Palaeontological Impact Assessment for the proposed Mpolweni and Thokozani Water Supply, near Albert Falls, KwaZulu Natal Province

Desktop Study (Phase 1)

For

EnviroPro

27 April 2020

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

Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 31 years research; 23 years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by EnviroPro, 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: 

Executive Summary

A palaeontological Impact Assessment was requested for the proposed construction of water supplies for the two residential areas east of Albert Falls, Mpolweni and Thogozani, about 20km north-northeast of Pietermaritzburg, KwaZulu Natal. 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 desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development.

Thokozani lies on rocks of the Pietermaritzburg Formation (Ecca Group) while Mpolweni lies mostly on rocks of the Pietermaritzburg Formation but in the east on rocks of the Dwyka Group. Both groups can potentially reserve fossil plants of the *Glossopteris* flora but they are very uncommon. Nonetheless, 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 the geologist or engineer on site, once excavations for pipes have commenced, find putative fossils, and photographs sent to a palaeontologist confirm that the fossils need to be collected.

Table of Contents

1. Background

A project for the construction of the Mpolweni & Thokozani Water Supply Scheme, near Albert Falls, about 20k north-northeast of Pietermaritzburg, KwaZulu Natal is being planned. Province.

A Palaeontological Impact Assessment was requested for the Mpolweni and Thokozani water supply 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 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

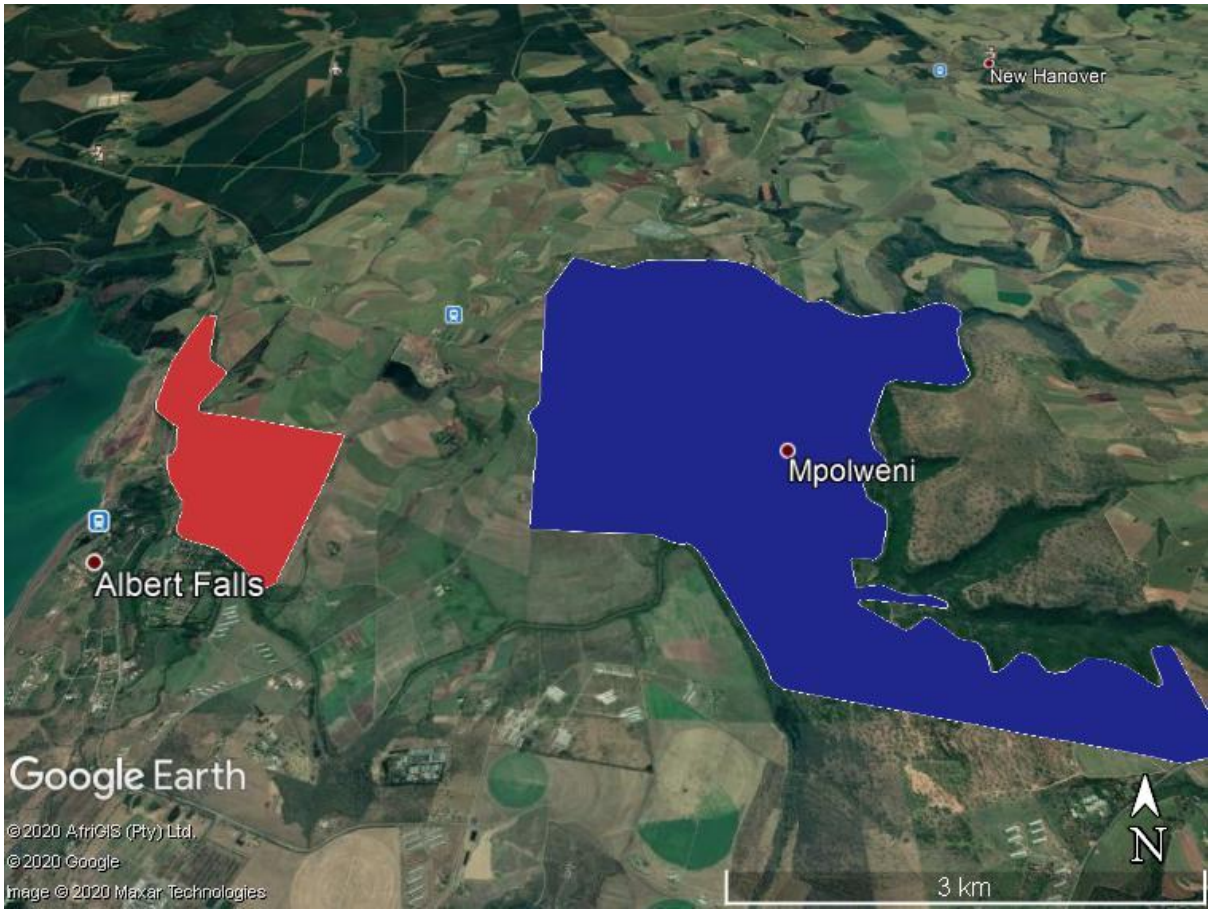


Figure 1: Google Earth map of Thokozani (red) and Mpolweni (blue) for the proposed water supply project. Map supplied by EnviroPro.

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

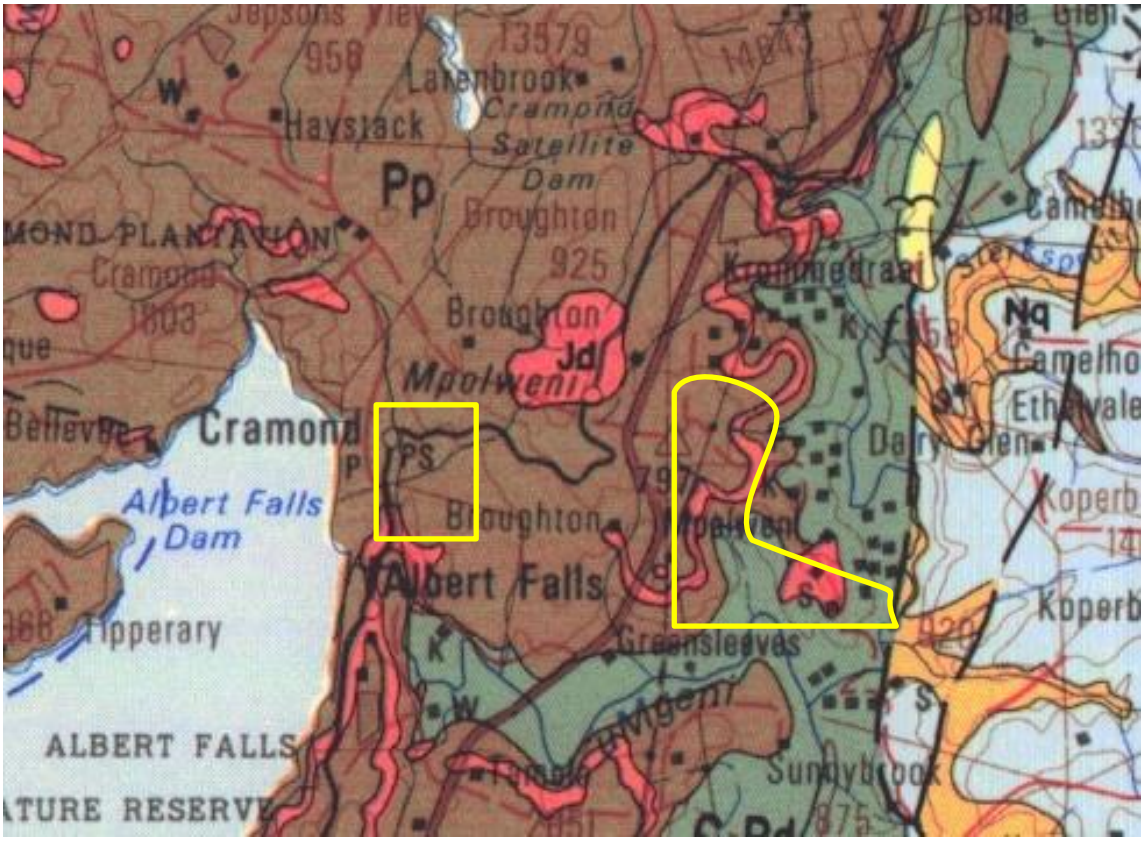


Figure 2: Geological map of the area around Albert Falls. The location of the proposed projects is indicated within the yellow outlines, with Thokozani to the west and Mpolweni to the east. Note

that abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2930 Durban.

Table 2: Explanation of symbols for the geological map and approximate ages (Cornell et al., 2006; 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 (yellow)	Alluvium, sand, calcrete	Neogene, ca 25 Ma to present
Jd	Jurassic dykes (pink)	Dolerite dykes, intrusive	Jurassic, approx. 180 Ma
Pp	Pietermaritzburg Fm, Ecca Group, Karoo SG (brown)	Shales, sandstone, coal	Early Permian, Lower Ecca
C-Pd	Dwyka Group, Karoo SG (teal)	Tillites, diamictites, mudstone	Late Carboniferous- early Permian
O-Sn	Natal Group (light blue)	Sandstones, shales	Ordovician- Silurian
Nq	Mapumulo Metamorphic suite, Natal Province	Pink leucocratic gneiss	Ca 1200 – 1000 Ma

The eastern margin of the younger Karoo basin overlies the older Natal Group rocks in this region with some of the oldest Karoo rocks exposed, namely the basal Dwyka Group and then the Pietermaritzburg Formation of the Ecca Group. The oldest rocks are the Natal Group volcanic rocks, here called the Mapumulo Metamorphic Suite that do not have any fossils. Overlying these are the younger Ordovician to Silurian sandstones of the Natal Group that does not preserve fossils either.

During the Carboniferous the huge landmass, Gondwana, was positioned over the South Pole so was covered by a series of ice sheets (Visser, 1986, 1989; Isbell et al., 2012). As the continent moved northwards and the ice sheets melted, the water began to fill the Karoo Basin, and deposited the debris that had been incorporated into the moving ice sheets. These sediments are known as the Dwyka Group and are composed of tillites, diamictites, various types of mudstones. The next layer to be deposited in this large inland sea are known as the Pietermaritzburg Formation in the east and the Prince Albert, Whitehill and Collingham Formations (Ecca Group) in the west (Rubidge, 2005; Johnson et al., 2006). The Pietermaritzburg Formation is composed of fine-grained dark shales from deep to shallow water settings.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 3. The Thokozani area is entirely on rocs of the Pietermaritzburg Formation while Mpolweni lies on the sae rocks in the west but on rocks of the Dwyka Group in the southeastern section.

Fossils are rare in the Pietermaritzburg Formation because they are mainly deep water sediments so may have a few terrestrial fragments of plants (*Glossopteris* flora leaf

impressions, wood fragments) or, along the shoreline settings, micobioturbated traces of worm and invertebrate fossils (Johnson et al., 2006). The older Dwyka Group rocks are mostly glacial debris but in the mudstone facies from sites near Douglas (Northern Cape Province, along the Orange River) some fossil plants and bones have been found (Anderson and McLachlan, 1976). Dwyka Group sediments are widespread around the Karoo margin but fossils are very rare.

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 these are called the Mbizane Formation, and the Elandsvlei Formation in the south. Described below are the seven facies (Johnson et al., 2006 p463-465):

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 (Anderson and McLachlan 1976; Anderson and Anderson, 1985; Johnson et al., 2006;) although the Dwyka Group exposures are very extensive. Jurassic Dolerites do not contain fossils as they are igneous intrusives.

Vertebrate fossils are very rare in the early Permian with only several *Mesosaurus* specimens from the black shales of the Whitehill Formation (Oelofson and Araujo, 1987; Modesto, 2005) having been recorded to date.

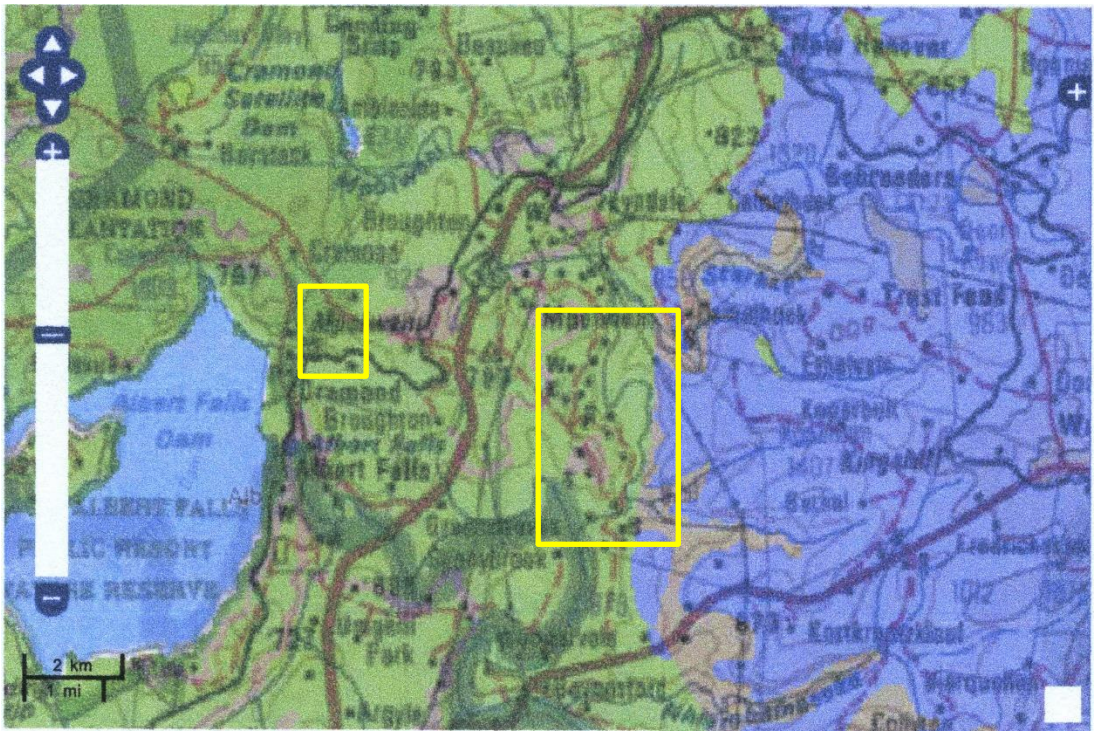


Figure 3: SAHRIS palaeosensitivity map for the site for Thokozani and Mpolweni areas shown within the yellow rectangles. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

From the SAHRIS map above the area is indicated as moderately sensitive (green) so a desktop assessment has been completed.

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	Glacial and deepwater sediments only rarely preserve plant fossils; so far there are no records from the Dwyka Group or Pietermaritzburg 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.
SPATIAL SCALE	**L**	Since only the possible fossils within the area would be fragments of marine fauna or fossil plants from the *Glossopteris* flora 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 diamictites, tillites or dark shales of the Dwyka and Ecca Group. 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 too old to contain terrestrial vertebrate fossils but might contain fragments of marine or plant fossils in the Dwyka Group mudrock facies only, or fragments of Glossopteris plants or microbioturbated trace fossils in the Pietermaritzburg Formation (Ecca Group). None has been reported from this area. Since there is an extremely small chance that fossils 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 diamictites, tillites, mudrocks, dolomites,

sandstones, shales and sands are typical for the country and could contain fossil plant fragments of marine fossil fragments. None had been reported from here and the area is already highly disturbed from urban activities.

6. Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the urban developments of Thokozani or Mpolweni. There is only a very small chance that fragmentary fossils may occur in the Dwyka mudrock facies only, or in the deep water Pietermaritzburg dark shales so a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found once excavations for water pipes and associated infrastructure has 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: Prodromus of South African megafloras, Devonian to Lower Cretaceous. A.A. Balkema, Rotterdam. 423 pp.

Anderson, A.M., McLachlan, I.R., 1976. The plant record in the Dwyka and Ecca Series (Permian) of the south-western half of the great Karoo Basin, South Africa. Palaeontologia africana 19, 31-42.

Cornell, D.H., Thomas, R.J., Moen, H.F.G., Reid, D.L., Moore, J.M., Gibson, R.L., 2006. The Namaqua-Natal Province. 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 325-379.

Isbell, J.L., Henry, L.C., Gulbranson, E.L., Limarino, C.O., Fraiser, F.L., Koch, Z.J., Ciccioli, P.l., 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.

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.

Modesto, S. 2010. The postcranial skeleton of the aquatic parareptile *Mesosaurus tenuidens* from the Gondwanan Permian, Journal of Vertebrate Paleontology, 30:5, 1378-1395, DOI: 10.1080/02724634.2010.501443

Oelofson, B.W., Araujo, D. 1987. *Mesosaurus tenuidens* and *Stereosternum tumidum* from the Permian of Gondwana of both southern Africa and South America. South African Journal of Science 83, 370-372.

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.

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.

Visser, J.N.J., 1986. Lateral lithofacies relationships in the glacigene 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 activities begin.

1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone) 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 Figures 4, 5). 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 Dwyka Group mudrocks

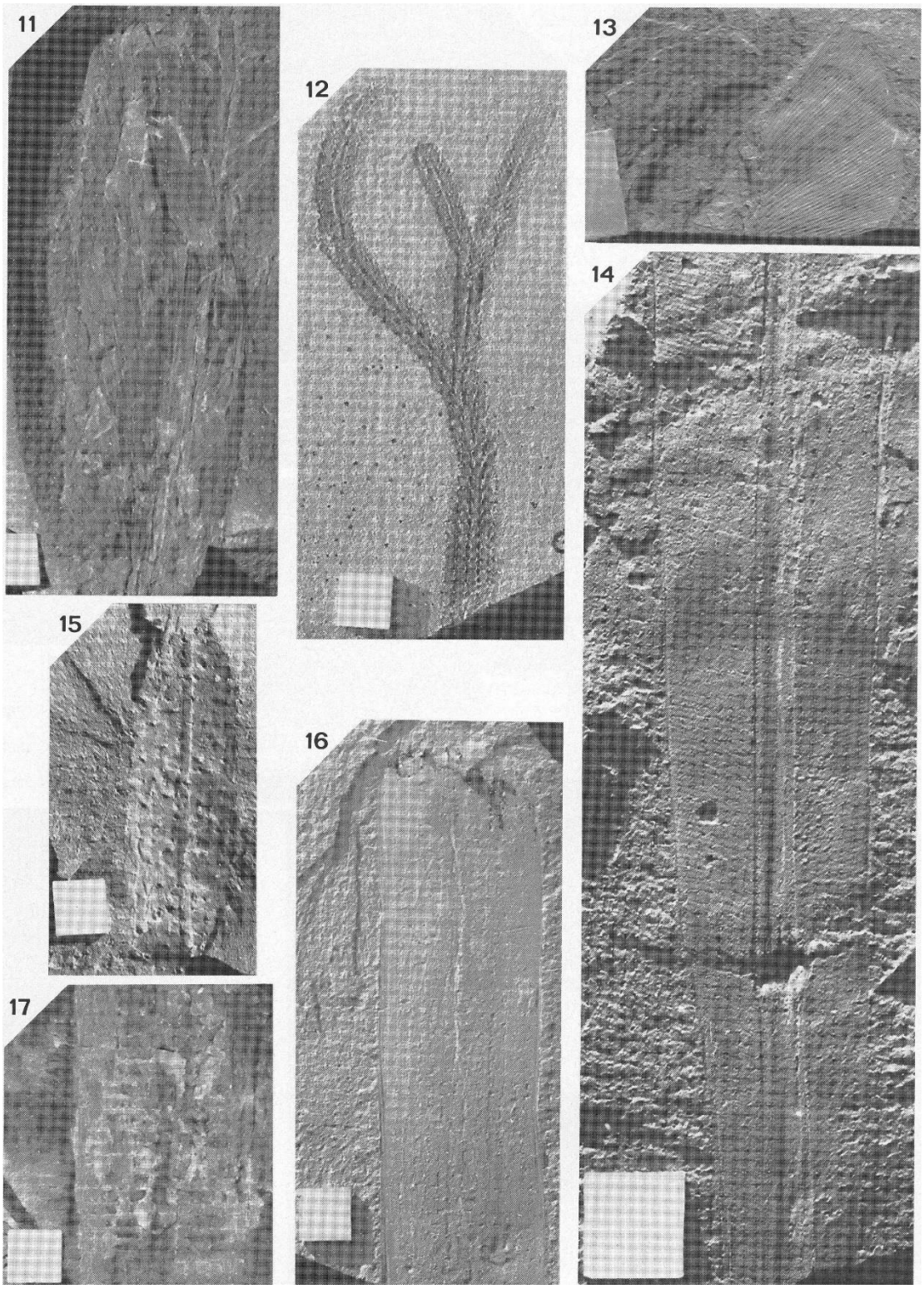
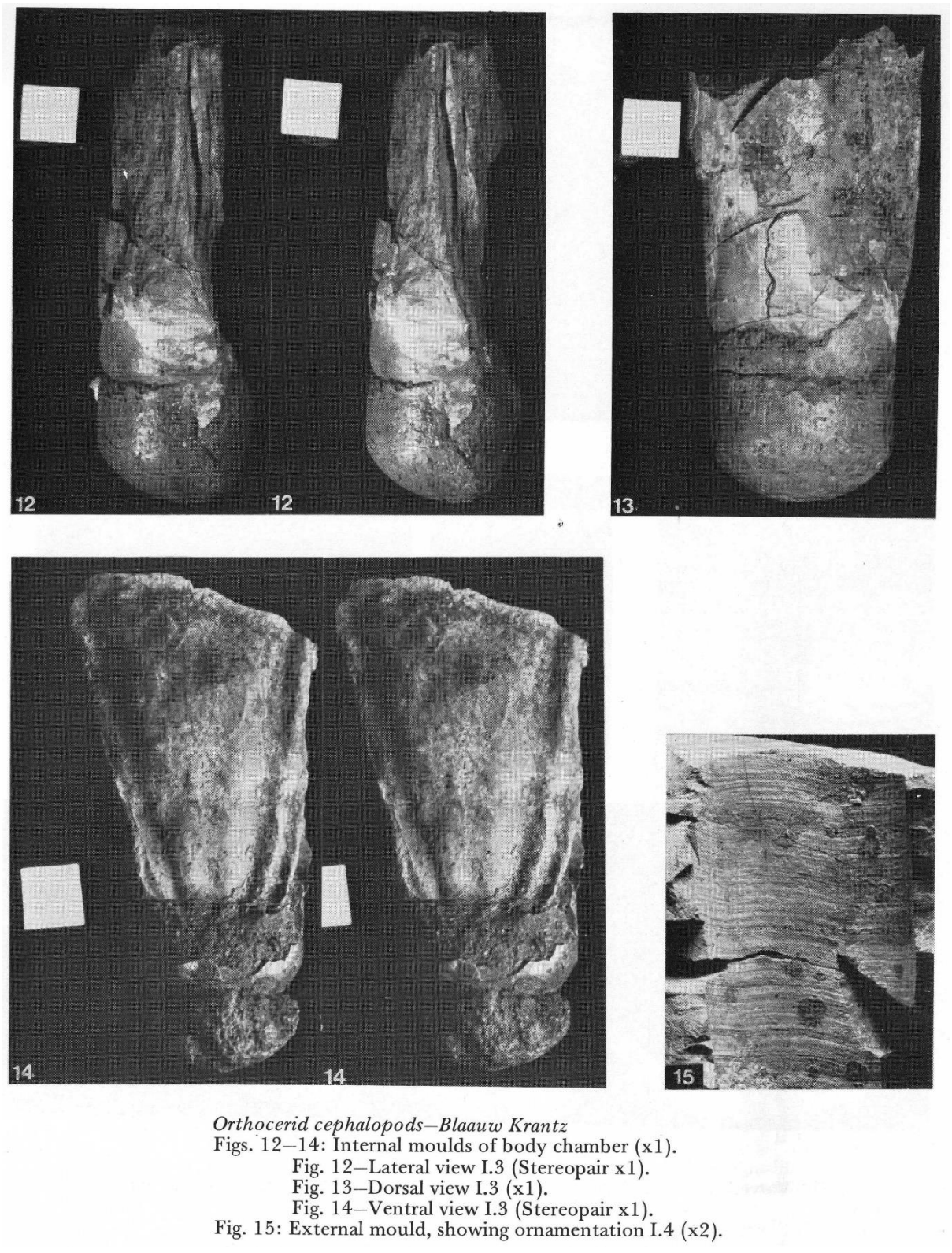


Figure 4: Fossil plant fragments from Dwyka and Early Permian sediments near Douglas, Northern Cape Province. (Plate 2 from Anderson and McLachlan, 1976).



Orthocerid cephalopods—Blaauw Krantz
Figs. 12–14: Internal moulds of body chamber (x1).
Fig. 12—Lateral view I.3 (Stereopair x1).
Fig. 13—Dorsal view I.3 (x1).
Fig. 14—Ventral view I.3 (Stereopair x1).
Fig. 15: External mould, showing ornamentation I.4 (x2).

Figure 5. Examples of marine fossil fragments from the Dwyka rocks near Douglas. (Figure from McLachlan, I.R., Anderson, A., 1973. A review of the evidence for marine conditions in southern Africa during Dwyka times. Palaeontologia africana 15(2), 37-64.)

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
April 2020

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	9	2
Masters	9	5
PhD	11	5
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:

- 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
-

xi) Research Output

Publications by M K Bamford up to December 2019 peer-reviewed journals or scholarly books: over 140 articles published; 5 submitted/in press; 8 book chapters.
Scopus h-index = 27; Google scholar h-index = 32; -i10-index = 80
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)