Palaeontological Impact Assessment for the proposed N4 Schoemanskloof R539 road upgrade, Mpumalanga Province

Desktop Study (Phase 1)

For

Beyond Heritage

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Expertise of Specialist

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Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Beyond Heritage, Modimolle, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

A Palaeontological Impact Assessment was requested by SAHRA (Case ID:18255) for the Proposed upgrade of the Schoemankloof road, R539 between its junctions with the N4, Mpumalanga Province because of the high number of road accidents.

To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development.

The R539 mostly lies on ancient rocks of the Transvaal Supergroup with some sections on Quaternary alluvium in the valleys. Some formations of the Pretoria Group (Transvaal Supergroup) have stromatolites or microbial trace fossils and are considered highly sensitive for palaeontology. Only a short section (about 800m near Koedoeshoek and Crocgrove) occurs on the very highly sensitive Malmani Subgroup that could have stromatolites. The route is already very disturbed from the road and servitude, as are the minor roads that join the R539. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological impact assessment is required unless fossils are found by the contractor, environmental officer or other designated responsible person once excavations or drilling have commenced. Since the impact will be low, as far as the palaeontology is concerned, the project should be authorised.

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1. Background

SANRAL is proposing road upgrades and improvements to the existing Schoemanskloof Route (R539) in order to improve traffic flow speeds and improve safety. This will be undertaken by lengthening existing overtaking lanes, introducing new overtaking lanes, re-aligning certain sections, introducing road safety upgrades and introducing formal and safer intersections to reduce the high number of informal access roads of the R539. These activities will take place along the existing Schoemanskloof R539 road is situated between eNtokozweni (Machadodorp) and Mbombela (Nelspruit) in the Mpumalanga Province of South Africa.

SANRAL (SOC) Ltd have appointed Prism Environmental Management Services (Pty) Ltd to undertake an Scoping and Environmental Impact Assessment application process in support for an Environmental Authorisation (EA) application for the upgrade the Schoemanskloof Route (539) between eNtokozweni and a T-Junction between the N4 and R539.

SAHRA has requested that a palaeontological impact assessment be completed for this project (SAHRA Case Id:18255).

The Basic Assessment process assessed design options regarding the Schoemanskloof Road Upgrade Project. The options were determined from the below list of alternatives investigated by the design engineers. These included:

- Option A: Introduce shoulders to the existing route, instead of passing lanes
- Option B: Upgrading to an undivided dual carriageway for the entire Schoemanskloof Road
- Option C: Upgrading the Elandsvalley/Ngodwana route instead of Schoemanskloof
- Option D: Inclusion of consolidated accesses and associated access roads
- Option E: Inclusion of consolidated accesses and associated access roads and introducing road safety upgrades and features on either end of- and along the existing bend at Poplar Creek
- **Option F: Inclusion of consolidated accesses and associated access roads and re-alignment of the existing bend at Poplar Creek**
- Option G: Do nothing option

The preferred option from the Basic Assessment Process was found to be Option F, which was assessed as Alternative 2 in the Basic Assessment Report which is described as: *Upgrades of Schoemanskloof Road inclusive of lengthening of passing lanes, widening some lanes and re-aligning certain sections; taking into account inclusion of consolidated accesses and associated access roads, and introducing road safety upgrades and features on either end of- and along the existing bend at Poplar Creek.*

A Palaeontological Impact Assessment (PIA) was completed for the Schoemanskloof R539 road upgrade project. To comply with the regulations of the South African Heritage

Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), and is reported herein.

Table 1: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report,	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
k	Any mitigation measures for inclusion in the EMPr	Section 8, Appendix A
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8, Appendix A

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
nii	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Sections 6, 8
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A
p	A summary and copies of any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A
2	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

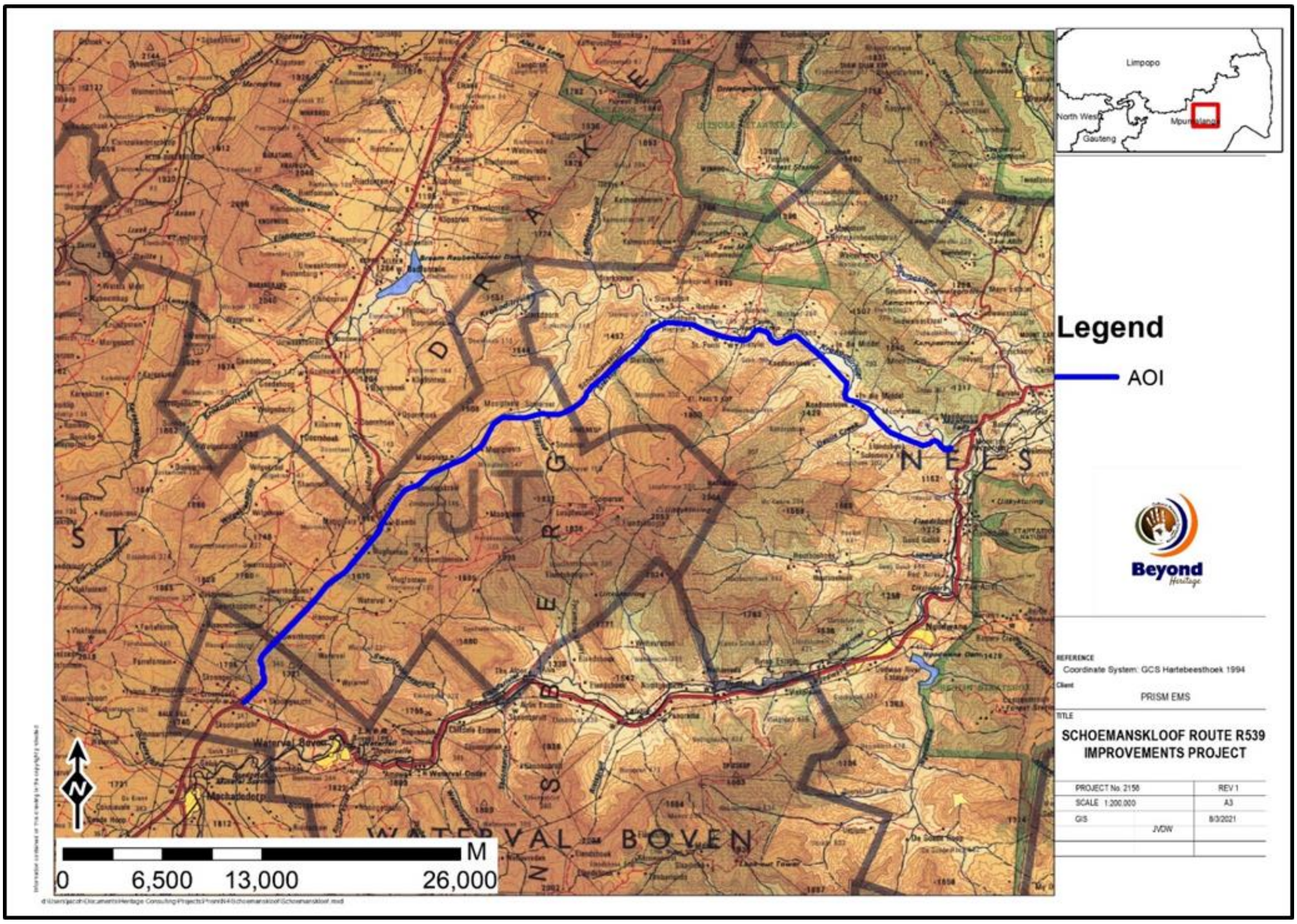

Figure 1: Topographic Map of the area and proposed road upgrade on the R539 from where it joins the N4 in the west and the east. Note – the minor roads that join the R539 are not visible at this scale. Map supplied by Beyond Heritage.

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 include 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

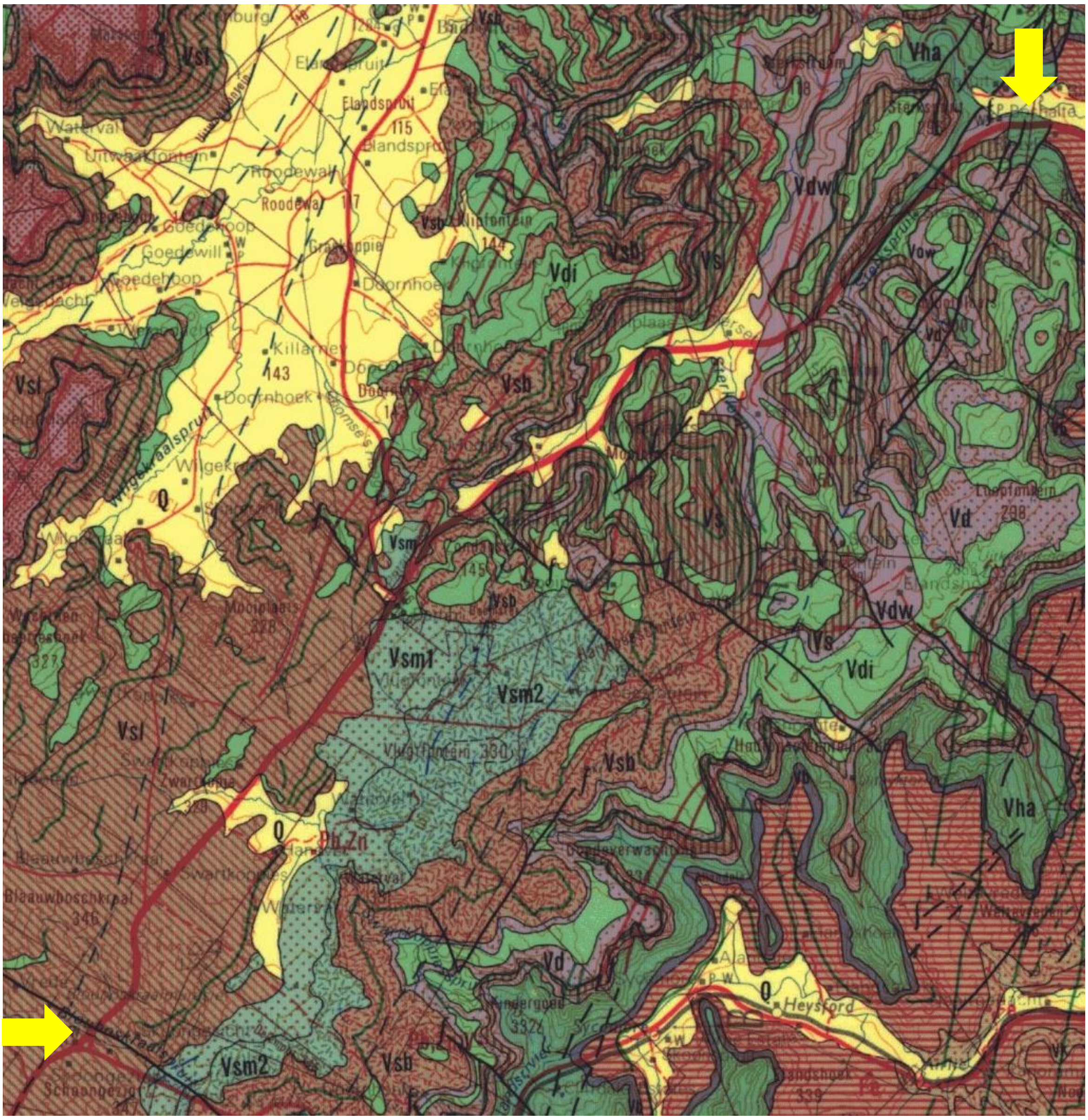

Figure 2: Geological map of the area along the R539 (red line) from the southwest to its northern-most point (arrows). See Figure 3 for the eastern section. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2530 Barberton.

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	Quaternary, ca 1.0 Ma to present

Symbol	Group/Formation	Lithology	Approximate Age
Vdi	Diabase	Intrusive volcanic dykes and sills	Post Transvaal SG
Vsq	Steenkampsberg Fm, Pretoria Group, Transvaal SG	Quartzite, subordinate shale	<2124 Ma
Vv	Vermont Fm, Pretoria Group, Transvaal SG	Hornfels, minor quartzite, limestone, chert	<2112 Ma
Vm	Magaliesberg Fm, Pretoria Group, Transvaal SG	Quartzite, minor hornfels	<2080 Ma
Vsi	Silverton Fm, Pretoria Group, Transvaal SG	Shale, carbonaceous in places, hornfels, chert	Ca 2202 Ma
Vsm	Machadadorp Mbr, Silverton Fm, Pretoria Group, Transvaal SG	Tuff, agglomerate, lava	
Vdw	Dwaalheuvel Fm, Pretoria Group, Transvaal SG	Quartzite with interbeds of shaley quartzite and shale	
Vt	Timeball Hill Fm Pretoria Group, Transvaal SG	Shale, siltstone, conglomerate in places; dotted = Quartzite	Ca 2316 – 2266 Ma
Vs	Strubenkop Fm, Pretoria Group, Transvaal SG	Shale, sandstone, hornfels	
Vmd	Malmani SG, Chuniespoort Group, Transvaal SG	Dolomite, chert	Ca 2585 – 2480 Ma
Vbr	Black Reef Fm, Transvaal SG	Quartzite, conglomerate, shale	<2618 Ma
Zn	Nelspruit Suite	Biotite granite	Archaean >3400 Ma

The project lies in the eastern part of the Transvaal Basin that is composed of the Transvaal Supergroup sediments and volcanic rocks. It unconformably overlies the ancient basement of the Nelspruit Suite in the east. In the valley there is Quaternary alluvium and sands.

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.

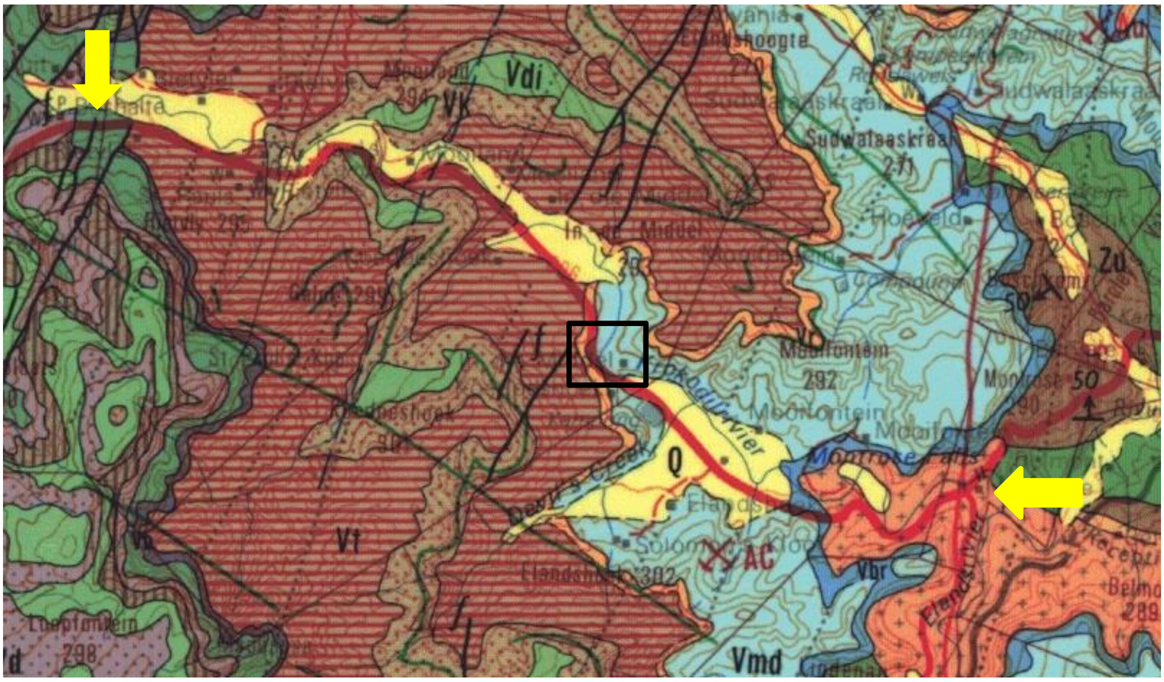

Figure 3: Geological map along the eastern route of the R539 with arrows from the northernmost point (overlapping with Figure 2) to the eastern point where it intersects with the N4 again. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2530 Barberton. Black square – see Fig 6-7.

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.

Making up the lower Pretoria Group are the **Timeball Hill Formation** and the Boshoek 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. Upper Pretoria Group formations are the **Silverton, Magaliesberg, Vermont**, Lakenvalei, Nederhorst, **Steenkampsberg** and Houtenbek Formations

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).

In the river valleys are sands and alluvium that have been eroded from the catchment area and deposited.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The R539 transects all the formations highlighted in bold above. Since the area has been compressed by tectonic activity the rocks have been contorted and folded so they are repeated across the route.

The Transvaal Supergroup sequence of sedimentary and volcanic rocks has been interpreted as having undergone three cycles of tectonically controlled basin subsidence and infilling with clastic deposits from the west and northwest. The first cycle (Chuniespoort Group) was a shallow seaway in a marine environment where the carbonate platform (**Malmani Subgroup**) was deposited and has a variety of limestones and dolomite (Erikson et al., 2012). The different lithofacies represent different depths of formation of carbonates, for example, intertidal zone, high energy zone and shallow subtidal deposits are limestone and dolomite, with flat domes and columnar stromatolites being formed in the intertidal zone. In the high energy zone oolites, oncolites and ripples were formed, while in the deep tidal zone elongated stromatolitic mounds were formed (Truswell and Eriksson, 1973; Eriksson and Altermann, 1998).

After a hiatus of about 80 Myr, the second cycle (Duitschland, Rooihoogte and Timeball Hill Formations) occurred under glacial influence. The stromatolites in the **Timeball Hill** Formation are questionable but they are present in the Duitschland Formation (Schrôder et al., 2016).

The third cycle after a brief hiatus, represented by the rest of the Pretoria Group, was deposited in a shallow embayment. Carbonates (not necessarily stromatolites) are reported from the upper Silverton Formation, the Houtenbeck and Vermont Formations. From the **Magaliesberg Formation** there have been several reports of microbial features. No fossils are recorded from the Rayton Formation, and the upper Pretoria Group rocks are not listed in the Palaeotechnical report for Gauteng (Groenewald et al., 2014), however the rocks are quartzites and shales like the underlying members of the Pretoria Group. Since Parizot et al., (2005) first recorded microbial mat features from the Magaliesberg Formation north of Pretoria, a number of other occurrences have been reported in this formation (Bosch and Eriksson, 2008; Eriksson et al., 2012).

Bosch and Eriksson (2008) described crack-like features, vermiform structures and circular imprints resembling concretions or, possibly oncolites, that occur on sand sheet surfaces within the uppermost beds of the **Magaliesberg Formation**. They indicated two localities, one north of Pretoria, on the farm Baviaanspoort 330 JR and the other on the farm Rietvlei 518 JR, east of Pretoria. Leeuwpoort is northeast of Pretoria. The presence of such microbial mat-like features are found in epeiric marine tidally dominated coastline. The rhythmic alternation of water levels inherent in such settings can explain desiccation of microbial mats growing on the sandy substrates formed within the palaeoenvironment. In addition, the shifting loci of deposition were probably also related to braided fluvial inputs, through the medium of braid deltas (Bosch and Eriksson, 2008).

Stromatolites are the trace fossils that were formed by colonies of green algae and blue-green algae (Cyanobacteria) that grew in warm, shallow marine settings. These algae were responsible for releasing oxygen via the photosynthetic process where atmospheric carbon dioxide and water, using energy from the sun, are converted into carbon chains and compounds that are the building blocks of all living organisms. The released carbon dioxide initially was taken up by the abundant reducing minerals to form oxides, e.g. iron oxide. Eventually free oxygen was released into the atmosphere and some was converted into ozone by the bombardment of cosmic rays. The ozone is critical for the filtering out of harmful ultraviolet rays.

Stromatolites are the layers upon layers of inorganic materials that were deposited during photosynthesis, namely calcium carbonate, magnesium carbonate, calcium sulphate and magnesium sulphate. These layers can be in the form of flat layers, domes or columns depending on the environment where they grew (Beukes, 1987). Some environments did not form stromatolites, just layers of limestone that later was converted to dolomite. The algae that formed the stromatolites are very rarely preserved, and they are microscopic so they can only be seen from thin sections studies under a petrographic microscope.

Microbialites (sensu Burne and Moore, 1987) are organo-sedimentary deposits formed from interaction between benthic microbial communities (BMCs) and detrital or chemical sediments. In addition, microbialites contrast with other biological sediments in that they are generally not composed of skeletal remains. Archean carbonates mostly consist of stromatolites. These platforms could have been the site of early O2 production on our planet. Stromatolites are the laminated, organo-sedimentary, non-skeletal products of microbial communities, which may have included cyanobacteria, the first photosynthetic organisms to produce oxygen. Another type of trace fossil has been termed Microbially-induced sedimentary structures (MISS sensu Noffke et al., 2001) or simply 'fossil mats' (sensu Tice et al., 2011). These include swirls, rip-ups, crinkled surfaces and wrinkles that were formed by the mucus extruded by littoral algae or microbes and bound together sand particles. Davies et al. (2016) caution against the assumption that all such structures are microbially induced unless there is additional evidence for microbes in the palaeoenvironment.

Nonetheless, stromatolites and microbialites are accepted as trace fossils of algal colonies. MISS could be microbially or abiotically formed. The oldest stromatolites have been recorded from the Barberton Supergroup that was deposited between 3.55 to ca. 3.20 Ga, and stromatolites still form today in warm, shallow seas (Homan, 2019).

Quaternary aeolian sands and alluvium are fairly mobile and very porous so they not provide suitable conditions for preservation of organic matter (Cowan, 1995). Only in places where the sands have been waterlogged, such as palaeo-pans or palaeo-springs, is there any chance of fossilisation. For example, roots can be encased in calcium-rich or silica-rich sands and crusts, known as rhizoliths or rhizocretions, can form around the roots, invertebrates or bones around the margin of a pond, pan or spring (Klappa, 1980; Cramer and Hawkins, 2009; Peters et al., 2022).

Table 3: Summary of the fossils that could be found in each of the Formations intersected along the route.

Symbol	Group/Formation	Fossils. Colour coded for palaeosensitivity
Q	Quaternary	Rare transported fragmentary bones, wood, rhizoliths
Vdi	Diabase	None
Vsq	Steenkampsberg Fm,	Microbialites (?)
Vv	Vermont Fm,	Stromatolites (?)
Vm	Magaliesberg Fm,	Microbialites
Vsi	Silverton Fm,	Stromatolites (?)
Vsm	Machadadorp Mbr,	None
Vdw	Dwaalheuvel Fm,	None
Vt	Timeball Hill Fm	Microbialites (?)
Vs	Strubenkop Fm,	None
Vmd	Malmani SG,	Stromatolites
Vbr	Black Reef Fm,	None
Zn	Nelspruit Suite	None

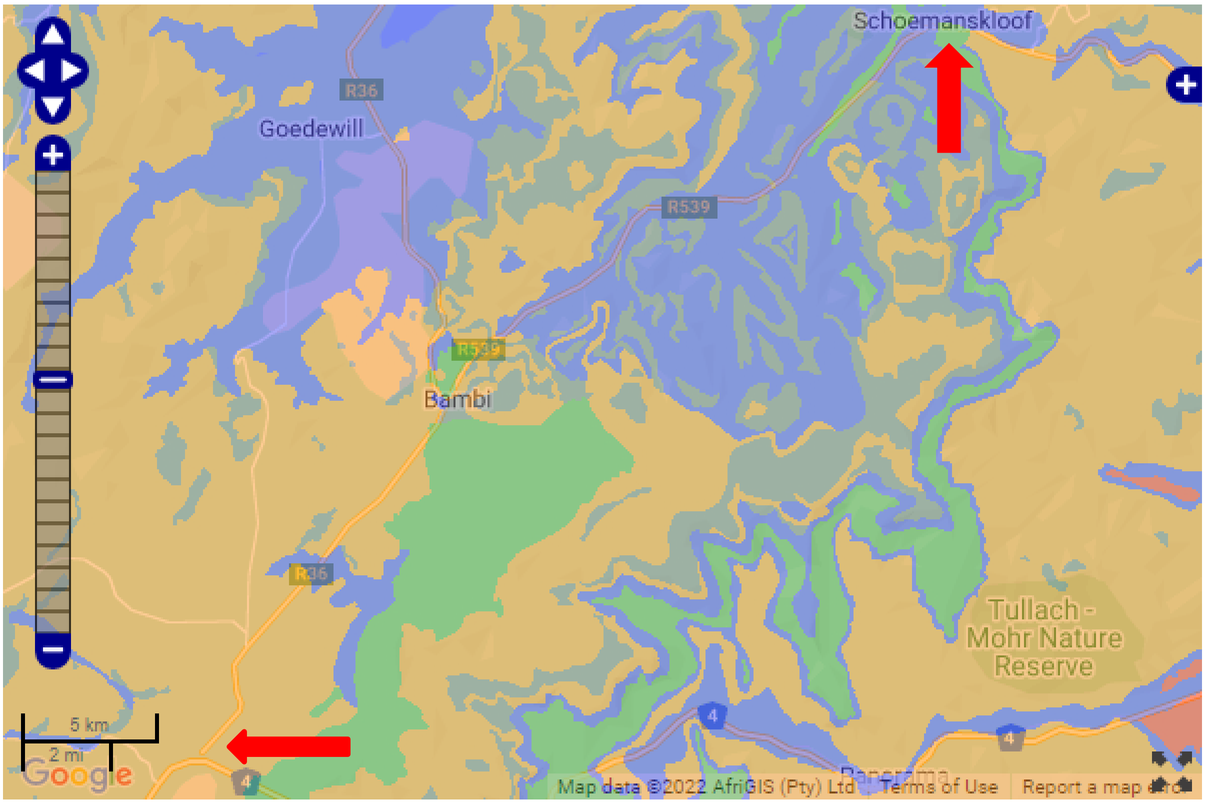

Figure 1: SAHRIS palaeosensitivity map from the southwestern start of the R539 to its northernmost part (arrows) representing Figure 2. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

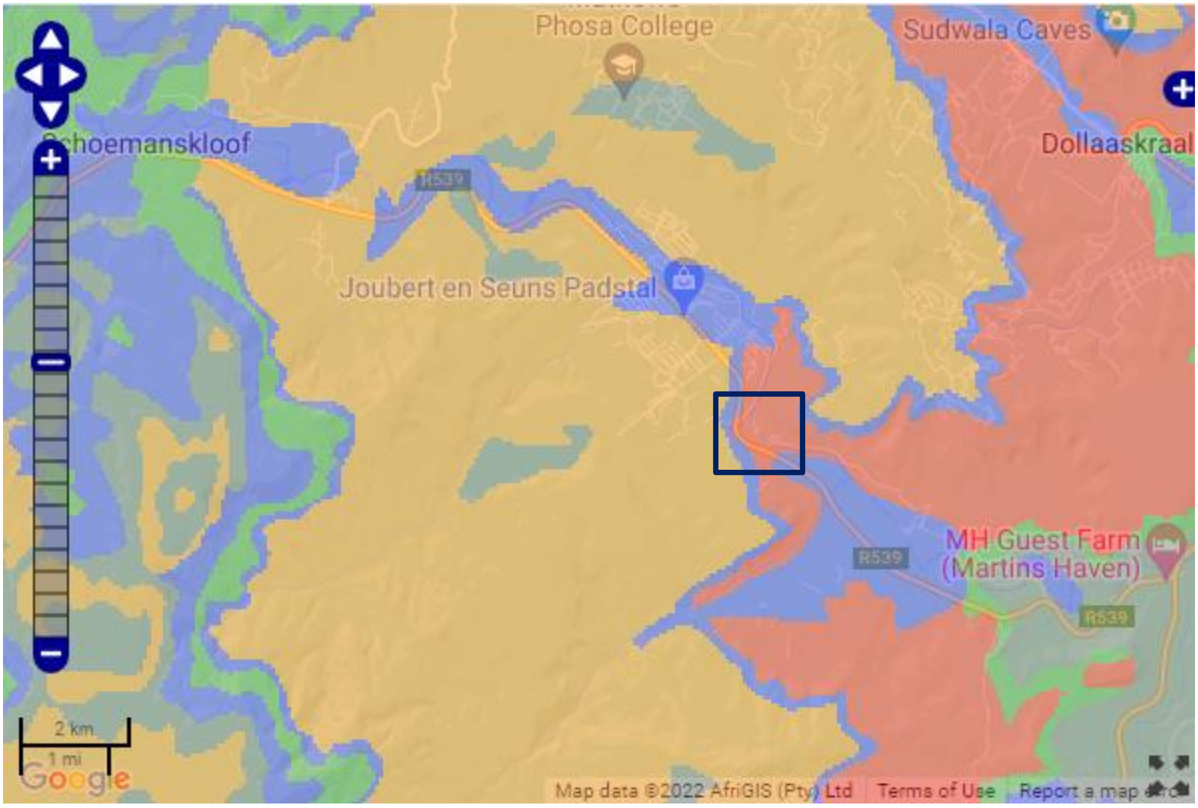

Figure 5: SAHRIS palaeosensitivity map from the eastern section of the R539 from its northernmost part to the junction with the N4 (arrows) as for Figure 3. Note the scales are different. Background colours as for Figure 4. Black square enlarged in Figure 6.

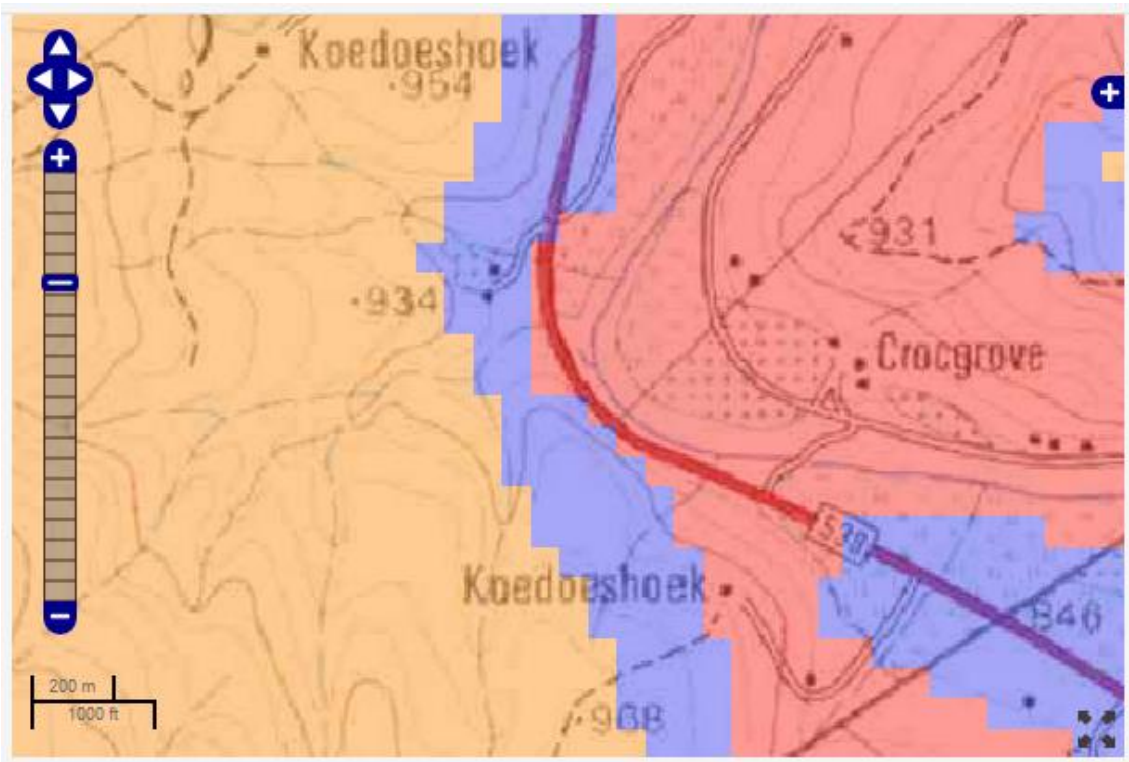

Figure 6: SAHRIS palaeosensitivity map of the section indicated in Figure 5. Note the scales are different. Background colours as for Figure 4.

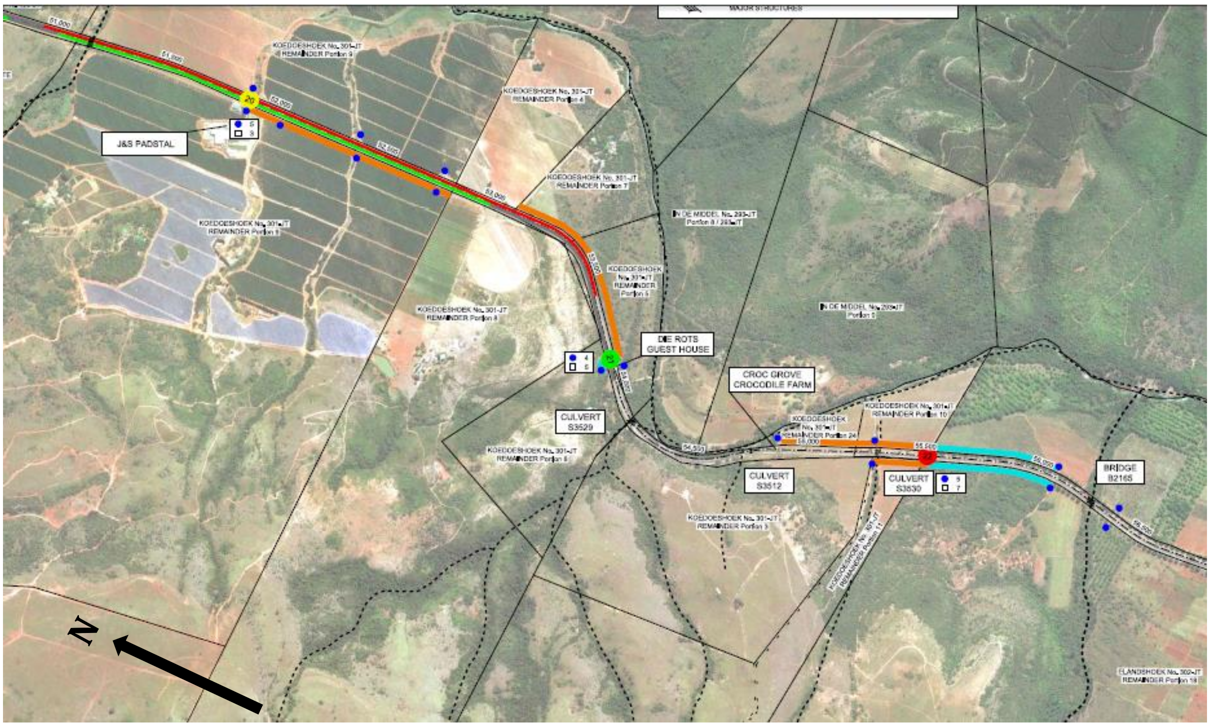

Figure 7: Annotated aerial map to show the planned upgrade for the Koedoeshoek bend upgrade.

From the SAHRIS map above the section of road that is indicated as very highly sensitive (red) is about 800m long and is already disturbed by the road itself and the servitude. No trace fossils such as stromatolites would remain in this footprint. If excavations of new rock are required for the upgrade and possible re-alignment of the road then fossils might occur there. This is the only section along the entire route that is indicated as very highly sensitive.

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	Volcanic rocks and soils do not preserve fossils; so far there are no records from the Malmani Subgroup, or Pretoria Group of microbial mats, traces or stromatolites in this region so it is very unlikely that fossils occur on the site. The impact would be negligible
	L+	-
	M+	-
	H+	-
DURATION	**L**	-
	M	-
	H	Where manifest, the impact will be permanent.
SPATIAL SCALE	**L**	Since the only possible fossils within the area would be fossil trace fossils such as microbial mats or stromatolites in the dolomites or shales, the spatial scale will be localised within the site boundary.
	M	-
	H	-

PART B: Assessment		
PROBABILITY	**H**	-
	M	-
	L	It is extremely unlikely that any fossils would be found in the loose soils and sands that cover the area or in the road margins that will be disturbed. There is a small chance that stromatolites occur in the unbroken ground of the Malmani Subgroup (800m section). 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 most of the rocks are either much too old to contain fossils or of the incorrect type. Furthermore, the material to be excavated is soils and this does not preserve fossils. Since there is an extremely small chance that stromatolites from the Malmani Subgroup for an 800m section and may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low.

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the dolomites, sandstones, shales and sands are typical for the country and only some contain trace fossils such as microbial mats, microbialites or stromatolites. The sands of the Quaternary period would not preserve fossils. The area / route is already highly disturbed from the road, servitude and minor roads joining the R539.

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 soils of the Quaternary. There is a very small chance that trace fossils may occur in the dolomites or shales of the Malmani Subgroup or Pretoria Group, respectively, so a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found by the contractor, environmental officer, or other responsible person once excavations alongside the road and also for the minor roads that adjoin the R539, have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample. The most sensitive section is in the eastern section for the bend around Koedoeshoek and Crocgrove for about 800m of the road (Figures 6-7). The impact on the palaeontological heritage would be low, therefore as far as the palaeontology is concerned, the project should be authorised.

7. References

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8. Chance Find Protocol

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

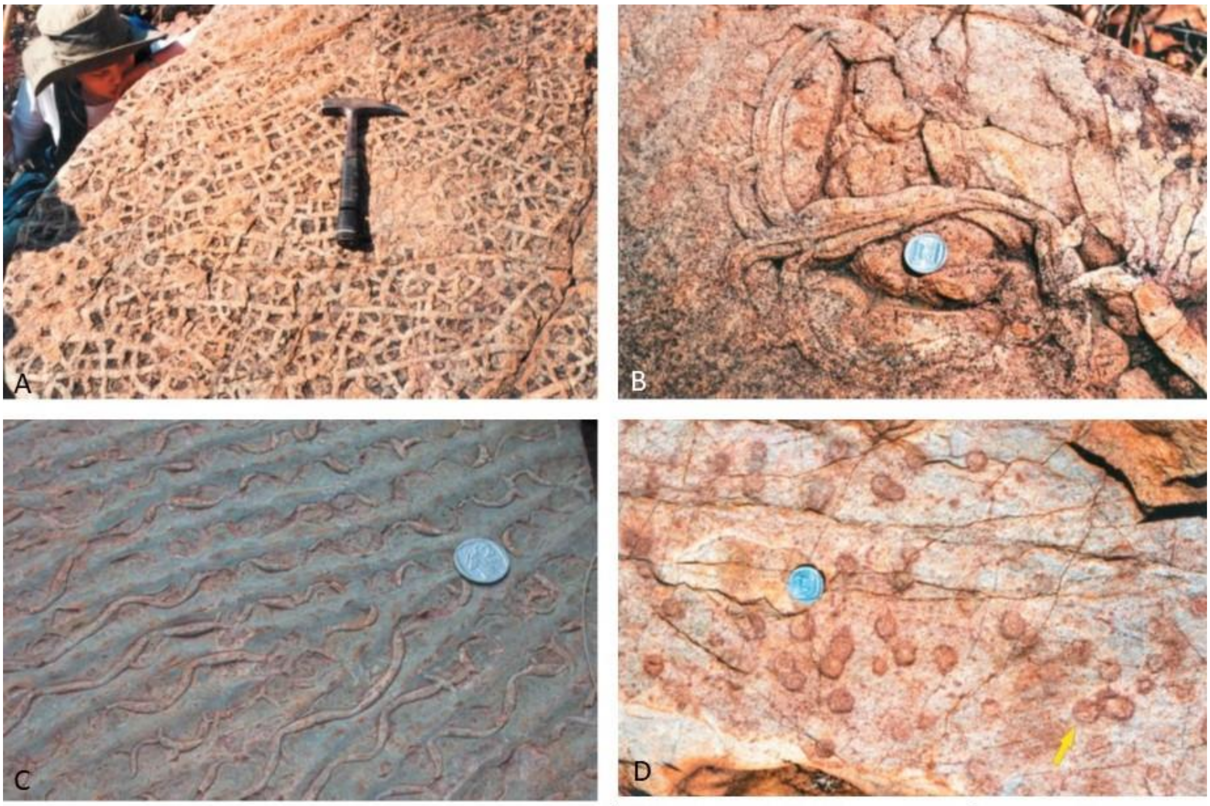
1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone or coal) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of similar fossils must be provided to the developer to assist in recognizing the trace fossils such as stromatolites or microbially features (trails, curls, rip-ups, mudcracks) trace fossils in the dolomites, limestones,

shales and mudstones (for example see Figure 7-8). 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 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.

9. Appendix A – Examples of trace fossils from the Malmani Subgroup and Pretoria Group

Figure 7: Photographs from the Malmani Subgroup of different types of stromatolites in dolomite.



Magaliesberg Fm trace fossils, near Pretoria (all from Bosch & Eriksson, 2008): A – cracks,. B – sinuous structure, C – *Manchuriphycus*, D – circular structures. R1 coin for scale.

Figure 8: Photographs of microbial features from the Magaliesberg Formation (in Bosch and Eriksson, 2008)

10. Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD June 2022

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.
NRF Rating: C-2 (1999-2004); B-3 (2005-2015); B-2 (2016-2020); B-1 (2021-2026)

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	13	0
Masters	12	2
PhD	13	4
Postdoctoral fellows	15	2

viii) Undergraduate teaching
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 45 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 12-20 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 –
Associate Editor Open Science UK: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international journals
Reviewing of funding applications for NRF, PAST, NWO, SIDA, National Geographic, Leakey Foundation

x) Palaeontological Impact Assessments

Selected from the past five years only – list not complete:

- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for EnviroPro
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for EnviroPro
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe
- Wolf-Skilpad-Grassridge Eskom line for Zutari
- Iziduli and Msengi WEFs, Eastern Cape for CTS Heritage
- Dealesville Springhaas SEFs for ASHA

xi) Research Output

Publications by M K Bamford up to June 2022 peer-reviewed journals or scholarly books: over 165 articles published; 5 submitted/in press; 12 book chapters.
Scopus h-index = 30; Google scholar h-index = 35; -i10-index = 92
Conferences: numerous presentations at local and international conferences.