Palaeontological Impact Assessment for the proposed infrastructure development and opencast mining at Vandyksdrift Central (VDDC) Section of South32's Wolvekrans Colliery.
Mpumalanga Province

Desktop Study

For

Jones and Wagener Engineering and Environmental Consultants

05 July 2019

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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

Refer to Appendix D for a detailed Curriculum vitae.

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Jones and Wagener Engineering and Environmental Consultants, 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

South32 SA Coal Holdings (Pty) Ltd (South32), is the holder of an amended mining right for coal for Wolvekrans and Ifalethu Collieries, south of Middelburg in the Witbank coalfield, Mpumalanga. As part of the request approved, to allow the opencast mining of the remaining No. 5, No. 4, No. 2 and No. 1 seams, some additional infrastructure is required. The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery.

The whole mining property falls in palaeontologically sensitive sediments (shales, mudstones and coal) of the early Permian Vryheid Formation in the Witbank coalfield. Coal seams are between 15-110m below the land surface that is covered by soils. It is very unlikely that any fossils would be impacted upon by the excavations for the proposed infrastructure because the fossils would occur in the shales associated with the coal seams and, furthermore, the fossils are rare and sporadic.
The potential impact of the proposed opencast mining not previously authorised on paleontological resources have been assessed. The Impact Risk Class is 3 as the Rating is 2.1 and falls in the range 2.1 – 3.0, so the impact is rated as moderate. This is attributed to the depth of excavation associated with the opencast mining.

It is, therefore, recommended that a Fossil Chance Find Protocol be included in the EMPr. Any further palaeontological assessment is only required once mining activities have commenced and if the responsible person finds fossils.

Table of Contents

1. Background

South32 SA Coal Holdings (Pty) Ltd (South32), is the holder of an amended mining right for coal, granted by the Minister of Mineral Resources, in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA) and notarially executed on the 21st of May 2015 under DMR reference MP30/5/1/2/2/379MR, in respect of its Wolvekrans – Ifalethu Colliery. This mining right comprises of the following areas:

- Ifalethu Colliery (previously referred to as Wolvekrans North Section, and prior that as the Middleberg Colliery) consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant; and
- Wolvekrans Colliery (previously referred to as the Wolvekrans South Section) consisting of the Wolvekrans, Vlaklaagte (mining ceased), Driefontein, Boschmanskrans, Vandyksdrift, Albion and Steenkoolspruit sections, as well as the South Processing Plants (Eskom and Export). Some of these areas were previously known as Douglas Colliery.

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow pillar mining (opencast) of the area previously mined by underground bord and pillar mining. Authorisation of the VDDC mining project included the following:

- Opencast operation on the farm Kleinkopje 15 IS;
- Opencast operation on the farm Steenkoolspruit 18 IS;
- Pillar extraction operation on the farm Vandyksdrift 19 IS;
- Reclamation of existing slurry ponds; and
- Rewashing of existing discard dumps (PHD, 2006).

The water uses associated with the opencast mining have been authorised in terms of Water Use Licence (WUL) number 24084535 dated 10 October 2008, issued to Douglas Colliery Services Limited.

The No. 2 seam workings are flooded with water and must be dewatered to enable the open pit development to proceed. A dewatering strategy has therefore been developed and an application for Environmental Authorisation (EA) of the dewatering activities was submitted to the Department of Mineral Resources (DMR) (Jaco-K Consulting, 2016(a)); a decision in this regard is pending. The water use activities associated with this upfront dewatering strategy have been authorised by WUL number 06/B11F/GCIJ/7943 dated 19 July 2018.

The 2007 approved EMPR Amendment included limited additional infrastructure in support of the opencast mining operations, as it was assumed at that stage that existing infrastructure will be used. In addition, the applications for authorisation of the activities associated with the dewatering strategy, were limited to the infrastructure to facilitate dewatering (i.e. dewatering boreholes, pumps, pipelines, storage tanks, mechanical evaporators, roads and power lines).

A pre-feasibility investigation has since been conducted, and the need to develop additional infrastructure to support the proposed opencast mining was identified. The additional infrastructure includes the following:

- Storm water management structures (drains and berms);
- Water management measures for the management of mine impacted water;
- Overburden dumps;
- ROM coal stockpile areas;
- Mixed ROM coal and slurry stockpile areas;
- Topsoil stockpiles following clearance of vegetation;
- Pipelines for the conveyance of water;
- Hard park area and brake test ramp; and
- Haul roads and service roads.

The proposed VDDC opencast pit boundary as determined through the pre-feasibility investigation also differs from the mining area approved in the 2007 EMPR amendment. An area of approximately 196 hectares in the latest mine lay-out was not included in the previous mine lay-out and is therefore not approved to be opencast mined.

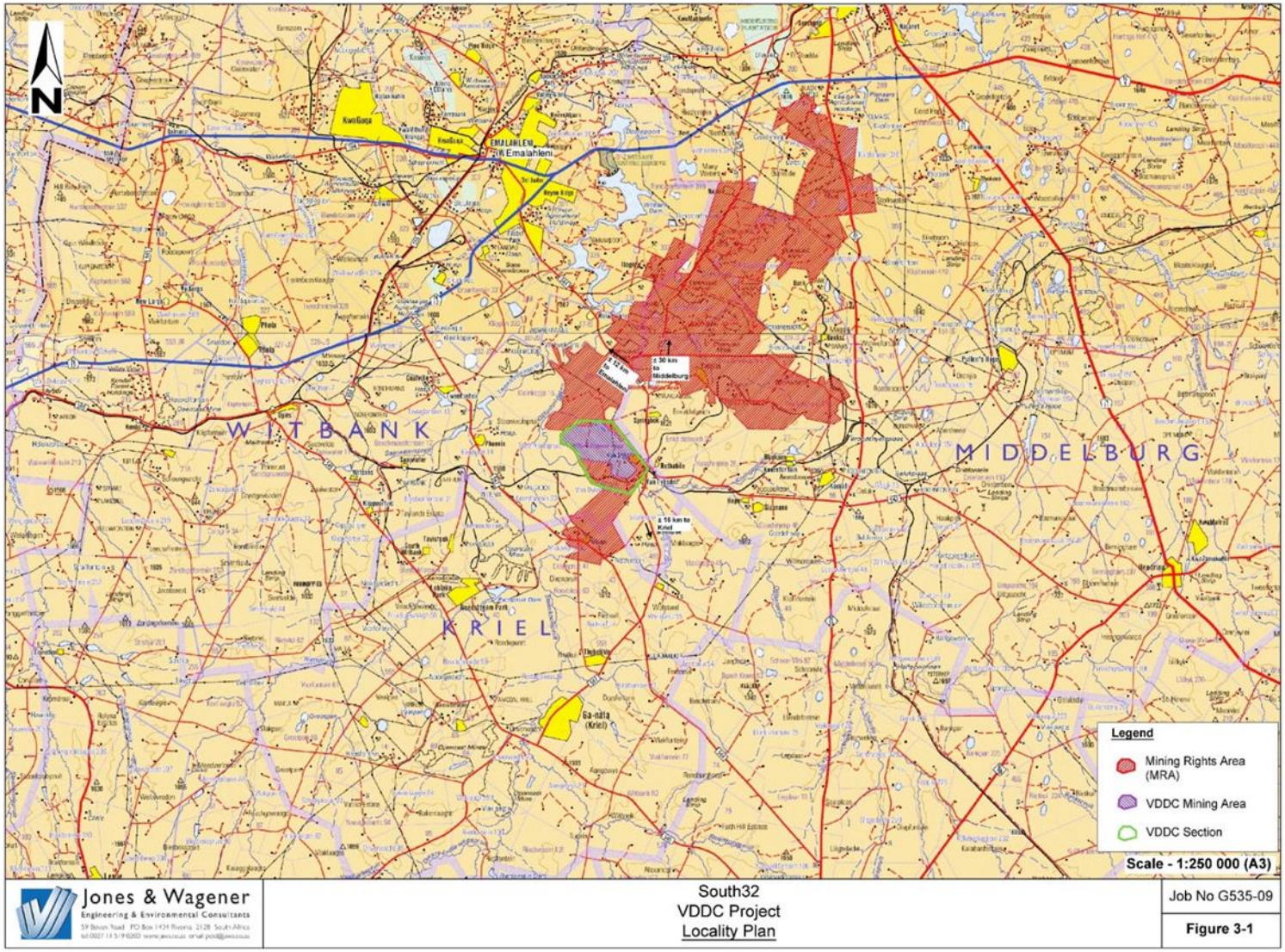

Figure 1: **General plan of the Wolvekrans Colliery with VDDC (Vandyksdrift Central) shown in purple. Map supplied by Jones and Wagener.**

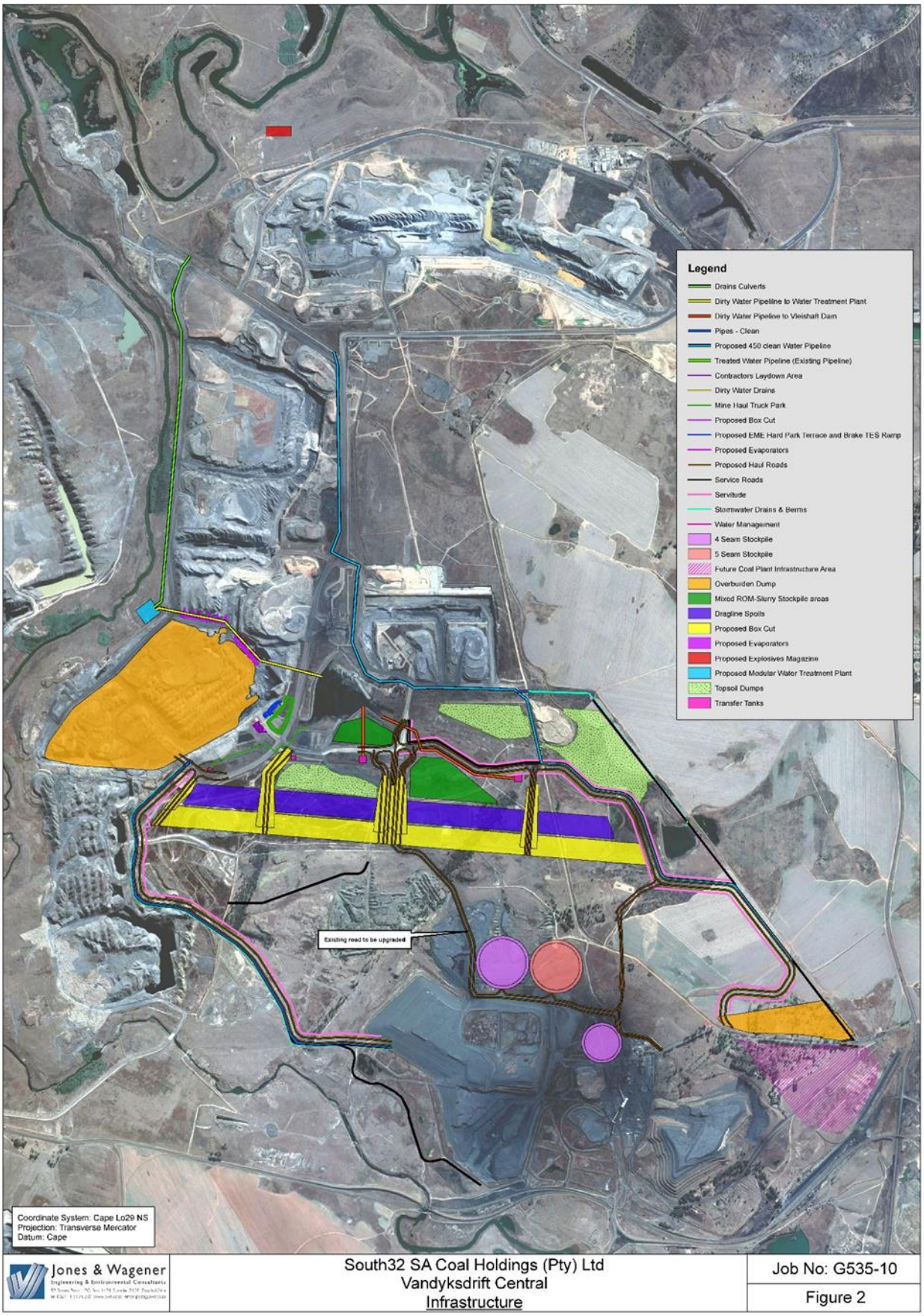

Figure 2: Detailed map of the VDDC development.

This report is the palaeontological impact assessment (PIA) for the project.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (2017)

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page i
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	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
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	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
k	Any mitigation measures for inclusion in the EMPr	Appendix A
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	N/A
nii	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
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A

p	A summary and copies if any comments that were received during any consultation process	N/A
q	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 and provide feasible management measures to comply with the requirements of South African Heritage Resources Agency (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;

3. Geology and Palaeontology

i. Project location and geological context

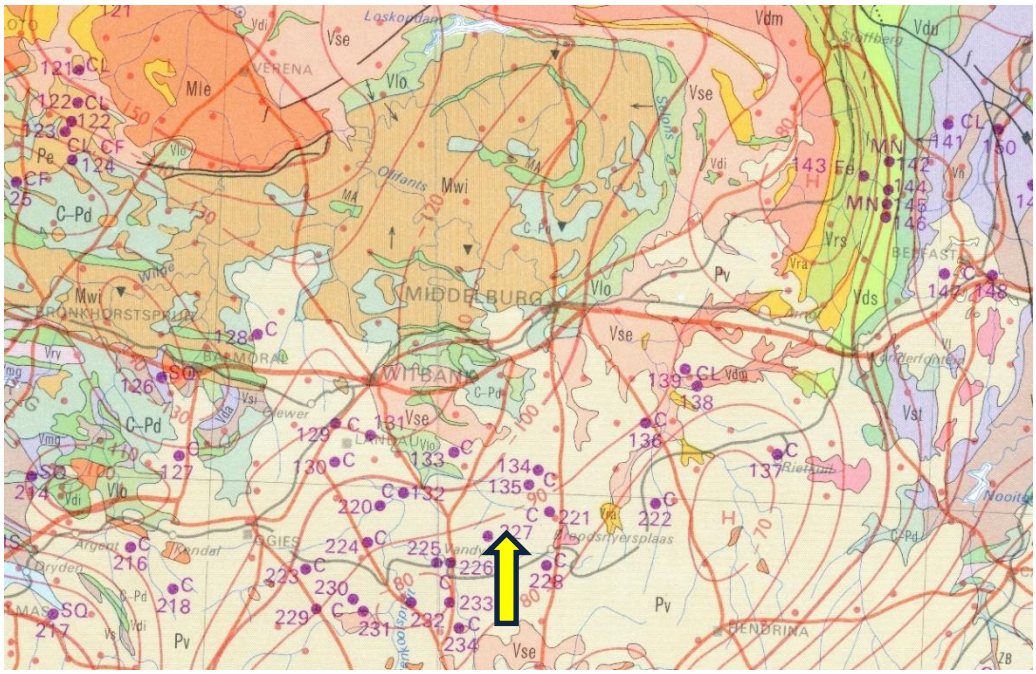

Figure 3: **Geological map of the area around Vandyksdrift, Mpumalanga Province, where the proposed mining project is located. The proposed site is indicated by the yellow arrow. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 1 000 000 map 1984.**

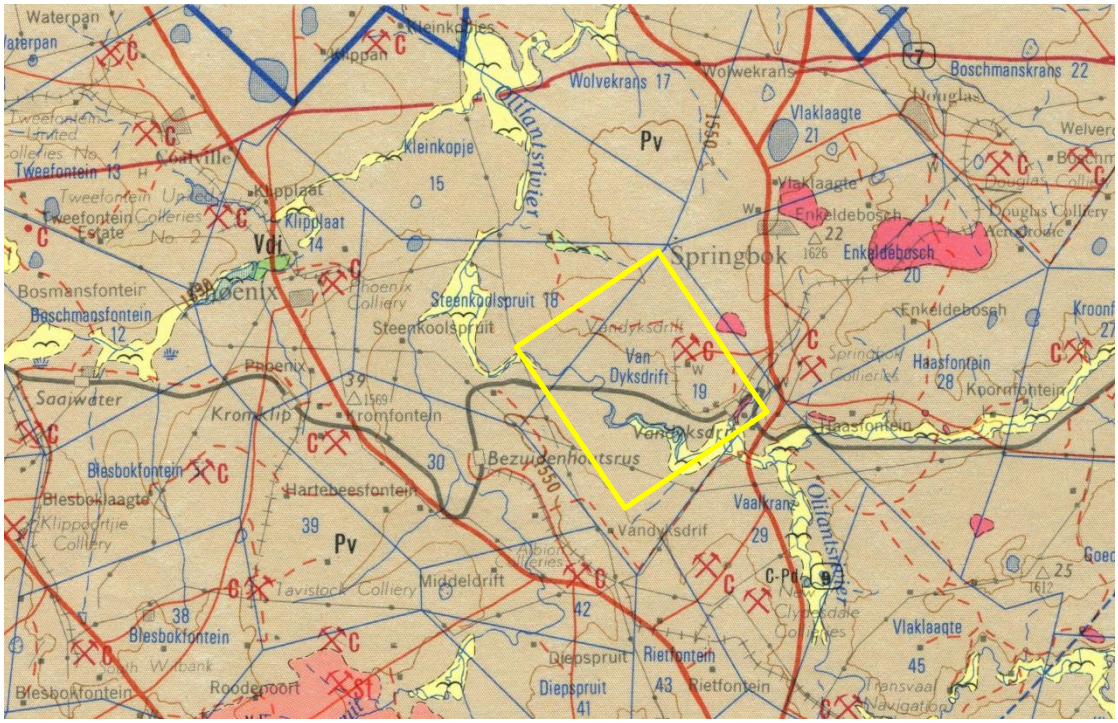

Figure 4: **Detailed geological map of the Vandyksdrift farm (within the yellow outline) and adjacent farms. Geological Survey 1:250 000 map 2628 East Rand 1996.**

Table 2: **Explanation of symbols for the geological map and approximate ages (Barker *et al.*, 2006; Cawthorne et al., 2006; Cornell *et al.*, 2006; Johnson *et al.*, 2006;). SG = Supergroup; Fm = Formation; Ma = Million years.**

Symbol	Group/Formation	Lithology	Approximate Age
Pv	Vryheid Fm, Ecca Group, Karoo SG	Sandstone, shale, coal	Lower Permian, Middle Ecca
C-Pd	Dwyka Group	Tillite, sandstone, mudstone, shale	Upper Carboniferous, Early Permian 295-290 Ma
Mwi	Wilge River Fm, Waterberg Group	Red-bed sandstones, conglomerates	Ca 1700 Ma
Mle	Lebowa Granite Suite, Bushveld Complex	Granite	Ca 2050 Ma
Vlo	Loskop Fm, top of Transvaal Sequence	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

The VDDC project is in the southern part of the Witbank Coalfield where there are typically all five coal seams and sometimes several layers of No 4 seam (Snyman, 1998). They are overlain by soils for 5-10m from the land surface and then sandstones, shales and siltstones.

In this coalfield the various coal seams occur anywhere between 15m below surface down to 110m. Between the coal seams are bands of sandstones, shales and siltstones.

The older rocks distal from the collieries do not contain fossils and will not be considered further. Most are igneous in origin.

ii. Palaeontological context

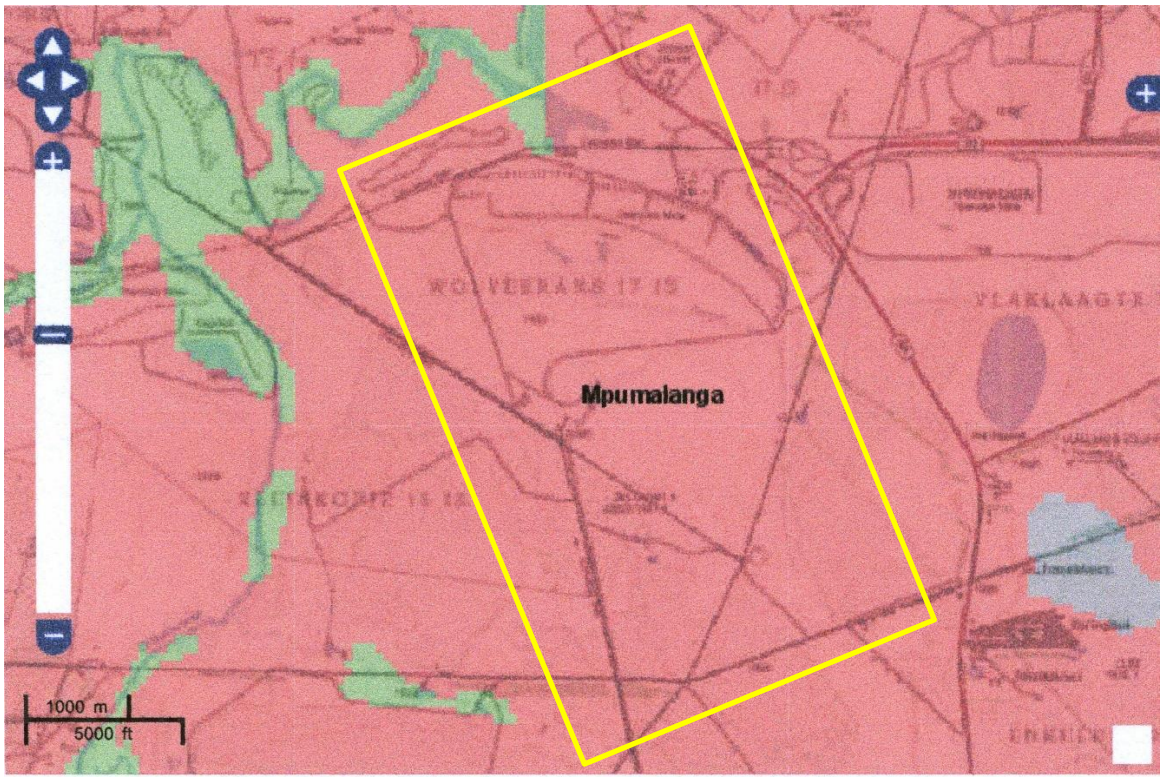

Figure 4: **SAHRIS palaeosensitivity map of the region around Vandyksdrift Central of the Wolvekrans Colliery, Mpumalanga. The site in the red area. Colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.**

The project is located in a well established coal mining area with economically productive coal seams. While coal *per se* does not preserve any recognisable fossil plant material because it has been altered and compressed by high temperatures and pressures, impressions of the coal flora can be found in the shales and mudstones between the coal lenses. Typical coal flora plants are the seed fern *Glossopteris*, various lycopods, sphenophytes and ferns, with rare early gymnosperms.

The sediments in this area are the middle Ecca Group Vryheid Formation sandstones, shales and coals. Based on the palynological record the Vryheid Formation is 269-265 million years old and equivalent to the Wordian stage of the Guadalupian Epoch (Barbolini *et al*., 2016). The macroplant flora does not assist with age constraints but the Vryheid Formation taxa are

listed in Appendix A. Vertebrates are seldom found to occur with fossil plants as the preservation conditions are different and vertebrate fossils are extremely rare at this time.

4. Impact assessment

The criteria and rating scales for the impact assessment are given in **Table 4-1 to Table 4-5**.

Table 4-1: Quantitative rating and equivalent descriptors for the impact assessment criteria

RATING	SIGNIFICANCE	EXTENT SCALE	TEMPORAL SCALE	PROBABILITY
1	VERY LOW	Isolated corridor / proposed corridor	Incidental	Practically impossible
2	LOW	Study area	Short-term	Unlikely
3	MODERATE	Local	Medium-term	Could happen
4	HIGH	Regional / Provincial	Long-term	Very Likely
5	VERY HIGH	Global / National	Permanent	It's going to happen / has occurred

Table 4-2: Description of the significance rating scale

RATING		DESCRIPTION
5	VERY HIGH	Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity that could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit.
4	HIGH	Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these.
3	MODERATE	Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those that could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc.

2	LOW	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these.
1	VERY LOW	Impact is negligible within the bounds of impacts that could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale.
0	NO IMPACT	There is no impact at all - not even a very low impact on a party or system.

Table 4-3: Description of the spatial scale

RATING		DESCRIPTION
5	Global/National	The maximum extent of any impact.
4	Regional/Provincial	The spatial scale is moderate within the bounds of impacts possible and will be felt at a regional scale (District Municipality to Provincial Level). The impact will affect an area up to 50km from the proposed site / corridor.
3	Local	The impact will affect an area up to 5km from the proposed route corridor / site.
2	Study Area	The impact will affect a route corridor not exceeding the boundary of the corridor / site.
1	Isolated Sites / proposed site	The impact will affect an area no bigger than the corridor / site.

Table 4-4: Description of the temporal rating scale

RATING		DESCRIPTION
1	Incidental	The impact will be limited to isolated incidences that are expected to occur very sporadically.
2	Short-term	The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater.
3	Medium term	The environmental impact identified will operate for the duration of life of the project.
4	Long term	The environmental impact identified will operate beyond the life of operation.
5	Permanent	The environmental impact will be permanent.

Table 4-5: Description of the degree of probability of an impact occurring

RATING	DESCRIPTION
1	Practically impossible
2	Unlikely
3	Could happen
4	Very Likely
5	It's going to happen / has occurred

Table 4-5: Impact Risk Classes

RATING	IMPACT CLASS	DESCRIPTION
0.1 – 1.0	1	Very Low
1.1 – 2.0	2	Low
2.1 – 3.0	3	Moderate
3.1 – 4.0	4	High
4.1 – 5.0	5	Very High

Based on the nature of the infrastructure development, the surface soils will be excavated to a depth of several metres for the construction of the storm water management structures, Mixed ROM coal and slurry management area; topsoil stockpile following clearance of vegetation; pipelines for the conveyance of water; and new haul roads. Since there is no

chance of finding fossils in the top soils and down to about 15m or more, there would be no impact on the fossil heritage. Taking account of the defined criteria, the potential impact to fossil heritage resources associated with the infrastructure development is very low.

Opencast mining in the area not approved previously will result in the excavation of the shales and mudstones between the coal lenses where paleontological finding could be made.
The results are summarised below for the palaeontology impact of the opencast mining:

- Significance = 2 (Impact is of a low order and therefore likely to have little real effect)
- Spatial scale = 1 (Isolated Sites / proposed site. The impact will affect an area no bigger than the corridor / site)
- Temporal scale = 5 (Permanent. The environmental impact will be permanent)
- Probability = 4 (Very Likely)

Degree of certainty = high.

When the results are inserted into the following formula to obtain the Impact Risk rating = 2.133 (moderate; see table 4-6)

$$\textbf{\textit{Impact Risk}} = \frac{(\text{SIGNIFICANCE} + \textit{Spatial} + \text{Temporal})}{3} \times \frac{\text{Probability}}{5}$$

$(2 + 1 + 5)/3 \times 4/5 = 2.1333333$

A Chance Find Protocol should be added to the EMPr given that there are fossiliferous sediments below ground and associated with the coal seams.

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 shales, mudrocks and coal seams could contain impressions of leaves of the Glossopteris flora in the associated shales BUT these would not be preserved in the surface soils or coarse sandstones. Vertebrate fossils are extremely rare at this time and seldom occur with fossil plants. Although no fossils have been recorded from this region, there is a small chance that they could, so a Chance Find Protocol should be included (see appendix A and photographs of fossil plants).

6. Recommendation

Since the whole area of this project is palaeontologically sensitive, a monitoring programme and Chance Find Protocol should be included in the EMPr that should come into effect once mining for the project commence. It is not known at what depth fossils could occur. Topsoils

do not preserve fossils so there is no point in carrying out a site visit before excavations begin as any potential fossils would not be visible. If recognisable fossils are found by the responsible person monitoring the excavated sediments, then a palaeontologist should be called to assess them. As far as the palaeontology is concerned the proposed development can go ahead. Any further palaeontological assessment would only be required after mining has commenced and if fossils are found by the geologist or environmental personnel.

7. References

Aitken, G. 1994. Permian palynomorphs from the Number 5 Seam, Ecca Group, Witbank Highveld Coalfields, South Africa. Palaeontologia africana 31: 97-109.

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.

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.

Rubidge BS (ed). 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy Biostratigraphic Series 1. Council for Geoscience, South Africa.

Snyman, C.P., 1998. Coal. In: Wilson, M.G.C., and Anhaeusser, C.P., (Eds) The Mineral Resources of South Africa: Handbook, Council for Geosciences 16, 136-205.

Appendix A – Chance Find Protocol and examples of fossil plants from the Vryheid Formation

Monitoring programme is outlined below.

Monitoring Programme for Palaeontology – to commence once the mining activities have begun.

1. The following procedure is required when deep excavations commence. The surface activities most likely 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 1 and 2). 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. A report must be submitted to SAHRA as required by the relevant permits.
6. If any open pit inspection is deemed necessary then the normal safety procedures that the mine management endorses, must be followed by the palaeontologist and associated mine employees.
7. If no good fossil material is recovered then no site visits will be required by the palaeontologist.

Table 1: List of Vryheid Formation flora and fauna (Aitken, 1994; Anderson & Anderson, 1985; Barbolini et al., 2016; Plumstead, 1969; Rubidge et al., 1995).

Flora - macroplants	Flora – microfossils	Fauna
Azaniodendron fertile, *Cyclodendron leslii,* *Sphenophyllum hammanskraalensis,* *Annularia sp.,* *Raniganjia sp.,* *Asterotheca spp.,* *Liknopetalon enigmata*, *Glossopteris* > 20 species, *Hirsutum 4 spp.,* *Scutum 4 spp.,* *Ottokaria 3 spp.,* *Estcourtia sp.,* *Arberia 4 spp.,* *Lidgetonia sp.,* *Noeggerathiopsis sp.* *Podocarpidites sp*	*Protohaploxypinus microcarpus* *Praecolpatities sinuous* *Microbaculispora trisina* *Striatopodocarpites cancellatus* *Striatopodocarpites fusus* *Pseudoreticulatispora pseudoreticulata* *Pseudoreticulatispora confluens* Taeniate bisaccate pollen	*Mesosaurus* in the lowest part

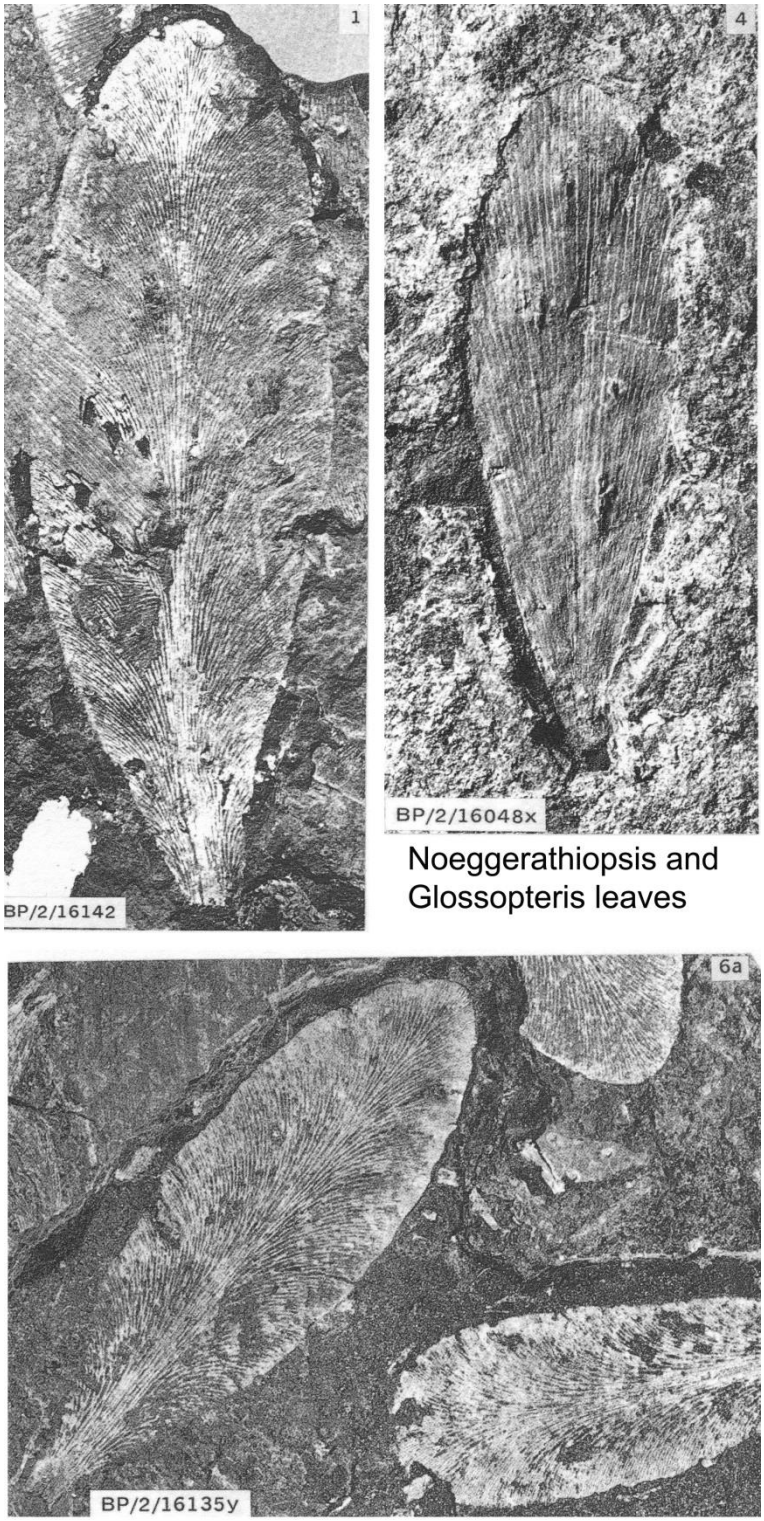

Figure 1: **examples of fossils from the Vryheid Formation, *Glossopteris* sp. and *Noeggerathiopsis* sp.**

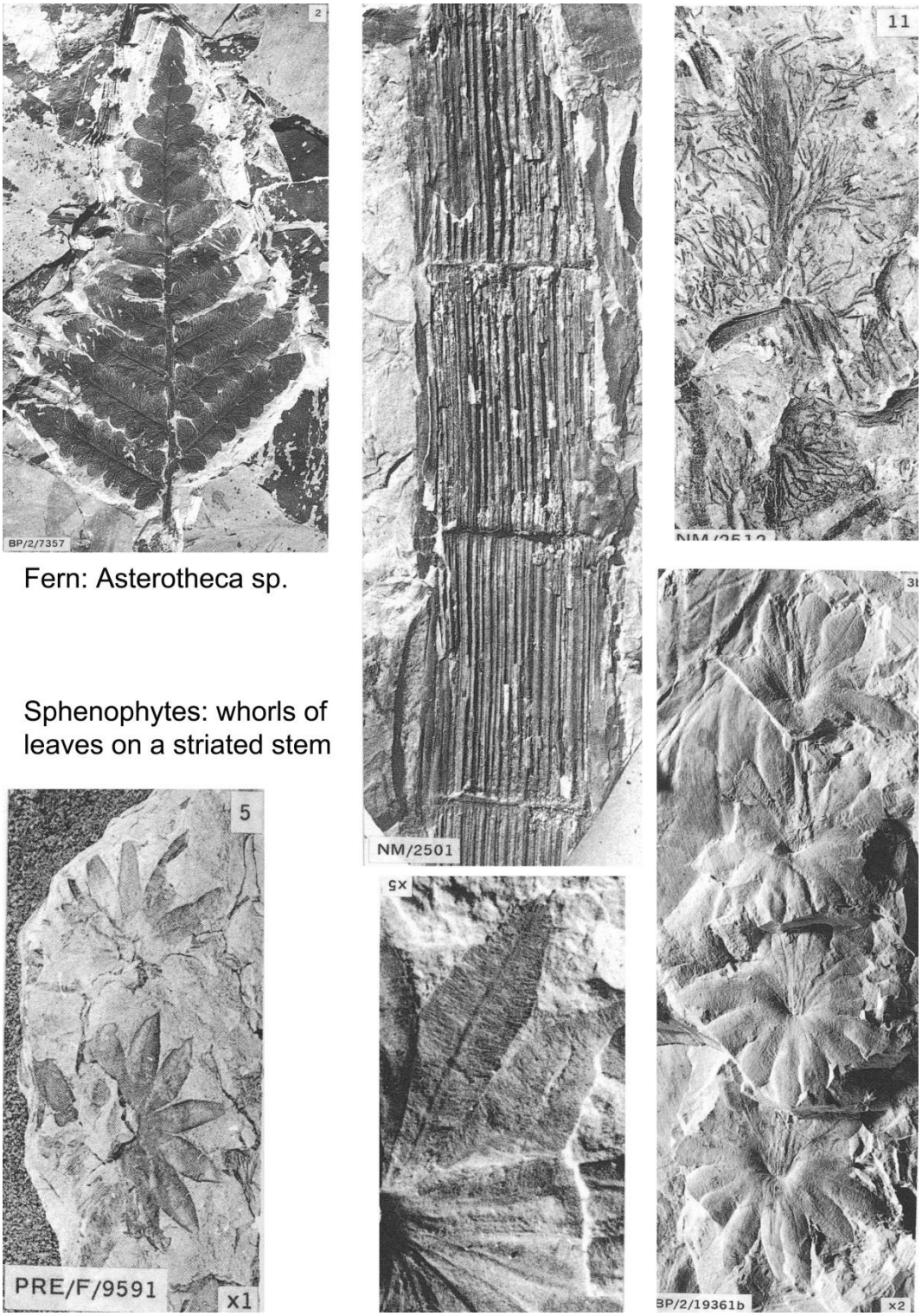

Figure 2: Examples of ferns and sphenophytes (horsetails) from the Vryheid Formation.

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
June 2019

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

vii) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/completed	Current
Honours	5	2
Masters	8	1
PhD	10	2
Postdoctoral fellows	9	3

viii) 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.

ix) Editing and reviewing
Editor: Palaeontologia africana: 2003 to 2013; 2014 – current Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 – current
Cretaceous Research: 2014 - current

Review of manuscripts for ISI-listed journals: 25 local and international journals

x) 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
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO

xi) Research Output

Publications by M K Bamford up to June 2019 peer-reviewed journals or scholarly books: over 135 articles published; 5 submitted/in press; 8 book chapters.
Scopus h-index = 26; Google scholar h-index = 30;
Conferences: numerous presentations at local and international conferences.

xii) 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)