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PHASE 1 PALAEONTOLOGICAL IMPACT ASSESSMENT

Msebe Block Opencast Coal Mining

(PHASE II of mining plan)

(Nongoma, Zululand District, KwaZulu-Natal)

Specialist report by:

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31 March 2014

1. EXECUTIVE SUMMARY

Rose Prevec was appointed by Prime Resources (on behalf of Mbila Resources) to assess the site of a proposed opencast coal mine, near Nongoma, Zululand District, KwaZulu-Natal. The site of the mine overlies rocks of the Emakwezini Formation (Beaufort Group, Karoo Supergroup, Limpopo Basin; lateral equivalent of the Normandien Formation in the main Karoo Basin). Mining will target multiple coal seams found in these Late Permian deposits. These coal-bearing host rocks have been previously demonstrated to have high potential for fossil plants (*Glossopteris*-dominated fossil floras) of high quality and significance. A field survey of exposed rock in the development area and immediate surrounds resulted in the documentation of 13 fossil sites. Despite the paucity of rock exposure in the region (due to thick vegetation and soil cover), nine plant fossil localities, and four wood sites were recorded, 10 of these of such good quality as to require significant mitigation prior to any mining activities. This abundance and high quality of sites provides an indication of the high potential palaeontological wealth of the strata to be impacted upon by mining activities. SAHRA (South African Heritage Resources Agency) lists the Emakwezini Formation as being of 'very high' palaeontological significance. Damage to or destruction of any fossil during mining or construction activities would be a highly negative, permanent impact of international significance.

SIGNIFICANCE RATING=90 : (magnitude +duration+scale) x probability							
Rock Unit	**Duration**	**Scale**	**Probability**	**Magnitude**		**Overall Significance**	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Emakwezini Formation	5-permanent	5 - International	5 - Definite	beneficial	8-High negative	beneficial	High negative

Recommendation: Prior to any mining activity that will impact on the plant localities P3, P4, P5a&b, P15, P16, P17, MW1-4, a Phase II palaeontological impact assessment must be carried out in order to mitigate damage to and loss of valuable fossil material. Considering the unusually high concentration and quality of fossil sites in the area, regular monitoring of all bedrock disturbances during the course of this development must be carried out by an appropriately trained Environmental Control Officer. Should any significant plant fossil sites of good quality be exposed during excavations, the ECO must contact the Provincial Heritage Resources Agency, AMAFA (Tel: 0333 946543; A. van de Venter Radford, amafaddps@amafapmb.co.za) immediately to facilitate expert documentation and collecting of the site by a qualified palaeontologist. Allowance must be made by the mine to facilitate regular inspection visits (eg. every 6 months) by a qualified palaeontologist.

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3. INTRODUCTION AND BRIEF

A Palaeontological Impact Assessment was requested by Prime Resources Environmental Consultants (on behalf of the developers, Mbila Resources) for a proposed coal mining development near Nongoma, in the Zululand district, north-eastern KwaZulu-Natal (Figs 1, 2, 3).

Mbila Resources was awarded a Mining Right for coal (anthracite) in 2008, for 52 946 ha of Portion 9 of the Farm Reserve Number 12 | 15832 HU. No mining activities have been undertaken to-date at this site. The proposed development comprises an open cast coal mine and associated infrastructure in the south-western part of the area subject to the Mining Right Application, referred to as the Msebe Block (indicated in Figs1-3). Coal extracted will be hauled along existing roads.

Mining will specifically target the Emakwezini Formation coal seams of the Beaufort Group, which is known to be of high palaeontological sensitivity (SAHRA palaeontological

sensitivity map; http://www.sahra.org.za/map/palaeo; Figs 4-6), thereby necessitating a field assessment and production of a Palaeontological Impact Assessment Report (as per the SAHRA Minimum Standards for Palaeontological Components of Heritage Impact Assessment Reports, 2012), as part of the Environmental Management Plan for the development.

4. LEGISLATIVE FRAMEWORK

Protection of South Africa's environmental resources is regulated by the Department of Environmental Affairs (DEA), in part through the National Environmental Management Act ("NEMA" Act 107 of 1998). In accordance with the Act, developers must apply to the competent authority for approval of their plans, which, depending on the nature of the development, are subject to an assessment of the anticipated impacts these activities will have on the environment. The primary piece of legislation protecting national heritage in South Africa, is the South African Heritage Resources Act (Act No. 25) of 1999. In accordance with Section 38 (Heritage Resources Management) of the act, developers must apply to the relevant authority (South African Heritage Resources Agency - SAHRA) for authorisation to proceed with their planned activities. This application must be accompanied by documentation detailing the expected impact this will have on national heritage in particular.

Categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act, and which therefore fall under its protection, include among other categories:

- 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;
- objects with the potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage.

To address concerns relating to the protection of these particular heritage resources, a Heritage Impact Assessment (HIA) may be required to assess any potential impacts to archaeological and palaeontological heritage within the footprint of the proposed development. This report represents the palaeontological component of the HIA, conducted as part of an Environmental Management Plan (EMP).

5. DETAILS OF THE STUDY AREA

The study area lies approximately 15 km (as the crow flies) East-northeast of Nongoma in the Zululand district, north-eastern KwaZulu-Natal (Figs 1, 2; 2731DD Ngxongwane 1:50 000 topographical map). The site is situated to the North of the R618 (eastbound from Nongoma), off an unnamed dirt road that diverges west from the D1815, on Portion 9 of the Farm Reserve Number 12 | 15832 HU.

The proposed development will entail opencast mining (surface mining, also called strip mining), employing roll-over mining methods (back-filling of open pit as excavations progress) and associated infrastructure. Existing road infrastructure (current and projected from Phase I of the greater mining development) will be utilised to haul the coal to a coal handling plant situated near G-Block in the adjacent Mining Right Area.

6. GEOLOGICAL SETTING

As indicated by the geological map of the region provided by Prime Resources, the underlying rocks in the area fall within the palaeobotanically highly significant **Emakwezini Formation** (light green areas in Figs 4-6). The entire area was heavily intruded by dolerite dykes and sills of the **Karoo Dolerite Suite (Jd)** during Jurassic times (scattered pink areas in Fig. 4; Duncan & Marsh, 2006).

Emakwezini Formation

The Emakwezini Formation, of the Adelaide Subgroup, Beaufort Group, Karoo Supergroup (Fig. 6), is a fluvial sequence that was laid down in a swampy, fluvio-lacustrine setting in the Lebombo Basin, east of, and contemporaneous with, the main Karoo Basin (Bordy & Prevec, 2008). It crops out in a narrow, highly faulted belt that runs approximately parallel to the coast from central Swaziland into north-eastern KwaZulu-Natal (Bordy & Prevec, 2008). The formation is considered a stratigraphic and temporal equivalent of the Normandien Formation (which includes now the informally recognised Estcourt Formation) of the eastern and north-eastern Karoo Basin (Snyman, 1998; Johnson *et al.*, 2006), and the Balfour Formation of the southern Karoo Basin, and it is considered to range in age from Middle Permian to Late Permian (Lopingian) (Bordy & Prevec, 2008; Johnson et al., 2006). The Emakwezini Formation comprises predominantly grey, green-grey and black mudrocks and

siltstone, with subordinate fine- to coarse-grained, but mainly medium-grained sandstones (in a ratio of approximately 2:1), with multiple intercalated coal seams that range in thickness from <1m to up to 15 m (Johnson *et al.*, 2006; Bordy & Prevec, 2008). Up to four fining-upward clastic-coal sequences are present.

Post-Karoo faulting of the area resulted in the down-throw of blocks within a complex graben structure, bringing the stratigraphically higher Emakwezini Formation deposits to the same level as those of the adjacent Vryheid Formation, as we see in Figs 4-5. The lower boundary with the Volksrust Formation is gradational and conformable.

Both Emakwezini and Vryheid Formation coals have been mined in the Nongoma area since 1985 (Zululand Anthracite) (Snyman, 1998).

7. PALAEONTOLOGICAL POTENTIAL

The dolerites in the development area (pink areas in Fig. 4), are igneous in nature, and by definition are non-fossiliferous.

Any fine-grained sedimentary rocks of the Emakwezini Formation have a high potential for containing fossilised plants, including those intercalated with the coal seams. The coal itself is of limited macro-palaeontological value due to the high density and compaction of organic material, but all associated clastics, particularly those of fine grain size should be carefully monitored for fossil heritage.

SAHRA (South African Heritage Resources Agency) lists the Emakwezini Formation as being of ‘very high’ palaeontological significance, and of global importance (see SAHRIS webpage: http://www.sahra.org.za/fossil-layers).; see Table 01 for list of taxa found in the Emakwezini Formation to date.

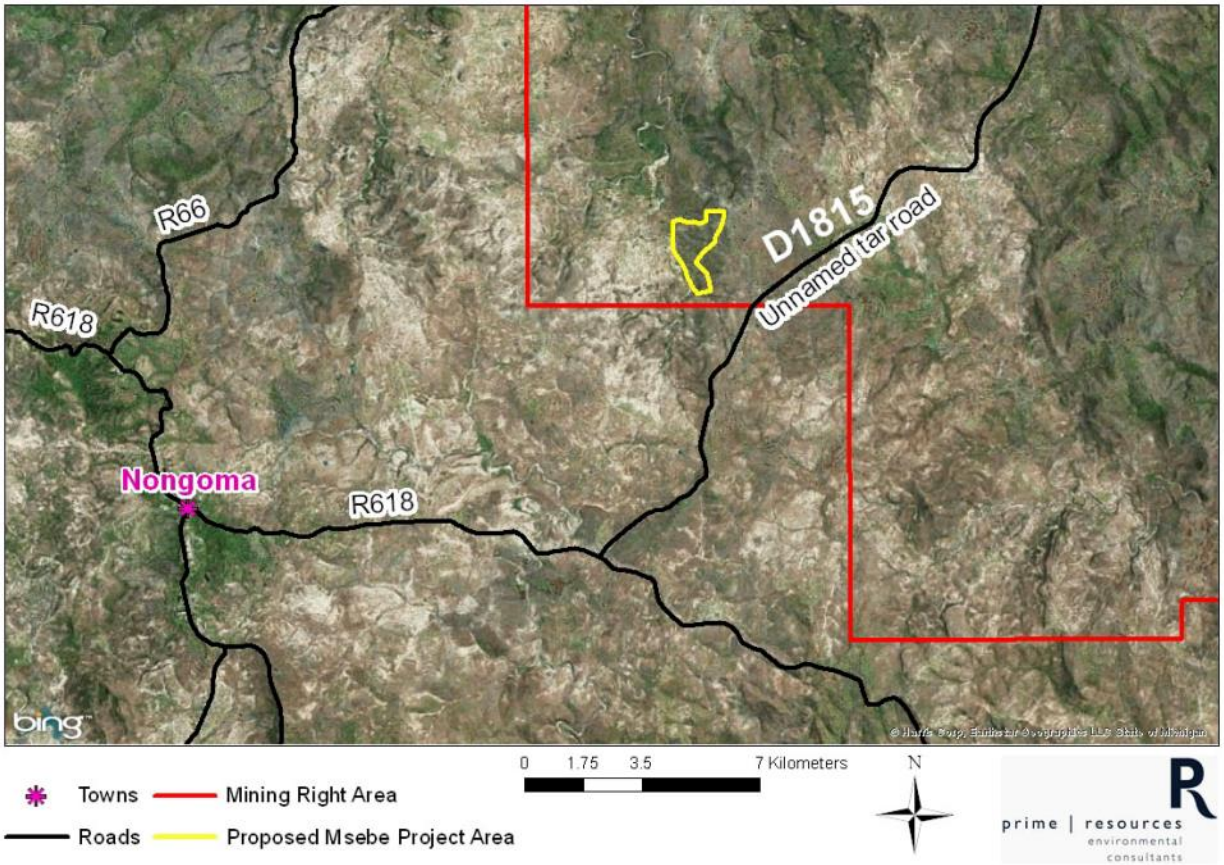

Figure 1. Location of Msebe Coal mine development off the R618, approximately 15 km to the northeast of Nongoma, and 60 km inland, West of Lake Saint Lucia.

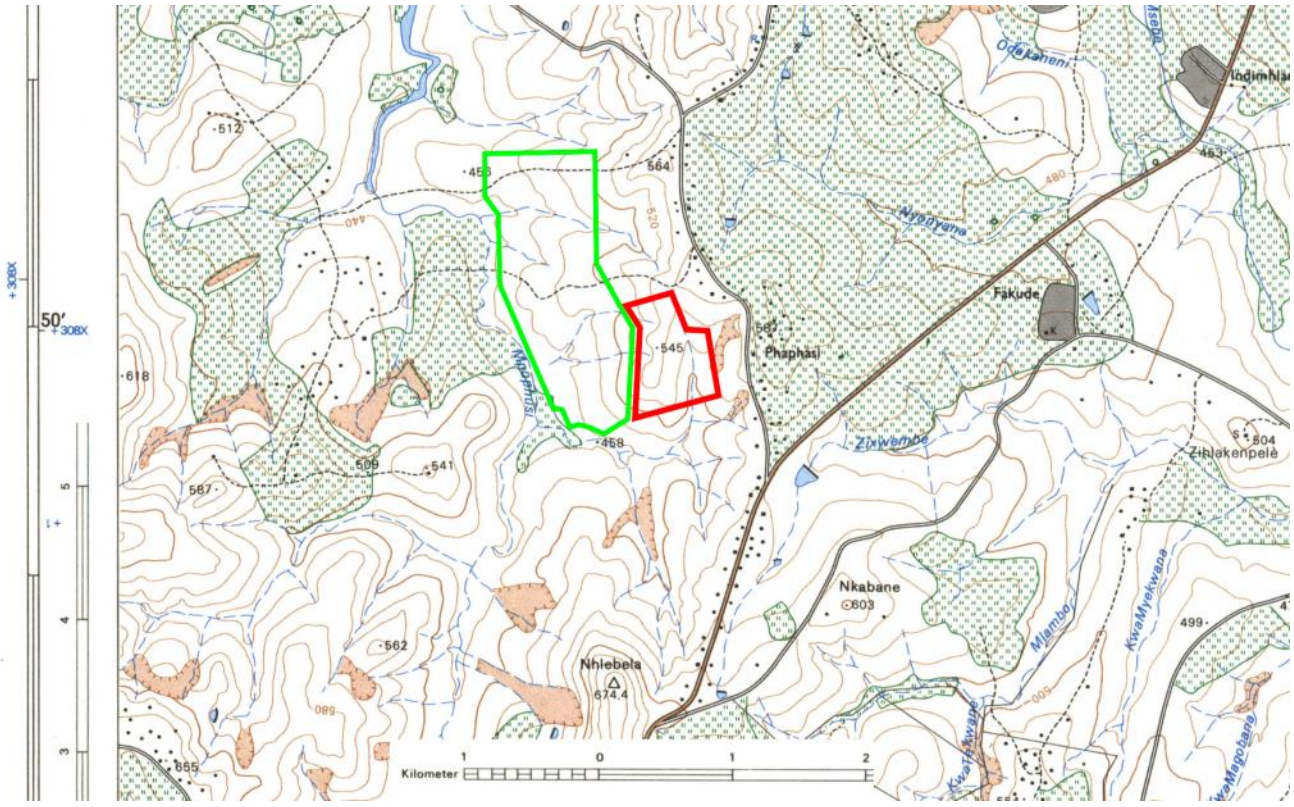

Figure 2. Location of the Msebe coal mine development; opencast pit indicated with a green line, associated infrastructure with a red line (1:50 000 Topographical map; 2731DD Ngxongwane; 1986])

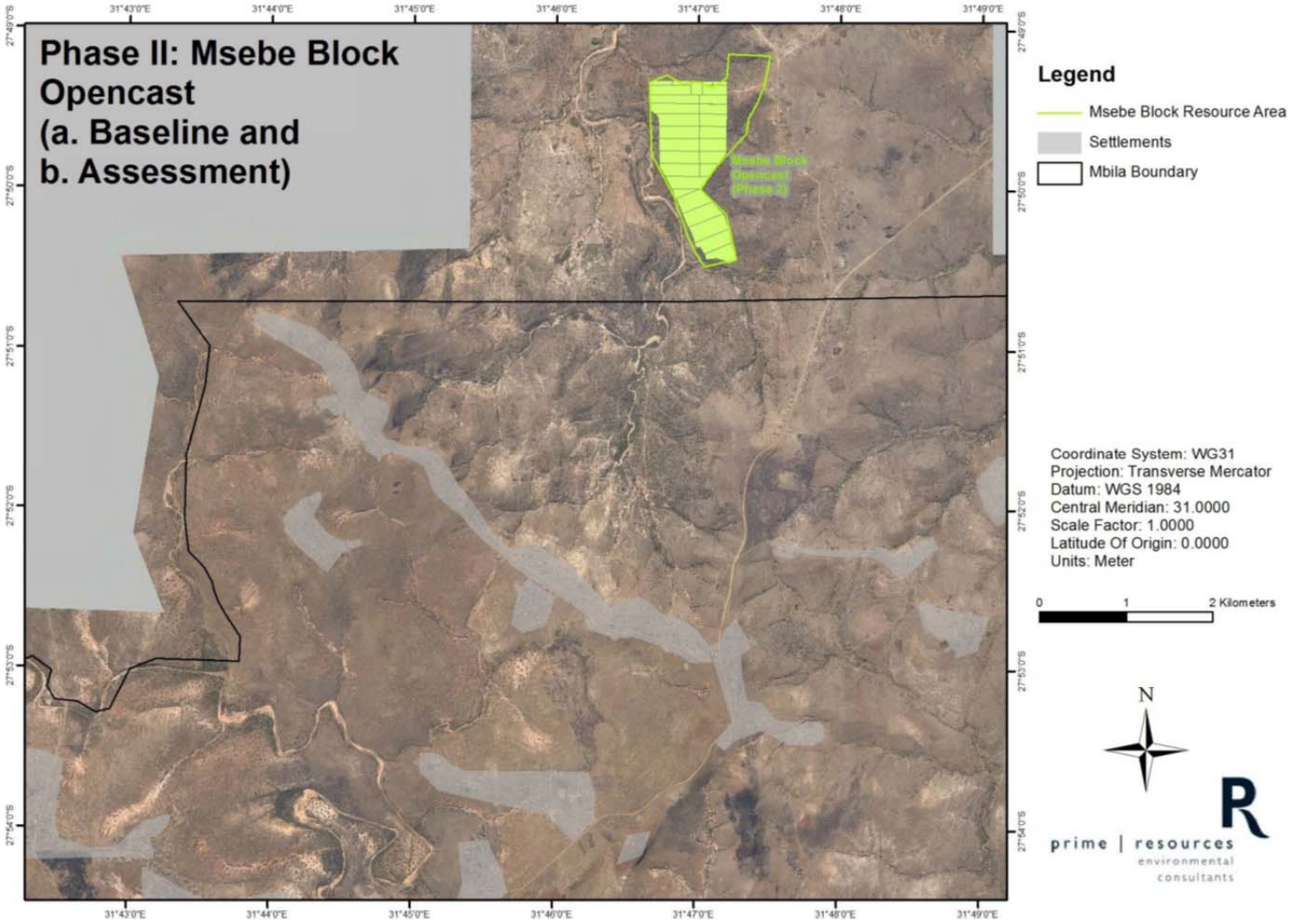

Figure 3. Msebe Block Opencast Coal Mine Phase II development

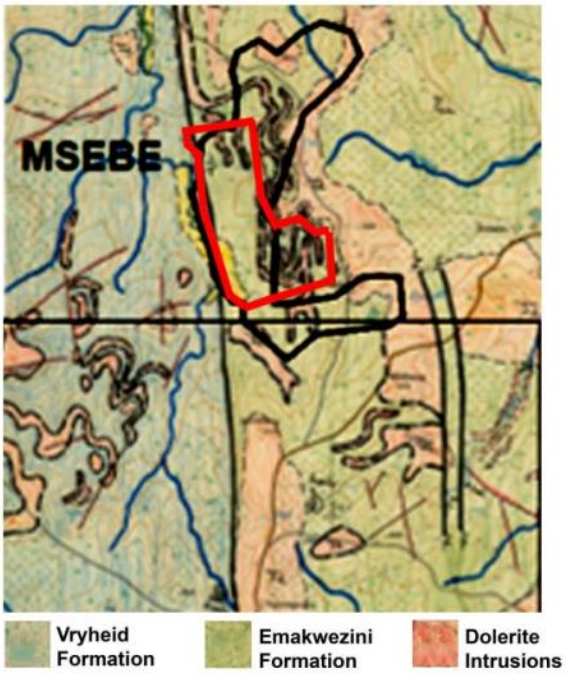

Figure 4. Extract of geological map produced in a Mining Works Programme (2013) provided by Prime Resources. Phase II: Msebe Opencast Mine is superimposed

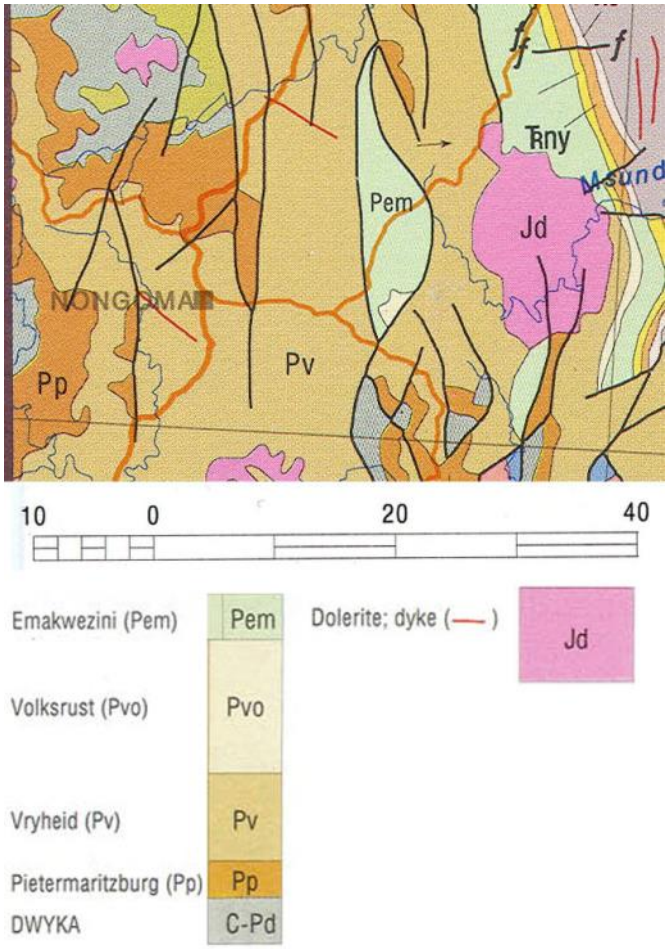

Figure 5. Extract from the 1:1000 000 geological map of South Africa (1997, Council for Geoscience).

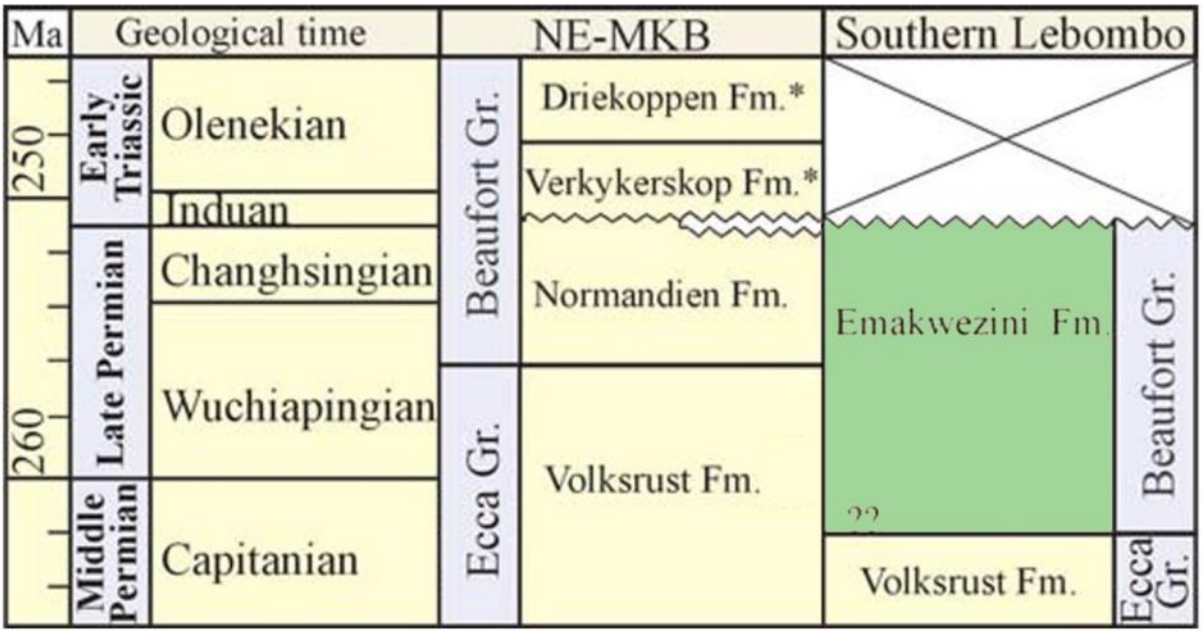

Figure 6. Lithostratigraphic subdivisions (Upper Permian to Lower Triassic) of the Karoo Supergroup, Main Karoo Basin of South Africa, and equivalents in the Southern Lebombo Basin, including the Emakwezini Formation. A * indicates a stratigraphic unit not formally recognised by SACS (Johnson *et al.,* 2006). [Modified from Bordy & Prevec, 2008].

Table 1. Fossils previously recorded from deposits of the Emakwezini Formation of South Africa.

	Taxon	References
PLANTS		
Sphenophytes (horsetail ferns)	*Phyllotheca australis*	Etheridge, 1902; Seward, 1907; Plumstead, 1970; Anderson & Anderson, 1985; Bordy & Prevec, 2008
	Raniganjia kilburnensis	Bordy & Prevec, 2008
	Trizygia speciosa	Bordy & Prevec, 2008
	Schizoneura gondwanensis	Bordy & Prevec, 2008
Glossopterid and affiliated leaves	*Glossopteris* (multiple species)	Etheridge, 1902; Seward, 1907; Plumstead, 1970; Anderson & Anderson, 1985; Bordy & Prevec, 2008.
Glossopterid fertile organs	*Rigbya arberioides*	Bordy & Prevec, 2008
	Dictyopteridium flabellatum	Anderson & Anderson, 1985; Bordy & Prevec, 2008
	Lidgettonia africana	Bordy & Prevec, 2008
	Lidgettonia lidgettonioides	Bordy & Prevec, 2008
	Plumsteadia gibbosa	Bordy & Prevec, 2008
	Samaropsoid seeds	Bordy & Prevec, 2008
	Eretmonia natalensis	Bordy & Prevec, 2008
Glossopterid roots	*Vertebraria indica*	Seward, 1907; Bordy & Prevec, 2008
incertae sedis	*Benlightfootia* sp.	Bordy & Prevec, 2008
INVERTEBRATES		
Grylloblatid insect	*Neoliomopterum picturatum*	Aristov *et al.* 2009
Grylloblatid insect	*Iphikozulu kwayayaensis*	Aristov et al. 2009
Clam shrimp	*Cyzicus greyii*	Etheridge, 1902
VERTEBRATES		
Fish scales	*Coelacanthus dendrites*	Gardiner, 1973
Ganoid fish scales		Etheridge, 1902; Anderson, 1907

See also MacRae (1999) and McCarthy & Rubidge (2005) for photographs and information on the palaeontological riches of the Beaufort Group in general.

8. METHODOLOGY

Due to the widely acknowledged palaeontological sensitivity of the Emakwezini Formation underlying the development area, and which is the target for proposed mining activity, a field inspection was conducted in February 2014.

The aim of this report is to:

1) identify exposed and subsurface rock formations that are considered to be palaeontologically significant;
2) assess the level of palaeontological significance of these formations by consulting the literature for prior records of heritage in the area and geological formation, and by undertaking a field examination to identify exposed and potential heritage;
3) comment on the impact of the development on these exposed and/or potential fossil resources;

4) make recommendations as to how the developer should conserve or mitigate damage to these resources;

with the purpose of assessing the exposed and potential palaeontological heritage of the area targeted for development.

9. FIELD OBSERVATIONS

A visual assessment of the field area was conducted on foot, with the assistance of Albany Museum employee Mr Armstrong Khoso, where access was possible. The entire area is densely vegetated, with outcrop only exposed in road cuttings, erosion gullies and stream and river beds. The rolling grasslands on the hill slopes revealed no outcrop. As a result, mostly the larger streams and erosion gullies were targeted. Reference points (A-Z) are marked in Fig.7 with yellow icons, plant fossil sites with a green tree icon.

Northern opencast section (A-B-F-M)

The only exposed rock in the area was observed in gullies, and very occasionally at surface on the hill slopes. The eastern part of the development area is densely vegetated, and access to the gullies from the road side of the property was largely unsuccessful. The gully at E is completely overgrown with impenetrable vegetation (Figs 7, 19). Approach from the western side, along the Mpaphusi River and into the base of Gully E proved considerably easier. Not long after proceeding East up Gully E, several plant localities were encountered (about 200 m from the river). Exposures are small and limited, yet yielded plant localities with fossils of high density and quality of preservation in the section of gully between P3? and P3 (see Table 2; Figs 8-9).

P2: (Fig. 8) small outcrop of sandstone, underlain by olive-grey siltstone that yielded moderate to poorly preserved, fragmentary and sparse *Glossopteris* leaves, but that also contains a layer that produced high quality sphenophyte axes, some with roots.

P3: (Figs 9, 10) approximately 80 m further along the steep-sided gully, is an outcrop of horizontally laminated coarse to fine-grained siltstone of what appears to be lacustrine/ abandoned channel deposits, that contains a profusion of well-preserved *Glossopteris* leaf impressions. The leaves are preserved in high-density mats in this finely laminated deposit, imparting an almost papery texture to the rock in places. A highly carbonaceous layer present in the section has good palynological potential. At least 4 morphotypes are apparent, including typically Upper Permian forms found elsewhere attached to or

associated with *Plumsteadia*, *Lidgettonia* and *Estcourtia* fructifications (leaves of *Plumsteadia gibbosa* and *Estcourtia bergvillensis* of Anderson & Anderson, 1985).
MW1: (Fig. 11) Msebe Wood Site 01 is the location (north of Gully E) of an impressive *in situ* fossilised tree trunk, lying partially embedded in a surface-exposed sandstone layer. Oriented roughly WNW-SSE (120° from North), the exposed log measures 330 cm long and 50-52 cm in diameter. Preservation is variable, but growth rings and wood-cell textures are present in places (identification would be possible in thin section). Many weathered pieces of wood are scattered around and downstream of the log.
MW2: (Fig. 12a,b) A second *in situ* fossil log (54 cm diameter), but badly weathered; cellular preservation probably good enough for identification.
MW3: (Fig. 12 c) Two large chunks of permineralized wood, less convincingly *in situ*, also with cellular details preserved.

Southern opencast section (F-K-L-M)
The gullies in the southern part of the opencast development were accessed from the Mpaphusi River, approximately halfway between M and L (Fig. 20).
P15: (Fig. 13) Locality P15 was found approximately 130 meters from the river, along the very steep-sided gully that runs East-West in this area. Very well-preserved *Glossopteris* leaf impressions were found in mats in dark olive grey, fine-grained siltstone. This is an excellent site. An additional site that may represent a lateral continuation of P15 was found a short distance further along the gully, also with high quality impression fossils.
P16: (Fig. 14) This locality was found in the northern branch of the gully, near point ‘G’ in Fig. 7.This site appeared to be another lacustrine/abandoned channel setting, with horizontally bedded fine and course-grained siltstones making up several meters of exposure. Plant impressions with oxide staining were preserved in light olive grey, fine-grained siltstone.

Infrastructure (G-H-J-k)
(Fig. 20).
P4: (Fig. 15) Approximately 50 meters beyond the eastern limits of the infrastructure development area, in a gully near point ‘I’ in Fig. 7, is an excellent plant site found by Mr Khoso. Not laterally extensive, the site is located near the top of the steep south-eastern facing gully. Impression fossils in olive grey siltstone included well-preserved *Glossopteris* leaves and a fragment of *Sphenopteris* fern. Concentration of leaves was slightly less than

at P3. This site provides yet another indication of the fossil riches of the area.

MW4: (Fig. 16a) Scattered, washed out pieces of fossil wood lay in a dense surface accumulation at this site.

P5 & P5b: (Fig. 16b-e, 17) The locality marked P5 and P5b represents a laterally extensive (over 40 m) exposure of olive grey siltstones along the gully that runs North-South through the area earmarked for mine Infrastructure. This siltstone is richly fossiliferous, with an abundance of *Glossopteris* leaf impressions in several layers (within 50 cm of vertical exposure) of variable preservation quality, ranging from excellent to very dense and poorly resolved. At P5 *Sphenopteris* ferm impressions and sphenophyte axes were also found.

MW5: (Fig. 18a-b) An isolated piece of float fossil wood was found in open grassveld. Preservation was good, with growth rings visible.

P17: (Fig. 18c-e) This site is right on the boundary of the Infrastructure development site, south of ‘I’ in Fig. 7. Well-preserved impressions of *Glossopteris* were found in leaf mats, towards the top of an exposure of alternating fine and course, horizontally bedded, siltstone layers.

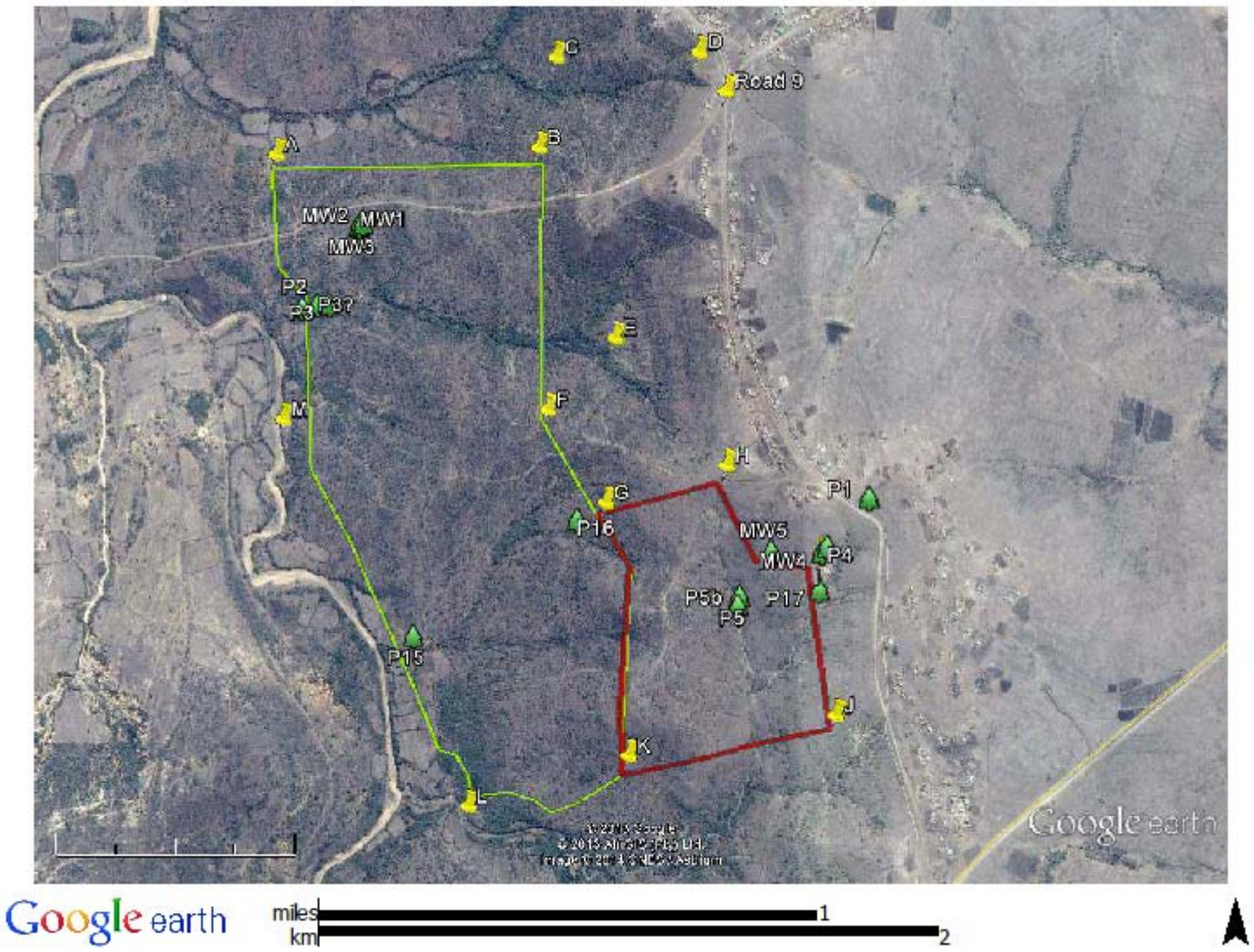

Figure 7. Google Earth map illustrating Phase II Msebe mining area (opencast area with green outline, infrastructure in red) Green icons (eg. P2, MW3) indicate location of plant fossil localities; yellow icons are for easy of reference to areas described and photographed.

(a) **(b)** **(c)**

Figure 8. Plant fossil site P2 (a) yielded well-preserved sphenophyte axes with attached roots (b), and poorly to moderately preserved *Glossopteris* impressions (c).

(a)

(b)

(c)

Figure 9. Plant fossil site P3 in laterally extensive outcrop of lacustrine/abandoned channel deposits (a-c)

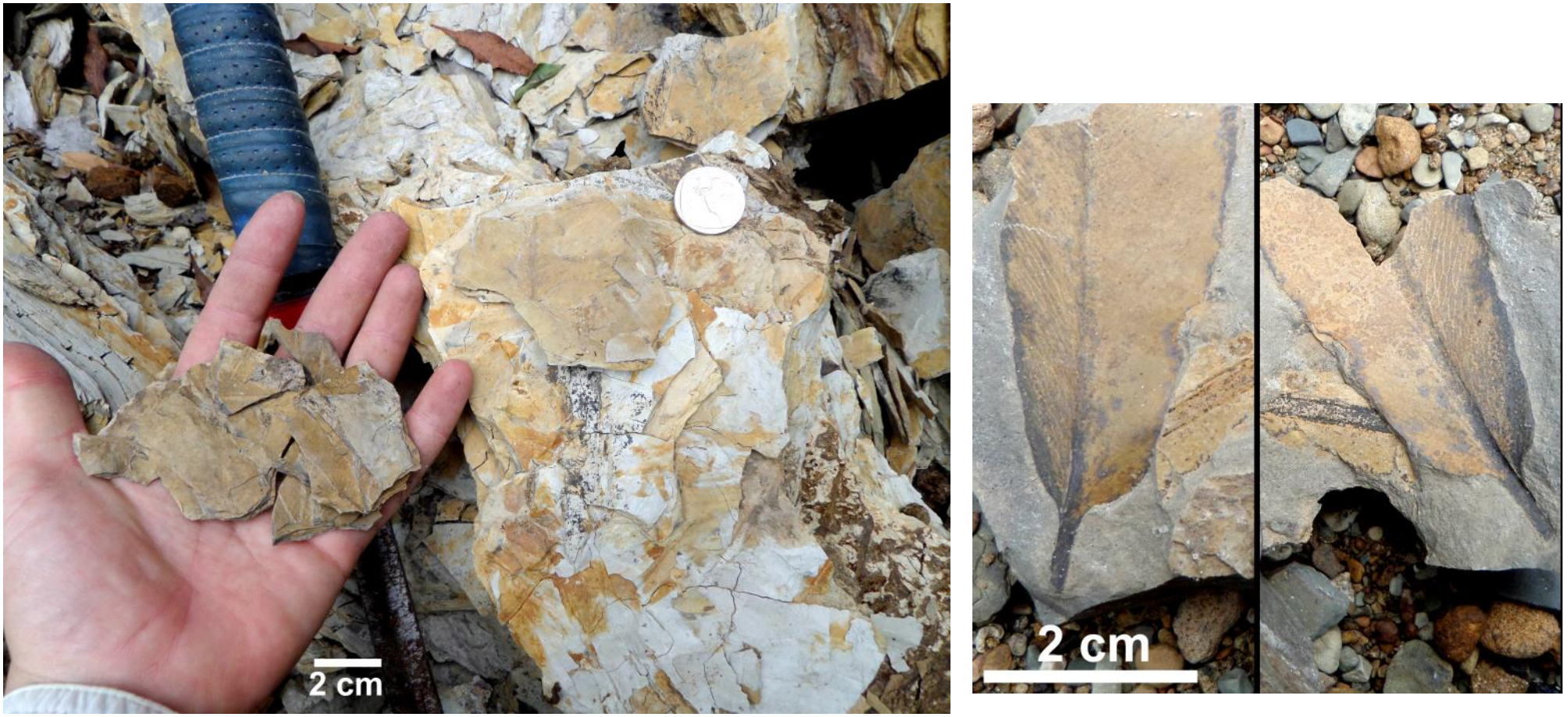

Figure 10. High quality *Glossopteris* leaves preserved at P3, in very high densities in some layers, with excellent venation detail.

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Figure 11. Msebe Wood site 01 (MW1): an impressive *in situ* fossilised tree trunk, lying partially embedded in a surface exposed sandstone layer.

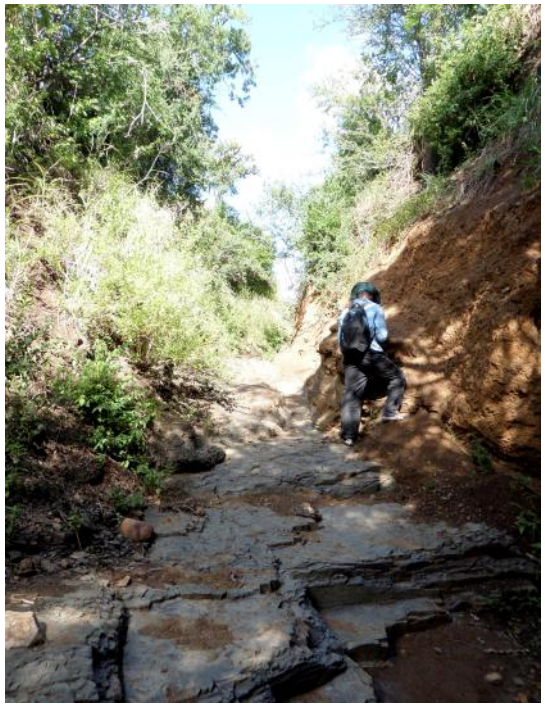
(a)

(b)

(c)

Figure 12. (a) & (b) Msebe Wood site 02 (MW2): A second in situ fossil log, although much more weathered and fragmented; (c) MW3: two large chunks of permineralized wood.

(a)



(b)

(c-s)

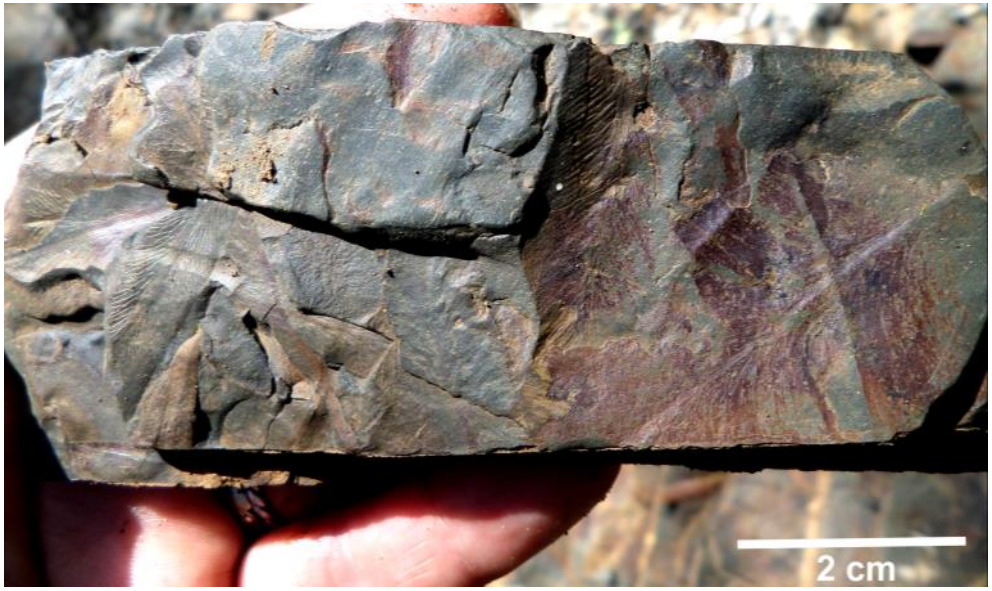


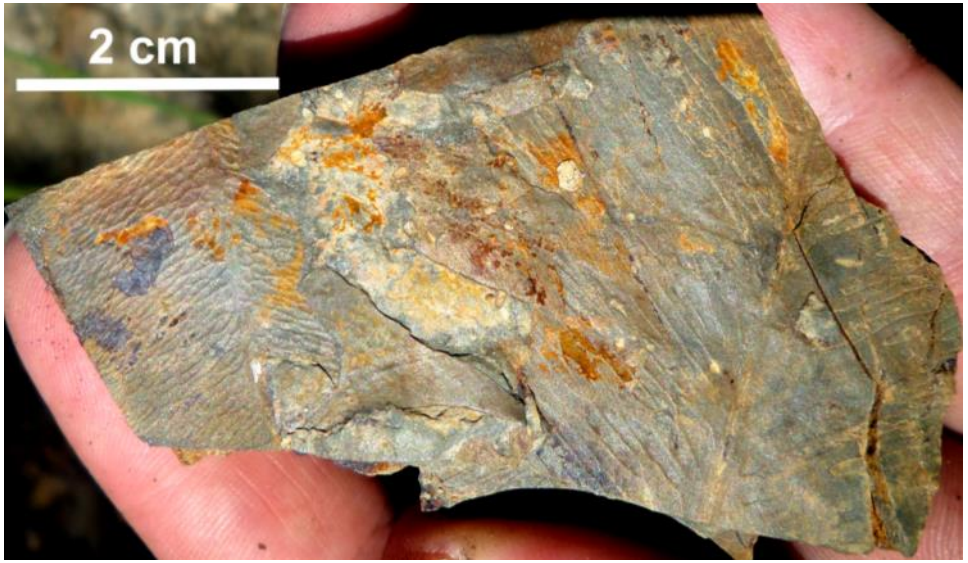
Figure 13. Plant fossil locality P15: (a) Steep sided E-W gully off the Mpaphusi River, in the southern part of the development; (b) Low outcrops of olive grey siltstone with high quality impression fossils of *Glossopteris* leaves in mats (c-e).

(a)

(c)

(d)

(b)

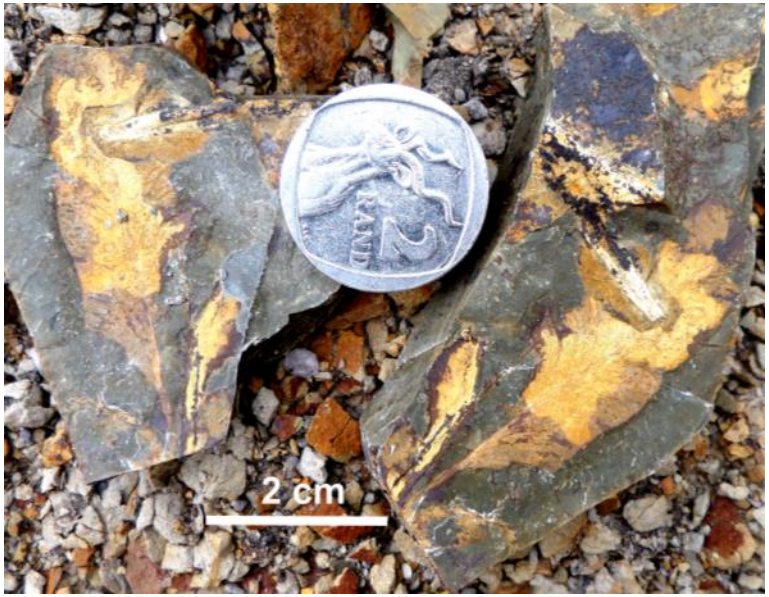


(e)

Figure 14. Plant fossil locality P16: High quality impressions of *Glossopteris* leaves are preserved in an olive grey siltstone sequence (a, b); a diverse *Glossopteris* flora is evident, with morphotypes typical of other Emakwezini Formation localities (c-e).

(a)

(b)



(c)

(d)

Figure 15. Plant fossil locality P4: olive grey siltstone layer near the top of fairly extensive exposures in a gully on the far eastern side of the site for infrastructure development (a), yielded good quality plant impression fossils of *Glossopteris* leaves, roots and small branches (b-d).

(a)

(b)

(c)

(d)

(e)

Figure 16. (a) Fossil wood locality MW4: Scattered, washed out pieces of fossil wood in a dense surface accumulation; (b) Plant fossil locality P5: laterally extensive olive grey siltstones with several fossiliferous horizons; (c-) High quality plant impressions, stained in some cases with oxides.

(a)

(b)

(c)

(d)

Figure 17. Plant fossil locality P5: (a) laterally extensive exposures of olive-grey siltstone (weathers white in places) with multiple horizons rich in fossil leaf impressions (c, d). Note large slab that has fallen, exposing a leaf mat with sphenophyte axes and branches, seen close-up in (b);

(a)

(b)

(c)

(d)

(e)

Figure 18. MW5: (a-b) isolated piece of washed out fossil wood in open grassveld; Plant fossil locality P17: (c-e) Good quality leaf impressions of *Glossopteris* were found in the uppermost layer in this olive-grey siltstone sequence in a gully on the eastern side of the development.

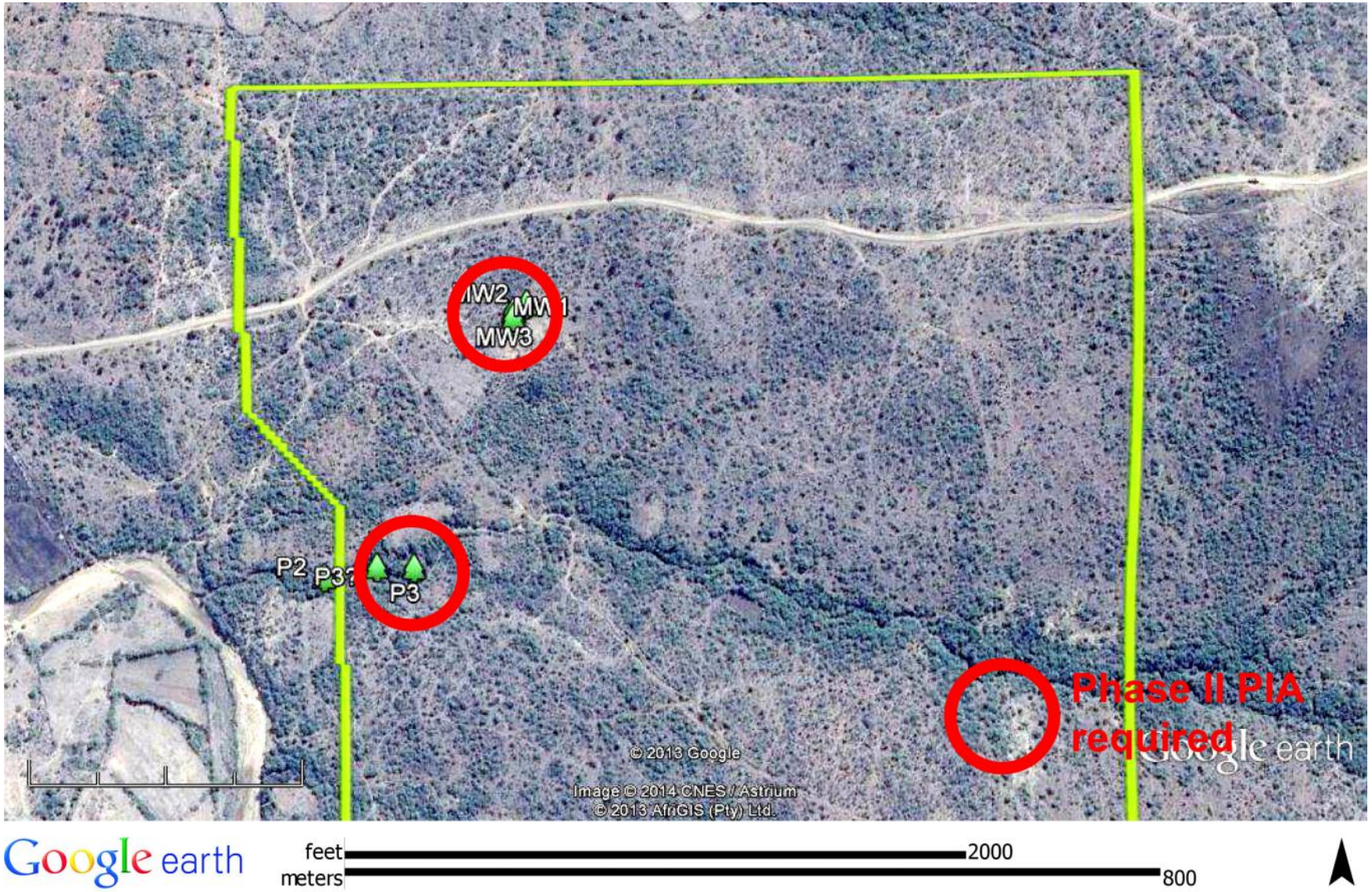


Figure 19. Google image of the northern half of the Msebe development area, indicating the location of fossil plant localities (green tree icons). Red circles indicate localities in need of Phase II mitigation.

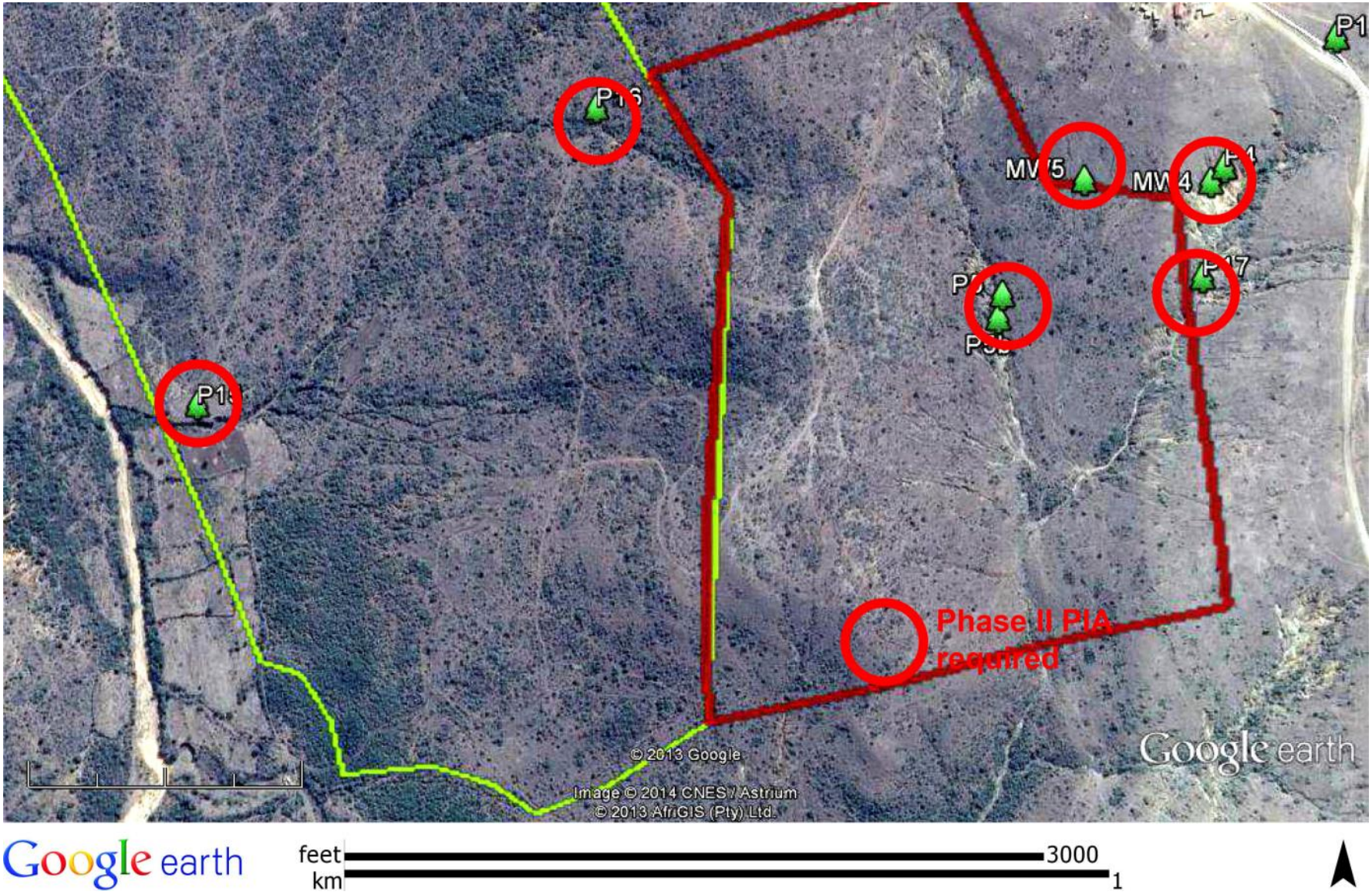


Figure 20. Google image of the southern half of the Msebe development area, and area earmarked for infrastructure, indicating the location of fossil plant localities (green tree icons). Red circles indicate localities in need of Phase II mitigation.

Table 2. Summary of palaeontological findings in the vicinity of the development area (see Fig.*)

Fossil site number	GPS co-ordinates	Locality notes	Fossils found	Quality of preservation	Recommendations
P1	27° 49.936'S; 31° 47.816'E	Road cutting on D1815 dirt road off the R618; fine-grained carbonaceous siltstone near base of section contains plant fragments	*Glossopteris* leaf fragments, non-diagnostic sphenophyte axes	Moderate to poor preservation; scattered elements; venation detail preserved	Not worth collecting
P2	27° 49.600'S 31° 46.708'E	Small, weathered exposure on banks of tributary gully; fragmentary, sparse leaves preserved in medium-grained siltstone; widespread evidence of rock metamorphism; very well-preserved sphenophyte axes in a lower horizon, but no diagnostic leaf material.	*Glossopteris* leaf fragments, non-diagnostic sphenophyte axes with attached roots	Moderate preservation; venation detail visible, but sparse occurrence, low diversity	Not worth collecting
P3	27° 49.594'S 31° 46.764'E	Gully wall exposure;finley laminated, lacustrine deposit (probably abandoned channel/floodplain lake setting); laterally extensive over approximately 20 m; fine grained siltstone/mudrock; ranging in colour from olive grey to dark carbonaceous grey; densely fossiliferous layer weathers pale in exposed slabs.	*Glossopteris* leaf mats; typical Emakwezini flora, multiple Late Permian morphotypes;woody stems; intercalated carbonaceous layers offer good potential for palynological studies	Excellent preservation	**PHASE II mitigation required:** site must be bulk-collected prior to any disturbance due to mining activity
P4	27° 50.019'S 31° 47.752'E	Near the top of steep exposure in erosion gully wall; fairly carbonaceous, fine-grained siltstone layer with fairly well-developed bedding planes, extends laterally for several metres.	*Glossopteris* leaves (typical Emakwezini, Upper Permian morphotypes), sphenophyte axes, rootlets, *Sphenopteris* fern fragment	Good preservation, excellent venation detail; not preserved in mats as in P1, but moderate plant density.	**PHASE II mitigation required:** site must be bulk-collected prior to any disturbance due to mining activity
P5a & b	27° 50.106'S 31° 47.582'E	Low but steep, heavily weathered exposures extending along eastern side of erosion gully; fossiliferous layer extends laterally for over 100m; olive grey, very fine-grained, indurate siltstone	*Glossopteris* leaves, typical of Lopingian, Emakwezini Formation, multiple morphotypes; sphenophyte axes, *Sphenopteris* fern fragments.	Excellent preservation, leaf mats of moderate density, venation detail superb.	**PHASE II mitigation required:** site must be bulk-collected prior to any disturbance due to mining activity

P15	27° 50.182'S 31° 46.933'E	Narrow, steep-walled gully (tributary of Mpaphusi River) with occasional, small, low but steep outcrops of indurated, olive grey, fine-grained siltstone; fossiliferous horizon approximately 50 cm thick, and laterally continuous.	Fantastic *Glossopteris* leaf mats with multiple morphotypes typical of Emakwezini Formation floras; sphenophyte axes	Excellent preservation, leaf mats of moderate to high density, venation detail superb, complete leaves.	**PHASE II mitigation required:** site must be bulk-collected prior to any disturbance due to mining activity
P16	27° 49.973'S 31° 47.263'E	Same gully system as P15, but further upstream; another abandoned channel/lacustrine deposit; light olive grey, fine-grained siltstone	*Glossopteris* leaf mats with multiple morphotypes typical of Emakwezini Formation floras; sphenophyte axes	Excellent preservation, leaf mats of moderate density, venation detail superb, complete leaves.	**PHASE II mitigation required:** site must be bulk-collected prior to any disturbance due to mining activity
P17	27° 50.094'S 31° 47.738'E	Steep exposure of coarse and fine-grained siltstone; horizontally laminated; fossils in fine-grained, olive grey siltstone at top of outcrop	*Glossopteris* leaf mats with multiple morphotypes typical of Emakwezini Formation floras; sphenophyte axes	Excellent preservation, leaf mats of moderate to high density, venation detail superb, complete leaves.	**PHASE II mitigation required:** site must be bulk-collected prior to any disturbance due to mining activity
MW1	27° 49.459'S 31° 46.826'E	Surface exposure of sandstone, revealing weathered-out and partially weathered-out wood fragments and logs over a fairly broad area in shallow gullies	Fantastic *in situ* fossil log! Huge with multiple pieces *in situ*; oriented WNW-SSE (120°); 330 cm length exposed, more subsurface; diameter of 50-52 cm.	Variable preservation, but some sections appear to be well permineralized, with growth rings clearly visible – identification via wood anatomy should be possible	**PHASE II mitigation required:** Entire log should be carefully excavated reconstructed and conserved; samples analysed for identification purposes.
MW2	27° 49.452'S 31° 46.834'E	Surface exposure of sandstone, revealing weathered-out and partially weathered-out wood fragments and logs over a fairly broad area in shallow gullies	*In situ* log, approximately 54 cm diameter but badly weathered and fragmented	Reasonable preservation, growth rings apparent	**PHASE II mitigation required:** Samples must be collected for identification, documentation and curation
MW3	27° 49.456'S 31° 46.826'E	Weathered-out wood fragments and log at surface	Two large associated chunks of fossil wood at surface	Reasonable preservation, growth rings apparent	**PHASE II mitigation required:** Samples must be collected

					for identification documentation and curation
MW4	27° 50.029'S 31° 47.742'E	Multiple, scattered but dense accumulation of fossil wood pieces washed out and concentrated at base of exposure, near P4 plant fossil locality	Multiple pieces of permineralized wood	Variable preservation, some fragments with reasonable preservation, growth rings apparent	**PHASE II mitigation required:** Samples must be collected for identification documentation and curation
GREEN SHADING: HIGH QUALITY SITES REQUIRING **PHASE II MITIGATION** IF AT RISK FROM DEVELOPMENT					

10. IMPACT SIGNIFICANCE

The fossil coal floras of South Africa are of international interest, and represent an important part of our local heritage. Any loss of this heritage due to mining or construction activities is permanent, and should be regarded as a highly significant negative impact. Alternatively, discovery of fossils during excavation, followed by effective mitigation in collaboration with a palaeontologist, would result in the curation of new and important fossil material – therefore the development could potentially have a positive, beneficial impact on South Africa's palaeontological heritage. It should be noted that mitigation has only been recommended for plant fossil localities that are of high quality, as determined by quality of preservation and/or abundance.

SIGNIFICANCE RATING=90 : (magnitude +duration+scale) x probability							
Rock Unit	**Duration**	**Scale**	**Probability**	**Magnitude**		**Overall Significance**	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Emakwezini Formation	5-permanent	5 - International	5 - Definite	beneficial	8- High negative	beneficial	High negative

11. MANAGEMENT OF COAL-ASSOCIATED FOSSIL HERITAGE IN A MINING CONTEXT

A commonly encountered attitude with regard to the palaeobotanical heritage associated with coal mines (as evidenced in a disappointingly high number of Heritage Impact Assessments currently being produced), is that since coal is itself a fossil of sorts, there is no need to attempt any form of heritage conservation. This does not align with the goals of current legislation, which seeks to protect all fossil heritage of South Africa. A more constructive approach would be to forge a strategy that allows for regular monitoring and occasional intervention when fossiliferous deposits of exceptional quality are exposed during mining activities.

Coal itself is classified as a compaction fossil, and apart from the very important and useful information that can be derived at the microscopic level from macerals (including cuticle, pollen, spores) and from charcoal inclusions, it is of limited value paleontologically. Generally the material of greatest interest palaeontologically is contained within the fine-

grained shale partings between coal seams. Personal experience has indicated that good quality plant compression and impression fossils are not overly abundant, and may be quite localised, occurring in lenses of fine-grained mudrock, although impressions, casts, charcoalified wood or permineralised sections of tree trunks may be found in the sandstones associated with the coal seams. At any one time on the site of a mine there might be no good quality fossil localities exposed, but certainly during the lifetime of a mining endeavour on a commercial scale, it is highly likely that multiple fossil sites of significance will be exposed.

It should also be noted that it is not just the actual bone/plant material/shell etc. itself that is of interest and importance to a palaeontologist. Increasingly, scientists appreciate the value of information evident in the immediate vicinity of fossils that is not necessarily inherent to the fossil itself, such as the geology of the host rock stratum, the orientation of individual fossil organs, organism associations, preservational aspects etc. These types of information can provide important clues about past environments, and can help to place fossils within their original context. These types of information can be lost through indiscriminate sampling/attempted mitigation by untrained parties.

When the potential exists for new fossils to be exposed through excavations, it is the responsibility of the on-site Environmental Control Officer (ECO) to monitor excavation activities and report the occurrence of any fossiliferous material to SAHRA and an appropriate palaeontological expert, to allow the material to be thoroughly assessed, recorded and professionally excavated or sampled. The collection, photography and documentation of fossil plants is specialised. Even the handling and packing is something that needs to be done with great care.

<u>Effective conservation of fossil heritage in a mining situation would entail the following mitigation measures:</u>

1) regular inspection of excavation sites by an ECO capable of searching for and recognising plant and insect fossils: inspections should be performed during any excavations that disturb bedrock, and between blasting cycles in open cast mines, when the face wall and floor of the pit are exposed; in the case of underground mining activities, it would be particularly the roof of the shaft that should be examined for evidence of fossil floras;

2) when lenses of sedimentary rocks containing well-preserved plant fossils are found (venation and/or other details of the plant are visible), a palaeontologist must be afforded the opportunity to assess these, and if necessary excavate a sample of the flora, and document the depositional context as reflected by the adjacent rocks and coal seams. The decision as to whether plant fossils that are encountered during excavations are worthy of mitigation is a subjective one, and effective mitigation will require specific training of the ECO or alternative monitoring official to allow them to effectively judge the significance of any particular occurrence. If any doubt is raised an expert palaeontologist should be consulted. A scientifically useful and comprehensive palaeobotanical collection must be made – there is little value in collecting a few blocks of the material, as this would not be a representative sample of a fossil flora. A strategy of bulk collecting must be employed, whereby a relatively large and unbiased sample of the flora is collected, with collectors not giving undue attention to those elements that are attractive, well-preserved or rare. The associated geology that will also be destroyed during mining must be documented photographically (with scale). Floras with no context are increasingly coming to be considered of limited palaeontological value.

3) to avoid delays, the mine must be prepared to assist in the removal of blocks containing high quality plant fossil material, and in the storage on the mine property of unprepared fossiliferous blocks until such a time as the material can be properly processed by a palaeontologist. Storage facilities must be such that the blocks are not exposed directly to the elements.

12. RECOMMENDATIONS

- Phase II mitigation of sites P3, P4, P5a&b, P15, P16, P17, MW1, MW2, MW3 and MW4 as per Table 2. is strenuously recommended.
- Regular on-site monitoring as outlined in previous section, between blast cycles when face wall and floor of pit are exposed;
- Training of Environmental Control Officer or supervisory personnel: plant fossils are not always obvious, and some minimal training would be required;
- Annual monitoring by a qualified palaeontologist should be a requirement.

13. CONCLUSIONS

This development is likely to have an impact on plant fossil heritage of the highly palaeontologically sensitive Emakwezini Formation. Phase II mitigation is required for 6 plant localities and 4 fossil wood sites. In the longer term, it is imperative that onsite monitoring by a trained ECO is conducted at any time bedrock is exposed, throughout the lifetime of the mine, with regular inspections by and interactions with a qualified palaeontologist capable of effectively mitigating damage to fossil heritage during mining and development. With appropriate mitigation, this development could have a positive outcome in the conservation of fossil heritage, but without mitigation, extremely valuable fossil material will be destroyed.

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