

**Palaeontological Impact Assessment for the proposed  
Kokosi Outfall 2 project on Elandsfontein 144, about  
16km south of Carltonville,  
Gauteng**

**Desktop Study (Phase 1)**

**For**

**Asha Consulting (Pty) Ltd**

**05 September 2020**

**Prof Marion Bamford**

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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 Asha Consulting (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 Kokosi Outfall 2 sewerage pipe on Farm Elandsfontein 144, about 16km south of Carlton and south east of Fochville, North West Province. 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 presented herein.

The proposed site lies on the Silvertown Formation (Pretoria Group, Transvaal Supergroup) that is indicated as paleontologically highly sensitive on the SAHRIS map however, the geology and published records 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 unless the responsible person on site finds fossils once excavations have commenced.

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# 1. Background

A sewerage pipe on Farm Elandsfontein 144, the Kokosi Outfall 2 project has been proposed and is located to the west of Kokosi residential area, just south west of the town of Fochville and about 16km south of Carltonville (Figure 1).

A Palaeontological Impact Assessment was requested for the project. 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)

	<b>A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:</b>	<b>Relevant section in report</b>
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 <b>Error! Reference source not found.</b>

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 Kokosi Outfall 2 sewerage line to the west of Kokosi residential area shown by the blue line. Map supplied by EcoSphere.

## 2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.

The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

## 3. Geology and Palaeontology

### i. Project location and geological context



Figure 2: Geological map of the area around Fochville and Kokosi, south of Carltonville. The location of the proposed project is indicated within the yellow rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2626 West Rand Parys.

Table 2: Explanation of symbols for the geological map and approximate ages (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
Vdi	diabase	dolerite	Post Transvaal SG
Vm	Magliesberg Fm, Pretoria Group, Transvaal SG	Quartzite	CA 2080 Ma
Vsi	Silverton Fm, Pretoria Group, Pretoria SG.	Shale with interbedded quartzite, hornfels, limestone	Ca 2240 Ma

The site lies in the Transvaal Basin, one of three basins of the Transvaal Supergroup. 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; Lenhardt et al., 2012). 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 Pretoria Group (upper part of the Transvaal Supergroup) is approximately 6-7km thick and is composed mostly of mudrocks alternating with quartzitic sandstones, significant interbedded basaltic-andesitic lavas and subordinate conglomerates, diamictites and carbonate rocks. These have been subjected to low grade metamorphism (Eriksson et al., 2006). The Bushveld Complex intrusion has affected the layering of the formations.

The model of Eriksson and collaborators (2006, 2012) shows the Transvaal Basin to have experienced three major tectonically controlled transgressive-regressive sequences. The first shallow seaway with a carbonate and a BIF platform is represented by the Chuniespoort Group followed by an 80 Ma gap. The second shallow embayment with clastic sediments is represented by the Rooihogte and Timeball Hill Formations, and the third shallow embayment is represented by the Daspoort, Silverton and Magaliesberg Formations.

Within the Silverton Formation is the lower Boven Shale Member, Machadorp Volcanic Member and upper Lydenburg Shale Member. The lower shales are alumina-rich and best represented in the eastern part of the Transvaal Basin. Shallow subaqueous eruptives formed the tholiitic basalts and then the tuffaceous shales that are high in CaO-MnO-MgO formed the Lydenburg Member (Eriksson et al., 2006). The Silverton Formation has been interpreted as a high-stand facies tract that reflected the advance of an epeiric sea onto the



Kaapvaal Craton from the east, so the Daspoort Formation would represent a lowstand facies tract or a transgressive systems tract (ibid). There are numerous diabase dykes intruding through the sediments and they are from younger volcanic events.

Considerably younger fluvial and aeolian sands and soils of Quaternary age overlie the ancient sediments, particularly along rivers and streams.

## ii. Palaeontological context

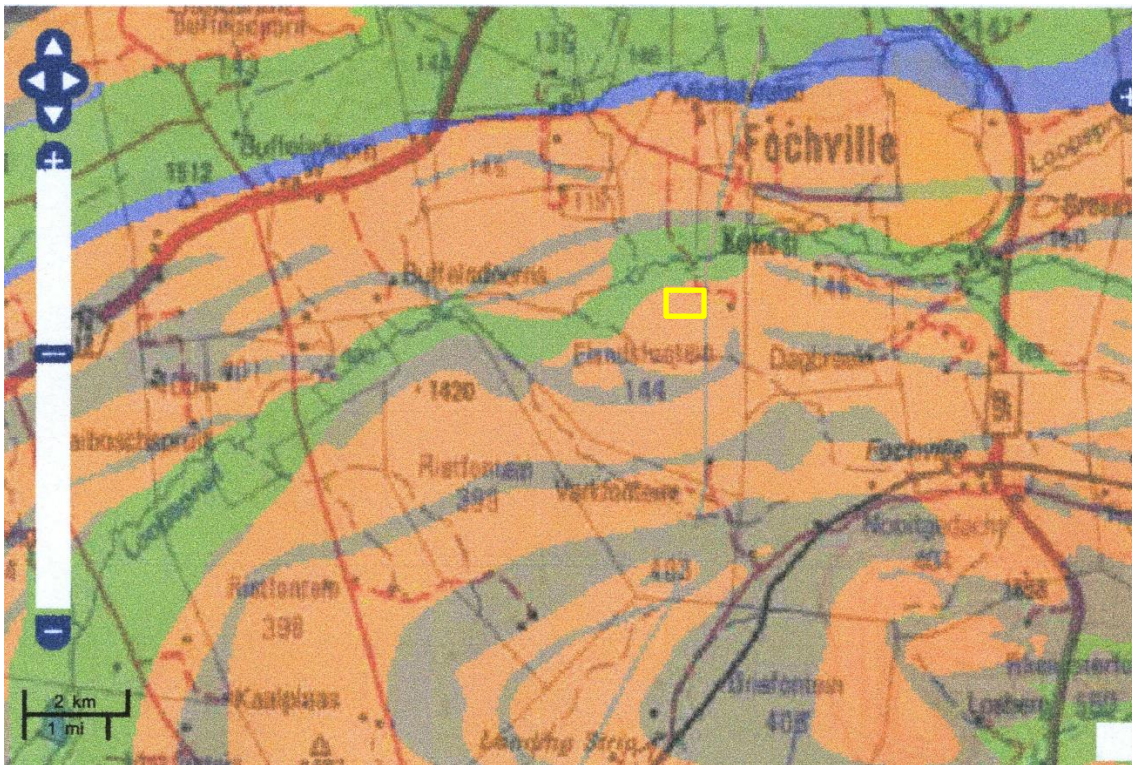


Figure 3: SAHRIS palaeosensitivity map for the site for the proposed Kokosi Outfall 2 pipeline shown within the yellow rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

The palaeontological sensitivity of the area under consideration is presented in Figures 3 and 4. The site for development is in the Silverton Formation, most probably the basal Boven Shale Member. It has been interpreted as a high-stand facies tract that reflects the advance of an epeiric sea onto the Kaapvaal Craton from the east, and therefore the underlying Daspoort Formation would represent a low-stand facies tract or a transgressive systems tract (Eriksson et al., 2006). There is consensus in the geological literature that the Silverton Formation environment was a high energy one with shallow to deep water shales being deposited as sub-storm wave-base pelagic deposits, within an epeiric embayment on the Kaapvaal Craton (Eriksson et al., 2002, 2006, 2012; Frauenstein et al., 2009; Lenhardt et al., 2020). Several sub aqueous dykes and volcanic eruptions have also been recorded

(Lenhardt et al., 2020). The formation is dated between 2202 and 2253 Ma (Zeh et al., 2020) and this is too old for any body fossils so the only potential fossils would be microscopic algae and bacteria which, if preserved, are in the form of the trace fossils such as stromatolites or microbial mats. There are as yet no records of such trace fossils in the Silverton formation although they are present in the overlying Magaliesberg Formation.

The North West Province Palaeotechnical Report indicates that the Silverton Formation is highly sensitive as there are stromatolites (Groenewald et al., 2014), but no evidence has been supplied and the geological records do not support this conclusion. Stromatolites and microbial mats are usually formed in shallow, low energy environments.

The diabase dykes are of volcanic origin and do not preserve any fossils. Much younger fluvial and aeolian sands and soils of the quaternary occasionally preserve fossils but they are either fairly recent (e.g. Holocene) or out of context because they have been transported. They would therefore be of low significance.

From the SAHRIS map above (Figure 3) the area is indicated as highly sensitive (orange) and refers to the Silverton Formation. Grey bands indicate the non-fossiliferous dykes and the green band to the north is the Quaternary 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**

<b>PART A: DEFINITION AND CRITERIA</b>		
<b>Criteria for ranking of the SEVERITY/NATURE of environmental impacts</b>	<b>H</b>	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.
	<b>M</b>	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.
	<b>L</b>	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	<b>L+</b>	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	<b>M+</b>	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	<b>H+</b>	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
<b>Criteria for ranking the DURATION of impacts</b>	<b>L</b>	Quickly reversible. Less than the project life. Short term
	<b>M</b>	Reversible over time. Life of the project. Medium term
	<b>H</b>	Permanent. Beyond closure. Long term.
<b>Criteria for ranking the SPATIAL SCALE of impacts</b>	<b>L</b>	Localised - Within the site boundary.
	<b>M</b>	Fairly widespread – Beyond the site boundary. Local
	<b>H</b>	Widespread – Far beyond site boundary. Regional/ national
<b>PROBABILITY</b>	<b>H</b>	Definite/ Continuous
	<b>M</b>	Possible/ frequent

(of exposure to impacts)	L	Unlikely/ seldom
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**TABLE 3B: IMPACT ASSESSMENT**

<b>PART B: ASSESSMENT</b>		
<b>SEVERITY/NATURE</b>	<b>H</b>	-
	<b>M</b>	-
	<b>L</b>	Surface soils and sands do not preserve significant fossils and are of little further concern. Below ground is the Silverton Fm from which there are no records of fossils (although indicated as highly sensitive on the Sahrís map) so it is very unlikely that fossils occur on the site. The impact would be very unlikely.
	<b>L+</b>	-
	<b>M+</b>	-
	<b>H+</b>	-
<b>DURATION</b>	<b>L</b>	-
	<b>M</b>	-
	<b>H</b>	Where manifest, the impact will be permanent.
<b>SPATIAL SCALE</b>	<b>L</b>	Since the only possible fossils within the area would be trace fossils of microbial activity or stromatolites, the spatial scale will be localised within the site boundary and of minimal scientific interest.
	<b>M</b>	-
	<b>H</b>	-
<b>PROBABILITY</b>	<b>H</b>	-
	<b>M</b>	-
	<b>L</b>	It is extremely unlikely that any fossils would be found in the loose surface sand or soils. 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 much too old to contain body fossils as they are about 2250 million years old and were deposited in a shallow to deep water, high energy environment. Since there is an extremely small chance that trace fossils such as stromatolites and microbial mats do occur in the shales of the Silverton Formation (Pretoria Group, Transvaal Supergroup), 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 of extremely low significance.

## 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 diabase dykes, sandstones and shales are typical for the country and the Silverton Formation do not contain fossils, as indicated in the geological publications. Only the Palaeotechnical Report for the North West Province indicates that stromatolites occur in this formation but no evidence or reference is provided. The overlying soils of the Quaternary period would not preserve significant 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 shales of the Silverton Formation (Pretoria Group, Transvaal Supergroup) because the rocks are ancient and were deposited in a high energy environment where neither stromatolites would grow nor microbial mats form. According to the Palaeotechnical Report fossil stromatolites are present so a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found once excavations have commenced then work in the immediate area should stop and a palaeontologist called to assess and collect a representative sample as required.

## 7. References

Bosch, P., Erikssen, P., 2017. A note on two occurrences of inferred microbial mat features preserved in the c. 2.1 Ga Magaliesberg Formation (Pretoria Group, Transvaal Supergroup) sandstones, near Pretoria, South Africa. *South African Journal of Geology* 111, 251-262.

Eriksson, P.G., Altermann, W., Eberhardt, L., Ahrend-Heidbrinck, S., Bumby, A.J., 2002b. Palaeoproterozoic epeiric sea palaeoenvironments: the Silverton Formation (Pretoria Group, Transvaal Supergroup), South Africa. In: Altermann, W., Corcoran, P.L. (Eds.), *Precambrian Sedimentary Environments: A Modern Approach to Ancient Depositional Systems*. Special Publication, 33. International Association of Sedimentologists, Blackwell, Oxford, pp. 351–367.

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  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  records. *Precambrian Research* 175, 149–160.

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

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.

Lenhardt, N., Bleeker, W., Ngwa, C.N., Aucamp, T., 2020. Shallow marine basaltic volcanism of the Machadodorp Member (Silverton Formation, Pretoria Group), Transvaal Basin, South Africa — An example of Paleoproterozoic explosive intraplate volcanic activity in an epeiric embayment. *Precambrian Research* 338, 105580.

<https://doi.org/10.1016/j.precamres.2019.105580>

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

## 8. Chance Find Protocol

### **Monitoring Programme for Palaeontology – to commence once the excavations begin.**

1. The following procedure is only required if fossils are seen on the surface and when 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 (trace fossils, stromatolites, plants, insects, bone) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of potentially expected fossils must be provided to the developer to assist in recognizing the fossils in the shales and mudstones (for example see Figure 4, 5). This information must be built into the EMPr'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 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 and/or 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.

### **Appendix A – Examples of fossils from the Transvaal Supergroup.**



Figure 4: Examples of stromatolites seen from the surface, from the Malmani Subgroup.



Figure 6: Vermiform trace fossil *Manchuriophycus* from a bedding plane in the Magaliesberg Formation east of Pretoria. Figure taken from Bosch and Erikssen (2017; Fig 7).

## 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-  
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#### 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)