PALAEONTOLOGICAL IMPACT ASSESSMENT

Desktop skoping level report:

Paardeplaats coal mining project, Belfast, Mpumalanga

Specialist report by:

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1. SUMMARY

This specialist evaluation represents a Desktop Study for a Scoping Level Report on the potential impacts on palaeontological heritage, by the proposed coal mining activities at Paardeplaats Farm near Belfast, Mpumalanga. Mining activities will expose and destroy bedrock of the (Early Permian) Vryheid Formation, that is of high palaeontological sensitivity, with a strong probability of containing well-preserved fossil plant material, and may also impact on limited Quaternary deposits with a much lower probability of containing fossils.

Summary impact significance rating table

SIGNIFICANCE RATING					
Rock Unit	**Temporal Scale**	**Spatial Scale**	**Degree of confidence**	**Impact severity**	
				with mitigation	**without mitigation**
Quaternary	permanent	international	unsure	beneficial	moderate negative
Vryheid Formation	permanent	international	probable	beneficial	high negative

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.

Mitigation measures should be implemented, commencing with a continuous monitoring programme by a qualified Environmental Control Officer throughout construction and mining activities that result in the exposure of bedrock. Fossil occurrences must be reported to the South African Heritage Resources Agency and a qualified palaeontologist must be provided the opportunity to document and excavate the fossils concerned.

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3. ABBREVIATIONS

ECO - environmental control officer
SARHA - South African Heritage Resource Agency
PGS - Professional Grave Solutions (Pty) Ltd T/A
DEA - Department of Environmental Affairs
NEMA - National Environmental Management Act
HIA - Heritage Impact Assessment
PIA - Palaeontological Impact Assessment

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5. INTRODUCTION AND BRIEF

The purpose of this specialist palaeontological study is to provide a brief Scoping Level Report on the proposed coal mining and ancillary service activities to take place on the Paardeplaats Farm near Belfast, Mpumalanga (Figs 1-3).

The Paardeplaats project is located on Portions 13, 28, 29, 30 and 40 of the farm Paardeplaats 380 JT and the Remaining Extent of Portion 2 of the farm Paardeplaats 425 JS (Figs 2, 3). It covers an area of approximately 1 415 ha and falls within the jurisdiction of the Nkangala District Municipality and Emakhazeni Local Municipality (ELM).

Project details

The purpose of the proposed Paardeplaats Project is to provide coal to the Glisa mine beneficiation plant at a rate of 4.2-4.4 mtpa and to Eskom at a rate of 2.4 mtpa.

Proposed mining activities will involve a hybrid process between roll-over mining and bench mining. (Roll-over when only one seam is present, and where overburden <20m thick; bench mining when two or more seams are present and where overburden >20m thick).

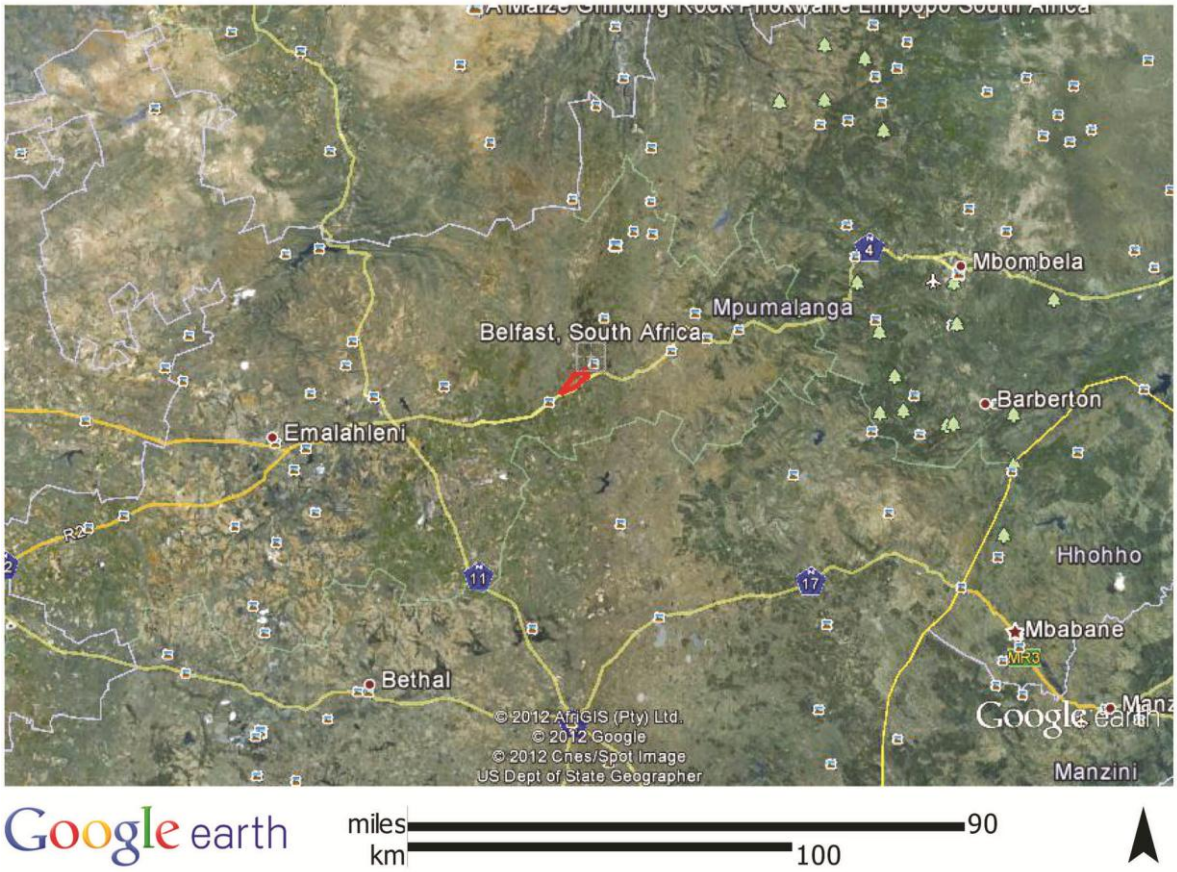

Figure 1. Google map indicating the location of the study area (red outline) in a regional context.

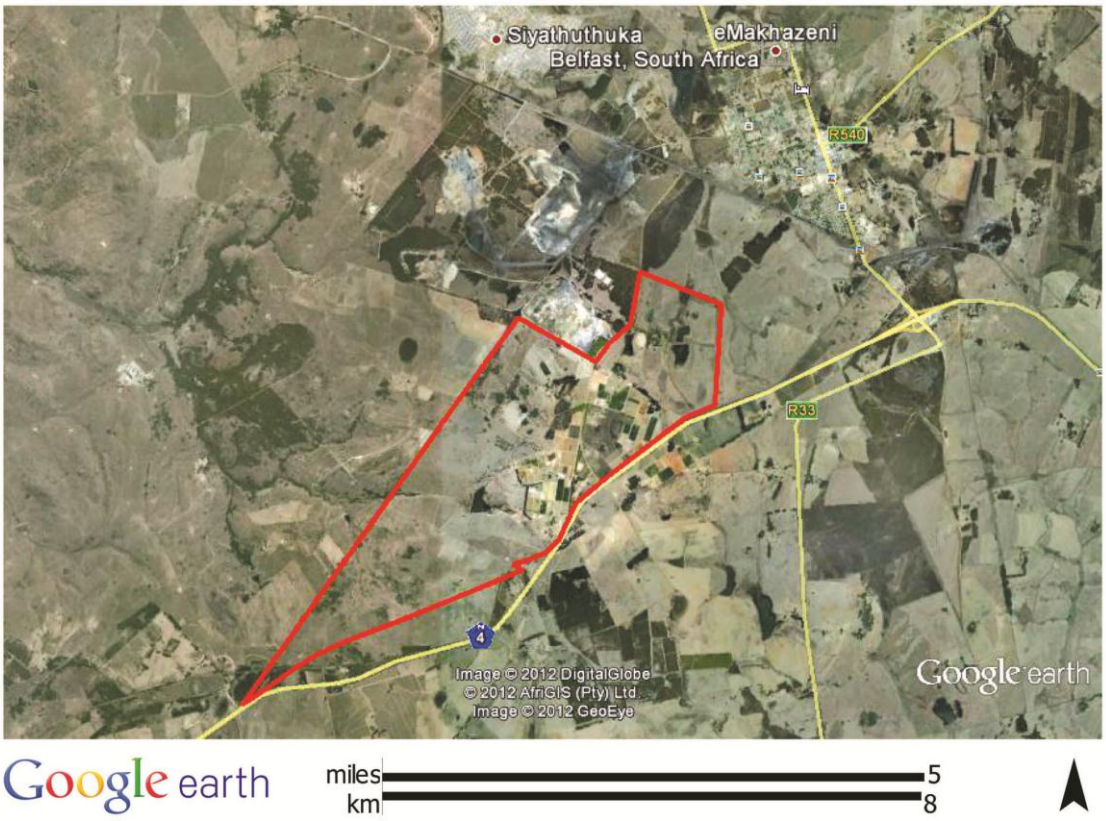

Figure 2. Google map indicating the location of the proposed Paardeplaats Project.

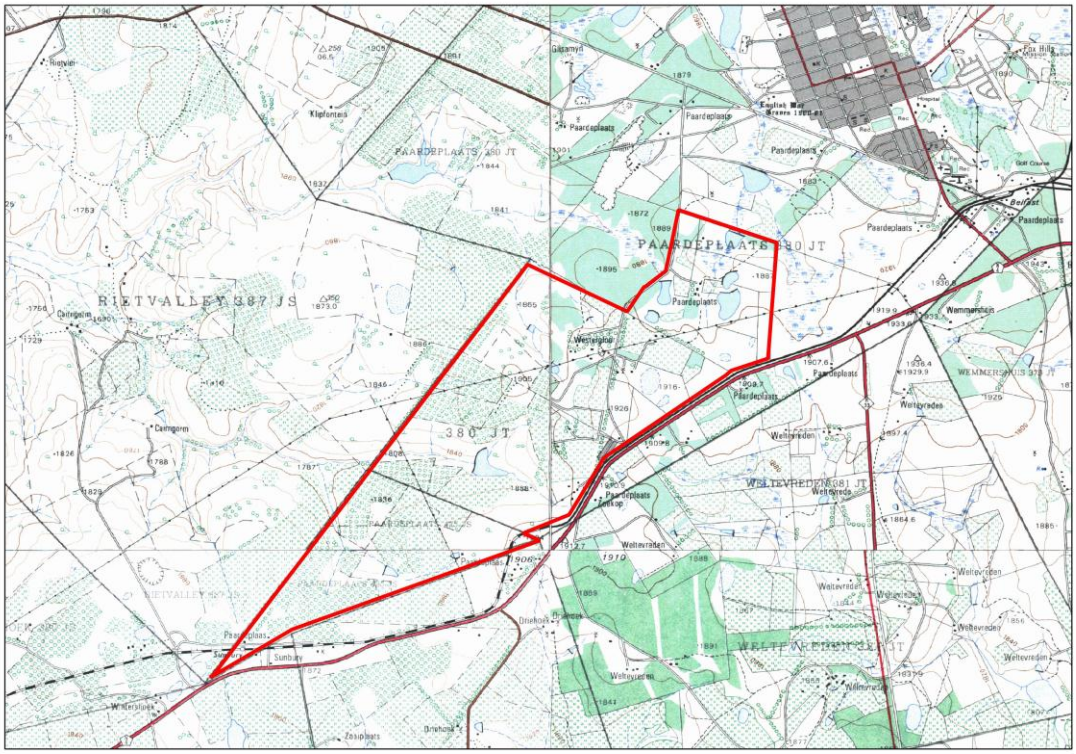

Figure 3. Topographic map of the site area on the Paardeplaats Farm (provided by PGS).

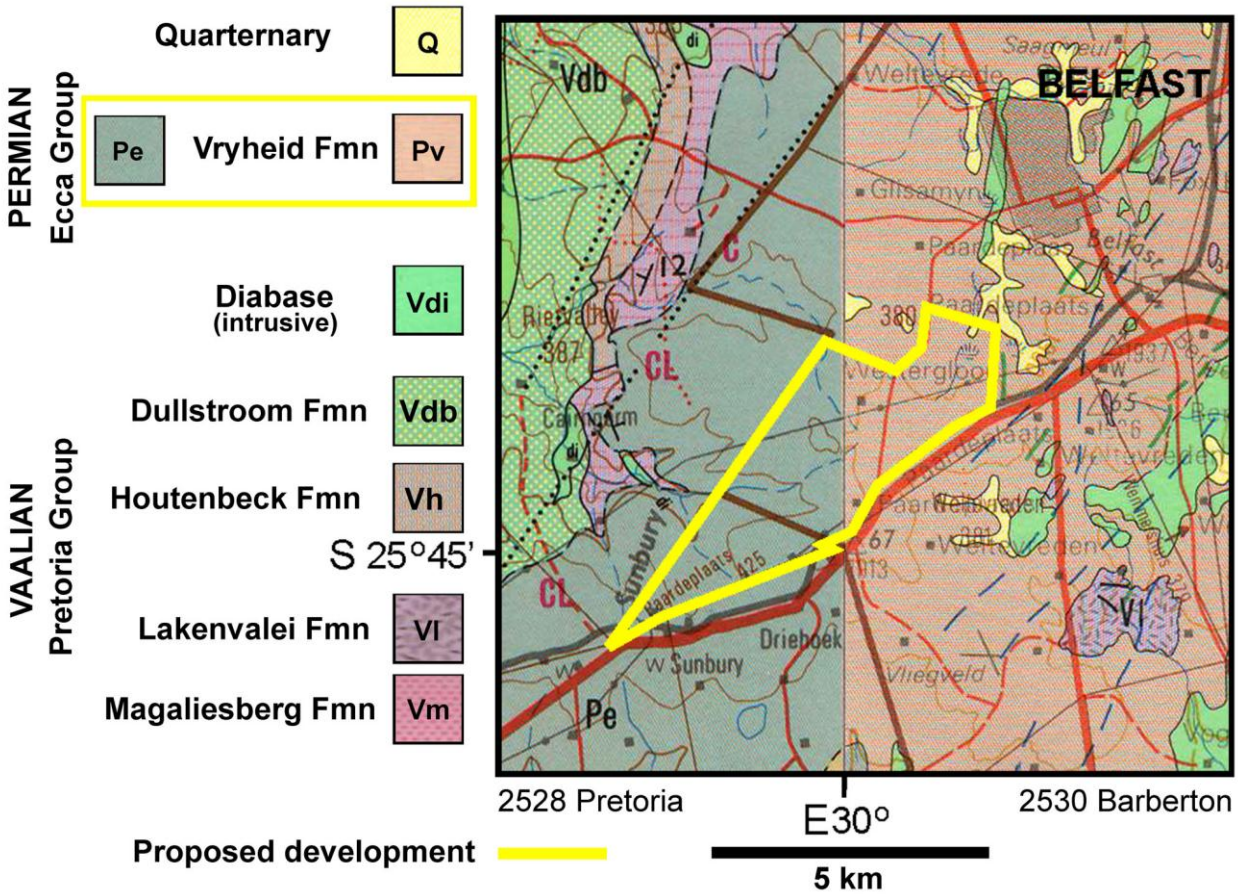

Figure 4. Geological map of the Belfast area (from the 1:250 000 maps: 2530 Barberton and 2528 Pretoria, Council for Geoscience).

6. LEGISLATIVE CONTEXT

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.

7. TERMS OF REFERENCE

This report represents a literature-based palaeontological desktop study (no field component), that aligns with the guidelines in the latest version of the SAHRA guidelines (May 2007, revised 2009), 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;
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.

8. GENERAL APPROACH AND METHODOLOGY USED FOR DESKTOP PALAEONTOLOGICAL IMPACT ASSESSMENTS

Geological maps (1:250 000) of the development area are consulted to gain an understanding of the local and regional geology. Various sources such as the scientific literature, previous heritage impact assessments, institutional collections and prior personal experience, are drawn upon to identify potentially fossiliferous rock units and the fossil taxa that have been previously recorded from these units. This information is then used to assess the palaeontological sensitivity of the rock units.

Topographic maps and Google Earth images of the development site are examined to assess the topography and potential for surface outcrops of palaeontologically sensitive rock strata.

The nature of the proposed development is considered, and activities where bedrock will be impacted are identified. If the affected bedrock is deemed to be palaeontologically sensitive, the degree of anticipated impact on fossil heritage is assessed and appropriate mitigation measures are proposed.

9. ASSUMPTIONS AND LIMITATIONS

A heritage desktop survey does not obviate the need for a field examination of the site. This report represents a preliminary, scoping phase assessment of the potential of the development to impact of fossil heritage. A field examination may reveal high quality fossil material exposed at surface, but it is far more likely that the majority of the envisioned impacts, both positive and negative, will occur during the mining process itself, and for the entire duration of the mining activity.

The distribution of fossil plant material within coal mines is in many cases extremely localised, so for effective mitigation measures to be employed repeated evaluation of exposed bedrock would be required as mining efforts progress.

10. GEOLOGY OF THE STUDY AREA

As indicated in the (1:250 000) geological maps of the Barbarton (2530) and Pretoria (2528) regions (Fig. 4), the geology is dominated by rocks of the Transvaal Supergroup, in particular the Pretoria and Rooiberg Groups (Vaalian in age, 2050+ million years old). In the study area, these basement rocks are unconformably overlain by deposits of the Vryheid Formation (Ecca Group, Karoo Supergroup), and patchy occurrences of Quaternary deposits, mostly associated with extant fluvial systems.

Since the development will impact mainly rocks of the Vryheid Formation (Ecca group, Early Permian) and potentially, to a minor extent, Quaternary deposits in the north-eastern parts of the development area (Fig. 4), the much older rocks of the Transvaal Supergroup will not be considered further in this report.

The project area falls within the Witbank Coalfield, close to the north-eastern edge of the main Karoo Basin. Mining activities will specifically target the coal seams within the Vryheid Formation, in particular the No. 2 seam of the Springs-Witbank Coalfield in Mpumalanga.

Quaternary Deposits

As per the explanation to sheet 2530 Barberton (Walraven, 1989), the quaternary deposits present in the region include residual soils, alluvial deposits and scree deposits. These deposits are found along active streams on the property, particularly in the northern to north-eastern parts of the study area (Fig. 4).

Vryheid Formation

The Vryheid Formation (Ecca Group, Karoo Supergroup; Fig. 5) underlies the entire study area, although surface exposures are poor due to the relatively low relief and extensive vegetation cover. Most of the Paardeplaats property appears to be used currently for pasture and crop cultivation.

As described by Walraven (1989) the Vryheid Formation in this area comprises grit, sandstone and shale and contains several coal seams. Intercalations of siltstone and mudstone are common in the sandstone, particularly in the upper part of the Formation, and lenses of calcareous sandstone and sandy limestone occur fairly regularly. Upward fining cycles are typical of the coal-bearing strata, manifesting as repeating sequences of conglomerate and grit overlain by sandstone, shale and finally coal seams, and representing channel-lag, point-bar and overbank deposits respectively, of meandering river systems (Walraven, 1989).

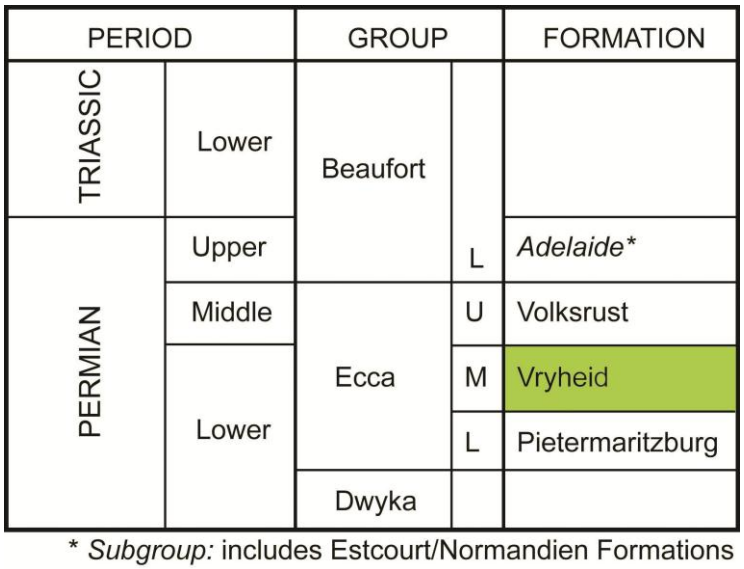

Figure 5. Major lithostratigraphic subdivisions (Lower Permian to Lower Triassic) of the Karoo Supergroup, Main Karoo Basin of South Africa.

11. PALAEONTOLOGICAL HERITAGE

The **Quaternary deposits** in the far north-east of the development area are unlikely to contain fossils and are considered to be of low palaeontological sensitivity. That said, fossils have been found occasionally in coeval deposits elsewhere, such as mammal bones and teeth, early humans, trace fossils, non-marine invertebrates.

*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 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.

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, Hammanskraal	Anderson & Anderson, 1985
	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

12. IMPACT RATING

Table 2. Impact significance rating table*

Criteria		Status	Comments
Temporal Scale		Permanent	Destruction of a fossil represents loss of an irreplaceable heritage resource
Spatial Scale		study area	⅄ physical effects limited to development footprint; ⅄ destruction of fossil heritage registers at the national or international level depending on the type and quality of fossil destroyed
Frequency		ongoing, cumulative	The potential to impact negatively on fossil floras will remain as long as mining continues to expose and destroy fossiliferous strata
Severity	**without mitigation**	high; unpredictable	⅄ destruction of well-preserved coal floras during construction and mining activities represents a high negative impact; ⅄ the occurrence of these floras is patchy,making the likelihood and extent of the impact difficult to define
	with mitigation	beneficial	Monitoring by a trained ECO and recording and collecting of fossil material by a professional palaeontologist could result in a high positive impact.
Likelihood		probable	Since these deposits are by definition coal-associated, there is a strong possibility of encountering well-preserved plant fossils
Confidence		high	Coal floras in the Vryheid Formation are known from other areas in this province.
Reversibility		irreversible	⅄ destruction of fossil heritage is permanent; ⅄ destruction of rare fossil forms could mean a significant loss to our scientific knowledge base.
Significance		high negative	⅄ mitigation measures are required to reduce high negative impact of fossil heritage destruction; ⅄ specialist intervention could make a significant contribution to the understanding of South Africa's coal floras.

* format and categories modified from Almond (2012)

Impact significance and duration	In palaeontological terms any destruction of fossils is a **permanent negative impact** and must be regarded as potentially a **high impact significance**. New taxa are fairly regularly encountered in plant fossil studies, and destruction of well-preserved, undescribed fossil beds could represent a heavy loss in terms of our understanding of historical biodiversity.	
Certainty	Definite	More than 90% sure of a particular fact. Substantial supportive data exist to verify the assessment.
	Probable	Over 70% sure of a particular fact, or of the likelihood of impact occurring.
	Possible	Only over 40% sure of a particular fact or of the likelihood of an impact occurring.
	Unsure	Less than 40% sure of a particular fact or likelihood of an impact occurring.

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.

13. MITIGATION

Official guidelines specifically for mitigation of damage to and destruction of fossil heritage during mining of coal deposits are currently not in place, and this is a matter that needs to be raised with SAHRA. 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 serves to protect the 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 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.

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 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 would be examined for evidence of fossil floras;

2) when lenses of sedimentary rocks containing well-preserved plant fossils are found, a palaeontologist must be afforded the opportunity to excavate a representative sample of the flora, and to document the depositional context as reflected by the adjacent rocks and coal seams; a scientifically useful palaeobotanical collection must be made. There is little value in collecting a few blocks of the material – this is not 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.

14. CONCLUSIONS

The proposed Paardeplaats coal mining project will impact on bedrock of the Vryheid Formation, that has a high potential for containing plant fossils. Although little consideration has been afforded coal-associated fossils in the past, these are scientifically valuable and are protected as South African heritage. The recommendation presented here is for mitigation measures to be implemented throughout construction and mining, involving monitoring for fossil occurrences by a trained ECO, and documentation and retrieval by a qualified palaeontologist of any well-preserved plant fossils that are exposed.

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16. SPECIALIST QUALIFICATIONS

Dr Rose Prevec has PhDs in Palaeontology and Plant Pathology from the University of the Witwatersrand (2005) and University of KwaZulu- Natal (1998) respectively. She specialises in research on South African Permian macrofossil floras, with an interest in taxonomy, biostratigraphy, and palaeoecological aspects such insect- plant interactions. She has held four postdoctoral fellowships, at Wits and Rhodes University, and is currently a Research Associate at the Albany Museum in Grahamstown and in the Geology Department at Rhodes University. Dr Prevec has more than 10 years of experience in locating, collecting and curating fossils, including exploration field trips in search of new localities in the southern, eastern and north- eastern parts of the country. Her publication record includes multiple articles in internationally recognized journals. Dr Prevec is accredited by the Palaeontological Society of Southern Africa (society member for 13 years, and a member of the Executive Committee for 5 years).

Declaration of Independence

I, Rosemary Prevec, 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 Rosemary Prevec
Palaeontologist