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PHASE 1 PALAEONTOLOGICAL IMPACT ASSESSMENT

Underground Mining at G-Block, Mbila Coal Mine

(PHASE I MINING)

(Nongoma, Zululand District, KwaZulu-Natal)

Specialist report by:

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11 March 2014

1. EXECUTIVE SUMMARY

Rose Prevec was appointed by Prime Resources (on behalf of Mbila Resources) to assess the site of a proposed coal mining development, near Nongoma, Zululand District, KwaZulu-Natal. The development involves the construction of infrastructure (new mine haul road and coal handling plant) and underground mining, employing the board and pillar method. The development site overlies rocks of the Vryheid Formation (Ecca Group, Karoo Supergroup), and mining will target the coal seams found in these Lower to Middle Permian deposits. These coal-bearing host rocks are known to have high potential for fossil plants (*Glossopteris*-dominated fossil floras) of high quality and significance. A field survey of exposed rock in the broad vicinity of the proposed underground coal mine resulted in the discovery of 7 plant fossil sites. This provides an indication of the high potential palaeontological wealth of the strata to be mined. No fossil were found within the footprint itself, due to lack of exposure (mostly grassland).

SAHRA (South African Heritage Resources Agency) lists the Vryheid 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. Discovery of fossils during excavation, followed by effective mitigation in collaboration with a palaeontologist however, would result in the curation of new and important fossil material, and therefore the development could potentially have a positive, beneficial impact on South Africa's palaeontological heritage. Since bedrock will be impacted during the construction of the mine-haul road, the handling plant, and during underground mining activity, monitoring by a trained Environmental Control Officer will be required during active construction.

SIGNIFICANCE RATING= 72: (magnitude +duration+scale) x probability							
Rock Unit	**Duration**	**Scale**	**Probability**	**Magnitude**		**Overall Significance**	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Vryheid Formation	5- permanent	5 - International	4- High probability	beneficial	8- High negative	beneficial	High negative

Recommendation: It is imperative that regular monitoring of all bedrock disturbances during the course of this development 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 (Pietermaritzburg Office; Tel: 0333 946543; Fax: 0333 426097; lindim@amafapmb.co.za) immediately to facilitate expert documentation and collecting of the site 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 19 180 ha of Portion 9 of the Farm Reserve Number 12 | 15832 HU. No mining activities have been undertaken to-date. The proposed development comprises a new mine haul road and coal handling plant (where primary beneficiation via washing of coal will occur) and underground mining, employing the board and pillar method via one surface adit, in the G-Block area indicated in purple in Figs1-3.

Mining will specifically target the Ecca Group coal seams on the property, of the Vryheid Formation, which is known to be of high palaeontological sensitivity (SAHRA palaeontological sensitivity map; http://www.sahra.org.za/map/palaeo; Figs 4, 5), 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).

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 10 km East-northeast of Nongoma, off and to the North of the R618 (eastbound), on the D1815 dirt road, in the Zululand district, north-eastern KwaZulu-Natal (Figs 1, 2, 3; 2731DD Ngxongwane 1:50 000 topographical map), on Portion 9 of the Farm Reserve Number 12 | 15832 HU.

The proposed development comprises a new mine haul road and coal handling plant (where primary beneficiation via washing of coal will occur) and underground mining, employing the board and pillar method via one surface adit, in the G-Block area indicated in purple in Figs1-3.

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 **Vryheid Formation** (blue areas in Fig. 4; brown in Fig. 5), of the Karoo Supergroup (Fig. 6), in the north-eastern reaches of the main Karoo Basin. 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).

The **Vryheid Formation** (middle Ecca Group, Lower to Middle Permian) typically comprises fine-grained mudstone, carbonaceous mudstone and coarse-grained sandstone lithofacies, depicting upward-coarsening cycles of deltaic origin (Johnson *et al.*, 2006). Sheet-like fluvial, fining-upward cycles are a feature of the Vryheid Formation in the eastern parts of the basin, and the most economically important coal seams developed as peat swamps on abandoned alluvial floodplains and in backswamps, within these fluvially dominated deltaic systems. The Vryheid Formation in the Nongoma area is particularly thick, as a result of prolonged accumulation within the subsiding Nongoma Graben, where they reach a thickness of up to 1030m (Whateley, 1980). Formation of the graben is attributed to the early stages of Gondwana breakup, leading to episodes of tensional build-up and release within the crust, with vertical displacement creating accommodation space for the accumulation of these thick deltaic and fluvial complexes (Whateley, 1980; Turner *et al.* 1981).

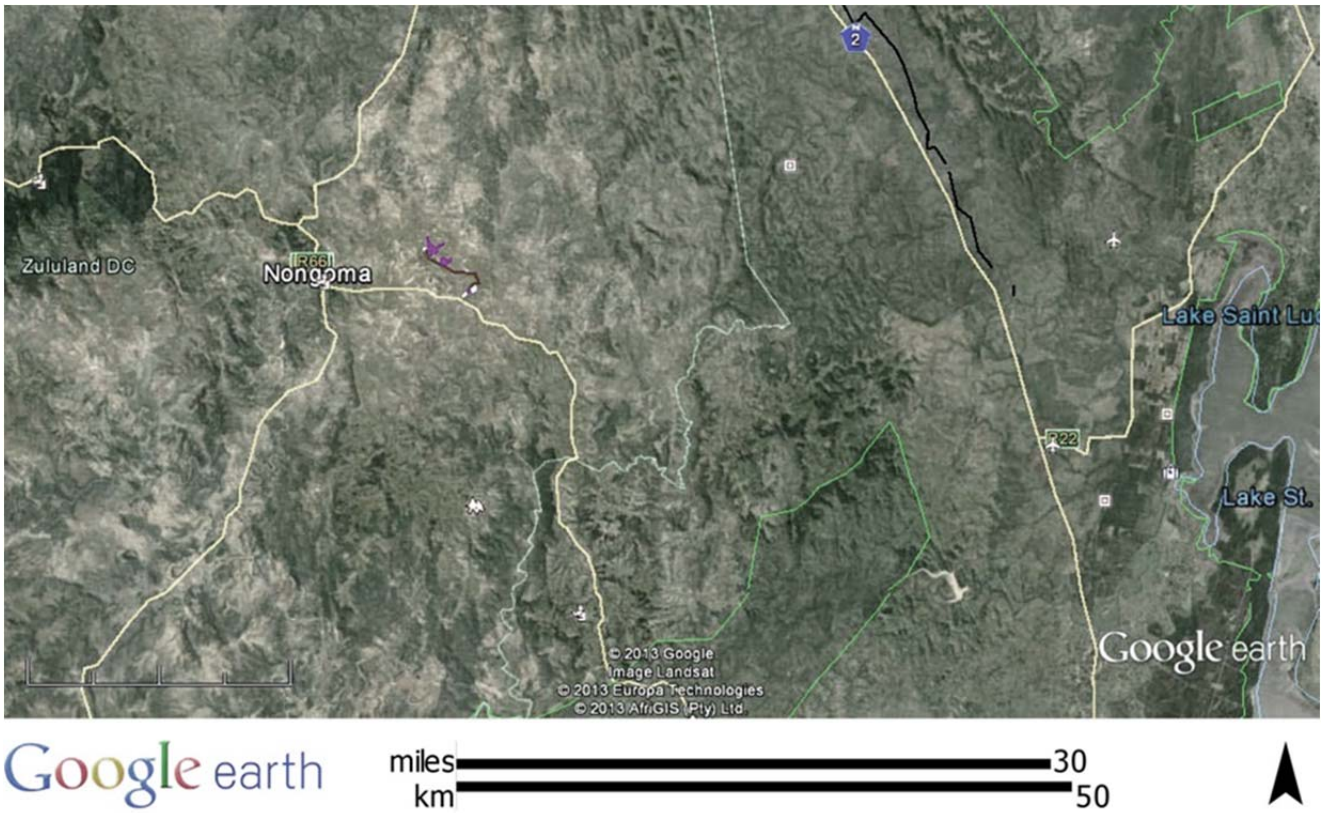


Figure 1. Location of development (purple) off the R618, approximately 10 km to the East-northeast of Nongoma, and 60 km inland, West of Lake Saint Lucia.

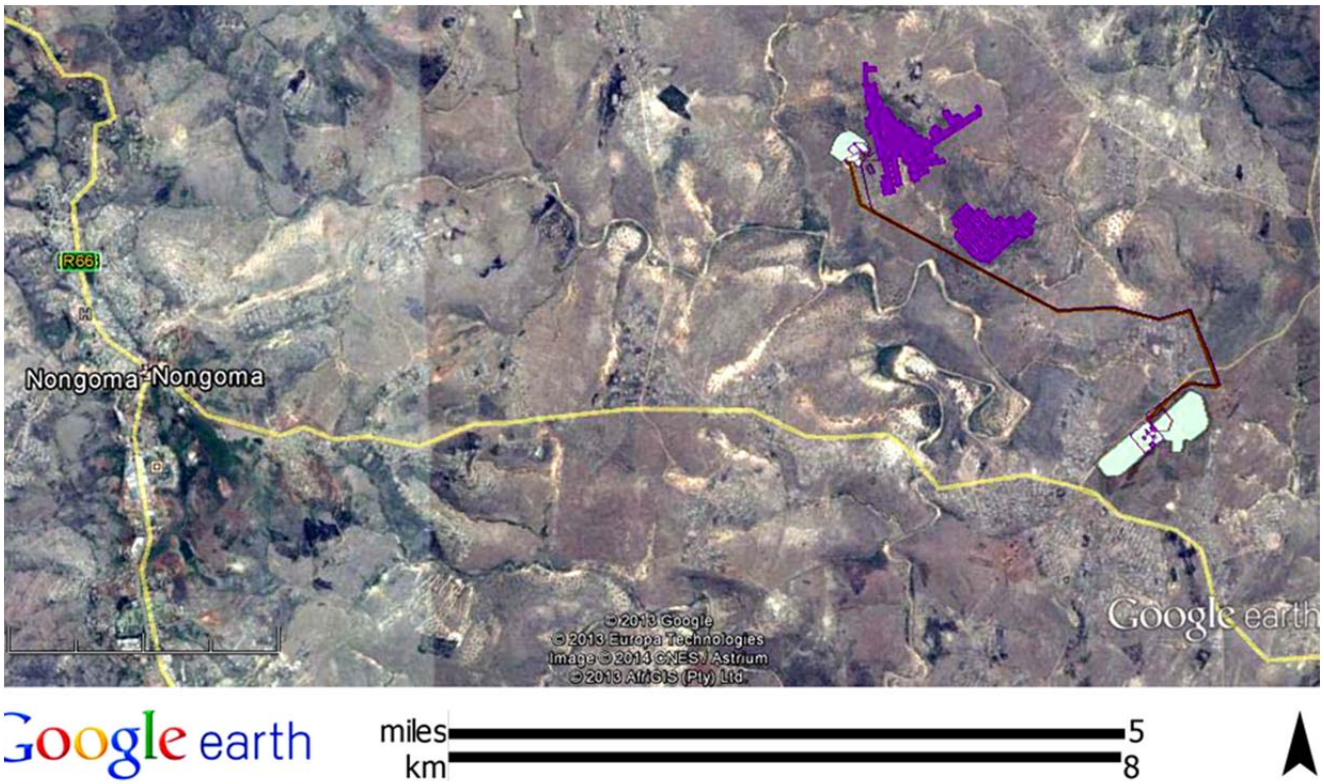


Figure 2. Mbila Resources Phase I, G Block underground mining development and associated infrastructure, East off the D1815 (north of the R618, approximately 10 km East of Nongoma).

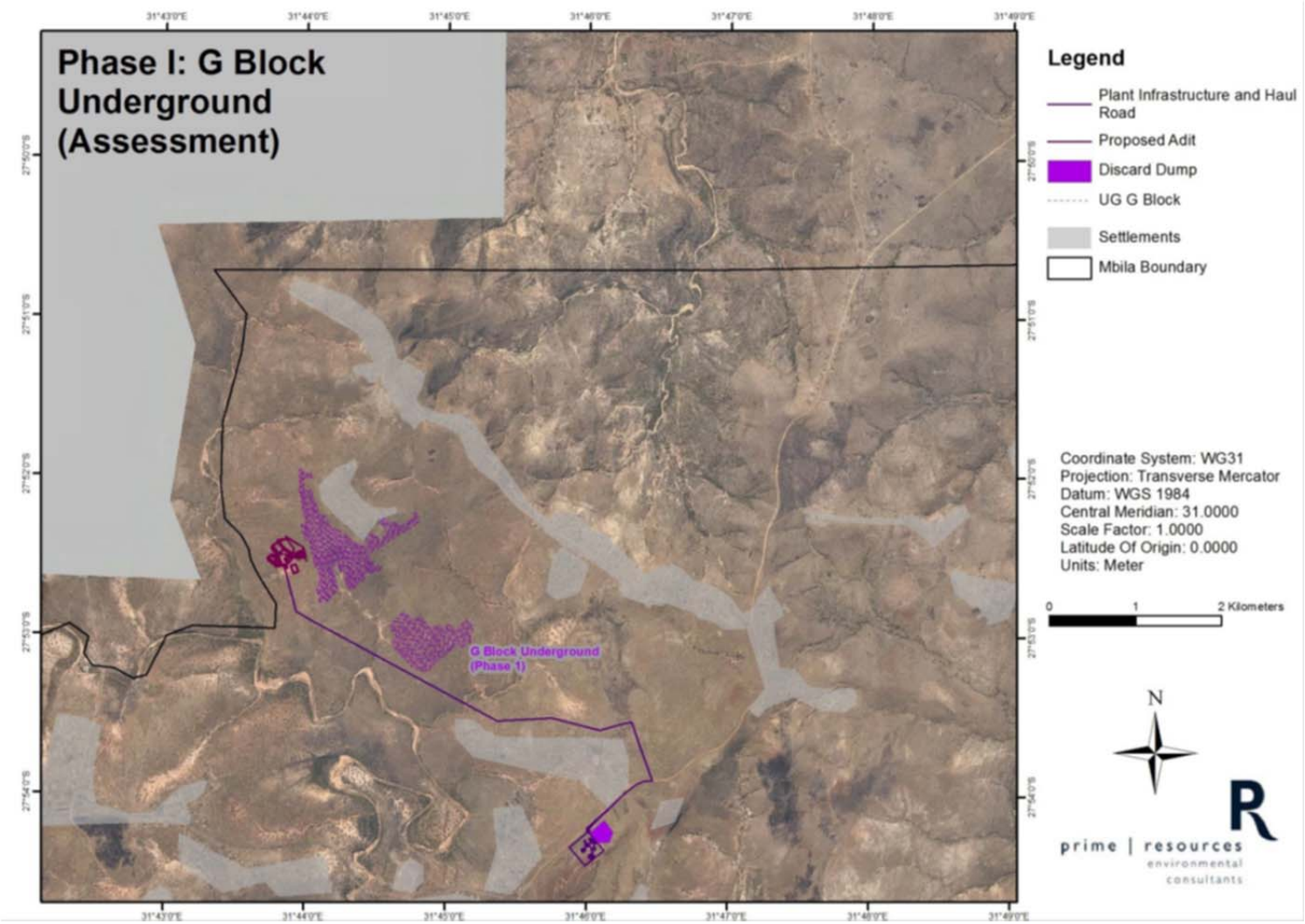


Figure 3. Mbila Coal Mine Phase I development, involving underground mining (G Block) and the construction of a mine haul road and coal handling plant.

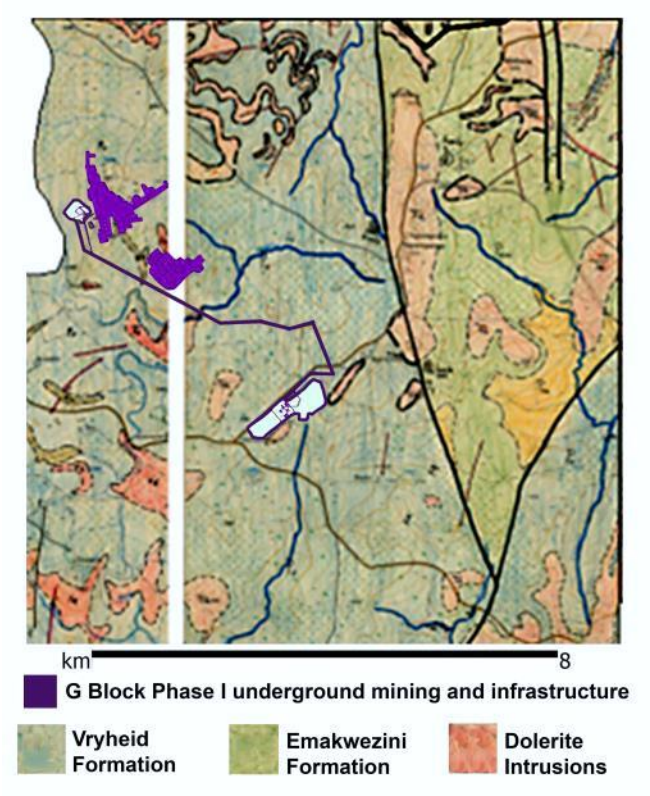


Figure 4. Extract of geological map produced in an Abbreviated Geological Report on the Mbila Project (2007), provided by Prime Resources. Phase I of the G Block underground mining activities is superimposed

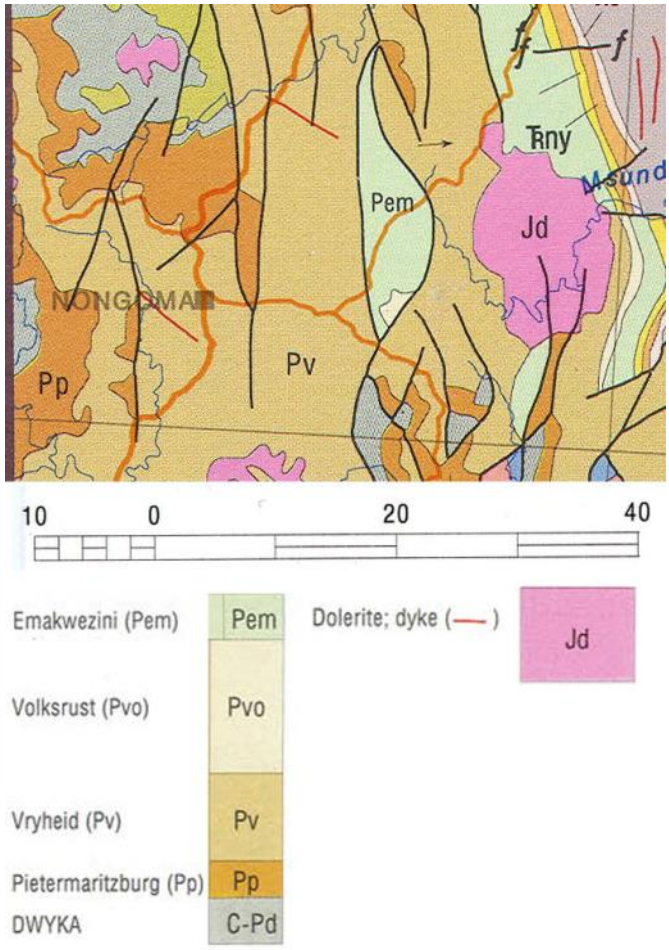


Figure 5. Extract from the 1:1000 000 geological map of South Africa (1997, Council for Geoscience).

Three phases of deposition have been recognised, viz. lower regressive deltaic sequences, succeeded by a phase of fluvial deposition culminating in high sinuosity channel development along with deposition of thick, fine-grained floodplain sediments (source of coal), with termination of fluvial sedimentation effected by a transgressive deltaic deposition phase (Whateley, 1980). Three major coal seams occur in the Nongoma Coalfield: Main Seam (‘M seam’; the only one of economic importance) and the M-1 Seam and M+1 Seam. The M seam at Mbila occurs at an average depth of 36 m.

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

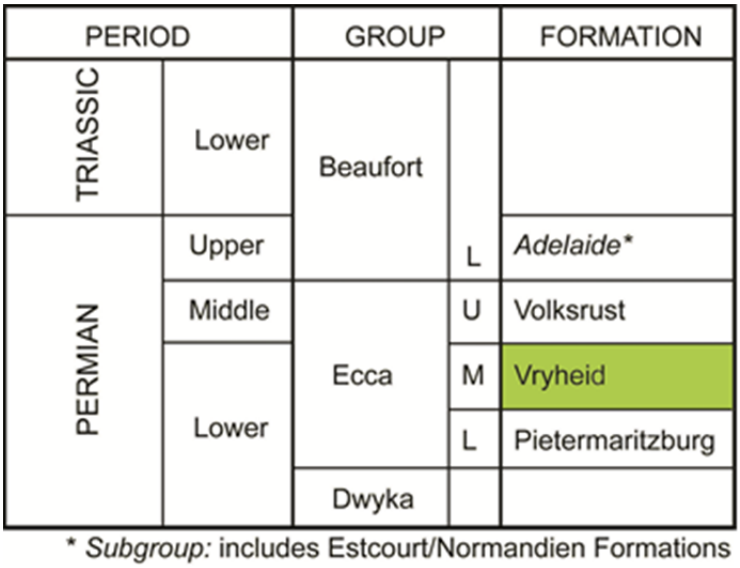


Figure 6. Major lithostratigraphic subdivisions (Lower Permian to Lower Triassic) of the Karoo Supergroup, Main Karoo Basin of South Africa.

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 sedimentary rocks of the **Vryheid Formation**, and particularly those in close spatial proximity to coal seams, have a **high potential** for containing fossilised plants. The coal seams themselves are of minimal value as far as macrofossil potential is concerned, but all associated clastic deposits, particularly those of fine grain size should be carefully monitored for fossil heritage.*

The Early Permian, coal associated, *Glossopteris*-dominated floras of South Africa are World famous, and this reputation has been built on fossils described from only a handful of localities. The most well-known and best documented localities are the quarries near Vereeniging in the Gauteng Province, and at Hammanskraal, north of Pretoria in Mpumalanga Province. The spectacular fossil floras from these localities have been documented by a number of palaeobotanists over the years (e.g. Leslie, 1903; Plumstead, 1952, 1956a,b, 1958, 1969; Kovacs-Endrody, 1976, 1991; Le Roux & Anderson, 1977; Smithies, 1977; Anderson & Anderson, 1985), and elements of this flora continue to stimulate palaeontological debate on the *Glossopteris* plant and associated elements (e.g.

Adendorff *et al.,* 2002, 2003; Prevec *et al.,* 2008; Prevec, 2011). Compared to other areas of palaeontological endeavour in South Africa, remarkably little has been done to understand the floras that provided us with our primary energy source, and this represents an area of major potential growth in the field. This lack of research is not due to a paucity of fossil material, which is abundant and being destroyed daily in mining activities, but to a lack of human resources. Very little is known about the Vryheid Formation floras in KwaZulu-Natal, and any new flora would make a large contribution to our understanding of regional variation in these floras.

SAHRA (South African Heritage Resources Agency) lists the Vryheid Formation as being of 'very high' palaeontological significance, and of global importance with 'rich fossil plant assemblages of the Permian *Glossopteris* Flora (lycopods, rare ferns and horsetails, abundant glossopterids, cordaitaleans, conifers, ginkgoaleans), rare fossil wood, diverse palynomorphs. Abundant, low diversity trace fossils, rare insects, possible conchostracans, non-marine bivalves, fish scales' (see SAHRIS webpage: http://www.sahra.org.za/fossil-layers/vryheid-formation).

Turner *et al.* (1981) documented a diversity of scarce trace fossils in the deltaic Vryheid Formation successions of the Nongoma Graben, including *Skolithos*, *Diplocraterion*, *Helminthopsis* and *Planolites*.

Table 1. Fossil floral elements previously recorded from coal deposits of the Vryheid Formation (and equivalents) of South Africa (only key and recent references included).

Plant group	Taxon	Localities	References
Lycopods	*Azaniodendron fertile*	Vereeniging, Hammanskraal	Anderson & Anderson, 1985
	Cyclodendron leslii	Vereeniging, Hammanskraal, Ermelo, Hlobane	Anderson & Anderson, 1985
Sphenophytes (horsetail ferns)	*Sphenophyllum hammanskraalense, S. mesoeccaense*	Hammanskraal	Smithies, 1977; Anderson & Anderson, 1985
	Annularia hammanskraalensis	Hammanskraal	Anderson & Anderson, 1985
Ferns	*Asterotheca hammanskraalensis*	Hammanskraal,	Anderson & Anderson, 1985
	Asterotheca leeukuilensis	Vereeniging	Anderson & Anderson, 1985
	Sphenopteris lobifolia	Vereeniging,	Anderson & Anderson, 1985

		Hammanskraal	
	Liknopetalon enigmata	Vereeniging, Hammanskraal	Anderson & Anderson, 1985; Adendorff *et al.*, 2003
Glossopterid and affiliated leaves	*Palaeovittaria kurtzii; 'Gangamopteris'*; *Glossopteris* (multiple species)	Ermelo, Hlobane, Vereeniging, Hammanskraal	Kovács-Endrödy, 1976, 1991; Anderson & Anderson, 1985
Glossopterid fertile organs (see Prevec 2005 for a review)	*Arberia madagascariensis*	Hammanskraal	Smithies, 1977; Anderson & Anderson, 1985
	Arberia hlobanensis	Hlobane	Plumstead, 1969; Anderson & Anderson, 1985; Plumstead, 1969
	Arberia leeukuilensis	Vereeniging	Plumstead, 1969; Anderson & Anderson, 1985
	Bifariala (Hirsutum) intermittens	Vereeniging	Plumstead, 1952, 1956a, 1958; Anderson & Anderson, 1985; Prevec *et al.*, 2008
	Gladiopomum elongatum	Rietspruit	Adendorff *et al.* 2002
	Gladiopomum (*Hirsutum) dutoitides*	Vereeniging, Hlobane	Plumstead, 1952, 1956a, 1958; Anderson & Anderson, 1985; Adendorff *et al.* 2002
	Ottokaria buriadica	Vereeniging, Hlobane	Plumstead, 1956b, 1969; Smithies, 1978; Anderson & Anderson, 1985
	Ottokaria hammanskraalensis	Hammanskraal	Smithies, 1978; Anderson & Anderson, 1985
	Ottokaria transvaalensis	Vereeniging	Smithies, 1978; Plumstead, 1956b; Anderson & Anderson, 1985
	Plumsteadia (Lanceolatus) lerouxii	Vereeniging	Plumstead, 1952, 1956a, 1969; Anderson & Anderson, 1985
	Gonophylloides (Lanceolatus) strictum	Vereeniging, Hammanskraal	Plumstead, 1952, 1956a, 1969; Smithies, 1978; Anderson & Anderson, 1985
	Gonophylloides (Lanceolatus) waltonii	Vereeniging	Plumstead, 1952, 1956a, 1969; Anderson & Anderson, 1985
	Elatra (Hirsutum) leslii	Vereeniging, Hammanskraal	Smithies, 1978; Anderson & Anderson, 1985
	Scutum leslii	Vereeniging, Ermelo	Plumstead, 1952, 1956a, 1958, 1969; Anderson & Anderson, 1985; Prevec, 2011
Ginkgoalean elements	*Sphenobaeira eccaensis*, *Metreophyllum lerouxii, Ginkgophyllum kidstonii, Ginkgophyllum spatulifolia, Flabellofolium leeukuilensis*	Vereeniging	Plumstead, 1969; Anderson & Anderson, 1985
Conifers	*Noeggerathiopsis hislopii*	Vereeniging, Hammanskraal, Ermelo, Hlobane	Anderson & Anderson, 1985
	Walkomiella transvaalensis	Vereenging	Plumstead, 1969; Anderson & Anderson, 1985
	Podozamites hlobanensis	Hlobane	Anderson & Anderson, 1985
incertae sedis	*Botrychiopsis valida*	Vereeniging, Hammanskraal	Plumstead, 1969; Anderson & Anderson, 1985

See also MacRae (1999) and McCarthy & Rubidge (2005) for additional photographs and

information on the palaeontology of the Ecca Group.

8. METHODOLOGY

Due to the widely acknowledged palaeontological sensitivity of the Vryheid 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 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 assigned capital letters (A-Z) are marked in Fig.7 with yellow icons, and plant fossil sites have been marked with a green tree icon.

A) South-eastern infrastructure

Infrastructure planned for the area to the east of the D1815 (just north of where this dirt

road intersects with the R618) includes a mine dump, and the start of the mine haul road. This area is devoid of outcrop, and is currently being used as a pasture for cattle and by the local Tribal Council (Fig. 8).

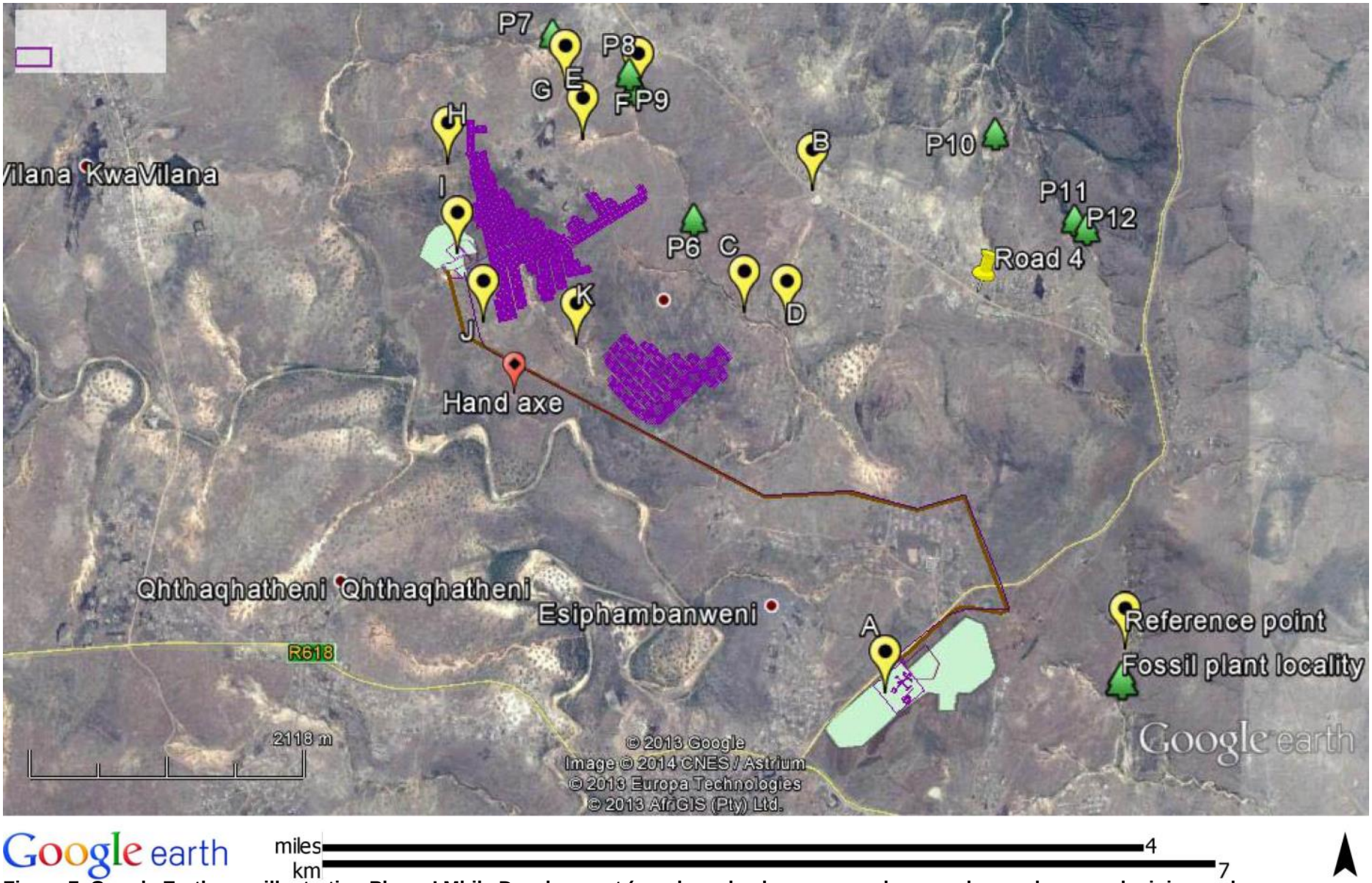


Figure 7. Google Earth map illustrating Phase I Mbila Development (purple and pale green overlay; purple – underground mining; pale green - infrastructure). Green icons (eg. P7) indicate location of plant fossil localities; yellow icons are for easy of reference to areas described and photographed in report.

(a)

(b)

(c)

Figure 8 (a, b, c). Rolling grasslands at the site of the south-eastern Mbila infrastructure, including a discard dump and the start of the mine haul road. No exposure in the vicinity of this development.

B) & (C) North- eastern slopes of G Block ridge: P6 fossil locality

Fig. 9 is a view from the dam at B in Fig. 7, looking towards the development area. Outcrop is restricted to erosion gullies in these rolling grasslands. Exploration of the gully at the base of the ridge led to discovery of **plant site P6** (see Figs 7 and 10; Table 2).

Gully at (E): P7 fossil locality

Well-preserved *Glossopteris* leaves were observed at this site (Fig. 7, Fig. 14; Table 2). Morphologically, some of these were identical to the most common form found at the Hammanskraal locality north of Pretoria (those found attached to *'Hirsutum' leslii* in Anderson & Anderson, 1985), in the Springbok Flats Basin (Vryheid Formation equivalent deposits).

Gully at (F): Fossil localities P8 and P9

Typical Vryheid Formation lithologies exposed sporadically along gully (F), with a lot of micaceous minerals in the siltstones. Some highly carbonaceous layes, including the two that yielded *Glossopteris* leaf fragments. Although preservation at P8 and P9 was not very good, venation details were still visible, and density of fossils (in leaf mats) was high (Figs 15 & 16).

South-western slopes above Mona River

Grassy slopes extend from the top of the north-west to south-east trending ridge that is to be the site of the G Block underground mining, down to the banks of the Mona River to the south-west (Figs 17, 18). Virtually the only exposures of bedrock were those in erosion gullies, and no fossil were found in those explored along these slopes. The only heritage found in this area was archaeological in nature - a lone hand axe, lying on the slopes of an erosion gully (Fig. 7; red icon, hand axe). Disappointingly, the Mona River itself provided no outcrop, only flat expanses of alluvium, sand and vegetation.

Prominent gully between underground mining areas (K)

Mostly course, massive sandstones exposed, as well as extensive dolerite intrusions.

Plant sites P10, P11 and P12

Although these plant localities are not in the immediate vicinity of the underground mining area, they do provide some local context, and provide insights as to the frequency of plant occurrences in the Vryheid Formation in the Nongoma area. See Table 2 and Figs 18-20 for details on these plant sites.

Figure 9. View from dam, at (B), looking toward development area to the south west.

(a)

(b)

Figure 10. Exposures along gully at (C) in Fig. 7, of (a) sandstone, (b) carbonaceous siltstones (metamorphosed; abundance of micaceous minerals).

(a)

(b)

Figure 11. Plant site 6. Laminated, laterally extensive, carbonaceous siltstone with dense, moderately well-preserved plant impressions (arrows).

Figure 12. Beautiful Vryheid Formation exposures in test/exploration trench near (D) in Fig. 7; anthracite layer at base.

a)

(b)

Figure 13. (a) gully near P7; (b) site P7.

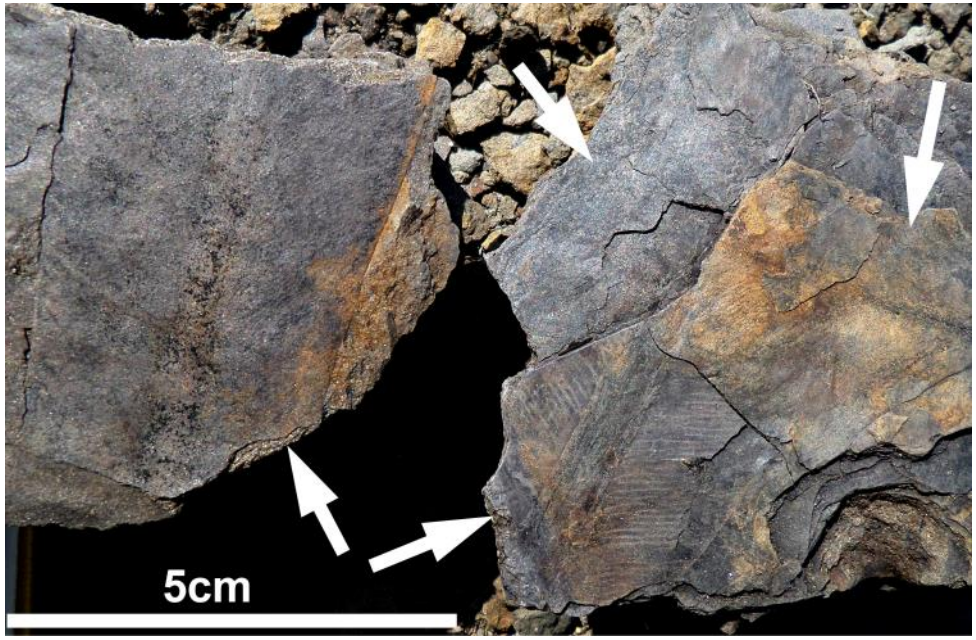
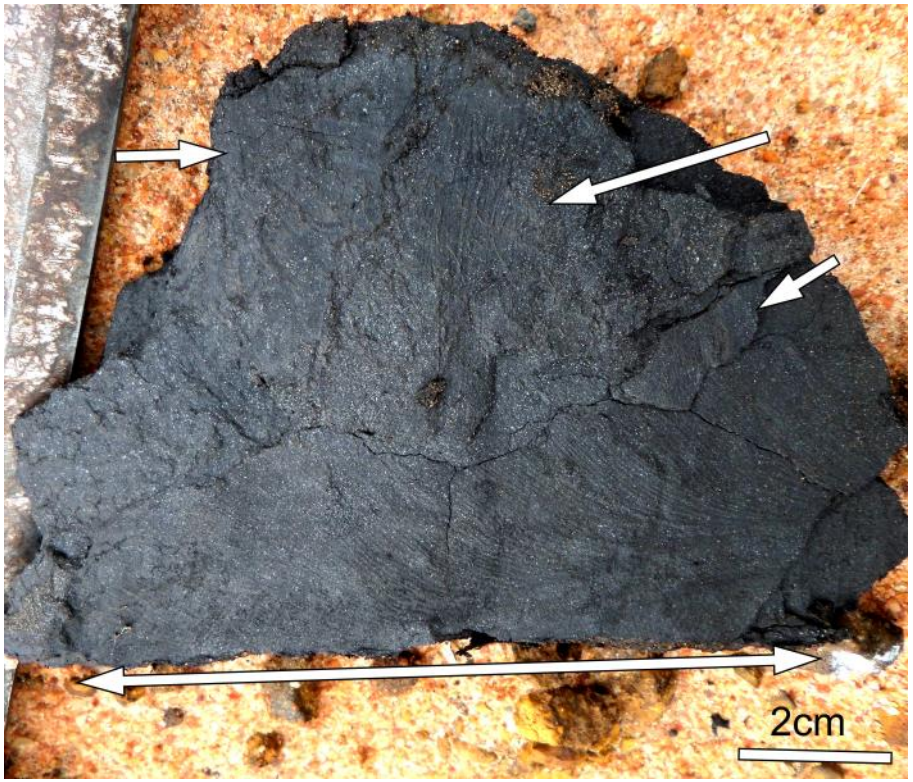


Figure 14. Typical Vryheid Formation *Glossopteris* leaves from site P7.

(a) **(b)**

Figure 15. (a) Fossil plant site P8 in Gully (F). (b) *Glossopteris* leaves at site P8.

(a)



(b)

(c)

Figure 16. (a) Fossil plant site P9 in Gully (F). (b) Glossopteris leaves at site P9. (c) View of top of Gully (G), mostly sandstone and modern alluvium

(a)

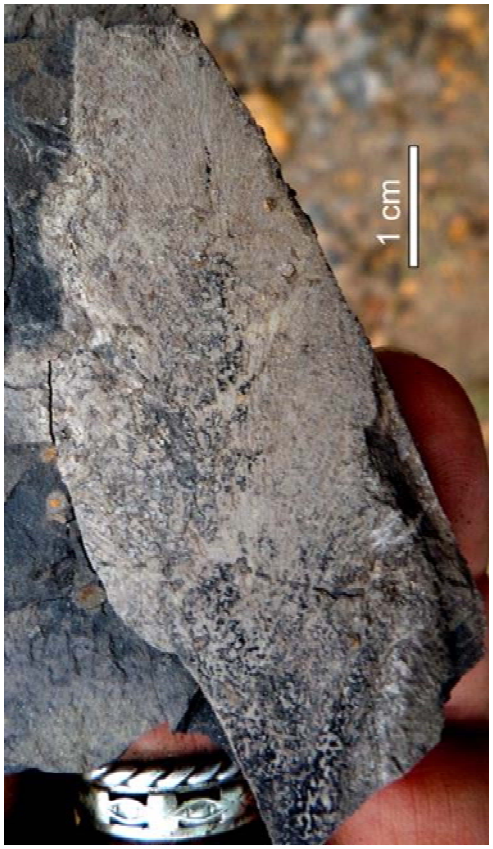
(b)

Figure 17. (a) View of uninformative grassy western slopes of G-block underground mining area, at (H). (b) A view of the same grassy ridge further south at (I). Similar view of G Block underground mining area, from vantage point (J). (d) Hand axe in gully south of development area (Fig. 7).

(c)

(d)

(a)



(b)

(c)

(d)

Figure 18. (a) Plant fossil site P10; (b)-(d) *Glossopteris* leaf fragments from P10.

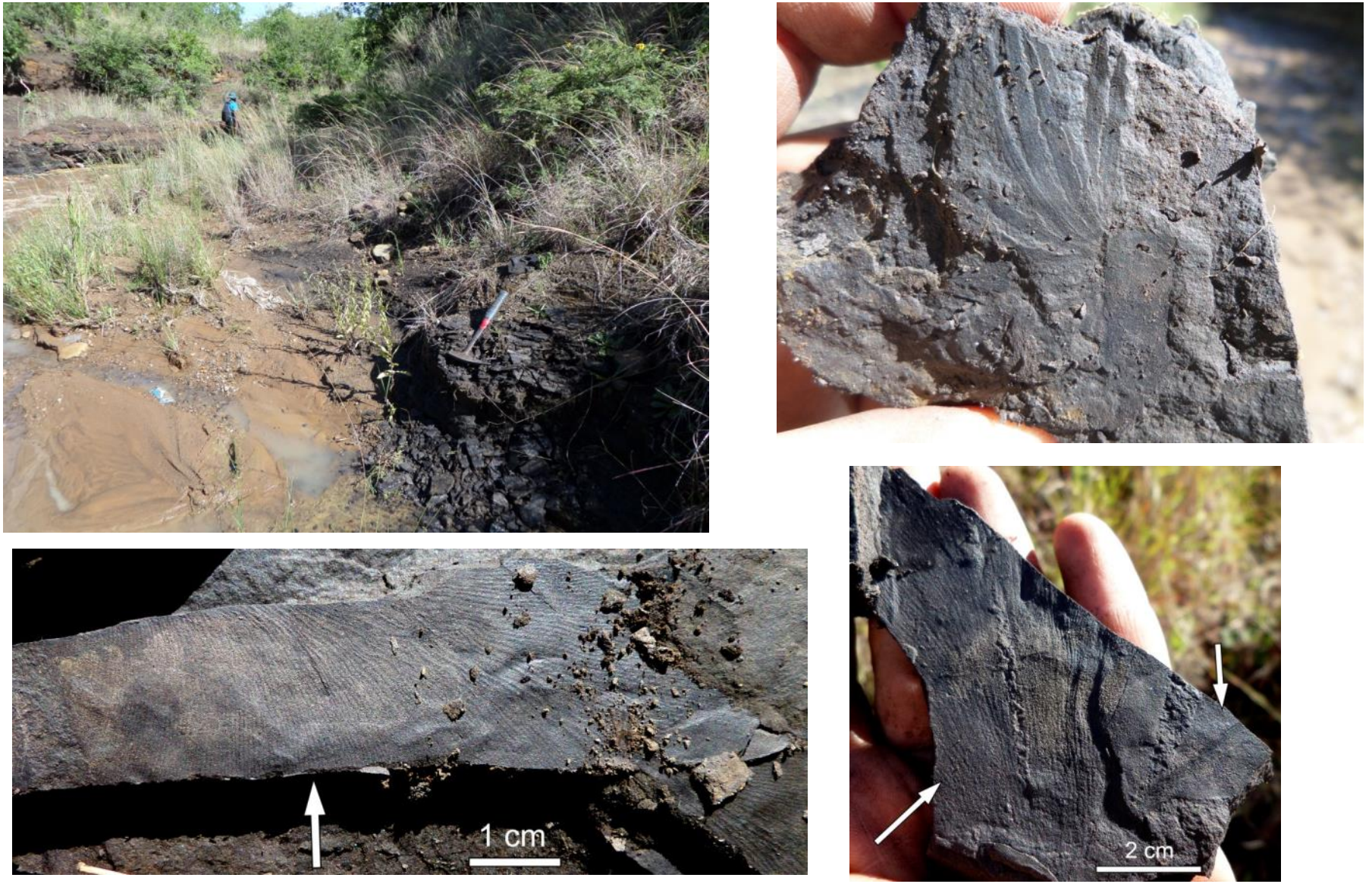


Figure 19. Plant fossil site P11: *Phyllotheca* sphenophyte whorl and fragments of large *Glossopteris* leaves.

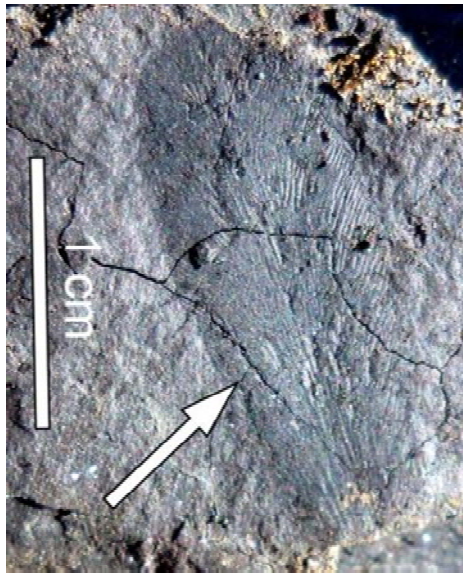


Figure 20. Plant fossil site P12: small *Glossopteris* leaf with good venation detail and insect damage.

Table 2. Summary of palaeontological findings in the vicinity of the development area (see Fig. 7)

Fossil site number	GPS co-ordinates	Locality notes	Fossils found	Quality of preservation	Recommendations
P6	27° 52.459'S; 31° 45.026'E	Exposure in wall of gully (C); 80 cm thick, highly laminated, laterally extensive horizon with horizontal bedding planes	*Glossopteris* leaf fragments	Moderate preservation; high density of leaves, but fairly poor detail preserved	Not worth collecting
P7	27° 51.690'S 31° 44.356'E	Low, weathered exposures in gully floor; patchy, multiple plant occurrences in fine-grained, carbonaceous mudrock with well-developed bedding planes	*Glossopteris* leaf fragments	Very good preservation, venation detail excellent, high fossil density	A bulk collection required, should mining activities impact this site
P8	27° 51.856'S 31° 44.720'E	Gully wall exposure; discrete layer of fine-grained, highly carbonaceous siltstone	*Glossopteris* leaf fragments	Moderate to poor preservation; high density of leaves, but fairly poor detail preserved	Not worth collecting
P9	27° 51.919'S 31° 44.749'E	Low, weathered exposures in gully floor; patchy plant occurrences in highly carbonaceous, medium-grained, micaceous, carbonaceous siltstone	*Glossopteris* leaf fragments	Moderate preservation; high density of leaves, but fairly poor detail preserved	Not worth collecting
P10	27° 52.091'S 31° 46.472'E	Small weathered outcrop on broad gully slopes, in a narrow layer of fairly carbonaceous, fine-grained siltstone	*Glossopteris* leaf fragments	Well-preserved, good venation detail, but most leaves fragmentary	A bulk collection required, should mining activities impact this site
P11	27° 52.459'S 31° 46.846'E	Fairly small, weathered outcrop; approximately 10 cm layer of fine grained, carbonaceous siltstone beneath a weathered sandstone	*Glossopteris* leaf fragments	Well-preserved, good venation detail, but most leaves fragmentary	A bulk collection required, should mining activities impact this site
P12	27° 52.498'S 31° 46.903'E	Narrow band of very black (carbonaceous), fine-grained mudrock.	*Glossopteris* leaf fragments	Well-preserved, good venation but very sparse	Not worth doing a large collection
GREEN SHADING: HIGH QUALITY SITES REQUIRING 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 abundance.

SIGNIFICANCE RATING= 72: (magnitude +duration+scale) x probability							
Rock Unit	**Duration**	**Scale**	**Probability**	**Magnitude**		**Overall Significance**	
				with mitigation	**without mitigation**	**with mitigation**	**without mitigation**
Vryheid Formation	**5** permanent	**5** International	**4** High probability	beneficial	**8** High negative	beneficial	High negative

11. RECOMMENDATIONS

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 or sub-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.

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

1) regular inspection of excavation sites by an ECO capable of searching for and recognising plant 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 representative sample of the flora, and to 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 and expert palaeontologist should be consulted. A scientifically useful 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. CONCLUSIONS

This development is likely to have an impact on plant and trace fossil heritage of the highly palaeontologically sensitive Vryheid Formation. 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.

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