Environmental & Engineering Consultants
Postal Address: P.O Box 2311, Westville, 3630
Tel: 031 262 8327
Fax: 086 726 3619
Company Registration: 2015/084540/07

Palaeontological Impact Assessment for the proposed DF-SMF 11kV overhead powerline interconnector, Theunissen, Free State Province

Site Visit (Phase 2) Report

For

1World Consultants

11 October 2021

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

Environmental & Engineering Consultants
Postal Address: P.O Box 2311, Westville, 3630
Tel: 031 262 8327
Fax: 086 726 3619
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Expertise of Specialist

The Palaeontologist Consultant is 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 1World Consultants, Durban, 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: 

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Environmental & Engineering Consultants
Postal Address: P.O Box 2311, Westville, 3630
Tel: 031 262 8327
Fax: 086 726 3619
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Executive Summary

A Palaeontological Impact Assessment was requested for the proposed a new 11kV overhead power line route of approximately 5km length on the premises of the Beatrix mining operations of Sibanye StillWater Mine, in the Theunissen area, Free State Province. The line will be an interconnector between Dora Rural-Florida 11kV feeder and the Star Diamond-Mooifontein 11kV feeder.

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 site visit (phase 2) Palaeontological Impact Assessment (PIA) was completed for the proposed development on 06 October 2021.

The proposed site lies on the rocks of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup) that could potentially preserve vertebrate fossils of fish, amphibians, reptiles, therapsids, terrestrial and freshwater tetrapods, as well as freshwater bivalves, trace fossils including tetrapod trackways and burrows. The site visit walk down and survey revealed **NO fossils of any kind in the project footprint.** Although erosion gullies revealed the rocks to a depth of about one metre, it is not known what lies below the ground surface. Therefore, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological site visit is required unless fossils are found once excavations for foundations and amenities have commenced. As far as the palaeontological heritage is concerned, the project may be authorised.

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1. Background

A Palaeontological Impact Assessment was requested for the proposed a new 11kV overhead power line route of approximately 5km length on the premises of the Beatrix mining operations of Sibanye StillWater Mine, in the Theunissen area, Free State Province. The line will be an interconnector between Dora Rural-Florida 11kV feeder and the Star Diamond-Mooifontein 11kV feeder (Figure 1).

Since the area is indicated as very highly sensitive, a site visit (or phase 2) Palaeontological Impact Assessment was completed for the project. To comply with the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a site visit and walk down is reported herein.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (amended 2017)

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report	Appendix C
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix C
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 for fossils
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;	None

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	Section 8
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	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

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Figure 1: Google Earth map of the proposed 11kV powerline for Sibanye Stillwater Beatrix mine, north of Theunissen. Map supplied by 1World.

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 (as reported herein, and collect or rescue fossils if required);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*as indicated in section 4 below)*; and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a just a representative sample collected and housed in a recognised repository.

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3. Geology and Palaeontology

i. Project location and geological context

The project site is in the northeastern part of the Main Karoo Basin (Figure 1). Representing some 120 million years (300 – 183Ma), and covering a large proportion of South Africa, the Karoo Supergroup rocks have preserved a diversity of fossil plants, insects, vertebrates, and invertebrates. Four groups are recognised within the Karoo Supergroup.

During the Carboniferous period the melting ice sheets deposited tillites, diamictites, mudstones, siltstones, and sandstones. These are the oldest rocks in the system and are exposed around the outer part of the ancient Karoo Basin and are known as the Dwyka Group. Overlying the Dwyka Group rocks are rocks of the Ecca Group that are Early Permian in age. There are eleven formations recognised in this group, but they do not all extend throughout the Karoo Basin. All of these sediments have varying proportions of sandstones, mudstones, shales and siltstones and represent shallow to deep water settings, deltas, rivers, streams and overbank depositional environments. Overlying the Ecca Group rocks are the Beaufort Group Rocks that are late Permian and early Triassic in age. There two subgroups, the lower Adelaide Subgroup, and the upper Tarkastad Subgroup.

The **Adelaide Subgroup** is part of the eastern foredeep basin and was deposited in the overfilled or non-marine phase (Catuneanu et al., 2005) and so comprises terrestrial deposits. There are numerous fining-upward cycles, abundant red mudrocks and sedimentary structures that indicate deposition under fluvial conditions (Johnson et al., 2006). Some of the lower strata probably represent a subaerial upper delta-plain environment and the generally finer grained materials are typical of meandering rather than braided rivers. Channel deposits are indicated by sandstones while overbank deposits are indicated by the mudstones (Johnson et al., 2006). Intruding through these sediments are dolerite dykes that formed during the Jurassic Drakensberg basaltic eruptions.

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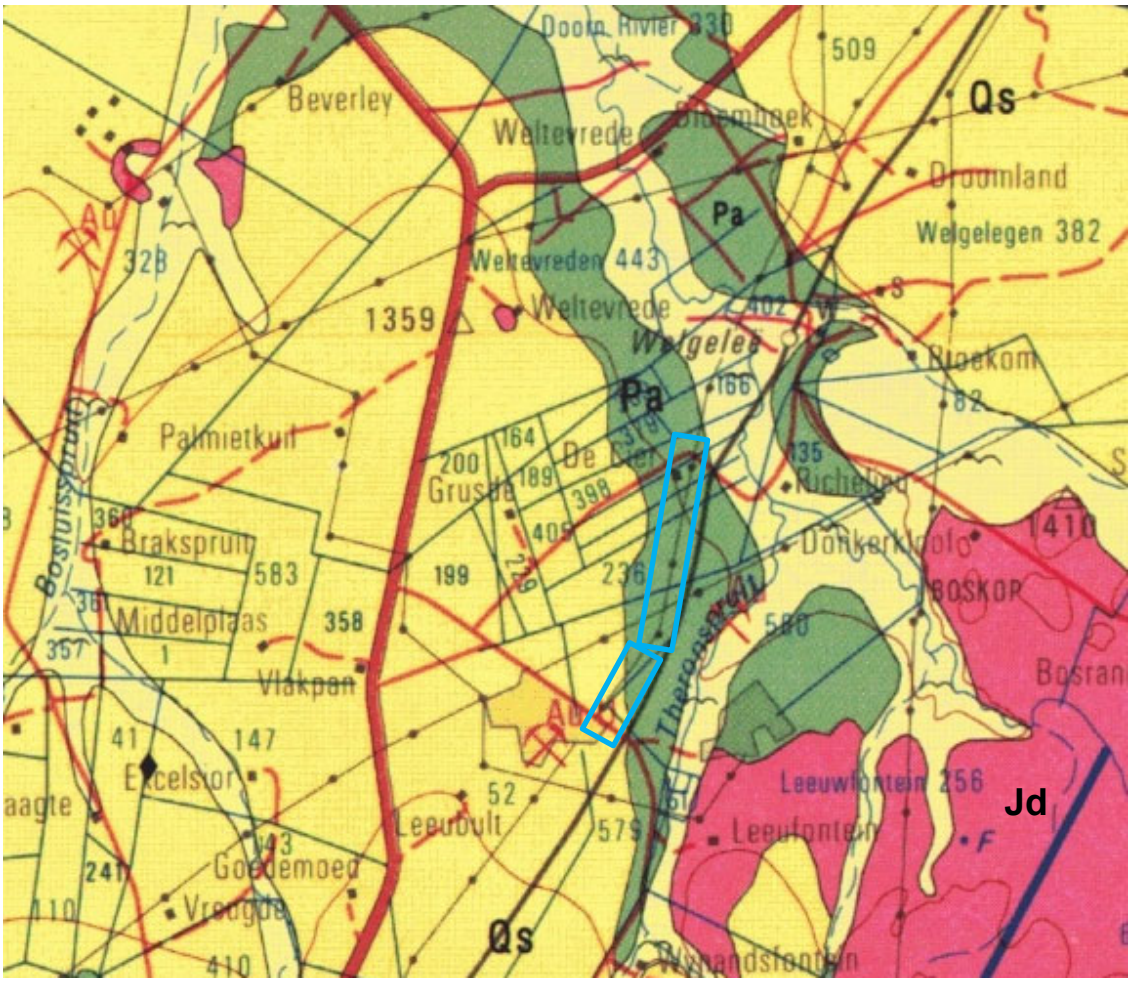

Figure 2: Geological map of the area around Theunissen with the power line route indicated within the blue rectangles. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2826 Winburg.

Table 2: Explanation of symbols for the geological map and approximate ages (Johnson 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
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 180 Ma
Pa	Adelaide Subgroup, middle Beaufort Group, Karoo SG	Shales, sandstone, mudstone	Late Permian, ca 235-250 Ma

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ii. Palaeontological context

The area proposed for the powerline route is underlain by geological sediments of the Adelaide Subgroup of the Beaufort Group (of very high paleontological sensitivity), and Jurassic Dolerite that has zero palaeontological sensitivity. According to the updated biostratigraphy (Smith et al., 2020), the whole of the Adelaide Subgroup has been divided into five Assemblage Zones based on the dominant or temporally exclusive vertebrate fossils (Rubidge et al., 1995; Rubidge, 2005; Smith et al., 2020). The zones are shown in Figure 3 below. If vertebrate fossils were common in this region and had been well mapped then the specific Assemblage Zone would have been indicated in the literature. Common names for the fossils that could occur here are fish, amphibians, reptiles, therapsids, terrestrial and freshwater tetrapods, as well as freshwater bivalves, trace fossils including tetrapod trackways and burrows. Where the vertebrates do not occur it is possible to find sparse to rich assemblages of vascular plants of the late Glossopteris Flora, including some petrified logs), and insects are also prevalent at some sites.

From the updated Karoo Biozone map in Smith et al. (2020) the Theunissen site is in the *Daptocephalus* Assemblage Zone (Figures 3 and 4; Appendix A).

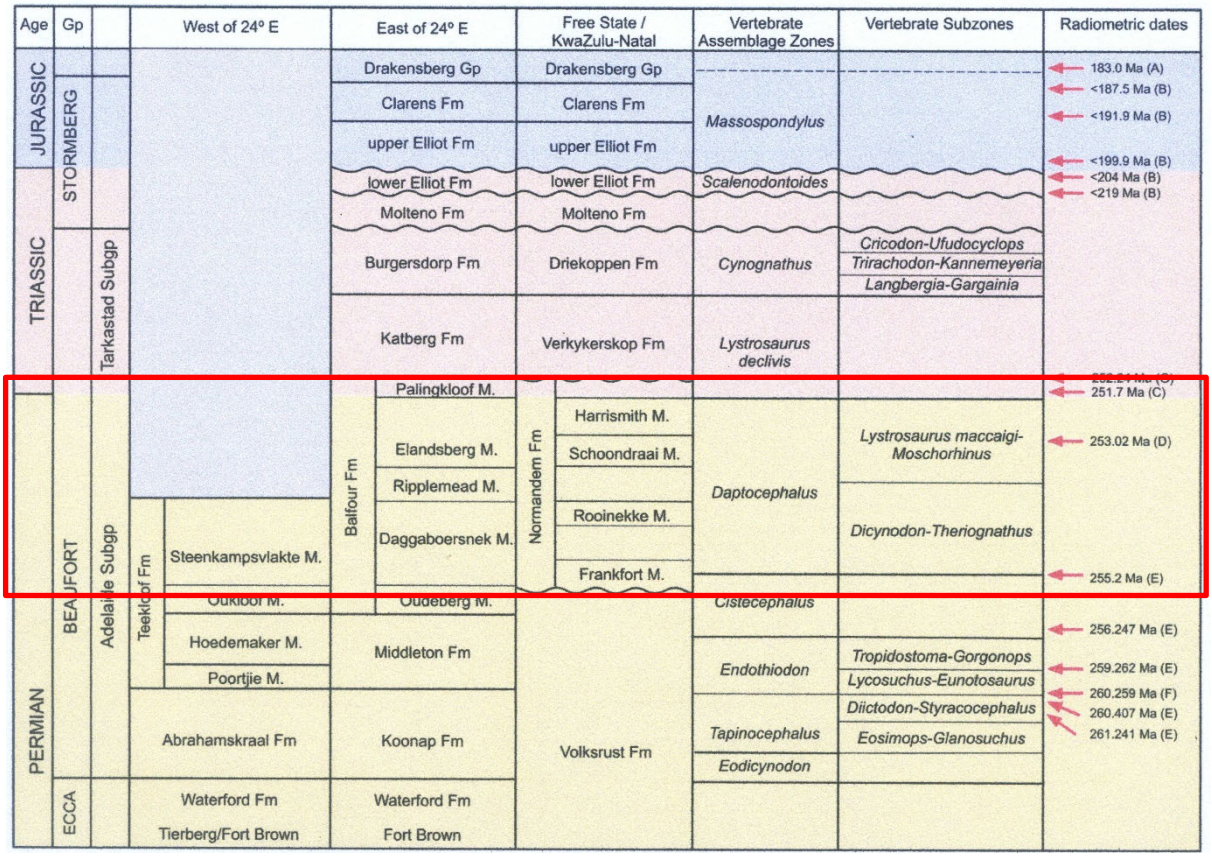

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Figure 3: Updated Karoo Vertebrate Assemblage Zones (Smith et al., 2020). Red box indicates the most likely zone for the Theunissen OH PL route location.

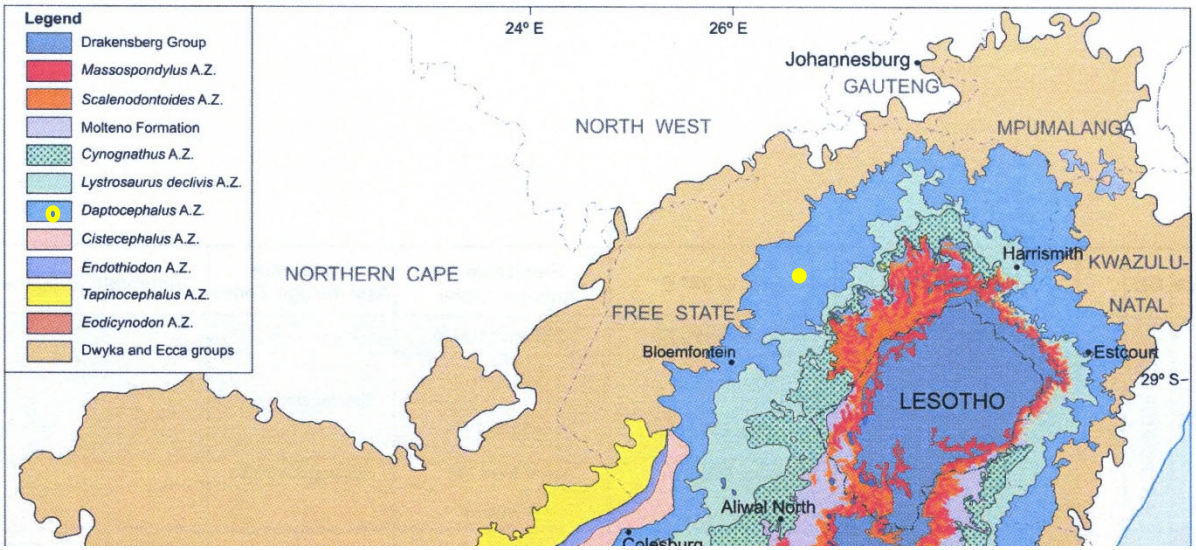

Figure 4: Top half only of the updated Karoo Vertebrate Assemblage Zones from Smith et al. (2020), with the Theunissen route indicated by the yellow dot. The site is in the Daptocephalus AZ.

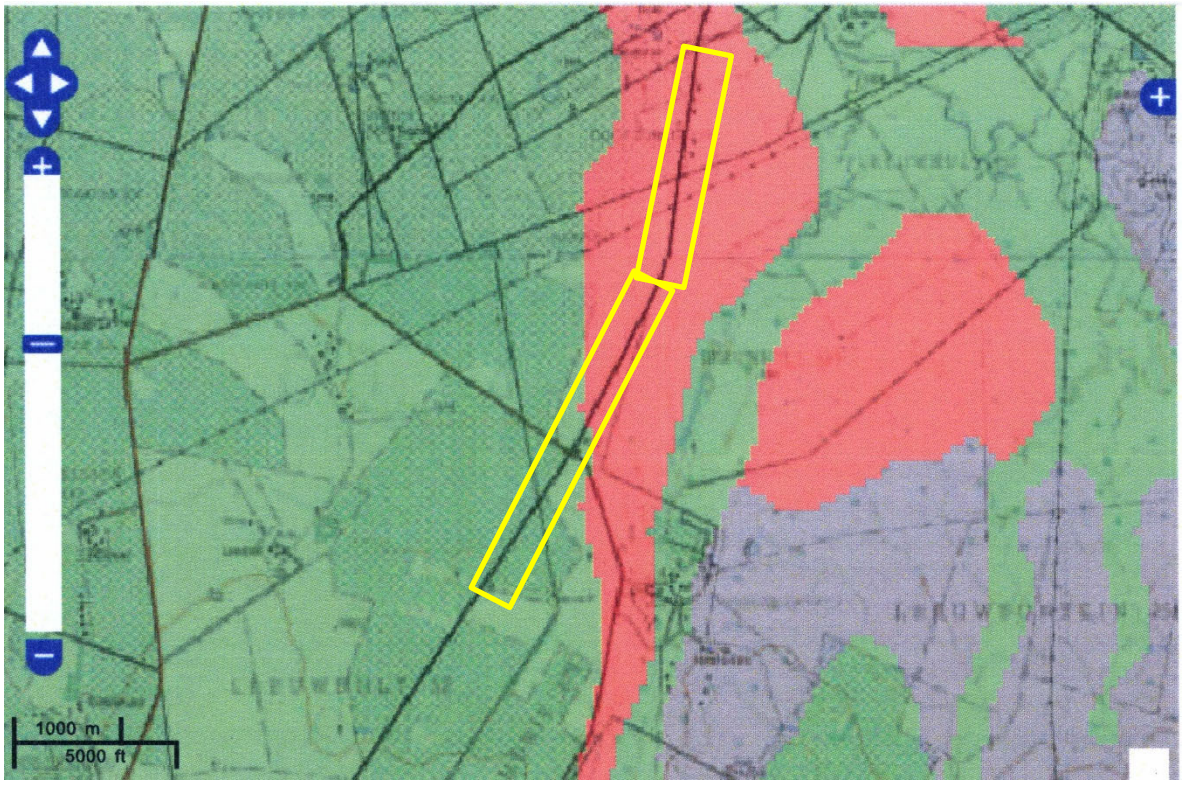

Figure 5: SAHRIS palaeosensitivity map for the site for the proposed Theunissen new PL route shown within the yellow rectangles. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Fossil plants also occur in the Adelaide Subgroup, and they are from the Glossopteris flora and include leaf impressions of *Glossopteris*, early gymnosperms, lycopods, sphenophytes, ferns, and silicified wood (see list in Appendix A). They are not common, however.

Iii Site visit observations

The site visit walk down with GPS, coordinates, photographs, and recorded observations was done on 06 October 2021, by Bailey Weiss and Brandon Stuart. The season is late winter-early spring; however, the time of year has no impact on the fossils. Observations at specific stops of interest are presented in Table 3 and relate to the Google Earth map in Figure 7 and the photographs in Figures 8—10 (taken by Weiss and Stuart). Full list of GPS coordinates is given in Appendix B.

Table 3: Site visit observations and coordinates for selected stops where photographs were taken. Full list in Appendix B. Refer to Figure 6 for OHL route. Note: numbers and route followed are from south to north.

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No	Latitude	Longitude	Observations	Fig
1	-28°16'30.05"	26°47'26.88"	South start of OHL adjacent to Beatrix Mine, roads and powerlines in place. No rocky outcrops and no fossils. B - shows a gully filled with water and exposes the deep soils.	7A
2	-28°16'29.69"	26°47'27.47"		7B
3	-28°16'29.25"	26°47'28.08"		7C
7	-28°16'27.18"	26°47'30.05"		7D
11	-28°16'24.93"	26°47'31.77"	Close-up of soils. No Fossils	8A
27	-28°16'15.89"	26°47'38.61"	Ploughed soils and mine-workings in the background.	8B
42	-28°16'7.391"	26°47'44.96"	Another gully exposing the deep soils.	8C
53	-28°16'1.070"	26°47'49.50"	Track alongside the new route. Exposed soils and no rocky outcrops.	8D
57	-28°15'58.57"	26°47'50.10"	Fields that have been ploughed in the past so flat topography. Roads and powerlines in place. No rocky outcrops and no fossils.	9A
66	-28°15'53.40"	26°47'53.53"		9B
189	-28°14'39.92"	26°48'28.76"		9C
211	-28°14'25.22"	26°48'31.20"		9D
237	-28°14'7.512"	26°48'34.15"	Northern section on the Adelaide Subgroup rocks. Old ploughed fields with no rocky outcrops and no fossils	10A
240	-28°14'5.441"	26°48'34.53"		10B

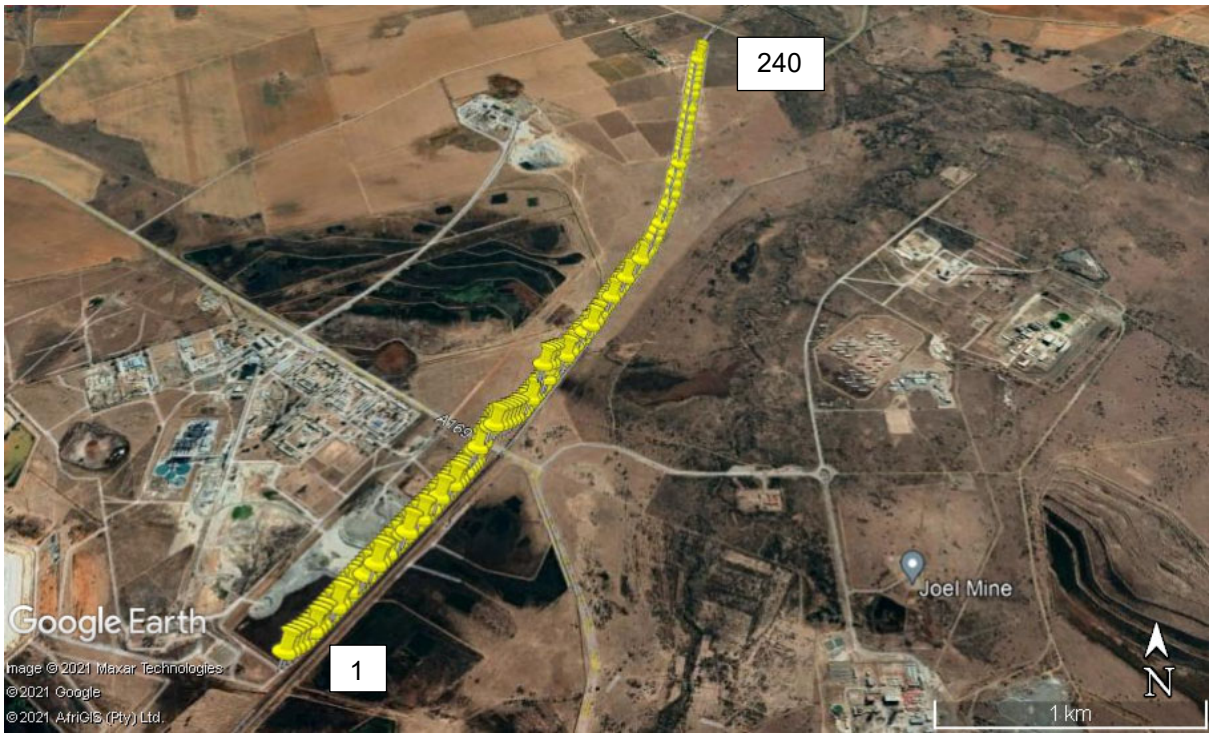

Figure 6: GPS points and tracking for the route for the new 11 kV PL near Theunissen site visit from Beatrix Mine in the South. Refer to Table 3 and Figures 8-10.

Figure 7: Theunissen site visit photographs. General views of the sites showing roads and ploughed fields. A – Stop No 1; B – Stop No 2; C - Stop No 3; D – Stop No 7 (southern part of route).

Figure 9: Theunissen site visit photographs. A – Stop No 11; B – Stop no 27; C – Stop no 42; D – Stop no 53. There are no fossils visible.

Figure 10: Theunissen site visit photographs. Northern section on the Adelaide Subgroup rocks. General view of stops: A – Stop No 57; B – Stop No 66; C – Stop No 189; D – Stop No 211. No fossils seen; only roads and ploughed fields.

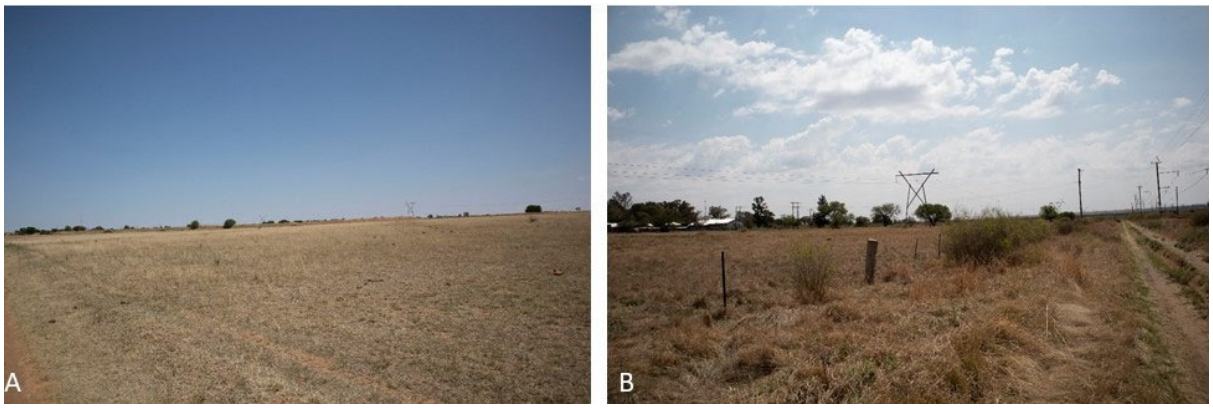

Figure 11: Theunissen site visit photographs. Northern section on the Adelaide Subgroup rocks. A – Stop No 237; B – Stop No 240. No fossils were seen.

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4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table :

TABLE 4A: 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 4B: IMPACT ASSESSMENT

PART B: ASSESSMENT		
SEVERITY/NATURE	**H**	-
	M	Dolerite does not preserve fossils; so far there are no records from the Adelaide Subgroup of plant or animal fossils in this region so it is unlikely that fossils occur on the site. The impact would be unlikely
	L	.
	L+	-
	M+	-
	H+	-
DURATION	**L**	-
	M	-
	H	Where manifest, the impact will be permanent.
SPATIAL SCALE	**L**	Since only the possible fossils within the area would be vertebrates from the Daptocephalus AZ or fossil plants from the *Glossopteris* flora in the shales, the spatial scale will be localised within the site boundary.
	M	-
	H	-

PART B: ASSESSMENT		
PROBABILITY	**H**	**-**
	M	It is unlikely that any fossils would be found in the loose soils or sand that will be excavated for foundations. NO FOSSILS WERE SEEN during the site visit walk down. Nonetheless, a Fossil Chance Find Protocol should be added to the eventual EMPr.
	L	-

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 the right age and type to contain fossils. No fossils were seen during the site visit. Furthermore, the material to be disturbed are the loose surface soils and sands and they do not preserve fossils. Since there is a very small chance that fossils from the Adelaide Subgroup below the ground surface 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 do might fossil plant, insect, invertebrate and vertebrate material. The surface soils and sands of the Quaternary period would not preserve fossils. No fossils of any kind were seen on the surface or in the erosion gullies or in the exposed shales in the gullies. Excavations for foundations or amenities are usually not very deep. It is not known if there are any fossils in the rocks below the ground surface.

6. Recommendation

Based on experience, the site visit walk down and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the loose sands of the Quaternary. Although no fossils were seen on the surface, there is a small chance that fossils may occur below the soils in the shales of the upper Adelaide Subgroup so a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found once excavations for foundations and amenities have commenced then their locations should be recorded (GPS), photographed, and a palaeontologist called to assess and collect a representative sample (details in Section 8). 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 and construction activities begin.

1. The following procedure is only required if fossils are seen on the surface and when excavations commence.

2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone, shells or trace fossils) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of similar fossil plants and vertebrates must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 11, 12). 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 excavations 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: List of fossils that occur in the Daptocephalus Assemblage Zone, Adelaide Subgroup (information from Anderson & Anderson, 1985; Plumstead, 1969; Smith et al., 2020)

Group/sG/Fm	Plant Group	*Genera*	Animal Group	Common Genera
Beaufort Balfour Fm Normandien Fm Daptocephalus AZ	Glossopteridales	*Glossopteris* *Eretmonia* *Lidgettonia*	Pisces	*Namaichthys, Atherstonia,*
	Cordaitales	*Noeggerathiopsis*	Amphibia	*Rhinesuchus, Laccosaurus*
	Ginkgoales	*Ginkgophyllum*	Parareptilia	*Pareiasaurus, Owenettia, Milleretta, Sauroichtus*
	Ferns	*Sphenopteris*	Eureptila	*Youngina, Saurostemon*
	Lycopods	*indet*	Biarmosuchia	*Burnettia*

	Sphenophytes	*Phyllotheca* *Schizoneura* *Raniganjia*	Anomodontia	*Pristerodon, Diictodon, Dicynodontoides, Oudeondon, Aulacephalodon, Dianomodon, Dicynodon, Daptocephalus*
	Incertae sedis	*Pagiophyllum* *Taeniopteris* *Benlightfootia*	Gorgonopsia	*Gorgonops, Lycaenops Cynosaurus, Rubidgea*
			Therocephalia	*Ichidosuchoides, Theriognathus, Ictidochampsia, Moschorhinus*
			Cynodontia	*Cynosaurus, Procynosuchus, Nanictosuchus*

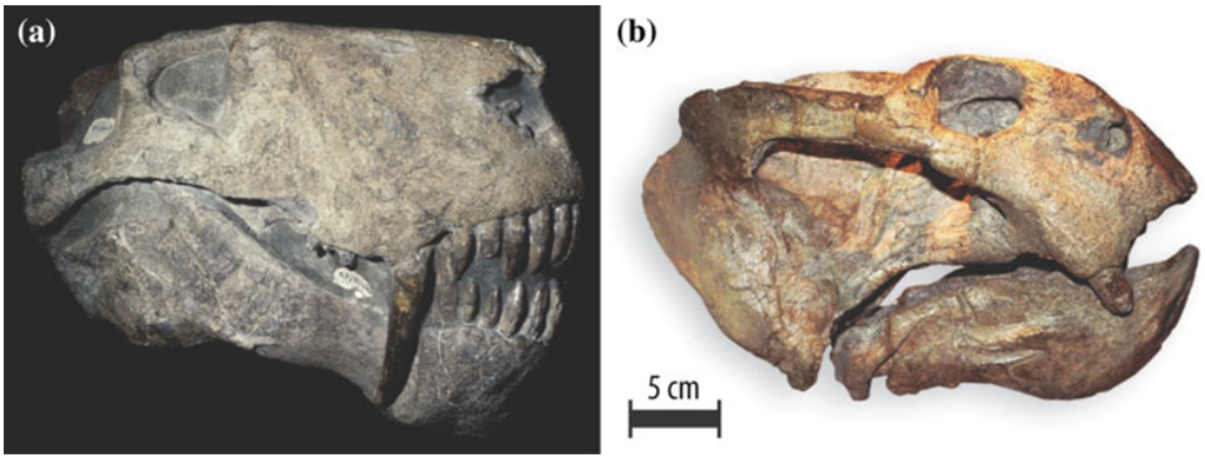

Figure 11: Examples of fossil vertebrates that could be found in the Adelaide Subgroup, Therapsid skulls representative of two families that went extinct in the Permian: a flesh eating gorgonopsian, and b the herbivore dicynodont *Daptocephalus* (Photos supplied by Bruce Rubidge). In Linol and de Wit (2016) book Preface

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Figure 12: Selection of plants of the *Glossopteris* flora. Bottom right shows bones *in situ* as found in the field.

Appendix B – Full list of pole positions and Site visit GPS coordinates for the Eskom 11 kV powerline adjacent to Beatrix Mine, south of Theunissen.

Number	Latitude	Longitude	Altitude (m)
001	-28°16'30.05"	26°47'26.88"	1425,82
002	-28°16'29.69"	26°47'27.47"	1424,74
003	-28°16'29.25"	26°47'28.08"	1425,53
004	-28°16'28.85"	26°47'28.69"	1425,42
005	-28°16'28.34"	26°47'29.20"	1425,4
006	-28°16'27.80"	26°47'29.66"	1426,3
007	-28°16'27.18"	26°47'30.05"	1426,09
008	-28°16'26.64"	26°47'30.48"	1426,33
009	-28°16'26.06"	26°47'30.95"	1426,4
010	-28°16'25.50"	26°47'31.37"	1426,5
011	-28°16'24.93"	26°47'31.77"	1425,99
012	-28°16'24.35"	26°47'32.24"	1425,98
013	-28°16'23.81"	26°47'32.65"	1426,41
014	-28°16'23.23"	26°47'33.08"	1425,33
015	-28°16'22.68"	26°47'33.51"	1425,45
016	-28°16'22.08"	26°47'33.92"	1425,76
017	-28°16'21.50"	26°47'34.36"	1425,36
018	-28°16'20.94"	26°47'34.78"	1425,25
019	-28°16'20.40"	26°47'35.21"	1424,98
020	-28°16'19.84"	26°47'35.60"	1424,94
021	-28°16'19.30"	26°47'36.08"	1424,54
022	-28°16'18.77"	26°47'36.51"	1424,04
023	-28°16'18.23"	26°47'36.91"	1424,59
024	-28°16'17.62"	26°47'37.29"	1424,04
025	-28°16'17.05"	26°47'37.75"	1424,28
026	-28°16'16.46"	26°47'38.19"	1424,05
027	-28°16'15.89"	26°47'38.61"	1424,05
028	-28°16'15.29"	26°47'39.04"	1424,64
029	-28°16'14.73"	26°47'39.50"	1424,21
030	-28°16'14.18"	26°47'39.90"	1423,92
031	-28°16'13.63"	26°47'40.33"	1423,94
032	-28°16'13.07"	26°47'40.77"	1424,26
033	-28°16'12.52"	26°47'41.17"	1423,32
034	-28°16'11.97"	26°47'41.58"	1423,63
035	-28°16'11.42"	26°47'42.02"	1423,31

036	-28°16'10.86"	26°47'42.46"	1422,71
037	-28°16'10.31"	26°47'42.89"	1422,59
038	-28°16'9.714"	26°47'43.34"	1422,3
039	-28°16'9.134"	26°47'43.77"	1423,23
040	-28°16'8.540"	26°47'44.20"	1422,57
041	-28°16'7.953"	26°47'44.55"	1422,46
042	-28°16'7.391"	26°47'44.96"	1422,75
043	-28°16'6.801"	26°47'45.33"	1422,78
044	-28°16'6.265"	26°47'45.84"	1422,48
045	-28°16'5.678"	26°47'46.21"	1423,12
046	-28°16'5.088"	26°47'46.62"	1423,48
047	-28°16'4.576"	26°47'47.12"	1423,2
048	-28°16'4.011"	26°47'47.59"	1422,79
049	-28°16'3.446"	26°47'47.99"	1422,85
050	-28°16'2.852"	26°47'48.36"	1423,09
051	-28°16'2.247"	26°47'48.75"	1423,4
052	-28°16'1.642"	26°47'49.10"	1423,26
053	-28°16'1.070"	26°47'49.50"	1422,96
054	-28°16'0.519"	26°47'49.95"	1423,41
055	-28°15'59.86"	26°47'50.23"	1423,51
056	-28°15'59.19"	26°47'50.07"	1423,15
057	-28°15'58.57"	26°47'50.10"	1424,12
058	-28°15'57.95"	26°47'50.51"	1424,96
059	-28°15'57.31"	26°47'50.79"	1424,28
060	-28°15'56.67"	26°47'51.10"	1423,27
061	-28°15'56.04"	26°47'51.45"	1423,23
062	-28°15'55.36"	26°47'51.57"	1423,74
063	-28°15'54.71"	26°47'51.87"	1424,05
064	-28°15'54.10"	26°47'52.23"	1424,13
065	-28°15'53.63"	26°47'52.78"	1424,49
066	-28°15'53.40"	26°47'53.53"	1424,37
067	-28°15'53.04"	26°47'54.20"	1423,61
068	-28°15'52.70"	26°47'54.89"	1423,77
069	-28°15'52.31"	26°47'55.50"	1423,05
070	-28°15'51.83"	26°47'56.07"	1422,93
071	-28°15'51.34"	26°47'56.60"	1422,68
072	-28°15'50.77"	26°47'57.03"	1421,66
073	-28°15'50.15"	26°47'57.39"	1421,75
074	-28°15'49.56"	26°47'57.75"	1420,77
075	-28°15'48.98"	26°47'58.13"	1419,97
076	-28°15'48.36"	26°47'58.50"	1419,12

077	-28°15'47.77"	26°47'58.87"	1417,93
078	-28°15'47.21"	26°47'59.28"	1417,21
079	-28°15'46.56"	26°47'59.58"	1416,71
080	-28°15'45.94"	26°47'59.93"	1415,86
081	-28°15'45.35"	26°48'0.341"	1415,06
082	-28°15'44.76"	26°48'0.755"	1414,13
083	-28°15'44.11"	26°48'1.083"	1413,52
084	-28°15'43.68"	26°48'1.583"	1414,2
085	-28°15'43.07"	26°48'1.756"	1413,1
086	-28°15'42.48"	26°48'1.472"	1413,33
087	-28°15'41.99"	26°48'0.907"	1413,22
088	-28°15'41.45"	26°48'0.403"	1413,11
089	-28°15'41.10"	26°48'0.316"	1414,22
090	-28°15'40.76"	26°48'1.018"	1413,78
091	-28°15'40.46"	26°48'1.692"	1413,09
092	-28°15'40.19"	26°48'2.376"	1412,61
093	-28°15'39.93"	26°48'3.077"	1412,27
094	-28°15'39.67"	26°48'3.794"	1412,28
095	-28°15'39.05"	26°48'4.204"	1411,07
096	-28°15'38.39"	26°48'4.575"	1412,04
097	-28°15'37.81"	26°48'4.939"	1411,22
098	-28°15'37.18"	26°48'5.299"	1411,05
099	-28°15'36.59"	26°48'5.702"	1410,96
100	-28°15'35.96"	26°48'6.029"	1410,35
101	-28°15'35.44"	26°48'6.544"	1410,01
102	-28°15'34.89"	26°48'6.991"	1410,04
103	-28°15'34.31"	26°48'7.336"	1409,87
104	-28°15'33.67"	26°48'7.455"	1410,5
105	-28°15'33.23"	26°48'7.999"	1410,24
106	-28°15'32.62"	26°48'8.326"	1410,09
107	-28°15'32.02"	26°48'8.675"	1409,47
108	-28°15'31.42"	26°48'9.032"	1410,52
109	-28°15'30.80"	26°48'9.352"	1410,2
110	-28°15'30.22"	26°48'9.727"	1409,83
111	-28°15'29.59"	26°48'9.918"	1410,76
112	-28°15'28.95"	26°48'10.19"	1411,39
113	-28°15'28.33"	26°48'10.56"	1411,64
114	-28°15'27.73"	26°48'10.93"	1411,39
115	-28°15'27.15"	26°48'11.28"	1411,24
116	-28°15'26.51"	26°48'11.61"	1412,01
117	-28°15'25.93"	26°48'12.02"	1412,22

118	-28°15'25.34"	26°48'12.40"	1411,23
119	-28°15'24.75"	26°48'12.74"	1410,84
120	-28°15'24.12"	26°48'13.08"	1411,36
121	-28°15'23.53"	26°48'13.46"	1410,22
122	-28°15'22.91"	26°48'13.77"	1409,13
123	-28°15'22.33"	26°48'14.16"	1408,95
124	-28°15'21.75"	26°48'14.52"	1408,51
125	-28°15'21.15"	26°48'14.88"	1408,09
126	-28°15'20.49"	26°48'15.21"	1408,55
127	-28°15'19.87"	26°48'15.53"	1409,16
128	-28°15'19.26"	26°48'15.91"	1408,95
129	-28°15'18.66"	26°48'16.28"	1409,89
130	-28°15'18.05"	26°48'16.65"	1408,89
131	-28°15'17.44"	26°48'16.99"	1409,02
132	-28°15'16.85"	26°48'17.37"	1408,96
133	-28°15'16.22"	26°48'17.76"	1409,47
134	-28°15'15.69"	26°48'18.25"	1409,73
135	-28°15'15.02"	26°48'18.37"	1409,49
136	-28°15'14.43"	26°48'18.72"	1410,04
137	-28°15'13.84"	26°48'19.06"	1408,49
138	-28°15'13.24"	26°48'19.40"	1408,3
139	-28°15'12.66"	26°48'19.80"	1408,4
140	-28°15'12.05"	26°48'20.10"	1408,45
141	-28°15'11.41"	26°48'20.39"	1406,96
142	-28°15'10.77"	26°48'20.58"	1407,35
143	-28°15'10.10"	26°48'20.76"	1407,82
144	-28°15'9.489"	26°48'21.03"	1407,85
145	-28°15'8.859"	26°48'21.25"	1407,64
146	-28°15'8.207"	26°48'21.50"	1407,84
147	-28°15'7.523"	26°48'21.69"	1408,1
148	-28°15'6.890"	26°48'21.92"	1407,05
149	-28°15'6.256"	26°48'22.12"	1406,68
150	-28°15'5.605"	26°48'22.39"	1407,87
151	-28°15'4.993"	26°48'22.70"	1408,16
152	-28°15'4.381"	26°48'23.03"	1408
153	-28°15'3.722"	26°48'23.11"	1407,84
154	-28°15'3.088"	26°48'23.32"	1407,58
155	-28°15'2.430"	26°48'23.55"	1407,76
156	-28°15'1.760"	26°48'23.79"	1408,07
157	-28°15'1.087"	26°48'23.99"	1407,96
158	-28°15'0.410"	26°48'24.23"	1406,91

159	-28°14'59.74"	26°48'24.44"	1406,16
160	-28°14'59.09"	26°48'24.60"	1406,25
161	-28°14'58.42"	26°48'24.82"	1406,38
162	-28°14'57.80"	26°48'25.00"	1405,93
163	-28°14'57.14"	26°48'25.28"	1405,16
164	-28°14'56.46"	26°48'25.42"	1404,53
165	-28°14'55.80"	26°48'25.60"	1406,14
166	-28°14'55.14"	26°48'25.66"	1405,29
167	-28°14'54.45"	26°48'25.78"	1405,59
168	-28°14'53.76"	26°48'25.79"	1405,36
169	-28°14'53.04"	26°48'25.83"	1405,34
170	-28°14'52.33"	26°48'25.87"	1404,8
171	-28°14'51.66"	26°48'25.97"	1404,37
172	-28°14'50.98"	26°48'26.12"	1404,51
173	-28°14'50.29"	26°48'26.25"	1404,34
174	-28°14'49.62"	26°48'26.46"	1402,62
175	-28°14'48.99"	26°48'26.72"	1402,8
176	-28°14'48.35"	26°48'26.99"	1402,6
177	-28°14'47.65"	26°48'27.08"	1402,3
178	-28°14'46.99"	26°48'27.24"	1401,64
179	-28°14'46.32"	26°48'27.32"	1401,42
180	-28°14'45.65"	26°48'27.43"	1403,03
181	-28°14'45.00"	26°48'27.55"	1402,83
182	-28°14'44.43"	26°48'27.95"	1403,08
183	-28°14'43.95"	26°48'28.24"	1401,32
184	-28°14'43.27"	26°48'28.29"	1400,7
185	-28°14'42.59"	26°48'28.35"	1403,12
186	-28°14'41.93"	26°48'28.37"	1401,45
187	-28°14'41.26"	26°48'28.52"	1400,73
188	-28°14'40.60"	26°48'28.63"	1402,17
189	-28°14'39.92"	26°48'28.76"	1402,46
190	-28°14'39.29"	26°48'28.65"	1401,67
191	-28°14'38.62"	26°48'28.82"	1400,36
192	-28°14'37.96"	26°48'28.96"	1400,21
193	-28°14'37.29"	26°48'29.07"	1401,58
194	-28°14'36.61"	26°48'29.25"	1401,83
195	-28°14'35.92"	26°48'29.28"	1402,15
196	-28°14'35.29"	26°48'29.49"	1402,21
197	-28°14'34.63"	26°48'29.62"	1401,26
198	-28°14'33.96"	26°48'29.64"	1400,66
199	-28°14'33.31"	26°48'29.76"	1399,52

200	-28°14'32.62"	26°48'29.99"	1399,22
201	-28°14'31.99"	26°48'29.95"	1400,29
202	-28°14'31.35"	26°48'30.19"	1399,17
203	-28°14'30.64"	26°48'30.26"	1401,41
204	-28°14'29.96"	26°48'30.41"	1401,76
205	-28°14'29.30"	26°48'30.54"	1400,9
206	-28°14'28.62"	26°48'30.65"	1401,06
207	-28°14'27.92"	26°48'30.71"	1401,25
208	-28°14'27.25"	26°48'30.88"	1400,6
209	-28°14'26.59"	26°48'30.97"	1399,63
210	-28°14'25.90"	26°48'31.04"	1400,24
211	-28°14'25.22"	26°48'31.20"	1400,22
212	-28°14'24.54"	26°48'31.29"	1400,74
213	-28°14'23.90"	26°48'31.46"	1399,87
214	-28°14'23.24"	26°48'31.54"	1399,98
215	-28°14'22.56"	26°48'31.65"	1399,89
216	-28°14'21.90"	26°48'31.86"	1399,68
217	-28°14'21.21"	26°48'31.88"	1399,73
218	-28°14'20.55"	26°48'31.95"	1398,73
219	-28°14'19.88"	26°48'32.15"	1397,43
220	-28°14'19.19"	26°48'32.26"	1396,6
221	-28°14'18.51"	26°48'32.38"	1395,22
222	-28°14'17.84"	26°48'32.51"	1396,39
223	-28°14'17.15"	26°48'32.63"	1396,19
224	-28°14'16.49"	26°48'32.71"	1397,21
225	-28°14'15.79"	26°48'32.84"	1397,51
226	-28°14'15.11"	26°48'32.90"	1397,1
227	-28°14'14.42"	26°48'33.01"	1398,55
228	-28°14'13.71"	26°48'33.13"	1397,65
229	-28°14'13.02"	26°48'33.22"	1396,39
230	-28°14'12.35"	26°48'33.34"	1395,92
231	-28°14'11.66"	26°48'33.49"	1397,28
232	-28°14'10.99"	26°48'33.58"	1397,1
233	-28°14'10.28"	26°48'33.71"	1396,82
234	-28°14'9.535"	26°48'33.83"	1396,33
235	-28°14'8.861"	26°48'33.93"	1397,31
236	-28°14'8.188"	26°48'34.01"	1396,75
237	-28°14'7.512"	26°48'34.15"	1395,53
238	-28°14'6.820"	26°48'34.25"	1394,84
239	-28°14'6.133"	26°48'34.39"	1393,44
240	-28°14'5.441"	26°48'34.53"	1391,74

Appendix C – Details of specialists

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-
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.

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	2
Masters	10	5
PhD	11	4
Postdoctoral fellows	10	4

viii) Undergraduate teaching

Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 2-8 students per year.

ix) Editing and reviewing

Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Cretaceous Research: 2014 –
Journal of African Earth Sciences: 2020 –

Review of manuscripts for ISI-listed journals: 25 local and international journals

x) Palaeontological Impact Assessments

Selected – list not complete:

- 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 July 2021 peer-reviewed journals or scholarly books: over 150 articles published; 5 submitted/in press; 8 book chapters.
Scopus h index = 29; Google scholar h index = 36;
Conferences: numerous presentations at local and international conferences.

Bailey M. Weiss CV

October 2021

I am currently enrolled as an MSc student, at the University of the Free State (UFS), completing a research project entitled: *Bone microanatomy of Anomodontia (Synapsida: Therapsida) from the Karoo Basin of South Africa*. This project is supervised by Dr Jennifer Botha (National Museum, Bloemfontein) and Co-Supervised by Dr Alexandra Houssaye (Muséum national d'Histoire naturelle, Paris). I completed my BSc honours degree in which I completed a research project entitled: *Limb bone histology of theropod dinosaurs from the Early Jurassic of South Africa*. This project was supervised by Dr Jennifer Botha. I majored in Genetics and Zoology for my BSc degree. I have worked as an Osteohistology Technician at the National Museum, Bloemfontein, as well as a Laboratory Assistant at the UFS. I have been on two Palaeontological field trips one with the National Museum in the Balfour and Katberg Formations. The other with the University of the Witwatersrand in the Lower Elliot Formation of South Africa.

Qualifications

BSc – Majors: Genetics and Geology - University of the Free State – 2018
BSc Honours – Palaeontology – University of the Free State – 2019
MSc – Palaeontology – University of the Free State – registered 2020, in progress.

PIA fieldwork Experience

July 2021 – Sannaspos PV Facility, Free State for CTS Heritage

References:

Dr Jennifer Botha, Head of Palaeontology, National Museum, Bloemfontein
jbotha@nasmus.ac.za

Prof Jonah Choiniere, Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg
Jonah.choiniere@wits.ac.za

Brandon Stuart CV

October 2021

After completing my BSc degree majoring in Zoology and Genetics in 2019. In 2020 enrolled and completed a BSc Hons. degree majoring in Zoology and specializing in Paleontology. My Honours research project was focused on describing the postcranial anatomy of the therocephalian *Moschorhinus kitchingi,* supervised by Dr. Jennifer Botha at the National Museum, Bloemfontein.

I am currently enrolled at the University of the Free State for my MSc degree in Palaeobiology. I am carrying out my research through the National Museum, Bloemfontein supervised by Dr. Jennifer Botha. My research is focused on studying the postcranial morphology of therocephalian therapsids from the Karoo Basin of South Africa.

Qualifications

BSc – Majors: Genetics and Geology - University of the Free State – 2019

BSc Honours – Palaeontology – University of the Free State – 2020

MSc – Palaeontology – University of the Free State – registered 2021, in progress.

PIA Fieldwork Experience

July 2021 – Sannaspos SEF, Free State, for CTS Heritage

References:

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jbotha@nasmus.ac.za

Prof Jonah Choiniere, Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg

Jonah.choiniere@wits.ac.za