Zebediela Nickel Mine Project

Mogalakwena Local Municipality, Waterberg District Municipality, Limpopo Province

Farm: Portions of Uitloop 3-KS, Piet Potgietersrust Town and Townlands 44-KS, Amamtava 41-KS, Bloemhof 4-KS

Fourie, H. Dr

heidicindy@yahoo.com

012 322 7632/012 942 0110 x 1057

Palaeontological Impact Assessment: Phase 1: Field Study

Facilitated by: Exigo Sustainability (Pty) Ltd

Postnet Suite 74, Private Bag X04, Menlo Park, 0102

Tel: 012 751 2160

2019/07/25

Ref: LP30/5/1/2/2/1017MR

B. Executive summary

Outline of the development project: Exigo Sustainability (Pty) Ltd has facilitated the appointment of Dr H. Fourie, a palaeontologist, to undertake a Paleontological Impact Assessment (PIA), Phase 1: Field Study of the suitability of Zebediela Nickel Mine Project on various portions of the Farm Uitloop 3-KS, Piet Potgietersrust Town and Townlands 44-KS, Amatava 41-KS and Bloemhof 4-KS, within the Mogalakwena Local Municipality, Waterberg District Municipality in the Limpopo Province.

The applicant, Lesego Platinum Uitloop (Pty) Ltd is planning to extract mainly nickel and possibly platinum group minerals (PGM's) and associated minerals (platinum, palladium, rhodium, gold, ruthenium, iridium, osmium, copper, cobalt and chromite), iron ore and vanadium from magnetite via an opencast conventional truck and shovel operation..

The Project includes several Options (see google.earth image):
Total area: An area blocked in black approximately 9 km north-east of the town of Mokopane, to the east and west of the Percy Fyfe Road. The nearest settlement is Mahwelereng B. The Mining Right Area is approximately 4660.9 hectares in size.
Overburden and stockpile facilities 4 Options, Processing Plant 3 Options and Tailings Storage Facility (TSF) 4 Options.

Legal requirements:-

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.

"palaeontological" means any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or traces.

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

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

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

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

Outline of the geology and the palaeontology:
The geology was obtained from map 1:100 000, Geology of the Republic of South Africa (Visser 1984) and the 1:250 000 (2428) Geological Map Nylstroom (Du Plessis 1978).¨

Figure 2: The geology of the development area.

Legend to Map and short explanation.
Vl – Melanorite, pyroxenite, serpentinized harzburgite, chromite layer [·−−·] (green). Lower zone, Rustenburg Layered Suite, Bushveld Complex. Vaalian.
Vt – Shale, hornfels, subordinate schist: [::] Nooitgedacht Quartzite Member (brown). Time Ball Hill, Pretoria Group, Transvaal Supergroup. Vaalian.
Vd – Limestone, dolomite, chert, shale, quartzite, diamictite, hornfels, and conglomerate (purple [::]). Duitschland Formation, Chuniespoort Group, Transvaal Supergroup. Vaalian.
Vmd – Dolomite, chert [=] (blue), Malmani Subgroup, Chuniespoort Group, Transvaal Supergroup. Vaalian.
Vbr – Quartzite, shale, sandstone, volcanic rocks (dark blue). Black Reef Formation. Vaalian.
Rg – Leucocratic grey biotite granite-gneiss, leucocratic granite and pegmatite (pink). Randian.

Zp – Acid to intermediate lava, pyroclasts (dark purple). Zwazian.
---f--- – (black) Fault.
⊥ 30 - Strike and dip of bed.
…… – Linear structure (Landsat and aeromagnetic).
------ - Concealed geological boundary.
□ – Approximate position of hatchery (in white on the Figure).

The Transvaal Supergroup fills an east-west elongated basin in the south-central part of the old Transvaal (now North – West, Gauteng and Mpumalanga) as far south as Potchefstroom. It is Vaalian in age, approximately 2600 Ma to 2100 Ma. A maximum thickness of the Transvaal Supergroup reaches 2000 m in the north-eastern section. The east-west elongated basin is filled with clastic, volcanic and chemical sedimentary rocks. Three groups based on lithological differences have been established: they are the Rooiberg, Pretoria and Chuniespoort Groups as well as other smaller groups (Kent 1980, Snyman 1996). It is the Bushveld Complex that is responsible for the tilting of the Transvaal sediments and the heat of its intrusion having created andalusite crystals (Norman and Whitfield 2006). This Supergroup is underlain by the Ventersdorp, Witwatersrand and Pongola Supergroups, and the Dominion Group. Three prominent ridges are present from the oldest to the youngest, the Time Ball Hill, Daspoort and Magaliesberg Formations (Norman and Whitfield 2006).

The Chuniespoort Group is made up of chemical and biochemical sediments such as dolomite, chert, limestone and banded iron formation, carbonaceous shale is also present. At the top of the Malmani Subgroup is the Duitschland Formation underlain by the Penge and Monte Christo Formations. Sandstone is mostly absent. It is this formation that has great economic value for its lead, zinc, dolomite, and manganese (Kent 1980, Snyman 1996). Fluorspar, concrete aggregate, iron ore and manganese is also mined from this formation. Cave formation in the dolomite is a major concern in developing areas, especially in the 1500 m thick dolomite of the Malmani Subgroup. Chemical sediments such as fine grained limestone and dolomite is made up of deposits of organically derived carbonate shells, particles or precipitate. Dolomite is magnesium-rich limestone formed from algal beds and stromatolites. The Black Reef Formation is known for stromatolite carbonates and fossiliferous Late Cenozoic cave breccias similar to the Malmani dolomite.

Palaeontology - 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 sedimentary rocks the palaeontological sensitivity can generally be **LOW** to **VERY HIGH**, and here locally **HIGH** for the Chuniespoort Group (SG 2.2 SAHRA APMHOB, 2012).

Stromatolites are likely to be present in the dolomites. These structures range from a centimetre to several tens of metres in size. They are the result of algal growth in shallow water, indicating a very rich growth that would have caused an enrichment in the amount of oxygen in the atmosphere. Stromatolites are significant indicators of palaeoenvironments and provide evidence of algal growth between 2640 and 2432 million years ago (Groenewald and Groenewald 2014).

Summary of findings **(1d):** The Palaeontological Impact Assessment: Phase 1: Field Study was undertaken in July 2019 in the winter in dry and mild conditions (Appendix 6 of Act, 1(d)), and the following is reported:

The development will partly sit on the dolomite and chert of the Chuniespoort Group, Transvaal Supergroup. Alternative Options are proposed. Areas with dolomite present on the surface should be avoided if possible. There are two formations in the development area that contains chert and dolomite namely, the Malmani Subgroup and the Duitschland Formation.

Recommendation:
The impact of the development on fossil heritage is **HIGH** and therefore a field survey or further mitigation or conservation measures may be necessary for this development (according to SAHRA protocol) if fossils are found during excavating, digging or blasting.

Table 2: Criteria used (Fossil Heritage Layer Browser/SAHRA).

Rock Unit	Significance/vulnerability	Recommended Action
Chuniespoort Group	High	Desktop study is required and based on the outcome of the desktop study, a field assessment is likely.

The Project includes several Options (see google.earth image):
Total area: An area blocked in black approximately 9 km north-east of the town of Mokopane, to the east and west of the Percy Fyfe Road. The nearest settlement is Mahwelereng B. The Mining Right Area is approximately 4660.9 hectares in size.
Overburden and stockpile facilities 4 Options, Processing Plant 3 Options and Tailings Storage Facility (TSF) 4 Options.

Concerns/threats (**1g,1ni,1nii,1o,1p**) to be added to the EMP'r:

1. Threats are earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction, digging of foundations, the sealing-in, disturbance, damage or destruction of the fossils by development, vehicle traffic, and human disturbance.
2. The overburden and inter-burden must always be surveyed for fossils during construction or mining. Special care must be taken during the digging, drilling, blasting and excavating of foundations, trenches, channels and footings and removal of overburden during construction not to intrude upon fossiliferous layers. This should be overseen by an Environmental Control Officer.
3. Care must be taken during the dolomite risk assessment according to SANS 1936-1 (2012) as stromatolites may be present.

Recommendations:

1. Mitigation may be needed if a fossil is found, in this case, the area must be fenced off with a no-go barrier of 30 m (Appendix 3).
2. No consultation with parties was necessary.
3. The development may go ahead with caution, if a fossil is found, all construction must stop, and SAHRA must be notified. The Environmental Control Officer must familiarise him- or herself with the Malmani Subgroup fossils.
4. As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to monitor 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. Therefore, the EMPr must be updated to include the involvement of a palaeontologist (for training of ECO and in an advisory capacity). The ECO together with the mine geologist must survey for fossils after blasting, digging and excavation (ground breaking).

Stakeholders: Developer – Lesego Platinum Uitloop (Pty) Ltd.
Environmental – Exigo Sustainability (Pty) Ltd, Postnet Suite 74, Private Bag X04, Menlo Park, 0102.
Tel. 012 751 2160.
Landowner – Several private.

C. Table of Contents

D. Background information on the project

Report

This report is part of the environmental impact assessment process under the National Environmental Management Act, as amended (Act No. 107 of 1998) (NEMA) and includes Appendix 6 (GN R326 7 April 2017) of the Environmental Impact Assessment Regulations (see Appendix 2). It is also in accordance with the SG 2.2 SAHRA APMHOB Guidelines, 2012. Minimum standards for palaeontological components of Heritage Impact Assessment Reports, Pp 1-15.

Outline of development

This report discusses and aims to provide the developer with information regarding the location of palaeontological material that will be impacted by the development. In the pre-construction or construction phase it may be necessary for the developer to apply for the relevant permit from the South African Heritage Resources Agency (SAHRA / PHRA).

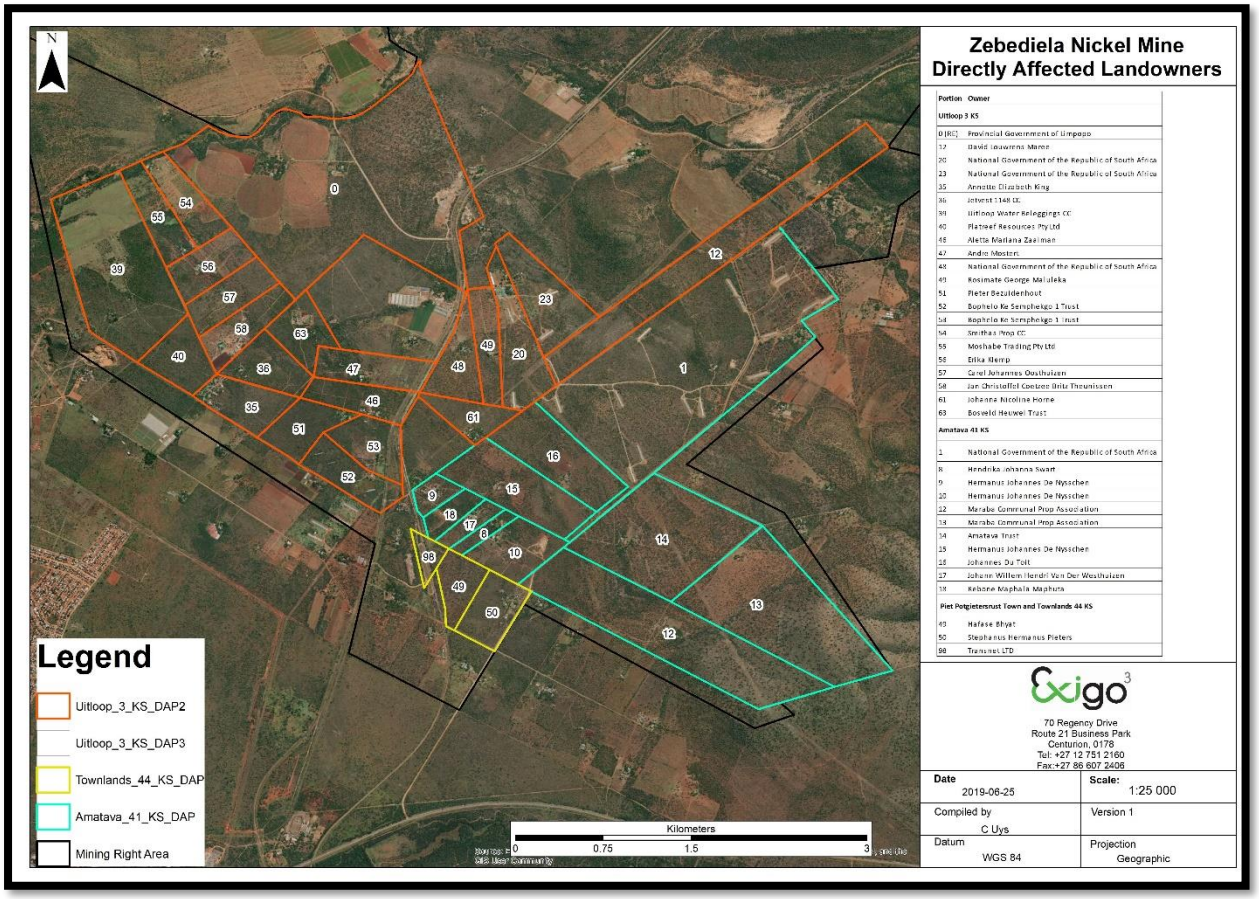
The applicant, Lesego Platinum Uitloop (Pty) Ltd is planning to extract mainly nickel and possibly platinum group minerals (PGM's) and associated minerals (platinum, palladium, rhodium, gold, ruthenium, iridium, osmium, copper, cobalt and chromite), iron ore and vanadium from magnetite nickel as well as magnetite as a by-product via an opencast conventional truck and shovel operation. Blasting will also take place as part of the mining process.. The entire proposed mining right area is approximately 4660.9 hectares (ha), however the open pit and mine infrastructure will occupy a smaller footprint (approximately 350 ha) of the larger area.

The following is proposed:

- Open Pit
- Processing Plant
- Ore handling and storage facilities (ROM stockpiles)
- Administration building, security building, change house, messing and canteen facilities, mining and geology offices, maintenance and engineering workshops and offices, warehouse and offices, medical station, fire station, laboratory and satellite ablutions
- Potable water tank and reticulation

- Process water dam and process water tanks and reticulation
- Electricity distribution facilities (overhead powerlines, transformers and mini substations)
- Hydrocarbon storage facilities
- Sewage treatment plant & Sewage reticulation
- Water treatment plant
- Pollution Control Dam (PCD)
- Haul and access roads and bridges
- Perimeter and internal fencing
- Overburden and topsoil storage facilities
- Tailings Storage Facility (TSF) & Return Water Dam
- Explosives Store
- .

Figure 1: Map of directly affected farm portions (Exigo).



The Project includes several Options (see google.earth image):
Total area: An area blocked in black approximately 9 km north-east of the town of Mokopane, to the east and west of the Percy Fyfe Road. The nearest settlement is Mahwelereng B. The Mining Right Area is approximately 4660.9 ha in size.
Overburden and stockpile facilities 4 Options, Processing Plant 3 Options and Tailings Storage Facility (TSF) 4 Options.

<u>Rezoning/ and or subdivision of land:</u> From Agriculture.

Name of Developer and Environmental Consultant: Lesego Platinum Uitloop (Pty) Ltd and Exigo Sustainability (Pty) Ltd.
Terms of reference: Dr H. Fourie is a palaeontologist commissioned to do a palaeontological impact assessment to ascertain if any palaeontological sensitive material is present in the development area. This study will advise on the impact on fossil heritage, provide mitigation or conservation measures necessary, if any.
Dr Fourie obtained a Ph.D from the Bernard Price Institute for Palaeontological Research (now ESI), University of the Witwatersrand. Her undergraduate degree is in Geology and Zoology. She specialises in vertebrate morphology and function concentrating on the Therapsid Therocephalia. She is presently employed by Ditsong: National Museum of Natural History as the Curator of fossil invertebrate, plant, fish, amphibia, reptile, Therapsid and dinosaur collections. For the past 13 years she carried out field work in the Western Cape, Eastern Cape, North West, Northern Cape, Limpopo, Mpumalanga, Gauteng and Free State Provinces. Dr Fourie has been employed at the Ditsong: National Museum of Natural History in Pretoria (formerly Transvaal Museum) for 25 years.
Legislative requirements: South African Heritage Resources Agency (SAHRA) for issue of permits if necessary. In terms of the National Heritage Resources Act (Act No. 25 of 1999), an electronic copy of this report must be supplied to SAHRA for comment.

E. Description of property or affected environment

Location and depth:
The Zebediela Nickel Mine Project will be located on Portions of the Farm Uitloop 3-KS, Piet Potgietersrust Town and Townlands 44-KS, Amatava 41-KS and Bloemhof 4-KS, within the Mogalakwena Local Municipality, Waterberg District Municipality in the Limpopo Province.

Depth is determined by the related infrastructure to be developed, and the thickness of the formation in the development area, such as foundations, footings and channels. Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to determine due to thick topsoil, subsoil, overburden and alluvium. Geological maps do not provide depth or superficial cover, it only provides mappable surface outcrops.

The thickness of the dolomite is 1500 m. and it is present on the surface in this area. The top 40 m to 50 m of the disseminated sulphide material is oxidized (Oxide Zone) and will be stockpiled on an overburden facility. Soill depth in the project area ranges between 50 mm and more than 1200 mm depending on the soil form. The opencast pit will be 220 m deep.

The Project includes several Options (see google.earth image):
Total area: An area blocked in black approximately 9 km north-east of the town of Mokopane, to the east and west of the Percy Fyfe Road. The nearest settlement is Mahwelereng B. The Mining Right Area is approximately 4660.9 hectares in size.
Overburden and stockpile facilities 4 Options, Processing Plant 3 Options and Tailings Storage Facility (TSF) 4 Options.

F. Description of the Geological Setting

Description of the rock units:
The Transvaal Supergroup fills an east-west elongated basin in the south-central part of the old Transvaal (now North – West, Gauteng, Limpopo and Mpumalanga) as far south as Potchefstroom. It is Vaalian in age, approximately 2600 Ma to 2100 Ma. A maximum thickness of the Transvaal Supergroup reaches 2000 m in the northeastern section. The east-west elongated basin is filled with clastic, volcanic and chemical sedimentary rocks. Three groups based on lithological differences have been established: they are the Rooiberg, Chuniespoort, and Pretoria Groups as well as other smaller groups (Kent 1980, Snyman 1996). It is the Bushveld Complex that is responsible for the tilting of the Transvaal sediments and the heat of its intrusion having created

andalusite crystals (Norman and Whitfield 2006). This Supergroup is underlain by the Ventersdorp, Witwatersrand and Pongola Supergroups, and the Dominion Group. Three prominent ridges are present from the oldest to the youngest, the Time Ball Hill, Daspoort and Magaliesberg Formations (Norman and Whitfield 2006).

The Pretoria Group consists predominantly of quartzite and shale, together with a prominent volcanic unit, minor conglomerate, chemical and volcanic members. It comprises the Hekpoort Andesite, Dullstroom Basalt, Time Ball Hill, Silverton, and Magaliesberg Quartzite Formations as well as several smaller formations (in total 15) and overlies the Chuniespoort Group (Kent 1980). Both the shale and quartzite of the Pretoria Group are utilised in the building industry (Snyman 1996). The Time Ball Hill shale Formation is known to contain 'algal microfossils' diagenetic in origin. Stromatolites as they are known are preserved in the subordinate carbonate rocks (Kent 1980). The Pretoria Group is clastic sedimentary in nature (Eriksson 1999). The pile of sedimentary rocks, mainly mudstones and quartzites with some basalt can collectively reach a thickness of up to 5 km (Visser 1989). The Rooihoogte Formation sits at the base of the Pretoria Group and is quite thin (10 – 150 m). The chert is present as boulders or a breccia. It is often lumped with the Time Ball Hill Formation (Visser 1989).

The Chuniespoort Group is made up of chemical and biochemical sediments such as dolomite, chert, limestone and banded iron formation, carbonaceous shale is also present. At the top of the Malmani Subgroup is the Duitschland Formation underlain by the Penge and Monte Christo Formations. Sandstone is mostly absent. It is this formation that has great economic value for its lead, zinc, dolomite, and manganese (Kent 1980, Snyman 1996). Fluorspar, concrete aggregate, iron ore and manganese is also mined from this formation. Cave formation in the dolomite is a major concern in developing areas, especially in the 1500 m thick dolomite of the Malmani Subgroup. Chemical sediments such as fine grained limestone and dolomite is made up of deposits of organically derived carbonate shells, particles or precipitate. Dolomite is magnesium-rich limestone formed from algal beds and stromatolites. The Malmani dolomites are home to most of the cave systems that has yielded hominin fossils such as those at Mokopane's cave. It is also home to Middle and Late Stone Age cultures. This cave and the caves in the Cradle of Humankind, near Johannesburg, provided a refuge for man's distant ancestors. The breccia yielded internationally renowned hominins.

The Black reef Formation of the Transvaal Supergroup consists of quartzite with lenses of grit and conglomerate. Shale is always present, particularly near the top close to the contact with the overlying dolomite (Kent 1980). It is Vaalian in age and not very thick, only up to 500 m in the north-east. It contains a fair amount of gold and the limestone is mined (Snyman 1996). The Black Reef Formation is known for stromatolite carbonates and fossiliferous Late Cenozoic cave breccias similar to the Malmani dolomite. Algal microfossils are reported from shales and are probably from diagenetic origin. Stromatolites are preserved in the subordinate carbonate rocks.

Figure 2: The geology of the development area (Keyser *et al.*1986).

Legend to Map and short explanation.

Vl – Melanorite, pyroxenite, serpentinized harzburgite, chromite layer [·−−·] (green). Lower zone, Rustenburg Layered Suite, Bushveld Complex. Vaalian.

Vt – Shale, hornfels, subordinate schist: [::] Nooitgedacht Quartzite Member (brown). Time Ball Hill, Pretoria Group, Transvaal Supergroup. Vaalian.

Vd – Limestone, dolomite, chert, shale, quartzite, diamictite, hornfels, and conglomerate (purple [::]). Duitschland Formation, Chuniespoort Group, Transvaal Supergroup. Vaalian.

Vmd – Dolomite, chert [=] (blue), Malmani Subgroup, Chuniespoort Group, Transvaal Supergroup. Vaalian.

Vbr – Quartzite, shale, sandstone, volcanic rocks (dark blue). Black Reef Formation. Vaalian.

Rg – Leucocratic grey biotite granite-gneiss, leucocratic granite and pegmatite (pink). Randian.

Zp – Acid to intermediate lava, pyroclasts (dark purple). Zwazian.

---f--- – (black) Fault.

┴ 30 - Strike and dip of bed.

------ - Concealed geological boundary.

□ – Approximate position of development (in white on the Figure).

<u>Mining Activities in the area</u>

Ls – Limestone and dolomite.

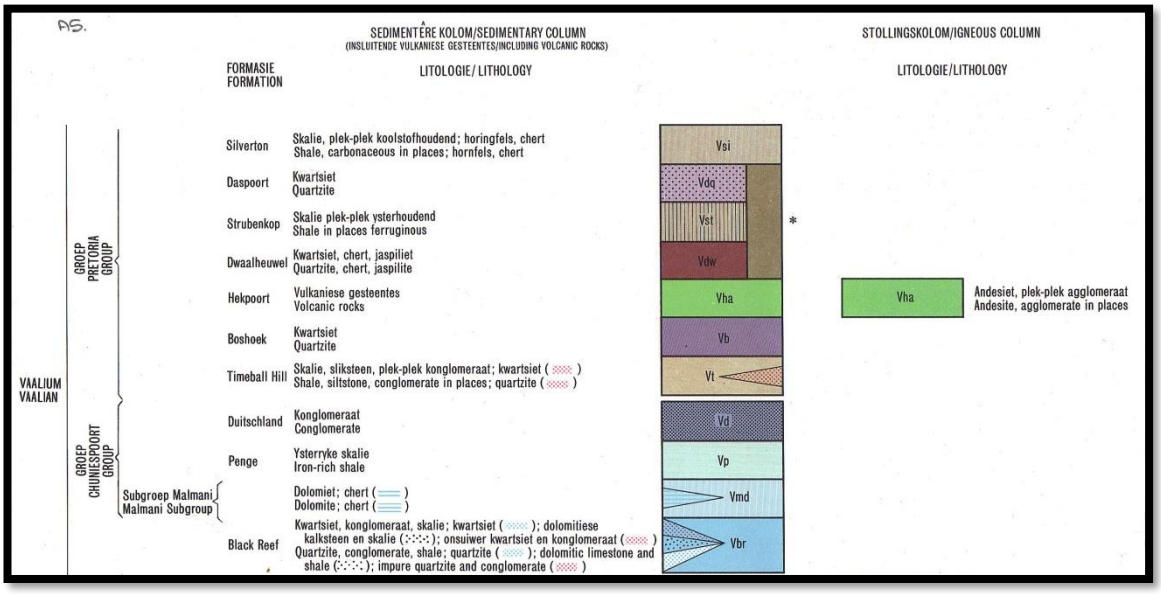
The mining past and present has no influence on the project.

The Project includes several Options (see google.earth image):

Total area: An area blocked in black approximately 9 km north-east of the town of Mokopane, to the east and west of the Percy Fyfe Road. The nearest settlement is Mahwelereng B. The Mining Right Area is approximately 4800 hectares in size.

Overburden 4 Options, Plant 3 Options and TSF 4 Options.

Figure 3: Lithostratigraphic column of the geology of the site (Muntingh 1992).



It is recommended to wait for the response from SAHRA on the Palaeontological Impact Assessment (this report). .

Field Observation

Nickel sulphide will be mined from an intrusive pyroxenite-harzburgite-dunite body. It outcrops for 8 km by 1.5 km with a thickness of 600 m. The open pit design is considerably smaller than the mineralised zone with an approximate pit length of 1,150 m, with an average width on surface of 639 m and a depth of 220 m. The associated minerals will also be extracted. Mining will be via open pit mining methods.

The table below indicates the properties on which dolomite occurs.

Portion	Farm	Infrastructure
RE	Uitloop	Plants 1, 2, overburden 1
12	Uitloop	Overburden 4, TSF's 1, 4
49	Uitloop	Plant 1
48	Uitloop	Plant 1
20	Uitloop	Plant 1, Overburden 4, TSF 1
23	Uitloop	Plant 1
65	Uitloop	Plant 1
1	Amatava	Overburden 2, 4, TSF's 1, 3, 4
12	Amatava	TSF's 2, 3
14	Amatava	TSF's 2, 3
16	Amatava	Overburden 2, 4, TSF 3

Options that will have surface dolomite must be avoided if feasible. See Section B.

Figure 4: Most of the farms are covered with thick and lush vegetation and outcrops can't be seen.

Figure 5: Dolomitic-calcrete on the Farm Uitloop.

Figure 6: Dolomite outcrops on the Farm Amatava.

Figure 7: Dolomite outcrops on the Farm Amatava.

Figure 8: Overburden Layout Options.

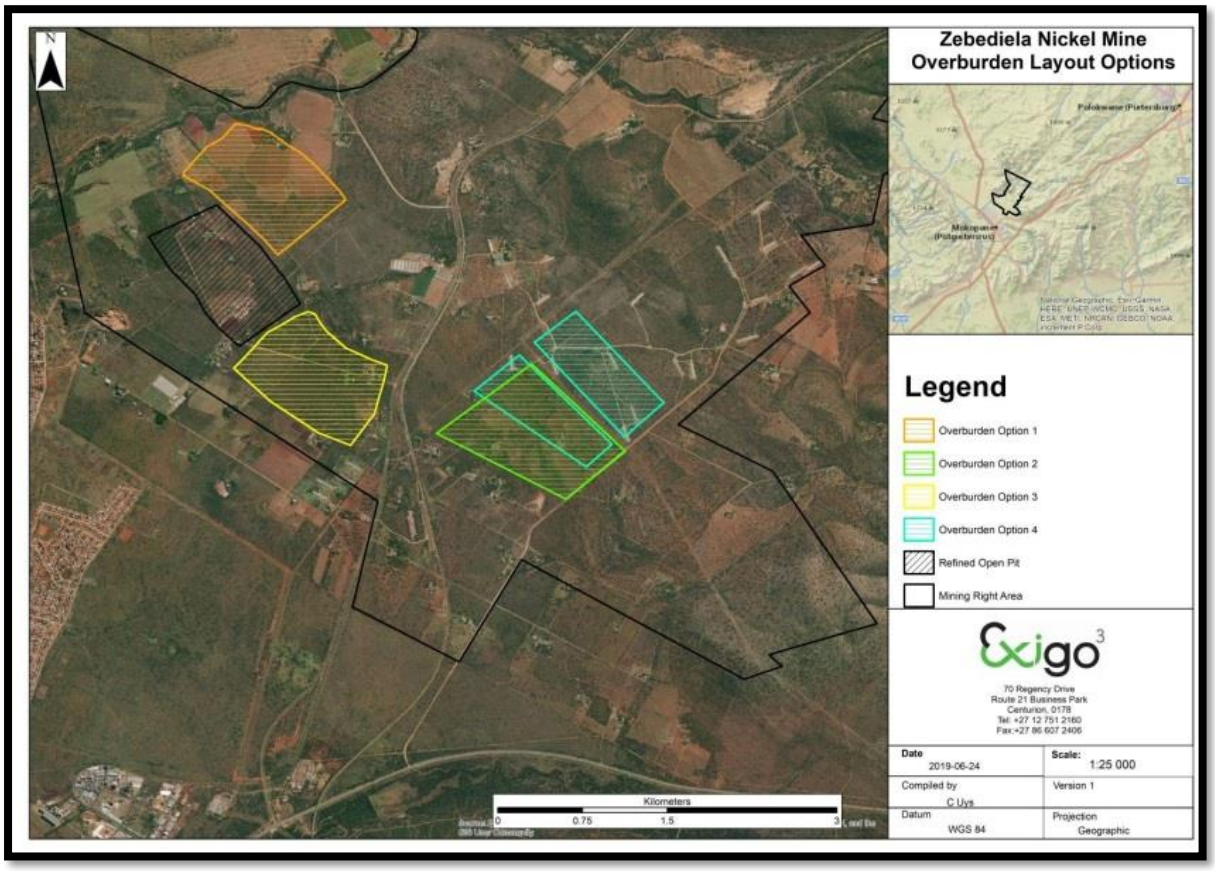


Figure 9: Plant Layout Options.

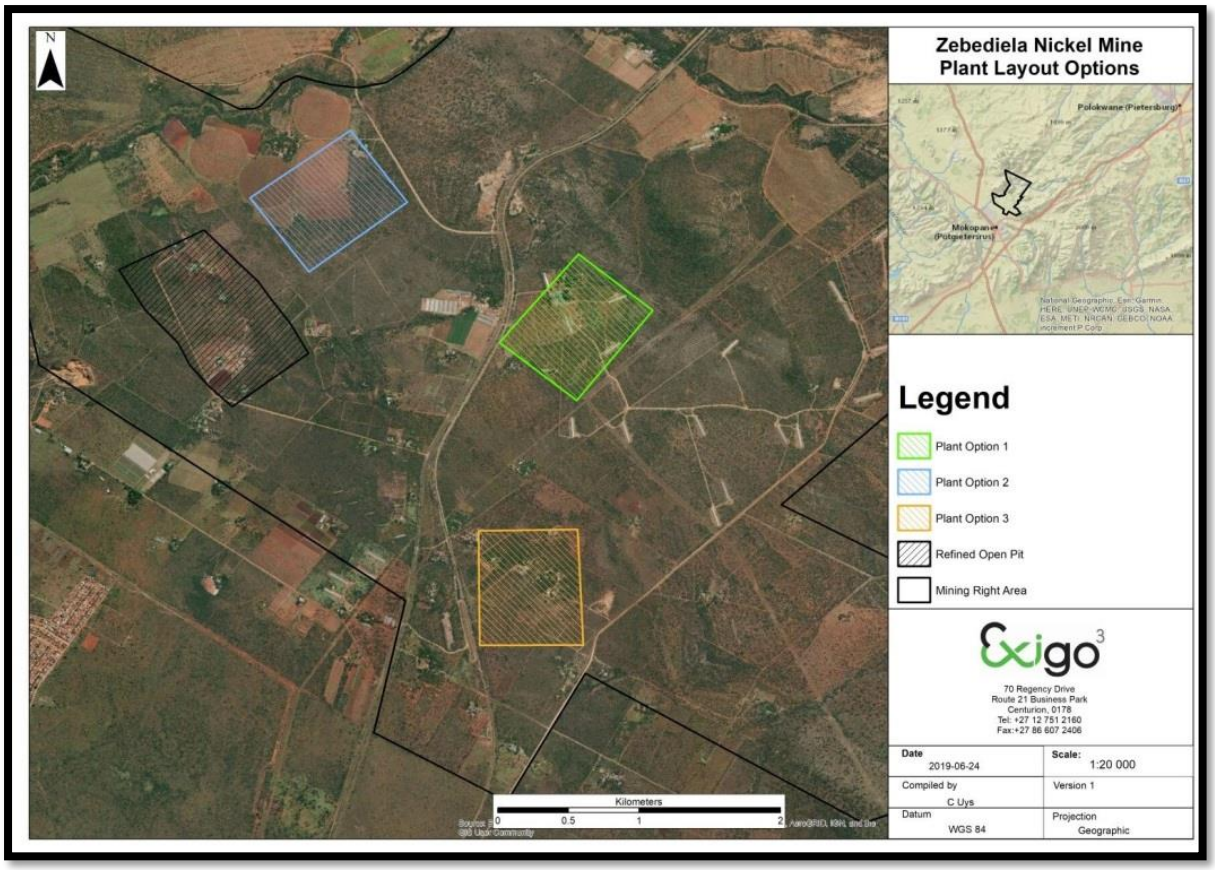
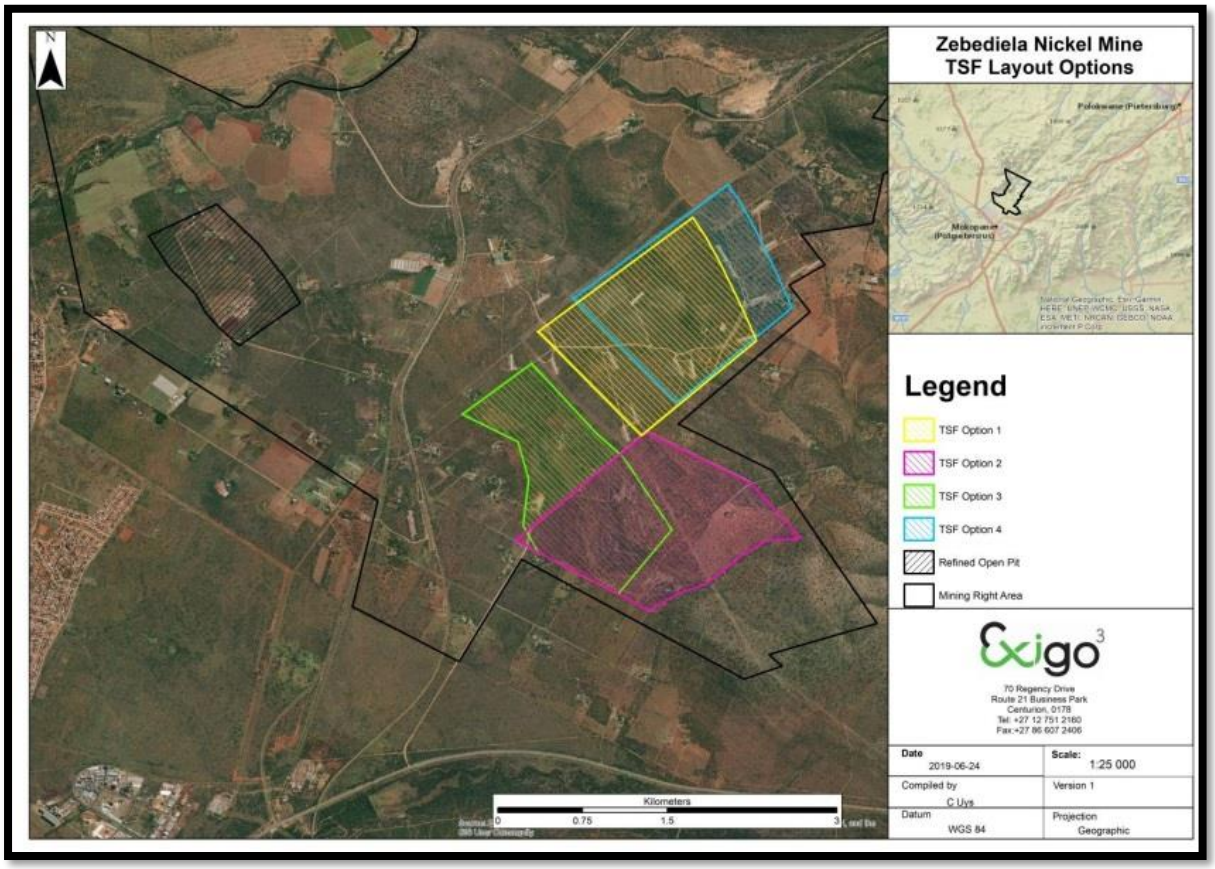


Figure 10: Trailing Storage Facility Options.



G. Background to Palaeontology of the area

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

Chemical sediments such as fine grained limestone and dolomite is made up of deposits of organically derived carbonate shells, particles or precipitate. Dolomite is magnesium-rich limestone formed from algal beds and stromatolites. These Early Proterozoic Transvaal stromatolitic dolomites formed and released free oxygen at around 2900 – 2400 Ma. Stromatolites are common in the Malmani dolomites, accepted to be the fossil remnants of the simplest single-celled organisms. They are finely layered, concentric, mound-like structures formed by microscopic algal organisms (Norman and Whitfield 2006). Chert may contain fossils such as echinoids or sponges if nodular, although not common and is rated unlikely.

Cyanobacteria have been described from the gold bearing conglomerates of the Witwatersrand Supergroup (MacRae 1999). These are significant recordings as it gives a possible indication of very early life forms, possibly ancient lichens that existed up to 2900 million years ago. These structures are for example associated with the Carbon Leader Seam in the Carletonville Goldfield, with native gold visible to the naked eye. Very large stromatolites can be found in the Campbell Rand Subgroup in the North West Province (Groenewald and Groenewald 2014).

Figure 11: Example of a stromatolite present in dolomite (Photograph: E. Butler).

Stromatolites are significant indicators of palaeoenvironments and provide evidence of algal growth between 2640 and 2432 million years ago (Groenewald and Groenewald 2014). Caves in the Malmani dolomite (Vmd) of the Transvaal Supergroup provided a refuge for man's distant ancestors (Norman and Whitfield 2006). These caves are also home to Middle and Late Stone Age cultures. The cave breccia in the Cradle of Humankind, near Johannesburg, yielded internationally renowned hominins such as *Australopithecus africanus and robustus* and extinct mammals and other fauna. The caves are actively being researched and excavated and this has led to many international collaborations. The caves are filled with sediments from the Kalahari Group. The cave of Makapansgat is close by (20 km).

In the rocks overlying the Black Reef Formation there is evidence for life on an abundant scale as cyanobacteria came to dominate the shallow sea forming stromatolites of varying shapes. Large, elongate stromatolite domes can be seen at Boetsap in the North West Province (McCarthy and Rubidge 2005) and the algal microfossils reported from the Time Ball Hill Formation shales are probably of diagenetic origin (Eriksson 1999).

The Time Ball Hill Formation (Vt), Transvaal Supergroup is present in the Pretoria Group. Nixon *et al.* (1988) described the black shales south-west of Potchefstroom as consisting of overlapping laminated basal mounds which are stromatolitic as well as spheroidal possible planktonic fossil algae. These can range in size from 3.5 - 17 mm in height and up to 10 mm in diameter and may occur in the development area.

Table 1: Taken from Palaeotechnical Report (Groenewald and Groenewald 2014).

Group/ supergroup	Subgroup	Formation	Lithology	Fossil Heritage	Comment
		Timeball Hill (Vt; Vtl)	Klapperkop (Vkp)	Lacustrine and fluvio-deltaic mudrocks with diamictite, conglomerates, quartzite, minor lavas. Shale, siltstone, conglomerate, quartzite	Stromatolites	Included within top of Transvaal Supergroup but now regarded as separate succession
		Rooihoogte (Vt)		Basal breccio-conglomerates, quartzites, mudrocks, carbonates (alluvial fan, lakes, karst infill)	No fossils recorded	
CHUNIESPOORT		Duitschland (Vd)		Conglomerate	No fossils recorded	Good examples of stromatolites in Cradle of Humankind region ALERT FOR POTENTIALLY FOSSILIFEROUS LATE CAENOZOIC CAVE BRECCIAS WITHIN "TRANSVAAL DOLOMITE" OUTCROP AREA (breccias not individually mapped)
		Penge (Vp)		Iron-rich shale	Stromatolites	
		Malmani (Vm; Vmd; Vma)		Stromatolitic carbonates (limestones / dolomites), minor secondary cherts, mudrocks including carbonaceous shales	Range of shallow marine to intertidal stromatolites (domes, columns etc), organic-walled microfossils	
		Black Reef (Vbr)		Siliciclastic sediments (mature sandstones plus minor mudrocks, conglomerates) deposited during a fluvial to shallow marine transition	Possible equivalent of Black Reef Fm in N. Cape (Vryburg Formation) contains stromatolitic carbonates	

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 sedimentary rock strata the palaeontological sensitivity is generally LOW to VERY HIGH, but here locally **HIGH** for the Chuniespoort Group, Transvaal Supergroup.

Table 2: Criteria used (Fossil Heritage Layer Browser/SAHRA).

Rock Unit	Significance/vulnerability	Recommended Action
Chuniespoort Group	High	Desktop study is required and based on the outcome of the desktop study, a field assessment is likely.

Databases and collections: Ditsong: National Museum of Natural History and the National Museum of Bloemfontein.
Impact: **HIGH** for the Chuniespoort Group, Transvaal Supergroup. There are significant fossil resources that may be impacted by the development and if destroyed are no longer available for scientific research or other public good.

H. Description of the Methodology (1e)

The palaeontological impact assessment desktop study was undertaken in July 2019. A literature survey is included and the study relied on literature, geological maps, google.maps and google.earth images. A Phase 1: Field Assessment includes a walk-through of the affected portion and photographs (in 20 mega pixels) taken of the site with a digital Canon camera (Power Shot SX620HS). It may be necessary to use a Global Positioning System (GPS) (Garmin eTrex 10) to records outcrops where not covered with topsoil, subsoil, overburden, and vegetation.

The SAHRA Document 7/6/9/2/1 only requires track records/logs from archaeologists not palaeontologists as palaeontologists concentrate on outcrops, if none then it is not recorded on a GPS. An archaeozoologist can be

used to survey any quaternary or tertiary material for more recent fossil material. 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 is used to predict what type of fossil and zone will occur in any particular region.

Assumptions and Limitations (Appendix 6 of Act **1i**):-
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 layout plan for all structures.

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. Field 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.

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

Act No. 25 of 1999. National Heritage Resources Act, 1999.
National Estate: 3 (2) (f) archaeological and palaeontological sites,
(i)(1) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens,
Heritage assessment criteria and grading: (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.

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

I. Description of significant fossil occurrences (1f)

Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to determine due to thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot.

Stromatolites are likely to be present in the dolomites. These structures range from a centimetre to several tens of metres in size. They are the result of algal growth in shallow water, indicating a very rich growth that would have caused an enrichment in the amount of oxygen in the atmosphere (Groenewald and Groenewald 2014).

Details of the location and distribution of all significant fossil sites or key fossiliferous rock units are often difficult to be determined due to lush vegetation, thick topsoil, subsoil, overburden and alluvium. Depth of the overburden may vary a lot.

Figure 12: Thin section of a stromatolite (De Zanche and Mietto 1977).

The threats are:- earth moving equipment/machinery (front end loaders, excavators, graders, dozers) during construction, the sealing-in or destruction of fossils by development, vehicle traffic, and human disturbance. See Description of the Geological Setting (F) above.

J. Recommendation (1j,1l)

a. There is no objection (see Recommendation B) to the development. The palaeontological sensitivity is **HIGH** so caution is recommended. A Phase 2 Palaeontological Mitigation will be required if a fossil is found during construction (for example a stromatolite).
b. This project may benefit the economy, the growth of the community, and social development in general.
c. Preferred choice: The impact on the palaeontological heritage is **HIGH.**
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, a 30 m no-go barrier must be constructed and a palaeontologist should be called in to determine proper mitigation measures.

Sampling and collecting **(1m,1k)**:
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 Appendix 3.
c. Areas that may need a permit: Yes, if a fossil is found (Section G).
d. Permits for mitigation: Needed from 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 Field Study was provided by the Environmental Consultant. All technical information was provided by Exigo Sustainability (Pty) Ltd.
c. Areas that would require mitigation and may need a permit from the South African Heritage Resources Agency are discussed (see Recommendations in Section B).
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, a 30 m no-go barrier constructed and a palaeontologist should be called in to determine proper mitigation measures. Especially shallow caves.
e. Condition in which development may proceed: It is further suggested that a Section 37(2) agreement of the Occupational, Health and Safety Act 85 of 1993 is signed with the relevant contractors to protect the environment and adjacent areas as well as for safety and security reasons.

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Declaration / Disclaimer (1b)

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.

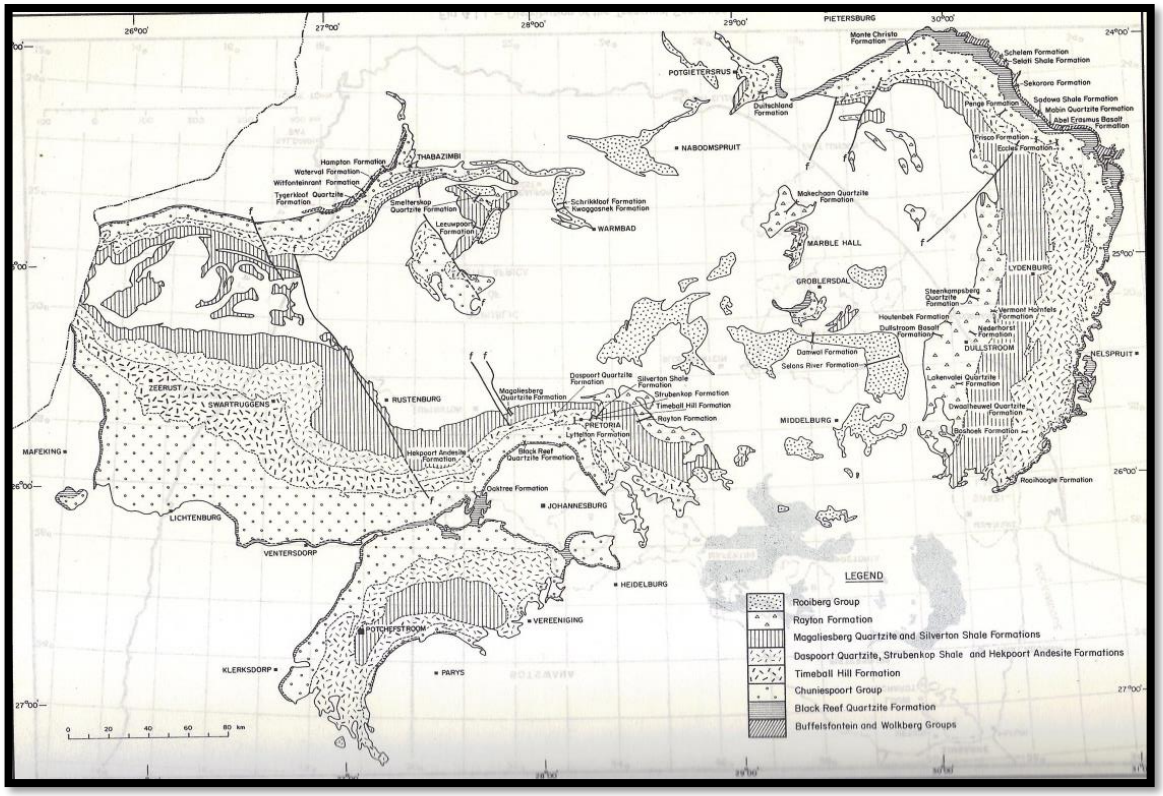
I accept no liability, and the client, by receiving this document, indemnifies me against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by the use of the information contained in this document.

It may be possible that the field study may have missed palaeontological resources in the Project Area as the presence of outcrops are not known and may only be found 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.

Heidi Fourie 2019/07/25

Apppendix 1: Geology of the Transvaal Supergroup (Kent 1980).



Appendix 2: Listing points in Appendix 6 of the Act and position in Report.

Section	Point in Act	Heading
B	1(c)	Outline of development project
	1(d)	Summary of findings
	1(g)	Concerns/threats
	1(n)i	Concerns/threats
	1(n)ii	Concerns/threats
	1(o)	Concerns/threats
	1(p)	Concerns/threats
D	1(h)	Figures
	1(a)i	Terms of reference
H	1(e)	Description of Methodology
	1(i)	Assumptions and Limitations
I	1(f)	Heritage value
J	1(j)	Recommendation
	1(l)	Recommendation
	1(m)	Sampling and collecting
	1(k)	Sampling and collecting
Declaration	1(b)	Declaration
Appendix 1	1(k)	Protocol for finds
	1(m)	Protocol for finds
	1(q)	Protocol for finds

Appendix 3: Protocol for a Chance Find 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 / ECO on site and

should not be attempted by the layman / developer. The ECO should familiarise him- or herself with the applicable formations and its fossils. The Evolutionary Studies Institute, University of the Witwatersrand has good examples of fossils that can be studied. As part of the Environmental Authorisation conditions, an Environmental Control Officer (ECO) will be appointed to monitor 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 with a 30 m barrier and the construction workers must be informed that this is a no-go area. Therefore, the EMPr must be updated to include the involvement (training of ECO) of a palaeontologist during the digging and excavation (ground breaking) phase of the development. The EMPr already covers the conservation of heritage and palaeontological material that may be exposed during construction activities. A regular monitoring presence over the period during which excavations are made, by either the palaeontologist / palaeobotanist, is generally not practical.

The developer must survey the areas affected by the development and indicate on a 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, preservation style, and taphonomy. This can only be done during mining or excavations. In order for this to happen, in case of coal mining operations, the process will have to be closely scrutinised by a professional palaeontologist / palaeobotanist to ensure that only the coal layers are mined and the interlayers (siltstone and mudstone) are surveyed for fossils or representative sampling of fossils are taking place.

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

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

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

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

Mitigation involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or excavation, recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction

phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before a Phase 2 may be implemented.

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

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

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

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

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

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

Fossil excavation if necessary during Phase 2:

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

SAHRA Documents:

Guidelines to Palaeontological Permitting policy.
Minimum Standards: Palaeontological Component of Heritage Impact Assessment reports.
Guidelines for Field Reports.
Palaeotechnical Reports for all the Provinces.