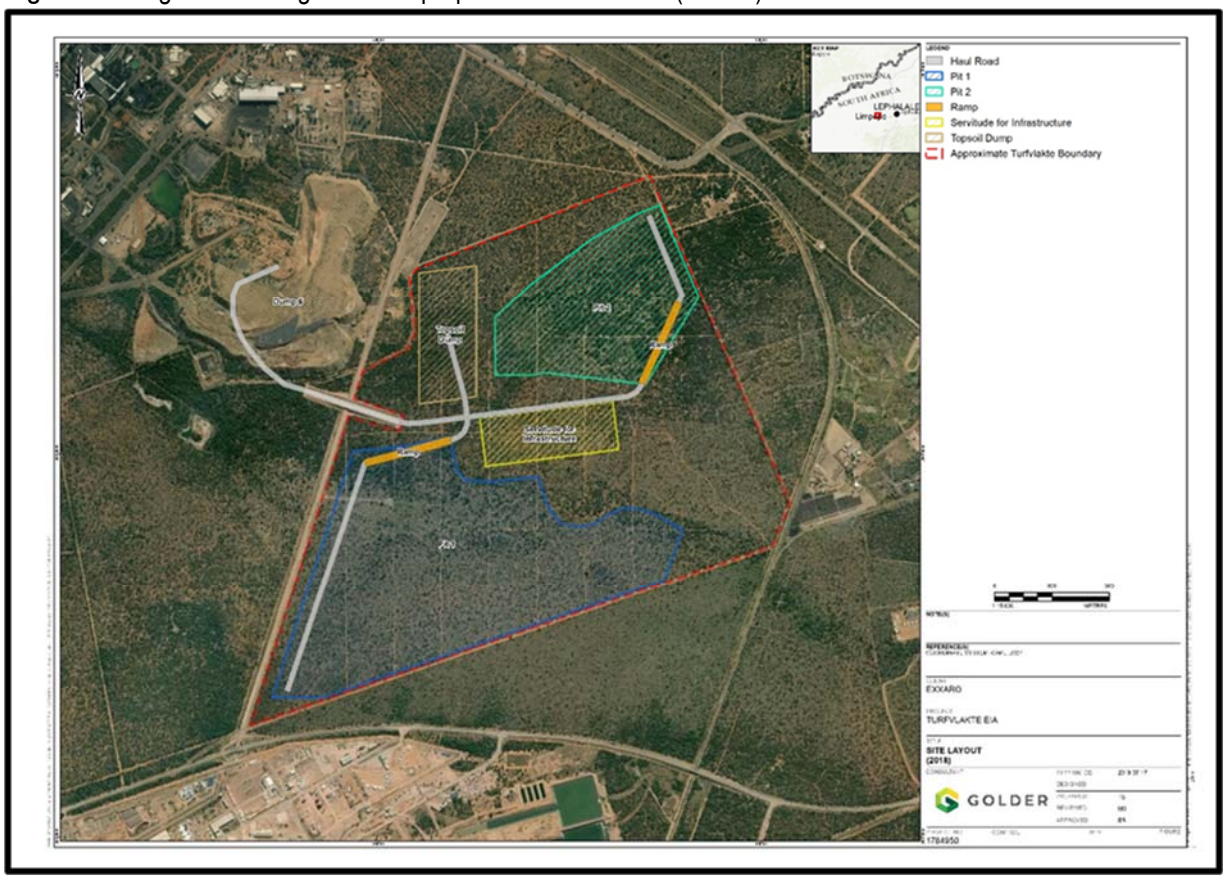
E. Description of property or affected environment

Location and depth:
The Grootegeluk Coal Mine is situated approximately 20 km west of Lephalale, the proposed development of these opencast pits and associated infrastructure will be situated on the eastern portion of the Mining Right area. The mine development will be situated on Daarby 458, Appelvlakte 448 (Portion 0 and 1), Enkelbult 462 (Portion 0 and 1), Turfvlakte 463, Grootestryd 465 (Portion 3), and Nelsonskop 464 (Portion 1) in the Lephale Municipality, Waterberg District Municipality in the Limpopo Province.

The depth is determined by the infrastructure to be developed and the thickness of the formation in the development area, in this instance, the mining activities.

A typical profile includes soil and clay, sandstone and siltstone, shale, coal upper seam, coal seam, sandstone, no 1 seam, shale and dolomite at the bottom. In Lephalale, the entire coal sequence attains a thickness of up to 70 m.

Figure 2: Google.earth image to show proposed infrastructure (Golder).



The site is underlain by the Grootegeluk Formation, Karoo Supergroup.

F. Description of the Geological Setting

Description of the rock units:

The Karoo Supergroup is renowned for its fossil wealth (Kent 1980, Visser 1989). Large areas of the southern African continent are covered by the Karoo Supergroup. An estimated age is 150 – 180 Ma. and a maximum thickness of 7000 m is reached in the south. Three formations overlie the Beaufort Group, they are the Molteno, Elliot and Clarens Formations. At the top is the Drakensberg Basalt Formation with its pillow lavas, pyroclasts, and basalts (Kent 1980, Snyman 1996). The Beaufort Group is underlain by the Ecca Group which is underlain by the Dwyka Group.

The southern part of the Karoo basin is 3000 m thick, but the northern part of the basin is much thinner. The animals present during Beaufort times flourished on the floodplanes, lakes and marshes. Sandstone is deposited in times of flooding in the river channels and the mudstones were deposited on the floodplains in the shallow lakes (Snyman 1996).

The Ecca Group is early to mid-Permian (545-250 Ma) in age. Sediments of the Ecca group are lacustrine and marine to fluvio-deltaic (Snyman 1996). The Ecca group is known for its coal (mainly the Vryheid Formation) (five coal seams) and uranium. Coalfields formed due to the accumulation of plant material in shallow and large swampy deltas (see Appendix 1). The Ecca Group conformably overlies the Dwyka Group and is conformably overlain by the Beaufort Group, Karoo Supergroup. It consists essentially of mudrock (shale), but sandstone-rich units occur towards the margins of the present main Karoo basin in the south, west and north-east, with coal seams also being present in the north-east (Kent 1980, Johnson 2009).

Map 1: Geology of the Karoo Supergroup (Faure *et al.*1996).

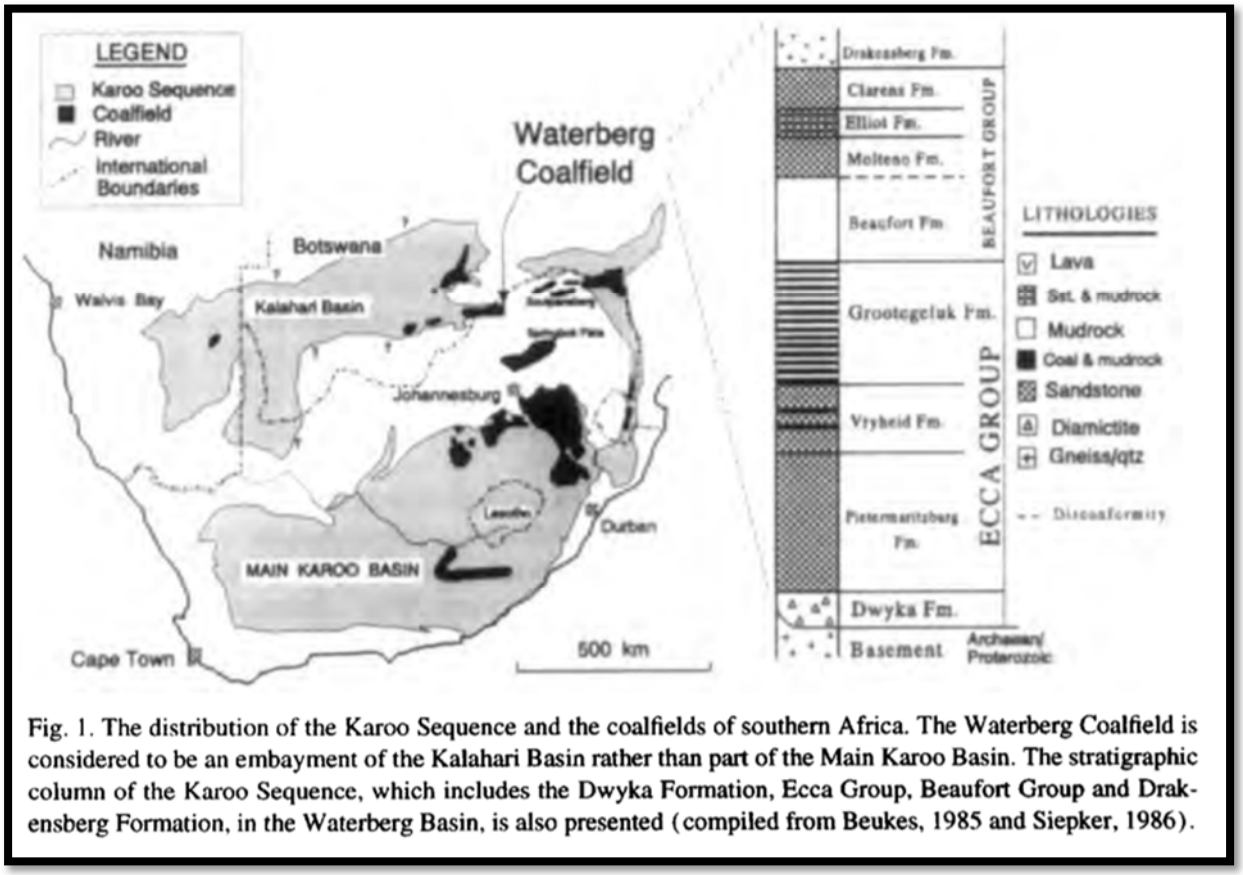
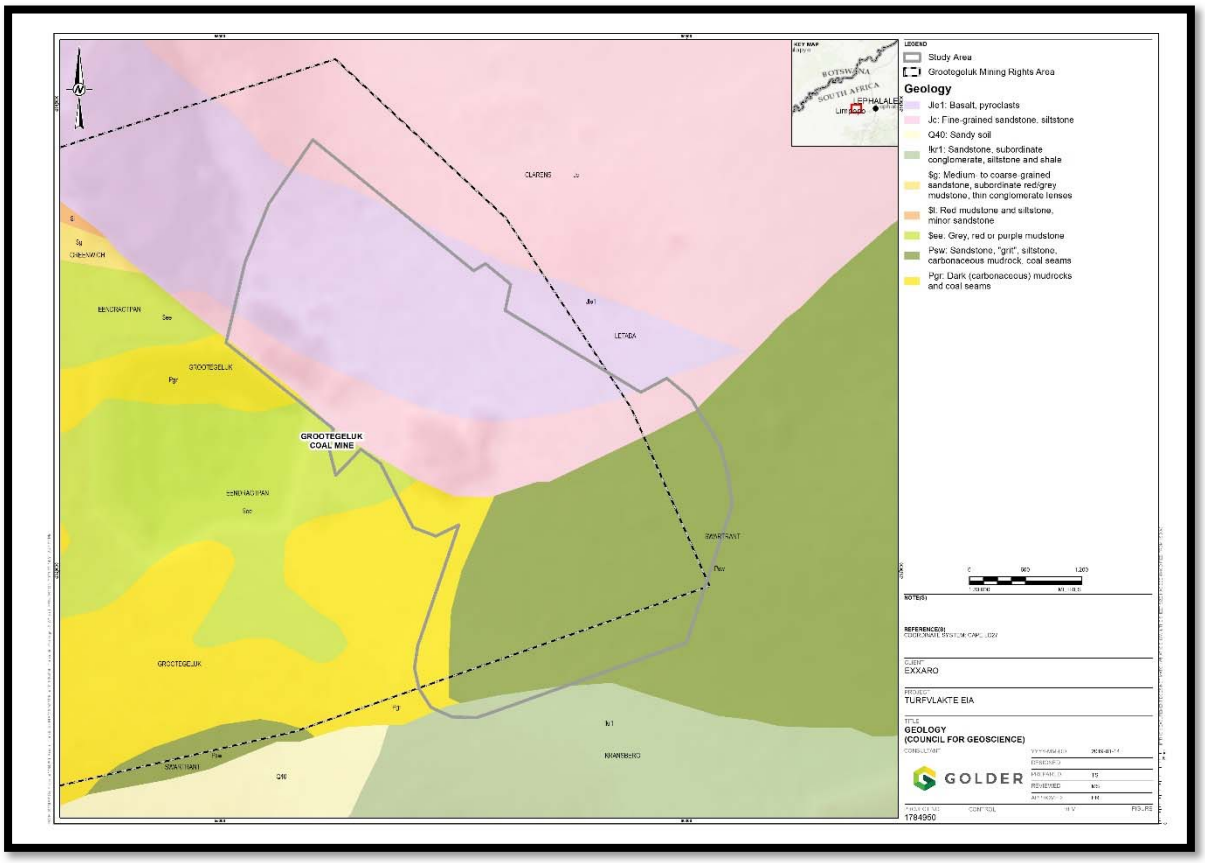


Fig. 1. The distribution of the Karoo Sequence and the coalfields of southern Africa. The Waterberg Coalfield is considered to be an embayment of the Kalahari Basin rather than part of the Main Karoo Basin. The stratigraphic column of the Karoo Sequence, which includes the Dwyka Formation, Ecca Group, Beaufort Group and Drakensberg Formation, in the Waterberg Basin, is also presented (compiled from Beukes, 1985 and Siepker, 1986).

Figure 3: Excerpt of 1:250 000 Geological Map (Golder).



Legend to map and short explanation.

TRc – (pink) Sandstone, siltstone. Clarens Formation, Stormberg Group, Karoo Supergroup. Triassic.

P-TR – (khaki) Sandstone, shale, mudstone, coal. Grootegeluk Formation, Ecca Group, Karoo Supergroup. Permian.

Msm – (brown) Sandstone, conglomerate. Sandriviersberg & Mogalakwena Formation, Subgroup Kransberg, Waterberg Supergroup. Mokolian.

…… – (black) Lineament (Landsat, aeromagnetic).

------ - Concealed geological boundary.

□ - Pointing to two farms where the mine development will take place.

Coal has always been the main energy source in industrial South Africa. It is in Mpumalanga, south of the N4, that most of the coal-fired power stations are found. Eskom is by far the biggest electricity generator in Africa. Thick layers of coal just below the surface are suited to open-cast mining and where the overlying sediments are too thick, shallow underground mining. In 2003, coal was South Africa's third most valuable mineral commodity and is also used by Sasol for fuel- and chemicals-from-coal (Norman and Whitfield 2006). Grodner and Cairncross (2003) proposed a 3-D model of the Witbank Coalfield to allow easy evaluation of the sedimentary rocks, both through space and time. Through this, one can interpret the environmental conditions present at the time of deposition of the sediments. This can improve mine planning and mining techniques. The Vryheid Formation is underlain by the Dwyka Group and is gradually overlain by mudstones (and shale) and sandstones of the Volksrust Formation. 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.

The Waterberg (Ellisras) coalfield is situated north-west of the Karoo basin. A series of horsts and grabens allow shallow coal to be mined. In this area, the Vryheid Formation together with the Volksrust Formation is named the Grootegeluk Formation (Cairncross 2001). Yellow and red shale with brown mudstone, white grit, conglomerate, coal rich shale, 4 coal seams, and dark grey to black shale are present. *Glossopteris* is abundant as for the Vryheid Formation (Visser 1989). The Grootegeluk Formation in the Waterberg Coalfield is about 70 m thick and consists of relatively thin coal beds interbedded with numerous mudstone and carbonaceous mudstone layers. It is considered to be an embayment of the much larger Kalahari Basin with the coal layers numbered 5-11. Palynological evidence are present in the form of spores from mosses, ferns, alae and fungi (Faure *et al.*1996).

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 partly situated on the flat-lying Grootegeluk 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 entire coal sequence attains thicknesses of up to 115 m. (Cairncross 2001). A typical profile includes soil and clay, sandstone and siltstone, shale, 2 upper seam, shale, 2 seam, sandstone, no 1 seam, shale and dolomite at the bottom. Diabase or dolerite dykes are also present in the area. The thickness of the grey shale can vary and this is interlayered with the also variable yellow sandstone and coal seams.

The walk through the project site was done towards the middle of December 2017, conditions were hot and dry. Photographs below show the flat topography. A variety of soil types (overburden and topsoil) will be present. The walk through did not locate fossils.

Field Observations

Figure 4: View of the Turfvlakte section on the Manketti Game Reserve property.

Figure 5: Another view with some Ecca Group rocks present.

Figure 6: Another view of property.

The second part of the development will take place within the existing Grootegeluk mine area. This area is already well developed and highly disturbed.

There is some concern with the project due to the possible presence of plant fossils (see Section I for a discussion on the significance of the plant fossils). All the site layout alternatives will be situated on the Grootegeluk Formation. The depth of the Formation can be verified with geological cores. The topsoil, subsoil and overburden must be surveyed for fossils and Mitigation is needed for the shale layer if fossils are present.

The project includes several site layout alternatives (Figure 1)
All alternatives will have the same impact.

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).

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).

Subgroup / Supergroup	Group	Formation	Fossil Heritage	Comment
Karoo Supergroup	Ecca	Grootegeluk	Glossopterid coal flora abundant associated with thick coal seams	Globally important and under collected

Table 1: Taken form The Palaeotechnical Report (Groenewald and Groenewald 2014).

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 Grootegeluk Formation.

Rock Unit	Significance/vulnerability	Recommended Action
Grootegeluk Formation (Pg, Pgr)	Very High	Field assessment and protocol for finds is required

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

Databases and collections: Ditsong: National Museum of Natural History. Evolutionary Studies Institute, University of the Witwatersrand (ESI).

Impact: VERY HIGH for the Grootegeluk Formation. There are significant fossil resources that may be impacted by the development (shale).

H. Description of the Methodology (1e)

The palaeontological impact assessment field study was undertaken towards the middle of December 2017. The walk through and drive through of the affected portion were 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 Grootegeluk 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. Insufficient data from developer and exact lay-out plan for all structures (for this report all required data/information was provided).

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 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 (1f)

All Karoo Supergroup geological formations are ranked as LOW to VERY HIGH, and here the impact is potentially VERY HIGH for the Grootegeluk 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 occur also 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 determine due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot. The vast coal mining industry (Vryheid Formation) provides palaeontologists with fantastic access to coal-associated plant fossils, while simultaneously resulting in the destruction of important National Palaeontological Heritage.

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 (see Recommendation B) to the development, but it was necessary to request a Phase 1 Palaeontological Impact Assessment: Field study to determine whether the development will affect fossiliferous outcrops as the palaeontological sensitivity is VERY HIGH. A Phase 2 Palaeontological Mitigation is only required if the Phase 1 Palaeontological Assessment identified a fossiliferous formation or surface fossils or if fossils are found during construction or mining. Fossils were not found during the walk through. The Protocol for Finds and Management Plan is attached (Appendix 2) for the ECO, the development may go ahead.
b. This project will benefit the environment, economy, and social development of the community.

c. Preferred choice: Any of the site layout alternatives will have the same impact. The impact on the palaeontological heritage is VERY HIGH. Care must be taken during the digging of foundations and removing topsoil, subsoil and overburden (see Executive Summary).
d. 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 and a palaeontologist should be called in to determine proper mitigation measures.

Sampling and collecting (1m,1k):
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, for the shale layer if a fossil is unearthed.
d. Permits for mitigation: Needed from SAHRA/PHRA.

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 Phase 1 Palaeontological Impact Assessment and Field scope was provided by the Consultant. All technical information was provided by Golder Associates.
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 and a palaeontologist should be called in to determine proper mitigation measures, especially for 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 and adjacent areas as well as for safety and security reasons.

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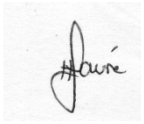
Declaration (disclaimer) 1(b)

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 Phase 1 PIA 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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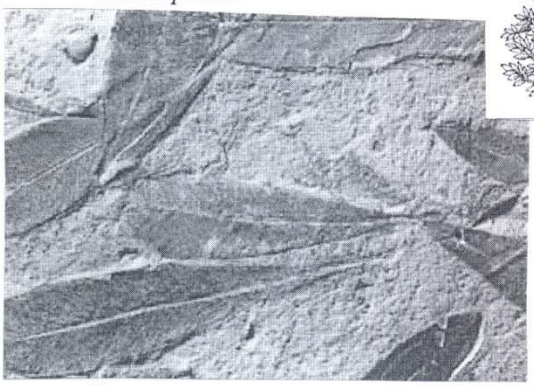
Heidi Fourie
2018/02/27

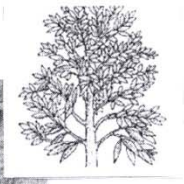
Appendix 1: Examples of Vryheid Formation fossils.

Ecca Group

Vryheid Formation

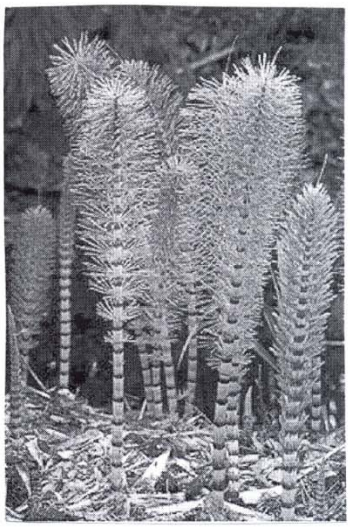
Glossopteris





Ferns

Horsetails



Clubmosses

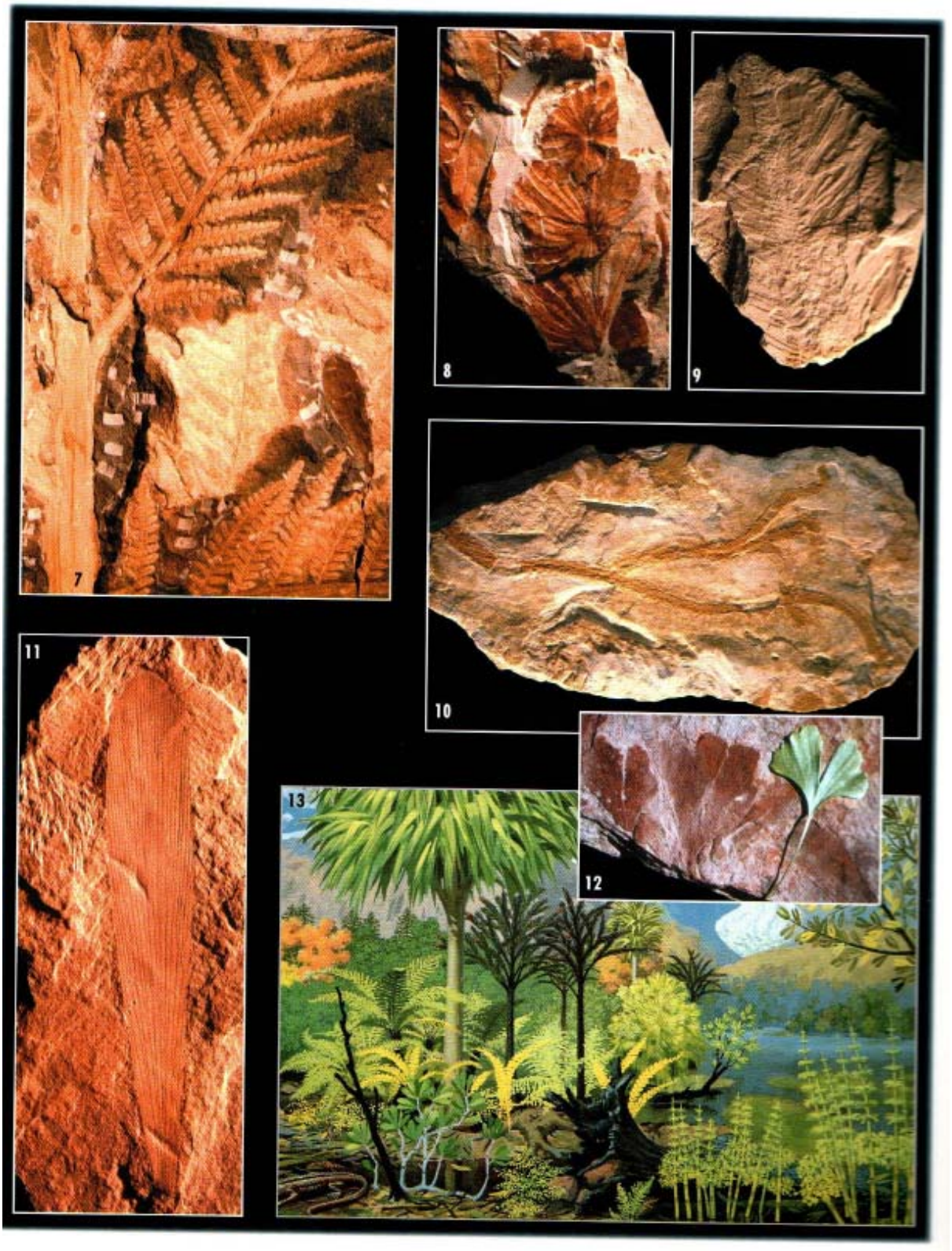

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Figure 7: Example of a plant fossil (courtesy of the ESI). *Glossopteris* leave.

Appendix 2: Protocol for finds and Management plan

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. 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 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 protocol is to immediately cease all construction activities if a fossil is unearthed and contact SAHRA for further investigation. It is recommended that the EMPr be updated to include the involvement (provide training to ECO / relevant construction personnel) of a palaeontologist / archaeozoologist during the digging and excavation phase of the development. 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 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. Fossils likely to occur are for example the fossil plants from the Vryheid Formation, these are present in the grey shale (or any other fossiliferous layer ranked as VERY HIGH or HIGH) or invertebrates from the Volksrust Formation (or any other fossiliferous layer).
3. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work.
4. 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.
5. 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.
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 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).
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. 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 3: Table of Appendix 6 requirements.

Section	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)	"

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