SASOL SOUTH AFRICA (PTY) Ltd

Alexander MINING Project

DRAFT Specialist IMPACT ASSESSMENT REPORT

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Palaeontological Impact Assessment: Phase 1 Field Study

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EXECUTIVE SUMMARY

Summary of findings (6d)

The Phase 1 PIA Field Study was undertaken in January 2019 in the summer in hot and dry conditions and the following is reported:

The Karoo Supergroup is renowned for its fossil wealth. The Vryheid Formation (Pe,Pv), Ecca Group is rich in plant fossils such as the *Glossopteris* flora represented by stumps, leaves, pollen and fructifications. This formation is early to mid-Permian (Palaeozoic) in age and consists of sandstone, shaly sandstone, grit, conglomerate, coal and shale. Coal seams are present in the Vryheid Formation within the sandstone and shale layers. Fossils are mainly present in the grey shale which is interlayered between the coal seams (Kent 1980, Visser 1989). Borehole logs in the coalfields show the following layers; soil, shale and sandstone, shale and sandstone interbedded, sandstone, coal, conglomerate reworked diamictite, Dwyka Tillite, and the Pre-Karoo Basement.

Recommendation

Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, if there is the presence of Karoo Supergroup strata the palaeontological sensitivity can generally be LOW to VERY HIGH, and here locally **VERY HIGH** for the Vryheid Formation (SG 2.2 SAHRA APMHOB, 2012).

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

During the survey, it was found that the related infrastructure will be developed on the Vryheid Formation. It is located on an undulating topography. The area is undermined and disturbed by historic mining in the Bethal area.

The area is covered by overburden, vegetation, natural grassland and other land uses include the road. The development will benefit the community. Fossils were not found during the walk through and drive through.

Concerns/threats ((6g,6ni,6nii,6o,6p) to be added to the EMPr)

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

2. Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden as a site visit may have missed a fossiliferous outcrop. An appropriate Protocol and Management plan is attached for the Environmental Control Officer.

The recommendations are:

1. Mitigation may be needed (Appendix 2) if fossils are found.
2. No consultation with parties was necessary. The Environmental Control Officer must familiarise him- or herself with the formation present and its fossils.
3. The development may go ahead with caution, but the ECO together with the mine geologist must survey for fossils before or after blasting or excavating.
4. The EMPr already covers the conservation of heritage and palaeontological artefacts that may be exposed during construction activities. For a chance find, the protocol is to immediately cease all construction activities, construct a 30 m no-go barrier, and contact SAHRA for further investigation. It is recommended that the EMPr be updated to include the involvement of a palaeontologist (pre-construction training of ECO) during the digging and excavation phase of the development either for training or a site visit once a month during construction. The ECO must visit the site weekly.

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# 1. INTRODUCTION

## 1.1 Background Information

Sasol Mining operates several underground coal mines near Secunda, Mpumalanga Province. The Syferfontein Colliery represents one of these production areas and was established in 1989 with the purpose of supplying coal to the Sasol Synthetic Fuels (SSF) Plant in Secunda. Between 1991 and 2000, coal was mined from the Highveld Coalfield by means of the opencast strip mining method, followed by underground mining which commenced in 1993.

Originally Syferfontein was an open pit strip mine, however, since initiation several underground sections have been developed through high wall adits. The original strip mine has been decommissioned and partially backfilled and rehabilitated. Final voids, facilitating the different underground mine adits, are still open.

To ensure an uninterrupted coal supply to the Secunda Synfuels plants, Sasol Mining has acquired new reserves and in future will expand its mining activities into these new areas. Taking this into consideration, the Syferfontein complex needs to optimise infrastructure development and coal reserve utilisation to achieve its objectives.

Recently Sasol acquired coal reserves (Block IV) in the Tweedraai area and applied for an alone standing Mining Right (Tweedraai mine) with a high wall entrance from Pit 4 (located within the decommissioned Syferfontein open pit mine). The Mining Right has been issued, and mining will continue into this area.

The current Environmental Authorisation (EA) for the Syferfontein complex comprises of the:

- Decommissioned and partially rehabilitated strip mine; and
- Riversdale, Tweedraai and Weltevrede operational underground mining areas, each with its own high wall adit.

The amendments included in the proposed project consist of:

- Expansion of the Syferfontein mining area into newly acquired coal reserves called Alexander, north-east of the current Riversdale mining area;
- A new ventilation shaft or shaft complexes (up- & down-cast) at the Alexander section.

The proposed future mining activities will be conducted by means of underground mining operations, utilising the board-and-pillar and high extraction to extract coal from the No.4 coal seam at Alexander.

The Life-of-Mine (LOM) of the current Syferfontein Colliery will be substantially extended by the addition of Alexander's mining right as the Department of Mineral Resources (DMR) recently granted approval for the transfer of a mining right from Anglo American Inyosi Coal (Pty) Ltd, referred to as the Alexander coal reserve.

### 1.2 Scope and Purpose

Jones & Wagener (Pty) Ltd Engineering & Environmental Consultants (J&W) has been appointed to undertake the Alexander Environmental Management Programme (EMPr) amendment and Water Use Licence (WUL) application process for the abovementioned project. As part of the process, specialist studies need to be undertaken. This report details the methods, analysis and findings of the Palaeontological Impact Assessment undertaken for the proposed Alexander Mining Project.

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 (6c).

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.

### 1.3 Site Location

The Syferfontein Mine is located north-east of the existing Sasol Secunda operations – see **Figure 1-1**. The Syferfontein Mine is situated in the Mpumalanga Highveld area, approximately 6.5 km north of Trichardt and 8 km north-east of Secunda. Alexander is located approximately 12 km northwest of Bethal and directly to the south and south-east of Kriel in the Mpumalanga Province. The project overlaps the Emalahleni Local Municipality (ELM) and Govan Mbeki Local Municipality (GMLM) within the Nkangala District Municipality (NDM) and Gert Sibande District Municipality (GSDM).

The target mineral resource lies between the R547 provincial road to the west and the R35 provincial road to the east. Alexander's mining right application area is approximately 10,700ha of which ~ 7300ha covers the mine plan.

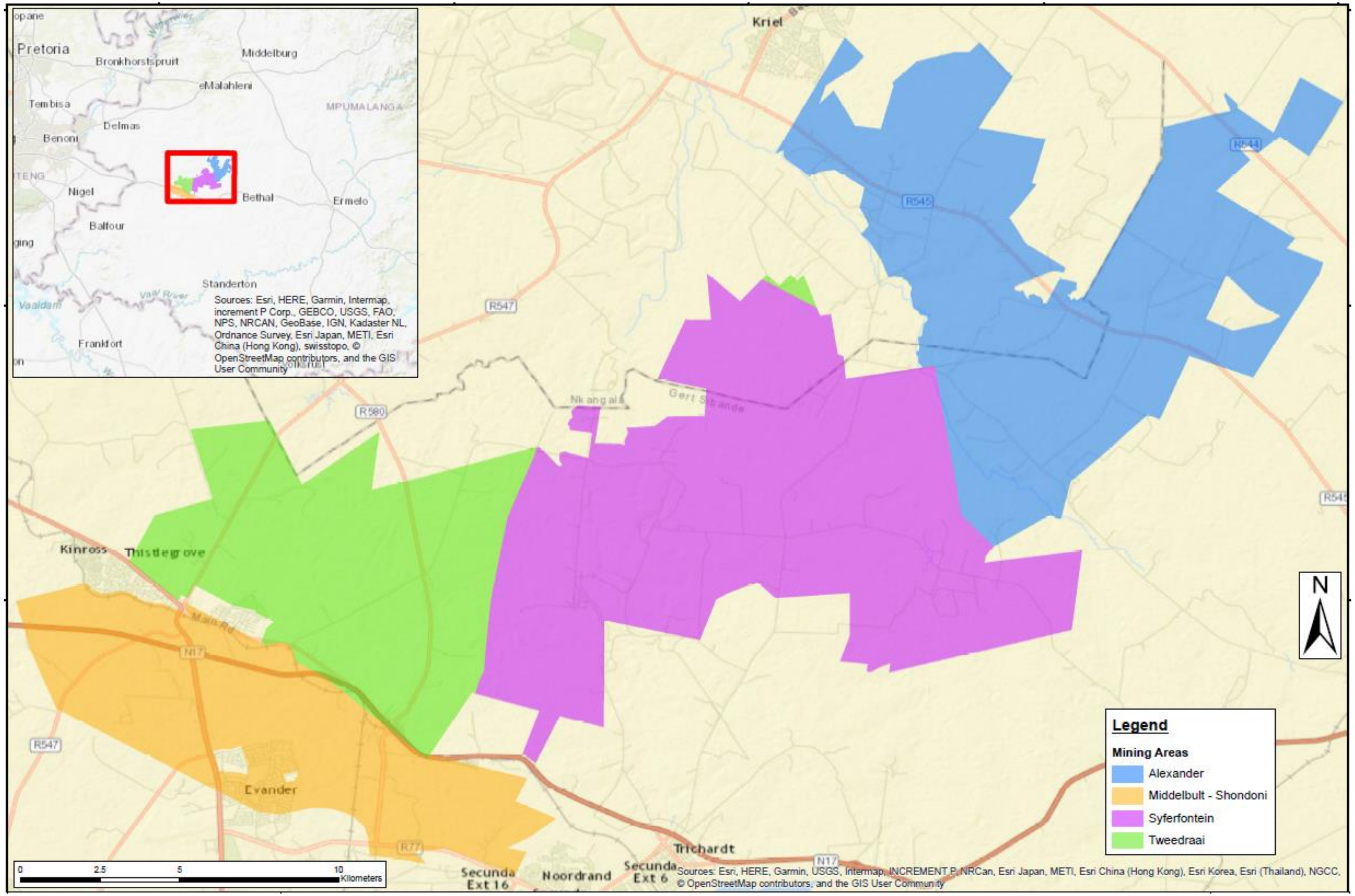


**Figure 1-1: Locality of the project**

## 1.4 Proposed Infrastructure

A ventilation shaft with ventilation fans will be established to provide ventilation to the Alexander underground workings. The shaft will consist of an up-cast and down-cast shaft adjacent to each other (See **Figure 1-2** and **Figure 1-3**). These shafts typically have a diameter of 7m and will be sunk to the mine workings.

The preferred position for the ventilation shaft system is seen in **Figure 1-2** and **Figure 1-3**, where up- and down-cast shafts are required with two 750 Kw main fans delivering airflow at 700 m³/s (350 m³/s at 1600 Pa per fan). See Error! Reference source not found. for a detailed map of the location for the proposed ventilation shaft system.

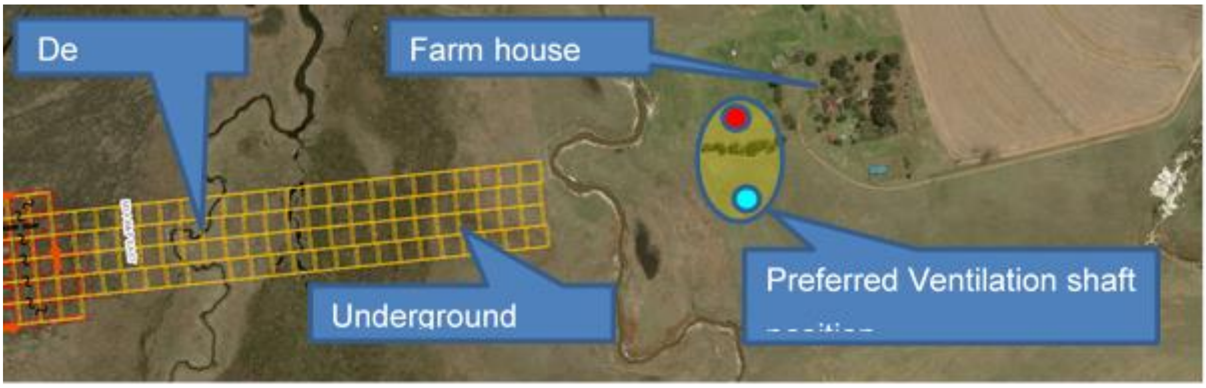


**Figure 1-2: Preferred position for the ventilation shaft system**

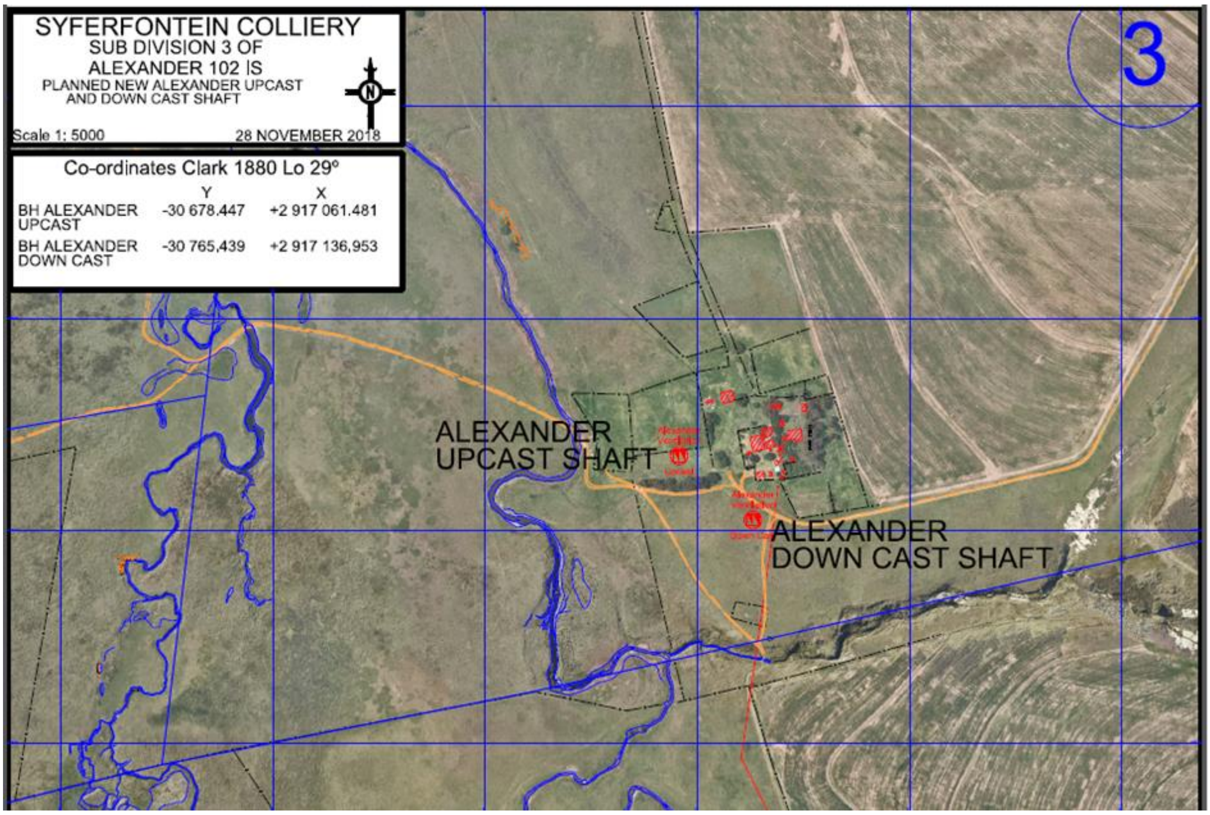


**Figure 1-3: Planned Alexander up-cast and down-cast shaft**

The ventilation requirements are based on the following assumptions:

- 10 Sections (8 Production and two Stone work);
- Total volume of 850 $m^3/s$ airflow required for the sections @85 $m^3/s$ per section;
- Volume required for commitments and 10% leakage factor = 170 $m^3/s$;
- Minimum total volume of airflow required = 1020 $m^3/s$.

### 1.4.1 Construction Phase Activities

The shaft area is located on the farm Alexander 102 IS, in close proximity to an existing farmstead. The site will be accessed via existing farm roads. An agreement will be signed with the farmer for access to land and the necessary contracts and agreements will be concluded.

The topography of the proposed shaft area is fairly flat and mildly modified due to increased activities associated with the farmstead, machinery and animal activities over many years. The farmstead area will be used during construction for drilling equipment and also as a laydown area.

The up- and down-cast ventilation shafts will be drilled via raise bore technology on two separate locations, in the same area, approximately 120m apart. The raise bore process includes *inter alia* a percussion borehole which will be drilled into the underground workings of the mine. A reamer, with a 7m diameter will then be installed underground and used to cut the shaft from the bottom up. All the waste rock will fall into the underground mine workings and will be stored underground in mined out areas. The drilling machine will generate the required electricity for drilling purposes on site. No compressed air will be used during the raise boring process.

Once the raise bore reaches the surface, a concrete shaft collar (approximately 15m x 15m) will be constructed. The shaft area will be fenced for security and access control purposes.

Contractors on site will use chemical toilets and potable water will be provided in containers, if not available from existing potable water facilities at the farmstead. During drilling, some water may be used for dust suppression, and water will be recycled as part of the drilling process. Any remaining water after completion (if applicable) will be disposed into the mine water management system underground.

### 1.4.2 Operational Phase Activities

The shaft areas will remain fenced and regular inspections, by duly appointed mine personnel, will take place. Grass cutting will be required to prevent veld fires and to safeguard equipment. A concrete slab and goose neck structure will be visible on site at the down-cast shaft. See **Figure 1-4**.

**Figure 1-4: Surface infrastructure associated with a down-cast shaft**

The up-cast shaft is equipped with structures as illustrated in **Figure 1-5** and **Figure 1-6**. The up-cast shaft will be equipped with two 750Kw main fans, delivering combined 700m$^3$/s (350m$^3$/s each) air replacement (ventilation).

There will be lights during the operational phase and noise generated on site from the up-cast shaft.

**Figure 1-5: Example of completed up-cast ventilation shaft (Height 12-15m)**

EXAMPLE OF 2 X 750 Kw UPCAST VENTILATION SHAFT

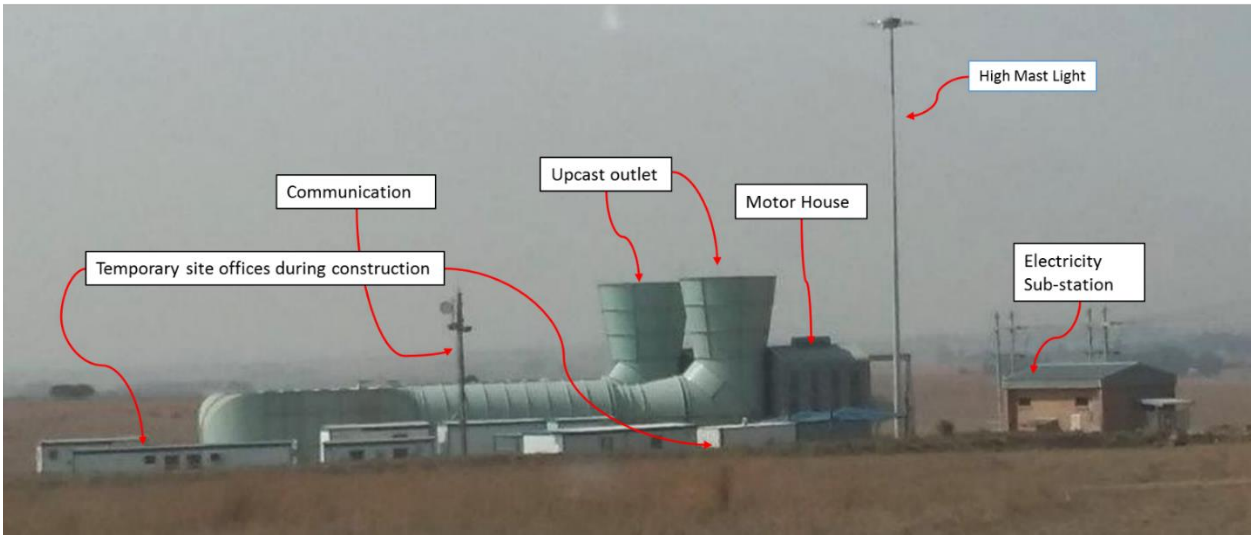


**Figure 1-6: Up-cast ventilation shaft in final construction phase**

#### 1.4.3 Decommissioning Phase Activities

During the decommissioning of the shafts, the structures will be removed and the shafts backfilled with inert material. A concrete slab will be placed on top of the shafts to prevent access.

Alien invasive plant species will be controlled in the area for a minimum period of three years after decommissioning.

#### 1.4.4 Access road

An existing road (the farmstead access road) will be upgraded to serve as an access road to the Alexander ventilation shaft.


**Figure 1-7: Locality of the Proposed Ventilation Shaft**

## 2. Policy and legislative context

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.

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

- Heritage assessment criteria and grading used:

- (a) Grade 1: Heritage resources with qualities so exceptional that they are of special national significance;
- (b) Grade 2: 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 3: 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 2 heritage resources.
- Local authorities identify and manage Grade 3 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.

## 3. Specialist Project Team

**Table 1-1: Specialist Team Members.**

| Name | Organisation | Highest Qualifications | Experience | Professional Registrations |
|---|---|---|---|---|
| Dr H. Fourie | Private | Ph.D Palaeontology | 24 Years | PSSA |

## 4. 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. Inaccessibility of site.
7. Insufficient data from developer and exact lay-out plan for all structures (for this report all required data/information was provided).

# 5. BASELINE ASSESSMENT

## 5.1 Approach and Methodology

The palaeontological impact assessment field study was undertaken in January 2019. The walk through and drive through of the affected portion were done and photographs (in 20 mega pixels) were taken of the site with a digital Canon camera (PowerShot SX620HS). It was not necessary to use a Global Positioning System (GPS) (Garmin eTrex 10) to record outcrops if not covered with topsoil, subsoil, overburden, and vegetation. A literature survey is included and the study relied on literature, geological maps, google.maps, and google.earth images. The walk through and drive through did identify the Vryheid Formation.

The area is not large and was criss-crossed on foot, fossiliferous outcrops were not found. The SAHRA Document 7/6/9/2/1 requires track records/logs from archaeologists not palaeontologists as palaeontologists concentrate on outcrops which may be recorded on a GPS. Isolated occurrences of rocks usually do not constitute an outcrop. Fossils can occur in dongas, as nodules, in fresh rock exposures, and in riverbeds. Finding fossils require the experience and technical knowledge of the professional palaeontologist, but that does not mean that an amateur can’t find fossils. The geology of the region is used to predict what type of fossil and zone will be found in any particular region. Archaeozoologists concentrate on more recent fossils and can be asked to survey quaternary and tertiary deposits.

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

1. Recommendations for the future of the site.
2. Background information on the project.
3. Description of the property of affected environment with details of the study area.
4. Description of the geological setting and field observations.

5. Background to palaeontology of the area.
6. Heritage rating.
7. Stating of significance (Heritage Value).

A Phase 2 Palaeontological Impact Assessment: Mitigation will include:

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

### 5.2 Consultation Process

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).

## 5.3 Findings

### 5.3.1 Description of the rock units:

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

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

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

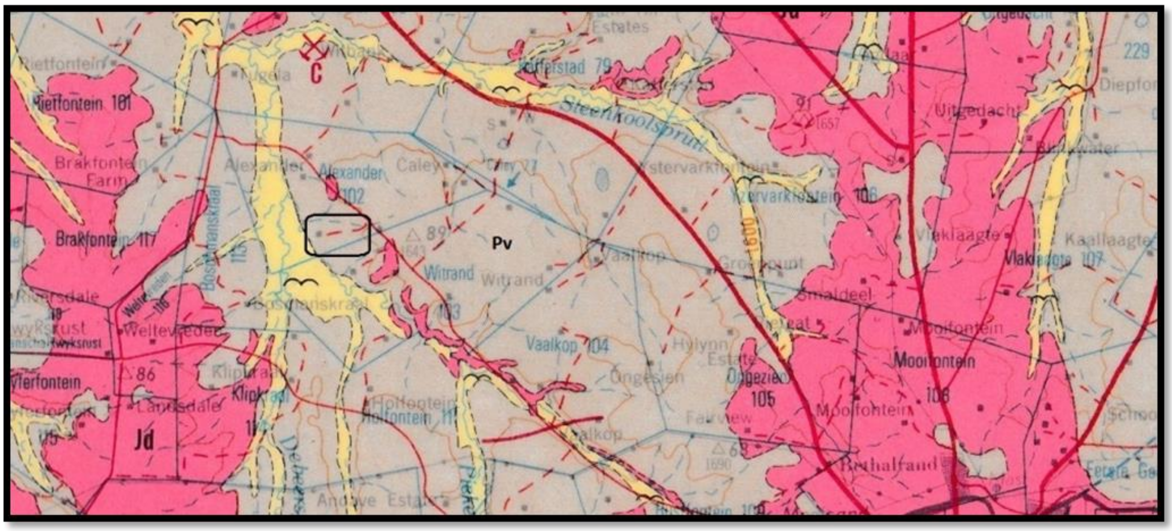


**Figure 5-1: geological map indicating the Alexander Project area**

| Legend to map and short explanation | |
|---|---|
| M | (yellow) Alluvial deposits. Quaternary. |
| Jd | (pink) Jurassic dolerite. |
| Pv | (brown) Sandstone, shaly sandstone, grit, shale, conglomerate and coal near base and top. Vryheid Formation, Ecca Group, Karoo Supergroup. Permian. |
| …… | (blue) Lineament (Landsat, aeromagnetic). |
| ------ | Concealed geological boundary. |
| ⊥12 | Strike and dip of bed. |
| □ | Proposed development. |

The Vryheid Formation is named after the type area of Vryheid-Volksrust. In the north-eastern part of the basin the Vryheid Formation thins and eventually wedges out towards the south, southwest and west with increasing distance from its source area to the east and northeast (Johnson 2009). The Vryheid Formation consists essentially of sandstone, shale, and subordinate coal beds, and has a maximum total thickness of 500 m. It forms part of the Middle Ecca (Kent 1980). This formation has the largest coal reserves in South Africa. The pro-delta sediments are characterised by trace and plants fossils (Snyman 1996).

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

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

### 5.3.2 Field observation:

The area is very lush with grass, but there are no visible outcrops. Both areas surveyed have the same impact.


**Figure 2:** View of area where ventilation shaft will be.


**Figure 3:** Another view of same area showing underlying rocks.


**Figure 4:** Alternative area where ventilation shaft will be.


**Figure 5:** Road that will be upgraded.

### 5.3.3 Background to Palaeontology

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, cordaitales, ferns, clubmosses and horsetails thrived (McCarthy and Rubidge 2005).

The *Glossopteris* flora is thought to have been the major contributor to the coal beds of the Ecca. These are found in Karoo-age rocks across Africa, South America, Antarctica, Australia and India. This was one of the early clues to the theory of a former unified Gondwana landmass (Norman and Whitfield 2006).

Rocks of Permian age in South Africa are particularly rich in fossil plants (Rayner and Coventry 1985). The fossils are present in the grey shale interlayered with the coal seams. The fossils are not very rare and occur also in other parts of the Karoo stratigraphy. The pollen of the Greenside Colliery also on the Vryheid formation was the focus of a Ph.D study. It is often difficult to spot the greyish fossils as they are the same colour as the grey shale in which they are present as these coalified compressions have been weathered to leave surface replicas on the enclosing shale matrix. A locality close to Ermelo, also Vryheid Formation, has yielded *Scutum, Glossopteris* leaves, *Neoggerathiopsis* leaves, the lycopod *Cyclodendron leslii,* and various seeds and scale leaves (Prevec 2011).

Fossils likely to be found are mostly plants such as '*Glossopteris* flora'. The aquatic reptile *Mesosaurus* and fossil fish may also occur with marine invertebrates, arthropods and insects. Trace fossils can also be present (Johnson 2009).

During storms a great variety of leaves, fructifications and twigs accumulated and because they were sandwiched between thin films of mud, they were preserved to bear record of the wealth and the density of the vegetation around the pools. They make it possible to reconstruct the plant life in these areas and wherever they are found, they constitute most valuable palaeobotanical records (Plumstead 1963) and can be used in palaeoenvironmental reconstructions.

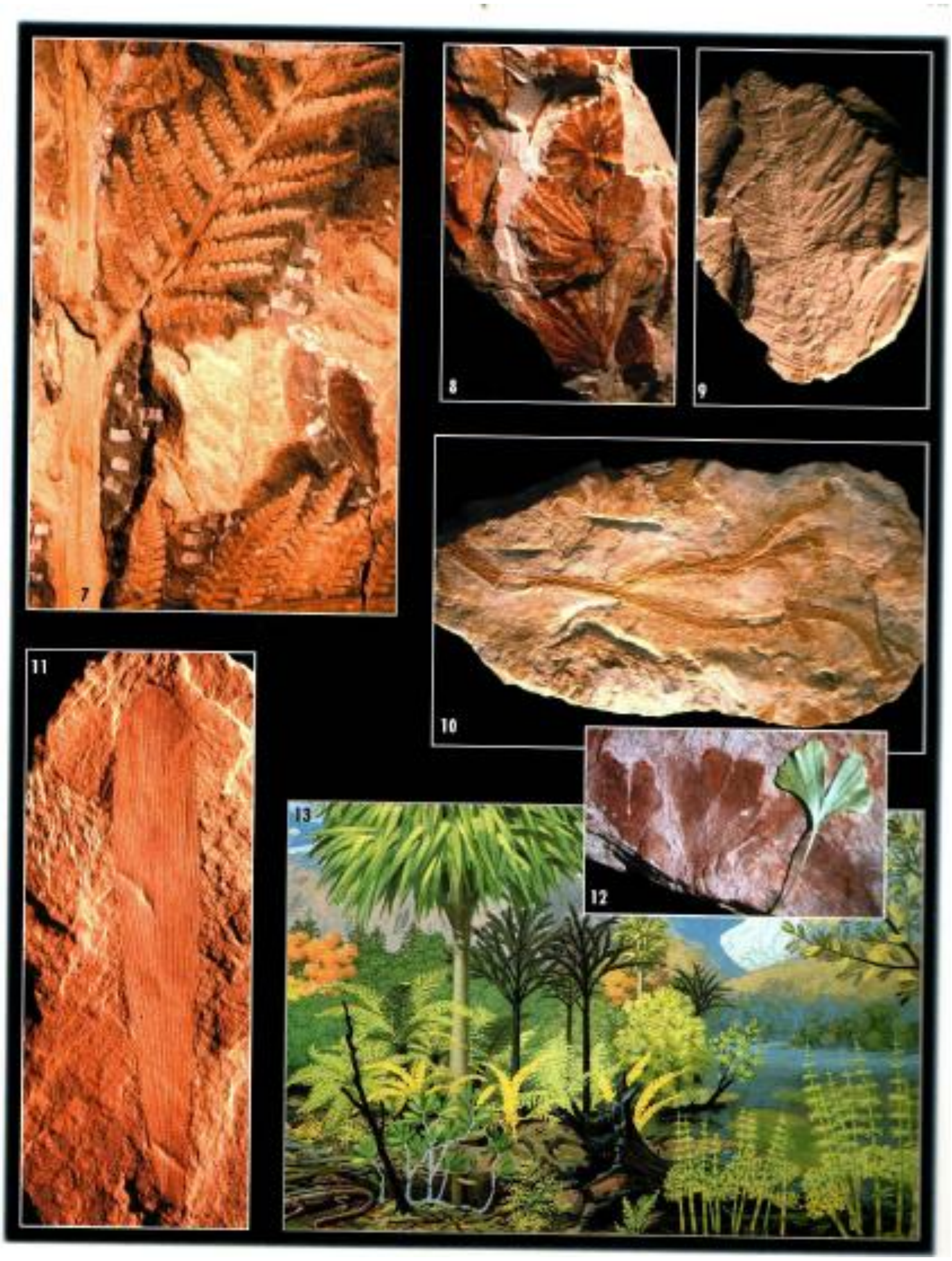

**Figure 6:** Examples of fossil flora.

A fossil bivalve imprint was found on the same farm, but not at the survey area. Figure below shows relation to where the ventilation shaft will be constructed. It appears to be the imprint of a fossil clam.

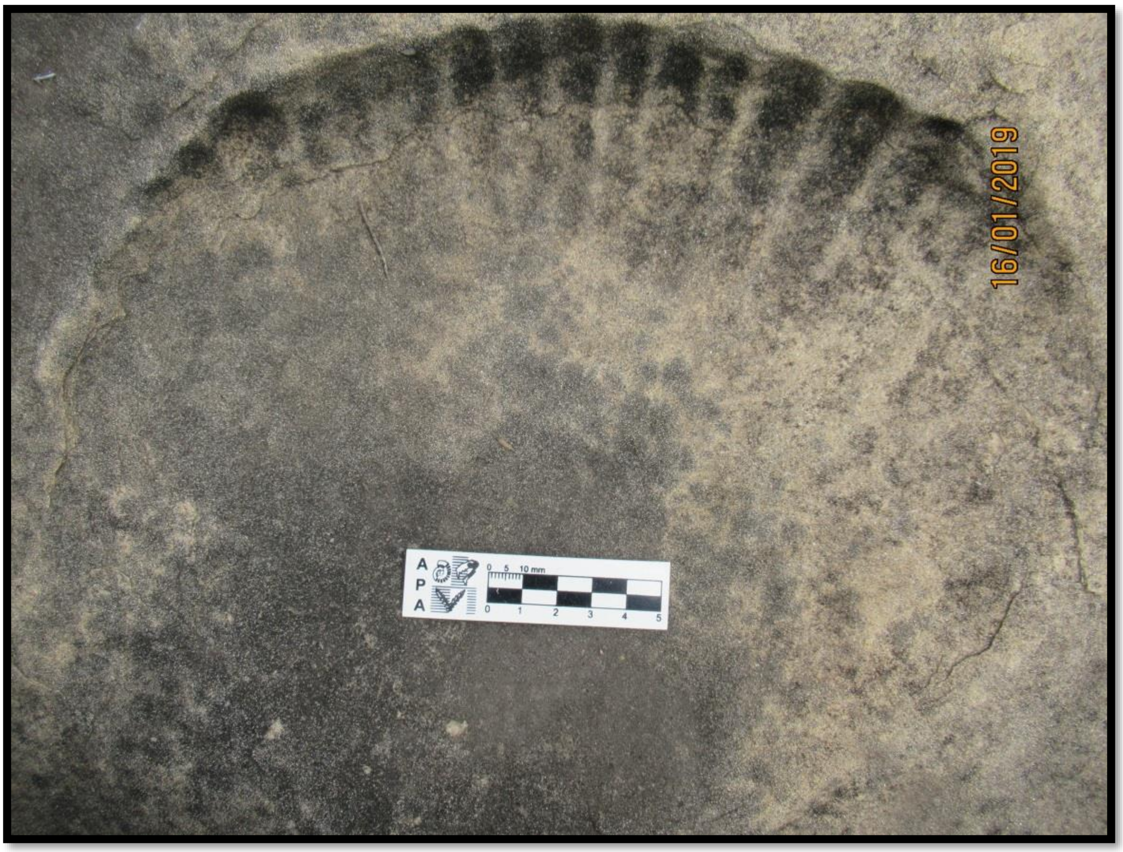


**Figure 7:** Fossil imprint found by J. Nel.

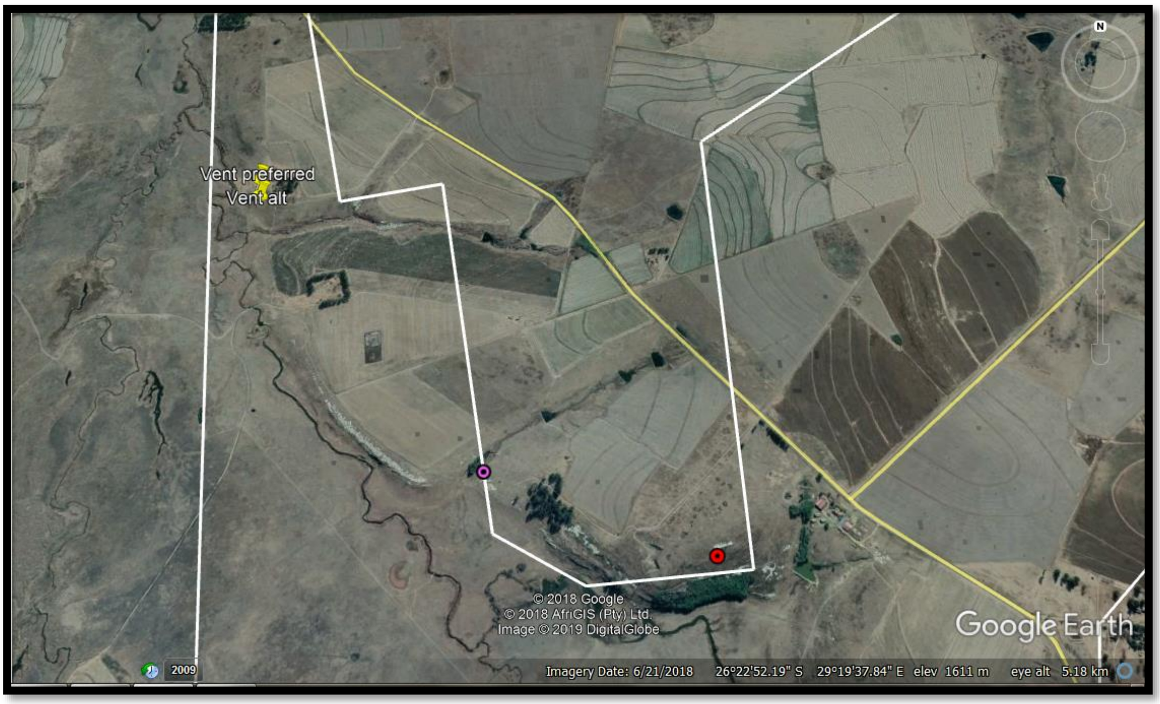


**Figure 8:** Google.earth image with GPS coordinates of where fossil imprint was found (red dot).

Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to be determined due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot. The vast coal mining industry (Vryheid Formation) provides palaeontologists with fantastic access to coal-associated plant fossils, while simultaneously resulting in the destruction of important National Palaeontological Heritage.

## 6. IMPACT ASSESSMENT

| | |
|---|---|
| RED | Very High Palaeontological sensitivity/vulnerability. Development will most likely have a very significant impact on the Palaeontological Heritage of the region. Very high possibility that significant fossil assemblages will be present in all outcrops of the unit. Appointment of professional palaeontologist, desktop survey, phase I Palaeontological Impact Assessment (PIA) (field survey and recording of fossils) and phase II PIA (rescue of fossils during construction ) as well as application for collection and destruction permit compulsory. |
| ORANGE | High Palaeontological sensitivity/vulnerability. High possibility that significant fossil assemblages will be present in most of the outcrop areas of the unit. Fossils most likely to occur in associated sediments or underlying units, for example in the areas underlain by Transvaal Supergroup dolomite where Cenozoic cave deposits are likely to occur. Appointment of professional palaeontologist, desktop survey and phase I Palaeontological Impact Assessment (field survey and collection of fossils) compulsory. Early application for collection permit recommended. Highly likely that aPhase II PIA will be applicable during the construction phase of projects. |
| GREEN | Moderate Palaeontological sensitivity/vulnerability. High possibility that fossils will be present in the outcrop areas of the unit or in associated sediments that underly the unit. For example areas underlain by the Gordonia Formation or undifferentiated soils and alluvium. Fossils described in the literature are visible with the naked eye and development can have a significant impact on the Palaeontological Heritage of the area. Recording of fossils will contribute significantly to the present knowledge of the development of life in the geological record of the region. Appointment of a professional palaeontologist, desktop survey and phase I PIA (ground proofing of desktop survey) recommended. |

| Period | Supergroup/ Sequence | Group | Subgroup | Formation | Member | Lithology | Fossil Heritage | Comments |
|---|---|---|---|---|---|---|---|---|
| Permian | KAROO (Undifferentiated Karoo (P-TR)) | ECCA (Undifferentiated (Pe)) | | Volksrust (Pvo) | | Basinal dark mudrocks with phosphatic / carbonate / sideritic concretions, minor coals<br>Offshore shelf, but possibly also nearshore / lacustrine / lagoonal deposits | Rare temnospondyl amphibian remains, invertebrates (bivalves, insects), minor coals with plant remains, petrified wood, organic microfossils (acritarchs), low-diversity marine to non-marine trace fossil assemblages<br>Late Permian *Cistecephalus* Assemblage Zone biotas | |
| | | | | Vryheid (Pv) | | Deltaic mudrocks and sandstones, locally coastal and fluvial deposits, with occasional coal seams (Ecca "Coal Measures") | Rich fossil plant assemblages of the Permian Glossopteris Flora (lycopods, rare ferns and horsetails, abundant glossopterids, cordaitaleans, conifers, ginkgoaleans), rare fossil wood, diverse palynomorphs. Abundant, low diversity trace fossils, rare insects, possible conchostracans, non-marine bivalves, fish scales. | Globally important fossil floras from Middle Permian Gondwana. Seriously under-collected in recent years, despite ongoing mining for coal |

Initial Impact

Fossils in South Africa mainly occur in rocks of sedimentary nature and not in rocks from igneous or metamorphic nature. Therefore, if there is the presence of Karoo Supergroup strata the palaeontological sensitivity is generally LOW to VERY HIGH, but here locally **VERY HIGH** for the Vryheid Formation.

**Impact: VERY HIGH** for the Vryheid Formation. There are significant fossil resources that may be impacted by the development (shale). Impact is during construction. Both options for the construction of the shaft will have the same impact.

## 7. MONITORING REQUIREMENTS

- Protocol for Chance Finds and Management plan
- This section covers the recommended protocol for a Phase 2 Mitigation process as well as for reports where the Palaeontological Sensitivity is LOW; this process guides the palaeontologist / palaeobotanist on site and should not be attempted by the layman / developer. As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to oversee the construction activities in line with the legally binding Environmental Management Programme (EMPr) so that when a fossil is unearthed they can notify the relevant department and specialist to further investigate. When a fossil is found, the area must be fenced-off and the construction workers must be informed that this is a no-go area. Therefore, the EMPr must be updated to include the involvement of a palaeontologist during the digging and excavation (ground breaking) phase of the development.
- The EMPr already covers the conservation of heritage and palaeontological artefacts that may be exposed during construction activities. The protocol is to immediately cease all construction activities if a fossil is unearthed and contact SAHRA for further investigation. The ECO should familiarise him- or herself with the fossiliferous formations and its fossils. A bi-weekly site visit is recommended and the keeping of a photographic record. The Evolutionary Studies Institute, University of the Witwatersrand has good examples of Ecca Group Fossils.
- The developer must survey the areas affected by the development and indicate on plan where the construction / development / mining will take place. Trenches have to be dug to ascertain how deep the sediments are above the bedrock (can be a few hundred metres). This will give an indication of the depth of the topsoil, subsoil, and overburden, if need be trenches should be dug deeper to expose the interburden.

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

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

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

## 8. CONCLUSIONS AND RECOMMENDATIONS

J. Recommendation (1j,1l)

a. There is no objection (see Recommendation B) to the development, but it was necessary to request a Phase 1 Palaeontological Impact Assessment: Field study to determine whether the development will affect fossiliferous outcrops as the palaeontological sensitivity is **VERY HIGH for the Vryheid Formation**. A Phase 2 Palaeontological Mitigation is only required if the Phase 1 Palaeontological Assessment identified a fossiliferous formation or surface fossils or if fossils are found during construction. Fossils were not found during the walk through. The Protocol for Finds and Management Plan is attached (Appendix 2) for the ECO.

b. This project will benefit the environment, economy, and social development of the community.

c. Preferred choice: The impact on the palaeontological heritage is of a **VERY HIGH** sensitivity (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 (6m,6k):

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: Only if a fossil is unearthed.

d. Permits for mitigation: **SAHRA/PHRA**.

K. Conclusions

a. All the land involved in the development was assessed and none of the property is unsuitable for development (see Recommendation B).

b. All information needed for the Phase 1 Palaeontological Impact Assessment and Field scope was provided by the Consultant. All technical information was provided by Jones and Wagener.

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.

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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Dr H. Fourie

Specialist Name

Date 2019/01/30

## Appendix 1: Curriculum Vitae

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 specialised in vertebrate morphology and function concentrating on the Therapsid Therocephalia. At present she is curator of a large fossil invertebrate collection, Therapsids, dinosaurs, amphibia, fish, reptiles and plants at Ditsong: National Museum of Natural History. For the past 13 years she carried out field work in the Eastern Cape, Western Cape, Northern Cape, North West, Free State, Gauteng, Limpopo and Mpumalanga Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 24 years.

**Appendix 2: Declaration of independence**

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

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

It may be possible that the Phase 1 PIA study may have missed palaeontological resources in the project area as outcrops are not always present or visible due to vegetation while others may lie below the overburden of earth and may only be present once development commences.

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

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Heidi Fourie

2019/01/30