A new opencast coal mine, Yoctolux Investments (Pty) Ltd

Nkangala District Municipality, Steve Tshwete Local Municipality, Mpumalanga Province

Farm: Elandspruit 291 JS.

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Palaeontological Impact Assessment: Phase 1 Field study

Commissioned by: ENVASS

394 Tram Street, New Muckleneuk, 0181, Pretoria, Gauteng

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2014/10/07

MDEDET Ref: 17/2/3N-247

B. Executive summary

Outline of the development project: Environmental Assurance (ENVASS) has appointed Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment, Phase 1 Field study of the suitability of the proposed new opencast coal mine on Portion 38 of the farm Elandspruit 291 JS, in the Middelburg area, Nkangala District, Steve Tshwete Local Municipality, Mpumalanga Province.

Yoctolux Investments (Pty) Ltd proposes the development of an opencast mine with an estimated life of mine of 5 years including the rehabilitation of the site. The proposed site is near Middelburg, approximately north of the N4. It may entail the construction of a coal handling and preparation plant (CHPP) and tailings storage facility (TSF). The coal handling and preparation plant will process the coal by washing it of impurities and preparing it for transportation to the end user or market. Currently there are no mining activities taking place on the proposed site.

The Project includes two location Alternatives (see map):
Alternative 1: The farm Elandspruit, located 11 km west-south-east of the town of Middelburg. A 155 hectare section of land north of the N4 above the east-west section of the railway line and some 20 km north of the Duvha Power Station. Only 55 ha will be mined.
Alternative 2: None as no other location was found that maximises efficient and sustainable resource utilisation and minimise waste production and the coal is contained in an underlying belt in the development area.

The **National Heritage Resources Act 25 of 1999** 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.

This report prescribes to the Heritage Impact Assessment of Section 38 of the National Heritage Resources Act 25 of 1999.

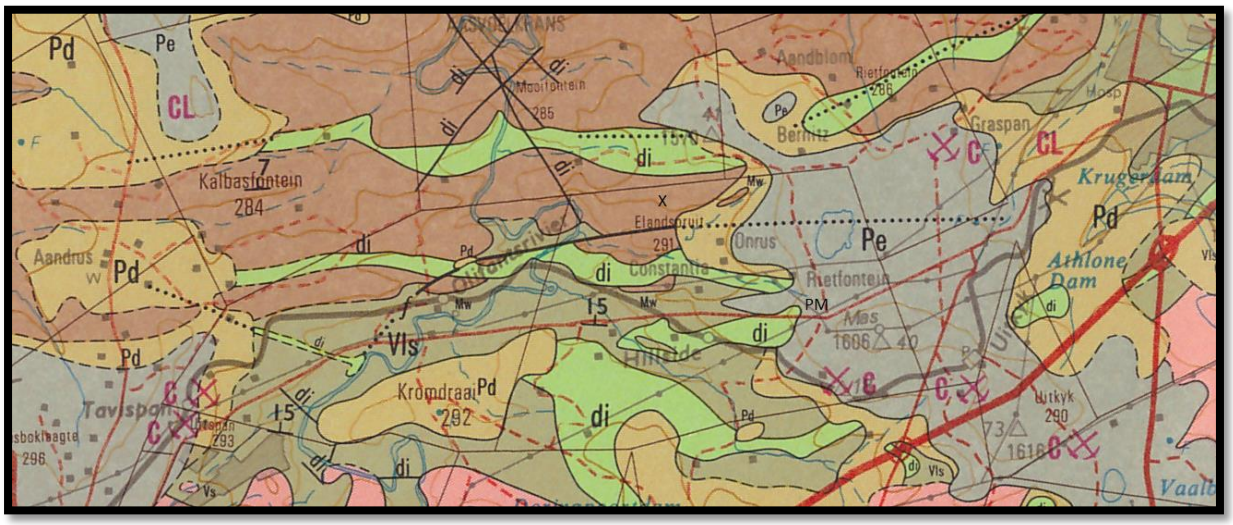
For this study, resources such as geological maps, scientific literature, institutional fossil collections, satellite images, aerial maps and topographical maps were used. It provides an assessment of the observed or inferred palaeontological heritage within the study area, with recommendations (if any) 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, 1999 (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.
Section 38, 1(b) requires the details of the construction of a bridge or similar structure exceeding 50m in length.

It is proposed to comment and recommend on the impact of the development on fossil heritage, and if mitigation or conservation is necessary.

Outline of the geology and the palaeontology:
The geology was obtained from maps 1:100 000, South Africa (Visser 1984) and Pretoria 2528 (Walraven 1978).



Legend to Map and short explanation.
Pe – (grey) Sandstone, shaly sandstone, grit, shale, conglomerate and coal, Vryheid Formation, Ecca Group, Karoo Supergroup. Permian.
Pd – (light brown) Tillite, shale. Dwyka Group, Karoo Supergroup. Permian.
Mw – (brown) Sandstone, quartzite in places, conglomerate. Wilgerivier Formation, Waterberg Group. Mokolian.
Vls – Shale, sandstone, conglomerate, volcanic rocks. Loskop Formation. Vaalian.
di – (green) Diabase. From Vaalian to post-Mokolian
C – Coal.
…f-- - Fault.
X – Farm Elandspruit.
PM – Proposed open cast mine.

Summary of findings: The Phase 1 Palaeontological Impact Assessment Field study was undertaken during September 2014 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 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. The borehole logs show the following layers; soil, shale and sandstone, shale and sandstone interbedded, sandstone, coal, conglomerate reworked diamictite, Dwyka Tillite, and the Pre-Karoo Basement at a level of 110 m. (Huisamen 2013).

The area to the west is covered by the Wilgerivier Formation of the Waterberg Group (sandstone, conglomerate, quartzite), the Dwyka Group and the Loskop Formation (shale, sandstone, conglomerate, volcanic rocks). The Farm Elandspruit 291 JS was visited and there are some visible rocky outcrops of the Vryheid Formation on the surface visible as baked shale. The topsoil, subsoil and overburden may be substantial (± 14 m deep) and most of the land is covered in grassland. Coal seams present are 4 Seam and 2 Seam.

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.

Recommendation:
The Phase 1 Palaeontological Impact Assessment Field study of the suitability of the proposed development recommend a Phase 2 Palaeontological Impact Assessment, Mitigation with protocol. This will take place during the construction and excavation phases of the mine development.
The Project includes two location Alternatives (see map):
Alternative 1: The farm Elandspruit, located 11 km west-south-east of the town of Middelburg. A 155 hectare section of land north of the N4 above the east-west section of the railway line and some 20 km north of the Duvha Power Station. Only 55 ha will be mined.
Alternative 2: None as no other location was found that maximises efficient and sustainable resource utilisation and minimise waste production and the coal is contained in an underlying belt in the development area.

During the survey it was found that the farm Elandspruit is directly underlain by rocks of the Vryheid Formation and is presently underutilised. Recent structures are present. It is located on a gentle facing slope. The development of the plant includes several projects that will need foundations, footings, channels and trenches to be dug. Infrastructure include - access and haul roads; contractor's yard; weighbridge, workshop and stores; diesel facilities and a hard park; box cut and opencast pit (drill & blast); stockpiles; crushing and screening plant; DMS wash plant; and surface water management measures. The opencast strip mine will extract bituminous and anthracite to semi-anthracite coal.

The 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 Palaeontological Impact Assessment and or mitigation are recommended. The overburden and inter-burden consisting of Ecca rocks must be surveyed for fossiliferous outcrops. Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden.

Concerns/threats:

1. Threats are earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction and mining, the sealing-in or destruction of the fossils by development, vehicle traffic and human disturbance.

Stakeholders: Developer – Yoctolux Investments (Pty) Ltd, PO Box 14522, Hatfield,Pretoria, 0028. 012 809 3505.
Environmental – Environmental Assurance (ENVASS) Pty (Ltd), 394 Tram Street, New Muckleneuk, 0181, 460 9768.
Landowner – Yoctolux Investments (Pty) Ltd.

C. Table of Contents

A. Title page	1
B. Executive Summary	2
C. Table of Contents	4
D. Background Information on the project	4
E. Description of the Property or Affected Environment	6
F. Description of the Geological Setting	7
G. Background to Palaeontology of the area	14
H. Description of the Methodology	15
I. Description of significant fossil occurrences	16
J. Recommendation	17
K. Conclusions	17
L. Bibliography	17
Declaration	18
Appendix 1: Examples of Vryheid Formation fossils	19
Protocol for finds	20

D. Background information on the project

Report

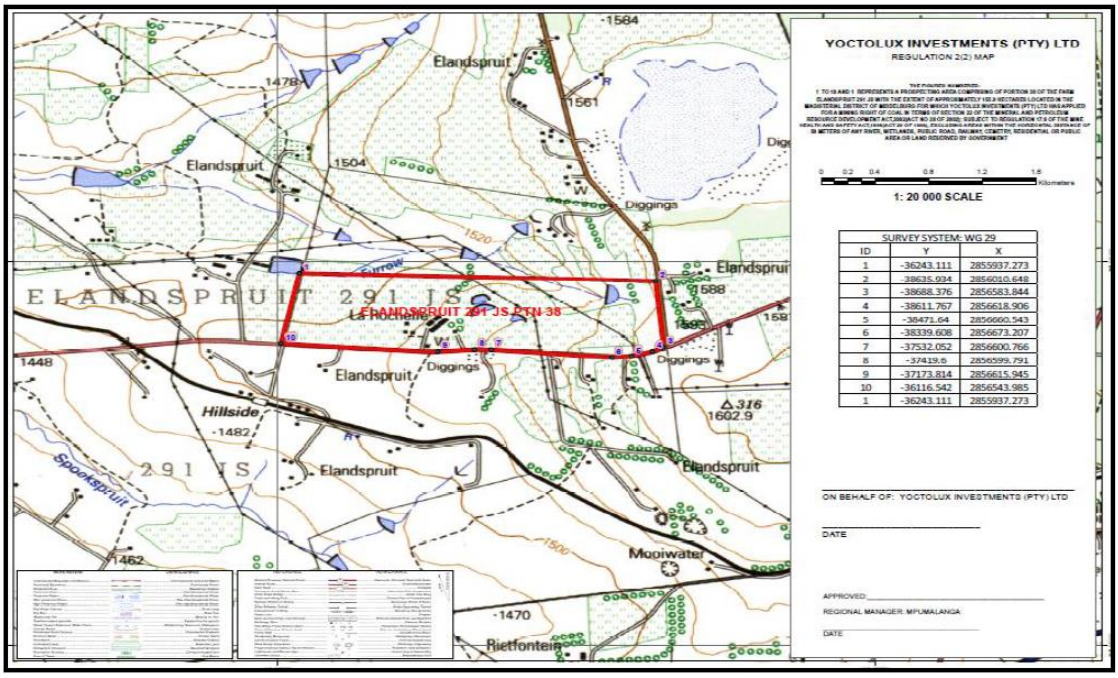
This report is part of the environmental impact assessment process under the NEMA (National Environmental Management Act 108 of 1998) [as amended].

Outline of development

This report discusses and aims to provide the developer with information regarding the location of palaeontological material that will be impacted by the development of the opencast mine.

In the pre-construction phase it is necessary for the developer to apply for the relevant permit from the South African Heritage Resources Agency (SAHRA). Topsoil will be removed two strips in advance of the current working strip. The subsoil will be removed one strip in advance of the current working strip. The coal seams are near the surface and therefore an opencast mine is preferential. The first intersected coal seam is approximately 14.61 m below the surface, with an average parting thickness of 0.97 m between the 2 and 2L Seams, and a total coal thickness average of 6.09 m thick. Mining operations will last approximately 29 months. A box cut (70 m wide) will be established during the construction phase. It is also during this phase that the infrastructure will be developed. During the life of the mine or operational phase, coal will be drilled and blasted in a strip mining method. The final phase will include the filling of the void and the stockpiled topsoil will then be placed on to the levelled area.

Topographic map (provided by ENVASS).



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The following infrastructure is anticipated:-

1. Access road: to be upgraded by digging 0.5 m deep and filling with sandstone and ferricrete.
2. Contractor's yard: a 1 m deep excavated area.
3. Workshop: dedicated workshop of 10 x 10 m with a concrete platform.
4. Fencing and trenching: the property will be fenced (electric) and a 2m trench will be dug along the western and northern boundaries.

5. Security and access control: a permanent security house (brick and mortar) and boom gate will be constructed at the mine entrance.
6. Ablution facilities: this will be built with bricks and mortar.
7. Haul roads: permanent haul roads will be constructed with laterite for the transportation of coal, machinery, general goods, etc.
8. Drainage and pollution control facilities: a series of clean water drains as well as dirty water drains will be constructed. The Pollution Control Dam will also be constructed.
9. Weighbridge: will require minimal cut and fill.
10. Stores and Material: a mobile facility will service equipment, a separate store will hold minimal supplies.
11. Offices: three mobile offices (4 x 10m) will be used, an office for the weighbridge will be built.
12. Electricity: a generator will be used for lights.

Construction may also include several other needs such as the installation of water pipelines, fire water reticulation system, and septic tank. Stockpile will be placed directly on the rehabilitated area behind the advancing strip or placed nearby. Channels and trenches will need to be dug for the pollution control dam, workshop and office complex foundations. Bulk diesel and oil storage tanks will be erected and roads will be scraped.

Stockpile

The run of mine (ROM) stockpile will store a maximum of 150 000 ton of ore, at a steady state in the beginning, a stockpile will be built of up to 200 000 tons so as to start up the mine at 60 000 ton per month.

Workshop/wash bay and associated Administrative and Security building Complex

The workshop complex may also need refuelling bays and parking bays. Septic tanks and soak ways will be required. Parking bays should be provided, a dust suppression water tank will be required. Potable water may have to be used.

Fuel depot and vehicle parking

There should be fuel tanks within the bunded facilities on site. Quarry plant vehicles need to be parked when not in use.

Rezoning/ and or subdivision of land: No.

Name of developer and consultant: Yocolux Investments (Pty) Ltd and Environmental Assurance (ENVASS).

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, University of the Witwatersrand. Her undergraduate degree is in Geology and Zoology. She specialises in vertebrate morphology and function concentrating on the Therapsid Therocephalia. For the past nine years she carried out field work in the Eastern Cape. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 20 years.

Legislative requirements: South African Heritage Resources Agency (SAHRA) for issue of permits if necessary. National Heritage Resources Act no: 25 of 1999. An electronic copy of this report must be supplied to SAHRA.

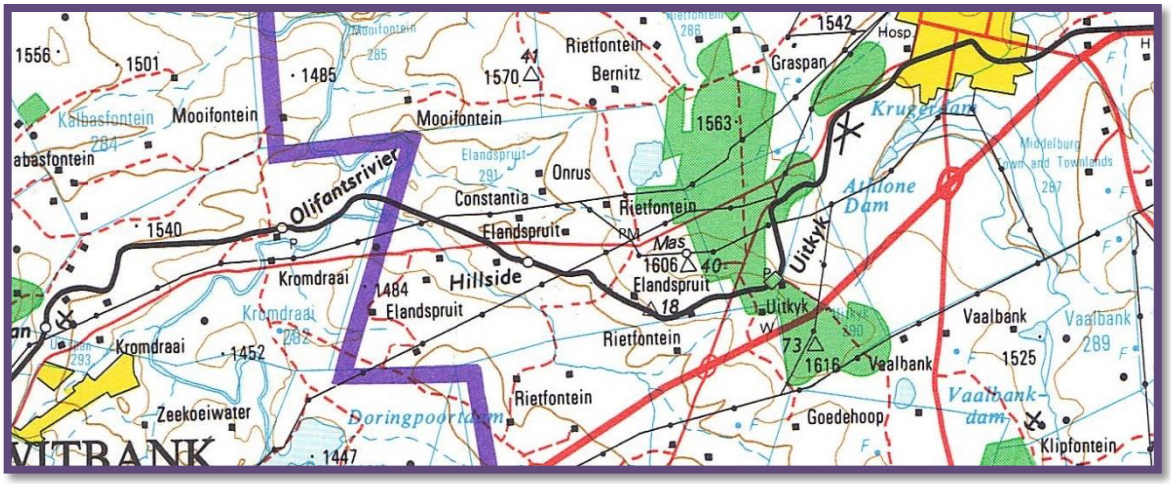
E. Description of property or affected environment

Location:

A new opencast coal mine on Portion 38 of the farm Elandspruit 291 JS, in the Middelburg area, Nkangala District, Steve Tshwete Local Municipality, Mpumalanga Province will be developed.

Google.earth map (2014/10/07) showing location of Portion 38 and proximity to Middelburg.

Topographic map to show location of Elandspruit (2529 CD).



PM – Open cast mine.

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The bulk of the site is on the flat-lying Vryheid Formation of the Ecca Group, Karoo Supergroup sediments covered by grassland, trees, shrubs and bushes.

F. Description of the Geological Setting

Description of the rock units:

The Waterberg Group of rocks today occurs in several separate regions: in the Limpopo and Mpumalanga Provices. These separate patches probably originally formed a single sheet of sedimentary rocks that since become fragmented as a result of erosion. A deep red iron oxide is responsible for the colouration. As the rocks are chemically resistant and very hard, they produce spectacular cliffs and mountainous topography (McCarthy and Rubidge 2005).The Waterberg Group (Kent 1980) is known for its reddish sandstone with conglomerates present between Pretoria and Middelburg, older than the coal and younger than the Magaliesberg Quartzite Formation. In the Cullinan-Middelburg base only one formation has been

recognised, the unconformable Wilgerivier Formation. No fossils are found in the Waterberg Group. Snyman (1996) places the age as 1 800 Ma till 1 700 Ma (Mokolian). A threefold subdivision is recognised, the Nylstroom, Matlabas and Kransberg Subgroups. It overlies the Loskop Formation.

The Loskop Formation follows more or less concordantly on the Rooiberg Group without any trace of a regional unconformity. The Formation is separated from the overlying Waterberg sediments by a prominent regional unconformity and consists of a thick succession of finely layered siltstone, mudstone, feldspathic sandstone and shale. Volcanic rocks also occur (2528 sheet information).

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) (5 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 (Johnson 2009) (Kent 1980).

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 prodelta 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 this part of 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). In 2003 Grodner and Cairncross 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 sandstones of the Volksrust Formation.

Vaalian to post-Mokolian diabase intrusions occur throughout the area in the form of sills and dykes. The Witbank coalfield has five minable seams with No. 1 at the base and No 5 at the top. It is a basin-like feature (9000 km²) that extends from Brakpan in the west to Belfast in the east. 2 Seam provides most of the coal mined to date. Coal seams ranges in thickness between 80-200 m.

The Elandspruit project area is located on Ecca strata, including the coal seams, which generally dip towards the west, displaying a weak undulating altitude. The predominant coal seams located within the mining area are 4 Seam, 3 Seam and 2 Seam. The client intends to mine 4 Seam and 2 Seam. The borehole logs show the following layers; soil, shale and sandstone, shale and sandstone interbedded, sandstone, coal, conglomerate reworked diamictite, Dwyka Tillite, and the Pre-Karoo Basement at a level of 110 m. (Huisamen 2013).

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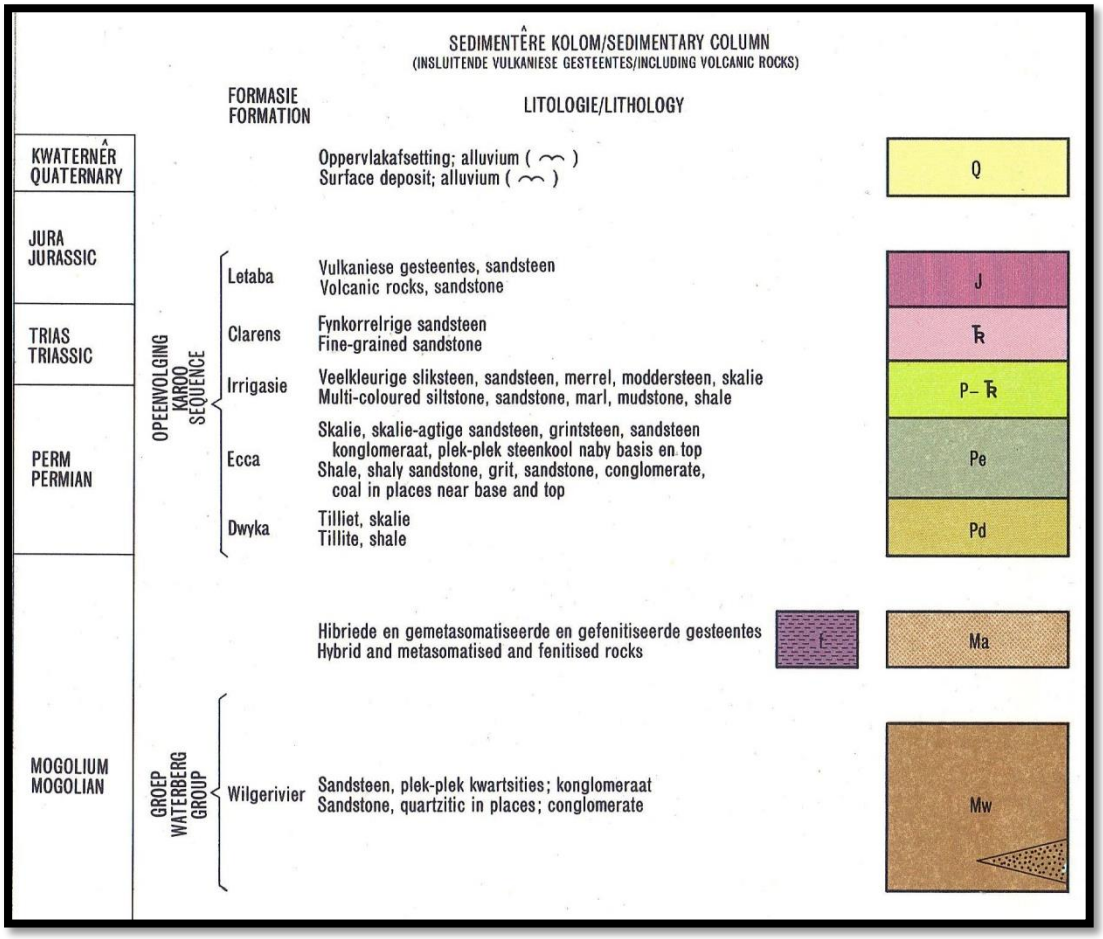
Lithostratigraphic column to show the Ecca Group within the Karoo Supergroup (Walrafen 1978).



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

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

The walk through was done in middle September, conditions were dry. The study area shows one portion, portion 38 which is roughly rectangular. A fair amount of levelling will be needed for infrastructure. The stream is flowing at present. The photographs show the gentle sloping topography. Rocky outcrops are mostly absent. The opencast mine on the neighbouring property is also visible. Remnants of the dolerite dyke are present at the lowest point close to the stream and the border of the property (portion 38). Baked shale is in abundance close to the dolerite outcrops and also scattered throughout the property. The topsoil is not very thick and loose sands are mostly absent.

The photograph below shows the view towards the farmstead, nursery and wattle trees to the south with cemetery to the left. The gentle slope and grazing are visible. To the left of the photograph behind the dam and workers grave is an area which is being bulk sampled (the east corner of the block).

The photograph below shows the dolerite dyke outcrop near the Elandspruit stream at the northern perimeter of the property. It is present at 25˚ 48’318” S, 28˚ 18’033” E and has an east-west orientation.

A borehole for water with the samples, probably 1 m apart. The second photograph shows the grey shale present in the Vryheid Formation. Grey shale to the far right. The topsoil can be seen in this area and some of the well vegetated grassland, small shrubs and trees. The gentle slope is also visible below.

Photograph above shows the baked shale formed during the process when the dolerite/diabase intrudes through the Vryheid Formation.

Photograph below is towards Witbank.

Dolerite dyke present at 25° 48'642" S, 29° 22'124" E.

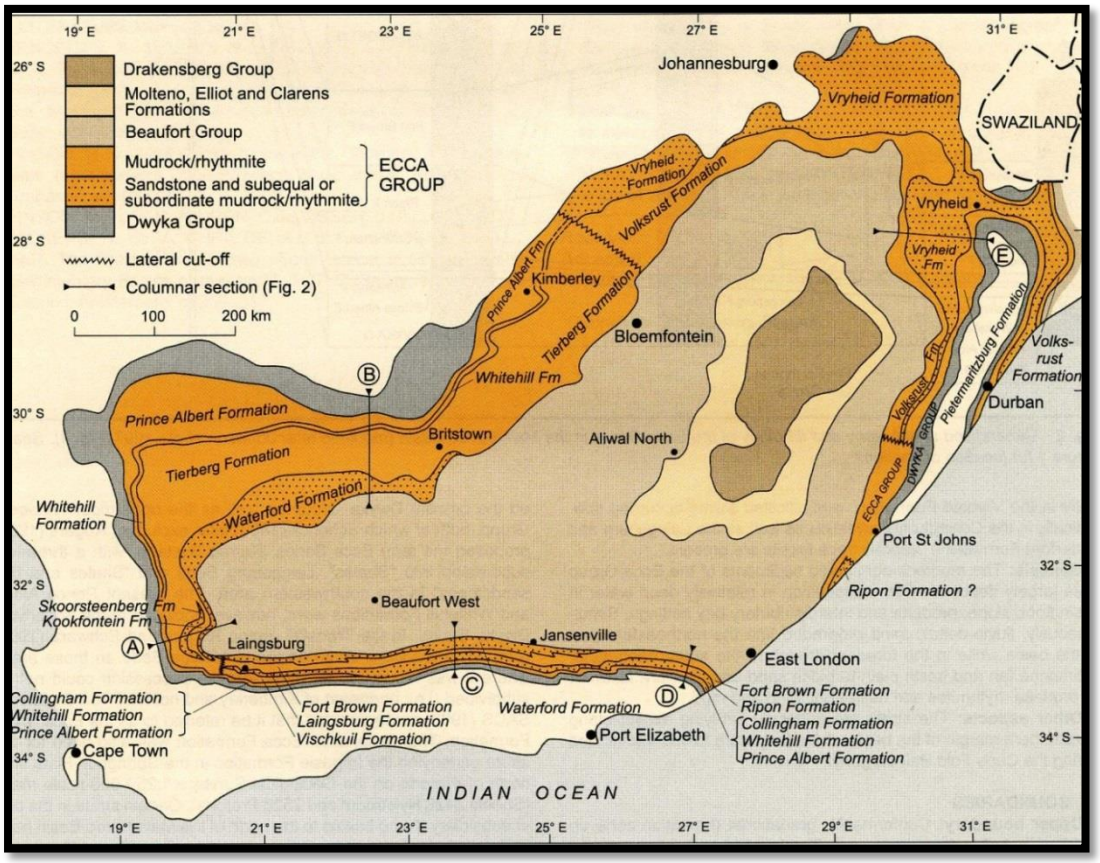
There is very little concern with the property (portion 38) which Yoctolux wants to develop for mining as it is large and presently used for cattle grazing. At present it is not used for agriculture. The topsoil, subsoil and overburden are thick and care should be taken if foundations for buildings and associated structures are dug. Patches of invader trees and plants are present on portions 38. The whole of portion 38 will be affected by the coal handling and processing plant, pollution control

dam, roads, buildings, waste rock dump, and coal stockyard, these structures will need several trenches, foundations and footings to be dug which may enter the more solid Vryheid Formation.

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 (ENVASS Report) 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 from Johnson (2009) to show extent of the Ecca Group, more specifically the Vryheid Formation.

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).

Photograph H. Fourie: Fossil courtesy of Prof. Bamford, The Evolutionary Studies Institute. A Horsetail fern stem.

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.

Criteria used (Fossil Heritage Layer Browser/SAHRA):

Rock Unit	Significance/vulnerability	Recommended Action
Vryheid Formation (Pv) (Pe)	VERY HIGH	Field assessment and protocol for finds is required
Karoo Dolerite Suite (do/Jd)	Insignificant or Zero	No action required

Databases and collections: Ditsong: National Museum of Natural History. Evolutionary Studies Institute, University of the Witwatersrand (ESI).
Impact: VERY HIGH. There are significant fossil resources that may be impacted by the development.

H. Description of the Methodology

The palaeontological impact assessment field study was undertaken during September 2014. The walk through of the affected portions was done and photographs (in 7.1 mega pixels) were taken of the sites with a digital Canon camera (PowerShot A470). It was not necessary to use a Global Positioning System (GPS) (Garmin eTrex 10) to record fossiliferous finds as the area is covered with topsoil, subsoil and overburden, grassland (Rand Highveld, Mesic Higveld), trees, shrubs and bushes. The walk through did find baked 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.

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.

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 (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 (front end loaders, excavators, graders, dozers) during construction and mining, 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 of the new opencast coal mine and associated infrastructure, but it was necessary to request a Phase 1 Palaeontological Impact Assessment to determine whether the development will affect fossiliferous outcrops as the palaeontological sensitivity is VERY HIGH. A Phase 2 Palaeontological Mitigation will be required as the Phase 1 Palaeontological Assessment found traces of fossiliferous outcrops (baked shale) and the fact that the development is for an opencast mine.

b. This project may benefit the economy, the growth of the community and social development in general.

c. Preferred choice: Location Alternative one, but the impact on the palaeontological heritage is VERY HIGH for the Vryheid Formation. 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:

Wherefore a permit is needed from the South African Heritage Resources Agency (SAHRA).

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 taken from the Scoping Documents provided by ENVASS.
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 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.

L. Bibliography

ALMOND, J., PETHER, J, and GROENEWALD, G. 2013. South African National Fossil Sensitivity Map. SAHRA and Council for Geosciences.

ENVASS Draft Environmental Impact Assessment Report, 2014. Proposed Yoctolux coal mine located on portion 38 of the farm Elandspruit 291 JS, Mpumalanga Province.

GRODNER, M. and CAIRNCROSS, B. 2003. A regional scale 3-D model of the Witbank Coalfield, Northern Karoo Basin, South Africa. *South African Journal of Geology,* **106(4):** 249-264.

HUISAMEN, A. 2013. Geohydrological Report for the proposed opencast colliery, on the farm Elandspruit 291 JS PTN 38, Middelburg, Mpumalanga, Geo Pollution Technologies, Pp82.

KENT, L. E., 1980. Part 1: Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda. SACS, Council for Geosciences, *Stratigraphy of South Africa. 1980. South African Committee for Stratigraphy.* Handbook 8, Part 1, pp 690.

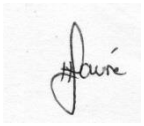
JOHNSON, M.R. 2009. Ecca Group. Karoo Supergroup. Catalogue of South African Lithostratigraphic Units. SACS, **10:** 5-7.
MCCARTHY, T & RUBIDGE, B. 2005. *The Story of Earth Life: A southern African perspective on a 4.6-billion-year journey.* Struik. Pp 333.
NORMAN, N. and WHITFIELD, G., 2006. *Geological Journeys.* De Beers, Struik, P 1-320.
PLUMSTEAD, E.P. 1963. The influence of plants and environment on the developing animal life of Karoo times. *South African Journal of Science,* **59(5):** 147-152.
PREVEC, R. 2011. A structural re-interpretation and revision of the type material of the glossopterid ovuliferous fructification *Scutum* from South Africa. *Palaeontologia africana,* **46:** 1-19.
RAYNER, R.J. and COVENTRY, M.K. 1985. A *Glossopteris* flora from the Permian of South Africa. *South African Journal of Science,* **81:** 21-32.
RUBIDGE, B. S. (Ed.), 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Biostratigraphy, Biostratigraphic Series No. 1, 46pp. Council for Geoscience, Pretoria.
SG 2.2 SAHRA APMHOB Guidelines, 2012. Minimum standards for palaeontological components of Heritage Impact Assessment Reports, Pp 1-15.
SNYMAN, C. P., 1996. *Geologie vir Suid-Afrika*. Departement Geologie, Universiteit van Pretoria, Pretoria, Volume 1, Pp. 513.
VAN DER WALT, M., DAY, M., RUBIDGE, B. S., COOPER, A. K. & NETTERBERG, I., 2010. Utilising GIS technology to create a biozone map for the Beaufort Group (Karoo Supergroup) of South Africa. *Palaeontologia Africana,* **45:** 1-5.
VISSER, D.J.L. 1984. Geological Map of South Africa 1:100 000. South African Committee for Stratigraphy. Council for Geoscience.
WALRAVEN, F. 1978.Geological Map of Pretoria, 1:250 000 (2528),South African Committee for Stratigraphy, Council for Geoscience.

Declaration

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.

Heidi Fourie accepts no liability, and the client, by receiving this document, indemnifies Heidi Fourie 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.

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



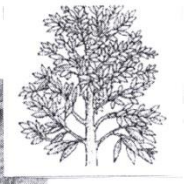
Heidi Fourie
2014/10/07

Appendix 1: Examples of Vryheid Formation fossils.

Ecca Group

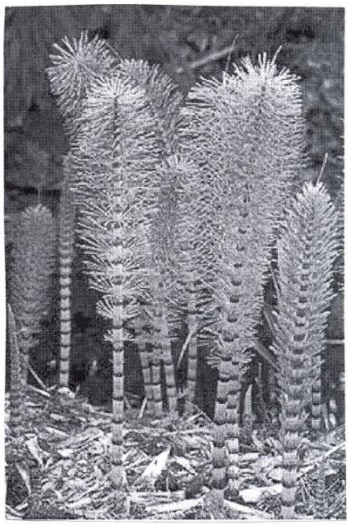
Vryheid Formation

Glossopteris



Ferns

Horsetails



Clubmosses

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

Protocol for finds

This section covers the recommended protocol for a Phase 2 Mitigation process. The developer has not yet surveyed the areas affected by the development and only indicated on plan where the construction/development will take place. As no trenches have been dug it is uncertain how deep the sediments are (can be a few hundred metres).

Mitigation will involve recording, rescue and judicious sampling of the fossil material present in the layers sandwiched between the 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, the mining operations 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 borehole data.
2. Fossils likely to occur are the fossil plants from the Vryheid Formation, these are present in the grey shale.
3. When clearing topsoil, subsoil or overburden and hard rock 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 may be asked to move structures, and put the development on hold.
5. If the palaeobotanist is satisfied, development and removing of the topsoil can continue.
6. After this process the same 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.
7. When permission for the development is granted, the next layer can be removed, if this is part of the Vryheid Formation, then with the removal of each layer of sediment, the palaeobotanist must do an investigation (a minimum of once every two weeks).
8. At this stage the 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 palaeobotanist.

Fossil excavation if necessary during Phase 2:
Photography of fossil / fossil layer and surrounding strata.
Once a fossil has been identified as such, the task of extraction begins.
It usually entails the taking of a GPS reading and recording lithostratigraphic, biostratigraphic, date, collector and locality information.

Using Paraloid as an adhesive and protective glue, parts of the fossil can be kept together (not necessarily applicable to plant fossils).
Slowly chipping away of matrix surrounding the fossil using a geological pick, brushes and chisels.
Once the full extent of the fossil / fossils are visible, it can be covered with a plaster jacket (not necessarily applicable to plant fossils).
Chipping away sides to loosen underside.
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 Permiting policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.