

**Palaeontological Impact Assessment for the proposed  
mining rights application for mine “84”, near  
Christiana, Free State Province**

**Desktop Study**

**For**

**Heritage Contracts and Archaeological Consulting**

**31 March 2019**

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Palaeobotanist

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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 Heritage Contracts and Archaeological Consulting, Modimolle, 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 mining rights application for mine "84" located east and south of the Vaal River on farm Van Aswegens Hoek 493 RD And Greylingslyn 355 RD , Free State Province. 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 site lies on the sands of the Quaternary group which are non-fossiliferous. There is a chance that there are underlying rocks of the Dwyka Group and Vryheid Formation that might contain fossil plants of the *Glossopteris* flora. Since there is a chance that the excavations for foundations and for mining activities might penetrate these rocks and that they might contain fossils, a chance Find Protocol should be added to the EMP. It is the opinion of the palaeontologist that the project can proceed.

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# 1. Background

A Palaeontological Impact Assessment was requested for a mining rights application for the project known as Mine “84” on the property Aswegens Hoek 493 RD and Greylingslyn 355 RD that lies to the south and east of the Vaal River, about 2-4 km from Christiana (Fig 1).

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 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 ii                 |
| 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 authorisation   | Section 8                  |
| 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 EMP, 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 |

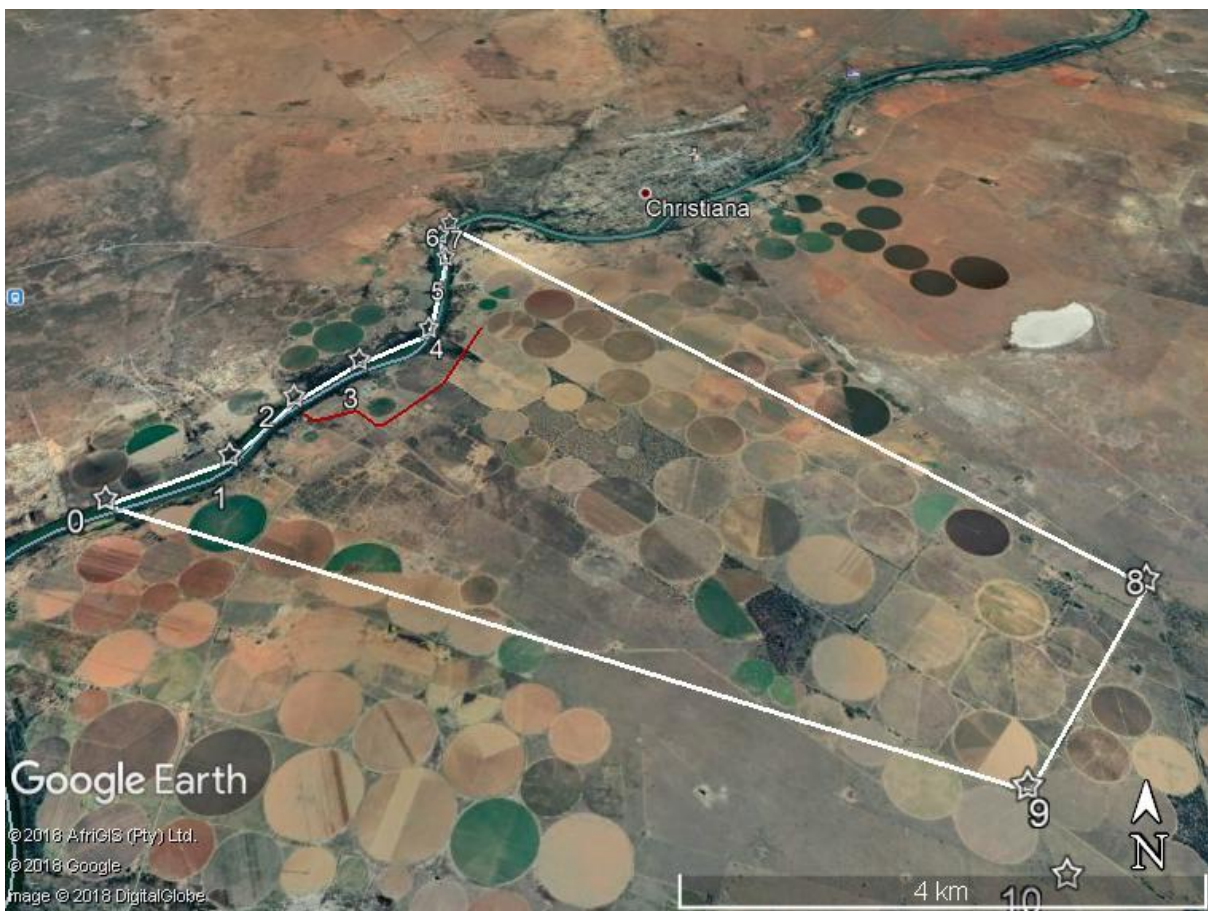


Figure 1: Google Earth map of the proposed mining rights application of property Van Aswegenshoek 483 close to the Vaal River. Map supplied by HCAC.

## 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 property for the proposed mining rights application is adjacent to and just to the southeast of the Vaal River. The rocks here are Kalahari sands, alluvium and calcrete. To the north of the river the sands overlie the Dwyka Group tillites and these possibly extend to the south side of the river. There are large expanses of Vryheid and Volksrust formation sediments to the north east and east (Fig 2).

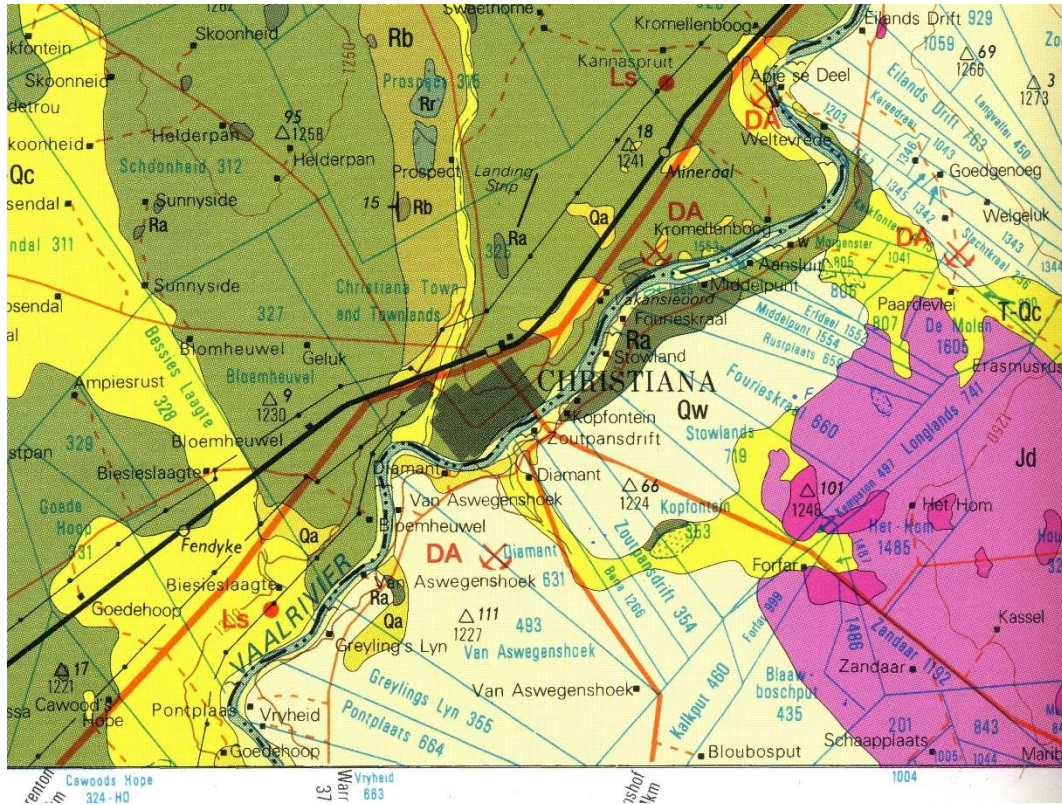


Figure 3: Geological map of the area around Christiana and south of the Vaal River. The location of the proposed project is lower central. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map Christiana 1984.

Table 2: Explanation of symbols for the geological map and approximate ages (Erikssen et al., 2006; Johnson et al., 2006; McCarthy et al., 2006; Robb et al., 2006; van der Westhuizen et al., 2006). SG = Supergroup; Fm = Formation.

| Symbol | Group/Formation                  | Lithology  | Approximate Age  |
|--------|----------------------------------|--|--|
| Q      | Quaternary, Kalahari             | Alluvium, sand, calcrete   | Neogene, ca 25 Ma to present                           |
| Jd     | Jurassic dykes                   | Dolerite dykes, intrusive  | Jurassic, approx. 180 Ma                               |
| Q/C-Pd | Quaternary overlying Dwyka       | Alluvium, sand and calcrete overlying tillites, sandstone, mudstone, shale | Neogene overlying Upper Carboniferous to Lower Permian |
| Ra     | Allan Ridge Fm, Ventersdorp SG   | Andesite, basaltic lavas   | >2650 Ma   |
| R-Vha  | Hartswater Group, Ventersdorp SG | Andesite, tuff, feldspar, porphyry, chert, conglomerate                    | >2650 Ma   |



## ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 3. Both farms lie on Quaternary sands, alluvium and calcretes of Neogene age (last ca 25 million years). Although they are the correct age to contain fossils these are extremely rare and confined to ancient river channels or pans since the sands are mobile and the sandstones often represent stabilised dunes.

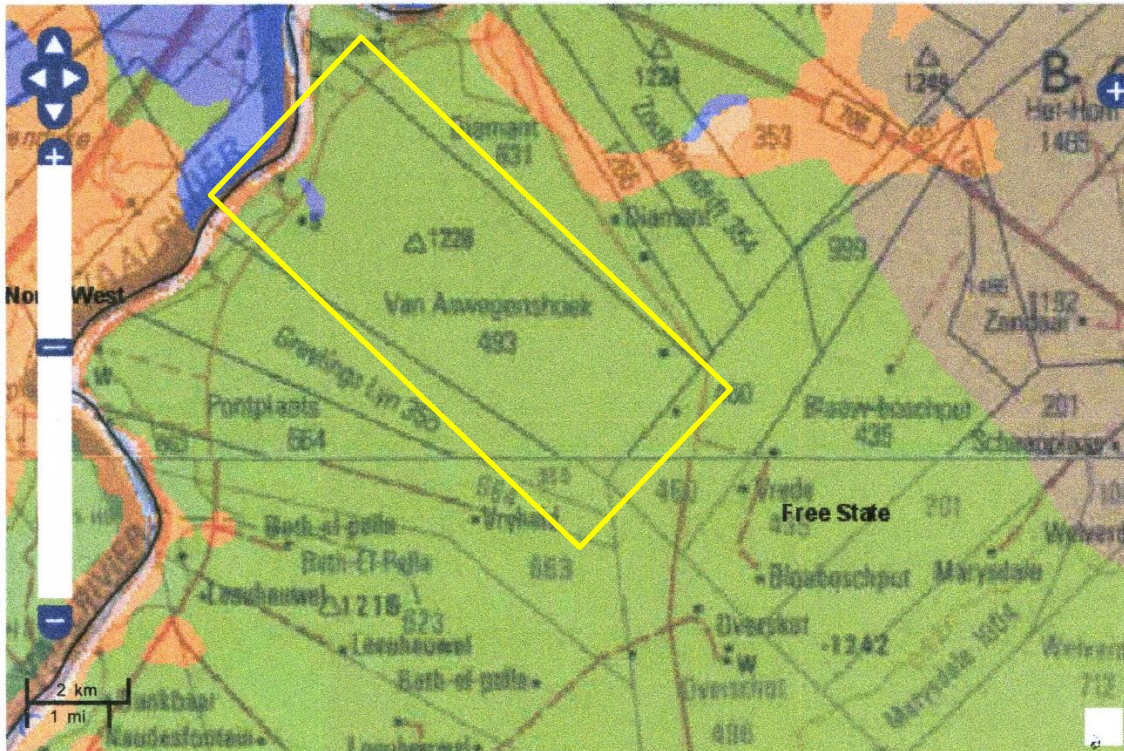


Figure 3: SAHRIS palaeosensitivity map for the properties to the south and east of the Vaal River, just south of Christiana. Colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Along the river there are exposures of Dwyka Group tillites, sandstone, mudstone or shales that are the remnants of the receding glaciers of the Carboniferous period. Fossils from this time are rare as there was a large inland sea from the meltwater of the glaciers forming deepwater deposits. Land animals were extremely rare, only *Mesosaurus*, and plants were also rare because of the very cold climate. In South Africa fossils from the Dwyka Group deposits have only been recorded from farther south, east of Douglas, near the confluence of the Vaal and Orange Rivers (McLachlan and Anderson, 1973; Anderson and McLachlan, 1976). These are fragments of *Glossopteris* and *Noeggerathiopsis* leaves, wood fragments and possible insect wings.

The Vryheid Formation shales and sandstones are in close proximity to the site and to dolerite dykes but they are unlikely to contain fossils because this is at the extreme margin of the Karoo sediments and no fossils have been reported. The Volksrust Formation shales have been interpreted as transgressive open shelf sequence muds deposits from suspension and fossils have not been recorded in this site and very rarely from this formation (Johnson et al., 2006).

From the SAHRIS map above the area is indicated as moderately sensitive (green) so a desktop study is presented here. There is a possibility that Dwyka or Vryheid rocks underlie the Quaternary sands and could preserve fossils of the *Glossopteris* flora as indicated on earlier maps.

The Ventersdorp group volcanic rocks do not contain fossils as they are too old and of the wrong type to preserve fossils.

## 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**

| <b>PART A: DEFINITION AND CRITERIA</b>                                      |           |  |
|---|-----------|--|
| <b>Criteria for ranking of the SEVERITY/NATURE of environmental impacts</b> | <b>H</b>  | Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.   |
|   | <b>M</b>  | Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.   |
|   | <b>L</b>  | Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. |
|   | <b>L+</b> | Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.                                     |
|   | <b>M+</b> | Moderate improvement. Will be within or better than the recommended level. No observed reaction.   |
|   | <b>H+</b> | Substantial improvement. Will be within or better than the recommended level. Favourable publicity.  |
| <b>Criteria for ranking the DURATION of impacts</b>                         | <b>L</b>  | Quickly reversible. Less than the project life. Short term   |
|   | <b>M</b>  | Reversible over time. Life of the project. Medium term   |
|   | <b>H</b>  | Permanent. Beyond closure. Long term.  |
| <b>Criteria for ranking the SPATIAL SCALE of impacts</b>                    | <b>L</b>  | Localised - Within the site boundary.  |
|   | <b>M</b>  | Fairly widespread – Beyond the site boundary. Local  |
|   | <b>H</b>  | Widespread – Far beyond site boundary. Regional/ national  |
| <b>PROBABILITY (of exposure to impacts)</b>                                 | <b>H</b>  | Definite/ Continuous   |
|   | <b>M</b>  | Possible/ frequent   |
|   | <b>L</b>  | Unlikely/ seldom   |

**TABLE 3B: IMPACT ASSESSMENT**

| <b>PART B: ASSESSMENT</b> |          |   |
|---------------------------|----------|---|
| <b>SEVERITY/NATURE</b>    | <b>H</b> | - |
|                           | <b>M</b> | - |

| PART B: ASSESSMENT |    |  |
|--------------------|----|--|
|                    | L  | Loose sands do not preserve fossils; so far there are no records from the Dwyka or Vryheid Formation 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 the only possible fossils within the area would be fossil plants from the <i>Glossopteris</i> 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 loose sand that will be excavated. Nonetheless a chance find protocol should be added to the eventual EMPr for the rocks below the sands.                                |

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 much too old to contain fossils or of a kind that does not preserve fossils (Kalahari sands). Mining operations are likely to penetrate below the surface and so could impact any fossils if present. Since there is an extremely small chance that fossils from the underlying Dwyka Group or Vryheid 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 volcanic andesites, basalts and tuffs, and the Quaternary sands, alluvium and calcretes are typical for the country and do not contain fossil plant, insect, invertebrate and vertebrate material. Since there may be underlying Dwyka tillites or Vryheid shales and they might contain fossils, they might be impacted upon by the mining 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 loose sands of the Quaternary. There is a very small chance that fossil may occur in the underlying shales of the early Permian Vryheid Formation so a Chance Find Protocol should be added to the EMPr: if fossils are found

once excavations for infrastructure, foundations or mining operations have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample.

## 7. References

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.

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.

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.

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.

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.

Van der Westhuizen, W.A., de Bruijn, H., Meintjes, P.G., 2006. The Ventersdorp 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 187-208.

## 8. Chance Find Protocol

**Monitoring Programme for Palaeontology – to commence once the excavations or mining operations begin.**

1. The following procedure is only required if fossils are seen on the surface or 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 excavations 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 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 and Ecca fossil plants**

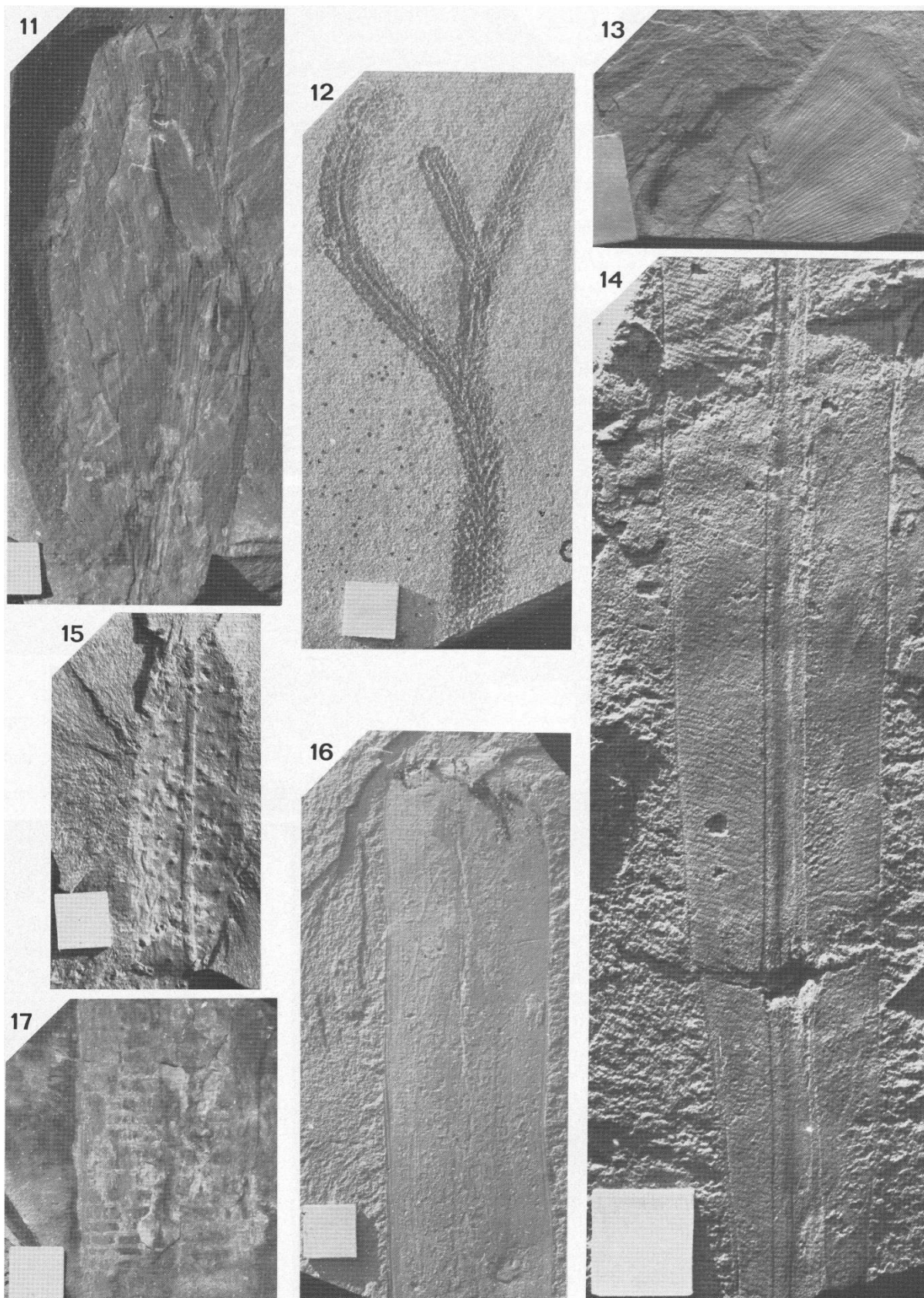
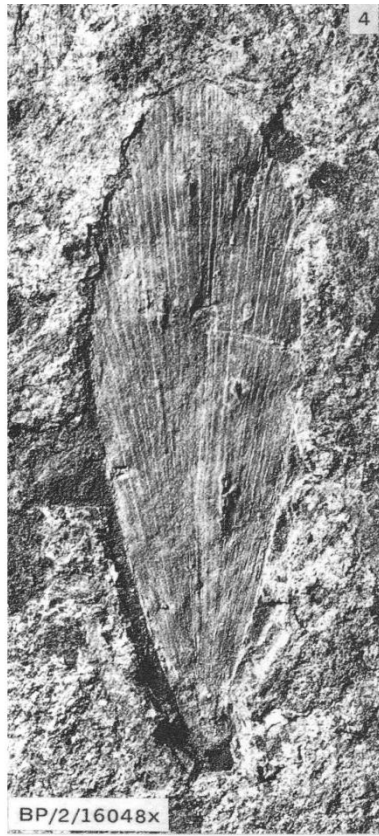
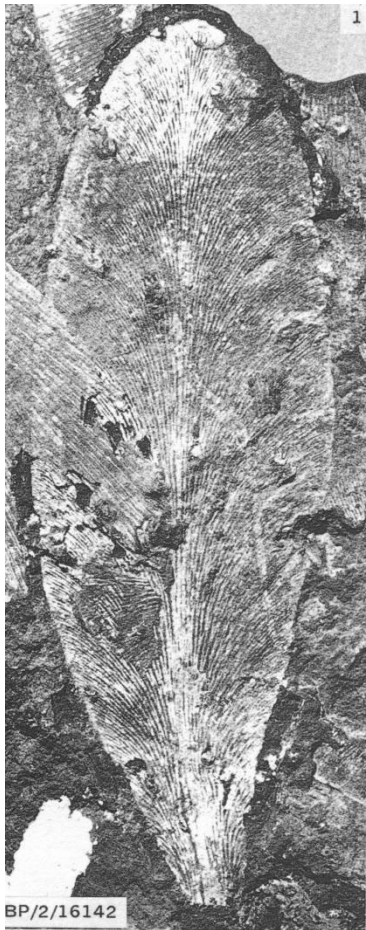


Figure 5: Dwyka fossil plants from near Douglas from McLachlan and Anderson, 1976, Figure 2).



Noeggerathiopsis and  
Glossopteris leaves

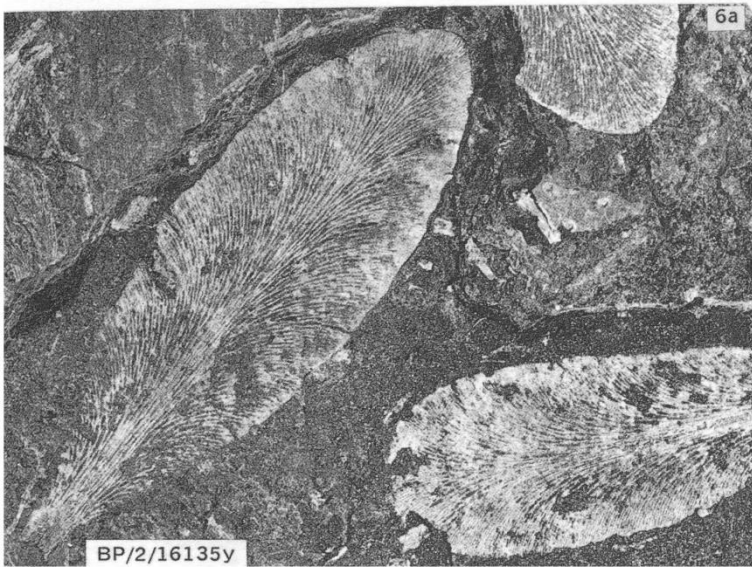


Figure 6: Examples of Ecca fossil plants – leaves of *Glossopteris* and *Noeggerathiopsis*.

## 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-  
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E-mail : [marion.bamford@wits.ac.za](mailto:marion.bamford@wits.ac.za) ; [marionbamford12@gmail.com](mailto: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              | 6                   | 1       |
| Masters              | 8                   | 1       |
| PhD                  | 10                  | 2       |
| 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 – 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
- Klipootjie 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
- 

## **xi) Research Output**

Publications by M K Bamford up to June 2018 peer-reviewed journals or scholarly books: over 125 articles published; 5 submitted/in press; 8 book chapters.

Scopus h index = 26; 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)