Proposed confirmatory drilling and mining related activities for Makhado Colliery, Vhembe District Municipality, Limpopo Province

PALAEONTOLOGICAL IMPACT ASSESSMENT

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For:

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Table of Contents:

List of Figures:

1. Executive Summary

Rocks of two geological periods dominate the study site, these are the rock formations of the Soutpansberg Group (Mololian) which is overlain by rock formations of the younger Karoo Supergroup (Permian to Jurassic).

The main focus of this report is on the fossiliferous nature of the study site and for that reason the Karoo-aged sedimentary rocks that have a Very High Palaeosensitivity are discussed in more detail than the Soutpansberg Group rocks that have a Low to Moderate Palaeosensitivity.

Although no fossils have been reported from previous studies of the study site and no fossils were found during the site visit, the rocks of the Karoo Supergroup are generally relatively fossil rich and there is a possibility that fossils may be discovered during mining or development.

The ECO should take responsibility of monitoring the excavations. If a significant find is made the procedure stipulated under Procedure for Chance Palaeontological Finds (p.27-28) should be followed which includes the safeguarding of the exposed fossils and the contacting of a palaeontologist for further advice.

2. Introduction

The Heritage Act of South Africa stipulates that fossils and fossil sites may not be altered or destroyed. The purpose of this document is to detail the probability of finding fossils in the study area that may be impacted by the proposed development.

The purpose of this document is to detail the probability of finding fossils in the study area and whether, if indeed there are fossils, what the impact of the mining activities will be on the fossils and fossil sites.

The palaeontological heritage of South Africa is unsurpassed and can only be described in superlatives. The South African palaeontological record gives us insight in inter alia the origin of dinosaurs, mammals and humans. Fossils are also used to identify rock strata and determine the geological context of the subregion with other continents and played a crucial role in the discovery of Gondwanaland and the formulation of the theory of plate tectonics. Fossils are also used to study evolutionary relationships, sedimentary processes and palaeoenvironments.

South Africa has the longest record of palaeontological endeavour in Africa. South Africa was even one of the first countries in the world in which museums displayed fossils and palaeontologists studied earth history. South African palaeontological institutions and their vast fossil collections are world-renowned and befittingly the South African Heritage Act is one of the most sophisticated and best considered in the world.

Fossils and palaeontological sites are protected by law in South Africa. Construction and mining in fossiliferous areas may be mitigated in exceptional cases but there is a protocol to be followed.

This is a Palaeontological Impact Assessment which was prepared in line with regulation 28 of the National Environmental Management Act (No. 107 of 1998) Regulations on Environmental Impact Assessment. This involved a site visit where the palaeontologist evaluated the nature of the geology and potential palaeontology of the study site and an overview of the literature on the palaeontology and associated geology of the area. Although there are no publications that mention fossil finds in the study area, several palaeontological studies have been done in the areas to the northwest and northeast of the study site (Van Eeden & Keyser, 1972; Van den Berg, 1980; Durand, 1996; 2001; Bordy, 2000).

3. Terms of reference for the report

According to the South African Heritage Resources Act (Act 25 of 1999) (Republic of South Africa, 1999), certain clauses are relevant to palaeontological aspects for a terrain suitability assessment.

- **Subsection 35(4)** No person may, without a permit issued by the responsible heritage resources authority-
- (a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
- (b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
- (c) trade in, sell for private gain, export or attempt to export from the republic any category of archaeological or palaeontological material or object, or any meteorite; or
- (d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist with the detection or recovery of metals or archaeological material or objects, or use such equipment for the recovery of meteorites.
- **Subsection 35(5)** When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedures in terms of section 38 has been followed, it may-
- (a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
- (b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
- (c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph (a) to apply for a permit as required in subsection (4); and
- (d) recover the costs of such investigation form the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

South Africa's unique and non-renewable palaeontological heritage is protected in terms of the NHRA. According to this act, heritage 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.

As areas are developed and landscapes are modified, heritage resources, including palaeontological resources, are threatened. As such, both the environmental and heritage legislation require that development activities must be preceded by an assessment of the impact undertaken by qualified professionals. Palaeontological Impact Assessments (PIAs) are specialist reports that form part of the wider heritage component of:

- Heritage Impact Assessments (HIAs) called for in terms of Section 38 of the National Heritage Resources Act, Act No. 25, 1999 by a heritage resources authority.
- Environmental Impact Assessment process as required in terms of other legislation listed in s. 38(8) of NHRA;
- Environmental Management Plans (EMPs) required by the Department of Mineral Resources.

HIAs are intended to ensure that all heritage resources are protected, and where it is not possible to preserve them in situ, appropriate mitigation measures are applied. An HIA is a comprehensive study that comprises a palaeontological, archaeological, built environment, living heritage, etc specialist studies. Palaeontologists must acknowledge this and ensure that they collaborate with other heritage practitioners. Where palaeontologists are engaged for the entire HIA, they must refer heritage components for which they do not have expertise on to appropriate specialists. Where they are engaged specifically for the palaeontology, they must draw the attention of environmental consultants and developers to the need for assessment of other aspects of heritage. In this sense, Palaeontological Impact Assessments that are part of Heritage Impact Assessments are similar to specialist reports that form part of the EIA reports. The standards and procedures discussed here are therefore meant to guide the conduct of PIAs and specialists undertaking such studies must adhere to them. The process of assessment for the palaeontological (PIA) specialist components of heritage impact assessments, involves:

Scoping stage in line with regulation 28 of the National Environmental Management Act (No. 107 of 1998) Regulations on Environmental Impact Assessment. This involves an **initial assessment** where the specialist evaluates the scope of the project (based, for example, on NID/BIDs) and advises on the form and extent of the assessment process. At this stage the palaeontologist may also decide to compile a **Letter of Recommendation for Exemption from further Palaeontological Studies**. This letter will state that there is little or no likelihood that any significant fossil resources will be impacted by the development. This letter should present a reasoned case for exemption, supported by consultation of the relevant geological maps and key literature.

A **Palaeontological Desktop Study** – the palaeontologist will investigate available resources (geological maps, scientific literature, previous impact assessment reports, institutional fossil collections, satellite images or aerial photos

, etc) to inform an assessment of fossil heritage and/or exposure of potentially fossiliferous rocks within the study area. A Desktop studies will conclude whether a further field assessment is warranted or not. Where further studies are required, the desktop study would normally be an integral part of a field assessment of relevant palaeontological resources.

A **Phase 1 Palaeontological Impact Assessment** is generally warranted where rock units of 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 project area is unknown. In the recommendations of Phase 1, the specialist will inform whether further monitoring and mitigation are necessary. The Phase 1 should identify the rock units and significant fossil heritage resources present, or by inference likely to be present, within the study area, assess the palaeontological significance of these rock units, fossil sites or other fossil heritage, comment on the impact of the development on palaeontological heritage resources and make recommendations for their mitigation or conservation, or for any further specialist studies that are required in order to adequately assess the nature, distribution and conservation value of palaeontological resources within the study area.

A **Phase 2 Palaeontological Mitigation** involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or the 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 Phase 2 may be implemented.

A **'Phase 3' Palaeontological Site Conservation and Management Plan** may be required in cases where the site is so important that development will not be allowed, or where development is to co-exist with the resource. Developers may be required to enhance the value of the sites retained on their properties with appropriate interpretive material or displays as a way of promoting access of such resources to the public.

The assessment reports will be assessed by the relevant heritage resources authority, and depending on which piece of legislation triggered the study, a response will be given in the form of a Review Comment or Record of Decision (ROD). In the case of PIAs that are part of EIAs or EMPs, the heritage resources authority will issue a comment or a record of decision that may be forwarded to the consultant or developer, relevant government department or heritage practitioner and where feasible to all three.

4. Details of study area and the type of assessment:

Figure 1: Google Earth photo indicating the study area (white polygon)

The study site is located on the Farms Windhoek and Tanga approximately 25 km north of Louis Trichardt (Makhado Town). The ground surface consists of sandy red soil and characteristic mopane/bushveld vegetation occurs in the study area.

The northerly slope one of the mountain ranges (Mapalione) that forms part of the Soutpansberg Mountains forms the southern border of the farm. The N1 runs along the western border of the farm (Fig. 1).

Colour	Palaeontological Significance	Action
RED	VERY HIGH	Field assessment and protocol for finds are required.
ORANGE	HIGH	Desktop study is required and based on the outcome of the desktop study, a field assessment is likely.
GREEN	MODERATE	Desktop study is required.
BLUE	LOW	No palaeontological studies are required however a protocol for finds is required.
GREY	INSIGNIFICANT / ZERO	No palaeontological studies are required.

Figure 2: Palaeosensitivity map of the study area (black polygon) and surroundings (SAHRA, 2018)

The proposed development will take place in an area that is considered by the South African Heritage Resources Agency (SAHRA) to have range from a Very High to Insignificant Palaeontological Sensitivity (see Fig. 2).

The relevant literature and geological maps for the study area in which the development is proposed to take place, have been studied and a site visit was done as part of a Palaeontological Impact Assessment.

5. Geological setting of the study area

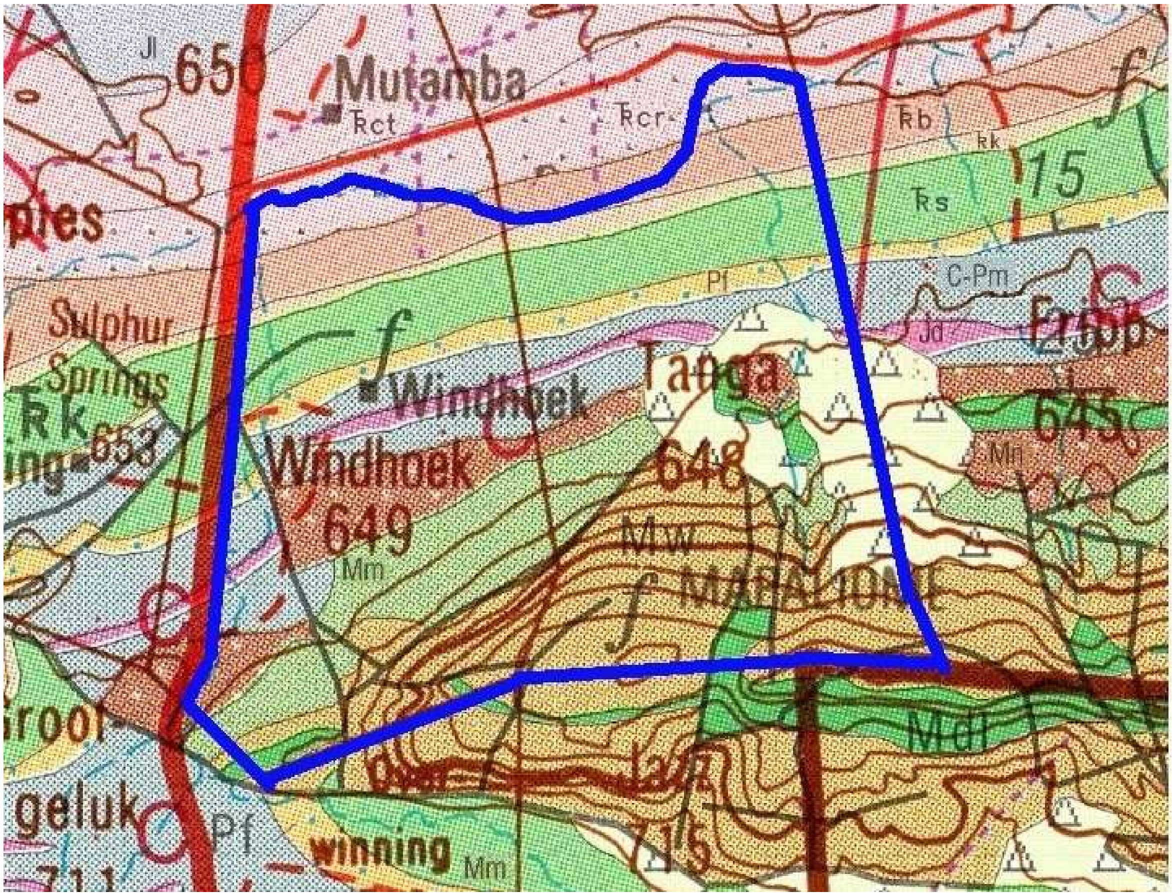

Figure 3: Geology of the study area (blue polygon) and surroundings. Adapted from the 2228 PONT DRIFT 1:250 000 Geology Map (Geological Survey, 2000)

The position and dimentions of the Tshipise Basin were controlled by ENE-WSW faults that followed the movements along the Limpopo Belt. The original basin in which the sediments were deposited was much larger than the present outcrops that are preserved in fault blocks. The geological layers constituting the Tshipise Basin are tilted to the north-northwest like those of the Tuli and the Soutpansberg Basins. The series of narrow strips of Karoo Supergroup rocks with an east-northeast – west southwest orientation that occur in the northern part of the Limpopo Province are the result a series of stepped half-grabens that are the result of the massive block-faulting that occurred in this region (Johnson *et al.*, 2009). One of these strips of Karoo-aged rocks occurs in the study area (Fig. 3).

GEOLOGY LEGEND of the detail of the 2228 PONT DRIFT 1:250 000 Geology Map (Fig.3)

	Lithology	Stratigraphy		Age
	Scree			Quaternary
Jd	Dolerite intrusion			Jurassic
Jl	Basalt, minor andesite, limburgite, rhyolite, tuff	Letaba Formation	Karoo Supergroup	
TRct	Fine-grained, cream coloured, occasionally pinkish sandstone	Tshipise Member of the Clarens Formation		Triassic
TRcr	Fine-grained, mottled red and white, argillaceous sandstone	Red Rocks Member of the Clarens Formation		
TRb	Red siltstone, in places very fine-grained sandstone	Bosbokpoort Formation		
TRk	White feldspathic grit, sandstone, conglomerate	Klopperfontein Formation		
TRs	Multi-coloured shale and mudstone, siltstone, sandstone	Solitude Formation		
Pf	White feldspathic grit, sandstone, conglomerate, in places quarzitic	Fripp Formation		
C-Pm	Mudstone, shale, subordinate micaceous sandstone; Shale, carboniferous shale, siltstone, micaceous sandstone, coal seams; Diamictite.	Mikambeni, Madzaringwe and Tshidzi Formations		Carboniferous to Permian
Mdi	Diabase			Mokolian
Mn	Sandstone, quartzite in places, red shaly sandstone, basalt, tuff, tuffaceous shale, ignimbrite	Nzhelele Formation	Soutpansberg Group	
Mm	Quartzite, sandstone , shale, conglomerate	Musekwa Formation		
Mw	Pink quartzite, sandstone, minor conglomerate, shale, basalt, tuff	Wyliespoort Formation		

Rocks of two geological periods dominate the study site, these are the rock formations of the Soutpansberg Group (Mololian) which is overlain by rock formations of the younger Karoo Supergroup (Permian to Jurassic) (Fig. 3).

The main focus of this report is on the fossiliferous nature of the study site and for that reason the Karoo-aged sedimentary rocks which have a Very High Palaeosensitivity (see Fig. 2) are discussed in more detail than the Soutpansberg Group rocks which have a Low to Moderate Palaeosensitivity.

The stratigraphic terminology used by Brandl (1981) is used in this report because it is generally accepted by the broader geological community and used on geology maps and geology books eg. Johnson *et al*., 2009. Sedimentary geologists (eg. Van den Berg, 1980; Bordy, 2000 and Luyt, 2017), who have conducted their research in this region, have challenged Brandl's attempt to correlate the stratigraphy of the Tuli and Tshipise Basins with that of the Main Karoo Basin and have created an alternative subdivision and chronostratigraphy for some of the Karoo-aged geological units. This approach is supported in this report because it concurs with the fossil evidence. The figure below shows a more recent attempt to correlate the Karoo-aged layers in the different Karoo-aged basins in Southern Africa (Johnson *et al*., 2009).

The Soutpansberg Group is represented in the study site by the Wyliespoort, Musekwa and Nshelele Formations. Sedimentary deposits commenced when volcanic activity in the area subsided. These deposits formed the Fundudzi (not represented in study site) and Wyllie's

Poort Formations (Luyt, 2017). Renewed volcanic activity formed the Musekwa Formation. A period of uplift following this brief volcanic episode, caused the deposition of a thick sequence of clastic sediments which is the Nzhelele Formation (Luyt, 2017).

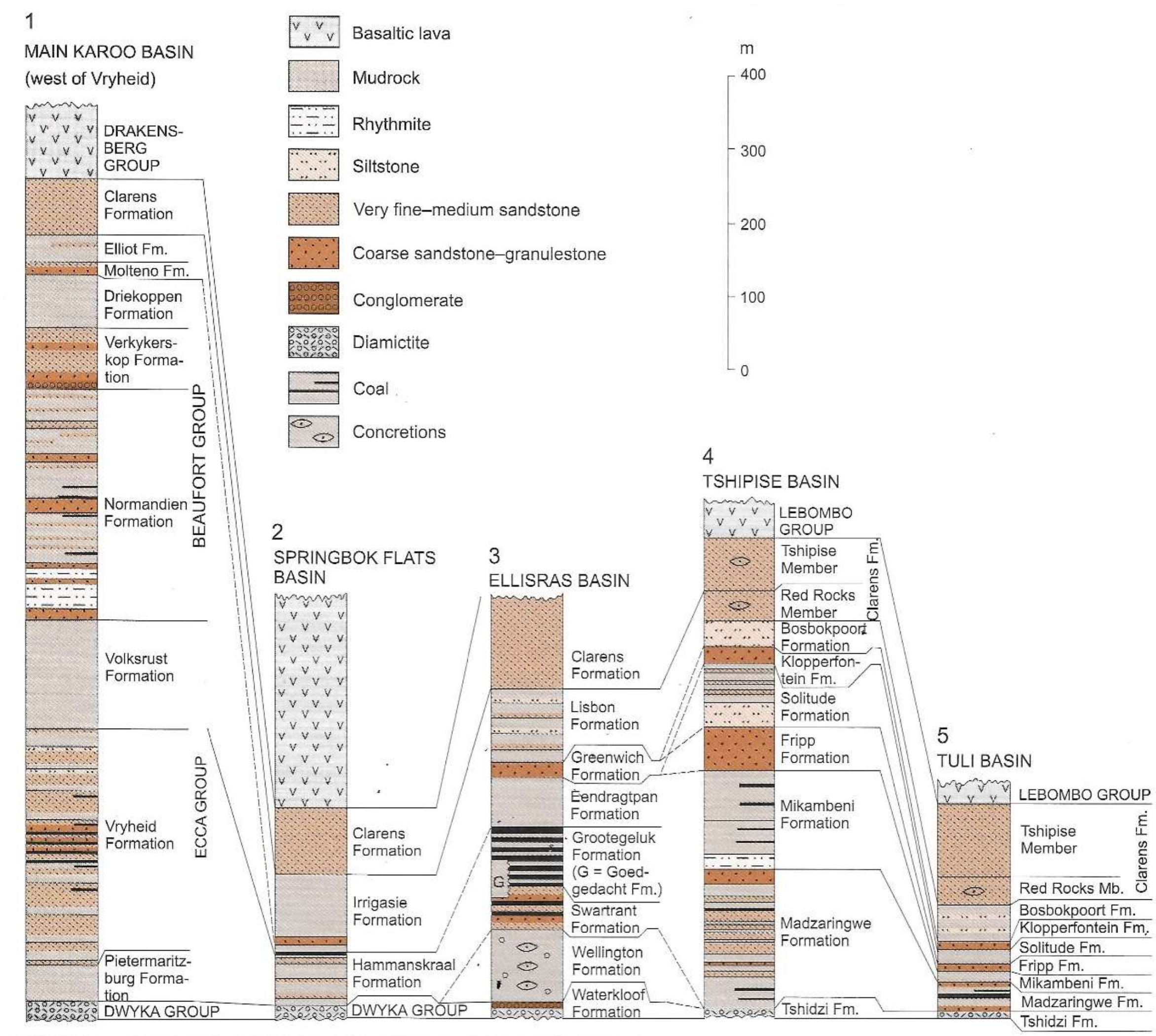

Figure 4: Stratigraphy and correlation of Karoo Supergroup strata in the north-eastern part of the Main Karoo Basin and the Springbok Flats, Ellisras, Tshipise and Tuli Basins (modified after Johnson *et al*., 1996, Fig. 4) (from: Johnson *et al*., 2009)

Tshidzi Formation (Brandl, 1981)
The Tshidzi Formation is equivalent to Sone 1 of Van der Berg (1980). The Tshidzi Formation consists mostly of diamictite with clasts ranging up to 2 m in diameter set in an argillaceous matrix. In places course-grained sandstones are interbedded with the diamictite. Cross-bedding appears in places where the sand content increases. These diamictites and interbedded sandstones were set down in glacial and fluvioglacial (braided stream) environments whereas the argillaceous diamictite may have originated as mud flows (Johnson *et al*., 2009).

Madzaringwe Formation (Brandl, 1981)

The Madzaringwe and Mkabeni Formations together is equivalent to Sone 2 of Van der Berg (1980). The Madzaringwe Formation consist of up to 200 m alternating sandstone, siltstone and shale containing thin coal seams. The sandstone is feldspathic, usually micaceous and usually cross-bedded. Fining-upward cycles occur in these layers. The lower 24-35 m of the formation consists of carbonaceous shale and thin coal seams. The main coal seam is developed between 85 and 100 m above the carbonaceous zone and is 2-3 m thick. A massive, course-grained, micaceous, feldspathic sandstone, 10-15 m thick layer, caps this formation. The sediments of this formation seem to have been set down by meandering rivers flowing from levee and crevasse splay deposits. Plant material that accumulated in flood basins under cool, reducing conditions, gave rise to the coal seams (Johnson *et al*., 2009).

Mikambeni Formation (Brandl, 1981)

This formation comprises mudstones, shales and laminated sandstones in which the following three units can be recognised:

1) Lower 15-20m thick unit, comprising alternating black shale and grey, feldspathic sandstone.
2) Middle 50 m thick unit, comprising dark-grey mudstone with plant fragments and occasional seams of bright coal.
3) Upper 60-70 m thick unit, comprising dark-grey mudstone with plant fragments and occasional seams of bright coal.

The formation attains a maximum thickness of 150 m. The overall fine-grained character of the rocks suggests deposition on the distal floodplains of meandering rivers (Johnson *et al*., 2009)

Major coal seams occur in the sandstone-rich Madzaringwe and overlying Mikambeni Formations (Brandl and McCourt, 1980) which is the reason why the study site is of interest.

The Fripp, Solitude and Klopperfontein Formations are included in the Sone 3 of Van der Berg (1980) and the Middle Unit of Bordy (2000). Van der Berg (1980) describes this 16 – 204 m zone into a basal sandstone unit that grades upwards into mudstone.

Fripp Formation (Brandl, 1981)

The Fripp Formation is the equivalent of the Sandstone Unit of Sone 3 of Van den Berg (1980). In the northeastern part of the basin, the Fripp Formation reaches its maximum thickness of up to 110 m. It comprises medium-to coarse-grained, white, feldspathic sandstone or "grit" with thin pebble layers (Van der Berg, 1980; Johnson *et al*., 2009). Trough cross-bedding is present, and thin siltstone and mudrock beds occur interbedded with the sandstone (Johnson *et al*., 2009). The sandstones were probably deposited by braided streams flowing towards the northwest and west. Thin coal seams occur in this formation in some areas within the Tshipise Basin (Luyt, 2017).

SACS (1980) correlated the Fripp Formation with the Molteno Formation in age while Brandl (1981) and more recently Malaza (2014) consider the Fripp Formation to be of Permian age and part of the Ecca Group (Johnson *et al*., 2009).

The presence of *Dicroidium* fossils in this formation indicate that it probably is a time-equivalent of the Molteno Formation of the Main Karoo Basin and therefore cannot be an equivalent of either the Ecca nor the Beaufort Groups. Van den Berg suggests that the Fripp Formation (his Sone 3) follows discordantly on the coaliferous Permian sediments.

<u>Solitude Formation</u> (Brandl, 1981)
The Solitude Formation is the equivalent of the Mudstone Unit of Sone 3 of Van den Berg (1980). The Solitude Formation mainly comprises of purple mudstones and grey shales. At the type locality 30 m of grey shale is overlain by 80 m of alternating purple and grey mudstone with three intercalated siltstone units. Elsewhere, the bottom part of the lower unit may consist of black shale with occasional bands of bright coal. Greenish or reddish, fine-to coarse-grained sandstones layers, of up to 5 m thick, occur in places. The formation has a maximum thickness of about 170 m. The Solitude Formation presumably represents the overbank deposits of meandering rivers with extensive floodplains. The dark shales and associated coals accumulated in flood basins and marshes under reducing conditions (Johnson *et al*., 2009).

Van der Berg (1980) notes that the upper contact is gradational and consists of upward-fining cyclical units of mud and fine to medium-grained sandstone with a gradual decrease in the argillaceous facies until it ultimately disappears (Luyt, 2017). Brandl (1981) has correlated this unit with the Beaufort Group of the Main Karoo Basin.

<u>Klopperfontein Formation</u>
This unit comprises medium- to course-grained feldspathic sandstone which reaches a maximum thickness of 20 m. Cross-bedding is present, but not well developed. Bordy (2000) considers that the Klopperfontein Formation probably represents a proximal bedload-dominated fluvial wedge associated with fast-flowing braided streams.

<u>Bosbokpoort Formation</u>
The Bosbokpoort Formation is equivalent to Sone 4 of Van den Berg (1980) who correlated it with the Elliot Formation. This formation comprises dominantly red lithologies which vary from mudstone to very fine-grained sandstone. In places where the Klopperfontein Formation is not developed the lower boundary of the Bosbokpoort Formation is placed at the top of the purple mudstone of the Solitude Formation. In boreholes southwest of Tshipise a basal unit, comprising 60 m of dark-red mudstone, is overlain by 40 m of dark-red siltstone grading in places into very fine-grained sandstone. Calcareous concretions is common in both the mudstone and sandstone. The red colours and abundance of concretions suggest deposition on the floodplains of meandering rivers under dry, oxidising conditions (Johnson *et al*., 2009). Bordy (2000) mentions that this formation is rarely exposed owing to the friable nature of the rocks.

<u>Clarens Formation</u>
The Clarens Formation is equivalent to Sone 5 of Van den Berg (1980). The Clarens Formation has been divided into the Red Rocks and Tshipise Members by Brandl (1981).

The Red Rocks Member comprises very fine- and fine-grained, light red, argillaceous sandstone with irregular patches or occasional layers of cream-coloured sandstone. Calcareous concretions are common in this unit. Borehole information from the Tshipise area indicates a maximum thickness of 150 m, but in some areas this member seem to be absent (Johnson *et al*., 2009).

In the type area the Tshipise Member reaches a thickness of 150 m and consists of fine-grained, well-sorted, white or cream-coloured sandstone. Large-scale crossbedding is present, while calcareous concretions are often developed towards the base. The Clarens Formation is generally considered to be aeolian, but water-lain deposits may be present in the lower part of the succession (Johnson *et al*., 2009).

The deposit of sediments in the Tshipise Basin was interrupted by the outpour of basaltic lavas of the Letaba Formation during the early Jurassic – a portion of which can be seen to the north of the study site.

A dolerite dyke runs through the study site, cutting through the basal Karoo-aged deposits (see Fig. 3).

Quaternary deposits in the form of scree occur along the northern face of the mountain in the study site.

6. Site visit

A site visit was conducted on 2 December 2018. The geology of the largest part of the study site is obscured under thick reddish to buff-coloured sand (see Fig. 5). More resistant rocks like that of the Soutpansberg Group and the sandstone of the Clarens Formation (see Fig. 6) were exposed in the study site.

The geological strata are exposed in a bulk test pit on the Farm Tanga (see Fig. 7) and the rock piles (see Fig. 8) provided opportunity for sampling in order to look for fossils (see Fig. 9).

No fossils were found in the rocks at the study site.

Figure 5: The study site is mostly covered in deep red to buff-coloured sandy soils with few outcrops

Figure 6: Clarens Formation sandstone outcrops in northwestern corner of the study site (Farm Windhoek)

Figure 7: Bulk sampling pit on Farm Tanga

Figure 8: Waste rock piles on Farm Tanga

Figure 9: Sample of carboniferous shale on Farm Tanga

7. Palaeontology of the study area

Although no fossils have been reported from the study site and no fossils were found during the site visit, the rocks of the Karoo Supergroup are relatively fossil rich. Fossils have been discovered in the Tuli Basin as well as the northern part of the Tshipise Basin (Van Eeden & Keyser, 1972; Van den Berg, 1980; Brandl & McCourt, 1980; Durand, 1996; 2001, 2005).

Tshidzi Formation (Brandl, 1981)
Van den Berg (1980) reports imprints of wood fragments and scarce *Glossopteris* (see Fig. 10) leaf imprints from this formation and the presence of fossilised worm burrows in mudstones under the coaliferous layers.

Figure 10: *Glossopteris* leaf imprint

Madzaringwe and Mkambeni Formations (Brandl, 1981)
The Madzaringwe and Mkambeni Formations (Brandl, 1981) are considered to be a single unit (Sone 2) by Van der Berg (1980). Van den Berg reports *Vertebraria* (see Fig. 11) as being the most common plant fossil in this geological unit, while scarce *Glossopteris* and *Phyllotheca* (see Fig. 12) imprints, fossilised tree trunks and wood fragments have also been found. Worm burrows are also common in the bioturbated sandstones and siltstones between the coaliferous layers (Van der Berg, 1980).

Fripp Formation (Brandl, 1981)
This formation is the equivalent of the Sandstone unit of Sone 3 of Van den Berg, 1980). Fossils from the Fripp Formation include *Skolithos*-type worm burrows (see Fig. 13) in the sandstone, which erodes out positively as white protrusions on the sandstone surface. Imprints of fossil wood and tree stems are common in the sandstone. Leaf imprints of *Dicroidium* (see Fig. 14) have been reported in the siltstone and sandstones of the Fripp Formation by Visser (1975) and Van der Berg (1980).

Figure 11: Vertebraria fossil (*Glossopteris* stem)
(https://www.google.co.za/imgres?imgurl=http%3A%2F%2Ffossilsaustralia.com%2Fwp-content%2Fuploads%2F2013%2F04%2FGlossopteris-Vertebraria.jpg&imgrefurl=http%3A%2F%2Ffossilsaustralia.com%2Fglossopteris-vertebraria-2%2F&docid=IW1C3sdmGcO8FM&tbnid=ImTt3BOXydwU8M%3A&vet=10ahUKEwjjucnTh4vfAhXuSBUIHbA_CdkQMwg-KAAwAA..i&w=800&h=800&bih=913&biw=1280&q=vertebraria&ved=0ahUKEwjjucnTh4vfAhXuSBUIHbA_CdkQMwg-KAAwAA&iact=mrc&uact=8)

Figure 12: Example of *Phyllotheca* stem leaf whorl
http://www.fossilmall.com/EDCOPE_Enterprises/plants/plfossil74/plant-fossil-74.htm

Figure 13: Example of *Skolithos* worm burrows
https://commons.wikimedia.org/wiki/File:Skolithos_trace_fossils_in_quartzose_sandstone_(Mazomanie_Formation,_Upper_Cambrian;_riverside_cliff,_western_side_of_the_St._Croix_River,_northeast_of_Lookout_Point,_Minnesota,_USA)_1_(18377933714).jpg

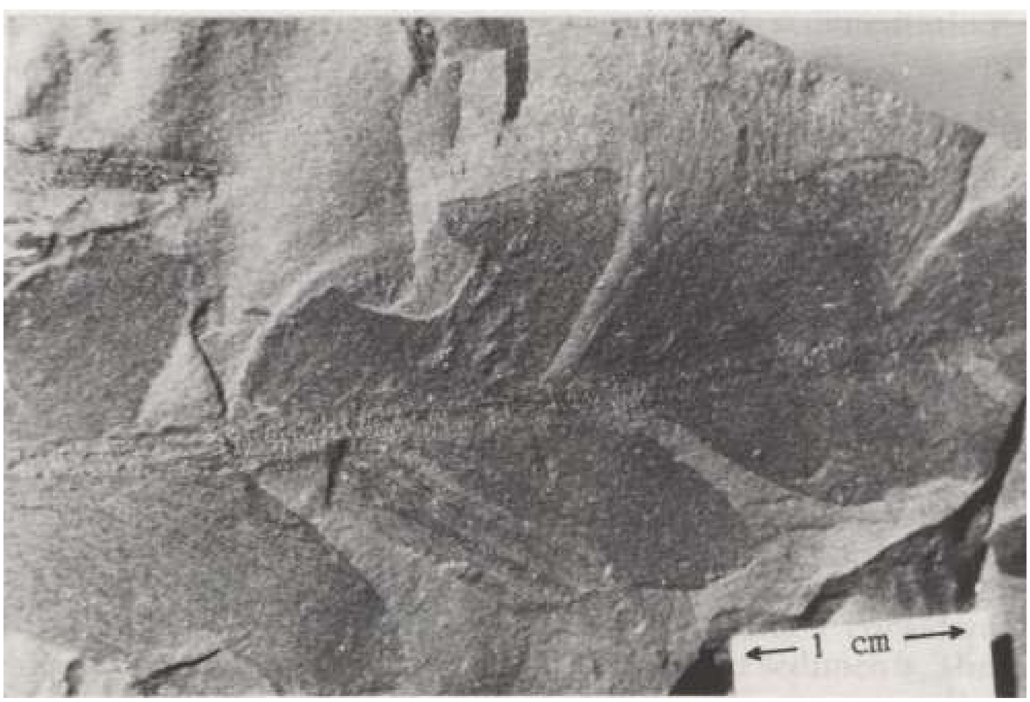

Figure 14: Part of a *Dicroidium* leaf from the Tuli Basin (Visser, 1984)

The presence of *Dicroidium* fossils indicate that this unit is probably a time-equivalent of the Molteno Formation of the Main Karoo Basin and therefore cannot be an equivalent of either the Ecca or the Beaufort Groups. Van den Berg suggests that the Fripp Formation (his Sone 3) follows discordantly on the coaliferous Permian sediments.

Solitude Formation (Brandl, 1981)
This formation is the equivalent of the Mudstone unit of Sone 3 of Van den Berg (1980). The argillaceous layers of this entire geological unit are mostly heavily bioturbated to such a degree that the original bedding cannot be identified. Vertical and horizontal burrowing cylinders (*Skolithos*) have been identified and range from several millimetres to 1 cm in width. Fossils such as *Dicroidium*, *Phyllotheca* and wood fragments have been found in this unit. Root casts are common in the clayey rocks under the coaliferous layers. The presence of *Dicroidium* would rule out the possibility that this unit is a time equivalent of the Beaufort Group of the Main Karoo Basin as has been suggested by Brandl (1981).

Bosbokpoort Formation (Brandl, 1981)
This formation is the equivalent of Sone 4 of Van den Berg (1980) who correlated it with the Elliot Formation. Van der Berg (1980) reports that the whole unit has been subject to bioturbation and that it is sometimes so severe that the original layering of the geological layers is obscured. No other fossils but that of *Skolithos*-type worm burrows have been found in this unit.

Clarens Formation (Brandl, 1981)
This formation is the equivalent of Sone 5 of Van den Berg (1980). This geological formation is renowned for its fossil trackways (see Fig.15) and fossils of dinosaurs (see Fig. 16) and thecodonts (see Fig. 17) in the Tuli and Tshipise Basins (Durand, 1996; 2001). In the Main Karoo Basin fossils of vascular plants, molluscs, arthropods, fish, coprolites, eggs, rare late cynodonts and the earliest mammaliaforms have been discovered in addition to those of dinosaurs and thecodonts (MacRae, 1999; Durand, 2005 and McCarthy & Rubidge, 2005).

Figure 15: Fossil trackways in the Clarens sandstone in the Tuli Basin

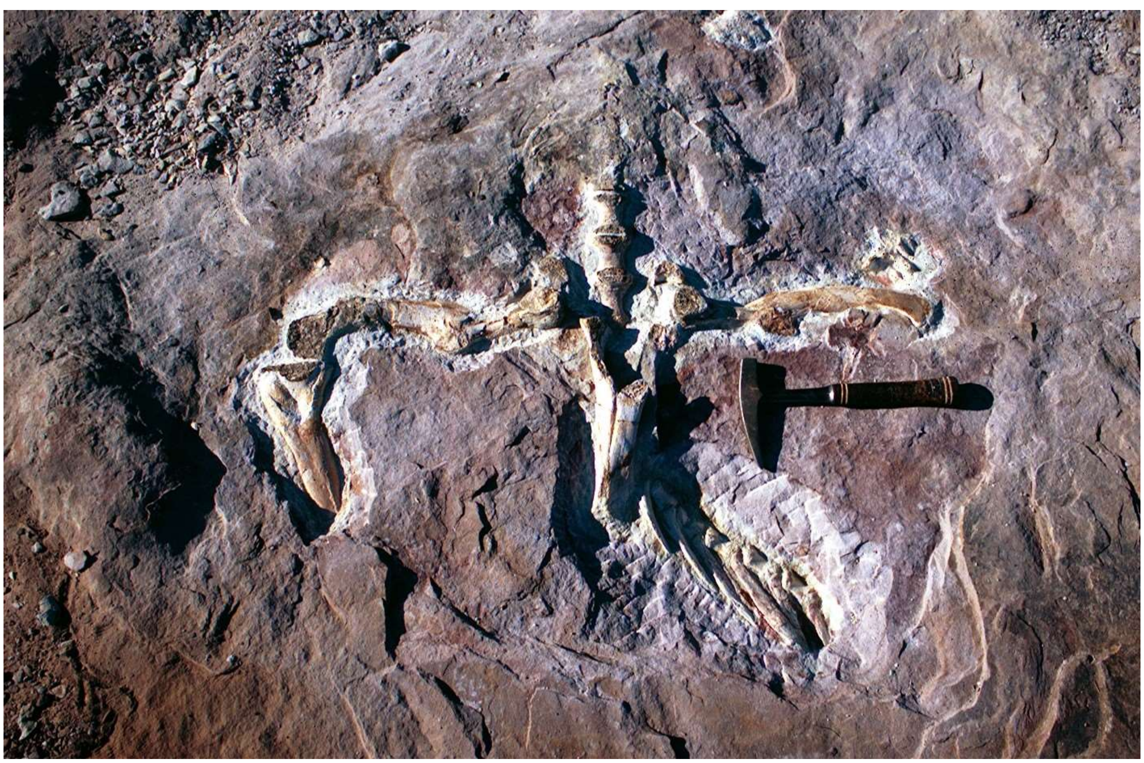

Figure 16: Dinosaur fossil in the Clarens sandstone in the Tuli Basin

Figure 17: Thecondont tooth from the Tuli Basin

SAHRA considers the sedimentary units of the Soutpansberg Group to be of Low to Moderate Palaeosensitivity (see Fig. 2). This is because the earliest known (1.8 Ga) terrestrial cyanobacterial mats were recorded from playa lake deposits in the Waterberg Group on the Makgabeng Plateau, Waterberg (Groenewald, 2014). Although the Soutpansberg Group is older than the Waterberg Group, it is possible that cyanobacterial mats may actually be older than originally thought and one should be aware of the possibility that they could occur in the Soutpansberg sedimentary rock units.

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8. Conclusion and recommendations:

No fossils have been reported from the study site, neither were any fossils discovered during the site visit.

The dolerite dike that runs along the Ecca-aged layers would have had a major thermal metamorphic effect on the adjacent deposits and may have contributed to the paucity of fossils at this site.

Although fossils are scarce in this particular locality, it is not be seen as an indication that no fossils will be discovered here. In fact, the paucity of fossils in this particular area increases the importance of preserving any fossil that will aid in understanding the sedimentology and chronostratigraphy of the rocks in this area.

In the event of significant fossils (bones, fossil leaves, petrified wood) being discovered at the study site, the ECO should follow the Chance Find Procedure. Although disturbed fossils should be collected and stored safely until a palaeontologist can inspect it, no attempt should be made to remove such accidentally discovered fossils from the rock by an unqualified person.

SAHRA should be notified immediately during such an event. A palaeontologist should then be employed by the developer in order to implement the correct mitigation procedure which will include the recording of the site, advice about the storage and protection of fossils from further damage and if necessary, the salvaging of the fossils by a qualified palaeontologist with the necessary excavation permit from SAHRA.

PROCEDURE FOR CHANCE PALAEONTOLOGICAL FINDS

Extracted and adapted from the National Heritage Resources Act, 1999 Regulations Reg No. 6820, GN: 548.

The following procedure must be considered in the event that previously unknown fossils or fossil sites are exposed or found during the life of the project:

1. Surface excavations should continuously be monitored by the ECO and any fossil material be unearthed the excavation must be halted.

2. If fossiliferous material has been disturbed during the excavation process it should be put aside to prevent it from being destroyed.

3. The ECO then has to take a GPS reading of the site and take digital pictures of the fossil material and the site from which it came.

4. The ECO then should contact a palaeontologist and supply the palaeontologist with the information (locality and pictures) so that the palaeontologist can assess the importance of the find and make recommendations.

5. If the palaeontologist is convinced that this is a major find an inspection of the site must be scheduled as soon as possible in order to minimise delays to the development.

From the photographs and/or the site visit the palaeontologist will make one of the following recommendations:

a. The material is of no value so development can proceed, or:

b. Fossil material is of some interest and a representative sample should be collected and put aside for further study and to be incorporated into a recognised fossil repository after a permit was obtained from SAHRA for the removal of the fossils, after which the development may proceed, or:

c. The fossils are scientifically important and the palaeontologist must obtain a SAHRA permit to excavate the fossils and take them to a recognised fossil repository, after which the development may proceed.

7. If any fossils are found then a schedule of monitoring will be set up between the developer and palaeontologist in case of further discoveries.

9. Declaration of Independence:

I. Jacobus Francois Durand declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

<u>Palaeontological specialist</u>:
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