# Palaeontological Impact Assessment for the proposed Umzimkhulu bulk water pipeline, KwaZulu Natal Province

**Desktop Study**

**For**

**SPHE Consulting**

**07 April 2019**

**Prof Marion Bamford**
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# Expertise of Specialist

The Palaeontologist Consultant is: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 30 years research; 22 years PIA studies

# Declaration of Independence

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

## Executive Summary

A palaeontological Impact Assessment was requested for the proposed construction of a bulk water pipeline to bring drinking water to Umzimkhulu in KwaZulu Natal, of some 1.7km in length. 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 project.

The proposed route lies on the sandstones and mudstones of the late Carboniferous-early Permian Dwyka Group and Pietermaritzburg Formation shales (Ecca Group, early Permian) that are potentially fossiliferous. Early *Glossopteris* flora plants might occur in the Dwyka mudstones only. Surface exposures are likely to be very weathered but fossil may occur below the surface. 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 revealed once excavations and drilling has commenced. As far as the palaeontology is concerned the project can proceed.

# Table of Contents

# 1. Background

Impande Consulting Engineers were appointed by the Harry Gwala District Municipality to construct the Umzimkhulu bulk water pipeline. The residents of the District Municipality require clean drinking water. There have been recent service delivery protests regarding the issue and the provision of clean drinking water will play a role in improving the lives of the people of the District. The length of the pipeline is 1.70 km in length. The town of Umzimkhulu is situated in southern KwaZulu-Natal. The pipeline is situated on the northern outskirts of the town and to the west of the Umzimkhulu River.

The pipeline is more than 300m so in order 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 project.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (2014)

| **A specialist report prepared in terms of the Environmental Impact Regulations of 2014 must contain:** | **Relevant section in report** |
|---|---|
| Details of the specialist who prepared the report | Appendix B |
| The expertise of that person to compile a specialist report including a curriculum vitae | Appendix B |
| A declaration that the person is independent in a form as may be specified by the competent authority | Page 1 |
| An indication of the scope of, and the purpose for which, the report was prepared | Section 1 |
| The date and season of the site investigation and the relevance of the season to the outcome of the assessment | N/A |
| A description of the methodology adopted in preparing the report or carrying out the specialised process | Section 2 |
| The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure | Section i |
| An identification of any areas to be avoided, including buffers | N/A |
| 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 |
| A description of any assumptions made and any uncertainties or gaps in knowledge; | Section 5 |
| 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 |
| Any mitigation measures for inclusion in the EMPr | N/A |
| Any conditions for inclusion in the environmental authorisation | N/A |
| Any monitoring requirements for inclusion in the EMPr or environmental | Section 8 |

| | |
|---|---|
| authorisation | |
| A reasoned opinion as to whether the proposed activity or portions thereof should be authorised | N/A |
| 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 |
| A description of any consultation process that was undertaken during the course of carrying out the study | N/A |
| A summary and copies if any comments that were received during any consultation process | N/A |
| Any other information requested by the competent authority. | N/A |

Figure 1: Google Earth map of the proposed route (red line) for the bulkwater supply pipeline for Umzimkhulu. Map supplied by JLB 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 southern KwaZulu Natal where there are ancient igneous rocks of the Mapumulo Group, the Natal Group and basal Karoo Supergroup sediments.

The Mzumbe Terrane of the Natal-Namaqua Province is made up of an older sequence of amphibolite-grade supracrustal gneisses and the older of the intrusions into the Mzumbe Terrane are known as the Mapumulo Group and are Proterozoic in age, ca 2050-1000 million years old (Cornell et al., 2006).

Overlying the Proterozoic basement rocks are the early Palaeozoic rocks of the Natal Group that are considered to be between approximately 580 and 300 Ma (Cornell et al., 2006). The Natal Group has been divided into two formations and eight members. The basal Durban Formation comprises five members (from base upwards: the Ulundi, Eshowe, Kranskloof, Situndu and Dassenhoek Members) while the upper Marianhill Formation comprises the Tulini, Newspaper and Westville Members. Their lithologies range from conglomerates sandstones and arkosic sandstones and shales (ibid).

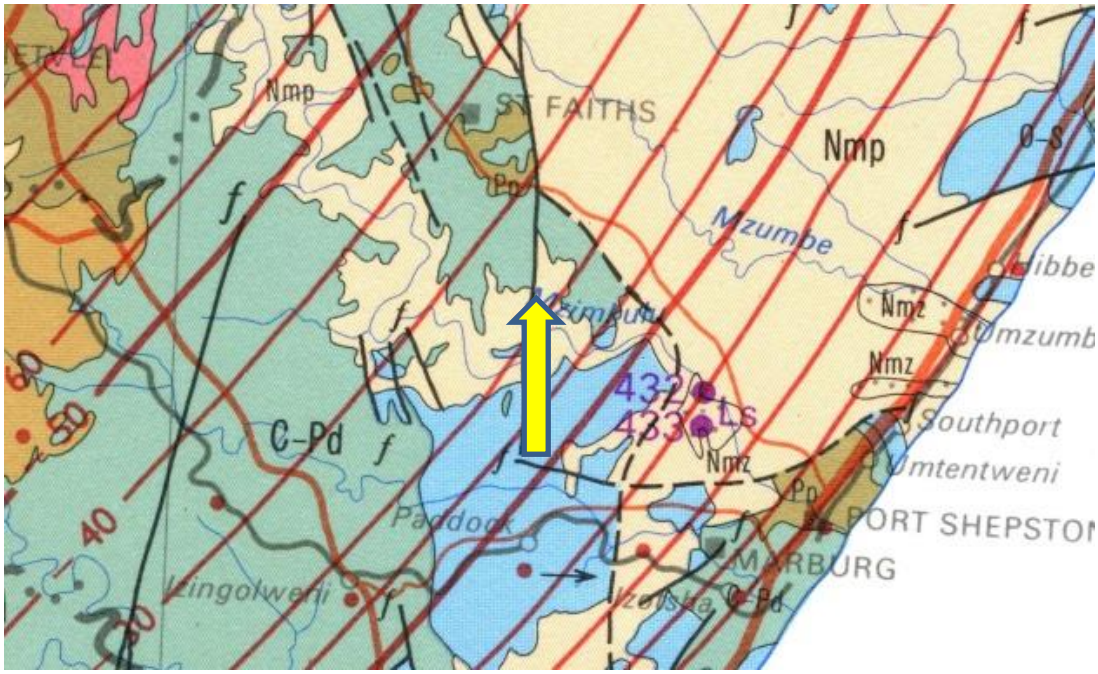


Figure 2: Geological map of the area around Umzimkhulu, approximately 20km west northwest of Port Shepstone which is on the coast. The project site is indicated by the arrow. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1:1 000 000 geological map for South Africa 1984.

Table 2: Explanation of symbols for the geological map and approximate ages (Barbolini et al., 2016; Cornell et al., 2006; Johnson et al., 2006; Rubidge, 2005). SG = Supergroup; Fm = Formation; Ma = million years.

| Symbol | Group/Formation | Lithology | Approximate Age |
|---|---|---|---|
| Pp | Pietermaritzburg Fm, Ecca Group, Karoo SG | shales | |
| C-Pd | Dwyka Group, Karoo SG | Tillites, sandstones mudstones , shales | Upper Carboniferous to early Permian, ca 310-290 Ma |
| O-S | Natal Group | Quartzitic sandstones, arkose, shales, conglomerate | Early Palaeozoic ca 580-300 Ma |
| Nmp | Mapumulo Group, Namaqua-Nata Sequence | Amphiboles, gneisses | 2050-1000 Ma |

The overlying Dwyka tillites represent the deposits from the receding glaciers during the Upper Carboniferous. The next stratum is the Pietermaritzburg Formation comprising shales that represent a major post-glacial transgression and a relatively shallow water setting (Johnson et al., 2006). It is the lowermost part of the Ecca Group of the Karoo Supergroup.

## i. Palaeontological context

Granites and gneisses of the Archean Mapumulo Group are too old and of the wrong type (igneous) to preserve fossils. By the time the Natal group was deposited there were marine organisms on earth but these rock too are the wrong kind to preserve fossils.

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 (Johnson et al., 2006; Anderson and McLachlan 1976) although the Dwyka Group exposures are very extensive.

The Pietermaritzburg dark silty mudrock and shales are the result of a major post-glacial transgression from the melting of the Dwyka ice sheets. Invertebrate trace fossils are present in some areas and no fossils have been recorded (Johnson et al., 2006).

The area has been disturbed from previous urban and agricultural activities so any surface fossils are likely to be very weathered (naturally) or destroyed by previous activities. Along the streams there could be downcutting into underlying sediments that contain vertebrates or fossil plants (they are seldom found together). There is, however, a very small chance that fossil vertebrates or plants could be found where new excavations are made for the foundations, utilities and access roads.

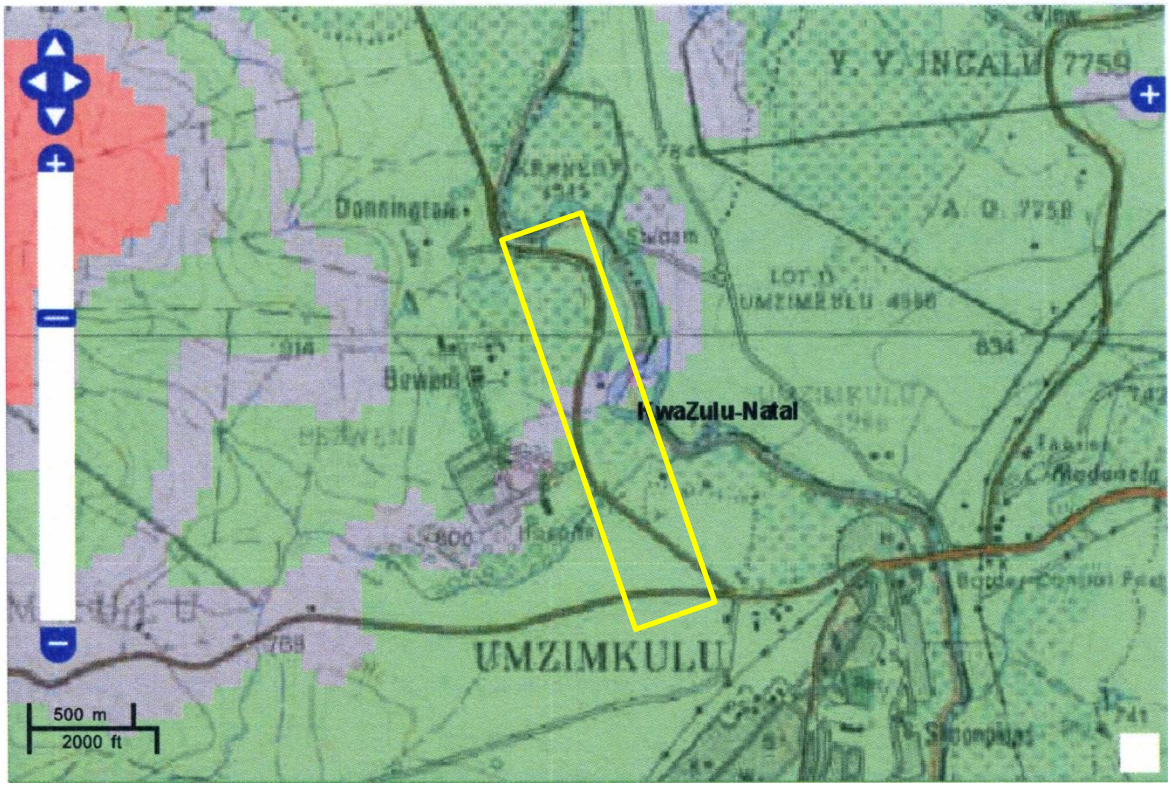


Figure 3: SAHRIS palaeosensitivity map for the site for the proposed residential township on farm Carolina 217 indicated within the yellow lines. Colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

From the SAHRIS map above the area is indicated as moderately sensitive (green; Figure 3) so a desktop assessment is being reported upon here. No fossils have been reported from the area but there is a small chance that fossil vertebrates or plant fragments could occur in the building area. Fossils are not likely to be seen on the land surface because of extensive weathering and previous agricultural or urban activities.

# 4. Impact assessment

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

**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** | There is a small chance that fossil vertebrates or plants occur in the Dwyka Group mudstones but any surface occurrences would have been disturbed by previous agricultural and urban activities. 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 a variety of vertebrates or fossil plants from the *Glossopteris* flora in the mudstones the spatial scale will be localised within the site boundary. |
| | **M** | - |
| | **H** | - |
| **PROBABILITY** | **H** | **-** |
| | **M** | **-** |
| | **L** | It is unlikely that any fossils would be found in the surface sediments but there may be vertebrates or plant fragments in the underlying mudstones. No surface fossils are likely to be found. Therefore, 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. Underlying rocks of the late Carboniferous-early Permian Dwyka Group, Karoo Supergroup, namely the tillites, shales and mudstones, might preserve fossil vertebrates or plants but this will only be evident once excavations commence. Although no fossils have been recorded from near Umzimkhulu there is a small chance that fossils from the Dwyka Group may be disturbed so a Fossil Chance Find Protocol has been added to this report (Section 8). 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 dolomites, sandstones and mudstones are typical for the country and could contain fossil vertebrates or plant material. The Jurassic dolerite dykes would not preserve any fossils.

# 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 on the surface. There is a very small chance that fossil vertebrates or plant fragments may occur in the Dwyka Group mudstones only so a Chance Find Protocol should be added to the EMPr: If fossils are found once excavations for foundations have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample, with a relevant permit from AMAFA.

# 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.

Bamford, M.K. 2016. Fossil woods from the Upper Carboniferous to Lower Jurassic Karoo Basin and the environmental interpretation. In: Linol, B. and de Wit, M., (Eds), Origin and Evolution of the Cape Mountains and Karoo Basin. Regional Geology Reviews, pp. 158-167. DOI 10.1007/978-3-319-40859-0_16

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.

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.

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.

# 8. Chance Find Protocol

**Monitoring Programme for Palaeontology – to commence once the excavations for foundations for the foundations, pipeline and access roads begin.**

1. The following procedure is only required if fossils are seen on the surface and when excavations commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, wood, bone) should be put aside in a suitably protected place. This way the building 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 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/engineers 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 the site inspections by the palaeontologist will not be necessary. Annual reports by the palaeontologist must be sent to SAHRA.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

## Appendix A - Examples of Dwyka Group fossils

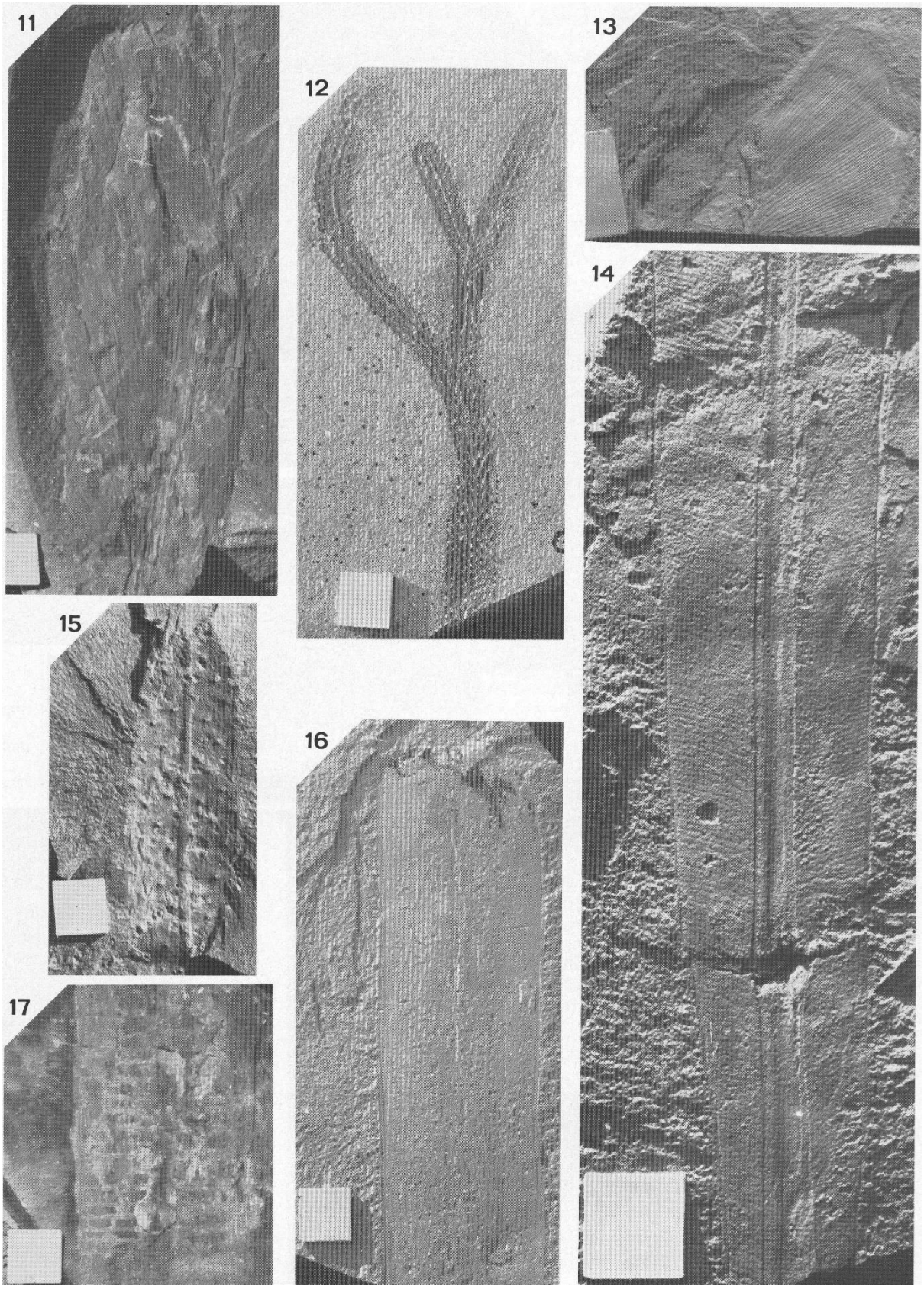

Figure 4: Fossil plants from the Dwyka Group of South Africa (plate 1 from Anderson and McLachlan, 1976).

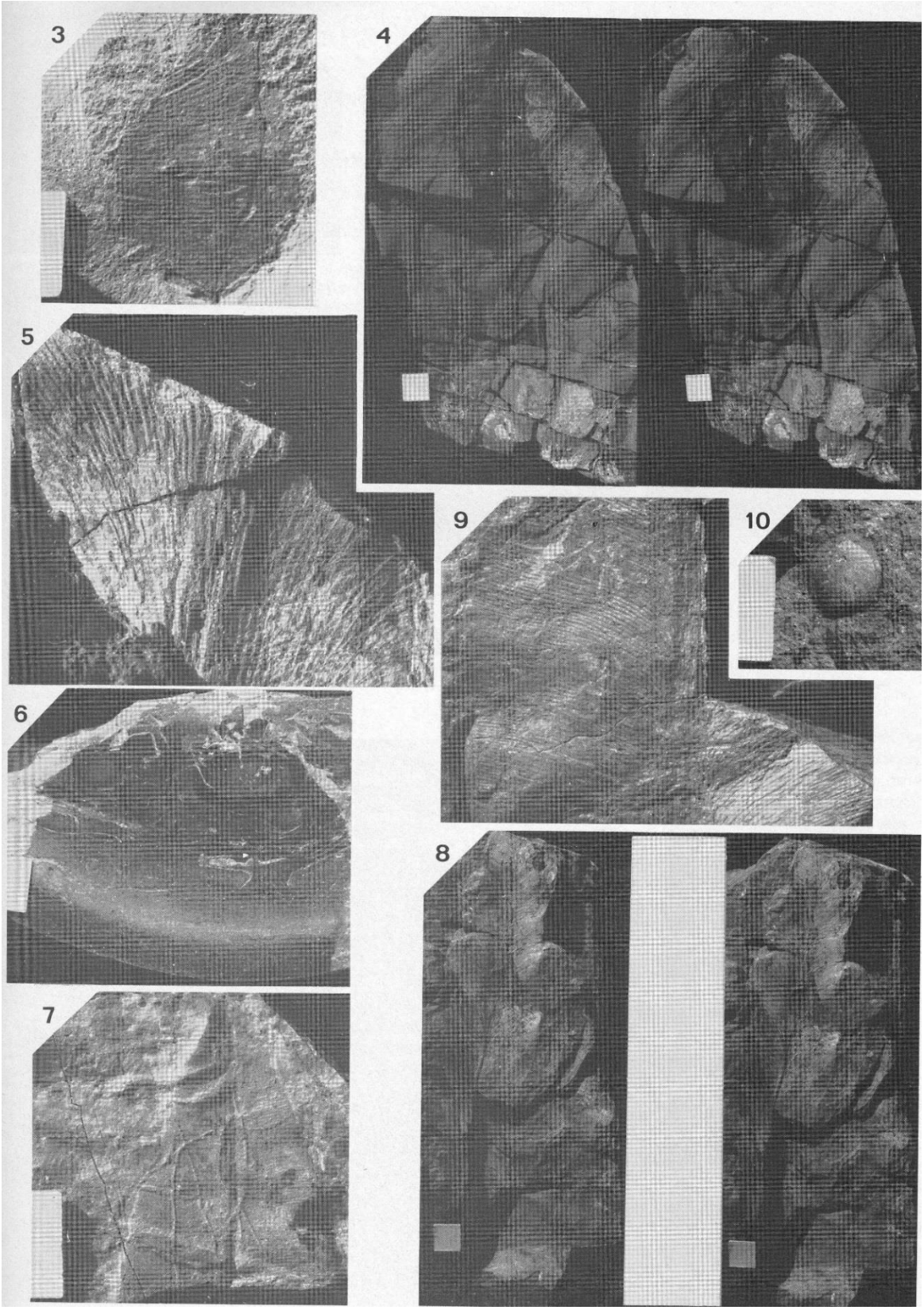


Figure 5: More examples of fossil plants from the Dwyka Group of South Africa (plate 2 from Anderson and McLachlan, 1976).

## Appendix B – Details of specialist

# Curriculum vitae (short) - Marion Bamford PhD
# January 2019

### 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 – 1984 to present
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 | 6 | 1 |
| Masters | 8 | 1 |
| PhD | 10 | 3 |
| Postdoctoral fellows | 9 | 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 2-8 students per year.

**ix) Editing and reviewing**
Editor: Palaeontologia africana: 2003 to 2013; 2014 onwards – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Cretaceous Research: 2014 -
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
- Amandelbult 2018 for SRK
- 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
- SARAO 2018 for Digby Wells
- Ventersburg B 2018 for NGT
- Hanglip Service Station 2018 for HCAC

## xi) Research Output

Publications by M K Bamford up to January 2019 peer-reviewed journals or scholarly books: over 125 articles published; 5 submitted/in press; 8 book chapters.
Scopus h index = 27; Google scholar h index = 30;
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)