MOKOLO CROCODILE WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2)

ENVIRONMENTAL BASELINE STUDIES

PHASE 1 PALAEONTOLOGICAL IMPACT ASSESSMENT

Prepared for:

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EXECUTIVE SUMMARY

Gideon Groenewald was appointed by GIBB Bigen Nyeleti Joint Venture (GBN-JV) to undertake a Phase 1 Palaeontological Assessment Survey and a site visit for the proposed Mokolo Crocodile Water Augmentation Project Phase 2 (MCWAP-2), Lephalale and Thabazimbi Local Municipalities, Waterberg District Municipality in the Limpopo Province.

This Phase 1 Survey is done to prepare a "Chance Find Protocol" (CFP) document to assist with possible future field visits and to complete a Phase 2 PIA since very large parts of this development fall in areas underlain by geological formations with a known Very High sensitivity for palaeontological heritage.

This Palaeontological Assessment forms part of the Heritage Impact Assessment (HIA) and complies with the requirements of the South African National Heritage Resource Act No 25 of 1999 (revised 2017)(NRA). In accordance with Section 38 of the NRA (Heritage Resources Management), a HIA is required to assess any potential impacts to palaeontological heritage within the development footprint.

A Phase 1 site investigation is often the only opportunity to record the fossil heritage within the development footprint. These records are very important to understand the past and form an important part of South Africa's National Estate.

The development site applicable to the application for the proposed MCWAP-2 is underlain by Vaalian Aged stromatolitic dolomite, Mokolian aged quartzitic sandstone and shale, Carboniferous and Permian to Permo-Triassic aged sandstone and mudstones and Quaternary aged surface deposits which varies in palaeontological sensitivity from very low to very high (Table 1). No significant fossils are expected from the Mokolian aged diabase or the Jurassic aged dolerite dyke areas, but the association of termitaria with these rock types are significant in terms of possible Human burial sites.

Significant fossils are expected in areas with deep exposure, and more fossils are expected during excavation for trenching in areas indicated in red and orange on the Palaeontological sensitivity map. It is important that a suitably qualified Palaeontologist be appointed to visit the site of the development to identify potential fossils in areas indicated as High and Very High significance during the first week of excavations. If any fossils are exposed during the lifetime of the project, the finds must be reported as soon as possible to the relevant authority (SAHRA) for collection and safe keeping of Palaeontological Heritage.

In areas underlain by the Malmani Subgroup the field investigation confirmed the presence of stromatrolitess (Table 2), and it will be very important that a suitably qualified Palaeontological Specialist be appointed to do a Phase 2 PIA and to upgrade the "Chance Find Protocol" (CFP) document. The CFP document must then be included as part of the Construction Environmental Management Programme (CEMPr) of this project, to record all unexpected fossils associated with the geological formations on site.

It is recommended that:

- The Environmental Assessment Practitioner (EAP) and Environmental Management (EM) must be informed of the fact that a high and very high Palaeontological Sensitivity is allocated to the parts of study area underlain by Transvaal Supergroup and Karoo Supergroup sedimentary rocks and a moderate sensitivity over the rest of the site underlain by Waterberg Group Quartzitic sandstone and shale. A moderate sensitivity is allocated to areas covered in Quaternary aged sand. Diabase and dolerite will not contain fossils but can be associated with important termateria.
- Further mitigation for Palaeontological Heritage is recommended for this project before excavation of deeper than 1.5m is done. Collection of a representative sample ($1m^3$) of stromatolitic dolomite must be done during the first week of excavation into these rocks and the sample must be transported to

the Evolutionary Studies Institute (ESI) at WITS University for further research. Areas where access was not possible during the field visit have been allocated a moderate sensitivity since the geology pose no greater sensitivity for Palaeontological Heritage and the team must only be vigilant and report any outstanding structures that they deem important for Palaeontological investigation during construction.

- A suitably qualified palaeontologist must do a Phase 2 PIA and upgrade the “Chance Find Protocol” (CFP) when fossils are recorded from any formation in this area during excavations.
- Recommendations contained in this Phase 1 PIA must be approved by SAHRA.
- These recommendations must be included in the CEMPr of this project.

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1 INTRODUCTION

Gideon Groenewald was appointed by GIBB Bigen Nyeleti Joint Venture (GBN-JV) to undertake a Phase 1 Palaeontological Assessment Survey and a site visit for the proposed Mokolo Crocodile Water Augmentation Project Phase 2 (MCWAP-2), Lephalale and Thabazimbi Local Municipalities, Waterberg District Municipality in the Limpopo Province.

This Phase 1 Survey is done to prepare a "Chance Find Protocol" (CFP) document to assist with possible future field visits and to complete a Phase 2 PIA (Site visits during construction, most probably only a once-off site visit to collect a representative sample of the Malmani Dolomite) since parts of this development fall in areas underlain by geological formations with a known Very High sensitivity for palaeontological heritage.

1.1 Legal Requirements

This Palaeontological Assessment forms part of the Heritage Impact Assessment (HIA) and complies with the requirements of the South African National Heritage Resource Act No 25 of 1999 (revised 2017)(HRA). In accordance with Section 38 of the (HRA) (Heritage Resources Management), a HIA is required to assess any potential impacts to palaeontological heritage within the development footprint.

Categories of heritage resources recognised as part of the National Estate in Section 3 of the HRA, and which therefore fall under its protection, include:

- geological sites of scientific or cultural importance;
- objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens; and
- objects with the potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage.

1.2 Aims and Methodology

A Phase 1 site investigation is often the only opportunity to record the fossil heritage within the development footprint. These records are very important to understand the past and form an important part of South Africa's National Estate.

Following the "*SAHRA APM Guidelines: Minimum Standards for the Archaeological & Palaeontological Components of Impact Assessment Reports*" the aims of the palaeontological impact assessment are to:

- Identify exposed and subsurface rock formations that are considered to be paleontologically significant;
- Assess the level of palaeontological significance of these formations;
- Comment on the impact of the development on these exposed and/or potential fossil resources; and
- Make recommendations as to how the developer should conserve or mitigate damage to these resources.

Prior to a field investigation, a preliminary assessment (desktop study) of the topography and geology of the study area was made (Butler, 2018; Groenewald et al, 2014), using appropriate 1:250 000 geological information (2326 Ellis Ras and 2426 Thabazimbi) in conjunction with Google Earth. Potential fossiliferous rock units (groups, formations, etc) are identified within the study area and the known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region (Butler, 2018) and the author's field experience.

Priority palaeontological areas are identified within the development footprint to focus the field investigator's time and resources. The aim of the desktop survey was to document any exposed fossil material and to assess the palaeontological potential of the region in terms of the type and extent of rock outcrop in the area.

The likely impact of the proposed development on local fossil heritage is determined on the basis of the palaeontological sensitivity of the rock units concerned and the nature and scale of the development itself, most notably the minimal extent of fresh bedrock excavation envisaged. The different sensitivity classes used are explained in Table 1 below.

Table 1: Palaeontological sensitivity analysis outcome classification.

PALAEONTOLOGICAL SIGNIFICANCE/VULNERABILITY OF ROCK UNITS	
The following colour scheme is proposed for the indication of palaeontological sensitivity classes. This classification of sensitivity is adapted from that of Almond et al (2008, 2009) (Groenewald et al., 2014).	
RED	Very High Palaeontological sensitivity/vulnerability. Development will most likely have a very significant impact on the Palaeontological Heritage of the region. Very high possibility that significant fossil assemblages will be present in all outcrops of the unit. Appointment of professional palaeontologist, desktop survey, phase I Palaeontological Impact Assessment (PIA) (field survey and recording of fossils) and phase II PIA (rescue of fossils during construction) as well as application for collection and destruction permit compulsory.
ORANGE	High Palaeontological sensitivity/vulnerability. High possibility that significant fossil assemblages will be present in most of the outcrop areas of the unit. Fossils most likely to occur in associated sediments or underlying units, for example in the areas underlain by Transvaal Supergroup dolomite where Cenozoic cave deposits are likely to occur. Appointment of professional palaeontologist, desktop survey and phase I Palaeontological Impact Assessment (field survey and collection of fossils) compulsory. Early application for collection permit recommended. Highly likely that a Phase II PIA will be applicable during the construction phase of projects.
GREEN	Moderate Palaeontological sensitivity/vulnerability. High possibility that fossils will be present in the outcrop areas of the unit or in associated sediments that underlie the unit. For example areas underlain by the Gordonia Formation or undifferentiated soils and alluvium. Fossils described in the literature are visible with the naked eye and development can have a significant impact on the Palaeontological Heritage of the area. Recording of fossils will contribute significantly to the present knowledge of the development of life in the geological record of the region. Appointment of a professional palaeontologist, desktop survey and phase I PIA (ground proofing of desktop survey) recommended.
BLUE	Low Palaeontological sensitivity/vulnerability. Low possibility that fossils that are described in the literature will be visible to the naked eye or be recognized as fossils by untrained persons. Fossils of for example small domal Stromatolites as well as micro-bacteria are associated with these rock units. Fossils of micro-bacteria are extremely important for our understanding of the development of Life, but are only visible under large magnification. Recording of the fossils will contribute significantly to the present knowledge and understanding of the development of Life in the region. Where geological units are allocated a blue colour of significance, and the geological unit is surrounded by highly significant geological units (red or orange coloured units), a palaeontologist must be appointed to do a desktop survey and to make professional recommendations on the impact of development on significant palaeontological finds that might occur in the unit that is allocated a blue colour. An example of this scenario will be where the scale of mapping on the 1:250 000 scale maps excludes small outcrops of highly significant sedimentary rock units occurring in larger alluvium deposits. At least one site visit by a competent palaeontologist is compulsory. Collection of a representative sample of potential fossiliferous material is recommended.

GREY	Very Low Palaeontological sensitivity/vulnerability. Very low possibility that significant fossils will be present in the bedrock of these geological units. The rock units are associated with intrusive igneous activities and no life would have been possible during implacement of the rocks. It is however essential to note that the geological units mapped out on the geological maps are invariably overlain by Cenozoic aged sediments that might contain significant fossil assemblages and archaeological material. Examples of significant finds occur in areas underlain by granite, just to the west of Hoedspruit in the Limpopo Province, where significant assemblages of fossils and clay-pot fragments are associated with large termite mounds. Where geological units are allocated a grey colour of significance, and the geological unit is surrounded by very high and highly significant geological units (red or orange coloured units), a palaeontologist must be appointed to do a desktop survey and to make professional recommendations on the impact of development on significant palaeontological finds that might occur in the unit that is allocated a grey colour. An example of this scenario will be where the scale of mapping on the 1:250 000 scale maps excludes small outcrops of highly significant sedimentary rock units occurring in dolerite sill outcrops. It is important that the report should also refer to archaeological reports and possible descriptions of palaeontological finds in Cenozoic aged surface deposits. At least one site visit by a suitably qualified palaeontologist is recommended.

Rocks with Very Low to High palaeontological sensitivity are present within the development footprint and palaeontological mitigation measures are incorporated into the CEMPr for this project. Due to the fact that the 1:250 000 scale vector maps obtained from the Council for Geoscience indicates the rock unit underlying the area applicable to this Phase 1 PIA Report as being the Malmani Subgroup of the Transvaal Supergroup, lead to an initial assessment that very distinctive fossils will be present in parts of the study area. Field work during this survey as well as comments by Elize Butler (2018) proved that the rock unit that will be most sensitive for palaeontological heritage is the potential fossiliferous Malmani Subgroup, a well-known stromatolitic dolomite of the Tranvaal Supergroup that contains highly significant palaeontological heritage.

1.3 Scope and Limitations of the Phase 1 Investigation

The scope of a Phase 1 Investigation includes:

- An analysis of the area's stratigraphy, age and depositional setting of fossil-bearing units;
- A review of all relevant palaeontological and geological literature, including geological maps, and previous palaeontological impact reports;
- Data on the proposed development provided by the developer (e.g. location of footprint, depth and volume of bedrock excavation envisaged); where feasible, location and examination of any fossil collections from the study area (e.g. museums); and
- An on-site investigation to assess the identified palaeontological sensitive areas within the development footprint/study area, including a formal palaeontological collection if fossils are of collectable quality. The investigation focus on the bedrock exposure where excavations would most probably require palaeontological monitoring.

The results of the field investigation are used to predict the potential of buried fossil heritage within the development footprint. In some investigations, (this study), this involves the examination of similar accessible bedrock exposures, such as road cuttings and quarries, along roads that run parallel to or across the development footprint.

2 LOCALITY AND PROPOSED DEVELOPEMENT

The Mokolo Crocodile Water Augmentation Project Phase 2 (MCWAP-2), Lephalae and Thabazimbi Local Municipalities, Waterberg District Municipality in the Limpopo Province spans a linear development footprint of nearly 100km in the Waterberg District of the Limpopo Province (Figure 1).

The development falls mostly in rural, highly disturbed terrain underlain by sandy and clayey soils of mainly deeply weathered rocks of the Transvaal Supergroup. The vegetation is dominated by open bushveld with very large areas cleared for irrigation farming and intensive mining activities concentrated at Thabazimbi and Lephalale.

An important observation in terms of potential palaeontological heritage impact assessments is the numerous termite mounds that might contain important Quaternary aged fossil material of Human origin (Watson, 1967).

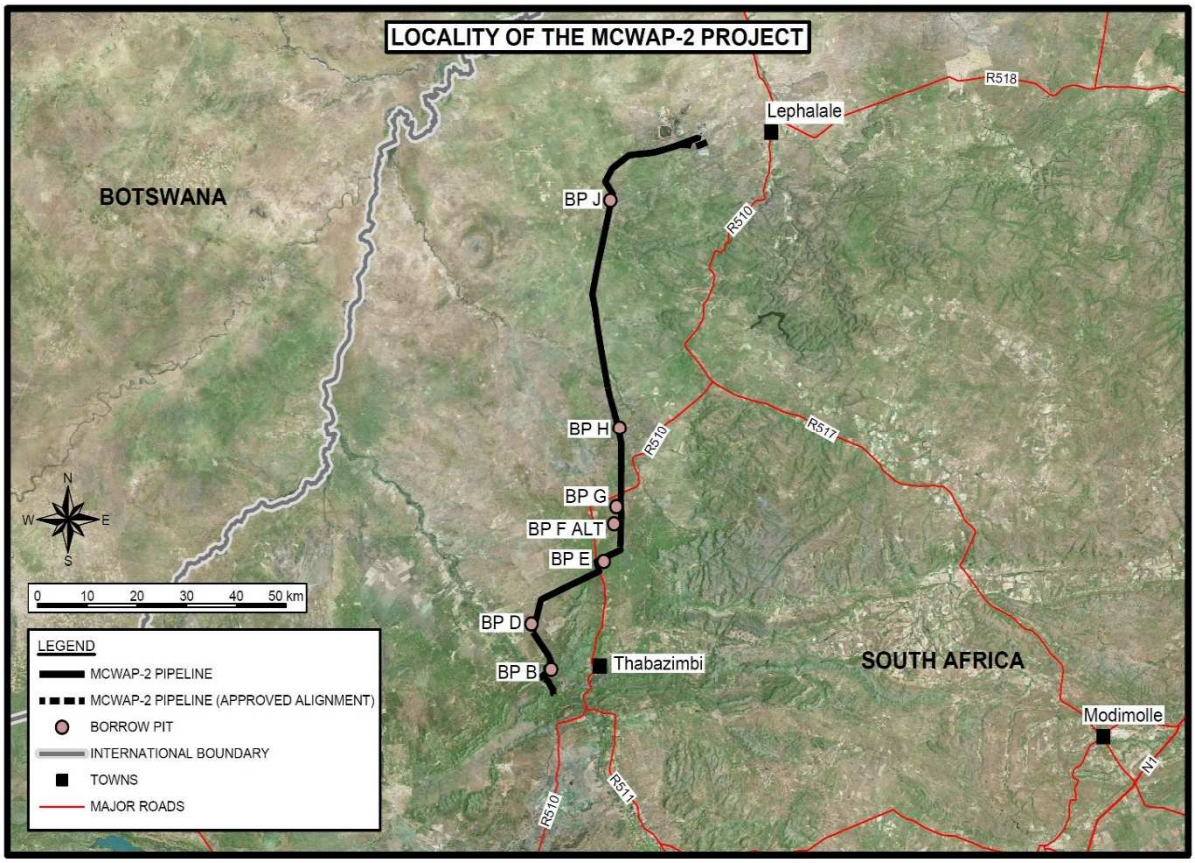


Figure 1. Locality of the routes of the main rising main for the MCWAP-2 development

3 GEOLOGY

The study area is underlain by several groups of sedimentary, igneous as well as metamorphic rocks that varies in age from ancient Vaalian stramatolitic dolomites of the Malmani Subgroup to Mokolian aged Waterberg Group sedimentary rocks along most of the route of the rising main to Permian, Traiassic, Jurassic and even Quaternary and Tertiary deposits in the Lephalale region at the outfall

side of the pipeline (Groenewald et al 2014, see Phase 1 PIA, Appendix 1). The importance of Tertiary aged deposits associated with deep sandy soils that date back to only a few thousand years, was only recently highlighted when significant heritage information was discovered in association with termite activity in the Lowveld of Southern Africa. (Gideon Groenewald, personal observation, and Watson, 1967).

3.1 Transvaal Supergroup

The southern part of the MCWAP-2 linear development is underlain by rocks of the Vaalian aged Transvaal Supergroup (Figure 2).

3.1.1 Chuniespoort Group, Malmani Subgroup

The Chuniespoort Group forms the most important outcrops of rocks in the region to the southwest of Thabazimbi and the pipeline route cuts into well-defined examples of this Group, dominated by the Malmani Subgroup (Figure 3).

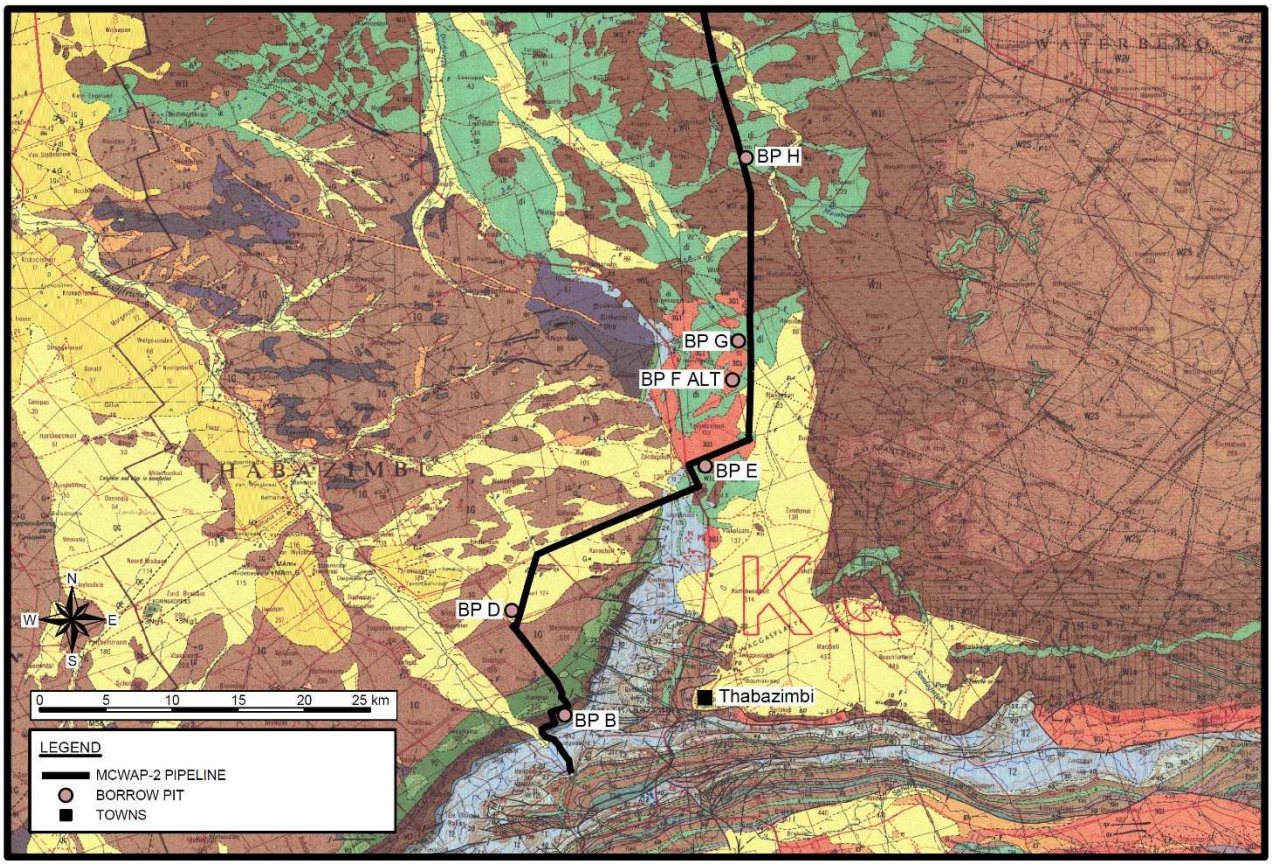


Figure 2. Geology of the southern part of the MCWAP-2 initiative

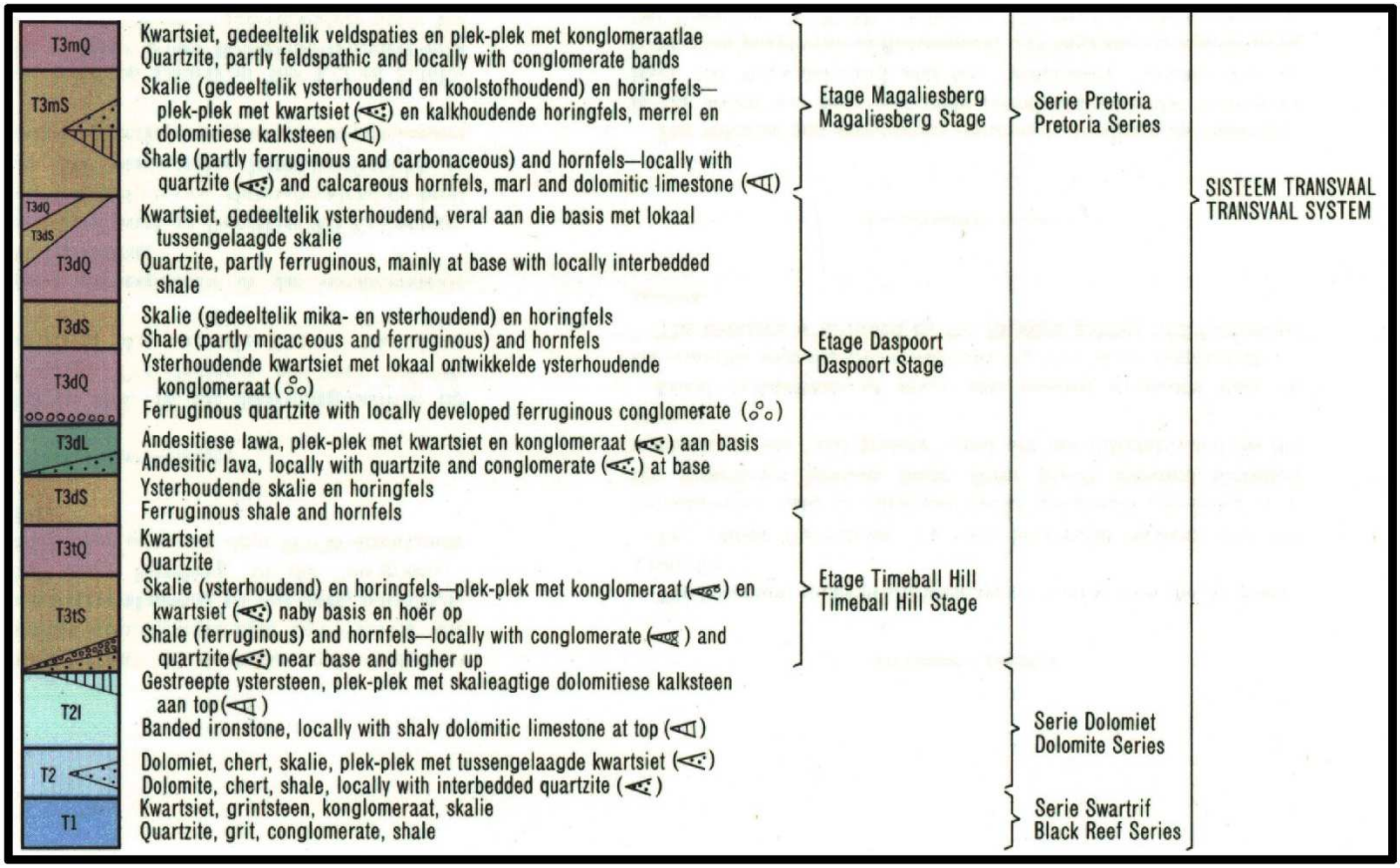


Figure 3. Geological legend to explain the lower most part of the geological profile along the route where most of the rocks are dolomites and shales of the Malmani Subgroup

3.2 Waterberg Group

The lower Vaalian aged dolomite is unconformably overlain by the Mokolian aged Waterberg Group of rocks (Figure 4).

The midway to northern sections of the MCWAP-2 development is underlain by rocks of Mokolian age, consisting mostly of units of interbedded conglomerate, coarse-grained to fine-grained quartzitic sandstone and shale beds that that build the impressive Waterberg Plateau and high mountain ranges in the area (Figure 5).

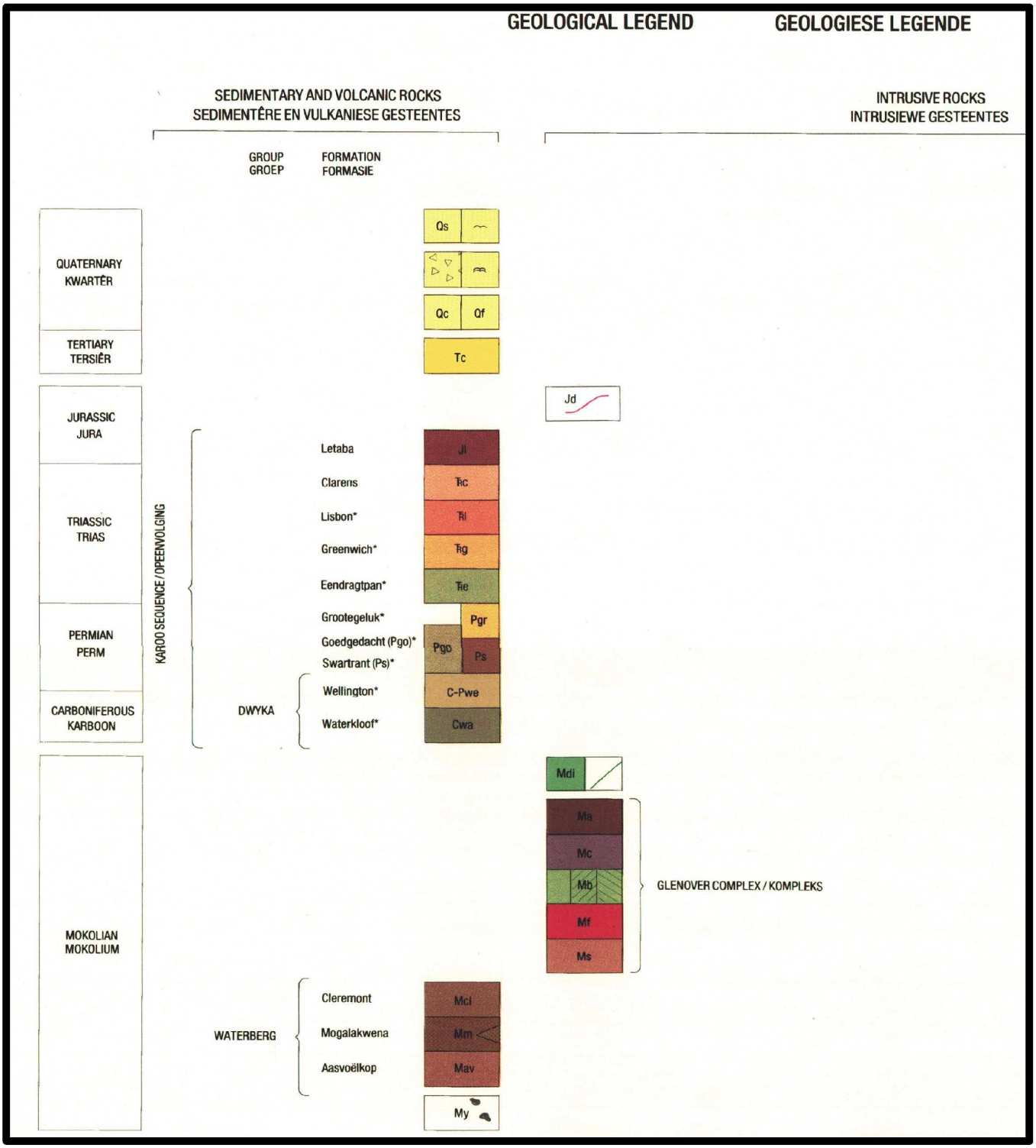


Figure 4. Geological legend for the rocks above the Vaalian aged Malmani Subgroup. These Mokoloian to Quaternary deposits underlie the entire northern part of the study area

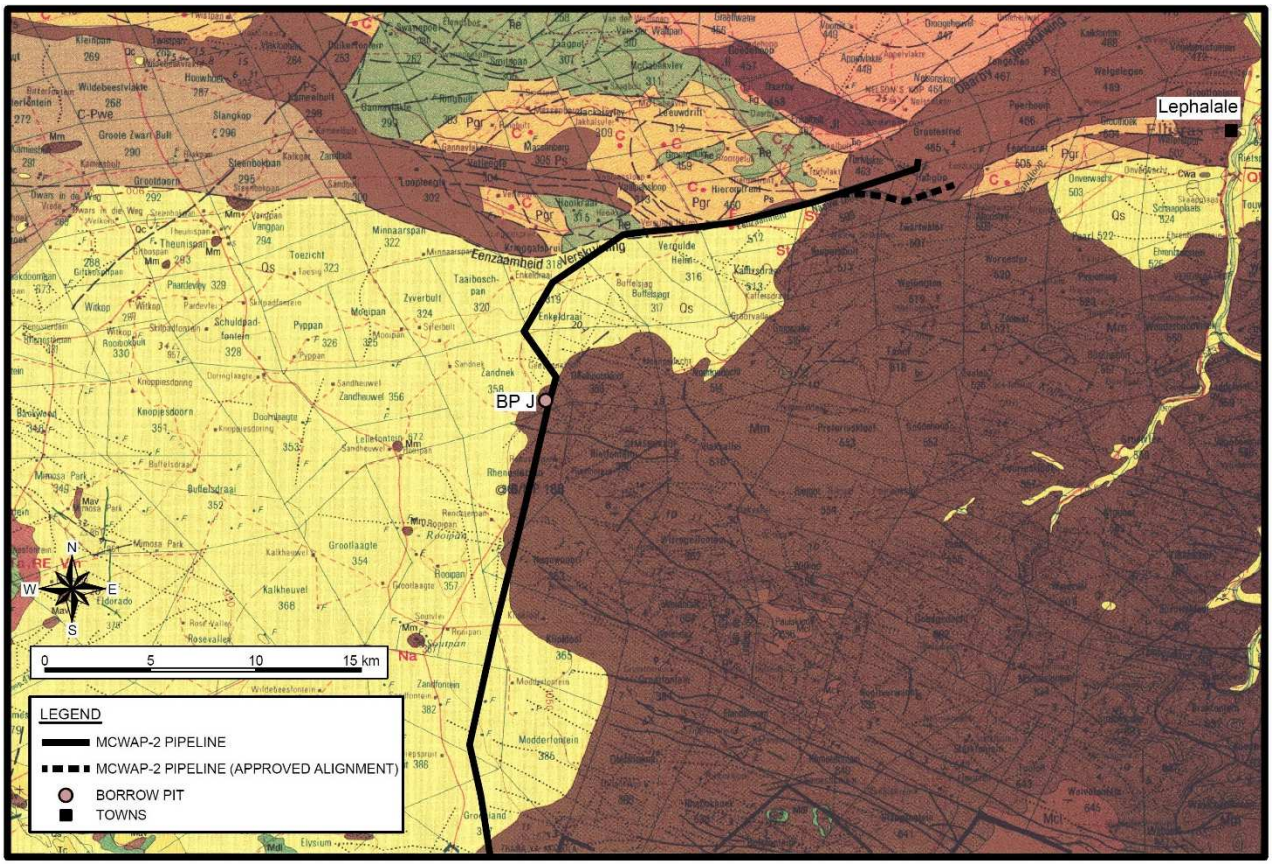


Figure 5. The northern sections are mainly underlain by Mokolian aged rocks of the Waterberg Group and then a succession of Permian to Quaternary Karoo Supergroup rocks that contains economic coal deposits close to Lephalale.

3.3 Mokolian aged Diabase Intrusive rocks and Granites

Significant lengths of the pipeline as well as most of the planned borrow pits are underlain by Mokolian aged diabase sills and granite. Most of the igneous rocks have a preferred chemistry for termite activity as well as suitable habitat for many nocturnal and burrowing vertebrates and invertebrates. It is therefore important to map the sections of the pipeline route that are underlain by these rock formations and to record possible significant termite activity along these lines.

3.4 Karoo Supergroup

The northern sections of the pipeline route crosses the very prominent fault zones into the graben structures that contains the remains of Carboniferous to Jurassic aged rocks of the Karoo Supergroup southwest of Lephalale (Figures 4 and 5). The geological formations of the Karoo Supergroup do not crop out in the study area and all the mapping was done by interpretation of borehole data as well as first-hand information available from mining activities southwest of Lephahlale. The geology is summarized in Figure 4 and it is superfluous to discuss the sequences of sandstone and shale, with very rich fossil fuel beds for this survey.

The chance find of Karoo aged fossils during the excavations for this pipeline is very high but no outcrops were observed along the planned routes of this project during the field inspection.

3.5 Karoo Dolerite

Jurassic aged Karoo Dolerite is present as prominent dykes in the study area.

3.6 Tertiary and Quaternary aged sand

Extensive parts of the route of the pipeline is underlain by Tertiary and Quaternary aged sand and soils (Figures 3 and 5), which in many cases contain well-defined termite mounds, that can be important for this survey.

4 PALAEONTOLOGY

The palaeontology of the study area has been discussed in detail in the Desktop Survey (Butler, 2018) as well as the SAHRA Technical Report (Groenewald et al, 2014). The reader is referred to "Phase 1 PIA Appendix 1" (addendum to this report) if so required.

For this report, the author will briefly give some reference to the usual palaeontological heritage treasures that are expected from this study area and then embark on a detailed photographic report that will lead to the "Chance Find Protocol" (CFP) that will govern the future recommendations of the CEMPr for this project.

4.1 Transvaal Supergroup

4.1.1 The Chuniespoort Group, Malmani Subgroup

The oldest rock formations that will be exposed during excavation for the construction of the MCWAP-2 development is the Vaalian aged Dolomite of the Malamani Subgroup. This subgroup is also referred to as the "stromatolitic dolomite" unit (Figure 6).

Stromatolites are not fossils of an organism, but rather the remains of structures built during the growth of colonies of cyanobacteria, or better known as "blue-green algae". These organisms are in a class of their own and are not included in the Plant Kingdom but in a group of Bacteria that could multiply in the absence of sunlight. By concentrating minerals from the water (in the case of the iron ore associated with the rocks at Thabazimbi – iron was concentrated by these bacteria) the minerals are deposited in layers to give the impression of a growing mushroom-like structure, called "stromatolites". Stromatolites are used in the study of palaeo-environments and contributes vastly towards a better understanding of the environments that existed near where Thabazimbi is today, about 2800 million years ago (MacRae, 1999; Mc Carthy and Rubidge, 2005).

The Malmani Subgroup is also well-known for the presence of cave breccias that represent the remains of sinkholes in the dolomitic or cast topography. These breccias are known to contain very important fossil remains of Early Human Ancestry (Cradle of Humankind at Krugersdorp) (Figure 7). Although difficult to recognize, the cave breccias might be exposed during excavation for the first 5km of the rising main from the weir in the Crocodile River.

Eon	Era	Period	Supergroup/ Sequence	Group/ Complex / Belt	Subgroup	Sedimentary Basin	Formation	Member	Lithology	Fossil Heritage	Comments
ARCHEAN			TRANSVAAL	PRETORIA			Hekpoort (Vh, Vhd, Vha)		Volcanics (basalts, pyroclastics) with minor lacustrine shales	No fossils recorded	ALERT FOR POTENTIALLY FOSSILIFEROUS LATE CAENOZOIC CAVE BRECCIAS WITHIN OUTCROP AREA OF CARBONATE SUBUNITS – i.e. LIMESTONES & DOLOMITES (breccias not individually mapped)
							Boshoek (Vb)		Sandstones, conglomerats, diamictite (alluvial fans, slumps)	No fossils recorded	
							Timeball Hill (Vt; Vti)	Klapperkop (Vkp)	Lacustrine and fluvio-deltaic mudrocks with diamictite, conglomerates, quartzite, minor lavas. Shale, siltstone, conglomerate, quartzite	Stromatolites	
							Rooihoogte (Vt)		Basal breccio-conglomerates, quartzites, mudrocks, carbonates (alluvial fan, lakes, karst infill)	No fossils recorded	
				CHUNIESPOORT			Duitschland (Vd)		Conglomerate	No fossils recorded	
							Penge (Vp; Vpe)		Iron-rich shale	Stromatolites	
							Lyttelton (Vly)		"Stromatolitic carbonates (limestones / dolomites), minor secondary cherts, mudrocks including carbonaceous shales"	Range of shallow marine to intertidal stromatolites (domes, columns etc), organic-walled microfossils	Stromatolites in Makapansgat Valley ALERT FOR POTENTIALLY FOSSILIFEROUS LATE CAENOZOIC CAVE BRECCIAS WITHIN "TRANSVAAL DOLOMITE" OUTCROP AREA (breccias not individually mapped)
	Vaalial						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	

Figure 6. Cave deposits have become one of the most important sources of information on early Homo inhabitation in Southern Africa and it is highly likely that cave breccias can be exposed during trenching for the pipeline. For colours see Table 1.

Eon	Era	Period	Supergroup/ Sequence	Group/ Complex / Belt	Subgroup	Sedimentary Basin	Formation	Member	Lithology	Fossil Heritage	Comments
PHANEROZOIC	Caenozoic		Cave Deposits. Not mapped on 1:1million scale Late Pliocene to Holocene						Bone-bearing breccias, calc tufa (flowstones, speleothems), colluvial and alluvial gravels, collapse debris, "cave earth" and other cave deposits (< 3 to 0 Ma)	Diverse Makapanian to Florisian mammalian biotas (Late Pliocene to Late Pleistocene) mammal fossils including rare fossil hominins (e.g. Australopithecus africanus, Homo heidelbergensis), wide range of micromammals. Also hyaena coprolites, arthropod remains, reptiles (snake, tortoises), seeds, mammal footprints, Early, Middle and Late Stone Age stone artefacts. Florisian (Late Pleistocene) mammalian faunas at Kalkbank Pan near Polokwane (400, 000-10 000 BP)	Several fossiliferous cave sites in Makapansgat Valley including Cave of Hearths, Limeworks, Buffalo Cave etc. Also nearby Wolkberg Cave. N.B. Numerous undiscovered fossiliferous cave deposits can be expected at or near the ground surface in the karstic-weathered outcrop area of the "Transvaal Dolomites" (Malmani Group etc). Likewise ancient pan deposits may be hidden beneath the surface.
				KALAHARI (@k; @k1)			Gordonia (Qg); Qsi; Qa		"Fluvial gravels, sands, lacustrine and pan mudrocks, diatomites and diatomaceous limestones, evaporites, consolidated to unconsolidated aeolian sands, pedocretes (especially calcrete) Late Cretaceous to Recent <90 Ma to 0 Ma"	"Palynomorphs, root casts (rhizomorphs / rhizoliths) and burrows (eg termitaria), rare vertebrate remains (mammals, fish, ostrich eggshell etc), diatoms, freshwater stromatolites, freshwater and terrestrial shells (gastropods, bivalves), ostracods, charophytes"	"Fossils mainly associated with ancient pans, lakes and river systems Palaeontology poorly studied. Basal Late Cretaceous gravels and lacustrine clays probably fossiliferous (bones, teeth, petrified wood, palynomorphs?) but very rarely exposed."
		Tertiary					T-Qc; Tl				

Figure 7. Summary of known fossils and fossil structures in the Vaalian aged rocks in the study area. For explanation of colours see Table 1

4.2 Waterberg Group

The Mokolian aged Waterberg Group overlies the Vaalian aged Malmani Subgroup and represents an influx of fluvial conglomerate, sand, mud into the Waterberg Basin. Although, due to the very old age of the rocks, never thought of as an important unit in terms of palaeontological heritage, the Waterberg Group is now an important source of information on the oldest forms of life in Southern Africa (Figure 8).

The most important fossil evidence of early life is found in the trace fossils (markings of organic origin) in the shale units and even on the bedding planes of quartzitic sandstone units in the Waterberg (for photographic evidence, refer to Table 2).

The trace fossils are primarily interpreted as the remains of algal mats but new evidence suggests that higher forms of life, including possible soft bodied multi-cellular life forms were present at the time of deposition of the sediments in the Waterberg Basin (Figure 8).

4.3 Mokolian Aged Diabase Sills and associated Granite

The Mokolian Aged diabase sills and Granite are of igneous origin and will not contain fossil remains. The association of termitaria with these structures is however of high significance and all the sites identified for development of borrow pits must be inspected for possible termitaria that might be associated with burial sites (Watson, 1967; Wylie et al, 1987; McBrearty S. 1990; Hutchet et al, 2011; Govorushko, 2019).

4.4 Karoo Supergroup

The Carboniferous to Jurassic aged Karoo Supergroup is most probably one of the most well-known sequences of fossil-rich rocks in the World (MacRae, 1999; Mc Carthy and Rubidge 2005, Johnson et al, 2009; Groenewald et al, 2014). This sequence of sedimentary deposits contain the most complete record of the development of higher forms of vertebrate, invertebrate as well as plant life in the World. The most notable palaeontological heritage in this unit is the complete record of mammal-like reptiles as well as the presence of some of the best examples of the Gondwanaland plant fossil group called the Glossopteris Assemblage.

Due to the fact that sedimentary rocks and lava were deposited in solitary grabens in the study area, the Karoo Supergroup is represented by isolated basins with specific depositional environments and specific fossil assemblages.

Eon	Era	Period	Supergroup/ Sequence	Group/ Complex / Belt	Subgroup	Sedimentary Basin	Formation	Member	Lithology	Fossil Heritage	Comments
				Glenover			&g1; &g2; &g3; &g4; &g5; &g6; &g7; Ma; Mc; Mb; Mf; Ms		Carbonatite	No fossils recorded	
PROTEROZOIC	Mokolian (M)			WATERBERG	Kransberg (!kr1)		Vaalwater (Mv; !vw) Cleremont (Mc; !c) Sandriviersberg & Mogalakwena (Msm)		Continental "red beds" - predominantly braided stream deposits (sandstones, conglomerates with minor mudrocks), Also beach, tidal flat, lacustrine, aeolian and possible marine shelf sediments Musekwa Member also refered to as Musekwa Formation. 400m thick volcanic assemblage Early to Mid Proterozoic (Mokolian) c. 2 to 1.7 Ga	Earliest known terrestrial cyanobacterial mats recorded from playa lake deposits of the Makgabeng Fm (Waterberg Group) (1.8 Ga) on the Makgabeng Plateau, Waterberg	Early Proterozoic "red beds" provide evidence for the development of an oxygenated atmosphere after c. 2Ga Glentig Formation was previously included within the uppermost Pretoria Group (1: 1 million map) but is now regarded as a proto-Waterberg / Soutpansberg unit.
					Matlabas		Aasvoëlkop (Mam; !as) & Makgabeng (!mk) Skilpadkop (!sk) & Setlaole (Mss)				
					Nylstroom		Alma (Ma; !al) Swaershoek (Msw; !sw)				
							Glentig (Vgl)				
				SOUTPANSBERG			Stayt (Ms) Sibasa (!si) & Tshifhefhe (Mt; !t) Mf Wyllies Poort (Mwy; !wy) Nzhelele (Mnz; !nz) Mabaligwe (Mmb; !ma) Blouberg (Mbl)	Musekwa (!mw) lava			

Figure 8. Early life forms and cynobacteria mats recorded in the Waterberg Group. For colour coding see Table 1

The erosion of the Karoo sediments is much faster than that of the more resistant Waterberg Group sedimentary units and Mokolian diabase sills, leading to a lack of outcrop of Karoo Supergroup rocks along the pipeline route. Most of the mapping of the Karoo rocks are based on borehole data and geophysical evidence.

The rich palaeontological heritage associated with the Karoo Supergroup (Figure 9) makes this an important target rock group for the discovery of “never seen before” fossils in Southern Africa.

4.5 Dwyka Group

The Dwyka Group has been recorded in drilling logs and recording of plant fossils such as Glossopteris, will be highly significant (Figure 9).

4.6 Ecca Group

Although no vertebrate fossils have been recorded from the Permian aged Ecca Group, invertebrate trace fossils have been described in previous reports from KwaZulu-Natal.

The trace fossils are difficult to see and it will only be observed in either highly weathered shale where the bedding planes are still preserved, or in unweathered shale of the Ecca Group where excavation is up to at least 3m of shale. In all cases the trace fossils are poorly exposed and no significant trace fossils were observed during this field investigation.

The most significant fossils associated with the Ecca Group is the very high volumes of plant material, associated with the Glossopteris Assemblage, that is presently supplying fossil fuel to the Medupi and Matimba Coal driven power stations southwest of Lephalale (Figure 10). Due to the deep weathering of the shale it is very difficult to find fossils of these plants outside of the active mining areas. Recording of any plant fossils during excavation for the pipeline will add significantly to our understanding of the palaeo-environments in this region.

4.7 Triassic to Jurassic Aged Karoo Supergroup

Triassic to Jurassic aged sandstone, red mudstone and volcanic rocks are rocks are associated with numerous fault-bound basin in the Limpopo Province (Figure 11).

Eon	Era	Period	Supergroup/ Sequence	Group/ Complex / Belt	Subgroup	Sedimentary Basin	Formation	Member	Lithology	Fossil Heritage	Comments
PHANEROZOIC	Palaeozoic	Permian	"KAROO (Undifferentiated Karoo (P-TR; C-Jk7; C-Jk))"			TSHIPISE & TULI (Unfidiferentiated Mikambeni and Madzaringwe (C-Jk7))	Madzaringwe (Pm; Pma)		Fluvial sandstones with conglomerates, siltstones, shales plus coals	Glossopterid coal flora, including root casts (Vertebraria) and root impressions	Ecca equivalent plant fossils include leaves, Vertebraria root systems and petrified wood. Probably = Ecca Group
		Carboniferous to Permian		DWYKA (C-Pd)		ELLISRAS	Wellington (C-Pwe; Pwe)		Laminated mudrocks, sandstones, dropstones	No fossils recorded to date. Possibility of Glossopterid flora fossils	
							Waterkloof (Cwa)		Diamictite, mudstone, rhythmitite, conglomorates		
						SPRINGBOK FLATS	Dwyka (Pd)		Thin mudrock, diamicitite, conglomerates and coals	Glossopterid coal flora	Very poor levels of surface exposure (most data obtained from borehole cores)
						"TSHIPISE & TULI"	Tschidzi (Pm; Pts)		Glacial and fluvioglacial diamictite, sandstone.	No fossils recorded to date. Possibility of Glossopterid flora fossils	
		Devonian									

Figure 9. No fossils have been recorded from the Dwyka Group at Lephalale and the recording of fossils in this group will be of very high significance. For colour coding see Table 1

Eon	Era	Period	Supergroup/ Sequence	Group/ Complex / Belt	Subgroup	Sedimentary Basin	Formation	Member	Lithology	Fossil Heritage	Comments
PHANEROZOIC	Palaeozoic	Permian to Triassic	KAROO (Undifferentiated Karoo (P-TR; C-Jk7; C-Jk))	ECCA (Pe)		TSHIPISE & TULI	Solitude (P-TRs; P-$s)		Reddish and grey mudrocks, sandstones and minor coals, meandering fluvial setting	Coal floras including Dicroidium in basal Solitude succession. Dinosaur remains supposedly recorded from this unit may rather be from the younger Bosbokport Fm (qv)	Upper part possibly = Elliot Lower part probably = Molteno
							Fripp (Pm; Pfr) Prob. = Molteno		Braided fluvial sandstones, grits, conglomerates, mudrocks	Dicroidium flora in upper part of succession (i.e. Triassic)	
		Permian				SPRINGBOK FLATS	Hammanskraal (Pe) Vryheid (Pv) equivalent		Sandstone, carbonaceous mudrock, and shaly coals Fluvial / lacustrine / deltaic setting	Glossopterid coal flora abundant, especially in Coal Zone at top of succession	Important plant fossil locality at Hammanskraal on Limpopo / Gauteng border (palynology by C. MacRae).
						ELLISRAS	Grootegeluk (Pg; Pgr)		Cycles of thick coals, carbonaceous mudrocks	Glossopterid coal flora abundant associated with thick coal seams	"Historical records of fossil plants along the Sabie River (Kruger Park) in the late 19th Century Probably = Ecca Group. Basal Unit = Pm (Dwyka + Ecca of Main Karoo Basin). Coal Zone of Pm correlated with Vryheid Fm (Middle Ecca) of Main Karoo Basin "
							Goedgedacht (Pg; Pgo)		Mudstones, sandstones, coals of proglacial alluvial fans, braided streams	Glossopterid coal flora	
							Swartrant (Pg; Psw)		Deltaic sandstones, mudrocks, with coals, glacio-lacustrine, fluvial and swamp sediments	Glossopterid coal flora	
						TSHIPISE & TULI (Unfidiferentiated Mikambeni and Madzaringwe (C-Jk7))	Mikambeni (Pm; Pmi)		Fluvial sandstones with conglomerates, siltstones, shales plus coals	Diverse Glossopterid coal flora preserved in buff siltstones. Siderite nodules might also be fossiliferous (cf Euamerican Carboniferous Coal Measures)	

Figure 10. Permian to Permo-Triassic aged sediments of the Karoo Supergroup with significant records of plant fossils. For colour coding see Table 1

Eon	Era	Period	Supergroup/ Sequence	Group/ Complex / Belt	Subgroup	Sedimentary Basin	Formation	Member	Lithology	Fossil Heritage	Comments
PHANEROZOIC	Mesozoic	Jurassic	KOMATIPOORT SUITE (Jkg; Jk)						Granophyre, gabbro	No fossils recorded	
			KAROO (Undifferentiated Karoo (P-TR; C-Jk7)	KAROO DOLERITE (Jd)			Dolerite (Jd)		Dolerite intrusions Early Jurassic 183 ± 2 Ma	No fossils recorded	Karroo-Ferrar igneous intrusions associated with Early Jurassic global mass extinction event
				LEBOMBO			Josini (Jj) Letaba & Sabi River (J; Jl; Jle)		Up to 13 km of volcanic rocks (basic and acid lavas) and rare interbedded sandstones. Early Jurassic 183 ± 2 Ma	Fossils might occur within thin sedimentary intervals (e.g. plants, traces, bones)	
						SPRINGBOK FLATS ELLISRAS	Clarens (TR; TRc; Jc)		Aeolian sandstones, minor ephermeral stream deposits	Dinosaur remains and trackways can be expected	Very poor levels of surface exposure (most data obtained from borehole cores)
		Triassic				TSHIPISE & TULI	Clarens (TR; TRc; Jc) (Probably Upper Elliot and Clarens)	Tshipise (Jt)	Cream-coloured aeolian sandstone, playa lake deposits (“Cave Sandstone”) = Clarens Formation of Main Karoo Basin"	Aeolianites contain petrified logs, trace fossils of insects (including controversial fossil termitaria), dinosaur trackways (possibly Massospondylus, Syntarsus / Coelophysis).	Fault-bound basins within Limpopo Belt. Stratigraphic context of dinosaur fossils often unclear in the literature. Note revised stratigraphy and correlations with Main Karoo Basin proposed in recent papers on Tuli Basin by E. Bordy (UCT): Upper Unit = P-Trkb in part + Red Rocks Member (= Elliot Fm)
						TSHIPISE & TULI		Red Rocks (Jr)	"Pale red argillaceous sandstone with calcareous concretions (fluvial / sabkha setting). White silcrete at top of succession, beneath Tshipise Member Probably = Upper Elliot of Main Karoo Basin"	Skeletal remains of dinosaurs (Massospondylus), possible dinosaur eggshells, dinosaur and other tracks, trace fossils of insects and root casts	
						ELLISRAS	Lisbon (TRl; $l)		Red mudrocks with calcareous concretions, minor sandstones	Trace fossils (“Cruziana”, “Skolithos”, extensive bioturbation, possible fossil termitaria, rhizoliths) Large sauropodomorph dinosaurs (possibly “Euskelesaurus” and / or Massospondylus)	Early records of dinosaur remains from 1920s

Figure 11. Triassic to Jurassic aged rocks are associated with graben structures in the study area. The Lisbon Formation is the most important fossiliferous unit in the study area. For colour coding see Table 1

4.7.1 Lisbon Formation

The Lisbon Formation consists of red mudstone, with numerous calcareous concretions and sandstone beds. The first fossils of large vertebrates such as the Massospondylus dinosaur, have been recorded from this formation as long ago as 1920. The chance find of significant fossils of dicoidium plants, trace fossils and body fossils is therefore very high (Figure 11).

4.8 Karoo Dolerite

Dolerite is an igneous rock and will not contain fossils. The association of termitaria with these rock types must however be noted for possible association with ancient burial sites of Mankind.

4.9 Quaternary aged Kalahari and superficial sand and alluvial deposits

Very extensive linear sections of the development is underlain by surface deposits of the Caenozoic Era that are of Quaternary age or the times when modern man was already part of the eco-system (Figure 7 and Figure 12). The Quaternary deposits can contain various highly significant fossil remains of plants and animals as well as the remains of artifacts and even fossils of Early Man.

The study of numerous termite mounds in the Southern African landscape has led to the discovery of an important association of burial sites with termite activity (Watson, 1967; Wylie et al, 1987; McBrearty S. 1990; Hutchet et al, 2011; Govorushko, 2019). Termitaria were recorded along the entire length of the proposed pipeline route and the author specifically paid attention to detail around these structures. One of the termite mounds was associated with several coins washing from the side of the mound (Table 2) and it is assumed that easy access to this specific termite mound might indicate that the termite mound is used as a possible burial site. Confirmation of this assumption will only be possible if people who are presently living in the area, can witness to the possible source of the coins that is associated with the site. There is a slight chance that the presence of the coins is purely by chance and that a person dropped the coins a few years ago by accident.

4.10 Dolerite

Due to the igneous character of dolerite, it will not contain fossils. It is however important to observe that many termitaria are associated with the linear features caused by the deep weathering of the dolerite. The fractures associated with dolerite intrusions also allow for groundwater movement along these structures and spring sites are invariably associated with dolerite dykes. The association of water and suitable sites for burial places might be the reason why termite mounds are associated with Human activity and Archaeological sites of importance (Watson, 1967; Wylie et al, 1987; McBrearty S. 1990; Hutchet et al, 2011; Govorushko, 2019).

Eon	Era	Period	Supergroup/ Sequence	Group/ Complex / Belt	Subgroup	Sedimentary Basin	Formation	Member	Lithology	Fossil Heritage	Comments
			ALLUVIAL DEPOSITS				mmm; Q-a; Q-sc; Q8. Several symbols used for alluvium, colluvium and scree		Recent sandy and clayey deposists allong water courses	Wide range of fossils possible, including mammalian bones and teeth, tortoise remains, ostrich egg etc	Alluvial deposits associated with recent water courses of main rivers and streams. These sediments are presently not well studied and records of fossil occurrences are mainly associated with archaeological reports Fossils recorded from these beds are highly significant
	CAENOZOIC	QUATERNARY	CAENOZOIC SUPERFICIAL DEPOSITS (Q) Quaternary (1.6 to 0 Ma)"				Qs; Qw; Q; Q40; T5; Qc; Qf; Tc; Q-c; T; @mo2; Te7; Q27; Q3	Aeolian sand, alluvium, colluvium, spring tufa (calcareous) and sinter (siliceous), lake deposits, peats, pedocretes or duricrusts (calcrete, ferricrete), soils, river terrace gravel	Very wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms and other microfossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens	Aeolian sand, alluvium, colluvium, spring tufa (calcareous) and sinter (siliceous), lake deposits, peats, pedocretes or duricrusts (calcrete, ferricrete), soils, river terrace gravel	Very wide range of possible fossil remains, though these are often sparse, such as: mammalian bones and teeth, tortoise remains, ostrich eggshells, non-marine mollusc shells, ostracods, diatoms and other microfossil groups, trace fossils (e.g. calcretised termitaria, rhizoliths, burrows, vertebrate tracks), freshwater stromatolites, plant material such as peats, foliage, wood, pollens

Figure 12. Caenozoic Era material is associated with Quaternary aged surface deposits that overlies very extensive parts of the study area. For colour coding see Table 1

5 PRELIMINARY ASSESSMENT RESULTS

The palaeontological sensitivity was predicted after identifying potentially fossiliferous rock units; ascertaining the fossil heritage from the literature and evaluating the nature and scale of the development itself. The palaeontological sensitivity was predicted as Very Low to Very Highly significance, due to the potential abundance of Vaalian Stromatolites, Mokolian trace fossils, Permian to Permo-Triassic aged fossils of the Ecca Group and Quaternary surficial sand and termitaria in which the remains of Mankind could be found.

Diabase and Dolerite will not contain any significant fossil remains.

6 FIELD INVESTIGATIONS

An experienced fieldworker, visited the site of the proposed MCWAP-2 development on Monday 20 July 2020 to Friday 24 July 2020.

The topography of the area varies from very mountainous in the southern part where the Crocodile Rivers cuts through the dolomites and shale units of the Chuniespoort Group, to very gently undulating topographic features, albeit having some rugged river valleys with diabase batholiths and thick diabase sills or extensive outcrops of flat lying quartzitic sandstone of the Waterberg Group dominating the higher ground. The general landscape is dominated by extensive, deeply weathered middle slopes and extensive foot slopes ending in a poorly-defined, albeit limited, valley floors, of the local streams and the main river (Matlabas River) of the area. The study area comprises a linear construction and development site that cuts the topography and cuts the contours where the proposed pipeline constructions will cut the hills, mainly along the existing route of the railway line between Thabazimbi and Lephalale. The area is mostly open bushveld and in places overgrown with remains of fire-climax grass species but a very high percentage of increasers indicating extensive grazing by cattle after regular burning of the veld to try and increase the palatability of the grass during the beginning of the growing season.

Field investigation confirmed that excavations for the new developments will expose stromatolitic dolomite of the Malmani Subgroup, quartzitic sandstone and shale of the Waterberg Group, sandstone and shale of the Ecca Group and in many areas deep excavation into Quaternary sand and alluvium. It is envisaged that the development of borrow pits will cause extensive removal of topsoil and possible termitaria in the footprint of the borrow pit. The presence of termitaria must be noted to ensure that no accidental damage is done to possible ancient burial sites associated with termite activity.

Detailed observations were recorded in the area that will be developed and observations were recorded photographically at GPS points (Figure 13).

All recorded Photographic Recordings of coins associated with termitaria as well as imprints of fossils, including trace fossils, will be provided as a formal record of observation. Significant observations included well-defined stromatolites in the Malmani Subgroup, one termitaria with coins washing from the termite mound and some poorly defined, but significant trace fossils in shale beds associated with the Waterberg Group. The Palaeontologist recommend that the EM or site manager, be vigilant in areas where deep excavations are still planned for construction of the pipeline. No fossils are expected in areas underlain by diabase and dolerite and no fossils were observed during this field investigation. It is however important to note the association of termitaria with diabse and dolerite dykes, where the termite mounds can be associated with burial sites of Mankind.

Photographic recordings of geological information and fossils occurring in the outcrops are presented in Table 2 below. These Photographic recordings might be the only records of palaeontological heritage for this project. Due to very deep weathering of the sedimentary rocks the author expects that the chance find of well-preserved fossils in this environment is not very high.

Poorly defined trace fossils are present but these fossils did not warrant collection or a request for standing time and collection of fossils (Table 2). It is however very likely that significant fossils will be exposed as deep excavation and possible blasting continues to open more material during the lifetime of the excavation.

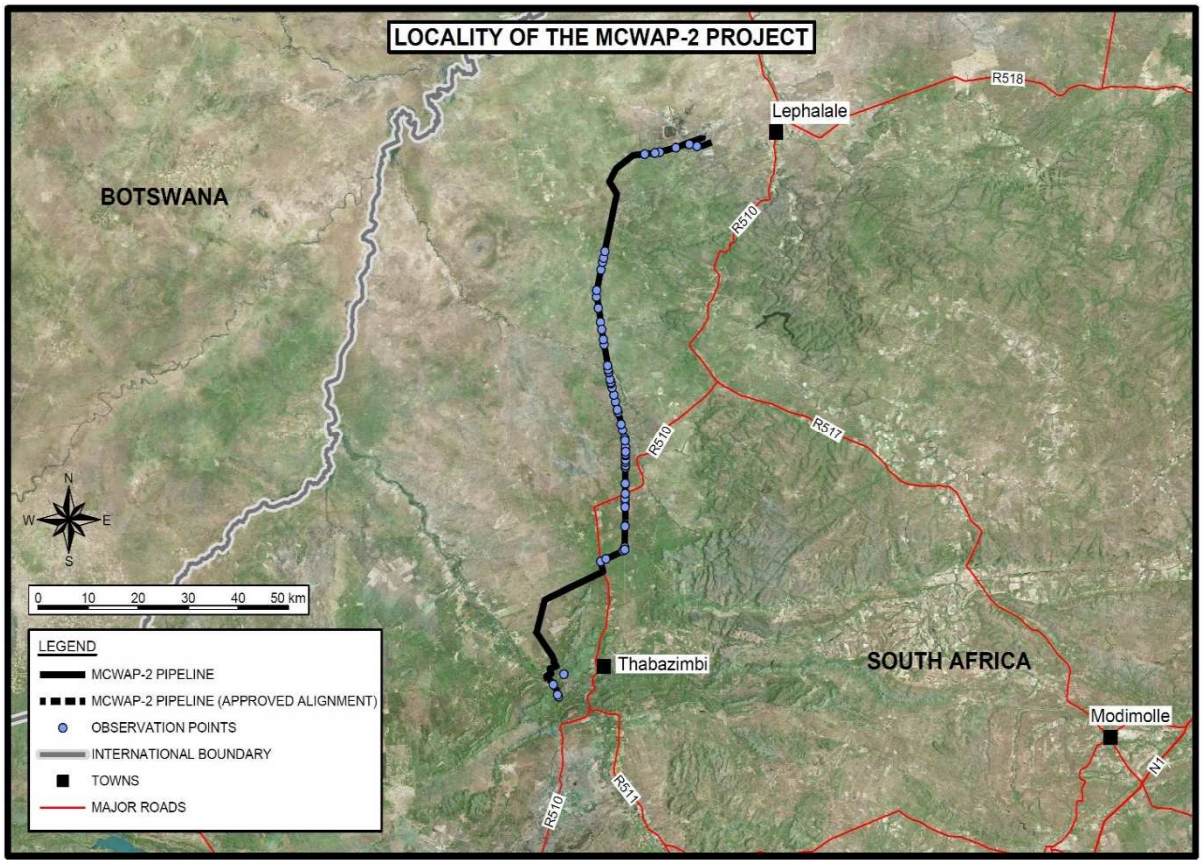


Figure 13. GPS sites of observations and Photographic Records as in Table 2

6.1 Field Observations South

Field observations followed the route of the pipeline and photographic observations were recorded at specific GPS points to give an overall picture of the most important palaeontological heritage objects and landscapes recorded. Observation points are presented for each observation section from south to north, starting from the south (Figure 14).

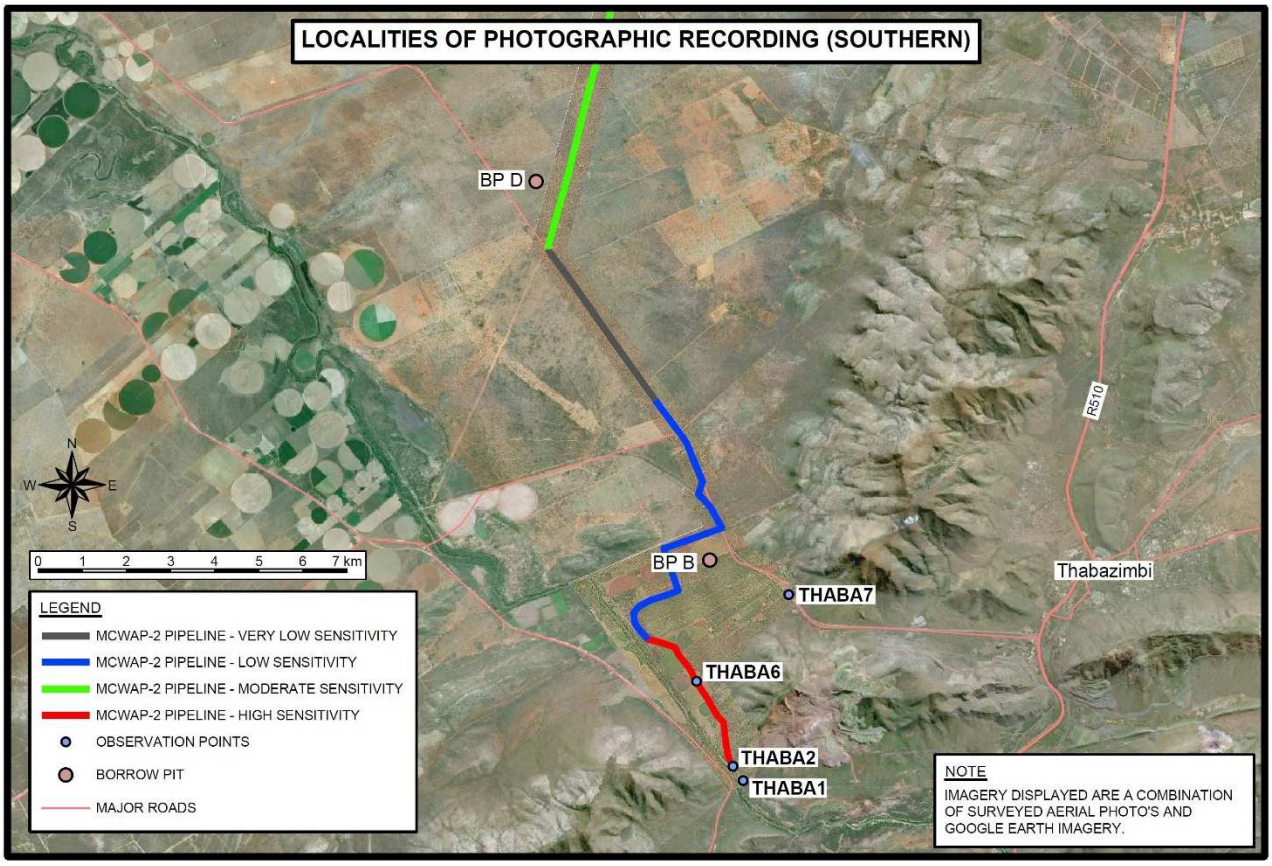


Figure 14. Observation points Southern region with Photographic Observations summarized in Table 2. The number of observation points indicate sites where photographic observations were recorded and is not an indication of actual field site visits. The colours used on the sensitivity lines for all these diagrams are discussed in Table 1

Observations in the southern section of the project area confirmed the presence of very well-defined stromatolite structures in the Malmani Subgroup (Table 2).

6.2 Field Observations Southern 1

To be able to print maps that give the localities of observations, the observation points are provided in a set of several Google images, to assist with identification of each observation point. The observations made in section South 1 is in fact to the north of Thabazimbi (Figure 15) and the Photographic observations are also included in Table 2.

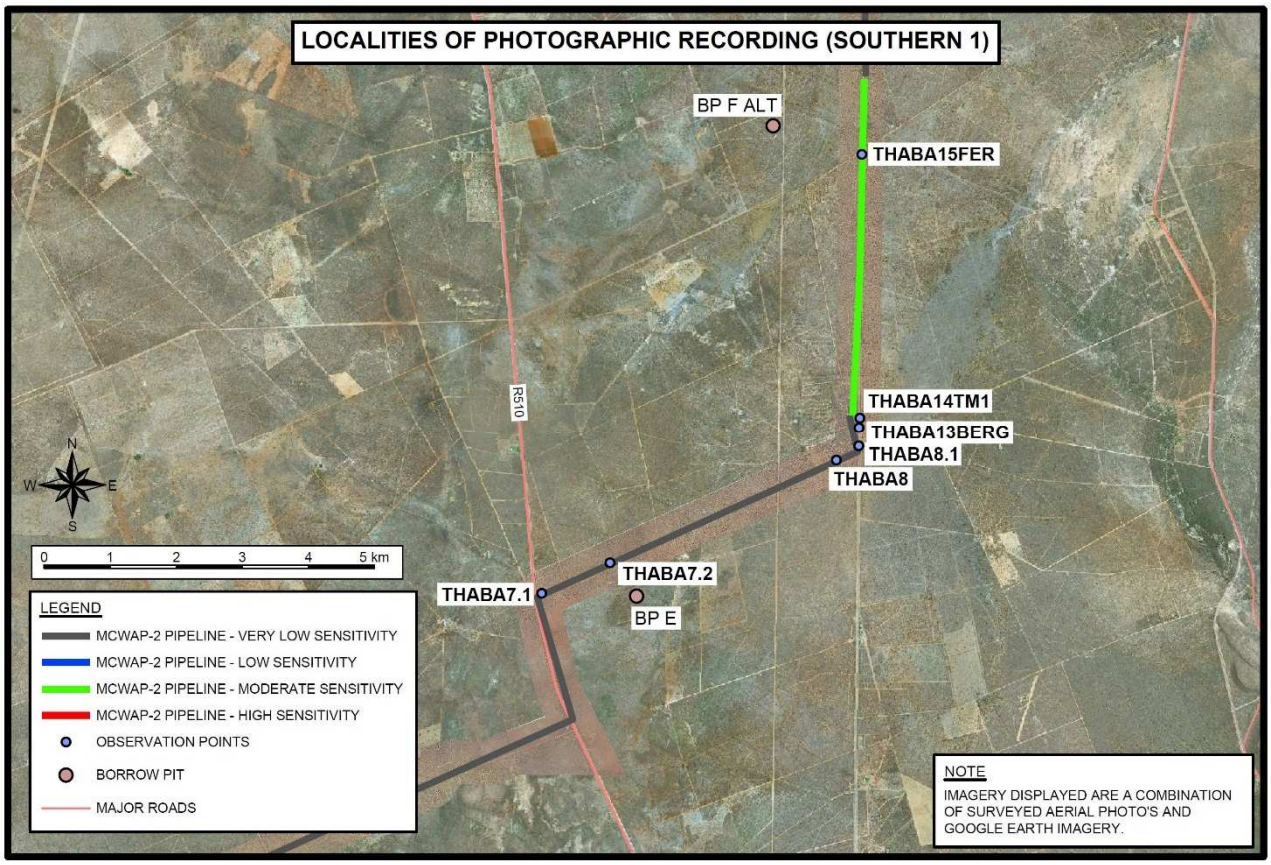


Figure 15. Localities of observations in the Southern 1 section of the surveys. The most important observation is the Termite Mound where coins are being exposed (Table 2)

Table 2. Photographic Observations in the Southern and Southern 1 sections

Photo	GPS	Description	Photographic Observation
Thaba 1	**24.636183° S** **27.319173° E**	Deep alluvium, sensitive for fossils during excavation. Quaternary aged fossils and remains of vertebrates that might have been caught during flooding of the Crocodile River.	

Photo	GPS	Description	Photographic Observation
Thaba 2	**24.633237° S** **27.316933° E**	Stromatolitic dolomite of the Malmani Subgroup observed along the route of the pipeline. No samples were collected during this field investigation.	
Thaba 2	**24.633237° S** **27.316933° E**	Stromatolitic dolomite of the Malmani Subgroup observed along the route of the pipeline. No samples were collected during this field investigation.	
Thaba 2	**24.633237° S** **27.316933° E**	Stromatolitic dolomite of the Malmani Subgroup observed along the route of the pipeline. No samples were collected during this field investigation.	

Photo	GPS	Description	Photographic Observation
Thaba 6	**24.615878° S** **27.308679° E**	Typical dome-like growth structures of cyanobacteria (blue-green algae) that was preserved to form these characteristic stromatolite structures in dolomite of the Malmani Subgroup.	
Thaba 6	**24.615878° S** **27.308679° E**	Typical dome-like growth structures of cyanobacteria (blue-green algae) that was preserved to form these characteristic stromatolite structures in dolomite of the Malmani Subgroup.	
Thaba 7	**24.598132° S** **27.329289° E**	Rugged mountain landscape in the southern part of the study area with iron enriched shale of the Pench Formation exposed by historic mining.	

Photo	GPS	Description	Photographic Observation
Thaba 7.1	**24.406418° S** **27.401620° E**	Typical bushveld vegetation along the Southern Route with sandy soils overlying diabase and granite of the Bushveld Igneous Complex. No fossils were expected in the residual material from granite and no fossils were observed along this route.	
Thaba 7.2	**24.402202° S** **27.411826° E**	Typical bushveld vegetation along the Southern Route with sandy soils overlying diabase and granite of the Bushveld Igneous Complex. No fossils were expected in the residual material from granite and no fossils were observed along this route. This site is also identified as the locality for borrow pit E and it is important to ensure that termitaria in this region do not have signs of possible burial sites as is evident in the termite mound at site Thaba 14TM.	
Thaba 8	**24.388117° S** **27.445540° E**	Typical bushveld vegetation along the Southern Route with sandy soils overlying diabase and granite of the Bushveld Igneous Complex. No fossils were expected in the residual material from granite and no fossils were observed along this route. This site is also identified as the locality for borrow pit E and it is important to ensure that termitaria in this region do not have signs of possible burial sites as is evident in the termite mound at site Thaba 14TM.	

Photo	GPS	Description	Photographic Observation
Thaba 8.1	**24.386148° S** **27.448872° E**	The route of the pipeline follows the railway servitude for most of this section of the South 1 section (Figure 15) and although this servitude has been extensively disturbed by human activity, it is important to be vigilant and inspect the numerous termitaria for possible Heritage objects as will be seen at Thaba 14TM.	
Thaba 13	**24.383597° S** **27.448889° E**	General view of the mountainous terrain towards the east of the pipeline route. The Waterberg Group builds an impressive escarpment in this part of the Limpopo Province.	
Thaba 14MT	**24.382241° S** **27.449045° E**	Termite mound are distributes over the entire study area and vary in size from small, inconspicuous structures to large mound that can in some cases encircle the stems of large trees.	
Thaba 14MT	**24.382241° S** **27.449045° E**	This specific termetaria is of interest to Heritage Conservation since it clearly have some coins washing from the side of the mound. Literature surveys indicate that Humans are known to use the termite mounds as burial sites, but the most important observation is that termites can prefer colonizing a grave site for the fact that the remains of bones contain rich supplies of Nitrogen that is lacking in the natural environment at these sites.	

Photo	GPS	Description	Photographic Observation
Thaba 14MT	**24.382241° S** **27.449045° E**	The coins observed in this termite mound has been left at the site, either on purpose or by accident. The most obvious reason for the presence of these coins is the possibility that the termite mound is associated with a grave site that descendants of the people who as buried at the site visit the site for historical rituals to honor the dead. The specific termite mound is accessible from the road and it does fall on secure private property.	
Thaba 15FER	**24.346310° S** **27.449184° E**	Large scale termitaria in the servitude of the railway line must be inspected before clearance for construction is done. The termite mounds might contain valuable information that can contribute towards our understanding of the history of this region.	
Thaba 15FER	**24.346310° S** **27.449184° E**	Ferricrete on granite and diabase. No fossils were expected and no fossils were observed. This scenario will also be found at borrow pit F (Alternative) and it is important to ensure that no termitaria is destroyed before ensuring that the termite mounds are not associated with a burial site.	

6.3 Field Observations Southern 2

Field observations and photographic recording was done along the railway servitude towards the north (Figure 14) and several termite mounds were recorded (Table 3) but no obvious presence of any burial sites were recorded in this section of the survey. The most important observations are the outcrops of quartzitic sandstone and mica-rich shales of the Waterberg Group. No trace fossils were recorded in this section of the survey.

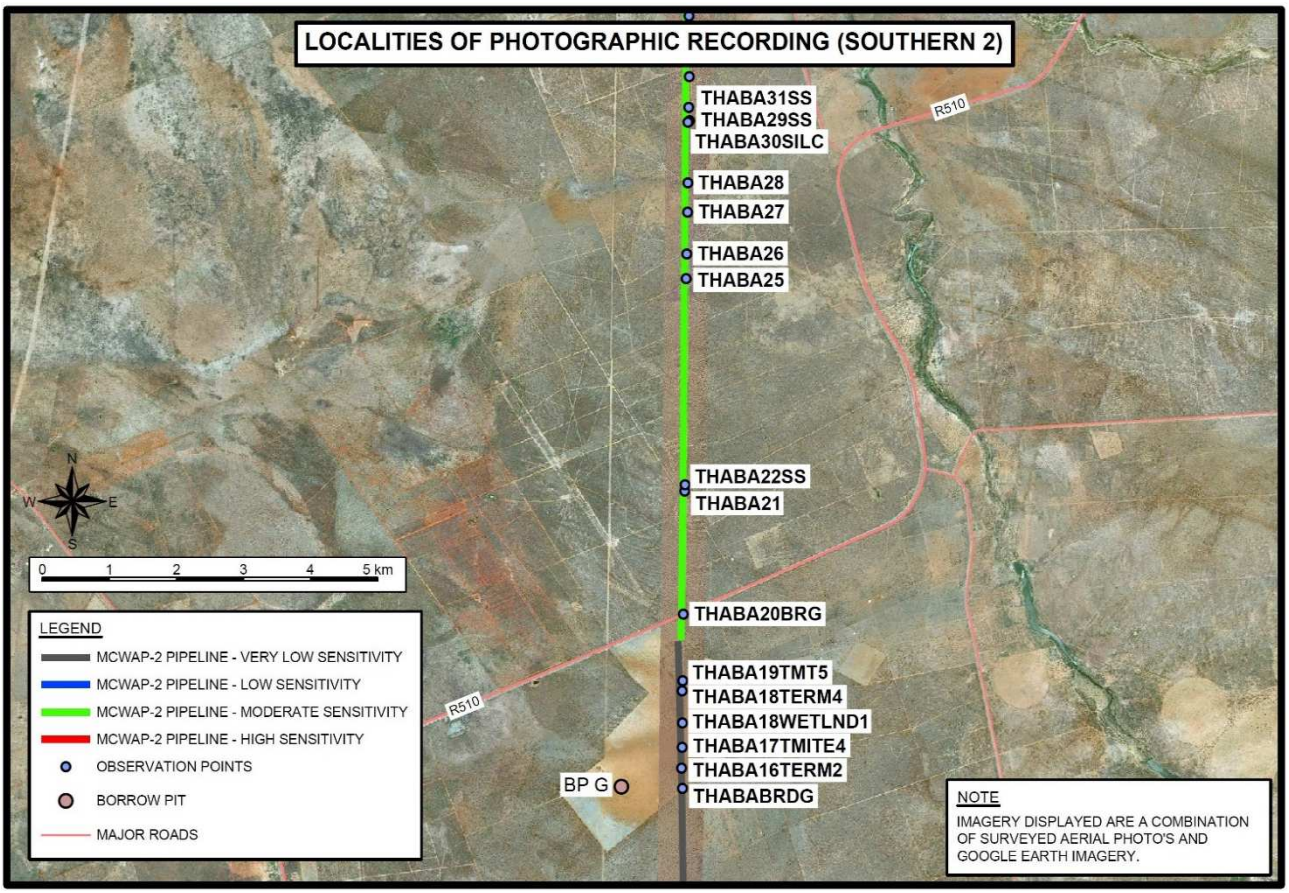


Figure 16. GPS localities of photographic observations made along the railway servitude in the Southern 2 section of the survey (Table 3)

6.4 Field Observations Central

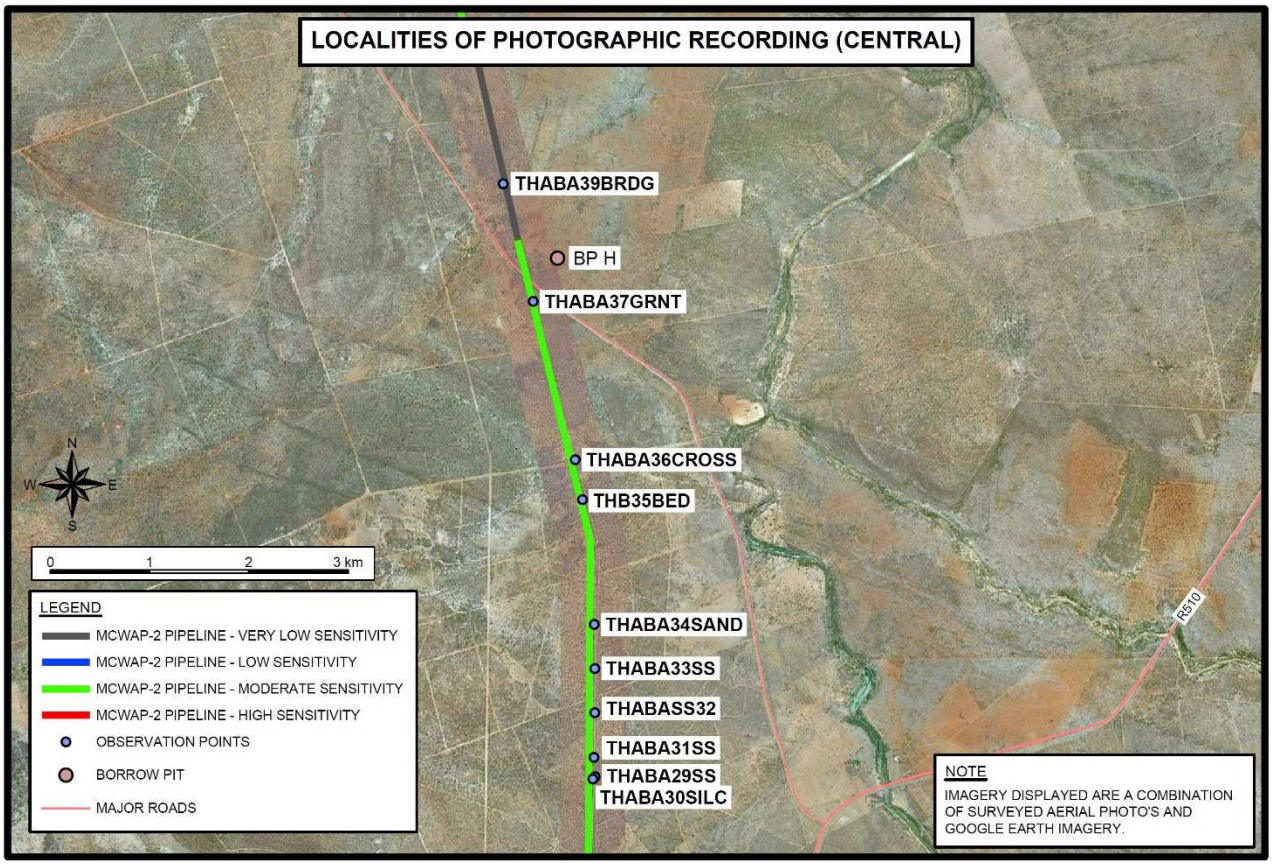


Figure 17. GPS points of field observation sites in the central region of the survey, photographic recording (Table 3)

Table 3. Photographic record of observations along the southern 2 and central part of the surveys

Photo	GPS	Description	Photographic Observation
Thaba Brdg	**24.313841° S** **27.449432° E**	Deep sandy soils on diabase and granite. Quaternary aged fossils and remains of vertebrates, rhizomes and ostrich egg shell have been recovered from these sands. The presence of termitaria in this region is important and the EM must inspect termite mounds at the locality of burrow pit G for possible remains of Human origin.	

Photo	GPS	Description	Photographic Observation
Thaba 16 Term	**24.311169°° S** **27.449300° E**	Abundant termite activity was found in areas underlain by diabase and granite. Termitaria must be inspected for artifacts, bone remains and coins or gemstones before destruction.	
Thaba 17 Term	**24.308412° S** **27.449371° E**	Typical termitaria associated with the presence of bigger trees. The association of these structures with larger trees will assist the EM in identifying these potential burial sites in areas that will be opened up, for example the site of borrow pit G in this region.	
Thaba 18 Wetlnd	**24.305209°S** **27.449406° E**	Seepage areas with deep clay-rich soils, indicative of wetland environments. Excavation for trenching can expose fossils of animals that occurred in this region over thousands of years.	
Thaba 18 Term	**24.300977° S** **27.449355° E**	Typical termitaria with large open corridors that can provide suitable habitat for smaller organism to hide. Termitaria can also indicate possible burial sites in the bushveld regions of Southern Africa.	

Photo	GPS	Description	Photographic Observation
Thaba 19	**24.299609° S** **27.449413° E**	Termite mounds can be partly destroyed by human activities and it is important to inspect these sites for possible fossil remains. No fossils were observed at this locality.	
Thaba 19 Term	**24.299609° S** **27.449413° E**	Termite mounds can be partly destroyed by human activities and it is important to inspect these sites for possible fossil remains. No fossils were observed at this locality.	
Thaba 20 Brg	**24.290822° S** **27.449494° E**	Bridge site as a marker along the route.	
Thaba 21	**24.274593° S** **27.449654° E**	Outcrop of Waterberg Group quartzitic sandstone and micaceous shale in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms,	

Photo	GPS	Description	Photographic Observation
		including algal mats, have been recorded from these rocks.	
Thaba 21	**24.274593° S** **27.449654° E**	Outcrop of Waterberg Group quartzitic sandstone and micaceous shale in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from these rocks.	
Thaba 22	**24.273751° S** **27.449688° E**	Outcrop of Waterberg Group quartzitic sandstone with cross-bedding in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from these rocks.	
Thaba 22	**24.273751° S** **27.449688° E**	Outcrop of Waterberg Group quartzitic sandstone with cross-bedding in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from these rocks.	

Photo	GPS	Description	Photographic Observation
Thaba 22	**24.273751° S** **27.449688° E**	Outcrop of Waterberg Group quartzitic sandstone in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from these rocks.	
Thaba 25 Brdg	**24.246447° S** **27.449767° E**	Deep sandy soils on Waterberg Group sediments. Bridge as a marker along the route of the pipeline.	
Thaba 26 Gen no outcrop	**24.243209°S** **27.449798° E**	The Southern 2 section crosses vast open plains, underlain by deep sand that was allocated a moderate sensitivity for palaeontological Heritage. No fossils were recorded during this site visit.	

Photo	GPS	Description	Photographic Observation
Thaba 27	**24.237696° S** **27.449941° E**	The Southern 2 section is allocated a moderate sensitivity for palaeontological heritage. Recent reports of trace fossils from the bedding plane of the quartzitic sandstones are the first indication of advanced live in some of the oldest sedimentary sequences in South Africa.	
Thaba 28	**233841° S** **27.449947° E**	Waterberg Group sandstone with very thin shale bands. Bedding planes are not well enough exposed to look for trace fossils.	
Thaba 29	**24.225665° S** **27.450164° E**	Ferricrete on Waterberg Group sandstone. No fossils were expected and no fossils were observed.	

Photo	GPS	Description	Photographic Observation
Thaba 30	**24.225847° S** **27.449918° E**	Ferricrete on Waterberg Group sandstone. No fossils were expected and no fossils were observed.	
Thaba 31	**24.223905° S** **27.450040° E**	Outcrop of Waterberg Group quartzitic sandstone and micaceous shale in the railway servitude in the Central survey section Figure 17. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from these rocks.	
Thaba 32	**24.219833° S** **27.450110° E**	Outcrop of Waterberg Group quartzitic sandstone and cobbles in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from bedding planes associated with these rocks.	
Thaba 33	**24.215849° S** **27.450092° E**	Waterberg Group Quartzitic sandstone exposed in the excavations for the railway line. Bedding planes not well-defined, no fossils observed.	

Photo	GPS	Description	Photographic Observation
Thaba 34	**24.211852° S** **27.450034° E**	Deep sand overlying all geology. The importance of termitaria in this environment must be noted when removal of topsoil id planned in this part of the Southern 2 section.	
Thaba 35	**24.200520° S** **27.448803° E**	Waterberg Group Quartzitic sandstone exposed in the excavations for the railway line. Bedding planes not well-defined, no fossils observed.	
Thaba 36	**24.196899° S** **27.448075° E**	Waterberg Group sediments are in most cases covered in deep sandy soils and no fossils were expected and no fossils observed. All the sections of the route indicated as moderate sensitive where access was impossible due to overgrown roads and access routes can be compared to this general observation where the EM must only record significant outcrops of rock. Such chance finds are highly unlikely in this environment.	
Thaba 37	**24.182452° S** **27.443858° E**	Diabase outcrop in railroad cuttings. No fossils expected accept in the termite mounds associated with these rocks. It is important to note that borrow pit H is planned into the diabase. The EM must ensure that all termitaria are inspected before topsoil is removed during preparation to start the quarry.	

Photo	GPS	Description	Photographic Observation
Thaba 39	**24.171764° S** **27.440861° E**	Bridge over the railroad as a marker for the end of the central section of the survey.	

6.5 Field Observations Central 1

Field observations towards the north in the central 1 section of the survey (Figure 18) confirmed the presence of moderately sensitive quartzitic sandstone and slate of the Waterberg Group. The bedding planes on the slate displayed some very interesting structures that might be sedimentary or organic in origin. Following the latest discoveries of trace fossils in the Waterberg Group, it is very important to follow up on these surveys during construction and to record any trace fossils properly.

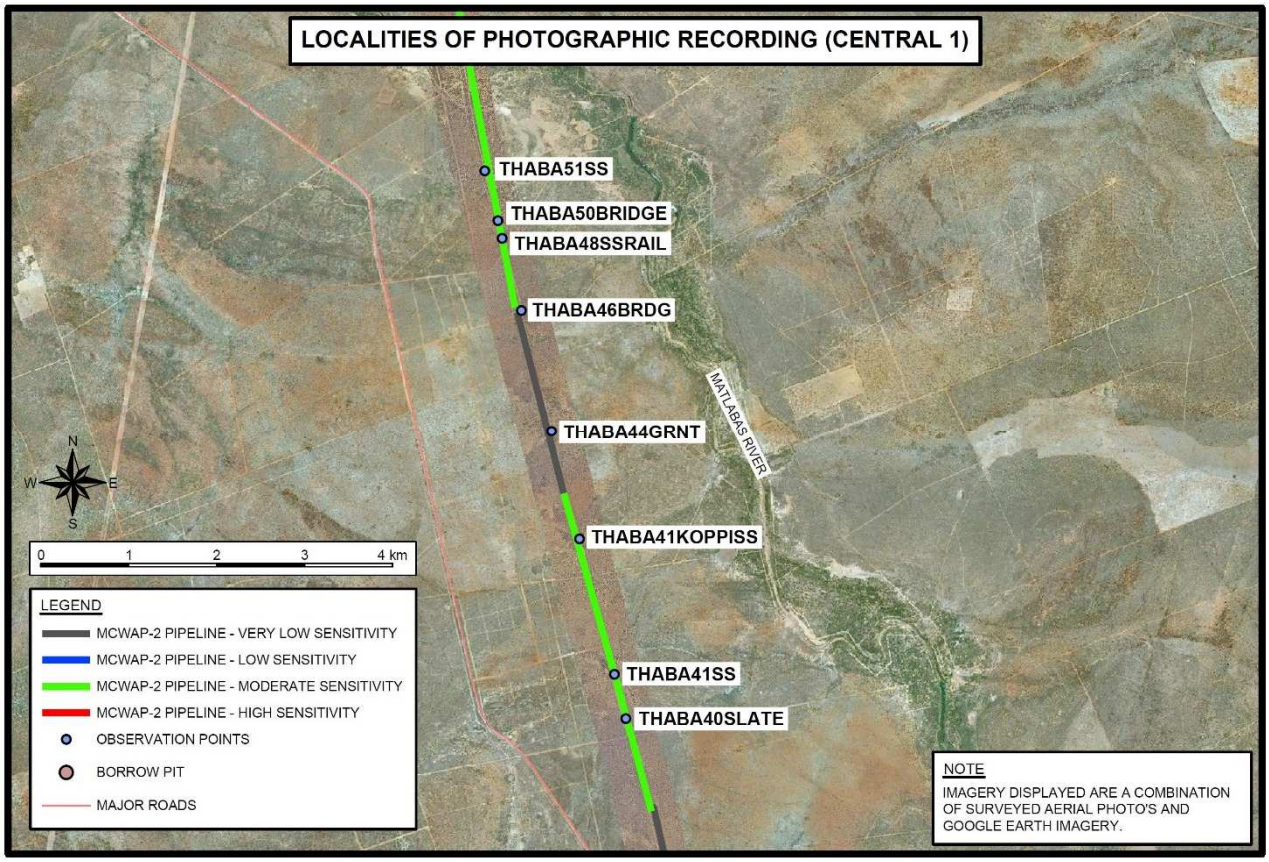


Figure 18. GPS localities of Photographic observations for the central 1 section (Table 4)

6.6 Field observations central 2

Field observation in the central 2 section of the survey confirmed outcrop of quartzitic sandstone of the Waterberg Group and well-defined slate beds with interesting structures present on the bedding planes. It will be important to monitor excavation for trenching into these shales.

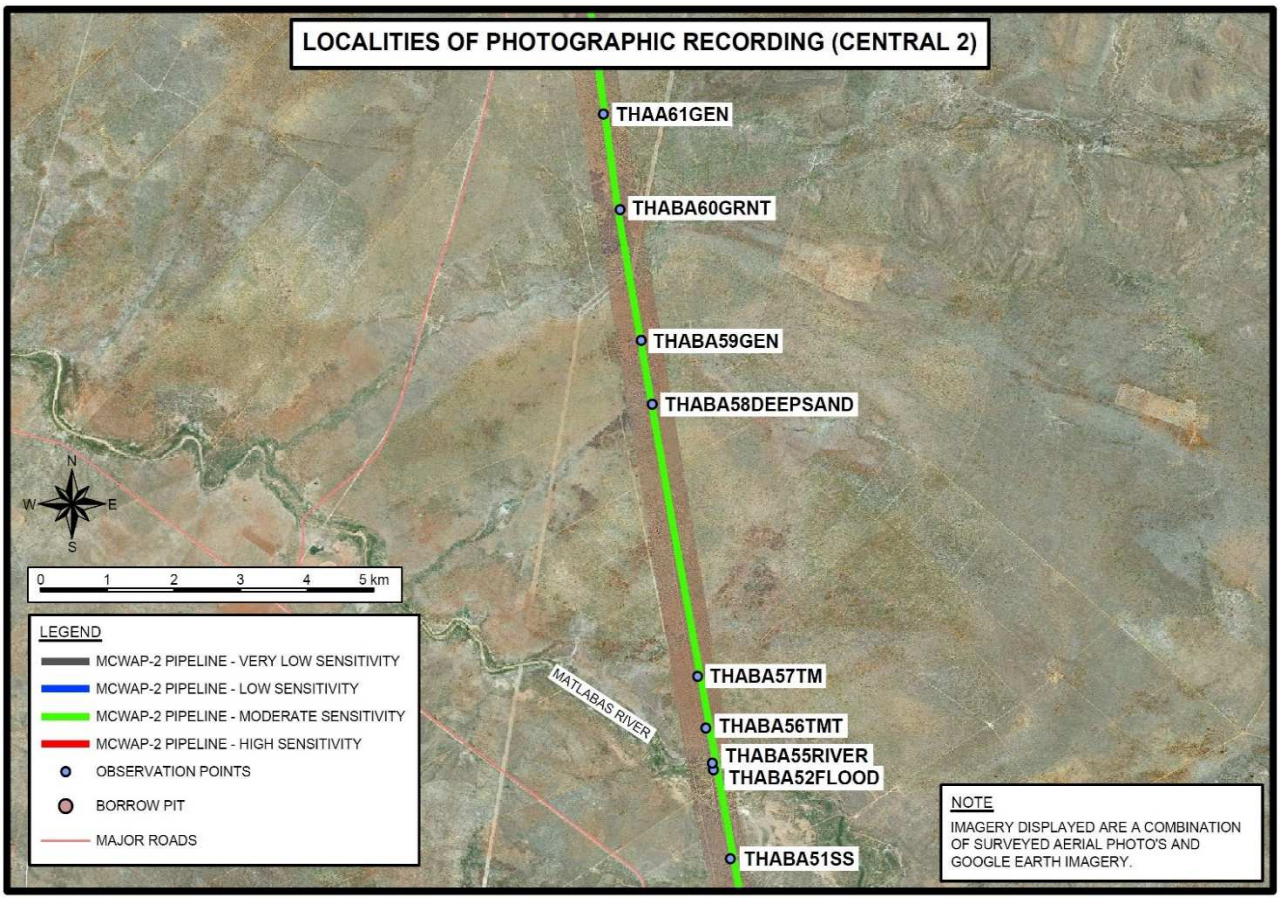


Figure 19. GPS locations of photographic observation points for Section Central 2 (Table 4)

Table 4. Photographic observations in the central 1 and central 2 sections of the survey (Figures 18 & 19)

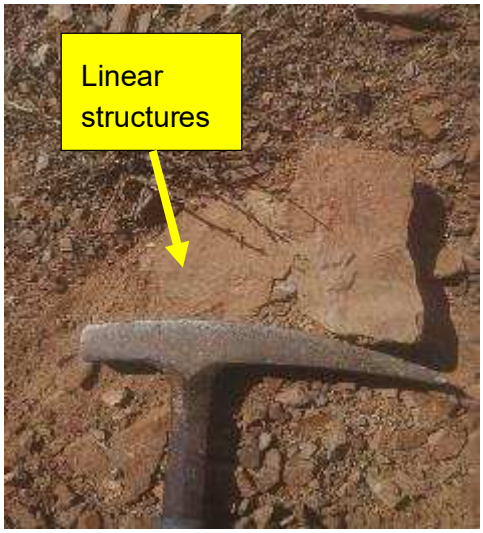
Photo	GPS	Description	Photographic Observation
Thaba 40 Slate	**24.151068° S** **27.435003° E**	Waterberg Group slate displays linear features that can be interpreted as casts of desiccation cracks but in association with these structures, there are several features that suggest soft body trace marks which, combined with the red colour of the sediments, indicates some of the oldest terrestrial deposits in the geological history of South Africa.	
Thaba 40 Slate	**24.151068° S** **27.435003° E**	Waterberg Group slate displays linear features that can be interpreted as casts of desiccation cracks but in association with these structures, there are several features that suggest soft body trace marks which, combined with the red colour of the sediments, indicates some of the oldest terrestrial deposits in the geological history of South Africa.	

Photo	GPS	Description	Photographic Observation
Thaba 40 Slate	**24.151068° S** **27.435003° E**	Waterberg Group slate displays linear features that can be interpreted as casts of desiccation cracks but in association with these structures, there are several features that suggest soft body trace marks which, combined with the red colour of the sediments, indicates some of the oldest terrestrial deposits in the geological history of South Africa.	
Thaba 40 Slate	**24.151068° S** **27.435003° E**	Waterberg Group slate displays linear features that can be interpreted as casts of desiccation cracks but in association with these structures, there are several features that suggest soft body trace marks which, combined with the red colour of the sediments, indicates some of the oldest terrestrial deposits in the geological history of South Africa.	
Thaba 41	**24.146550°S** **27.433715° E**	The Central 1 section is underlain by Quartzitic sandstone of the Waterberg Group and the EM must inspect all excavations for possible slate beds that can contain significant palaeontological heritage.	

Photo	GPS	Description	Photographic Observation
Thaba 41	**24.132687°S** **27.429738°E**	High ground along the Central 1 section is underlain by sandstone of the Waterberg Group and excavation into this sandstone must be monitored by the EM. If any trace fossils are exposed the EM must follow the recommendations in the Chance Find Protocol (CFP)	
Thaba 44	**24.121639° S** **27.426585° E**	The northern part of section Central 1 is underlain by quartzitic sandstone with shallow soils on Waterberg Group sediments	
Thaba 46 Brdg	**24.109211° S** **27.423184° E**	Bridge site as a marker along the route. Waterberg Group sandstone is exposed in the cuttings along the railway servitude	

Photo	GPS	Description	Photographic Observation
Thaba 48	**24.101844° S** **27.420998° E**	Outcrop of Waterberg Group quartzitic sandstone and micaceous shale in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from these rocks.	
Thaba 50	**24.100032° S** **27.420508° E**	Outcrop of Waterberg Group quartzitic sandstone and micaceous shale in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from these rocks. Bridge as a marker along the Central 1 section.	
Thaba 51	**24.094914° S** **27.419020° E**	Outcrop of Waterberg Group quartzitic sandstone with cross-bedding in the railway servitude. A moderate palaeontological sensitivity is allocated to these rocks and important trace fossils as well as some of the earliest life forms, including algal mats, have been recorded from these rocks.	
Thaba 52	**24.083312° S** **27.416481° E**	Alluvial sand in the river valley. No fossils expected and no fossils found. It is however important for the EM to be on the lookout for bones in the alluvial deposits. Any fossils from these sediments will contribute toward our understanding of the history of this region.	

Photo	GPS	Description	Photographic Observation
Thaba 55	**24.082402° S** **27.416340° E**	Alluvial sand in the river valley. No fossils expected and no fossils found. It is however important for the EM to be on the lookout for bones in the alluvial deposits. Any fossils from these sediments will contribute toward our understanding of the history of this region. The railway bridge over the Matlhabatsi (Matlabas) River is a marker on the Central 2 study line.	
Thaba 56 Tmt	**24.077835° S** **27.415365° E**	Deep sandy soils on Waterberg Group sediments and diabase sill environments. The termitaria are important markers of potential burial sites.	
Thaba 57 Tmt	**24.071087°°S** **27.414131° E**	Deep sandy soils on Waterberg Group sediments and diabase sill environments. The termitaria are important markers of potential burial sites.	

Photo	GPS	Description	Photographic Observation
Thaba 58	**24.035359° S** **27.407326° E**	The Central 2 section is allocated a moderate sensitivity for palaeontological heritage. Recent reports on the role that termitaria can play in the preservation of and even use as burial sites, or the association of termites with burial sites where the termites choose to digest bone for the Nitrogen in the bone, makes these deep sandy deposits in this aree an important potential site for the discovery of new fossils, including the remains of Human ancestors in South Africa.	
Thaba 59	**24.026986° S** **27.405639° E**	The Central 2 section is allocated a moderate sensitivity for palaeontological heritage. Recent reports on the role that termitaria can play in the preservation of and even use as burial sites, or the association of termites with burial sites where the termites choose to digest bone for the Nitrogen in the bone, makes these deep sandy deposits in this aree an important potential site for the discovery of new fossils, including the remains of Human ancestors in South Africa	
Thaba 60	**24.009842° S** **27.402498° E**	The Central 2 section is allocated a moderate sensitivity for palaeontological heritage. Recent reports on the role that termitaria can play in the preservation of and even use as burial sites, or the association of termites with burial sites where the termites choose to digest bone for the Nitrogen in the bone, makes these deep sandy deposits in this aree an important potential site for the discovery of new fossils, including the remains of Human ancestors in South Africa	

Photo	GPS	Description	Photographic Observation
Thaba 61	**23.997329° S** **27.400005° E**	Ferricrete on Waterberg Group sandstone. No fossils were expected and no fossils were observed.	

6.7 Field observations North

North of the Central 2 section of the investigation the route of the pipeline underlain by thick sandy deposits on Waterberg Group sediments. Termiteria are the most important features in terms of palaeontological heritage and the sand can also contain artifacts of Human origin, ostrich shells and other less obvious heritage objects that, if recorded by the EM, will add to our present understanding of the history of this region. No fossils were observed along most of the route (Table 5).

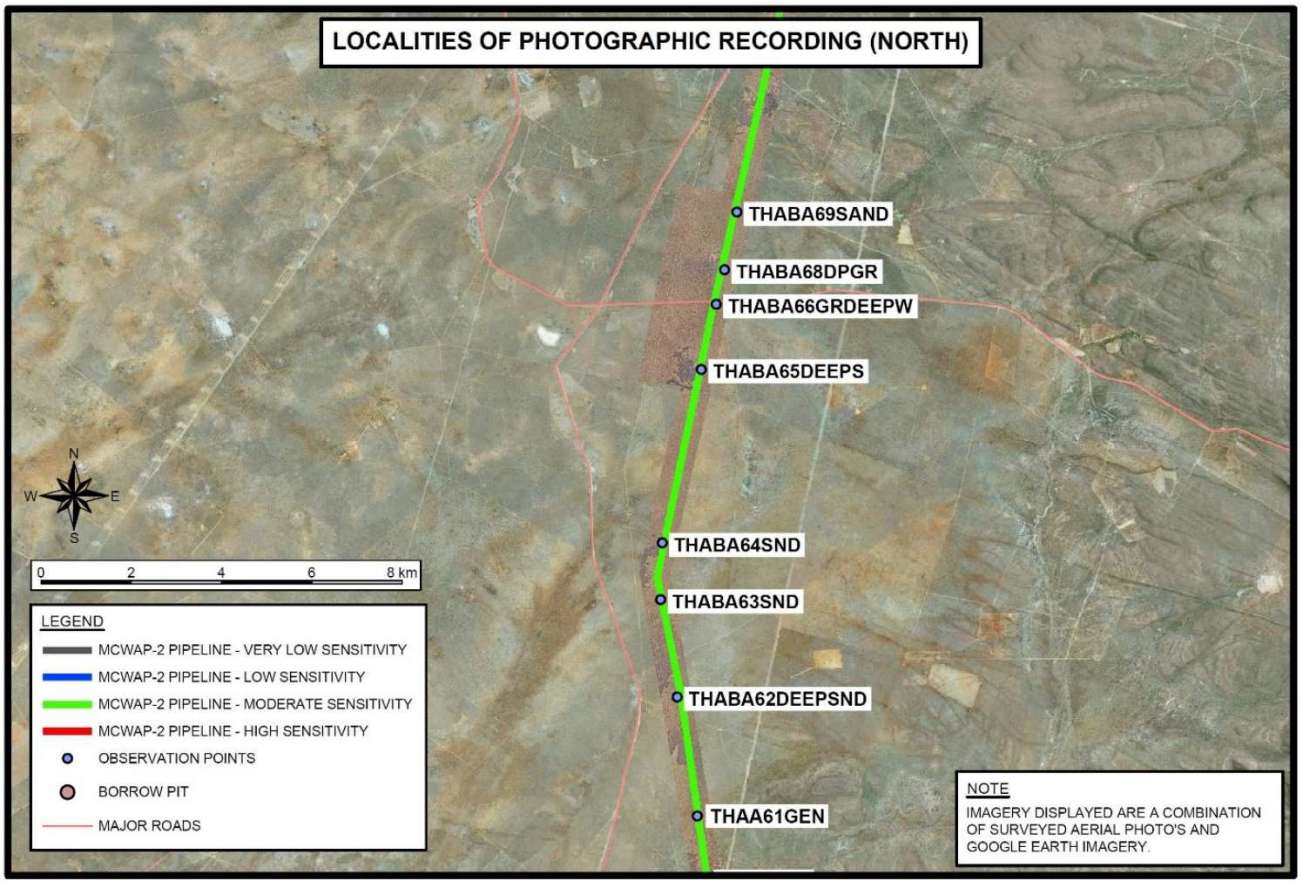


Figure 20. GPS locations of photographic observation points for Section North (Table 5)

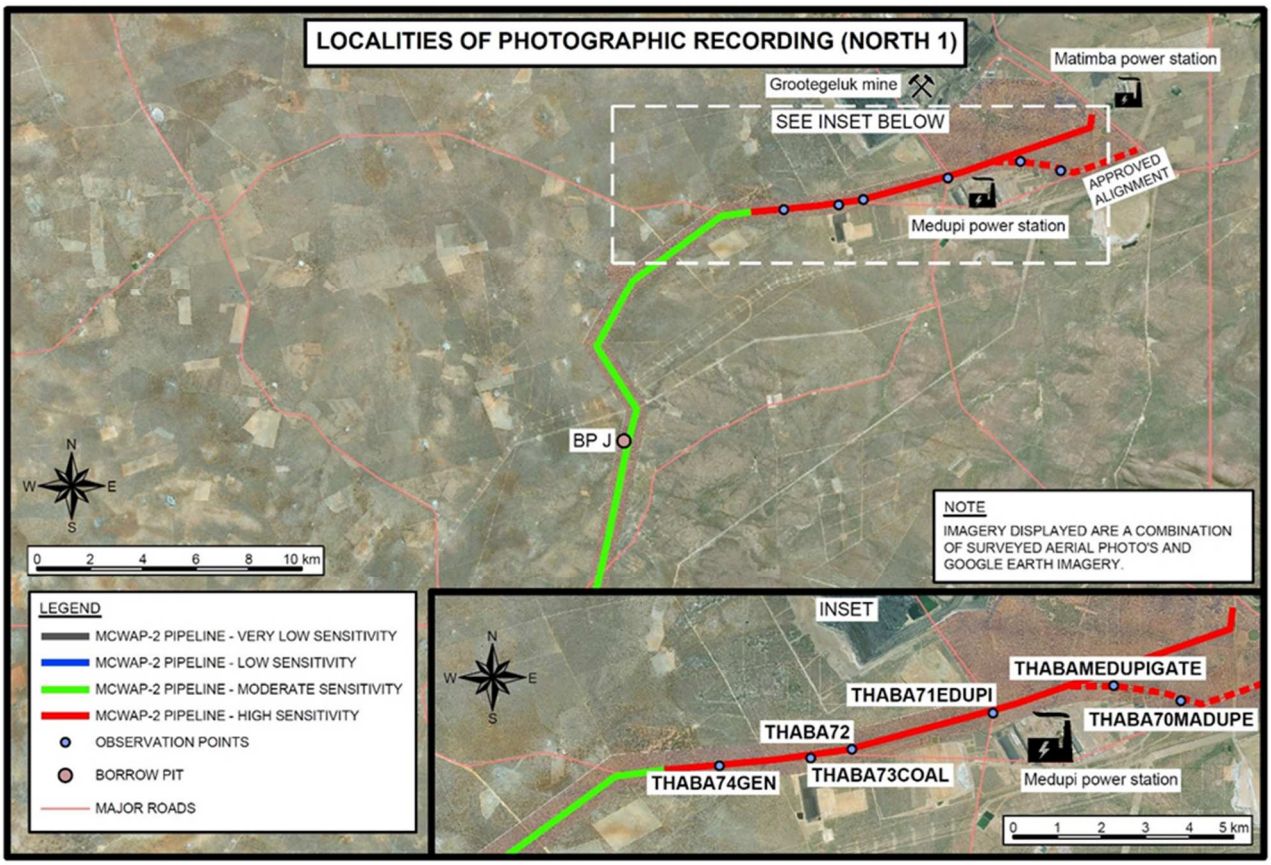


Figure 21. GPS locations of photographic observation points for Section North 1 (Table 5)

6.8 Field observations North 1

Further to the north in the study area the pipeline route crosses the important graben fault zones that lead to the accumulation of Karoo Supergroup rock sequences of Carboniferous and Permian to Triassic and Jurassic aged rocks in this part of South Africa (Figure 21).

Field observations (Table 5) confirmed that there are very few outcrops of these rock formations and most of the pipeline route is underlain by thick accumulation of Kalahari sands and other Caenozoic aged material. Most of the mapping was done following extensive drilling of boreholes and geophysical work in planning for the mining of coal at the mines that supplies coal to Medupi and Matimba Power Stations.

The chance find of plant fossils in the Permian and Triassic rocks in this region is very high. Some of the first fossils of the relatively large *Massospondylus* dinosaur from this area was described in the 1920's. The EM must be vigilant and if any fossils are exposed the palaeontologist must be informed and appropriate procedures, discussed in the "Chance Find Protocol", and the EMPr, must be followed.

Borrow Pit J is underlain by moderately sensitive quartzitic sandstone of the Waterberg Group.

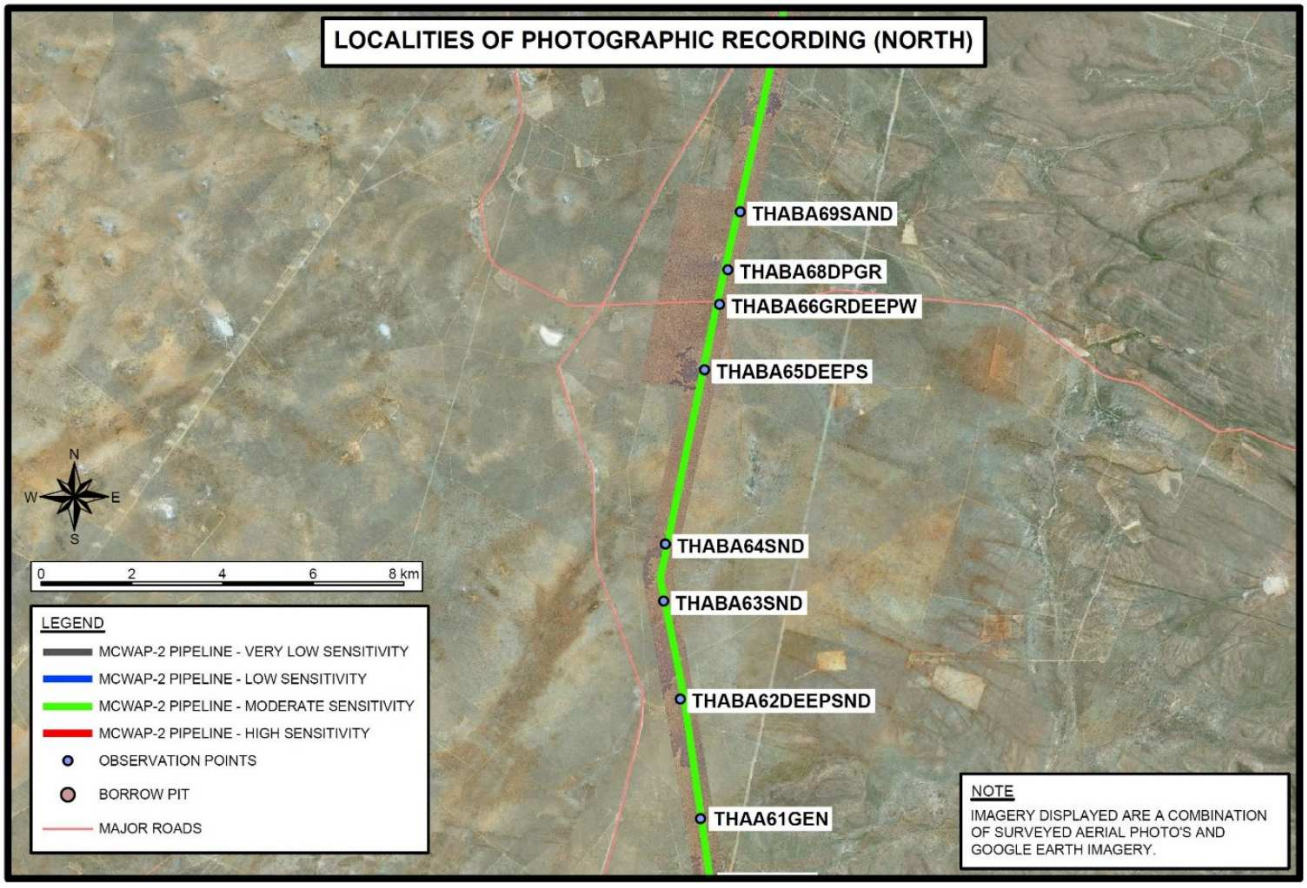


Figure 22. GPS locations of photographic observation points for Section North 2 (Table 5)

6.9 Field observations North 2

The field observations along the North 2 section (Figure 22) confirmed the absence of significant outcrop of bedrock (Table 5) and most of the route is underlain by deep sand of Caenozoic age. The most important sites where significant palaeontological heritage can be expected is at sites where termite activity might be associated with burial sites.

The entire North 2 section has been allocated a moderate sensitivity for palaeontological heritage.

Table 5. Photographic observations in the North, North 1 and North 2 sections of the survey (Figures 20, 21&22)

Photo	GPS	Description	Photographic Observation
Thaba 62 Deep sand	**23.973543° S** **27.395559° E**	Waterberg Group sediments covered in thick deposits of Ceanozoic aged sand, mostly refrred to as Kalahari sand. The most important palaeontological heritage will be associated with termitaria. The route of the pipeline falls in highly disturbed servitude of the railway line and it is unlikely that significant finds will be made during the construction phase of the development.	
Thaba 63 Deep sand	**23.954081° S** **27.391915° E**	Waterberg Group sediments covered in thick deposits of Ceanozoic aged sand, mostly refrred to as Kalahari sand. The most important palaeontological heritage will be associated with termitaria. The route of the pipeline falls in highly disturbed servitude of the railway line and it is unlikely that significant finds will be made during the construction phase of the development.	
Thaba 64 Deep sand	**23.942746° S** **27.392219° E**	Waterberg Group sediments covered in thick deposits of Ceanozoic aged sand, mostly refrred to as Kalahari sand. The most important palaeontological heritage will be associated with termitaria. The route of the pipeline falls in highly disturbed servitude of the railway line and it is unlikely that significant finds will be made during the construction phase of the development.	

Photo	GPS	Description	Photographic Observation
Thaba 65 Deep sand	**23.907832° S** **27.400639° E**	Waterberg Group sediments covered in thick deposits of Ceanozoic aged sand, mostly refrred to as Kalahari sand. The most important palaeontological heritage will be associated with termitaria. The route of the pipeline falls in highly disturbed servitude of the railway line and it is unlikely that significant finds will be made during the construction phase of the development.	
Thaba 66 Bridge	**23.894834°°S** **27.403821° E**	The bridge on the Pipeline route as a marker.	
Thaba 68	**27.403821°S** **27.405595°E**	The route of the pipeline follows the railway line servitude towards the north of section North and field observation confirms that the route is underlain by deep sand with high disturbance of the natural environment. No fossils were expected and no fossils were observed.	

Photo	GPS	Description	Photographic Observation
Thaba 69	**23.876383° S** **27.408242° E**	The northern part of section North is underlain by quartzitic sandstone with deep sand of Caenozoic age and no outcrop. Most of the geology shown on the maps has been interpreted from borehole data and geophysical surveys. This photographic observation is a good example of how vegetation has made it impossible for the access to the sections in the report where a general moderate sensitivity is allocated and the palaeontologist do not expect any significant chance finds on these sections. Representative samples were recorded therefore there was no need to explore further in these sections.	
Thaba 70 Matimba	**23.696519° S** **27.588351° E**	In the northern section of North 1 fossil rich deposits of the Permian and Triassic aged Karoo Supergroup is covered in deep sand of Caenozoic age. Chance find of fossils in the disturbed areas in road reserves will be low, but in all areas where excavation for the pipeline reach into Permian aged shale the chance find of plant fossils and even vertebrate fossil in Triassic aged rocks is very high.	

Photo	GPS	Description	Photographic Observation
Thaba 71	**23.699162° S** **27.546543° E**	In the northern section of North 1 fossil rich deposits of the Permian and Triassic aged Karoo Supergroup is covered in deep sand of Caenozoic age. The Medupi Power Sration is a coal fired power plant in this part of South Africa and plant fossils are by definition the source of the fossil fuel mined at local mines. For an understanding of the Palaeontological Heritage of the area it is recommended that the EM studies reports on the plant fossils at these facilities.	
Thaba 72	**23.708489° S** **27.506017° E**	Outcrop of Permian aged rocks are very sparse and most of the route of the pipeline is covered in Caenozoic sand with extreme disturbance in the road reserve. The chance find of fossils during deep excavation, if the rocks of the Karoo Supergroup are exposed is very high.	
Thaba 73	**24.094914° S** **27.419020° E**	Outcrop of Permian aged rocks are very sparse and most of the route of the pipeline is covered in Caenozoic sand with extreme disturbance in the raod reserve. The chance find of fossils during deep excavation, if the rocks of the Karoo Supergroup are exposed is very high. The photo shows large storage heaps of carbonaceous shale and coal.	

Photo	GPS	Description	Photographic Observation
Thaba 74	**23.710163° S** **27.485734° E**	Outcrop of Permian aged rocks are very sparse and most of the route of the pipeline is covered in Caenozoic sand with extreme disturbance in the road reserve. The chance find of fossils during deep excavation, if the rocks of the Karoo Supergroup are exposed is very high	
Thaba 75	**23.708729° S** **27.440629° E**	Route of the pipeline follows the road reserve and also an existing pipeline route. The natural environment is totally disturbed and the chance find of fossils is moderate to low.	
Thaba 76 Works	**23.709536° S** **27.435282°E**	Deep sandy soils of Caenozoic age on sediments of Karoo Supergoup age The mining of coal in this region indicate the presence of significant plant fossils but the collection of these fossils is best left to the geologists at the mines in this area. The chance find of fossils in the highly disturbed geology along the pipeline route is low.	
Thaba 76.1 Bridge to nowhere	**24.071087°°S** **27.414131° E**	Planned route of the pipeline and possibly a new railway line towards the west? The bridge to nowhere is used as a marker along the North 1 section of the survey.	

Photo	GPS	Description	Photographic Observation
Thaba 77	**23.686769° S** **27.367923° E**	The North 1 section follows the servitude of the road and no outcrops were found during the field survey. The chance find of fossils in the highly disturbed environment is low.	
Thaba 78	**23.685520° S** **27.321915° E**	The Eskom substation on the North 1 section is used as a marker.	
Thaba 78.1 NGK	**23.699143° S** **27.287961° E**	The North 1 section is allocated a moderate sensitivity for palaeontological heritage. Recent reports on the role that termitaria can play in the preservation of and even use as burial sites, or the association of termites with burial sites where the termites choose to digest bone for the Nitrogen in the bone, makes these deep sandy deposits in this area an important potential site for the discovery of new fossils, including the remains of Human ancestors in South Africa	

Photo	GPS	Description	Photographic Observation
Thaba 80	**23.754193° S** **27.285469° E**	The most western part of the survey Section North 1 (Figure 21) confirmed that the thick Caenozoic soils are a dominant geological feature and a moderate sensitivity for palaeontological heritage is allocated to this part of the project area. It is important to note that termitaria can be places with significant palaeontological and heritage value.	
Thaba 81	**23.783622° S** **27.311655° E**	The most western part of the survey Section North 1 (Figure 21) confirmed that the thick Caenozoic soils are a dominant geological feature and a moderate sensitivity for palaeontological heritage is allocated to this part of the project area. It is important to note that termitaria can be places with significant palaeontological and heritage value.	
Thaba 81.1	**23.795085° S** **27.324851° E**	The most western part of the survey Section North 1 (Figure 21) confirmed that the thick Caenozoic soils are a dominant geological feature and a moderate sensitivity for palaeontological heritage is allocated to this part of the project area. It is important to note that termitaria can be places with significant palaeontological and heritage value.	

Photo	GPS	Description	Photographic Observation
Thaba 82 Wetland	**23.812056° S** **27.355510° E**	The route of the pipeline crosses an extensive wetland at GPS 82 on the North 2 section (Figure 22).	
Thaba 85	**23.833244° S** **27.357744° E**	Most of the remaining part of the survey Section North 2 (Figure 22) confirmed that the thick Caenozoic soils are a dominant geological feature and a moderate sensitivity for palaeontological heritage is allocated to this part of the project area. It is important to note that termitaria can be places with significant palaeontological and heritage value.	
Thaba 86	**23.847365° S** **27.359500° E**	Most of the remaining part of the survey Section North 2 (Figure 22) confirmed that the thick Caenozoic soils are a dominant geological feature and a moderate sensitivity for palaeontological heritage is allocated to this part of the project area. It is important to note that termitaria can be places with significant palaeontological and heritage value.	

Photo	GPS	Description	Photographic Observation
Thaba 87	**23.863511° S** **27.358591° E**	Most of the remaining part of the survey Section North 2 (Figure 22) confirmed that the thick Caenozoic soils are a dominant geological feature and a moderate sensitivity for palaeontological heritage is allocated to this part of the project area. It is important to note that termitaria can be places with significant palaeontological and heritage value.	
Thaba 88	**23.895061° S** **27.378353° E**	Final marker on western route and filed survey section North 2 (Figure 22) is the road signs. This section of the pipeline is underlain by sedimentary rocks of the Waterberg Group, covered in deep sand. Fossils will most probably only be associated with termitaria.	

7 PALAEONTOLOGICAL IMPACT AND MITIGATION

The predicted palaeontological impact of the development (Figure 12) is based on the initial mapping assessment and literature reviews, as well as information gathered during the field investigation (Tables 2, 3 4 & 5).

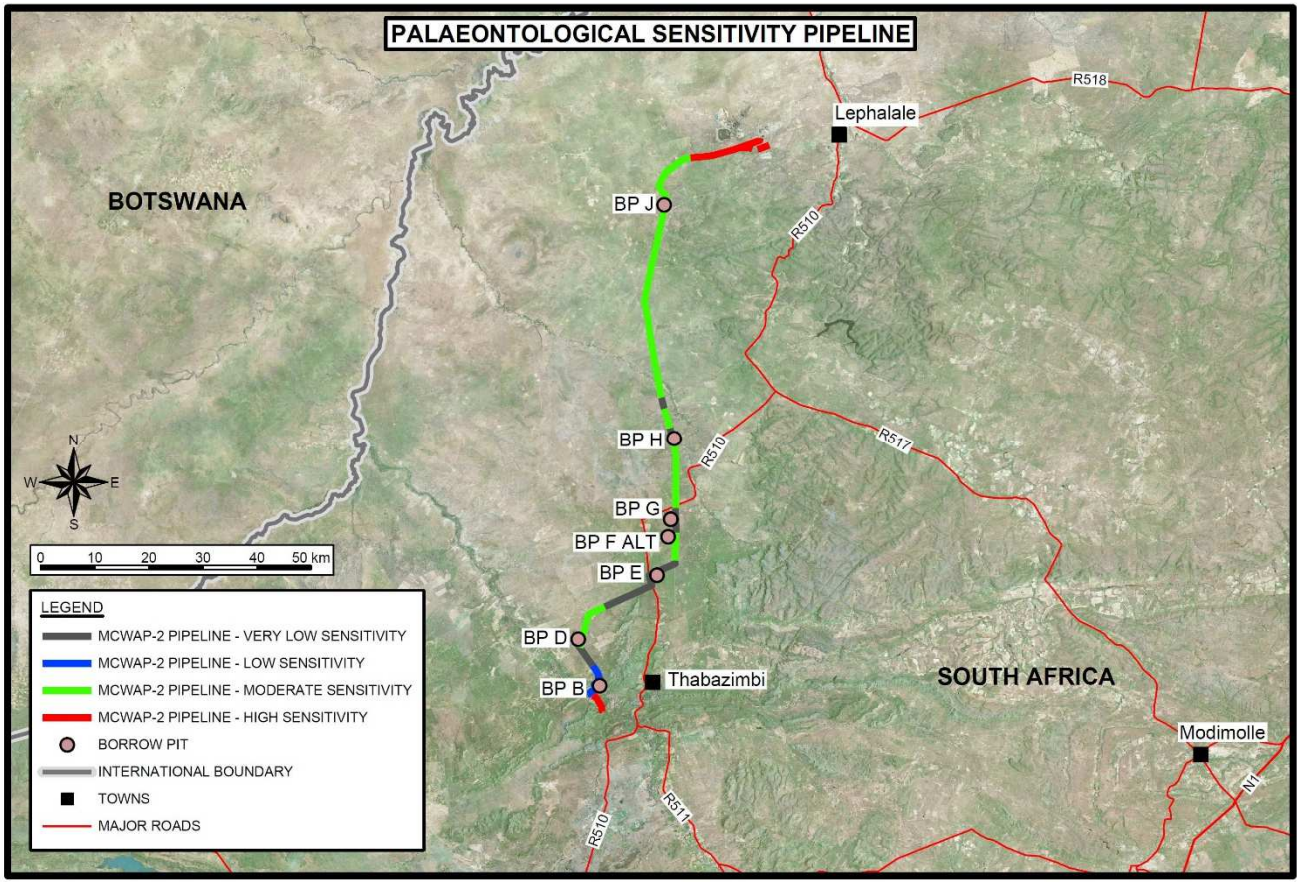


Figure 23. Palaeontological Sensitivity of the rocks underlying the MCWAP-2 development area. For colour codes see Table 1

The field investigation confirms that the study area is underlain by rocks that range from the very low sensitive dolerite intrusive igneous rocks to the very highly sensitive stromatolitic dolomite of the Malmani Subgroup, Transvaal Supergoup and carbonaceous (coal rich) shale of the Ecca Group, Karoo Supergroup of South Africa.

The excavations for the construction of the infrastructure for the proposed developments can expose some sediments of very highly sensitive geological formations and some sites revealed evidence of very highly significant remains of fossils (Observations on site by the Palaeontologist, but not collectable samples yet). A significant part of the excavation project will cut into rocks of the Malmani Subgroup that has a very high sensitivity for palaeontological heritage and the EM must be on the lookout for trace fossils. The high ground of the entire project cut very important areas underlain by the moderately sensitive Waterberg Group and in the small exposure investigated during this filed survey revealed significant remains of trace fossils (Table 2). The most northern part of the route falls on very highly sensitive geology and if sandstone or shale is exposed in any excavation, the EM must be vigilant and report all fossils exposed for verification and collection by the appointed Palaeontologist.

The construction team must be aware of the sensitivity of the area and the very high potential of exposing significant fossils. If any fossils are exposed the palaeontologist must be informed and the procedures set out in the “Chance Find Protocol” (CFP) attached to this report, must be followed.

8 CONCLUSIONS

The development site applicable to the application for the proposed Mokolo Crocodile Water Augmentation Project Phase 2 (MCWAP-2), Lephalale and Thabazimbi Local Municipalities, Waterberg District Municipality in the Limpopo Province is underlain by Vaalian Aged stromatolitic dolomite, Mokolian aged quartzitic sandstone and shale, Carboniferous and Permian to Permo-Triassic aged sandstone and mudstones and Quaternary aged surface deposits which varies in palaeontological sensitivity from very Low to very high (Table 1). No significant fossils are expected from the Mokolian aged diabase or the Jurassic aged dolerite dyke areas, but the association of termitaria with these rock types are significant in terms of possible Human burial sites.

Significant fossils are expected in areas with deep exposure, and more fossils are expected during excavation for trenching in areas indicated in red and orange on the Palaeontological sensitivity map (Figure 12). It is important that a suitably qualified Palaeontologist be appointed to visit the site of the development to identify potential fossils in areas indicated as High and Very Highly significant during the first week of excavations. If any fossils are exposed during the lifetime of the project, the finds must be reported as soon as possible to the relevant authority (SAHRA) for collection and safe keeping of Palaeontological Heritage.

In areas underlain by the Malmani Subgroup the field investigation confirmed the presence of stromatolites (Table 2), and it will be very important that a suitably qualified Palaeontological Specialist be appointed to do a Phase 2 PIA and to upgrade the “Chance Find Protocol” document. The CFP document must then be included as part of the CEMPr of this project, to record all unexpected fossils associated with the geological formations on site.

It is recommended that:

- The EAP and EM must be informed of the fact that a high and very high Palaeontological Sensitivity is allocated to the parts of study area underlain by Transvaal Supergroup and Karoo Supergroup sedimentary rocks and a moderate sensitivity over the rest of the site underlain by Waterberg Group Quartzitic sandstone and shale. A moderate sensitivity is allocated to areas covered in Quaternary aged sand. Diabase and dolerite will not contain fossils but can be associated with important termateria.
- Further mitigation for Palaeontological Heritage is recommended for this project before excavation of deeper than 1.5m is done. Collection of a representative sample (1 m^3) of stromatolitic dolomite must be done during the first week of excavation into these rocks and the sample must be transported to the ESI at WITS University for further studies. (** See Note to Contractors below)
- A suitably qualified palaeontologist must do a Phase 2 PIA and upgrade the “Chance Find Protocol” (CFP) when fossils are recorded from any formation in this area during excavations.
- Recommendations contained in this Phase 1 PIA must be approved by SAHRA.
- These recommendations must be included in the CEMPr of this project.

** Note to Contractors – Sampling of 1m^3 of rock sample with stromatolite structures.

Following the recommendation to collect at least 1m^3 of rock samples as a representable sample of well-defined stromtolites from the Malmani Group dolomite at **GPS 24.633237° S27.316933° E** or as

close to this point as deemed appropriate by the palaeontologist, the following site instruction is proposed.

1. The contractor or his site manager must familiarise himself with the definition of the term stromatolite.
2. The machine operator responsible for excavation at **GPS 24.633237° S27.316933° E** or in that area, must familiarise himself with the term stromatolite.
3. The exposure of bedrock must be inspected to confirm that the dolomite in fact displays significant stromotolite structures. The only way to define "significant structures", is by on-site observation by a trained person. The significance of fossil structures are unfortunately subjective and what one scientist regards as highly significant due to unique features in his/her judgement might be insignificant to a scientist with less experience in a specific field of study.
4. The sampling of rocks that display well-defined stromatolites is also subjective and the sampling size of the actual rock samples can vary from 100mm x 100mm x 100mm to as big as 300mm by 300mm x 300mm and the actual size will depend on the size of the stromatolites present in the rock. From the field observation it is proposed that the largest samples will be about 300mm x 300mm x 200mm. Only three samples of rock of this size will constitute a "representative sample".
5. The appointed palaeontologist must apply for a permit from SAHRA to collect the samples and then also apply for a destruction permit for the rest of the excavation into rocks of the Malmani Subgroup. The permit will be on behalf of the developer and application must preferably done long before the time of actual excavation to prevent possible standing time.
6. The collected samples must be transported to the EIS at Wits University at the cost of the contractor or developer. Preferably the removal of the rocks from site to the ESI must be included into the Bill of Quantities of the appointed contractor and must form part of the CEMPr for the project.

9 REFERENCES

Almond J.E. and Pether J. 2008. *Palaeontological Heritage of the Western Cape.* Internal Report Heritage Western Cape.

Almond J.E., De Klerk B. and Gess R., 2009. *Palaeontological Heritage of the Eastern Cape*. Internal Report, SAHRA.

Butler E. 2018. Palaeontological Desktop Assessment of the proposed Mokolo and Crocodile River (West) Water Augmentation Project (Phase 2a) (Mcwap-2a): Water Transfer Infrastructure. Heritage Impact Report, PGS (Reports for Nemai Consuilting)

Govorushko, S. 2019 Economic and ecological importance of termites: A global review. Entomological Science V22. Pp21-35.

Groenewald GH. 1990. Stratigrafie en Sedimentologie van die Groep Beaufort in die Noord-oos Vrystaat. Bull 96, Geological Survey of South Africa.

Groenewald GH. 1996 Stratigraphy and Sedimentology of the Tarkastad Subgroup, Karoo Supergroup of South Africa. Unpubl PhD Thesis, University of Port Elizabeth.

Groenewald G.H., 2012. *Palaeontological Technical Report for KwaZulu-Natal*. Internal Report, AMAFA.

Groenewald G.H., Groenewald D.P. and Groenewald S.M., 2014. *Palaeontological Heritage of the Free State, Gauteng, Limpopo, Mpumalanga and North West Provinces*. Internal Palaeotechnical Reports, SAHRA.

Groenewald DP. 2016. *Tetrapod trackways and the Ecca-Beaufort contact in the Estcourt district.* Unpublished BSc Hons project, University of the Witwatersrand, Johannesburg.

Huchet, J-B, Deverly, D., Gutierrez B. and Chauchat, C. 2011. Taphonomic Evidence of a Human Skeleton Gnawed by Termites in a Moche-Civilisation Grave at Huaca de la Luna, Peru. International Journal of Osteoarchaeology, V21, pp92-102.

Johnson MR , Anhaeusser CR and Thomas RJ (Eds). 2009. The Geology of South Africa. GSSA, Council for Geoscience, Pretoria.

Linstrom W. 1987 Die Geologie van die gebied Durban. Explanation Sheet 2930 (1:250 000). Geological Survey of South. Africa.

MacRae C. 1999. Life Etched in Stone. Geological Society of South Africa, Linden, South Africa.

Mason TR and Christie ADM 1986. Palaeoevironmental significance of ichnogenus *Diplocraterion* torell from the Permian Vryheid Formation of the Karoo Supergroup, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 53(3-4):249-265.

McBrearty S. 1990. Consider the Humble Termite: Termites as Agents

of Post-depositional Disturbance at African Archaeological Sites. Jour of Archaeological Science V17, pp111-143.

McCarthy T and Rubidge BS. 2005. Earth and Life. 333pp. Struik Publishers, Cape Town.

Van Dijk, D.E. 2011. Taphonomic Aspects of the Wagondrift Quarry Site, and their implications for the depositional environment of the Upper Permian Estcourt Formation (KwaZulu-Natal, South Africa). South African Journal of Geology. Jun2011, Vol. 114 Issue 2, p105-109.

Watson J.P. 1967. A Termite Mound in an Iron Age Burial Ground in Rhodesia. Jour of Ecology, V55, pp663-669.

Wylie F.R., Walsh, G.L. and Yule R.A. 1987. Insect damage to Aboriginal Relics at Burial and Rock-Art Sites near Carnarvon in Central Queensland. J. Aust. Ent. Soc., V26. Pp335 - 345.

10 QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

Dr Gideon Groenewald has a PhD in Geology from the University of Port Elizabeth (Nelson Mandela Metropolitan University) (1996) and the National Diploma in Nature Conservation from Technicon RSA (the University of South Africa) (1989). He specialises in research on South African Permian and Triassic sedimentology and macrofossils with an interest in biostratigraphy, and palaeo-ecological aspects. He has extensive experience in the locating of fossil material in the Karoo Supergroup and has more than 20 years of experience in locating, collecting and curating fossils, including exploration field trips in search of new localities in the southern, western, eastern and north-eastern parts of the country. His publication record includes multiple articles in internationally recognized journals. Dr Groenewald is accredited by the Palaeontological Society of Southern Africa (society member for 25 years).

11 DECLARATION OF INDEPENDENCE

I, Gideon Groenewald, declare that I am an independent specialist consultant and have no financial, personal or other interest in the proposed development, nor the developers or any of their subsidiaries, apart from fair remuneration for work performed in the delivery of palaeontological heritage assessment services. There are no circumstances that compromise the objectivity of my performing such work.

Dr Gideon Groenewald

Geologist/Palaeontologist

APPENDIX A

CHANCE FIND PROTOCOL FOR PALAEONTOLOGICAL HERITAGE

PHASE 1 PALAEONTOLOGICAL ASSESSMENT SURVEY AND A SITE VISIT FOR THE PROPOSED MOKOLO CROCODILE WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2), LEPHALALE AND THABAZIMBI LOCAL MUNICIPALITIES, WATERBERG DISTRICT MUNICIPALITY IN THE LIMPOPO PROVINCE.

MITIGATION FOR EXCAVATION IMPACT ON PALAEONTOLOGICAL HERITAGE RESOURCES

It is essential that the appointed palaeontologist, in consultation with the Project Environmental Manager and the contractors and EM of the excavation works develop a short-term strategy for the recovery of significant fossils during the excavation operation. As part of such a strategy, the discussions with the palaeontologist must include:

- Initially, and at least for the duration of excavation, visit the site on request of the EM of the specific construction site, to ensure recording of all potentially significant fossil strata. Due to the longevity of this contractual involvement it is not possible to have pre-determined timing on these visits and it is a conclusion from present excavations, that more frequent visits by the Palaeontologist during excavations into the Malmani Subgroup, Waterberg Group, Karoo Supergroup Group and Quaternary sediments will most probably be required.
- Determine a short-term strategy and budget for the recording of significant fossils. This strategy is simply an oral agreement on when the site is to be inspected and what the finds are that might be recorded. The site visit must include an introduction session with all the managers of the project team, including training of the EM and site managers by the appointed palaeontologist, to basically train people to know what to look out for in terms of fossil heritage on site. This action will be required at the start of each individual construction activity for the duration of construction in the “greenfield sections” of the route.
- In the case of reporting of any unusual sedimentary structures, the Palaeontologist must be notified, and a site visit must be arranged at the earliest possible time with the Palaeontologist. In the case of the site EM or the Site Manager becoming aware of suspicious looking material that might be a “Significant Find”, the construction must be halted in that specific area and the PEM must be informed who will inform the Project Engineer. The Palaeontologist must be given enough time to reach the site and the PEM will request a Site Instruction from the Engineer to allow for removal the material before excavation continues. Although significant finds of Stromatolites were recorded during the first site inspections (Phase 1 PIA, included in this document) the Palaeontologist foresee much more significant finds during the lifetime of the Project.

Mitigation Measures Normally Encountered

i. Mitigation of palaeontological material must begin as soon as possible and preferably when "trial excavation" takes place. The appointed specialists must acquaint themselves with the operation and determine feasible mitigation strategies.

ii. A plan for systematic sampling, recording, preliminary sorting and storage of palaeontological and sedimentological samples will be developed during the early stages of the project, in collaboration with the Evolutionary Studies Institute (ESI) at WITS University, which is the closest Institute to the site. If appropriate, the Rhodes University as well as the University of KwaZulu-Natal, might be asked for their involvement in this project.

iii. Mitigation will involve an attempt to capture all rare fossils and systematic collection of all fossils discovered. This will take place in conjunction with descriptive, diagrammatic and photographic recording of exposures, also involving sediment samples and samples of both representative and unusual sedimentary or biogenic features. The fossils and contextual samples will be processed (sorted, sub-sampled, labelled, boxed) and documentation consolidated, to create an archive collection from the excavated sites for future researchers.

Functional responsibilities of the Developer and Project Environmental Managers for the Project

i. Ensuring, at their cost, that a representative archive of palaeontological samples and other records are assembled to characterise the palaeontological occurrences affected by the excavation operation.

ii. Provide field aid, if necessary, in the supply of materials, labour and machinery to excavate, load and transport sampled material from the excavation areas to the sorting areas, removal of overburden if necessary, and the return of discarded material to the disposal areas. In the case of this project it is foreseen that stromatolites, vertebrate, plant and trace fossils will be present. (*If more fossils of Vaalian, Mokolian, Permian, Triassic or Quaternary age are exposed, it will be very highly significant and the Palaeontologist will obviously be in close communication with the site Environmental Manager (EM) to act as required by SAHRA without causing undue standing time for the contractors*).

iii. "Facilitate" systematic recording of the stratigraphic and palaeo-environmental features of exposures in the fossil-bearing excavations, by allowing time to describe and measure geological sections, and by providing aid in the surveying of positions where significant fossils are found. (In the case of this specific development, the likelihood of such finds is high for the southern part of the development).

iv. Provide safe storage for fossil material found routinely during excavation operations by construction personnel. In this context, isolated fossil finds in disturbed material qualify as "normal" fossil finds.

v. Provide covered, dry storage for samples and facilities that is defined as a work area for sorting, labelling and boxing/bagging of samples.

vi. Costs of basic curation and storage in the sample archive at the ESI, WITS University (labels, boxes, shelving and, if necessary, specifically-tasked temporary employees).

Documentary record of palaeontological occurrences

The contractors will, after consultation with the EM and in collaboration with the Palaeontologist, make the excavation plan available to the appointed specialist, in which the following information are indicated on the

plan in the site office at the excavation site. This must be done in conjunction with the appointed specialist and form part of the on-going revision of the "Chance Find Protocol" (CFP) during the excavation stage of the project:

i. Initially, all known specific palaeontological information will be indicated on the plan. This will be updated throughout the excavation period.

ii. Locations of samples and measured sections are to be pegged, and routinely accurately surveyed. Sample locations, measured sections, etc., must be recorded three-dimensionally if any significant fossils are recorded during the time of excavation. This information must be recorded during the first site visit and a clearance from the Palaeontologist (e-mail message will suffice) must be followed up with subsequent e-mail communications with the Site Specific EM.

Functional responsibilities of the appointed Palaeontologist

i. Apply for a permit to collect fossils during the lifetime of the Project and establishment of a representative collection of fossils and a contextual archive of appropriately documented and sampled palaeoenvironmental and sedimentological geodata in collaboration with the ESI at WITS University, or the Rhodes University, University of KwaZulu-Natal, depending on the expertise available at each Institute.

ii. Undertake an initial evaluation of potentially affected areas and of available exposures in excavations. A short training session, inclusive of the PEM, Project Managers and the EM's or their representatives, must presented during the initial induction stages of this project.

iii. On the basis of the above, and evaluation during the early stages of excavation development, in collaboration with the PEM and the contractor management team, more detailed practical strategies to deal with the fossils encountered routinely during excavation, as well as the strategies for major finds must briefly be agreed on.

iv. Informal on-site training in responses applicable to "normal" fossil finds must be provided for the PEM, EM and environmental staff by the appointed specialist. This step will only be arranged following the discovery of significant fossils at the time of the Phase 2 site visits.

v. Respond to significant finds and undertake appropriate mitigation.

vi. Initially, for the first year of operation, and if the PEM or the appropriate EM indicates significant "strange looking rocks" that might be similar to the fossils indicated to the staff during the information sessions, visit at least once in twelve weeks to "touch base" with the monitoring progress. Document interim "normal" finds and undertake an inspection and documentation of new excavation faces. A strategy for further visits during the life of the excavation must be discussed.

vii. Transport of material from the site to the ESI, WITS University or the allocated Institute where an expert on the specific fossils discovered, is presently employed.

viii. Reporting on the significance of discoveries, as far as can be preliminarily ascertained. This report is in the public domain and copies of the report must be deposited at ESI and the South African Heritage Resources Authority (SAHRA). It must fulfil the reporting standards and data requirements of these bodies.

ix. Reasonable participation in publicity and public involvement associated with palaeontological discoveries.

Exposure of palaeontological material

In the event of construction exposing new palaeontological material, not regarded as normative/routine as outlined in the initial investigation, such as a major fossil find (for example the articulated remains of a vertebrate), the following procedure must be adhered to:

i. The appointed specialist or alternates (SAHRA; ESI WITS University, University of KZN; Rhodes University) must be notified by the responsible officer (e.g. the PEM, Chief Engineer, EM or Contractor Manager) This is also applicable if major or unusual discoveries are made by the Contractor Staff during excavation.

ii. Should a major in situ occurrence be exposed, excavation will immediately cease in that area so that the discovery is not disturbed or altered in any way until the appointed specialist or scientists from the ESI at WITS University, or its designated representatives, have had reasonable opportunity to investigate the find. Such work will be at the expense of the Developer.

Some poorly defined impressions of trace fossils were observed in the Waterberg Group Slate during the first site visit. The palaeontologist cleared the continued excavation on the proviso that any suspicious material will be indicated to the Palaeontologist via emailed photographic information.

CONCLUSION

The development site for the Phase 1 Palaeontological Assessment Survey and a site visit for the proposed Mokolo Crocodile Water Augmentation Project Phase 2 (MCWAP-2), Lephalale and Thabazimbi Local Municipalities, Waterberg District Municipality in the Limpopo Province falls on very low to very highly significant sedimentary rocks (Transvaal Supergroup, Karoo Supergroup and Quaternary surface deposits) that contain significant fossils. No fossils were collected to date due to very deep and severe weathering of rocks. No fossils will be present in granite, diabase and dolerite.

Poorly preserved imprints of trace fossils were recorded in the Waterberg Group slate. The potential for finding significant stromatolites, invertebrate, plant and trace-fossils, in any excavation into sediments of the Malmani Subgroup, Waterberg Group, Karoo Supergroup and Quaternary termitaria is very high and the cooperation of the entire team of engineers and contractors, is of critical importance. The interest and cooperation of the management team will be highly appreciated and it is essential that the excavations be monitored during the entire period of excavation and that this “Chance Find Protocol” be updated on a regular bases during the life-time of the excavation period for the Project. It is essential that the Palaeontologist be notified of the final sign-off of the project date, for final posting of the “Chance Find Protocol” on the SAHRIS Website for record purposes.

It is recommended that:

- The EM must be informed of the fact that a very low to very high Palaeontological sensitivity was allocated to the entire development and due to the highly weathered nature of the material, significant fossils is expected after the start of excavations for pipeline construction and foundations at the weir, as well as in borrow pits excavations that exceed 1.5m.
- The allocated team members in the teams of the contractor should be introduced to Palaeontological material that is likely to be found on site. A once-off information session with the Palaeontological specialist must be arranged at the start of each individual contractual Construction Site, to present a simple and understandable (preferably audio-visual presentation) to the majority

of the contractual Managers and EM's on site during the initial site visit as is indicated in the CEMPr for the Project.

- This "Chance Find Protocol" is included in the CEMPr of the Project and a reasonable budget must be allocated to ensure compliance with the legal responsibility of the developer in terms of the proper conservation of and storage of Palaeontological Heritage. This also applies to areas that will be flooded by the weir, where exposures will only occur after filling of the proposed weir.
- SAHRA must be informed of the content of this "Chance Find Protocol" and CEMPr arrangements by the PEM and the Developer, for final conclusion of the Project when completed.