Palaeontological Impact Assessment for the proposed development of a cement factory, Middelburg, Eastern Cape Province

Desktop Study (Phase 1)

For

CTS Heritage
Project no: CTS21_280

05 December 2021

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Expertise of Specialist

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

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by CTS Heritage, Cape Town, 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 development of a batch plant and pre-cast facility, by Concrete Units, for the construction of wind turbine tower components. The plant will be on the Remainder of the Farm Bultfontyn 128, south of Middelburg, Eastern Cape in the Chris Hani District Municipality.

To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development.

The proposed site for Option 1 lies on the Quaternary sands that are unlikely to have fossils so this is the preferred choice as far as the palaeontological heritage is concerned.

The proposed site for Option 2 lies partly on Quaternary sands and partly on potentially fossiliferous mudstones and sandstones of the Daptocephalus Assemblage Zone (Balfour Formation, Adelaide Subgroup, Beaufort Group, Karoo Supergroup). Based on the more or less flat topography of the site, it is unlikely that any fossils would be visible on the surface, but they might be below the soils. Therefore, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological impact assessment is required unless fossils are found by the developer/ environmental officer/ other designated responsible person once excavations/drilling activities have commenced. As far as the palaeontology is concerned, the project should be authorised.

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i. Background

Concrete Units is proposing to develop a batch plant and pre-cast facility for the construction of wind turbine tower components. Note that assembly will take place off the site on the respective wind farms. The plant will be on the Remainder of the Farm Bultfontyn 128, south of Middelburg, Eastern Cape in the Inxuba Yethemba Local Municipality, Chris Hani District Municipality.

The plant will cover approximately 16.68ha with foundations excavated to a maximum of 3m. Buildings include batch plant silos, aggregate stores, pre-cast warehouses, admin offices, laydown areas, fuel store and generators.

A Palaeontological Impact Assessment was requested for the project. To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development and is reported herein.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (amended 2017)

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section i.
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 ii.
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 vii.
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 vi.
k	Any mitigation measures for inclusion in the EMPr	Section 8, 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 8, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
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	Sections 6, 8
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 the proposed development of a cement factory near Middelburg with the sections shown by the red outline.

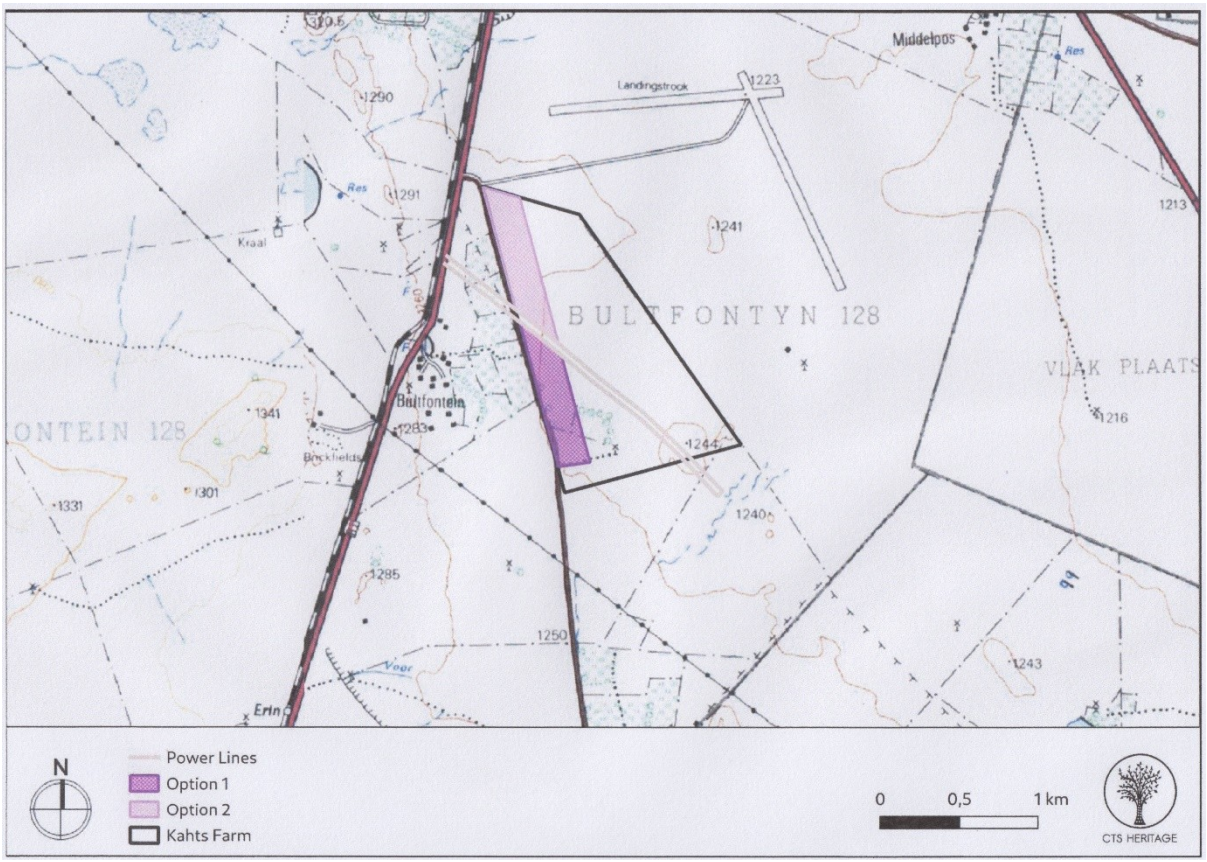

Figure 2: Topographic map of the proposed Cement plant site south of Middelburg. Note there are two options for the position of the buildings, option 1 to the south and option 2 to the north of the powerline.

ii. 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*).

iii. Geology and Palaeontology

iv. Project location and geological context

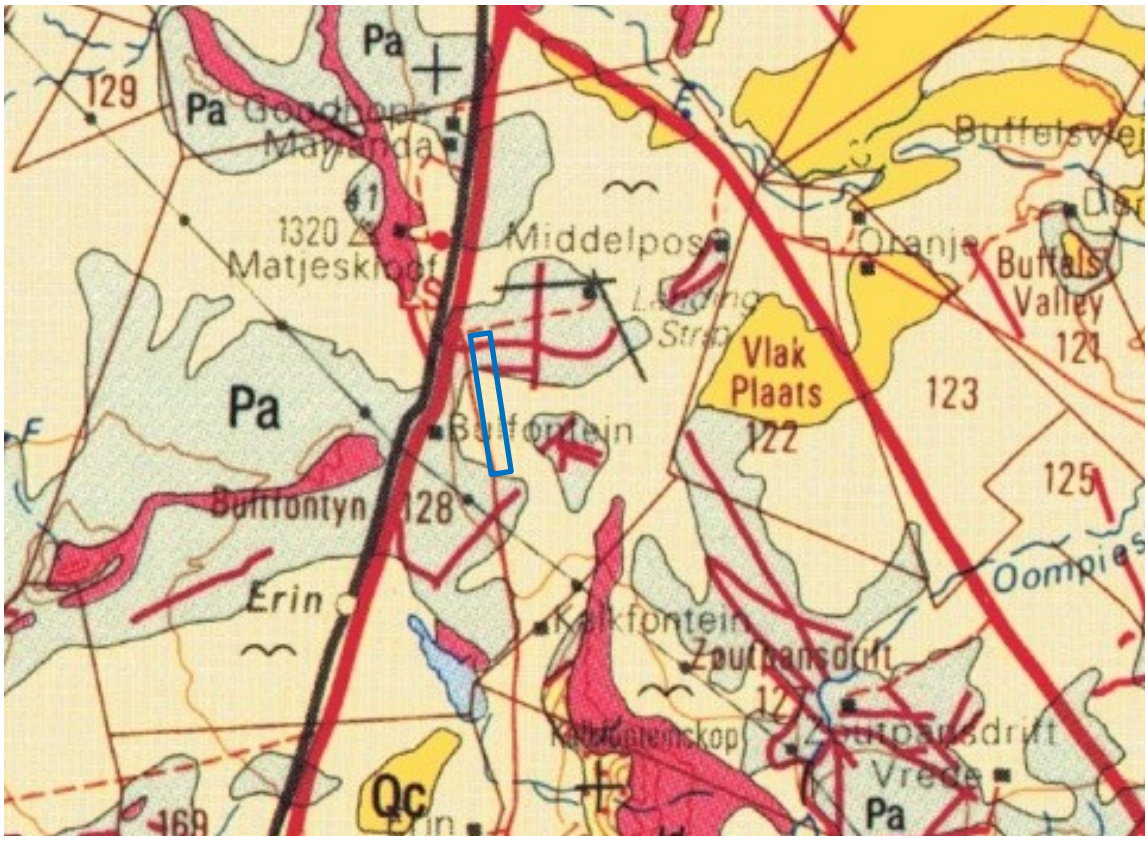

Figure 3: Geological map of the area around the Farm Bultfontyn with the proposed cement plant indicated within the blue rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 3124 Middelburg.

Table 2: Explanation of symbols for the geological map and approximate ages (Johnson et al., 2006; Smith et al., 2020). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Q	Quaternary	Alluvium, sand, calcrete	Neogene, ca 2.5 Ma to present
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 180 Ma
Pa	Adelaide Subgroup, Beaufort Group, Karoo SG		Late Permian, 255-251 Ma; Daptocephalus AZ

The Karoo Supergroup rocks cover a very large proportion of South Africa and represents some 120 million years (300 – 183Ma). These sedimentary

rocks have preserved a diversity of fossil plants, insects, vertebrates and invertebrates.

During the Carboniferous Period South Africa was part of the huge continental landmass known as Gondwanaland and it was positioned over the South Pole. As a result, there were several ice sheets that formed and melted, and covered most of South Africa . Gradual melting of the ice as the continental mass moved northwards and the earth warmed, formed fine-grained sediments in the large inland sea. These are the oldest rocks in the system and are exposed around the outer part of the ancient Karoo Basin, and are known as the Dwyka Group. They comprise tillites, diamictites, mudstones, siltstones and sandstones that were deposited as the basin filled (Johnson et al., 2006).

Overlying the Dwyka Group rocks are rocks of the Ecca Group that are Early Permian in age. There are eleven formations recognised in this group but they do not all extend throughout the Karoo Basin. All of these sediments have varying proportions of sandstones, mudstones, shales and siltstones and represent shallow to deep-qwater settings, deltas, rivers, streams and overbank depositional environments.

Overlying the Ecca Group are the rocks of the Beaufort Group that has been divided into the lower Adelaide Subgroup for the Upper Permian strata, and the Tarkastad Subgroup for the Early to Middle Triassic strata. As with the older Karoo sediments, the formations vary across the Karoo Basin.

Adelaide Subgroup west of 24°E. There are only two formations in this part of the Karoo Basin, the basal Abrahamskraal Formation and the Teekloof Formation. East of 24°E three formations are recognised in the Adelaide Subgroup, the basal Koonap Formation, Middleton Formation and thick upper Balfour Formation. The latter has been divided into five members, the lower four from the base up are the Oudeberg, Daggaboersnek, Ripplemead and Elandsberg Members. The topmost member, the Palingkloof Member, is in the earliest Triassic (Smith et al., 2020).

Intruding through the Karoo sediments are numerous dolerite dykes and sills that were emplaced in association with the massive outpourings of basalt during the middle Jurassic and formed the Drakensberg Mountains. Igneous rocks do not preserve fossils, and in fact tend to destroy fossils in their immediate vicinity because of the tremendous heat. The Jurassic dolerite, therefore, does not preserve any fossils.

Much younger soils and sands overly the older rocks over large parts of southern Africa, generally termed the Quaternary Kalahari sands. These weathered sediments have formed from older rocks and often have been transported great distances by wind (aeolian) or fluvial (river) forces, and deposited in small to large shallow basins.

v. Palaeontological context

The site for development is in the Quaternary sands and the Adelaide Subgroup. According to the updated Karoo biostratigraphy (Smith et al., 2020; Viglietti, 2020; reproduced here in Figure 5) the site lies in the *Daptocephalus* Assemblage Zone and in particular in the *Lystrosaurus maccaigi – Moschorinus* Subzone. Lithologically this is the upper Balfour Formation with the Elandsberg Member. The typical vertebrate fossils include fish, amphibians, parareptiles and therapsids (Viglietti, 2020). Typical plant fossils include mosses, sphenophytes, ferns, glossopterids, cordaitaleans and conifer wood (Anderson and Anderson, 1985; Bamford, 2004). See Appendix A for species lists and photographs.

Figure 4: Biostratigraphic map of the *Daptopcephalus* Assemblage Zone (from Viglietti, 2020) shown in blue with the lower part, the lower *Dicynodon-Theriognathus* Subzone shown with dotting and the upper *Lystrosaurus maccaigi – Moschorinus* Subzone without dotting.

According to the SAHRIS Palaeosensitivity Map (Figure 6), the area proposed for development is underlain by sediments of moderate sensitivity for the Quaternary sands (Option 1, south) and partly very high

for the Adelaide Subgroup (Option 2, north). According to the new map (Figure 5), the site is not close to the Permo-Triassic boundary (blue-yellow boundary). The palaeontological sensitivity of the area under consideration is presented in Figure 5.

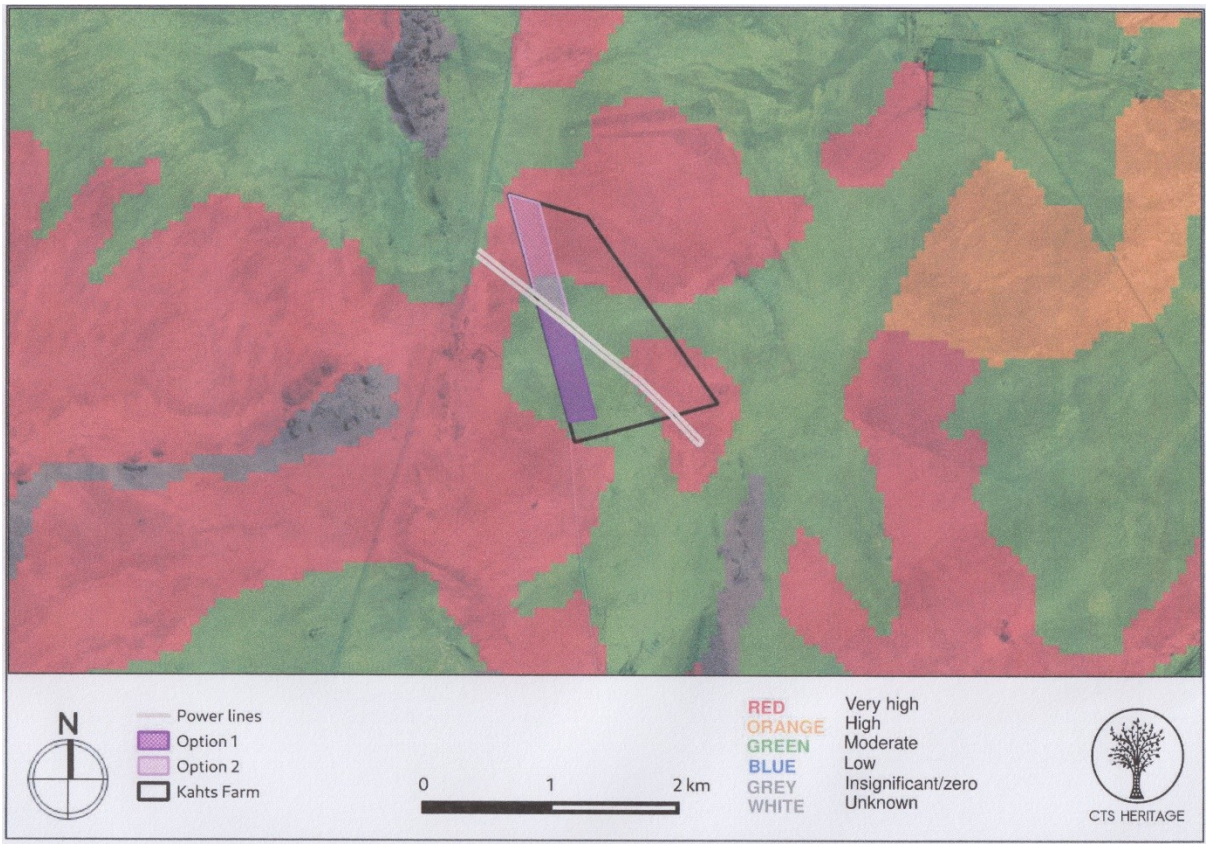

Figure 5: SAHRIS palaeosensitivity map for the site for the proposed cement plant shown by the light and darker purple polygons. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Quaternary sands do not preserve fossils but they might entrap fossils if there such features as palaeo-pans, palaeo-dunes or palaeo-springs but such features do not extend this far south (Goudie and Wells, 1995). Nor is any such feature visible on the satellite imagery (Figure 1).

It should be noted that the topography for both options 1 and 2 is on flat land with low vegetation. With reference to Option 2 on the Adelaide Subgroup shales and mudstones, in general Karoo fossils are found on slopes where the underlying rocks are exposed and not covered by soils and alluvium so it is unlikely that fossils, if present, would be visible from the surface. With reference to Option 1 on the Quaternary sands, it is very unlikely that any fossils are present.

vi. 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	Option 1: Soils and sands do not preserve fossils; Option 2: so far there are no records from the Adelaide subgroup of plant or animal fossils on this farm 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**	For both Option 1 and 2, since the only possible fossils within the area would be vertebrates or fossil plants from the *Glossopteris* flora in the shales, the spatial scale will be localised within the site boundary.
	M	-
	H	-

PART B: ASSESSMENT		
PROBABILITY	H	-
	M	**Option 2: there is a small chance that vertebrate or plant fossils of the Adelaide sG might occur below the ground so a Fossil Chance Find Protocol should be added.**
	L	Option 1: It is extremely unlikely that any fossils would be found in the loose soils and sand that will be excavated for the foundations.

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 the correct age and type to contain fossils. Surface soils and sands, however, do not preserve fossils. Since there is a small chance that fossils from the Adelaide Subgroup may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is low.

vii. 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, shales and sands are typical for the country and some do contain fossil plant, insect, invertebrate and vertebrate material. The sands of the Quaternary period would not preserve fossils. The Quaternary sands (Option 1) are extremely unlikely to preserve fossils. There is a moderate chance that fossils occur in the Adelaide Subgroup (Balfour Formation, Elandsberg Member) but because the topography is more or less flat there are no exposures so the chances of finding fossils is reduced. It is not known if there are fossils below the soil surface.

viii. 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 soils and sands of the Quaternary. Therefore, Option 1 is the preferred choice for the cement plant as far as the palaeontology is concerned. However, the chance fossil finds protocol should be implemented due to the proximity to the Adelaide Subgroup and possible impacts to palaeontological heritage.

There is a very small chance that fossils may occur on the surface and a better chance of them being revealed once excavations for foundations have commenced (Option 2). On palaeontological grounds, Option 2 is not recommended. However, if for other reasons Option 2 is selected, then a fossils chance find protocol is strongly recommended. If fossils are found by the environmental officer, or other responsible person, on the surface or once excavations have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample (Section 8, Appendix A). As far as the palaeontology is concerned, the project should be authorised.

ix. 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.

Bamford, M.K. 2004. Diversity of woody vegetation of Gondwanan southern Africa. Gondwana Research 7, 153-164.

Goudie, A.S., Wells, G.L., 1995. The nature, distribution and formation of pans in arid zones. Earth Science Reviews 38, 1–69.

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.

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

Viglietti, P.A., 2020. Biostratigraphy of the *Daptocephalus* Assemblage Zone (Beaufort Group, Karoo Supergroup). South African Journal of Geology 123, 191-206.

x. 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 or coal) should be put aside in a suitably protected place. This way the project activities will not be interrupted.
3. Photographs of similar fossils must be provided to the developer to assist in recognizing the fossil plants, vertebrates, invertebrates or trace fossils in the shales and mudstones (for example see Figure 6-8). 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 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 an ECPHRA or SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

Appendix A – Examples of fossils from the Beaufort Group and Quaternary sands.

Table 4: List of main taxa occurring in the *Daptocephalus* Assemblage Zone (compiled from Anderson and Anderson, 1985; Bamford, 2004, Viglietti, 2020)

Group/sG/Fm	Plant Group	*Genera*	Animal Group	Common Genera
Beaufort Gr Adelaide Subgroup Balfour Fm Daptocephalus AZ	Lycophyta	*Gregicaulis*	Ampbibia	*Lydekkerina, Thabanchuia, Eolydekkerina, Micropholus, Broomulus*
	Sphenophyta	*Calamites Phyllotheca Sphenophyllum*	Parareptila	*Saurodektes, Sauropareion, Procolphon, Colleta, Phonodus*
	Filicophyta	*Asterotheca Cladophlebis*	Eureptilia	*Protocuchus, Prolacerta*
	Incertae sedis	*Bergesia*	Anomodontia	*Lystrosaurus, Myosaurus*
	Glossopteridales	*Glossopteris Rigbya Eretmonia*	Therocephalia	*Tetracynodon, Scaloposaurus, Olivierosuchus, Ericiolacerta, Regiosaurus*
	Ginkgoales	*Ginkgoites Sphenobaiera*	Cynodontia	*Galesaurus, Progalesaurus, Thrinaxodon*
	Cycadales	*Pseudoctenis Nilsonia*		

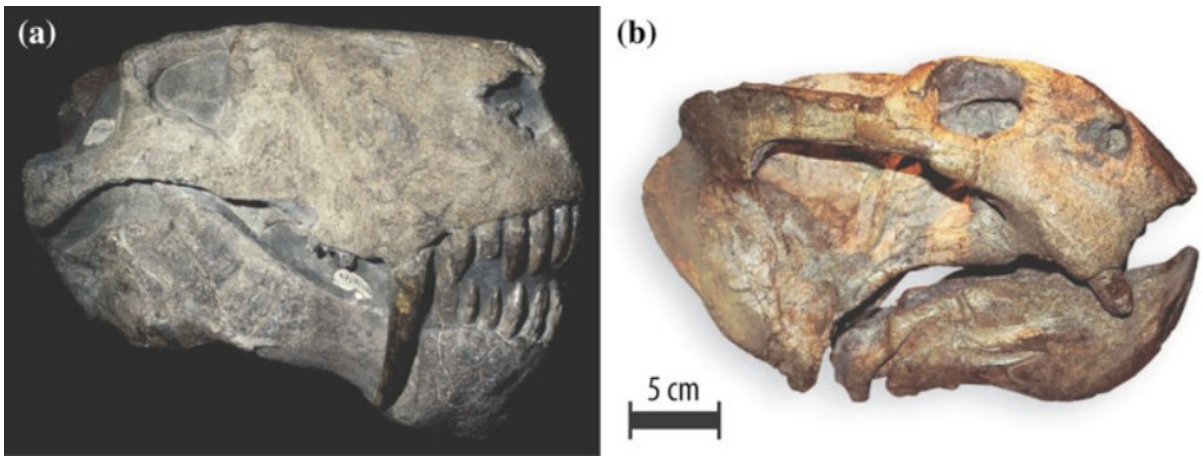

Figure 6: Therapsid skulls representative of two families that went extinct in the Permian: a flesh eating gorgonopsian, and b the herbivore dicynodont *Daptocephalus* (Photos supplied by Bruce Rubidge). In Linol and de Wit (2016) book Preface.

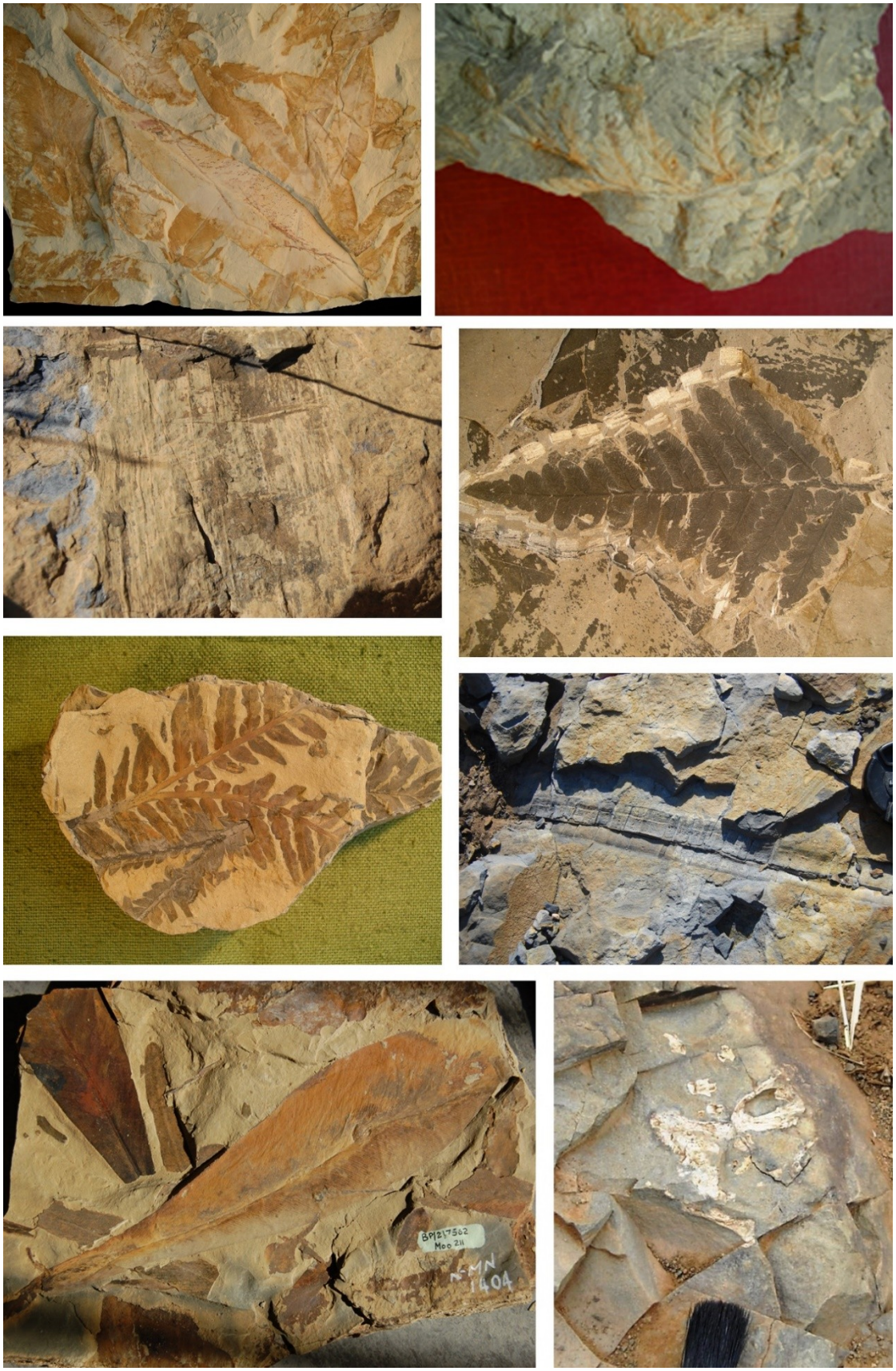

Figure 7: Selection of Permian fossil plants from the Karoo Supergroup. Bottom right photo shows vertebrate bone in situ, as would be seen in the field.

Figure 8: Robust but fragmentary fossils that have been found in Quaternary fluvial deposits and palaeo-pans.

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
July 2021

I) Personal details

Surname : **Bamford**
First names : **Marion Kathleen**
Present employment : Professor; Director of the Evolutionary Studies Institute.
Member Management Committee of the NRF/DST Centre of
Excellence Palaeosciences, University of the Witwatersrand,
Johannesburg, South Africa-
Telephone : +27 11 717 6690
Fax : +27 11 717 6694
Cell : 082 555 6937
E-mail : marion.bamford@wits.ac.za ; marionbamford12@gmail.com

ii) Academic qualifications

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) Professional qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) Membership of professional bodies/associations

Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991

International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

vii) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/ completed	Current
Honours	11	0
Masters	10	4
PhD	11	4
Postdoctoral fellows	10	5

viii) Undergraduate teaching

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

ix) Editing and reviewing

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

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

x) Palaeontological Impact Assessments

Selected – list not complete:

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

- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental
- Glencore-Tweefontein 2015 for Digby Wells
- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for EnviroPro
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for EnviroPro
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe

xi) Research Output

Publications by M K Bamford up to July 2021 peer-reviewed journals or scholarly books: over 150 articles published; 5 submitted/in press; 10 book chapters.
Scopus h-index = 29; Google scholar h-index = 35; -i10-index = 92
Conferences: numerous presentations at local and international conferences.