Palaeontological Impact Assessment for the proposed extraction of the No. 2 coal seam via open-pit strip mining within the 314MR, Elandsfontein Colliery, Mpumalanga Province

Site Visit Report

For

Digby Wells Environmental

18 February 2018

Prof Marion Bamford
Palaeobotanist
P Bag 652, WITS 2050
Johannesburg, South Africa
Marion.bamford@wits.ac.za

Expertise of Specialist

The Palaeontologist Consultant is: Prof Marion Bamford

Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf

Experience: 30 years research; 22 years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Digby Wells, Johannesburg, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

Anker Coal and Mineral Holdings propose to expand their Elandsfontein Mine Operations, located on the farm Elandsfontein 309 JS in the eMalahleni Local Municipality of Mpumalanga Province. The proposed expansion will be undertaken through rolling strip mining method and rehabilitating the open cast pit strips. To comply with the requirements stipulated by the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a Palaeontological Impact Assessment (PIA) was completed for the proposed expansion.

The site lies on the shales, sandstones and coals of the *Vryheid Formation*, Ecca Group, Early Permian of the main Karoo Basin. Associated with the shales between the coal seams fossil plants of the Glossopteris flora would be expected. Very poorly preserved, rare and patchy fossils were found during the site visit but the plants and other fragments are unidentifiable. Since the strip mining has not yet commenced and coals and shales of the proposed extension were not exposed, there is only a very small chance of well-preserved fossils being found, based on the very poorly preserved fossils in the adjacent sites. It is, therefore, recommended that a Chance Fund Protocol be followed once mining begins.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

1. Background

Digby Wells Environmental (Pty) Ltd have been appointed by Anker Coal and Mineral Holdings (Pty) Ltd to undertake an Environmental Impact Assessment (EIA) process in terms of the National Environmental Management Act, 107 of 1998 (NEMA) and the NEMA Environmental Impact Assessment (EIA) 2014 Regulations, as amended. Their in-house heritage specialist has undertaken a Heritage Impact Assessment (HIA) to inform the heritage component of the EIA application. An HIA report inclusive of a palaeontological exemption letter have been submitted to SAHRA for comments in terms of the National Heritage Resources Act, no. 25 of 1999 (NHRA).

Anker Coal and Mineral Holdings are proposing to expand their mining operations on the Elandsfontein Mine, located on the farm Elandsfontein 309 JS, in the eMalahleni Local Municipality of Mpumalanga Province. The mine will be using rolling strip mining method and rehabilitating the open cast pit strips. Associated infrastructure will be the topsoil heaps, spoil heap and haul road.

An exemption letter compiled by Dr M. Bamford was submitted to the case on 23/10/2017 in lieu of a field based Palaeontological Impact Assessment (PIA) as requested in the 3/10/2017 Interim Comment. The SAHRA Archaeology, Palaeontology and Meteorites do not accept the PIA exemption letter by Dr M. Bamford, stating that as the Elandsfontein Colliery consists of underground (314MR) and open-pit sections (63MR), i.e. it is an existing operation, plenty palaeontological material may have already been exposed during previous mining activities. Therefore, a field-based PIA must be done by a professional palaeontologist to investigate this state and submitted to SAHRA.

The mine was visited by a professional palaeontologist on 14 February 2018 and the finds are presented here.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (2014)

A specialist report prepared in terms of the Environmental Impact Regulations of 2014 must contain:	**Relevant section in report**
Details of the specialist who prepared the report	Appendix A
The expertise of that person to compile a specialist report including a curriculum vitae	Appendix A

A specialist report prepared in terms of the Environmental Impact Regulations of 2014 must contain:	**Relevant section in report**
A declaration that the person is independent in a form as may be specified by the competent authority	Page i
An indication of the scope of, and the purpose for which, the report was prepared	Section 1
The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4 Figure 2 and Figure 3
An identification of any areas to be avoided, including buffers	N/A
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
Any mitigation measures for inclusion in the EMPr	N/A
Any conditions for inclusion in the environmental authorisation	Section 5 Figure 9
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	N/A
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	N/A
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	N/A
A description of any consultation process that was undertaken during the course of carrying out the study	N/A
A summary and copies if any comments that were received during any consultation process	N/A
Any other information requested by the competent authority.	N/A

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA inclusive of a site-visit and provide feasible management measures to comply with the requirements of SAHRA.
The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance;
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility; and
4. Determination of fossils' representatively or scientific importance to decide if the fossils can be destroyed or a representative sample collected.

3. Geology and Palaeontology

I. Project location and geological context

The Elandsfontein Colliery is in the Witbank Coalfield and the coals are part of the *Vryheid Formation*. The predominant seams are numbered 1-5, lower to upper, with seams 2 and 4 generally thicker (Snyman, 1998). Typically the uppermost seam is 15-45 m below surface so the overburden has to be stripped away first for the opencast or strip mining operations.

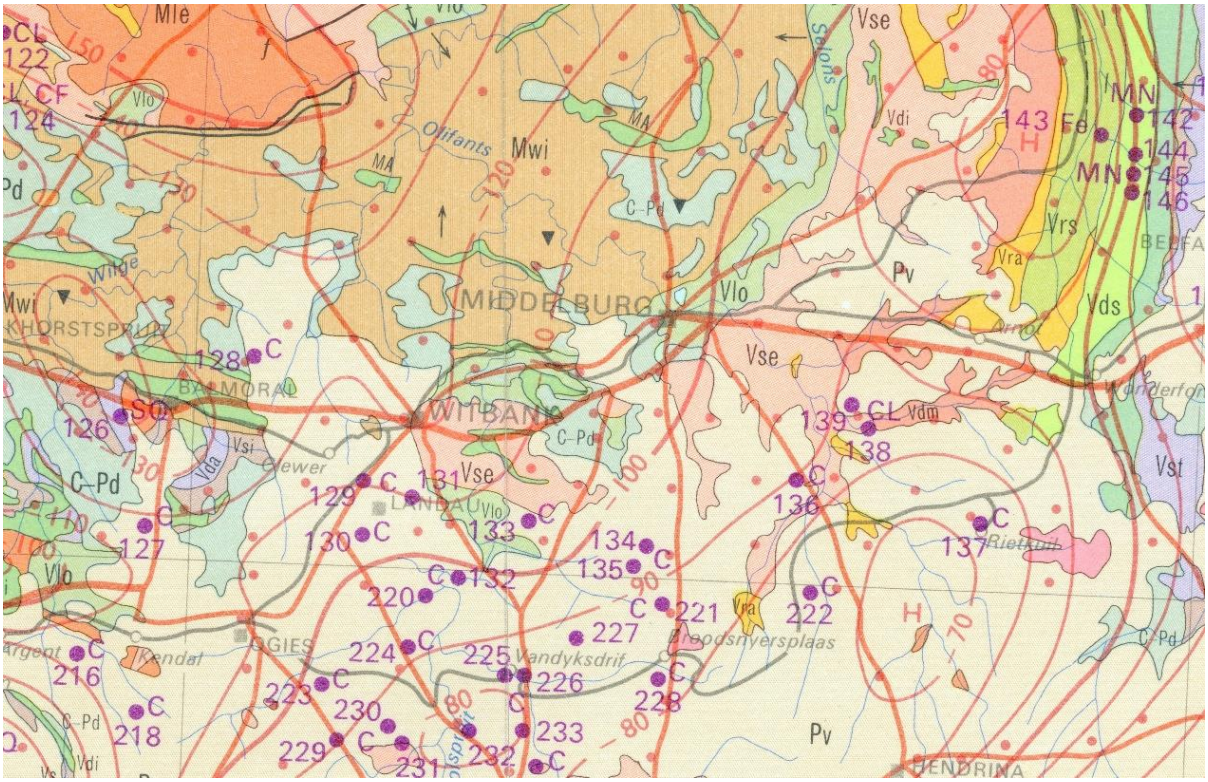

Figure 1: Geological Map of the Area around eMalahleni (Witbank)

The site of interest, Elandsfontein Colliery, is to the southwest of eMalahleni and is indicated with the arrow. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 1 000 000 map 1984.

Table 2: Explanation of symbols for the geological map and approximate ages

Symbol	Group/Formation	Lithology	Approximate Age
Pv	Vryheid Fm	Shales, sandstone, coal	Lower Permian, Middle Ecca
C-Pd	Dwyka	Tillite, sandstone, mudstone, shale	Upper Carboniferous, Early Permian 295-290 Ma
Vlo	Loskop Fm, Middleburg Basin	Shale, sandstone, conglomerate, volcanic rocks	Ca 2000 – 1700 Ma
Vse	Selons River Fm, Rooiberg Group, Bushveld Magmatic Province	Red porphyritic rhyolite	Ca 2061 - 2052 Ma

SG = Supergroup; Fm = Formation

(Buchanan, 2006; Erikssen et al., 2006. Johnson et al., 2006)

The other major rock formations in the region are the ancient volcanic rocks of the Rooiberg Group or the sedimentary rocks of the Loskop Formation but these are not being mined.

II. Palaeontological context

Although coal was formed from thick accumulations of plants in a swampy environment during the Permian, the coal itself is of no palaeontological interest because the plant matter has been compressed and altered by heat to such an extent that no material is distinguishable. In some settings fossil leaf impressions are preserved in the carbonaceous shales between the coal seams but these tend to be rare and very difficult to find. The expected flora is that of the Ecca *Glossopteris* flora comprising impressions of leaves, fructifications and scale leaves of *Glossopteris* as well as a variety of ferns, lycopods, sphenophytes and ginkgophytes (Plumstead, 1969; Anderson and Anderson, 1985).

The palaeontological sensitivity of the area under consideration is presented in Figure 2.

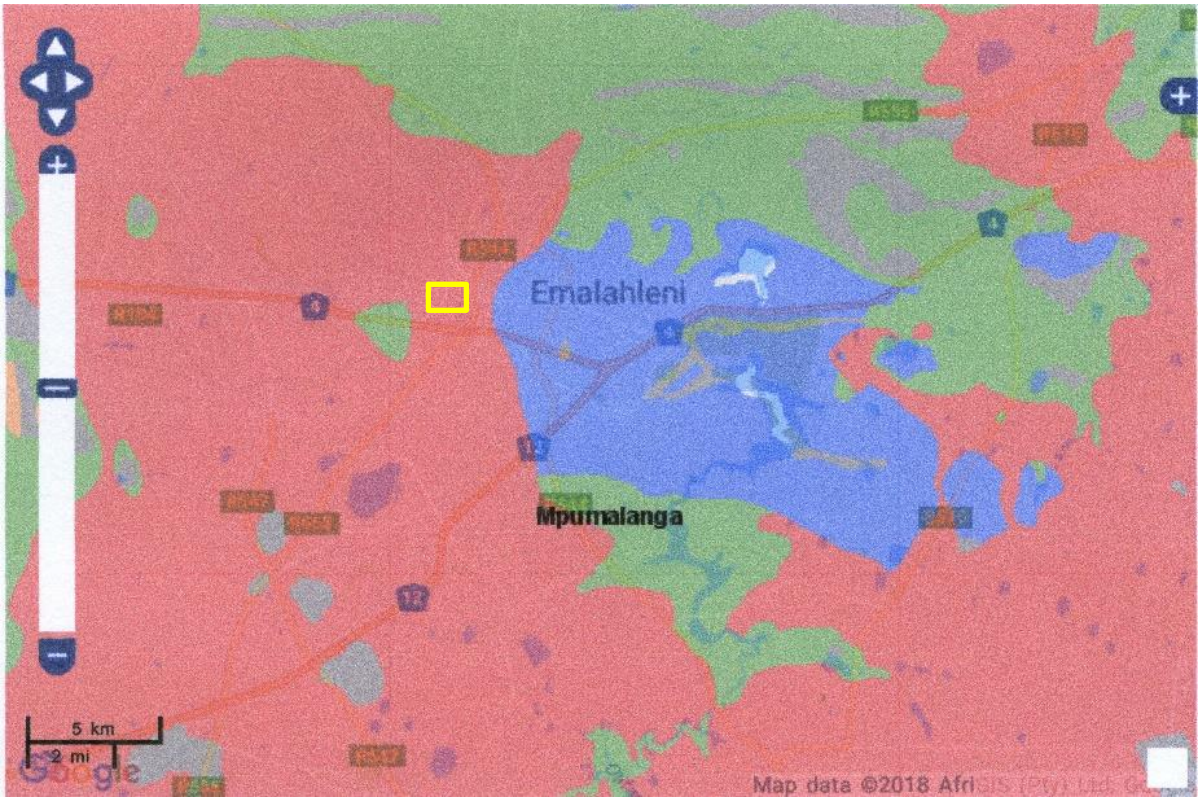

Figure 2: SAHRIS Palaeosensitivity Maps for the Region around eMalahleni

Elandsfontein colliery is shown within the yellow rectangular outline. Colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

III. Site Visit

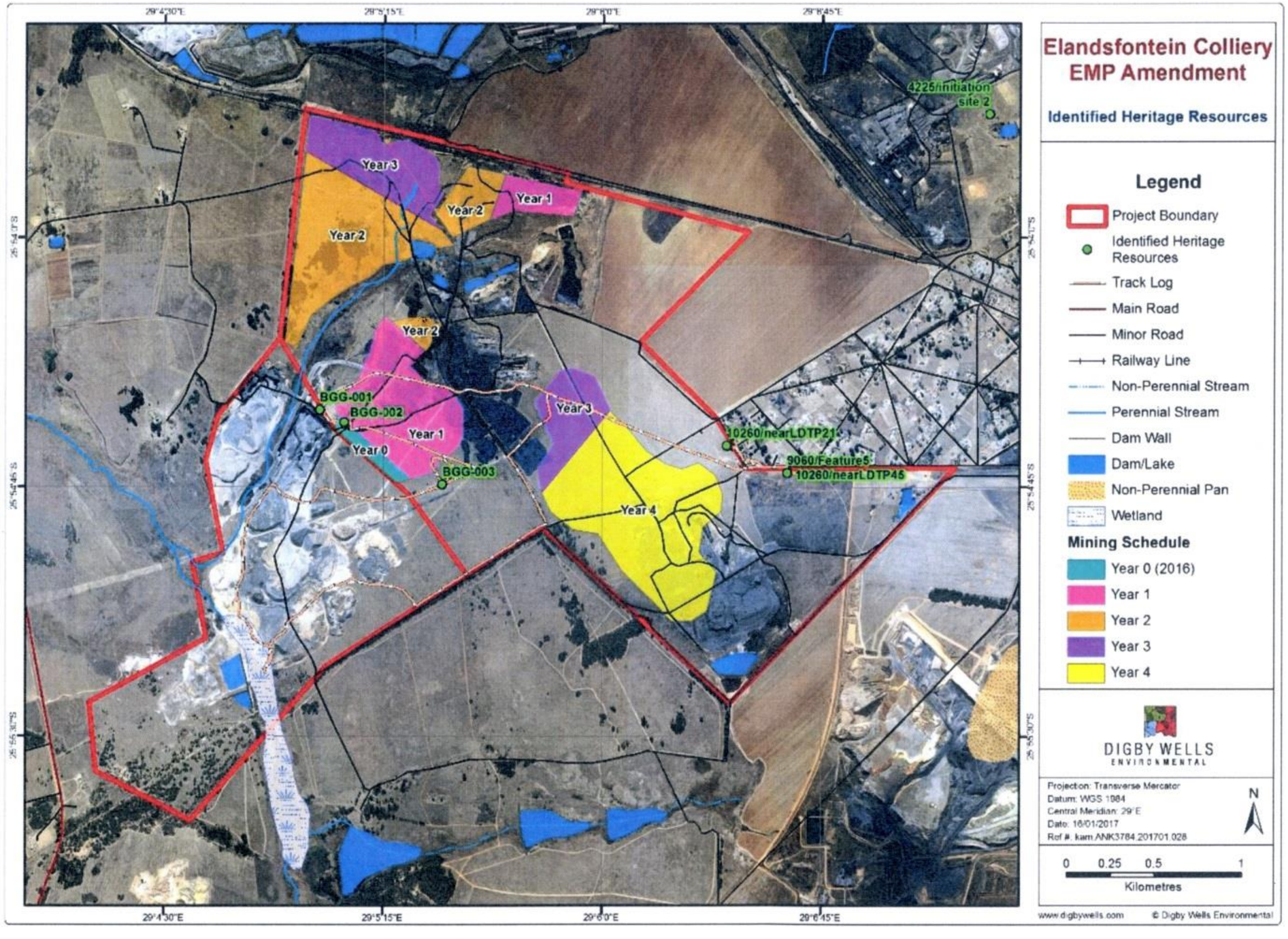

Figure 3: Proposed Sections to be Mined and the Planned Schedule

Based on this information sites were selected for the Phase 2 study (see Figure 4).

a. Extension 63 (South West Portion; Figure 5 to Figure 8)

This area, 63MR, has been mined by open pit mining but was visited as the coal seam and associated shales are exposed and accessible. A general view of the site is shown in Figure 5(a) and the very poorly preserved fossils found are shown in Figure 5(b-f). Vertical *Skolithos* burrows (Figure 5(b)) were seen in a sandstone block that had been dislodged so it was not possible to determine if where they originally occurred stratigraphically. Although several hours were spent searching for fossils very few were found and they were very poorly preserved. The large block shown in Figure 5(c) has impressions of plant fragments but they are unidentifiable. Some possible leaf impressions are shown in Figure 5(d) from a block that was split open, i.e. not weathered, and they are very carbonised and poorly preserved. The most common type of material is shown in Figure 5(e) and this is organic material with no structure preserved. The best fossil found, Figure 5(f), is probably a leaf impression of *Glossopteris* but the venation and leaf shape cannot be seen clearly.

Figure 4: Google Earth Map of Mine Area showing Sites that were visited on 14 February 2018

The south west portion, 63MR has open pit mining, as does the far north east section. This project area is the northeast (314MR) that has been mined underground to date and Anker Coal is proposing to extend the open pit form of mining to this section.

b. ***Area 314MR (Central and North East Section of Figure 3, Figure 4 and Figure 7(a-d)***

This section of the Elandsfontein Colliery is where underground mining has taken place. Now the proposal is to carry out open-pit strip mining to access the No 2 coal seam as the quality of the resource is such that it will be sold to Eskom's Primary Energy Division for the generation of electricity at various power stations. As this is an existing operation, all the necessary infrastructure is in place and no additional infrastructure is proposed as part of the amendment process. This is the focus of this report.

Only the adjacent margin of this section is visible as strip mining has NOT yet commenced. A section of a coal seam is shown in Figure 7(a) with overlying non-fossiliferous sands and soils and a thick coal seam. Fossils are not visible in the cut face and are also extremely difficult to find in the loose blocks. Typical examples of very fragmentary organic material (possibly plant) are shown in Figure 7(b) - an oxidized block with some patterning, but not of plants so possibly chemical only; c – carbonaceous shale with no fossils preserved and d – the only possible leaves found but they are carbonised and poorly preserved so no structure or detail can be seen. Figure 7(d) is also from a fresh split block and not due to natural weathering.

The **dumps** for 314MR underground mining operations were visited to see the potential of finding fossils from this area. Figure 8(a) shows the very fine coal material that remains in the dump. A view towards the area to be strip mined is shown in Figure 8(b) where the surface is still mostly intact (not yet mined), and with old dumps of overburden in the background. A mix of coal and white shales (Figure 8(c)) occur in the tall dumps but a close up of the material shows no fossils. The markings on the white shale are traces of iron chelate, possibly as a result of plant activity and oxidation, but no plant structure was seen (Figure 8(d)).

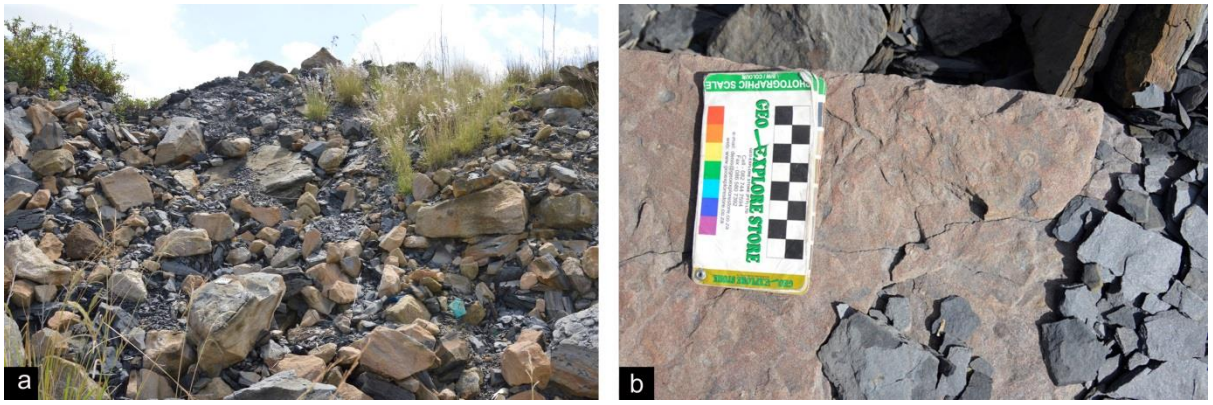

Figure 5: Extension 63 (Southwest Portion) of Elandsfontein Colliery

A - General view of the area. B – Vertical burrow of *Skolithos* in a disassociated block (DSC4051 marked on Figure 4). Age and context unknown. All site photographs taken by David Groenewald.

Figure 6: Extension 63 (Southwest Portion) of Elandsfontein Colliery

C – Large block of carbonaceous shale with unidentifiable fragmentary plant (?) material. D – Poorly preserved leaf impression, possibly Glossopteris sp. E – Example of the most common form of “fossils” - carbonaceous organic fragmentary material. F – Best example of a fossil leaf found, possibly *Glosspteris*, but shape and venation not seen.

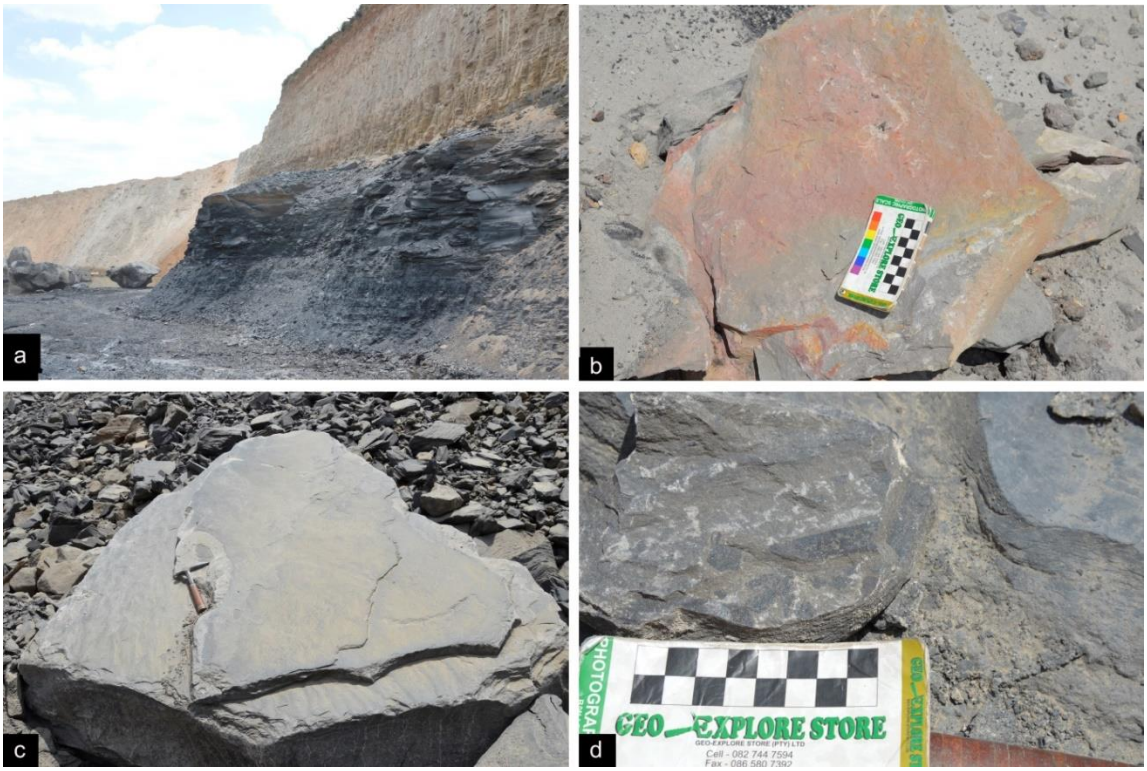

Figure 7: Area 314MR (Central and Northeast Section) Elandsfontein Colliery

A – Area of active mining with a coal seam exposed. B – Highly oxidised and very fragmentary material, possibly plant. C – Most common form of organic fragmentary material, unidentifiable. D – Only leaf impressions found but unidentifiable.

Figure 8: Dump Site of Area 314MR

A – General view of the dump and fine material remaining. B – Area to be strip mined with old dump in the background. C – Pile of coal and white shales from underground mining. D – White shale with iron chelate staining, possibly the oxidation process by ancient plants.

4. Impact Assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table 3 and Table 4 below.

Table 3: Criteria for assessing impacts

PART A: DEFINITION AND CRITERIA		
Criteria for ranking of the SEVERITY/NATURE of environmental impacts	H	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	L	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	L	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national
PROBABILITY (of exposure to impacts)	H	Definite/ Continuous
	M	Possible/ frequent
	L	Unlikely/ seldom

Table 4: Impact Assessment

PART B: ASSESSMENT		
SEVERITY/NATURE	H	-
	M	-
	L	The chance of finding fossil plants would be low because the preservation is very poor and they are extremely rare. There would be minor deterioration of the surface of sites and a minor impact on any potential fossils. Therefore the SEVERITY/NATURE of the environmental impact would be low.
	L+	-
	M+	
	H+	-
DURATION	L	-
	M	-
	H	Where manifest, the impact will be permanent.
SPATIAL SCALE	L	Since only the possible fossils within the area would be fossil plants such as leaf impressions and reproductive structures from the *Glossopteris* flora in the shales, the spatial scale will be localised within the site boundary.
	M	-
	H	-
PROBABILITY	H	-
	M	
	L	There is a chance of finding leaf fossils in the shales only as these have been seen here and reported from the same formation. The preservation is very poor for the whole area investigated.

Three sections of the mine were thoroughly investigated and although impressions of fossil leaves were found they were very few examples and very poorly preserved; no details of leaf venation were preserved so the leaves could not be identified and no other plant or plant part could be determined. This organic material was highly carbonised and fragmentary, as well as very few examples. As no further information can be gained from this material it is of very limited use scientifically. Nonetheless there is a very small chance of better preserved fossils being found so a chance find protocol is included in this report.

It is the opinion of the professional palaeontologist (a palaeobotanist in this instance) that the proposed mining extension can proceed but the geologist/environmental officer or other responsible person must monitor the material being removed and dumped (Chance Find protocol).

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the dolomites, sandstones, shales and coals are typical for the country and do contain fossil plant, insect, invertebrate and vertebrate material. The shales of the lower Permian *Vryheid Formation* could contain impression fossils of plants of the *Glossopteris* flora that are recognisable and are typical of the South African fossil flora.

Based on the site visit and experience the fossil plants in the shales between the coal seams on Elandsfontein 309 JS near eMalahleni are not at all abundant and are patchy in their distribution. Furthermore, their preservation is so poor that the plants are not recognisable (although deposits in other areas have well preserved fossil plants). The fossils examined to date are of very limited scientific interest except to record their presence. Since the proposed strip mining has not yet commenced it is not possible to say what fossils occur there BUT it is most likely that they would be the same as found in the adjacent deposits. As there is a low potential for finding fossils, in particular plants, a chance find protocol is included.

6. Recommendation

Based on the site visit the fossil plants in the area are rare and very poorly preserved on Elandsfontein 309 JS. No further intervention by a palaeontologist is required now. When strip mining operations commence the responsible person should follow the attached Chance Find Protocol as there is a very small chance of finding any recognisable fossil plants. This confirms the recommendation made in the earlier report by Digby Wells (ANK3784 HIA Report including appendices 2017-08-04).

7. References

Anderson, J.M., Anderson, H.M., 1985. Palaeoflora of Southern Africa: Prodromus of South African megafloras, Devonian to Lower Cretaceous. A.A. Balkema, Rotterdam. 423 pp.

Barbolini, N., Bamford, M. K., Rubidge, B., 2016. Radiometric dating demonstrates that Permian spore-pollen zones of Australia and South Africa are diachronous. Gondwana Research 37, 241–251.

Digby Wells, August 2017, Environmental Regulatory Processes relating to the amendment of the Environmental Management Programme for its Elandsfontein Operations. Heritage Impact Assessment Project Number: ANK3784, Prepared for: Elandsfontein Colliery (Pty) Ltd
SAHRIS Case ID: 11478. SAMRAD Ref: MP30/5/1/2/2/10132MR.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. Pp 461 – 499.

Plumstead, E.P., 1969. Three thousand million years of plant life in Africa. Geological Society of southern Africa, Annexure to Volume LXXII. 72pp + 25 plates.

Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the mine is operational.

1. The following procedure is only required if and when open pit strip-mining commences. The surface activities would not impact on the fossil heritage as the coal and any associated fossil plants are below ground.
2. When mining operations commence the shales and mudstones (of no economic value) that will be cut through in order to reach the coal seam must be given a cursory inspection by the mine geologist or designated person before being added to the waste rock dump used by the mine. Any fossiliferous material should be put aside in a suitably protected place. This way the mining activities will not be interrupted.
3. Photographs of similar fossil plants must be provided to the mine to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 9). This information will be built into the mine's training and awareness plan and procedures.
4. On a regular basis, to be determined by the mine management, the responsible person should examine a representative sample of non-coal material and look for fossil plants and take digital photographs of them to send to a qualified palaeontologist/palaeobotanist sub-contracted for this project to get an opinion on their scientific value.
5. Fossil plants that are considered to be of good quality or scientific interest by the palaeobotanist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the mine property a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
6. If no good fossil material is recovered then the site inspections by the responsible person can be terminated. Annual reports by the palaeontologist must be sent to SAHRA.

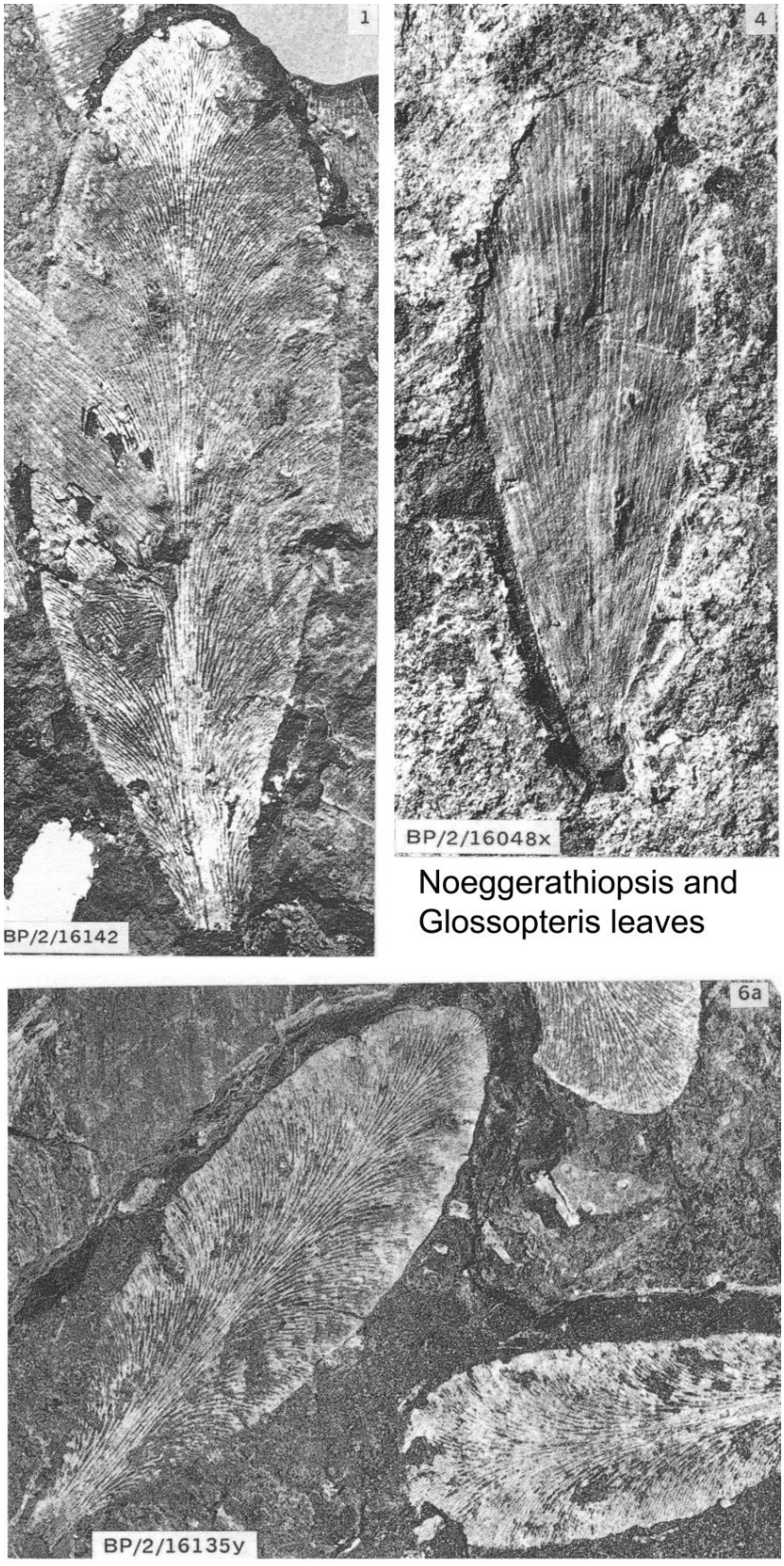

Figure 9: Examples of Well-Preserved Fossil Plants of Ecca Age

Curriculum Vitae (Short) - Marion Bamford PhD

January 2018

I) Personal Details

Surname	:	**Bamford**
First names	:	**Marion Kathleen**
Present employment	:	Professor;
		Director of the Evolutionary Studies Institute.

Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa-

Telephone	:	+27 11 717 6690
Fax	:	+27 11 717 6694
Cell	:	082 555 6937
E-mail	:	marion.bamford@wits.ac.za;
		marionbamford12@gmail.com

II) Academic Qualifications

Tertiary Education: All at the University of the Witwatersrand:

1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.

1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.

1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.

1986-1989: PhD in Palaeobotany. Graduated in June 1990.

III) Professional Qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):

1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps

1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer

1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

IV) Membership of Professional Bodies/Associations

Palaeontological Society of Southern Africa

Royal Society of Southern Africa - Fellow: 2006 onwards

Academy of Sciences of South Africa - Member: Oct 2014 onwards

International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

V) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/completed	Current
Honours	5	2
Masters	6	3
PhD	9	3
Postdoctoral fellows	5	3

VI) Undergraduate Teaching

Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 2-8 students per year.

VII) Editing and Reviewing

Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Cretaceous Research: 2014 - Review of manuscripts for ISI-listed journals: 25 local and international journals

VIII) Palaeontological Impact Assessments

Selected – list not complete:

- Thukela Biosphere Conservancy 1996; 2002 for DWAF
- Vioolsdrift 2007 for Xibula Exploration
- Rietfontein 2009 for Zitholele Consulting
- Bloeddrift-Baken 2010 for TransHex
- New Kleinfontein Gold Mine 2012 for Prime Resources (Pty) Ltd.
- Thabazimbi Iron Cave 2012 for Professional Grave Solutions (Pty) Ltd
- Delmas 2013 for Jones and Wagener
- Klipfontein 2013 for Jones and Wagener
- Platinum mine 2013 for Lonmin
- Syferfontein 2014 for Digby Wells
- Canyon Springs 2014 for Prime Resources
- Kimberley Eskom 2014 for Landscape Dynamics
- Yzermyne 2014 for Digby Wells
- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental
- Glencore-Tweefontein 2015 for Digby Wells
- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC

IX) Research Output

Publications by M K Bamford up to January 2018 peer-reviewed journals or scholarly books:

over 110 articles published; 5 submitted/in press; 8 book chapters.

Scopus h index = 22; Google scholar h index = 24;

Conferences: numerous presentations at local and international conferences.

X) NRF Rating

NRF Rating: B-2 (2016-2020)

NRF Rating: B-3 (2010-2015)

NRF Rating: B-3 (2005-2009)

NRF Rating: C-2 (1999-2004)