VELE COLLIERY PROJECT

DESK TOP STUDY
PALAEONTOLOGY

Compiled by: Dr JF Durand (Sci.Nat.)

For:
Vele Colliery, Musina District
09 March 2009

Executive Summary

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

Southern Africa is world renowned for its rich and scientifically important fossil heritage. The National Heritage Resources Act (NHRA - Act No. 25 of 1999) of South Africa stipulates that fossils and fossil sites may not be altered or destroyed.

An overview of the literature on the palaeontology and associated geology of the area is given. Although no publications exist of palaeontological studies that were done in the study area, several palaeontological studies were done on the areas to the north, east and south of the study area. The results of these studies enable us to predict that these fossiliferous strata exist within the study area due to the association of certain fossils with certain geological strata.

Recommendations on the minimizing of the impact on palaeontological sites and the treatment of palaeontological objects impacted upon during building and mining operations are given.

This report points out the probability of finding fossils on the terrain. The accuracy of these predictions can only be verified during a ground truthing exercise. It is imperative that one or more palaeontologists be involved in the process, firstly to identify the fossils *in situ* and secondly to salvage the fossils exposed both before and during excavation.

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List of Abbreviations

EIA	Environmental Impact Assessment
KNP	Kruger National Park
RSA	Republic of South Africa
SACNASP	South African Council for Natural Scientific Professions
SAHRA	South African Heritage Resource Agency
Sci. Nat.	Natural Scientist

1. Introduction to the importance of palaeontology in the northern part of the Limpopo Province

It is important to include palaeontology in an EIA of the study area because of the prevalence and importance of palaeontology in the northern part of the Limpopo Province. This is especially the case with Vele Colliery which will be situated in the Ecca age strata which is by nature fossiliferous, and secondly due to its proximity to other fossiliferous sites.

Palaeontology forms part of our unique national heritage and is therefore protected by the National Heritage Resources Act (NHRA - Act No. 25 of 1999). The South African Heritage Resources Agency (SAHRA) has to approve the proposed construction of the infrastructure and the open cast mine where an impact will occur on a palaeontological site.

It is possible to use the geology of the region to predict where fossiliferous areas may be encountered due to the correlation between the fossils with certain geological strata. The literature and personal experience of excavations to the north, west and east of the study area would suggest that the geological formations in the study area are fossiliferous.

2. Background and brief from Vele Colliery

The establishment and operation of an open cast coal mine on the Limpopo River will entail the construction of buildings, roads, pipelines, powerlines and other infrastructure, the removal of vegetation and top soil and ultimately the excavation of millions of tons of coal and rock. All these activities may have a detrimental impact on fossils and fossiliferous strata in the study area (Figure 1). Fossils could potentially be exposed, damaged and destroyed in the process.

It is necessary to identify the nature and extent of the fossiliferous strata in the study area that would be impacted upon by the proposed colliery. Since coal seams are the remains of prehistoric plants, it is inevitable that coal mining would impact on the fossiliferous strata between the coal seams. It is however possible to salvage some of these fossils for the purposes of scientific studies, educational material and tourism purposes.

Due to the association of the fossils with certain geological strata, it is possible to use the geological information to predict where fossils will be found in the study area. The study area is dominated by Ecca age rocks noted for its fossiliferous nature (Figure 2). The majority of these fossils consist of leaf impressions although petrified and coalified tree trunks and stems are known from the area.

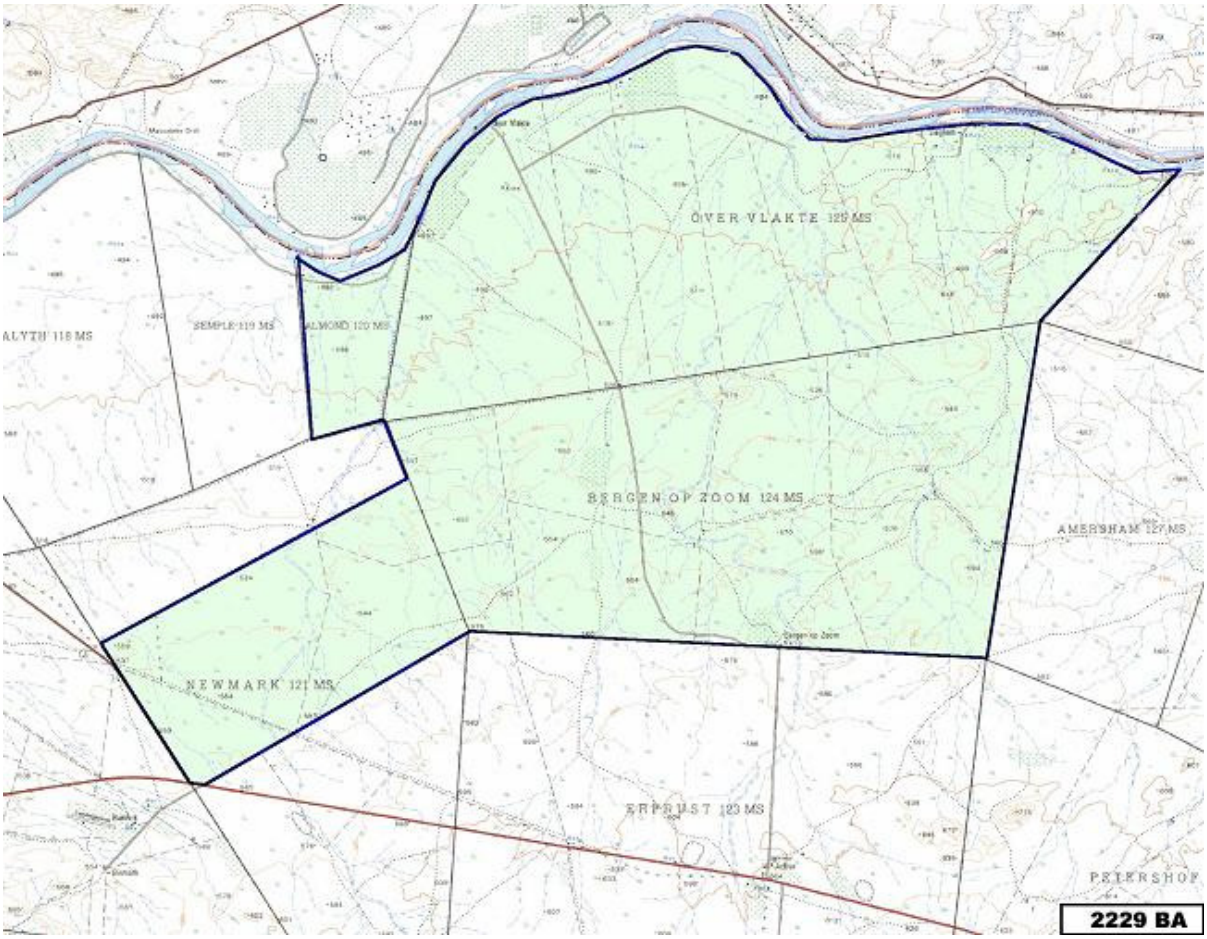


Figure 1: Map of the study area

3. Geological setting

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 Blocks with minor outliers between them. The study area lies on the eastern limit of the Tuli Block. The geology of this region is dominated by sedimentary rock with some occurrences of igneous rocks in the form of basalt and dolerite (see Figure 2).

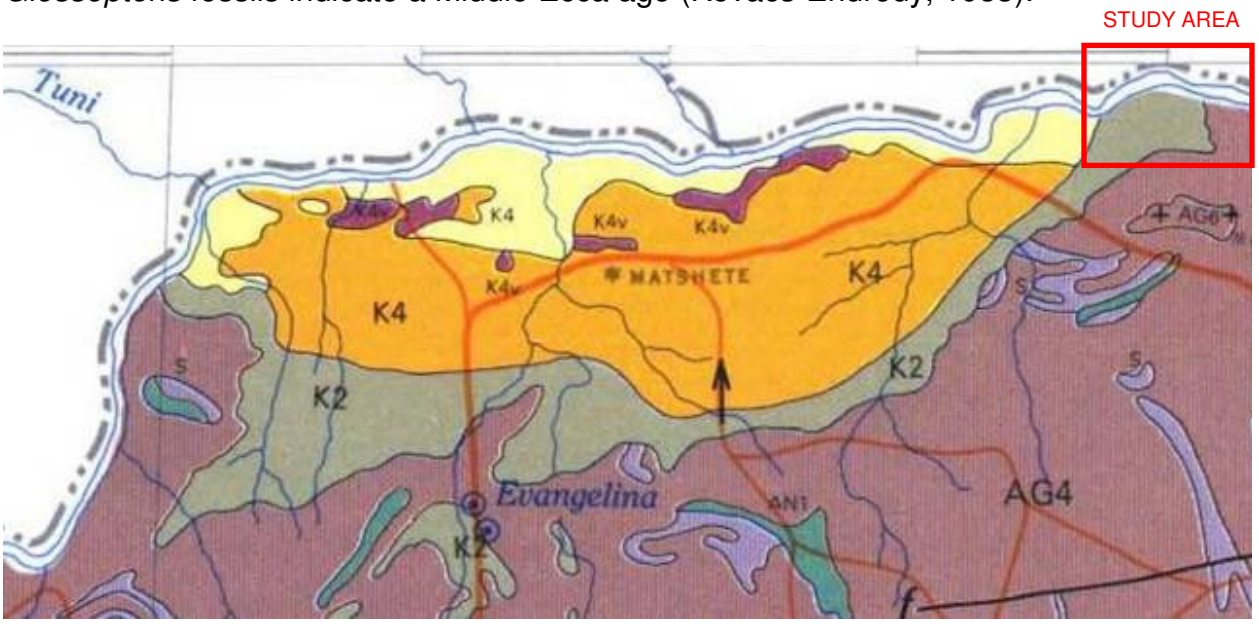
The sedimentary sequences of the Tuli Block were set down on top of the Beit Bridge gneisses in a small intercratonic graben-type depression before the break up of Gondwanaland. This depression formed part of an east-west trending aulacogen which formed the third arm of the triple junction with the Lebombo basin which in turn is the southern extent of the African Rift Valley. The basalts were set down on top of the sedimentary sequence during the break up of Gondwanaland (Brandl, 2002).

The basal Karoo sediments in the Tuli Block, known as the Tshidzi Formation, consist of angular blocks and fragments derived mainly from much older underlying strata imbedded in course 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.

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 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).



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

Figure 2: Geology of the Tuli Basin in South Africa (Geological Survey of the RSA, 1970)

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 Klopperfontein 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 of the 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).

4. Palaeontology of the Tuli Block

Although no published records of site locations of fossils in the study area exist, certain geological strata that occur in 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 Block in South Africa and Zimbabwe and from the Tshipise Block (Van Eeden & Keyser, 1971; Van den Berg, 1980; Durand, 1996; 2001; 2005; Brandl, 2002).

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

Fossil leaf imprints were found in the Tuli Block sedimentary rocks to the south of the study area on the Venetia mine grounds, to the east of the study area in the Tshipise Block, and to the north of the study area in southern Zimbabwe. The fossils from the Tuli Block are mainly leaf imprints of the extinct plant *Glossopteris* (see Figure3). However, stem imprints of the horsetail *Equisetales* and leaf imprints of ferns are also common. The fossil localities reported in the Tuli Block are contemporaneous to those in the Tshipise Block 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 Blocks (Brandl, 2002).

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

Figure 3: Leaf imprint of *Glossopteris* (Middle Permian)

Fossilised wood and *Vertebraria* fossils were reported from the Middle Permian strata in the Tshipise block (Van den Berg, 1980) and observed in Nyalaland in

the KNP by the author. This type of fossilised wood has been identified as *Dadoxylon* in the past. The current opinion is that *Dadoxylon* is the petrified trunks of trees that bore *Glossopteris*-type leaves (see Figure 4). *Vertebraria* fossils on the other hand are the more resistant fibres contained in the roots of this plant that were preserved in the fossil record (Arens *et al*., 1998).

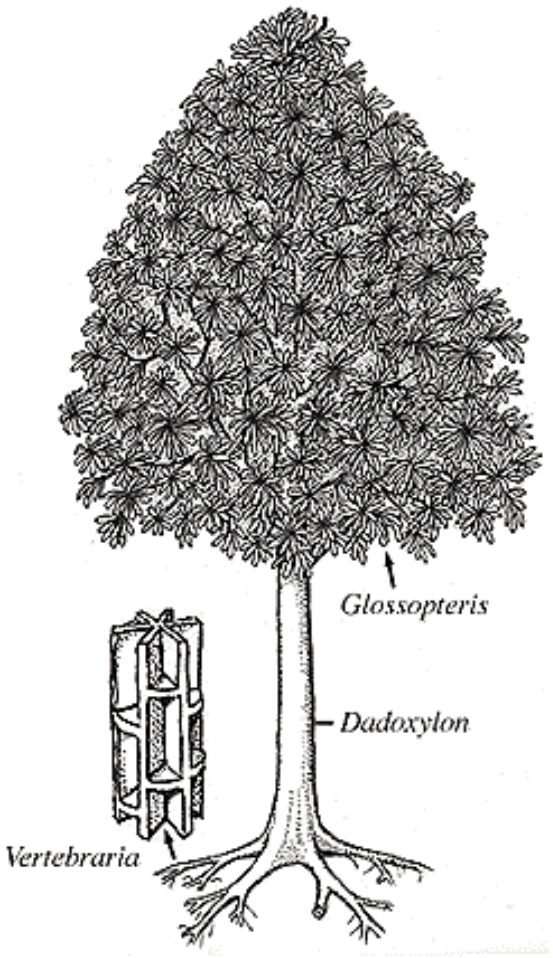


Figure 4: Reconstruction of *Glossopteris*, *Vertebraria* & *Dadoxylon* tree (from: Arens *et al*., 1998)

The late Triassic to Early Jurassic strata of the Tuli and Tshipise Blocks contain dinosaur and thecodont fossils and one known palaeosurface (Figures 5, 6 & 7). The fossils in these layers are scientifically very important and need to be excavated and collected for research purposes or preserved *in situ*.

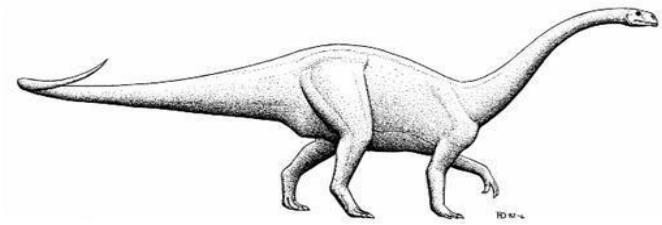
Euskelosaurus, the oldest of the South African dinosaur genera (Figure 5), and one of the oldest on earth, has been found in Nyalaland in the north of the KNP and on the Tshikondeni Mine grounds to the west of Nyalaland (Durand, 1996; 2001). The lithostratigraphy of the sites in which they were found is identified as the Solitude Formation (Council for Geoscience, 2000; Brandl, 2002).

The Solitude Formation occurs to the northwest of the study area and there is a strong possibility that similar fossils would be discovered there once the overburden is removed and the bedrock is exposed.

The fossil locality in Nyalaland in the KNP contained not only the largest known assemblage of *Euskelosaurus* fossils, but also the oldest baby dinosaurs on earth (Durand, 2001). The scientific importance of *Euskelosaurus* is exceptionally high. *Euskelosaurus* is very scarce, it is one of the oldest dinosaurs on earth, thus giving us an insight in the evolution of dinosaurs, and the discovery of the oldest baby dinosaurs on earth gives us an insight into dinosaur reproductive behaviour.

Baby Euskelosaurus fossils from the KNP

Euskelosaurus fossils from the KNP



Euskelosaurus reconstruction

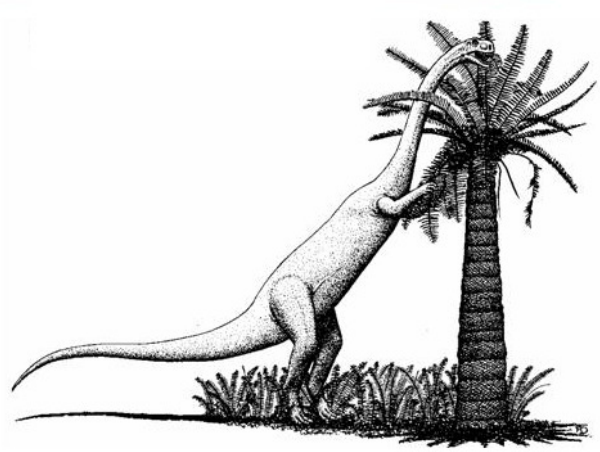
Adult and juvenile Euskelosaurus vertebrae

Figure 1: *Euskelosaurus* fossils from the Solitude Formation (Late Triassic) in the KNP.

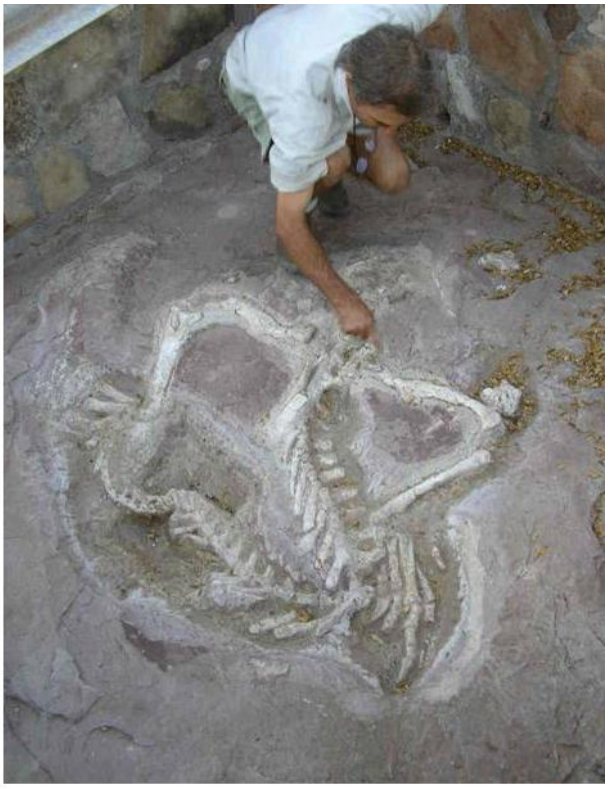
The slightly younger prosauropod dinosaur *Massospondylus* (Figure 6) have been discovered in the Clarens Formation in the KNP, the Vhembe Reserve adjacent to the study area and on Sentinel Ranch in southern Zimbabwe (Durand, 2005) to the north of the study area. Some thecodont remains were also found on Sentinel Ranch. The unique palaeosurface in the Clarens Formation sediments on the Limpopo River at Pontdrift contains the trackways of dinosaurs and possibly the earliest record of the existence of snakes (Van Eeden & Keyser, 1971, Durand 2005).

From these studies it can be concluded that the same fossils could be found in Clarens Formation strata in the northwestern part of the study area, currently overlain by alluvium.

Thecodont tooth



Massospondylus reconstruction



Massospondylus skeleton

Figure 2: Thecodont and *Massospondylus* fossils found in the Clarens Formation (Early Jurassic) in Tuli Block in the Limpopo Province and Zimbabwe.

5. Legislation related to Palaeontology

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 National Heritage Resources Act (NHRA - Act No. 25 of 1999) would be one of the most sophisticated and well considered in the world.

According to the National Heritage Resources Act (NHRA - Act No. 25 of 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.

6. Recommendations

6.1. Recommendations to be considered during the Environmental Impact Assessment

During the EIA it is essential that the study area be investigated thoroughly by a qualified palaeontologist registered with SACNASP to determine the fossiliferous nature of the geological strata exposed in the study area. It is also necessary for a palaeontologist to plan the best strategy for the salvaging of the surface fossils, which may begin before construction takes place.

6.4 Recommendations to be considered during the Construction and Mining Phase

Part of the mitigation will include the collection of fossils that are exposed during the excavation and building phases. Due to their complexity, rarity and scientific importance, vertebrate fossils exposed during excavations have to be salvaged by means of excavations however. Although no distances from fossil sites are prescribed by South African legislation it would be advisable to skirt extremely exceptional fossiliferous sites such as palaeosurfaces which may be encountered.

It will be impossible to avoid encountering fossiliferous horizons during mining in a colliery because of the alternating nature of coal and fossiliferous mudstone and shales. It is foreseen that in most cases the plant fossils exposed during the construction and mining phases could simply be collected from the spoil heaps.

Most of the fossiliferous layers are presently covered by alluvium and non-fossiliferous geological strata and will only be exposed during excavations during construction and the mining process. For this reason it is important that a palaeontologist should visit the mine on a regular basis in order to salvage representative and scientifically important fossils exposed.

It is significant that the dinosaur-bearing strata overlie the coal bearing strata. When permission is granted for open cast mining these layers will be stripped away in the northwestern part of the study area to expose the underlying coal bearing strata. It is important that vertebrate fossils should be salvaged from these areas before mining commences.

It is recommended that these fossils 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 necessitates the inclusion palaeontology in the EIA of the study area. The relevant literature and research done by the author indicate that there are fossils in the study area which will be encountered when construction and mining commences.

Due to the fact that specific fossils are associated with specific geological strata, the geology of the study area could be used as indicator where the fossiliferous areas could be expected.

A qualified palaeontologist who is registered with SACNASP should be appointed to inspect the palaeontologically sensitive sites during the EIA and during the construction and mining phases.

In most cases a salvage operation to remove the fossils from the affected area should be sufficient. The fossils may only be excavated and collected by a trained palaeontologist, registered with SACNASP and with a permit from the SAHRA.

The scarcity and scientific importance of dinosaur and thecodont fossils necessitates their excavation by the palaeontologist either before or, where necessary, during the construction or mining phases.

Fossil sites could be developed in tourism attractions or for teaching purposes. Fossils excavated during construction could be displayed at museums with appropriate acknowledgement of the mining company.

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Specialist:
Dr JF Durand
BSc Botany & Zoology (RAU), BSc Zoology (WITS), Museology Dipl. (UP), Higher Education Diploma (RAU), PhD Palaeontology (WITS)

Experience:
Palaeontological assessments:

- COHWHS: Letamo, Honingklip, Windgat, Sundowners
- Vereeniging: Goose Bay

Palaeontological research:

- Gauteng: Wonder Cave
- 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

Dr JF Durand (Sci. Nat.)

SPECIALIST REPORT:

PALAEONTOLOGICAL ASSESSMENT OF OVERVLAKTE 125 MS AND NEWMARK 121 MS, MUSINA DISTRICT

Client: Vele Colliery
Date: 11 April 2009

Methodology:
A surface survey of the rocky outcrops was done on the farms Overvlakte 125 MS and Newmark 121 MS in Musina District on 7-9 April 2009. In the event of the discovery of any fossiliferous material, the position of such a locality would have been recorded by GPS and the site would have been photographed.

Scope:
The Karoo age strata in this region, which form part of the Tuli Basin, consist of the Ecca Series which is overlain unconformably by the Fripp Formation. The Fripp Formation is followed by the Solitude Formation, the Klopperfontein Formation, the Bosbokpoort Formation and the Clarens Formation. The fossiliferous nature of the Solitude, Klopperfontein, Bosbokpoort and Clarens Formations are of importance due to its fossiliferous nature. Previous palaeontological studies in the Tshipise and Tuli Basins have shown that the Ecca Series contain plant fossil horizons alternating with coal seams and that the Solitude, Bosbokpoort and Clarens Formations vertebrate, including dinosaur fossils. Due to the relative scarcity and the scientific importance of the vertebrate fossils, the palaeontological survey of the area focused mainly on the Solitude and Bosbokpoort Formations.

Results:
The survey was limited to dry river beds and the outcrop on the farms Overvlakte and Newmark where the Solitude and Klopperfontein Formations occur in the region. The geology of the area is mostly obscured by soil cover. One of the few outcrops where the Klopperfontein Formation is exposed in the study area is on the farm Newmark. An east-west orientated doleritic dyke runs across the farm Newmark. The red silt- and mudstone of the Klopperfontein Formation adjacent to the doleritic dyke had been baked in this region and is therefore more resistant to weathering than that of the areas further to the south and north. No fossiliferous material was found *in situ* in the outcrop or weathered out in the alluvium below the outcrop. The dry river beds on Overvlakte and Newmark which run across the Solitude and Klopperfontein Formations did not yield any fossils either.

Recommendations:
From previous studies the presence of vertebrate fossils in the Tuli Block the Solitude, Klopperfontein and Clarens Formations contain vertebrate fossils. When the soil cover is stripped in the region and these formations are opened, vertebrate fossils will probably be exposed.

Part of the mitigation will include the collection of fossils that are exposed during the excavation and construction phases. Due to their complexity, rarity and scientific importance, vertebrate fossils exposed during excavations have to be salvaged by means of excavations. It is essential that these fossils are excavated and taken to an approved fossil repository after exposure. The excavation and collection of fossils must be done by a trained palaeontologist registered with SACNASP.

Most of the fossiliferous layers are presently covered by alluvium and non-fossiliferous geological strata and will only be exposed during excavations during construction and the mining process. For this reason it is important that a palaeontologist should visit the mine on a regular basis in order to salvage representative and scientifically important fossils exposed. It will be impossible to avoid encountering fossiliferous horizons during mining in a colliery because of the presence of plant fossils. It is foreseen that in most cases the plant fossils exposed during the construction and mining phases could be collected from the spoil heaps on a regular basis.

It is also suggested that a workshop be presented to the mining personnel and contractors who would be responsible for construction and mining on the palaeontology of the area and what fossils could be expected in the area. This will hopefully prevent the unnecessary destruction of fossils.

Acknowledgements:
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Specialist:
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Experience:
Palaeontological assessments:

- Cradle of Humankind World Heritage Site and surroundings: Letamo, Honingklip, Windgat, Sundowners; Goose Bay (Vereeniging); R21 (Pretoria to Boksburg); Buffalo Feldspar (Makopane District).

Palaeontological research:

- Gauteng: Wonder Cave
- KwaZulu/Natal: Bergville, 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, Pont Drift
- Zimbabwe: Sentinel Ranch, Nottingham

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