Palaeontological Impact Assessment for the 24G request for Scherp Arabie 743KS, near Marble Hall, Limpopo Province

Desktop Study (Phase 1)

For

ESZRO

03 October 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 by ESZRO and Manini Holdings, 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 24G application for Portions 18 and 19 of Farm Scherp Arabie 743KS, about 9km northeast of Marble Hall, Limpopo Province. The land has already been cleared for agricultural development.

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 required before development but is being completed now.

The tilled area lies on the non-fossiliferous Upper Zone (Rustenburg Layered Sequence, Bushveld Complex and Duitschland Formation (Chuniespoort Group, Transvaal Supergoup). It also lies on the supposedly fossiliferous dolomites of the Timeball Hill Formation, Pretoria Group, Transvaal Supergroup) but no stromatolites have been recorded. It is assumed that the tilled land is on soils and not on the dolomitic rocks so there has been no impact on the palaeontological heritage. For future tilling on Portions 18 and 19 of Scherp Arabie 743 KS, 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 no damage has been done. ……..

Table of Contents

1. Background

ESZRO has been asked to conduct a 24G application for the rectification of an unlawful development, clearance of vegetation to establish croplands on portions 18 & 19 of the Farm Scherp Arabie 743 KS. The farm is situated approximately 9km north-east of Marble Hall. The land was tilled previously and so is disturbed, and the area in question is approximately 70 hectares (Figure 1).

A Palaeontological Impact Assessment was requested for the 24G application. 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 done for the completed development and is presented 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 clearing of vegetation for agriculture on Portions 18 and 19 of Farm Scherp Arabie 743KS, with the land in question indicated. Map supplied by ESZRO.

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

Marble Hall is in the northeastern part of the Transvaal Basin, the largest of the three basins that contain the rocks of the Transvaal Supergroup that lie on the ancient Kaapvaal Craton. It is Late Archaean to early Proterozoic in age (Figure 2).

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 Basin is more extensive but the middle portion is overlain by younger rocks so appears as two separate 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.

Transvaal Supergroup rocks in the Transvaal Basin were intruded by the Bushveld Complex at around 2060 million year ago (Eriksson et al. 2006; 2055Ma in Zeh et al., 2020), with the Magaliesberg Formation of the Pretoria Group forming the floor rocks in most areas

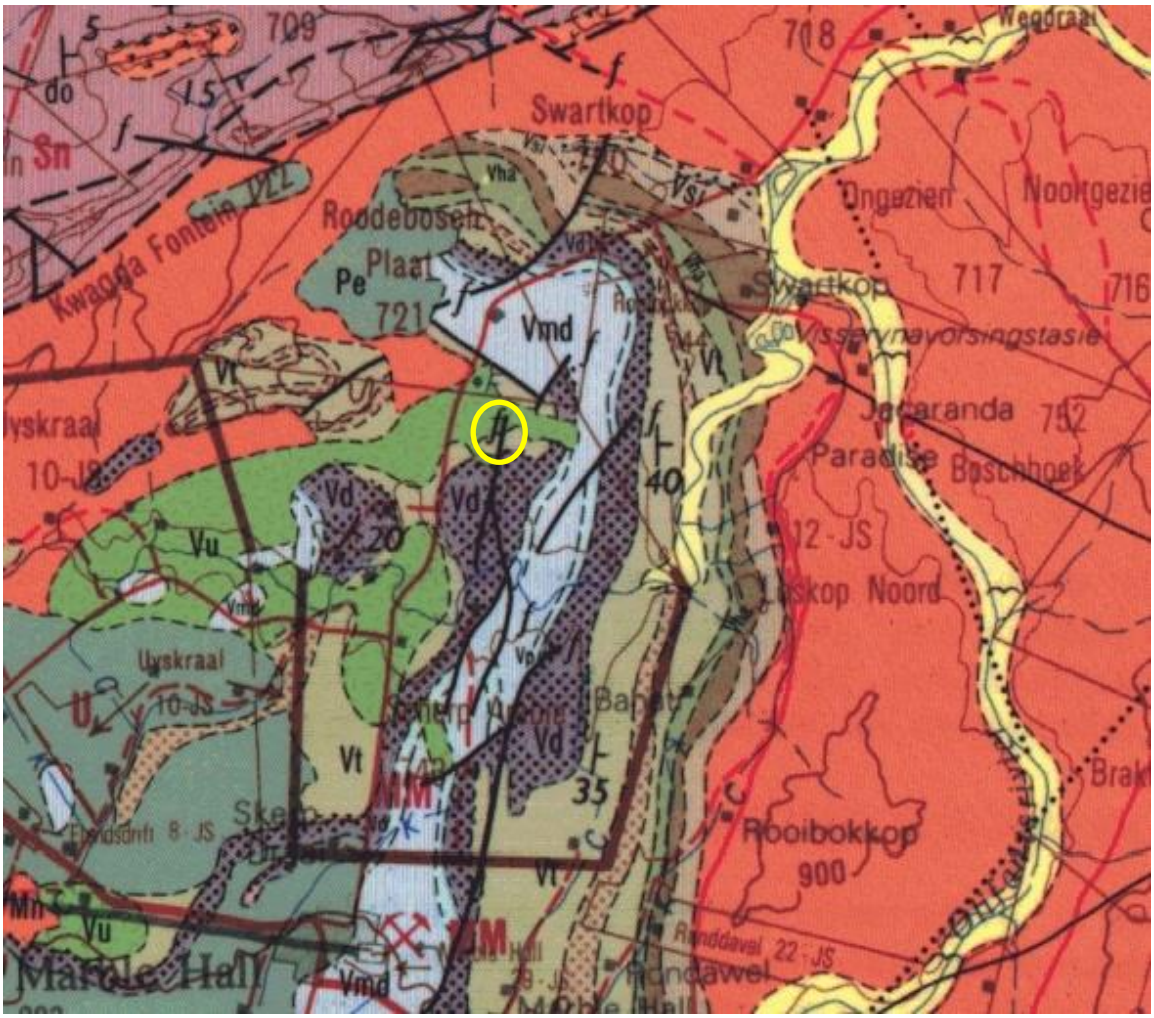

Figure 2: Geological map of the area around the Farm Scherp Arabie 743KS. The location of the project is indicated within the yellow circle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2428 Nylstroom.

Table 2: Explanation of symbols for the geological map and approximate ages (Cawthorn et al., 2006; Eriksson et al., 2006. Johnson 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
Q	Quaternary	Alluvium, sand, calcrete	Neogene, ca 2.5 Ma to present
Pe	Ecca Group, Karoo SG	Undifferentiated Ecca shales, sandstone, mudstone	Early Permian ca 290-270 Ma
Mn	Nebo Granite, Lebowa Granite Suite, Bushveld Complex	Coarse-grained grey-pink granite	<2050 Ma

Symbol	Group/Formation	Lithology	Approximate Age
Vu	Upper Zone, Rustenburg Layered Suite, Bushveld Complex	Ferro-gabbro, troctotite, anorthosite	<2080 Ma
Vt	Timeball Hill Fm, Pretoria Group, Ventersdorp SG	Shale, hornfels, schist	2316-2266 Ma
Vd	Duitschland Fm, Pretoria Group, Transvaal SG	Limestone, dolomite, chert	<2343 Ma
Vp	Penge Fm, Chuniespoort Group, Transvaal SG	Banded iron formation, shale, subordinate carbonaceous breccia	Ca 2840 Ma
Vmd	Malmani Subgroup, Chuniespoort Grop, Transvaal SG	Dolomite, limestone, chert	Ca 2585 – 2480 Ma

(Eriksson et al., 2006). In other areas of the basin the lavas and other subordinate sedimentary rocks of the Rooiberg Group form the floor instead (ibid). Outliers of the Transvaal Supergroup, i.e. surrounding the Bushveld complex exposures, occur in the Rooiberg, Crocodile River, Stavoren, Marble Hall and Dennilton areas. In the far western Transvaal, however, the Transvaal Supergroup rocks lie on the Archaean basement rocks, namely the Witwatersrand and Ventersdorp Supergroups.

There are outcrops of the lower group of the Transvaal Supergroup, namely the Duitschland and Penge Formations (Chuniespoort Group) as well as a few formations from the upper group, the Pretoria Group: the limestones and dolomites of the Malmani Subgroup and the shales, hornfels and schist of the Timeball Hill Formation (Figure 2; Table 2).

Only the Upper Zone of the Bushveld Complex are present in this region around Marble Hall, as well as the capping rocks of the Bushveld Complex, namely the granites of the Lebowa Suite. In this area is the Nebo Granite.

There are much younger deposits of the Ecca Group shales (Karoo Supergroup) to the west of Marble Hall, the northern extent of the Main Karoo Basin. Along the rivers are Quaternary Kalahari Sands (yellow in Figure 2). Both groups are considerably younger than the Transvaal Supergroup, with the Quaternary sands being very recent.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 3. The site that has been cleared for agriculture on Farm Scherp Arabie 743 KS. Portions 18 and 19 are in the northern part of the farm and lie on three types of rocks.

Granites and the Bushveld complex rocks are of volcanic origin and do not preserve any fossils and this applies to the Upper Zone of the Rustenburg Layered Suite (Bushveld Complex) indicated as grey on the SAHRIS map. Although the Timeball Hill shales, hornfels and schists are indicated as potentially fossiliferous on the SAHRIS palaeosensitivity map (Figure 3,

orange), this is by implication only as the geological literature does not provide any evidence in support of this.

The Penge formation is not fossiliferous as it comprises mainly banded iron formation, but the Duitschland Formation (indicated as blue on the map; low sensitivity) is composed of dolomites, limestones and chert. In some dolomites one can find the trace fossils of algal colonies, stromatolites, that were formed by the photosynthetic activity of bluegreen and green algae that deposited layers and layers of calcium carbonate, calcium sulphate, magnesium carbonate and magnesium sulphate. Although these strata are commonly formed in warm shallow seas, the algal cells are seldom preserved.

Ecca Group shales and siltstones frequently preserve impressions of plants of the *Glossopteris* flora (glossopterids, lycopods, sphenophytes, ferns and early gymnosperms) (Plumstead, 1969; Anderson and Anderson, 1985). In this region the Ecca Group has not been divided into any one of the three formations so this implies that there are no fossils and no clear lithology from which to make the distinction.

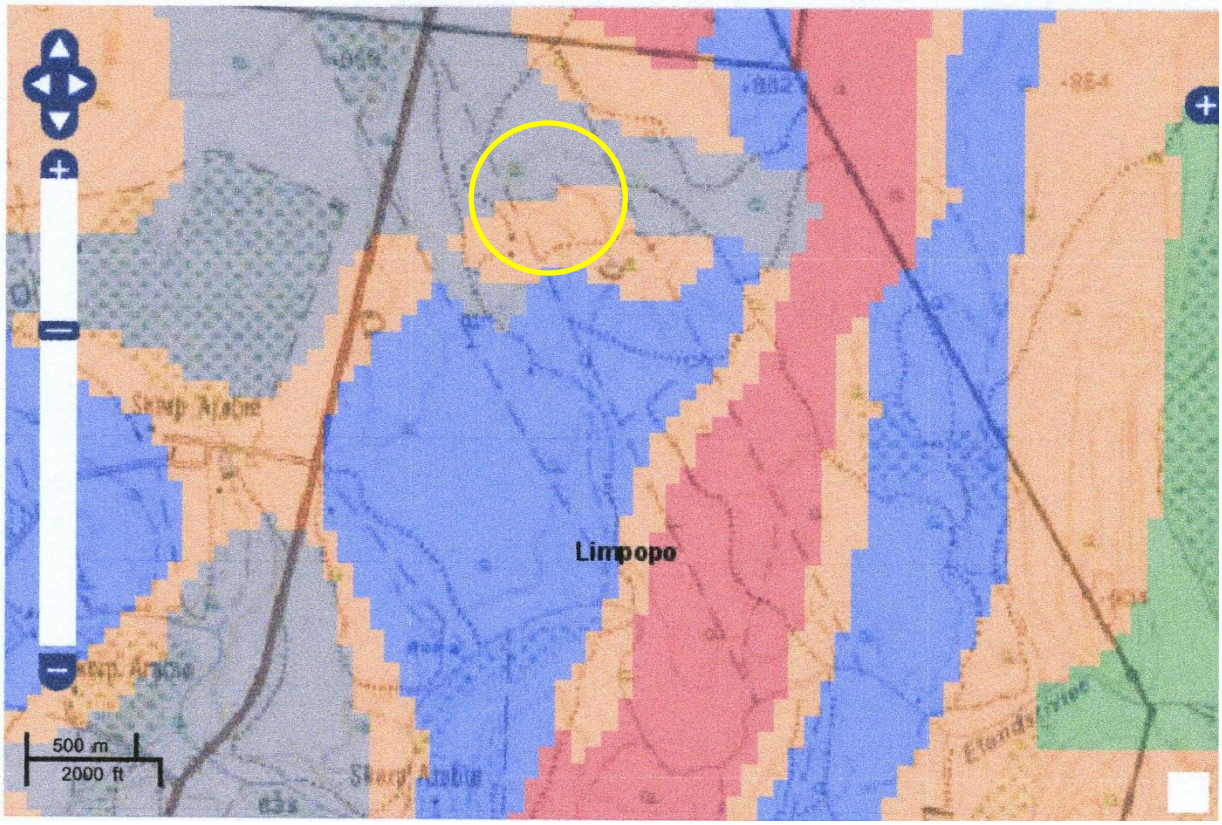

Figure 3: SAHRIS palaeosensitivity map for the Farm Scherp Arabie 743 KS with the cleared section shown within the yellow circle Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

From the SAHRIS map above the area is indicated as highly sensitive (orange) which applies to the Timeball Hill Formation and of low sensitivity (blue) for the Duitschland Formation, and of no Sensitivity (grey) for the Upper Zone (Figures 2 and 3).

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	Soils do not preserve any fossils; so far there are no records from the Timeball Hill Fm of stromatolites, plant or animal fossils 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 fossils such as stromatolites in the dolomites, the spatial scale will be localised within the site boundary.
	M	-

PART B: ASSESSMENT		
	H	-
PROBABILITY	**H**	**-**
	M	**-**
	L	It is extremely unlikely that any fossils would be found in the soils that have been tilled and cleared again recently. If dolomites with stromatolites are present, they are extremely hard and it is most unlikely that they were ever tilled. Nonetheless, a Fossil Chance Find Protocol should be added to the current EMPr in case any trace fossils are found..

Based on the nature of the project, surface activities such as tilling and planting may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are mostly of the wrong type (volcanic) to contain fossils, and although indicated as highly sensitive, it is unlikely that there are stromatolites in the dolomites, or that this rock type would ever be tilled. In case fossils are found or 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 fossils. It is assumed that the Timeball Hill formation dolomites do not preserve fossils, and more importantly, the rocks will not be tilled for agriculture. The 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 have been preserved in the tilled soils. Even if trace fossils, such as stromatolites, do occur in the Timeball Hill Formation, they are of little scientific value because they seldom preserve the algal cells that formed them. However, a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found during future clearing on Portions 18 and 19, they should be rescued and a palaeontologist called to assess and collect a representative sample.

7. References

Anderson, J.M., Anderson, H.M., 1985. Palaeoflora of Southern Africa: Prodromus of South African megafloras, Devonian to Lower Cretaceous. A.A. Balkema, Rotterdam. 423 pp.

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.

Cawthorn, R.G., Eales, H.V., Walraven, F., Uken, R., Watkeys, M.K., 2006. The Bushveld Complex. 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 261-281.

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.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. Pp 461 – 499.

Plumstead, E.P., 1969. Three thousand million years of plant life in Africa. Geological Society of southern Africa, Annexure to Volume LXXII. 72pp + 25 plates.

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

Programme for Palaeontology – to commence only if fossils are found in the footprint.

1. The following procedure is only required if fossils are seen on the surface and when further tilling occurs.
2. When tiling begins 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 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, farmer 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.

Appendix A – Examples of fossils from the Malmani Subroup (Chuniespoort Group, Transvaal Supergroup).

Figure 4. Stromatolites as seen from the surface. Note domed appearance of the rocks and the multiple layers revealed as the dolomite weathers naturally.

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
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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
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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)