

Proposed diamond mine adjacent to Venetia Mine, Limpopo Province

SCOPING REPORT PALAEONTOLOGY

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For:

G&A Heritage

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1. Introduction

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.

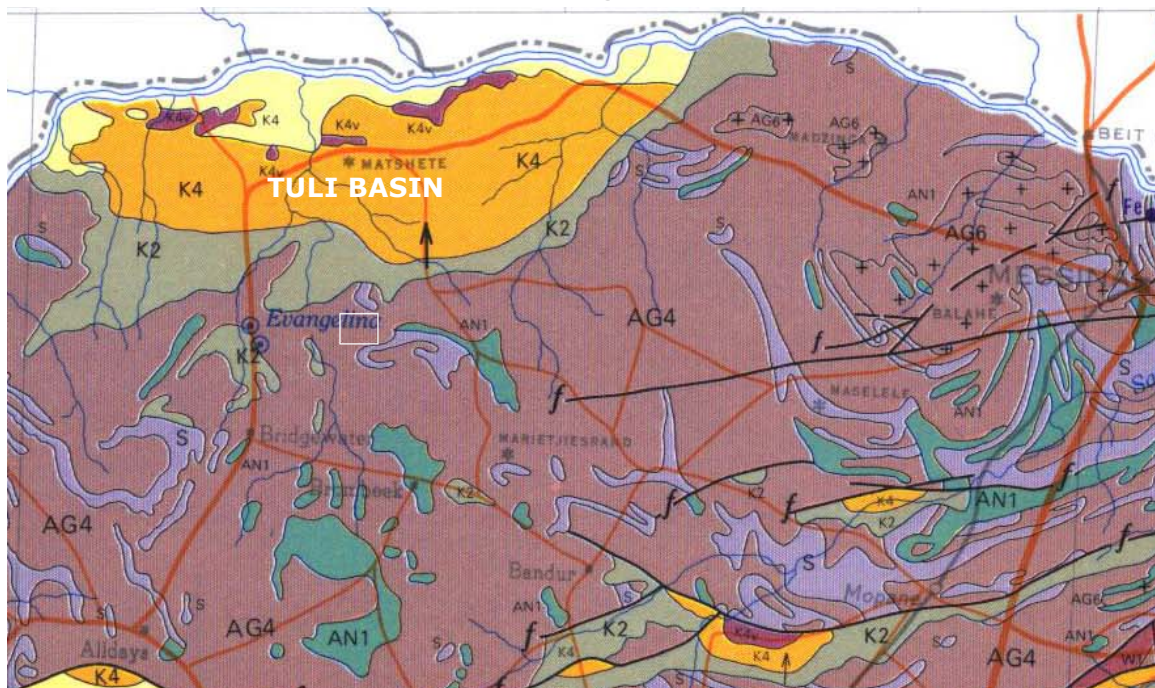
The palaeontological heritage of South Africa is unsurpassed and can only be described in superlatives. The South African palaeontological record gives us insight in *inter alia* the origin of dinosaurs, mammals and humans. Fossils are also used to identify rock strata and determine the geological context 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 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.

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. It follows logically that South African palaeontological institutions would be world renowned, the fossil collections would be vast and the Heritage Act would be one of the most sophisticated and best considered in the world.

This is a Scoping Report which was prepared 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 palaeontologist evaluates the scope of the project and as part of the assessment process gives an overview of the literature on the palaeontology and associated geology of the area. Although no publications which mention palaeontological studies that were done in the study area, several palaeontological studies were done on the areas to the north and south of the study site (De Jager 1983, Kovacs-Endrödy, 1983; Bordy & Catuneanu, 2002; Durand, 2005).

2. Broad description of the Geological formations found in the area



		Legend	
Map description		Brandl, 2002	Main Karoo Basin equivalent
	Unconsolidated superficial deposits, conglomerate, marl, limestone, sandstone, high-level gravel		
K4v	Basalt, limburgite, pyroclasts, minor sandstone	Letaba Formation	Drakensberg Formation
K4	Sandstone, shale, mudstone, marl, coal	Clarens Formation Bosbokpoort Formation Klopperfontein Formation Solitude Formation Fripp Formation	Clarens Formation Elliot Formation equivalent (lithologies differ) Molteno Formation
K2	Shale, sandstone, grit, coal	Mikambeni Formation Madzaringwe Formation Tshidzi Formation	Ecca Group Dwyka Group
AG4	Migmatite, gneiss, ultrametamorphic rocks	Limpopo belt of metamorphism and granitization	
AN1	Ultrabasic and basic intrusions and their metamorphic derivatives	Archaean complex	

Figure 1: Geological map of the Far North in the Limpopo Province indicating the locality of the study site (white block). Adapted from the 1: 1 000 000 Geology Map for South Africa, Lesotho and Swaziland, Geological Survey, 1970)

The Limpopo Metamorphic Belt which igneous and metamorphic rocks were overlain by Karoo sediments from approximately 240 million years ago. Subsequently, after the break-up of Gondwana, the Karoo layers were significantly reduced due to erosion which in places exposed the older non-fossiliferous rock strata as is the case in the study area. Some pockets of Karoo sediments which may be fossiliferous, remain to the south of the Tuli Basin.

The Main Karoo Basin, which covers more than 50 % of the surface of South Africa, can be subdivided into the Dwyka, Ecca and Beaufort Groups. The layers overlying the Beaufort Group can be subdivided into the Molteno, Elliot and Clarens Formations which are in turn overlain by the Drakensberg Basalts (Johnson *et al.*, 1996).

In the northern part of the Limpopo Province and in Mpumalanga the Karoo Supergroup is much attenuated and incomplete compared to the Main Karoo Basin to the south. The Karoo-aged rocks occur mainly in two areas in the Limpopo Province named the Tuli and Tshipise Basins with minor outliers between them. The study area lies to the south of the Tuli Basin. The geology of the Tuli Basin is dominated by sedimentary rock with some occurrences of igneous rocks in the form of basalt and dolerite (see Figures 1, 3).

The sedimentary sequences of the Tuli Basin were set down on top of the Beit Bridge gneisses in a small intercratonic graben-type depression before the break up of Gondwanaland (Brandl, 2002). The basal Karoo sediments in the Tuli Basin, known as the Tshidzi Formation (Dwyka Group equivalent), consist of angular blocks and fragments derived mainly from much older underlying strata imbedded in coarse sand and grit. These diamictite deposits are overlain by channel deposits in the form of coarse reddish micaceous grits which pass upward into the laminated shale of the Madzaringwe Formation (Ecca Group equivalent).

The Madzaringwe Formation consists primarily of shales with occasional lenses of red and yellow grits in the lower sequences. Higher up in the sequence the shales alternate rhythmically with coal seams which constitute a 20 m thick coal zone. The model which best describes the processes responsible for such a sequence would be a marsh that was periodically flooded. If this model is correct the coal consists primarily from autochthonous plant material as would be suggested by the occurrence of root impressions and *Vertebraria* fossils (Van den Berg, 1980). The top of the Madzaringwe Formation is marked by point bar and channel-lag deposits forming a coarse micaceous sandstone layer which may be up to 10m thick (Brandl, 2002).

The Mikambeni Formation (Ecca Group equivalent) consists of shales and siltstones identical to those forming the Madzaringwe Formation. This 15m thick sequence was formed in a shallow lacustrine environment. This sequence contains carbonaceous shales and small coal seams in places. *Glossopteris* fossils are found in a buff-coloured siltstone unit near the top of the Mikambeni Formation (Brandl, 2002). The *Glossopteris* fossils indicate a Middle Ecca age (Kovacs-Endrödy, 1983).

It seems as if the Beaufort Group (Late Permian-Triassic) age strata are missing in the Karoo sedimentary sequence in the Limpopo Province (Van Zyl, 1950). The late Triassic to early Jurassic rocks therefore unconformably overlies the Ecca Group sedimentary rocks (Permian) in the Limpopo (Van den Berg, 1980).

The Fripp Formation which lies between the Mikambeni Formation and the overlying Solitude Formation consists of a 5-10 m thick coarse-grained layer of sandstone. The sand originated from strongly uplifted granitoid rocks and were set down as point bars and channel lag deposits. The Solitude Formation consists of siltstone which is typical of distal flood plain overbank and natural levee deposits. In the west it is up to 25m in thickness but attenuates to 3.5 m in the east (Brandl, 2002).

The Kloppefontein Formation separates the Solitude Formation and the overlying Bosbokpoort Formation for most of its extent. It consists of coarse-grained poorly sorted sandstone and grit with occasional conglomeratic horizons. This unit is characterised by trough cross-bedding. The grain size of the sediments and the sedimentary environment would suggest that this unit was formed during the continued upliftment of the hinterland, heavy erosion of the scarps during scarp formation and the proximal deposition of coarse sediments in fast running braided river systems (Brandl, 2002). This 10-12 m unit was identified as a local contemporary of the Molteno Formation of the Main Karoo Basin (De Jager, 1983).

The Bosbokpoort Formation consists of up to 60m of red to purple mudstones alternating with minor white siltstones in the upper half. The sedimentary environment is described as flood plains with meandering streams. A semi-arid climate would have caused the oxidization of the sediments, the formation of calcareous nodules and surface limestone (Brandl, 2002).

The 200m thick Bosbokpoort Formation is overlain by the Clarens Formation which has been subdivided into the Red Rocks Member and the Tshipise Member (McCourt & Brandl, 1980). The 20m thick Red Rocks Member consists mainly of white to red argillaceous sandstones deposited in distal flood-plain overbank and natural levees environments that are associated with mature meandering streams. A 5 m thick mudstone layer, identical to the mudstones in the Bosbokpoort Formation, near the top of this sequence contains prosauropod dinosaur bones. A 1-3 m thick calcareous layer containing fossil bone fragments underlies the Tshipise Member in places (Brandl, 2002).

The Tshipise Member which varies considerably in thickness (5-140m) abruptly overlies the Red Rocks Member. This member is characterised aeolian sand with large-scale cross-bedding typical of desert environments with barchan dunes with occasional water-deposited sediments associated with playa lakes. Ichnofossils have been found in this unit. The Letaba Formation, consisting of basaltic lavas overlies the Clarens Formation, marking the end of the Karoo sedimentation (Brandl, 2002).

3. Geological setting of the study area

The purpose of this section is not meant to be a report on the geology of the study area. For that a geological report is required from a specialist geologist. This intention of this section is to describe the geological setting for the palaeontology of the area within which the study site falls.

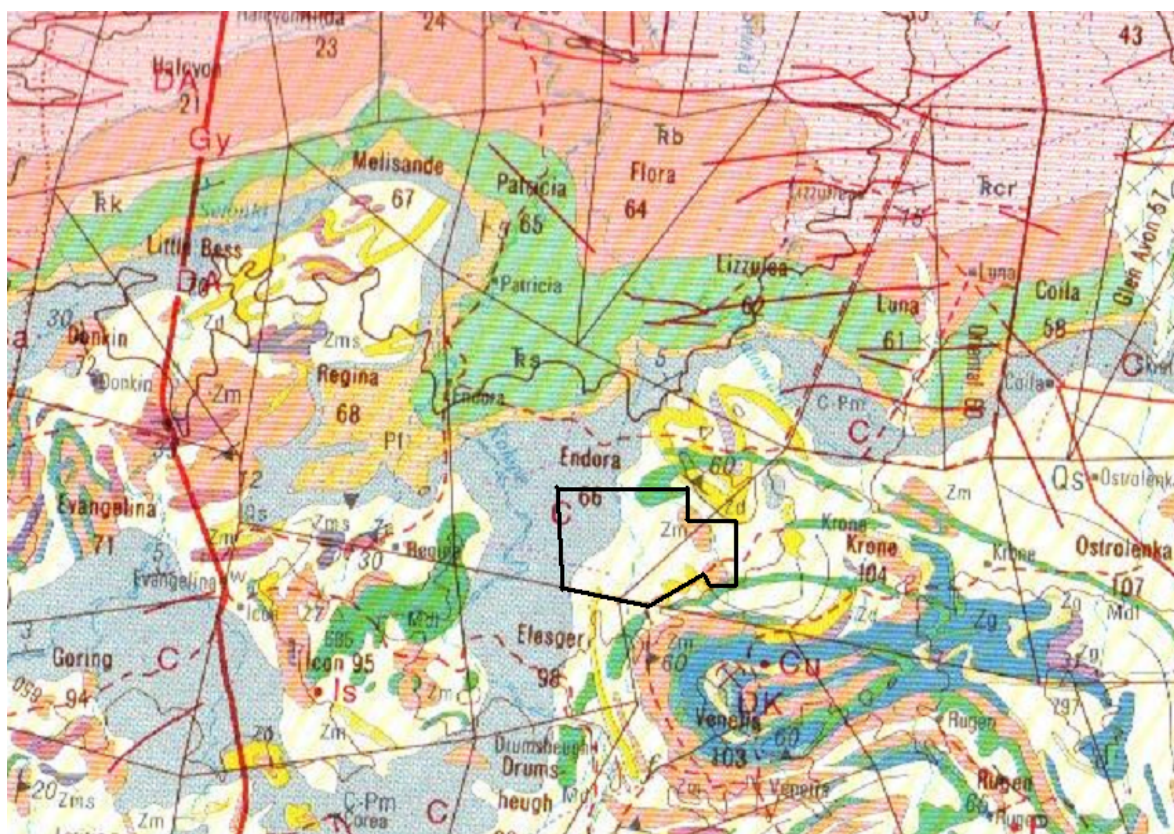
According to the 2228 ALLDAYS 1:250 000 Geology Map (Council for Geoscience, 2000) the study site is situated in an area dominated by migmatite, gneiss and

ultrametamorphic rocks of the Limpopo Metamorphic Belt and sediments of the Tuli Block of the Karoo Supergroup (Figure 2).

The Eccra Group is characterized by shale, mudstone, sandstone and seams of coal (Johnson, et al., 2006). In the Tuli Basin, the Eccra Group is represented by the Mikambeni and the Madzaringwe formations. The near horizontal layering of the geological strata and erosion of the adjacent and underlying rock strata results in a gently undulating landscape covered to a great extent by sandy soil. Exposures of the underlying geology are therefore exceptionally scarce in the Limpopo Province

Karoo and are mostly limited to gullies, river banks and road cuttings. However, when mining commences, large amounts of fossiliferous rock may be uncovered such as at the coal mines such as those in Mpumalanga and the Limpopo Province.

The Eccra Group of the Karoo Supergroup contain vast amounts of Permian leaf imprints of plants such as *Glossopteris* in places (Kovács-Endrödy, 1991). Millions of tons of fossiliferous material yielding mostly *Glossopteris* leaf imprints have been exposed at well studied sites in the northern rim of the main Karoo Basin such as Hammanskraal (Kovács-Endrödy, 1976), Witbank (Bamford, 2004) and Vereeniging (Rayner, 1986) and the ferromanganese mine at Ryedale (Pack et al., 2000).








LEGEND FOR THE STUDY AREA		
Lithology		
	Qs : Sandy soil	Quaternary
	C: Mudstone, shale, carbonaceous shale, sandstone, conglomerate, coal seams, diamictite	Dwyka & Eccca Groups
	Mdl: Diabase	Intrusion
	Zm: Leucocratic quartzo-feldspathic gneiss, metaquartzite, pink granitoid hornblende gneiss, felsic granulite, metaperlite, amphibolite or mafic granulite and marble or calc-silicate rocks	Malala Drift Group
	Zd: Metaquartzite. Magnetic quartzite, leucocratic quartzo-feldspathic gneiss, metaperlite, amphibolite or mafic granulite and marble or calc-silicate rocks.	Mount Dowe Group

Figure 2: Geological map indicating the study site (adapted from the 2228 ALLDAYS 1:250 000 Geology Map, Council for Geoscience, 2000)

The fossilised leaf imprints are not found ubiquitously throughout the Eccca Group, but in pockets where the physical and chemical conditions during deposition resulted in the preservation of not only the structure of the leaves but also in some cases the organic material itself. The structure of the fossilised leaves is better preserved in the shales than in the sandstone units.

The study site (Figure 3) is mostly covered in sandy soils (Figure 3) and fossil localities are very scarce in this region. The plant fossil site on the grounds of the adjacent Venetia Mine yielded only very fragmentary fossils. This site, approximately 2km north of the study site, was however on the surface in a shallow gully and was exposed to the elements which would have contributed to its deteriorated state.



Figure 3: Google Earth view of the study site indicated with a white pin. The yellow pin indicate Venetia mine on the south eastern border of the study site

4. Palaeontology of the Tuli Basin

Although no published records of site locations of fossils in the study area exist, certain geological strata (i.e. the fossiliferous Madzaringwe and Mikambeni Formations of the Tuli Basin) that occur to the north of adjacent to the study area are known to be fossiliferous. The available literature shows that the Karoo strata of the Limpopo Province are exceptionally rich in fossils. Several palaeontological sites have been reported from the Tuli Basin in South Africa and Zimbabwe and from the Tshipise Basin (Van den Berg, 1980; Kovacs-Endrödy, 1983; Durand, 1996; 2001; 2005; Brandl, 2002).

These fossils fall mainly into two groups: firstly, the plant leaf imprints, stem fossils and coal from the lower part of the Karoo-age sedimentary succession (Middle Permian) and secondly, the dinosaur and thecodont fossils from the upper part (Late Triassic to Early Jurassic) of the Karoo-age sedimentary succession.

Fossil leaf imprints were found in the Tuli Basin sedimentary rocks on the Venetia mine grounds, to the east of the study area in the Tshipise Basin, and to the north of the study area in southern Zimbabwe. The fossils from the Tuli Basin are mainly leaf imprints of the extinct plant *Glossopteris*. (See Figure 4). However, stem imprints of the horsetail *Equisetales* and leaf imprints of ferns are also common. The fossil localities reported in the Tuli Basin are contemporaneous to those in the Tshipise Basin described by Van den Berg (1980) and studied by the author in the Njalaland section of the Kruger National Park, Tshikondeni Mine, Venetia Mine and the farm Nottingham in southern Zimbabwe. The species composition of the fossils and the lithologies of the palaeontological sites are similar in the Tuli and Tshipise Basins (Brandl, 2002).

The most recent taxonomic work on the Middle Permian fossil plants of the Tuli Basin was done by Kovacs-Endrödy in 1983 who identified 37 *Glossopteris* species from the Mikambeni Formation (Brandl, 2002).



Figure 4: Leaf imprint of *Glossopteris* (Middle Permian)

5. Legislation related to Palaeontology

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 from 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.

6. Recommendations

Part of the mitigation will include the collection of fossils that may be exposed during mining in the western part of the study. In the unlikely event of vertebrate fossils being found in this area, they would have to be salvaged due to their complexity, rarity and scientific importance.

Most of the geology in the study site is presently covered by alluvium consisting mainly of sandy soils and the bedrock will only be exposed during excavations during the mining process. If plant fossils are excavated during mining or construction it could simply be collected from the spoil heaps periodically by a qualified palaeontologist. For this reason it is important that a palaeontologist should visit the mine periodically in order to salvage representative and scientifically important fossils if necessary.

It is recommended that these fossils, if there are any, should be housed in an acknowledged repository such as the Council for Geoscience (CGS), Transvaal Museum or the Bernard Price Institute for Palaeontology.

7. Conclusion

The occurrence of geological strata with a palaeontological content in the region necessitates the inclusion palaeontology in the EIA of the study site. The relevant literature and research done by the author indicate that there could be fossils in the study site which may be encountered when construction and mining commences.

A qualified palaeontologist who is registered with SACNASP should be appointed to collect fossils if any are found during excavation.



Specialist:

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BSc Botany & Zoology (RAU), BSc Zoology (WITS), Museology Dipl. (UP),
Higher Education Diploma (RAU), PhD Palaeontology (WITS)

Experience:

Palaeontological assessments:

- Urban development in the COHWHS: Letamo, Honingklip, Windgat, Sundowners, Ekutheni
- Urban development at Goose Bay, Vereeniging
- Upgrade of R21 between N12 and Hans Strydom Drive
- Vele Colliery, Limpopo Province
- De Wildt 50 MW Solar Power Station Gauteng
- 10 MW PV Plant Potchefstroom
- Omega 342 50MW Solar Power Station, Viljoenskroon
- Solar power plant, Bethal

Palaeontological research:

- Gauteng: Wonder Cave (COHWHS)
- KwaZulu/Natal: Newcastle, Mooi River, Rosetta, Impendle, Himeville Underberg, Polela & Howick Districts, Sani Pass
- Eastern Cape: Cradock District, Algoa Basin
- Western Cape: Clanwilliam District
- Free State: Memel & Warden Districts
- Limpopo Province: Nyalaland (KNP), Vhembe Reserve, Pont Drift
- Zimbabwe: Sentinel Ranch, Nottingham

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