APPENDIX O: PALAEONTOLOGICAL STUDY

Palaeontological Impact Assessment for the proposed opencast South East Pit for Jindal MIOP, near Melmoth, KwaZulu-Natal Province

SLR Project (Job) Number:
720.10023.00003

Desktop Study (Phase 1)

For

SLR Consulting (South Africa) (Pty) Ltd

06 May 2023

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

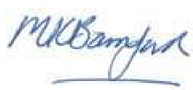
Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, mASSAf; PSSA
Experience: 34 years research and lecturing in Palaeontology
26 years PIA studies and over 350 projects completed

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by SLR Consulting (South Africa) (Pty) Ltd, 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

A Palaeontological Impact Assessment was requested for the preferred site for the Jindal Melmoth Iron Ore Mine opencast pit, the South East Pit, KwaZulu Natal. The project includes the EIA and IWULA for the mine.

To comply with the regulations of 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 desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development.

The proposed site lies entirely on the ancient non-fossiliferous rocks of the Nondweni Group in the Archaean Barberton Greenstone belt that is composed of basaltic lavas, komatiitic lavas, schists rhyolites and granites. These rocks are about 3 400 million years old. Traces of early life have been found in other greenstones in South Africa, namely the Barberton Greenstone Belt. Therefore, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological impact assessment is required. It is strongly recommended that samples of the black laminated rocks of the Nondweni Group overlying the iron ore deposit be collected and put aside for AMAFA forf uture research. Since the impact will be low, as far as the palaeontology is concerned, the project should be authorised.

Table of Contents

1. Background

Jindal Iron Ore (Pty) Ltd (Jindal), a subsidiary of the multinational Indian conglomerate Indian Steel and Power Limited (JSPL) is proposing to develop an open cast iron ore mine on a site located 25 km southeast of Melmoth, within the Mthonjaneni Local Municipality and the King Cetshwayo District Municipality in the KwaZulu Natal Province. (Figure 1).

Jindal has now requested SLR to undertaking the Environmental Authorisation, Waste Management Licence (WML) and Integrated Water Use Licence Application (IWULA) processes for the proposed opencast South East Pit to support the Jindal Melmoth Iron Ore Project (MIOP).

In 2021, Epoch undertook a site selection study to identify potential TSF sites for the Jindal MIOP. Epoch identified eight sites that were investigated and classified according to predetermined design criteria, and the risks/hazards associated with each facility. Through this process, an opencast pit, the South East Pit, preferred site was identified. Through the input from various specialist studies a matrix was generated that identified the location for this large opencast pit (Figure 2)

The Jindal MIOP site is east of the R65 on land that currently under agriculture, and south of the Mhlatuze River.

A Palaeontological Impact Assessment was requested for the Jindal Melmoth Iron Ore Project. To comply with the regulations of 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 desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development and is reported herein.

Table 1: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

	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 1
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

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
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	Section 8, 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	Section 8, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
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	Sections 6, 8
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 of any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A
2	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

Figure 1: Topographic map of the general area to show the relative land marks and components of the Jindal Iron ore mine. Map supplied by SLR Consulting.

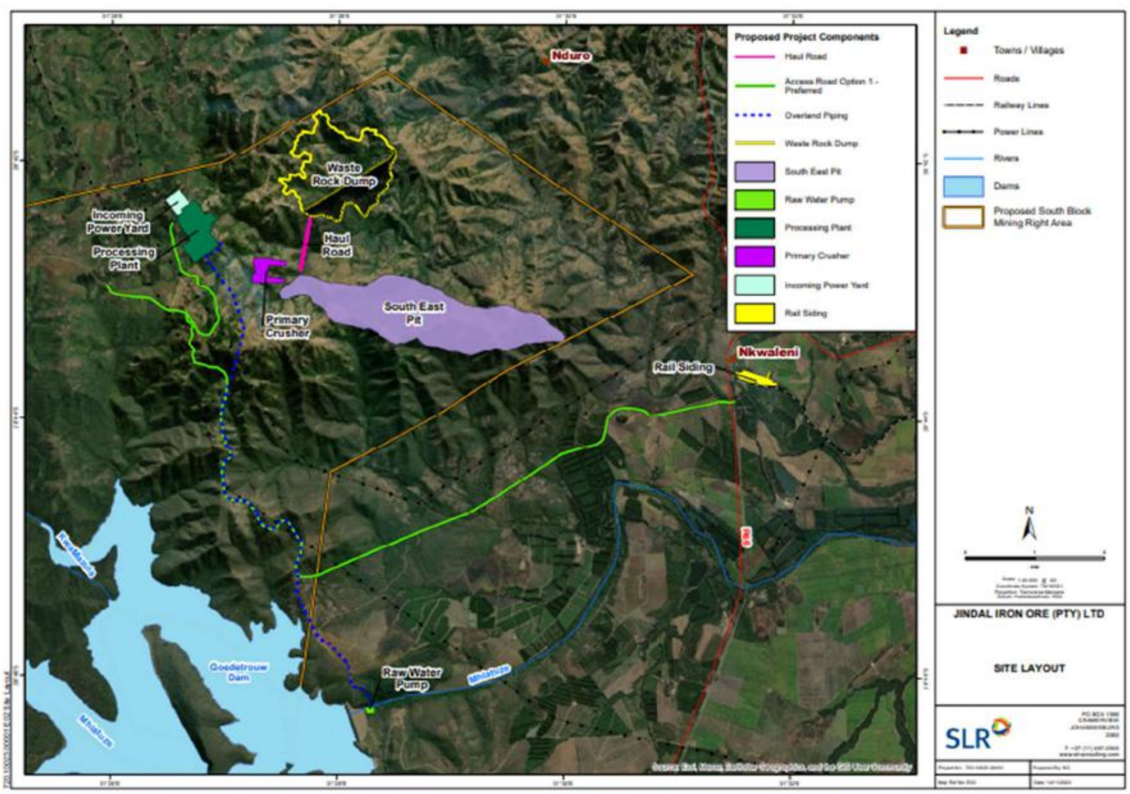


Figure 2: Google Earth Map of the proposed South East Pit (lilac polygon) location for the Jindal iron ore mine with the other sections shown by the coloured polygons.

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 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 (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

3. Geology and Palaeontology

i. Project location and geological context

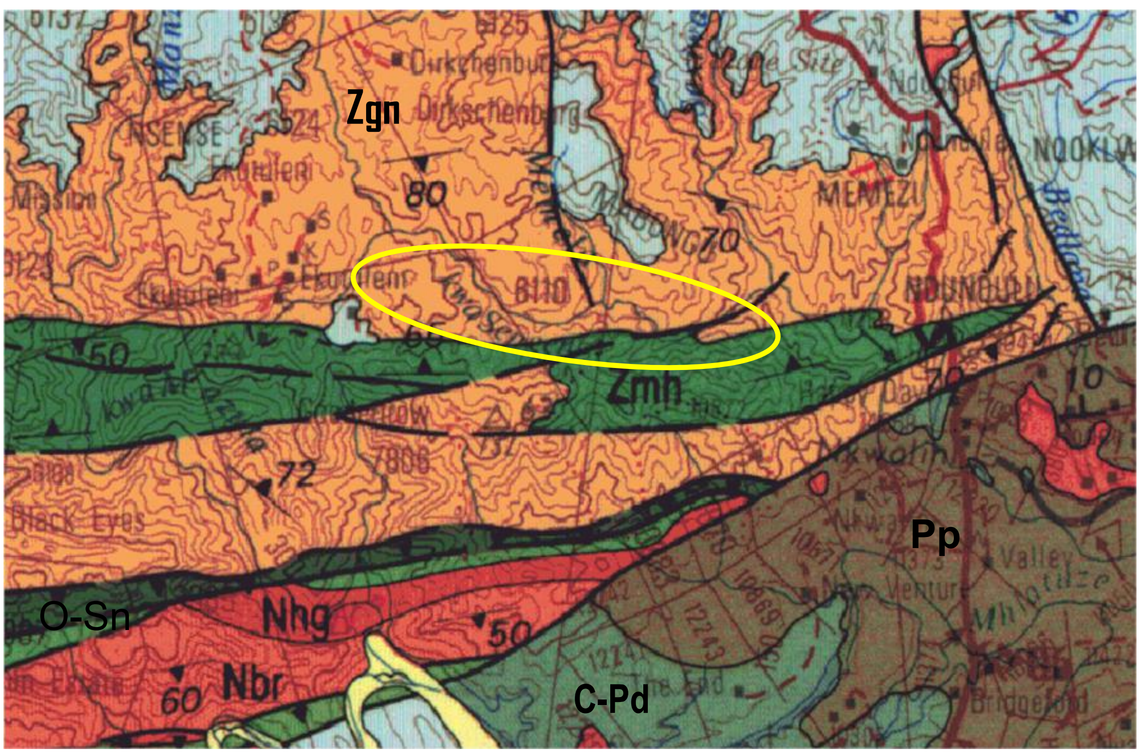


Figure 2: Geological map of the area around the proposed opencast South East Pit for Jindal Colliery with the proposed site indicated within the yellow oval. Abbreviations of

the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2830 Dundee.

Table 2: Explanation of symbols for the geological map and approximate ages (Cornell et al., 2006; Johnson et al., 2006). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Q	Quaternary	Alluvium, sand, calcrete	Neogene, ca 2.5 Ma to present
Pp	Pietermaritzburg Fm, Ecca Group, Karoo SG	Dark-grey shale, siltstone, mudstone	Middle Permian ca 269 – 266 Ma
C-Pd	Mbizane Fm, Dwyka Group, Karoo SG	Tillites, diamictites, sandstone, mudstone, shale	Early Permian, ca 298 - 290 Ma
O-Sn	Natal Group	Quartzites	Ordovician-Silurian Ca 480-420 Ma
Nhg	Halumbu Gneiss, Nkomo Nappe, Tugela Group	Gneiss	Ca 1200 Ma
Zgn	Unnamed	Granitic gneiss	Ca 3400 Ma
Zmh	Mhlatuze Fm, Nondweni Group, Barberton Greenstone Belt	Amygdaloidal basaltic lava, schist	>3400 Ma

The project lies in the southeastern part of the main Karoo Basin where the Karoo Sequence unconformably overlies the ancient intrusive igneous rocks of the Tugela Group, Natal sector of the Namaqua-Natal Province that have been metamorphosed. They in turn lie on some of the oldest basement rocks in the world, the Nondweni Group (Figure 3). This is the Ilangwe remnant of southern exposures of the Barberton Greenstone Belt (Wilson and Versfeld, 1992; Brandl et al., 2006; Wilson and Riganti, 2022).

The Karoo Supergroup rocks cover a very large proportion of South Africa and extend from the northeast (east of Pretoria) to the southwest and across to almost the KwaZulu Natal south coast. It is bounded along the southern margin by the Cape Fold Belt and along the northern margin by the much older Transvaal Supergroup rocks. Representing some 120 million years (300 – 183Ma), the Karoo Supergroup rocks have preserved a diversity of fossil plants, insects, vertebrates and invertebrates.

During the Carboniferous Period South Africa was part of the huge continental landmass known as Gondwanaland and it was positioned over the South Pole. As a result, there were several ice sheets that formed and melted, and covered most of South Africa (Visser, 1986, 1989; Isbell et al., 2012). Gradual melting of the ice as the continental mass moved northwards and the earth warmed, formed fine-grained sediments in the large inland sea. These are the oldest rocks in the system and are exposed around the outer part of the ancient Karoo Basin, and are known as the **Dwyka Group**. They comprise tillites, diamictites, mudstones, siltstones and sandstones that were deposited as the basin filled. This group has been divided into two formations with Elandsvlei Formation occurring throughout the basin and the upper Mbizane Formation occurring only in the Free State and KwaZulu Natal (Johnson et al., 2006).

Overlying the Dwyka Group rocks are rocks of the Ecca Group that are Early Permian in age. There are eleven formations recognised in this group but they do not all extend throughout the Karoo Basin. In the central and eastern part are the following formations, from base upwards: **Pietermaritzburg**, Vryheid and Volksrust Formations. All of these sediments have varying proportions of sandstones, mudstones, shales and siltstones and represent shallow to deep water settings, deltas, rivers, streams and overbank depositional environments.

ii. Palaeontological context

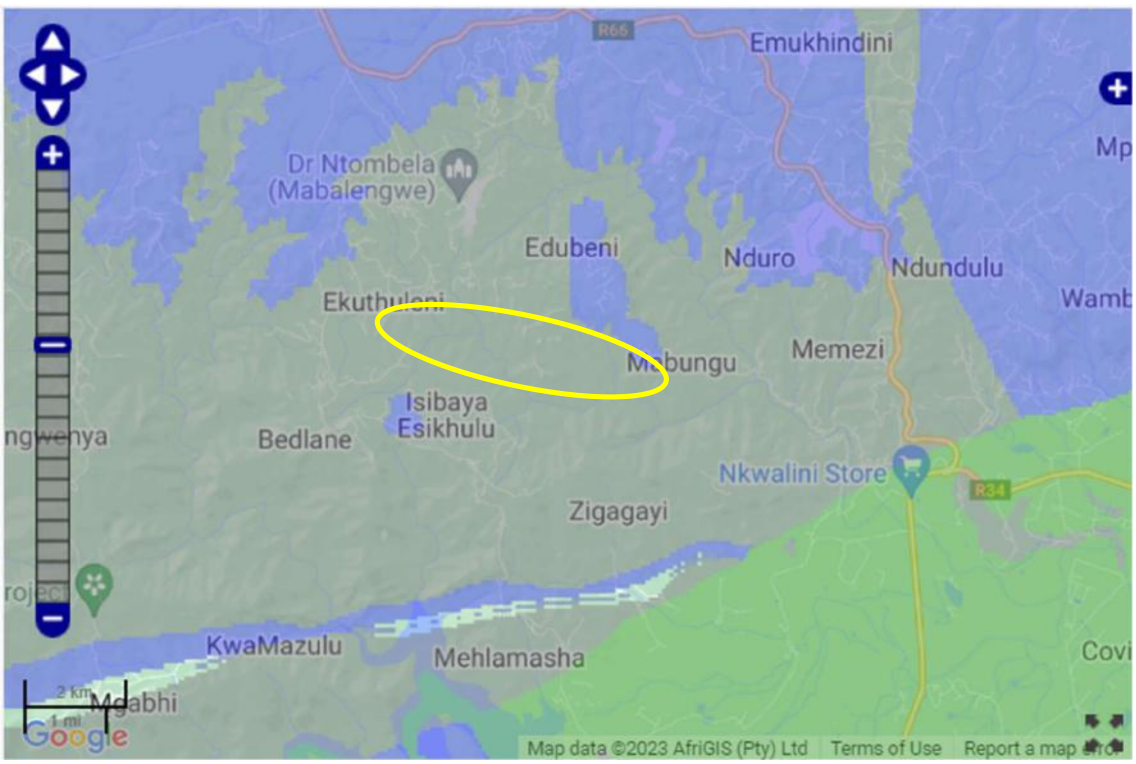


Figure 3: SAHRIS palaeosensitivity map for the site for the proposed opencast South East Pit for Jindal iron ore mine shown within the yellow oval. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The site for development is in the unnamed granitic gneiss (Zgn on the map) and the Mhlatuze Formation of the Nondweni Group. These rocks are ancient volcanic rocks but single-celled algae or bacteria have been found in other exposures of this group, to the north. According to Wilson and Versfeld (1994) and Wilson and Riganti (2022) the Nondweni Greenstone belt represents an ancient ocean floor.

There are two strata in the Barberton Greenstone Belt that have strong evidence of the earliest microbial life forms, namely the deposits of the 3.416 Ga Buck Reef Chert (in the Onverwacht Anticline and Kromberg Syncline, central part) and the sandstones of the 3.22 Ga Moodies Group (see recent review by Homan (2019)). These strata have a wealth of remarkably preserved microbial mats and microfossils, consistent lateral exposure for several tens of kilometres and with a fairly thick stratum. Based on its universal and outstanding geological and palaeobiological value the Barberton-Makhonjwa Mountains were inscribed in the UNESCO World Heritage Site register in 2018. This legislation will ultimately help to protect these exceptional outcrops for future studies of Earth's early evolution.

Research on the earliest evidence of early life from the Barberton Greenstone Belt has allowed many researchers to reconstruct its habitat, metabolism, biogeochemical cycling and mode of preservation (Homann, 2019). The rocks preserve the oldest traces of microbial mats or microbial structures, which include lenticular, spheroidal, and filamentous microstructures that are generally regarded as the prokaryotes (Schopf, 2006; Homann, 2019). The other forms of microbial life that have been reported from the rocks are microbial mats (Homann, 2019).

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria provided in Appendix C (SLR method), and summarised in **Error! Reference source not found.**:

Phase	Construction (excavation, boundaries)	
Feature	Pre-mitigation	Post-mitigation
Mitigation – remove any fossils found (see Section 8)	No action	Follow Fossil Chance Find Protocol – remove any fossils found
Intensity	Low	Low positive
Duration	Very long term/ Permanent (> 20 years)	Very long term/ Permanent (> 20 years)
Extent	Site	Site
Consequence	Low	Low
Probability (from above)	Unlikely /Improbable	Unlikely/Improbable
Significance (Consequence x probability)	Insignificant -	Insignificant -

Phase: Only the construction and operational phases are relevant to the Palaeontology. The surface rocks and volcanic rocks overlying the iron ore deposits should be assessed (mitigation).

Mitigation: Implement the Fossil Chance Find Protocol (Section 8 and Appendix A). If fossils occur on site they need to be photographed, removed and stored in a safe place for a palaeontologist to assess. Since the fossils are too small to see it is recommended that samples of the black, finely laminated rocks of the Nondweni Group that overlie the iron ore deposits are put aside for future research.

Intensity: Fossils have not been recorded from the area but might be present although they will be difficult to recognise because they are microscopic. If fossils are found during excavations this would be a positive addition to our knowledge.

Duration: Once rescued, fossils would be removed from the site and have no impact on future activities.

Extent: Only fossils on the surface or underground, but above the iron deposits, in the opencast pit would be affected.

Summary: Based on the nature of the project, surface activities and excavations may impact upon the fossil heritage only if preserved in the opencast pit footprint. The geological structures suggest that the rocks might preserve very old microbial fossils. Taking account of the defined criteria, the potential impact to fossil heritage resources is insignificant, both before and after mitigation.

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 granites, gneisses and volcanic rocks are typical for the country. Since very important early evidence of life on earth (prokaryotes/microbes) has been found in the Barberton Greenstone Belt, there is a chance they might be found in the Nondweni Group rocks. These fossils are very small and not visible to the naked eye.

6. Recommendation

Although fossils have not been recorded from this area, very important ancient prokaryotes (microbes) have been found in similar rocks to the north. For this reason geologists from University of the Witwatersrand and the University of Johannesburg are now looking at the Nondweni Group for microfossils, microbial mats and carbonaceous laminations. It is recommended that he site geologist retains samples of the black rocks from the Nondweni Group for future research. The impact on the palaeontological heritage would be low, so as far as the palaeontology is concerned, the project should be authorised.

7. References

Agangi, A., Hofmann, A., Elburg, M.A., 2018. A review of Palaeoarchaean felsic volcanism in the eastern Kaapvaal craton: Linking plutonic and volcanic records. Geoscience Frontiers 9, 667-688.

Brandl, G., Cloete, M., Anhaeusser, C.R., 2006. Archaean Greenstone belts. 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 9-56.

Homann, M., 2019. Earliest life on earth: evidence from the Barberton Greenstone Belt, South Africa. Earth-Science Reviews 196, p.102888.

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.

Schopf, J.W., 2006. Fossil evidence of Archaean life. Philosophical Transactions of the Royal Society B: Biological Sciences, 361(1470), pp.869-885.

Wilson, A., Riganti, A., 2022. Architectural and compositional diversity of early Earth ocean floor evidenced by the Paleoarchean Nondweni Greenstone Belt, South Africa. Journal of Petrology 63(11), 1-32.

Wilson, A.H., Versfeld J.A., 1994. The early Archaean Nondweni greenstone belt, southern Kaapvaal Craton, South Africa, part II: characteristics of the volcanic rocks and constraints on magma-genesis. Precambrian Research 67,277–320. https://doi.org/10.1016/0301-9268(94)90013-2.

8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations / drilling / mining activities begin.

1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations/mining commence.
2. When excavations begin the rocks and discard must be given a cursory inspection by the geologist, environmental officer or designated person. Samples of potentially fossiliferous material (black rocks with very fine laminations) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of similar fossils must be provided to the developer to assist in recognizing the rocks that could contain microfossils (Figures 5-6). This information will be built into the EMP's training and awareness plan and procedures.
4. Photographs of the putative fossils can be sent to a geologist or the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the developer/environmental officer then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Microfossils that are considered to be of good quality or scientific interest by the palaeontologist 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 site an AMAFA or SAHRA permit must be obtained. Annual reports must be submitted to AMAFA and SAHRA as required by the relevant permits.

7. If no good fossil material is recovered then no site inspections by the palaeontologist will be necessary. A final report by the palaeontologist must be sent to AMAFA and SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations of the overburden have finished then no further monitoring is required.

9. Appendix A – Examples of fossils from the Barberton Supergroup.

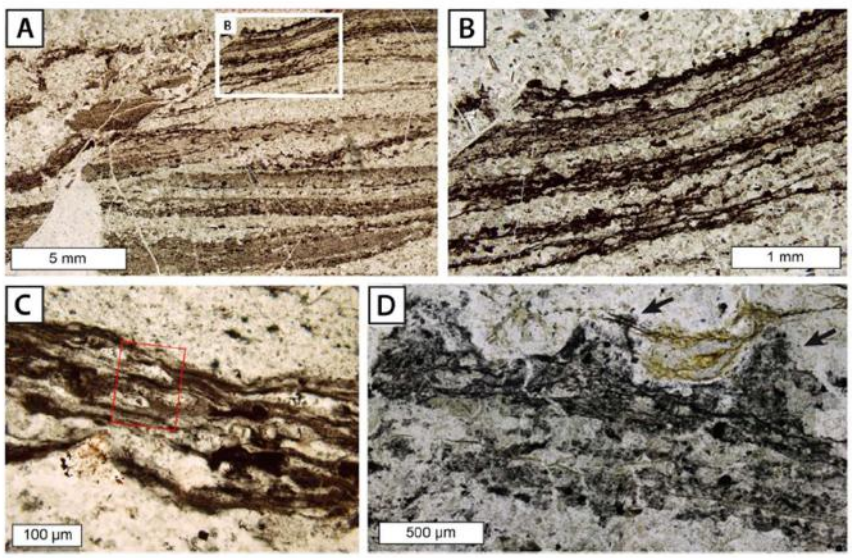


Fig. 3. Photomicrographs of carbonaceous laminations from silicified volcaniclastic sediments of the 3.47 Ga Middle Marker interpreted as remnants of microbial mats. A) Multi-layered mats on horizontally-laminated and cross-bedded sediments, disrupted by secondary fracture. B and C) Close-up view of crinkly laminations of carbonaceous composition. D) Laminations with 'pseudo-tufted' morphology (arrows), which formed secondary as the result of plastic deformation. *Images (A-D) from* Hickman-Lewis et al. *(2018).*

Figure 5: Photomicrographs of carbonaceous laminations from the Moodies Group, Barberton Greenstone Belt (from Homann, 2019).

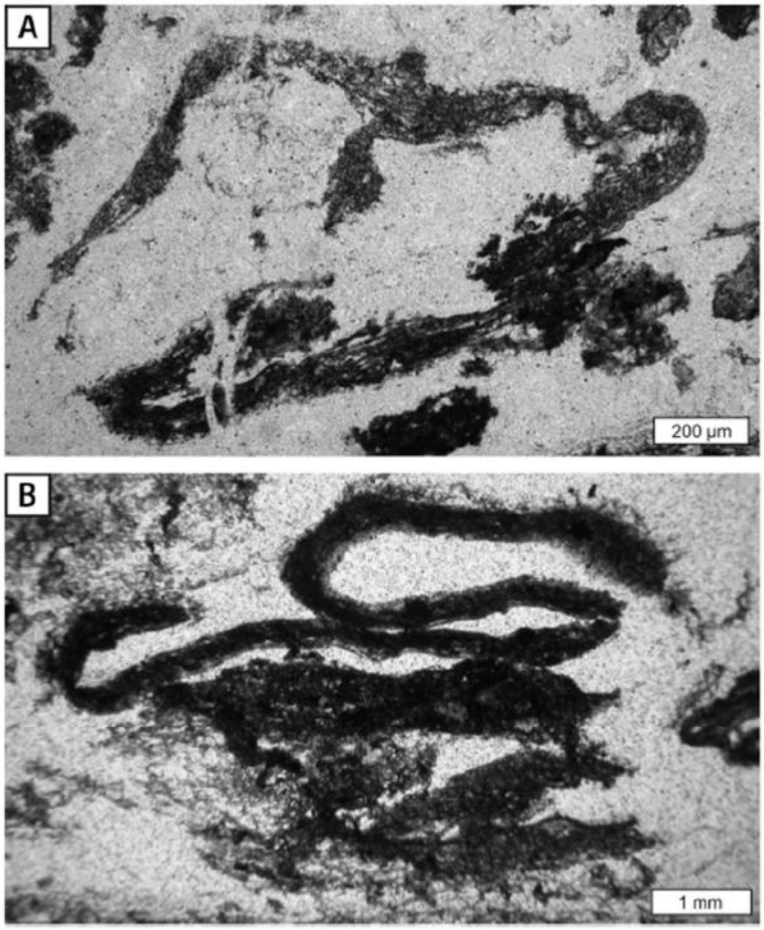


Fig. 5. Photomicrographs of eroded and rolled-up microbial mat fragments from the Buck Reef Chert. A) Close-up view of boxed area in Fig. 4A showing a plastically-deformed segment of alpha-type mat. B) Large, rolled-up fragment of a beta-type mat. Image (A) from Tice (2009) and (B) from Tice and Lowe, 2006b.

Figure 6: Photomicrographs of microbial mats from the Buck Reef Chert, Moodies Group, Barberton Greenstone Belt (from Homann, 2019).

10. Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD July 2022

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.
NRF Rating: C-2 (1999-2004); B-3 (2005-2015); B-2 (2016-2020); B-1 (2021-2026)

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	13	0
Masters	11	3
PhD	11	6
Postdoctoral fellows	15	1

viii) Undergraduate teaching

Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 45 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 12-20 students per year.

ix) 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 –
Associate Editor Open Science UK: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international journals
Reviewing of funding applications for NRF, PAST, NWO, SIDA, National Geographic, Leakey Foundation

x) Palaeontological Impact Assessments

Selected from the past five years only – list not complete:

- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- 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
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for EnviroPro
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for EnviroPro
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe

xi) Research Output
Publications by M K Bamford up to January 2023 peer-reviewed journals or scholarly books: over 170 articles published; 5 submitted/in press; 10 book chapters.
Scopus h-index = 31; Google scholar h-index = 39; -i10-index = 116
Conferences: numerous presentations at local and international conferences.

11. Appendix C – SLR Impact Assessment Methodology

PART A: DEFINITIONS AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of intensity, spatial extent and duration**
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)

Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE							
INTENSITY = VL							
DURATION	Very long	**VH**	Low	Low	Medium	Medium	High
	Long term	**H**	Low	Low	Low	Medium	Medium
	Medium term	**M**	Very Low	Low	Low	Low	Medium
	Short term	**L**	Very low	Very Low	Low	Low	Low
	Very short	**VL**	Very low	Very Low	Very Low	Low	Low
INTENSITY = L							
DURATION	Very long	**VH**	Medium	Medium	Medium	High	High
	Long term	**H**	Low	Medium	Medium	Medium	High
	Medium term	**M**	Low	Low	Medium	Medium	Medium
	Short term	**L**	Low	Low	Low	Medium	Medium
	Very short	**VL**	Very low	Low	Low	Low	Medium
INTENSITY = M							
DURATION	Very long	**VH**	Medium	High	High	High	Very High
	Long term	**H**	Medium	Medium	Medium	High	High
	Medium term	**M**	Medium	Medium	Medium	High	High
	Short term	**L**	Low	Medium	Medium	Medium	High
	Very short	**VL**	Low	Low	Low	Medium	Medium
INTENSITY = H							
DURATION	Very long	**VH**	High	High	High	Very High	Very High
	Long term	**H**	Medium	High	High	High	Very High
	Medium term	**M**	Medium	Medium	High	High	High
	Short term	**L**	Medium	Medium	Medium	High	High
	Very short	**VL**	Low	Medium	Medium	Medium	High
INTENSITY = VH							
DURATION	Very long	**VH**	High	High	Very High	Very High	Very High
	Long term	**H**	High	High	High	Very High	Very High
	Medium term	**M**	Medium	High	High	High	Very High

	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High

VL	L	M	H	VH
A part of the site/ property	Whole site	Beyond the site, affecting neighbours	Extending far beyond site but localised	Regional/ National
EXTENT				

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	VH	Very Low	Low	Medium	High	Very High
	Probable	H	Very Low	Low	Medium	High	Very High
	Possible/ frequent	M	Very Low	Very Low	Low	Medium	High
	Conceivable	L	Insignificant	Very Low	Low	Medium	High
	Unlikely/ improbable	VL	Insignificant	Insignificant	Very Low	Low	Medium
			VL	L	M	H	VVH
			CONSEQUENCE				

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.