Palaeontological Impact Assessment for the proposed construction of Kronos-Hydra second 400kV powerline and associated infrastructure, Pixley ka Seme District Municipality, Northern Cape Province.

Desktop Report (Phase 1)

For

DIGES Group

01 July 2023

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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 Vhubvo Consultancy, Midrand, 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

Executive Summary

A Palaeontological Impact Assessment was requested for the proposed construction of Kronos-Hydra second 400kV powerline and associated infrastructure, Pixley ka Seme District Municipality, Northern Cape Province.

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

The Kronos Substation lies on moderately fossiliferous **Dwyka Group** (Karoo Supergroup) that might preserve fragmentary fossils of the early *Glossopteris* flora or invertebrates. The powerline route traverses moderately to highly sensitive rocks of the **Ecca Group** (Karoo Supergroup) and Quaternary sands of the Gordonia Formation. A short section south of De Aar is on potentially highly fossiliferous rocks of the *Tapinocephalus* Assemblage Zone (**Adelaide Subgroup**, Beaufort Group, Karoo Supergroup). The powerline route is already disturbed from the existing powerline and roads. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information, no further palaeontological impact assessment is recommended unless fossils are found by the contractor, developer, environmental officer or other designated responsible person once excavations for foundations for the pylons have commenced. Since the impact will be low, as far as palaeontology is concerned, the project should be authorised. There is no cumulative impact and no no-go area.

ASPECT	SCREENING TOOL SENSITIVITY	VERIFIED SENSITIVITY	OUTCOME STATEMENT/ PLAN OF STUDY	RELEVANT SECTION MOTIVATING VERIFICATION
Palaeontology	Low to High	Very Low to Low	Paleontological Impact Assessment	Section 7.2. SAHRA Requirements

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1. Background

A Palaeontological Impact Assessment was requested for the proposed construction of Kronos-Hydra second 400kV powerline and associated infrastructure, Pixley ka Seme District Municipality, Northern Cape Province (Figures 1-5).

The Department of Mineral Resources and Energy released the 2019 Integrated Resource Plan (IRP 2019) in October 2019. The Integrated Resource Plan, 2019 will see around 6 GW of new solar PV capacity and 14.4 GW of new wind power capacity commissioned by 2030. Since there is favourable sun and wind in the Northern Cape, the province has around 3.3 GW of committed renewable generation with over 10 GW expected by 2030. Eskom is therefore required to respond to the aggressive plans for the country to achieve a diversified energy mix. This entails the strengthening of the Transmission infrastructure network to evacuate the existing and expected renewable power out of the Northern Cape province to other load centres in the country. Aries – Kronos – Hydra 400 kV is one of the three major backbone corridors that move power to and from the Northern Cape. Furthermore, with the current generation allocation, the existing Kronos – Hydra 400 kV line will experience thermal overload by 2023 thus requiring the need for a second (2nd) Kronos – Hydra 400 kV line. The work associated with the second 400kV line is a listed activity according to National Environmental Management Act 107 of 1998: Environmental Impact Assessment (EIA) regulations of 2014 (as amended) for which an Environmental Authorisation (EA) is required before the powerline can be constructed. In addition, other permits such as Water Use Licence (WUL)/ General Authorisation (GA), heritage and tree-cutting permits will be required. Eskom has therefore appointed DIGES to lodge applications for Environmental Authorisation (EA), WUL/GA, heritage and tree-cutting permits with the relevant Competent Authorities.

The scope of work entails the following:

i. Construction of a second 187 km, 400 kV line from Kronos substation to Hydra substation.
ii. Equipping the existing 400 kV feeder bay at Hydra Substation.

At the Kronos substation:

iii. Establishment of a 400kV HV Yard and equipping it with a new 400kV transformer bay.
iv. Equipping a new 400kV transformer bay at the 132kV yard.
v. Installation of a new 400/132kV, 500 MVA transformer at the 132kV yard.
vi. The extension of the 6m width road to the storage area by 85m; and the extension of a 9m wide road to the new 400 kV yard by 110m.

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 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 2
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
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

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
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

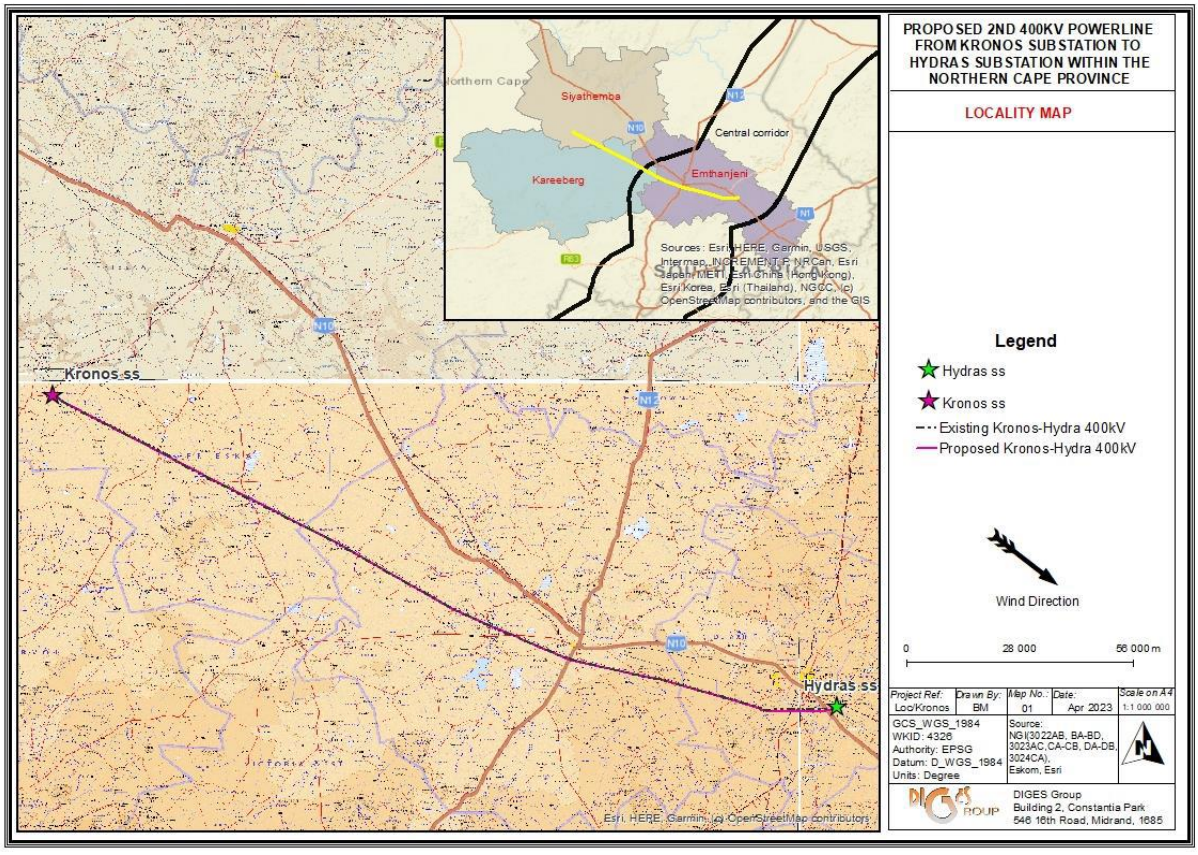

Figure 1: Project map supplied by DIGES for the proposed construction of Kronos-Hydra second 400kV powerline and associated infrastructure, Pixley ka Seme District Municipality, Northern Cape Province.

Figure 2: Google Earth map of the proposed Kronos-Hydra project with Kronos substation in the northwest and Hydra in the southeast. The powerline is shown as a thin red line with a 300m wide corridor.

Figure 3: Google Earth map for the proposed expansion of Kronos Substation powerline (red line) heading southeast.

Figure 4: Google Earth map of the proposed 400 kV yard to be constructed on the southwest side of the Kronos Substation. (Map not oriented to the North).

Figure 5: Google Earth map to show the powerline route south of De Aar to Hydra Substation, along the existing powerline route.

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 field archaeologist to locate any fossils and assess their importance, as is the case here;
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

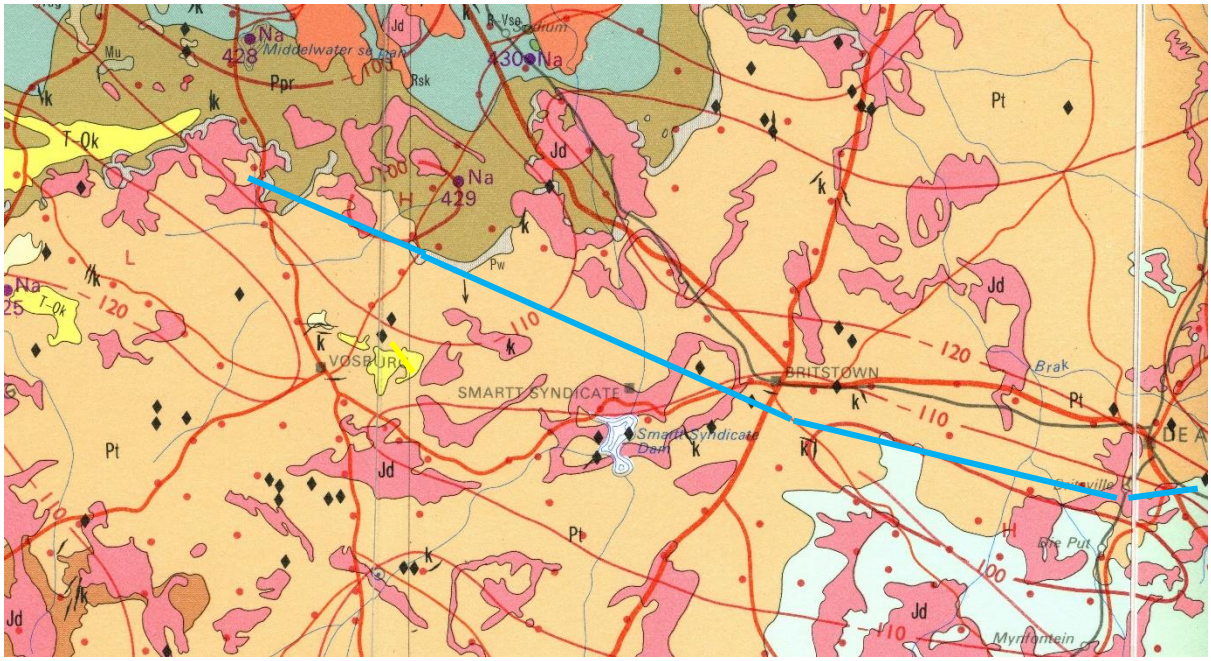

Figure 6: Geological map of the route along the Kronos-Hydra powerline (blue line) area. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 1 000 000 map for South Africa.

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

Symbol	Group/Formation	Lithology	Approximate Age
(white)	Recent	Alluvium and debris	Last few millenia
Qc	Quaternary	Alluvium, sand, calcrete	Quaternary ca 1.0 Ma to present
T-Qc	Tertiary-Quaternary calcrete	Sand calcrete, surface limestone	Tertiary to Quaternary
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 183 Ma
Pa	Adelaide Subgroup, Beaufort Group, Karoo SG	Blue-grey silty mudstone, subordinate brownish-red mudstone; sandstone	Late Permian Ca 265 – 250 Ma
Pc/Pwa	Carnarvon Fm = Waterberg Fm, Ecca Group, Karoo SG	Sandstone, shale	Middle Permian ca 266 – 265 Ma
Pt	Tierberg Fm, Ecca Group, Karoo SG	Blue-grey to black shales with carbonate-rich concretions; subordinate siltstone and sandstone in the upper layers	Middle Permian ca 269 – 266 Ma
Pp	Prince Albert Fm, Ecca Group, Karoo SG	Shales, siltstones, mudstones	Early Permian Ca 290 – 283Ma
C-Pd	Dwyka Group, Karoo SG	Tillites, diamictites, mudstone	Upper Carboniferous to Early Permian
Mg	Namaqua intrusive rocks	Porphyritic granite	Mesoproterozoic Ca 1200 Ma
Vp	Spionkop granite	Quartzite, schist, gneiss, granite	Palaeoproterozic

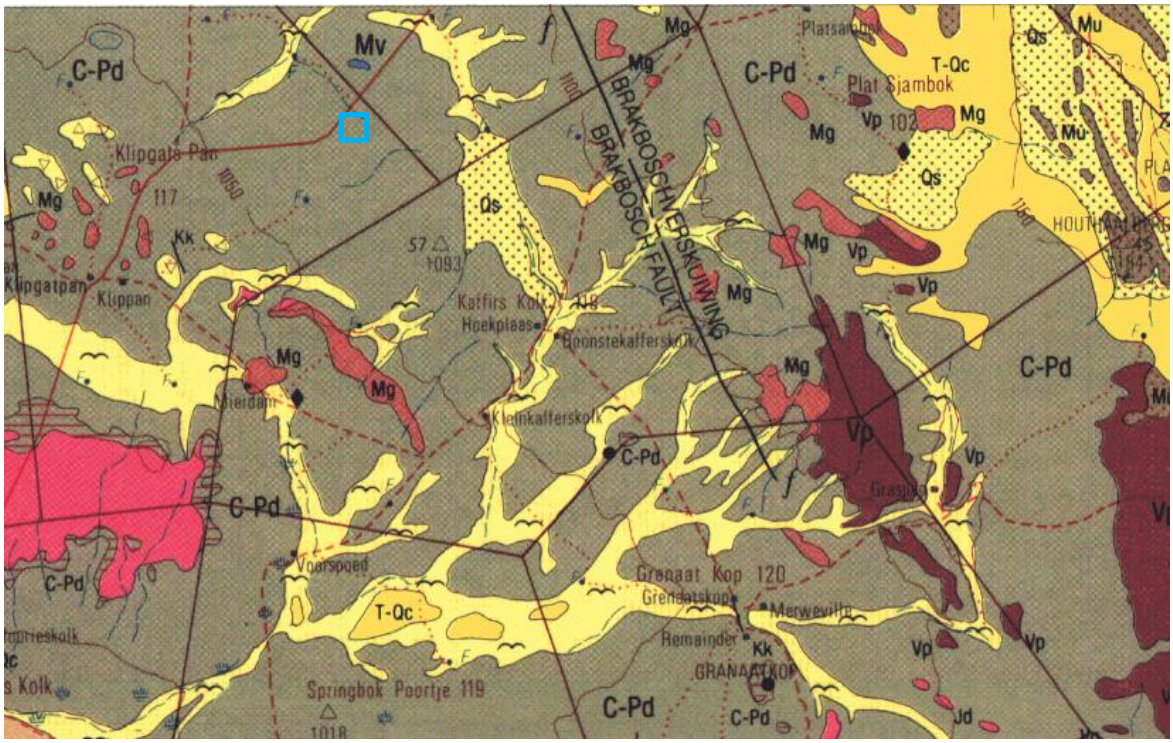

Figure 7: Geological map for the area around Kronos Substation (blue outline).

Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 3022 Britstown.

The site lies in the northwestern part of the Karoo basin where the middle Karoo Supergroup strata are exposed (Figures 6-8). Along the rivers and streams much younger reworked sands and alluvium overlie the older strata. Underlying these sediments are much older volcanic rocks of the Palaeoproterozoic and Mesoproterozoic Namaqualand Metamorphic Sequence.

The Karoo Supergroup rocks cover a very large proportion of South Africa and extend from the northeast (east of Pretoria) to the southwest and across to almost the KwaZulu Natal south coast. It is bounded along the southern margin by the Cape Fold Belt and along the northern margin by the much older Transvaal Supergroup rocks. Representing some 120 million years (300 – 183Ma), the Karoo Supergroup rocks have preserved a diversity of fossil plants, insects, vertebrates and invertebrates.

During the Carboniferous Period South Africa was part of the huge continental landmass known as Gondwanaland and it was positioned over the South Pole. 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**. They comprise tillites, diamictites, mudstones, siltstones and sandstones that were deposited as the basin filled (Johnson et al., 2006).

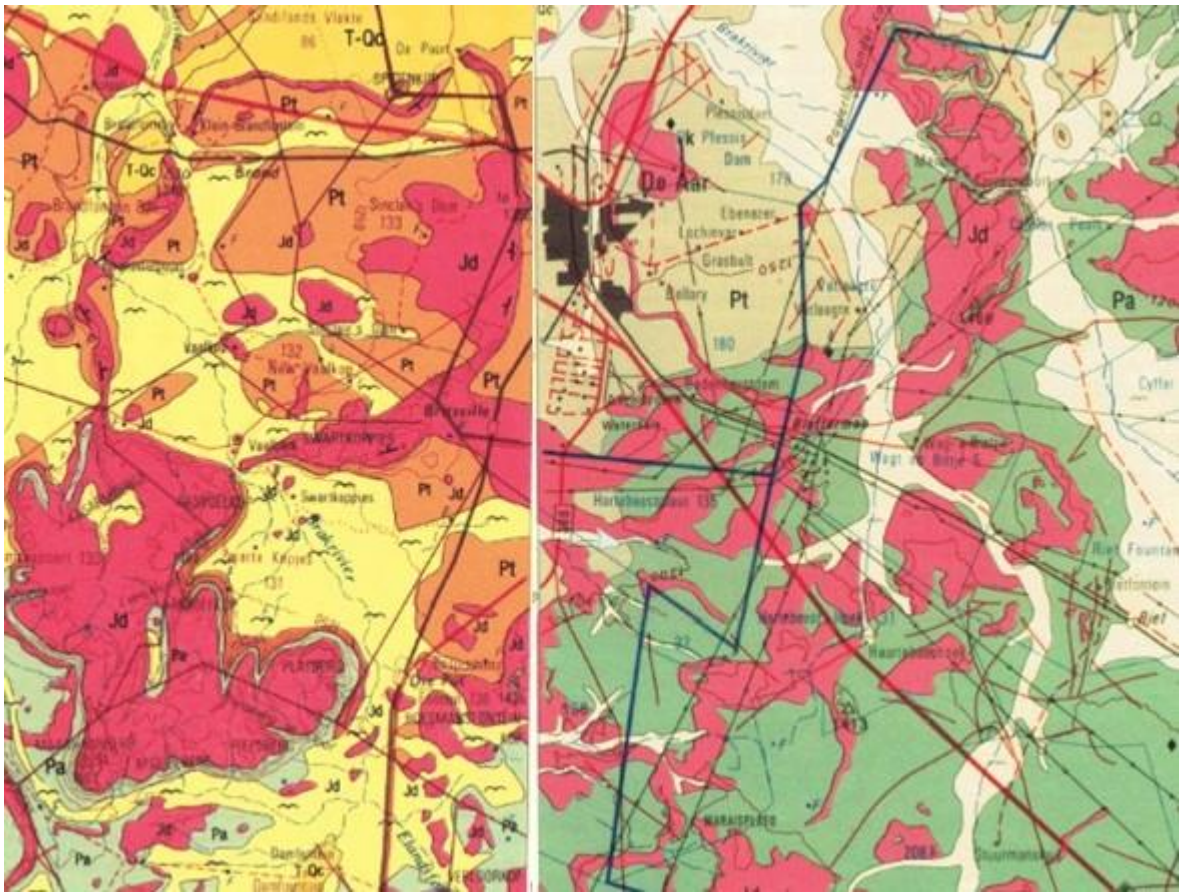

Figure 8: Geological map for the area around De Aar with the Hydra Substation and powerline shown by the blue outlines. Abbreviations of the rock types are explained in

Table 2. Map enlarged from the Geological Survey 1: 250 000 maps 3022 Britstown (west) and 3024 Colesburg (east).

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. In the west and central part are the following formations, from base upwards: **Prince Albert Formation**, Whitehill Formation, Collingham Formation, Laingsburg / Ripon Formations, **Tierberg** / Fort Brown Formations, and **Waterford Formation**. The Carnarvon Formation is an old term and the current accepted term is the Waterford Formation (Groenewald et al., 2022). 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 are the rocks of the Beaufort Group that has been divided into the lower **Adelaide Subgroup** for the Upper Permian strata, and the Tarkastad Subgroup for the Early to Middle Triassic strata. As with the older Karoo sediments, the formations vary across the Karoo Basin.

There are only two formations in this part of the Karoo Basin in the Adelaide Subgroup west of 24°E, the basal Abrahamskraal Formation and the Teekloof Formation. The latter has been divided into four members, from the base upwards they are the Poortje, Hoedemaker, Oukloof and Steenkampsvlakte Members. There are no younger strata in this part of the basin.

With the uplift of the African continent over time much of the land surface has eroded away, the so-called African Surfaces of Partridge and Maud (review in Partridge at al., 2006). Although the timing of the orogeny has been challenged (Braun et al., 2014) the net result is a long hiatus and then only much more recent sediments being deposited during the **Quaternary**. These have been captured in some of the flat areas and river cuttings.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration are presented in Figures 8-10. The Kronos Substation lies on the Dwyka Group tillites and diamictites that are moderately sensitive. The route for the power line traverses the Dwyka Group, the Waterford Formation (moderately sensitive – orange), and from Britstown to De Aar on the highly sensitive Tierberg and Prince Albert Formation (orange). South of De Aar the powerline partly is in the very highly sensitive Adelaide Subgroup rocks (red).

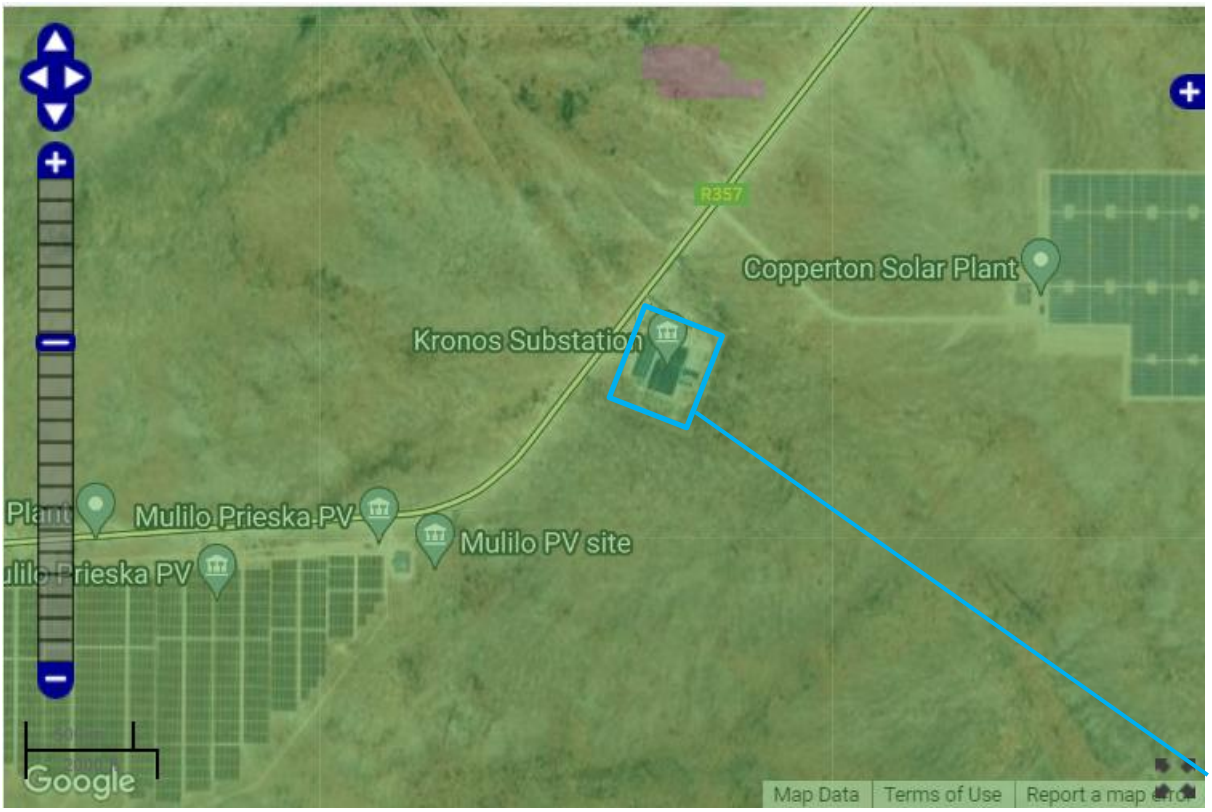

Figure 9: SAHRIS palaeosensitivity map for the Kronos Substation expansion and the present powerline route to Hydra that will be strengthened (blue square and line, respectively). Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

The **Dwyka Group** is made up of seven facies that were deposited in a marine basin under differing environmental settings of glacial formation and retreat (Visser, 1986, 1989; Johnson et al., 2006). In the north and east these are called the Mbizane Formation, and the Elandsvlei Formation in the south and west. Described below are the seven facies (Johnson et al., 2006 p. 463-465):

The massive diamictite facies comprises highly compacted diamictite that is clast-poor in the north. It was deposited in subaqueous or subglacial positions.
The stratified diamictite comprises alternating diamictite, mudrock, sandstone and conglomerate beds. They are interpreted as being rapidly deposited, sediment gravity flows but with some possible reworking of the subglacial diamictites.
The massive carbonate-rich diamictite facies is clast-poor and was formed by the rainout of debris, with the carbonate probably originating by crystallisation from interstitial waters.
The conglomerate facies ranges from single layer boulder beds to poorly sorted pebble and granule conglomerates. The boulder beds are interpreted as lodgement deposits whereas the poorly sorted conglomerates are a product of water-reworking of diamicton by high-density sediment gravity flows.
The sandstone facies were formed as turbidite deposits.
The mudrock with stones facies represents rainout deposits in the distal iceberg zone.

The **mudrock facies** consists of dark-coloured, commonly carbonaceous mudstone, shale or silty rhythmite that was formed when the mud or silt in suspension settled. This is the only fossiliferous facies of the Dwyka Group.

The Dwyka *Glossopteris* flora outcrops are very sporadic and rare. Of the seven facies that have been recognised in the Dwyka Group fossil plant fragments have only been recognised from the mudrock facies. They have been recorded from around Douglas only (Johnson et al., 2006; Anderson and McLachlan 1976) although the Dwyka Group exposures are very extensive. Jurassic Dolerites do not contain fossils as they are igneous intrusives.

West and east of 24°E, the Ecca Group comprises the basal **Prince Albert Formation**, in the southwestern half of the Karoo Basin, and comprises shales and silty shales. In the west where is overlies the Dwyka Group there are fining upward sequences of sandstones, siltstones, silty shales and rhythmites. Marine fossils such as cephalopods, lamellibranches and brachiopods, and fragmentary plant fossils and palaeoniscoid fish remains (Douglas area; McLachlan and Anderson, 1973). The southern facies of the Prince Albert Formation has darker shales, chert and carbonaceous nodules produced under a reducing environment, with rare marine fossil fragments (Johnson et al., 2006).

In the southern part of the basin the **Waterford Formation** comprises alternating very fine-grained lithofeldspathic sandstones and mudrock or clastic rhythmite units. These sediments represent fairly shallow water accumulations with deformation and dewatering features. A delta front setting is implied and trace fossils of trails, tubes and burrows have been reported (Johnson et al., 2006).

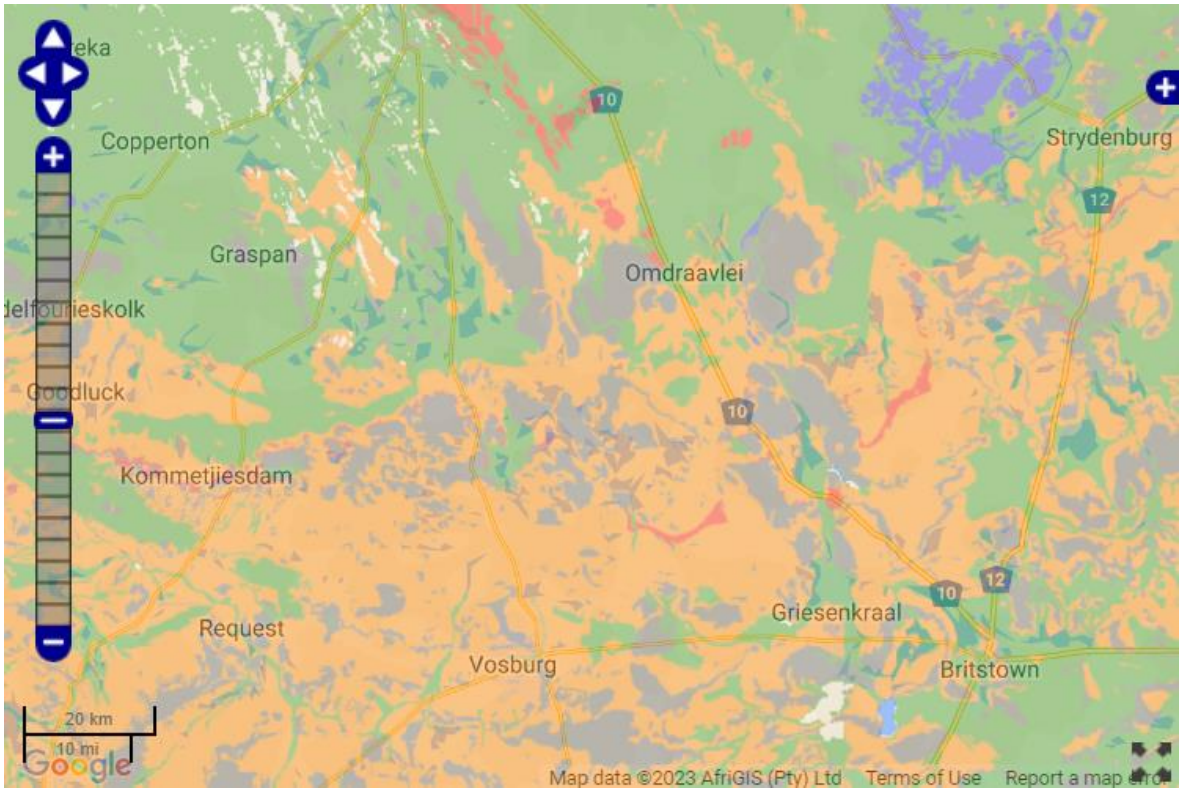

Figure 10: SAHRIS palaeosensitivity map for the section of the powerline route from Kronos to Britstown. Colours as for Figure 9.

Figure 11: SAHRIS palaeosensitivity map of the section of the powerline route from Britstown to De Aar (Hydra Substation). Colours as for Figure 9.

Figure 12: SAHRIS palaeosensitivity map for the section of powerline south of De Aar to the Hydra Substation. Colours as for Figure 9.

In the westernmost part of the basin the **Tierberg Formation** is predominantly argillaceous. In the northwest of its occurrence where it is in contact with the Collingham or Whitehill Formations, it grades up into the arenaceous overlying Waterford Formation (Johnson et al., 2006). Trace fossils of *Nereites, Planolites* and *Zoophycus* can be found in the fine mudstones (Johnson et al., 2006).

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). From the updated Karoo Biostratigraphic map and biostratigraphy, De Aar is in the Abrahamskraal Formation and the *Tapinocephalus* Assemblage Zone (Smith et al., 2020). The main faunal groups that occur are the fish, amphibians, Parareptilia, Eureptilia, Biarmosuchia, Dinocephalia, Anomodontia and Therocephalia. In separate areas one might find plants of the Glossopteris flora, especially fossil wood and rarely leaf impressions (Plumstead, 1969; Anderson and Anderson, 1985; Bamford, 2004;). Fossil plants and animals seldom occur together because different conditions are required for their preservation.

There are vast exposures of Jurassic dolerite that intruded through the Karoo Sequence but this is volcanic rock and does not preserve fossils.

Sands of the **Quaternary** period do not preserve fossils but might obscure traps such as palaeo-pans, palaeo-springs or tufas. Most pans in the Kalahari Basin are filled by a layer of clayey sand or calcareous clays and are flanked by lunette dunes formed as a result of deflation of the pan floor during arid periods (Lancaster, 1978a,b; Haddon and McCarthy, 2005). At some localities in the south western Kalahari spring-fed tufas have formed at the margins of pans during periods where groundwater discharge was high (Lancaster, 1986). These tufas may contain evidence of algal mats and stromatolites and may also be associated with calcified reed and root tubes (Lancaster, 1986). Many of the pans are characterised by diatomaceous earth, diatomite or kieselguhr, a white or grey, porous, light-weight, fine-grained sediment composed mainly of the fossilised skeletons of diatoms. Associated with some palaeo-pans and palaeo-springs are fossil bones, root casts, pollen and archaeological artefacts.

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	-
	L	Soils and sands do not preserve plant fossils; so far there are no records from the Dwyka or Ecca Groups or the Abrahamskraal Fm of plant or animal fossils in this region so it is very unlikely that fossils occur on the site. The impact would be very unlikely.
	L+	-
	M+	-
	H+	-
DURATION	**L**	-
	M	-
	H	Where manifest, the impact will be permanent.

PART B: Assessment		
SPATIAL SCALE	**L**	Since the only possible fossils within the area would be trace fossils, fossil plants from the *Glossopteris* flora or vertebrates of the *Tapinocephalus* AZ in the shales, the spatial scale will be localised within the site boundary.
	M	-
	H	-
PROBABILITY	**H**	**-**
	M	**-**
	L	It is extremely unlikely that any fossils would be found in the loose sand that will be excavated. Only fragments of transported silicified wood were found on the surface. Nonetheless, a Fossil Chance Find Protocol should be added to the eventual EMPr.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are the correct age and type to preserve fossils. The powerline route is along or adjacent to the existing powerline. Only the area south of De Aar is very highly sensitive and the areas is highly disturbed from a number of powerlines, farms and solar energy facilities. Since there is a small chance that fossils from the Abrahamskraal Formation may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is 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 do contain fossil plant, insect, invertebrate and vertebrate material. The sands of the Quaternary period would not preserve fossils. It is not known if there are fossils below the ground surface.

6. Recommendation

Based on the fossil record and previous surveys in the area, fossils are very rare in this area which is already disturbed. It is extremely unlikely that any fossils would be preserved in the overlying soils and sands of the Quaternary. There is a very small chance that fossils may occur below the ground surface in the shales of the Ecca Group and the Abrahamskraal Formation so a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found by the environmental officer, or other responsible person once excavations and drilling have commenced, then they should be rescued and a palaeontologist called to assess and collect a representative sample.

Since each fossil deposit is unique and does not impact on nearby sites, there is NO cumulative impact. There are NO no-go areas because along the section south of De Aar, the only very highly sensitive rocks, the route is already disturbed from existing powerlines. Mitigation: if fossils are found when excavations commence they can be removed and rescued – following the Fossil chance Find Procedure (Section 8).

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 excavation commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (trace fossils, fossils of plants, insects, bone or coalified material) 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 13-14). 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 contractor/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.

Appendix A – Examples of fossils from the Ecca and Beaufort Groups.

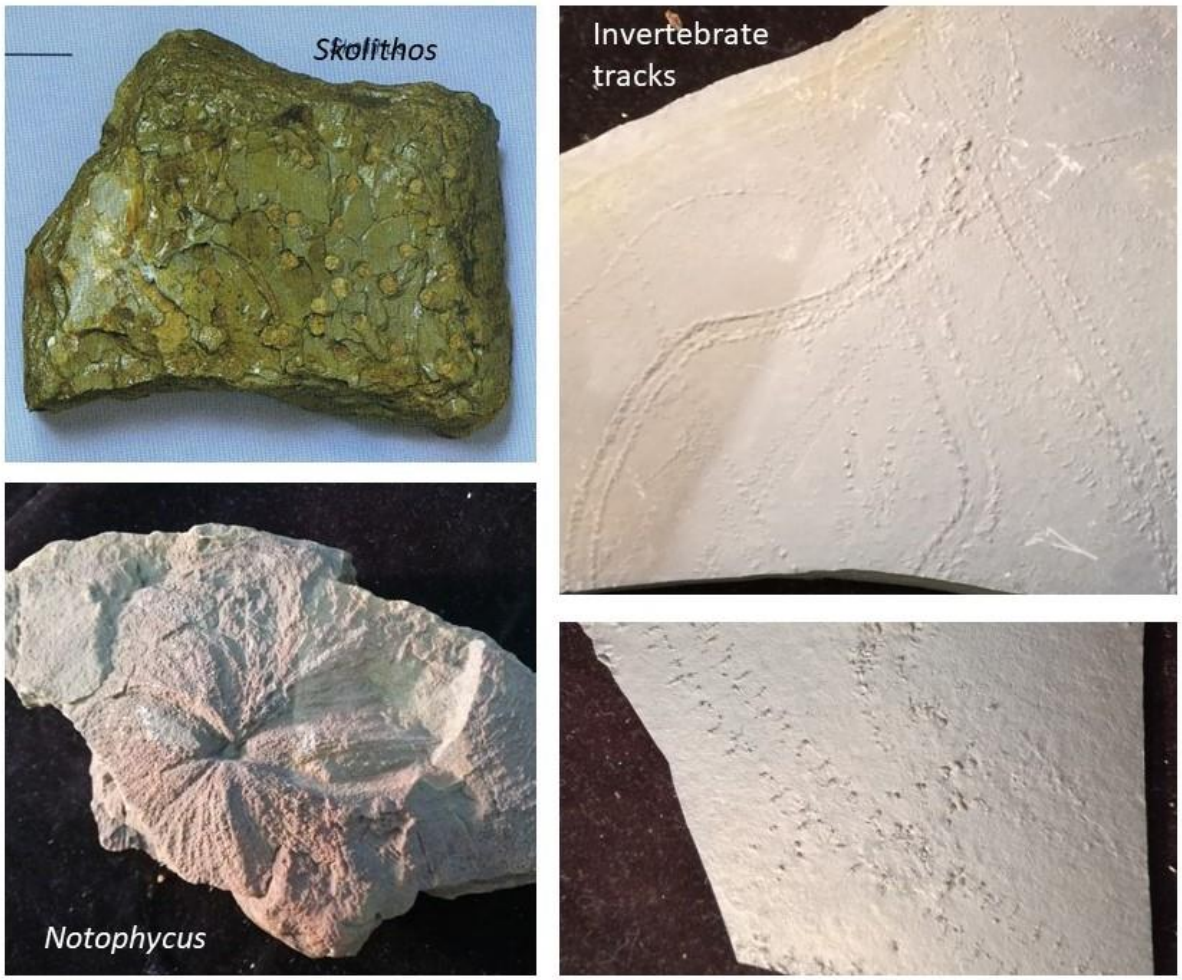

Figure 13: Photographs of trace fossils from the Ecca Group.

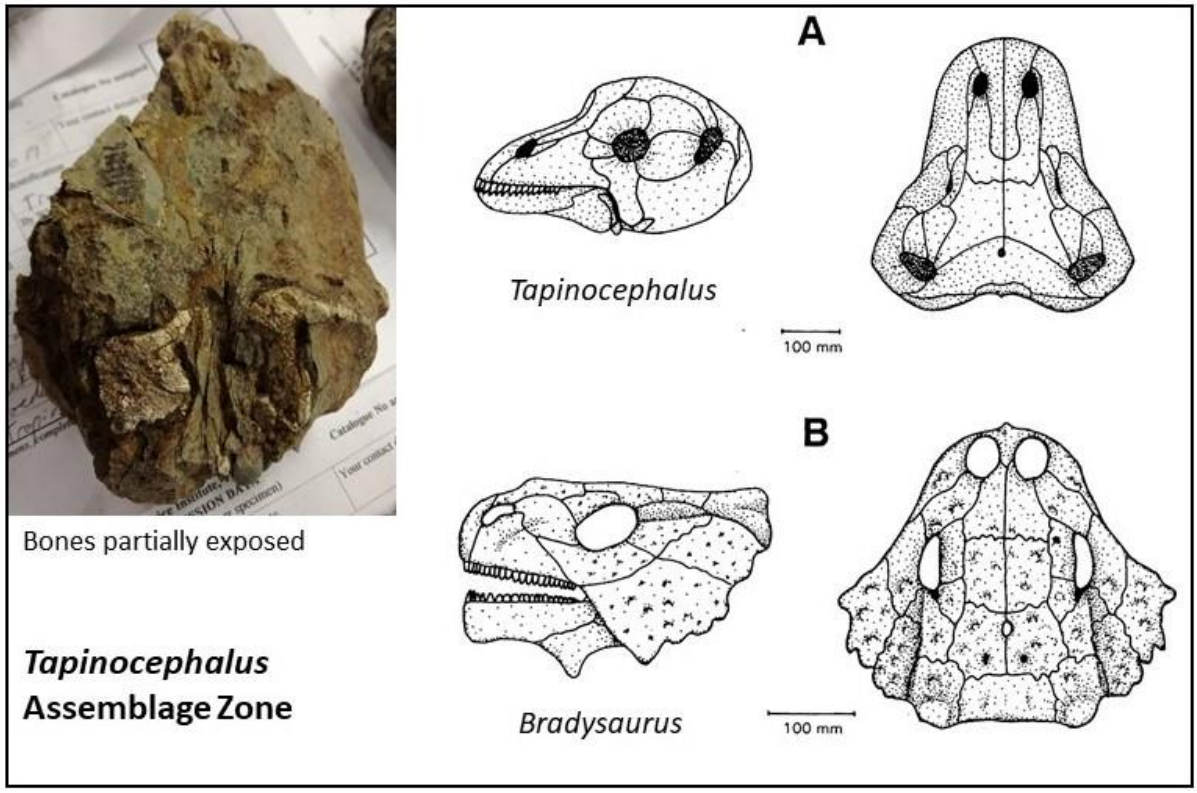

Figure 14: Photograph of bones as seen in the field and reconstruction diagrams of some examples from the *Tapinocephalus* Assemblage Zone.

9. Appendix B – Details of specialists

Marion Bamford (PhD)

Short CV for PIAs – July 2023

I) **Personal details**

Present employment: Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa

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ii) **Academic qualifications**

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.

1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) **Professional qualifications**
Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) **Membership of professional bodies/associations**
Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

vii) **Supervision of Higher Degrees**
All at Wits University

Degree	Graduated/completed	Current
Honours	11	0
Masters	14	3
PhD	13	6
Postdoctoral fellows	13	3

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 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: Cretaceous Research: 2018-2020
Associate Editor: Royal Society Open: 2021 -
Review of manuscripts for ISI-listed journals: 25 local and international journals

x) **Palaeontological Impact Assessments**
Selected from recent project 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
- Glosam Mine 2021 for AHSA

Xi) **Research Output**

Publications by M K Bamford up to July 2023 peer-reviewed journals or scholarly books: over 175 articles published; 5 submitted/in press; 10 book chapters.
Scopus h-index = 31; Google Scholar h-index = 39; -i10-index = 116.
Conferences: numerous presentations at local and international conferences.