# Palaeontological Impact Assessment for the proposed development of the Fairview TSF and reclamation of historical dumps on Fairview Mining Rights Area, Mpumalanga Province

**Desktop Study**

**For**

**Cabanga Environmental**

**21 October 2019**

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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 Cabanga Environmental, Johannesburg, 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 desktop Palaeontological Impact Assessment has been completed for Barberton Mines (Pan Africa Resources) who propose to undertake certain development activities within their Fairview Mining Right Area. They intend to reclaim a number of waste deposits resulting from past mining activities (commencing in the 1880's), and to construct a new Tailings Storage Facility at the site of the Bramber TSF which they have recently reclaimed.

The Fairview Mining Right Area lies on the greywacke of the Moodies and Fig Tree Groups, Barberton Greenstone Belt, Swaziland Supergroup. These are some of the oldest rocks on the earth's surface, ca 3550-3250 million years old so predate all forms of multicellular life. Based on the age of the sediments and extremely rare occurrence of fossils in this formation, and the fact that no fossils have been recorded from this area, there is almost no chance that fossils would be preserved in the rocks. In particular, the mine dumps have already been disturbed and no fossils, even if present, would have survived. No further palaeontological assessment is required. It is recommended that if stromatolites are excavated then a hand sample should be sent to the University of Johannesburg, Department of Geology, for their records and possible further research. As far as the palaeontological heritage is concerned, the proposed reclamation and construction of a TSF can proceed.

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# 1. Background

A desktop Palaeontological Impact Assessment (PIA) has been completed for the proposed reclamation of a number of waste deposits resulting from past mining activities (commencing in the 1880's), and the construction of a new Tailings Storage Facility at the site of the Bramber TSF which Barberton Mines have recently reclaimed.

The applicant is Barberton Mines (Pty) Ltd: Fairview Gold Mine (Pan Africa Resources). The area is the existing Fairview Mine (Figures 1, 2).

The National Heritage Resources Act (Act 25 of 1999) and the National Environmental Management Act (Act 107 of 1998) requires that the proposed development must be preceded by the relevant impact assessment, in this case for palaeontology.

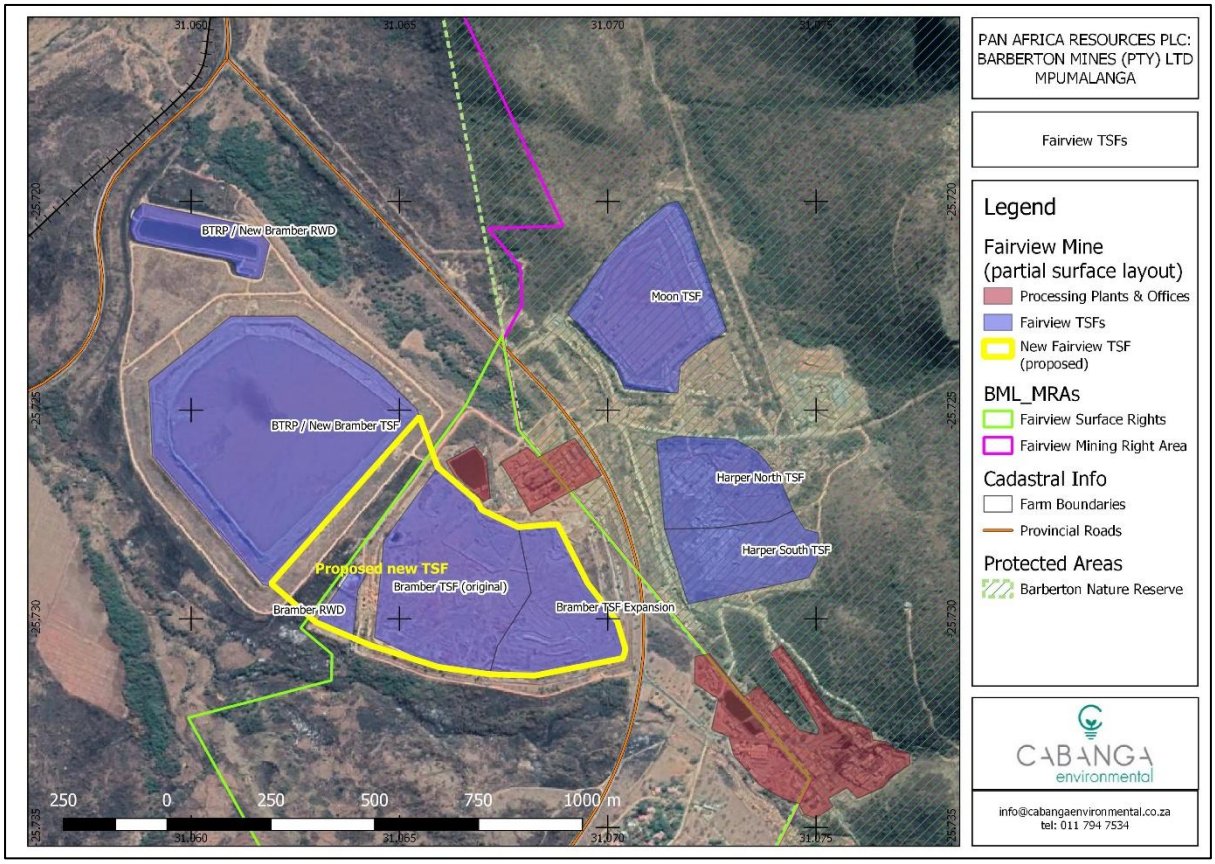


Figure 1: Detailed map from Google Earth of the proposed area for the proposed new Tailings Storage Facility (TSF) (within the yellow outline) at the Fairview Mine. Map supplied by Cabanga Environmental.

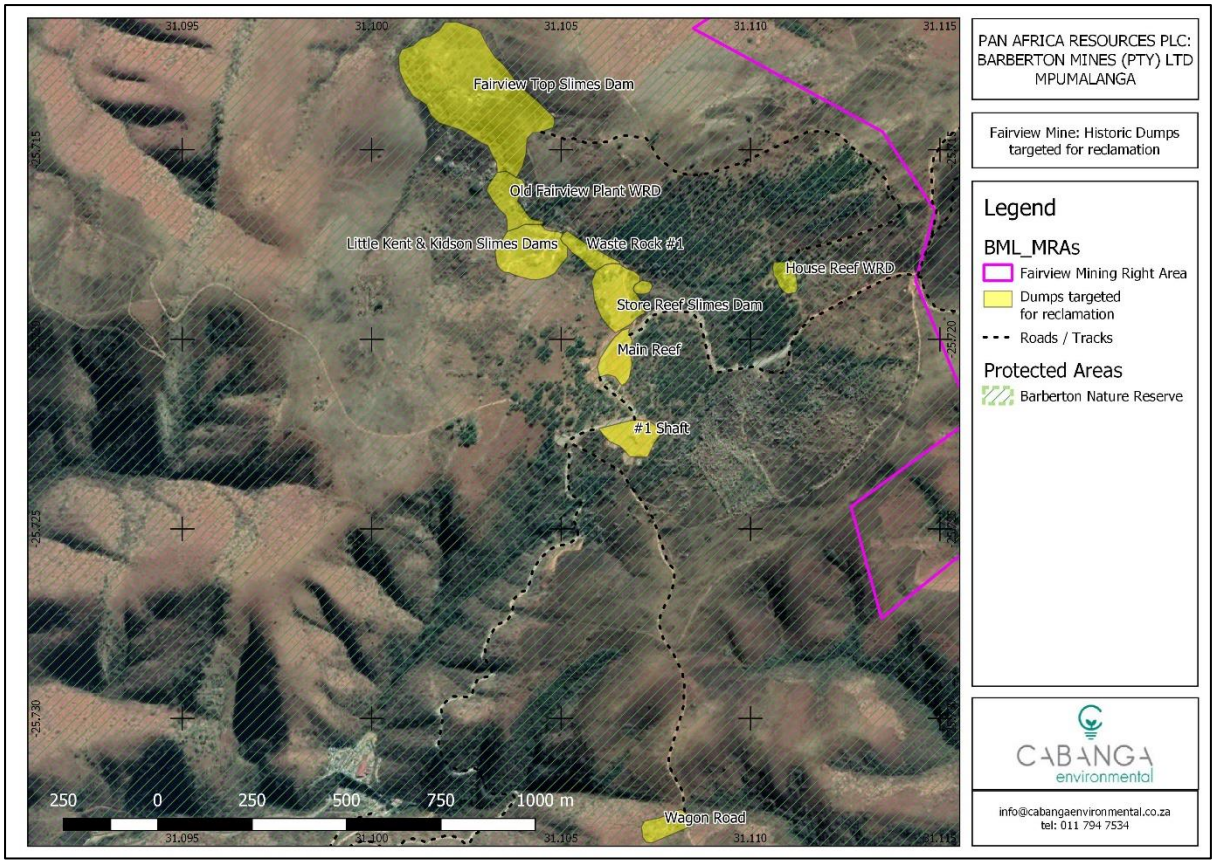


Figure 2: Google Earth map of the Fairview Mine historical dumps that are the target for reclamation (yellow).

This report is the palaeontological impact assessment for the project.

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

| | **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 – desktop only |
| 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 (none) |
| 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; | See palaeosensitivity map |
| 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 | Appendix A |
| l | Any conditions for inclusion in the environmental authorisation | N/A (None) |
| m | Any monitoring requirements for inclusion in the EMPr or environmental authorisation | Section 8 |
| ni | A reasoned opinion as to whether the proposed activity or portions thereof should be authorised | See Executive Summary |
| 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 (none except as included in Appendix A) |
| o | A description of any consultation process that was undertaken during the course of carrying out the study | N/A – consultation will be undertaken by the EAP |
| p | A summary and copies if any comments that were received during any consultation process | N/A (none) |
| q | Any other information requested by the competent authority. | N/A (none) |

# 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 the South African Heritage Resource Agency (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.

# 3. Geology and Palaeontology

## i. Project location and geological context

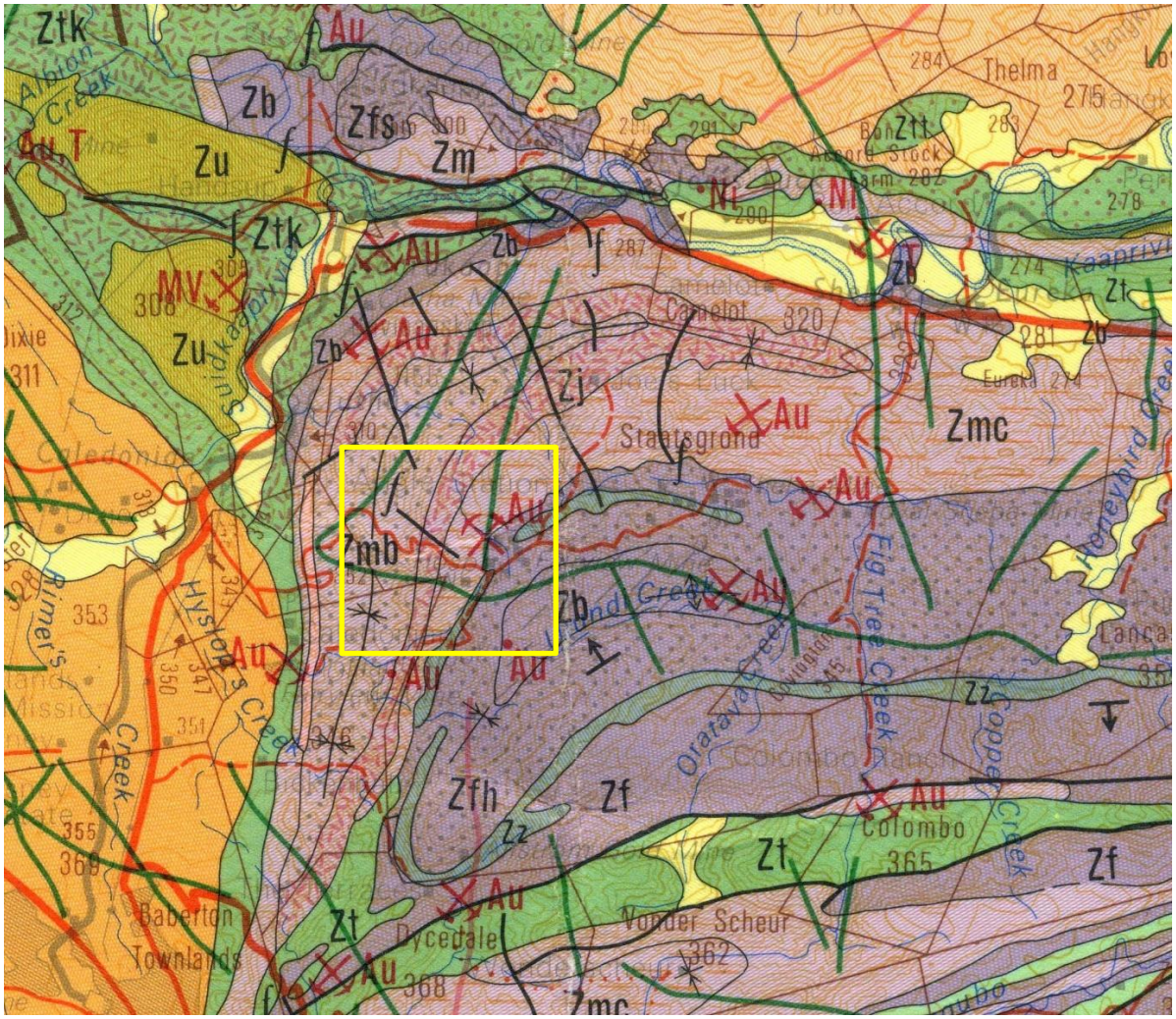


Figure 3: Geological map of the area to the northeast of Barberton, Mpumalanga Province, where the Fairview Mining Right area (yellow rectangle) and Sheba Mine (arrow) are located. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map Barberton 2530.

Table 2: Explanation of symbols for the geological map and approximate ages (Brandl et al., 2006; Cornell et al., 2006; Duncan and Marsh, 2006; Erikssen et al., 2006. Johnson et al., 2006). SG = Supergroup; Fm = Formation.

| Symbol | Group/Formation | Lithology | Approximate Age |
|---|---|---|---|
| Rmp | Mpuluzi Granite | Quartz monzonite | <3105 Ma |
| Zu | Kaap Valley Granite | Serpeninised dunite, gabbro, anorthosite | 3411 – 3230 Ma |
| Zmb | Baviaanskop Fm, Moodies Group, Barberton SG | Sandstone, grit, conglomerate, shale, greywacke | Ca 3255 – 3215 Ma |
| Zj | Joe's Luck Fm, Moodies Group, Barberton SG | Shale, subgreywacke, quartzite, phyllite, basaltic lava | |
| Zmc | Clutha Fm, Moodies Group, Barberton SG | Shale, quartzite, conglomerate, jaspilite | |
| Zfs | Schoongezicht Fm, Figtree Group, Barberton GS | Trachytic tuff, agglomerate, lava, tuffaceous greywacke | Ca 3250 Ma |
| Zb | Belvue Road Fm, Figtree Group, Barberton SG | Siltstone, shale, greywacke | |
| Zfh | Sheba Fm, Figtree Group, Barberton SG | | |
| Zz | Zwartkoppies Mb, Geluk Fm, Onverwacht Group, Barberton SG | Mafic and felsic lava | Ca 3550 - 3250 Ma |
| Zt | Tarkastad Mb, Onverwacht, Group, Barberton SG | | Ca 3600 Ma |

The proposed site lies on several outcrops of the oldest rocks in South Africa, those of the Barberton Greenstone Belt (BGB), which is mid Archean in age (3600- 3100 Ma; Brandl et al., 2006) and in particular on the Onverwacht, Figtree and Moodies Groups. There are also a number of plutons and batholiths in the area that range in age from 3509 to 3104 Ma. The Barberton Greenstone Belt is one of the best studied granite-greenstone terranes in the world (Brandl et al., 2006) because it is one of the oldest known, it is composed of a unique sequence of the best-preserved, first-formed lithologies on the planet, and geologists have used it as a model to interpret other greenstone belts (ibid).

The Barberton Supergroup comprises three major lithostratigraphic units (Figure 3), with the Onverwacht Group at the base, the Figtree Group in the middle and the Moodies Group at the top. It is thought that these sediments formed in an oceanic setting, followed by island arc development as a consequence of some primitive form of Archaean plate tectonic processes (ibid).

Most research has been done on the southern part of the BGB and little on the northern part, where Fairview Mine is situated. Currently the basal Onverwacht Group is divided into seven

formations, from the bottom, the Sandspruit, Theespruit, Komati, Hooggenoeg, Kromberg, Mendon and Weltevreden Formations. The Figtree Group is divided into three formations in the northern part as follows (basal to top): Sheba Formation, Belvue Road Formation and Schoongezicht Formation. They comprise various combinations of deepwater facies such as turbiditic lithic greywacke, shale, turbiditic siltstone and locally coarse volcaniclastic rocks (Brandl et al., 2006). The overlying Moodies Group is divided into three formations, from the base upwards, the Clutha Formation, Joe's Luck Formation and the Baviaanskop Formation. These formations each represent an upward-fining cycle comprising a coarse basal unit of conglomeratic quartzose sandstone, siltstone and shale (Brandl et al., 2006).

The Fairview Mine is positioned mainly in the Moodies Group, with the Fig Tree Group where there are extensive gold reserves, exposed to the southeast (Ward and Wilson, 1998) (Figure 4).

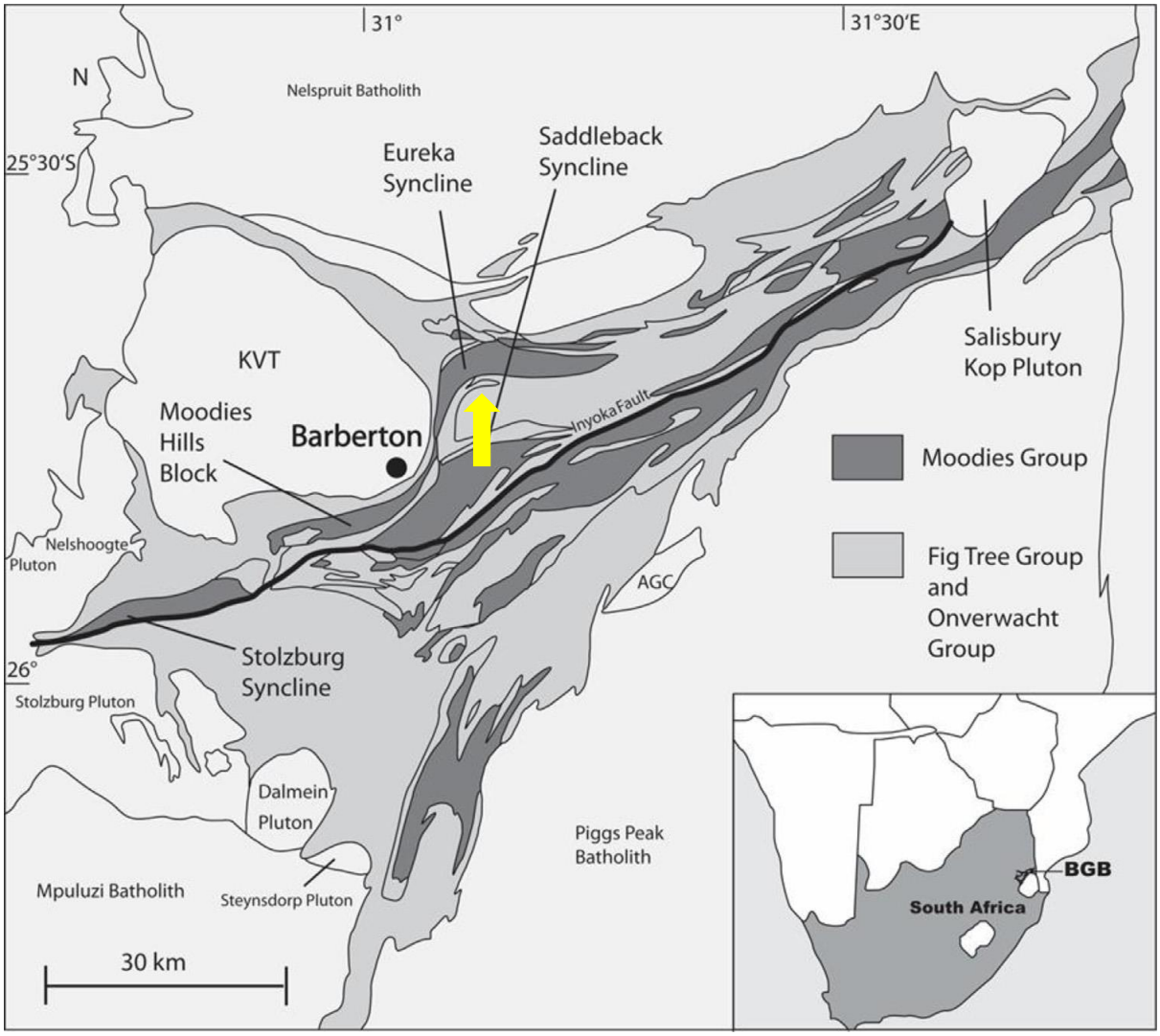


Figure 4: Map showing the updated geological groups in the Barberton Greenstone Belt (from Noffke et al., 2006, Brandl et al., 2006, figure 1, page 120) with a focus on the three main stratigraphic divisions and the volcanic rock types. Fairview Mine, arrow, is in the northeast part.

## ii. Palaeontological context

The Onverwacht Group is predominantly volcanic in origin and the seven formations within this group represent volcanic rocks, basalts, komatiites, etc., and different degrees of metamorphism. According to Altermann et al. (2006) there are stromatolites in the Onverwacht Group. Stromatolites are trace fossils because they are the accumulations of layers of minerals laid down by colonies of primitive algae (bluegreen algae or cyanobacteria) in warm shallow seas. Very rarely the microscopic algae are preserved within the stromatolites. Recently Kremer and Kazmierzak (2017) reported the presence of microscopic algae in rocks of the Kromberg Formation, Onverwacht Group, along the Komati River, Songimvelo Nature Reserve.

The Figtree Group depositional environment was a deep-water one and about 3461-3225 million years ago (Brandl et al., 2006), and comprises sales and banded ironstone. According to Altermann et al (2006) there are stromatolites in this Group.

The Moodies Group is slightly younger at about 3225 to 3126 Ma and represents a foreland basin with braided alluvial plains, deltas, shallow water coastal systems and shelf facies (Brandl et al., 2006). Although no stromatolites have been reported from this Group other trace fossils have been. Microbially induced sedimentary structures, another form of trace fossils, have been reported from the Dycedale and Saddleback Synclines, Moodies Group, close to Barberton (Noffke et al., 2006; Altermann et al., 2006; Nabham et al., 2016). Homan et al. (2016) mapped in detail along the Saddleback Syncline and noted microbial mats in four of the five facies.

The Kaap Valley Tonalite and ultrabasic rocks do not preserve fossils because they are volcanic in origin. They also predate the origin of body fossils.

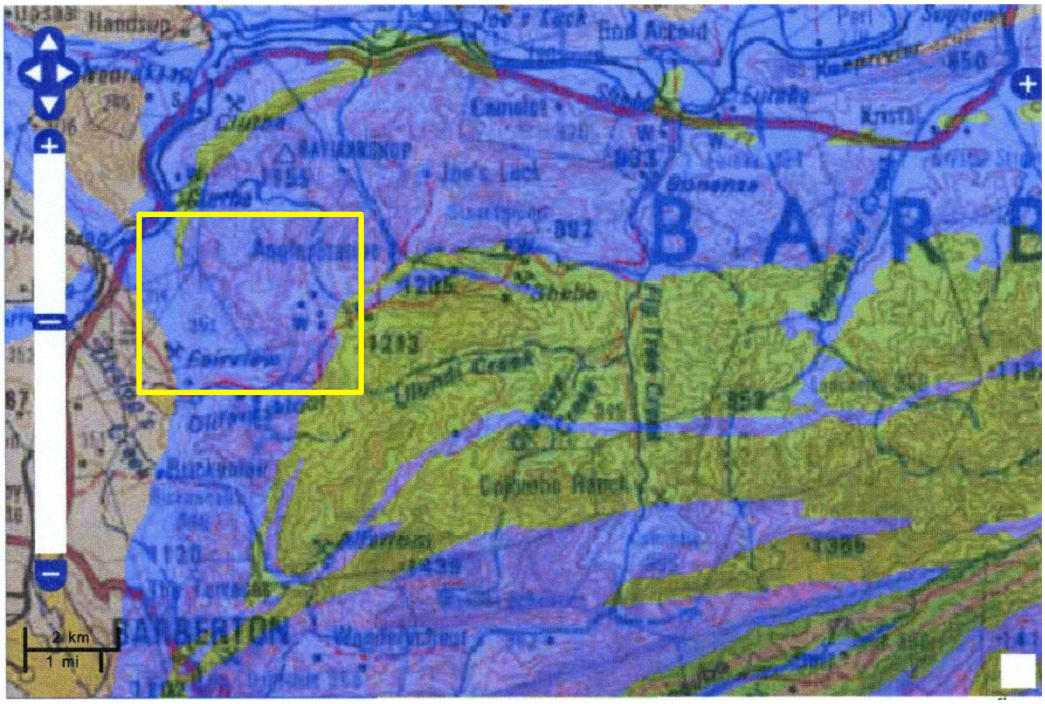


Figure 5: SAHRIS palaeosensitivity map of the region around Fairview Mining area (yellow rectangle) and Sheba Gold Mine (arrowed). The project site is in in the blue area with sections on the east (unaffected by the proposed Project) in the green area. Colours indicate the following degrees of sensitivity: 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** | There is none to a very small chance of fossils being found here |
| | **L+** | - |
| | **M+** | |
| | **H+** | - |
| **DURATION** | **L** | - |
| | **M** | - |
| | **H** | Where manifest, the impact will be permanent. |
| **SPATIAL SCALE** | **L** | The spatial scale is extremely small. |
| | **M** | - |
| | **H** | - |
| **PROBABILITY** | **H** | **-** |
| | **M** | |
| | **L** | There is no chance to a very small chance of finding fossils in the stromatolites (trace fossils) and microbial mats as they are microscopic and would NOT be visible to the naked eye. Furthermore, the dumps represent already disturbed and crushed sediments. |

Based on the nature of the project, the granites, tonalities, greywackes and volcanic rocks would not preserve fossils. There is a small chance that stromatolites of the Fig Tree Group could occur in the site to be developed but there is a much smaller chance that there could be microscopic algal cells preserved in the stromatolitic layers. Microbial mats are also trace fossils and do not preserve any fossils. Only if any stromatolites are noted and are going to be disturbed, should they be sampled (GPS coordinates and hand specimens of rock taken) and posted to a research facility (university or museum – for example the University of Johannesburg geologists work on rocks of this age). There is no chance of finding fossils BEFORE excavations commence so a phase 2 or site visit is NOT recommended at this stage. Taking account of the defined criteria, the potential impact to fossil heritage resources is very low. The mining dumps to be reclaimed are already highly disturbed and no fossils, even if originally present, would have survived the excavation, crushing and processing for the extraction of gold.

## 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 gneisses, schists, granites, greywackes and basalts are typical for the country and do not contain any fossil plant, insect, invertebrate and vertebrate material. There is a very small chance that the stromatolites of the Fig Tree Group may contain microfossils of early unicellular bluegreen algae but these are not visible to the naked eye. No fossils, however, have been reported from this region.

## 6. Recommendation

Based on the age of the sediments and extremely rare occurrence of fossils in this formation, and the fact that no fossils have been recorded from this area, there is almost no chance that fossils would be preserved in the rocks. In particular, the dump sediments are already highly disturbed. No further palaeontological assessment is required. It is recommended that if stromatolites are excavated then a hand sample should be sent to the University of Johannesburg, Department of Geology, for their records and possible further research. As far as the palaeontological heritage is concerned the proposed TSF construction and reclamation of dumps can proceed.

## 7. References

Altermann, W. Kazmierczak, J. Oren, A., Wright, D.T., 2006. Cyanobacterial calcification and its rock-building potential during 3.5 billion years of earth history. Geobiology 4, 147-166.

Brandl, G., Cloete, M., Anhauaeusser, C.R., 2006. Archaean Greenstone belts. 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 9-56.

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Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. pp 237-260.

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Kremer, B., Kazmierczak, J., 2017. Cellularly preserved microbial fossils from ca 3.4 Ga deposits of South Africa: A testimony of early appearance of oxygenic life? Geology 34(4), 253–256.

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Noffke, N., Erikssen, K.A., Hazen, R.M., Simpson, E.L. 2006. A new window into Early Archean life: Microbial mats in Earth's oldest siliciclastic tidal deposits (3.2 Ga Moodies Group, South Africa). Geology 34, 253–256.

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Ward, J.H.W., Wilson, M.G.C., 1998. Gold outside the Witwatersrand Basin. In: M.G.C. Wilson and C.R. Anhaeusser (Eds). The mineral resources of South Africa: Handbook, Council for Geoscience, 16, 350-386.

# 8. Monitoring Programme for Palaeontology – to commence once the excavations 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 sediments 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 construction activities will not be interrupted. Small samples of stromatolites can be taken and sent to an interested party – the algae are microscopic so will not be seen under the naked eye.
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). 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. As required and to be agreed upon by the developer and the qualified palaeontologist sub-contracted for this part of the project and appointed only if required, the palaeontologist should visit the site to inspect the selected material and check the samples where feasible. The frequency of inspections should be determined by the finding of interesting material. However, if the onsite designated person is diligent and extracts the fossil material then inspections can be less frequent.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist (if any are identified) 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 can be reduced to annual events until construction has ceased. 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 stromatolites


Figure 4: Examples of stromatolites as seen in the field; A and C are vertical cuts and B is the surface view.

## Appendix B – Details of specialist

# Curriculum vitae (short) - Marion Bamford PhD
# September 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
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 | 7 | 0 |
| Masters | 10 | 4 |
| PhD | 12 | 5 |
| Postdoctoral fellows | 10 | 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
- 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

## xi) Research Output

Publications by M K Bamford up to June 2018 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;
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)