PROPOSED ROAD UPGRADE PROJECT NEAR MAGOGO, KWAZULU/NATAL

DESKTOP STUDY
PALAEONTOLOGY

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Table of Contents:

List of Figures:

1. 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 *i.a.* the origin of life, mammals, dinosaurs and humans. Fossils are also used to identify rock strata and determine the geological context of the sub region with other continents and to study evolutionary relationships, sedimentary processes and palaeoenvironments.

The Ecca Group in the northern part of the Karoo Supergroup has yielded fossils of *Glossopteris*, cordaitales, horsetails, ferns and clubmosses. In the southern part fossils of *Mesosaurus* reptiles and marine invertebrates were discovered. The distribution of Glossopteris fossils was the first evidence of the existence of the supercontinent Gondwana. *Glossopteris* fossils were found in Karoo-age rocks in Africa, South America, Antarctica, Australia and India.

The Heritage Act of South Africa stipulates that fossils and fossil sites may not be altered or destroyed. The purpose of this document is to detail the probability of finding fossils in the study area which may be impacted by the proposed development. The impact of the development can be ameliorated in several ways in the areas where fossils are common.

2. 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.

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

The relevant literature and geological maps for the region in which the development is proposed to take place, have been studied for this Desktop Study.

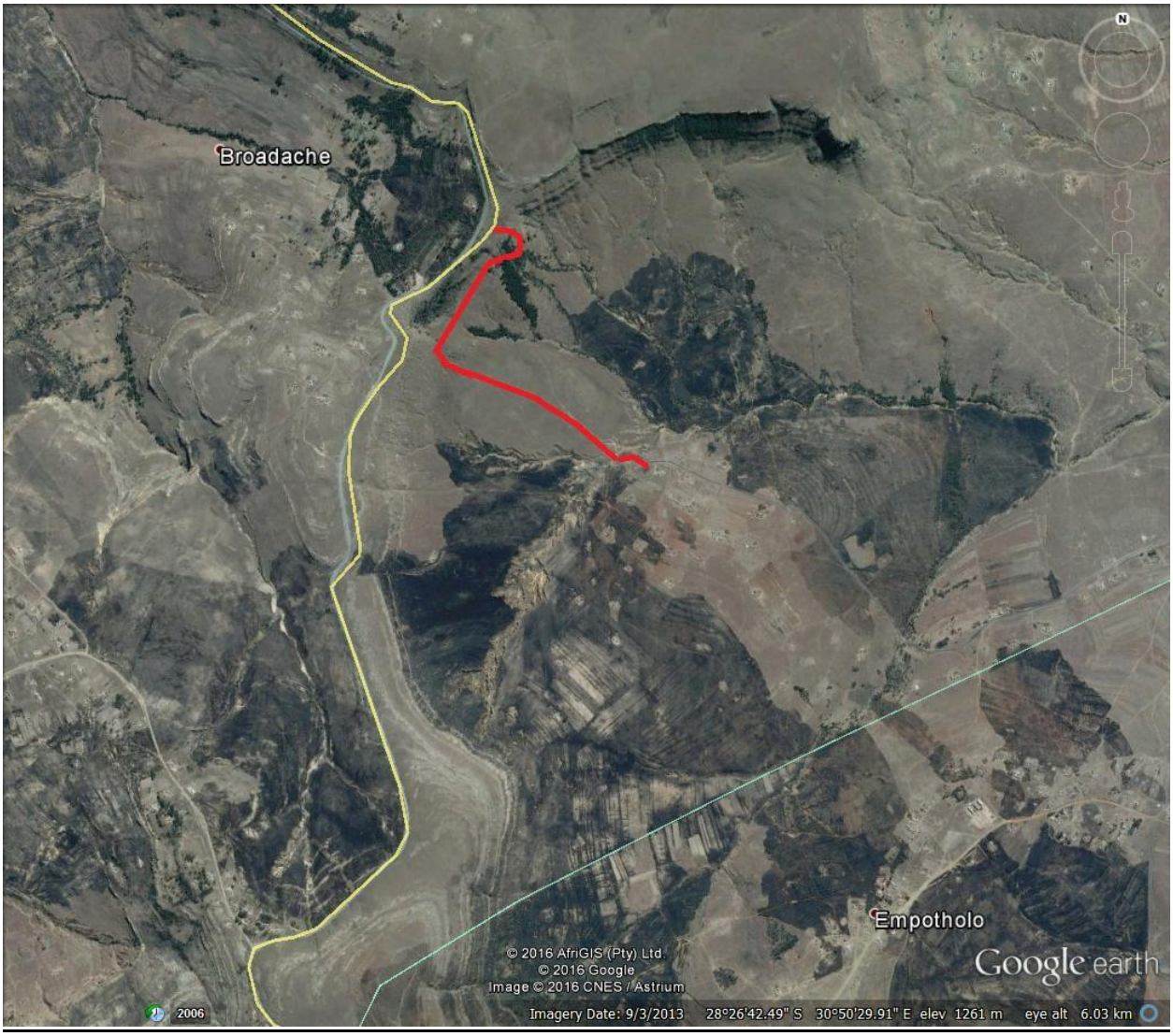

Figure 1: Google Earth photo depicting the study site (red line) and surroundings

The study site consists of a dirt road approximately 66km east southeast of Dundee in KwaZulu-Natal near the village of aMagogo. The study site is located in a mountainous area dotted by small settlements. Vegetation is sparse and the bedrock is exposed due to erosion.

4. Geological setting

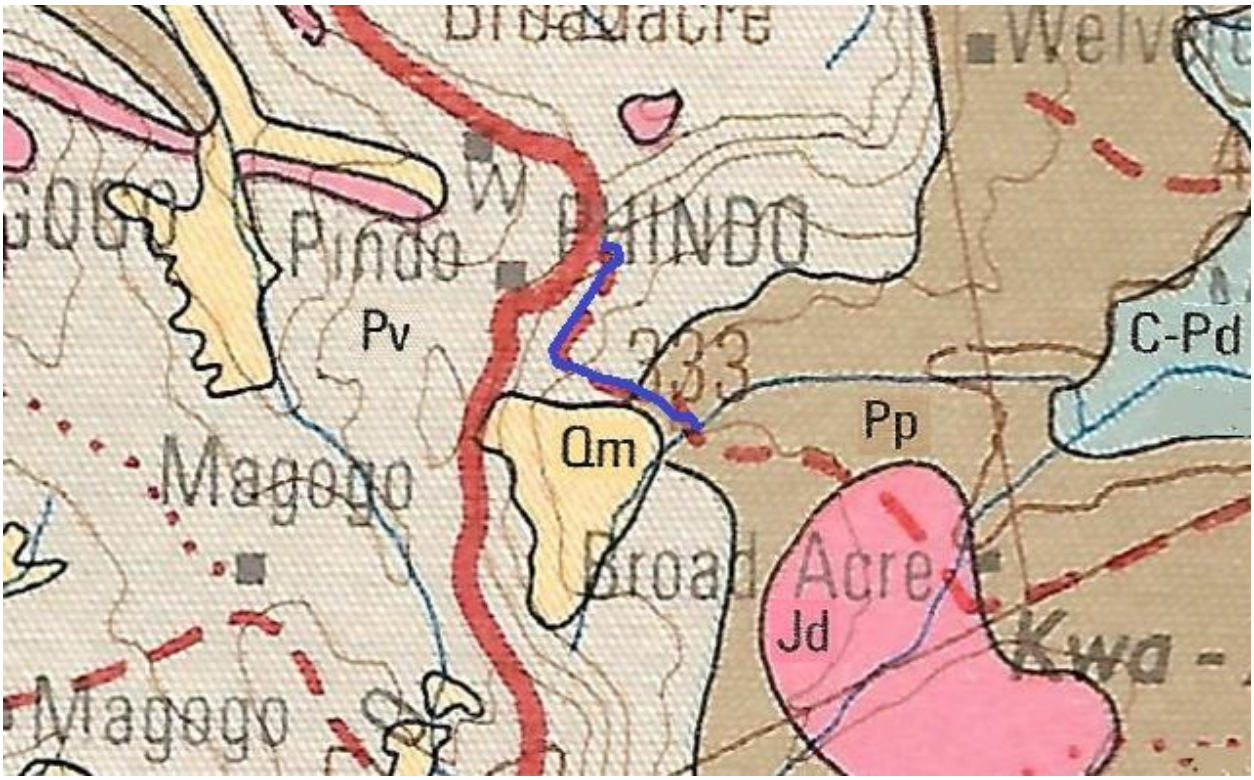

Figure 2: Geology of the study site (indicated with the blue line) and surroundings adapted from the Dundee 2830 1: 250 000 Geology Map (Geological Survey, 1988)

LEGEND:

Proposed road upgrade

	Geological unit	Lithology	Age
Qm	Masotcheni Formation	Unconsolidated colluvial deposits	Late Pleistocene and Holocene
Jd	Dolerite	Dolerite intrusions	Jurassic
Pv	Vryheid Formation of the Ecca Group of the Karoo Supergroup	Sandstone, shale and grit with coal and oil-shale beds	Permian
Pp	Pietermaritzburg Formation of the Ecca Group of the Karoo Supergroup	Shale, siltstone	Permian
C-Pd	Dwyka Group of the Karoo Supergroup	Diamictite, sandstone, shale	Carboniferous

The study area is dominated by sedimentary rocks of the Ecca Group of the Karoo Supergroup which were set down unconformably on the Dwyka sediments. The Dwyka sedimentary rocks consist of coarse unstratified diamictite with subordinate laminated

sandstone and shale. These sediments were set down in the large newly formed Karoo Basin during the Carboniferous as the ice sheet covering southern Gondwanaland melted.

Two subunits of the Ecca Group – the Vryheid Formation and the Pietermaritzburg Formation occur in the study area. The Pietermaritzburg Formation, which overlies the Dwyka sediments, consists of blue-black silty shales which are micaceous towards the top. These sediments were set down in a large inland sea that filled the Karoo Basin as layers of thick clay and silt during the early Permian (Johnson, *et al*., 2006).

The Vryheid Formation of the Ecca Group, which overlies the Pietermaritzburg Formation, consists mostly of shale (metamorphosed mudstone), shaly sandstone, sandstone, grit, gravel and conglomerate. The Vryheid Formation was formed when glacial and fluvio-glacial sediments were deposited in shallow marine to fluvio-deltaic environments approximately 280 Ma ago. In places coal seams are associated with these fluvial valley deposits. The coal seams formed in peat swamps which originated on alluvial plains or more rarely in back swamps (Johnson, *et al*., 2006).

5. Palaeontology of the Ecca Group

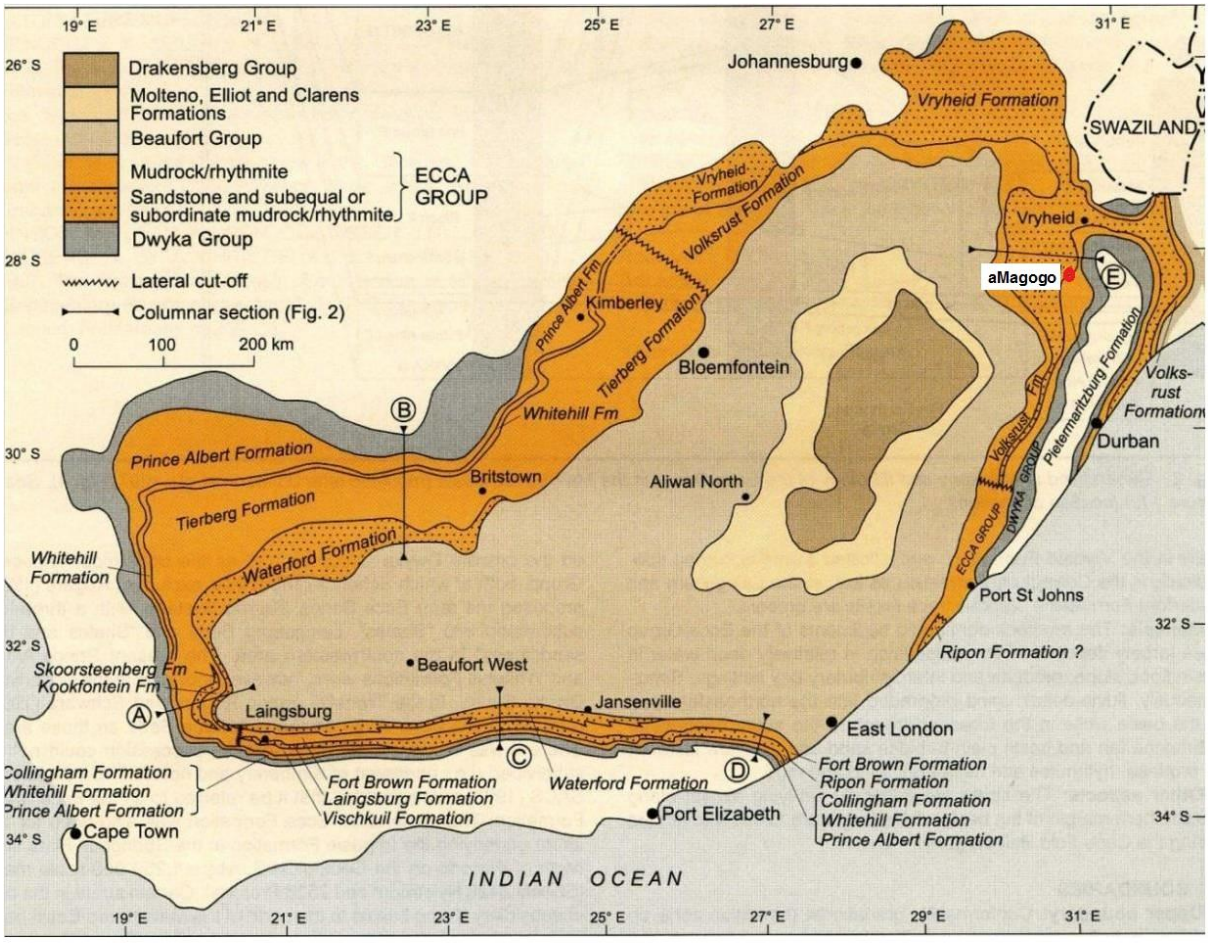

Figure 3: Map showing the location of aMagogo in the Main Karoo Basin (Johnson *et al*., 2009)

The study area falls within the Ecca Group of the Karoo Supergroup (see Fig. 3). The Ecca Group is characterized by shale, mudstone, sandstone and seams of coal and is renowned for its fossil content (Johnson *et al*., 2006). The fossils of the region are mostly that of plant leaf imprints mainly of *Glossopteris* (see Fig. 4) but could also include cordaitales, horsetails, ferns, clubmosses and silicified and coalified wood.

The Ecca Group contain vast amounts of Permian leaf imprints of plants such as *Glossopteris* in places (Kovács-Endrödy, 1991). Fossiliferous material yielding mostly *Glossopteris* leaf imprints have been exposed at well studied sites in the northern rim of the main Karoo Basin such as Hammanskraal (Kovács-Endrödy, 1976), Witbank (Bamford, 2004) and Vereeniging (Rayner, 1986), the ferromanganese mine at Ryedale (Pack *et al*., 2000) and Moorfield near Newcastle (Claassen, 2008).

Fossilised leaf imprints are however not found ubiquitously throughout the Ecca Group, but in pockets such as in the Witbank and the Newcastle areas where the physical and chemical conditions during deposition resulted in the preservation of not only the structure of the leaves but also in some cases the organic material itself. The structure of the fossilised leaves is better preserved in the shale than in the sandstone units. The leaf structures are mostly lost in the coal layers.

The Ecca Group is represented by the Vryheid Formation and the Pietermaritzburg Formation in the study area. The Pietermaritzburg Formation is unfossiliferous and therefore of no palaeontological concern. The Vryheid Formation is fossiliferous and has yielded millions of tons of fossiliferous rock in the north-eastern part of the Karoo Basin.

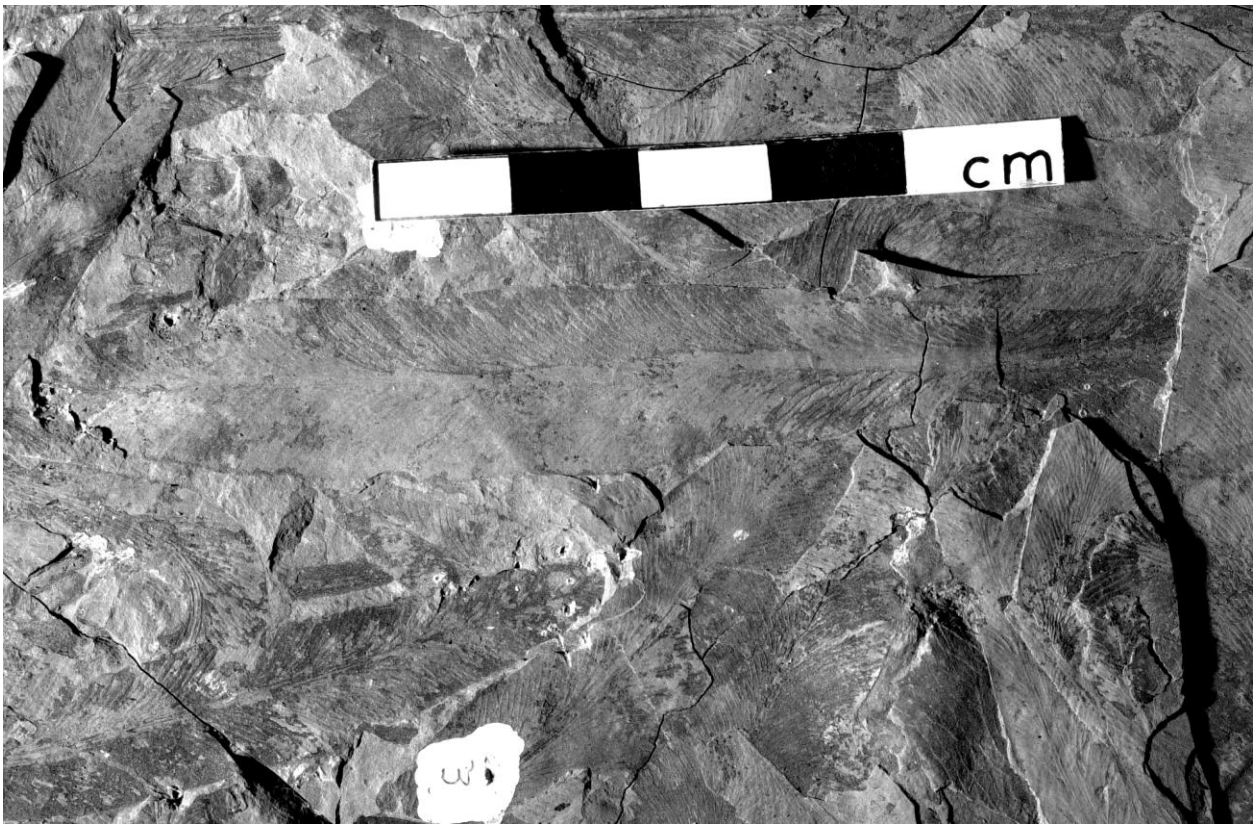

Figure 4: *Glossopteris* leaf imprints typical of that found in the north eastern part of the Karoo Basin (from: Claassen, 2008)

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6. Conclusion and Recommendations:

The Vryheid Formation and Pietermaritzburg Formation of the Ecca Group dominate the geology of the study area. The Pietermaritzburg Formation is non-fossiliferous and of no palaeontological concern while the Vryheid Formation is fossiliferous in places.

It is highly likely that fossils will be found during the construction process. The Ecca Group of the Main Karoo Basin contains millions of tons of fossils of leaf imprints. Extensive collections of fossil material from the Vryheid Formation are housed at the Council for Geoscience in Pretoria and at the Bernard Price Institute for Palaeontology at the University of the Witwatersrand in Johannesburg.

Despite the abundance of Ecca fossils in collections new fossil localities should still be recorded. If fossils are found during construction the ECO must take photographs of the site and determine the locality by means of GPS and document the date, locality, photograph number and short description of the site in a log book. This information should be sent to the palaeontology section of the Museum of Natural History in Pietermaritzburg.

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