Appendix G.7

PALAEONTOLOGICAL IMPACT ASSESSMENT

Palaeontological Impact Assessment for the proposed Igolide WEF, north of Fochville and southeast of Carltonville, Gauteng Province

Desktop Study (Phase 1)

For

ASHA Consulting (Pty) Ltd & WSP

14 May 2023

Prof Marion Bamford
Palaeobotanist
P Bag 652, WITS 2050
Johannesburg, South Africa
Marion.bamford@wits.ac.za

Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, mASSAf
Experience: 34 years research and lecturing in Palaeontology
26 years PIA studies and over 350 projects completed

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, Lakeside, 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 WSP for the proposed Igolide Wind Energy Facility (WEF). The WEF area Project footprint will be approximately 130 hectares (ha) (subject to finalization based on technical and environmental requirements) and include 12 turbines that are expected to produce up to 100MW. The Project is located approximately 6km northeast of Fochville, within the Merafong City Local Municipality in the Gauteng Province. (The Electrical Grid Infrastructure is in a separate report.)

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 study (Phase 1) Palaeontological Impact Assessment (PIA) was completed for the proposed development.

The proposed WEF lies on potentially highly sensitive rocks of the Timeball Hill Formation (northern part of the project area), and on moderately fossiliferous rocks of the Hekpoort and Silverton Formations (central and southeast, respectively). Based on the published records it is unlikely that any trace fossils such as stromatolites or microbialites, occur in the project footprint. 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 activities have commenced.

Any impact would only occur during the Construction Phase. **As far as the palaeontology is concerned, the impact will be low negative pre-mitigation and very low positive post-mitigation because prior to this the particular fossils or fossil deposit were unknown to science.; there is no no-go area for the turbines or infrastructure**.

Table of Contents

1. Background

The proposed Igolide Wind Energy Facility ("WEF") (hereafter "Project) will be operated under a Special Purpose Vehicle (SPV), Igolide Wind (Pty) Ltd (the "Proponent"). The project developer aims to =bid the Project into the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) or a similar procurement programme under the Integrated Resource Plan (IRP).

The proposed Project will be developed within a project area of approximately 680 hectares (ha). Within this project area, the extent of the Project footprint will be approximately 130 hectares (ha), subject to finalization based on technical and environmental requirements. The Project is located approximately 6km northeast of Fochville, within the Merafong City Local Municipality in the Gauteng Province.

The Project site, including the turbine locations, is indicated in Figure 1. The details of the properties associated with the proposed Project, are outlined in Table 1.

Figure 1: Annotated Google Earth map of the Igolide WEF and infrastructure. WTG--- are the turbines and yellow block is the onsite IPP Substation and BESS.

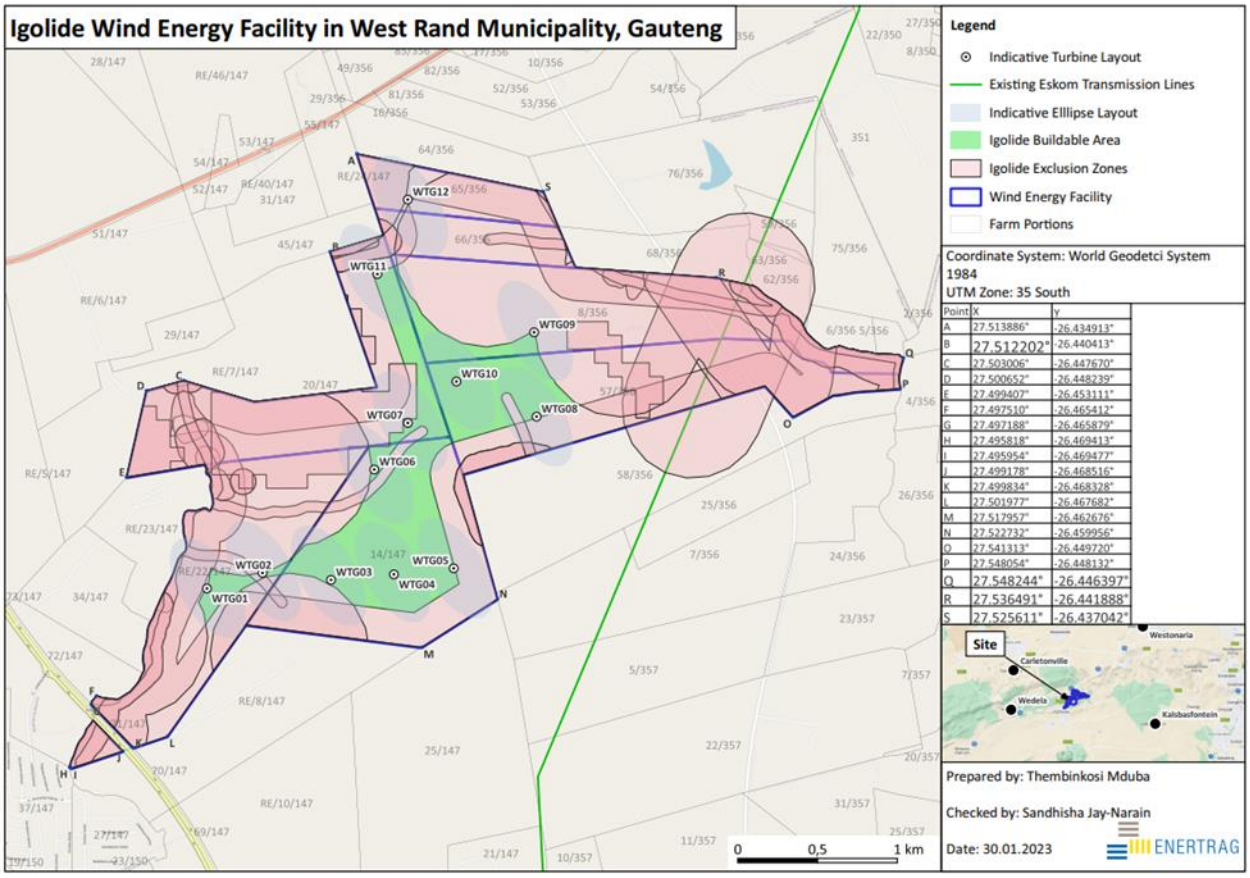

Figure 2: Project layout map to show the proposed layout of the wind turbines (WTG--) for the Igolide WEF plus the infrastructure. Map provided by the project developer.

Table 1: List of farm portions affected by the proposed project.

Farm Name	Farm No	Portions
LEEUWPOORT	356	8, 57, 65, 66
KRAALKOP	147	14, 20, RE/22

Table 2: Details of the Igolide Wind Energy Facility (WEF)

Facility Name:	Igolide Wind Energy Facility (WEF)
Applicant:	Igolide Wind (Pty) Ltd
Municipalities:	Merafong City Local Municipality in the Gauteng Province of South Africa
Extent:	680ha
Capacity:	Up to 100MW
No. of turbines:	12
Turbine hub height:	Up to 200m
Rotor Diameter:	Up to 200m
Tip Height :	Up to 300m

Foundation:	Approximately 25m diameter x 3m deep – 500 m^3 – 650m^3 concrete. Excavation approximately 2200m^3, in sandy soils due to access requirements and safe slope stability requirements.
Turbine Hardstand:	Hardstands do not require concrete. Area needed will be approximately 1ha per turbine required.
Tower Type	Steel or concrete towers can be utilised at the site. Alternatively, the towers can be of a hybrid nature, comprising concrete towers and top steel sections.
On-site IPP substation and battery energy storage system (BESS):	Total footprint will be up to 4ha in extent. The on-site IPP portion substation will have a footprint of approximately 2ha. The substation will consist of a high voltage substation yard to allow for multiple up to 132kV feeder bays and transformers, control building, telecommunication infrastructure, and other substation components, as required. A 500m buffer around the on-site IPP substation has been identified to ensure flexibility in routing the powerline. The Battery Energy Storage System (BESS) footprint will be up to 2ha. The BESS storage capacity will be up to 100MW/400 megawatt-hour (MWh) with up to four hours of storage. It is proposed that Lithium Battery Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology; however, the specific technology will only be determined following Engineering, Procurement, and Construction ("EPC") procurement. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers. The BESS components will arrive on site pre-assembled.
Grid (to form part of a separate application for EA)	A single or double circuit 132kV overhead powerline and 132kV switching station (adjacent to the on-site IPP substation) to feed the electricity generated by the proposed WEF into Eskom's Midas Main Transmission Substation via a 11km overhead line. A corridor of up to 250m in width (125m on either side of the centre line) has been identified for the placement of the up to 132kV single or double circuit power line to allow flexibility in the design of the final powerline route, and for the avoidance of sensitive environmental features (where possible).
Cables:	The medium voltage collector system will comprise cables up to and including 33kV that run underground, except where a technical assessment suggests that overhead lines are required, connecting the turbines to the on-site IPP.
Operations and Maintenance (O&M) building footprint:	Operations and Maintenance ("O&M") building footprint to be located near the on-site substation. Typical areas include: Conservancy tanks with portable toilets. Typical areas include: Operations building – 20m x 10m = 200m^2 Workshop and stores area – of ~300m^2 Refuse area for temporary waste storage and conservancy tanks to service ablution facility.

	The total combined area of the buildings will not exceed 5 000m^2.
Construction camps:	Typical area of 0.5ha. Sewage typically septic tanks and portable toilets.
Temporary laydown or staging areas:	Typical area of 2ha. Could increase to 3ha for concrete towers, should they be required. Will include diesel, cement and chemical storage, as well as a small workshop area.
Cement Batching Plant	Footprint of up to 1 - 3ha.
Access and Internal Roads:	Internal roads will have a width of 8 - 10m, increasing up to 15m for turning circle/bypass areas to allow for larger component transport. Existing access roads will be used to minimise impact. Where required, the width of the existing roads will be widened to ensure the passage of vehicles.
Supporting Infrastructure:	Fencing; Lighting; Lightning protection; Telecommunication infrastructure; Stormwater channels; Water pipelines; Offices; Operational control centre; Warehouse; Ablution facilities; Gatehouse; Security building; Visitor's centre; and Substation building.
Site coordinates (centre point)	26°27'2.44"S / 27°30'58.82"E

Table 3: 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

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
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	Spring
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	None
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;	Figures 2-4
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	Appendix A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8, Appendix A
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

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

The project lies in the Transvaal Basin with exposed strata of Transvaal Supergroup (Figure 3).

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.

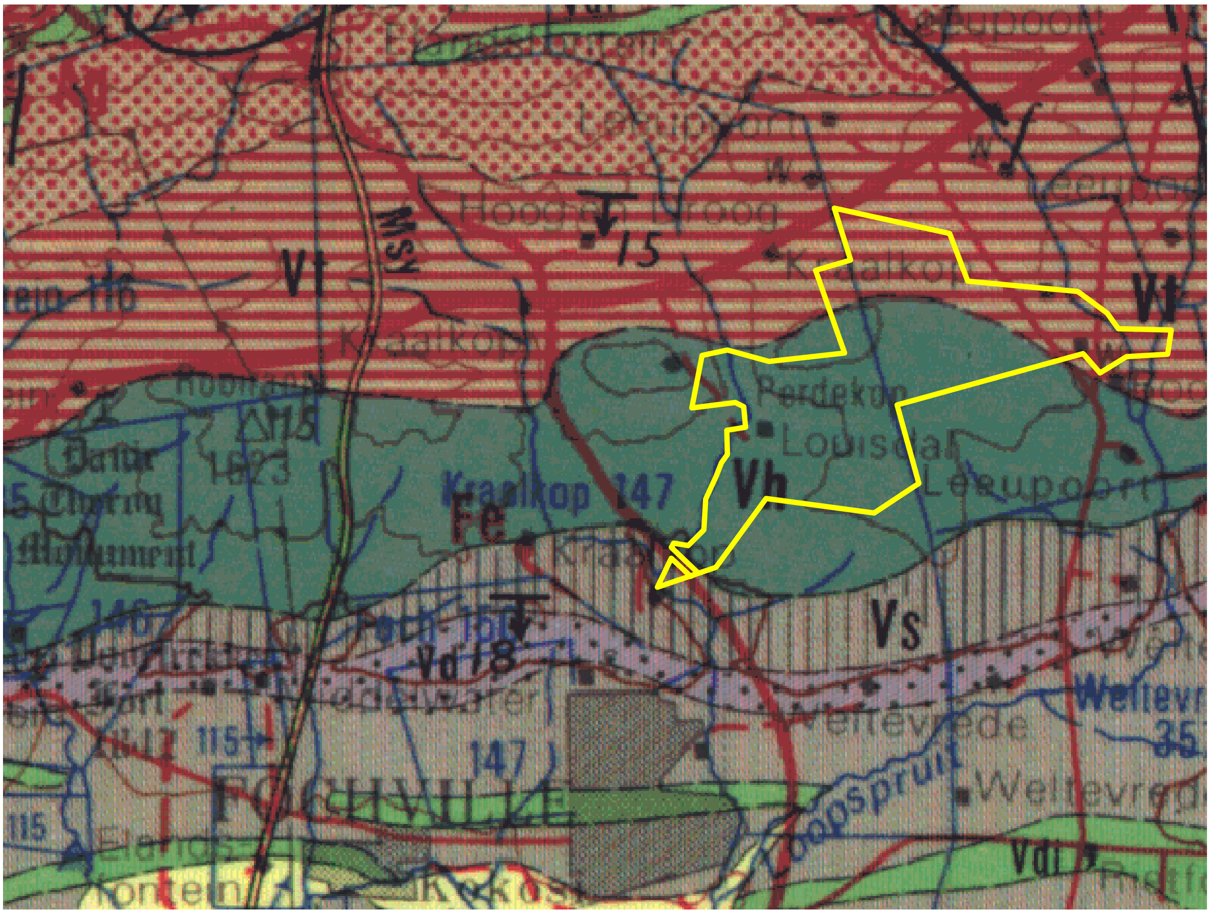

Figure 3: Geological map of the area around the proposed Igolide WEF indicated within the yellow polygon. Abbreviations of the rock types are explained in Table 4. Map enlarged from the Geological Survey 1: 250 000 map 2626 West Rand.

Table 4: Explanation of symbols for the geological map and approximate ages (Eriksson 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
Vdi	Diabase	Intrusive volcanic rocks	Post Transvaal SG
Vsi	Silverton Fm, Pretoria Group, Transvaal SG	Shale, carbonaceous in places, hornfels, chert	Ca 2202 Ma
Vd	Daspoort Fm, Pretoria Group, Transvaal SG	Sandstone, mudrock	Ca 2230 Ma
Vs	Strubenkop Fm, Pretoria Group, Transvaal SG	Shale, in places ferruginous	Ca 2242 Ma
Vdw	Dwaalheuvel Fm, Pretoria Group, Transvaal SG	Quartzite, chert, jaspilite	<2242 Ma
Vh	Hekpoort Fm, Pretoria Group, Transvaal SG	Volcanic rocks	Ca 2224 Ma
Vt	Timeball Hill Fm Pretoria Group, Transvaal SG	Shale, siltstone, conglomerate in places; dotted = Quartzite	Ca 2316 – 2266 Ma

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 Duitschland Formation.

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).

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.

Overlying the Rooihoogte Formation is the Timeball Hill Formation which is composed of thick shales and subordinate sandstones that were deposited in a fluvio-deltaic basin-filling sequence (Eriksson et al., 2006). A number of facies are included in this formation. At the base is black shale facies associated with subsurface lavas and pyroclastic rocks of the Bushy Bend Lava Member. Above these are rhythmically interbedded mudstones/siltstones and fine-grained sandstones that have been interpreted as turbidite deposits (Eriksson et al., 2006). These fine-grained sediments grade up into the medial Klapperkop Quartzite Member that has been interpreted as fluvio-deltaic sandstones which fed the more distal turbidites (ibid). Above this is an upper shale member and rhythmite facies. In the east of the Transvaal Basin the Upper Timeball Hill shales have undergone extensive soft-sediment deformation caused by the onset of tectonic instability that led to the eventual fan deposits of the Boshoek Formation and the flood basalts of the Hekpoort Formation (ibid).

The Hekpoort Formation is composed of subaerial lavas that intruded into the Boshoek sandstones. These basaltic-andesitic lavas are thickest in the south of the Transvaal basin, thinning to the west and thinnest in the northeast (Eriksson et al., 2006).

The Dwaalheuwel Formation sandstones overlie the Hekpoort Formation volcanic deposits and form two lobes, one from the northeast and one from the northwest (Eriksson et al., 2006). These are sandy distal fan and fluvial braid-plain deposits and are absent from the south of the Transvaal Basin (ibid).

The Strubenkop Formation depositional setting has been interpreted as either a lacustrine one (Eriksson et al., 1991, 1993a) or a shallow marine one (Button, 1973a). This formation comprises alternating mudstones and siltstones with subordinate interbedded, immature, fine-grained sandstones and is generally upward-coarsening.

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 Silverton Formation (Erikson et al., 2006). At the top of the Daspoort Formation are localised occurrences of stromatolitic carbonates and cherts (ibid).

Within the Silverton Formation are 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).

ii. Palaeontological context

The palaeontological sensitivity of the WEF site under consideration is presented in Figures 4-5. The site is mostly on moderately fossiliferous Hekpoort Formation (green on SAHRIS and orange in the DFFE map) and on the highly fossiliferous Timeball Hill Formation (SAHRIS orange; DFFE dark orange). The southwestern corner is on the moderately fossiliferous 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 2240 and 2080 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.

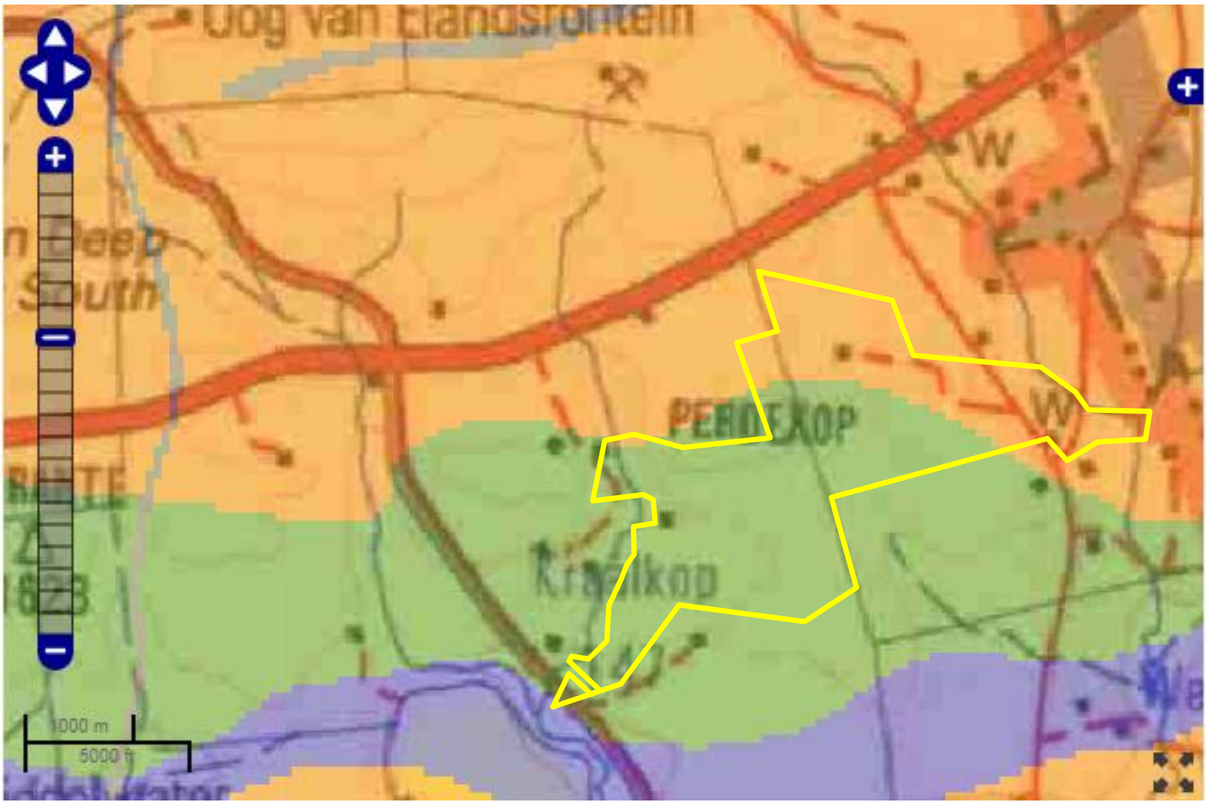

Figure 4: SAHRIS palaeosensitivity map for the site for the proposed Igolide WEF with the project boundary indicated within the yellow outline. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

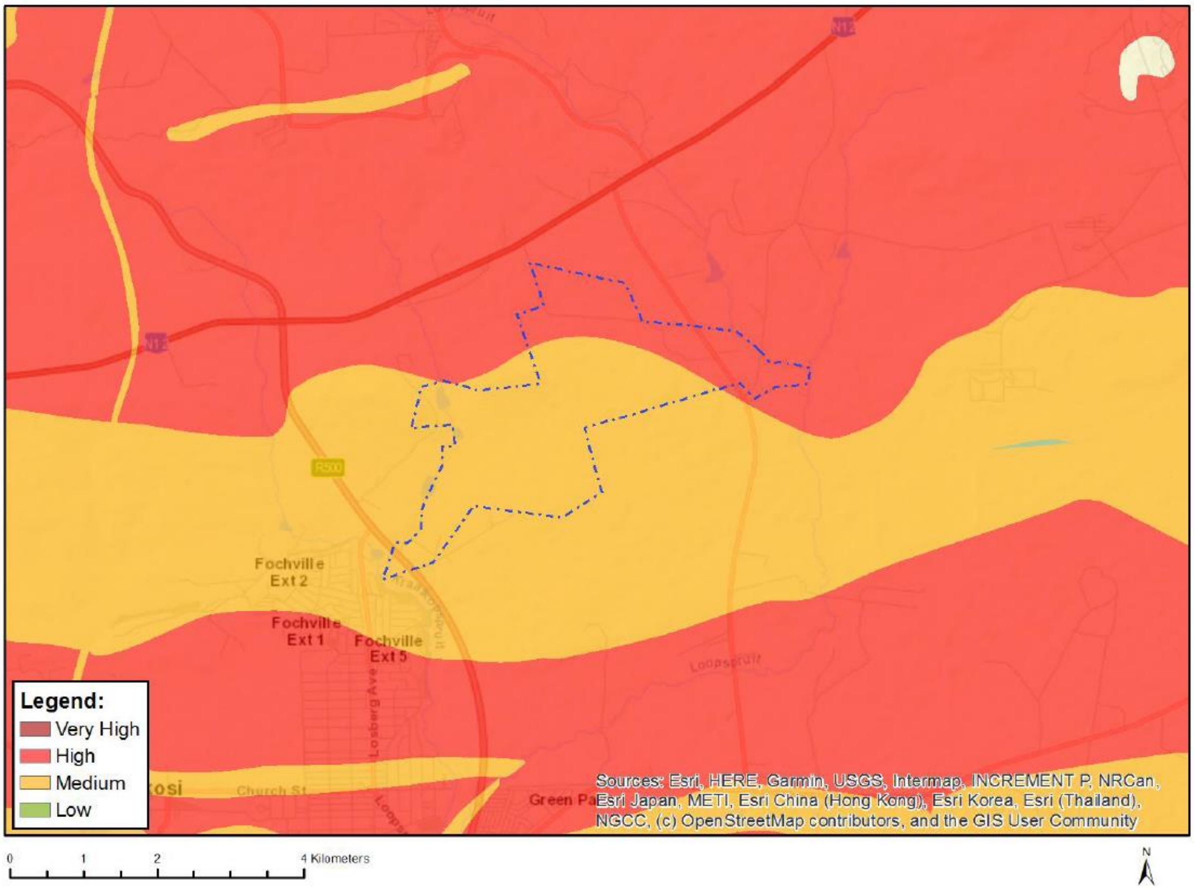

Figure 5: DFFE Screening palaeosensitivity map for the Igolide WEF. Colours as indicated. Note that highly sensitive = dark orange in DFFE and light orange in SAHRIS, and moderately sensitive = yellow in DFFE and green in SAHRIS maps.

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 **Hekpoort Formation** is predominantly composed of basaltic andesite and pyroclastic rocks (Eriksson et al., 2006) and this type of rock does not preserve fossils. This is noted in the Palaeotechnical Report (Groenewald et al., 2014) but they advise that caves or solution cavities could occur and these might have fossils. No fossiliferous caves are known from this area and for geological and engineering reasons, it is unlikely that turbines would placed over cave sites.

Although the Hekpoort Formation is indicated as moderately sensitive in the Gauteng Palaeotechnical Report (Groenewald et al., 2014) this is based on “no fossils recorded”. According to Retallack et al. (2013), the palaeosol in a road cutting near Waterval Onder contains urn-shaped microfossils measuring 1 x 0.2mm. He named the putative fossils *Diskagma buttoni*. Lenhardt et al. (2020) are very sceptical about the “fossils” and the reconstruction of the fossils from the thin-sections are extremely fanciful (own opinion; see Appendix A).

The **Timeball Hill Formation** is composed of black shales and subordinate sandstones that are interpreted cycles of fluvio-deltaic deposits, turbidites and even diamictites from glacial outwash in the northern part (Eriksson et al., 2006). Groenewald et al. (2014) suggest that there are stromatolites in this formation but none have been recorded. Stromatolites and microbial features occur in the overlying formations of the Pretoria Group.

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.

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in **Error! Reference source not found.**. It is only the project footprint / ground surface that are relevant to each turbine foundation, BESS, laydown area and other infrastructure.

Assessment of Impacts and Mitigation
The assessment of impacts and mitigation evaluates the likely extent and significance of the potential impacts on identified receptors and resources against defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise or compensate for any adverse environmental impacts, to enhance positive impacts, and to report the significance of residual impacts that occur following mitigation.

Following the mitigation sequence/hierarchy of five levels:

a) Avoid/prevent significant impact
b) Minimise
c) Rehabilitate/restore
d) Off-set
e) No-go,

mitigation in the form of removing any important fossils (steps a and b) will reduce realty the impact of this project on the palaeontological heritage.

The key objectives of the risk assessment are to identify any additional potential environmental issues and associated impacts likely to arise from the proposed project, and to propose a significance ranking. Ranked criteria listed in Table 5a and the scores for the palaeontological impact are given in Table 5b.

Table 5a: Impact Assessment and Scoring according to WSP protocols.

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Magnitude (M) The degree of alteration of the affected environmental receptor	Very low: No impact on processes	Low: Slight impact on processes	Medium: Processes continue but in a modified way	High: Processes temporarily cease	Very High: Permanent cessation of processes
Impact Extent (E) The geographical extent of the impact on a given environmental receptor	Site: Site only	Local: Inside activity area	Regional: Outside activity area	National: National scope or level	International: Across borders or boundaries
Impact Reversibility (R) The ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change	Reversible: Recovery without rehabilitation		Recoverable: Recovery with rehabilitation		Irreversible: Not possible despite action
Impact Duration (D) The length of permanence of the impact on the environmental receptor	Immediate: On impact	Short term: 0-5 years	Medium term: 5-15 years	Long term: Project life	Permanent: Indefinite
Probability of Occurrence (P) The likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation	Improbable	Low Probability	Probable	Highly Probability	Definite
Significance (S) is determined by combining the above criteria in the following formula:	$[S = (E + D + R + M) \times P]$ $Significance = (Extent + Duration + Reversibility + Magnitude) \times Probability$				
IMPACT SIGNIFICANCE RATING					

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Total Score	4 to 15	16 to 30	31 to 60	61 to 80	81 to 100
Environmental Significance Rating (Negative (-))	Very low	Low	Moderate	High	Very High
Environmental Significance Rating (Positive (+))	Very low	Low	Moderate	High	Very High

Table 5b: Impact Assessment score and significance for Palaeontology for the Igolide WEF project.

Project: Igolide WEF area		
Criteria (from table above)	**Scores**	
	Pre-mitigation	**Post-mitigation**
Impact Magnitude (M)	2	1
Impact Extent (E)	1	1
Impact Reversibility (R)	3	3
Impact Duration (D)	5	5
Probability of Occurrence (P)	2	1
Significance (M+E+R+D) x P	(2+1+3+5) x 2 = 22	(1+1+3+5) x 1 = 10
Significance Rating	Low	Very Low
Negative / Positive	Negative	Positive

Mitigation
The impact on the palaeontological heritage can be reduced greatly by a palaeontologist conducting a pre-construction walk-through of the site during final micro-siting/layout finalisation to look for fossils and removing any scientifically important fossils with the relevant SAHRA permit.
(See Section 8 and Appendix A).

Positive/Negative Impact
The discovery and removal of fossils as a direct result of this project has a positive impact because prior to this the particular fossils or fossil deposit were unknown to science.

Alternatives
None provided to date.

Additional Environmental Impacts
As far as the palaeontology is concerned, there are no additional impacts because the fossils are inert and inactive.

Cumulative Impacts

As far as the palaeontology is concerned, there are no cumulative impacts because each site is unique and may or may not have fossils. Stromatolites may be scattered over the landscape but their distribution is erratic and unpredictable. If a stromatolite outcrop occurs this would be an aerially small concentration of fossils and very unlikely to extend beyond tens of metres. Therefore, projects on adjacent land parcels are unlikely to result in a cumulative impact on the palaeontology of the area.

No-Go areas
There are no-go areas because the fossils, if present, can be removed and curated in a recognised institution such as a museum or university that has the facilities to store and research the fossil material.

Only the **construction phase** could have any impact on the palaeontology because this is when the ground will be excavated and any fossils, if present, would be removed (Annexure 2). During the operational and decommissioning phases no new ground will be excavated so there will be no impact.

Impact on the Palaeontology
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 only some of the rocks are the correct age and type to contain trace fossils, namely stromatolites or microbialites in the Timeball Hill and Silverton Formations. There is an extremely small chance that fossils from beneath soils in the dolomites may be disturbed. Therefore, a Fossil Chance Find Protocol has been added to this report (Annexure 1). 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, sandstones, shales and sands are typical for the country and only some contain trace fossils such as stromatolites or microbialites. The overlying soils and sands of the Quaternary period would not preserve fossils.

6. Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the overlying sands and soils of the Quaternary. There is a very small chance that trace fossils may occur in the below ground dolomites of the Timeball Hill and Silverton Formations 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 for foundations and infrastructure have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample. The impact on the palaeontological heritage would be low, therefore as far as the palaeontology is concerned the project should be authorised. There is no preferred site and there is no no-go area.

7. References

Eriksson, P.G., Altermann, W., Hartzer, F.J., 2006. The Transvaal Supergroup and its pre-cursors. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. pp 237-260.

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

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

Groenewald, G., Groenewald, D., Groenewald, S., 2014. SAHRA Palaeotechnical Report. Palaeontological Heritage of Gauteng. 20 pages.

Lenhardt, N., Altermann, W., Humbert, F., de Kock, M., 2020. Lithostratigraphy of the Palaeoproterozoic Hekpoort Formation (Pretoria Group, Transvaal Supergroup), South Africa. South African journal of Geology 123(4), 655-668.

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

Retallack, G.J., Krull, E.S., Thackray, G.D. and Parkinson, D., 2013. Problematic urn-shaped fossils from a Paleoproterozoic (2.2 Ga) paleosol in South Africa. Precambrian Research 235, 71-87.

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 discard must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (trace fossils, 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 fossil plants, vertebrates, invertebrates or trace fossils in the shales and mudstones (for example see Figures 6-8). 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 environmental officer then a qualified palaeontologist should be sub-contracted to conduct a site visit 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 Pretoria Group

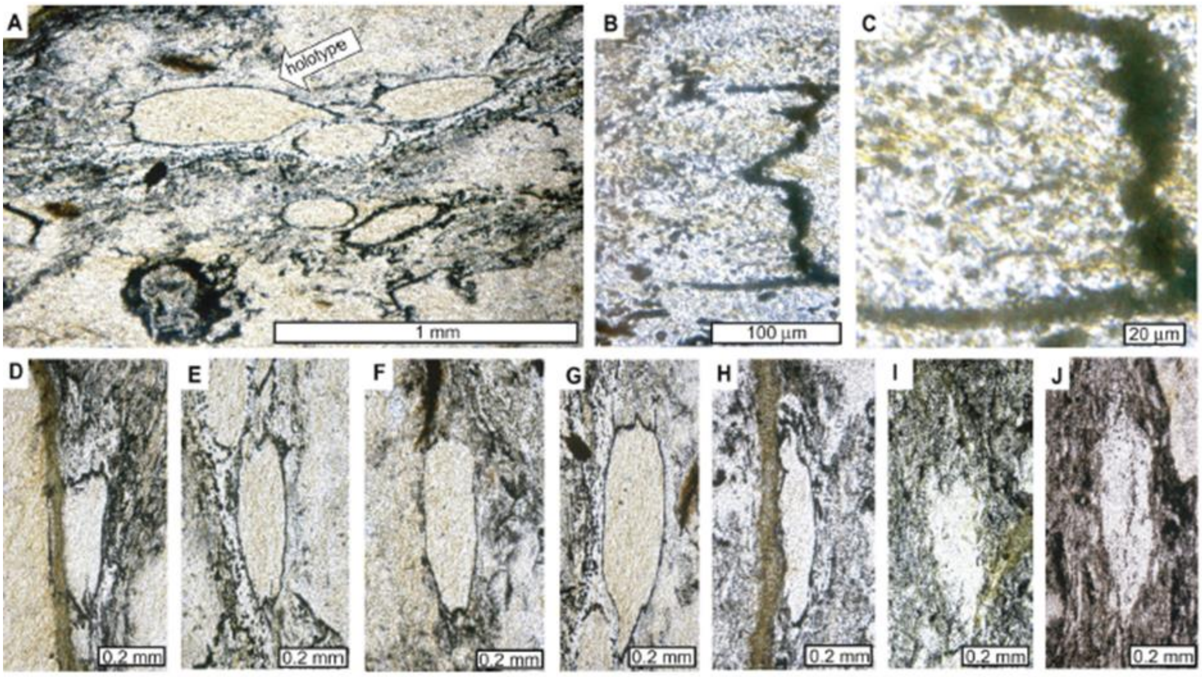

Figure 6: Figure 5: Photomicrographs of the putative microfossils *Diskagma buttoni.* Note the size – these would not be visible. Figure 4 of Retallack et al., 2013.

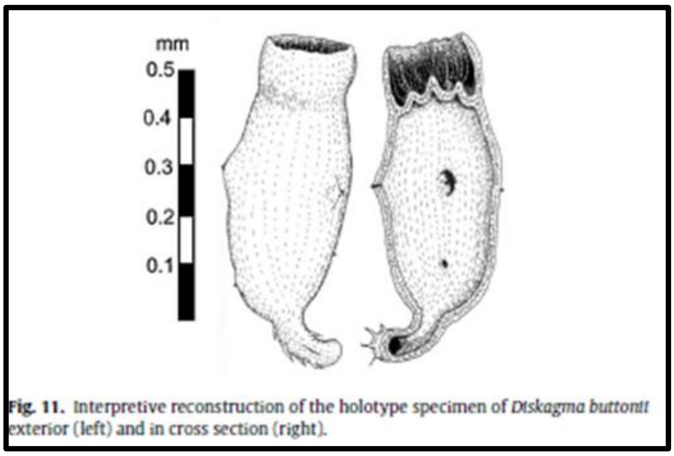

Figure 7: Reconstruction of the microfossil in Retallack et al., (2013) with features not visible in the micrographs.

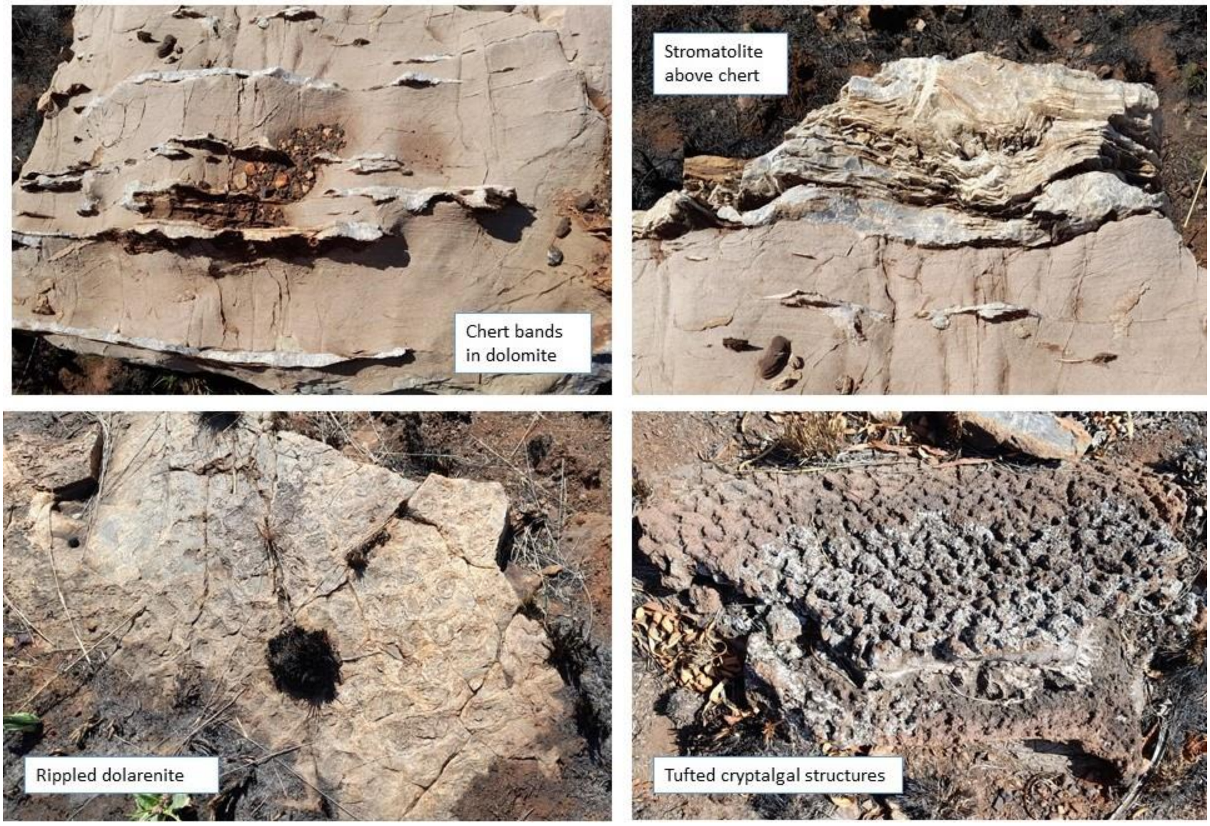

Figure 8: Photographs of stromatolites as seen in the field.

9. Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD January 2023

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	13	3
PhD	13	6
Postdoctoral fellows	15	4

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:

- 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
- 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

xi) Research Output
Publications by M K Bamford up to January 2023 peer-reviewed journals or scholarly books: over 170 articles published; 5 submitted/in press; 10 book chapters.
Scopus h-index = 30; Google scholar h-index = 39; -i10-index = 116
Conferences: numerous presentations at local and international conferences.