Palaeontological Impact Assessment for the proposed Prospecting Right Application by Camel Thorn Group (Pty) Ltd for 1- Farms Uitspanberg 52 and Kalkfontein 53 Northern Cape Province

Desktop Study (Phase 1)

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Prepared for

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Experience: 34 years research and lecturing in Palaeontology
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Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Archaeological and Heritage services Africa, Pretoria, 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 Prospecting Right Application on Portion 1 of the Farm Uitspanberg 52; Remaining Extent of Portion 2 of the Farm Uitspanberg 52; and Several other Portions, near Prieska in the Siyathemba Local Municipality, Northern Cape Province. The applicant is Camel Thorn Group (Pty) Ltd in terms of Regulation 2(2) of the MPRDA, Act 28 of 2002.

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 lies on the non-fossiliferous metamorphosed and volcanic rocks of the Namaqua-Natal Province. It is also on the westernmost margin of the Kaapvaal Craton with sediments of the Griqualand sequence (Transvaal Supergroup), all overlain by much younger transported sands of the Gordonia Formation (Kalahari Group). The Campbell Rand Formation dolomites and limestones might preserve trace fossils such as stromatolites. The Gordonia Formation sands would not preserve fossils but might obscure fossil trap features such as palaeo-pans or palaeo-springs although none is visible in the satellite imagery Nonetheless, 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 contractor, environmental officer or other designated responsible person once excavations, drilling or mining activities have commenced. The impact on the palaeontological heritage would be low, so as far as the palaeontology is concerned, the prospecting permit should be authorised as long as the dolomites are avoided. **If prospecting is to take place in the dolomitic areas in the north, a site visit (phase 2) palaeontology impact assessment is advisable.**

Table of Contents

1. Background

A Palaeontological Impact Assessment was requested for the Prospecting Right Application on Portion 1 of the Farm Uitspanberg 52; Remaining Extent of Portion 2 of the Farm Uitspanberg 52; and Several other Portions near Prieska in the Siyathemba Local Municipality, Northern Cape Province. The applicant is Camel Thorn Group (Pty) Ltd in terms of Regulation 2(2) of the MPRDA, Act 28 of 2002.

At this stage only a desktop study is feasible as permission to access the properties has not been granted.

In Figure 1, the properties comprising this application are shown. They are the following portions of Farm Uitspanberg 52:
Portion 1; REM of Portion 2; Portion 3 (a portion of Portion 2); Portion 4; Portion 5 (Witdam); Portion 6; Portion 7 (a portion of Portion 2); Portion 8; Portion 9 (a portion of Portion 2); Portion 10 (a portion of Portion 2); Portion 11 (a portion of Portion 2)
AND
The following portions of Farm Kalkfontein 53:
REM, Portion 1(Middelpunt); REM of Portion 2 (Kalkgat); REM of Portion 3 (Klipfontein); Portion 4; Portion 5 (a portion of Portion 2 – Asbestos Mine); Portion 6 (a portion of Portion 1 – Bakenskop); Portion 7 (a portion of Portion 3).

Total area: 34 515.5161 HA

A Palaeontological Impact Assessment was requested for the Uitspansberg and Kalkfontein Farms PRA 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: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

	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

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
k	Any mitigation measures for inclusion in the EMPr	Section 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 of any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A
2	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

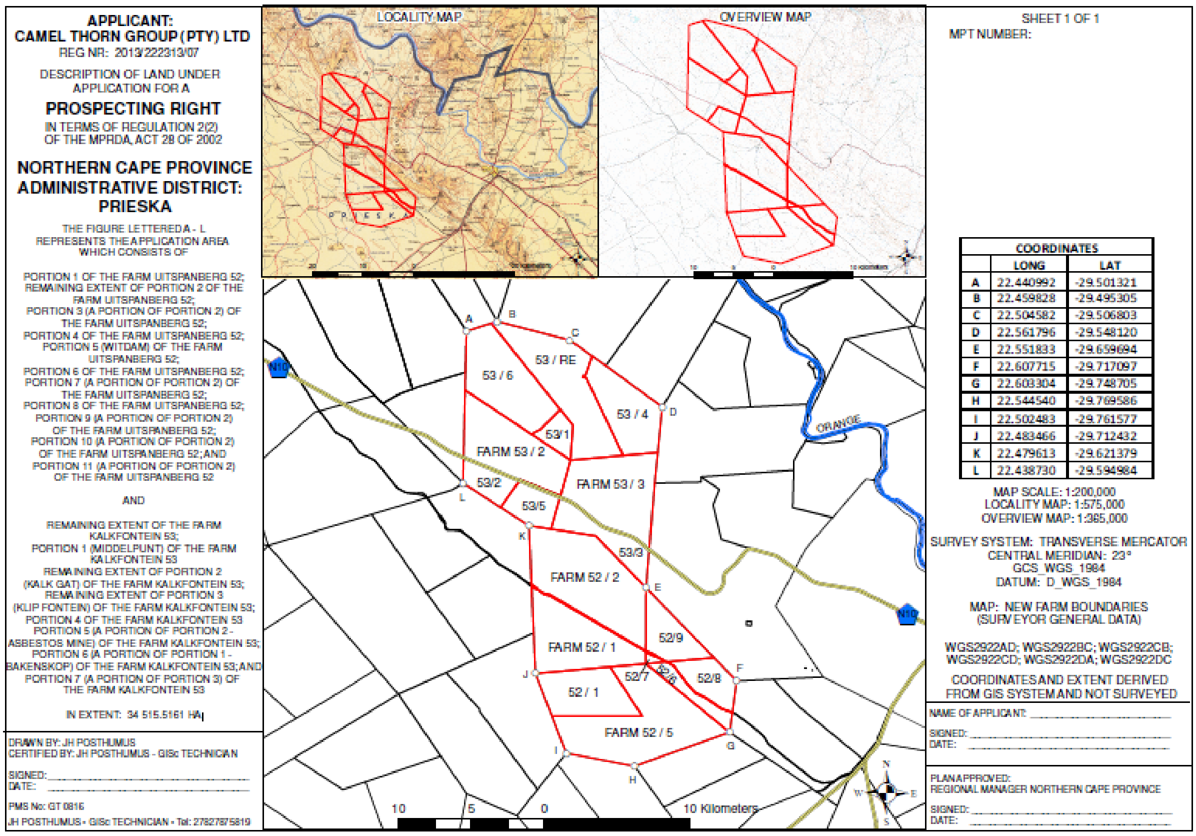

Figure 1: Locality maps for the PR application – Farms Uitpansberg 52 and Kalkfontein 53 (project 1). The prospecting area is shown by the red outlines.

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 include records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

3. Geology and Palaeontology

i. Project location and geological context

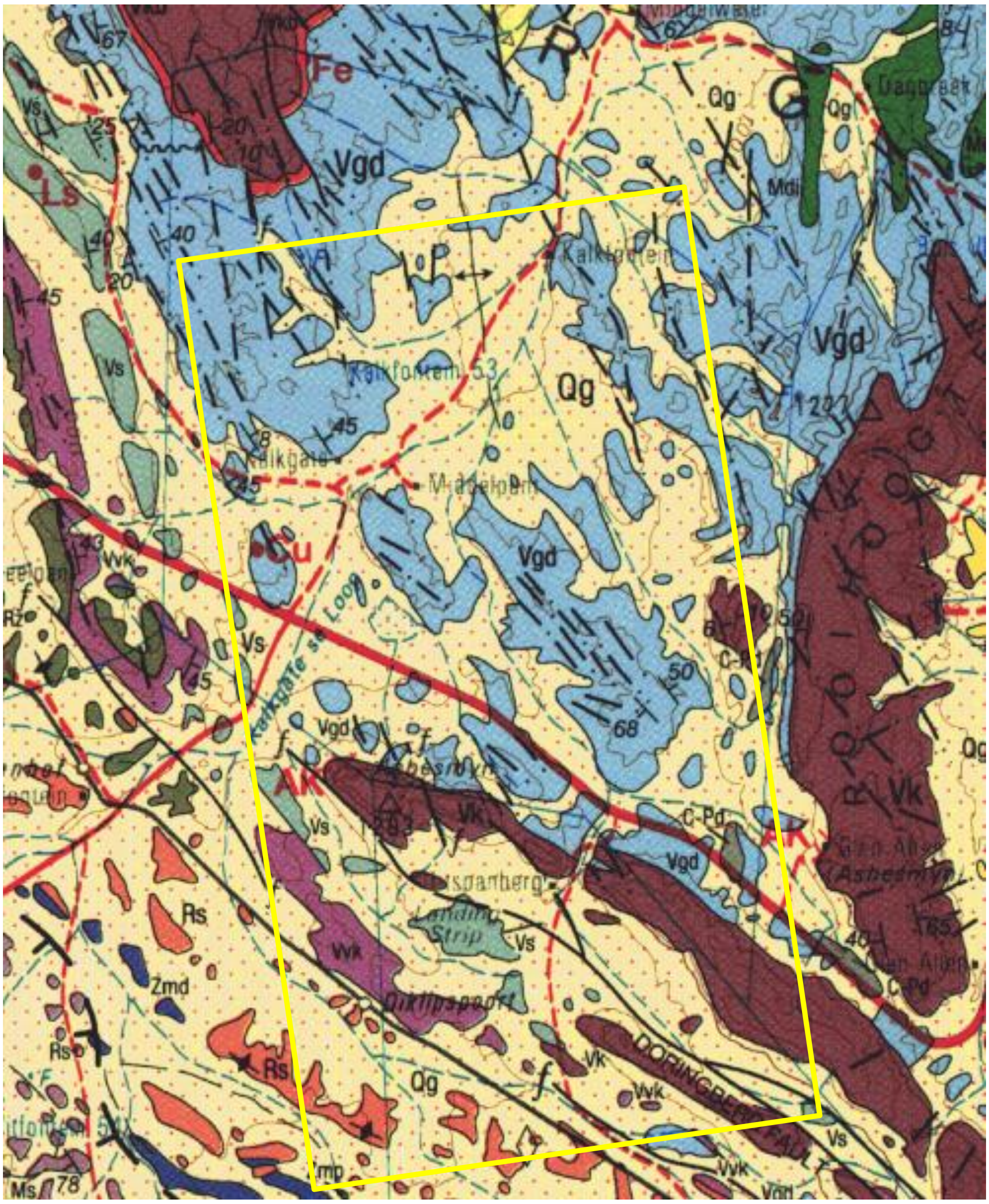

Figure 2: Geological map of the area around the Farms Uitpansberg and Kalkfontein with the prospecting area indicated within the yellow rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2922 Prieska.

Table 2: Explanation of symbols for the geological map and approximate ages (Eriksson et al., 2006. Johnson et al., 2006; McCarthy et al., 2006; Schier et al., 2018). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Qg	Gordonia Fm, Kalahari Group	Unconsolidated sand, red or white	Quaternary or Holocene; Post 1 Ma

Symbol	Group/Formation	Lithology	Approximate Age
Tc	Tertiary calcretes	Calcrete, dune pan	Cenozoic; last 65 Ma to 2.5 Ma
C-Pd	Dwyka Group, Karoo SG	Tillites, diamictites, mudstone,	Late Carboniferous to Early Permian
Ms, Mu, Mke	Brulpan Group, Namaqua-Natal Sequence	Gneiss, schist	Neoproterozoic Ca 1200 Ma
Vd	Griquatown/Danielskuil Fm; Asbestos Hills Subgroup, Ghaap Group, Transvaal SG	Blue riebeckitic jaspilite, subordinate brown jaspilite, chert	Palaeoproterozoic Ca 2489 Ma
Vk	Kuruman Fm, Asbestos Hills Subgroup, Ghaap Group, Transvaal SG	Banded iron formation, lenses of haematite, brown jaspilite, chert	Palaeoproterozoic Ca 2460 Ma
Vd	Campbell Rand Subgroup, Ghaap Group, Transvaal SG	Limestone, dolomite, chert	Palaeoproterozoic
Vvk	Kalkput Mb, Vryberg Fm, Griqualand West / Transvaal SG	White quartzite	Palaeoproterozoic
Rd, Rs	Olifantshoek Group intrusives	Granite, gneiss	Palaeoproterozoic Ca 2100 Ma
Znd, Zmp	Marydale Group	Granite, gneiss	Archaean >3300 Ma

The project lies in the Griqualand West Basin of the Transvaal Supergroup where the formations of the Campbell Rand and Asbestos Hills Groups are exposed (Figure 2). Much of the area is unconformably overlain by Quaternary sands of the Kalahari Group, the Gordonia Formation in particular. Various ancient granites and gneisses of the Marydale Group, Platberg group of the Ventersdorp Supergroup, and Olifantshoek Group have intruded through the rocks, as well as the younger Namaqua-Natal Sequence intrusives. The various volcanic and metamorphosed rocks are the target of the prospecting project.

The Late Archaean to early Proterozoic Transvaal Supergroup is preserved in three structural basins on the Kaapvaal Craton (Eriksson et al., 2006). In South Africa are the Transvaal and Griqualand West Basins, and the Kanye Basin is in southern Botswana. The Griqualand West Basin is divided into the Ghaap Plateau sub-basin and the Prieska sub-basin. Sediments in the lower parts of the basins are very similar but they differ somewhat higher up the sequences. Several tectonic events have greatly deformed the south western portion of the Griqualand West Basin between the two sub-basins

The Transvaal Supergroup comprises one of world’s earliest carbonate platform successions (Beukes, 1987; Eriksson et al., 2006; Zeh et al., 2020). In some areas there are well preserved stromatolites that are evidence of the photosynthetic activity of blue green bacteria and green algae. These microbes formed colonies in warm, shallow seas.

The Transvaal Supergroup rocks in the Griqualand West Basin can be correlated with the rocks in the Transvaal Basin, closely according to Beukes and colleagues, or not so closely according to Moore and colleagues. Nonetheless, these rocks represent on a very large scale, a sequence of sediments filling the basins under conditions of lacustrine, fluvial, volcanic and glacial cycles in a tectonically active region. The predominantly carbonaceous sediments are evidence of the increase in the atmosphere of oxygen produced by algal colony photosynthesis, the so-called Great Oxygen Event (ca 2.40 – 2.32 Ga) and precursor to an environment where diverse life forms could evolve. The Neoarchean-Paleoproterozoic Transvaal Supergroup in South Africa contains the well-preserved stromatolitic Campbellrand -Malmani carbonate platform (Griqualand West Basin – Transvaal Basin respectively), which was deposited in shallow seawater shortly before the Great Oxidation Event (GOE).

Campbell Rand Subgroup (Ghaap Group, Griqualand West Seeeeeeequence of the Transvaal Supergroup)

Based on the earlier works of Button (1976) and Beukes (1980, 1987) and updated after the application of sequence stratigraphy, Sumner and Beukes (2004) have described the 2650-2500 Ma Campbellrand and Malmani subgroups as being correlative and they form an extensive carbonate platform. Today there are preserved outcrops that cover 190,000 km^2 but these carbonate platforms probably originally covered the entire Kaapvaal Craton, >600,000 km2 (ibid). The thick platform has predominantly peritidal facies in the north and east and deeper facies to the south and west. However, thinner basinal sediments and plaform slopes are preserved near Prieska. The ca 2.5 - 2.46 Ga Kuruman iron-formations conformably overlie the Campbellrand Subgroup and the Penge Formation overlies the Malmani Subgroup. Both the Kuruman Iron Formation and the lower Penge Iron Formation consist of deep water, microbanded iron formation that formed on a stable marine shelf below wave base and then shallowed to sea level (Sumner and Beukes, 2006).

The Asbestos Hills Subgroup has three formations, the lower Kliphuis Formation, the **Kuruman Formation** and the **Danielskuil Formation**. They are all banded iron formations and have vast economically important reserves,

Above the Asbestos Hills Subgroup is the **Postmasburg Group**. The Makganyene Formation has diamictites and shales from glacial conditions. Disconformably overlying these are the Ongeluk Formation basaltic andesitic lavas. According to Cornell et al. (1996) and Schroder et al. (2016) the Ongeluk Formation is equivalent to the lavas of the Hekpoort Formation in the Transvaal Basin.

Tertiary Calcretes

Tertiary calcretes cover large parts of the Northern Cape but they are difficult to date and there are several schools of thought (see Partridge et al., 2006). Nonetheless, it is accepted that calcretes form under alternating cycles humid and arid climatic conditions in strata that have calcium carbonate (Netterberg, 1969). More recent research using geophysical techniques to measure uplift of the continent during the Cretaceous and tertiary, combined with the fossil record (Braun et al., 2014) suggest that there were two predominant humid periods during the Tertiary. The whole of the Eocene (56-33 Ma) and a short period during the early Miocene (ca 20-19 Ma) were humid according to their estimation. It is possible that the Northern Cape calcretes formed during one of these periods.

Overlying many of these rocks are loose sands and sand dunes of the Gordonia Formation, Kalahari Group of Neogene Age. The Gordonia Formation is the youngest of six formations and is the most extensive, stretching from the northern Karoo, Botswana, Namibia to the Congo River (Partridge et al., 2006). It is considered to be the biggest palaeo-erg in the world (ibid). The sands have been derived from local sources with some additional material transported into the basin (Partridge et al., 2006). Much of the Gordonia Formation comprises linear dunes that were reworked a number of times before being stabilised by vegetation (ibid).

The Kalahari Group fills the Kalahari Basin and is composed of six formations but these formations show considerable lateral variation and do not all occur throughout the basin (Partridge et al., 2006; Maud, 2012). At the base, and common in but not exclusively in the deeper palaeovalleys, is the Wessels Formation. It is composed of coarse, angular and poorly sorted gravel in a clay matrix. The upper part is moderately sorted. Overlying the Wessels Formation is the Budin Formation that comprises red and brown calcareous clays with scattered pebbles that likely were deposited in shallow saline lakes. Representing braided streams, the overlying Eden Formation has a poorly sorted basal gravel layer and then sandstone and siltstone with minor pebble and clay layers. The Mokalanen Formation is composed of calcrete with some pebble layers and is considered to have been formed in drier times during the 2.8 – 2.6 Ma global arid phase. A thin overlying layer of gravels, sand and pebbles is the Obobgorpop Formation. These clasts were derived from erosion of the Dwyka tillites. The most laterally extensive layer is the **Gordonia Formation** that is composed of unconsolidated sands. The sand is up to 30m thick and consists of rounded quartz grains with a thin coating of haematite that imparts a red colouration. The sand is white, however, in river bottoms and bottomlands where the colouration has been removed. The primary sources of the Gordonia sands are unknown.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 3. The site for prospecting is in the non-fossiliferous ancient granites, gneisses and schists. Sections also occur on the potentially fossiliferous Campbell Rand Group that could preserve trace fossils such as stromatolites. Most of the rocks are overlain by the Quaternary Gordonia Formation.

In some of the Campbell Rand Subgroup formations there are trace fossils, for example, giant stromatolitic domes overlain by microbial laminites with fenestrae and carbonate argillites, shales and siltstones make up the Monteville Formation (Beukes, 1987; Eriksson et al. 2006). The thickest stratum is the overlying Reivilo Formation that is made up of dolomite with giant stromatolitic domes, columnar stromatolites and fenestral facies (Beukes, 1980a). Possibly due to the lack of trace fossils, the Campbell Rand Subgroup has not been divided into formations in this region (Figure 2).

Stromatolites are the trace fossils that were formed by colonies of green algae and blue-green algae (Cyanobacteria) that grew in warm, shallow marine settings. These algae were responsible for releasing oxygen via the photosynthetic process where atmospheric carbon dioxide and water, using energy from the sun, are converted into carbon chains and compounds that are the building blocks of all living organisms. The released carbon dioxide initially was taken up by the abundant reducing minerals to form oxides, e.g. iron oxide. Eventually free oxygen was released into the atmosphere and some was converted into ozone by the bombardment of cosmic rays. The ozone is critical for the filtering out of harmful ultraviolet rays.

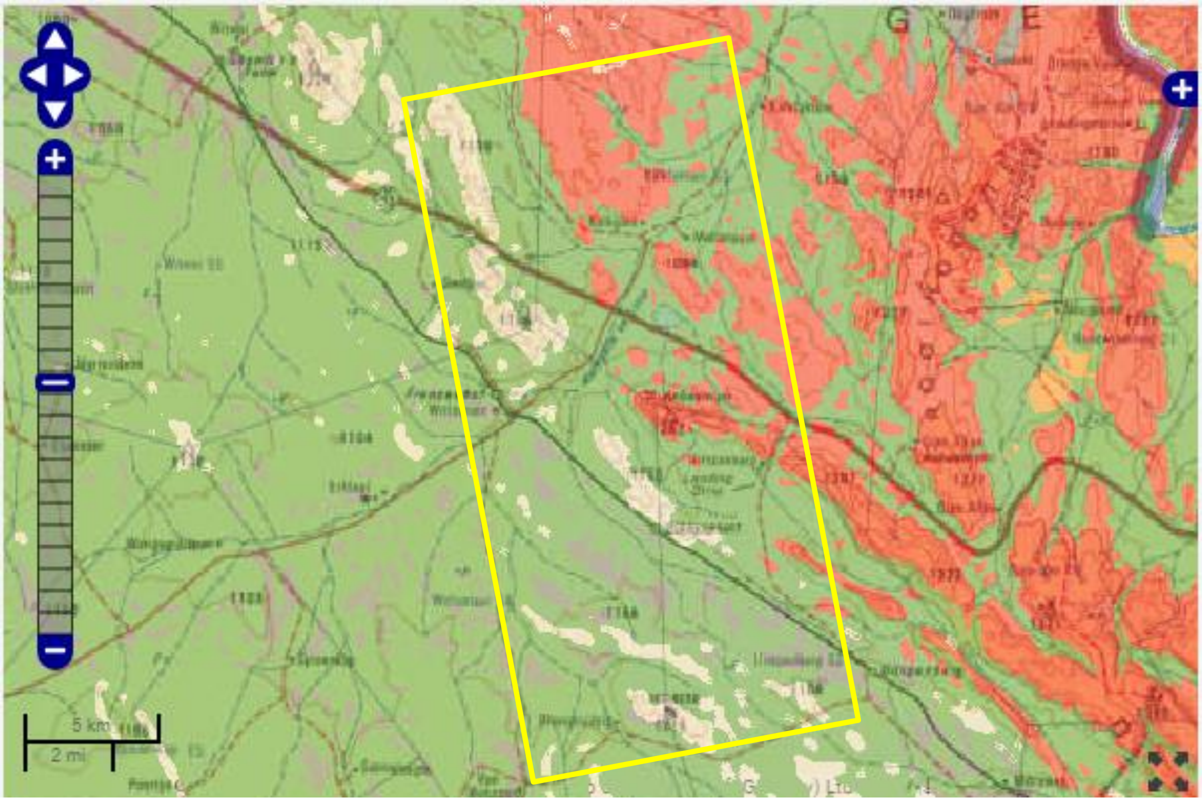

Figure 3: SAHRIS palaeosensitivity map for the site for the proposed PRA on Farms Uitspanberg 52 and Kalkfontein 53 (project 1) shown within the yellow rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Stromatolites are the layers upon layers of inorganic materials that were deposited during photosynthesis, namely calcium carbonate, magnesium carbonate, calcium sulphate and magnesium sulphate. These layers can be in the form of flat layers, domes or columns depending on the environment where they grew (Beukes, 1987). Some environments did not form stromatolites, just layers of limestone that later was converted to dolomite. The algae that formed the stromatolites are very rarely preserved, and they are microscopic so they can only be seen from thin sections studies under a petrographic microscope.

The Kuruman Formation banded iron formation is indicated as very highly sensitive but this is incorrect. Although the layers of iron were formed by the oxidation (free oxygen released by the photosynthetic activity of algae) and precipitation of iron, no algae were directly involved so there are no fossils or trace fossils in banded iron (Cowan, 1995; Havig et al., 2017).

KALAHARI GROUP
Aeolian sands and alluvium are fairly mobile and very porous so they not provide suitable conditions for preservation of organic matter (Cowan, 1995). Only in places where the sands have been waterlogged, such as palaeo-pans or palaeo-springs, is there any chance of fossilisation. For example, roots can be encased in calcium-rich or silica-rich sands and crusts, known as rhizoliths or rhizocretions, can form around the roots, invertebrates or bones around the margin of a pond, pan or spring (Klappa, 1980; Cramer and Hawkins, 2009; Peters et al., 2022).

From the SAHRIS map above parts of the northern area are indicated as very highly sensitive (red) for the outcrops of the Campbell Rand Subgroup in the north while most of the area is moderately fossiliferous for the Gordonia sands (green). The volcanic rocks are indicated a grey or white (zero to unknown sensitivity).

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.
	L	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local

Criteria for ranking the SPATIAL SCALE of impacts	**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	Volcanic rocks do not preserve fossils; so far there are no records from the Campbell Rand Subgroup of stromatolites or from the Gordonia Fm of palaeo-pans or palaeo-dunes or of plant or animal fossils in this region so it is very unlikely that fossils occur on the site. The impact would be negligible
	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 trace fossils such as stromatolites in the dolomites of the Campbell Rand Subgroup, 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 soils and sands that cover the area or in the dolomites that are not the target or prospecting. Nonetheless, a Fossil Chance Find Protocol should be added to the eventual EMPr.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are either much too old and the wrong types to contain fossils or are not the target for prospecting. Furthermore, the material to be prospected is the volcanic rock and this does not preserve fossils. Since there is an extremely small chance that trace fossils from the Campbell Rand 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 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 dolomites, sandstones, shales and sands are typical for the country and only some contain trace fossil plants such as stromatolites. The sands of the Quaternary period would not preserve fossils but they might obscure fossils traps such as palaeo-pans or palaeo-dunes although none is visible in the satellite imagery.

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 Gordonia Formation sands of the Quaternary. There is a very small chance that trace fossils such as stromatolites may occur in the dolomites of the Campbell Rand Subgroup so a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found by the environmental officer, or other responsible person once prospecting or mining has commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample. The impact on the palaeontological heritage would be low, so as far as the palaeontology is concerned, the prospecting permit should be authorised as long as the dolomites are avoided. If prospecting is to take place in the dolomitic areas in the north, a site visit (phase 2) palaeontology impact assessment is advisable.

7. References

Almond, J.E., Pether, J. 2009. Palaeontological Heritage of the Northern Cape; Palaeotechnical Report for SAHRA. 115pp.

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.

Beukes, N.J., 1987. Facies relations, depositional environments and diagenesis in a major early Proterozoic stromatolitic carbonate platform to basinal sequence, Campbellrand Subgroup, Transvaal Supergroup, southern Africa. Sedimentary Geology 54, 1-46.

Beukes, N.J., 1980. Stratigrafie en lithofacies van die Campbellrand-Subgroep van die Proterofitiese Ghaap-Groep, Noordkaapland. Transactions of the Geological Society of South Africa 83, 141-170.

Button, A., 1976. Iron formation as an end member in carbonate sedimentary cycles in the Transvaal Supergroup, South Africa. Economic Geology 71, 193-201.

Cramer, M.D., Hawkins, H.-J., 2009. A physiological mechanism for the formation of root casts. Palaeogeography, Palaeoclimatology, Palaeoecology 274, 125-133.

Cowan, R., 1995. History of Life. 2nd Edition. Blackwell Scientific Publications, Boston. 462pp.

Eriksson, P.G., Altermann, W., Hartzer, F.J., 2006. The Transvaal Supergroup and its pre-cursors. 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 237-260.

Havig, J.R., Hamilton, T.L., Bachan, A., Kump, L.R., 2017. Sulfur and carbon isotopic evidence for metabolic pathway evolution and a four-stepped Earth system progression across the Archean and Paleoproterozoic. Earth-Science Reviews 174, 1–21.

Klappa, C.F., 1980. Rhizoliths in terrestrial carbonates: classification, recognition, genesis and significance. Sedimentology 27, 613-629.

Peters, C.R., Bamford, M.K., Shields, J.P., 2022. Ch 33. Lower Bed II Olduvai Basin, Tanzania: Wetland Sedge Taphonomy, Seasonal Pasture, and Implications for Hominin Scavenging. In Reynolds, SC., Bobe, R., (Eds). African Paleoecology and Human Evolution, Cambridge University Press & Assessment. 413-434.

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.

Schier, K., Bau, M., Münker, C., Beukes, N., Viehmann, S., 2018. Trace element and Nd isotope composition of shallow seawater prior to the Great Oxidation Event: Evidence from stromatolitic bioherms in the Paleoproterozoic Rooinekke and Nelani Formations, South Africa. Precambrian Research 315, 92-102.

Sumner, D.Y., Beukes, N.J., 2006. Sequence stratigraphic development of the Neoarchean Transvaal carbonate platform, Kaapvaal Craton, South Africa. South African Journal of Geology 109, 11–22.

Walraven, F., Martini, J., 1995. Zircon-Pb evaporation age determinations of the Oaktree Formation, Chuniespoort Group, Transvaal Sequence: implications for Transvaal-Griqualand West basin correlations. South African journal of Geology 98, 58-67.

Zeh, A., Wilson, A.H., Gerdes, A., 2020. Zircon U-Pb-Hf isotope systematics of Transvaal Supergroup – Constraints for the geodynamic evolution of the Kaapvaal Craton and its hinterland between 2.65 and 2.06 Ga. Precambrian Research 345, 105760. https://doi.org/10.1016/j.precamres.2020.105760

8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations / drilling / mining activities begin.

1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations/mining commence.
2. When excavations begin the rocks and discard 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 trace fossils such as stromatolites in the dolomites or the Quaternary bones, rhizoliths, traces (for example see Figures 4-6). 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. Trace fossils, fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

9. Appendix A – Examples of fossils from the Transvaal Supergroup

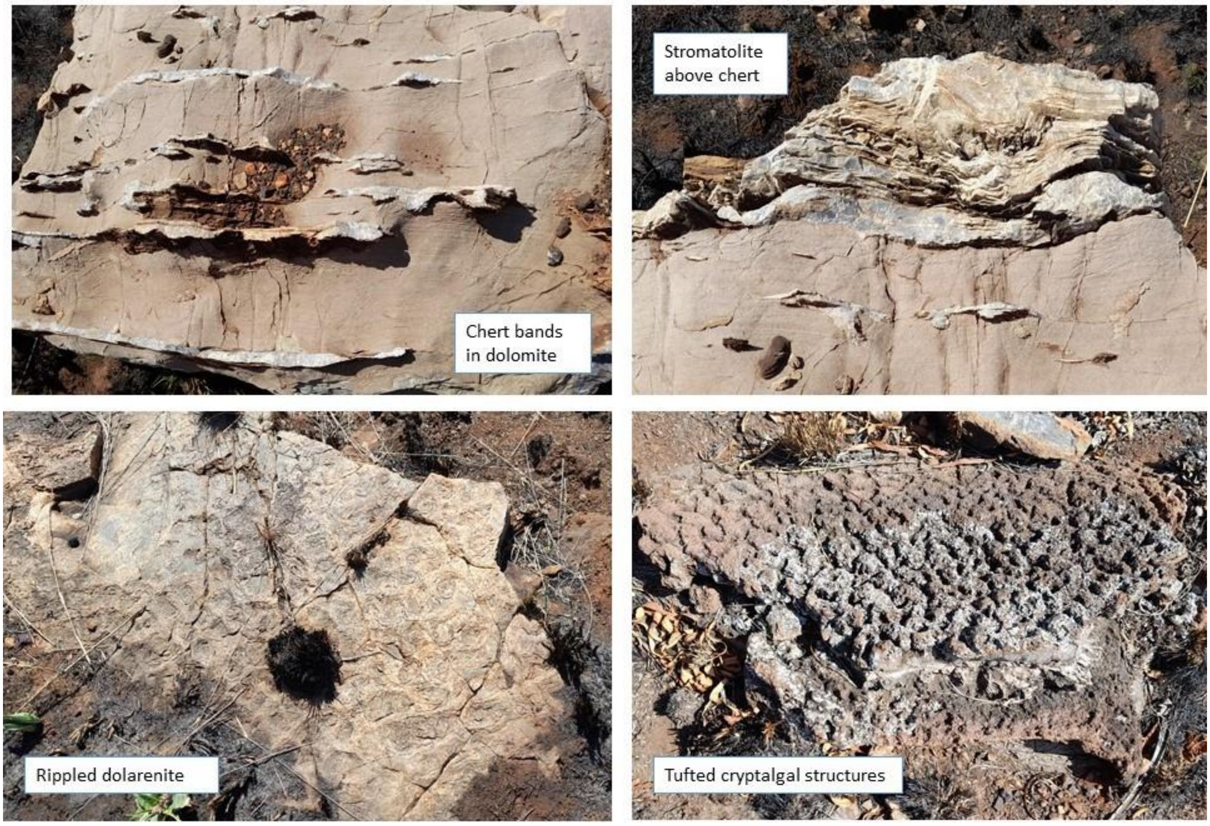

Figure 4: Photographs of various types of stromatolites in dolomite from the Malmani Subgroup. (Equivalent of the Campbell Rand Subgroup).

Figure 5: Photographs of fragmentary but robust fossils recovered from Quaternary alluvium.

Figure 6: Photographs of rhizoliths or rhizocretions from stabilised dunes associated with a palaeo-pan.

10. Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
January 2023

Present employment	:	Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DSI Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa
Telephone	:	+27 11 717 6690
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

v) **Supervision of Higher Degrees**

All at Wits University

Degree	Graduated/completed	Current
Honours	13	0
Masters	13	3
PhD	13	7
Postdoctoral fellows	14	4

vi) **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 12 - 20 students per year.

vii) **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 –
Associate Editor: Cretaceous Research: 2018-2020
Associate Editor: Royal Society Open: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international journals

viii) **Palaeontological Impact Assessments**
25 years' experience in PIA site and desktop projects

- Selected from recent projects only – list not complete:
- 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
- Glosam Mine 2022 for AHSA
- Wolf-Skilpad-Grassridge OHPL 2022 for Zutari
- Iziduli and Msenge WEFs 2022 for CTS Heritage
- Hendrina North and South WEFs & SEFs 2022 for Cabanga
- Dealesville-Springhaas SEFs 2022 for GIBB Environmental
- Vhuvhili and Mukondelei SEFs 2022 for CSIR
- Chemwes & Stilfontein SEFs 2022 for CTS Heritage
- Equestria Exts housing 2022 for Beyond Heritage
- Zeerust Salene boreholes 2022 for Prescali
- Tsakane Sewer upgrade 2022 for Tsimba
- Transnet MPP inland and coastal 2022 for ENVASS
- Ruighoek PRA 2022 for SLR Consulting (Africa)
- Namli MRA Steinkopf 2022 for Beyond Heritage

ix) **Research Output**
Publications by M K Bamford up to January 2022 peer-reviewed journals or scholarly books: over 170 articles published; 5 submitted/in press; 14 book chapters.
Scopus h-index = 31; Google Scholar h-index = 39; -i10-index = 114 based on 6691 citations.
Conferences: numerous presentations at local and international conferences.