Proposed development of the Maluti-A-Phofung Landfill Site

Thabo Mofutsanyana District Municipality, Maluti-A-Phofung Local Municipality, Free State Province

Farm: Portion 110 Witsieshoek 1903

Fourie, H. Dr heidicindy@yahoo.com

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Palaeontological Impact Assessment: Phase 1 Field study

Facilitated by: Tholoana

First Floor Building 5, Fancourt Office Park, Northriding, 2169

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2015/07/27

Ref: WML/EIA/10/2014

B. Executive summary

Outline of the development project: Tholoana has facilitated the appointed of Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA), Phase 1 Field study of the suitability of the proposed establishment of a landfill site near the township of Phuthaditjaba on Portion 110 of the Farm Witsieshoek 1903, Thabo Mofutsanyana District Municipality, Maluti-A-Phofung Local Municipality, Free State Province.

The applicants, Maluti-A-Phofung and the Local Municipality, propose to develop a landfill site to service the following three areas, Harrismith, Kestel, and Phuthaditjaba with recycling, compost and inert waste disposal facilities.

The Project includes one Option (see map):
Option 1: An area outlined in red of approximately 20 ha next to the township of Matsikeng, east of Phuthaditjaba on the Makwane Road and just off the S20 on a hill in QwaQwa.

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

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

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

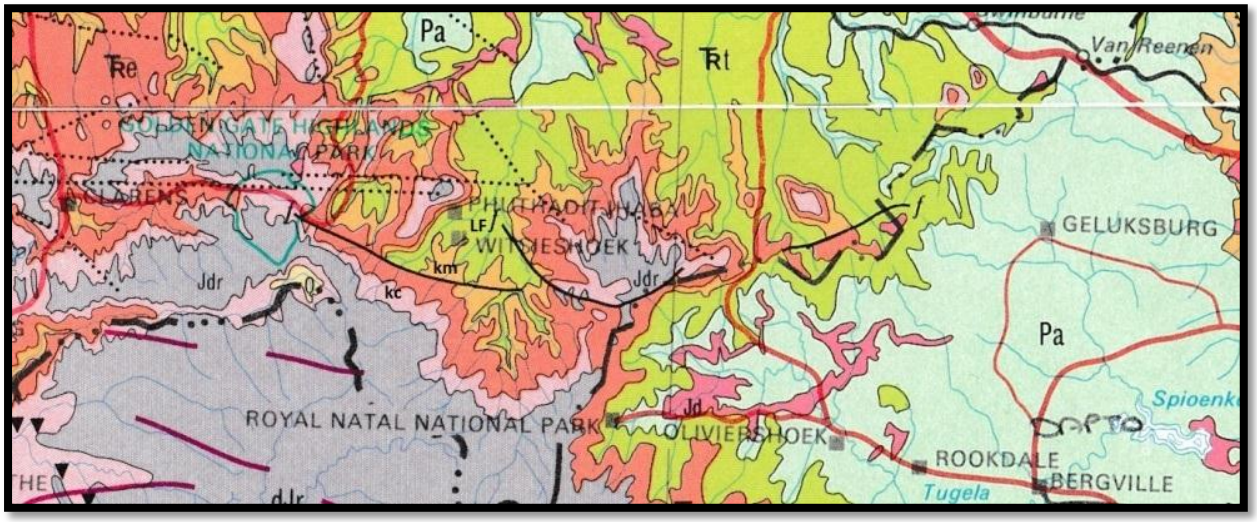
A Palaeontological Impact Assessment is generally warranted where rock units of LOW to VERY HIGH palaeontological sensitivity are concerned, levels of bedrock exposure within the study area are adequate; large scale projects with high potential heritage impact are planned; and where the distribution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

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

This report aims to provide comment and recommendations on the potential impacts that the proposed development could have on the fossil heritage of the area and to state if any mitigation or conservation measures are necessary.

Outline of the geology and the palaeontology:
The geology was obtained from map 1:100 000, Geology of the Republic of South Africa (Visser 1984).

Figure 1: The geology of the development area.



Legend to Map and short explanation.
Jdr – (purple) Basalt. Drakensberg Group, Karoo Supergroup.
Kc – (pienk) Sandstone, siltstone. Clarens Formation, Karoo Supergroup.
Ke – (orange) Mudstone, sandstone. Elliot Formation, Karoo Supergroup.
Km – (light orange) Sandstone, mudstone, shale. Molteno Formation, Karoo Supergroup.
Kt – (green) Mudstone, sandstone. Tarkastad Subgroup, Beaufort Group, Karoo Supergroup.
…… – (black) Lineament (Possible dyke).
--f— Fault.
LF – Approximate position of Landfill site.

Mining Activities:
None.

Summary of findings: The Phase 1 Palaeontological Impact Assessment Field study was undertaken in July in the winter in dry and cold conditions and the following is reported:

Formations present are part of the Karoo Supergroup. The Karoo Supergroup is renowned for its fossil wealth. (Kent 1980, Visser 1989) (Figure 1). 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. The Elliot Formation is also known as the Red Beds and the old Cave Sandstone is known as the Clarens Formation. At the top is the Drakensberg Basalt Formation with its pillow lavas, pyroclasts, and basalts. (Kent 1980, Snyman 1996).

The Tarkastad Subgroup of the Beaufort Group consists of a lower predominantly arenaceous Katberg Sandstone Formation and a predominantly upper argillaceous Burgersdorp Formation (Kent 1980, Cole *et al*. 2004). It is Early Triassic in age. Fossils are abundant. The Molteno Formation consists of a collection of quartzitic sandstones and grey shale, also present are basal conglomerate, pebbles, and siltstone. Plant and insect fossils are common with coal beds also present. The Elliot Formation overlies the Molteno Formation and has a maximum thickness of 500 m. It consists of siltstone, mudstone and sandstone. Oxygenation of the iron coloured the sediments red during and after deposition. Reptile, mammal-like reptile, trace fossils, dinosaurs, the earliest known tortoise in Gondwana, small, early mammals, and wood, are plentiful (Snyman 1996, Visser 1998, Norman and Whitfield 2006). The Clarens Formation has a maximum thickness of 250 m in the south and consists of pink and yellow sandstone which is fine and never coarse. Cave and cliff formation is common. Fossils are scarce, but dinosaurs are found with the fish *Semionotus capensis* (Snyman 1996, Visser 1998, Norman and Whitfield 2006).

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 Tarkastad Subgroup (SG 2.2 SAHRA APMHOB, 2012).

Recommendation:
The impact of the development on fossil heritage is **VERY HIGH** and therefore a field survey or further mitigation or conservation measures may be necessary for this development (according to SAHRA protocol). A Phase 2 Palaeontological Impact Assessment and or mitigation may be recommended. The overburden and inter-burden consisting of Karoo rocks must be surveyed for fossiliferous outcrops (mudstone, shale). Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden. Protocol is attached (Appendix 1).

During the survey it was found that the site is directly underlain by siltstone, sandstone, and mudstone of the Karoo Supergroup and is presently underutilised. Recent structures are absent, but there are townships and a road nearby. The site is located on a sloping topography. The development of the landfill site includes several projects that will need foundations, footings, channels and trenches to be dug.

The survey was done in winter, conditions were dry and cold and the area is covered by overburden, vegetation and grassland. There is only one option with a very high impact. The construction of the landfill site will take place on the Karoo Supergroup Formations more specifically the Tarkastad Subgroup known for its wealth of fossils. Large informal settlements are present. Most of the site is directly underlain by the sandstone bank which may be used as a base for the foundations.

The Project includes one Option (see map):
Option 1: An area outlined in red of approximately 20 ha next to the township of Matsikeng, east of Phuthaditjaba on the Makwane Road and just off the S20 on a hill in QwaQwa.

Concerns/threats:

1. Threats are earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction, the sealing-in or destruction of the fossils by development, vehicle traffic and human disturbance.
2. Mitigation is needed (Appendix 1).
3. No consultation with parties was necessary.

Stakeholders: Developer – Maluti-A-Phofung, T. Taetsane, Private Bag X805, Witsieshoek, 9870, 058 718 3700 and Local Municipality.
Environmental – Tholoana, V. Hlatshwayo, First Floor Building 5, Fancourt Office Park, Northriding, 2169, 011 057 1847.
Landowner – Maluti-A-Phofung and Local Municipality.

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

The applicants, Maluti-A-Phofung and Local Municipality intend to establish a landfill site to service three areas, Harrismith, Kestel, and Phuthaditjaba, including the following services,

1. Recycling facility (and a Buy-Back center),
2. Compost facility,
3. Inert waste disposal facility.

The type of waste to be landfilled is general waste; no hazardous waste will be accepted at the landfill site. The proposed waste disposal site is classified as a General (G) Waste Landfill site. As per the design report conducted by All Green Consultants, the size of the landfill site is classified as Large (L). Furthermore there is a potential that the waste disposal site will generate leachate, which classifies the site as a B plus (B+) waste disposal facility. Therefore a leachate management system will be required for this landfill site.

The physical footprint of the proposed landfill site is estimated to be approximately 20 ha (1000 x 720 m). Subdivisions and rezoning processes will be done separately by the applicant. The design report calculates the life span for the landfill site facility to be approximately 20 years.

The following infrastructure is anticipated:

- Perimeter fencing,
- Remote-controlled gate,
- Security guard house and toilet,
- Administration block with ablution facilities, computers and workshop,
- Platform station,
- Recycling facilities and sorting facilities,
- Construction of landfill cells and leachate management system,
- Un-surfaced access road, ring road and storm-water drainage management system.
- Mini-substation.

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Rezoning/ and or subdivision of land: Yes (Agriculture) to Special.
Name of developer and consultant: Maluti-A-Phofung and Local Municipality, and Tholoana.
Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a palaeontological impact assessment: field study to ascertain if any palaeontological sensitive material is present in the development area. This study will advise on the impact on fossil heritage mitigation or conservation necessary, if any.

Dr Fourie obtained a Ph.D from the Bernard Price Institute for Palaeontological Research (now ESI), University of the Witwatersrand. Her undergraduate degree is in Geology and Zoology. She specialises in vertebrate morphology and function concentrating on the Therapsid Therocephalia. For the past nine years she carried out field work in the Eastern Cape, Limpopo, Gauteng and Free State Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 21 years.
Legislative requirements: South African Heritage Resources Agency (SAHRA) for issue of permits if necessary. National Heritage Resources Act (Act No. 25 of 1999). An electronic copy of this report must be supplied to SAHRA.

E. Description of property or affected environment
Location and depth:
A new landfill site located near the township of Phuthaditjaba on Portion 110 of the Farm Witsieshoek 1903, Thabo Mofutsanyana District Municipality, Maluti-A-Phofung Local Municipality, Free State Province.

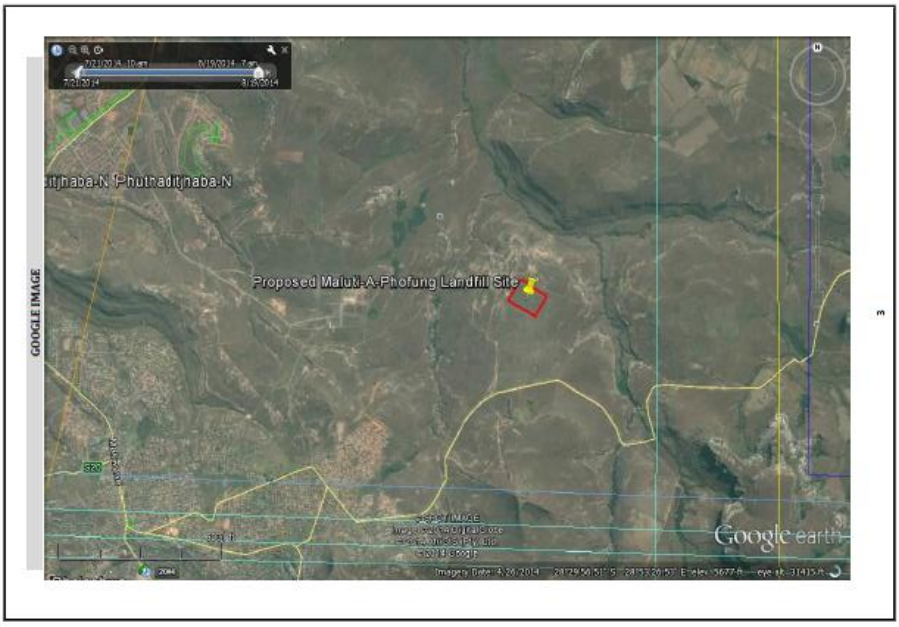
The applicants Maluti-A-Phofung and the Local Municipality, propose to develop a landfill site to service the following three areas, Harrismith, Kestel, and Phuthaditjaba with recycling, compost and inert waste disposal facilities.

The depth of structures is determined by the foundations. The average depth of excavatable cover is 1.8 m. Basin excavation is to a depth of 0.3 m below natural ground level. Buildings are to be founded on strip footing 750 mm wide and 250 mm deep at a depth of 1 m below ground (Design Report).

There are many illegal dumping sites in the Phuthaditjaba area which presents a lot of challenges in terms of water pollution, odours, air pollution and global warming. It was decided to manage solid waste in the area also addressing the unemployment, illegal dumping, environmental degradation, encourage a healthy, clean environment through its awareness program linked to its recycling facilities, and promote principles of sustainable development.

The Project includes one Option (see map):
Option 1: An area outlined in red of approximately 20 ha next to the township of Matsikeng, east of Phuthaditjaba on the Makwane Road and just off the S20 on a hill in QwaQwa.

Figure 2: Google.earth image showing location of Landfill site (Tholoana).



The bulk of the site is underlain by the Karoo Supergroup Formations covered by vegetation, grassland and sandstone outcrops.

F. Description of the Geological Setting
Description of the rock units:

Large areas of the southern African continent are covered by the Karoo Supergroup (Figures 4, 5, Map 1). It covers older geological formations with an almost horizontal blanket. Several basins are present with the main basin in the central part of south Africa and several smaller basins towards Lebombo, Springbok Flats and Soutpansberg. 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. The Elliot Formation is also known as the Red Beds and the old Cave Sandstone is known as the Clarens Formation. At the top is the Drakensberg Basalt Formation with its pillow lavas, pyroclasts, etc. (Kent 1980, Snyman 1996).

The Tarkastad Subgroup of the Beaufort Group consists of a lower predominantly arenaceous Katberg Sandstone Formation and a predominantly upper argillaceous Burgersdorp Formation (Kent 1980, Cole *et al*. 2004). It is Early Triassic in age. This Subgroup is absent in the west. A maximum thickness of 900 m can be measured for the Katberg sandstone. Red, bluish and green mudstone, siltstone and fine- to medium-grained sandstone lenses are characteristic of the Burgersdorp Formation. This Subgroup marks the boundary of the Plaeozoic and the Mesozoic (Snyman 1996, Visser 1998). Fossil mammal-like reptiles are present (Norman and Whitfield 2006).

The rocks of the Beaufort Group were deposited by large, northward-flowing, meandering rivers in which sand accumulated, flanked by extensive floodplains where periodic floods deposited mud. Following the end-Permian mass extinction, the meandering rivers were replaced by multi-channelled, braided river systems that deposited sand rather than the silts and muds of the earlier meandering rivers. The sandstone-dominated strata deposited by these braided rivers, known as the Katberg Formation, can be as much as 1000 m thick. As time passed, the high-energy, braided rivers of the Katberg Formation reverted to a meandering form, possibly reflecting recovery of the vegetation. These sedimentary deposits are the Burgersdorp Formation (McCarthy and Rubidge 2005).

A short period of uplift and erosion followed. This was short-lived, however, and sedimentation was renewed, forming the rocks of the Stormberg Group on top of the slightly eroded rocks. The rocks of the Stormberg Group reflect a gradual change to increasingly more arid conditions. The Molteno Formation rocks were deposited mainly by large braided rivers. A change in climate is reflected in the floodplain sediments of the Elliot Formation. In addition to meandering river deposits, salt-pan deposits are found, containing fossilised lungfish, as well as fossilised, thick, arid-zone soil layers. Warming and aridity increased towards the end of the deposition of the Elliot Formation. By the time of deposition of the rocks of the upper Clarens Formation, true desert conditions prevailed, with the development of an extensive sand sea (McCarthy and Rubidge 2005).

Further to the lithostratigraphy, the Beaufort Group is divided into biostratigraphic units. The *Lystrosaurus* Assemblage Zone includes the Katberg Formation and the lower third of the Burgersdorp Formation and is characterised by the abundance of *Lystrosaurus* in association with *Procolophon.* Overlying this biozone is the *Cynognathus* Assemblage Zone characterised by *Cynognathus, Diademodon* and *Kannemeyeria* and occupying the upper two-thirds of the Burgersdorp Formation (Rubidge 1995).

The Molteno Formation consists of a collection of quartzitic sandstones and grey shale, also present are basal conglomerate, pebbles, and siltstone. Plant and insect fossils are common with coal beds. This formation is relatively thin, as thin as 100 – 700 m. The cool climate led to a lush plant growth with *Dicroidium* ferns (Figure 3), arthopoda, mollusca, wood in the sandstone, and fresh water fish (Snyman 1996, Visser 1998, Norman and Whitfield 2006).

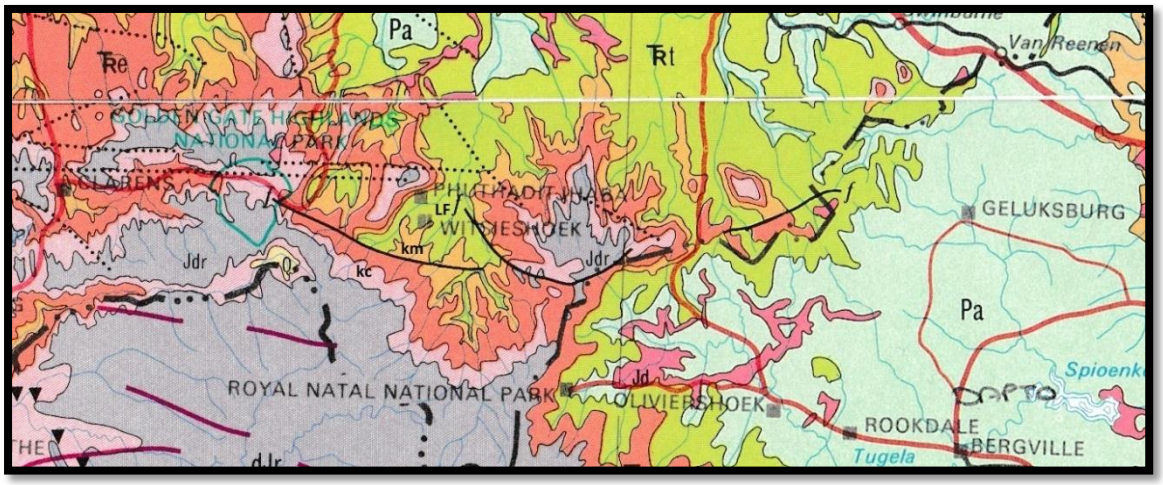
Figure 3: Example of a Molteno plant fossil, TM3289 (H. Fourie).

The Elliot Formation overlies the Molteno Formation and has a maximum thickness of 500 m. It consists of siltstone, mudstone and sandstone. Oxygenation of the iron coloured the sediments red during and after deposition. Reptile, mammal-like reptile, trace fossils, dinosaurs, the earliest known tortoise in Gondwana, small, early mammals, and wood, are plentiful (Snyman 1996, Visser 1998, Norman and Whitfield 2006).

The Clarens Formation has a maximum thickness of 250 m in the south. Pink and yellow sandstone is fine and never coarse. Cave and cliff formation is common. Fossils are scarce, but dinosaurs are found with the fish *Semionotus capensis* (Snyman 1996, Visser 1998, Norman and Whitfield 2006).

Around 190 Ma years ago the first basalt magma created the Drakensberg Basalt Formation through shield vulcanos. The resultant Drakensberg covers an area of 140 000 km² peaking at nearly 3500 m above sea level. The lava is dark grey to black, but weathers chocolate brown with abundant whitish amygdales. It is early Jurassic in age and here locally known as the Maluti (Snyman 1996, Visser 1998, Norman and Whitfield 2006).

Figure 4: Excerpt of geological map (Visser 1984).



Legend to Map and short explanation.
Jdr – (purple) Basalt. Drakensberg Group, Karoo Supergroup.
kc – (pienk) Sandstone, siltstone. Clarens Formation, Karoo Supergroup.
Ke – (orange) Mudstone, sandstone. Elliot Formation, Karoo Supergroup.
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Kt – (green) Mudstone, sandstone. Tarkastad Subgroup, Beaufort Group, Karoo Supergroup.
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LF – Approximate position of Landfill site.

The Project includes one Option (see map):
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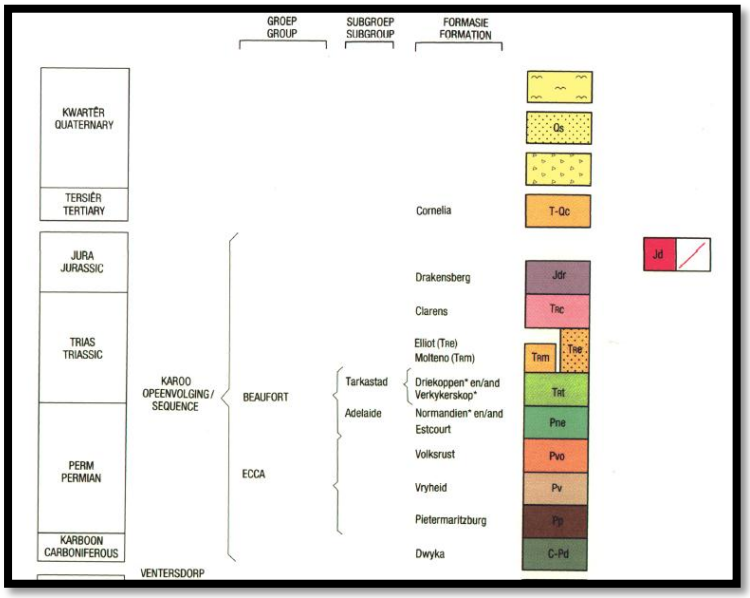
Figure 5: Lithostratigraphic column of the Karoo Supergroup (Muntingh 1992).



Dolerite dykes (Jd) 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 walk through was done early July of 2015, conditions were dry and cold. Photographs below show the sloping topography. A variety of soil types (overburden and topsoil) and sandstone banks are present (Figures 6-11).

Figure 6: Site is currently not cultivated, but covered with grassland, topsoil and overburden.

Figure 7: This site will house the Landfill, view to show sloping topography and the Clarens Formation on the mountain in the background.

Figure 8: View of site showing the sandstone outcrop, mostly in a bank of solid sandstone.

Figure 9: Localised digging presumably for the sand.

Figure 10: View towards northern section and road.

Figure 11: View towards the western perimeter of the site. Note the sandstone bank.

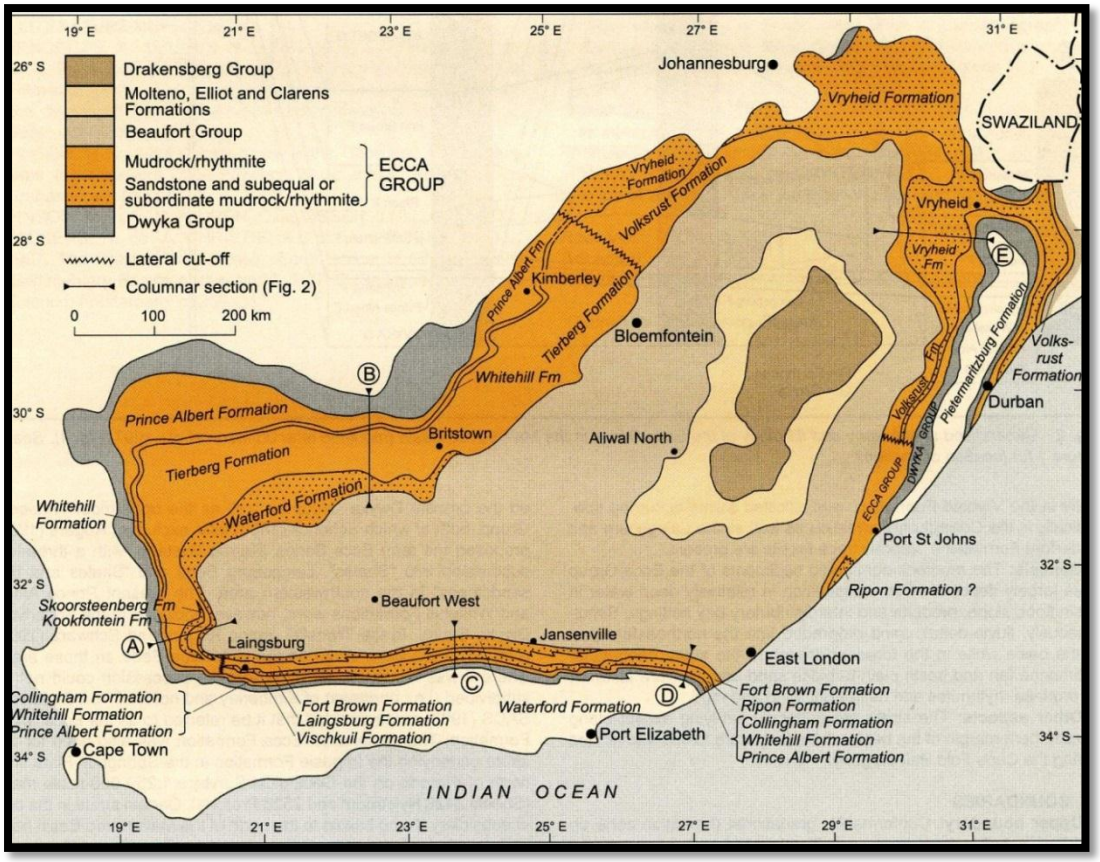
The geological formations consist mainly of flat-lying sandstones and subsidiary siltstones and mudstones. The spectacular banks of cream-, and yellow Katberg sandstone make this part of the Tarkastad Subgroup of the Beaufort Group. The walk through did not find any fossils. Most of the site is directly underlain by the sandstone bank and the landfill site may not intrude into the fossiliferous mudstone, siltstone or shale if the sandstone is used as base for the foundations.

There is some concern with the property due to the presence of the Karoo Supergroup. The depth of the Formation can be verified with geological cores. The topsoil, subsoil and overburden must be surveyed for fossils and Mitigation is needed for the fossiliferous layer.

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

G. Background to Palaeontology of the area

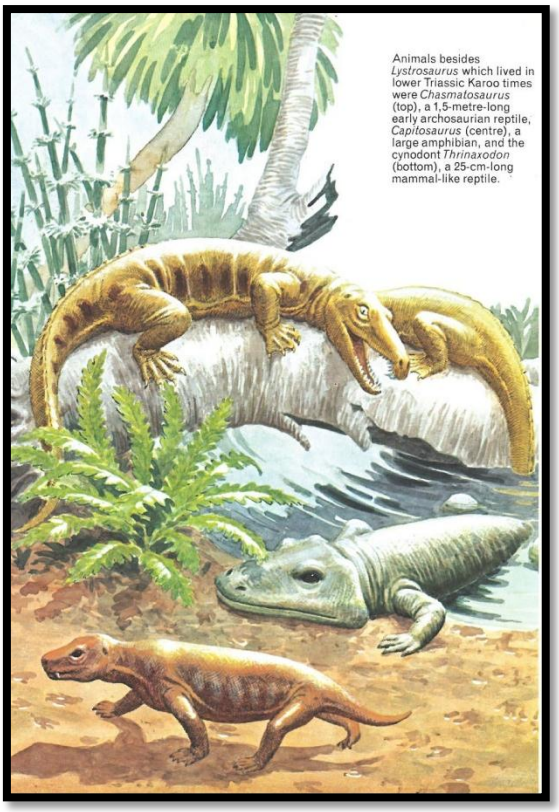
Summary: When rock units of moderate to very high palaeontological sensitivity are present within the development footprint, a desk top and or field scoping (survey) study by a professional palaeontologist is usually warranted. The main purpose of a field scoping (survey) study would be to identify any areas within the development footprint where specialist palaeontological mitigation during the construction phase may be required (SG 2.2 SAHRA AMPHOB, 2012).



Map 1: Extent of the Karoo Supergroup (Johnson 2009).

Fossils of *Lystrosaurus, Thrinaxodon, Moschorhinus, Galesaurus* and the small amphibian *Lydekkerina* are frequently preserved as articulated skeletons within well-defined blue-grey or red-brown calcareous nodules present in the *Lystrosaurus* Assemblage Zone. *Procolophon* has been recorded from burrow casts (Rubidge 1995) (Figure 12). The *Cynognathus* Assemblage Zone is characterised by the presence of *Cynognathus, Diademodon* and *Kannemeyeria.* Fossil fishes, invertebrates, plants and trace fossils may also occur in both biozones.

Figure 12: Typical Karoo scene during the *Lystrosaurus* Assemblage Zone times (Cluver 1978).



Lystrosaurus is a dicynodont (mammal-like reptile) (Figure 13) with a distinctive, down-turned snout, lending the skull its characteristic shape. It is one of three genera that survived the end-Permian extinction event. *Cynognathus* was a large, bear sized, carnivorous cynodont. Plant fossils dominate the fossil assemblage of the Molteno Formation. Insects, *Dicroidium, Spenobaieria* and *Heidiphyllum* are abundant (Cole *et al.* 2004).

Figure 13: Skull of *Lystrosaurus* (H. Fourie).

The Molteno Formation is Late Triassic in age and has an abundance of gymnosperms, insects such as cockroaches, beetles, hemiptera and dragonflies. The diminishing synapsid populations were being superseded by dinosaurs such as the long-necked *Antetonitis* and *Aardonyx* of the early Elliot Formation times. Amphibians, non-dinosaurian archosaurs, theropod dinosaurs, therapsids, mammaliaformes, crocodilomorphs, and chelonia make up the fauna of the Elliot and Clarens Formations (Chinsamy-Turan 2012).

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 Tarkastad Subgroup.

Criteria used (Fossil Heritage Layer Browser/SAHRA):

Rock Unit	Significance/vulnerability	Recommended Action
Tarkastad Subgroup	Very High	Field assessment and protocol for finds is required
Molteno Formation	Very High	Field assessment and protocol for finds is required
Elliot Formation	Very High	Field assessment and protocol for finds is required
Clarens Formation	High	Desktop study is required and based on the outcome of the desktop study, a field assessment is likely
Drakensberg Basalt	Low	No palaeontological studies are required however a protocol for finds is required

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

Impact: **VERY HIGH** for the Tarkastad Subgroup, Molteno and Elliot Formations, **HIGH** for the Clarens Formation and **LOW** for the Drakensberg Basalt Formation. There are significant fossil resources that may be impacted by the development (mudstone, shale).

H. Description of the Methodology

The palaeontological impact assessment field study was undertaken in June 2015. The walk through of the affected portion was done and photographs (in 7.1 mega pixels) were taken of the site with a digital Canon camera (PowerShot A470). A Global Positioning System (GPS) (Garmin eTrex 10) is used to record fossiliferous finds if the area is not covered with topsoil, subsoil, overburden, vegetation, grassland, trees and waste. The walk through did identify the Karoo Supergroup. 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 Tarkastad Subgroup.

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

J. Recommendation

a. There is no objection (see Recommendation B) to the development, but it was necessary to request a Phase 1 Palaeontological Impact Assessment: Field study to determine whether the development will affect fossiliferous outcrops as the palaeontological sensitivity is **VERY HIGH**. A Phase 2 Palaeontological Mitigation may be required as the Phase 1 Palaeontological Assessment identified a fossiliferous formation (Karoo Supergroup). Protocol is attached (Appendix 2).
b. This project may benefit the economy, the growth of the community and social development in general.
c. Preferred choice: The impact on the palaeontological heritage is **VERY HIGH.** The presence of Karoo Formations is problematic. 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 / PHRA).

a. Objections: Cautious. See heritage value and recommendation.
b. Conditions of development: See Recommendation.
c. Areas that may need a permit: Yes.
d. Permits for mitigation: **Needed from SAHRA/PHRA prior to Mitigation**.

K. Conclusions

a. All the land involved in the development was assessed and none of the property is unsuitable for development (see Recommendation B).
b. All information needed for the Phase 1 Palaeontological Impact Assessment and Field scope was provided by the Consultant. All technical information was provided by Tholoana.
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.

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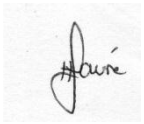
Declaration

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.



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Heidi Fourie
2015/07/27

Appendix 1: **Protocol for finds**

This section covers the recommended protocol for a Phase 2 Mitigation process as well as for reports where the Palaeontological Sensitivity is LOW; this process guides the palaeontologist / palaeobotanist on site and should not be attempted by the layman / developer.

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

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

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

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

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

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

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

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

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

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

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

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

1. The developer needs to clearly stake or peg-out (survey) the areas affected by the mining/ construction/ development operations and dig representative trenches and if possible supply geological borehole data.
2. Fossils likely to occur are for example the fossil plants from the Vryheid Formation, these are present in the grey shale (or any other fossiliferous layer ranked as VERY HIGH or HIGH) or invertebrates from the Volksrust Formation (or any other fossiliferous layer).
3. When clearing topsoil, subsoil or overburden and hard rock (outcrop) is found, the contractor needs to stop all work.
4. A Palaeobotanist / palaeontologist (contact SAHRIS for list) must then inspect the affected areas and trenches for fossiliferous outcrops / layers. The contractor / developer may be asked to move structures, and put the development on hold.
5. If the palaeontologist / palaeobotanist is satisfied that no fossils will be destroyed or have removed the fossils, development and removing of the topsoil can continue.
6. After this process the same palaeontologist / palaeobotanist will have to inspect and offer advice through the Phase 2 Mitigation Process. Bedrock excavations for footings may expose, damage or destroy previously buried fossil material and must be inspected.
7. When permission for the development is granted, the next layer can be removed, if this is part of a fossiliferous layer, then with the removal of each layer of sediment, the palaeontologist / palaeobotanist must do an investigation (a minimum of once every two weeks).
8. At this stage the palaeontologist / palaeobotanist in consultation with the developer / mining company must ensure that a further working protocol and schedule is in place. Onsite training should take place, followed by an annual visit by the palaeontologist / palaeobotanist.

Fossil excavation if necessary during Phase 2:

1. Photography of fossil / fossil layer and surrounding strata.
2. Once a fossil has been identified as such, the task of extraction begins.
3. It usually entails the taking of a GPS reading and recording lithostratigraphic, biostratigraphic, date, collector and locality information.
4. Using Paraloid (B-72) as an adhesive and protective glue, parts of the fossil can be kept together (not necessarily applicable to plant fossils).
5. Slowly chipping away of matrix surrounding the fossil using a geological pick, brushes and chisels.
6. Once the full extent of the fossil / fossils are visible, it can be covered with a plaster jacket (not necessarily applicable to plant fossils).
7. Chipping away sides to loosen underside.
8. Splitting of the rock containing palaeobotanical material should reveal any fossils sandwiched between the layers.

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

Appendix 2:

Table 1: 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 2	1(k)	Protocol for finds
	1(m)	"
	1(q)	"