Palaeontological heritage specialist report: combined desktop and field-based study

COMBINED PROJECT AREA FOR THE GREAT KAROO RENEWABLE ENERGY CLUSTER (ANGORA WIND FARM, MERINO WIND FARM, NKU, MORIRI & KWANA SOLAR PV FACILITIES) NEAR RICHMOND, PIXLEY KA-SEME DISTRICT, NORTHERN CAPE PROVINCE AND ASSOCIATED GRID CONNECTIONS TO THE GAMMA MTS NEAR HUTCHINSON

John E. Almond PhD (Cantab.)
***Natura Viva* cc**
76 Breda Park, Breda Street, Oranjezicht
Cape Town 8010, RSA
naturaviva@universe.co.za

December 2021

EXECUTIVE SUMMARY

Great Karoo Renewable Energy (Pty) Ltd is proposing to develop a cluster of commercial renewable energy facilities and associated infrastructure, to be known as Great Karoo Renewable Energy (GKRE), approximately 35km south-west of Richmond. The cluster comprises the adjoining **Angora Wind Farm**, **Merino Wind Farm** as well as the **Nku (PV1)**, **Moriri (PV2)** and **Kwana (PV3) Solar PV Facilities**, to be situated within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province

Fluvial to lacustrine sedimentary bedrocks of Late Permian Teekloof Formation (Lower Beaufort Group, Karoo Supergroup) in the combined GKRE and grid connection project areas are generally poorly exposed and have been thermally metamorphosed by a dense network of Early Jurassic dolerite intrusions. The Teekloof Formation sediments here have yielded very sparse, low-diversity and generally poorly preserved fossil assemblages of the *Endothiodon* and *Cistecephalus* Assemblage Zones. These fossils record the aftermath and full recovery of continental biotas of southern Gondwana from the major End Guadalupian Mass Extinction Event of ~260 million years ago (Ma).

Fossil specimens recorded from the Teekloof Formation bedrocks during a 3-day site visit to the combined GKRE and grid connection project areas mainly comprise a handful of scrappy therapsid cranial and post-cranial material. The only specimens of potential scientific or conservation interest are several skeletal elements of a small-bodied pareiasaur reptile - possibly a juvenile or dwarf taxon. Almost all the other specimens are fragmentary and very poorly preserved due to thermal metamorphism and metasomatism (*i.e.* alteration through secondary mineralisation and dissolution by hot circulating groundwaters) during dolerite intrusion. Thick deposits of Late Caenozoic, semi-consolidated alluvium might contain important assemblages of Plio-Pleistocene mammalian fossils (*e.g.* horn cores, bones and teeth) as well as reworked petrified wood and trace fossils (*e.g.* calcretised termitaria). However, the only fossils recorded here comprise assemblages of subvertical, calcretised rhizoliths (plant root casts) in riverbank settings. Voluminous, doleritic and quartzitic colluvial rock rubble mantling the steeper mountain slopes as well as younger alluvial sands and gravels mantling extensive *vlaktes* within the project area are unlikely to be fossiliferous.

A high proportion of the WEF infrastructure will be placed along upland ridges underlain by unfossiliferous intrusive dolerite and low palaeosensitivity, thermally metamorphosed Lower Beaufort Group sediments. The solar PV project areas are focused on low relief terrain that is mantled by low palaeosensitivity Late Caenozoic sediments (alluvial sands, gravels, soils) with little or no exposure of potentially fossiliferous sedimentary bedrocks. Most of the main grid connection corridor to Gamma MTS is also floored by thick, sandy to gravelly alluvium or dolerite; limited areas of sedimentary bedrock exposure here are strongly baked with few or almost no well-preserved fossils. No palaeontological Very High Sensitivity / No-Go areas have been identified within the GKRE and grid connection project areas. With the exception of two fossil sites of low scientific value, none of the recorded fossil sites overlaps directly with, or lies close to (< 20 m), the proposed WEF and solar PV project footprints and no modification of the layouts through micro-siting is proposed here on palaeontological grounds. While a number of fossil sites are recorded within the main grid connection corridor, none is of conservation significance while most of the sites are already protected within standard ecological buffer zones along drainage lines. Mitigation of the known fossil sites within the GKRE and grid connection project areas is therefore not proposed here.

Most of the proposed renewable energy project infrastructure - including wind turbines, laydown areas, underground cables, access and internal distribution roads, electrical pylons, solar panel arrays, on-site substations, BESS, site office and maintenance buildings, concrete batching plant *etc* - will overlie unfossiliferous dolerite or metamorphosed bedrocks and geologically recent superficial deposits of low palaeosensitivity. The anticipated impact significance of the proposed WEF and solar PV projects in terms of palaeontological heritage resources is likely to be VERY LOW due to (1) the very sparse distribution of fossil remains as well as (2) their almost universally poor preservation. Given the very uniform geological, and hence palaeontological, setting throughout the combined project areas, this assessment applies equally to all the proposed WEF, solar PV and grid connection projects as well as to the various grid connection corridors under consideration. There is accordingly no preference on palaeontological heritage grounds for any particular grid connection route option. The proposed renewable energy projects and grid connections are not fatally flawed from a palaeontological heritage viewpoint and there are no objections to their authorisation.

All the fossil sites recorded so far could, if necessary, be effectively mitigated through specialist palaeontological collection and recording of associated geological data, and this is likely to be the case for the great majority of any unrecorded fossil sites encountered in the pre-construction or construction phases as well. The potential for rare, unrecorded fossil sites of high scientific and/ or conservation value cannot be completely excluded, however. These are best handled through a Chance Fossil Finds Protocol driven by the responsible environmental site officers and ECO, as outlined in Appendix 3. Pending the discovery of significant new fossil remains, no further specialist palaeontological studies or mitigation are recommended for the GKRE and grid connection projects. Should specialist palaeontological mitigation be triggered by significant Chance Fossil Finds, the palaeontological specialist involved will need to submit an application for a Fossil Collection Permit (SAHRA) or Work Plan (HWC) to the relevant Provincial Heritage Resources Agency. The palaeontological studies should conform to international best practice for palaeontological fieldwork and adhere as far as possible to the minimum standards for palaeontological heritage studies developed by SAHRA (2013) and HWC (2021). The palaeontological assessment reports must be submitted for consideration to the responsible Provincial Heritage Resources Agency.

1. INTRODUCTION

1.1. Project outline and brief

The company Great Karoo Renewable Energy (Pty) Ltd is proposing to develop a cluster of commercial renewable energy facilities and associated infrastructure, to be known as Great Karoo Renewable Energy (GKRE), on a site located approximately 35km south-west of Richmond and 80km south-east of Victoria West. The proposed cluster comprises the adjoining **Angora Wind Farm**, **Merino Wind Farm** as well as the **Nku (PV1)**, **Moriri (PV2)** and **Kwana (PV3) Solar PV Facilities**, to be situated on the following land parcels within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province (Fig. 1):

- Portion 11 of Farm Gegundefontein 53
- Portion 0 of Farm Vogelstruisfontein 84
- Portion 1 of Farm Rondavel 85
- Portion 0 of Farm Rondavel 85
- Portion 0 of Farm Rondavel 85
- Portion 9 of Farm Bult
- Rietfontein 96

Detailed descriptions for each Great Karoo Renewable Energy project, listing land parcels concerned and key infrastructural components, are provided in Appendix 1. Grid connection infrastructure associated with each of the renewable energy projects will include a 132kV on-site substation and a 132kV overhead power line connecting with the existing Gamma Main Transmission Substation (MTS) near Hutchinson, located *c*. 25 km to the southwest of the core GKRE project area. Grid connection corridor route options under consideration are indicated in yellow and blue in Figure 1. It is noted that the grid corridors lie entirely within the Northern Cape, apart from a very short (< 500 m) sector just east of Gamma Substation.

Since the GKRE renewable energy projects fall outside of a gazetted Renewable Energy Development Zone (REDZ), a full Scoping & EIA process is required for the wind farm and solar PV facilities while BA processes are being undertaken for the associated grid connections.

The proposed GKRE and grid connection project area is underlain by potentially fossiliferous sedimentary rocks of Late Permian and Late Caenozoic age (Sections 2 and 3). The construction phase of the renewable energy and grid developments will entail substantial surface clearance as well as excavations into the bedrocks and superficial sediment cover (*e.g.* for wind turbine footings, laydown areas, underground cables, substation and building foundations, internal and transmission line access roads, electrical pylon footings). All these activities may adversely affect potential fossil heritage preserved at or beneath the surface of the ground within the study area by destroying, disturbing or permanently sealing-in fossils which are then no longer available for scientific research or other public good.

The present combined desktop and field-based palaeontological heritage report will contribute to the separate broad-based heritage assessments (HIAs) of all the component projects for the GKRE and grid connections that are being compiled by CTS Heritage, Cape Town (Contact details: Ms Jenna Lavin. CTS Heritage. 16 Edison Way, Century City, RSA. Tel: +27 (0)87 073 5739. Cell: +27 (0)83 619 0854. E-mail: info@ctsheritage.com).

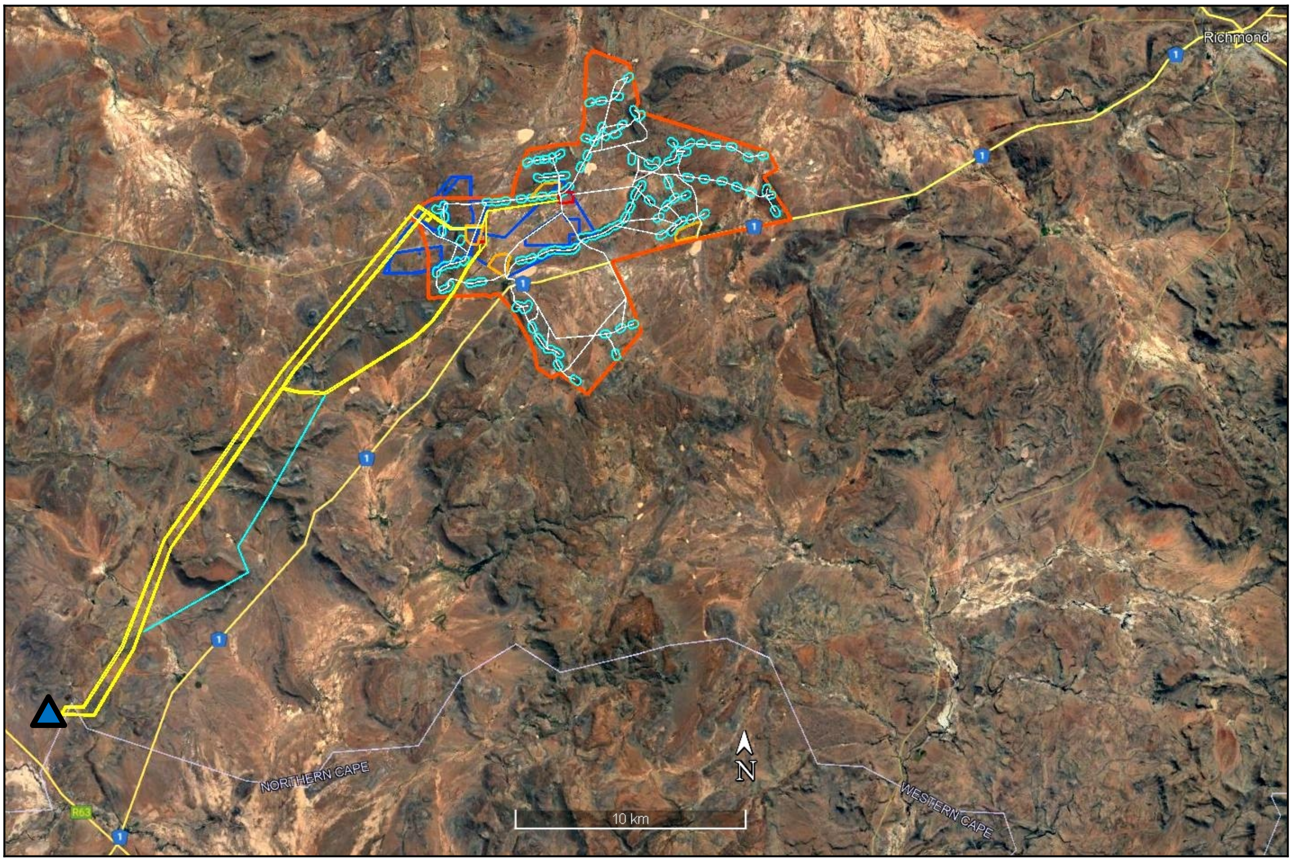


Figure 1: Google Earth© satellite image showing the location (orange polygon) of the combined project areas for the Great Karoo Renewable Energy cluster of projects near Richmond, Pixley-ka-Seme District, Northern Cape Province (WEF project areas outlined in orange; solar PV project areas outlined in dark blue). The 132 kV grid connection corridor options to the existing Gamma MTS near Hutchinson (blue triangle) are shown in yellow and pale blue. The combined GKRE and grid project area lies to the north of the N1 and almost entirely within the Northern Cape Province, except for a very short sector of grid corridor just east of the Gamma MTS.

1.2. Legislative context for palaeontological assessment studies

All palaeontological heritage resources in the Republic of South Africa are protected by the National Heritage Resources Act (Act 25 of 1999). Heritage resource management in the Western Cape is the responsibility of Heritage Western Cape (HWC) (3rd Floor, Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 021 483 9598. Fax: 021 483 9845. E-mail: hwc.hwc@westerncape.gov.za). For the Northern Cape Province the responsible body is SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za).

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (Act 25 of 1999) 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 Agency.

(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 agency, or to the nearest local agency offices or museum, which must immediately notify such heritage resources Agency.

(4) No person may, without a permit issued by the responsible heritage resources agency—

(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 agency 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 agency 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 been published by SAHRA (2013) and Heritage Western Cape (2021).

1.3. Approach to the palaeontological heritage study (PIA)

The approach to this palaeontological heritage study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images. Known fossil heritage in each rock unit is inventoried from scientific literature, previous PIA assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc.*) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to a development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008a, 2008b).

The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned, and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present and exposed within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

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 are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and judicious sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management Agency (*i.e.* Heritage Western Cape for the Western Cape, SAHRA for the Northern Cape). It should be emphasized that, *provided that appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

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. A Karoo fossil vertebrate database is now accessible for impact study work.

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 present case, site visits to the various loop and borrow pit study areas in some cases considerably modified our understanding of the rock units (and hence potential fossil heritage) represented there.

In the case of the present study area near Richmond the main constraint for fossil heritage studies is the very limited surface exposure of *unmetamorphosed*, potentially fossiliferous bedrocks (especially readily-weathered mudrocks) due to (1) the extensive dolerite intrusion which has thermally metamorphosed more or less all the sedimentary country rocks in the region as well as (2) the, in part related, very high levels of cover by superficial sediments such as colluvium (scree), eluvial gravels and alluvium. For the same reasons, there has been very little academic palaeontological work in this particular sector of the Main Karoo Basin. However, this is partially offset by the long (> 100 years) history of scientific fossil collection in comparable bedrock successions within the wider Victoria West region such as the Noblesfontein area, some 20 km west of Gamma Substation (see Day & Rubidge 2020a and the recent PIA report by Almond 2021). Despite these limitations, a sufficient number of reasonably informative exposures of bedrock and superficial sedimentary rock units were examined during the course of the present field survey, so confidence levels for this assessment are rated as Medium.

1.5. Information sources

The information used in this combined desktop and field-based palaeontological study was based on the following:

1. A short project outline, heritage screener reports, geological maps, palaeosensitivity maps and kmz files provided by CTS Heritage, Cape Town;
2. A review of the relevant scientific literature (especially Day & Rubidge 2020 and refs. therein), including published geological maps and accompanying sheet explanations (*e.g.* Le Roux & Keyser 1988) as well as several desktop and field-based palaeontological assessment studies in the broader Victoria West region of the Northern Cape by the author and others (*e.g.* Almond 2010a-b, 2012a-c, 2013c, 2015a-b, 2021, Rossouw 2011);
3. Examination of relevant topographical maps (*e.g.* 1: 250 000 sheet 3122 Victoria West, 1: 50 000 sheets 3123DA Ouplaas, 3123BC Bokfontein & 3123CB Bulberg) and Google Earth© satellite images;
4. A three-day palaeontological site visit by the author (28 November to 30 November 2021) which focussed on a representative sample of potentially-fossiliferous exposures of bedrock units (especially mudrock exposures) and older - probably Pleistocene - alluvial deposits within the broader GKRE and grid conection project areas. Note that

the survey did *not* focus on proposed turbine positions, many of which are situated on unfossiliferous dolerite or thermally-metamorphosed sediments, since these do not constitute the most important potential threat to local fossil heritage resources. Due to time and access constraints, most of the Option 3 and Option 6 grid corridors were *not* surveyed. However, based on satellite imagery and geological maps, these corridors have a very similar geology to those surveyed, which are all of Low to Very Low palaeosensitivity, so this omission does not seriously undermine the conclusions reached here.

5. The author's previous field experience with the formations concerned and their palaeontological heritage (See also reviews of Western and Northern Cape fossil heritage by Almond & Pether 2008a and 2008b respectively.

2. GEOLOGICAL OUTLINE OF THE STUDY AREA

The combined GKRE and grid connection project area between Richmond and Hutchinson near Victoria West is situated just to the north of the N1 trunk road within the semi-arid Upper Karoo region of the Northern Cape Province (Fig. 1). It features scenically attractive, dissected, mountainous to hilly terrain with numerous low, rocky doleritic ridges and *koppies*, stepped surfaces and low *kranzes* of sandstone, rubbly alluvial fans and intervening extensive, gravelly to sandy *vlaktes* or alluvial plains (Figs. 2 to 14). The vegetation here is typical karroid *bossieveld*, often grassy in doleritic areas, and trees are largely restricted to intermittently-flowing watercourses. The dolerite ridges reach elevations of up to 1464 m amsl. while higher points within the wider region – many capped by dolerite - include Blouberg (1563 m amsl), Bloukop (1480) and Platberg (1456). Drainage in the region is complex and often internal, largely due to interruptions by the network of resistant doleritic intrusions which are often associated with springs, as suggested by several local farms names. There are no major water courses. Shallow, intermittently-flowing tributary streams feed into the Ongersrivier towards the NE, the Brakpoortrivier to the NW and, *via* the more deeply incised Burgerspruit, into the Brakrivier to the south. While dolerite intrusions are well-represented, exposure levels of sedimentary bedrocks - especially as far as the potentially fossiliferous mudrocks are concerned - are usually low to very low. This is due to extensive, thick alluvial sands and gravels in the lower-lying areas *plus* colluvium (scree) and eluvial (downwasted / relictual) gravels of dolerite and metasediments on steeper hillslopes and their marginal alluvial fans. Good, but generally small, exposures of potentially fossiliferous mudrocks are mainly located along drainage lines (*e.g.* Burgerspruit), on several steep, gullied hillslopes and in farm dams; they are often indicated by dark grey areas on satellite images but these may be deceptive (Figs. 21, 23, 33 to 37).

Figure 2: The elongate, sinuous Bakenskop dolerite ridge that runs between Rondawel and Vogelstruisfontein farmsteads, seen from the N1, with a low scarp capped by pale yellow, baked channel sandstones in the middle ground – possibly within the Poortjie Member.

Figure 3: Rugged terrain featuring small, rubbly dolerite *koppies* to the NW of Vogelstruisfontein farmstead.

Figure 4: Extensive alluvial *vlaktes* with little or no Beaufort Group bedrock exposure and ringed by dolerite ridges, as here on Vogelstruisfontein 84, are an important landscape element in the GKRE project area.

Figure 5: Common appearance of pale yellowish, baked Beaufort Group channel sandstone horizons along flanks of ridges where they are usually overwhelmed by doleritic colluvium with little or no mudrock exposure, Farm Rondavel 85.

Figure 6: Exposures of Beaufort Group mudrocks in lower-lying areas are mainly confined to shallow erosion gullies and occasional borrow pits, as here on Rondavel 85.

Figure 7: Low hills with gentle slopes (middle ground) built of baked Beaufort Group metasediments in the Miedkop area on the border between Vogelstruisfontein 84 and Gegundefontein 53. Note angular, quartzitic surface rubble in the foreground.

Figure 8: Flat terrain in the PV1 project area on Gegundefontein 53 with bedrocks entirely obscured by sandy alluvial soils, sparse surface gravels and low *bossieveld* vegetation.

Figure 9: Escarpment featuring pale yellow baked channel sandstones of the Balfour Formation capped by a rusty-brown dolerite sill, viewed southwards from the main grid corridor on Farm 96.

Figure 10: View south-westwards along the main grid connection corridor on Nieuwefontein 89 showing an extensive blanket of rubbly quartzitic surface gravels in this upland area.

Figure 11: Main grid connection corridor just north of Blouberg showing considerable range in elevation between rocky dolerite ridges in the foreground and low-relief alluvial *vlaktes* in the middle ground. The latter are flanked by occasional prominent *koppies* of Beaufort Group bedrock such as Blouberg on the left.

Figure 12: View from the main grid corridor on Farm 92 looking south-eastwards towards the dolerite-capped Platberg with an unnamed, moderately incised, sandy stream valley on the right.

Figure 13: The south-eastern slopes of Platberg, seen from the N1, showing a low *krans* of Poortjie Member channel sandstone towards the base, inclined, pale, baked sandstones higher up and a dolerite sill capping the summit plateau. The hillslopes are largely mantled by rusty-brown doleritic colluvium. One of the alternative grid connection corridor options (blue line in Figure 1) traverses these slopes but in such terrain is unlikely to have any substantial impact on fossiliferous bedrocks.

Figure 14: Most grey areas on satellite images of the south-western sector of the main grid connection corridor feature weathered, baked surface shale or crumbly mudrock overlying alluvial soils with no good exposure of potentially fossiliferous bedrock, as seen here on Farm 93.

The geology of the GKRE and grid connection project areas is outlined on the 1: 250 000 geology sheet 3122 Victoria West (Fig. 15) with a short accompanying sheet explanation by Le Roux & Keyser (1988). The project area is almost entirely underlain by Late Permian continental sediments of the **Lower Beaufort Group** (Adelaide Subgroup, Karoo Supergroup) (Johnson *et al.* 2006) (Figs. 19 to 37). According to the published geological map three subunits or members of the **Teekloof Formation** are represented within the combined project area, namely the basal sandstone-dominated **Poortjie Member** (**Ptp**), the overlying mudrock-dominated **Hoedemaker Member** (**Pth**) as well as the following sandstone package assigned to the **Oukloof Member** (See stratigraphic tables in Figs. 16 & 17). In addition, mudrocks of the **Steenkampsvlakte Member** build the summit slopes of Bloukop, close to but outside the main grid connection project area (Fig. 19). The mapping of the various Teekloof Formation members in the Richmond – Victoria West region and the associated biostratigraphy remain somewhat equivocal (*cf* Day & Rubidge 2020, Almond 2021). For some reason, the Oukloof and Steenkampsvlakte Members in or close to the study area are currently mapped within the **Balfour Formation** (**Pb**, dark green in Fig. 15) which normally occurs east of 24° East.

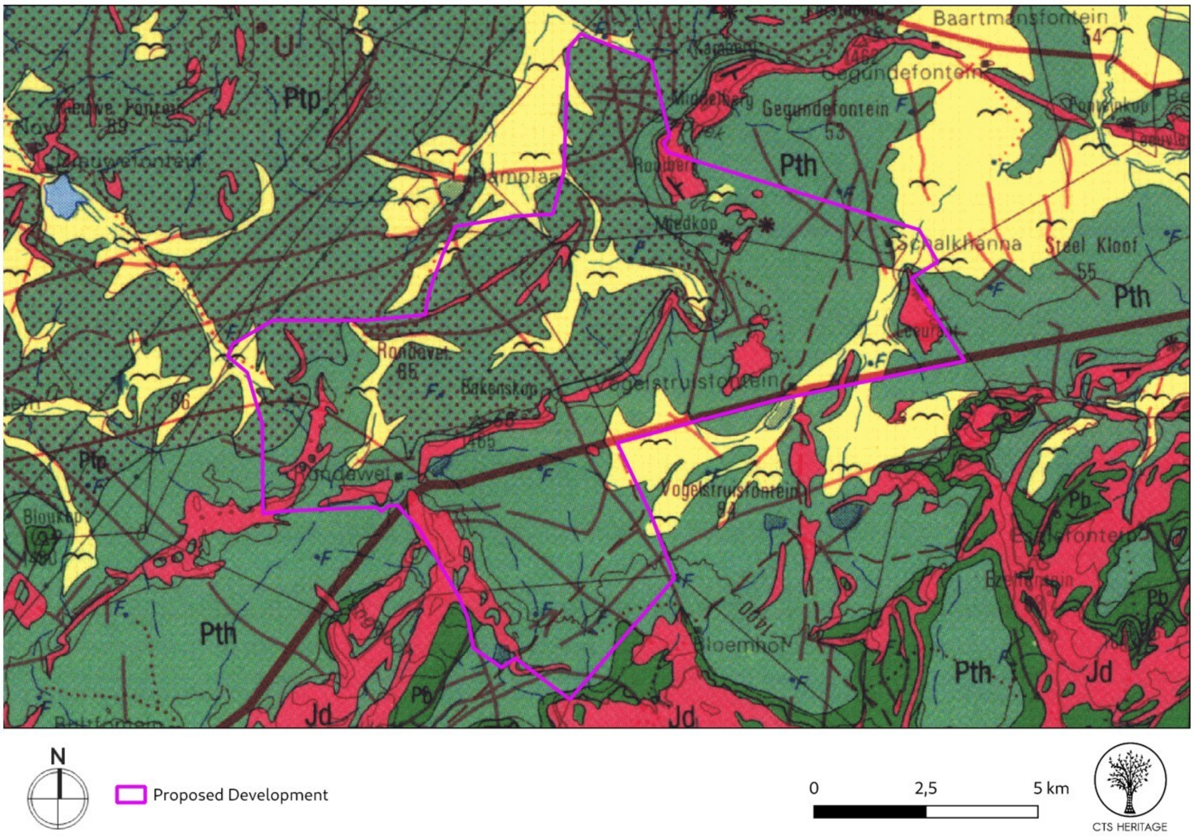
Yellow-weathering channel sandstones of the Poortjie Member are well exposed on the lower slopes of Blouberg and build low-lying sandstone plateaux and their fringing escarpments close to the N1 (*e.g.* Fig. 2). The more readily-weathered Hoedemaker Member is mapped in the low-relief *vlaktes* in the eastern and southern sectors of the GKRE project area as well as along the majority of the grid connection project area, but here its outcrop area appears to be exaggerated. Sandstone-rich scarps on or just outside the southern margins of the GKRE project area are assigned to the Oukloof Member ("Balfour Formation") and are also well seen on the lower slopes of Bloukop as well as capping the escarpment to the south (*e.g.* Farm 96) (Figs. 9. 19 & 25). It is likely that the Oukloof Member outcrop afea is much more extensive than mapped.

The Late Permian sedimentary country rocks are very extensively intruded, thermally metamorphosed (baked) as well as metasomatised (altered by hot subterranean fluids) by a network of substantial dolertic sills and dykes of the Early Jurassic **Karoo Dolerite Suite** (Jd) (Duncan & Marsh 2006) (Figs. 2, 38 to 40). The intrusions are themselves unfossiliferous and underlie large portions of the proposed GKRE project and grid connection project areas (*cf* rusty-brown areas in satellite images, Fig. 1). The Karoo dolerites are a major component of the Karoo Large Igneous Province (KLIP) dated to *c*. 183 Ma. An interesting recent account of nested or stacked, saucer-shaped sill complexes and associated funnel-shaped feeders in the Victoria West region has been provided by Coetzee (2020) (See also Chevallier & Woodford 1999; Fig. 18). An earlier phase of sill complex intrusion at 184-180 Ma at shallow depths (*c*. 500 to 2000 m below surface) under a compressive stress regime was followed by intrusion of dyke swarms around 182-174 Ma in the context of crustal tension preceding Gondwana break-up.

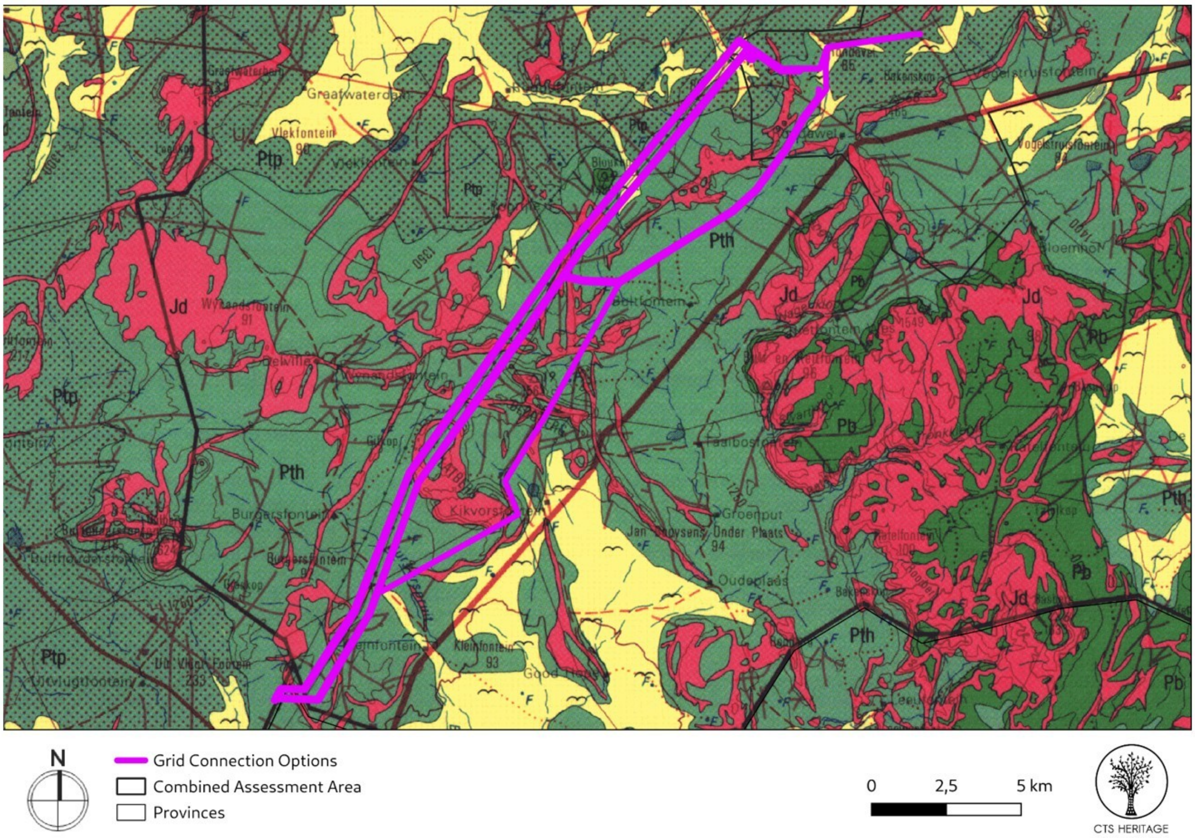
Various types of **superficial deposits** of Late Caenozoic (Miocene / Pliocene to Recent) age mantle most of the Lower Beaufort Group sediments and intrusive dolerite bedrocks in the present study area (Figs. 41 to 48). They include pedocretes (*e.g*. calcrete hardpans and veins), voluminous colluvial slope deposits dominated by quartzite, hornfels and dolerite scree, sheet wash deposits, sandy to gravelly river channel alluvium and soils, as well as spring and pan sediments (Johnson & Keyser 1979, Le Roux & Keyser 1988, Cole *et al.,* 2004, Partridge *et al*. 2006).

The geology of most of these rock successions has been outlined in a recent field-based PIA report for the Victoria West region by Almond (2012). Representative or unusually good exposures of the various igneous and sedimentary rock units within the present GKRE and grid connection project area are provided in Figures 19 to 48 below, together with explanatory figure legends.

Figure 15 (following page): Extracts from 1: 250 000 geology sheet 3122 Victoria West showing the outline of the combined GKRE project area (wind and solar PV projects) above and the grid connection project area below (lilac polygons) (Base map published by the Council for Geoscience, Pretoria. Images prepared by CTS Heritage, Cape Town). The main rock units represented here include:
Ptp (middle green with stipple) = Middle to Late Permian Poortjie Member, Teekloof Formation (Adelaide Subgroup).
Pth (middle green without stipple) = Late Permian Hoedemaker Member, Teekloof Formation (Adelaide Subgroup).
Pb (middle green without stipple) = Late Permian Balfour Formation (Adelaide Subgroup) – but here mainly involving the basal sandstone package of the Oukloof Member (Teekloof Formation).
Jd (red) = sills and dykes of the Early Jurassic Karoo Dolerite Suite.
Pale yellow with flying bird symbol = Late Caenozoic (Neogene / Pleistocene to Recent) alluvium.
***N.B.* The mapping of the various stratigraphic subunits of the Lower Beaufort Group shown here is currently contested and may require considerable revision in future, based on detailed field mapping and collection of additional biostratigraphic data. In particular, the Hoedemaker Member outcrop area has probably been underestimated while sandstone packages of the overlying Oukloof Member might be present at higher elevations in the south.**



Baartmansfontein
Gegundefontein
Pth
Ptp
Jd
Pb
Vogelstruisfontein
Bloemhof
N
Proposed Development
0
2,5
5 km
CTS HERITAGE



Ptp
Pth
Jd
Pb
N
Grid Connection Options
Combined Assessment Area
Provinces
0
2,5
5 km
CTS HERITAGE

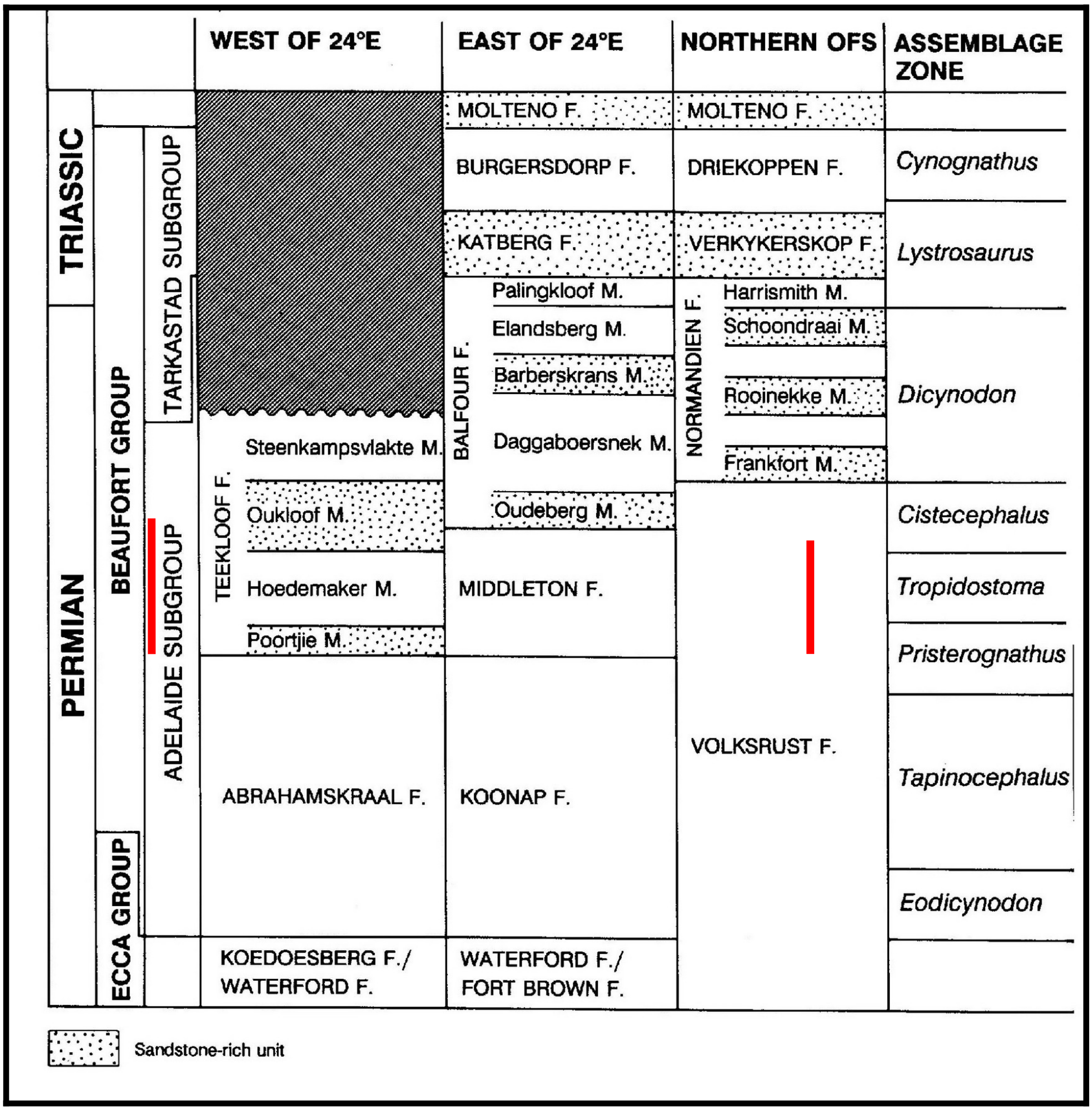


Figure 16: Stratigraphy and biostratigraphic zonation of the Beaufort Group of the Main Karoo Basin (From Rubidge (ed.) 1995). The vertical red lines indicate the Lower Beaufort subunits and fossil assemblage zones that are represented in the GKRE and grid connection project areas. However, the mapping of these subunits may require future revision while the precise, and apparently anomalous, relationship between the lithostratigraphy and successive fossil assemblages in the area south of Victoria West is currently unclear (*cf* Day & Rubidge 2020). Note that the *Pristerognathus* and *Tropidostoma* Assemblage Zones (AZ) have recently been combined within a redefined *Endothiodon* AZ (see following figure).

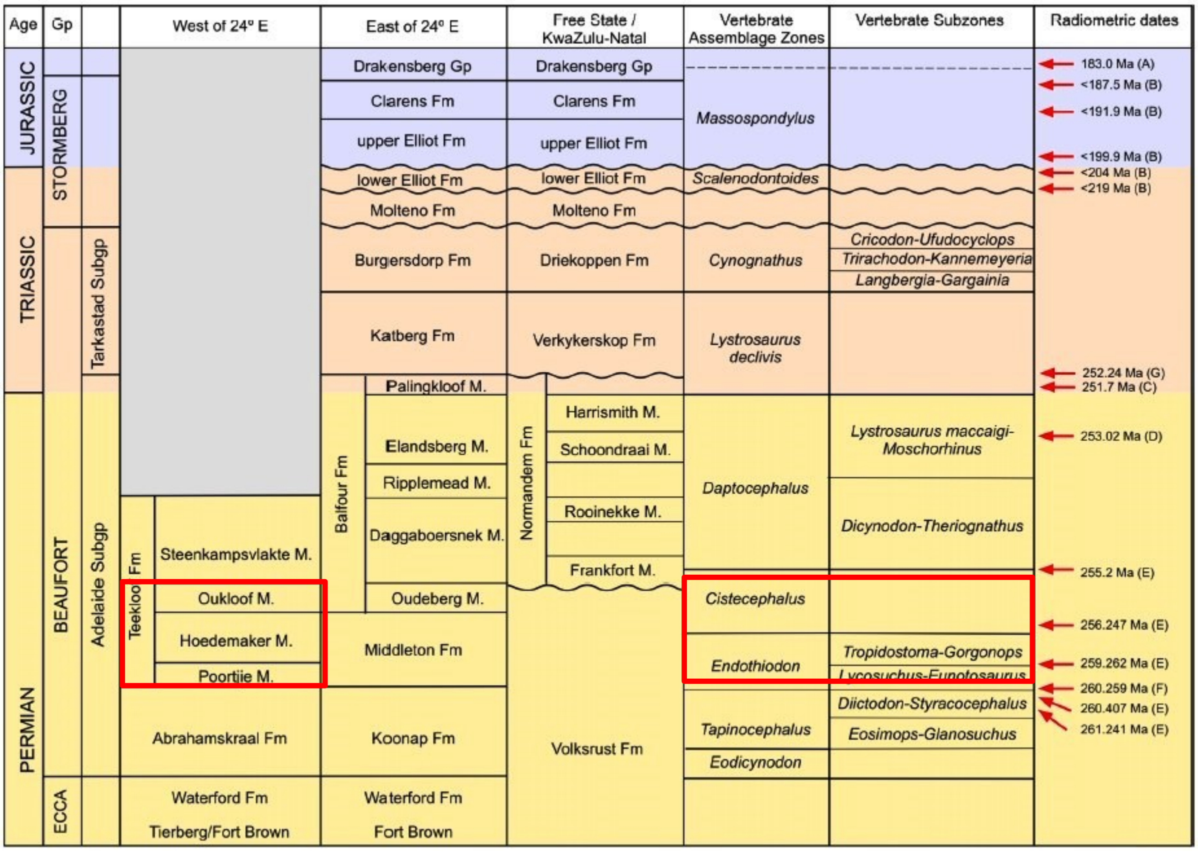


Figure 17: Revised biostratigraphic zonation of the Karoo Supergroup in the Main Karoo Basin (from Smith et al. 2020). Rock units and assemblage zones represented in the present project areas are outlined in red. *N.B.* Lower Beaufort Group sediments in the present project area (just west of 24° E) are conventionally assigned to the Teekloof Formation and dated between 260 to 255 Ma but have been assigned in part to the Balfour Formation on the published 1: 250 000 geological map (See Figs. ** and **).

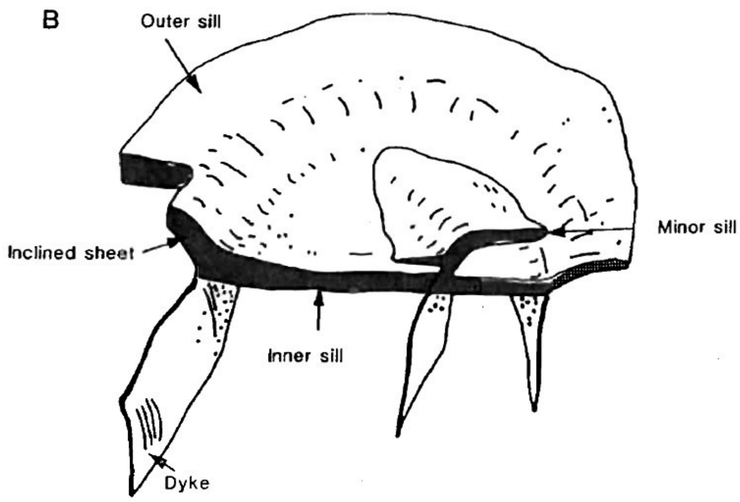


Figure 18: Reconstruction of the complex, saucer-shaped geometry of many Early Jurassic dolerite sills and associated feeder dykes of the Karoo Dolerite Suite, as well seen in the Victoria West region (from Chevallier & Woodford 1999). Stacked sets of sills, younging downwards, have been recorded here.

Figure 19: Upper portion of the Lower Beaufort Group stratigraphic succession in the study region near Richmond, as seen in the slopes of Bloukop (Farm Nieuwefontein 89), just NW of the main grid connection corridor, *viz*: the upper Teekloof Formation comprising the Oukloof Member sandstone package overlain by mudrocks of the Steenkampsvlakte Member. The latter, characterised by *Dicynodon* AZ fossil assemblages, does not occur within the present project footprint, however.

Figure 20: Lower portion of the Lower Beaufort Group (Teekloof Formation) stratigraphic succession in the study region near Richmond as seen in the slopes of Blouberg (Farm Wynandsfontein 91), just SE of the main grid connection corridor, *viz:* Poortjie Member sandstone package overlain by mudrocks and thin channel sandstones of the Hoedemaker Member, capped here by a dolerite sill.

Figure 21: Reasonably good exposure of dusky purple-brown mudrock facies of the Poortjie Member close to the main grid connection corridor on the lower slopes of Blouberg, Burgers Fontein 92.

Figure 22: Low exposure of Teekloof Formation mudrocks - mapped within the Poortjie Member - showing horizons of weathered-out, pedogenic ferruginous calcrete concretions, *vlaktes* on Gegundefontein 53. Isolated fragments of ferruginised rolled bone have been recorded in such settings (Figure 65).

Figure 23: Heterolithic package of tabular, thin-bedded sandstones and pedocrete-rich mudrocks exposed in the bed of the Burgerspruit, Burgersfontein 92 (Hammer = 30 cm). Unusually good mudrock exposures here have yielded several fragmentary and baked vertebrate fossils (Figs. 61 & 62). These beds are mapped within the Hoedemaker Member but may belong to the Poortjie Member.

Figure 24: Golden-brown, tabular channel sandstone horizons of the Poortjie Member on the eastern side of the main grid connection corridor northwest of Platberg, Burgers Fontein 92.

Figure 25: Dolerite-capped escarpment just outside the south-western margins of the GKRE project area. The sandstone package is probably the Oukloof Member of the Teekloof Formation (or alternatively the Oudeberg Member at the base of the Balfour Formation; see map Fig. 15). Note the limited exposure of potentially fossiliferous mudrocks here.

Figure 26: Thin *krans* of well-jointed, blocky-weathering, quartzitic channel sandstone on Vogelstruisfontein 84 with a higher-lying dolerite sill in the background.

Figure 27: Low ridge of tough, vuggy quartzite - a baked channel sandstone - running across the extensive *vlaktes* on Gegundefontein 53.

Figure 28: Thick breccia of reworked mudflakes and calcrete (now represented as voids due to metasomatic dissolution during dolerite intrusion) at the base of a channel sandstone at the southern end of the Rooiberg ridge on Gegundefontein 53 (Hammer = 30 cm). Unbaked Beaufort Group channel breccias often contain transported fragments of bone and teeth but, if originally present, they have probably been dissolved away here.

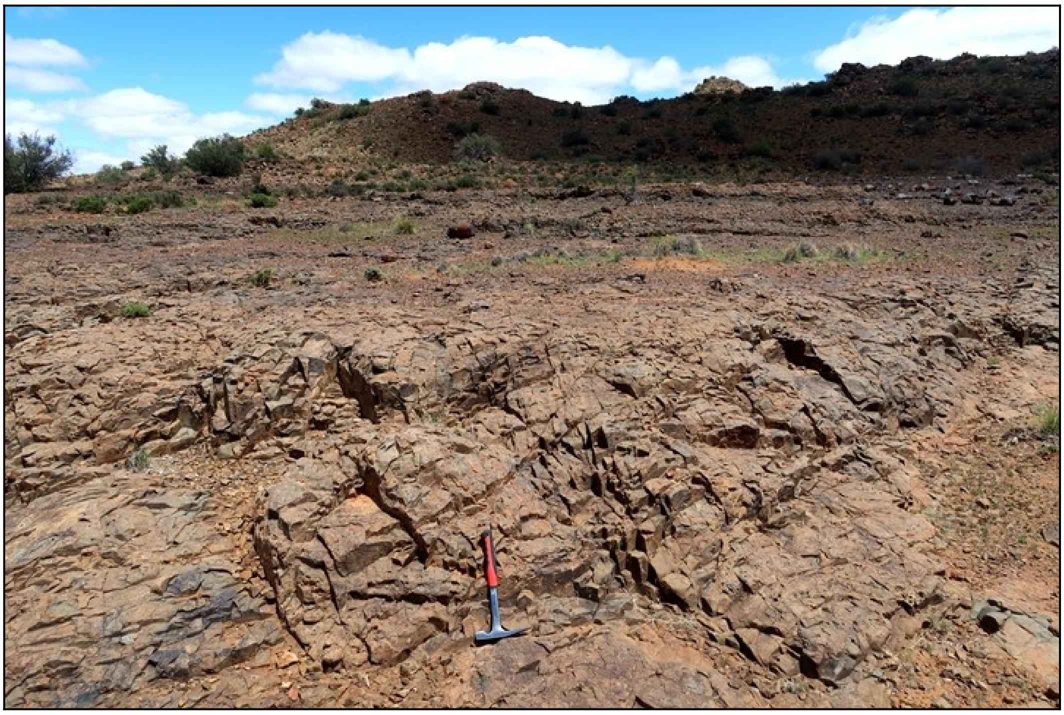


Figure 29: Densely-jointed exposure of tough, brownish-weathering, locally vuggy hornfels (baked mudrock), southern end of the Rooiberg ridge on Gegundefontein 53 (Hammer = 30 cm).

Figure 30: Stream gulley exposure of baked Beaufort Group sediments comprising typically very dark to black, blocky-weathering hornfels (an important raw material for stone artefacts locally) capped by a thin, pale brown quartzite, southern end of the Rooiberg ridge on Gegundefontein 53 (Hammer = 30 cm).

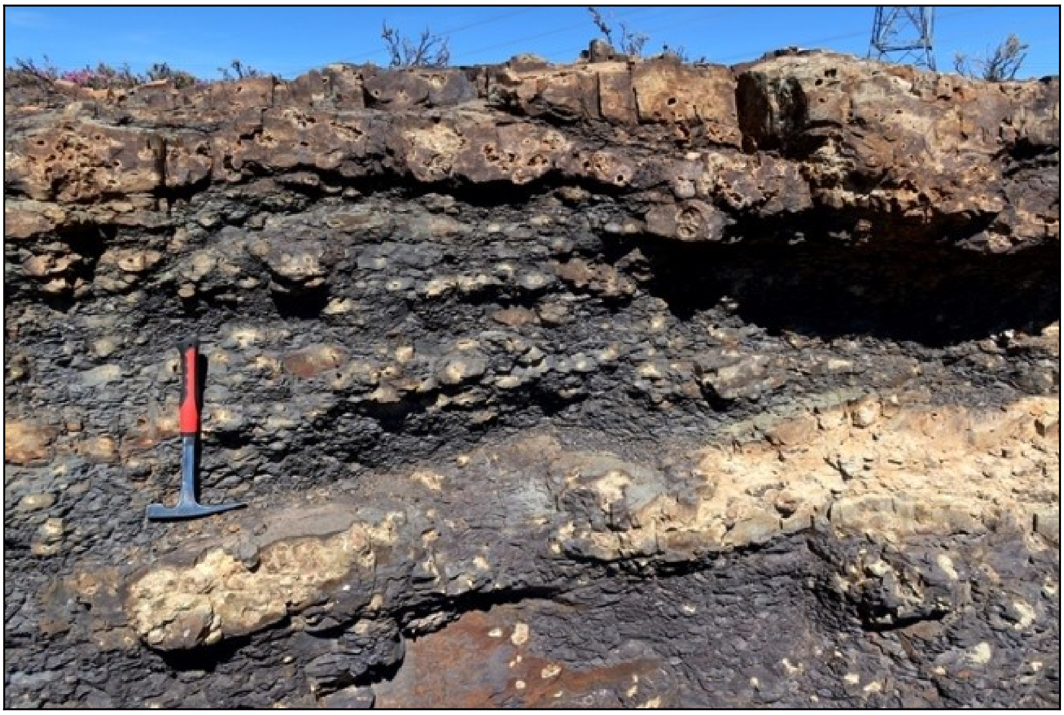


Figure 31: Baked, dark grey mudrocks and paler fine-grained sandstones of the Balfour Formation close to the main grid connection corridor on Farm 96 (hammer = 30 cm). The sandstone facies shows numerous cavities or *vugs* while the pale, irregularly rounded structures within the mudrocks are mainly calcrete concretions affected by thermal metamorphism and metasomatism by hot circulating fluids during dolerite intrusion. Any fossils originally present are likely to have been destroyed.

Figure 32: Horizon of large (meter-scale), oblate sphaeroidal concretions of ferruginous carbonate weathering out of the top of an Oukloof Member channel sandstone, southern sector of Rondavel 85 (Hammer = 30 cm).

Figure 33: Small exposure of purple-brown mudrock and thin sandstone of the Lower Beaufort Group surrounded by quartzitic and doleritic colluvial gravels, southern sector of Rondavel 85. Such isolated hillslope exposures are a key target for palaeontological recording (*cf* possible tetrapod burrow in Fig. 66 recorded here).

Figure 34: Basal contact of a baked, thin-bedded channel sandstone on Vogelstruisfontein 84 showing fallen blocks of mudflake breccia (beneath 30 cm-long hammer) and local deep erosional gullying into underlying grey-green overbank mudrocks.

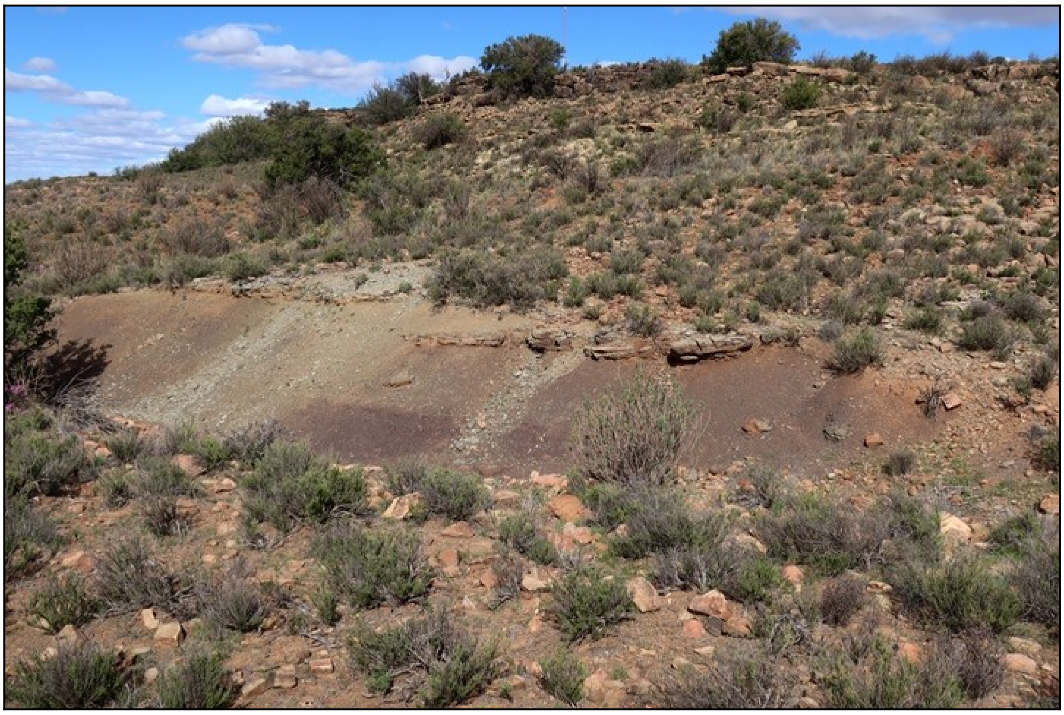


Figure 35: Hillslope gulley exposure of weathered, crumbly, purple-brown overbank mudrocks on Vogelstruisfontein 84.

Figure 36: Unusually extensive exposure of grey-green and purple-brown overbank mudrocks along a low escarpment, south-eastern sector of Rondavel 85. These beds are currently mapped within the upper Hoedemaker Member.

Figure 37: Weathered, colour-banded mudrocks exposed in a small quarry near Rondawel homestead, currently mapped within the Hoedemaker Member (*N.B.* The overlying sandstone package is mapped as Poortjie Member, which does not make stratigraphic sense).

Figure 38: Northern flank of the major Bakenskop dolerite ridge on Vogelstruisfontein 84 showing intermittent, pale exposures of an underlying baked sandstone package.

Figure 39: Dolerite dyke building the crest of a N-S trending *koppie* with a subsidiary feeder dyke on the lower slopes, Rondavel 85.

Figure 40: Olive-green, deeply-weathered, friable dolerite (*sabunga*) exposed on a lower hillslope on Gegundefontein 53.

Figure 41: Typical colluvial gravels in a region extensively intruded by dolerite, dominated by rounded, rusty-brown dolerite corestones and paler, more angular metaquartzite clasts, Gegundefontein 53 (Hammer = 30 cm).

Figure 42: Thick prism of orange-brown, well-sorted, well-bedded sandy alluvium with only sparse gravel clasts overlying Lower Beaufort Group bedrocks exposed in the deeply-incised banks of the Burgerspruit along the main grid connection corridor (Hammer = 30 cm).

Figure 43: Banks of the Burgerspruit on Burgers Fontein 92 showing partially calcretised older alluvium overlying weathered, calcrete-veined dolerite. Fossil root casts (rhizoliths) seen here are shown in more detail in Figure 68.

Figure 44: Good incised stream back section through thick, gravelly to sandy alluvial deposits as well as comparable modern stream alluvium, downstream of a farm dam on Bult and Rietfontein 96.

Figure 45: Erosion gulley section through orange-brown sandy alluvium typical of doleritic areas, Gegundefontein 53 (Hammer = 30 cm). The basal gravels overlie a composite gritty to gravelly calcrete hardpan which is in turn underlain by weathered Teekloof Formation mudrocks.

Figure 46: Three dimensional polygonal network of calcrete veins – perhaps shrinkage cracks – within older, semi-consolidated alluvial sands seen in an erosion gulley incised into older alluvial deposits on Rondavel 85.

Figure 47: Donga-eroded, thick sandy to gravelly alluvium underlying *vlaktes* in the main grid connection corridor west of Blouberg, Farm Burgers Fontein 92.

Figure 48: Typical orange-brown ferruginous sands and doleritic or quartzitic surface gravels that mantle many alluvial plains in the study area, as seen here on Vogelstruisfontein 84.

3. PALAEONTOLOGICAL HERITAGE WITHIN THE GKRE AND GRID CONNECTION PROJECT AREAS

The Late Permian Teekloof Formation bedrocks in the GKRE and grid connection project areas are characterised by fossil assemblages of what have, until recently, been termed the *Pristerognathus*, *Tropidostoma* and *Cistecephalus* Assemblage Zones (AZs) (Kitching 1977, Keyser & Smith 1977-78, Rubidge 1995, Van der Walt *et al.* 2010, Smith *et al.* 2012, 2020) (Figs. 16, 17 & 49). Recent revision of the Lower Beaufort Group biostratigraphic zonation has incorporated most of the first two assemblages into the *Endothiodon* Assemblage Zone (Day & Smith 2020). The fossils recorded within these AZs include a wide range of fossil vertebrates – especially reptiles and therapsids ("mammal-like reptiles" or protomammals"") – as well as fish, amphibians, plant remains, microfossils and trace fossils (Rubidge 1995, Rubidge 2005, Smith *et al.* 2012, Day & Smith 2020, Smith 2020). Le Roux and Keyser (1988) briefly mention fossil vertebrate taxa recorded in the Teekloof Formation in the Victoria West sheet area. In addition Kitching (1977) provides palaeofaunal lists for specific localities within the Great Karoo region, including several near Victoria West. The recent review of Beaufort Group vertebrate fossil sites by Nicolas (2007) shows a high concentration of finds along the N1 to the northeast of Three Sisters and south of Victoria but fewer sites between Victoria West and Richmond (Fig. 50). In the vicinity of dolerite intrusions the preservation of vertebrate fossils has been seriously compromised due to baking and chemical alteration, while voluminous doleritic and metasedimentary colluvium often masks the nearby fossiliferous sedimentary bedrocks. Thick deposits of older, semi-consolidated alluvium in the Karoo region may occasionally contain important assemblages of fossil vertebrates (*e.g.* Plio-Pleistocene mammal bones and teeth) as well as reworked petrified wood, trace fossils (*e.g.* calcretised termitaria, rhizoliths) and freshwater molluscs such as unionid bivalves (swan mussels).

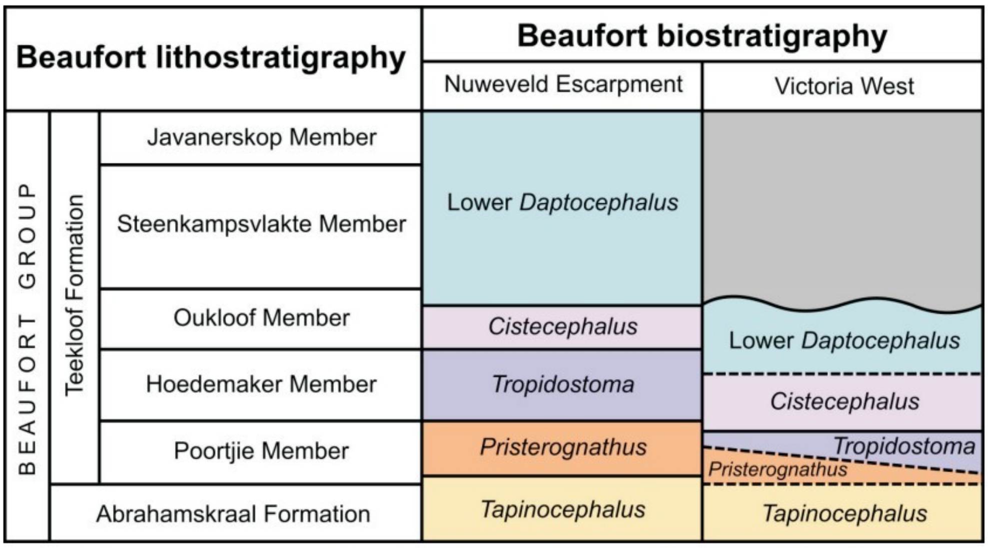


Figure 2. Relationship of Karoo biostratigraphy to the lithostratigraphy along the Nuweveld. Escarpment and in the Victoria West area. Nuweveld relationships based on Rubidge (1995), with amendments from Day *et al.* (2015) and Viglietti *et al.* (2016, 2017).

Figure 49: Table from Day and Rubidge (2020a) illustrating possible differences in the distribution of Lower Beaufort Group fossil assemblage zones in relation to the lithostratigraphy along the Nuweveld Escarpment *versus* the Victoria West region. Some of these real or apparent contrasts might be resolved by detailed geological re-mapping and palaeontological surveying in the latter area.

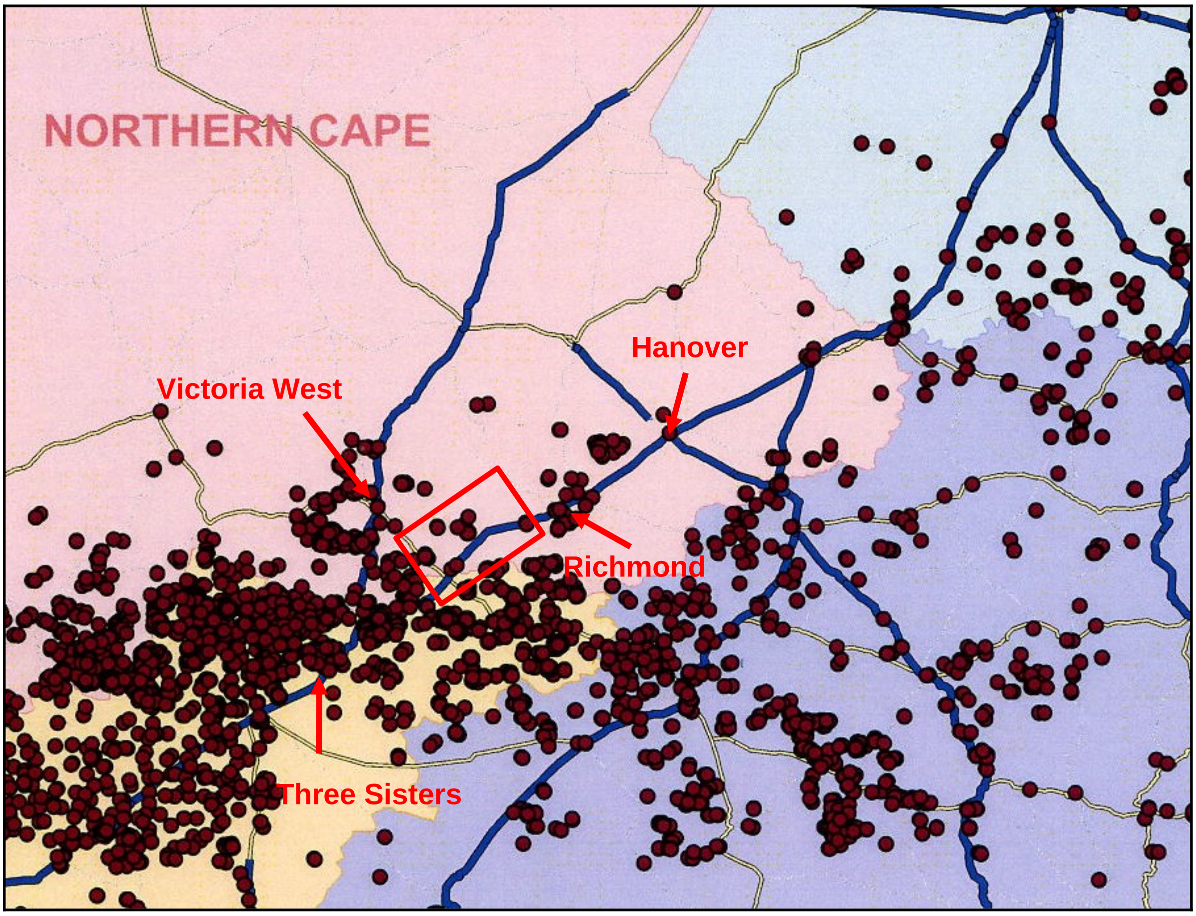


Figure 50: Distribution map of recorded vertebrate fossil sites within the Beaufort Group of the Great Karoo around the junction of the Western, Northern and Eastern Cape and the Free State (From Nicolas 2007). Few fossil sites are recorded in the vicinity of the present GKRE and grid connection project area between Richmond and Hutchinson / Gamma MTS (see red rectangle). There is a long history (> 100 years) of fossil collection by both academic palaeontologists as well as knowledgeable amateurs at sites close to Biesiespoort Station just to the west of Gamma MTS.

3.1. Fossil biotas within the Teekloof Formation : Poortjie Member

The arenaceous Poortjie Member as well as the uppermost beds of the underlying Abrahamskraal Formation are characterised palaeontologically by fossils of what was until recently termed the *Pristerognathus* Assemblage Zone (Smith & Keyser 1995a) which now forms the lower portion of a new *Endothiodon* Assemblage Zone (Day & Smith 2020). This important Late Permian, low-diversity (post-extinction recovery phase) terrestrial biota is dominated by various therapsids ("mammal-like reptiles") such as the moderate-sized therocephalian carnivore *Pristerognathus* as well as several gorgonopsian predators / scavengers and herbivorous dicynodonts. The commonest genus by far is the small burrowing dicynodont *Diictodon* (Keyser and Smith 1977-78, Smith & Keyser 1995a, MacRae 1999, Cole *et al*., 2004, Rubidge 2005, Almond 2010a, 2014a, Smith *et al.* 2012; Fig. 51 herein). There are also large, rhino-sized herbivorous pareiasaur reptiles (*Bradysaurus* spp.), the small parareptile *Eunotosaurus* (Day *et al.* 2013), crocodile-like temnospondyl amphibians (*Rhinesuchus*), palaeoniscoid fish, vascular plant fossils of the *Glossopteris* Flora (fossil wood, leaves *etc*) and various trace fossils, including invertebrate burrows and tetrapod trackways. Rare relict dinocephalians recorded recently within the lowermost Poortjie Member are now assigned to the impoverished post-extinction biota at the top of the revised *Tapinocephalus* Assemblage Zone (Day *et al.* 2015a, 2015b, Day & Rubidge 2020b).

Most fossils in the *Pristerognathus* Assemblage Zone are found in the softer-weathering mudrock facies (floodplain sediments) that are usually only exposed on steeper hill slopes and in stream gullies. Fossils here are often associated with pedogenic limestone nodules or calcretes (Smith 1993a, Smith & Keyser 1995a). The mudrocks lie between the more resistant-weathering channel sandstones, which in the classic Poortjie Member sections along the Nuweveld Escarpment often display a distinctive "golden yellow" tint. Fossil skeletal remains also occur in the lenticular channel sandstones, especially in intraformational lag conglomerates towards the base, but are usually very fragmentary and water-worn ("rolled bone").

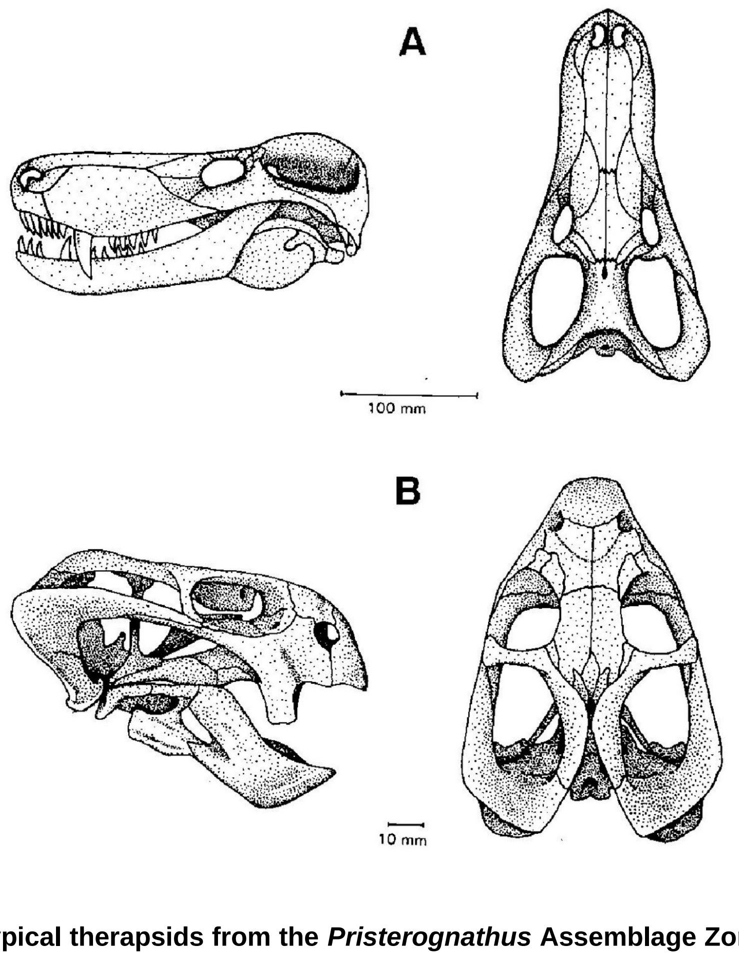


Figure 51: Skulls of typical therapsids from the *Pristerognathus* Assemblage Zone (now the lower part of the *Endothiodon* Assemblage Zone): A. the dog-sized carnivorous therocephalian *Pristerognathus* and B. the small herbivorous dicynodont *Diictodon* (From Smith & Keyser 1995a).

3.2. Fossil biotas within the Teekloof Formation: Hoedemaker Member

The *Tropidostoma* Assemblage Zone (AZ) characterizes the Hoedemaker Member of the Teekloof Formation along the Great Escarpment and elsewhere (Le Roux & Keyser 1988, Smith & Keyser, 1995b). This faunal assemblage is assigned to the early Lopingian (Wuchiapingian) Age of the Late Permian Period. It has recently been incorporated into the upper part of a revised *Endothiodon* Assemblage Zone (Day & Smith 2020).The following major categories of fossils have been recorded within *Tropidostoma* AZ sediments in well-collected sections along the Nuweveld Escarpment and elsewhere (Kitching 1977, Keyser & Smith 1977-78, Le Roux & Keyser 1988, Anderson & Anderson 1985, Smith & Keyser 1995, MacRae 1999, Cole *et al*., 2004, Smith *et al.* 2012, Day & Smith 2020):

- isolated petrified bones as well as rare articulated skeletons of terrestrial vertebrates (tetrapods) such as true reptiles (notably large herbivorous pareiasaurs) and therapsids or "mammal-like reptiles" (*e.g.* diverse herbivorous dicynodonts, flesh-eating gorgonopsians, and insectivorous therocephalians) (Fig. 52);
- aquatic vertebrates such as large temnospondyl amphibians (*Rhinesuchus* spp., usually disarticulated), and palaeoniscoid bony fish (*Atherstonia*, *Namaichthys*, often represented by scattered scales rather than intact fish);
- freshwater bivalves (*e.g. Palaeomutela*);
- trace fossils such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings), fish swimming trails;
- vascular plant remains including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterid trees and arthrophytes (horsetails).

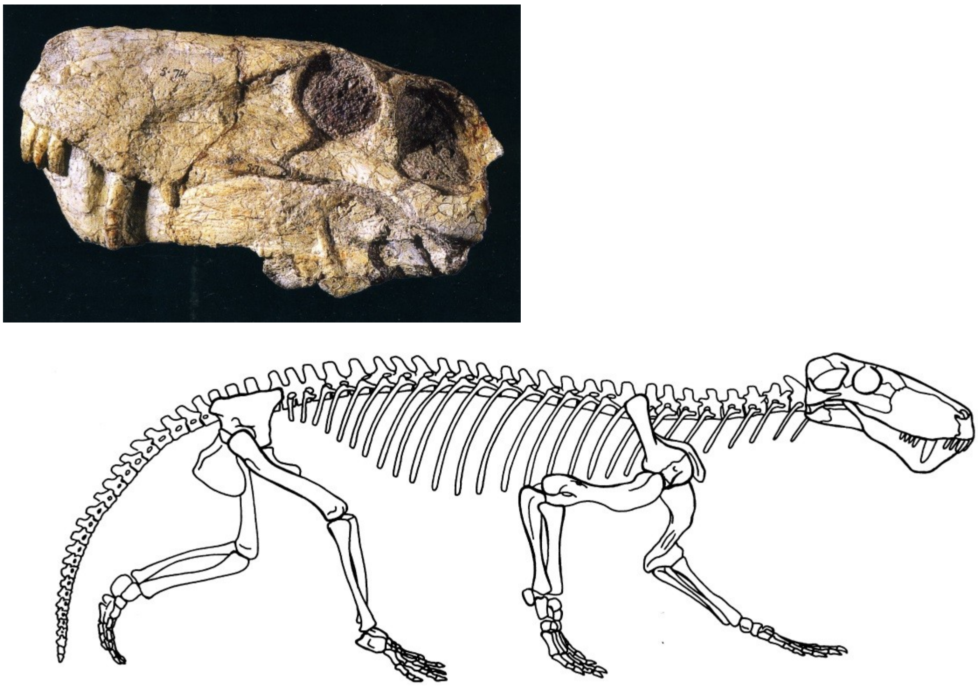


Figure 52: Skull and skeleton of a saber-toothed carnivore, the gorgonopsian *Lycaenops* – a typical, albeit rare, member of the *Tropidostoma* (now upper *Endothiodon*) Assemblage Zone.

According to Smith and Keyser (1995b) the tetrapod fauna of the *Tropidostoma* Assemblage Zone is dominated by the small burrowing dicynodont *Diictodon* that constitutes some 40% of the fossil remains recorded here. There are several genera of small-bodied toothed dicynodonts (*e.g. Emydops, Pristerodon*) as well as medium-sized forms like *Rachiocephalus* and *Endothiodon* (*cf* Cluver & King 1983, Botha & Angielczyk 2007 for more details about these genera). Carnivores are represented by medium-sized gorgonopsians (*e.g. Lycaenops, Gorgonops*; Fig. 33) as well as smaller, insectivorous therocephalians such as *Ictidosuchoides*. Among the large (2.3-3 m long), lumbering pareiasaur reptiles the genus *Pareiasaurus* replaces the more primitive *Bradysaurus* seen in older, Middle Permian Beaufort Group assemblages.

As far as the biostratigraphically important tetrapod remains are concerned, the best fossil material within the Hoedemaker Member succession is generally found within overbank mudrocks, whereas fossils preserved within channel sandstones tend to be fragmentary and water-worn (Rubidge 1995, Smith 1993b). Many vertebrate fossils are found in association with ancient soils (palaeosol horizons) that can usually be recognised by bedding-parallel concentrations of calcrete nodules. Smith and Keyser (1995b) report that in the *Tropidostoma* Assemblage Zone / Hoedemaker Member most tetrapod fossils comprise isolated disarticulated skulls and post-cranial bones, although well-articulated skeletons of the small dicynodont *Diictodon* are locally common, associated with burrows (See also Smith 1993b for a benchmark study of the taphonomy of vertebrate remains in the Hoedemaker Member near Loxton).

3.3. Fossil biotas within the Teekloof Formation: Oukloof Member

Diverse fossil assemblages from the sandstone-dominated package in the middle of the Teekloof Formation (Oukloof Member) as well as the correlative sandstone package at the base of the Balfour Formation (Oudeberg Member) are referred to the *Cistecephalus* Assemblage Zone of Late Permian (Wuchiapingian) age (*c*. 257-255 Ma). They record full recovery of continental biotas of southern Gondwana from the end-Middle Permian Mass Extinction Event of *c*. 260 Ma. Vertebrate and other fossil taxa recorded in this AZ have been outlined by Smith and Keyser (1995c), Smith *et al.* (2012) and, most recently, by Smith (2020). Terrestrial tetrapods – mainly therapsids - include a wide range of small- to large-bodied dicynodont herbivores (Fig. 53), several biarmosuchians, large gorgonopsian carnivores and a range of smaller predators such as therocephalians, cynodonts and lizard-like eureptiles (*Euparkeria*). There are also several genera of pareiasaur reptiles, such as the large *Pareiasaurus* as well as a few much smaller forms (Fig. 54). Aquatic vertebrates are represented by a limited variety of palaeoniscoid fish and rhinesuchid temnospondyl amphibians. Non-vertebrate fossil groups include freshwater bivalves, vertebrate and invertebrate trace fossils (coprolites, burrows, trackways, rhizoliths) and vascular plants of the *Glossopteris* Flora.

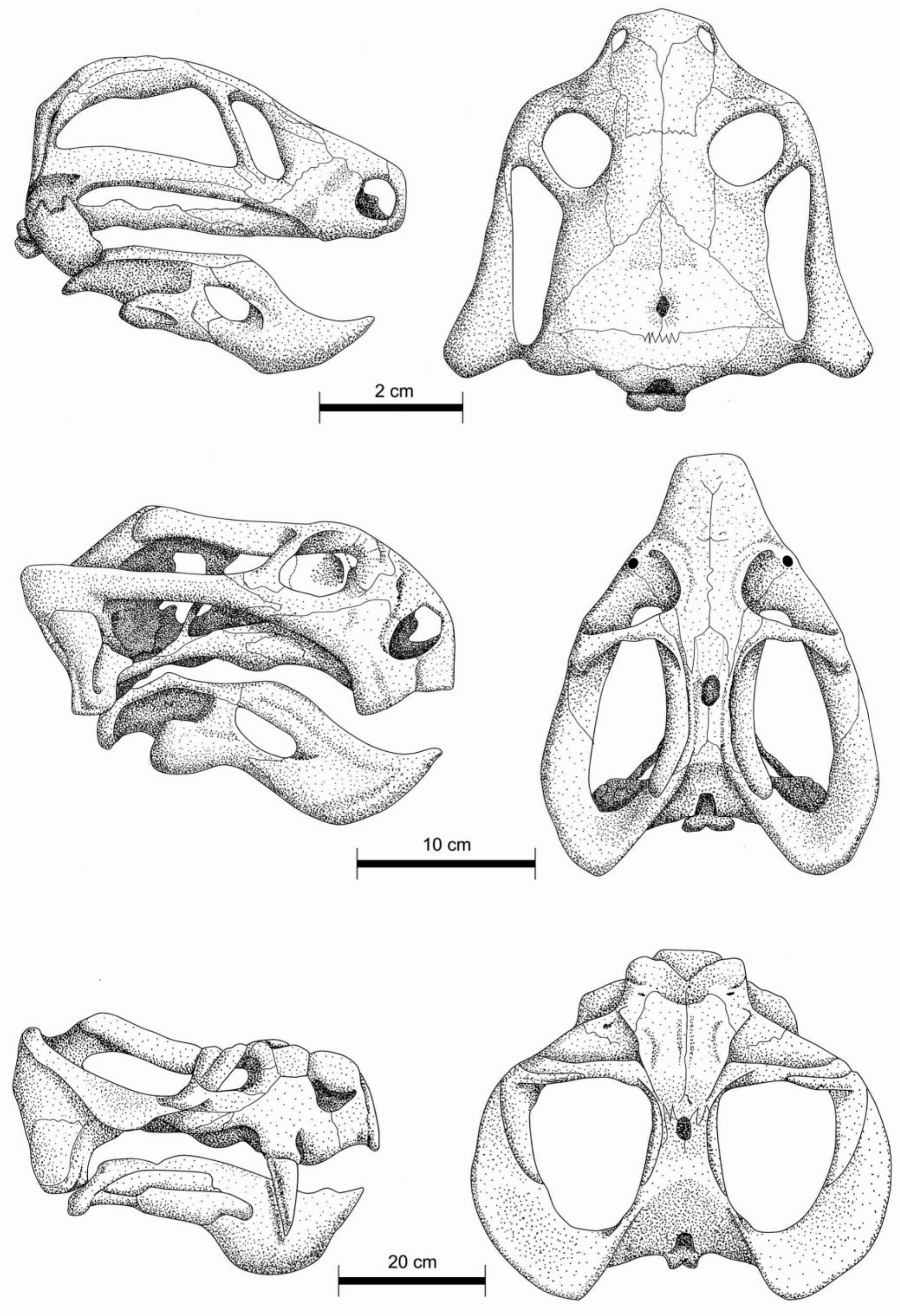


Figure 53: Skulls of key therapsids from the Late Permian *Cistecephalus* Assemblage Zone. From top to bottom these are *Cistecephalus*, *Oudenodon* and *Aulocephalodon* (from Smith 2020). All these genera of herbivorous dicynodonts shave been recorded from the Victoria West 1: 250 000 sheet area but not, to the author's knowledge, from the present project area.

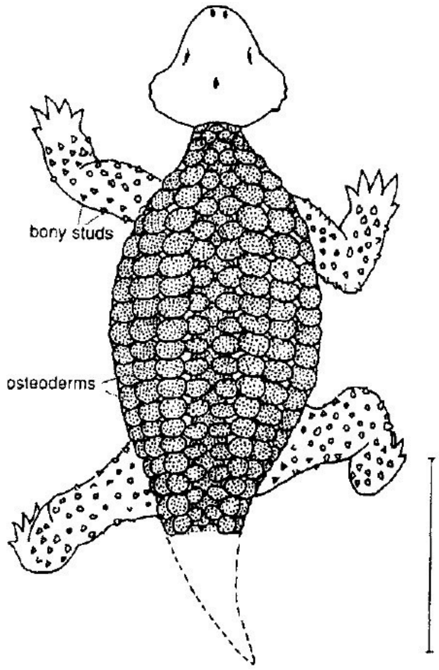


Figure 54: Reconstruction of *Anthodon*, a small-bodied pareiasaur reptile (*c*. 1.0-1.5 m long) from the Late Permian *Cistecephalus* AZ of the Main Karoo Basin showing distinctive dermal armour composed of closely spaced bony scutes or osteoderms (Image from Lee 1997). See also figures 56 to 58 below.

3.4. Teekloof fossils in the GKRE and grid connection project areas

While no historical fossil sites are indicated on the relevant 1: 250 000 Victoria West geological map (Fig. 15), or specifically mentioned here in the sheet explanation by Le Roux and Keyser (1988), a small number of vertebrate fossil sites are recorded within or close to the present project area in the database compiled by Nicolas (2007) (see Fig. 50 herein). Almost no useful palaeontological field data can be gleaned from several PIA reports relating to proposed or authorised renewable energy projects in the broader Richmond – Victoria West subregion of the Great Karoo, the great majority of which are only at desktop level (*e.g.* Rossouw 2011. 2021, Almond 2010a, 2010b, 2012a-c, 2015a, 2015b, Fourie 2016, 2021).

Few, and then generally very fragmentary and highly baked, fossil remains are recorded within channel sandstone facies of the Teekloof Formation (Figs. 63, 64). Where mudrock exposure is exceptionally good, such as long the bed of the Burgerspruit, a higher concentration of vertebrate fossils is indeed recorded but even here they tend to be sparse and fragmentary (Figs. 60 to 62). Unfossiliferous mudrocks tend to occur lower down within the Teekloof succession - within the probable Poortjie Member – and may reflect an early phase of the faunal recovery following the end Middle Permian Mass Extinction event of *c*. 260 Ma. The only potentially interesting fossils recorded during this study come from the upper parts of the Teekloof succession here (Oukoof Member).

Fossil material recorded during the recent 3-day palaeontological site visit to the combined GKRE and grid connection project area near Richmond is tabulated in Appendix 2, together with GPS locality data, a brief description, provisional Field Rating and recommended mitigation (if any is necessary). These sites are mapped in relation to the proposed GKRE infrastructure layouts and grid connection corridor options in Figures A1 to A3 (See Appendix 2). In addition to a handful of scrappy, and often thermally metamorphosed, vertebrate skeletal remains from both sandstone and mudrock facies of the Teekloof Formation (Figs. 55 to 68), the recorded Palaeozoic fossils include a small range of trace fossils (*e.g.* equivocal tetrapod burrows and small-scale invertebrate burrows (Figs. 66 & 67). Possible plant stem casts were seen in association with pond margin palaeosurfaces, but no plant skeletal remains such as stem or leaf compression material or petrified wood.

The only fossil remains of potential scientific value recorded here are several blocks of ferruginised pedogenic calcrete containing the fragmentary post-cranial remains of a small-bodied pareiasaur reptile – either a juvenile or perhaps a member of one of the dwarf pareiasaur genera known from the *Cistecephalus* Assemblage Zone (Figs. 54, 55 to 58). The material comes from the lowest part of the Oukloof Member (Balfour Formation as mapped) and, if identifiable, might help resolve the current lithostratigraphic and biostratigraphic confusion surrounding the Teekloof succession in this subregion of the Main Karoo Basin. Among the skeletal elements preserved are partial moulds of several discoidal, ellipsoidal dermal scutes or osteoderms that characterize pareiasaur reptiles and appear to have taxonomic value (*cf* Boonstra 1934, Findlay 1970, Lee 1997, Scheyer & Sander 2009).

Please note that:

- The fossil sites recorded represent only a representative fraction of all the sites present at surface. The absence of recorded sites in an area does *not* imply that no fossils are present here, at or beneath the land surface;
- Given current considerable uncertainties concerning the mapping and lithostratigraphy of the Lower Beaufort Group bedrocks in the project area between Richmond and Victoria West (*cf* Day & Rubidge 2020a, Almond 2021), the fossils listed here (Appendix 2) are only provisionally referred, if at all, to a specific subunit or member of the Teekloof Formation.

As illustrated in satellite map Figures A1 to A3, remarkably few fossils were recorded during the 3-day site visit. This is, to a considerable extent, attributable to the extensive network of dolerite intrusions (sills, dykes *etc*) which compromise fossil preservation, exposure and recording by:

(1) Destroying or degrading fossils *in situ* through thermal metamorphosis and metasomatism, leading to white, friable bone or complete dissolution of skeletal material and associated pedocretes;
(2) Indirectly generating large volumes of rubbly colluvium composed of doleritic waste as well as resistant-weathering metaquartzite and hornfels from the metamorphic aureoles of the dolerite intrusions;
(3) Promoting the accumulation of thick prisms of sandy to gravelly alluvium overlying sedimentary bedrocks in low-lying terrain because normal denudation and drainage processes are hampered by numerous inclined sills and dykes of dolerite.

In addition, near-surface Teekloof Formation mudrock facies seen in erosion gullies, borrow pits and some hillslope exposures often appear to be highly weathered (crumbly / leached) and / or veined by secondary calcrete, further decreasing their palaeontological heritage potential (Fig. 37).

The palaeosensitivity of the GKRE and grid connection project area (dolerites, thermally metamorphosed Teekloof bedrocks, alluvial and colluvial deposits, calcrete hardpans, soils) is consequently Low to Very Low overall. As apparent on satellite images, there are very few - and then only small - good exposures of Teekloof mudrock facies (*N.B.* Several promising-looking grey areas on satellite images do not show good mudrock exposure on the ground).

The great majority of the fossils recorded are (1) fragmentary, (2) degraded by thermal metamorphosis and (3) probably represent common taxa. Within the combined GKRE project area none of the known fossil sites lies within 20 m of the proposed infrastructure footprints, so they do not warrant palaeontological mitigation. Fossil sites recorded within the grid connection corridor are all of low scientific and / or conservation value while several are protected within the standard ecological buffer zone along drainage lines. Again, no mitigation is recommended with respect to these low significance sites.

Figure 55: Several blocks of brown ferruginous carbonate containing post-cranial remains, including vertebrae, ribs and dermal scutes, of a small to medium-sized tetrapod – probably a juvenile or dwarf pareiasaur reptile (See following 3 figures for details), Oukloof Member, Rondavel 85 (Scale = 15 cm) (Loc. 863).

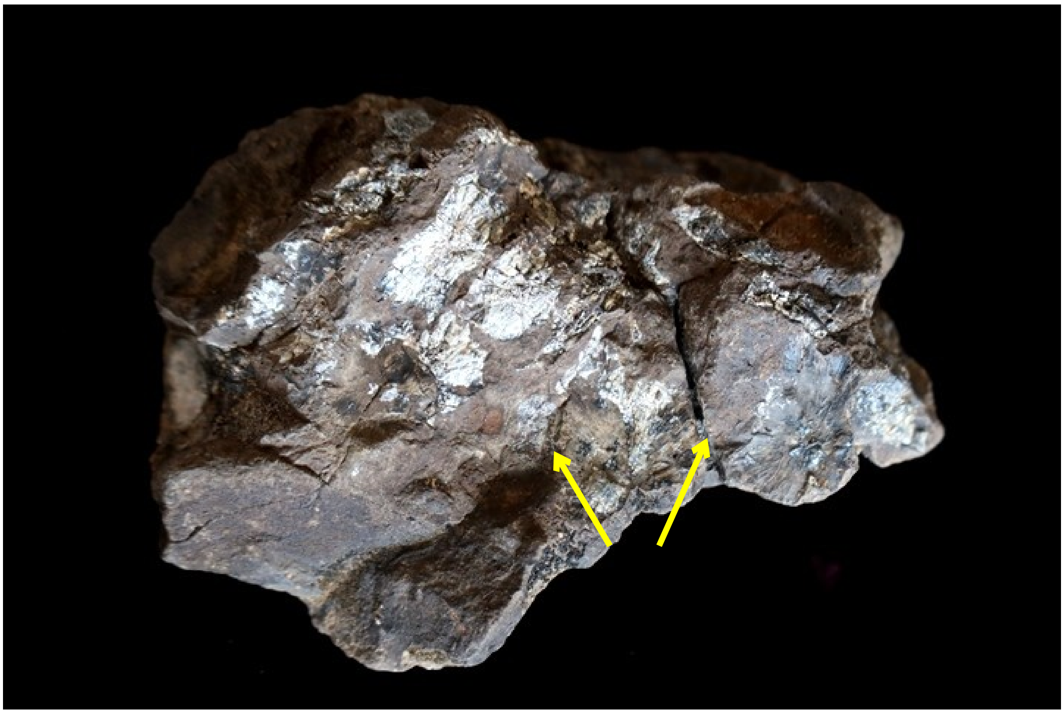


Figure 56: Close-up of two of the blocks illustrated above (specimen is *c*. 13 cm across as seen here) showing impressions of rounded dermal scutes / osteoderms (arrowed) (Loc. 863).

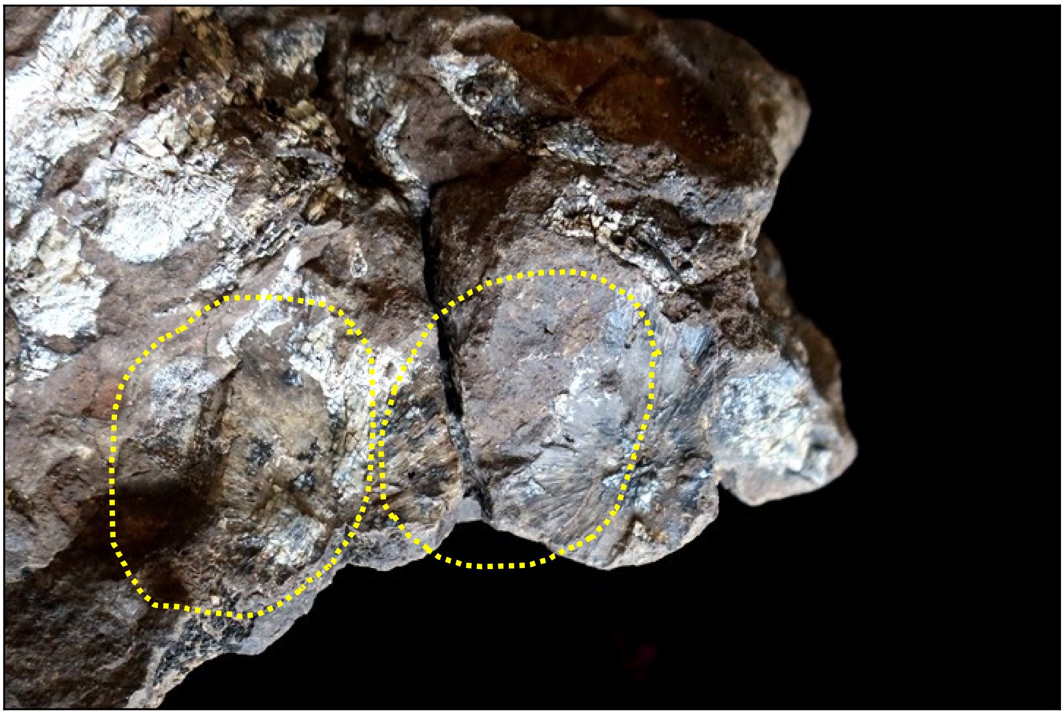


Figure 57: Close up of two adjacent dermal scutes on the specimen illustrated above, preserved in part as moulds, showing low convexity, absence of a pronounced central boss and presence of fine radial lines. The roughly elliptical scutes are very roughly 2.5 to 4 cm in maximum diameter.

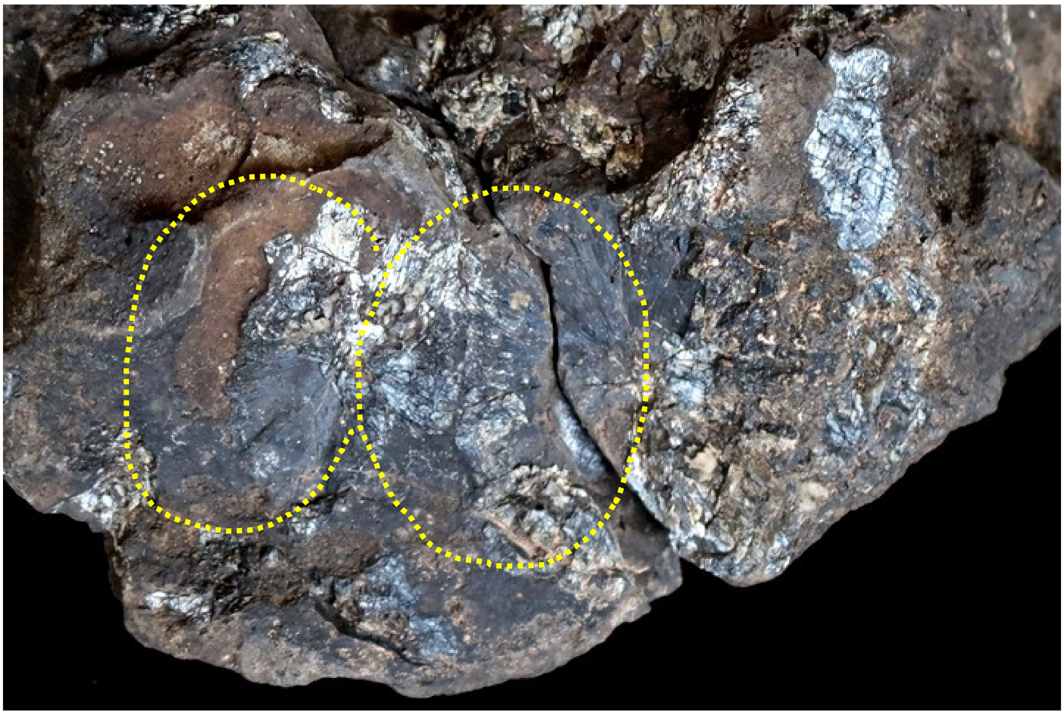


Figure 58: Two more adjoining and possibly overlapping dermal scutes, same specimen as two previous figures.

Figure 59: Distorted / crushed, baked skeletal material - possibly a small (*c*. 5 cm long) skull - embedded within a purple-brown mudflake-rich debris flow deposit, Oukloof Member, Rondavel 85 (Loc. 859).

Figure 60: Crushed and metamorphosed small tetrapod skull within baked, thin-bedded, grey-green Poortjie Member siltstone associated with possible baked gypsum roses and exposed on the bed of the Burgerspruit, Burgersfontein 92 (specimen is *c*. 6.5 cm across as seen here) (Loc. 918).

Figure 61: Fragment of skull (probably palate) of small tetrapod embedded within baked, grey-green wacke, Poortjie Member, bed of the Burgerspruit, Burgersfontein 92 (specimen is 4 cm across as seen here) (Loc. 914).

Figure 62: White, postcranial bone of a small to medium-sized tetrapod embedded within baked, grey-green wacke, Poortjie Member exposure in the bed of the Burgerspruit, Burgersfontein 92 (specimen is 8.5 cm across as seen here) (Loc. 915).

Figure 63: Small blocks of baked grey-green quartzite (largest block is *c*. 5 cm across) containing baked white bone fragments of one or more small-bodied tetrapods, Oukloof Member, Farm 96 (Loc. 896).

Figure 64: Isolated fragment of baked, whitish postcranial bone (possibly associated with pedogenic concretion) with reaction halo, embedded within pale yellowish metaquartzite quartzite channel sandstone, possibly Poortjie Member, Gegundefontein 53 (Loc. 833) (specimen is *c*. 6 cm across).

Figure 65: Small (*c*. 5.5 cm diameter), well-rounded block of ferruginised "rolled bone" in surface float among weathering-out ferruginous, purple-brown pedocrete concretions, probably of the Poortjie Member, Gegundefontein 53 (Loc. 828).

Figure 66: *Equivocal* inclined tetrapod burrow cast (*c*. 25-30 cm wide) infilled with grey-green sandstone and surrounded by crumbly purple brown mudrock, possibly Oukloof Member, Rondavel 85 (Hammer = 30 cm).

Figure 67: Upper bedding surface of a thin crevasse splay sandstone with sandstone-infilled mudcracks, microbial mat textures, narrow horizontal burrows of undermat miners and possible vertical burrows or plant stem casts (rounded features, *c*. 1 cm wide), borrow pit exposure of the Hoedemaker Member on Rondavel 85 (Loc. 884).

Figure 68: Late Caenozoic sandy to gravelly alluvium exposed in the banks of the Burgerspruit, Burgersfonteion 92 (hammer = 30 cm) (Loc. 917). The subvertical, subcylindrical structures are probably calcretised rhizoliths (plant stem or root casts).

3.4. Fossils within the Karoo Dolerite Suite

The dolerite outcrops criss-crossing the GKRE and grid connection project areas are in themselves of no direct palaeontological significance since these are high temperature igneous rocks emplaced at depth within the Earth's crust. However, as a consequence of their proximity to large dolerite intrusions, the Lower Beaufort Group country rocks in the vicinity have to a great extent been thermally metamorphosed or "baked" and metasomatised (*i.e*. recrystallised, impregnated with secondary minerals or leached by hot circulating fluids). Embedded fossil material of phosphatic composition, such as bones and teeth, has frequently been altered by baking and hot, mineral-rich circulating groundwaters – bones may become whitened and brittle or powdery, for example - and can be very difficult to extract from the hard matrix by mechanical preparation (Smith & Keyser, p. 23 *in* Rubidge 1995). Several examples of poorly preserved, thermally-altered vertebrate fossils have been recorded within the current project area (*e.g.* Figs. 60, 62 to 64). Thermal metamorphism by dolerite intrusions has therefore tended to substantially reduce the palaeontological heritage potential of adjacent Beaufort Group sediments. In addition, the large volumes of colluvial gravels of dolerite and resistant, baked metasediments (hornfels and quartzite) associated with dolerite intrusions tend to seal-in adjacent outcrop areas of Beaufort Group bedrocks whose fossils are consequently no longer inaccessible.

3.5. Fossil biotas within Late Caenozoic superficial deposits

The Quaternary to Recent superficial deposits of the Great Karoo region have been comparatively neglected in palaeontological terms for the most part. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals (*e.g.* Skead 1980, Klein 1984, MacRae 1999, Partridge & Scott 2000). These may include ancient human remains of considerable palaeoanthropological significance (*e.g*. Grine *et al.* 2007). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites, rhizoliths or plant root casts), and plant remains such as peats or palynomorphs (pollens) in fine-grained, organic-rich alluvial horizons. Quaternary alluvial sediments may contain reworked Stone Age artifacts that are useful for constraining their maximum age.

The only fossil remains recorded from the Late Caenozoic superficial deposits within the WEF project area are subcylindrical calcretized rhizoliths (root casts) within older, semi-consolidated alluvial deposits associated with major drainage lines (Figs. 43 & 68). No special mitigation is recommended for these very common fossils. No reworked petrified wood or freshwater molluscs were observed.

4. CONCLUSIONS AND RECOMMENDATIONS

The fluvial to lacustrine sedimentary bedrocks of Late Permian Teekloof Formation (Lower Beaufort Group, Karoo Supergroup) in the combined GKRE and grid connection project areas near Richmond, Northern and Western Cape Provinces, are generally poorly exposed and have also been thermally metamorphosed due to the dense network of Early Jurassic dolerite intrusions in the region. The Teekloof Formation channel sandstones and overbank mudrocks here have yielded only very sparse, low-diversity and generally poorly preserved fossil assemblages of the *Pristerognathus* and *Tropidostoma* Assemblage Zones (recently combined within the new *Endothiodon* Assemblage Zone) as well as marginal representation of the slightly younger *Cistecephalus* Assemblage Zone. These fossils record the aftermath and full recovery of continental biotas of southern Gondwana from the major End Guadalupian Mass Extinction Event of ~260 million years ago (Ma).

Fossil specimens recorded from the Teekloof Formation bedrocks during a 3-day site visit to the combined GKRE and grid connection project areas mainly comprise a handful of scrappy therapsid cranial and post-cranial material. The only specimens of potential scientific or conservation interest are several skeletal elements of a small-bodied pareiasaur reptile - possibly a juvenile or dwarf taxon. Almost all the other specimens are fragmentary and very poorly preserved due to thermal metamorphism and metasomatism (*i.e.* alteration through secondary mineralisation and dissolution by hot circulating groundwaters) during dolerite intrusion. Furthermore, because of current considerable uncertainties regarding the geological mapping of Teekloof Formation subunits within the Richmond – Victoria West region, it is usually not possible to assign the fossil sites to a specific stratigraphic member with confidence. No fossil wood has been recorded so far within the present project area.

Thick deposits of Late Caenozoic, semi-consolidated alluvium might contain important assemblages of Plio-Pleistocene mammalian fossils (*e.g.* horn cores, bones and teeth) as well as reworked petrified wood and trace fossils (*e.g.* calcretised termitaria). However, the only fossils recorded here comprise assemblages of subvertical, calcretised rhizoliths (plant root casts) in riverbank settings. Voluminous, doleritic and quartzitic colluvial rock rubble mantling the steeper mountain slopes as well as the younger alluvial sands and gravels mantling extensive *vlaktes* within the GKRE and grid connection project areas are unlikely to be fossiliferous.

A high proportion of the WEF infrastructure will be placed along upland ridges underlain by unfossiliferous intrusive dolerite and low palaeosensitivity, thermally metamorphosed Lower Beaufort Group sediments. The solar PV project areas are focused on low relief terrain that is mantled by low palaeosensitivity Late Caenozoic sediments (alluvial sands, gravels, soils) with little or no exposure of potentially fossiliferous sedimentary bedrocks. Most of the main grid connection corridor to Gamma MTS is also floored by thick, sandy to gravelly alluvium or dolerite; limited areas of sedimentary bedrock exposure here are strongly baked with few or no well-preserved fossils. No palaeontological Very High Sensitivity / No-Go areas have been identified within the GKRE and grid connection project areas. With the exception of two fossil sites of low scientific value, none of the recorded fossil sites overlaps directly with, or lies close to (< 20 m), the proposed WEF and solar PV project footprints and no modification of the layouts through micro-siting is proposed here on palaeontological grounds. While a number of fossil sites are recorded within the main grid connection corridor, none is of conservation significance while most sites found are already protected within standard ecological buffer zones along drainage lines. Mitigation of the known fossil sites within the GKRE and grid connection project areas is not proposed here.

Most of the proposed renewable energy project infrastructure - including wind turbines, laydown areas, underground cables, access and internal distribution roads, electrical pylons, solar panel arrays, on-site substations, BESS, site office and maintenance buildings, concrete batching plant *etc* - will overlie unfossiliferous dolerite or metamorphosed bedrocks and geologically recent superficial deposits of low palaeosensitivity. The anticipated impact significance of the proposed WEF and solar PV projects in terms of palaeontological heritage resources is likely to be VERY LOW due to (1) the very sparse distribution of fossil remains as well as (2) their almost universally poor preservation. Given the very uniform geological, and hence palaeontological, setting throughout the combined project areas, this assessment applies equally to all the proposed WEF, solar PV and grid connection projects as well as the various grid connection corridors under consideration. There is accordingly no preference on palaeontological heritage grounds for any particular grid connection route option. The proposed renewable energy projects are not fatally flawed from a palaeontological heritage viewpoint and there are no objections to their authorisation.

All the fossil sites recorded so far could, if necessary, be effectively mitigated through specialist palaeontological collection and recording of associated geological data, and this is likely to be the case for the great majority of any unrecorded fossil sites encountered in the pre-construction or construction phases as well. The potential for rare, unrecorded fossil sites of high scientific and conservation value cannot be completely excluded, however. These are best handled through a Chance Fossil Finds Protocol driven by the responsible environmental site officers and ECO, as outlined in Appendix 3. Pending the discovery of significant new fossil remains, no further specialist palaeontological studies or mitigation are recommended for the GKRE and grid connection projects. Should specialist palaeontological mitigation be triggered by significant Chance Fossil Finds, the palaeontological specialist involved will need to submit an application for a Fossil Collection Permit (SAHRA) or Work Plan (HWC) to the relevant Provincial Heritage Resources Agency. The palaeontological studies should conform to international best practice for palaeontological fieldwork and adhere as far as possible to the minimum standards for palaeontological heritage studies developed by SAHRA (2013) and HWC (2021). The palaeontological assessment reports must be submitted for consideration to the responsible Provincial Heritage Resources Agency.

6. ACKNOWLEDGEMENTS

Ms Jenna Lavin and Mr Nic Wiltshire of CTS Heritage, Century City, are thanked for commissioning this study, for facilitating the palaeontological fieldwork, for discussions about heritage aspects of the project and for providing relevant background information. Mnr Pieter van der Merwe and Mnr Jan Victor are thanked for permission to visit their properties. I am grateful to Dr Marc J. Van den Brandt (Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg) for authoritative comments on the Richmond pareiasaur material.

7. REFERENCES

ALMOND, J.E. 2010a. Eskom Gamma-Omega 765kV transmission line: Phase 2 palaeontological impact assessment. Sector 1, Tanqua Karoo to Omega Substation (Western and Northern Cape Provinces), 95 pp + appendix. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010b. Proposed Mainstream wind farm near Hutchinson to the southeast of Victoria West, Northern Cape Province. Palaeontological impact assessment: pre-scoping desktop study, 22 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012a. Proposed PV3 Brakpoort Karoo photo-voltaic solar power plant on Farm Wildebeest Vlakte No. 51, Victoria West, Northern Cape Province. Recommended exemption from further palaeontological studies, 9 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012b. Proposed PV2 Brakpoort Karoo photo-voltaic solar power plant on Farm David's Kraal No. 116, Victoria West, Northern Cape Province. Recommended exemption from further palaeontological studies, 9 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012c. Proposed Brakpoort Solar Farm on Portion 3 of Farm Kliphokkies No. 173 near Victoria West, Northern Cape Province. Palaeontological assessment: combined desktop & field-based assessment, 18 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015a. Proposed Noblesfontein 2 Wind Energy Facility near Three Sisters, Central Karoo District, Western Cape. Palaeontological specialist assessment: desktop study, 26 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2015b. Proposed Noblesfontein 3 Wind Energy Facility near Three Sisters, Central Karoo District, Western Cape. Palaeontological specialist assessment: desktop study, 26 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2021. Proposed Modderfontein Wind Energy Facility near Victoria West, Central Karoo and Pixley Ka-Seme Districts, Western Cape & Northern Cape Provinces. Palaeontological specialist assessment: combined desktop and field-based study, 68 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. & PETHER, J. 2008a. Palaeontological heritage of the Western Cape. Interim SAHRA technical report, 20 pp. Natura Viva cc., Cape Town.

ALMOND, J.E. & PETHER, J. 2008. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 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. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

BAMFORD, M. 1999. Permo-Triassic fossil woods from the South African Karoo Basin. Palaeontologia africana 35, 25-40.

BENDER, P.A. 2004. Late Permian actinopterygian (palaeoniscid) fishes from the Beaufort Group, South Africa: biostratigraphic and biogeographic implications. Council for Geoscience Bulletin 135, 84 pp.

BOONSTRA, L. D. 1934. Pareiasaurian studies X. The Dermal Armour. Annals of the South African Museum 31,39-48.

BOTHA, J. & ANGIELCZYK, K.D. 2007. An integrative approach to distinguishing the Late Permian dicynodont species *Oudenodon bainii* and *Tropidistoma microtrema* (Therapsida: Anomodontia). Palaeontology 50, 1175-1209.

CHEVALLIER, L. & WOODFORD, A. 1999. Morpho-tectonics and mechanism of emplacement of the dolerite rings and sills of the western Karoo, South Africa. South African Journal of Geology 102, 43-54.

CLUVER, M.A. & KING, G.M. A reassessment of the relationships of Permian Dicynodontia (Reptilia, Therapsida) and a new classification of dicynodonts. Annals of the South African Museum 91, 195-273.

COETZEE, A. 2020. Geometry and emplacement controls of dolerite sill complexes in the Karoo Basin. Unpublished PhD thesis, Stellenbosch University. http://hdl.handle.net/10019.1/108017

COLE, D.I., NEVELING, J., HATTINGH, J., CHEVALLIER, L.P., REDDERING, J.S.V. & BENDER, P.A. 2004. The geology of the Middelburg area. Explanation to 1: 250 000 geology Sheet 3124 Middelburg, 44 pp. Council for Geoscience, Pretoria.

COLE, D. & SMITH, R. 2008. Fluvial architecture of the Late Permian Beaufort Group deposits, S.W. Karoo Basin: point bars, crevasse splays, palaeosols, vertebrate fossils and uranium. Field Excursion FT02 guidebook, AAPG International Conference, Cape Town October 2008, 110 pp.

DAY, M., RUBIDGE, B., ALMOND, J. & JIRAH, S. 2013. Biostratigraphic correlation in the Karoo: The case of the Middle Permian parareptile *Eunotosaurus*. Research Letter, South African Journal of Science 109, 4 pp.

DAY, M.O., GÜVEN, S., ABDALA, F., JIRAH, S., RUBIDGE, B. & ALMOND, J. 2015a. Youngest dinocephalian fossils extend the *Tapinocephalus* Zone, Karoo Basin, South Africa Research Letter, South African Journal of Science 111, 5 pp.

DAY, M.O., RAMEZANI, J., BOWRING, S.A., SADLER, P.M., ERWIN, D.H., ABDALA, F. & RUBIDGE, B.S. 2015b. When and how did the terrestrial mid-Permian mass extinction occur? Evidence from the tetrapod record of the Karoo Basin, South Africa. Proc. R. Soc. B 282: 20150834. http://dx.doi.org/10.1098/rspb.2015.0834

DAY, M.O. & SMITH, R.M.S. 2020. Biostratigraphy of the *Endothiodon* Assemblage Zone (Beaufort Group, Karoo Supergroup), South Africa. South African Journal of Geology 123, 164 - 180.

DAY, M.O. & RUBIDGE, B.S. 2020. Biesiespoort revisted: a case study on the relationship between tetrapod assemblage zones and Beaufort lithostratigraphy south of Victoria West. Palaeontologia Africana 53, 51-65.

DUNCAN, A.R. & MARSH, J.S. 2006. The Karoo Igneous Province. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 501-520. Geological Society of South Africa, Marshalltown.

FINDLAY, G.H. 1970. Skin structure of small pareiasaurs. Palaeontologia africana 13, 15–23.

FOURIE, W. 2016. Basic assessment for the proposed construction of supporting electrical infrastructure for the Victoria West Wind Farm, Victoria West, Northern Cape Province. Heritage Impact Assessment, 37 pp. PGS Heritage, Pretoria.

GRINE, F.E., BAILEY, R.M., HARVATI, K., NATHAN, R.P., MORRIS, A.G., HENDERSON, G.M., RIBOT, I. & PIKE, A.W.G. 2007. Late Pleistocene human skull from Hofmeyr, South Africa, and modern human origins. Science 315, 226-229.

HERITAGE WESTERN CAPE 2021. Guide for minimum standards for archaeology and palaeontology reports submitted to Heritage Western Cape - June 2021, 6 pp.

JOHNSON, M.R., VAN VUUREN, C.J., VISSER, J.N.J., COLE, D.I., WICKENS, H. DE V., CHRISTIE, A.D.M., ROBERTS, D.L. & BRANDL, G. 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson. M.R., Anhaeusser, C.R. & Thomas, R.J. (eds.) The geology of South Africa, pp. 461-499. Geological Society of South Africa, Johannesburg & the Council for Geoscience, Pretoria.

KEYSER, A.W. & SMITH, R.M.H. 1977-78. Vertebrate biozonation of the Beaufort Group with special reference to the Western Karoo Basin. Annals of the Geological Survey of South Africa 12: 1-36.

KITCHING, J.W. 1977. The distribution of the Karroo vertebrate fauna, with special reference to certain genera and the bearing of this distribution on the zoning of the Beaufort beds. Memoirs of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, No. 1, 133 pp (incl. 15 pls).

KLEIN, R.G. 1984. The large mammals of southern Africa: Late Pliocene to Recent. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 107-146. Balkema, Rotterdam.

LE ROUX, F.G. & KEYSER, A.W. 1988. Die geologie van die gebied Victoria-Wes. Explanation to 1: 250 000 geology Sheet 3122, 31 pp. Council for Geoscience, Pretoria.

LEE, M.S.Y. 1997. Pareiasaur phylogeny and the origin of turtles. Zoological Journal of the Linnaean Society 120,197–280.

LUCAS, D.G. 2009. Global Middle Permian reptile mass extinction: the dinocephalian extinction event. Geological Society of America Abstracts with Programs 41, No. 7, p. 360.

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

McCARTHY, T. & RUBIDGE, B. 2005. The story of Earth and life: a southern African perspective on a 4.6-billion-year journey. 334pp. Struik, Cape Town.

PARTRIDGE, T.C., BOTHA, G.A. & HADDON, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

RETALLACK, G.J., METZGER, C.A., GREAVER, T., HOPE JAHREN, A., SMITH, R.M.H. & SHELDON, N.D. 2006. Middle – Late Permian mass extinction on land. GSA Bulletin 118, 1398-1411.

ROSSOUW, L. 2011. Palaeontological desktop assessment of a commercial renewable energy facility site located approximately 34 km south of Victoria West in the Western Cape Province, 10 pp. Palaeo Field Services, Langenhoven Park.

ROSSOUW, L. 2021. Palaeontological Impact Statement concerning amendment to the layout for 33 turbines at the Ishwati Emoyeni Wind Energy Facility near Murraysburg in the Western Cape, 13 pp. Palaeo Field Services, Langenhoven Park.

RUBIDGE, B.S. (Ed.) 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Biostratigraphy, Biostratigraphic Series No. 1., 46 pp. Council for Geoscience, Pretoria.

RUBIDGE, B.S. 2005. Re-uniting lost continents – fossil reptiles from the ancient Karoo and their wanderlust. 27th Du Toit Memorial Lecture. South African Journal of Geology 108, 135-172.

RUBIDGE, B.S., ERWIN, D.H., RAMEZANI, J., BOWRING, S.A. & DE KLERK, W.J. 2010. The first radiometric dates for the Beaufort Group, Karoo Supergroup of South Africa. Proceedings of the 16th conference of the Palaeontological Society of Southern Africa, Howick, August 5-8, 2010, pp. 82-83.

RUBIDGE, B.S., ERWIN, D.H., RAMEZANI, J., BOWRING, S.A. & DE KLERK, W.J. 2013. High-precision temporal calibration of Late Permian vertebrate biostratigraphy: U-Pb zircon constraints from the Karoo Supergroup, South Africa. Geology published online 4 January 2013. doi: 10.1130/G33622.1.

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

SCHEYER, T.M. & SANDER, P.M. 2009. Bone microstructures and mode of skeletogenesis in osteoderms of three pareiasaur taxa from the Permian of South Africa. Journal of Evolutionary Biology 22, 1153–1162. doi:10.1111/j.1420-9101.2009.01732.x

SKEAD, C.J. 1980. Historical mammal incidence in the Cape Province. Volume 1: The Western and Northern Cape, 903pp. Department of Nature and Environmental Conservation, Cape Town.

SMITH, R.M.H. 1979. The sedimentology and taphonomy of flood-plain deposits of the Lower Beaufort (Adelaide Subgroup) strata near Beaufort West, Cape Province. Annals of the Geological Survey of South Africa 12, 37-68.

SMITH, R.M.H. 1980. The lithology, sedimentology and taphonomy of flood-plain deposits of the Lower Beaufort (Adelaide Subgroup) strata near Beaufort West. Transactions of the Geological Society of South Africa 83, 399-413.

SMITH, R.M.H. 1986. Trace fossils of the ancient Karoo. Sagittarius 1 (3), 4-9.

SMITH, R.M.H. 1987a. Morphological and depositional history of exhumed Permian point bars in the southwestern Karoo, South Africa. Journal of Sedimentary Petrology 57, 19-29.

SMITH, R.M.H. 1987b. Helical burrow casts of therapsid origin from the Beaufort Group (Permian) of South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 60, 155-170.

SMITH, R.M.H. 1988. Fossils for Africa. An introduction to the fossil wealth of the Nuweveld mountains near Beaufort West. Sagittarius 3, 4-9. SA Museum, Cape Town.

SMITH, R.M.H. 1989. Fossils in the Karoo – some important questions answered. Custos 17, 48-51.

SMITH, R.M.H. 1990. Alluvial paleosols and pedofacies sequences in the Permian Lower Beaufort of the southwestern Karoo Basin, South Africa. Journal of Sedimentary Petrology 60, 258-276.

SMITH, R.M.H. 1993a. Sedimentology and ichnology of floodplain paleosurfaces in the Beaufort Group (Late Permian), Karoo Sequence, South Africa. Palaios 8, 339-357.

SMITH, R.M.H. 1993b. Vertebrate taphonomy of Late Permian floodplain deposits in the southwestern Karoo Basin of South Africa. Palaios 8, 45-67.

SMITH, R.M.H. 2020b. Biostratigraphy of the *Cistecephalus* Assemblage Zone (Beaufort Group, Karoo Supergroup), South Africa. South African Journal of Geology 123, 181 - 190.

SMITH, R.M.H. & KEYSER, A.W. 1995a. Biostratigraphy of the *Pristerognathus* Assemblage Zone. Pp. 13-17 *in* Rubidge, B.S. (ed.) Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R.M.H. & KEYSER, A.W. 1995b. Biostratigraphy of the *Tropidostoma* Assemblage Zone. Pp. 18-22 *in* Rubidge, B.S. (ed.) Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R.M.H. & KEYSER, A.W. 1995c. Biostratigraphy of the *Cistecephalus* Assemblage Zone. Pp. 23-28 *in* Rubidge, B.S. (ed.) Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R.M.H. & ALMOND, J.E. 1998. Late Permian continental trace assemblages from the Lower Beaufort Group (Karoo Supergroup), South Africa. Abstracts, Tercera Reunión Argentina de Icnologia, Mar del Plata, 1998, p. 29.

SMITH, R., RUBIDGE, B. & VAN DER WALT, M. 2012. Therapsid biodiversity patterns and paleoenvironments of the Karoo Basin, South Africa. Chapter 2 pp. 30-62 in Chinsamy-Turan, A. (Ed.) Forerunners of mammals. Radiation, histology, biology. xv + 330 pp. Indiana University Press, Bloomington & Indianapolis.

SMITH, R.M.H. *et al.* 2020. Introduction to the tetrapod biozonation of the Karoo Supergroup. South African Journal of Geology 123, 131 - 140.

STEAR, W.M. 1978. Sedimentary structures related to fluctuating hydrodynamic conditions in flood plain deposits of the Beaufort Group near Beaufort West, Cape. Transactions of the Geological Society of South Africa 81, 393-399.

STEAR, W.M. 1980. Channel sandstone and bar morphology of the Beaufort Group uranium district near Beaufort West. Transactions of the Geological Society of South Africa 83: 391-398.

TURNER, B.R. 1981. The occurrence, origin and stratigraphic significance of bone-bearing mudstone pellet conglomerates from the Beaufort Group in the Jansenville District, Cape Province, South Africa. Palaeontologia africana 24, 63-73.

VAN DER WALT, M., DAY, M., RUBIDGE, B., COOPER, A.K. & NETTERBERG, I. 2010. A new GIS-based biozone map of the Beaufort Group (Karoo Supergroup), South Africa. Palaeontologia Africana 45, 1-5.

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 as well as Limpopo, Free State, Mpumalanga, KwaZulu-Natal and Northwest Provinces under the aegis of his Cape Town-based company *Natura Viva* cc. He has served for several years as a 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 development 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.

John E. Almond

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

APPENDIX 1: GREAT KAROO RENEWABLE ENERGY - PROJECT DESCRIPTIONS

Angora Wind Farm, Northern Cape Province (WEF1)– Project Description

Great Karoo Renewable Energy (Pty) Ltd is proposing the development of a commercial wind farm and associated infrastructure on a site located approximately 35km south-west of Richmond and 80km south-east of Victoria West, within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province.

A preferred project site with an extent of ~29 909ha and a development area of ~4 544ha within the project site has been identified by Great Karoo Renewable Energy (Pty) Ltd as a technically suitable area for the development of the Angora Wind Farm with a contracted capacity of up to 140MW that can accommodate up to 43 turbines. The development area consists of the four (4) affected properties, which include:

- Portion 11 of Farm Gegundefontein 53
- Portion 0 of Farm Vogelstruisfontein 84
- Portion 1 of Farm Rondavel 85
- Portion 0 of Farm Rondavel 85

The Angora Wind Farm project site is proposed to accommodate the following infrastructure, which will enable the wind farm to supply a contracted capacity of up to 140MW:

- Up to 43 wind turbines with a maximum hub height of up to 120m. The tip height of the turbines will be up to 165m.
- Concrete turbine foundations to support the turbine hardstands.
- Inverters and transformers.
- Temporary laydown areas which will accommodate storage and assembly areas.
- Cabling between the turbines, to be laid underground where practical.
- A temporary concrete batching plant.
- 33/132kV onsite facility substation.
- Underground cabling from the onsite substation to the 132kV collector substation.
- Electrical and auxiliary equipment required at the collector substation that serves that wind energy facility, including switchyard/bay, control building, fences, etc.
- Battery Energy Storage System (BESS).
- Access roads and internal distribution roads.
- Site offices and maintenance buildings, including workshop areas for maintenance and storage.

The wind farm is proposed in response to the identified objectives of the national and provincial government and local and district municipalities to develop renewable energy facilities for power generation purposes. It is the developer’s intention to bid the Angora Wind Farm under the Department of Mineral Resources and Energy’s (DMRE’s) Renewable Energy Independent Power Producer Procurement (REIPPP) Programme, with the aim of evacuating the generated power into the national grid. This will aid in the diversification and stabilisation of the country’s electricity supply, in line with the objectives of the Integrated Resource Plan (IRP) with the Angora Wind Farm set to inject up to 140MW into the national grid.

Merino Wind Farm, Northern Cape Province (WEF2) – Project Description

Great Karoo Renewable Energy (Pty) Ltd is proposing the development of a commercial wind farm and associated infrastructure on a site located approximately 35km south-west of Richmond and 80km south-east of Victoria West, within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province.

A preferred project site with an extent of ~29 909ha and a development area of ~5 516ha within the project site has been identified by Great Karoo Renewable Energy (Pty) Ltd as a technically suitable area for the development of the Merino Wind Farm with a contracted capacity of up to 140MW that can accommodate up to 43 turbines. The development area consists of the three (3) affected properties, which include:

- Portion 1 of Farm Rondavel 85
- Portion 0 of Farm Rondavel 85
- Portion 9 of Farm Bult & Rietfontein 96

The Merino Wind Farm project site is proposed to accommodate the following infrastructure, which will enable the wind farm to supply a contracted capacity of up to 140MW:

- Up to 43 wind turbines with a maximum hub height of up to 120m. The tip height of the turbines will be up to 165m.
- Concrete turbine foundations to support the turbine hardstands.
- Inverters and transformers.
- Temporary laydown areas which will accommodate storage and assembly areas.
- Cabling between the turbines, to be laid underground where practical.
- A temporary concrete batching plant.
- 33/132kV onsite facility substation.
- Underground cabling from the onsite substation to the 132kV collector substation.
- Electrical and auxiliary equipment required at the collector substation that serves that wind energy facility, including switchyard/bay, control building, fences, etc.
- Battery Energy Storage System (BESS).
- Access roads and internal distribution roads.
- Site offices and maintenance buildings, including workshop areas for maintenance and storage.

The wind farm is proposed in response to the identified objectives of the national and provincial government and local and district municipalities to develop renewable energy facilities for power generation purposes. It is the developer's intention to bid the Merino Wind Farm under the Department of Mineral Resources and Energy's (DMRE's) Renewable Energy Independent Power Producer Procurement (REIPPP) Programme, with the aim of evacuating the generated power into the national grid. This will aid in the diversification and stabilisation of the country's electricity supply, in line with the objectives of the Integrated Resource Plan (IRP) with the Merino Wind Farm set to inject up to 140MW into the national grid.

Great Karoo Renewable Energy (Pty) Ltd is proposing the construction and operation of a photovoltaic (PV) solar energy facility and associated infrastructure on Portion 1 of Farm Rondavel 85, located approximately 35km south-west of Richmond and 80km south-east of Victoria West, within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province.

A preferred project site with an extent of ~29 909ha and a development area of ~571ha within the project site has been identified by Great Karoo Renewable Energy (Pty) Ltd as a technically suitable area for the development of the Nku Solar PV Facility with a contracted capacity of up to 100MW.

The Nku Solar PV Facility project site is proposed to accommodate the following infrastructure, which will enable the facility to supply a contracted capacity of up to 100MW:

- Solar PV array comprising PV modules and mounting structures.
- Inverters and transformers.
- Cabling between the panels.
- 33/132kV onsite facility substation.
- Cabling from the onsite substation to the collector substation (either underground or overhead).
- Electrical and auxiliary equipment required at the collector substation that serves that solar energy facility, including switchyard/bay, control building, fences, etc.
- Battery Energy Storage System (BESS).
- Site offices and maintenance buildings, including workshop areas for maintenance and storage.
- Laydown areas.
- Access roads and internal distribution roads.

The solar PV facility is proposed in response to the identified objectives of the national and provincial government and local and district municipalities to develop renewable energy facilities for power generation purposes. It is the developer's intention to bid the Nku Solar PV Facility under the Department of Mineral Resources and Energy's (DMRE's) Renewable Energy Independent Power Producer Procurement (REIPPP) Programme, with the aim of evacuating the generated power into the national grid. This will aid in the diversification and stabilisation of the country's electricity supply, in line with the objectives of the Integrated Resource Plan (IRP) with the Nku Solar PV Facility set to inject up to 100MW into the national grid.

Moriri Solar Photovoltaic (PV) Energy Facility, Northern Cape Province (PV2) – Project Description

Great Karoo Renewable Energy (Pty) Ltd is proposing the construction and operation of a photovoltaic (PV) solar energy facility and associated infrastructure on Portion 0 of Farm Rondavel 85, located approximately 35km south-west of Richmond and 80km south-east of Victoria West, within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province.

A preferred project site with an extent of ~29 909ha and a development area of ~577ha within the project site has been identified by Great Karoo Renewable Energy (Pty) Ltd as a technically suitable area for the development of the Moriri Solar PV Facility with a contracted capacity of up to 100MW.

The Moriri Solar PV Facility project site is proposed to accommodate the following infrastructure, which will enable the facility to supply a contracted capacity of up to 100MW:

- Solar PV array comprising PV modules and mounting structures.
- Inverters and transformers.
- Cabling between the panels.
- 33/132kV onsite facility substation.
- Cabling from the onsite substation to the collector substation (either underground or overhead).
- Electrical and auxiliary equipment required at the collector substation that serves that solar energy facility, including switchyard/bay, control building, fences, etc.
- Battery Energy Storage System (BESS).
- Site offices and maintenance buildings, including workshop areas for maintenance and storage.
- Laydown areas.
- Access roads and internal distribution roads.

The solar PV facility is proposed in response to the identified objectives of the national and provincial government and local and district municipalities to develop renewable energy facilities for power generation purposes. It is the developer’s intention to bid the Moriri Solar PV Facility under the Department of Mineral Resources and Energy’s (DMRE’s) Renewable Energy Independent Power Producer Procurement (REIPPP) Programme, with the aim of evacuating the generated power into the national grid. This will aid in the diversification and stabilisation of the country’s electricity supply, in line with the objectives of the Integrated Resource Plan (IRP) with the Moriri Solar PV Facility set to inject up to 100MW into the national grid.

Kwana Solar Photovoltaic (PV) Energy Facility, Northern Cape Province (PV3) – Project Description

Great Karoo Renewable Energy (Pty) Ltd is proposing the construction and operation of a photovoltaic (PV) solar energy facility and associated infrastructure on Portion 0 of Farm Rondavel 85, located approximately 35km south-west of Richmond and 80km south-east of Victoria West, within the Ubuntu Local Municipality and the Pixley Ka Seme District Municipality in the Northern Cape Province.

A preferred project site with an extent of ~29 909ha and a development area of ~991ha within the project site has been identified by Great Karoo Renewable Energy (Pty) Ltd as a technically suitable area for the development of the Kwana Solar PV Facility with a contracted capacity of up to 100MW.

The Kwana Solar PV Facility project site is proposed to accommodate the following infrastructure, which will enable the facility to supply a contracted capacity of up to 100MW:

» Solar PV array comprising PV modules and mounting structures.
» Inverters and transformers.
» Cabling between the panels.
» 33/132kV onsite facility substation.
» Cabling from the onsite substation to the collector substation (either underground or overhead).
» Electrical and auxiliary equipment required at the collector substation that serves that solar energy facility, including switchyard/bay, control building, fences, etc.
» Battery Energy Storage System (BESS).
» Site offices and maintenance buildings, including workshop areas for maintenance and storage.
» Laydown areas.
» Access roads and internal distribution roads.

The solar PV facility is proposed in response to the identified objectives of the national and provincial government and local and district municipalities to develop renewable energy facilities for power generation purposes. It is the developer's intention to bid the Kwana Solar PV Facility under the Department of Mineral Resources and Energy's (DMRE's) Renewable Energy Independent Power Producer Procurement (REIPPP) Programme, with the aim of evacuating the generated power into the national grid. This will aid in the diversification and stabilisation of the country's electricity supply, in line with the objectives of the Integrated Resource Plan (IRP) with the Kwana Solar PV Facility set to inject up to 100MW into the national grid.

APPENDIX 2: GPS DATA FOR NEWLY RECORDED FOSSIL SITES WITHIN THE GKRE AND GRID CONNECTION PROJECT AREA

All GPS readings were taken in the field using a hand-held Garmin GPSmap 64s instrument. The datum used is WGS 84.

Please note that:

- The fossil sites recorded represent only a representative fraction of the sites present at surface. The absence of recorded sites in an area does not imply that no fossils are present here, at or beneath the land surface.

- Given the considerable current uncertainties concerning the mapping and lithostratigraphy of the Lower Beaufort Group bedrocks in the project area (*cf* Day & Rubidge 2020a), the precise stratigraphic provenance (*e.g.* member of Teekloof Formation) of fossils listed here often remains uncertain. In most cases, the published geological map is followed, but this clearly requires revision in some areas.

Loc	GPS data	Comments
828	-31.457021003589034 23.660014998167753	Gegundefontein 53. Small (5.5 cm diam), well-rounded block of ferruginised rolled bone in surface float among weathering-out ferruginous, purple-brown pedocrete concretions, probable Poortjie Member. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
833	-31.457954999059439 23.675080966204405	Gegundefontein 53. Isolated fragment of baked, whitish postcranial bone (possibly associated with pedogenic concretion) with reaction halo embedded within pale yellowish metaquartzite quartzite channel sandstone, possibly Poortjie Member. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
852	-31.53030 23.63432	Rondavel 85. Stratigraphic level uncertain – *possibly* Oukloof Member / "Balfour Fm". Possible but *equivocal* tetrapod burrow cast (c. 25-30 cm wide), straight, inclined, infilled with grey-green sandstone and surrounded by crumbly purple brown mudrock. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
854	-31.54013 23.64365	Rondavel 85. Flaggy slabs of greenish-grey sandstone (stratigraphic provenance unclear) associated with ruined farm building showing probable sandstone-infilled mudcracks, wave rippled palaeosurfaces and invertebrate bioturbation and / or plant stem casts. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
859	-31.543518975377083 23.641590988263488	Rondavel 85. "Balfour Fm" (Oukloof Member of Teeklof Fm). Distorted / crushed, baked (v. white) skeletal material - possibly a small (*c*. 5 cm long) skull - embedded within mudflake-rich debris flow deposit. Proposed Field Rating IIIB. Professional palaeontological collection only necessary of specimen lies < 20 from project footprint.
863	-31.536312969401479 23.663475969806314	Rondavel 85. "Balfour Fm" (Oukloof Member of Teekloof Fm). Surface concentration of coffee-brown ferruginous concretionary material including several blocks containing bone preserved as moulds or silicified. Symmetrical array of low convexity, rounded plates with a radial ornamentation suggests pareiasaur reptile affinity (dermal scutes) – possibly juvenile or dwarf form. Proposed Field Rating IIIB. Professional palaeontological collection only necessary of specimen lies < 20 from project footprint.
884	-31.49779200553894 23.597218031063676	Rondavel 85. Hoedemaker Member. Thin crevasse splay sandstone exposed in shallow borrow pit with sandstone-infilled mudcracks, microbial mat textures, small-scale invertebrate trace fossils (narrow horizontal burrows of undermat miners), possible vertical burrows or plant stem casts. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
896	-31.543560968711972 23.516006022691727	Farm 96. "Balfour Formation" (Oukloof Member of Teekloof Fm). Scatter of baked white bone fragments of small-bodied tetrapod within quartzite surface gravels, in part preserved as moulds. Proposed Field Rating IIIC

		Local Resource. No mitigation recommended.
914	-31.632864028215408 23.450985001400113	Burgersfontein 92. Probable Poortjie Member, baked heterolithic package in bed of Burgerspruit. Fragment of skull (probably palate) of small tetrapod embedded within baked, grey-green wacke. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
915	-31.632765959948301 23.450854998081923	Burgersfontein 92. Probable Poortjie Member, bed of Burgerspruit. Postcranial bone of small tetrapod embedded within baked, grey-green wacke. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
917	-31.631848979741335 23.449530992656946	Burgersfontein 92. Late Caenozoic sandy to gravelly alluvium overlying calcrete-veined weathered dolerite exposed in banks of Burgerspruit. Assemblage of subvertical, subcylindrical calcretised structures – probably rhizoliths. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
918	-31.630922025069594 23.448976026847959	Burgersfontein 92. Probable Poortjie Member. Crushed, baked probable small tetrapod skull within thin-bedded grey-green siltstone with possible baked gypsum roses exposed on bed of Burgerspruit. Proposed Field Rating IIIB. Site protected in river bed within standard ecological riverine buffer.

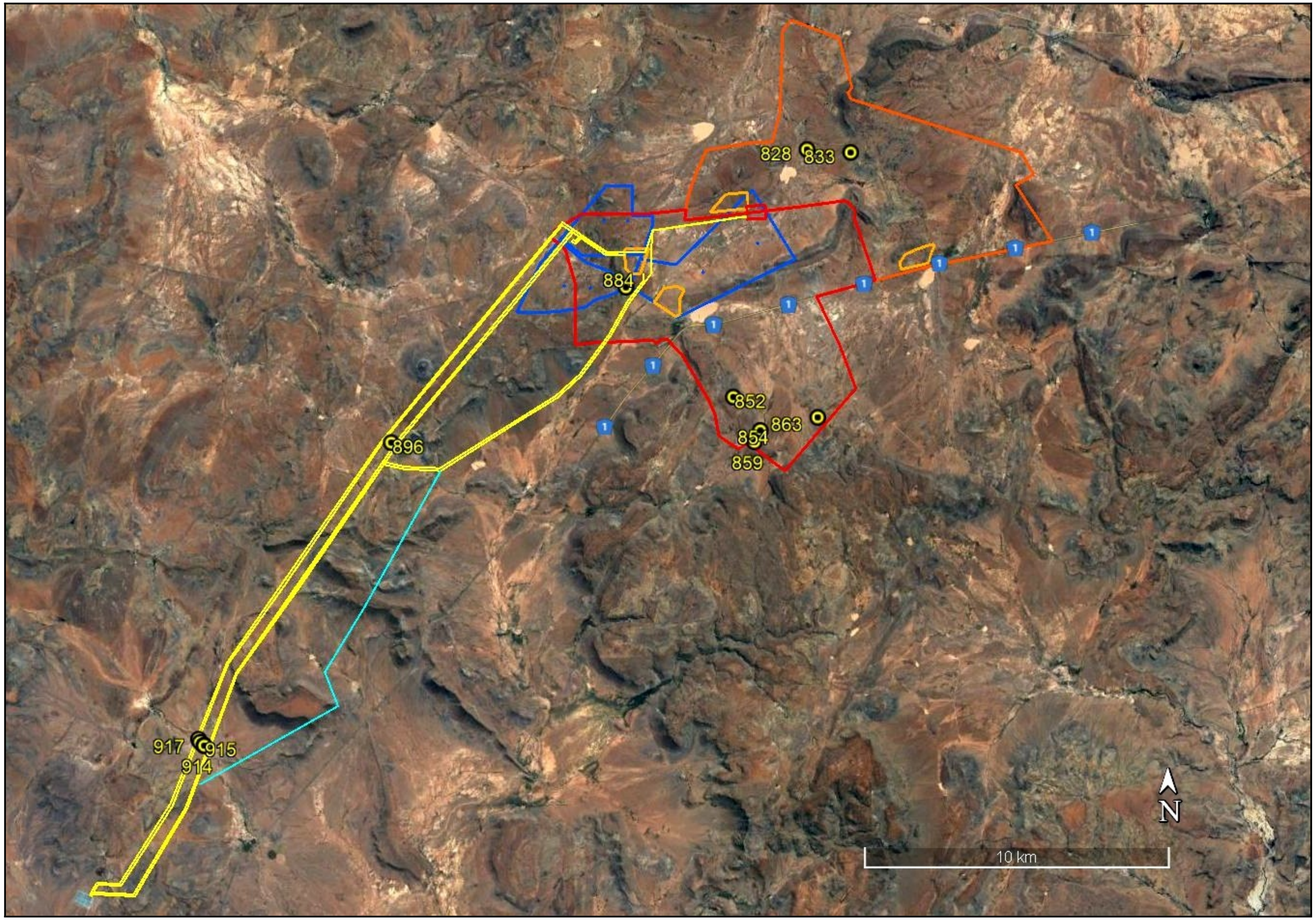


Figure A1: Google Earth© satellite image showing the newly recorded fossil sites (yellow circles) in the context of the combined GKRE (WEFs and solar PV projects) project area (orange polygon) as well as the grid connection route options to Gamma MTS (yellow and pale blue lines) between Richmond and Victoria West, Northern Cape Province. Fossil site details are provided in the table above. Almost all of the recorded fossil sites are of low scientific and / or conservation value.

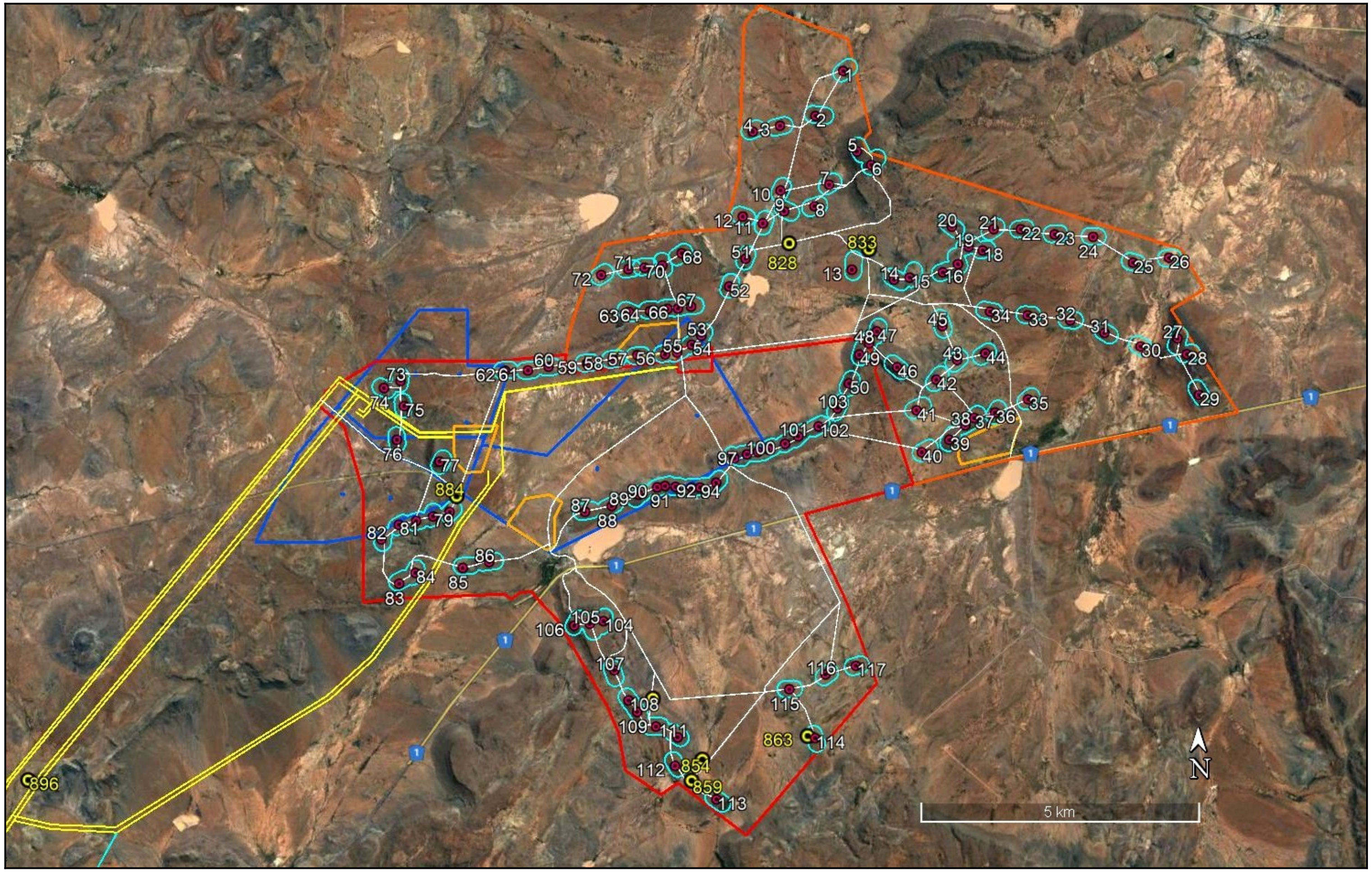


Figure A2: Google Earth© satellite image showing the newly recorded fossil sites (numbered yellow circles) in the context of the provisional layouts for the GKRE WEFs (turbine sites – red; buffers – pale blue; internal access roads – white) and solar PV project areas (dark blue polygons). With the exception of sites 828 and 884 (both of very low scientific / conservation value), all the recorded fossil sites lie well away (> 20 m) from the project footprints and no mitigation of any of these sites is recommended here.

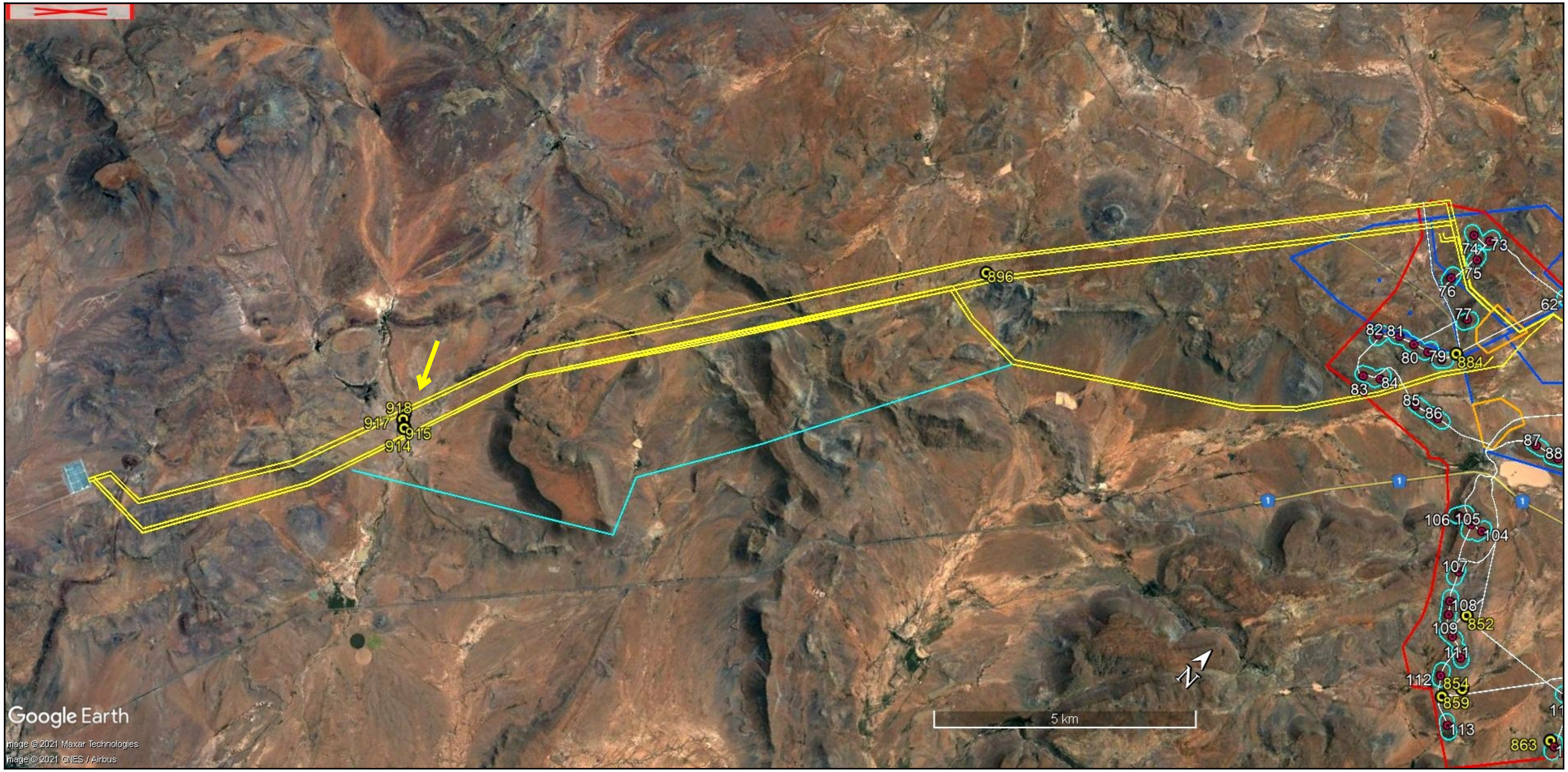


Figure A3: Google Earth© satellite image showing the newly recorded fossil sites (numbered yellow circles) in the context of the various grid connection route options (yellow, pale blue) under consideration between the GKRE project area (orange, blue polygons) and the Gamma MTS. All of the fossil sites mapped here are of low scientific and conservation value while the cluster along the Burgerspruit (arrowed) wil be protected within the standard ecological buffer along drainage lines. No specialist palaeontological mitigation of these fossil sites is therefore recommended here.

<table>
<tr><td colspan="3">APPENDIX 3. CHANCE FOSSIL FINDS PROCEDURE: GKRE renewable energy facilities and grid connections between Richmond and Victoria West</td></tr>
<tr><td>Province & region:</td><td colspan="2">Northern Cape (Pixley Ka-Seme District) and Western Cape (Central Karoo District) &</td></tr>
<tr><td>Responsible Heritage Management Agencies</td><td colspan="2">SAHRA: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za
HERITAGE WESTERN CAPE. Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 021 483 9598. E-mail: ceoheritage@westerncape.gov.za</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Teekloof Formation (Lower Beaufort Group), Late Caenozoic alluvium.</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Fossil skulls, postcrania of tetrapods, amphibians, fish as well as rare petrified wood, vertebrate and invertebrate burrows within bedrocks.
Mammalian bones, teeth & horn cores, freshwater molluscs, calcretised trace fossils & rhizoliths and plant material in alluvium.</td></tr>
<tr><td rowspan="5">ECO / ESO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
• Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
• Context – describe position of fossils within stratigraphy (rock layering), depth below surface
• Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
• Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation
• Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Agency for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
• Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
• Photograph fossils against a plain, level background, with scale
• Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
• Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
• Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Agency, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Agency</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Apply for Fossil Collection Permit Record / submit Work Plan to relevant Heritage Resources Agency. Describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Agency. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Agency minimum standards.</td></tr>
</table>