Palaeontological Impact Assessment for the proposed remediation project for Ngodwana Dam, Mpumalanga Province

Desktop Study (Phase 1)

For

Ecoleges

01 June 2020

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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 Ecoleges, 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 preposed remediation project for Ngodwana Dam, about 30 km west southwest of Nelspruit. 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 project and is presented herein.

The Dam site lies on the lavas of the Godwan Group that are non-fossiliferous, and on the arenites and quartzites of the Black Reef Formation (basal Transvaal Supergroup). Although the SAHRIS palaeosensitivity map indicates that this formation is moderately fossiliferous, the geology and lithology do not support this interpretation. Nonetheless, 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 and, as far as the palaeontology is concerned, the project may proceed.

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1. Background

A Palaeontological Impact Assessment was requested for the Ngodwana Dam project. Some remediation work is required for Ngodwana Dam, about 30km west-southwest of Nelspruit, Mpumalanga Province. The Dam is on Farm Ngodwana 1030JT and just south of the settlement of Ngodwana (Figure 1).

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 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 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: Google Earth map of the proposed remediation project for Ngodwana Dam, Mpumalanga Province, with the Dam site indicated by the pin. Map supplied by Kudzala.

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 area is in ancient rocks of the Archaean Greenstone Belts and the basal Transvaal Supergroup rocks (Figure 2; Table 2). The oldest rocks are the tonalite-trondhjemite-granodiorite gneiss plutons of the Kaap Valley Batholith (Robb et al., 2006), in other words a large granitoid intrusion composed of different proportions of granites and gneiss. As part of a younger geological sequence are the Late Archean to Early Proterozoic "protobasinal rocks" that were deposited before the Transvaal Supergroup rocks. One of these clusters is the Godwan Group and it is exposed in the Transvaal Basin (the eastern basin of the Transvaal Supergroup's three basins). Composed of lava, sandstone and grit, the Godwan Group has been interpreted as a succession of clastic sedimentary and lesser volcanic rocks that were deposited in a fluvial and tectonically controlled setting (Eriksson and Reczko, 1995; Eriksson et al., 2006).

The basal rocks of the Transvaal Supergroup are exposed in this region and include the Black Reef Formation, Malmani Group and the Rooihoogte and Timeball Hill Formations of the early Pretoria Group. The Black Reef Formation is composed of relatively mature quartz arenites with lesser conglomerates and subordinate mudrocks (Eriksson and Reczko, 1995; Eriksson et al., 2006, 2012; Fuchs et al., 2016; Zeh et al., 2020). Note that none of these works, by different groups of researchers, mentions the presence of carbonates in the Black Reef formation. There are two general models for the deposition of the Black Reef Formation, either initially a fluvial setting followed by shallow marine conditions or a purely fluvial model (ibid). More recent research has not resolved the depositional model but has re-confirmed the lithology and ages. According to Zeh et al., (2020), the Chuniespoort Group

is predominately made up of chemical sediments, even though the stratigraphic sequence starts with clastic sediments of the Black Reef formation, which overly clastic sedimentary rocks of the Wolkberg Group. Both Wolkberg and Black Reef rocks were deposited in a subsiding intracratonic basin, either in alluvial, braiddelta, or shallow marine to lacustrine environments (Eriksson and Reczko, 1995; Eriksson et al., 2006, 2012; Zeh et al., 2020). The clastic sediments are overlain by platform carbonates of the Malmanisubgroup (limestones, dolostones), locally intercalated by shales, and overlain by thick, economically important iron-formations of the Penge Formation (ibid).

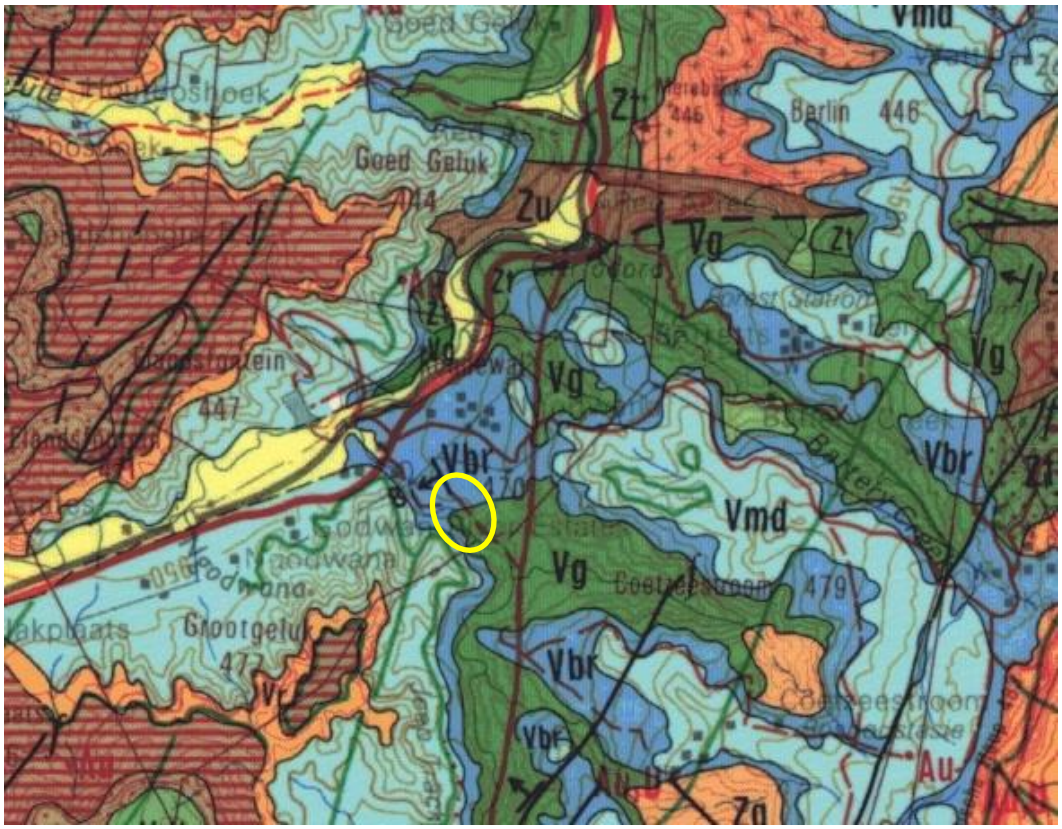

Figure 2: Geological map of the area around the Ngodwana Dam. The location of the proposed project is indicated within the yellow outline. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map Barberton 2530.

Table 2: Explanation of symbols for the geological map and approximate ages (Brandl et al., 2006; Eriksson et al., 2006, 2012; Zeh et al., 2020). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Vk	Klapperkop Member, Timball hill Fm, Pretoria Group, Transvaal SG	Quartzite	Ca 2260 Ma
Vt	Timeball Hill Fm, Pretoria Group, Transvaal SG	Quartzite	Ca 2224-2300 Ma
Vr	Rooihoogte Fm, Pretoria	Quartzite, conglomerate,	>2300 Ma

Symbol	Group/Formation	Lithology	Approximate Age
	Group, Transvaal SG	shale	
Vm	Malmani Subgroup, Chuniespoort Group, Transvaal SG	Dolomite, chert	Ca 2550 – 2440 Ma
Vbr	Black Reef Fm, Transvaal SG	Quartzite, conglomerate, shale, basalt	Ca 2650 – 2550 Ma
Vg	Godwan Group, pre Transvaal SG volcanics	Lava, sandstone, grit	Ca 2700 Ma
Zg	Kaap Valley Pluton (Tonalite)	Biotite, trondhjemite gneiss	>3230 Ma
Zk	Kaap Valley Pluton (Tonalite)	Hornblende biotite granite	>3230 Ma

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 3. The site for development is in the Black Reef Formation and the Godwan Group. The latter is non-fossiliferous.

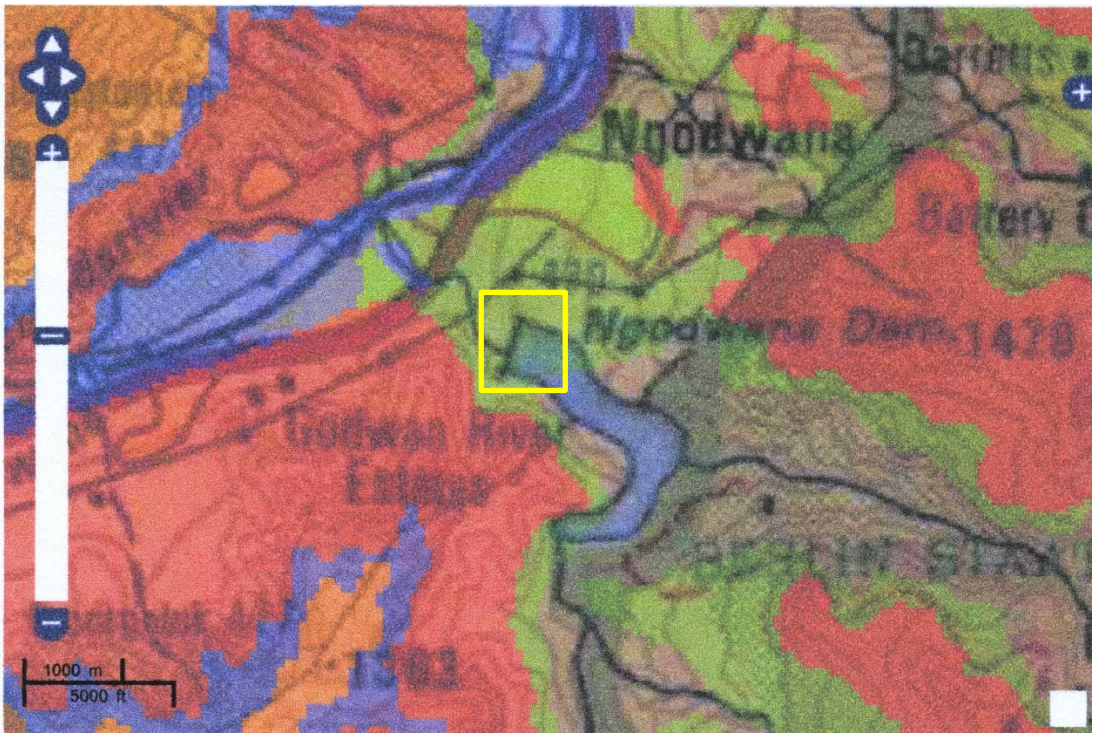

Figure 3: SAHRIS palaeosensitivity map for the site for the Ngodwana Dam with the remediation area within the yellow outline. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

According to the SAHRIS map, which is based on information in the Mpumalanga Palaeotechnical Report (Groenewald et al., 2014), the Black Reef Formation potentially could contain stromatolites because the equivalent aged Vryburg Formation (Griqualand West Basin, Transvaal Supergroup) does contain stromatolites and stromatolitic carbonates. However, the Black Reef Formation does not have any carbonate-like rocks, and is somewhat younger than the Vryburg Formation. Walraven and Martini (1995) dated both the Vryburg and Black Reef formations at ca 2642 Ma. More recent dating of zircons by Fauenstein et al. (2009) place the Vryburg Formation at ca 2669 Ma, and at ca 2618 Ma for the Black Reef Formation (Zeh et al., 2020).

From the SAHRIS map above the Black Reef Formation is indicated as moderately sensitive (green) yet there is no evidence for fossils or any carbonates that could contain early microbes or trace fossils. The map needs to be updated. Until this is done, a Fossil Chance Find Protocol has been added to this report (Section 8).

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	-

PART B: ASSESSMENT		
	L	Lavas (Godwan Group) and arenites (Black Reef Fm) do not preserve fossils; so far there are no records from the area or formations so it is very unlikely that fossils occur on the site. The impact would be very unlikely.
	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 trace fossil of early microbes, 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 lavas or the arenites because they do not preserve fossils. The SAHRIS map is incorrect and should be updated. In the interim, 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 much too old to contain body fossils and the wrong type to preserve trace fossils or microbes, although the Sahris map indicates moderate sensitivity. Since there is an extremely small chance that fossils from the nearby Malmani Subgroup 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 arenites, quartzites, sandstones and conglomerates are typical for the country and do not contain fossil plant, insect, invertebrate and vertebrate material. The surface soils 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 Black Reef Formation (basal Transvaal Supergroup). Based on the literature survey and more recent publications, the SAHRIS map needs to be updated to reflect this. However, in the interim and to satisfy SAHRA regulations a Fossil Chance Find Protocol should be added to the EMPr: if fossils of stromatolites are found once excavations for the remedial project have commenced then

they should be rescued and a palaeontologist called to assess and collect a representative sample.

7. References

Brandl, G., Cloete, M., Anhauaeusser, 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.

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.

Eriksson, P.G., Bartman, R., Catuneanu, O., Mazumder, R., Lenhardt, N., 2012. A case study of microbial mats-related features in coastal epeiric sandstones from the Palaeoproterozoic Pretoria Group, Transvaal Supergroup, Kaapvaal craton, South Africa; the effect of preservation (reflecting sequence stratigraphic models) on the relationship between mat features and inferred palaeoenvironment. Sedimentary Geology 263, 67-75.

Eriksson, P.G., Reczko, B.F.F., 1995. The sedimentary and tectonic setting of the Transvaal Supergroup floor rocks to the Bushveld Complex. Journal of African Earth Sciences 21, 487-504.

Frauenstein, F., Veizer, J., Beukes, N., Van Niekerk, H.S., Coetzee, L.L., 2009. Transvaal Supergroup carbonates: Implications for Paleoproterozoic δ18O and δ13C records. Precambrian Research 175, 149–160.

Fuchs, S., Williams-Jones, A.E., Przybylowicz, W.J., 2016. The origin of the gold and uranium ores of the Black Reef Formation, Transvaal Supergroup, South Africa. Ore Geology Reviews 72, 149-164.

Groenewald, G., Groenewald, D., Groenewald, S., 2014. SAHRA Palaeotechnical Report. Palaeontological Heritage of Mpumalanga. 23 pages.

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.

Robb, L.J., Brandl, G., Anhaeusser, C.R., Poujol, M., 2006. Archaean Granitoid Intrusions. 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 57-94.

Walraven, F., Martini, J., 1995. Zircon-Pb evaporation age determinations of the Oaktree Formation, Chuniespoort Group, Transvaal Sequence: implications for Transvaal-Griqualand West basin correlations. South African journal of Geology 98, 58-67.

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.

8. Chance Find Protocol

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

1. The following procedure is only required if fossils are seen on the surface and when drilling or excavations commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (tracefossils, 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 Figure 4). 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 younger Malmani Subgroup

Figure 4. Stromatolite, about 50cm diameter. This is a trace fossil formed by ancient algal colonies that deposited layers of calcium carbonate, magnesium carbonate and magnesium sulphate in domes or layers in a warm, shallow marine environment.

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
-

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)