Palaeontological Impact Assessment for the Mining Rights Application for Farm Makganyene 667, Kuruman District, Northern Cape Province

Desktop Study (Phase 1)

For

Heritage Contracts and Archaeological Consulting

04 September 2021

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Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 32 years research; 24 years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Heritage Contracts and Archaeological Consulting, Modimolle, 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 by SAHRA (Case ID:17612) for the Mining Rights application on a Portion 2 (a portion of Portion 1) of Farm Makganyene 667, about 26km northwest of Postmasburg, in the Kuruman District, Northern Cape Province.

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 project.

The proposed site lies on the Quaternary Kalahari aeolian sands that might have paaleopans or palaeo-springs that have entrapped fossils. It also lies partly on the non-fossiliferous Makganyene Formation (Postmasburg Group, Griqualand West Sequence of the Transvaal Supergroup) that is non-fossiliferous. Since there is a very small chance of fossils being disturbed in the Quaternary sands, 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 unless fossils are found once excavations and mining commences. As far as the palaeontology is concerned, this project may be authorised.

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1. Background

Makganyane Resources (Pty) Ltd holds a prospecting right (NC 30/5/1/1/2/2292 PR) over Portion 2 (portion of Portion 1), Remainder Extent, Remainder Portion of Portion 1, and Portion 3 of the farm Makganyene No 667. Consequently, the company identified the need to apply for a mining permit over a 4.9 ha area of the proven iron ore resource on the Remaining Extent of the farm Makganyene No 667 (see Figure 1).

SITE DESCRIPTION
The property lies ±26 km north-west of Postmasburg, and the proposed footprint area is situated on the north-eastern part of the Remaining Extent of the farm Makganyene No 667. The application received NC 30/5/1/3/2/10915 MP as departmental reference number.

The mining method will represent open-cast mining where blasting will be used to loosen the hard rock, the loosened material will then be transported to a mobile processing plant where it will be screened to various stockpiles. The iron ore will be hauled from the property to the Sishen iron ore export railway line. The application includes offices and other infrastructure to be established on site. Presently, no permanent infrastructure is planned for the proposed development. The proposed project will appoint ±50 employees, that will mainly be sourced from the local community. All employees will daily be transported to the mining area. The Applicant has an existing workshop ±2 km from the proposed mining area where chemicals and fuels will be stored and emergency vehicle/equipment maintenance can be done.

The proposed mining area will be reached via the existing roads on the property that will be widened and upgraded if needed. The improvement of the roads will remain below the threshold of the NEMA EIA Regulation activities.

GEOLOGY (from the BID document by Greenminded Environmental, July 2021):
The regional geology of the study area forms part of the Transvaal Super Group. According to the Makganyane Geological and Preliminary Exploration Report (2019), most of the surface outcrop features towards the east of the property comprises diamictites of the Makganyene Formation. Some quartzite splays cover the diamictite in places. The flat laying topography to the west comprises mostly of sand and sporadic outcrops of the Ongeluk lava. Two almost parallel linear features with a south-southwest to north-north-east trend are present on the geological sheet, possibly representing the continuation of thrust faults. The western feature seems to connect with a thrust-fault. Both the Gamagara Formation and the Rooinekke Iron Formation are hosts rocks to iron and manganese mineralization. Clastic ore deposits present on Kameelhoek, Aucampsrust and Makganyene were documented by Nel, T in 1929.

SAHRA (CaseID: 16712) has requested a Palaeontological Impact Assessment for the Makganyene 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: 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 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 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: Google Earth Map to show the outline of the whole Farm Makganyene 667 (red outline) and the portion for the Mining Rights Application (white outline). Map from the BID document, July 2021.

Figure 2: Google Earth map of the proposed mining rights application area only (white outline) on Farm Makganyene 667.

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

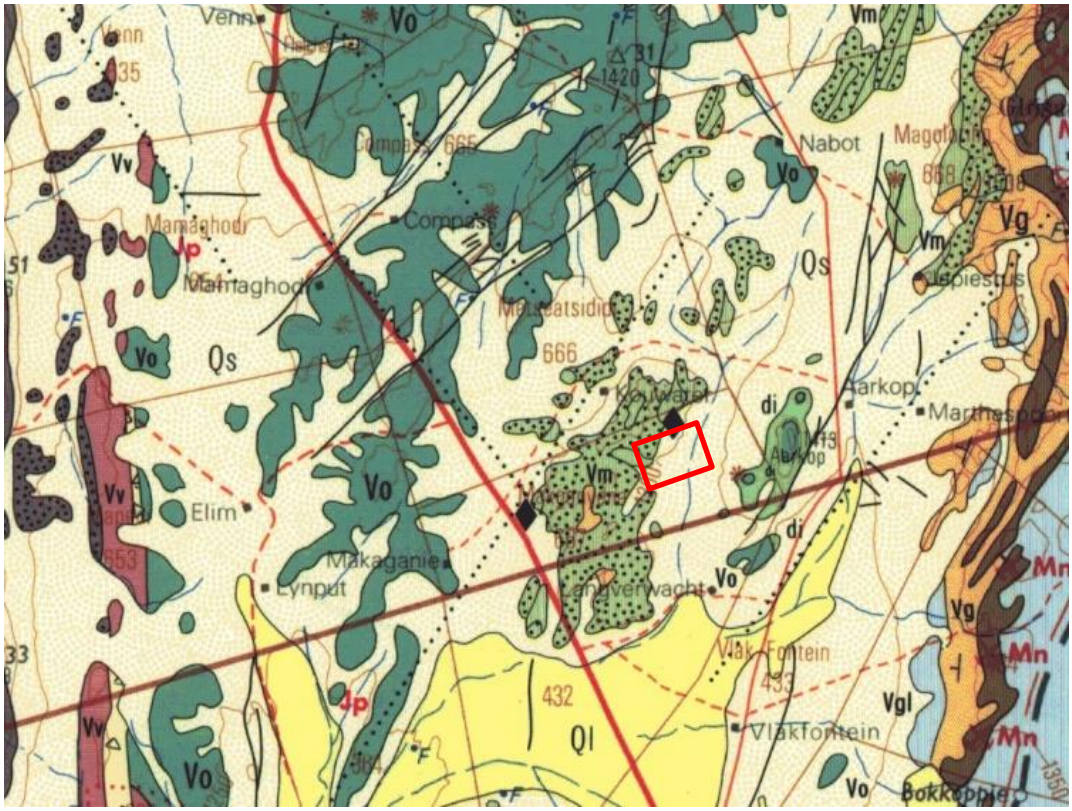

Figure 3: Geological map of the area around the Farm Makganyene 667, Northern Cape Province. The location of the proposed project is indicated within the red rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2822 Postmasburg.

Table 2: Explanation of symbols for the geological map and approximate ages (Eriksson et al., 2006. Johnson et al., 2006; Partridge et al., 2006; Zeh et al., 2020). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Qs	Quaternary/Kalahari Sands	Alluvium, sand, calcrete	Neogene, ca 2.5 Ma to present
Ql	Quaternary/Kalahari Sands	Surface limestone	Last ca 30 000 years
Vl	Lucknow Fm, Olifantshoek Supergroup,	Quartzitic sandstone, dolomitic limestone, shale, conglomerate	>1930 Ma
Vv	Voelwater Fm, Postmasburg Group, Transvaal SG	Banded iron Formation, red jasper, dolomite, chert, lava	

Symbol	Group/Formation	Lithology	Approximate Age
Vo	Ongeluk Fm, Postmasburg Group, Transvaal SG	Amygdaloidal andesitic lava,tuff, conglomerate, chert, red jasper	2430 Ma
Vm	Makganyene Fm, Postmasburg Group, Transvaal SG.	Diamictites, banded jasper, sandstone, mudstone, dolomite; dotted = chert with greywacke	>2430 Ma

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.

Makganyene Farm, with the type rocks of the Makganyene Formation, is in the upper part of the Transvaal Supergroup in the Griqualand West Basin (Figure 3, Table 2). Only a few outcrops of the Postmasburg Group occur in the area as there is an extensive covering of much younger sands of Quaternary age.

The Quaternary Kalahari sands form an extensive cover of much younger deposits over much of the Northern Cape Province and Botswana. Extensive uplifting of the continent during the Cretaceous and the Oligocene-Miocene has resulted in a number of African Erosion Surfaces for southern Africa, although the timing and causes of the uplift are still debated (Partridge et al., 2006; Burke, 2011; Braun et al., 2014).

Haddon and McCarthy (2005) proposed that the Kalahari basin formed as a response to down-warp of the interior of the southern Africa, probably in the Late Cretaceous. More uplift during the Pliocene caused erosion of the sand that was then reworked and redeposited by aeolian processes during drier periods, resulting in the extensive dune fields that are preserved today.

The oldest dated sands are from the northwest of Kuruman at Mamatwan, ca 60 – 58 ka (Thomas and Shaw, 2003; Haddon and McCarthy, 2005). Dates from sands farther to the west and northwest, showed that in much of the southern dune field two significant phases of linear dune development occurred, between about 30 and 23 ka and 17 and 8 ka ago (ibid). OSL dates on minor dune forms within the linear dune field reveal that Holocene dune building activity possibly occurred at 6 and 2–1 ka. Some of these old surfaces have been stabilised by the formation of calcretes, silcretes and duricrusts that formed by

chemical action in wet to dry to wet cycles. The “Tertiary limestones” are a catchall phrase for these deposits

There are numerous pans in the Kalahari, generally 3–4 km in diameter (Haddon and McCarthy, 2005). According to Goudie and Wells (1995) there are two conditions required for the formation of pans. Firstly, the fluvial processes must not be integrated, and second, there must be no accumulation of aeolian material that would fill the irregularities or depressions in the land surface. Favoured materials or substrates for the formation of pans in South Africa are Dwyka and Ecca shales and sandstones (ibid).

Most pans in the Kalahari Basin are filled by a layer of clayey sand or calcareous clays and are flanked by lunette dunes formed as a result of deflation of the pan floor during arid periods (Lancaster, 1978a, b; Haddon and McCarthy, 2005). At some localities in the south western Kalahari spring-fed tufas have formed at the margins of pans during periods where groundwater discharge was high (Lancaster, 1986). These tufas may contain evidence of algal mats and stromatolites and may also be associated with calcified reed and root tubes (Lancaster, 1986).Many of the pans are characterised by diatomaceous earth, diatomite or kieselguhr, a white or grey, porous, light-weight, fine-grained sediment composed mainly of the fossilised skeletons of diatoms. Associated with some palaeo-pans and palaeo-springs are fossil bones, root casts, pollen and archaeological artefacts. Well-known sites are Florisbad and Deelpan in the Free State, Wonderkrater in Limpopo and Bosluispan in the Northern Cape. In in this broader region under study is the Kathu Complex.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The site for mining is on the ancient Makganyene Formation and on much younger Kalahari aeolian sands.

Polteau et al (2006) studied the stratigraphy and geochemistry of the glaciogenic Makganyene Formation, in order to constrain its palaeoenvironmental settings. Geochemical investigations of glacial strata of the Makganyene Formation demonstrated that underlying banded iron formations of the Transvaal Supergroup acted as the main clastic source for the diamictite detritus. Given the age of the Makganyene Formation, around 2430 Ma (Zeh et al., 2020), which is older than the evolution of any body fossils (Plumstead, 1968), the only living organisms were microbes such as algae and bacteria. Given the environmental conditions with icehouse conditions and glacial icesheets (Polteau et al., 2006), the chances of any microbial presence or traces is unlikely. There are some stromatolitic bioherms, however, that are manganese-rich, carbonaceous, layered, dome-like structures formed by algal colonies, in this formation.

While aeolian and dune sands do not preserve fossils, they might have included transported, and therefore, very small or fragmentary fossils. Palaeo-pans and palaeo-springs are much better sites for preserving fossils because burial, water and some kind of cementing medium (calcrete, silcrete or ferricrete) are required to preserve organisms and form fossils. No such features are visible in the satellite imagery.

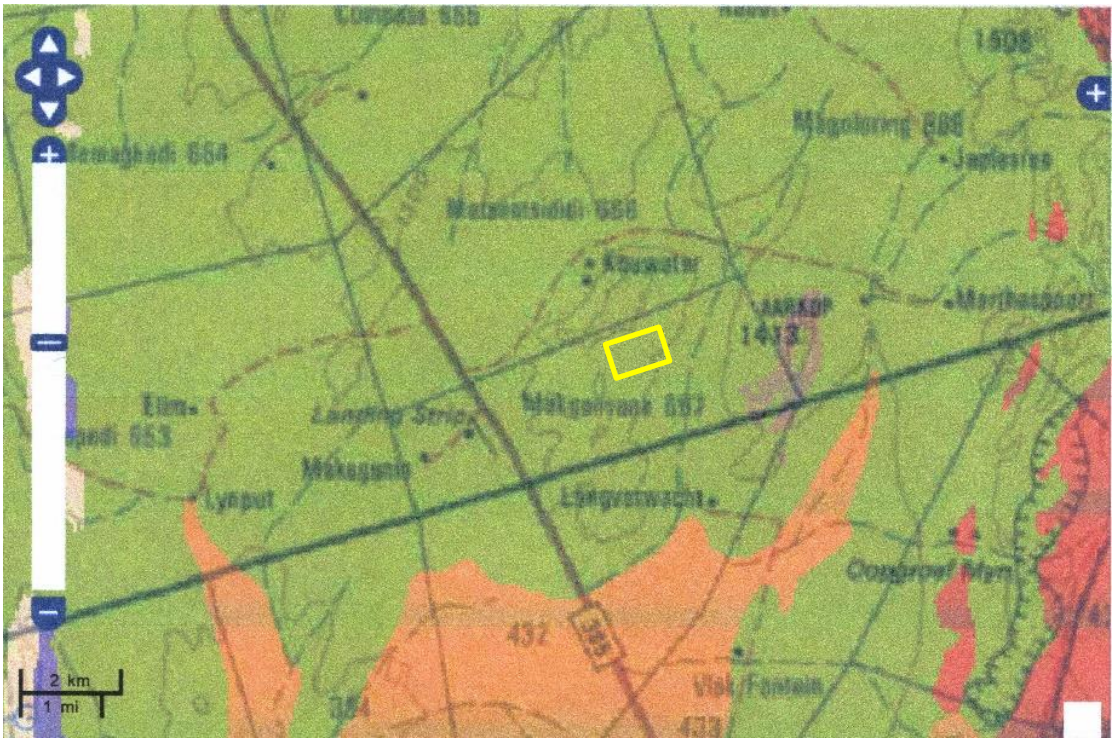

Figure 4: SAHRIS palaeosensitivity map for the site for the proposed Mining Rights Application on Farm Makganyene 667 shown within the yellow rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

From the SAHRIS map (Figure 4), the project area is indicated as moderately sensitive (green) for both the Makganyene Formation and the Kalahari aeolian sands.

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	-
	L	Aeolian sands do not preserve any fossils; so far there are no records from the Quaternary pans or springs in this region so it is very unlikely that fossils occur on the site. There might be trace fossils of stromatolites or bioherms in the Makganyene Fm. The impact would be very unlikely.
	L+	-
	M+	-
	H+	-
DURATION	**L**	-
	M	-
	H	Where manifest, the impact will be permanent.
SPATIAL SCALE	**L**	Since the only possible fossils within the area would be stromatolites or bones or fragments in palaeo-pans or palaeo-springs of Quaternary age, the spatial scale will be localised within the site boundary.
	M	-
	H	-
PROBABILITY	**H**	**-**
	M	**-**
	L	It is extremely unlikely that any fossils would be found in the loose sand that will be removed. Stromatolitic bioherms in the Makganyene Fm are very rare. Nonetheless, a Fossil Chance Find Protocol should be added to the eventual EMPr.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are either much too old to contain body fossils but might contain trace fossils, or are transported so would only contain small or fragments of fossils. Since there is an extremely small chance that trace fossils from the Makganyene Formation or transported fossils from the Quaternary aeolian sands, may be disturbed a Fossil Chance Find Protocol has been added to this report. 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 and do not contain fossil plant, insect, invertebrate and vertebrate materials except where there are features to trap Quaternary fossils. Although stromatolitic bioherms have been preserved in the Makganyene Formation, the single report has no site information (Polteau et al., 2006). The aeolian sands 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 aeolian sands of the Quaternary and there are no palaeo-pans or palaeo-springs visible in the satellite imagery. Stromatolitic bioherms are trace fossils and of limited interest to palaeontologists. Nonetheless, since there is a very small chance that fossils may occur in the sands that will be removed and the rocks that will be mined, a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found once clearing and mining has commenced by the environmental officer or other responsible person, then they should be rescued and a palaeontologist called to assess and collect a representative sample (Section 8, Appendix A).

7. References

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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.

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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 must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone, stromatolites) 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 fossil plants, vertebrates, invertebrates or trace fossils in the shales and mudstones (for example see Figure 5-7). 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 vertebrates 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 no fossils are found and the excavations have finished then no further monitoring is required.

Appendix A – Examples of fossils from the Makganyene Formation and Quaternary deposits

Figure 5: Stromatolites as seen from the surface. Diameter of exposed part = 50cm.

Figure 6: Fragmentary bones from a Quaternary fluvial deposit

Figure 7: Fragments of silicified woods from a Quaternary fluvial deposit. Scale = 1cm

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
July 2021

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
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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	11	0
Masters	10	4
PhD	11	4
Postdoctoral fellows	10	5

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 –

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
- 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 July 2021 peer-reviewed journals or scholarly books: over 150 articles published; 5 submitted/in press; 10 book chapters.
Scopus h-index = 29; Google scholar h-index = 35; -i10-index = 92
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)