African Carbon Energy Ltd. Underground Coal Gasification and Power Generation Project near Theunissen

Matjhabeng Local Municipality, Lejweleputswa District Municipality, Free State Province

Farm: Palmietkuil 548 (Power station and ancillaries)

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Palaeontological Impact Assessment: Phase 1 Field Study

Facilitated by: Golder Associates (Pty) Ltd

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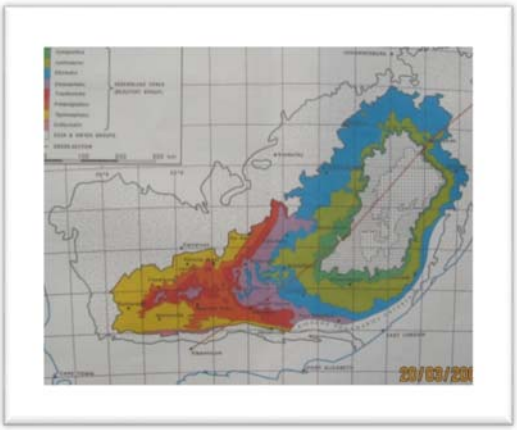
Ref: DEA 14/12/16/3/3/3/116

DETEA EMS/9,22,23,3,4,5,26/13/11



A. Executive summary

Outline of the development project: Golder Associates (Pty) Ltd has facilitated the appointment of Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA), Phase 1 Field Study of the suitability of the Proposed African Carbon Energy Ltd. Underground Coal Gasification and Power Generation Project near Theunissen on the Farm Palmietkuil 548 (power station and ancillaries) with services crossing the Farms of Palmietkuil 548, Jordaansrust 59, Klein Palmietkuil 407, Youlon 368, DeKlerkskraal 231, Kleinbegin 134, Helpmekaar 47, Kalkoenrand 225 and Palmietkuil 328 in the Matjhabeng Local Municipality, Lejweleputswa District Municipality, with related infrastructure in the Free State Province.

The applicant, Africary Holdings (Pty) Ltd, proposes to drill boreholes into and along a coal seam about 340 m below ground level and inject a mixture of heated air, steam and oxygen, which will cause the coal to smoulder and produce a mixture of combustible gases by chemical reactions between carbon, oxygen and water. The gas mixture will be piped to the surface and used to generate about 55 Mwe of electrical power by means of gas engines. The ash will remain underground.

The Project includes five Alternatives for the power line, but one for the mining and power plant (see google.earth image):
Alternative 1 (Route 1): Red. Northern farms.
Alternative 2 (Route 2): Blue. Northern farms.
Alternative 3 (Route 3): Purple. Southern farms.
Alternative 4 (Route 4): Green. Southern farms.
Alternative 5 (Route 5): Black. Southern farms.
The power plant and ancillaries will have a footprint of about 3 hectares and will be connected to the national grid *via* a ±13 km power line.

Legal Requirements:-

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

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

"palaeontological" means any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or traces.

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

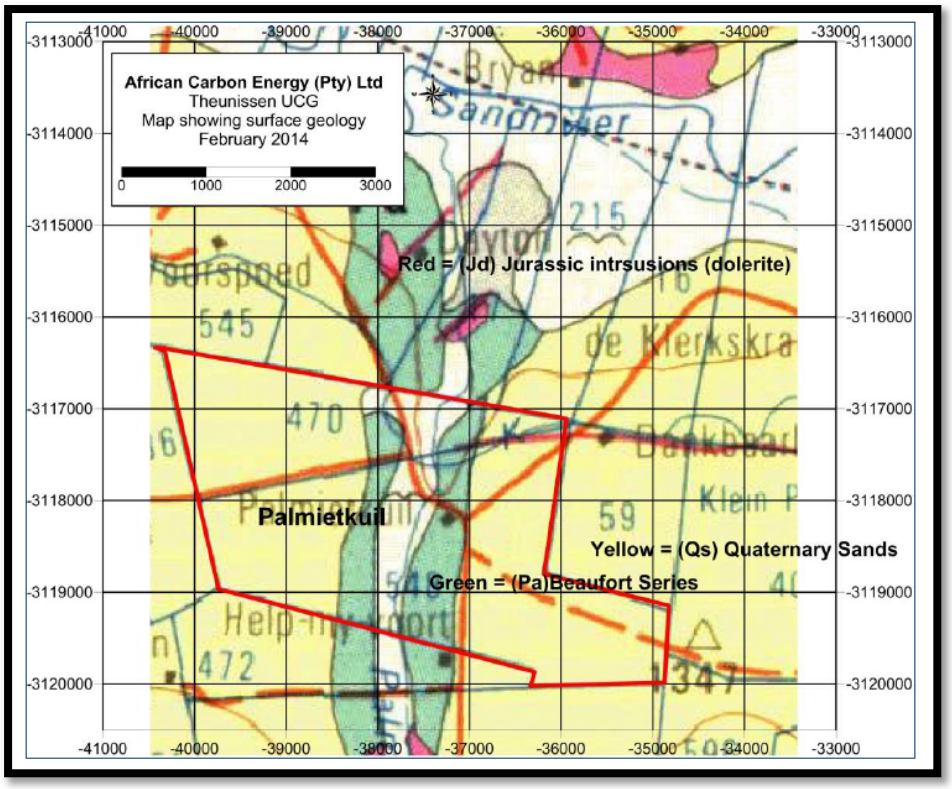
A Palaeontological Impact Assessment is generally warranted where rock units of LOW to VERY HIGH palaeontological sensitivity are concerned, levels of bedrock exposure within the study area are adequate; large scale projects with high potential heritage impact are planned; and where the distribution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

Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No.25 of 1999):
(i) (i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens.
This report adheres to the guidelines of Section 38 (1) of the National Heritage Resources Act (Act No. 25 of 1999).
Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as (a) the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length; (b) the construction of a bridge or similar structure exceeding 50 m in length; (c) any development or other activity which will change the character of a site (see Section 38); (d) the re-zoning of a site exceeding 10 000 m² in extent; (e) or any other category of development provided for in regulations by SAHRA or a PHRA authority.

This report aims 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). Geological Map 2826 Winburg, 1:250 000 (Visser and Nolte 1998).

Figure 3: The geology of the development area.



Legend to Map and short explanation.

m – (white). Quaternary.

Qs – Aeolian sand, alluvium, colluvium, spring tufa, lake deposits (yellow). Quaternary sands.

Jd - Karoo Dolerite (pink). Early Jurassic.

Pa – Mudstone, sandstone (green) Adelaide Subgroup, Beaufort Group, Karoo Supergroup. Permian.

□ – Development (in red on the Figure).

Mining Activities

Au - Gold. Has no influence on this type of power generation.

Summary of findings: The Palaeontological Impact Assessment: Phase 1: Field Study was undertaken in July 2017 in the winter in dry and mild conditions (Appendix 6 of Act, 1(d)), and the following is reported:

The development is taking place on the Normandien Formation, Adelaide Subgroup of the Karoo Supergroup (plant and substation), the gas will be tapped from the Vryheid Formation and the power lines will be constructed over the Adelaide Subgroup and Quaternary.

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

The Tarkastad Subgroup is Early Triassic in age and conformably overlies the Adelaide Subgroup. Sandstone predominates and 'red' mudstone is more abundant above the contact of the two subgroups. The main Karoo

basin is divided into eight Biozones called Assemblage Zones characterised by specific groups of fossils. This development lies on the *Dicynodon* Assemblage Zone (now known as the *Daptocephalus* Assemblage Zone).

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).

The Gordonia Formation (Qs), Kalahari Group consists of wind-blown sand, red in colour with alluvium, collovium, spring tufa (calcareous) and sinter (siliceous), lake deposits, peats, pedocretes or duricrusts (calcrete, ferricrete), soils and gravel also present. The sand can vary from fairly thick to very thin covering the Beaufort Group rocks and dolerite (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 sedimentary rocks the palaeontological sensitivity can generally be LOW to VERY HIGH, and here locally VERY HIGH for the Adelaide Subgroup and the Vryheid Formation and MODERATE for the Quaternary (SG 2.2 SAHRA APMHOB, 2012).

Recommendation:
The impact of the development on fossil heritage is VERY HIGH and MODERATE and therefore a field survey or further mitigation or conservation measures were necessary for this development (according to SAHRA protocol). A Phase 1 Palaeontological Impact Assessment and or mitigation were done. The walk through did not locate any fossils.

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

Rock Unit	Significance/vulnerability	Recommended Action
Quaternary	Moderate	Desktop study required and based on the outcome, a field assessment is likely
Adelaide Subgroup	Very High	Field assessment and protocol for finds is required

- The site has previously been used for agriculture and there are existing buildings.
- Outcrops of the Normandien Formation will be scarce. Outcrops of alluvium in the riverbed will not be disturbed due to the 1:100 and 1: 50 year flood lines, as the plant will not be constructed near the river, but rather on the hill, and these are protected by the EMPr.
- As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to oversee the construction activities in line with legally binding Environmental Management Programme (EMPr).The EMPr already covers the conservation of heritage and palaeontological artefacts that may be exposed during construction activities. The protocol is to immediately cease all construction activities if a fossil is unearthed and contact SAHRA for further investigation. It is recommended that the EMPr be updated to include the involvement of a palaeontologist during the digging and excavation phase of the development. A palaeontologist should be employed to visit the site once a month during construction of the plant.
- The borehole and underground mining will have a MODERATE to LOW Sensitivity (Groenewald 2016).
- The EAP as well as the ECO must be made aware of the fact that sediments of the Normandien Formation are well-known for the very high content of significant plant and vertebrate fossils.

- It is necessary to provide a clear explanation of the drilling procedures and the methods that will be used to prevent hydrocarbons and associated gas from the drilling from entering the linear aquifers and polluting them or to avoid the creation of conduits through which deep-seated groundwater could migrate to shallow aquifers. The information must be disseminated to the South African Heritage community as well as to all affected communities.

The Project includes five Alternatives for the power line, but one for the mining and power plant (see google.earth image):
Alternative 1 (Route 1): Red. Northern farms.
Alternative 2 (Route 2): Blue. Northern farms.
Alternative 3 (Route 3): Purple. Southern farms.
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Alternative 5 (Route 5): Black. Southern farms.
The power plant and ancillaries will have a footprint of about 3 hectares and will be connected to the national grid *via* a ±13 km power line.

Concerns/threats (1g,1ni,1nii,1o,1p) to form part of the EMPr:

1. Threats are earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction, digging of foundations, the sealing-in, disturbance, damage or destruction of the fossils by development, vehicle traffic, mining activities and human disturbance.
2. The overburden and inter-burden must always be surveyed by the ECO for fossils during construction. Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden during construction not to intrude fossiliferous layers.
3. Mitigation may be needed if a fossil is found, in this case, the area must be fenced off and a palaeontologist / archaeozoologist must be called to excavate (Appendix 3).
4. No consultation with parties was necessary.
5. Alternatives are showed. The mine plant has one Alternative.
6. The walk through did not find fossils as the area is covered with lush vegetation. Once vegetation is cleared outcrops will be more visible.

Stakeholders: Developer – Africary Holdings (Pty) Ltd, Mr E. Roberg, P.O. Box 10020, Secunda, 2302. Tel: 086 651 5138.
Environmental – Golder Associates (Pty) Ltd, P.O. Box 6001, Halfway House, 1685.
Landowner – Agricary Farming (Pty) Ltd, P.O. Box 10020, Secunda, 2302.

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 2).

Outline of development

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

The applicant, Africary Holdings (Pty) Ltd, proposes to drill boreholes into and along a coal seam about 340 m below ground level and inject a mixture of heated air, steam and oxygen, which will cause the coal to smoulder and produce a mixture of combustible gases by chemical reactions between carbon, oxygen and water. The gas mixture of carbon monoxide (CO), hydrogen (H2), methane (CH4) and a small percentage of hydrocarbons will be piped to the surface and used to generate about 55 Mwe of electrical power by means of gas engines. The ash will remain underground (Appendix 4).

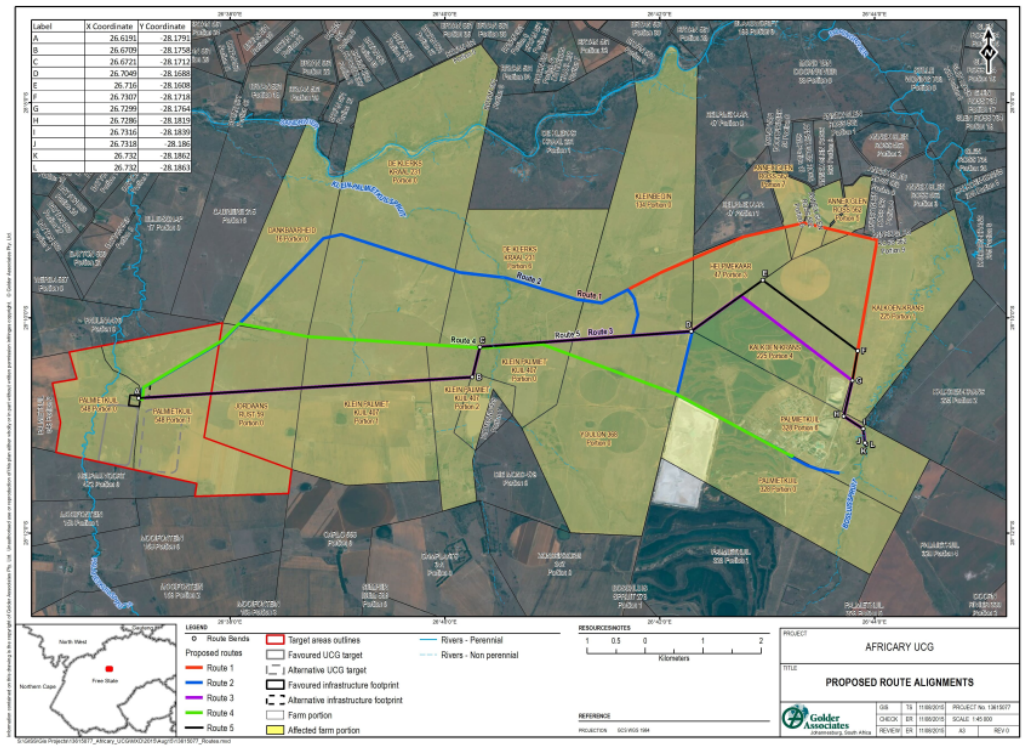
The power plant and ancillaries will have a footprint of about 3 hectares and will be connected to the national grid via a ±13 km power line. The project area is flat and the rest of the topography slopes towards the small non-perennial stream (Palmiet spruit). The electrical power will be fed into the national grid *via* a ±20 km long 132 kV transmission line. Water will be piped to the site from either Sedibeng Water or one of the gold mines.

a) UCG is a much more environmentally friendly way of utilising coal and generating power than coal mining and burning it in conventional power plants; and
b) UCG operates on coal that cannot be mined economically. It has the potential to double the country's energy reserves.

The following infrastructure is anticipated:

1. Access road,
2. Power plant,
3. Gas cleaning plant,
4. Air separation unit,
5. Workshop,
6. Offices and ablution facilities,
7. Sewage, storm water drainage
8. Pollution control dam,
9. Power lines (5 Routes).
10. ESKOM yard (substation)

Figure 1: Showing Farms that will be crossed by electricity lines (Golder Associates).



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Boreholes are already drilled as deep as the underlying Dwyka Tillite, these cores were destroyed by crushing the coal to analyse its chemical content.

Rezoning/ and or subdivision of land: No. It will remain Agriculture.
Name of Developer and Environmental Consultant: Africary Holdings (Pty) Ltd and Golder Associates (Pty) Ltd.
Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a palaeontological impact assessment to ascertain if any palaeontological sensitive material is present in the development area. This study will advise on the impact on fossil heritage mitigation or conservation necessary, if any.
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, Limpopo, Mpumalanga, Gauteng and Free State Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 23 years.

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

E. Description of property or affected environment

Location and depth:

The Proposed African Carbon Energy Ltd. Underground Coal Gasification and Power Generation Project near Theunissen will be situated on the Farm Palmietkuil 548 with services crossing the Farms of Palmietkuil 548, Jordaansrust 59, Klein Palmietkuil 407, Youlon 368, DeKlerkskraal 231, Kleinbegin 134, Helpmekaar 47, Kalkoenrand 225 and Palmietkuil 328 in the Matjhabeng Local Municipality, Lejweleputswa District Municipality, with related infrastructure in the Free State Province. The total size of the site is 3 hectares and Palmietkuil 548 is located 26 km north-west of Theunissen in the Free State Province.

Depth is determined by the related infrastructure such as foundations, trenches, footings and channels. The presence of numerous dolerite sills and dykes makes it difficult to determine the thickness of the *Daptocephalus* Assemblage Zone, but in the Graaff-Reinet and Murraysburg districts this zone reaches a maximum thickness of approximately 500 m. (Rubidge 1995). The Vryheid Formation consists of a 50 – 90 m thick package of white to grey fine-grained sandstones interlaminated with shale bands. The depth of the coal reserves is at 250 – 550 m below the surface.

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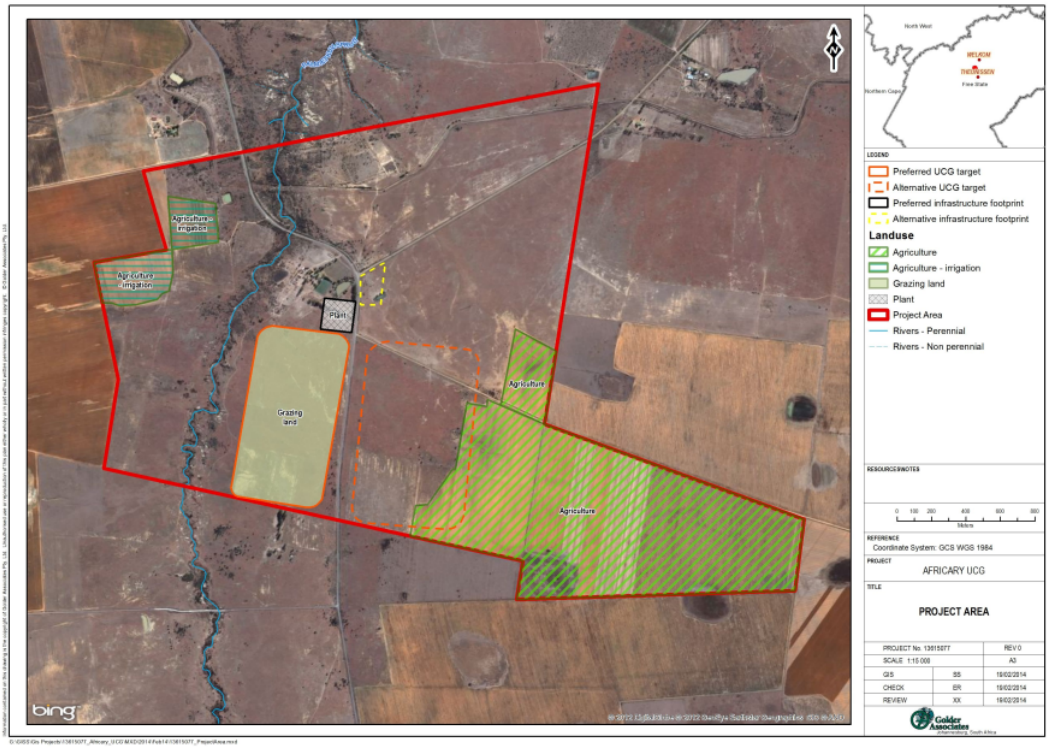
The power plant and ancillaries will have a footprint of about 3 hectares and will be connected to the national grid *via* a ±13 km power line.

The site is underlain by the Karoo Supergroup.

Figure 2: Google.earth image showing where underground mining will take place (Golder Associates).



F. Description of the Geological Setting

Description of the rock units:

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

The southern part of the Karoo basin is 3000 m thick, but the northern part of the basin is much thinner. The animals present during Beaufort times flourished on the floodplanes, lakes and marshes. Sandstone is deposited in times of flooding in the river channels and the mudstones were deposited on the floodplains in the shallow lakes. The Katberg Formation (T-Rt) is a sandstone body, 1000 m in thickness (Snyman 1996).

The Beaufort Group consists of greenish-grey, bluish-grey or red mudstones. Sandstones are often cross-bedded. Deposition is mainly terrestrial, river-dominated. Two subgroups are distinguished, the upper Tarkastad- and the lower Adelaide Subgroups. The Tarkastad Subgroup possesses a greater abundance of both sandstone and red mudstone. The base of the Katberg Formation divides the two subgroups (Kent 1980). The Tarkastad Subgroup is not present in the study area.

The Tarkastad Subgroup is Early Triassic in age and conformably overlies the Adelaide Subgroup. Sandstone predominates and 'red' mudstone is more abundant above the contact of the two subgroups. In the northern Free State the Tarkastad Subgroup is divided into the Driekoppen Formation and the Verkykerskop Formation (Rubidge 1995).

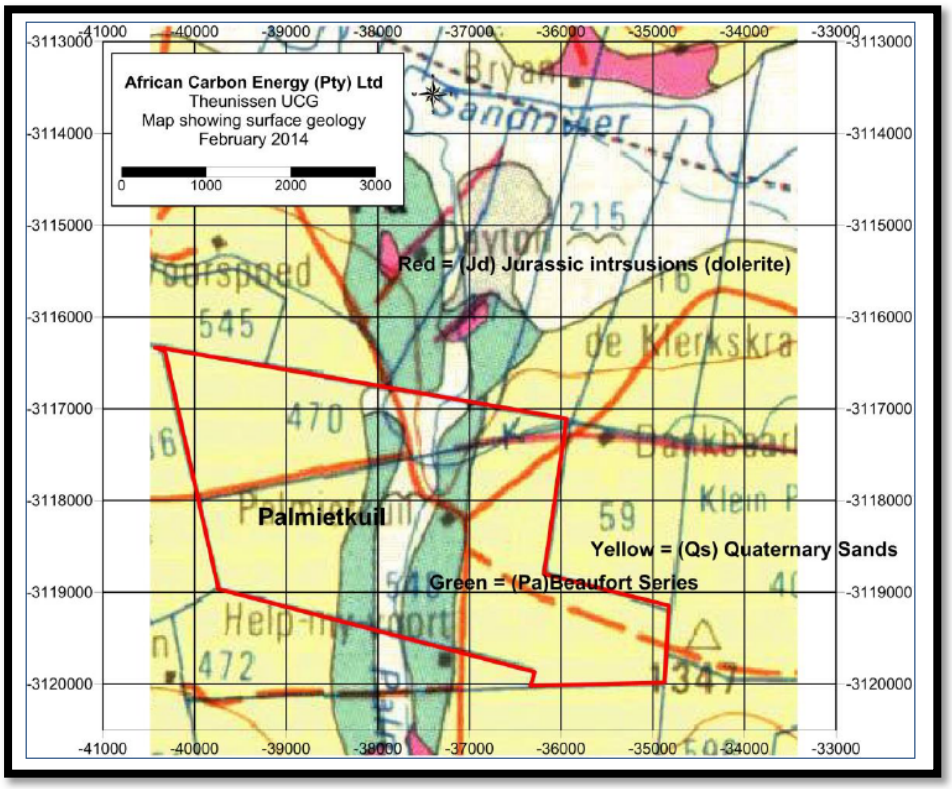
The Adelaide Subgroup is divided into the Normandien Formation and Volksrust Formation. The Normandien Formation has several Members, namely the Harrismith at the top, Schoondraai, Rooinekke, and Frankfort at the

base. As the study area is part of the Normandien Formation it will be part of the *Daptocephalus* Assemblage Zone (Rubidge 1995).

In the south the *Daptocephalus* Assemblage Zone rocks consist of bluish-grey and grey-green mudrocks, interbedded in places with siltstone lenses. Purple / red mudrocks are less abundant than in the underlying and overlying strata. Sandstone is of varying thicknesses. A major facies change occurs in the central and northeastern Free State. Here the mudrocks are dull grey-green to bluish-green in colour. It overlies the *Cistecephalus* Assemblage Zone and underlies the *Lystrosaurus* Assemblage zone (Rubidge 1995).

Jurassic dolerite (Jd) is abundant. Dolerite is an igneous rock and therefore does not contain fossils. Dish-shaped dolerite structures are especially prominent (Cole *et al.* 2004).

Figure 3: The geology of the development area (Visser 1984).



Legend to Map and short explanation.
m - (white). Quaternary.
Qs – Aeolian sand, alluvium, collovium, spring tufa, lake deposits (yellow) Quaternary sands.
Jd - Karoo Dolerite (pink) Early Jurassic.
Pa – Mudstone, sandstone (green) Adelaide Subgroup, Beaufort Group, Karoo Supergroup. Permian.

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).

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).

Over areas totalling fully 40% of Southern Africa the 'hard rocks', from the oldest to the Quaternary, are concealed by normally unconformable deposits – principally sand, gravel, sandstone, and limestone. Inland deposits are much more extensive than marine deposits and are terrestrial and usually unfossiliferous. Some of these deposits date back well into the Tertiary, whereas others are still accumulating. Owing to the all-to-often lack of fossils and of rocks suitable for radiometric or palaeomagnetic dating, no clear-cut dividing line between the Tertiary and Quaternary successions could be established (Kent 1980). The alluvium sands were deposited by a river system and reworked by wind action (Snyman 1996). Groenewald and Groenewald (2014) listed these as rarely containing fossils.

The Gordonia Formation (Qs), Kalahari Group consists of wind-blown sand, red in colour with alluvium, collovium, spring tufa (calcareous) and sinter (siliceous), lake deposits, peats, pedocretes or duricrusts (calcrete, ferricrete), soils and gravel also present. The sand can vary from fairly thick to very thin covering the Beaufort Group rocks and dolerite (Groenewald and Groenewald 2014).

Field Observation.

This property is large, quite overgrown with lush vegetation and has a slight undulating topography. The presence of buildings and lush grass make it difficult to observe outcrops. Quaternary deposits are present in the Sand River to the north of the development, the Heritage Impact assessment should cover this and if animal remains were found an archaeozoologist should have been called in to assess if the archaeologist felt it was necessary, this study covers the development of the plant and substation which will be situated on the shallow sandstone of the Adelaide subgroup. Once the vegetation is cleared outcrops will be more visible.

Figure 4: Figure to show view over the area where the new ESKOM Substation will be situated.

Figure 5: Trench that shows shallow sandstone layer.

Figure 6: Further up the hill, overview of where Plant will be constructed.

Figure 7: Photograph to show how overgrown the site is at present.

The Project includes five Alternatives for the power line, but one for the mining and power plant (see google.earth image):
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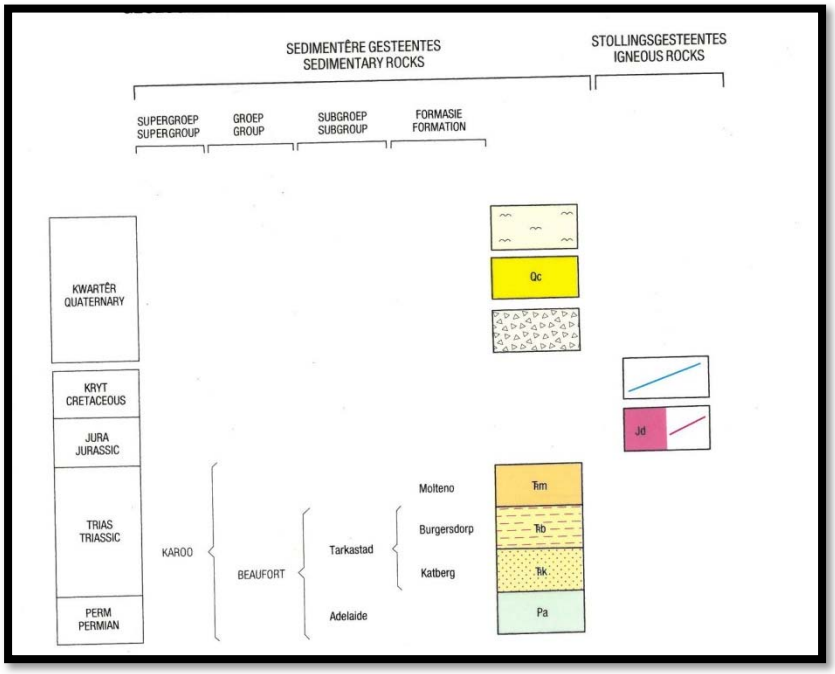
The power plant and ancillaries will have a footprint of about 3 hectares and will be connected to the national grid *via* a ±13 km power line.

The borehole and underground mining will have a MODERATE to LOW Sensitivity. It is assumed that fossil remains are not uniformly distributed in fossil bearing rock units. The affected Formation will be the coal of the Vryheid Formation which is of a VERY HIGH Sensitivity. The power lines will be constructed over the VERY HIGH Adelaide Subgroup and MODERATE Quaternary.

Figure 8: Lithostratigraphic column of the geology of the site (3124 Middelburg).



It is recommended to wait for the response from SAHRA on the (this report) Phase 1: Field study. All the Alternatives for the power line will be partly over the Adelaide Subgroup and the Quaternary.

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).

Refer to Heritage Impact Assessment for Quaternary archaeological sites nearby. Groenewald and Groenewald (2014) described these as alluvial deposits associated with recent water courses of main rivers and streams. These sediments are presently not well studied and records of fossil occurrences are mainly associated with archaeological reports. The floodplains are protected by the 1:100 and 1:50 year flood lines that cannot be intruded during construction, except for overhead power lines.

Fossils in the Gordonia Formation will be present in caves, calc tufa and pans and examples are a wide range of mammalian bones and teeth (rhino, bovids, horses), tortoise remains, ostrich egg, non-marine mollusc shells, ostracods, diatoms, other micro fossils, trace fossils, stromatolites, plant remains and wood (Groenewald and Groenewald 2014). Early Homo occurs in the more Recent Alluvium.

Map 1: Biostratigraphic map of the Karoo Supergroup.

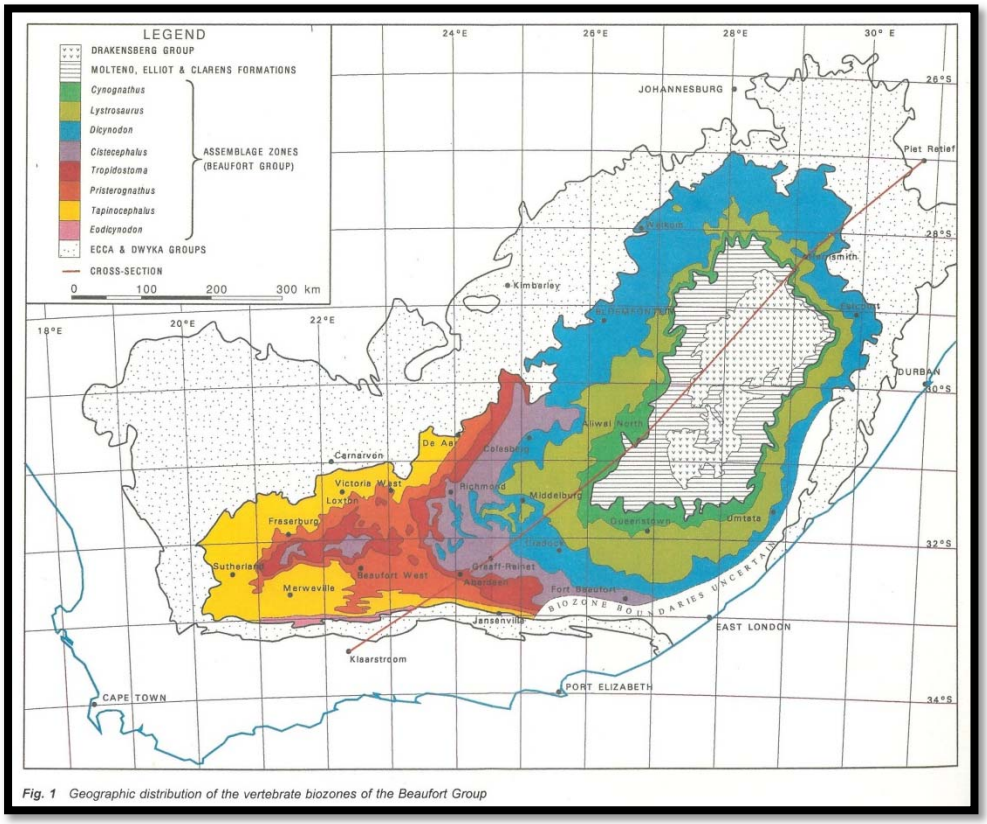


Fig. 1 Geographic distribution of the vertebrate biozones of the Beaufort Group

The *Daptocephalus* Assemblage Zone overlies the *Cistecephalus* Assemblage zone and underlies the *Lystrosaurus* Assemblage Zone. In the northern and northeastern Free State rocks belonging to this biozone are assigned to the Normandien Formation. The name is derived from a fairly common dicynodont genus *Daptocephalus* and also the presence of *Theriognathus* (Rubidge 1995).

Well preserved fossils of therapsids occur in mudrock horizons, and are usually found as dispersed, isolated specimens associated with an abundance of calcareous nodules. Fossil remains are commonly enclosed in some of these nodules; those which are not enclosed in these nodules are invariably badly distorted and fractured. Many exposures of this zone were metamorphosed by intrusions of dolerite dykes and sills causing changes in the colour and texture of the rocks as well as in the enclosed fossils. Particularly productive localities are areas of high relief such as on the slopes of the Onder Sneeuberg, the Sneeuberg Range, Koueveld, Agter Rhenosterberg and adjoining regions in the Middelburg-Graaff-Reinet area (Rubidge 1995).

Fossils common to the *Daptocephalus* Assemblage zone are *Atherstonia* fish, amphibia such as *Rhinesuchus*, reptilia such as *Anthodon, Milleretta, Owenetta, Pareiasaurus* and the Eosuchid *Youngina*, Therapsids such as *Aulacephalodon, Dicynodon sp., Diictodon sp., Dinanomodon, Emydops, Oudenodon, Palemydops, Pristerodon, Burnetia,* and *Cyonosaurus, Dinogorgon, Lycaenops, Prorubidgea, Rubidgea* gorgonopsia and the therocephalia *Akidognathus, Cerdops, Ictidosuchoides, Moschorhinus, Tetracynodon, Theriognathus* and *Cynosaurus, Nanictosaurus, Procynosuchus (*cynodonts) are present. It is not uncommon to find invertebrates, plant fossils and trace fossils.

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

Subgroup/ sequence	Group	Formation	Fossil Heritage	Comment
Quaternary sands	Kalahari	Gordonia	Often sparse in fossils. Mammal bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc, microfossils, plant remains, and stromatolites.	Not well studied.
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
Adelaide	Beaufort	Normandien	Terrestrial and freshwater tetrapods, invertebrates, plants, fish and trace fossils.	Pangaea fauna, mammalian evolution, late Permian mass extinction.

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).

A wealth of fossils is recorded from the Vryheid Formation, including rich fossil plant assemblages of the Permian *Glossopteris* Flora. Abundant, low diversity trace fossils, rare insects, possible conchostracans, non-marine bivalves and fish scales have also been reported (Groenewald and Groenewald). 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).

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.

Other fossil localities in the area are Senekal, Kroonstad and Winburg. These localities have yielded fossils such as Therapsids (*Daptocephalus, Zorillodontops,* dicynodonts) (Kitching 1977). Groenewald (2016) lists a site close to Theunissen known as the Virginia Railway Cutting Site (Matjhabeng Site) where quaternary fossils are found.

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 sedimentary rock strata the palaeontological sensitivity is generally LOW to VERY HIGH, but here locally VERY HIGH for the Adelaide Subgroup and Vryheid Formation, Karoo Supergroup and MODERATE for the Quaternary.

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

Rock Unit	Significance/vulnerability	Recommended Action
Adelaide Subgroup	Very High	Field assessment and protocol for finds is required
Vryheid Formation	Very High	Field assessment and protocol for finds is required
Quaternary	Moderate	Desktop study required and based on the outcome, a field study is likely

Databases and collections: Ditsong: National Museum of Natural History.
Impact: VERY HIGH for the Adelaide Subgroup, Beaufort Group and Vryheid Formation, Ecca Group, Karoo Supergroup and MODERATE for the Quaternary. There are significant fossil resources that may be impacted by the development and if destroyed are no longer available for scientific research or other public good.

H. Description of the Methodology (1e)

The palaeontological impact assessment field study was undertaken in July of 2017. A literature survey is included and the study relied on literature, geological maps, google.maps and google.earth images. The walk through of the affected portion was done and photographs (in 20 mega pixels) were taken of the site with a digital Canon camera (Power Shot SX620HS). It was not necessary to use a Global Positioning System (GPS) (Garmin eTrex 10) to records outcrops where not covered with topsoil, subsoil, overburden, and vegetation.

Assumptions and Limitations (Appendix 6 of Act 1i):-
The accuracy and reliability of the report may be limited by the following constraints:

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

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

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

A Phase 2 Palaeontological Impact Assessment: Mitigation will include:

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

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

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

No person may damage, deface, excavate, alter, remove from its original position, subdivide or change the planning status of a provincially protected place or object without a permit issued by a heritage resources authority or local authority responsible for the provincial protection.
Archaeology, palaeontology and meteorites: Section 35.
(2) Subject to the provisions of subsection (8) (a), all archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

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

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

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

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

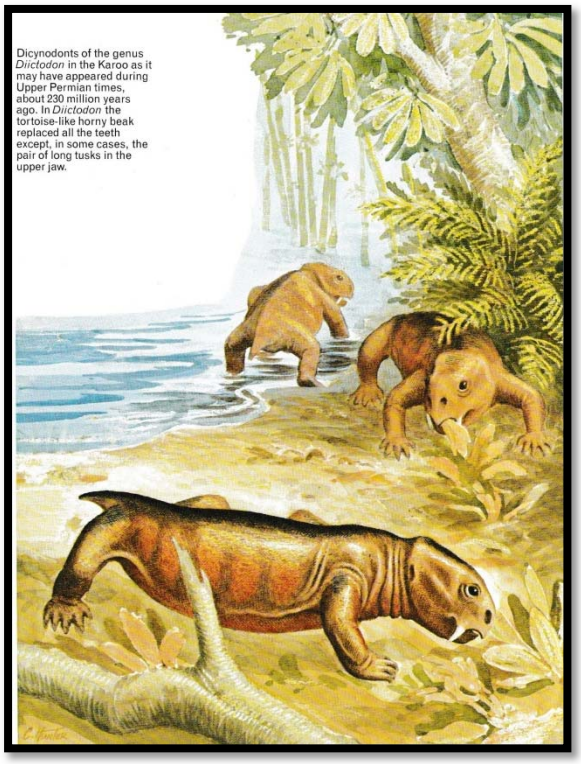
authorities, can minimise the impact of palaeontological surveys on development projects by selecting options that cause the least amount of inconvenience and delay.

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

I. Description of significant fossil occurrences (1f)

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

Figure 9: Typical Karoo scenes during the Late Permian (Cluver 1978).



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

The physical impact of the project on the palaeontological heritage will be restricted to the structures erected and to the actual areas where drilling will take place, the total impact on the National Heritage in terms of geological formations that provide unique aquifer rock units to the entire study area will be dramatic and irreversible. The Very High Sensitivity of the Adelaide Subgroup as well as the groundwater aquifer zones is retained. The groundwater specialist will have to determine sites where the impact of the pollution of groundwater aquifers with Petroleum Hydrocarbons as a gas, oil and other concentrates can be controlled to some extent (Groenewald 2016).

J. Recommendation (1j,1l)

a. There is no objection (see Recommendation B) to the development, and it is not necessary to request a Phase 2 Palaeontological Impact Assessment: Mitigation to determine whether the development will affect fossiliferous outcrops. The palaeontological sensitivity is VERY HIGH and MODERATE so caution is recommended. A Phase 2 Palaeontological Mitigation will be required if a fossil is found by the ECO during construction. Fossils were not

found during the walk through. A palaeontologist should be employed to visit the site once a month during construction of the plant and power line.
b. This project may benefit the economy, the growth of the community, and social development in general.
c. Preferred choice: All Alternatives are possible. Care must be taken during the grading of roads, digging of foundations, drilling, and removing topsoil, subsoil and overburden (see Executive Summary) or blasting of bedrock.
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 (see Recommendation in Section B).

Sampling and collecting (1m,1k):
Wherefore a permit is needed from the South African Heritage Resources Agency (SAHRA / PHRA).

a. Objections: Cautious. See heritage value and recommendation.
b. Conditions of development: See Recommendation.
c. Areas that may need a permit: Yes, if a fossil is found (Section G).
d. Permits for mitigation: Needed from SAHRA/PHRA.

K. Conclusions

a. All the land involved in the development was assessed and none of the property is unsuitable for development (see Recommendation B).
b. All information needed for the Field Study was provided by the Environmental Consultant.
c. Areas that would involve mitigation and may need a permit from the South African Heritage Resources Agency are discussed (see Recommendation B).
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 on 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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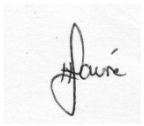
Declaration / Disclaimer (1b)

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

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

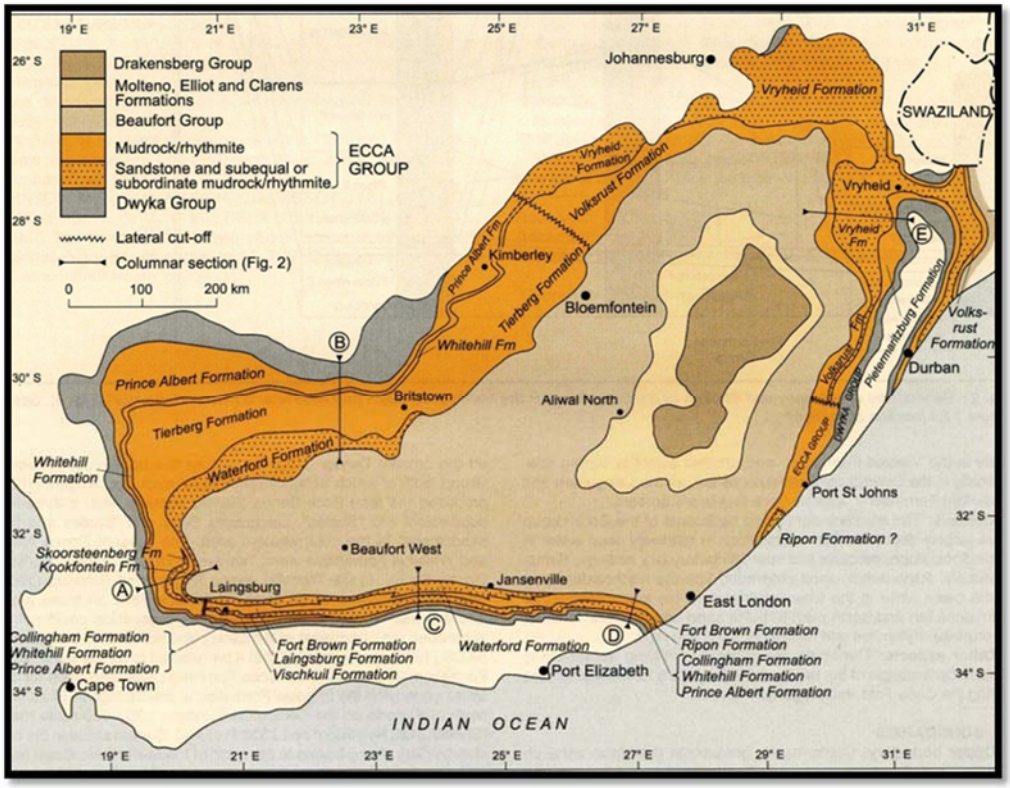
It may be possible that the field study may have missed palaeontological resources in the Project Area as the presence of outcrops are not known and may only be found once development commences.

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



Heidi Fourie
2017/08/09

Appendix 1: Geology of the Karoo Supergroup (Johnson 2009).



Appendix 2:

Table 3: Listing points in Appendix 6 of the Act and position in Report.

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 1	1(k)	Protocol for finds
	1(m)	"
	1(q)	"

Appendix 3: 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 / ECO on site and should not be attempted by the layman / developer. The developer needs to employ an Environmental Control

Officer (ECO) to oversee the construction activities so that when a fossil is unearthed they can notify the relevant department and specialist to further investigate. This ECO should familiarise him- or herself with the applicable formations and its fossils. Miners or construction workers should be informed that fenced-off areas are no-go areas. The Evolutionary Studies Institute, University of the Witwatersrand has good examples of fossils.

As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to oversee the construction activities in line with legally binding Environmental Management Programme (EMPr). The EMPr already covers the conservation of heritage and palaeontological artefacts that may be exposed during construction activities. The protocol is to immediately cease all construction activities and contact SAHRA for further investigation. It is recommended that the EMPr be updated to include the involvement of a palaeontologist during the digging and excavation phase of the development. A palaeontologist should be employed once a month during the construction phase of the Plant to inspect the site.

The developer must survey the areas affected by the development and indicate on plan where the construction / development / mining will take place. Trenches have to be dug to ascertain how deep the sediments are above the bedrock (can be a few hundred metres). This will give an indication of the depth of the topsoil, subsoil, and overburden, if need be trenches should be dug deeper to expose the interburden.

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

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

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

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

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

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

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

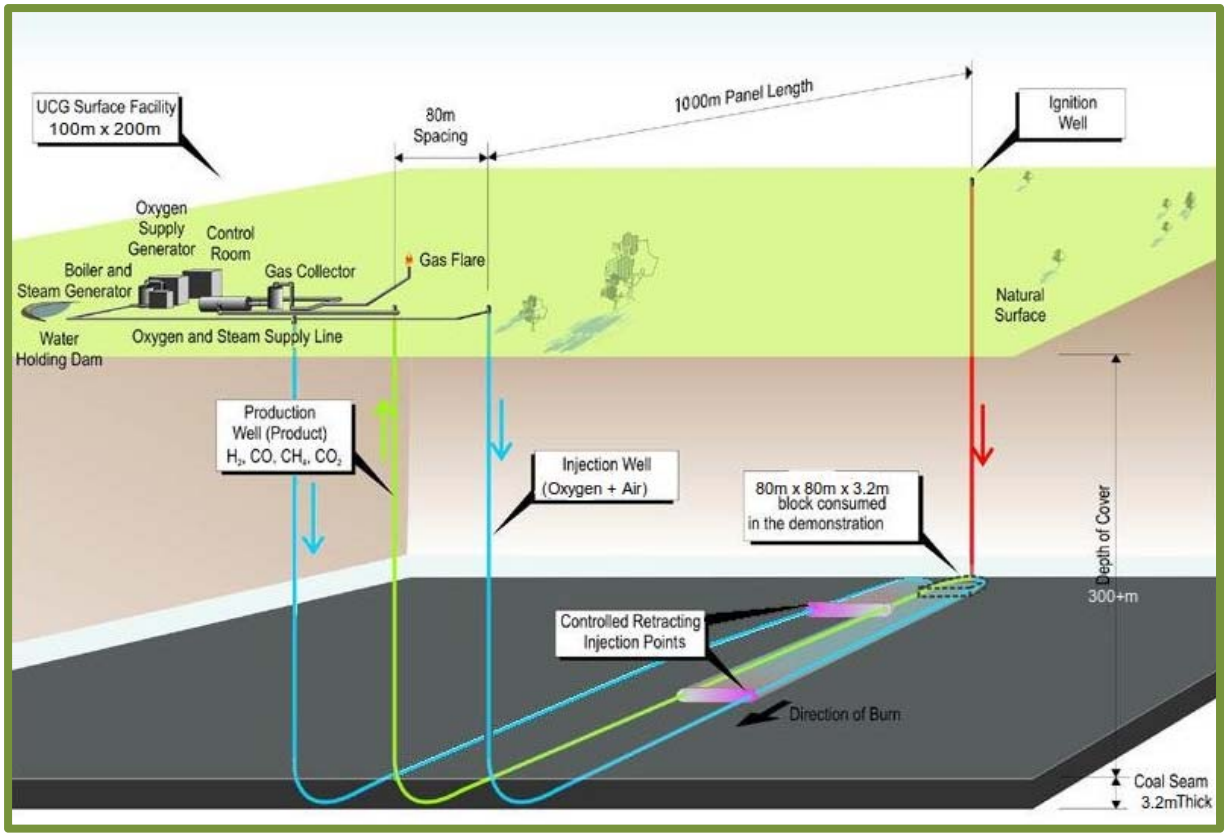
1. The developer needs to clearly stake or peg-out (survey) the areas affected by the mining/ construction/ development operations and dig representative trenches and if possible supply geological borehole data.
2. Fossils likely to occur are; see Report, or any other fossiliferous layer ranked as VERY HIGH or HIGH.
3. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work. The area needs to be fenced off.
4. A Palaeobotanist / palaeontologist (contact SAHRIS for list) / ECO 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 / ECO 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 / ECO must do an investigation (a minimum of once a week).
8. At this stage the palaeontologist / palaeobotanist / ECO 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 Documents:
Guidelines to Palaeontological Permitting policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.
Palaeotechnical Reports for all the Provinces.

Appendix 4: Schematic illustration of a UCG Project.


UCG Surface Facility
100m x 200m
80m
Spacing
1000m Panel Length
Ignition
Well
Oxygen
Supply
Generator
Control
Room
Boiler and
Steam Generator
Gas Collector
Gas Flare
Natural
Surface
Water
Holding Dam
Oxygen and Steam Supply Line
Production
Well (Product)
H_2, CO, CH_4, CO_2
Injection Well
(Oxygen + Air)
80m x 80m x 3.2m
block consumed
in the demonstration
Depth of Cover
300+m
Controlled Retracting
Injection Points
Direction of Burn
Coal Seam
3.2mThick