

# **Palaeontological Impact Assessment for the proposed Feedlot near Koster on Farm Naauwpoort, North West Province**

**Desktop Study (Phase 1)**

**For**

**WULA (SAS) and EHW Voerkraal CC**

**13 February 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 Water Use Licence Associates (Pty) Ltd, part of the SASA Group of Companies, 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:

A handwritten signature in blue ink, appearing to read 'M. Bamford', with a horizontal line underneath.

## **Executive Summary**

A palaeontological Impact Assessment was requested for the proposed expansion of an existing feedlot on Farm Blaauwpoort 437, near Koster, 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.

The proposed site lies on the slates, shales and hornfels of the Silverton Formation (Pretoria Group, Transvaal Supergroup). According to the published geological and palaeontological records this formation was deposited in a deep water setting that is not conducive to the formation of the trace fossils such as stromatolites. The Palaeotechnical Report for the North West Province, however, implies that stromatolites do occur in this formation. 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 stromatolites are found once excavations for foundations and amenities have commenced.

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# 1. Background

A palaeontological impact assessment was requested for the proposed expansion of an existing feedlot about 11km north of Koster in the North West Province in order 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.

## **Project Description**

The proposed project entails the expansion of the existing cattle feedlot located on the Remainder of Portion 4 of the Farm Naauwpoort 437. The existing feedlot is approximately 3000 m<sup>2</sup> and has a capacity to accommodate 300 units of cattle.

The entire feedlot will be designed to carry 7 000 units of cattle. Infrastructure directly associated with proposed cattle feedlot will comprise the following:

- 140 Feedlot pens:
  - A feedlot pen will have a footprint of 750 m<sup>2</sup> in size to hold 50 cattle.
- The feedlot pens will be constructed on an impermeable barrier<sup>[1]</sup> of concrete with a strength of 30 Megapascals (MPa).
- A Feedlot pen will be equipped with water and feed bowls, covered by galvanised roof sheeting (Figure 6).

Ancillary building and infrastructure will be established as part of the proposed cattle feedlot for administration and management purposes, and will include:

- One temporary structure with a footprint of approximately 36 m<sup>2</sup> will be installed and used as the administration office.
- One feed production facility of approximately 1 200 m<sup>2</sup> where feed for the cattle will be prepared.
- One weighbridge for the weighting of the cattle.
- One handling facility with a footprint of 260 m<sup>2</sup> where deworming and immunisation of the cattle will be undertaken.
- One mortuary room with a footprint of 36 m<sup>2</sup> where post-mortems will be carried out on the deceased animals.

The entire footprint of the proposed cattle feedlot expansion is approximately 16.3 hectares.

Figure 1 shows the site location and Figure 2 the details of the proposed feedlot expansion.

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<sup>[1]</sup> The impermeable barrier will reduce ingress of contaminated water into the soil, resulting in water pollution.

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
a ii	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
c ii	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
n ii	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 feedlot expansion site near Koster. The site is shown by the green outline. Map supplied by WULA-SAS.

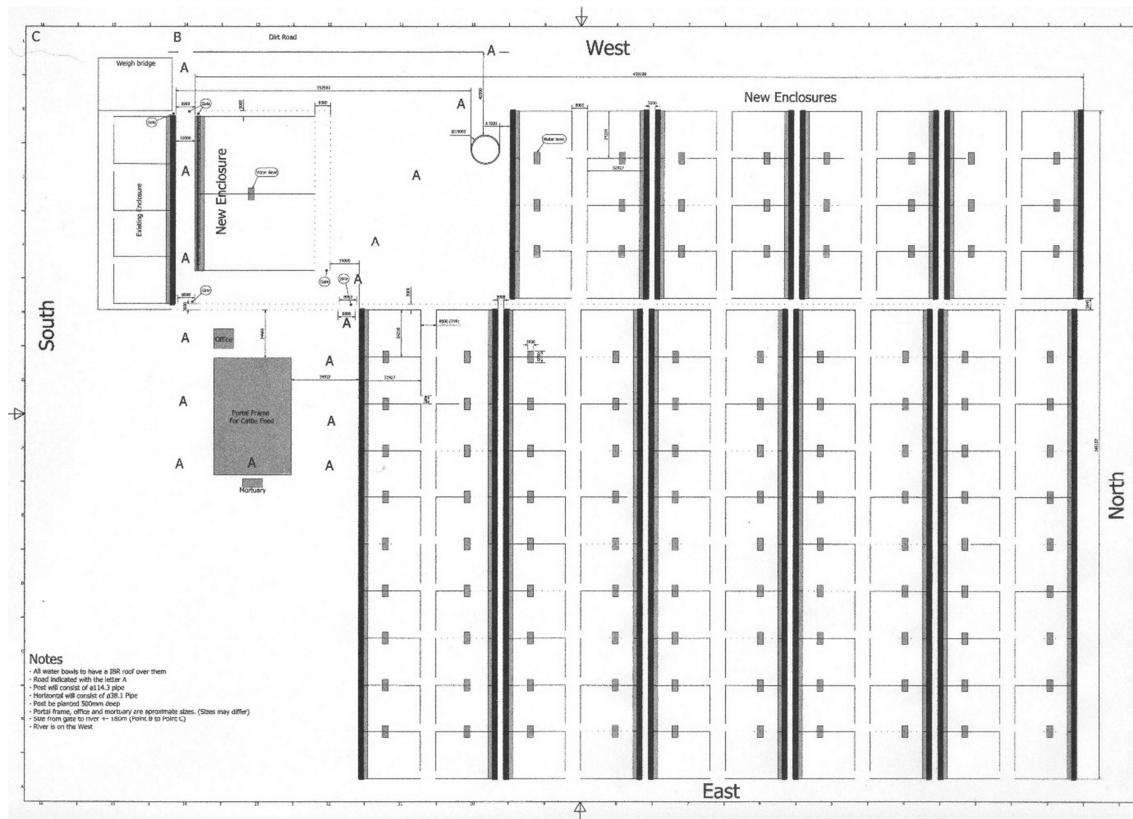


Figure 2: Schematic diagram of the feedlot details (provided by the client).

## 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' representativity 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 feedlot site. 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 2526 Rustenburg.

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

Symbol	Group/Formation	Lithology	Approximate Age
Q	Quaternary	Alluvium, sand, calcrete	Neogene, ca 2.5 Ma to present

Symbol	Group/Formation	Lithology	Approximate Age
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 180 Ma
Di	diabase	Intrusive volcanic rock diabase	Post Transvaal SG
Vsi	Silverton Fm, Pretoria Group, Transvaal SG	Upper: Slate, shale hornfels Lower: as above but graphitic	Central intrusion = ca 2205 Ma
Vdq	Daspoort Fm, Pretoria Group, Transvaal SG	Quartzite	<2240 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.

In the Transvaal Basin the Transvaal Supergroup is divided into two Groups, the lower Chuniespoort Group and the upper Pretoria Group (with ten formations; Eriksson et al., 2006). The Chuniespoort Group is divided into the basal Malmani Subgroup that comprises dolomites and limestones and is divided into five formations based on chert content, stromatolitic morphology, intercalated shales and erosion surfaces. The top of the Chuniespoort Group has the Penge Formation and the Deutschland Formation.

The Hekpoort, Dwaalheuwel, Strubenkop and Daspoort Formations form a sequence as the middle part of the Pretoria Group, Transvaal Supergroup, and represent rocks that are over 2060 million years old. The Hekpoort Formation is a massive lava deposit and is overlain by the Dwaalheuwel conglomerates, siltstone and sandstone (not present here). A hiatus separates the Strubenkop Formation slates and shales from the overlying quartzites of the Daspoort Formation.

The Transvaal sequence has been interpreted as three major cycles of basin infill and tectonic activity with the first deep basin sediments forming the Chuniespoort Group, the second cycle deposited the lower Pretoria Group, and the sediments in this area are from the interim lowstand that preceded the third cycle. These sediments were deposited in shallow lacustrine, alluvial fan and braided stream environments (Eriksson et al., 2012).

The Pretoria Group 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 et al., 2006, 2012 and collaborators 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 Rooihoogte and Timeball Hill Formations, and the third shallow embayment is represented by the Daspoort, Silvertown and Magaliesberg Formations.

There is an unconformity between the Strubenkop shales and the overlying Daspoort Formation. In the east of the Transvaal Basin the latter is composed of mature quartz arenites and subordinate mudrocks and ironstones, but in the west of the basin it is mostly made up of immature sandstones, pebbly arenites, conglomerates and mudrocks (Eriksson et al., 2006). This formation probably represents a fluvial setting succeeded by a shallow marine setting that was the precursor to a major transgression that formed the succeeding Silvertown Formation (Erikson et al., 2006). At the top of the Daspoort Formation are localised occurrences of stromatolitic carbonates and cherts (ibid).

Within the **Silvertown 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 Silvertown 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).

After the deposition of the Transvaal Supergroup sediments some volcanic activity resulted in the intrusion of these sediments by dykes so there are ribbons of diabase cutting through these sediments. In more recent times erosion and deposition of sands and soils has resulted in the deposition of Quaternary sands and alluvium, especially along the rivers.

## ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The site for development is in the lower part of the Silvertown Formation.

The palaeontological sensitivity of the area under consideration is presented in Figures 3 and 4. The site for development is in the Silvertown 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 Silvertown 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 fossils were microscopic algae and bacteria which if preserved, are in the form of the trace fossils such as stromatolites or microbial mats. There are 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.

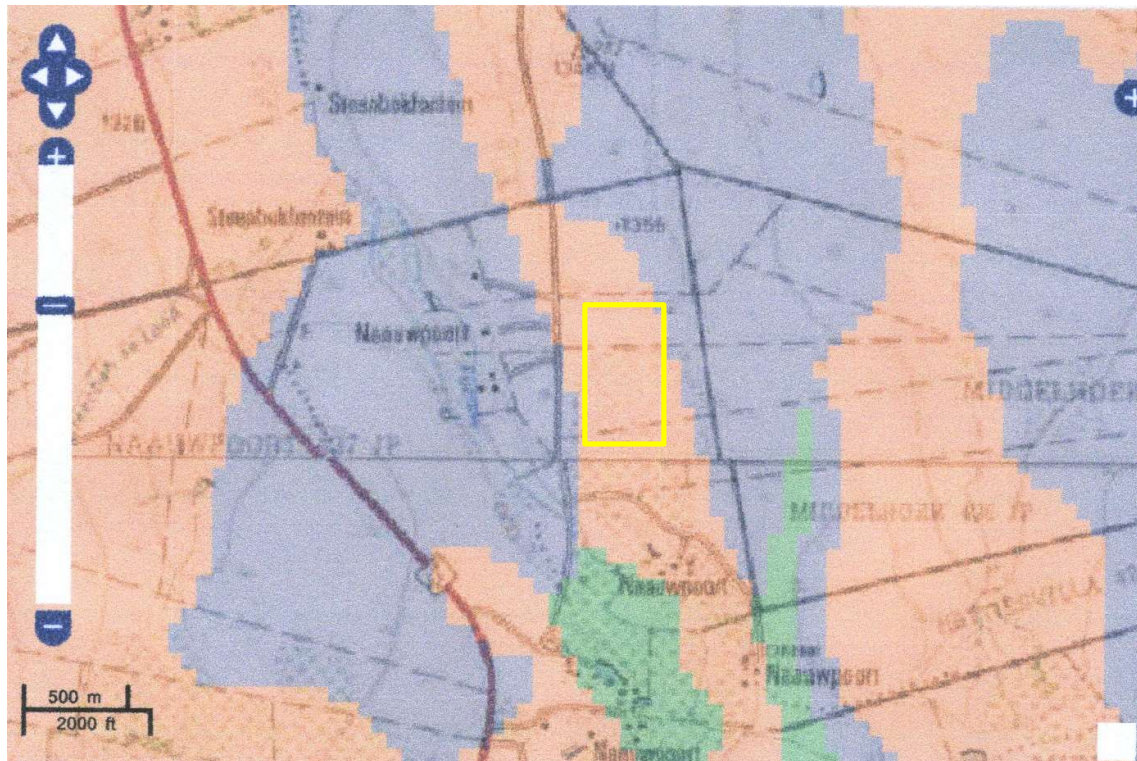


Figure 4: SAHRIS palaeosensitivity map for the site for the proposed feedlot expansion project shown within the yellow rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.



## 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 (of exposure to impacts)</b>	<b>H</b>	Definite/ Continuous
	<b>M</b>	Possible/ frequent
	<b>L</b>	Unlikely/ seldom

**TABLE 3B: IMPACT ASSESSMENT**

<b>PART B: ASSESSMENT</b>		
<b>SEVERITY/NATURE</b>	<b>H</b>	-
	<b>M</b>	-
	<b>L</b>	So far there are no records of stromatolites from the Silverton Fm but their presence is implied in the PTR for the North West Province. 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 only the possible fossils within the area would be trace fossils such as stromatolites, the spatial scale will be localised within the site boundary.
	<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 sand and soil that will be impacted. Nonetheless a Fossil Chance Find Protocol should be added to the eventual EMP.

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 fossils or of the wrong type. Furthermore, the material to be excavated for foundations and amenities is likely to be surface soils and these do not preserve fossils. Since there is an extremely small chance that fossils from the Silverton Formation 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 very 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, quartzites, sandstones, shales and sands are typical for the country and do not contain fossil plant, insect, invertebrate and vertebrate material. 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 or trace fossils would be preserved in the shales, slates and hornfels of the Silverton Formation (Pretoria Group, Transvaal Supergroup), although this is implied in the PTR (Palaeotechnical Report) for the North West Province. No fossils have been reported and the sedimentology indicates that the shales were deposited in deep water environments as opposed to shallow water that would be required for the growth of algal colonies that would have produced stromatolites. Since there is a very small chance that fossil may occur in the shales a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found once excavations for foundations and amenities has commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample.

## 7. References

Eriksson, P.G., Altermann, W., Hartzer, F.J., 2006. The Transvaal Supergroup and its precursors. 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.

- 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.
- Lenhardt, N., Eriksson, P.G., Catuneanu, O., Bumby, A.J., 2012. Nature of and controls on volcanism in the ca. 2.32–2.06 Ga Pretoria Group, Transvaal Supergroup, Kaapvaal Craton, South Africa. *Precambrian Research* 214–215, 06–123.
- 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

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

1. The following procedure is only required if fossils are seen on the surface and when drilling/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 (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 5). 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 Malmani Subgroup.

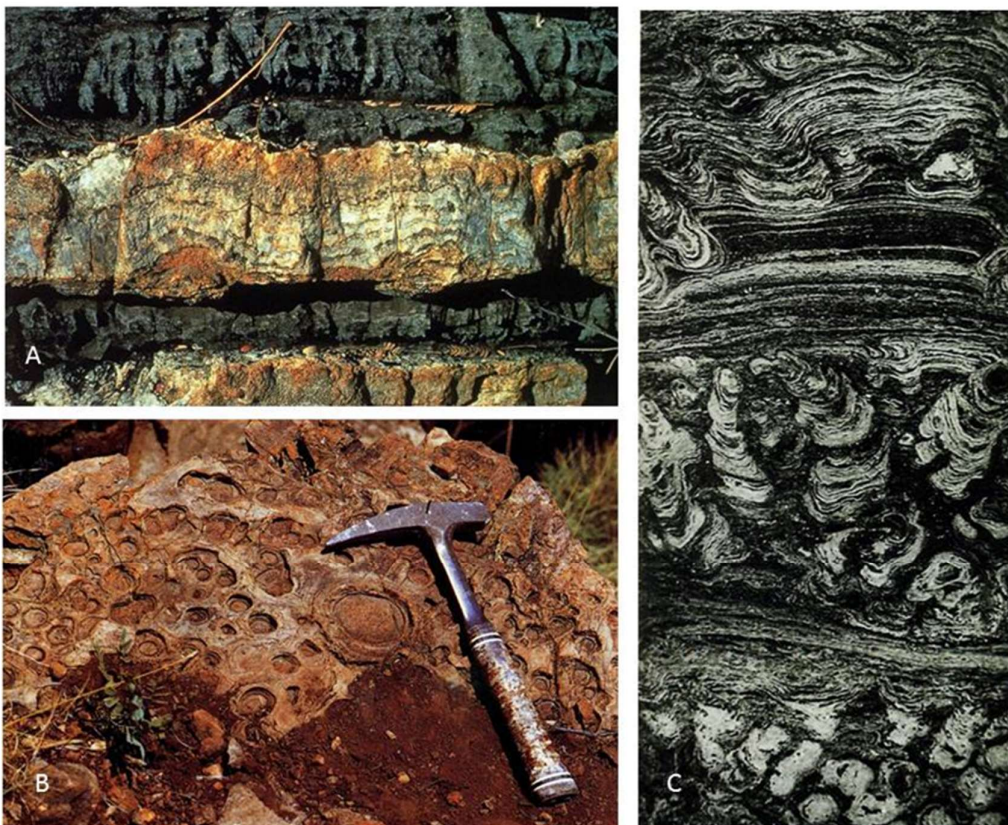


Figure 5: examples of stromatolites, a - in the field in side view; b – surface view in the field; c – side view in section. (Photographs from MacRae, 1999. Life etched in Stone).



## Appendix B – Details of specialist

### Curriculum vitae (short) - Marion Bamford PhD January 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-  
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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	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

#### **xi) Research Output**

Publications by M K Bamford up to December 2019 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)

