Palaeontological Impact Assessment for the proposed Prospecting and Mining Rights application by Thunderflex 78, north east of Griekwastad, Northern Cape Province

Desktop Study

For

Archaeological and Heritage Services Africa (Pty) Ltd

03 October 2020

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, ASSAf
Experience: 31 years research; 23 years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Archaeological and Heritage Services (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 proposed Prospecting and Mining Rights application on the remaining extent of the Farm Mesnard 28, Farm Rooi0an 43, Farm La Provence 5, Remaining Extent and Portion 1 (Turksvypan) of the Farm 52, Portin 1 of the Farm Hopefield Estate 552 and Remaining Extent of the Farm 565. This cluster of farms is northeast of Griquastad and the project is for Thunderflex 78 (Pty) Ltd.

To comply with 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 rights applications.

The proposed site lies on the potentially moderately fossiliferous Lime Acres Member, and Quaternary Limestone – based on the geology and recommendation of the Western Cape Palaeotechnical Report. The SAHRIS palaeosensitivity report incorrectly assigned the Kuruman Formation as very highly sensitive; BIF does not preserve fossils. Therefore, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no palaeontological site visit is required for the Prospecting Activities unless fossils are found by the geologist or responsible person. If mining is to be opencast then a site visit will be necessary so that a representative sample of fossils can be removed by a palaeontologist.

Table of Contents

1. Background

As part of a Phase 1 Heritage Impact Assessment, a palaeontological Impact Assessment was requested for the proposed Prospecting and Mining Rights application on the remaining extent of the Farm Mesnard 28, Farm Rooipan 43, Farm La Provence 5, Remaining Extent and Portion 1 (Turksvypan) of the Farm 52, Portion 1 of the Farm Hopefield Estate 552 and Remaining Extent of the Farm 565. This cluster of farms is northeast of Griekwastad and the total extent is ca 15 359Ha (Figure 1). The project is for Thunderflex 78 (Pty) Ltd.

To comply with 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 prospecting and mining rights application and is reported herein.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (amended 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 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
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 7, 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 7, 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

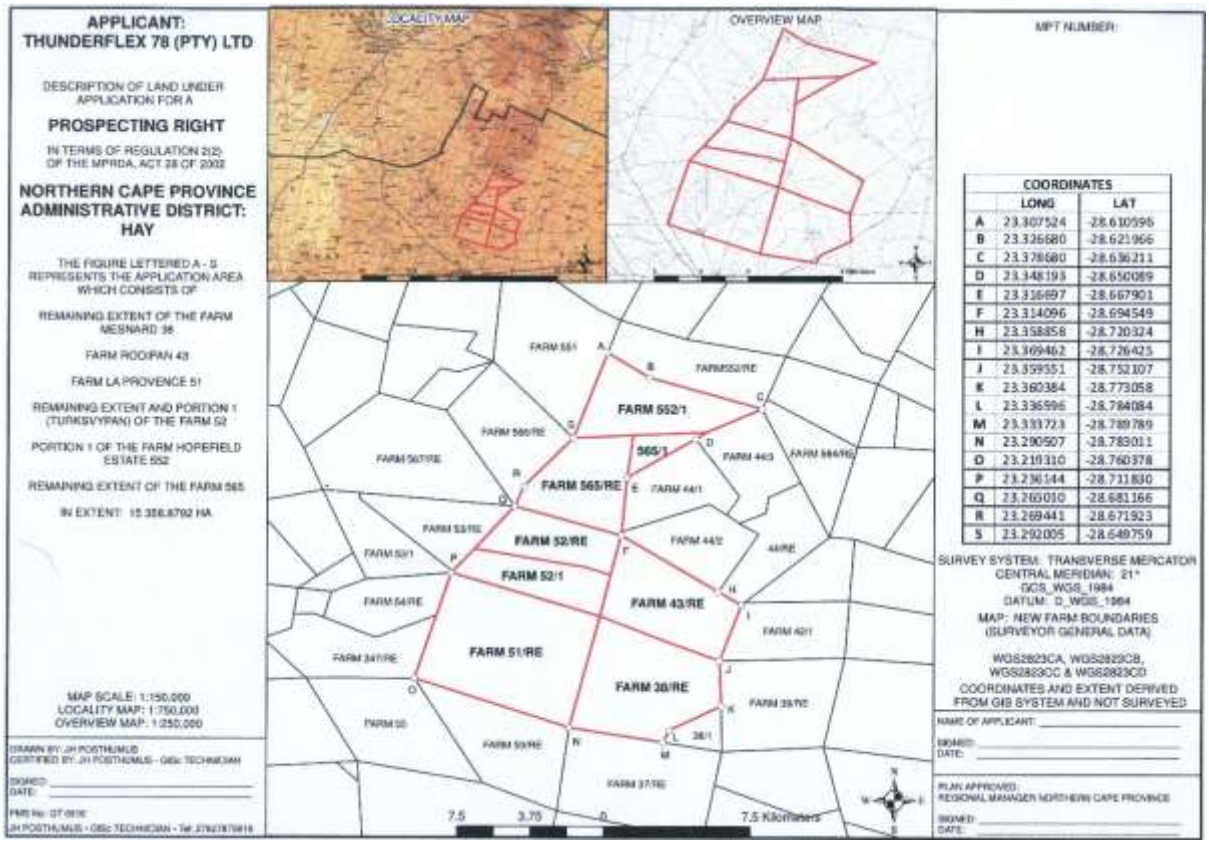

Figure 1: Locality map of the proposed PR and MR application, northwest of Griquastad, with the sections shown by the red outline.

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

The Late Archaean to early Proterozoic Transvaal Supergroup is preserved in three structural basins on the Kaapvaal Craton (Eriksson et al., 2006). In South Africa are the Transvaal and Griqualand West Basins, and the Kanye Basin is in southern Botswana. The Griqualand West Basin is divided into the Ghaap Plateau sub-basin and the Prieska sub-basin. Sediments in the lower parts of the basins are very similar but they differ somewhat higher up the sequences. Several tectonic events have greatly deformed the south western portion of the Griqualand West Basin between the two sub-basins

The Transvaal Supergroup comprises one of world's earliest carbonate platform successions (Beukes, 1987; Eriksson et al., 2006; Zeh et al., 2020). In some areas there are well preserved stromatolites that are evidence of the photosynthetic activity of blue green bacteria and green algae. These microbes formed colonies in warm, shallow seas

The Transvaal Supergroup rocks in the Griqualand West Basin can be correlated with the rocks in the Transvaal Basin, closely according to Beukes and colleagues, or not so closely according to Moore and colleagues. Nonetheless, these rocks represent on a very large scale, a sequence of sediments filling the basins under conditions of lacustrine, fluvial, volcanic and glacial cycles in a tectonically active region. The predominantly carbonaceous sediments are evidence of the increase in the atmosphere of oxygen produced by algal colony photosysnthesis, the so-called Great Oxygen Event (ca 2.40 – 2.32 Ga) and precursor to an environment where diverse life forms could evolve. The Neoarchean-Paleoproterozoic Transvaal Supergroup in South Africa contains the well-preserved stromatolitic Campbellrand -Malmani carbonate platform (Griqualand West Basin – Transvaal Basin

respectively), which was deposited in shallow seawater shortly before the Great Oxidation Event (GOE).

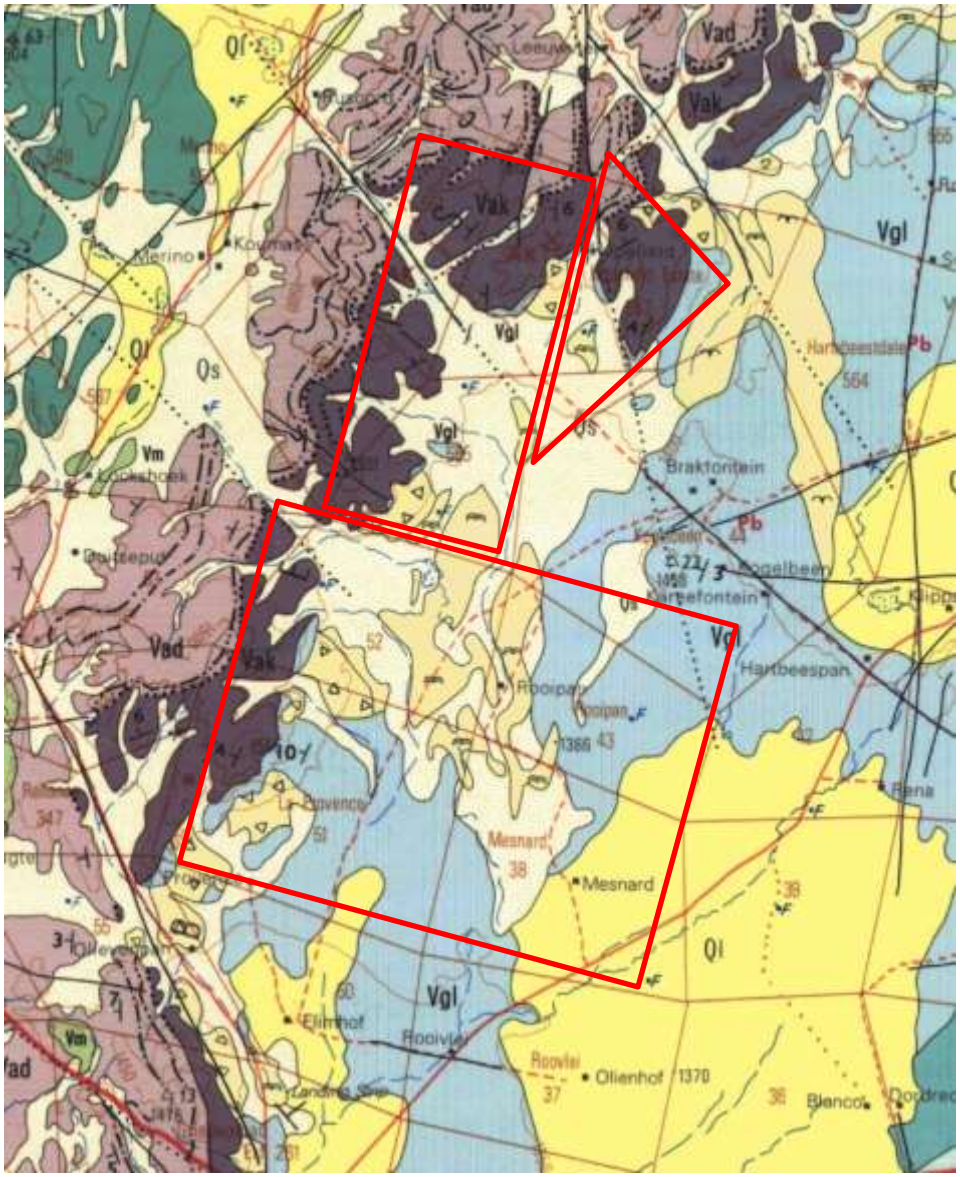

Figure 2: Geological map of the area around the cluster of farms for the PR and MR application by Thunderflex 78 (Pty), Ltd, indicated within the red outlines. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2822 Postmasburg.

Table 2: Explanation of symbols for the geological map and approximate ages (Eriksson 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
Qs	Quaternary Aeolian sands	Aeolian sands, sand dunes	Neogene, ca 2.5 Ma to present

Symbol	Group/Formation	Lithology	Approximate Age
Ql	Quaternary limestone	Surface limestone	Neogene, ca 2.5 Ma to present
Vad	Danielskul Fm, Asbestos Hills Subgroup, Ghaap Plateau Group, Transvaal SG	Jaspilite, crocidolite, shale	2500 – 2475 Ma
Vak	Kuruman Fm, Asbestos Hills Subgroup, Ghaap Plateau Group, Transvaal SG	Banded iron formation	2500 – 2475 Ma
Vgl	Lime Acres Mbr, Kogelbeen Fm, Campbell Rand Subgroup, Ghaap Plateau Group, Transvaal SG	Dolomite, limestone	>2521 Ma

The Transvaal Supergroup in the Griqualand West Basin in the Northern Cape Province conventionally has been subdivided into the basal Ghaap Group and the overlying Postmasburg Group. The Ghaap Group is subdivided into the Schmidtsdrif, Campbell Rand, Asbestos Hills and Koegas Subgroups, whereas the Postmasburg Group into the Makganyene and Ongeluk Formations and overlying Vöelwater Subgroup. Preserved in this area are the Lime Acres Member of the older Campbell Rand Subgroup as well as two Formations of the Asbestos Hills Subgroup (Table 2).

Much younger deposits of an arid environment, the Quaternary Kalahari Group is composed of alluvium, sands, aeolian sands, calcrete and surface limestones and are part of an extensive system originating from the northwest. As this is a rich mineral area, a number of boreholes show the depth of the underlying Transvaal Supergroup rocks.

ii. Palaeontological context

Dolomite and limestones can potentially preserve fossils and these ancient examples in the Campbell Rand Subgroup have trace fossils, stromatolites. They are the very fine layers of calcium carbonate, calcium sulphate, magnesium carbonate and magnesium sulphate that were laid down by the photosynthetic activity of colonies of green algae and blue-green algae in the warm shallow seas, intertidal zones or lagoonal platforms. Domes, columns or layered structures can be formed, depending on the local environments, but rarely are any of the algae themselves preserved (Beukes, 1987). From the Gamohaan Formation (uppermost Campbell Rand Subgroup) core material in petrographic thin section, *Siphonophycus transvaalensis*, a filamentous alga about 15-25µm in diameter, has been described (Klein et al., 1987). It should be noted that this microscopic and not visible to the naked eye.

Banded iron formation is the result of iron being oxidised by the newly released oxygen and forms finely laminated, possibly seasonally controlled, bands of haematite (Beukes, 1987).

These formations are not directly related to any microbes so are not fossiliferous but they may have a granular appearance (Smith et al., 2020).

According to Palaeotechnical Report for the Northern Cape Province (Almond and Pether, 2009), the Ghaap Plateau Group is only moderately sensitive and should be indicated as green on the SAHRIS Palaeosensitivity map. In contrast, for the same geological structures but for the North West Province Palaeotechnical Report Groenewald et al., (2012) classify the Ghaap Group as very highly sensitive (red) and SAHRIS seems to have applied this category for the Ghaap Group rocks.

Kalahari Group sands. Calcretes and surface limestones do not preserve fossil except in special features such as palaeo-pans or palaeo-springs. Such features have not been recorded for this area.

The palaeontological sensitivity of the area under consideration is presented in Figure 3, but the very highly sensitive category (red) for the Kuruman Formation banded iron along the western margin, and for the Lime Acres Member (eastern margins) are to be questioned. The highly sensitive (orange) for the Quaternary limestones is correct.

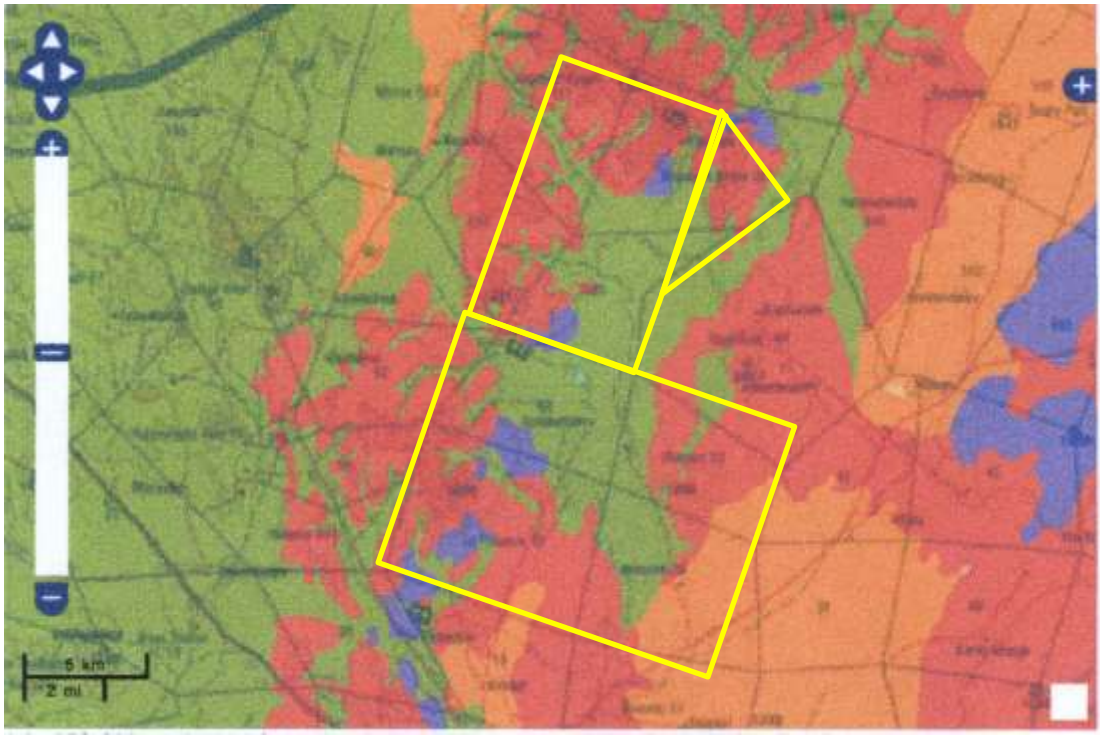

Figure 3: SAHRIS palaeosensitivity map for the site for the proposed PR and MR for the cluster of farms northeast of Griquadtad shown within the yellow rectangles. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table 3:

TABLE 3A: 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 3B: IMPACT ASSESSMENT

PART B: ASSESSMENT		
SEVERITY/NATURE	**H**	-
	M	Lime Acres Mbr dolomites might preserve stromatolites but these are trace fossils and of limited scientific interest.
	L	BIF (Kuruman Fm) does not preserve fossils; The impact would be very unlikely. Quaternary sands only preserve fossils in palaeo-pans and paleo-springs; none is evident in the area
	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 stromatolites or palaeo-pans and paleo-spring bones, wood, lithics, the spatial scale will be localised within the site boundary.
	M	-
	H	-

PART B: ASSESSMENT		
PROBABILITY	H	-
	M	**It is unlikely that stromatolites will be disturbed in the Lime Acres Mbr**
	L	It is very unlikely that any fossils fragments would be found in the surface limestone or loose sand. Nonetheless a Fossil Chance Find Protocol should be added to the eventual EMPr.

Prospecting activities (drill core) will have a small footprint so will not likely disturb any potential stromatolites in the Lime Acres Member and will have no impact on the Kuruman Formation BIF. Drilling through the surface limestone is also unlikely to disturb any fossils but the geologist should look out for pan or spring features.

Mining activities (underground) would have the same impact as prospecting. Open cast mining would impact a larger area and this would require a site visit if stromatolites or pans are in the footprint. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low.

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 sands are typical for the country. Limestone and dolomites might contain the trace fossils such as stromatolites. BIF does not preserve fossils and should not be indicated as very highly sensitive on the SAHRIS palaeosensitivity map. Surface limestones, only if there are special features such as palaeo-pans or palaeo-springs, might preserve fossil bones or wood fragments. The loose sands and alluvium of the Quaternary period would not preserve fossils.

6. Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the surface limestones or loose sands of the Quaternary. There is a very small chance that trace fossils such as stromatolites may occur in the Lime Acres Member. BIF does not preserve fossils although indicated as such in the SAHRIS map.

Since there is a small chance of finding stromatolites, or bones and wood in pans, a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found once drilling or mining has commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample.

7. References

Almond, J.E., Pether, J. 2009. Palaeontological Heritage of the Northern Cape; Palaeotechnical Report for SAHRA. 115pp.

Beukes, N.J., 1987. Facies relations, depositional environments, and diagenesis in a major early Proterozoic stromatolitic carbonate platform to basinal sequence, Campbell Rand Subgroup, Transvaal Supergroup, southern Africa. Sedimentary Geology 54, 1-46..

Eriksson, P.G., Altermann, W., Hartzer, F.J., 2006. The Transvaal Supergroup and its pre-cursors. 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 237-260.

Groenewald, G., Groenewald, D., Groenewald, S., 2014. SAHRA Palaeotechnical Report. Palaeontological Heritage of North West Province. 22 pages.

Klein, C., Beukes, N.J., Schopf, J.W., 1987. Filamentous microfossils in the Early Proterozoic Transvaal Supergroup: their morphology, significance and palaeoenvironmental setting. Precambrian Research 35, 81-94.

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.

Smith, A.J.B., Beukes, N.J., Gutzmer, J., Johnson, C.M., Czaja, A.D., Nhleko, N., de Beer, F., Hoffman, J.W., Awramik, S.M., 2020. Life on a Mesoarchean marine shelf – insights from the world's oldest known granular iron formation. Scientific Reports | (2020) 10:10519 | https://doi.org/10.1038/s41598-020-66805-0

Zeh, A., Wilson, A.H., Gerdes, A., 2020. Zircon U-Pb-Hf isotope systematics of Transvaal Supergroup – Constraints for the geodynamic evolution of the Kaapvaal Craton and its hinterland between 2.65 and 2.06 Ga. Precambrian Research 345, 105760. https://doi.org/10.1016/j.precamres.2020.105760

8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the 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 must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects,

bone, coal) should be put aside in a suitably protected place. This way the project activities will not be interrupted.

3. Photographs of similar fossil plants must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figures 4-7). 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 the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the developer/environmental officer/miners 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. Fossil plants or stromatolites 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 a SAHRA permit must be obtained. Annual reports must be submitted to 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 SAHRA once the project has been completed and only if there are fossils.
8. If the mining operation is to open cast and in the highly sensitive area, then a site visit by a palaeontologist will be necessary in order to remove and preserve a representative collection.

Appendix A – Examples of fossils from the South African record.

Figure 4: Stromatolites as seen from the surface (from the Malmani Subgroup).

Figure 5: examples of stromatolites, a - in the field in side view; b – surface view in the field; c – side view in section. (Photographs from MacRae, 1999. Life Etched in Stone. Geological Society of South Africa, Johannesburg.).

Figure 6: Fossil bone fragments from a Quaternary open air site.

Figure 7: Fragments of silicified wood from a Pleistocene fluvial deposit

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
April 2020

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	9	2
Masters	9	5
PhD	11	5
Postdoctoral fellows	10	4

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 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Cretaceous Research: 2014 –
Journal of African Earth Sciences: 2020 -

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
- 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
-

xi) Research Output

Publications by M K Bamford up to December 2019 peer-reviewed journals or scholarly books: over 140 articles published; 5 submitted/in press; 8 book chapters.
Scopus h-index = 27; Google scholar h-index = 32; -i10-index = 80
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)