Palaeontological specialist assessment: combined field-based and desktop study

PROPOSED MELKHOUT - PATENSIE 132 kV TRANSMISSION LINE PROJECT, HUMANSDORP & HANKEY MAGISTERIAL DISTRICTS, EASTERN CAPE.

John E. Almond PhD (Cantab.)

***Natura Viva* cc, PO Box 12410 Mill Street,**

Cape Town 8010, RSA

naturaviva@universe.co.za

May 2013

EXECUTIVE SUMMARY

Eskom are proposing to construct approximately 28 km of overhead 132 kV powerline from the existing Melkhout Substation near Humansdorp to a proposed new substation near Patensie, Eastern Cape. The project also entails decommissioning of redundant infrastructure, the construction of a new substation at Patensie, as well as the construction of new, or maintenance of existing, minor roads and the possible construction of minor bridge/s across a water course.

The proposed development footprint between Humansdorp and Patensie is underlain by Palaeozoic bedrocks of the Table Mountain Group and Bokkeveld Group (Cape Supergroup) as well as by Mesozoic continental sediments of the Uitenhage Group. Three of the Palaeozoic successions involved – the Late Ordovician Cederberg Formation as well as the Early Devonian Baviaanskloof Formation and Ceres Subgroup – are known elsewhere within the Cape Fold Belt for their important records of marine and terrestrial fossils. However in the Humansdorp region the Cape Supergroup bedrocks have generally suffered high levels of tectonic deformation and chemical weathering, seriously compromising their fossil heritage. Within the Uitenhage Group the thick alluvial fan to braided fluvial conglomerates of the Enon Formation are at most very sparsely fossilferous. The overlying Early Cretaceous fluvial to estuarine sediments of the Kirkwood Formation contain rare lignite lenses and carbonaceous clays that have yielded important plant fossil and palynomorph assemblages in the south-eastern Gamtoos Basin (*e,g.* Loerie area). However, the Kirkwood beds will only be intersected at the northern end of the proposed 132 kV transmission line development, north of the Gamtoos River (*e.g.* footprint of the proposed new Patensie Substation), where these rocks are on the whole highly weathered. Significant palaeontological impacts here are considered unlikely.

No fossil remains were observed during a one-day palaeontological field assessment of the Humansdorp – Patensie study area, neither within the Palaeozoic to Mesozoic bedrocks nor in the overlying Late Caenozoic superficial sediments (colluvium, alluvium, pedocretes, soil *etc*).

On the basis of the current field assessment as well as the paucity of previous fossil records from the Humansdorp - Patensie region it is concluded that the palaeontological sensitivity of the Palaeozoic and Mesozoic bedrocks here is low due to high levels of tectonic deformation (*e.g.* folding, cleavage)

and / or chemical weathering. This applies especially to the more mudrock-rich stratigraphic units (*e.g.* Cederberg Formation, Ceres Subgroup, Kirkwood Formation) that may originally have been highly fossiliferous. The various Late Caenozoic superficial deposits mantling the bedrocks in the study region (*e.g.* alluvium, colluvium, soils, pedocretes) are also of low palaeontological sensitivity.

Given the resulting low to very low impact significance of the proposed transmission line – including the associated new substation, road and bridge developments - as far as palaeontological heritage is concerned, no further specialist studies or mitigation are considered necessary for this project.

It is recommended that:

- The Environmental Control Officer (ECO) responsible for the transmission line development should be at least aware of the possibility – albeit low - of important fossils (*e.g.* shells, plant remains, trace fossils, mammalian bones and teeth) being present or unearthed on site and should regularly monitor all substantial excavations into superficial sediments as well as fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains. Particular note should be taken of the possibility of thin, plant-rich horizons (lignites) within the Kirkwood Formation bedrocks beneath the proposed new Patensie Substation;

- In the case of any significant fossil finds (*e.g.* vertebrate teeth, bones, lignites or plant-rich beds) made during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (ECPHRA. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer's expense; and

- These recommendations should be incorporated into the Environmental Management Plan (EMP) for the 132 kV transmission line project.

The palaeontologist concerned with mitigation work will need a valid palaeontological collection permit from SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za). All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies developed by SAHRA (2013).

1. INTRODUCTION

Eskom are proposing the following infrastructure developments as part (Project 2) of their planned network strengthening and upgrade in the Patensie, Humansdorp and Kareedouw areas, Humansdorp and Hankey Magisterial Districts, Eastern Cape (Arcus GIBB (Pty) Ltd Background Information Document, April 2012):

- Construction of approximately 28 km of overhead 132 kV powerline from the Melkhout Substation near Humansdorp through to the Patensie Substation.

- Construction of a new 2x20MVA 132/22 kV substation near Patensie.

- Decommissioning of redundant infrastructure once new infrastructure has been commissioned.

- Construction of new or maintenance of existing minor roads.
- Possible construction of minor bridge/s across a water course.

Arcus Gibb Engineering and Science have been commissioned to conduct an Environmental Impact Assessment of the proposed 132 kV transmission line developments between Kareedouw and Patensie, Eastern Cape. A Phase 1 Heritage Impact Assessment Report for the entire Kareedouw – Patensie 132 kV transmission line study area by eThembeni Cultural Heritage area (Van Schalkwyk & Wahl, May 2012) included the following remarks and recommendations regarding palaeontological heritage resources, largely based on desktop input by present author:

> The proposed electrical infrastructure between Kareedouw and Patensie is underlain by potentially fossiliferous bedrocks of Palaeozoic, Mesozoic and Caenozoic age, while the fossil potential of the Kareedouw – Dieprivier sector is likely low due to tectonism. Geological formations in the Dieprivier – Melkhout sector might contain well-preserved plant material. Early Cretaceous Kirkwood Formation beds near Patensie may contain important fossils of dinosaurs and other terrestrial vertebrates as well as petrified wood, while older alluvial sediments of the Gamtoos drainage system are also potentially fossil-bearing. The potential impact on palaeontological remains is low to medium.
>
> A heritage practitioner should complete a 'walk-through' of the final selected power line route and all other activity areas (access roads, construction camps, materials' storage areas, etc.) prior to the start of any construction activities and assess direct impacts on discrete resources such as traditional burial places, and archaeological and palaeontological sites.
>
> Since likely impacts on fossil heritage along the proposed new 132 kV transmission line are mainly associated with excavations for the pylon footings, as well as the construction of new substations, it is recommended that a Phase 1 palaeontological field assessment of the final transmission line route be undertaken once the pylon positions have been finalized and *before* construction commences. The resulting report should make recommendations regarding any necessary mitigation during the construction phase of the transmission line and associated infrastructure (*e.g.* recording, sampling of fossil assemblages, field monitoring of selected pylon positions).

The present palaeontological heritage assessment report dealing with Project 2 (Melkhout to Patensie) of the 132 kV development has accordingly been commissioned on behalf of Eskom and Arcus GIBB (Pty) Ltd by eThembeni Cultural Heritage (Contact details: Box 20057 Ashburton 3213, Pietermaritzburg, South Africa. Tel: 033 – 326 1136. Fax: 086 – 672 8557. E-mail: thembeni@iafrica.com).

It contributes to the Environmental Impact Assessment for the proposed transmission line development and it will also inform the Environmental Management Plan for the project.

1.1. Legislative context for palaeontological assessment studies

This report has been commissioned on behalf of Eskom and Arcus GIBB Engineering and Science by eThembeni Cultural Heritage (Contact details: Box 20057 Ashburton 3213, Pietermaritzburg, South Africa. Tel: 033 – 326 1136. Fax: 086 – 672 8557. E-mail: thembeni@iafrica.com). It contributes to the Environmental Impact Assessment for the proposed transmission line development, governed by the National Environmental Management Act (NEMA, Act 107 of 1998, amended in 2008), and it will also inform the Environmental Management Plan for the project. The present palaeontological heritage report also falls under Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999).

The proposed transmission line developments are located in areas that are underlain by potentially fossiliferous sedimentary rocks of Palaeozoic, Mesozoic and Late Tertiary or Quaternary age (Sections 2 and 3). The construction phase of the transmission line and associated infrastructure may entail substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. In addition, considerable areas of bedrock may be sealed-in or sterilized by lay-down areas as well as new gravel roads. All these developments may adversely affect fossil heritage resources at or beneath the surface of the ground within the development footprint by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good. Once constructed, the operational and decommissioning phases of the transmission line are unlikely to involve further adverse impacts on palaeontological heritage, however.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance;
- palaeontological sites;
- palaeontological objects and material, meteorites and rare geological specimens.

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(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 in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(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 procedure 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 from 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.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have recently been developed by SAHRA (2013).

1.2. Scope and brief for the desktop study

This palaeontological specialist report provides a combined desktop and field-based assessment of the observed or inferred palaeontological heritage along the proposed Melkhout – Patensie 132 kV transmission line corridor (Fig. 1), with recommendations for further specialist palaeontological studies and / or mitigation where this is considered necessary.

The deliverables and scope of work for this study, as defined by eThembeni Cultural Heritage, are as follows:

- One PIA report for the Transmission Line Project.
- Assessment of heritage resource significance in term of standards and criteria acknowledged and accepted by the South African Heritage Resources Agency (SAHRA). These criteria should be clearly stipulated in an appendix to each report.
- Assessment of the potential development impact on heritage resources in terms of the criteria included in Appendix B.
- *Précis* of the qualifications and experience of the person preparing the reports, demonstrating her/his ability to undertake the principal services.
- Statement of independence of the person preparing the reports, demonstrating her/his ability to undertake the principal services in an objective, unbiased manner.

1.3. Approach to the palaeontological heritage Assessment study

A preliminary desktop study on fossil heritage within the broader study area was undertaken prior to field work. This study involved a review of relevant palaeontological and geological literature, including geological maps as well as previous palaeontological heritage assessments carried out in the region (*e.g.* Almond 2009a, 2009b, 2010a, 2010b, 2010c, 2011a, 2011b, 2012). Potentially informative rock exposures within the study region were identified before fieldwork commenced using aerial photographs and / or satellite images.

The field-based palaeontological heritage assessment of the proposed power line route focused on the identification of those sections of the route that are underlain by potentially fossiliferous bedrocks and that may therefore require mitigation before or during the construction phase of the development. GPS data for all numbered localities mentioned in the text are given in the Appendix.

Palaeontological field assessment does not centre primarily on the examination of proposed pylon positions. Bedrock is often not well exposed at all these positions, while other components of the development footprint (including new access roads, construction camps, laydown areas) have not usually been finalised at the time of the field survey. Potential impacts of the power line development on fossil heritage must be *inferred* from a broader assessment of the palaeontological sensitivity of the rock units represented within and beneath the study area. This is primarily achieved through a careful field examination of representative exposures of all the rock units to determine the diversity, density and distribution of fossil remains within them. These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. For the present project road cuttings along the R330 Humansdorp to Patensie and R331 Hankey to Patensie tar roads as well as several borrow pits and quarries in the region proved the most informative sources of geological and palaeontological data. Unconsolidated or consolidated superficial deposits, such as alluvium, scree, calcrete or wind-blown sands, may occasionally contain fossils and were also included in the field assessment study where they are well-represented in the study area.

The present palaeontological field assessment report provides an illustrated, fully-referenced review of the (a) actual or known as well as (b) inferred palaeontological heritage within all rock units represented in the study area based on the initial desktop study as well as new data from fieldwork and any subsequent palaeontological analysis (*e.g.* lab identification of fossil material).

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation were then determined. The impacts are assessed in Section 4 of this report. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase.

1.4. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information;

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g*. of commercial mining companies) - that is not readily available for desktop studies;

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the case of the Melkhout – Patensie study area a major limitation for fossil heritage studies is the low level of exposure of potentially fossiliferous bedrocks, as well as the paucity of previous specialist palaeontological studies in this part of the Eastern Cape. However, representative exposures of almost all the relevant bedrock and superficial rock units were examined along or close to the proposed transmission line corridor and confidence levels for this assessment are correspondingly high.

1.5. Information sources

This combined desktop and field-based study was based on the following information sources:

1. A short Background Information Document produced by Arcus Gibb Engineering and Science (April, 2012);

2. A Phase 1 Heritage Impact Assessment Report by for the Patensie to Kareedouw transmission line projects by Len van Schalkwyk and Elizabeth Wahl (May 2012);

3. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations, as well as several desktop and field-based palaeontological assessment studies in the broader Humansdorp study region by the author (*e.g.* Almond 2009a, 2009b, 2010a, 2010b, 2010c, 2011a, 2011b, 2012).

3. A one-day field survey of potentially fossiliferous rock exposures along the preferred transmission line corridor by the author (13 April 2013).

4. The author's previous field experience with the formations concerned and their palaeontological heritage (See also review of Eastern Cape fossil heritage by Almond *et al.* 2008).

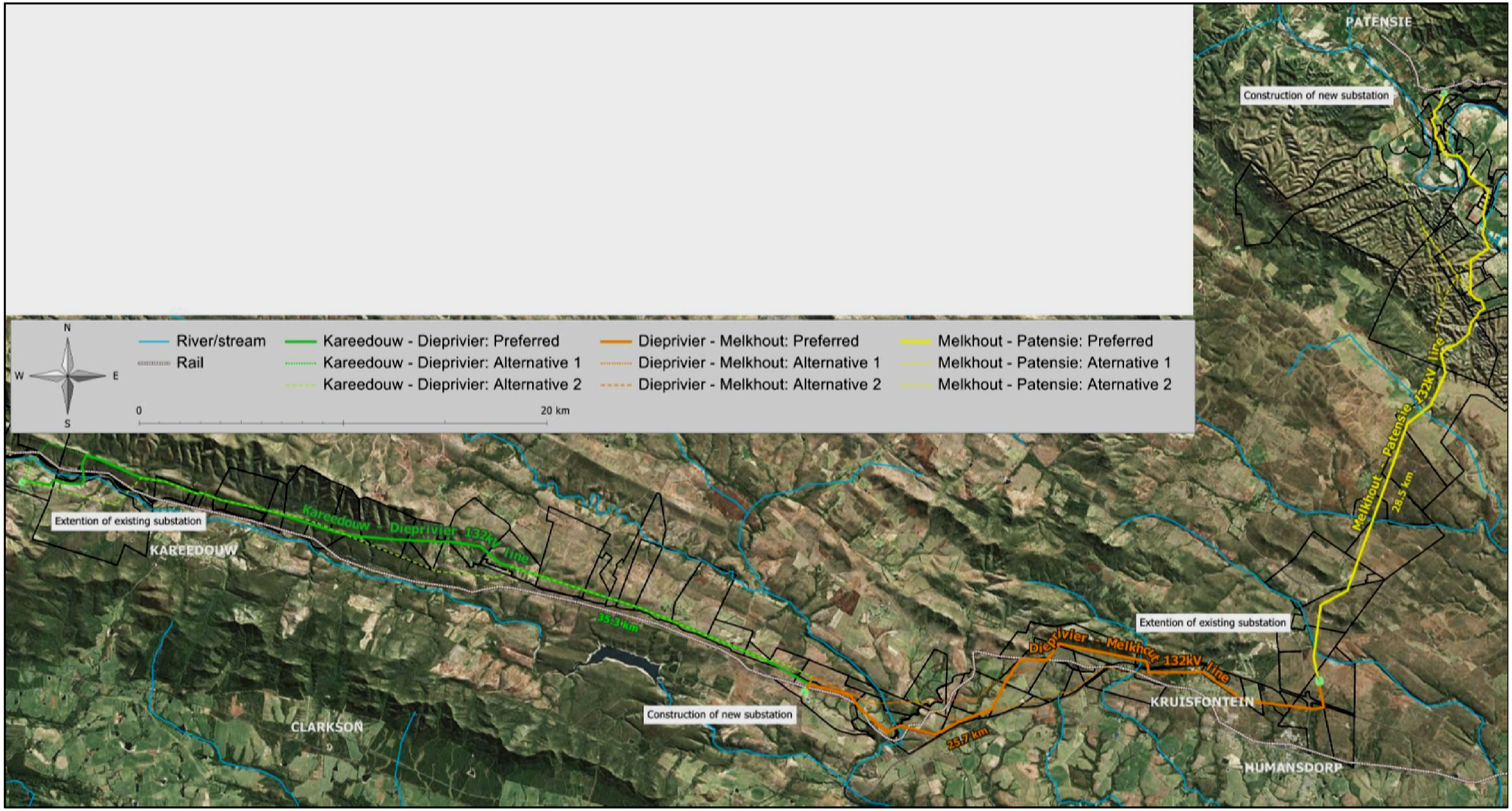

Fig. 1. Map showing proposed Eskom 132 kV transmission line developments between Kareedouw and Patensie in the Eastern Cape (from the Background Information Document, Arcus Gibb Engineering and Science, April 2012). This report assesses palaeontological heritage resources along the eastern sector (*c*. 28 km) between Melkhout Substation to the north of Humansdorp and the proposed new Patensie Substation to the north of the Gamtoos River (yellow line).

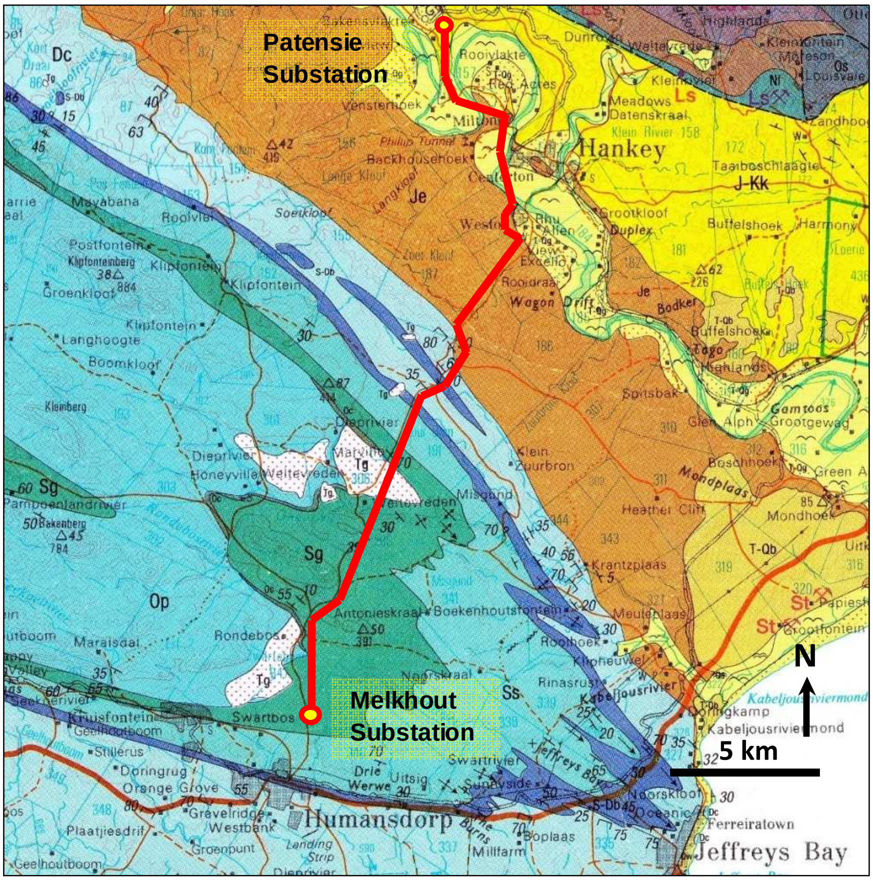

Fig. 2. Extract from 1: 250 000 geology sheet 3324 Port Elizabeth (Council for Geoscience, Pretoria) showing the *approximate* route of the proposed Melkhout - Patensie 132 kV transmission line to the north of Humansdorp (yellow line). Please note that the outcrop areas of the various formations shown are also approximate at this scale and can only be accurately determined through fieldwork and where superficial sediment cover is low. The N2 trunk road is not indicated on this map. The main geological units represented within the study include the following formations (Palaeontologically more sensitive sedimentary units indicated in red):

TABLE MOUNTAIN GROUP (Ordovician to Early Devonian)
Peninsula Formation (Op, middle blue)
Cederberg Formation (Oc, grey)
Goudini Formation (Sg, green)
Skurweberg Formation (Ss, pale blue)
Baviaanskloof Formation (S-Db, dark blue)

BOKKEVELD GROUP (Early Devonian)
Ceres Subgroup (Dc, v. pale blue)

UITENHAGE GROUP (Late Jurassic – Early Cretaceous)

Enon Formation (Je, orange)
Kirkwood Formation (J-Kk, yellow)

SUPERFICIAL DEPOSITS (Late Caenozoic)
Grahamstown Formation (Tg, white with red stipple) – ancient alluvial gravels, pedocretes (*e.g.* ferricrete)
Younger fluvial terrace gravels (T-Qg, pale yellow with red stipple)
Alluvium (pale yellow with flying bird symbol)

2. GEOLOGICAL OUTLINE OF THE STUDY AREA

The proposed Melkhout – Patensie 132 kV transmission line starts at the existing Melkhout Substation situated some 2 km north of Humansdorp on the east side of the R330 tar road to Patensie (Fig. 1). It heads NNE across the fairly flat-lying, wave-cut coastal platform incised into Table Mountain Group bedrocks at *c*. 220-240 m amsl, running subparallel to the R330 road. The transmission line route crosses incised tributaries of the Kabeljousrivier close to the homesteads of Weltevrede and Suurbron where the drainage exploits softer-weathering mudrocks of the Cederberg Formation and Ceres Subgroup respectively. Between these river crossings the deeply weathered coastal platform at *c*. 240 amsl is extensively mantled by ferruginised High Level Gravels. The line then descends from the platform down into the deeply incised valley of the Gamtoos River, a drop of some 100 m. Here it more or less follows the steep Hankey Pass and crosses finely-dissected hilly terrain underlain by thick conglomerates of the Enon Formation. At the bottom of the pass the transmission line heads away from the R330, skirting the village of Weston and heading broadly north across agricultural lands on the flat-lying alluvial plain of the Gamtoos River. At three points it crosses the Gamtoos River itself, here showing large-scale incised meander loops abutting spectacular cliffs of UItenhage Group sedimentary rocks. The line ends at the proposed new Patensie Substation, located on the northern side of the Gamtoos River, just south of the R331 and some 3.5 km southeast of Patensie.

The geology of the study area between Humansdorp and Patensie is shown on the 1: 250 000 geology sheet 3324 Port Elizabeth published by the Council for Geoscience, Pretoria (Toerien & Hill 1989) (Fig. 2). Additional relevant data is provided by the more recent 1: 50 000 geological sheet explanation for the Port Elizabeth – Uitenhage area to the east (Le Roux 2000) as well as the older sheet explanation by Haughton *et al.* (1937) covering the coastal belt near the Gamtoos Valley.

The southern half of the transmission line route is underlain by sandstone- and quartzite-dominated bedrocks of the Early Ordovician to Early Devonian **Table Mountain Group**. The bedrocks here have been largely planed off by coastal erosion in Tertiary times and locally mantled by surface gravels so that the topography is subdued and, with the exception of artificial excavations such as road cuttings, quarries and farm dams, levels of bedrock exposure are generally poor. The Table Mountain Group formations traversed include:

- predominantly fluvial sandstones and quartzites of the **Peninsula** (Op), **Goudini** (Sg) and **Skurweberg (**Ss**) Formations**, of Ordovician to Silurian age;
- post-glacial mudrocks of the **Cederberg Formation** (Oc) of late Ordovician age (Note that the glacial diamictites of the underlying **Pakhuis Formation** are not mapped separately in this area.);
- earliest Devonian wackes (= impure sandstones) and mudrocks of the **Baviaanskloof Formation** (S-Db), interpreted to be inshore coastal marine to paralic (near-shore) fluvial deposits;

From Suurbron into the upper part of the Hankey Pass the transmission line route traverses the highly cleaved mudrocks of the **Lower Bokkeveld Group** (**Ceres Subgroup**, Dc) of Early Devonian age, *plus* a narrow NW-SE elongated inlier of more resistant Baviaanskloof Formation.

The stratigraphic relationships of the Cape Supergroup sedimentary formations concerned are shown below in Fig. 3. The Cape Supergroup rocks in the study area lie within the south-eastern sector of the Cape Fold Belt of Permo-Triassic age (Newton *et al.* 2006). Levels of tectonic deformation here are high as a result of intense NNE-directed crustal compression, with steep bedding plane dips within tight folds along subparallel WNW-ESE trending axes (Some of these folds are overturned towards the north, as indicated by inverted bedding). As is clear on the geological map (Fig. 2), the Cape Supergroup formations in the study area between Humansdorp and Patensie build a broad, NW-SE trending, SE-plunging mega-anticline cored by Peninsula Formation quartzites (obscured by High

Level Gravels along the transmission line corridor) and terminating at Jeffrey's Bay. Minor folds around the margin of the mega-anticline are reflected in the pleated outcrop pattern of the Table Mountain Group formations. The mudrock-dominated successions of the Cederberg and Gydo Formations in this part of the Cape Fold Belt are usually highly cleaved, and locally faulted- or squeezed-out, but levels of metamorphism within the Cape Fold Belt are generally low.

Most of the Cape Supergroup rocks in the study area have a poor fossil record but the three marine units emphasized with an asterisk in Fig. 3 are potentially highly fossiliferous, as outlined in Section 3. All three potentially sensitive rock units crop out at various points along or near the proposed transmission line route (Fig. 2). Note that a separate Cederberg Formation is *not* mapped at all points along the contact between the Peninsula and Goudini Formations in the study area, probably due to mantling by superficial sediments; it is expected to occur in the subsurface here.

Due to protracted chemical weathering of bedrocks beneath the southern coastal plain and within the south-eastern margins of the Cape Fold Belt in Tertiary times, many of these Palaeozoic sedimentary rocks have been converted to poorly consolidated, easily eroded *saprolite* (*in situ* weathered bedrock). This is often pale or multi-hued due to the formation of kaolinitic clays and secondary ferruginous mineralisation respectively (Figs. 4 & 9, for example). Subdued relief and extensive chemical weathering ensures that bedrock exposures here often very limited, and mainly restricted to artificial excavations such as quarries, borrow pits, road and rail cuttings, dams and trenches. Under these circumstances, accurate geological mapping is impossible, and so the outcrop areas shown in Fig. 2 must be regarded as a provisional "best guess" pending further subsurface data.

In Hankey Pass the transmission line enters the Mesozoic Gamtoos Basin which forms part of the Oudtshoorn – Gamtoos Basin Line and is infilled by continental sedimentary rocks of the **Uitenhage Group**. The north-eastern edge of the basin is down-faulted against Late Precambrian basement rocks of the Gamtoos Group while the south-western edge is an unconformable sedimentary contact. Accounts of the Late Jurassic to Early Cretaceous sedimentary succession within the Gamtoos Basin are given by Haughton *et al.* (1937), Dingle *et al.* (1983), Toerien and Hill (1989) and Shone (2006). The Uitenhage succession youngs broadly towards the northeast and consists of a considerable thickness (> 1 km thick from borehole data) of fluvial conglomerates of the **Enon Formation** (Je) that underlie, and in part interfinger with, variegated alluvial siltstones and pebbly channel sandstones of the **Kirkwood Formation** (J-Kk). The Uitenhage sucession thickens and becomes finer-grained overall towards the southeast. The Enon beds build the greater part of the spectacular cliffs on the south-western side of the Gamtoos Valley (Fig. 10) while the Kirkwood succession builds the cliffs on the north-eastern side (Fig. 11). Enon sediments underlie a considerable length of the 132 kV transmission line in the lower parts of Hankey Pass but Kirkwood beds are unlikely to be directly impacted, apart from around the proposed site of the new Patensie Substation, because of thick alluvial cover along the Gamtoos River (Fig. 2).

A substantial portion of the Palaeozoic and Mesozoic bedrocks within the study area are mantled by a veneer of **Late Caenozoic superficial sediments**; most of these are not mapped at 1: 250 000 scale, however. They include various clay-rich and gravelly soils overlying the Cederberg and Gydo Formations, colluvial and down-wasted sandstone or quartzite gravels overlying the arenitic Table Mountain Group units, as well as silty, sandy to bouldery gravel **alluvium** along river and stream courses (*e.g.* Gamtoos River valley floor). Pebbly to cobbly quartzitic colluvial and alluvial gravels mantling the Enon Formation are often difficult to distinguish from *in situ* bedrock. Relict patches of ancient alluvial gravels (Late Caenozoic / Pleistocene "High Level Gravels") are mapped to the north of Humansdorp (*e.g.* northwest of Melkhout Substation and between Weltevrede and Suurbron) where they generally overlie ancient elevated land surfaces or pediment surfaces incised into the Table Mountain Group (Tg in map Fig. 2). Some of these older gravels, which are broadly subsumed into the **Grahamstown Formation** (Tg), have been secondarily cemented to form pedocretes, such as silica-rich **silcretes** and iron-rich **ferricretes** (*e.g.* Roberts 2003). Reworked and downwasted ferricrete gravels are well represented overlying the weathered Table Mountain and Bokkeveld Group outcrop areas, for example along the R330 near Rondebos.

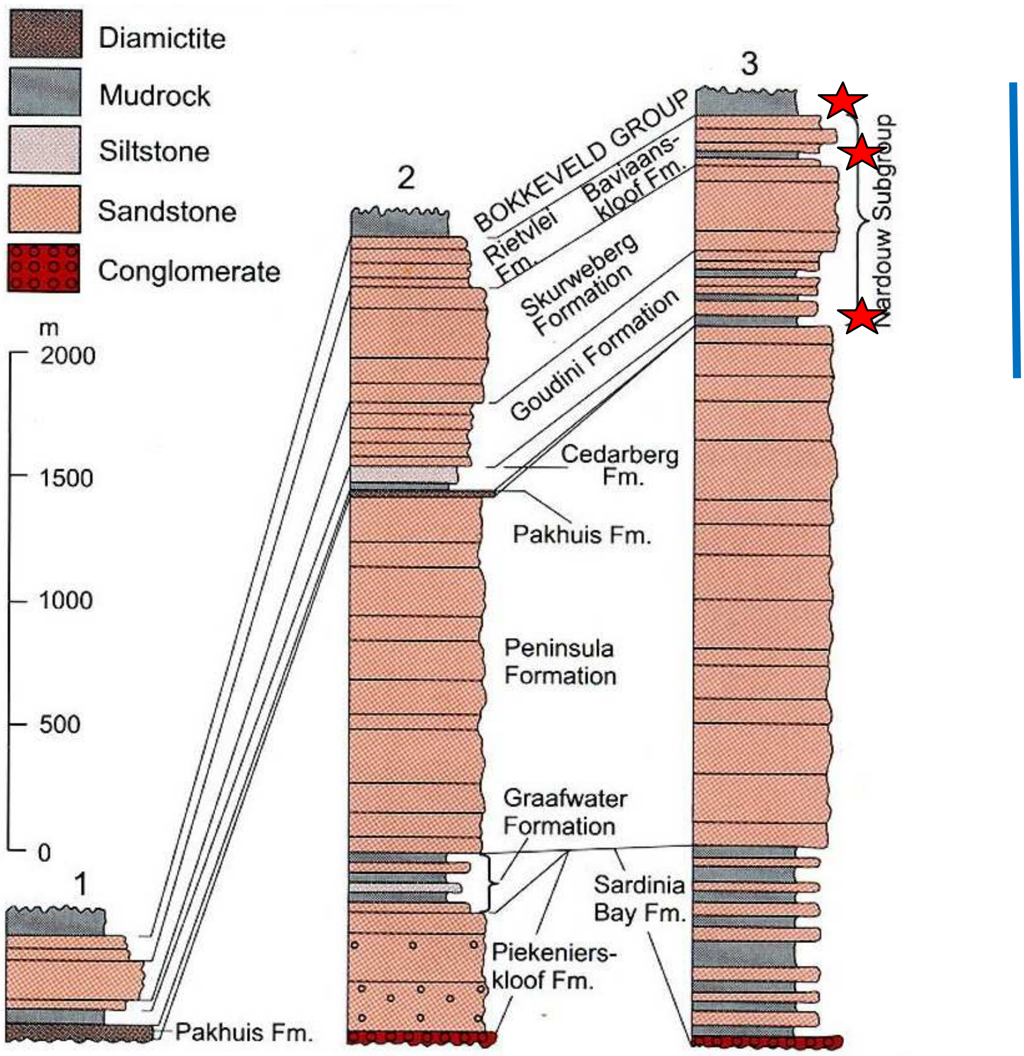

Fig. 3. Stratigraphy of the Table Mountain Group in the Western and Eastern Cape outcrop areas (From Thamm & Johnson 2006). Column 3 for the Eastern Cape is most relevant for the present study near Humansdorp. The vertical blue line indicated formations represented within the Humansdorp - Patensie study area. Table Mountain Group formations above the Cederberg Formation are grouped within the Nardouw Subgroup. Note the greater frequency of mudrock interbeds within the Goudini succession in the Eastern Cape, where the Cederberg Formation is often less well-defined. The fossiliferous mudrocks of the basal Bokkeveld Group belong to the Ceres Subgroup. The three marine rock units indicated with a red asterisk – *i.e.* Cederberg, Baviaanskloof and Ceres Subgroup - are potentially of high palaeontological sensitivity, but only where their fossil content is not compromised by chemical weathering and tectonism. The remaining units are predominantly non-marine and generally have a poor fossil record, dominated by low-diversity trace fossil assemblages.

In the following section of this report the main geological units represented within the broader Humansdorp – Patensie study region are briefly described, with short notes on representative exposures from the Melkhout - Patensie transmission line study area, paying special attention to those formations that may be of palaeontological heritage significance. GPS data for all numbered localities mentioned in the text is provided in the Appendix.

2.1. Table Mountain Group

Useful overviews of Table Mountain Group geology in general include Rust (1967, 1981), Hiller (1982), Malan & Theron (1989), Broquet (1992), Johnson *et a*l., (1999), De Beer (2002), Thamm & Johnson (2006), and Tankard *et al*., (2009). For the Port Elizabeth sheet area specifically, these rocks are briefly described by Toerien and Hill (1989) and Le Roux (2000) as well as in older sheet explanations such as those by Engelbrecht *et al*. (1962) and Haughton *et al*., (1937). Also useful are various reports by the South African Committee for Stratigraphy (SACS), such as those by Malan *et al*. (1989), Malan and Theron (1989) and Hill (1991). Due to poor exposure and high levels of bedrock weathering in the study region it is not always possible to differentiate the arenitic subunits of the Table Mountain Group in the field with full confidence.

The Mid to Late Ordovician **Peninsula Formation** is a very thick succession of resistant-weathering, well-washed, braided fluvial sandstones and quartzites with subordinate pebbly lenses and thin (< 1m) heterolithic (mudrock / sandstone) intervals with sparse trace fossils that are attributed to intermittent marine transgressive events (Toerien & Hill 1989, Le Roux 2000). Common sedimentary structures include unidirectional cross-bedding and over-turned cross-bedding. The thickness of the formation is unclear due to the frequent occurrence of tectonic reduplication but is unlikely to be more than 3000m.

The Peninsula Formation is not exposed at surface along the proposed 132 kV transmission line route. Peninsula bedrocks are overlain by thick, rubbly, semi-consolidated, ferruginised gravels to the north of Weltevrede and are likely to be highly weathered.

The **Cederberg Formation** of Latest Ordovician (Hirnantian) age is a thin, coarsening-upwards succession of mudrocks, siltstones and sandstones that was deposited within shallowing, frigid post-glacial seas following a short-lived, multiple Gondwana glacial event. The Cederberg rocks are generally recessive-weathering and poorly-exposed; pervasive cleavage formation may be expected in the Port Elizabeth sheet area. Dark, carbonaceous, finely-laminated shales with occasional dropstones typify the lower part of the succession. Glacial rocks (sandy, muddy and pebbly diamictites) of the **Pakhuis Formation** that occur directly below the Cederberg mudrocks in the Western Cape are not separately mapped in the study area. However, Toerien and Hill (1989) mention sporadically-developed glacial diamictites within the lower part of the "Cederberg Formation" (technically Winterhoek Subgroup) outcrop area in the Humansdorp District. They are exposed, for example, on the banks of the Kouga River. As shown in the stratigraphic column for the Table Mountain Group in the Eastern Cape (Fig. 3) the Cederberg / Goudini transition zone is characterised by heterolithic interbedding of arenitic and mudrock units or packages. Recognition of a discrete Cederberg Formation under these circumstances is difficult, and complicated by enhanced tectonism at this horizon in the eastern Cape Fold Belt.

As noted earlier, a discrete Cederberg Formation is *not* mapped at surface between the Peninsula and Goudini Formation outcrop areas along the proposed transmission line route, but is shown to the north of Melkhout Substation (Rondebosch area) and west of Weltevrede. Cederberg rocks underlie the transmission line route to the east and northeast of Weltevrede but are mantled here by ferruginised High Level Gravels (Tg). Several meters of highly weathered, kaolinitised, pale cream, lilac, buff and grey mudrocks of the Cederberg Formation, locally interbedded with thin-bedded sandstones, are seen in road cuttings along the R330 near Weltevrede (Loc. 054) (Fig. 4). Whitish, highly-weathered, interbedded tabular, ripple cross-laminated sandstones and massive to horizontally laminated cream-coloured claystones are exposed in a borrow pit along the R332 to the northwest of Zwartbosch Quarry (Loc. 085). This thin-bedded, heterolithic succession may belong to the upper Cederberg Formation (Disa Member) or perhaps the Goudini Formation. The Table Mountain Group rocks here are quartz veined and mantled with angular gravels, ferricrete nodules and brown soils.

The **Goudini Formation** (Sg) consists predominantly of quartzose sandstones, frequently cross-bedded, that characteristically display reddish to brownish tints due to higher levels of iron and / or manganese impurities compared with the purer underlying and overlying Peninsula and Skurweberg Formations. Sandstone beds are generally thinner, and heterolithic successions (*i.e.* interbedded sandstones and mudrocks) commoner, than in the overlying Skurweberg Formation. Consequently exposures of the Goudini rocks are more recessive weathering. The mudrocks, which are often reddish in colour, are rarely exposed. In the Western Cape at least, occasional trace fossil assemblages within the Goudini Formation suggest intermittent marine influence but the bulk of the succession is probably fluvial in origin.

The Goudini Formation underlies a major portion of the southern sector of the proposed 132 kV transmission line, from Melkhout Substation northwards to Weltevrede. Roadcuttings along the R330 to the northeast of Rondebos (Loc. 052) show thick-bedded, occasionally tabular cross-bedded Goudini quartzites dipping to the SE and unconformably overlain by thick colluvial gravels (Fig. 18). Further north, near Weltevrede, a long R330 road cutting exposes highly-jointed, medium- to thick-bedded, tabular to lenticular, buff to pinkish Goudini arenites, also locally cross-bedded (Loc. 053) (Fig. 6). Occasional thin (dm-scale) siltstone interbeds are cleaved, highly weathered and kaolinitised. The lower, more heterolithic portion of the Goudini succession here is pinkish-hued, showing honeycomb weathering (Fig. 5). It is clearly highly tectonised (brecciated zones, slickensides, dense jointing) and the basal contact with the Cederberg Formation here may well be faulted.

The **Skurweberg Formation** (Ss) is dominated by very pale, resistant-weathering sandstones and quartzites that typically show well-developed unidirectional (current) cross-bedding and sometimes thin quartz pebble lenticles (These last far less common in the Eastern than Western cape outcrops). Bedding is often thick (thicknesses of one or more meters are common) and although thin, lenticular, dark mudrock intervals also occur, these are rarely exposed at outcrop. Sedimentological features within this formation indicate deposition across an extensive sandy alluvial braidplain.

Good exposures of Skurweberg arenites were not observed during the present field study but are known from the Langkloof near Kareedouw to the west (Almond, pers. obs.). The Skurweberg bedrocks within the 132 kV transmission line corridor (*e.g.* Melkhout Substation area) have largely been planed-off by erosion, chemically weathered and mantled with downwasted, locally ferruginous surface gravels.

The **Baviaanskloof Formation** (S-Db) is typically less clean-washed than the older subunits of the Nardouw Subgroup, with a higher proportion of lithic grains and clay minerals giving darker hues and more recessive weathering patterns. Sandstones are often (but not invariably) greyish, impure wackes and may be massive or ripple cross-laminated. Dark grey to black carbonaceous and micaceous mudrock intervals are quite common but rarely well exposed (A *c.* 15m-thick band of micaceous shale within the upper Baviaanskloof Formation in the Gamtoos area is mentioned by Haughton *et al*., 1937, for example). The heterolithic “passage beds” of the Baviaanskloof Formation incorporate the sedimentary transition between the fluvial-dominated lower units of the Nardouw Subgroup and the marine shelf sediments of the Lower Bokkeveld Group (Fig. 3). Locally abundant shelly fossils such as articulate brachiopods, trace fossils as well as wave ripple lamination demonstrate the shallow marine origins of at least some of the upper sandstones, while the dark mudrocks with dense mats of vascular plant remains may be lagoonal in origin (See Section 3).

The R330 and transmission line corridor traverses a narrow inlier of Baviaanskloof Formation arenites to the east of Suurbron (Loc. 090). Here well-jointed, thin- to thick-bedded quartzites, locally trough cross-bedded, are interbedded with thin packages or beds of pale grey, recessive-weathering, friable, highly weathered sandstone and laminated, often ferruginised, laminated siltstone (Fig. 7).

Fig. 4. Deeply-weathered, kaolinitised mudrocks of the Cederberg Formation with thin sandstone interbeds towards the top, R330 road cutting near Weltevrede (Loc. 054) (Hammer = 27 cm).

Fig. 5. Tectonised, reddish-hued heterolithic beds of the lower Goudini Formation, R330 road cutting near Weltevrede (Loc. 087).

Fig. 6. Exposure of tabular-bedded sandstones of the Goudini Formation showing thin, darker siltstone interbeds towards the base, R330 road cutting near Weltevrede (Loc.053).

Fig. 7. Well-jointed wackes of the Baviaanskloof Formation with occasional interbeds of highly-weathered mudrock and sandstone, inlier along R330 road NE of Suurbron (Loc. 090).

2.2. Lower Bokkeveld Group

The lower **Bokkeveld Group** (= **Ceres Subgroup**) is a thick succession of fine- to medium-grained sedimentary rocks that were laid down in a range of shallow to moderately deep continental shelf environments during the Early to Middle Devonian Period (*c*. 140 to 390 Ma, *i.e*. Emsian to Eifelian; Ma = million years ago). Throughout this period of deposition the Cape Basin was situated at high palaeolatitudes (over 70º S) and was gradually approaching the southern palaeopole. In the eastern outcrop area of the Bokkeveld Group, near Port Elizabeth, it reaches a total thickness of *c*. 3.5km. Precise figures are difficult to obtain due to tectonic thickening and reduplication (folding, thrust faulting *etc*) as well as generally poor exposure. Key geological references for the Bokkeveld Group succession include Tankard and Barwis (1982), Theron and Loock (1988), Hiller and Theron (1988), as well as Theron and Johnson (1991), Broquet (1992), Thamm & Johnson (2006). Brief accounts of the Bokkeveld Group in the Port Elizabeth region have been given by Toerien and Hill (1989), and Le Roux (2000).

The rocks forming the Bokkeveld Group are predominantly fine-grained mudrocks – *claystones* formed from soft muds (mainly clay minerals) and *siltstones* formed from slightly larger, silt-sized particles including small quartz grains and micas. Extensive fresh outcrops are rare due to post-Gondwana weathering as well as drift (scree, soil *etc*) and vegetation cover. Sandstone-dominated successions with total thicknesses in the range of 50-100m also occur and are sometimes mapped as separate formations. The Ceres Subgroup has accordingly been subdivided into a series of six laterally persistent formations, alternately dominated by mudrocks and sandstones. However, with the exception of the basal **Gydo Formation** (Dg) with an estimated thickness of some 500m, these formations are generally grouped together as a single stratigraphic unit (Dc) on the published 1: 250 000 geology map of the Port Elizabeth region, due to poor exposure and locally intense folding towards the eastern end of the Cape Fold Belt (Toerien and Hill 1989). The clay-rich sediments of the lower Bokkeveld Group have often suffered extensive cleavage formation in the Humansdorp – Patensie area (Haughton *et al.* 1937) and deep Tertiary-age chemical weathering is also evident here.

The Bokkeveld sandstones are typically thin-bedded (dm scale to 50 cm or more), poorly-sorted by grain-size, and compositionally "impure"; *i.e.* they contain a small proportion of clay or mica minerals, tiny rock fragments (*lithic* grains), and feldspar in addition to the dominant mineral quartz. The technical term for quartz sandstones that contain over 15% of other (non-quartz) grain types is *wackes*, in contrast to purer quartz sandstones (> 85% quartz) such as those of the Table Mountain Group which are called *arenites*. The readily decomposed impurities give the Bokkeveld sandstones / wackes slightly darker, buff to brownish colours and a more friable or crumbly texture than pure sandstones or quartzites. Due to their higher clay and mica content the former are also more likely to develop a pronounced cleavage as a result of tectonic deformation than are purer sandstones, and are therefore more prone to weathering. Quartz cements are less well developed in the impure Bokkeveld sandstones than in the Table Mountain Group arenites.

Lower Bokkeveld Group (Ceres Subgroup) sediments within the study area are well exposed in several extensive road cuttings along the R330 in the upper part of the Hankey Pass (*e.g.* Locs. 091, 092a) (Fig. 8) as well as to the south of Suurbron (Loc. 089) (Fig. 9). The Lower Bokkeveld succession here is monotonous, being dominated by grey-green mudrocks with few sandstone interbeds, and is often deeply weathered so that the original bedding is often obscure. They display a pervasive, steeply-dipping to subvertical platy cleavage with a regional NW-SE strike (parallel to the anticlinal axis). A later crenulation cleavage is developed locally (e.g. Loc. 091). Sparse ferruginous blobs might represent deformed, secondarily mineralised fossil moulds. Sandstone interbeds are rare, also highly weathered, and bedding plane exposures are not usually available. The Bokkeveld bedrocks are typically mantled in brick red terra rossa-type soils, locally gravelly, beneath less ferruginous, brownish modern soils.

Fig. 8. Monotonous succession of cleaved, greyish-green mudrocks of the Lower Bokkeveld Group (Ceres Subgroup), R330 towards the top of Hankey Pass (Loc. 092).

Fig. 9. Deeply-weathered, cleaved mudrocks of the Ceres Subgroup capped by ferruginous gravelly soils, R330 road cutting to the south of Suurbron (Loc. 089).

2.3. Uitenhage Group

At the time that the Uitenhage sediments were being deposited, some 140 million years ago, Africa and South America – previously united within the West Gondwana supercontinent - were starting to pull apart. During the Late Jurassic / Early Cretaceous rifting, local uplift, block faulting and erosion of the youthful southern African continent led to the rapid deposition of huge amounts of silty, sandy and conglomeratic alluvium by systems of meandering rivers and estuaries fringing a new Mediterranean-sized seaway that was opening up in the southern Cape area. The frequently reddish-hued Enon conglomerates as well as well-preserved calcrete-rich palaeosols (fossil soils) within the Kirkwood alluvium suggest that prevailing climates were semi-arid, warm to hot, with a low seasonal rainfall of 100-500 mm / year. This pattern is supported by the abundance of leathery- and small-leaved plants in the fossil flora, while well-developed seasonal growth rings are preserved in at least some fossil woods.

The **Enon Formation** (Ke) is usually characterized by thick beds of moderately- to well-cemented, poorly to well-sorted, clast-supported, pebbly to bouldery conglomerates of greyish to reddish or purple-brown hue (See Shone 2006 for a good recent account of this rock unit). Clasts are predominantly of Table Mountain Group quartzites, subangular to very well-rounded, and may show surface impact crescents as well as pressure-solution hollows and post-depositional fracturing, these last two due to overburden pressure. Secondary (diagenetic) staining by ferruginous minerals (*e.g.* haematite, limonite) often imparts ochreous to reddish hues. The conglomerate matrix is usually coarse sand to fine gravel and may also be ferruginised. Bedding is often obscure and thick, but may be picked out by upward-coarsening cycles or occasional, thin (≤ 1m), recessive-weathering, grey to buff siltstone or sandstone interbeds. These last may contain dispersed pebbles or thin pebbly lenses and show current cross-bedding or ripple cross-lamination. Well-developed clast imbrication and occasional cross-bedding of conglomerates generated by downstream migration of gravel bars support a braided fluvial model for some parts of the succession. An alluvial fan (piedmont fanglomerate) to braided river depositional setting is generally inferred for the thick Enon Formation conglomerates. In the Gamtoos Basin the Enon Formation reaches over 2 km in thickness (based on borehole data) and contains numerous lenticular to laterally extensive, finer-grained silty or sandy interbeds (Shone 1986, 2006). Cavernous weathering is well-developed in cliff sections along the Gamtoos River. The stratigraphic relationship between the Enon and Kirkwood Formations here is complex and probably transitional to interfingering, with finer-grained facies becoming more prominent towards the southeast. An ill-defined Late Jurassic to Early Cretaceous age is inferred for the Enon Formation.

Impressive vertical sections through the thick Enon Formation succession of the Gamtoos Basin are seen in steep cliffs on the western side of the Gamtoos River Valley to the west of Hankey (Mooihoek area) (Fig. 10). The lower, orange-brown hued beds here show well-developed carvernous weathering and numerous recessive-weathering, finer-grained interbeds. The upper beds weather with more grey-green hues (*cf* "Wit Enon" of earlier authors) and may be transitional to the Kirkwood Formation. The Enon conglomerates are well exposed in several road cuttings along the R330 in the lower part of the Hankey Pass (Locs. 093, 094, 095) as well as in the large quarry on the eastern side of the pass (Loc. 096) (Figs. 12 to 14). Well-consolidated grey quartzitic conglomerates displaying a range of subfacies are observed here. They are generally poorly sorted, clast-supported and crudely bedded; bedding is picked out by contrasts in grain size and sorting. Fabrics vary from massive and chaotic to well-imbricated. The clasts range from pebbles to boulders, are usually well-rounded, and consist predominantly of pale Table Mountain quartzites with occasional darker, brownish wackes and vein quartz. The matrix is composed of gritty sand and fine gravels. Well-imbricated cobbles at the base of channels have suffered fracturing due to overburden pressure (Loc. 095). Lenticles of fine buff to grey sandstone and pale grey claystone (< 1m thick), well-seen in the steep cut face of the quarry at Loc. 096, are usually highly weathered and may include pebble stringers or lonestones. The sandstones sometimes preserve faint cross-bedding or ripple cross-lamination.

The **Kirkwood Formation** (J-Kk) comprises multi-hued, silty overbank mudrocks as well as grey-green channel sandstones with thin pebbly conglomerates that are of fluvial to estuarine origin and Early Cretaceous (Berriasian / Valanginian) age. Key geological accounts of the Kirkwood Formation include those by Du Preez (1944), Rigassi & Dixon (1972), McLachlan & McMillan (1976), Tankard *et al.* (1982), Dingle *et al.* (1983) and Shone (2006). Early geologists called these rocks the "Variegated Marls", referring to the distinctive reddish-brown, pinkish and greenish-grey colour spectrum shown by the sediments (*NB* "marl" is a misnomer, technically referring only to calcareous, clay-rich mudrocks). Another older name for the same succession was the "Wood Beds", referring to the abundant petrified wood recorded in the Algoa Basin and elsewhere. Channel sandstones are usually greyish-green, polymict and frequently contain thin pebble lenses. They may be massive but often display well-developed cross-bedding and erosional bases with coarse pebbly channel lags. Dispersed, highly-polished pebbles of various resistant lithologies are often associated with the overbank mudrocks. Volcanic tuffs (ashes) and reworked tuffs constitute an important component of the Kirkwood succession in parts of the Heidelberg – Riversdale Basin while a 4 m-thick *tuffite* (*i.e.* mixed sedimentary and volcanigenic material such as ash) is recorded from the eastern side of the Oudtshoorn Basin (Lock *et al.* 1975, McLachlan & Anderson 1976, Viljoen & Malan 1993). Useful accounts of the Kirkwood sediments in the Gamtoos Basin area have been given by Haughton *et al.* (1937) and Toerien and Hill (1989).

A thick succession of gently dipping, greyish-green Kirkwood Formation sediments builds the steep, cliffs bordering the eastern side of the Gamtoos Valley north of Hankey (Fig. 11). Good road cutting exposures through these rocks are seen along the R331 between Hankey and Patensie (Rockland Heights area; Locs. 098 to 101) (Figs. 15 & 16). Typical Kirkwood pebbly channel sandstone and overbank mudrock facies, as described earlier, are well seen here, but the rocks are on the whole highly weathered (*e.g.* leaching, honeycomb weathering, secondary ferruginisation). Away from the cuttings they are usually mantled in thick rubbly colluvium and soil. The pale, mottled to banded, recessive-weathering variegated siltstones are especially poorly exposed. Thick packets of tabular to lenticular channel sandstones, locally pebbly and horizontally-laminated to cross-bedded, occur here as well as thinner sandstones with irregular erosive bases lined with pebbly channel lags.

Fig. 10. Cliffs of lower Uitenhage Group sediments near Mooihoek, Gamtoos River Valley west of Hankey. The lower, orange-brown Enon Formation beds show prominent cavernous weathering. The paler, greyish-buff upper beds might be transitional to the Kirkwood Formation.

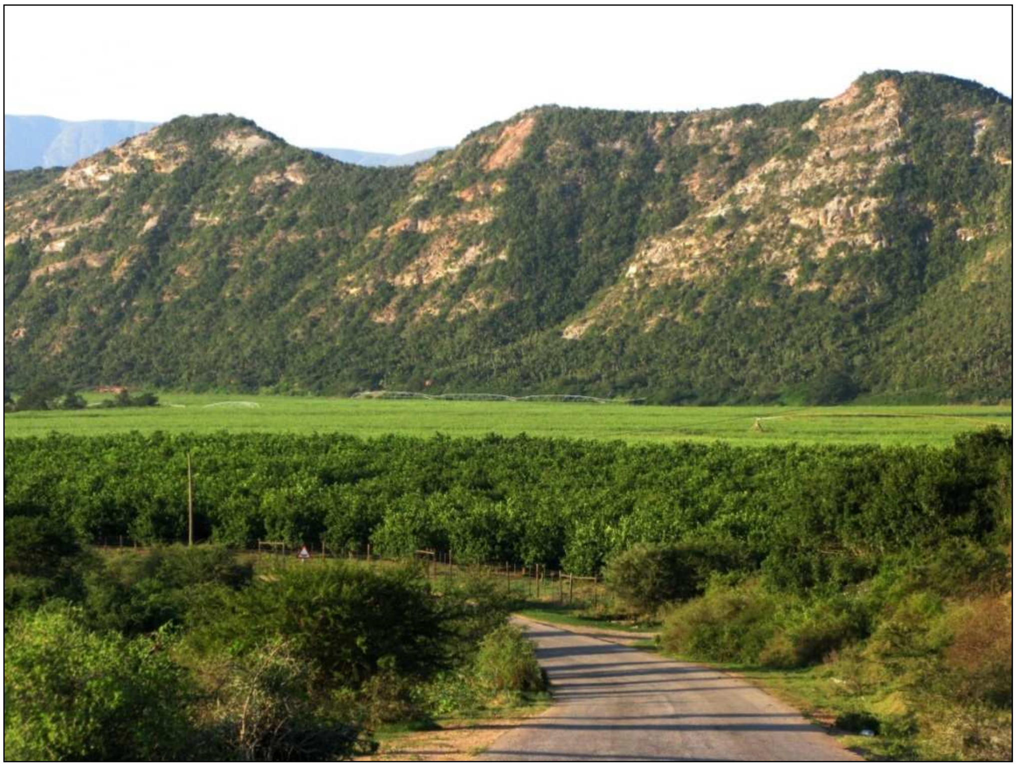

Fig. 11. Gently-dipping beds of the Kirkwood Formation building steep cliffs on the eastern side of the Gamtoos River Valley to the north of Hankey.

Fig. 12. Poorly-sorted Enon Formation conglomerates with better consolidated lenticular sandstone interbeds, R330 road cutting, Hankey Pass (Loc. 94) (Hammer = 27 cm).

Fig. 13. Channel base with clearly-imbricated cobbles showing overburden pressure fracturing overlain by crudely bedded pebbly conglomerates, Enon Formation in R330 road cutting, Hankey Pass (Loc. 095) (Hammer = 27 cm).

Fig. 14. Quarry cut face into the Enon Formation in Hankey Pass showing thin, lenticular interbeds of pale, weathered pebbly sandstone and siltstone (Loc. 096).

Fig. 15. Grey-green, pebbly channel sandstones incised into silty overbank mudrocks, R331 road cutting into the Kirkwood Formation between Hankey and Patensie (Loc.099) (Hammer = 27 cm).

Fig. 16. Highly-weathered, partially ferruginised Kirkwood Formation sandstones overlying variegated overbank siltstones, R330 road cutting between Hankey and Patensie (Loc. 101).

2.4. Superficial sediments

A wide spectrum of superficial sediments of Late Caenozoic (Tertiary to Recent) age mantle the Palaeozoic and Mesozoic bedrocks in the Humansdorp to Patensie study area. Because of their generally low palaeontological sensitivity these superficial deposits are only briefly treated here.

Fluvial to colluvial **High Level Gravels** informally assigned to the Grahamstown Formation cover considerable areas of the coastal plain in the study area. At Loc. 088 to the north of Weltevrede several meters of well-consolidated, dark brown to rusty red or ochreous, ferruginised gravels are well exposed in road cuttings where they erosively overlie deeply-weathered Table Mountain Group rocks (Fig. 17). The gravels here are poorly sorted, clast-supported, with a mixture of angular to well-rounded clasts that are mainly composed of Table Mountain quartzite or sandstone, some highly weathered. The matrix is sandy to gravelly.

Several-meters of well-consolidated, poorly-sorted, rubbly **colluvial gravels** overlie an uneven erosion surface cut into Goudini Formation sandstones at Loc. 052 to the northeast of Rondebosch (Figs. 18 & 19). The massive to crudely bedded, angular gravels here are ferruginised and partially silcretised. They contain occasional angular to subrounded boulder-sized megaclasts. Finer, better sorted and in part rounded ferricrete gravels up to several meters thick were observed overlying weathered Table Mountain Group rocks at Loc. 086, well to the west of the transmission line corridor. Soils overlying the Cederberg Formation often contain well-developed ferricrete nodules in the lower horizons (*e.g.* Loc. 054) (Fig. 22).

Colluvial gravels overlying the Enon Formation hill slopes on the western side of the Gamtoos Valley naturally consist largely of reworked Enon clasts (*e.g.* Loc. 096). When partially consolidated by siliceous and / or ferruginous cements they are often difficult to distinguish from *in situ* bedrock.

The floodplain of the Gamtoos River is mantled in thick, massive to bedded, silty to gravelly **alluvial deposits** that are generally poorly exposed and largely transformed for agriculture (*e.g.* Loc. 102) (Figs. 20 & 21). Conglomeratic facies consist largely of reworked pebbles and cobbles derived from the Enon Formation. Tributary streams incising the Bokkeveld Group outcrop area are associated with well-bedded silty alluvium, often ferruginsed, with thin gravel lenses (e.g. Loc. 092).

Fig. 17. Well-consolidated, poorly-sorted, ferruginised High Level Gravels of the Grahamstown Formation overlying weathered Table Mountain Group bedrocks, R330 road cutting north of Weltevrede (Loc. 088) (Hammer = 27 cm).

Fig. 18. Rubbly ferricrete gravels overlying gently-dipping, weathered Goudini Formation bedrocks, R330 road cutting NE of Rondebos (Loc. 052).

Fig. 19. Detail of silcretised, ferruginised, angular pedocrete gravels at the same locality as the previous figure (Hammer = 27 cm).

Fig. 20. Poorly-sorted fluvial conglomerates of the Gamtoos River near Weston (Loc. 97). The well-rounded quartzite megaclasts show well-developed current imbrication and are reworked from the Enon Formation (Hammer = 27 cm).

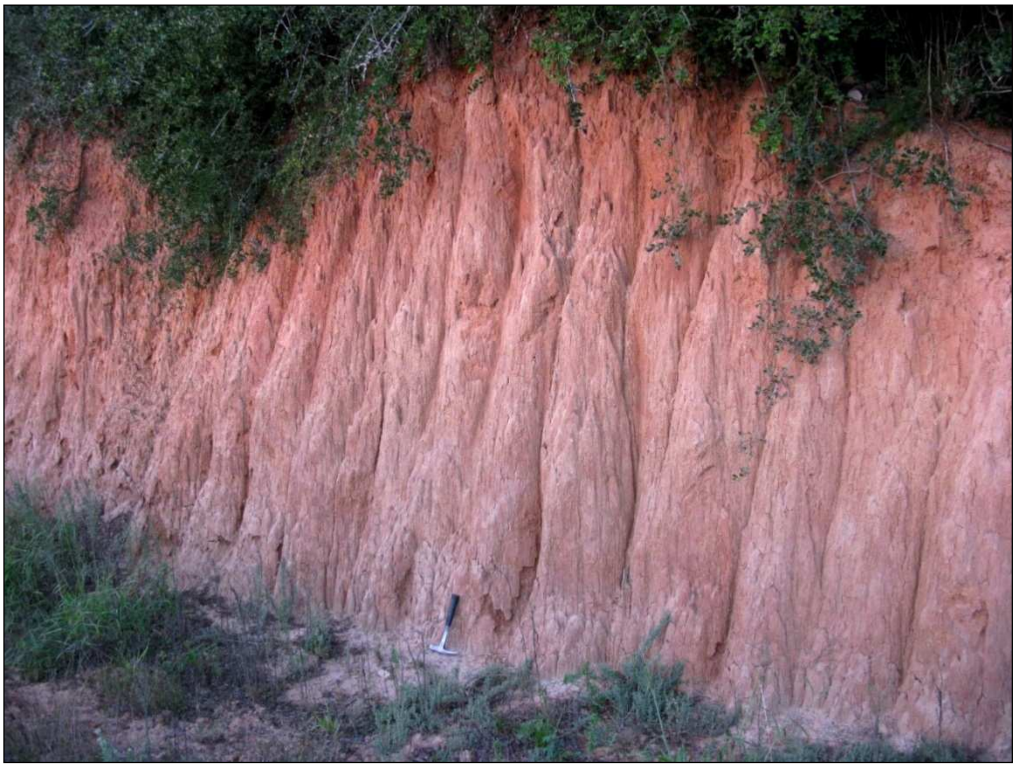

Fig. 21. Massive, silty alluvium of the Gamtoos River on its valley floor floodplain, railway cutting near Gonnakop to the south of Patensie (Loc. 102) (Hammer = 27 cm).

Fig. 22. Downwasted gravels, nodular ferricrete and silty soils overlying weathered Cederberg Formation mudrocks, borrow pit along R332 (Loc. 085).

3. PALAEONTOLOGICAL HERITAGE WITHIN THE STUDY REGION

A brief review of the fossil assemblages recorded from the various major rock units represented within the broader Humansdorp to Patensie study area is given here. Most of these rock units are only sparsely fossiliferous to unfossiliferous. However, rich and scientifically important fossil assemblages have been recorded from the Cedarberg and Baviaanskloof Formations of the Table Mountain Group as well as the Lower Bokkeveld Group elsewhere in the Cape Fold Belt. The palaeontological sensitivity of the Palaeozoic Cape Supergroup rock units has generally been seriously compromised in the study region near Humansdorp as a result of high levels of tectonic deformation (*e.g.* cleavage formation) as well as deep chemical weathering since the fragmentation of Gondwana some 120 million years ago. The Uitenhage beds here are also highly chemically weathered, but plant fossil-rich lignites are known from the Gamtoos Basin. Furthermore, the outcrop areas of the mudrock-rich sedimentary successions that are most likely to yield fossil remains are largely mantled in a veneer of superficial deposits such as soil, alluvium and gravels that may shield any fresher (less weathered), potentially fossiliferous bedrocks from significant disturbance during development.

3.1. Fossils in the Table Mountain Group

Body fossils (shells, teeth, bones *etc*) are so far unknown from the **Peninsula Formation** but a modest range of shallow marine to nearshore fluvial and / or estuarine trace fossils have been recognised, mainly from the Western Cape outcrop area (*e.g.* Rust 1967, Potgieter & Oelofsen 1983, Broquet 1990, 1992, Almond 1998a,b, Braddy & Almond 1999, Thamm & Johnson 2006). These traces include trilobite resting and feeding burrows (*Cruziana*, *Rusophycus*), arthropod trackways (*e.g. Diplichnites, Palmichnium*) that are variously attributed to eurypterids, crustaceans or trilobites, palmate, annulated feeding burrows (*Arthrophycus*), dense assemblages ("pipe rock") of vertical dwelling burrows of unknown suspension feeders (*Skolithos, Trichichnus*), vertical columns or cones of densely reworked sediment (*Metaichna* / possible *Heimdallia*), and several types of horizontal burrows (*Palaeophycus,* possible *Aulichnites*).

An important, albeit low diversity, assemblage of Peninsula Formation trace fossils was recently recorded from heterlithic beds exposed in the Rosenhof Quarry site within the broader Tsitsikamma Community Wind Energy Facility study region to the southwest of Humansdorp by Almond (2012). Traces here include vertical *Skolithos* burrows, *Rusophycus* and *Cruziana* arthropod scratch burrows that were probably generated by trilobites, possible bivalve burrows (*Lockeia*) and teichichnoid spreiten burrows, as well as abundant flower-shaped “gyrophyllitid” burrows that had previously been reported from beach boulders at Cape Saint Francis.

Recessive weathering of trace-rich heterolithic intervals is undoubtedly responsible for under-recording of fossils within the Peninsula Formation. It is also likely that relatively unweathered samples of fine-grained muddy sediments within these heterolithic intervals may eventually yield microfossil assemblages (*e.g.* organic-walled acritarchs) of biostratigraphic and palaeonvironmental significance.

Apart from vague meniscate backfilled burrows from late glacial or postglacial dropstone argillites in the Hex River Valley, no fossil remains have been described from the **Pakhuis Formation** (Almond 2008).

An exceptionally important and interesting biota of soft-bodied (*i.e.* unmineralised) and shelly invertebrates, primitive jawless vertebrates and microfossils has been recorded since the middle 1970s from finely laminated, black mudrocks of the **Soom Member**, forming the lower, mudrock-dominated portion of the **Cedarberg Formation**. This is one of only two so-called soft-body *Lagerstaette* of Late Ordovician age recorded worldwide (the other example was recently discovered in Canada; Young *et al.,* 2007). The “Soom Shale” is between 10-15m thick, and fossils occur sporadically throughout the succession, from 1m above the base upwards. This biota has been extensively reviewed by Aldridge *et al*. (1994, 2001) and Selden and Nudds (2004) while much new information remains to be published (See review in Almond 2008 and refs. therein). The macrofossils include a range of macroalgae, shelly invertebrates (*e.g.* inarticulate brachiopods, conical-shelled nautiloids and other molluscs, crustaceans, unmineralised trilobites and eurypterids or “water scorpions”) and several groups of primitive jawless fish (*e.g.* anaspids, conodonts). Important microfossil groups include chitinozoans, spore tetrads of land plants and marine acritarchs. A further interesting category of fossils recorded from the Soom Member of Kromrivier are bromalites. These are the various fossilised products of ancient animal guts such as droppings (coprolites), regurgitates and stomach contents that sometimes contain the comminuted remains of recognisable prey animals such as conodonts or brachiopods (Aldridge *et al*., 2006). The majority of Soom fossils have been collected from a handful of localities, most of which lie on the Clanwilliam sheet within the central to northern Cedarberg (Gray *et al*. 1986, Cocks & Fortey 1986, Theron *et al*. 1990, Aldridge *et al*. 1995). New fossiliferous localities have recently been identified in the Clanwilliam area, while well preserved trilobite trace fossils (*Rusophycus*) have been collected from thin tempestite sandstones towards the base of the Soom Member in the Hex River Mountains by Almond (unpublished obs., 2011).

A low diversity shelly faunule, dominated by articulate and inarticulate brachiopods together with a small range of trace fossils is recorded from the heterolithic **Disa Member** that forms the upper portion of the Cedarberg Formation. Marine invertebrate fossils have been recorded from the Disa Member in the Groot Winterkoek mountains near Porterville, some 30km southeast of Piketberg, while important post-glacial trace fossil assemblages are known from the Clanwilliam region (Rust 1967b, Cocks *et al.* 1970, Cocks & Fortey 1986, Almond 2008).

The fossil record of the **Goudini** and **Skurweberg Formations**, dominated by braided fluvial sandstones, is very sparse indeed. This reflects major global regression (low sea levels) during the

Silurian Period, peaking during the latter part of the period (Cooper 1986). Sporadic, low diversity ichnoassemblages from thin, marine-influenced stratigraphic intervals have been recorded from all three Nardouw formations in the Western Cape by Rust (1967a, 1981) and Marchant (1974). There are also scattered, often vague reports of trace fossils in geological sheet explanations and SACS reports (*e.g.* Malan *et al.* 1989, De Beer *et al.* 2002). Most involve "pipe rock" (*Skolithos* ichnofacies) or various forms of horizontal epichnial burrows, including possible members of the *Scolicia* group which may be attributable to gastropods. Also recorded are typical Early Silurian palmate forms of the annulated burrow *Arthrophycus*, poorly preserved "bilobites" (bilobed arthropod scratch burrows), gently curved epichnial furrows and possible arthropod tracks (Almond 2008). It is possible that more diverse ichnoassemblages (and even microfossils from subordinate mudrock facies where these have not been deeply weathered or tectonised) may eventually be recorded from the more marine-influenced outcrops of the Eastern Cape Fold Belt.

A distinctive marine shelly invertebrate faunule of Early Devonian, Malvinokaffric aspect characterises the upper portion of the **Baviaanskloof Formation** from the Little Karoo eastwards along the Cape Fold Belt. It is dominated by the globose, finely-ribbed articulate brachiopod *Pleurothyrella africana*. Rare homalonotid trilobites, a small range of articulate and inarticulate brachiopods, nuculid and other bivalves, plectonotid "gasteropods" and bryozoans also occur within impure brownish-weathering wackes (Boucot *et al*. 1963, Rossouw *et al*. 1964, Johnson 1976, Toerien & Hill 1989, Hill 1991, Theron *et al.* 1991, Almond *in* Rubidge *et al*. 2008). In many cases fossil shells are scattered and disarticulated, but *in situ* clumps of pleurothyrellid brachiopods also occur. This shelly assemblage establishes an Early Devonian (Pragian / Emsian) age for the uppermost Nardouw Subgroup, based on the mutationellid brachiopod *Pleurothyrella* (Boucot *et al*. 1963, Theron 1972, Hiller & Theron 1988). Trace fossils include locally abundant, mud-lined burrows (*Palaeophycus*, *Rosselia*) and rare giant rusophycid burrows of Devonian aspect (*R. rhenanus*) that are attributed to homalonotid trilobites. Recently, dense assemblages of primitive vascular plants with forked axes and conical terminal "sporangia" that are provisionally ascribed to the genus *Dutoitia* have been collected from Baviaanskloof Formation mudrocks near Cape St Francis, Eastern Cape (Dr Mark Goedhart, Council for Geoscience, Port Elizabeth, pers. comm., 2008; Robert Gess pers. comm., 2011; *cf* Hoeg 1930, Anderson & Anderson 1985).

During the present one-day field study almost all the Table Mountain Group exposures showed high levels of tectonic deformation (*e.g.* steep bedding, quartz veins, pervasive cleavage within mudrock intervals) as well as deep chemical weathering. These two factors, which are both more extremely developed within the potentially more fossiliferous mudrock-rich intervals of the Table Mountain Group (*e.g.* Cederberg, Goudini and Baviaanskloof Formation), have seriously compromised fossil preservation here. No fossil remains were observed within the Table Mountain Group sediments in the study area and the various formations concerned are considered to have a low palaeontological sensitivity in this region.

3.2. Fossils in the Lower Bokkeveld Group (Ceres Subgroup)

The most important fossil groups recorded from the lower Bokkeveld Group (Ceres Subgroup) include shelly marine invertebrates and traces (burrows *etc*), together with rare fish remains, primitive vascular plants, trace fossils (burrows, borings *etc*) and microfossils (*e.g.* foraminiferans, ostracods, palynomorphs). The overall palaeontological sensitivity of this stratigraphic unit is generally considered to be high to very high (Almond *et al*. 2008), but may be compromised locally by cleavage and weathering (*cf* Haughton *et al.* 1937, p. 23).

The Lower Bokkeveld Group is especially well known for its rich fossil assemblages of **marine invertebrates** of Early to Mid-Devonian age. The main invertebrate taxa concerned are trilobites, brachiopods, molluscs and echinoderms. Numerous more minor groups are also recorded - corals, conulariids, hyolithids, tentaculitids *etc* - making the Bokkeveld Group one of the palaeontologically most important Devonian units in the southern hemisphere. Fossil invertebrates are especially diverse and abundant within the mudrock-dominated formations, although low-diversity sandstone-hosted fossils assemblages also occur. Shells are generally preserved as external and internal moulds and casts (*e.g.* Schwarz 1906, Reed 1925, Du Toit 1954, Cooper 1982, Oosthuizen 1984, Hiller 1995, Hiller & Theron 1988, Theron & Johnson 1991, Jell & Theron 1999, Thamm & Johnson 2006, Almond 2008). Remarkably rich marine trace fossil assemblages are also known from the lower Bokkeveld Group, especially in nearshore facies (Almond 1998a, 1998b).

The only **vascular plants** recorded from the Ceres Subgroup are a small range of dichotomously branching, leafless forms known as psilophytes (*e.g. Dutoitia*) and primitive lycopods or “club mosses” such as *Palaeostigma*. The material is generally transported (washed offshore from the land), poorly preserved, and has mainly been recorded from the eastern outcrop area of the Bokkeveld Group (Plumstead 1967, 1969, Theron 1972, Anderson and Anderson 1985).

Very sparse **fossil fish** remains have been recorded from the Ceres Subgroup (Gydo and Tra Tra Formations), several retaining their original phosphatic bony material. They comprise acanthodians (“spiny sharks”), primitive sharks, placoderms, and bony fish or osteichthyans, but so far no agnathans (Almond 1997, Anderson *et al*. 1999a, 1999b). The material is fragmentary but of considerable palaeontological significance since so little is known about Early Devonian ichthyofaunas of the ancient supercontinent Gondwana.

So far, the great majority of published records of fossils from the Ceres Group refer to the much better known western outcrop areas in the Western Cape. In the Eastern Cape Province, where the potentially fossiliferous mudrocks are frequently highly deformed, cleaved, and often deeply weathered or covered by dense vegetation, the fossil known record is still rather sparse and understudied. Most of the early geological mapping surveys revealed very few useful fossil records – essentially a scattering of poorly preserved, often deformed marine shells and locally abundant trace fossils (*e.g.* Haughton 1928, 1935, Haughton *et al*., 1937, Engelbrecht *et al*., 1962). Apart from probable records of the primitive vascular plant *Dutoitea*, most early records of plant material and arthropods from the Bokkeveld Group in the Eastern Cape (such as those from near Port Alfred) are probably more correctly assigned to the younger lower Witteberg Group (*e.g.* Anderson & Anderson 1985).

Within the western part of the Eastern Cape Province, only a handful of productive fossil localities within the Ceres Subgroup have been recorded so far. Most notably, these include the Cockscomb area between Willowmore and Steytlerville, Klein Kaba near Alexandria, and the Uitenhage North area (*e.g.* Theron 1972, Johnson 1976, Hiller 1980, Oosthuizen 1984, Toerien & Hill 1989, Le Roux 2000). As is the case to the west, shelly fossils are most abundant in the mudrock-dominated formations, including the Gydo, Voorstehoek and Tra Tra Formations. Indeed, the Voorstehoek Formation in the Eastern Cape may prove quite productive, although the assignation of some faunal records to this unit requires confirmation (*e.g.* Hiller 1980, Oosthuizen 1984, Hiller 1990). Useful faunal lists for the rich Gydo Formation biota at the Cockscomb Mountains and the unconfirmed Voorstehoek Formation biota at Klein Kaba are given by Oosthuizen (1984, Table III and p.138 respectively). The Cockcomb biota is preserved as moulds within early diagenetic nodules of phosphatic or other composition (*cf* Browning 2008). It includes a wide range of trilobites, brachiopods, bivalves, gastropods, crinoids, a possible echinoid, corals, abundant well-preserved conulariids, ostracods and various problematic groups (*e.g.* hyolithids, tentaculitids and other tubular fossils). The Klein Kaba faunule listed by Oosthuizen (1984) is dominated by a number of articulate brachiopods, but also comprises gastropods, bivalves, nautiloids, trilobites , crinoids, conulariids, various tubular fossils and traces.

The Ceres Subgroup succession in the Humansdorp to Patensie study area is dominated by offshore mudrocks and has clearly suffered high levels of tectonic deformation (steep bedding, pervasive cleavage *etc*) as well as deep chemical weathering. Since no fossil remains (apart from possible ferruginised, tectonically deformed moulds) were observed during the present field study, these two factors have apparently obliterated most of all the fossil remains originally preserved in the near-surface bedrocks whose palaeontological sensitivity here is therefore assessed as low.

3.3 Fossils within the Uitenhage Group

In general, the proximal Uitenhage "red bed" sediments deposited in colluvial fans and energetic braided river systems such as the Enon Formation are fossil-poor. Shone (2006) refers to sparse fragmentary, disarticulated, rounded bones and charred wood of indeterminate age in the **Enon Formation**. The palaeontological heritage of the coarse-grained facies (conglomerates, breccias) within the Uitenhage Group is currently unclear because of the uncertain stratigraphic position of many records with respect to currently accepted lithostratigraphy. Key references to the earlier literature are given by Du Toit (1956), McLachlan and McMillan (1976), Tankard *et al.* (1982) and Dingle *et al.* (1983). In the south-eastern Gamtoos Basin lignites, pollens and a range of plant compression fossils are recorded from the Uitenhage Group beds, but these appear to stem from the Kirkwood Formation rather than the Enon Formation proper (These two units were not distinguished by Haughton *et al*., 1937; the reference by Le Roux, 2000, to fossil wood from the Enon is therefore probably erroneous; *cf* also McLachlan & McMillan 1976, Dingle *et al.* 1983). According to Dingle *et al.* (1983, p. 117) no fossil wood has been recorded from the conglomerate ("Enon") facies in the Gamtoos Basin. Silicified wood has been recorded, however, from conglomerates of the Enon Formation near Worcester and Nuy in the Western Cape (Sönghe 1934, McLachlan & McMillan 1976, Gresse & Theron 1992). Charred wood fragments are also reported as common within the Enon of the Algoa Basin (Rogers & Du Toit 1909, Haughton & Rogers 1924) while unidentifiable carbonized miospores from borehole cores in the same basin are mentioned by Scott (1976a, b).

The **Kirkwood Formation** is the most palaeontologically productive unit in southern Africa that yields terrestrial biotas of Early Cretaceous age. Its overall palaeontological sensitivity is rated as high (Almond & Pether 2008). Fossils include vascular plants (including concentrations of petrified logs, leaves and twigs, lignite beds, charcoal), tetrapod vertebrates (notably dinosaurs) and freshwater invertebrates, among others (Du Toit 1954, McLachlan & McMillan 1976, Almond 2010b). Recent palaeontological research has yielded a number of new dinosaur taxa, for the most part from the Algoa Basin to the northeast of Port Elizabeth, but also from the Oudtshoorn Basin of the Little Karoo (De Klerk 2008) and the Vleesbaai Basin (Almond 2012b).

Thin (≤ 5 cm), lenticular lignite layers and carbonaceous clays with yellowish amber, ferruginous concretions as well as sandstones containing plant fossils (*e.g.* carbonaceous stem compressions), but apparently no petrified wood, have been reported from **Kirkwood Formation** from two localities near Loerie, in the south-eastern Gamtoos Basin (Rogers 1906, Haughton *et al.* 1937 pp 28-29, Du Toit 1954 p. 379, McLachlan & McMillan 1976 pp. 207-208, Dingle *et. al.* 1983). These fossiliferous beds were previously prospected for coal. Among the macroplants various ferns, cycads and conifers have been identified, most of which are also known from the Kirkwood beds of the better knownAlgoa Basin. A rich palynoflora of some 36 taxa, including several fern groups, has been isolated from these beds by Martin (1960).

Fossiliferous marine beds of the Sundays River Formation have not been recorded from the Gamtoos Basin.

No fossil remains were recorded within the Uitenhage Group beds during the present field survey. Potentially fossiliferous finer-grained sediments in both the Enon and Kirkwood successions here were generally highly weathered and usually mantled with thick colluvial gravels and soils.

3.4. Fossils within Caenozoic superficial deposits

Sparse fossil remains have been recorded from Tertiary or younger silcretes (*i.e.* silica-cemented pedocretes) of the Grahamstown and equivalent formations by Roberts (2003) and earlier authors. These include a small range of trace fossils (*e.g.* rhizoliths or plant root casts and invertebrate burrows such as *Skolithos*), charophyte algae (calcareous stoneworts), reed-like wetland plants resembling the extant *Phragmites* (*fluitjiesriet*), and reworked Late Permian silicified wood from the Beaufort Group (See also Adamson 1934, Du Toit 1954, and Roberts *et al.,* 1997). Silicified termitaria might also be expected here, although termite activity is inhibited by waterlogged soils that probably prevailed in areas where silcrete formation occured.

Neogene to Recent alluvial deposits may also contain fossil remains of various types. In coarser sediments (*e.g.* conglomerates) these tend to be robust, highly disarticulated and abraded (*e.g*. rolled bones, teeth of vertebrates) but well-preserved skeletal remains of plants (*e.g.* wood, roots) and invertebrate animals (*e.g.* freshwater molluscs and crustaceans) as well various trace fossils may be found within fine-grained alluvium. Human artefacts such as stone tools that can be assigned to a specific interval of the archaeological time scale (*e.g.* Middle Stone Age) can be of value for constraining the age of Pleistocene to Recent drift deposits like alluvial terraces. Ancient alluvial "High Level Gravels" tend to be coarse and to have suffered extensive reworking (*e.g.* winnowing and erosional downwasting), so they are generally unlikely to contain useful fossils.

No fossil remains were observed within the various superficial deposits recorded within the Humansdorp to Patensie study area during the present field study.

4. ASSESSMENT OF TRANSMISSION LINE DEVELOPMENT IMPACTS ON PALAEONTOLOGICAL HERITAGE RESOURCES

The proposed 132 kV transmission line and associated substation developments are situated in areas that are underlain by potentially fossiliferous sedimentary rocks of Palaeozoic, Mesozoic and Late Tertiary or Quaternary age (Sections 2 and 3). The construction phase of the transmission line and associated infrastructure may entail substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. In addition, considerable areas of bedrock may be sealed-in or sterilized by lay-down areas as well as new gravel roads. All these developments may adversely affect fossil heritage resources at or beneath the surface of the ground within the development footprint by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good. Once constructed, the operational and decommissioning phases of the transmission line are unlikely to involve further adverse impacts on palaeontological heritage, however.

The inferred impact of the proposed transmission line development on local fossil heritage is analysed in Table 1 below. This assessment applies to the transmission line itself as well as associated substation and road infrastructure developments.

In general, the destruction, damage or disturbance out of context of fossils preserved at the ground surface or below ground that may occur during construction represents a *negative* impact that is limited to the development footprint. Such impacts can usually be mitigated but cannot be fully rectified (*i.e. permanent*). Because of the generally sparse occurrence of fossils within most of the formations concerned as well as within the overlying superficial sediments (soil *etc*), as inferred from better exposed localities elsewhere, the intensity and probability of impacts are conservatively rated as *low*.

Due to the high to very high levels of bedrock weathering and tectonic deformation observed within and close to the Humansdorp – Patensie study area, the impact significance of the construction phase of the proposed transmission line project is assessed as LOW with respect to fossil heritage resources. There are no fatal flaws in the development proposal as far as fossil heritage is concerned.

It should be noted that should fossils be discovered before or during construction and reported by the responsible ECO to the responsible heritage management authority, the Eastern Cape Provincial Heritage Resources Agency (ECPHRA) for professional recording and collection, as recommended here, the overall impact significance of the project would remain LOW. Residual negative impacts from any loss of fossil heritage would be partially offset by an improved palaeontological database as a direct result of appropriate mitigation. This is a *positive* outcome because any new, well-recorded and suitably curated fossil material from this palaeontologically under-recorded region would constitute a useful addition to our scientific understanding of the fossil heritage here.

Despite the low levels of bedrock exposure within the study area, confidence levels for this assessment are HIGH following the one-day field assessment of representative geological sites, supplemented by other palaeontological heritage assessment studies in the Humansdorp region.

Table 1: Assessment of impacts on palaeontological heritage resources resulting from the proposed 132 kV Melkhout to Patensie transmission line project

CRITERIA	**RATING**	**COMMENTS**
Nature	Negative	Disturbance, damage, destruction or sealing-in of fossil remains preserved on or beneath the ground surface within the development area, notably by bedrock excavations during the construction phase of the transmission line, substations.
Extent	Low	Site specific
Duration	High	Permanent
Intensity	Low	
Potential for impact on irreplaceable resources	Low	Sedimentary formations affected have large outcrop area outside development footprint
Consequence	Low	
Probability	Low	Almost all original fossil heritage has been destroyed near-surface by tectonic deformation and deep chemical weathering
Significance	LOW	No recommendation for further specialist palaeontological studies or mitigation for this project

5. CONCLUSIONS AND RECOMMENDATIONS

On the basis of the current field assessment as well as the paucity of previous fossil records from the Humansdorp - Patensie region it is concluded that the palaeontological sensitivity of the Palaeozoic (Table Mountain Group) bedrocks here is generally low due to high levels of tectonic deformation (*e.g.* folding, cleavage) and chemical weathering. This applies especially to the more mudrock-rich stratigraphic units (*e.g.* Cederberg and Ceres Subgroup) that may originally have been highly fossiliferous. The thick Enon Formation conglomerates on the western side of the Gamtoos Valley are at most very sparsely fossiliferous. Important fossil plant assemblages are known from the overlying Kirkwood Formation of the Gamtoos Basin (*e.g.* Loerie area). However, these Early Cretaceous rocks are mostly highly weathered and poorly exposed where they crop out at the northern end of the proposed transmission line, in the neighbourhood of the proposed new Patensie Substation. The various Late Caenozoic superficial deposits mantling the bedrocks in the study region (*e.g.* alluvium, colluvium, soils, pedocretes) are also of low palaeontological sensitivity.

Given the resulting low impact significance of the proposed transmission line – including the associated substation, bridge and road developments - as far as palaeontological heritage is concerned, no further specialist studies or mitigation are considered necessary for this project.

It is recommended that:

- The Environmental Control Officer (ECO) responsible for the transmission line development should be at least aware of the possibility – albeit low - of important fossils (*e.g.* shells, plant remains, trace fossils, mammalian bones and teeth) being present or unearthed on site and should regularly monitor all substantial excavations into superficial sediments as well as fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains. Particular note should be taken of the possibility of thin, plant-rich horizons (lignites) within the Kirkwood Formation bedrocks beneath the proposed new Patensie Substation.

- In the case of any significant fossil finds (*e.g.* vertebrate teeth, bones, plant-rich beds) made during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (ECPHRA. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer's expense; and

- These recommendations should be incorporated into the Environmental Management Plan (EMP) for the 132 kV transmission line project.

The palaeontologist concerned with mitigation work will need a valid palaeontological collection permit from SAHRA (Contact details: Mrs Colette Scheermeyer, P.O. Box 4637, Cape Town 8000. Tel: 021 462 4502. Email: cscheermeyer@sahra.org.za). All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies developed by SAHRA (2013).

6. ACKNOWLEDGEMENTS

I would like to thank Len van Schalkwyk and Elizabeth Wahl of eThembeni Cultural Heritage, Pietermaritzburg for commissioning this work as well as providing the necessary background information for the project.

7. REFERENCES

ADAMSON, R.S. 1934. Fossil plants from Fort Grey near East London. Annals of the South African Museum 31, 67-96.

ALDRIDGE, R.J., THERON, J.N. & GABBOTT, S.E. 1994. The Soom Shale: a unique Ordovician fossil horizon in South Africa. Geology Today 10: 218-221.

ALDRIDGE, R.J., GABBOTT, S.E. & THERON, J.N. 2001. The Soom Shale. In: Briggs, D.E.G. & Crowther, P.R. (Eds.) Palaeobiology II, pp. 340-342. Blackwell Science Ltd, Oxford.

ALDRIDGE, R.J., PURNELL, M.A., GABBOTT, S.E. & THERON, J.N. 1995. The apparatus architecture and function of *Promissum pulchrum* Kovács-Endrödy (Conodonta, Upper Ordovician) and the prioniodontid plan. Philosophical Transactions of the Royal Society of London B 347: 275-291.

ALDRIDGE, R.J., GABBOTT, S.E., SIVETER, L.J. & THERON, J.N. 2006. Bromalites from the Soom Shale Lagerstätte (Upper Ordovician) of South Africa: palaeoecological and palaeobiological implications. Palaeontology 49: 857-871.

ALMOND, J.E. 1997. Fish fossils from the Devonian Bokkeveld Group of South Africa. Stratigraphy. African Anthropology, Archaeology, Geology and Palaeontology 1(2): 15-28.

ALMOND, J.E. 1998a. Trace fossils from the Cape Supergroup (Early Ordovician – Early Carboniferous) of South Africa. Journal of African Earth Sciences 27 (1A): 4-5.

ALMOND, J.E. 1998b. Early Palaeozoic trace fossils from southern Africa. Tercera Reunión Argentina de Icnologia, Mar del Plata, 1998, Abstracts p. 4.

ALMOND, J.E. 2008. Palaeozoic fossil record of the Clanwilliam Sheet area (1: 250 000 geological sheet 3218), 42 pp. Report produced for the Council for Geoscience, Pretoria.

ALMOND, J.E. 2009a. Palaeontological impact assessment: desktop study. Farm 793 Zeekoerivier, Humansdorp, Eastern Cape Province, 9 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2009b. Oudebosch Kloof 159 and Klein Rivier 158, Hankey, Eastern Cape Province, RSA. Palaeontological impact assessment: desktop study, 8 pp. Natura Viva cc.

ALMOND, J.E. 2010a. Palaeontological impact assessment: desktop study. Jeffrey's Bay Wind Project, Kouga Municipality, Eastern Cape Province, 18 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010b. Palaeontological heritage impact assessment of the Coega IDZ, Eastern Cape Province, 112 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010c. Arcadia 139: Residential Development of Erf 709 and Erf 710 Kruisfontein, Humansdorp, Kouga Municipality, Eastern Cape Province. Palaeontological impact assessment: desktop study, 10 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011a. Proposed Oyster Bay Wind Energy Facility near Humansdorp, Kouga Local Municipality, Eastern Cape. Palaeontological specialist study: desktop assessment, 36 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011b. Proposed Tsitsikama Community Wind Energy Facility near Humansdorp, Kouga Local Municipality, Eastern Cape Province. Palaeontological specialist study: desktop assessment, 30 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012a. Proposed Tsitsikamma Community Wind Energy Facility near Humansdorp, Kouga Local Municipality, Eastern Cape Province. Palaeontological specialist study: combined desktop and field-based assessment, 44 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012. Proposed Sondereind Wind Energy Farm near Vleesbaai, Mossel Bay Magisterial District, Western Cape Province. Palaeontological impact assessment: combined desktop & scoping study, 59 pp. Natura Viva cc, Cape Town.

ALMOND, J.E., DE KLERK, W.J. & GESS, R. 2008. Palaeontological heritage of the Eastern Cape. Draft report for SAHRA, 20 pp. Natura Viva cc, Cape Town.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp, 226 pls. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

ANDERSON, M.E., ALMOND, J.E., EVANS, F.J. & LONG, J.A. 1999a. Devonian (Emsian-Eifelian) fish from the Lower Bokkeveld Group (Ceres Subgroup), South Africa. Journal of African Earth Sciences 29: 179-194.

ANDERSON, M.E., LONG, J.A., EVANS, F.J., ALMOND, J.E., THERON, J.N. & BENDER, P.A. 1999b. Biogeographic affinities of Middle and Late Devonian fishes of South Africa. Records of the Western Australian Museum, Supplement No. 57: 157-168.

BOUCOT, A.J., CASTER, K.E., IVES, D. & TALENT, J.A. 1963. Relationships of a new Lower Devonian terebratuloid (Brachiopoda) from Antarctica. Bulletin of American Paleontology 46, No. 207: 81-123, pls. 16-41.

BRADDY, S.J. & ALMOND, J.E. 1999. Eurypterid trackways from the Table Mountain Group (Ordovician) of South Africa. Journal of African Earth Sciences 29: 165-177.

BROQUET, C.A.M. 1990. Trace fossils and ichno-sedimentary facies from the Lower Palaeozoic Peninsula Formation, Cape Peninsula, South Africa. Abstracts, Geocongress '90, Cape Town, pp 64-67. Geological Society of South Africa.

BROQUET, C.A.M. 1992. The sedimentary record of the Cape Supergroup: a review. In: De Wit, M.J. & Ransome, I.G. (Eds.) Inversion tectonics of the Cape Fold Belt, Karoo and Cretaceous Basins of Southern Africa, pp. 159-183. Balkema, Rotterdam.

BROWNING, C. 2008. Some factors leading to the good preservation of trilobite fossils within nodules of the lower Bokkeveld, Steytlerville District, Eastern Cape. Abstracts and Programme, Biennial Conference of the Palaeontological Society of South Africa, 2008, 61-65.

COCKS, L.R.M., BRUNTON, C.H.C., ROWELL, A.J. & RUST, I.C. 1970. The first Lower Palaeozoic fauna proved from South Africa. Quarterly Journal of the Geological Society, London 125: 583-603, pls. 39-41.

COCKS, L.R.M. & FORTEY, R.A. 1986. New evidence on the South African Lower Palaeozoic: age and fossils revisited. Geological Magazine 123: 437-444.

COOPER, M.R. 1982. A revision of the Devonian (Emsian – Eifelian) Trilobita from the Bokkeveld Group of South Africa. Annals of the South African Museum 89: 1-174.

COOPER, M.R. 1986. Facies shifts, sea-level changes and event stratigraphy in the Devonian of South Africa. South African Journal of Science 82: 255-258.

DE BEER, C.H. 2002. The stratigraphy, lithology and structure of the Table Mountain Group. In: Pietersen, K. & Parsons, R. (Eds.) A synthesis of the hydrogeology of the Table Mountain Group – formation of a research strategy. Water Research Commission Report No. TT 158/01, pp. 9-18.

DE BEER, C.H., GRESSE, P.G., THERON, J.N. & ALMOND, J.E. 2002. The geology of the Calvinia area. Explanation to 1: 250 000 geology Sheet 3118 Calvinia. 92 pp. Council for Geoscience, Pretoria.

DE KLERK, W.J. 2008. A review of the occurrence of disarticulated Early Cretaceous sauropod dinosaur fossils from the Kirkwood Formation of the Oudtshoorn and Algoa Basins. Programme and abstracts, Biennial Conference of the Palaeontological Society of South Africa, Matjiesfontein September 2008, 90-91.

DE KLERK, W.J. 2010. Palaeontological Heritage Impact Assessment of the proposed wind farms in the coastal region of the Kouga Local Municipality near the villages of Oyster Bay and St Francis Bay, 14 pp. Albany Museum Earth Sciences, Grahamstown.

DINGLE, R.V., SIESSER, W.G. & NEWTON, A.R. 1983. Mesozoic and Tertiary geology of southern Africa. viii + 375 pp. Balkema, Rotterdam.

DU PREEZ, J.W. 1944. Lithology, structure and mode of deposition of the Cretaceous deposits in the Oudtshoorn area. Annals of the University of Stellenbosch 22(A): 209-237, pls. 1-12.

DU TOIT, A. 1954. The geology of South Africa. xii + 611pp, 41 pls. Oliver & Boyd, Edinburgh.

ENGELBRECHT, L.N.J., COERTZE, F.J. & SNYMAN, A.A. 1962. Die geologie van die gebied tussen Port Elizabeth en Alexandria, Kaapprovinsie. Explanation to geology sheet 3325 D Port Elizabeth, 3326 C Alexandria and 3425 B, 54pp., 8 pls. Geological Survey of South Africa / Council for Geosciences, Pretoria.

GRAY, J., THERON, J.N. & BOUCOT, A.J. 1986. Age of the Cederberg Formation, South Africa and early land plant evolution. Geological Magazine 123: 445-454.

GRESSE, P.G. & THERON, J.N. 1992. The geology of the Worcester area. Explanation of geological Sheet 3319. 79 pp, tables. Council for Geoscience, Pretoria.

HAUGHTON, S.H. 1928. The geology of the country between Grahamstown and Port Elizabeth. An explanation of Cape Sheet No. 9 (Port Elizabeth), 45 pp. Geological Survey / Council for Geoscience, Pretoria.

HAUGHTON, S.H. 1935. The geology of portion of the country east of Steytlerville, Cape Province. An explanation of Sheet No. 150 (Sundays River), 35 pp. Geological Survey / Council for Geoscience, Pretoria.

HAUGHTON, S.H. & ROGERS, A.W. 1924. The volcanic rocks south of Zuurberg. Transactions of the Royal Society of South Africa 11, 235-249.

HAUGHTON, S.H., FROMMURZE, H.F. & VISSER, D.J.L. 1937. The geology of portion of the coastal belt near the Gamtoos Valley, Cape Province. An explanation of Sheets Nos. 151 North and 151 South (Gamtoos River), 55 pp. Geological Survey / Council for Geoscience, Pretoria.

HILL, R.S. 1991. Lithostratigraphy of the Baviaanskloof Formation (Table Mountain Group), including the Kareedouw Sandstone Member. South African Committee for Stratigraphy, Lithostratigraphic Series No 12, 6 pp. Council for Geoscience, Pretoria.

HILLER, N. 1980. Lower Devonian fossils in the Kaba Valley. The Eastern Cape Naturalist 24 (3), 25-27.

HILLER, N. 1990. Devonian hyoliths in South Africa, and their palaeoenvironmental significance. Palaeontologia africana 27, 5-8.

HILLER, N. 1992. The Ordovician System in South Africa: a review. In Webby, B.D. & Laurie, J.R. (Eds.) Global perspectives on Ordovician geology, pp 473-485. Balkema, Rotterdam.

HILLER, N. 1995. Devonian chonetacean brachiopods from South Africa. Annals of the South African Museum 104: 159-180.

HILLER, N. & THERON, J.N. 1988. Benthic communities in the South African Devonian. In: McMillan, N.J., Embry, A.F., & Glass, D.J. (Eds.) Devonian of the World, Volume III: Paleontology, Paleoecology and Biostratigraphy. Canadian Society of Petroleum Geologists, Memoir No. 14, pp 229-242.

HOEG, O.A. 1930. A psilophyte in South Africa. Det Kongelige Norske Videnskabers Selskab Forhandlinger Band III (24), 92-94.

ILLENBERGER, W.K. 1992. Lithostratigraphy of the Schelm Hoek Formation (Algoa Group). Lithostratigraphic Series, South African Committee for Stratigraphy, 21, 7 pp. Council for Geoscience, Pretoria.

JELL, P.A. & THERON, J.N. 1999. Early Devonian echinoderms from South Africa. Memoirs of the Queensland Museum 43: 115-199.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape Province. Unpublished PhD thesis, Rhodes University, Grahamstown, xiv + 335 pp, 1pl.

JOHNSON, M.R., THERON, J.N. & RUST, I.C. 1999. Table Mountain Group. South African Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 6: 43-45. Council for Geoscience, Pretoria.

LE ROUX, F.G. 1990. Algoa Group. In: Johnson, M.R. (Ed.) Catalogue of South African Lithostratigraphic Units, 2, 1-2. South African Committee for Stratigraphy. Council for Geoscience, Pretoria.

LE ROUX, F.G. 1992. Lithostratigraphy of the Nanaga Formation (Algoa Group). Lithostratigraphic Series, South African Committee for Stratigraphy, 15, 9 pp. Council for Geoscience, Pretoria.

LE ROUX, F.G. 2000. The geology of the Port Elizabeth – Uitenhage area. Explanation to 1: 50 000 geology sheets 3325 DC & DD, 3425 BA Port Elizabeth, 3325 CD and 3425 AB Uitenhage, 3325 CB Uitenhage Noord and 3325 DA Addo, 55 pp. Council for Geoscience, Pretoria.

LOCK, B.E., SHONE, R., COATES, A.T. & HATTON, C.J. 1975. Mesozoic Newark-type sedimentary basins within the Cape fold belt of southern Africa. 9th International Sedimentological Congress, Nice 4: 217-226.

MACRAE, C. 1999. Life etched in stone. Fossils of South Africa. 305pp. The Geological Society of South Africa, Johannesburg.

MALAN, J.A. & THERON, J.N. 1989. Nardouw Subgroup. Catalogue of South African lithostratigraphic units, 2 pp. Council for Geoscience, Pretoria.

MALAN, J.A., THERON, J.N. & HILL, R.S. 1989. Lithostratigraphy of the Goudini Formation (Table Mountain Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 2, 5pp.

MARCHANT, J.W. 1974. Trace-fossils and tracks in the upper Table Mountain Group at Milner Peak, Cape Province. Transactions of the Geological Society of South Africa 77: 369-370.

MARTIN, A.R.H. 1960. A Mesozoic microflora from South Africa. Nature, London 186, p. 95.

MAUD, R.R. & BOTHA, G.A. 2000. Deposits of the South Eastern and Southern Coasts. Pp. 19-32 *in* Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of Southern Africa. Oxford Monographs on Geology and Geophysics No 40. Oxford University Press. Oxford, New York.

McLACHLAN, I.R. & McMILLAN, I.K. 1976. Review and stratigraphic significance of southern Cape Mesozoic palaeontology. Transactions of the Geological Society of South Africa. 79: 197-212.

McMILLAN, I.K. 1990. A foraminiferal biostratigraphy and chronostratigraphy for the Pliocene to Pleistocene upper Algoa Group, Eastern Cape, South Africa. South African Journal of Geology 93: 622-644.

NEWTON, A.R., SHONE, R.W. & BOOTH, P.W.K. 2006. The Cape Fold Belt. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 521-539. Geological Society of South Africa, Marshalltown.

PETHER, J. 2008. Fossils in dunes and coversands. Palaeontological potential in sand mines. A general information document. Unpublished report for Heritage Western Cape, Cape Town, 4 pp.

OOSTHUIZEN, R.D.F. 1984. Preliminary catalogue and report on the biostratigraphy and palaeogeographic distribution of the Bokkeveld Fauna. Transactions of the Geological Society of South Africa 87: 125-140.

PARTRIDGE, T.C. 1998. Of diamonds, dinosaurs and diastrophism: 150 million years of landscape evolution in Southern Africa. South African Journal of Geology 101:167-184.

PARTRIDGE, T.C. & MAUD, R.R. 1987. Geomorphic evolution of southern Africa since the Mesozoic. South African Journal of Geology 90: 179-208.

PARTRIDGE, T.C. & MAUD, R.R. 2000. Macro-scale geomorphic evolution of Southern Africa. Pp. 3-18 in Partridge, T.C. & Maud, R.R. (eds.) The Cenozoic of Southern Africa. Oxford University Press, Oxford.

PLUMSTEAD, E.P. 1967. A general review of the Devonian fossil plants found in the Cape System of South Africa. Palaeontologia africana 10: 1-83, 25 pls.

PLUMSTEAD, E.P. 1969. Three thousand million years of plant life in Africa. Transactions of the Geoogical Society of South Africa, Annexure to Volume 27, 72 pp, 25 pls.

PLUMSTEAD, E.P. 1977. A new phytostratigraphical Devonian zone in southern Africa which includes the first record of *Zosterophyllum*. Transactions of the Geological Society of South Africa 80: 267-277.

POTGIETER, C.D. & OELOFSEN, B.W. 1983. *Cruziana acacensis* – the first Silurian index-trace fossil from southern Africa. Transactions of the Geological Society of South Africa 86: 51-54.

REED, F.R.C. 1925. Revision of the fauna of the Bokkeveld Beds. Annals of the South African Museum 22: 27-225, pls. 4-11.

RIGASSI, D.A. & DIXON, G.E. 1972. Cretaceous of the Cape Province, Republic of South Africa. Proceedings, Conference on African Geology, Ibadan, Dec. 1970, 513-527.

ROBERTS, D.L. 2003. Age, genesis and significance of South African coastal belt silcretes. Council for Geoscience Memoir 95, 61 pp. Pretoria.

ROBERTS, D.L., BAMFORD, M. & MILLSTEED, B. 1997. Permo-Triassic macro-plant fossils in the Fort Grey silcrete, East London. South African Journal of Geology 100, 157-168.

ROBERTS, D.L., BOTHA, G.A., MAUD, R.R. & PETHER, J. 2006. Coastal Cenozoic deposits. Pp. 605 – 628 *in* Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa. Geological Society of South Africa, Johannesburg & Council for Geoscience, Pretoria.

ROBERTS, D.L., VILVOEN, J.H.A., MACEY, P., NHLEKO, L., COLE, D.I., CHEVALLIER, L., GIBSON, L. & STAPELBERG, F. 2008. The geology of George and its environs. Explanation to 1: 50 000 scale sheets 3322CD and 3422AB, 76 pp. Council for Geoscience, Pretoria.

ROGERS, A.W. 1906. Geological survey of parts of the divisions of Uitenhage and Alexandria, with appendix on Occurrence of the wood beds on Loerie and Gamtoos Rivers. Annual Report of the Geological Commission, Cape of Good GHope for 1905, 11-46, 1 map.

ROGERS, A.W. & DU TOIT, A.L. 1909. An introduction to the geology of the Cape Colony, 491. Longmans, Green and Co., London *etc*.

ROSSOUW, P.J., MEYER, E.I., MULDER, M.P. & STOCKEN, C.G. 1964. Die geologie van die Swartberge, die Kangovallei en die omgewing van Prins Albert, K.P. Explanation to geology sheets 3321B (Gamkapoort) and 3322A (Prins Albert), 96pp, 2 pls. Geological Survey, Pretoria.

RUBIDGE, B.S., DE KLERK, W.J. & ALMOND, J.E. 2008. Southern Karoo Margins, Swartberg and Little Karoo. Palaeontological Society of South Africa, 15th Biennial Meeting, Matjiesfontein. Post-conference excursion guide, 35 pp.

RUST, I.C. 1967a. On the sedimentation of the Table Mountain Group in the Western Cape province. Unpublished PhD thesis, University of Stellenbosch, South Africa, 110 pp.

RUST, I.C. 1967b. Brachiopods in the Table Mountain Series. An advance announcement. South African Journal of Science 63: 489-490.

RUST, I.C. 1981. Lower Palaeozoic rocks of Southern Africa. In: Holland, C.H. (Ed.) Lower Palaeozoic rocks of the world. Volume 3: Lower Palaeozoic of the Middle East, Eastern and Southern Africa, and Antarctica, pp. 165-187. John Wiley & Sons Ltd, New York.

SAHRA 2013. Minimum standards: palaeontological component of heritage impact assessment reports, 15 pp. South African Heritage Resources Agency, Cape Town.

SCHWARZ, E.H.L. 1906. South Africa Palaeozoic fossils. Records of the Albany Museum 1, 347-404, pls. 6-10.

SCOTT, L. 1976a. Palynology of Lower Cretaceous deposits from the Algoa Basin (Republic of South Africa). Pollen et Spores 18(4), 563-609, pls. 1-11.

SCOTT, L. 1976b. Palynology of the Lower Cretaceous deposits (the Uitenhage Series) from the Algoa Basin. Palaeoecology of Africa 7, 42-44.

SEILACHER, A. 2007. Trace fossil analysis, xiii + 226pp. Springer Verlag, Berlin.

SELDEN, P.A. & NUDDS, J.R. 2004. The Soom Shale. Chapter 3, pp. 29-36 *in* Evolution of fossil ecosystems, 160 pp. Manson Publishing, London.

SHONE, R.W. 1986. Field guide to an outcrop of Enon Conglomerate near Andrieskraal, Mesozoic Gamtoos Basin. In Sedplett ’86. Excursion guidebook 21c. Geocongress ’86. Geological Society of South Africa, 38-44.

SHONE, R.W. 2006. Onshore post-Karoo Mesozoic deposits. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 541-552. Geological Society of South Africa, Marshalltown.

SŐHNGE, A.P.G. 1934. The Worcester Fault. Transactions of the Geological Society of South Africa 37, 253-277.

TANKARD, A.J. & BARWIS, J.H. 1982. Wave-dominated deltaic sedimentation in the Devonian Bokkeveld Basin of South Africa. Journal of Sedimentary Petrology 52, 0959-0974.

TANKARD, A., WELSINK, H., AUKES, P., NEWTON, R. & STETTLER, E. 2009. Tectonic evolution of the Cape and Karoo Basins of South Africa. Marine and Petroleum Geology 3, 1-35.

THAMM, A.G. & JOHNSON, M.R. 2006. The Cape Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 443-459. Geological Society of South Africa, Marshalltown.

THERON, J.N. 1972. The stratigraphy and sedimentation of the Bokkeveld Group. Unpublished DSc thesis, University of Stellenbosch, 175pp, 17pls.

THERON, J.N. & LOOCK, J.C. 1988. Devonian deltas of the Cape Supergroup, South Africa. In: McMillan, N.J., Embry, A.F. & Glass, D.J. (Eds.) Devonian of the World, Volume I: Regional syntheses. Canadian Society of Petroleum Geologists, Memoir No. 14, pp 729-740.

THERON, J.N. & JOHNSON, M.R. 1991. Bokkeveld Group (including the Ceres, Bidouw and Traka Subgroups). Catalogue of South African Lithostratigraphic Units 3: 3-5. Council for Geoscience. Pretoria.

THERON, J.N., RICKARDS, R.B. & ALDRIDGE, R.J. 1990. Bedding plane assemblages of *Promissum pulchrum*, a new giant Ashgill conodont from the Table Mountain Group, South Africa. Palaeontology 33: 577-594, 4 pls.

THERON, J.N., WICKENS, H. DE V. & GRESSE, P.G. 1991. Die geologie van die gebied Ladismith. Explanation to 1: 250 000 geology sheet 3320, 99 pp. Council for Geoscience, Pretoria.

TOERIEN, D.K. & HILL, R.S. 1989. The geology of the Port Elizabeth area. Explanation to 1: 250 000 geology Sheet 3324 Port Elizabeth, 35 pp. Council for Geoscience, Pretoria.

VAN SCHALKWYK, L. & WAHL, E. 2012. Phase 1 Heritage Impact Assessment Report: 132kV Power Line and Substation Infrastructure, Patensie to Kareedouw, Kouga Local Municipality, Cacadu District Municipality, Eastern Cape Province, South Africa, 44 PP. Ethembeni Cultural Heritage, Pietermaritzburg, South Africa.

VILJOEN, J.H.A. & MALAN, J.A. 1993. Die geologie van die gebiede 3421 BB Mosselbaai en 3422 AA Herbertsdale. Explanation to 1: 50 000 geology sheets 3422AA and 3421BB, 79 pp. Council for Geoscience, Pretoria.

YOUNG, G.A., RUDKIN D.M., DOBRZANSKI, E.P., ROBSON, S.P. & NOWLAND, G.S. 2007. Exceptionally preserved Late Ordovician biotas from Manitoba, Canada. Geology 35, 883-886.

8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed transmission line 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.

Dr John E. Almond
Palaeontologist, *Natura Viva* cc

APPENDIX: GPS LOCALITY DATA FOR NUMBERED SITES LISTED IN TEXT

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

Location number	South	East	Comments
052	S33 58 12.2	E24 47 04.2	R330 road cutting through Goudini Fm overlain by ferruginous and silicified colluvial gravels
053	S33 56 30.2	E24 48 05.7	R330 road cutting nr Weltevrede through Goudini Fm, partially tectonised, possible contact with Cederberg Fm at base
054	S33 56 20.3	E24 47 56.0	R330 road cutting nr Weltevrede through highly weathered Cederberg Fm capped by ferricrete and soils
085	S33 57 19.2	E24 45 40.2	Borrow pit into highly weathered Cederberg Fm along R332 to NW of Swartbosch Quarry
086	S33 56 57.5	E24 45 13.8	Thick ferruginous surface gravels along R332
087	S33 56 23.4	E24 48 04.6	R330 road cutting nr Weltevrede through Goudini Fm, partially tectonised, possible contact with Cederberg Fm at base
088	S33 56 06.5	E24 48 14.1	Coarse rubbly, ferruginsed High Level Gravels (Grahamstown Fm) overlying weathered Table Mountain Group, R330 road cutting NE of Weltevrede
089	S33 54 09.6	E24 49 42.1	Deeply weathered, cleaved Ceres Subgroup capped by reddish soils, R330 road cutting near Suurbron
090	S33 53 48.2	E24 49 52.6	Baviaanskloof wackes with subordinate interbeds of weathered mudrock, R330 road cutting E of Suurbron
091	S33 53 32.1	E24 50 01.4	Ceres Subgroup showing crenulation cleavage, R330 towards top of Hankey Pass
092	S33 53 23.3	E24 50 08.6	Well-bedded stream alluvium in road cutting, R330 towards top of Hankey Pass
092a	S33 53 18.9	E24 50 09.9	Cleaved Ceres Subgroup mudrocks, R330 road cutting in Hankey Pass
093	S33 53 05.0	E24 50 23.1	Enon road cutting, R330 in Hankey Pass
094	S33 52 57.8	E24 50 27.2	Enon road cutting, R330 in Hankey Pass
095	S33 52 25.8	E24 51 06.0	Enon road cutting, R330 in Hankey Pass
096	S33 52 10.0	E24 51 13.9	Large quarry into Enon Formation, Hankey Pass
097	S33 51 01.4	E24 52 08.4	Cobbly alluvium of Gamtoos River near Weston, bottom of Hankey Pass
098	S33 47 04.8	E24 50 44.2	Kirkwood Formation road cutting, R331 SE of Patensie
099	S33 47 05.1	E24 50 52.4	Kirkwood Formation road cutting, R331 SE of Patensie
100	S33 47 05.9	E24 51 02.6	Kirkwood Formation road cutting, R331 SE of Patensie
101	S33 47 05.5	E24 51 04.4	Kirkwood Formation road cutting, R331 SE of Patensie
102	S33 46 58.2	E24 49 33.0	Silty alluvium of Gamtoos River, nr Gonnakop, south of Patensie