

**Palaeontological Impact Assessment for the proposed
Culvert on Road L2013, Bergville, Okhahlamba Local
Municipality, KwaZulu Natal Province**

Desktop Study (Phase 1)

For

Gedezar Consulting

20 March 2021

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Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 32 years research; 24 years PIA studies

Declaration of Independence

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

Specialist: Prof Marion Bamford

Signature:

A handwritten signature in blue ink that reads "MKBamford". The signature is written in a cursive style and is positioned above a horizontal line.

Executive Summary

A Palaeontological Impact Assessment was requested for the proposed construction of a culvert on road L2013 near Woodstock Dam, Bergville area, Okhahlamba Local District, southwestern KwaZulu Natal. In order to comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed project.

The proposed site lies on the grey-green shales of the Adelaide Subgroup (Beaufort Group, Karoo Supergroup). The rocks are potentially fossiliferous but fossils are rare and scattered because this stratum represents delta-plain deposits. The *Daptocephalus* Assemblage Zone possibly is present so there could be vertebrate bones below the surface, or fragmentary plants of the *Glossopteris* flora might occur. The culvert is over a stream and on an existing road, with paths and tracks alongside it, so the culvert site is already highly disturbed and no surface fossils would survive. Therefore, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no palaeontological site visit is required unless fossils are found once excavations for the culvert and foundations have commenced.

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1. Background

As part of a larger project to upgrade the roads and improve access in the Okhahlamba local district, near Bergville, Road **L2013** crosses a seasonal stream (Figures 1, 2), therefore a culvert needs to be constructed so that the road is passable even in wet weather. This is a cross-road that links the villages in the region and paths and tracks from all directions converge here (Figure 2).

This part of the project involves three proposed culverts in the area between Bergville (east) and the Woodstock Dam (west) in the Thukela District Municipality. These culverts are situated along district roads L 2013, L1511 and L 1526 (with two culverts).

The GPS coordinates for the proposed culverts are:

L1511: S 28° 51' 57.47" E 29° 16' 47.60"

L 2013: S 28° 46' 32.57" E 29° 14' 54.47" – this report.

L 1526: Culvert 1: S 28° 49' 38.59" E 29° 13' 15.67"

Culvert 2: S 28° 49' 36.18" E 29° 13' 12.67"

A Palaeontological Impact Assessment was requested for the Culvert project by Gedezar Consulting. To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development and 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 B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A

e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
k	Any mitigation measures for inclusion in the EMPr	Section 7, Appendix A
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 7, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	N/A
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



Figure 1: Google Earth Map showing the region around the proposed culvert for Road L2013, for orientation.



Figure 2: Google Earth map in more detail of the proposed L2013 culvert where a number of paths and roads intersect, shown by the blue line. Note that the route is along existing tracks and paths and crosses the Nhlambambasoka River. Map supplied by Gedezar Consulting.

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.

The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' 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 site lies in the southeastern part of the main Karoo Basin and the basal strata of the Karoo Supergroup are exposed in this region (Figure 3, Table 2).

The Karoo Basin is filled with the Karoo Supergroup rocks. The basin 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 positioned over the South Pole. As a result, there were several ice sheets that formed and melted, and covered most of South Africa (Visser, 1986, 1989; Isbell et al., 2012). Gradual melting of the ice as the continental mass moved northwards and the earth warmed, formed sediments in the large inland sea. These are the oldest rocks in the system and they are exposed around the outer part of the ancient Karoo Basin. They are known as the Dwyka Group and comprise tillites, diamictites, mudstones, siltstones and sandstones that were deposited as the basin filled. This group has been divided into two formations with Elandsvlei Formation occurring throughout the basin, and the upper Mbizane Formation occurring only in the Free State and KwaZulu Natal (Johnson et al., 2006).

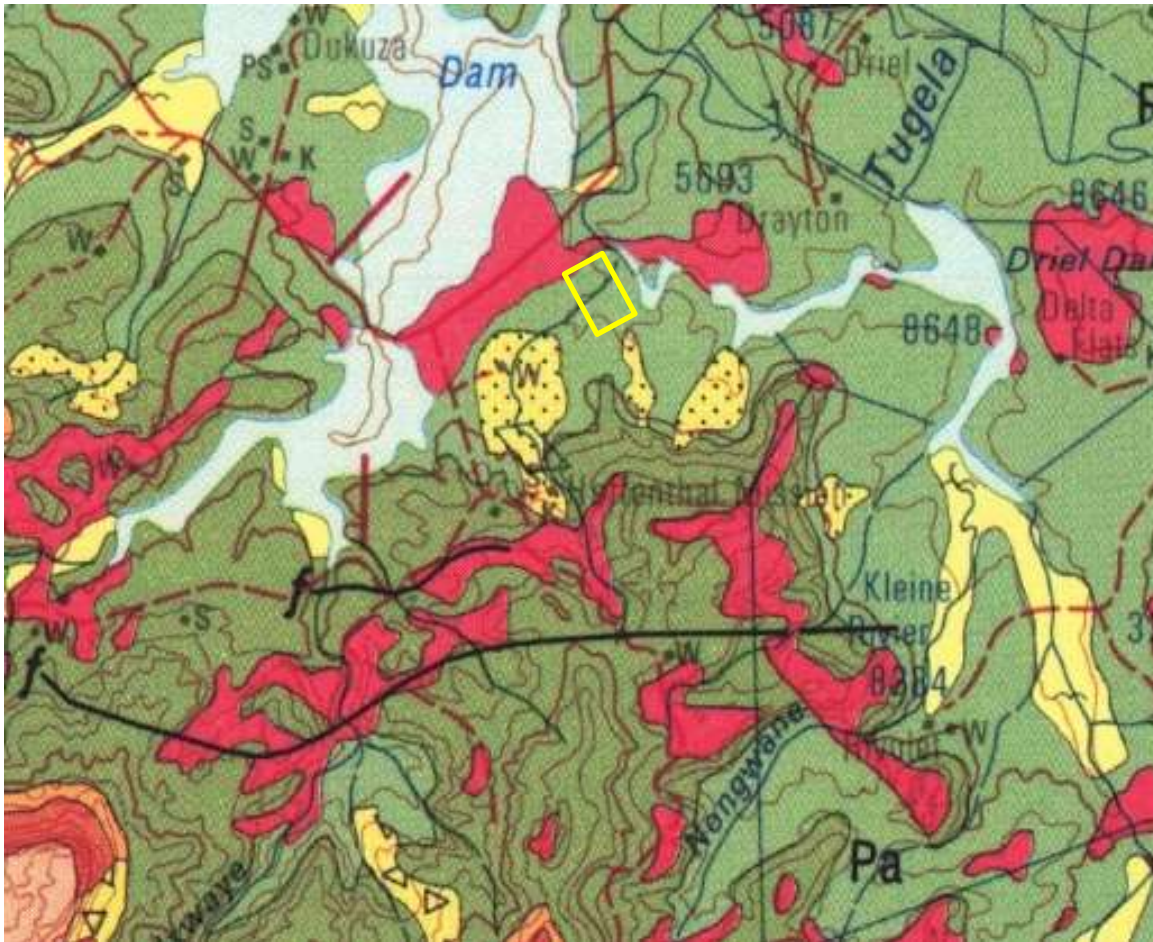


Figure 3: Geological map of the area around the proposed L2013 Culvert over the Nhlambambasoka River. The location of the proposed project is indicated within the yellow rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2828 Harrismith.

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, Beaufort Group, Karoo SG	Grey-green shales, yellow-grey fine-grained sandstone	Late Permian, Early Beaufort
Pvo	Volsrust Fm, Ecca Group, Karoo SG	Dark grey shale	Middle Permian, Upper Ecca

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. In the Free State and KwaZulu Natal, from the base upwards are the Pietermaritzburg Formation, Vryheid Formation and the Volksrust Formation. 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. The site lies in the south eastern sector of the Karoo Basin and the sediments are the alternating mudrocks and sandstones of the very thick, Adelaide Subgroup, Beaufort Group, Karoo Supergroup. They are late Permian in age with younger intrusive Jurassic-aged dolerite dykes occurring abundantly.

In this more eastern part of the Karoo Basin there are three formations in the Adelaide Subgroup, the basal Koonap Formation, then the Middleton Formation and the upper Balfour Formation (with five members, Rubidge, 2005; Smith et al., 2020). This part of the Karoo Basin has not been studied as well as the western part and so the maps do not indicate which of the three formations is represented.

Large exposures of Jurassic dolerite dykes occur throughout the area. These intruded through the Karoo sediments around 183 million years ago at about the same time as the Drakensberg basaltic eruption.

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 the Ecca and Beaufort Group strata are dolerite dykes that formed during the initial breakup of Gondwanaland and the massive eruption of basalts that form the Drakensberg Mountains. Forming the final capping and termination of the Karoo Supergroup is this Drakensberg Formation.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The site for development is on the Adelaide Subgroup and close to Jurassic dolerite. Since dolerite is of volcanic origin it does not preserve any fossils, and so has low sensitivity (blue in the SAHRIS palaeosensitivity map).

According to the currently accepted biostratigraphy, the whole of the Adelaide Subgroup has been divided into eight Assemblage Zones based on the dominant or temporally exclusive vertebrate fossils (Rubidge et al., 1995; Rubidge, 2005). 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.

Vertebrate fossils are fairly common in the **Adelaide Subgroup** in certain parts of the Karoo Basin and have been used to subdivide the strata into biozones (Rubidge et al., 1995; Day et al., 2015; Smith et al., 2020). In the eastern part of the basin the only formation is the Normandien Formation, with four members, that correspond to the Daptocephalus Assemblage Zone (Rubidge et al., 1995) and more recently divided into two subzones (Smith et al., 2020). Potential vertebrate fossils are fish, amphibians, Parareptilia, Eureptilia, Biarmosuchia, Anomodontia, Synapsida, Theriocephalia and Cynodontia (Appendix A).

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 (Appendix A).

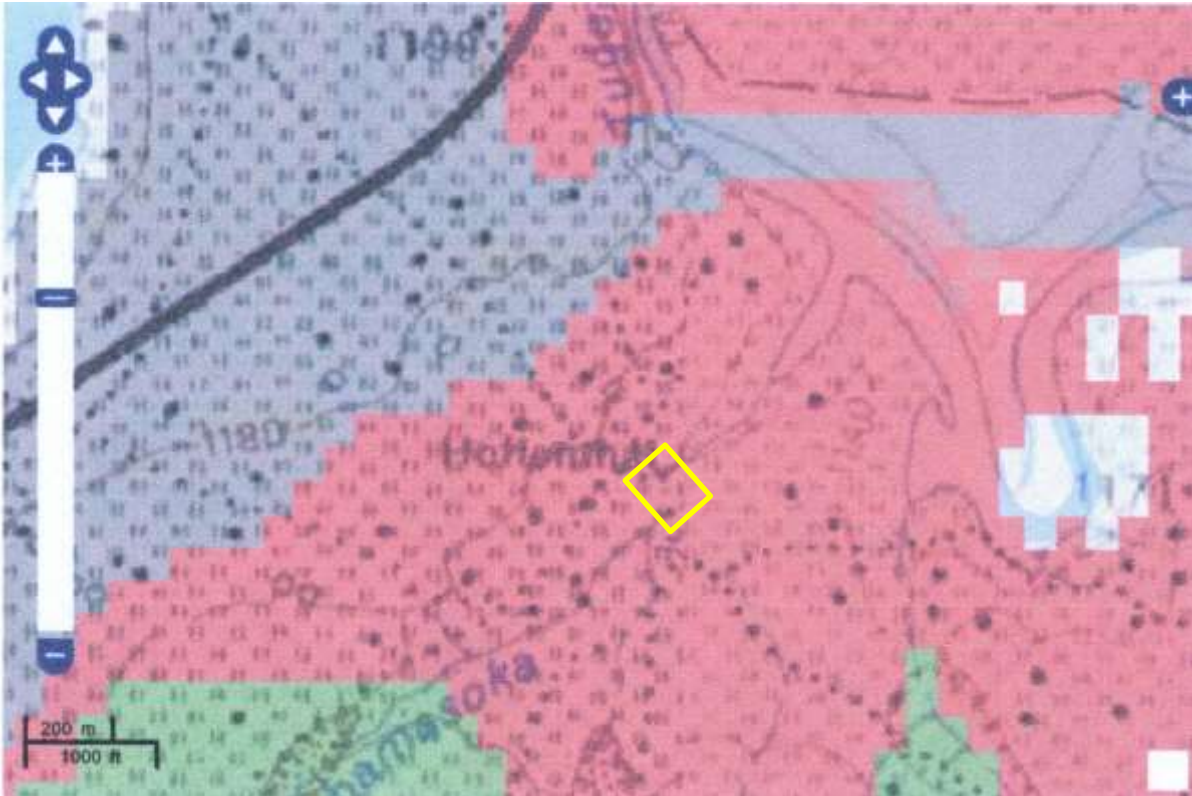


Figure 3: SAHRIS palaeosensitivity map for the site for the proposed L2013 Culvert over the Nhlambamasoka River shown within the yellow rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table 3:

TABLE 3A: CRITERIA FOR ASSESSING IMPACTS

PART A: DEFINITION AND CRITERIA		
Criteria for ranking of the SEVERITY/NATURE of environmental impacts	H	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	L	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term

	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	L	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national
PROBABILITY (of exposure to impacts)	H	Definite/ Continuous
	M	Possible/ frequent
	L	Unlikely/ seldom

TABLE 3B: IMPACT ASSESSMENT

PART B: ASSESSMENT		
SEVERITY/NATURE	H	-
	M	-
	L	Dolerite dykes do not preserve any fossils; so far there are no records from the Adelaide Subgroup of plant or vertebrate 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.
SPATIAL SCALE	L	Since only the possible fossils within the area would be fossil plant fragments from the <i>Glossopteris</i> flora in the shales or vertebrates of the Daptocephalus Assemblage Zone, the spatial scale will be localised within the site boundary.
	M	-
	H	-
PROBABILITY	H	-
	M	It is unlikely that any fossils would be found in the loose surface soils and sand that is exposed by the existing paths and tracks. There may be fossils below the surface, therefore 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 either the wrong type to preserve fossils (dolerite) or represent a delta-plain settings where scattered bones might have been buried and preserved. The surface is already very disturbed by the present paths and tracks. Since there is a very small chance that fossils from the Adelaide Subgroup may occur below ground and may be disturbed, a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is 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 sandstones, shales and sands are typical for the country and could contain fossil plants, insects, or invertebrate material. The chances

however are extremely low because these are very disturbed sites. This is confirmed in the heritage report by Frans Prins (March 2021, his figure 16) which shows a very disturbed crossing site. It is not known what lies below the ground surface.

6. Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is unlikely that any fossils would be preserved in the Normandien Formation (Adelaide Subgroup, Beaufort Group, Karoo Supergroup). No fossils occur in the dolerite. There is a very small chance that fossils may occur in the shales of the late Permian so a Fossil Chance Find Protocol should be added to the EMP: if fossils are found once excavations have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample.

7. References

Anderson, J.M., Anderson, H.M., 1985. Palaeoflora of Southern Africa: Prodrum of South African megaflores, Devonian to Lower Cretaceous. A.A. Balkema, Rotterdam. 423 pp.

Cairncross, B., Beukes, N.J., Coetzee, L.L., Rehfeld, U., 2005. The Bivalve *Megadesmus* from the Permian Volksrust Shale Formation (Karoo Supergroup), northeastern Karoo Basin, South Africa: implications for late Permian Basin development. South African Journal of Geology 108, 547-556.

DeWit, M., Linol, B., (Eds), 2016. Origin and Evolution of the Cape Mountains and Karoo Basin. Springer International Publishing. pp. 141-149.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. 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 461 – 499.

Isbell, J.L., Henry, L.C., Gulbranson, E.L., Limarino, C.O., Fraiser, F.L., Koch, Z.J., Ciccio, P.I., Dineen, A.A., 2012. Glacial paradoxes during the late Paleozoic ice age: Evaluating the equilibrium line altitude as a control on glaciation. Gondwana Research 22, 1-19.

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.

Prins, F., March 2021. Phase one Heritage Impact Assessment for the proposed construction of three culverts near Bergville, Okhahlamba Local Municipality, KwaZulu Natal. Report by Active Heritage cc for Gedezar Consulting. 35pp.

Rubidge, B.S. (Ed), 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). Biostratigraphy Series 1, South African Commission for Stratigraphy. Council for Geoscience, 46 pp.

Rubidge, B.S., 2005. 27th Du Toit Memorial Lecture: re-uniting lost continents — fossil reptiles from the ancient Karoo and their wanderlust. South African Journal of Geology 108: 135-172.

Smith, R.M.H., Rubidge, B.S., Day, M.O., Botha, J., 2020. Introduction to the tetrapod biozonation of the Karoo Supergroup. South African Journal of Geology 123(2), 131-140.

Visser, J.N.J., 1986. Lateral lithofacies relationship in the glacial Dwyka Formation in the western and central parts of the Karoo Basin. Transactions of the Geological Society of South Africa 89, 373-383.

Visser, J.N.J., 1989. The Permo-Carboniferous Dwyka Formation of southern Africa: deposition by a predominantly subpolar marine icesheet. Palaeogeography, Palaeoclimatology, Palaeoecology 70, 377-391.

8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations / drilling for the culvert begins.

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, coal) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of similar fossil plants must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 5, 6). This information will be built into the EMP's training and awareness plan and procedures.
4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the developer/environmental officer/miners then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a

suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.

7. If no good fossil material is recovered then no site inspections by the palaeontologist will be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

Appendix A – Examples of fossils from the Beaufort Group.

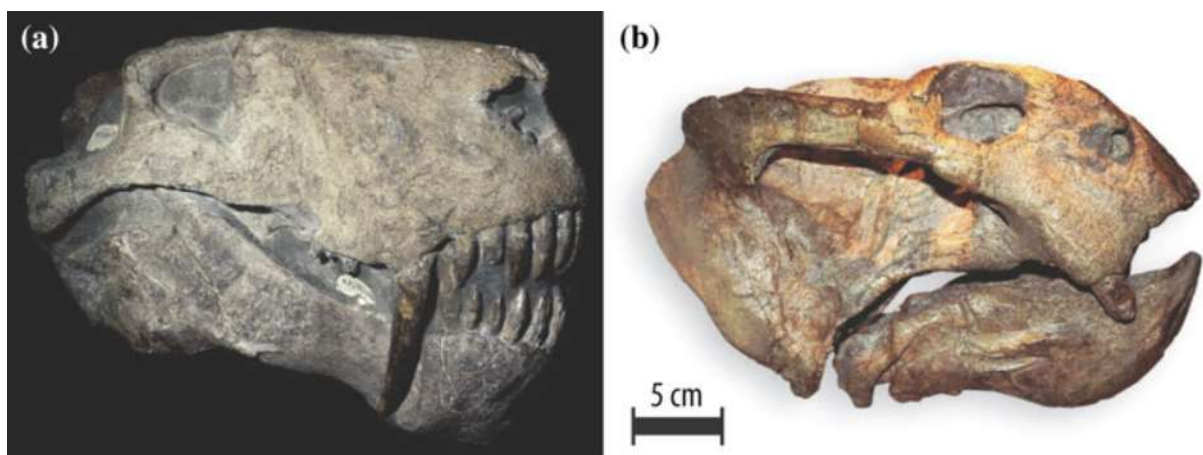


Figure 5: Therapsid skulls representative of two families that went extinct in the Permian: a flesh eating gorgonopsian, and b the herbivore dicynodont *Daptocephalus* (Photos supplied by Bruce Rubidge). In Linol and de Wit (2016) book Preface.



Figure 6: Photographs of a selection of plants from the Glossopteris flora from the Ecca Vryheid Formation but some could occur in the Normandien Formation of the Adelaide Subgroup. Bottom right - an example of the appearance fossil bones in the rock.).

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD January 2021

i) Personal details

Surname : **Bamford**
First names : **Marion Kathleen**
Present employment : Professor; Director of the Evolutionary Studies Institute.
Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa-
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	0
Masters	10	4
PhD	11	4
Postdoctoral fellows	10	5

viii) Undergraduate teaching

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

ix) Editing and reviewing

Editor: *Palaeontologia africana*: 2003 to 2013; 2014 – Assistant editor
 Guest Editor: *Quaternary International*: 2005 volume
 Member of Board of Review: *Review of Palaeobotany and Palynology*: 2010 –

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

x) Palaeontological Impact Assessments

Selected – list not complete:

- Thukela Biosphere Conservancy 1996; 2002 for DWAF
- Vioolsdrift 2007 for Xibula Exploration
- Rietfontein 2009 for Zitholele Consulting
- Bloeddrift-Baken 2010 for TransHex
- New Kleinfontein Gold Mine 2012 for Prime Resources (Pty) Ltd.
- Thabazimbi Iron Cave 2012 for Professional Grave Solutions (Pty) Ltd
- Delmas 2013 for Jones and Wagener
- Klipfontein 2013 for Jones and Wagener
- Platinum mine 2013 for Lonmin
- Syferfontein 2014 for Digby Wells
- Canyon Springs 2014 for Prime Resources
- Kimberley Eskom 2014 for Landscape Dynamics
- Yzermyne 2014 for Digby Wells
- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental

- Glencore-Tweefontein 2015 for Digby Wells
- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for EnviroPro
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for EnviroPro

xi) Research Output

Publications by M K Bamford up to December 2019 peer-reviewed journals or scholarly books: over 150 articles published; 5 submitted/in press; 10 book chapters.

Scopus h-index = 29; Google scholar h-index = 35; i10-index = 92

Conferences: numerous presentations at local and international conferences.

xii) NRF Rating

NRF Rating: B-2 (2016-2020)

NRF Rating: B-3 (2010-2015)

NRF Rating: B-3 (2005-2009)

NRF Rating: C-2 (1999-2004)

