Landau Dragline: Proposed dragline road from Kromdraai Section to Navigation Section of the Landau Mine

Nkangala District Municipality, eMalahleni Local Municipality, Mpumalanga Province

Farm: Kleinwater 301, Nooitgedacht 300, Rondebult 303, Doornrug 302, and Elandsfontein 309 JS

Fourie, H. Dr heidicindy@yahoo.com

012 0000040/012 993 3110

Palaeontological Impact Assessment: Phase 1 Field Study

Commissioned by: Aurecon South Africa (Pty) Ltd

P.O. Box 74381, Lynwood Ridge, 0040

012 427 2000

2016/04/06

Ref: Pending

B. Executive summary

Outline of the development project: Aurecon South Africa (Pty.) Ltd. appointed Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA), Phase 1 Field study of the suitability of the proposed new dragline road on the Farms Nooitgedacht 300, Kleinwater 301, Rondebult 303, Doornrug 302 and Elandsfontein 309 JS, in the Nkangala District Municipality, eMalahleni Local Municipality, Mpumalanga Province.

The applicant, Landau Colliery proposes to construct a dragline road from Kromdraai Section of Landau Colliery in the north in a southerly direction across the N4 national road to the Navigation Section of the Landau Colliery outside the town of Clewer in the south.

The Project includes two Alternatives (Figure 3):

- Alternative 1: (Green) The Dragline road located from the Kromdraai Mine in the north on the farm Kleinwater and Nooitgedacht, from where the road diverts, in a southerly direction towards the N4 and the farm Doornrug. It crosses the N4 towards the farm Rondebult then turns east towards the town of Clewer across the Elandsfontein Mine to end east of Clewer.
- Alternative 2: (Yellow) One alternative was considered for the southern section of the road through Clewer.

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) and 1:250 000 2528 Pretoria Geological Map (Walraven 1978).

Figure 1: The geology of the development area.

Legend to map and short explanation.
Pe – (grey) Sandstone, shaly sandstone, grit, shale, conglomerate and coal near base and top. Vryheid Formation, Ecca Group, Karoo Supergroup. Permian.
Pd – (khaki) Tillite, shale. Dwyka Group, Karoo Supergroup. Permian.
Mw – (brown) Sandstone, quartzitic in places; conglomerate. Waterberg Group.
Di – (green) Diabase (from Vaalian to post-Mokolian age).
…… – (black) Lineament (Possible dyke).
DL – Approximate position where dragline road crosses the N4.

Mining Activities:
C – Coal.

Summary of findings: The Phase 1 PIA Field study was undertaken towards the end of February and beginning of March 2016 in the summer in dry and hot conditions and the following is reported:

Formations present are 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 1).

Vaalian to post-Mokolian diabase (di) intrusions occur throughout the area in the form of plates, sills and dykes. These plates are common in the Transvaal Supergroup and when present in the Pretoria Group they are referred to as the Transvaal diabase (Kent 1980, Visser 1989). The diabase sills of Bushveld age (Norman and Whitfield 2006) is typically fine-grained, green-grey with plagioclase and pyroxenes (Visser 1989).

Both the Dwyka Group and Waterberg Group are present here, but the road only traverses through the Vryheid Formation and the Diabase.

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 Vryheid 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 are necessary for this development (according to SAHRA protocol). A Phase 2 PIA and or mitigation may be recommended. The overburden and inter-burden consisting of Ecca rocks must be surveyed for fossiliferous outcrops (shale). Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden. An appropriate protocol and management plan are attached (Appendix 2). A Phase 2 PIA is not recommended as the developer will not intrude into the shale layer, but the Protocol and Management Plan must be adhered to.

During the survey it was found that the site is directly underlain by Karoo shale, shaly sandstone, grit, conglomerate and sandstone of the Vryheid Formation and is presently underutilised. Recent structures such as graves are present. It is located on a gentle sloping topography. The development includes only the road that will be rehabilitated after use, however, it may be possible to widen existing roads.

The survey was done in summer, conditions were cloudy, dry and hot and the area is covered by overburden, vegetation, natural grassland and other land uses include a quarry, power lines, and the town of Clewer. The construction of the road will take place on the Vryheid Formation known for its plant fossils. The development will benefit the economy as mining will expand. There are two alternatives with a very high impact.

The Project includes two Alternatives (Figure 3):

- Alternative 1: (Green) The Dragline road located from the Kromdraai Mine in the north on the farm Kleinwater and Nooitgedacht, from where the road diverts, in a southerly direction towards the N4 and the farm Doornrug. It crosses the N4 towards the farm Rondebult then turns east towards the town of Clewer across the Elandsfontein Mine to end east of Clewer.
- Alternative 2: (Yellow) One alternative was considered for the southern section of the road through Clewer.

Concerns/threats:

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, human disturbance and opencast mining.
2. Mitigation may not be needed (Appendix 2).
3. Consultation with parties was necessary. The developer will in rocky areas excavate 200 mm above the rock and import a 200 mm protection layer between the rock and the final road level. No blasting will be done. The cut along the centre line is 800 mm deep for most of the way. The shale is expected near the first wetland crossing. On this section the developer plans to go above the normal ground level to avoid intruding into the wetland. This implies a 0% impact on the shale.

Stakeholders: Developer – Anglo Operations (Pty.) Ltd., Landau Colliery, P.O. Box 78, Clewer / Kwa Mthunzi Vilakazi, 1036. Tel: 013 693 0688.
Environmental – Aurecon South Africa (Pty.) Ltd, P.O Box 74381, Lynwood Ridge, 0040, Tel: 012 427 2000.
Landowner – Anglo Operations (Pty.) Ltd., Landau Colliery, P.O. Box 78, Clewer / Kwa Mthunzi Vilakazi, 1036. Tel: 013 693 0688.

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 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 pre-construction phase it is necessary for the applicant to apply for the relevant permit from the South African Heritage Resources Agency (SAHRA / PHRA).

The proposed project entails the construction of a dragline road, 30 m wide, from the Kromdraai Section in the north in a southerly direction across the N4 towards Navigation Section of the Landau Colliery in the south just outside Clewer. After the heavy machinery has been moved parts of the road will be rehabilitated. The road will consist of gravel only.

The following structures or properties will be intersected:

1. The N4 highway,
2. Various Eskom transmission lines (400 kV, 275 kV and 132 kV),
3. Transnet railway lines,
4. A portion of the Highveld Steel property,
5. Clewer Town,
6. Agricultural land, and
7. Hydrological features (streams, wetlands, and pans).

The Project includes two Alternatives (Figure 3):

- Alternative 1: (Green) The Dragline road located from the Kromdraai Mine in the north on the farm Kleinwater and Nooitgedacht, from where the road diverts, in a southerly direction towards the N4 and the farm Doornrug. It crosses the N4 towards the farm Rondebult then turns east towards the town of Clewer across the Elandsfontein Mine to end east of Clewer.
- Alternative 2: (Yellow) One alternative was considered for the southern section of the road through Clewer.

Rezoning/ and or subdivision of land: No.

Name of developer and consultant: Anglo Operations (Pty.) Ltd. and Aurecon (Pty.) Ltd.

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 21 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:
Landau Colliery is located near eMalahleni (Witbank) on the Eastern Highveld in the Nkangala District Municipality, Mpumalanga Province. Landau Colliery is a business unit of Anglo Coal (A Division of Anglo Operations (Pty) Ltd AOPL) and consists of two sections, namely the Kromdraai Section and the Navigation Section located north and south of the N4 highway, respectively.

The Navigation Section also includes a narrow piece of land to the north of the N4 which incorporates parts of Vosman, KwaGuqa and eMalahleni. Depth is determined by the foundations, footings, channels, and may reach depths of up to 500 m.

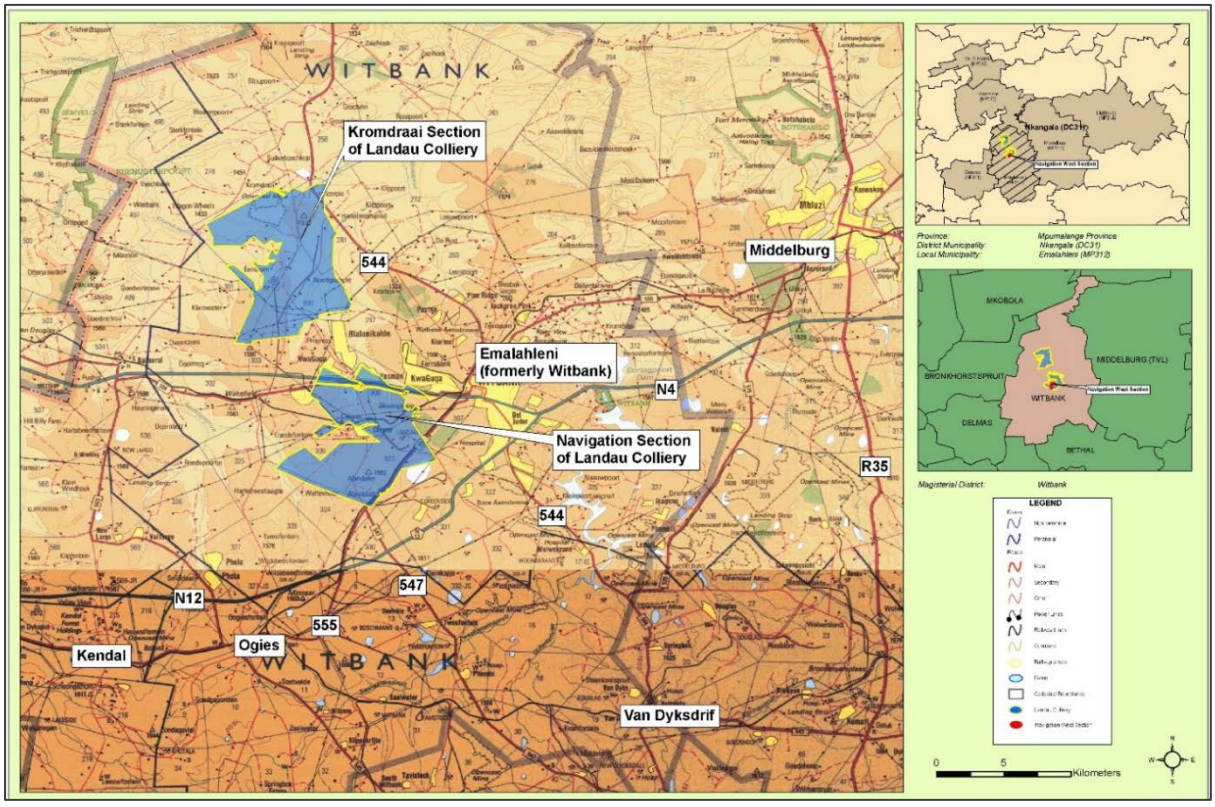

Figure 2: Map (Aurecon) showing location of Mine.

The Project includes two Alternatives (Figure 3):

- Alternative 1: (Green) The Dragline road located from the Kromdraai Mine in the north on the farm Kleinwater and Nooitgedacht, from where the road diverts, in a southerly direction towards the N4 and the farm Doornrug. It crosses the N4 towards the farm Rondebult then turns east towards the town of Clewer across the Elandsfontein Mine to end east of Clewer.
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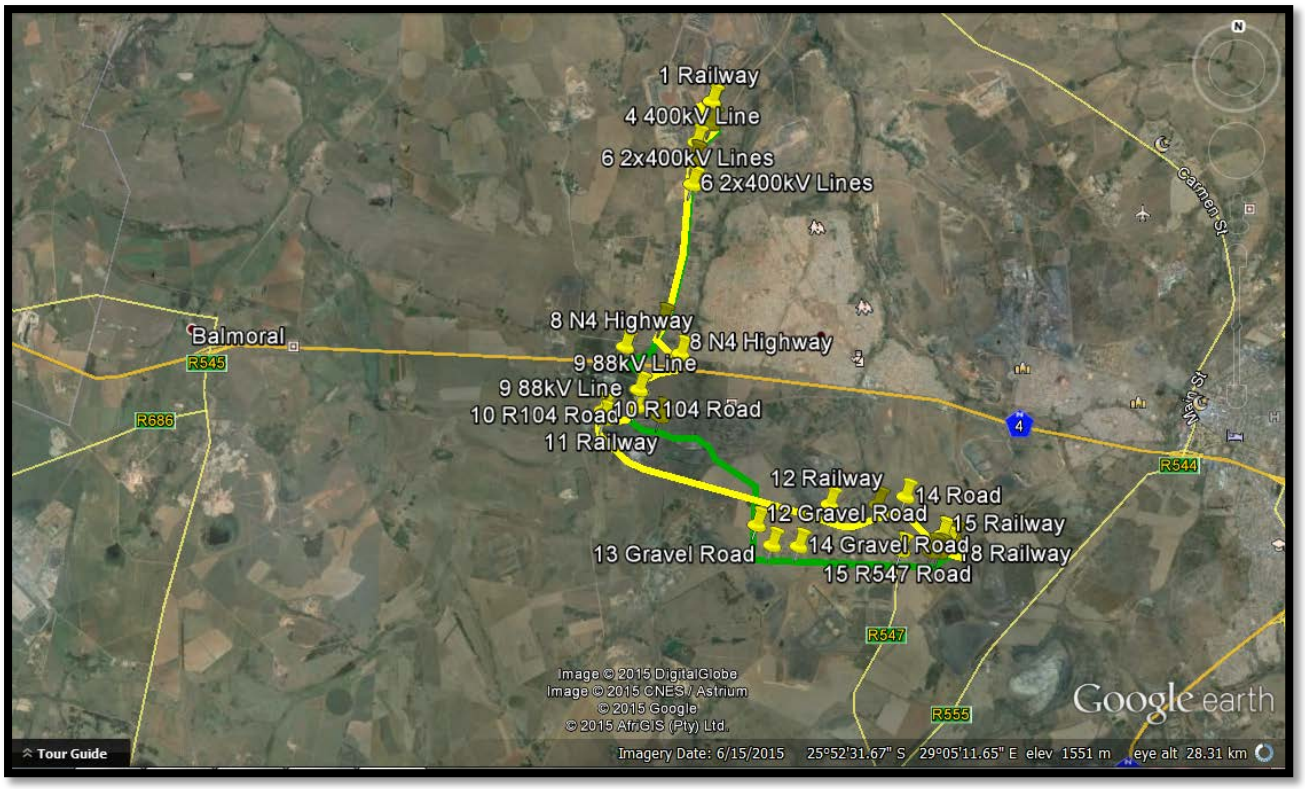

Figure 3: Google.earth image showing location of Dragline road and Alternatives (Aurecon).

The bulk of the site is underlain by the flat-lying Vryheid Formation of the Ecca Group, Karoo Supergroup sediments covered by grassland and vegetation.

F. Description of the Geological Setting

Description of the rock units:

Large areas of the southern African continent are covered by the Karoo Supergroup. 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) (Figure 4).

Figure 4: Excerpt of 1:250 000 Geological Map 2528 Pretoria (Walraven 1978).

Legend to map and short explanation.
Pe – (grey) Sandstone, shaly sandstone, grit, shale, conglomerate and coal near base and top. Vryheid Formation, Ecca Group, Karoo Supergroup. Permian.
Pd – (khaki) Tillite, shale. Dwyka Group, Karoo Supergroup. Permian.
Mw – (brown) Sandstone, quartzitic in places; conglomerate. Waterberg Group.
Di – (green) Diabase (from Vaalian to post-Mokolian age).
…… – (black) Lineament (Possible dyke).
DL – Approximate position where dragline road crosses the N4.

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).

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 gradually overlain by mudstones (and shale) and sandstones of the Volksrust Formation (Figure 5).

The Project includes two Alternatives (Figure 3):

- Alternative 1: (Green) The Dragline road located from the Kromdraai Mine in the north on the farm Kleinwater and Nooitgedacht, from where the road diverts, in a southerly direction towards the N4 and the farm Doornrug. It crosses the N4 towards the farm Rondebult then turns east towards the town of Clewer across the Elandsfontein Mine to end east of Clewer.
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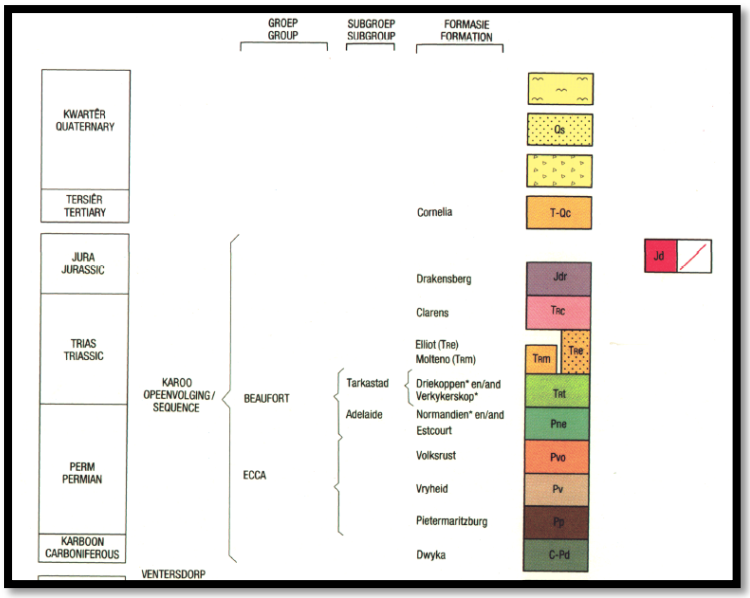


Figure 5: Lithostratigraphic column to show the Ecca Group within the Karoo Supergroup (Muntingh 1992).

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.

Vaalian to post-Mokolian diabase (di) intrusions occur throughout the area in the form of plates, sills and dykes. These plates are common in the Transvaal Supergroup and when present in the Pretoria Group they are referred to as the Transvaal diabase (Kent 1980, Visser 1989). The diabase sills of Bushveld age (Norman and Whitfield 2006) is typically fine-grained, green-grey with plagioclase and pyroxenes (Visser 1989).

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 walk through was done towards the end of February and beginning of March 2016, conditions were cloudy, hot and dry. Photographs below show the gentle sloping topography. A variety of soil types (overburden and topsoil) are present (Figures 6-10). The Vryheid Formation sediments may attain a thickness of 120 – 140 m. 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. The gritty sandstone is typically 1.08 m thick and separates the No. 2 Seam and No. 1 Seam (Final Scoping Report). Diabase or dolerite dykes are also present in the area.

Field Observations

Figure 6: The site is currently underutilised, but was covered by Highveld grassland. Photograph on road show northern view looking towards Kromdraai Mine.

Figure 7: Same position as above, but looking to the south

Figure 8: The northern section above the N4 is characterised by huge grit boulders (25˚ 50'46.8"S, 29˚ 03'39.5'E).

Figure 9: Section where road may cross the N4.

Figure 10: View at the crossing of the N4 looking south.

Figure 11: Quarry (25˚ 52' 15.1" S, 29˚ 03' 41.2" E) south of the N4 in the southern section. Sandstone banks of the Vryheid Formation are present here.

Figure 12: View near the R 104 at the Kooks dump.

Figure 13: View at Elandsfontein Mine.

Figure 14: Photograph near Alternative 2 through the town of Clewer.

Figure 15: Section of road just south of Clewer.

Figure 16: Road south of Clewer, there is an existing road here that is partially tarmac. Figure 17 shows the dirt road that runs parallel to this road.

Figure 17: End of road in Clewer east.

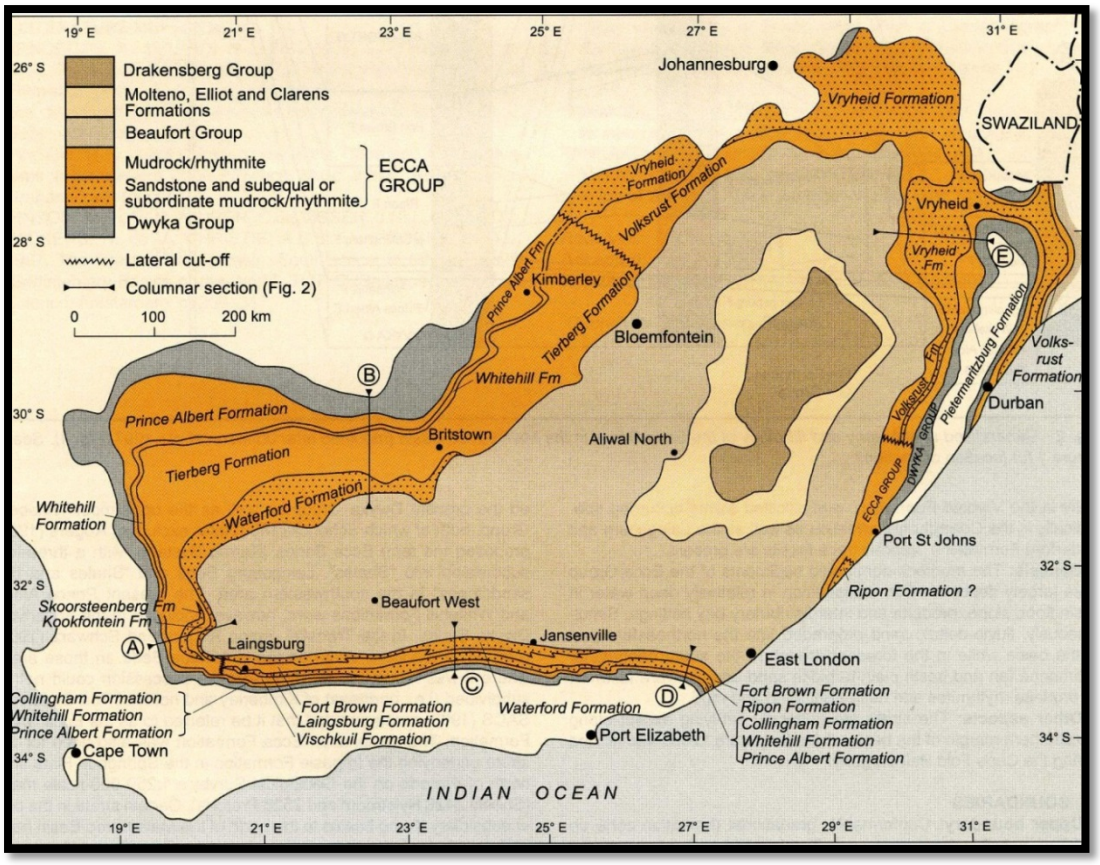
Figure 18: End of road in Clewer east at the Navigation Section.

There is some concern with the project due to the presence of the Vryheid 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.

It is recommended to wait for the response from SAHRA on the Phase 1 Field study (this report), and if mitigation is recommended then the SAHRA protocol must be followed. Alternatives will not be feasible as all proposed development portions and surrounding areas are on the Vryheid Formation.

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).



Map 1: Extent of the Ecca Group, more specifically the Vryheid Formation and the Volksrust Formation (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) (Figures 19 -21).

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).

Figure 19: Photograph of fossil horsetail fern stem, courtesy of Prof. Bamford, The Evolutionary Studies Institute (Photograph: H. Fourie).

Impact	High
Vryheid Formation	Very High Palaeontological Sensitivity
Pre-construction Construction phase Post-construction	Impact low. Impact high. Impact low after mitigation.

Table 1: Impact.

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

Table 2: Taken form 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 Vryheid Formation.

Rock Unit	Significance/vulnerability	Recommended Action
Vryheid Formation (Pv) (Pe)	Very High	Field assessment and protocol for finds is required

Table 3: 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 Vryheid Formation. There are significant fossil resources that may be impacted by the development (shale).

H. Description of the Methodology

The palaeontological impact assessment field study was undertaken towards the end of February and beginning of March 2016. The walk through of the affected portion was done and photographs (in 7.1 mega pixels) were taken of the site with a digital Canon camera (PowerShot A470). It was necessary to use a Global Positioning System (GPS) (Garmin eTrex 10) to record outcrops where not covered with topsoil, subsoil, overburden, and vegetation. The walk through did identify the Vryheid Formation and the underlying shale. A literature survey is included.
Assumptions and Limitations:-

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.

Other Palaeontological Impact Assessment Reports in the same area:-
Fourie, H. 4/2014. Greenside Colliery New Discard Facility. Phase 1 prepared for Shangoni Management Services.
Fourie, H. 5/2015. Klarinet Phase 2. Phase 1 prepared for Clean Stream Environmental Services.
Fourie, H 11/2015. Landau Colliery: Proposed Navigation West-South Block Extension Project. Phase 1 prepared for Shangoni Management Services.

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

All Karoo Supergroup geological formations are ranked as LOW to VERY HIGH, and 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.

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, and human disturbance. See Description of the Geological Setting (F) above.

J. Recommendation

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 may be required as the Phase 1 Palaeontological Assessment identified a fossiliferous formation (Vryheid Formation). Protocol is attached (Appendix 2).
b. This project may benefit the economy.
c. Preferred choice: Alternative 1. The impact on the palaeontological heritage is VERY HIGH for the Vryheid Formation. The presence of shale is problematic. Care must be taken during the digging of foundations and removing topsoil, subsoil and overburden (see Executive Summary). Alternative 1 has the least impact as it is has existing roads that can be widened.
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:
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 prior to Mitigation.

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 Aurecon (Pty.) Ltd.
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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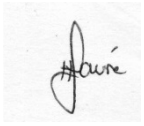
Declaration (disclaimer)

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.



Heidi Fourie
2016/04/06

Appendix 1:

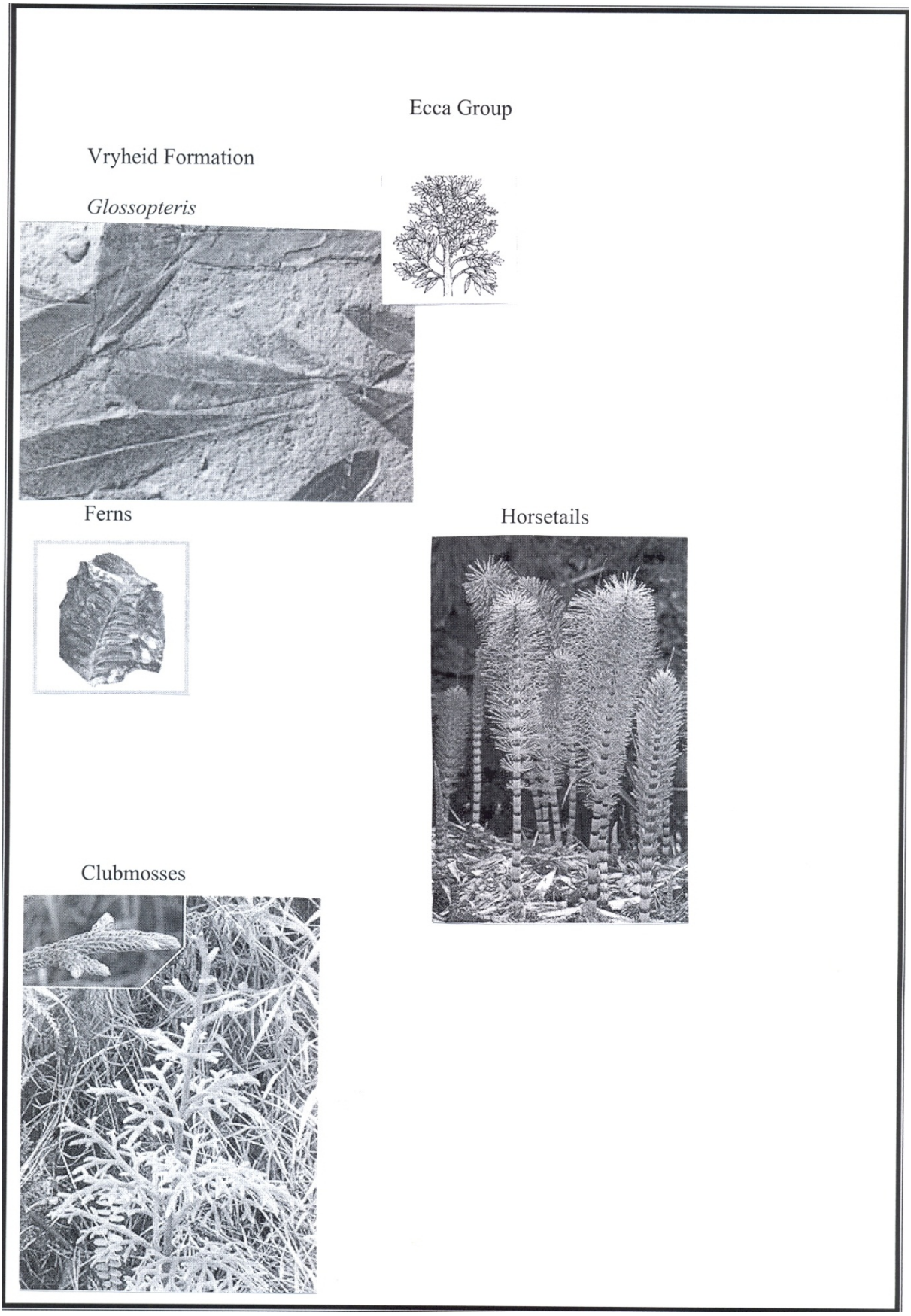


Figure 20: Examples of Vryheid Formation fossils.

Figure 21: 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.

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.

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 (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. 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 are 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 does have the following documents in place:
Guidelines to Palaeontological Permitting policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.

Appendix 3:

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)	"

Table 4: Listing points in Appendix 6 of the Act and position in Report.