Palaeontological Impact Study for proposed urban development at Mayfield X52 Putfontein, Gauteng

PALAEONTOLOGY IMPACT ASSESSMENT

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Table of Contents:

List of Figures:

1. Executive Summary

This area is demarcated as having a Very High Palaeontological Sensitivity due to the probability of finding stromatolites this region. Even though no distinct outcrops of stromatolites were found during the field assessment, there is a chance of exposing stromatolites during development and for this reason a Chance Find Procedure has been included in the Recommendations (p. 17-18).

Even though it is not essential to salvage every piece of stromatolite exposed because of its ubiquitous distribution in the dolomites of South Africa, it will be prudent not to destroy a major stromatolite find for scientific and heritage reasons. Although the chances of finding an exceptional site that surpasses those already known to science are small, it remains important to alert the palaeontological community and SAHRA if a major fossil find is made in order to mitigate the impact on the fossil site.

2. Introduction

The palaeontological heritage of South Africa is unsurpassed and can only be described in superlatives. The South African palaeontological record gives us insight in inter alia the origin of dinosaurs, mammals and humans. Fossils are also used to identify rock strata and determine the geological context of the subregion with other continents and played a crucial role in the discovery of Gondwanaland and the formulation of the theory of plate tectonics. Fossils are also used to study evolutionary relationships, sedimentary processes and palaeoenvironments.

Some of the oldest evidence of life on Earth came from the rocks at Barberton which contain fossilized bacteria. Stromatolites in the dolomitic regions in South Africa were formed by shallow marine mats of cyanobacteria. The cyanobacteria, which were some of the first photosynthesising organisms, provided most of the oxygen in our atmosphere.

South Africa has the longest record of palaeontological endeavour in Africa. South Africa was even one of the first countries in the world in which museums displayed fossils and palaeontologists studied earth history. South African palaeontological institutions and their vast fossil collections are world-renowned and befittingly the South African Heritage Act is one of the most sophisticated and best considered in the world.

Fossils and palaeontological sites are protected by law in South Africa. Construction and mining in fossiliferous areas may be mitigated in exceptional cases but there is a protocol to be followed.

This is a Palaeontological Impact Assessment which was prepared in line with Regulation 28 of the National Environmental Management Act (No. 107 of 1998) Regulations on Environmental Impact Assessment. This involved an overview of the literature on the palaeontology and associated geology of the area.

3. Terms of reference for the report

According to the South African Heritage Resources Act (Act 25 of 1999) (Republic of South Africa, 1999), certain clauses are relevant to palaeontological aspects for a terrain suitability assessment.

- **Subsection 35(4)** No person may, without a permit issued by the responsible heritage resources authority-
- (a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
- (b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
- (c) trade in, sell for private gain, export or attempt to export from the republic any category of archaeological or palaeontological material or object, or any meteorite; or
- (d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist with the detection or recovery of metals or archaeological material or objects, or use such equipment for the recovery of meteorites.
- **Subsection 35(5)** When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedures in terms of section 38 has been followed, it may-
- (a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
- (b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
- (c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph (a) to apply for a permit as required in subsection (4); and
- (d) recover the costs of such investigation form the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

South Africa’s unique and non-renewable palaeontological heritage is protected in terms of the NHRA. According to this act, heritage resources may not be excavated, damaged, destroyed or otherwise impacted by any development without prior assessment and without a permit from the relevant heritage resources authority.

As areas are developed and landscapes are modified, heritage resources, including palaeontological resources, are threatened. As such, both the environmental and heritage legislation require that development activities must be preceded by an assessment of the impact undertaken by qualified professionals. Palaeontological Impact Assessments (PIAs) are specialist reports that form part of the wider heritage component of:

- Heritage Impact Assessments (HIAs) called for in terms of Section 38 of the National Heritage Resources Act, Act No. 25, 1999 by a heritage resources authority.
- Environmental Impact Assessment process as required in terms of other legislation listed in s. 38(8) of NHRA;
- Environmental Management Plans (EMPs) required by the Department of Mineral Resources.

HIAs are intended to ensure that all heritage resources are protected, and where it is not possible to preserve them in situ, appropriate mitigation measures are applied. An HIA is a comprehensive study that comprises a palaeontological, archaeological, built environment, living heritage, etc specialist studies. Palaeontologists must acknowledge this and ensure that they collaborate with other heritage practitioners. Where palaeontologists are engaged for the entire HIA, they must refer heritage components for which they do not have expertise on to appropriate specialists. Where they are engaged specifically for the palaeontology, they must draw the attention of environmental consultants and developers to the need for assessment of other aspects of heritage. In this sense, Palaeontological Impact Assessments that are part of Heritage Impact Assessments are similar to specialist reports that form part of the EIA reports.
The standards and procedures discussed here are therefore meant to guide the conduct of PIAs and specialists undertaking such studies must adhere to them.
The process of assessment for the palaeontological (PIA) specialist components of heritage impact assessments, involves:

Scoping stage in line with regulation 28 of the National Environmental Management Act (No. 107 of 1998) Regulations on Environmental Impact Assessment. This involves an **initial assessment** where the specialist evaluates the scope of the project (based, for example, on NID/BIDs) and advises on the form and extent of the assessment process. At this stage the palaeontologist may also decide to compile a **Letter of Recommendation for Exemption from further Palaeontological Studies**. This letter will state that there is little or no likelihood that any significant fossil resources will be impacted by the development. This letter should present a reasoned case for exemption, supported by consultation of the relevant geological maps and key literature.

A **Palaeontological Desktop Study** – the palaeontologist will investigate available resources (geological maps, scientific literature, previous impact assessment reports, institutional fossil collections, satellite images or aerial photos , etc) to

inform an assessment of fossil heritage and/or exposure of potentially fossiliferous rocks within the study area. A Desktop studies will conclude whether a further field assessment is warranted or not. Where further studies are required, the desktop study would normally be an integral part of a field assessment of relevant palaeontological resources.

A **Phase 1 Palaeontological Impact Assessment** is generally warranted where rock units of high palaeontological sensitivity are concerned, levels of bedrock exposure within the study area are adequate; large-scale projects with high potential heritage impact are planned; and where the distribution and nature of fossil remains in the proposed project area is unknown. In the recommendations of Phase 1, the specialist will inform whether further monitoring and mitigation are necessary. The Phase 1 should identify the rock units and significant fossil heritage resources present, or by inference likely to be present, within the study area, assess the palaeontological significance of these rock units, fossil sites or other fossil heritage, comment on the impact of the development on palaeontological heritage resources and make recommendations for their mitigation or conservation, or for any further specialist studies that are required in order to adequately assess the nature, distribution and conservation value of palaeontological resources within the study area.

A **Phase 2 Palaeontological Mitigation** involves planning the protection of significant fossil sites, rock units or other palaeontological resources and/or the recording and sampling of fossil heritage that might be lost during development, together with pertinent geological data. The mitigation may take place before and / or during the construction phase of development. The specialist will require a Phase 2 mitigation permit from the relevant Heritage Resources Authority before Phase 2 may be implemented.

A **'Phase 3' Palaeontological Site Conservation and Management Plan** may be required in cases where the site is so important that development will not be allowed, or where development is to co-exist with the resource. Developers may be required to enhance the value of the sites retained on their properties with appropriate interpretive material or displays as a way of promoting access of such resources to the public.

The assessment reports will be assessed by the relevant heritage resources authority, and depending on which piece of legislation triggered the study, a response will be given in the form of a Review Comment or Record of Decision (ROD). In the case of PIAs that are part of EIAs or EMPs, the heritage resources authority will issue a comment or a record of decision that may be forwarded to the consultant or developer, relevant government department or heritage practitioner and where feasible to all three.

4. Details of study area and the type of assessment:

Figure 1: Google Earth photo indicating the study site (red polygon)

The site was visited and the relevant literature and geological maps for the region in which the development is proposed to take place, have been studied for a Palaeontological Impact Assessment. This region is already allocated for urban development and informal houses have been erected at the study site (Figs. 1 & 3).

5. Geological setting of the study area

Figure 2: Geological Map of the study area and surroundings (adapted from the 2628 East Rand 1:250 000 Geology Map, Geological Survey, 1986). The black polygon indicates the study site

GEOLOGICAL LEGEND OF THE STUDY AREA

	Lithology	Stratigraphy		Age
	Alluvium			Quarternary
Pv	Sandstone, shale, coal beds	Vryheid Formation of the Ecca Group	Karoo Supergroup	Perm
C-Pd	Diamictite, shale	Dwyka Group		Carboniferous
Vmd	Dolomite, chert	Malmani Subgroup of the Chuniesoort Group	Transvaal Supergroup	Vaalian

The northern part of the study site is underlain by Malmani Subgroup dolomite and chert (Fig. 2). This subgroup is subdivided into five formations based on the chert content, stromatolite structure, intercalated shales, erosion surfaces and colour of the dolomite (Eriksson *et al*., 2009). The Malmani Subgroup which follows on the Black Reef Formation is in places up to 2000 m thick and forms a substantial part of the geology of Gauteng.

The Oaktree Formation which forms the oldest unit of the Malmani Subgroup consists of 10-200 m of carbonaceous shales, stromatolitic dolomites and quartzites. The following Monte Christo Formation is a 300-500 m thick sedimentary unit which consists of erosive breccia and stromatolitic and oolitic platformal dolomites. The Lyttelton Formation which follows the Monte Christo Formation consists of a 100-200 m thick sequence of shales, quartzites and stromatolitic dolomites. This formation is covered by the up to 600m chert-rich Eccles Formation which also contains a series of erosion breccias which seperates it from the upper up to 400 m thick unit of the Malmani Subgroup – the Frisco Formation - which is characterised by its stromatolitic dolomites which becomes shale-rich towards the top of this unit (Eriksson *et al*., 2009).

The southern part of the study site is underlain by diamictite and shale of the Mbizane Formation of the Dwyka Group of the Karoo Supergroup (Fig. 2). The Vryheid Formation consists of glacial, fluvio-glacial sediments were deposited in shallow marine to fluvio-deltaic environments. The sedimentary rocks of the Ecca Group overlie the shale and diamictite of the Dwyka Group of the Karoo Supergroup. The Mbizane Formation comprises of thinly bedded mudstones and claystones, stratified conglomerates, pebbly sandstones, and diamictites. The clasts in the diamictites of the Mbizane Formation consist of material that eroded from the much older basement rocks and includes numerous different rock types such as quarzites, banded ironstone, dolomite, gneiss, granite, and amygdaloidal lavas. The Mbizane Formation represents valley-fill deposits, proglacial outwash fans, and subglacial till deposits left by continental glaciers retreating towards the south of the early Karoo Basin (Johnson *et al*., 2009).

6. Site visit

Figure 3: Informal houses at Putfontein

Figure 4: Facing southwest from 26°06'38.54"S 28°24'46.78"E

Figure 5: Facing northwest from 26°06'36.63"S 28°24'49.36"E

7. Palaeontological potential of Study Site

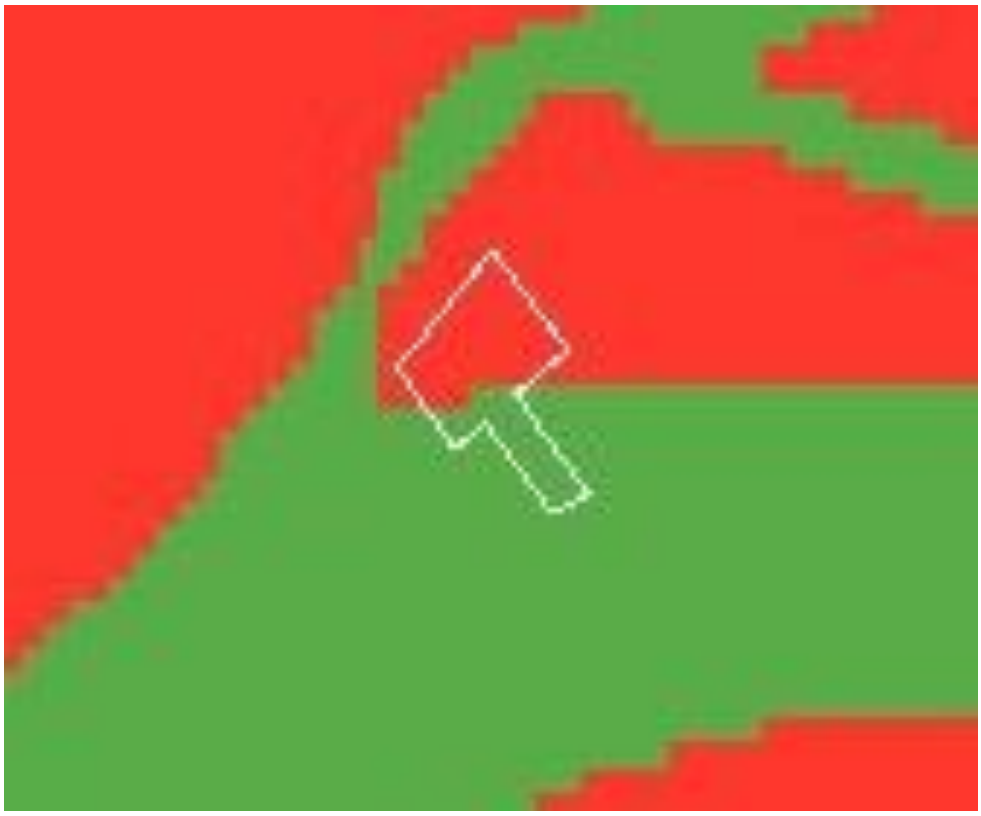

Figure 6: Palaeosensitivity of the study site (white polygon) (SAHRA, 2020)

Colour	Palaeontological Significance	Action
RED	VERY HIGH	Field assessment and protocol for finds are required.
GREEN	MODERATE	Desktop study is required.

The northern part of the study site is situated in an area that is considered to be of Very High Palaeontological Sensitivity, while the southern part of the study site is considered to have a Moderate Palaeontological Sensitivity (Fig. 6).

The underlying geology of the study site is mostly covered with soil (Figs 3 - 5). No significant geological formations or associated stromatolites were found during the site visit.

Although no fossils are known from the glacial and fluvioglacial diamictites, conglomerates, sandstones and shales that constitute the Dwyka Group in Gauteng, there is a possibility that these sedimentary rocks may contain interglacial or post-glacial trace fossil assemblages, fossil plants and shelly invertebrates (Groenewald & Groenewald, 2014).

The dolomite and chert of the Malmani Formation in Gauteng may contain stromatolites and micro-fossils (Groenewald & Groenewald, 2014).

From an evolutionary, environmental, ecological and geological perspective stromatolites are very important. Stromatolites were formed approximately 2.2 Ga ago when mats of cyanobacteria covered the sea floor up to a certain depth which allowed them to photosynthesize. The slimy surface caused fine-grained mud and precipitates to adhere to them after which cyanobacterial strands consisting of chains of bacterial cells would continue to extend by means through the sediment in order to get enough light to photosynthesize. Very thin layers of sediments were set down during this process. In time these sedimentary layers were petrified and turned into columns of rock. Some of these columns which are stacked closely together are as thin as pencils, while others are formed mushroom-like scallops (see Figs. 7 - 9) and others formed bigger domes and even megadomes which are meters across.

Figure 7: Stromatolites at Sterkfontein Caves

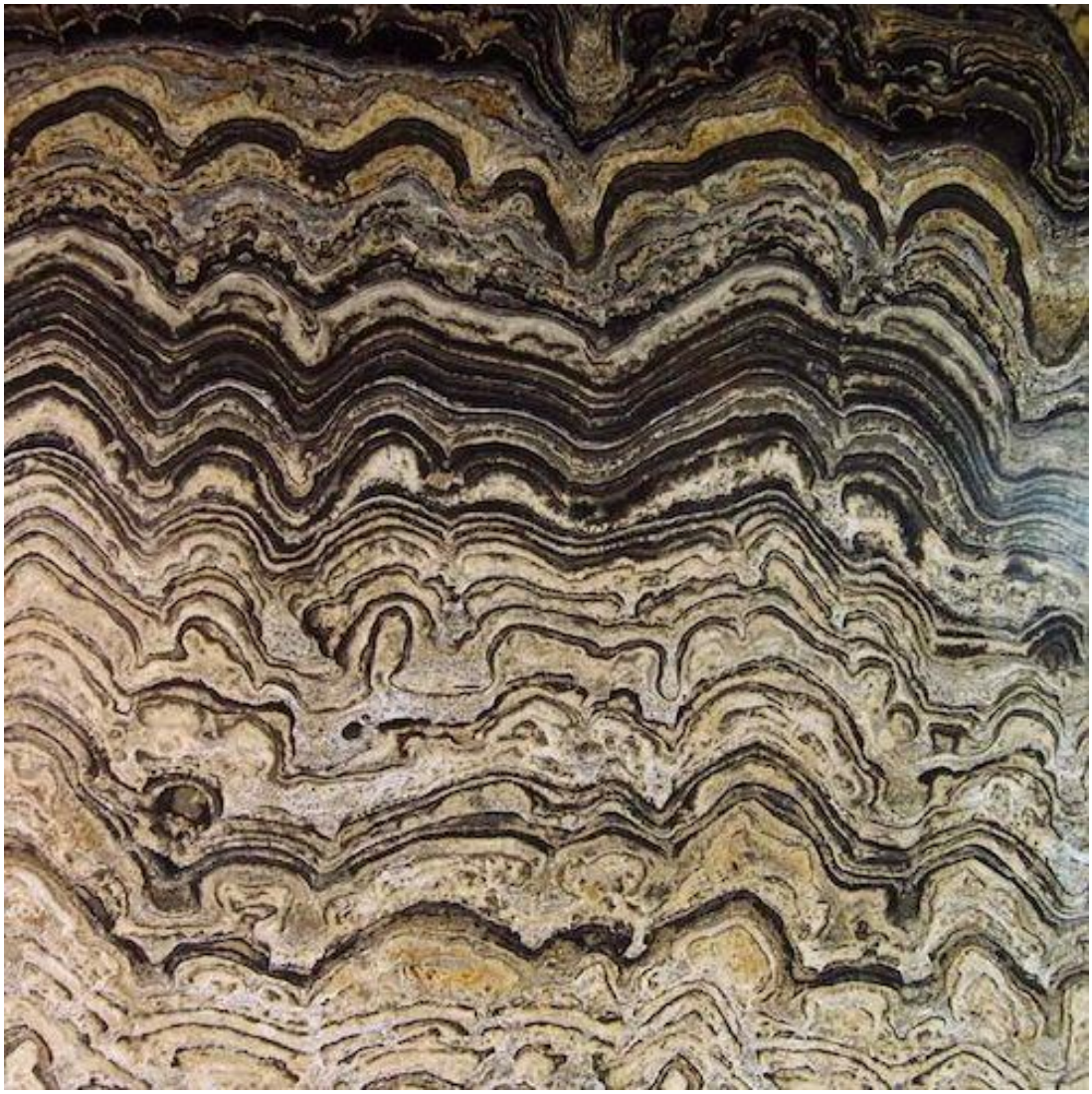

Figure 8: Polished vertical section through stromatolites (from: https://www.google.co.za/imgres?imgurl=http%3A%2F%2Fwww.therockgallery.co.uk%2Fekmps%2Fshops%2Ftherockgallery%2Fimages%2Fstromatolite-large-polished-slice-100-million-years-old-andes-mountains-bolivia-%5B4%5D-1997-p.jpg&imgrefurl=http%3A%2F%2Fwww.therockgallery.co.uk%2Fstromatolite-large-polished-slice----100-million-years-old-----andes-mountains-bolivia-1997p. asp&docid=2vFkg_vqTH0I5M&tbnid=FQcixxQGdtBUFM%3A&vet=10ahUKEwinl8rfwqjcAhUGsKQKHf8wBy0QMwgsKAYwBg..i&w=500&h=500&bih=918&biw=1280&q=stromatolites&ved=0ahUKEwinl8rfwqjcAhUGsKQKHf8wBy0QMwgsKAYwBg&iact=mrc&uact=8)

These bacteria were amongst the first photosynthesizing organisms and it is thought that the chloroplast found in plants has evolved from a cyanobacterial ancestor. Cyanobacteria released oxygen as a by-product of photosynthesis in such quantities that it irrevocably changed the atmosphere from a reducing to an oxidizing atmosphere which had a devastating effect to most bacteria which were and still are anoxic. On the other hand, higher organisms such as fungi, plants and animals would not have been able to exist without the oxygen in the atmosphere and would therefore not have evolved if it were not for cyanobacteria.

Figure 9: Domal structures of stromatolites seen from above
(from: https://www.google.co.za/imgres?imgurl=http%3A%2F%2Fwww.kidsdiscover.com%2Fwp-content%2Fuploads%2F2015%2F04%2FBacteria_2.jpg&imgrefurl=http%3A%2F%2Fwww.kidsdiscover.com%2Fspotlight%2Fbacteria%2F%3Fmc_cid%3D97b6810d71%26mc_eid%3Df31cca173c&docid=jpZALMrhmI6d1M&tbnid=6zCWRFeJArwpQM%3A&vet=10ahUKEwioiMq6z6jcAhWisqQKHTkzCSoQMwhCKAMwAw..i&w=1000&h=683&bih=344&biw=553&q=Bacteria_2%20stromatolites&ved=0ahUKEwioiMq6z6jcAhWisqQKHTkzCSoQMwhCKAMwAw&iact=mrc&uact=8)

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Geological Survey (1986) 2628 East Rand 1: 250 000 geology map.

Groenewald, G. & Groenewald, D. (2014) Palaeontological Heritage of Gauteng, SAHRA Palaeotechnical Report.

Johnson, M.R.; Van Vuuren, C.J; Visser, J.N.J.; Cole, D.I.; Wickens, H.de V.; Christie, A.D.M.; Roberts, D.L. & Brandl, G. (2009). Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R.; Anhaeusser, C.R. & Thomas, R.J. (eds.) *The geology of South Africa*. Johannesburg: GSSA. Pp. 461-499.

8. Conclusion and Recommendations

Although stromatolites are considered to be fossils, there are hundreds of square kilometres of stromatolites in South Africa and it is not considered to be so scarce that every stromatolite has to be preserved. In the event of the discovery of an exceptional stromatolite formation it is advised that it should on principle not be destroyed if an alternative position for the building of a structure can be found.

If rocks are exposed during development, it is possible that stromatolitic structures could be exposed. The Chance Find Procedure should be followed if an exceptional stromatolitic structure is exposed during development.

PROCEDURE FOR CHANCE PALAEONTOLOGICAL FINDS

Extracted and adapted from the National Heritage Resources Act, 1999 Regulations Reg No. 6820, GN: 548.

The following procedure must be considered in the event that previously unknown fossils or fossil sites are exposed or found during construction of the road:

1. Surface excavations should continuously be monitored by the ECO and any fossil material be unearthed the excavation must be halted.

2. If fossiliferous material has been disturbed during the excavation process it should be put aside to prevent it from being destroyed.

3. The ECO then has to take a GPS reading of the site and take digital pictures of the fossil material and the site from which it came.

4. The ECO then should contact a palaeontologist and supply the palaeontologist with the information (locality and pictures) so that the palaeontologist can assess the importance of the find and make recommendations.

5. If the palaeontologist is convinced that this is a major find an inspection of the site must be scheduled as soon as possible in order to minimise delays to the development.

From the photographs and/or the site visit the palaeontologist will make one of the following recommendations:

a. The material is of no value so development can proceed, or:

b. Fossil material is of some interest and a representative sample should be collected and put aside for further study and to be incorporated into a recognised fossil repository after a permit was obtained from SAHRA for the removal of the fossils, after which the development may proceed, or:

c. The fossils are scientifically important and the palaeontologist must obtain a SAHRA permit to excavate the fossils and take them to a recognised fossil repository, after which the development may proceed.

7. If any fossils are found then a schedule of monitoring will be set up between the developer and palaeontologist in case of further discoveries.

9. Declaration of Independence

I. Jacobus Francois Durand declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

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