PALAEONTOLOGICAL SPECIALIST STUDY: DESKTOP ASSESSMENT

Proposed Melkspruit - Riebeek 132 kV transmission line, Ukhahlamba District Municipality, Eastern Cape

John E. Almond PhD (Cantab.)
***Natura Viva* cc, PO Box 12410 Mill Street,**
Cape Town 8010, RSA
naturaviva@universe.co.za

October 2011

PALAEONTOLOGICAL HERITAGE IMPACT STATEMENT

Eskom are proposing to construct a new 132 kV transmission line of approximately 48 km length between the existing Melkspruit Substation, situated about 3 km west of Aliwal North, and the existing Riebeek Substation some 10 km southwest of Lady Grey, Ukhahlamba District Municipality, Eastern Cape. Two alternative routes for the new transmission line, known as Options 1 and 2, as well as a deviation are under consideration. Over the majority of the preferred Option 1 route the new transmission line will run parallel to an existing line.

All transmission line route options traverse the outcrop areas of several different rock units of contrasting palaeontological sensitivity:

- Middle Triassic fluvial sediments of the **Burgersdorp Formation** (Upper Beaufort Group = Tarkastad Subgroup) that contain important terrestrial assemblages of vertebrates, plants and traces documenting the gradual recovery of terrestrial life from the End Permian Mass Extinction Event (Palaeontological sensitivity = generally MODERATE TO HIGH, locally VERY HIGH);
- Late Triassic fluvial sediments of the **Molteno Formation** (Stormberg Group) that are famous for their exceptionally rich plant and insect fossil biotas (Palaeontological sensitivity = generally MODERATE TO HIGH, locally VERY HIGH);
- Late Triassic arid "red bed" sediments of the **Elliot Formation** (Stormberg Group) that have yielded a range of early dinosaurs and vertebrate trackways (Palaeontological sensitivity = generally MODERATE TO HIGH, locally VERY HIGH);
- Early Jurassic **dolerite intrusions** that are unfossiliferous (Palaeontological sensitivity = ZER0);
- **Quaternary to Recent superficial deposits** – river alluvium, colluvium (scree and other slope deposits), calcretes etc formed over the past c. 2.5 million years (Palaeontological sensitivity generally LOW, but may be locally HIGH to VERY HIGH).

Numerous palaeontologically important rock exposures as well as Karoo vertebrate and plant fossil localities of Middle to Late Triassic age have already been recorded close to the Orange River between Aliwal North and Lady Grey. These include, for example, fossil dinosaur localities from the Eliot Formation and fossil floras from the Burgersdorp and Molteno Formations around Aliwal North. This area was made famous in palaeontological terms by the well-known amateur fossil collector Alfred (Gogga) Brown in the late nineteenth century.

During the construction phase of the transmission line any fossils exposed at the ground surface or at shallow depths below this are vulnerable to disturbance, damage or destruction within the 6m wide strip to be cleared along the entire route. Bedrock excavations for pylon footings (up to 3m deep) and any new access roads may also expose, damage or destroy previously buried fossil material. Significant further impacts on local fossil heritage are not anticipated during the operational phase of the transmission line development.

Because (1) the Karoo Supergroup geological formations concerned are all ranked as *high* in terms of overall palaeontological sensitivity, and (2) a sizeable number of important vertebrate and plant fossil localities are already recorded within the broader study region close to the Orange River, the impact significance of the proposed transmission line development on fossil heritage is potentially MEDIUM to HIGH.

There is no substantial difference between the various transmission line route options in terms of overall palaeontological sensitivity or impact significance at the desktop level of analysis. Because it follows an existing transmission line route for much of its length, Option 1 will require a shorter length of new access road, and will therefore have a lower impact in this respect.

A realistic palaeontological heritage impact assessment for this project, with recommendations for any mitigation necessary, is only possible once the transmission line corridors have been surveyed in the field by a professional palaeontologist. It is recommended that such a field survey be carried out at the earliest opportunity so that any significant palaeontological heritage issues may be addressed in the project design. It should be noted that the most likely outcome of such a field study is that most sectors of the alternative transmission line corridors prove to be insensitive in practice because of a thick superficial sediment cover, high degree or near-surface weathering, or sparse fossil content. However, short sectors of high palaeontological sensitivity, with a concentration of near-surface fossil material, might also be identified and mapped. These sectors may require mitigation.

The recommended palaeontological field survey should focus on areas of good bedrock exposure along or close to the various transmission line route options. The focus of the study should be on:

- Identifying those sectors of the various route options (if any) that are recorded as, or inferred to be, of high palaeontological sensitivity;
- Comparing the alternative route options in terms of overall palaeontological impact significance;
- Making detailed recommendations regarding mitigation of impacts within route sectors of high palaeontological sensitivity (if any) during the pre-construction or construction phases. These mitigation recommendations should be incorporated into the EMP for the transmission line development.

TABLE OF CONTENTS

1. INTRODUCTION

1.1. Outline and location of the proposed development

Eskom are proposing to construct a new 132 kV transmission line of approximately 48 km length between the existing Melkspruit Substation, situated about 3 km west of Aliwal North, and the existing Riebeek Substation some 10 km southwest of Lady Grey, Ukhahlamba District Municipality, Eastern Cape. Two alternative routes for the new transmission line, known as Options 1 and 2, as well as a deviation are under consideration. These routes run roughly west – east and subparallel to the R58 tar road and old railway line between Aliwal North and Lady Grey. Over the majority of the preferred Option 1 route the new transmission line will run parallel to an existing transmission line. The outline of the broader study area for palaeontological basic assessment purposes is depicted in Fig. 1 below. The routes for Options 1, 2 and the deviation are approximately shown in Fig. 5, superimposed on the relevant 1: 250 000 geological map.

The following generic outline for the 132 kV transmission line development has been provided by Arcus Gibb Engineering and Science, East London, who have been appointed by Eskom to undertake a Basic Assessment for this project:

> For the proposed overhead power lines, an area with a strip width of 6m will be cleared along the entire route. Holes will be drilled or blasting may be employed for the support poles [monopoles]. A blast area of 1.5 x 1.5 x 2.5 m will be required for each supporting pole. Small amounts of concrete is mixed for the site stabilizing towers (± 0.5 cubes per strain tower / 1 every 1.5 km). The internal towers will generally be placed on pre-cast foundation (± 0.5 x 0.5 x 0.5 m). An 8-ton crane truck is usually used to erect the structures. No access routes are required where the proposed powerline follows an existing road, or is alongside an existing powerline, as access routes are already available.

Based on similar transmission line projects, excavations for the 132 kV transmission pylons may be up to 2-3 m deep, depending on substrate conditions.

Fig. 1: Extract from 1: 250 000 topographical map 3026 Aliwal North (Courtesy of the Chief Directorate of Surveys & Mapping, Mowbray). The outline of the broader study area between Aliwal North and Lady Grey for the proposed 132 kV transmission line between Melkspruit and Riebeek Substations, Eastern Cape Province, is shown by the black rectangle. The transmission line route options are shown in more detail in Fig. 5.

1.2. Approach to the study

The present desktop report, commissioned by Ethembeni Cultural Heritage, Pietermaritzburg on behalf of Arcus Gibb Engineering and Science, East London, forms part of the Basic Assessment for the proposed 132 kV transmission line project and it will also inform the EIA and Environmental Management Plan for the project. This development falls under Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

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

Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated May 2007.

This palaeontological specialist report provides an assessment of the observed or inferred palaeontological heritage within the study area, with recommendations for further specialist palaeontological input where this is considered necessary. Information sources used in compiling this desktop report are outlined in Section 1.5 below.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. 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 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 *et al.* 2008). 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 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 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 authority (*e.g.* SAHRA for the Eastern Cape). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.3. Terms of reference

The author has been commissioned by Ethembeni Cultural Heritage to provide specialist palaeontological input for the Basic Assessment of the proposed 132 kV transmission line in the form of a desktop report in accordance with the project description provided by Arcus Gibb.

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.

1.5. Information sources

The information used in this desktop study was based on the following:

1. A short project outline as well as detailed maps provided by Arcus Gibb Engineering and Science, East London;

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations;

3. The author's previous field experience with the formations concerned and their palaeontological heritage;

4. A review of Eastern Cape fossil heritage produced for SAHRA by Almond *et al.* (2008).

2. GEOLOGY OF THE STUDY AREA

The main geological units represented within the broader Melkspruit – Riebeek study area between Aliwal North and Lady Grey are briefly described here, paying special attention to those formations that may be of palaeontological heritage significance.

2.1. Outline of geological setting

The Melkspruit – Riebeek study area is situated on the northern margins of the Eastern Cape Province, just south of the Orange River, between the towns of Aliwal North and Lady Grey (Fig. 1). Most of this hilly, semi-arid region – essentially part of the western foothills of the Witteberg / Drakensberg massif - lies at elevations between 1300 and 1550 m amsl. The region is extensively dissected by episodically flowing, south bank tributaries of the Orange River drainage system, including its major tributary the Kraai River, that are associated with substantial alluvial deposits. The greater part of the study area is underlain by recessive-weathering sedimentary rocks of the Beaufort Group and Stormberg Group (Karoo Supergroup) while more resistant-weathering dolerite intrusions build several koppies and ridges. Unfortunately, Google Earth satellite imagery of the study area is still rather poor.

The geology of the Melkspruit – Riebeek study area is shown on the 1: 250 000 geology sheet 3026 Aliwal North published by the Council for Geoscience, Pretoria (Bruce *et al.* 1983) (Fig. 5). The Aliwal North sheet is currently out of print and is only available as a poor, digitized copy; hence the low quality of the geological map in Fig. 5. The proposed new 132 kV transmission line traverses the outcrop area of several potentially fossiliferous sedimentary formations of the **Karoo Supergroup**, ranging in age from Middle to Late Triassic (Fig. 2). Hardly any bedding dips are indicated on the Aliwal North geology sheet, reflecting the fact that the Karoo Supergroup succession here is largely flat-lying and undeformed. The lower-lying, western half of the study region is largely underlain by Middle Triassic fluvial sediments of the **Burgersdorp Formation** (Trt), the uppermost subunit of the **Upper Beaufort Group** (**Tarkastad Subgroup**). These older sediments are extensively overlain by alluvial deposits of the Kraai River drainage system of probable Late Quaternary to Recent age and are intruded by numerous arcuate dolerite bodies of the Late Jurassic **Karoo Dolerite Suite** (Jd). The higher-lying, more rugged eastern portion of the study area is underlain by Late Triassic fluvial sediments of the **Stormberg Group**, including the **Molteno Formation** (Trm) and, at the eastern extremity of the transmission line, the lower part of the **Elliot Formation** (Tre). Only small dolerite intrusions are mapped in this eastern sector.

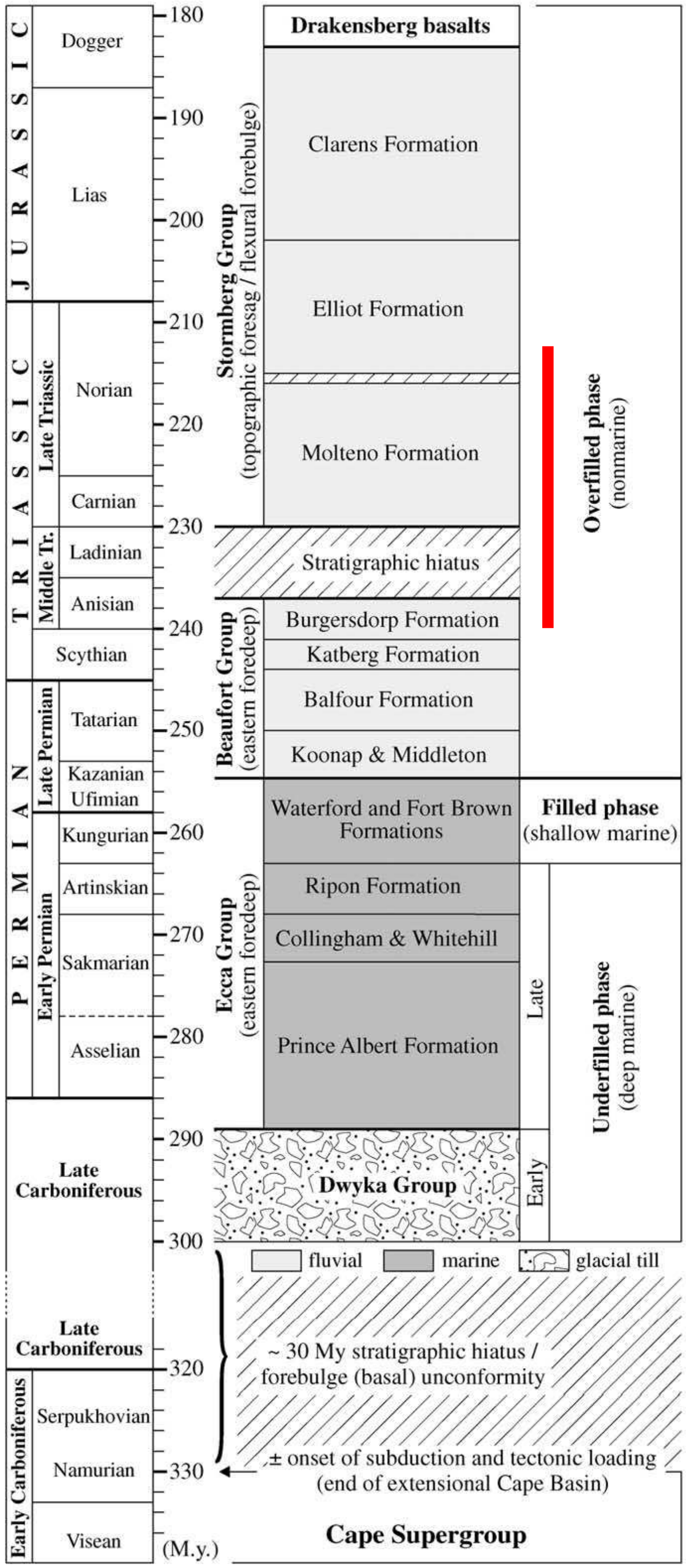


Fig. 2: Stratigraphic subdivision of the *c.* 12km-thick Karoo Supergroup in the Main Karoo Basin (From Catuneanu *et al.* 2005). The bold red line emphasizes the Middle to Late Triassic sedimentary units represented in the Melkspruit – Riebeek study area near Aliwal North.

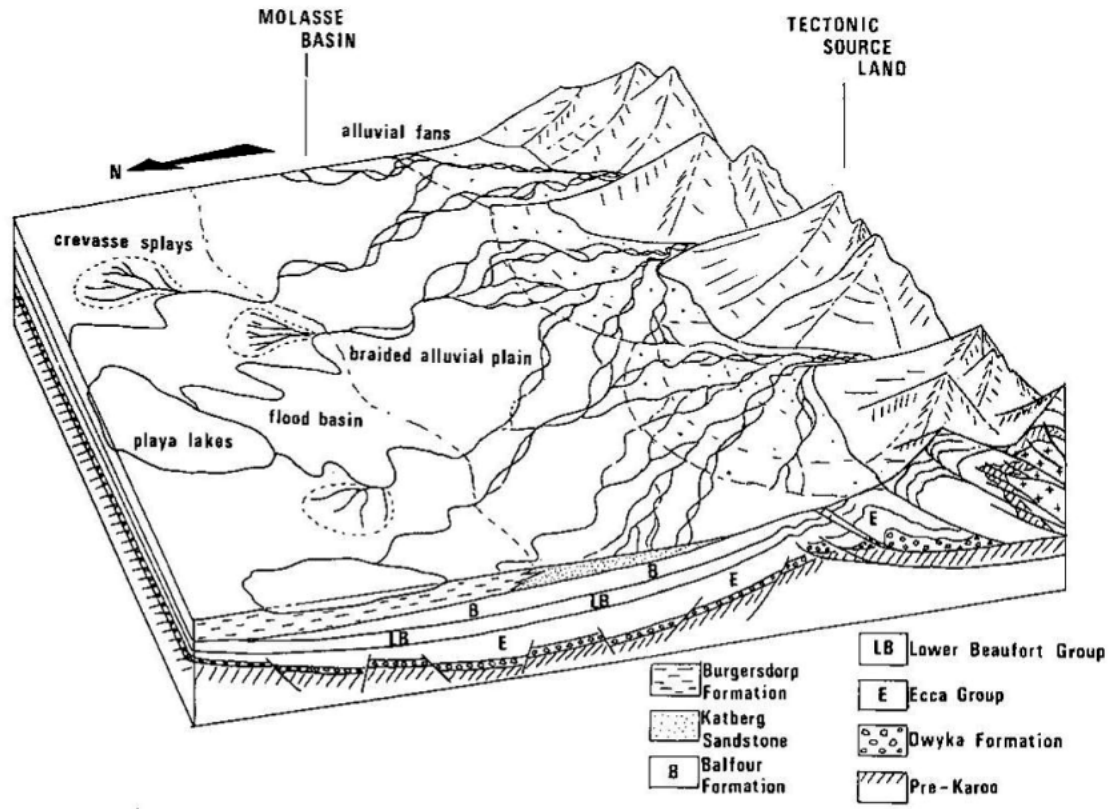


Fig. 3: Reconstruction of the south-eastern part of the Main Karoo Basin in Early Triassic times showing the deposition of the sandy Katberg Formation near the mountainous source area in the south. The mudrock-dominated Burgersdorp Formation was deposited on the distal floodplain where numerous playa lakes are also found (From Hiller & Stavrakis 1984).

2.1.1. Burgersdorp Formation (Tarkastad Subgroup)

A useful overview of the continental sedimentary succession of the Beaufort Group has been given by Johnson *et al.* (2006). The Tarkastad Subgroup rocks on the Aliwal North geology sheet have not been subdivided at the formational level, but the successions around Aliwal North itself directly underlie the Stormberg Subgroup and can be confidently assigned to the mudrock-dominated Burgersdorp Formation (See also Anderson & Anderson 1985, and Fig. ** herein).

The Burgersdorp Formation is the youngest subunit of the Permo-Triassic Beaufort Group (Karoo Supergroup, Tarkastad Subgroup) and is paraconformably overlain by the Molteno and Elliot Formations of the Stormberg Group. It is a mudrock-rich succession of Early to Middle Triassic age with a total thickness of some 900-1000m in its southern outcrop area near Queenstown (Johnson *et a*l. 2006). Kitching (1995) quotes a thickness of 600m in the type area for this formation between Queenstown and Lady Frere, well to the southeast of the present study area. Brief geological descriptions of the Burgersdorp Formation are given by Karpeta and Johnson (1979), Dingle *et al.* (1983), Johnson (1976, 1984), Hiller & Stavrakis (1984), Johnson & Hiller (1990), Kitching (1995) and Hancox (2000; see also extensive references therein).

The Burgersdorp rocks were laid down within the Main Karoo Basin by northwestwards-flowing meandering rivers during a warm, arid to semi-arid climatic interval (Fig. 3). They comprise isolated, lenticular, feldspathic channel sandstones, abundant crevasse splay sandstones, and typically greyish-red to dusky red overbank mudrocks, forming upwards-fining cycles of a few meters to tens of meters in thickness. Intraformational mudflake breccio-conglomerates are common at the base of the sandstone units. The mudrocks are generally massive (unbedded) but occasionally display sand-infilled mudcracks and clastic dykes. Well-laminated reddish mudrocks with pedocrete horizons are interpreted as playa lake deposits. Lacustrine palaeoenvironments predominated in the northern part of the Karoo Basin at this time and these lake deposits have recently received considerable palaeontological attention (*e.g.* Free State; Welman *et al.* 1991, Hancox *et al.* 2010 and refs therein).

2.1.2. Molteno Formation

The Molteno Formation is a stratigraphically complex wedge of perennial braided alluvial sediments of estimated Late Triassic age that crops out around the margins of the Stormberg Group outcrop area centred on the Drakenberg highlands (Fig. 3). At its thickest, in the south, the formation reaches 600-650m and has been subdivided into a series of five members but it tapers rapidly towards the north. The sandstone-rich Molteno succession is more resistant-weathering than the underlying and overlying rocks (Burgersdorp and Elliot Formations respectively) and therefore tends to form a topographic escarpment.

Useful short geological accounts of the Molteno Formation are given by Dingle *et al.* (1983), Visser (1984), Smith *et al.* (1998), Hancox (2000) and Johnson *et al.* (2006), while a short description of these rocks in the Aliwal North 1: 250 000 geology sheet area is provided by Bruce *et al.* (1983). Key technical papers include those by Turner (1975. 1983), Eriksson (1984), Christie (1981), Dingle *et al.* (1983), Cairncross *et al.* (1995), Anderson *et al.* (1998) and Hancox (1998); fuller geological references are provided by Hancox (2000).

The Molteno succession is made up of an alternation of laterally-persistent, erosive-based, medium- to coarse-grained, feldspathic sandstones and subordinate olive-grey to reddish mudrocks. These rocks were deposited in braided alluvial channels, overbank floodplains and lakes on an extensive, northwards-flowing alluvial braidplain. The sandstones typically show a "glittering" appearance due to extensive development of secondary quartz overgrowths. Internal sedimentary structures include trough and planar cross-bedding, flat-lamination and overturned cross-bedding. Numerous fining-upwards sequences of 5-50m thickness, averaging 20-30m, are commonly present within the Molteno succession (Johnson 1984). These sequences, which can be readily seen on aerial and satellite images, grade upwards from pebbly, coarse sandstones at the base through finer sandstones, siltstones and finally into carbonaceous, thinly-bedded to laminated claystones. These last may be highly fossiliferous. Thin, lenticular coals were formed in peaty swamp settings on the alluvial floodplain, but many so-called "coals" are effectively only carbonaceous mudstones. Humid, warm climates with a pronounced seasonality are suggested by the rich plant and insect life preserved in these sediments, especially the finer-grained mudrocks, as well as by the sedimentology and fossil soils (Hancox 2000). However, some authors infer an alternation of warm, dry summers and cool, wet winters (*e.g.* Anderson *et al.* 1998, Johnson *et al.* 2006). The precise age of the Molteno Formation has not yet been established, but a Late Triassic (Carnian, 228-216.5 Ma) age is favoured for at least the lower part of the formation by most recent authors on the basis of the fossil plants (*Dicroidium* Flora) and palynomorphs (*Allisporites / Falcisporites* assemblages) as well as biostratigraphic correlation with Australian Triassic successions (Hancox 2000, Rubidge 2005).

2.1.3. Lower Elliot Formation

Useful geological overviews of the Elliot Formation are provided by Tankard *et al.* (1982), Dingle *et al.* (1983), Hancox (2000, with extensive references to the earlier literature), Smith *et al.* (2002) and Johnson *et al.* (2006). More detailed accounts of the sedimentology of the Elliot Formation "red beds" can be found in Visser and Botha (1980), Visser (1984) as well as excellent recent publications by Smith and Kitching (1997) and Bordy *et al.* (2004a, 2004b, 2004c). General remarks on the Elliot Formation of the Aliwal North sheet area are provided by Bruce *et al.* (1983). The age of the Elliot Formation remains poorly constrained, with estimates ranging from Late Triassic (Carnian / Norian / Rhaetian) to Early Jurassic (Hettangian – Pliensbachian), *i.e.* within the period 235 to 183 Ma (See discussion in Hancox 2000, Smith *et al.* 2002, Rubidge 2005).

The Elliot Formation is a typical arid continental "red bed" succession of Late Triassic to Early Jurassic age that reaches a thickness of up to 500- 550m in the southern outcrop area. The type section is located in Barkly Pass near the town of Elliot in the Eastern Cape (Visser & Botha 1980, Smith *et al.* 1998). The predominantly fluvial succession consists largely of reddish to maroon, structureless overbank mudrocks and fine- to medium-grained channel sandstones. These rocks are interpreted as a distal facies equivalent to the more proximal alluvial braidplains of the underlying Molteno Formation (Turner 1983, 1986; Fig. 4). Sedimentary settings in the southern Elliot outcrop area include meandering rivers in the lower Elliot, braided stream systems in the middle Elliot and sandstone-dominated flood-fan (flash-flood), playa lake and aeolian dune complexes in the upper Elliot (with subordinate volcanics). A major period of erosional landscape degradation marked by a prominent fossiliferous calcrete nodule palaeosol occurs in the middle Elliot Formation (*Tritylodon* Acme Zone; Kitching & Raath 1984, Smith & Kitching 1997). Prevailing semi-arid to arid climates during Elliot Formation times are indicated by the reddish-hued mudrocks (oxidised iron minerals), desiccation cracks, abundant pedogenic carbonates (palaosol or fossil soil calcretes, rhizocretions) and the taphonomic styles of the fossils vertebrate remains (*e.g.* sun-cracked bones). During deposition of the Elliot Formation climates became increasingly arid, culminating in the establishment of the Clarens sand sea in Early Jurassic times.

Sedimentary bedrocks close to the contact with the Molteno Formation and can be assigned to the lower Elliot Formation of Late Carnian / Norian to Rhaetian age. Useful accounts of the lower Elliot sediments are provided by Kitching and Raath (1984) and Hancox (2000). This sandier lower portion of the Elliot succession is dominated by greyish red to pale red mudrocks and consists of several fining-upwards sequences of 25-50m thickness. Yellowish to pale red, tabular to lenticular sandstone units up to 7m thick with erosive bases are massive to cross-bedded and were laid down within the channels and on point bars of large volume, high sinuosity meandering rivers. Basal channel lags comprise intraformational breccio-conglomerates with mudflakes, occasional small rounded quartz pebbles and fragmentary reworked bone. Thinner sheet sandstones and coarsening-upwards packages were deposited by crevasse splay systems on the proximal flood plain when the rivers burst their banks during flood episodes. The overbank mudrocks are usually massive and contain numerous calcretised palaeosols (fossil soil horizons). The dominant palaeocurrent directions within the southern outcrop area of the lower Elliot vary from northwest to northeast.

2.1.4. Karoo Dolerite Suite

The Permo-Triassic Beaufort and Stormberg Group sediments across the study area are extensively intruded and thermally metamorphosed (baked) by subhorizontal sills and steeply inclined dykes of the **Karoo Dolerite Suite** (Jd). These Early Jurassic (*c.* 183 Ma) basic intrusions were emplaced during crustal doming and stretching that preceded the break-up of Gondwana (Duncan and Marsh 2006). The hot dolerite magma baked adjacent Beaufort Group mudrocks and sandstones to form splintery hornfels and quartzites respectively. Blocky colluvium and corestones released by weathering and erosion of the dolerites blanket many mountain slopes, often obscuring the underlying fossiliferous Karoo Supergroup sediments.

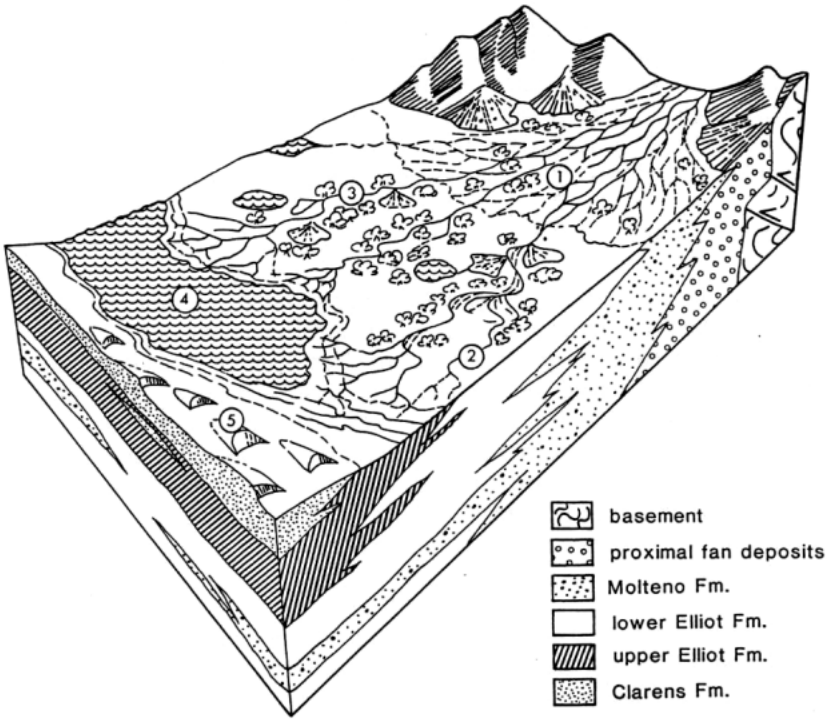


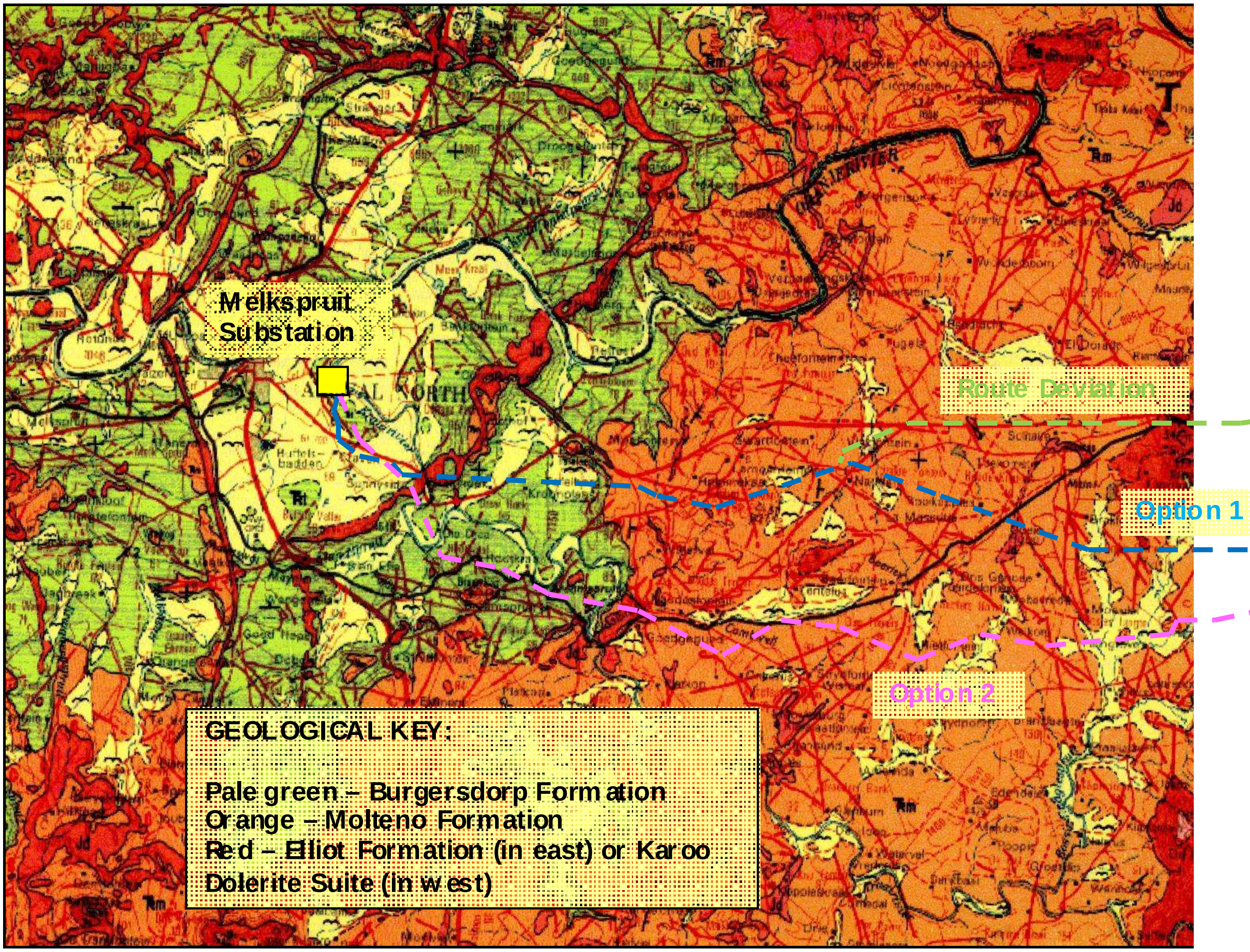
Figure 33 Looking eastwards over 1000 km-long slice through the upper Karoo Basin showing the depositional environments and lateral facies relationships of the Molteno, Elliot and Clarens formations (modified from Turner, 1986). In response to pulses of uplift in the southeasetrn mountains large brided fans(1) prograded into the semi arid Elliot basin. Basinwards, the rivers became more sinuous (3). Expansive semi arid floodplains drained by ephemeral crevasse splay channels (2) accumulated mostly silt (some brought in as loess). In the drier distal parts of the basin, end-point playas (4) and aeolian dune fields (5) developed.

Fig. 4: Inferred depositional settings of sediments of the Stormberg Group, including the lower Elliot Formation in the study area (From Smith *et al.* 2002).

2.1.5. Superficial deposits

Various types of **superficial deposits** ("drift") of Late Caenozoic (largely Quaternary to Recent) age occur widely throughout the Karoo region, including in the study area. They include pedocretes (*e.g*. calcretes or soil limestones), colluvial slope deposits (sandstone and dolerite scree, downwasted gravels *etc*), sheet wash, river channel alluvium and terrace gravels, as well as spring and pan sediments (Johnson & Keyser 1979, Le Roux & Keyser 1988, Cole *et al.,* 2004, Partridge *et al*. 2006). Only the larger tracts of Quaternary to Recent **alluvium** overlying the Beaufort Group bedrock that are associated with the larger drainage courses feeding into the Orange River system to the north are shown on the 1: 250 000 geological maps. The levels of potentially fossiliferous bedrock outcrop *versus* superficial sediment cover within the study area cannot be accurately estimated on the basis of the poor satellite images available; they can only be determined through fieldwork.

Fig. 5 (following page): Extract from 1: 250 000 geology sheet 3026 Aliwal North (Council for Geoscience, Pretoria) showing *approximate* routes of the two transmission line options and the northern route deviation (Option 1 in blue is the preferred option). Note that this map is a scan of a poorly-printed original and unfortunately does not clearly differentiate between the Late Triassic Elliot Formation (in the east) and Jurassic intrusive dolerite intrusions (in the west), both of which appear red here.


Melkspruit
Substation
Route Deviation
Option 1
Option 2
GEOLOGICAL KEY:
Pale green – Burgersdorp Formation
Orange – Molteno Formation
Red – Elliot Formation (in east) or Karoo Dolerite Suite (in west)

3. PALAEONTOLOGICAL HERITAGE

A brief review of the fossil assemblages recorded from the various major geological formations that are represented within the broader Melkspruit – Riebeek study area is given here. A recent plot of Beaufort Group fossil sites recorded within the Main Karoo Basin by Nicolas (2007) shows a concentration of localities along the border between the Eastern Cape and the Free State (Fig. 6 herein). This pattern probably reflects, at least in part, the higher levels of landscape denudation by river incision either side of the ancient Orange River. As a result, extensive sections of potentially fossiliferous bedrock are exposed here.

It is notable for the purposes of the present palaeontological impact study that since the late nineteenth century numerous scientifically important rock sections and Karoo vertebrate fossil localities from a number of Late Permian to Late Triassic formations have been recognised either side of the Orange River between Colesberg, Burgersdorp and Aliwal North and further east. These include, for example, one of the most informative fossiliferous sections across the Permo-Triassic mass extinction boundary in the Bethulie region, just north of the Gariep Dam (upper Adelaide Subgroup), several key fossil sites in the Katberg Formation between Aliwal North and the Gariep Dam, and the rich Triassic vertebrate faunas and floras of the Winnarsbaken, Burgersdorp and Aliwal North areas (Burgersdorp, Molteno and Elliot Formations; Smith *et al.* 2002 and references therein). Many, but not the more recent, of these fossil localities are listed according to their formation or assemblage zone by Kitching (1977) and Anderson and Anderson (1985). Among them are numerous fossil sites near Aliwal North, Burgersdorp and Rouxville, only some of which are shown in Fig. 6 below.

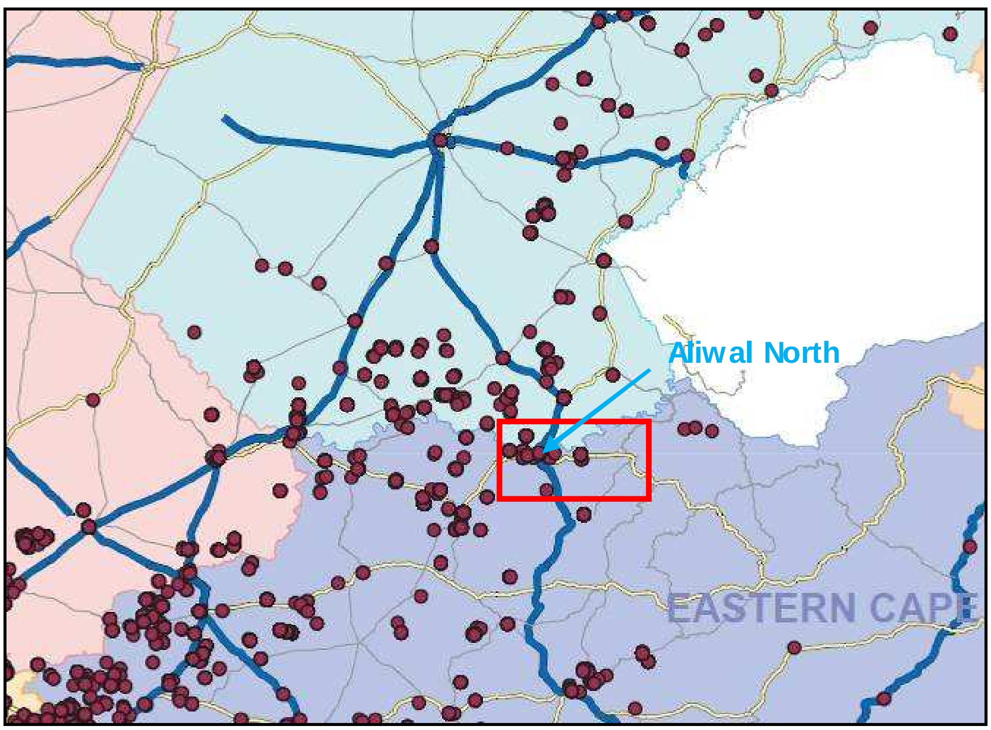


Fig. 6: Plot of known Beaufort Group fossil vertebrate localities within the broader study area (red rectangle) along the northern margins of the Eastern Cape between Aliwal North and Lady Grey (Modified from Nicolas 2007). A concentration of sites close to the Orange River in part reflects higher levels of bedrock exposure in this region due to protracted landscape denudation by stream erosion. Fossil taxa recorded from many of the Upper Beaufort Group sites, but not those in the Stormberg Group, are listed by Kitching (1977).

3.1. Fossils within the Burgersdorp Formation (Tarkastad Subgroup)

Both the Katberg and Burgersdorp Formations of the Main Karoo Basin have yielded important Triassic continental fossil assemblages, including a range of vertebrates, plants and trace fossils. These biotas are of special palaeontological significance in that they document the recovery phase of terrestrial ecosystems on Gondwana following the catastrophic end-Permian Mass Extinction of 251.4 million years ago (*e.g.* Benton 2003, Smith & Botha 2005, Botha & Smith 2007 and refs. therein). They also provide interesting insights into the adaptations and taphonomy of terrestrial animals and plants during a particularly stressful, arid phase of Earth history in the Early Triassic.

The biostratigraphy of the Early–Mid Triassic sediments of the Tarkastad Subgroup has been the focus of considerable palaeontological research in recent years, and the subdivision of the *Cynognathus* Assemblage Zone into three subunits has been proposed by several authors (See Hancox *et al.*, 1995, Hancox 2000, Neveling *et al.,* 2005, Rubidge 2005, Abdala *et al.* 2005, and refs therein). Recent research has also emphasized the rapidity of faunal turnover during the transition between the sand-dominated Katberg Formation (*Lystrosaurus* Assemblage Zone) and the overlying mudrock-dominated Burgersdorp Formation (Neveling *et al.,* 1999, 2005). In the proximal (southern) part of the basin the abrupt faunal turnover occurs in the uppermost sandstones of the Katberg Formation and the lowermost sandstones of the Burgersdorp Formation (*ibid*., p.83 and Neveling 2004). This recent work shows that the *Cynognathus* Assemblage Zone correlates with the entire Burgersdorp Formation; previous authors had proposed that the lowermost Burgersdorp beds belonged to the *Lystrosaurus* Assemblage Zone (*e.g.* Keyser & Smith 1977-78, Johnson & Hiller 1990, Kitching 1995).

The Burgersdorp Formation is characterized by a diverse continental fossil biota of Early to Mid Triassic (Olenekian to Anisian) age, some 249 to 237 milllion years old (Kitching 1995, Rubidge 2005, Neveling *et al.* 2005). The Burgersdorp fauna is dominated by a wide variety of tetrapod taxa, notably a range of amphibians, reptiles and therapsids ("mammal-like reptiles"). This distinctive biota is referred to the ***Cynognathus* Assemblage Zone** (= *Kannemeyeria – Diademodon* Assemblage Zone of earlier authors; see Keyser & Smith 1977-78, Kitching 1995). Comparable Triassic faunas have been described from various parts of the ancient supercontinent Pangaea, including Russia, China, India, Argentina, Australia and Antarctica.

Useful accounts of the palaeontological heritage of this stratigraphic unit – which has recently being recognised as one of the richest Early-Mid Triassic biotas worldwide – are given by Kitching (1977, 1995), Keyser and Smith (1977-78), MacRae (1999), Hancox (2000; see also many references therein), Cole *et al.* (2004) and Rubidge (2005). The Burgersdorp biotas include a rich freshwater vertebrate fauna, with a range of fish groups (*e.g.* sharks, lungfish, coelacanths, ray-finned bony fish such as palaeoniscoids) as well as large capitosaurid and trematosuchid amphibians. The latter are of considerable important for long-range biostratigraphic correlation. The interesting reptile fauna includes lizard-like sphenodontids, beaked rhynchosaurs, and various primitive archosaurs (distant relatives of the dinosaurs) such as the crocodile-like erythrosuchids, some of which reached body lengths of 5m, as well as the more gracile *Euparkeria* (Fig. 7). The therapsid fauna contains large herbivorous dicynodonts like *Kannemeyeria* (Fig. 8), which may have lived in herds, *plus* several small to medium-sized carnivorous or herbivorous therocephalians (*e.g. Bauria*) and advanced cynodonts. The most famous cynodont here is probably the powerful-jawed genus *Cynognathus* (Fig. 8), but remains of the omnivorous *Diademodon* are much commoner. Tetrapods are also represented by several fossil trackways while large *Cruziana*–like burrow systems with coarsely scratched ventral walls are attributed to burrowing vertebrates (*cf* Shone 1978). Locally abundant vertebrate burrows have been attributed to small procolophonid reptiles (Groenewald *et al.* 2001). Important new studies on lacustrine biotas in the northern Burgersdorp outcrop area have yielded rich microvertebrate faunas as well as vertebrate coprolites; sites such as Driefontein in the Free State are now among the best-documented non-marine occurrences of Early Triassic age anywhere in the world (Bender & Hancox 2003, 2004, Hancox *et al.* 2010, Ortiz *et al.* 2010 and refs. therein).

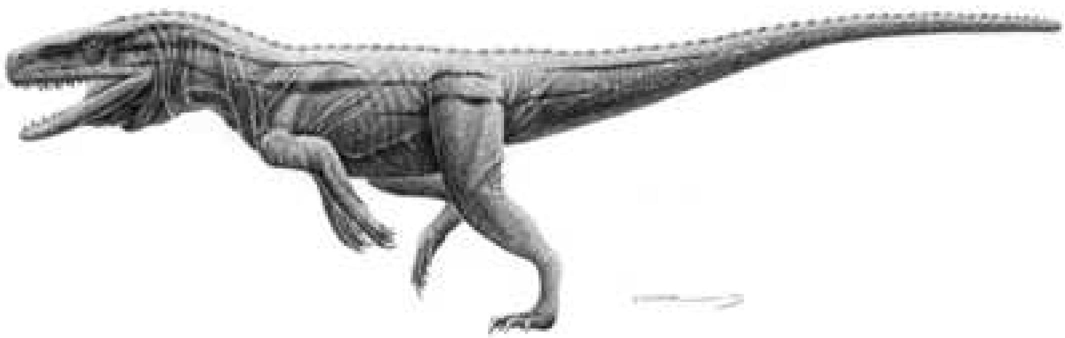


Fig. 7: Reconstruction of the small (*c.* 0.5m long) bipedal reptile *Euparkeria*, a primitive member of the archosaur group from which dinosaurs evolved later in the Triassic Period.

Contemporary invertebrate faunas are still very poorly known. Freshwater unionid molluscs are rare, while the chitinous exoskeletons of the once-abundant terrestrial arthropods do not preserve well in the highly oxidising arid-climate sediments found here; arthropod trace fossils are known but so far no fossil insects. Likewise fossil plants of the characteristic Triassic *Dicroidium* Flora are poorly represented and low in diversity. They include lycophytes (club mosses), ferns (including horsetails such as *Schizoneura*), "seed ferns" (*e.g. Dicroidium*) and several gymnospermous groups (conifers, ginkgos, cycads *etc*) (Anderson & Anderson, 1985, Bamford 2004). A small range of silicified gymnospermous fossil woods are also present including *Agathoxylon, Podocarpoxylon* and *Mesembrioxylon* (Bamford 1999, 2004). The famous amateur palaeontologist Alfred (Gogga) Brown collected Triassic plants from localities near Aliwal North in the late nineteenth century (See also plant fossil locality map, Fig. 9).

According to Kitching (1963, 1995) isolated, dispersed fossil bones, as well as some well-articulated skeletons, are associated with "thin localised lenses of silty sandstone" within the Burgersdorp Formation. Pedogenic, brown-weathering calcrete concretions occasionally contain complete fossil skeletons, while transported "rolled" bone is associated with intraformational conglomeratic facies at the base of channel sandstones. Fossil diversity decreases upwards through the succession. Complete tetrapod specimens are commoner lower down and amphibian remains higher up (Kitching 1995).

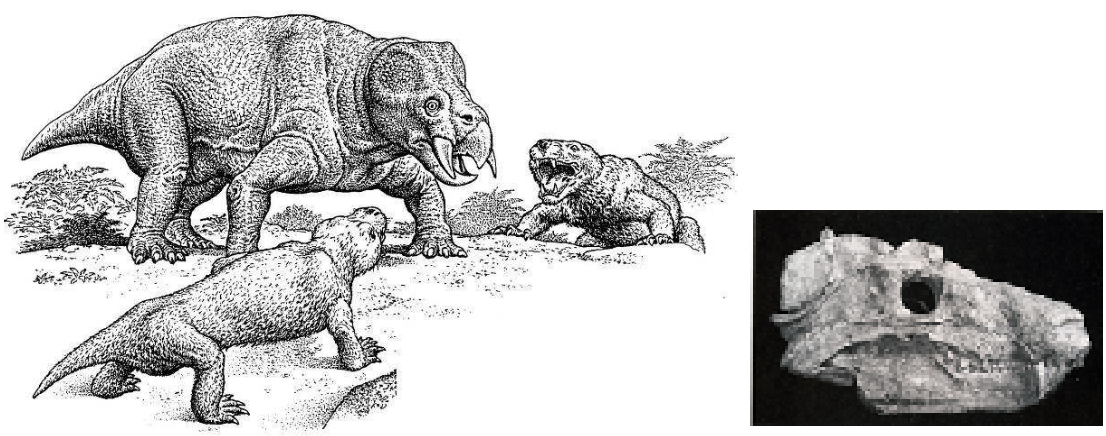


Fig. 8: Reconstruction of typical therapsids of the Early Triassic *Cynognathus* Assemblage Zone - the large tusked herbivorous dicynodont *Kannemeyeria* and the predatory, bear-sized cynodont *Cynognathus*. The inset shows the heavily-built skull of *Cynognathus* (*c.* 30cm long) in lateral view.

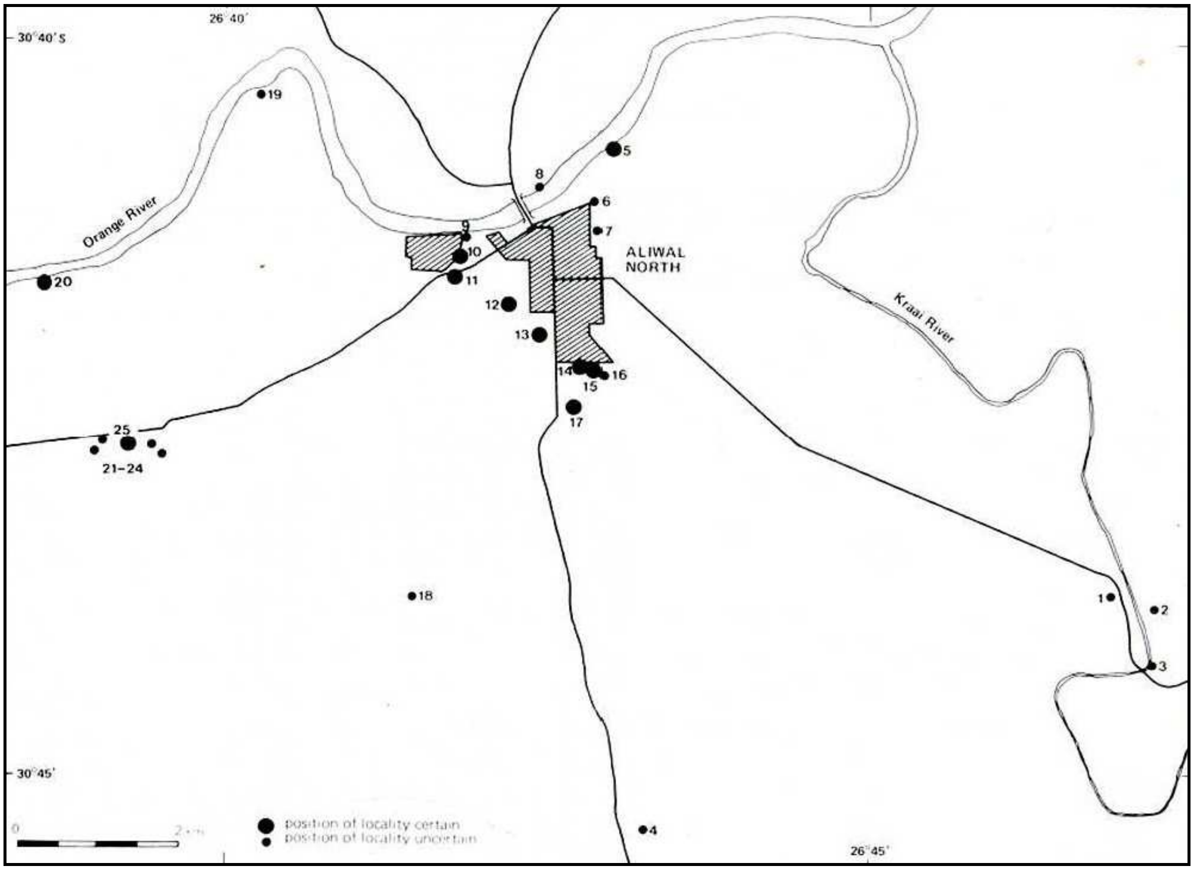


Fig. 9: Map showing the concentration of fossil plant fossil localities (black dots) within the Burgersdorp Formation in the region of Aliwal North (Modified from Anderson & Anderson 1985).

3.2. Fossils within the Molteno Formation

In terms of plant and insect fossils, but not vertebrates or traces, the Molteno Formation is one of the most productive rock units within the Main Karoo Basin. Indeed, it has produced the richest known floras of Triassic age anywhere in the world and its palaeontological sensitivity towards development is correspondingly high (Almond *et al.* 2008). Excellent reviews of the Molteno fossil biota have been provided by Cairncross *et al.* (1995), Anderson *et al.* (1998), Anderson and Anderson *in* MacRae (1999), Hancox (2000) and Anderson (2001). These key accounts include references to the extensive technical literature on the Molteno flora and fauna stretching back to pioneering work by Wyley (1856) and Stow (1871) on coals and petrified forests as well as by Alex du Toit in the early 1900s on fossil plant remains (See Hancox 2000 for early references). Here may be mentioned only the key systematic and synthetic papers on the Molteno palaeoflora published by John and Heidi Anderson that are listed towards the end of this report as well as the early collections of Molteno coal measure plants around Aliwal North by Alfred (Gogga) Brown in the late nineteenth century (MacRae 1999).

The fossil biota recorded so far from the Molteno Formation may summarised as follows:

- A very rich **megaflora** of fossil foliage, fruits, seeds and stems, mostly preserved as carbonaceous compressions within mudrocks. The flora contains over sixty genera and is strongly dominated by "pteridophytes" (over 50 species of spore-bearing ferns, including horsetails) and a rich variety of gymnosperms (27 genera, 114 species, including ginkgophytes, cycads, conifers and "seed ferns"). The four dominant plant genera are the characteristic Triassic "seed fern" *Dicroidium* (Peltaspermales; Fig. 11), the maidenhair tree relative *Sphenobaiera* (Ginkgoales), the conifer *Heidiphyllum* (Voltziales) and the horsetail fern *Equisetum* (Equisetales). Over 200 plant species have been identified, including sixteen orders of gymnosperms alone. Minor groups include bryophytes such as mosses, liverworts and club-mosses

- **Silicified woods**, including petrified tree trunks, now assigned to a range of gymnospermous genera (Bamford 1999, 2004);

- Poorly-studied **palynomorph assemblages** dominated by pteridophyte spores and gymnosperm pollens assigned to the Triassic *Allisporites / Falcisporites* assemblage (Hancox 2000 and refs. therein);

- Rare **fossil fish** belonging to four genera, representing the only vertebrate body fossils from the formation (Anderson *et al.* 1998);

- Relatively abundant and diverse **fossil insects** associated with compression floras in fine-grained mudrocks (Fig. 11). These important insect assemblages comprise several thousand specimens of about 350 species, mainly preserved as disarticulated wings but with some intact or partially intact bodies. They are dominated by cockroaches, beetles, bugs and dragonflies and include eighteen different insect orders. The only other terrestrial arthropods recorded so far are extremely rare spiders (Selden *et al.* 1999, Selden 2009);

- Rare shelly invertebrates including three genera of **conchostracans** (freshwater clam shrimps) and two genera of **bivalves**;

- Occasional **trace fossils** including dinosaur trackways (among the earliest indirect evidence for dinosaurs; Raath *et al.* 1990, Raath 1996), invertebrate burrows of the *Scolicia* Group, perhaps generated by gastropods (Turner 1975), *Skolithos* vertical burrows, arthropod traces and a few unnamed forms (Hancox 2000).

The absence of fossilised bone and coprolites of vertebrates is notable and, at least in the former case, is attributed to the diagenetic dissolution of bone under humic, poorly-oxygenated and acid conditions that rather favour the preservation of plant remains (Anderson *et al.* 1998).

The Molteno fossil flora is of considerable palaeontological interest in documenting the explosive radiation of Mesozoic, gymnosperm-dominated floras in the later Triassic Period, while the associated rich insect fauna shows great promise in illuminating early plant – insect interactions during this critical period in Earth history (See numerous references by J. & H Anderson listed below). Over one hundred Molteno plant fossil assemblages from some seventy localities have been recorded so far (Anderson 2001), with the richest assemblages yielding over seventy species. Insects are recorded from over forty localities. Fig. 10 below gives a rough idea of the distribution of fossil-rich localities within the outcrop area of the Molteno Formation. Note that there is a concentration of localities in the southwestern outcrop area close to the Aliwal North – Lady Grey study area (A more detailed map is presented by Anderson & Anderson 1985, map 2.13 therein). Due to poor *Google Earth* satellite images available for this region at present, it is unfortunately not possible to accurately gauge the extent or quality of Molteno Formation exposure within the study area. There is, however, a very real possibility that fossil-rich Molteno mudrocks are present close to or at the surface within the study area and that these may be compromised by excavations for new access roads and pylon installations during the construction phase of the proposed transmission line development.

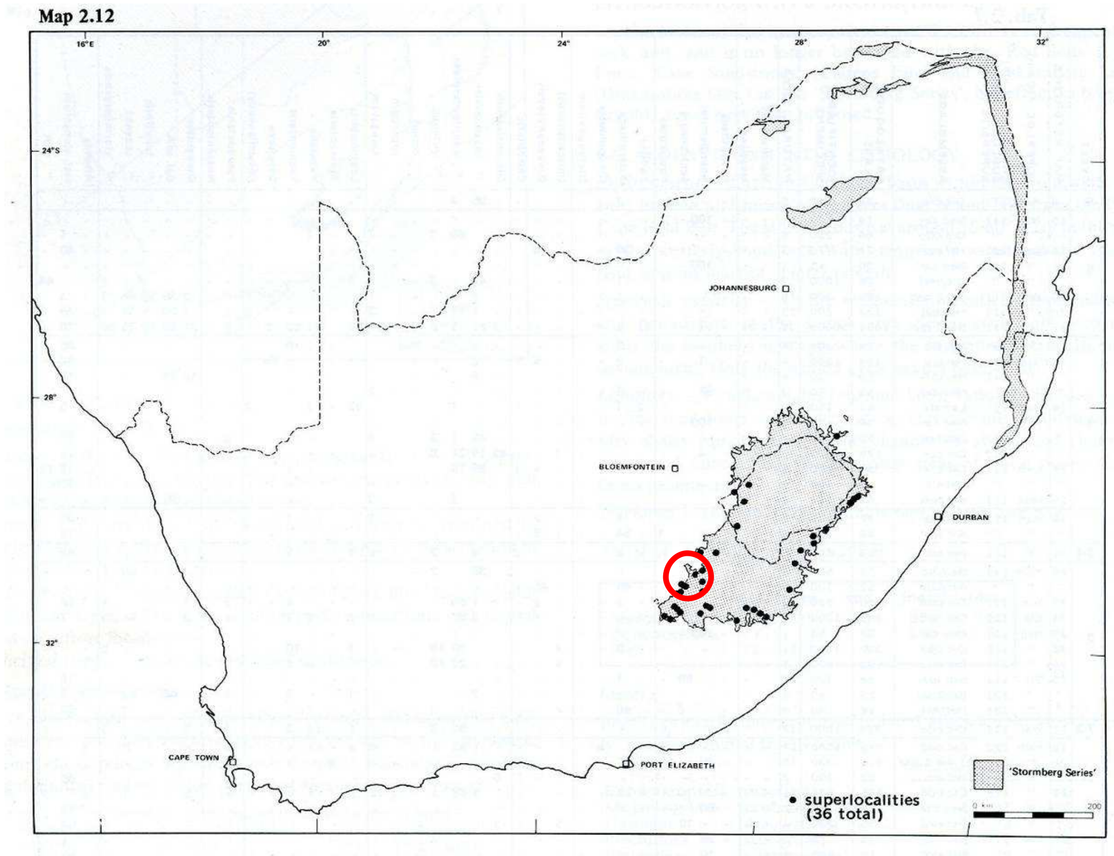


Fig. 10: Outline map showing the stippled outcrop area of the Triassic – Jurassic Stormberg Group and important fossil localities within the Molteno Formation (black dots). Note the concentration of fossil localities in the Aliwal North – Lady Grey area (red circle). Further fossil localities within the Molteno Formation have been identified since this map was published by Anderson and Anderson (1985).

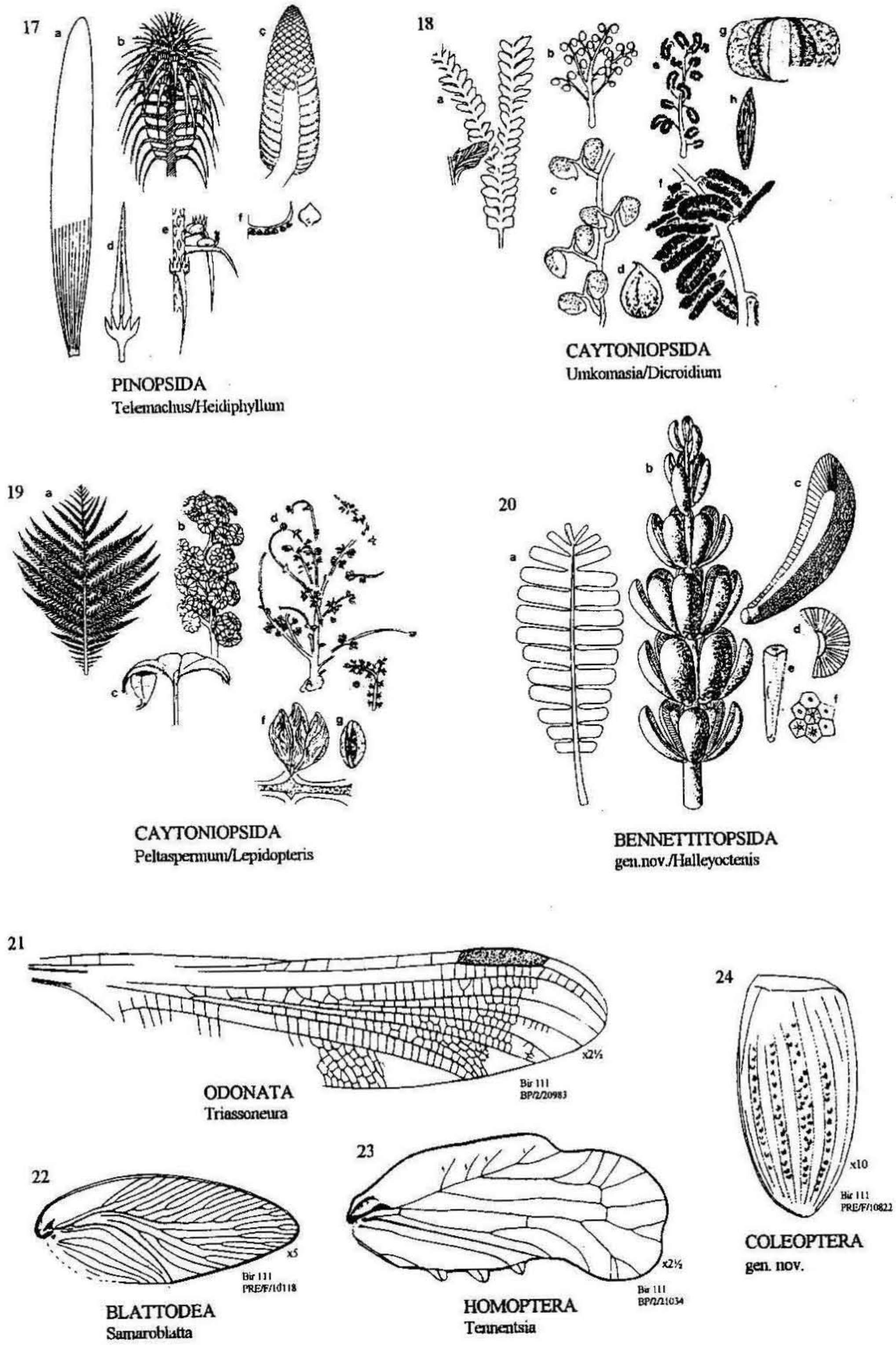


Fig. 11: Selection of Late Triassic plants (leaves and reproductive organs of gymnosperms) and insect remains (dragonflies, cockroaches, bugs and beetles) from the Molteno Formation of South Africa (From Anderson & Anderson 1997).

3.3. Fossils in the Lower Elliot Formation

The Late Triassic to Early Jurassic Elliot Formation as a whole contains a comparatively rich fossil reptile fauna dominated by early dinosaurs (principally sauropodomorphs) as well as rare amphibians, turtles, fish and advanced mammal-like reptiles (cynodont therapsids). Other fossil elements include petrified woods, phyllopod crustaceans (conchostacans or "clam shrimps") and trace fossils, principally tetrapod trackways. Following the benchmark palaeontological studies of the Stormberg Group fossil biotas by Haughton (1924), Kitching and Raath (1984) as well as Ellenberger (1970 and earlier works) and Olsen and Galton (1984), the fossil record of the Lower Elliot Formation has been recently reviewed by Anderson *et al.* (1998), Hancox (2000), Smith *et al.* (2002), Knoll (2004), and Rubidge (2005). The interested reader is also referred to the less technical, well-illustrated accounts by MacRae (1999) and McCarthy & Rubidge (2005).

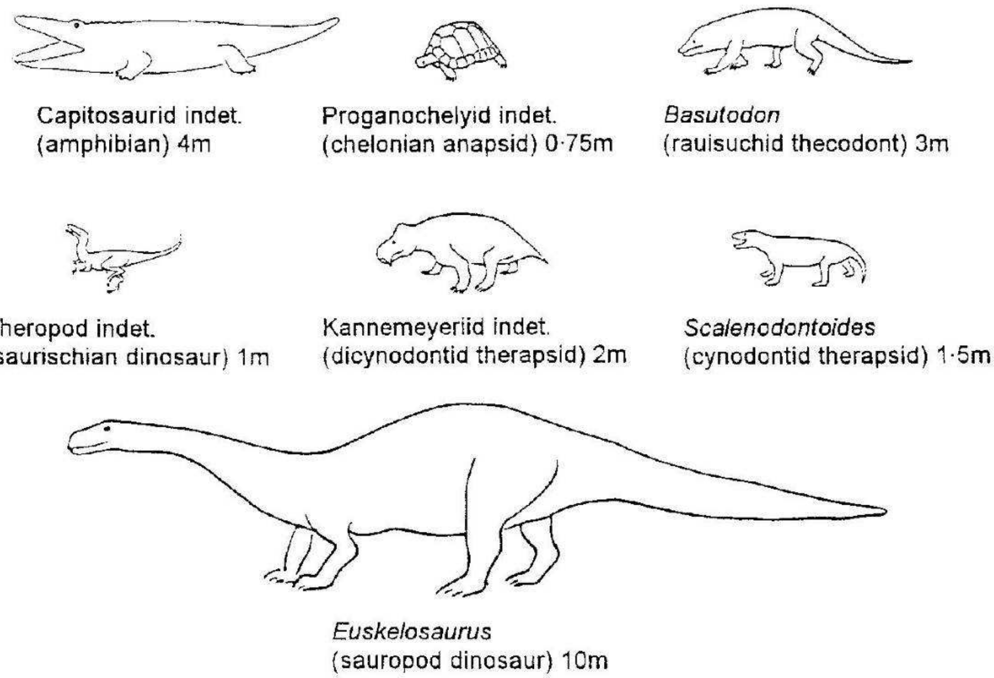


Fig. 12: Inferred or recorded tetrapod fauna of the *Eukelesaurus* Assemblage Zone based on skeletal material as well as vertebrate trackways (From Anderson *et al.* 1998). Note that a range of sauropodomorph dinosaurs are now recognised from this horizon.

The fossil assemblages of the lower Elliot Formation have been assigned to the ***Euskelesaurus* Assemblage Zone** of Late Triassic (Carnian / Norian / Rhaetian) age (Kitching & Raath 1984, Rubidge 2005). However, this assemblage zone has not yet been formally defined, not least because the genus *Euskelesaurus* has now been recognised as a *nomen nudum* that comprises a range of Late Triassic sauropodomorph dinosaurs (Yates 2003). This was one of the first dinosaur genera to be described from South Africa (Huxley 1866, 1867). The Elliot fauna is now recognised as one of the most important Late Triassic / Early Jurassic dinosaur assemblages known.

The main components of the lower Elliot Formation biotas (Figs. 12, 13) are:

- Rare large (4m) **temnospondyl amphibians** or capitosaurs (Ellenberger 1970, Olsen & Galton 1984, Warren & Damiani 1999, Damiani & Rubidge 2003). These crocodile-sized freshwater predators were piscivorous, but fossil fish remains have not yet been recorded from the lower Elliot Formation.

- A range of medium to large, herbivorous **sauropodomorph dinosaurs**, several of which were originally regarded as prosauropods and lumped together as the invalid taxon *Euskelesaurus*. The lower Elliot forms include the basal sauropodomorph *Eucnemesaurus* (including *Aliwalia*), the true sauropods *Melanorosaurus*, *Blikanasaurus* and *Antetonitrus* (Fig. 13), and the sauropodomorph *incertae sedis Plateosauravus* (Van Hoepen 1920, Haughton 1924, Van Heerden 1979, Cooper 1980, Cooper 1981, Galton 1985, Galton & Van Heerden 1985, Durand 2002, Yates 2003, Yates & Kitching 2003, Yates 2005, Yates 2007a and 2007b, Yates 2008, Blackbeard 2009). A true, as yetl unnamed prosauropod close to *Riojasaurus* from South America has recently been recognised by Yates (2003). Trackways of sauropodomorphs have been identified as the ichnogenus *Tetrasauropus* (Olsen & Galton 1984).

- Possible bipedal **theropod dinosaurs** based on trackways (*Grallator*) and isolated teeth (*e.g.* Olsen & Galton 1984, Ray & Chinsamy 2002).

- The rare primitive **ornithischian dinosaur** *Eocursor* (Butler *et al.* 2007, Butler 2010). This is currently the most complete Triassic ornithischian known.

- Fragmentary material and trackways (*Brachycheirotherium*) of large **rauisuchians**, a group of armoured thecodont archosaurs that were distantly related to crocodiles (crurotarsans) and were among the top predators of the Late Triassic Period (Seeley 1894, Haughton 1924, Kitching & Raath 1984, Olsen & Galton 1984, Gower 2000). Large serrated teeth of this group have been described from Lesotho as *Basutodon* (Von Heune 1932).

- Rare advanced **cynodont therapsids** including the large traversodont *Scalenodontoides* and the tritheledontid *Elliotherium* (Crompton & Ellenberger 1957, Hopson 1984, Gow & Hancox 1993, Abdala & Ribeiro 2003 and 2010, Battail 2006, Sidor & Hancox 2006). These small to medium-sized, rodent-like herbivores have transversely expanded ("gomphodont") teeth and belong to cynodont subgroups that are considered by many workers as close to the origins of the true mammals (a group that is represented in the upper Elliot Formation).

- Possible large **dicynodont therapsids**, based on trackways (*Pentasauropus*) that are probably attributable to a hippo-sized kannemeyeriid (Olsen & Galton 1984, Anderson *et al.* 1998).

- Local concentrations of large freshwater **conchostracans** (clam shrimps) within fluvial sandstones (Smith *et al.* 2002).

- Sparse, low diversity assemblages of **invertebrate trace fossils** (*e.g.* Smith *et al.* 2002, Bordy *et al.* 2004b).

- Very sparse **plant fossils** including petrified woods (Bamford 2004) and rhizocretions (calcretised root traces). The arid, oxidised settings of the lower Elliot Formation did not favour the preservation of plant material. Given their inferred stratigraphic equivalence, lower Elliot floras would have originally included many elements recorded from the rich plant fossil beds of the Molteno Formation (*cf* Anderson & Anderson 1985, Anderson *et al.* 1998 and numerous references therein).

The taphonomic settings of the lower Elliot Formation fossils are described in some detail by Kitching and Raath (1984). The lowermost few meters of the mudrock succession are palaeontologically barren apart from occasional beds rich in carbonaceous material. In the overlying strata vertebrate remains are uncommon and usually isolated, but occasionally well-preserved, articulated or semi-articulated skeletons are also found. The characteristic haematite (ferruginous) coating of bones seen in the upper Elliot is not found at these lower levels. Lag conglomerates at the base of channel sandsatones contain disarticulated remains (bones, teeth, osteoderms) of capitosaur amphibians. Tetrapod trackways occur on the rippled tops of sandstone beds. The *Euskelesaurus* Assemblage Zone fauna extends up to a widely distributed horizon marked by large calcrete concretions that represents a major arid zone palaeosol. Fossil bones preserved within this palaeosol are typically badly "sun-cracked" and coated with haematite and nodular calcareous growths.

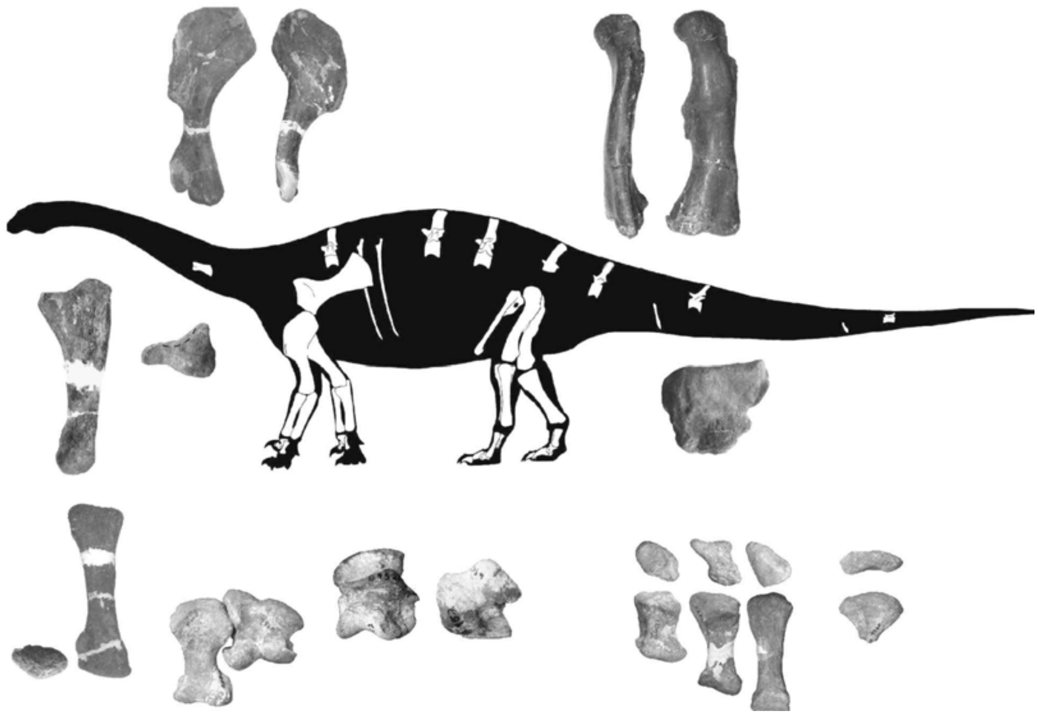


Fig. 13: Skeletal material of the earliest known sauropod dinosaur *Antetonitrus* that was recently described from the Elliot Formation by Yates & Kitching (2003). This early dinosaur is estimated to have been 8 to 10m long.

Numerous fossil sites within the thickly-developed Elliot Formation in its southern outcrop area are noted in the benchmark palaeontological reviews by Haughton (1924) and Kitching and Raath (1984) and doubtless many more sites have been discovered in this key region since. Unfortunately little useful palaeontological data for the Aliwal North 1: 250 000 sheet is provided in the geology sheet explanation by Bruce *et al.* (1983), although this has been a classic collecting area for Lower Elliot Formation fossils since the time of the famous late nineteenth century amateur fossil collector Alfred (Gogga) Brown – the original discoverer of the dinosaur *Euskelsaurus* (MacRae 1999).

3.4. Fossils in the Karoo Dolerite Suite

Dolerite outcrops within the study area are in themselves of no 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 in the Great Escarpment zone the adjacent Lower Beaufort Group sediments have often been thermally metamorphosed or "baked" (*i.e.* recrystallised, impregnated with secondary minerals). Embedded fossil material of phosphatic composition, such as bones and teeth, was frequently altered by baking. Bones may become blackened and they can be very difficult to extract from the hard matrix by mechanical preparation. Thermal metamorphism by dolerite intrusions therefore tends to *reduce* the palaeontological heritage potential of adjacent Beaufort Group sediments.

3.5. Fossils in Late Caenozoic superficial sediments

The Karoo "drift" deposits 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.* Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon, Free State and elsewhere; Wells & Cooke 1942, Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Churchill *et al*. 2000 Partridge & Scott 2000) including skeletal remains of early humans (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), and plant remains such as palynomorphs in organic-rich alluvial horizons (Scott 2000) and diatoms in pan sediments. In the Aliwal North sheet area Bruce *et al.* (1983) report abundant plant material throughout the Quaternary alluvial deposits as well as rounded, transported Earlier Stone Age implements in the basal gravels.

4. ASSESSMENT OF IMPACTS ON FOSSIL HERITAGE

The proposed new 132 kV transmission line traverses the outcrop area of several sedimentary formations of the Upper Beaufort and Stormberg Groups that are known to contain important fossil heritage – notably Middle to Late Triassic vertebrate, plant and trace fossil remains. During the construction phase any fossils exposed at the ground surface or at shallow depths below this are vulnerable to disturbance, damage or destruction within the 6m wide strip to be cleared along the entire route. Bedrock excavations for pylon footings (up to 3m deep) and any new access roads may also expose, damage or destroy previously buried fossil material.

Because (1) the Karoo Supergroup geological formations concerned are all ranked as *high* in terms of overall palaeontological sensitivity (Almond *et al.* 2008), and (2) a sizeable number of important vertebrate and plant fossil localities are already recorded within the broader study region close to the Orange River, the impact of the proposed transmission line development on fossil heritage is potentially MEDIUM to HIGH.

A desktop comparison of the various route options for the Melkspruit – Riebeek transmission line with respect to the rock formations traversed, as shown in Fig. 5, shows that there is no substantial difference between the various route options in terms of overall palaeontological sensitivity at this level of analysis. Because it follows an existing transmission line route for much of its length, Option 1 will require a shorter length of new access roads, and will therefore have a much lower impact in this respect.

Significant further impacts on local fossil heritage are not anticipated during the operational phase of the transmission line development.

Confidence levels for this desktop assessment are only *moderate* because of:

- the low stratigraphic resolution of the available 1: 250 000 geological maps (*e.g.* Upper Beaufort Group formations are not differentiated);
- uncertainties regarding the level of bedrock exposure within the study region (*e.g.* poor satellite imagery, lack of field data).

5. RECOMMENDATIONS

The present desktop study of the Melspruit – Riebeek transmission line development suggests that its impact on local fossil heritage may be moderate to high. However, a realistic palaeontological heritage impact assessment for this project, with recommendations for any mitigation necessary, is only possible once the transmission line corridors have been surveyed in the field by a professional palaeontologist. It is recommended that such a field survey be carried out at the earliest opportunity so that any significant palaeontological heritage issues may be addressed in the project design.

It should be noted that the most likely outcome of such a field study is that most sectors of the transmission line corridors prove to be insensitive in practice because of a thick superficial sediment cover, high degree or near-surface weathering, or sparse fossil content. However, short sectors of high palaeontological sensitivity, with a concentration of near-surface fossil material, might also be identified and mapped.

The recommended palaeontological field survey would focus on areas of good bedrock exposure along or close to the various transmission line route options. The focus of the study should be on:

- Identifying those sectors of the route options (if any) that are recorded as, or inferred to be, of high palaeontological sensitivity;
- Comparing the various route options in terms of overall palaeontological impact significance;
- Making detailed recommendations regarding mitigation of impacts within route sectors of high palaeontological sensitivity (if any) during the preconstruction or construction phases. These mitigation recommendations should be incorporated into the EMP for the transmission line development.

It is unlikely that any changes in the transmission line route or pylon positions will be necessary on palaeontological grounds since professional mitigation is usually the preferred option. This mitigation would involve recording and judicious sampling of surface or near-surface fossil material either (a) before construction commences or (b) during excavations for pylon emplacements or ancillary infrastructure (*e.g.* new roads).

Provided that the recommended mitigation measures are carried through, it is likely that any potentially negative impacts of the proposed development on local fossil resources will be substantially reduced and, furthermore, they will partially offset by the *positive* impact represented by increased understanding of the palaeontological heritage of the region.

Please note that:

- All South African fossil heritage is protected by law (South African Heritage Resources Act, 1999) and fossils cannot be collected, damaged or disturbed without a permit from SAHRA or the relevant Provincial Heritage Resources Agency;
- The palaeontologist concerned with mitigation work will need a valid collection permit from SAHRA;
- All palaeontological specialist work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 1 and 2 palaeontological studies currently being developed by SAHRA.

6. ACKNOWLEDGEMENTS

I would like to thank Mr Len van Schalkwyk and Ms Elizabeth Wahl of eThembeni Cultural Heritage, Pietermaritzburg, for commissioning this desktop study. Ms Mary-Anne Crocker kindly provided the necessary transmission line maps, and I am also grateful for discussions with her and her colleague Ms Nadia Grobbelaar at Arcus Gibb, East London, concerning palaeontological heritage assessments of transmission line projects.

7. REFERENCES

ABDALA, F. & RIBEIRO, A.M. 2003. A new traversodontid cynodont from the Santa Maria Formation (Ladinian – Carnian) of southern Brazil, with a phylogenetic analysis of Gondwanan traversodontids. Zoological Journal of the Linnean Society 139, 529-545.

ABDALA, F., HANCOX, P.J. & NEVELING, J. 2005. Cynodonts from the uppermost Burgersdorp Formation, South Africa, and their bearing on the biostratigraphy and correlation of the Triassic *Cynognathus* Assemblage Zone. Journal of Vertebrate Paleontology 25, 192-199.

ABDALA, F. & RIBEIRO, A.M. 2010. Distribution and diversity patterns of Triassic cynodonts (Therapsida: Cynodontia) in Gondwana. Palaeogeography, Palaeoclimatology, Palaeoecology 286, 202-217.

ABDALA, F., CISNEROS, J.C. & SMITH, R.M.H. 2006. Faunal aggregation in the Early Triassic Karoo Basin: earliest evidence of shelter-sharing behaviour among tetrapods. Palaios 21, 507-512.

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

ANDERSON, J.M. 2001. Towards Gondwana Alive. Vol. 1. Promoting biodiversity and stemming the Sixth Extinction (2nd. edition), 140 pp. SANBI, Pretoria.

ANDERSON, J.M. & ANDERSON, H.M. 1983. The palaeoflora of southern Africa: Molteno Formation (Triassic), Vol. 1, Part 1, Introduction, Part 2A, *Dicroidium*, 227 pp. A.A. Balkema, Rotterdam.

ANDERSON, J.M. & ANDERSON, H.M. 1984. The fossil content of the Upper Triassic Molteno Formation, South Africa. Palaeontologia Africana 25, 39-59.

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.

ANDERSON, J.M. & ANDERSON, H.M. 1989. The palaeoflora of southern Africa: Molteno Formation (Triassic) Vol. 2: The gymnosperms (excluding *Dicroidium*), 567 pp. A.A. Balkema, Rotterdam.

ANDERSON, J.M. & ANDERSON, H.M. 1993a. Terrestrial flora and fauna of the Gondwana Triassic: Part 2 – co-evolution. In: Lucas, S.G. & Morales, M. (Eds.) The nonmarine Triassic. New Mexico Museum of Natural History & Science Bulletin No. 3, 13-25.

ANDERSON, J.M. & ANDERSON, H.M. 1993b. Terrestrial flora and fauna of the Gondwana Triassic: Part 1 – occurrences. In: Lucas, S.G. & Morales, M. (Eds.) The nonmarine Triassic. New Mexico Museum of Natural History & Science Bulletin No. 3, 3-12.

ANDERSON, J.M. & ANDERSON, H.M. 1995. The Molteno Formation: window onto Late Triassic floral diversity. Pp. 27-40 in: Pant, D.D. (Ed.) Proceedings of the International Conference on Global Environment and Diversification of Plants through Geological Time (Birbal Sahni Centenary Vol. 1995). Society of Indian Plant Taxonomists, Allahabad, India, 462 pp.

ANDERSON, J.M. & ANDERSON, H.M. & SICHEL, H. 1996. The Triassic Explosion (?): a statistical model for extrapolating biodiversity based on the terrestrial Molteno Formation. Paleobiology 22, 318-328.

ANDERSON, H.M. & ANDERSON, J.M. 1997. Towards new paradigms in Permo-Triassic Karoo palaeobotany (and associated faunas) through the past 50 years. Palaeontologia Africana 33, 11-21.

ANDERSON, J.M. & ANDERSON, H.M. 1998. In search of the world's richest flora: looking through the Late Triassic Molteno window. Journal of African Earth Science 27, 6-7.

ANDERSON, J.M., ANDERSON, H.M. & CRUIKSHANK, A.R.I. 1998. Late Triassic ecosystems of the Molteno / Elliot biome of southern Africa. Palaeontology 41, 387-421, 2 pls.

ANDERSON, J.M., ANDERSON, H.M., ARCHANGELSKY, S., BAMFORD, M., CHANDRA, S., DETTMANN, M., HILL. R., MCLOUGHLIN, S. & RŐSLER, O. 1999. Patterns of Gondwana plant colonisation and diversification. Journal of African Earth Sciences 28, 145-167.

ANDERSON, J.M., ANDERSON, H.M. 2003. Heyday of the gymnosperms: systematics and biodiversity of the Late Triassic Molteno fructifications. Strelitzia 15, 398 pp. National Botanical Institute, Pretoria.

ANDERSON, J.M., CLEAL, C.J. & ANDERSON, H.M. 2007. A brief history of the gymnosperms: classification, biodiversity, phytogeography and ecology. Strelitzia 20, 280 pp. National Botanical Institute, Pretoria.

ANDERSON, H.M., ANDERSON, J.M. 2008. Molteno ferns: Late Triassic biodiversity in southern Africa. Strelitzia 21, 258 pp. National Botanical Institute, Pretoria.

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

BAMFORD, M.K. 2004. Diversity of woody vegetation of Gondwanan southern Africa. Gondwana Research 7, 153-164.

BATTAIL, B. 2006 (for 2005). Late Triassic traversodontids (Synapsida: Cynodontia) in southern Africa. Palaeontologia africana 41, 67-80.

BENDER, P.A. & BRINK, J.S. 1992. A preliminary report on new large mammal fossil finds from the Cornelia-Uitzoek site. South African Journal of Science 88: 512-515.

BENDER, P.A. & HANCOX, P.J. 2003. Fossil fishes of the *Lystrosaurus* and *Cynognathus* Assemblage Zones, Beaufort Group, South Africa: correlative implications. Council for Geoscience, Pretoria, Bullletin 136, 1-27.

BENDER, P.A. & HANCOX, P.J. 2004. Newly discovered fish faunas from the Early Triassic, Karoo Basin, South Africa, and their correlative implications. Gondwana Research 7, 185-192.

BLACKBEARD, M. 2009. Taphonomy and taxonomy of the rare Triassic dinosaur *Eucnemesaurus* based on an articulated skeleton from the Eastern Cape. Palaeontologia africana 44, 146.

BORDY, E.M., HANCOX, P.J. & RUBIDGE, B.S. 2004a. Fluvial style variations in the Late Triassic – Early Jurassic Elliot Formation, main Karoo Basin, South Africa. Journal of African Earth Sciences 38, 383-400.

BORDY, E.M., HANCOX, P.J. & RUBIDGE, B.S. 2004b. A description of the sedimentology and palaeontology of the Late Triassic – Early Jurassic Elliot Formation in Lesotho. Palaeontologia Africana 40, 43-58.

BORDY, E.M., HANCOX, P.J. & RUBIDGE, B.S. 2004c. Basin development during the deposition of the Elliot Formation (Late Triassic – Early Jurassic), Karoo Supergroup, South Africa. South African Journal of Geology 107, 397-412.

BOUSMAN, C.B. *et al.* 1988. Palaeoenvironmental implications of Late Pleistocene and Holocene valley fills in Blydefontein Basin, Noupoort, C.P., South Africa. Palaeoecology of Africa 19: 43-67.

BRINK, J.S. 1987. The archaeozoology of Florisbad, Orange Free State. Memoirs van die Nasionale Museum 24, 151 pp.

BRINK, J.S. *et al*. 1995. A new find of *Megalotragus priscus* (Alcephalini, Bovidae) from the Central Karoo, South Africa. Palaeontologia africana 32: 17-22.

BRUCE, R.W., KRUGER, G.P. & JOHNSON, M.R. 1983. Die geologie van die gebied Aliwal-Noord. Explanation to 1: 250 000 geology Sheet 3026 Aliwal-Noord, 7 pp. Council for Geoscience, Pretoria.

BUTLER, R.J. 2010. The anatomy of the basal ornithischian dinosaur Eocursor parvus from the lower Elliot Formation (Late Triassic) of South Africa. Zoological Journal of the Linnean Society 160, 648-684.

BUTLER, R.J., SMITH, R.M.H. & NORMAN, D.B. 2007. A primitive ornithischian dinosaur from the Late Triassic of South Africa, and the early evolution and diversification of Ornithischia. Proceedings of the Royal Society B (2007) 274, 2041-2046.

CAIRNCROSS, B., ANDERSON, J.M. & ANDERSON, H.M. 1995. Palaeoecology of the Triassic Molteno Formation, Karoo Basin, South Africa – sedimentological and palaeontological evidence. South African Journal of geology 98, 452-478.

CATUNEANU, O., WOPFNER, H., ERIKSSON, P.G., CAIRNCROSS, B., RUBIDGE, B.S., SMITH, R.M.H. & HANCOX, P.J. 2005. The Karoo basins of south-central Africa. Journal of African Earth Sciences 43, 211-253.

CHRISTIE, A.D.M.1981. Stratigraphy and sedimentology of the Molteno Formation in the Elliot and Indwe area, Cape Province. Unpublished MSc thesis, University of Natal, Durban.

CHURCHILL, S.E. *et al.* 2000. Erfkroon: a new Florisian fossil locality from fluvial contexts in the western Free State, South Africa. South African Journal of Science 96: 161-163.

CLUVER, M.A. 1978. Fossil reptiles of the South African Karoo. 54pp. South African Museum, Cape Town.

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.

COOKE, H.B.S. 1974. The fossil mammals of Cornelia, O.F.S., South Africa. In: Butzer, K.W., Clark, J.D. & Cooke, H.B.S. (Eds.) The geology, archaeology and fossil mammals of the Cornelia Beds, O.F.S. Memoirs of the National Museum, Bloemfontein 9: 63-84.

COOPER, M.R. 1980. The first record of the prosauropod *Euskelesaurus* from Zimbabwe. Arnoldia Zimbabwe 9, 1-17.

COOPER, M.R. 1981. The prosauropod dinosaur *Massospondylus carinatus* Owen from Zimbabwe: its biology, mode of life and phylogenetic significance. Occasional Papers, National Museum of Rhodesia (Zimbabwe), Natural Science Series B, 6, 689-840.

CROMPTON, A.W. & ELLENBERGER, F. 1957. On a new cynodont from the Molteno beds and the origin of the trytilodontids. Annals of the South African Museum 44, 1-14.

DAMIANI, R.J. 2004. Temnospondyls from the Beaufort group (Karoo Basin) of South Africa and their biostratigraphy. Gondwana Research 7, 165-173.

DAMIANI, R.J. & RUBIDGE, B.S. 2003. A review of the South African temnospondyl amphibian record. Palaeontologia africana 39, 21-36.

DAMIANI, R., MODESTO, S., YATES, A. & NEVELING, J. 2003b. Earliest evidence for cynodont burrowing. Proceedings of the Royal Society of London B. 270, 1747-1751.

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

DUNCAN, A.R. & MARSH, J.S. 2006. The Karoo Igneous Province. Pp. 501-520 in Johnson. M.R., Anhaeusser, C.R. & Thomas, R.J. (eds.) The geology of South Africa. Geological Society of South Africa, Johannesburg & the Council for Geoscience, Pretoria.

DURAND, J. F. 2002. The oldest juvenile dinosaurs from Africa. In: Eriksson, P. and Kampunzu, H. A. B (Eds.) Special Issue, African Renaissance and Geosciences. Journal of African Earth Sciences 33, 597-603.

ELLENBERGER, P. 1970. Les niveaux paléontologiques de premiere apparition des mammiferes primordiaux en Afrique du Sud et leur ichnologie. Establissement de zones stratigraphiques detaillees dans le Stormberg de Lesotho (Afrique du Sud) (Trias Superieur a Jurassique). Proceedings of the Second Gondwana Symposium, Pretoria 2, 340–370.

ERIKSSON, P.G. 1984. A palaeoenvironmental analysis of the Molteno Formation in the Natal Drakensberg. Transactions of the Geological Society of South Africa 87, 237-244.

GALTON, P.M. 1985. Notes on the Melanosauridae, a family of large prosauropod dinosaurs (Saurischia: Sauropodomorpha), Géobios 18, 671-676.

GALTON, P.M. & VAN HEERDEN, J. 1985. Partial hindlimb of *Blikanosaurus cromptoni* n. gen. and n. sp. representing a new family of prosauropod dinosaurs from the Upper Triassic of South Africa. Geobioas 18, 509-516.

GAUFFRE, F.X. 1993. Biochronostratigraphy of the Lower Elliot Formation (Southern Africa) and preliminary results on the Maphutseng dinosaur (Saurischia: Prosauropoda) from the same formation of Lesotho. In: Lucas, S.G. & Morales, M. (Eds.) The nonmarine Triassic. Bulletin of the New Mexico Museum of Natural History and Science 3, 147-149.

GOW, C.E. & HANCOX, P.J. 1993. First complete skull of the Late Triassic *Scalenodontoides* (Reptilia Cynodontia) from southern Africa. Pp. 161-168 in Lucas, S.G. & Morales, M. (Eds.) The nonmarine Triassic. New Mexico Museum of Natural History and Science Bulletin No. 3.

GOWER, D. J. 2000. Rauisuchian archosaurs (Reptilia, Diapsida): an overview. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen 218:447–488.
HANCOX, P.J. 2000. The continental Triassic of South Africa. Zentralblatt für Geologie und Paläontologie Teil 1,1998, Heft 11-12, 1285-1324.

GRINE, F.E., BAILEY, R.M., HARVATI, K., NATHAN, R.P., MORRIS, A.G., HENDERSON, G.M., RIBOT, I., PIKE, A.W. 2007. Late Pleistocene human skull from Hofmeyr, South Africa, and modern human origins. Science 315, 226–9.

GROENEWALD, G.H. 1996. Stratigraphy of the Tarkastad Subgroup, Karoo Supergroup, South Africa. Unpublished PhD thesis, University of Port Elizabeth, South Africa.

GROENEWALD, G.H. 2010. Palaeontology and construction – a case study at the Ingula Pumped Storage Scheme – Eskom Holdings (Pty) Ltd. Proceedings of the 16th conference of the Palaeontological Society of Southern Africa, Howick, August 5-8, 2010, p. 37.

GROENEWALD, G. H., J. WELMAN, AND J. A. MACEACHERN. 2001. Vertebrate burrow complexes from the Early Triassic *Cynognathus* Assemblage Zone (Driekoppen Formation, Beaufort Group) of the Karoo Basin, South Africa. Palaios 16, 148–160.

HANCOX, P.J. 1998. A stratigraphic, sedimentological and palaeoenvironmental synthesis of the Beaufort – Molteno contact in the Karoo Basin. Unpublished PhD thesis, University of Witwatersrand, Johannesburg, 381 pp.

HANCOX, P.J. 2000. The continental Triassic of South Africa. Zentralblatt für Geologie und Paläontologie, Teil 1, 1998, 1285-1324.

HANCOX, P.J., SHISHKIN, M.A., RUBIDGE, B.S. & KITCHING, J.W. 1995. A threefold subdivision of the *Cynognathus* Assemblage Zone (Beaufort Group, South Africa) and its palaeogeographic implications. South African Journal of Science 91, 143-144.

HANCOX, J., NEVELING, J. & RUBIDGE, B. 2010. Life in an Early Triassic lake: new developments at the Driefontein site, Burgersdorp Formation (*Cynognathus* Assemblage Zone), South Africa. Proceedings of the 16th Conference of the PSSA, Howick, Umgeni Valley Nature Reserve, 41-42.

HAUGHTON, S.H. 1924. The fauna and stratigraphy of the Stormberg Series. Annals of the South African Museum 12, 323-497, 55 textfigs.

HAYCOCK, C.A., MASON, T.R. & WATKEYS, M.K. 1994. Early Triassic palaeoenvironments in the eastern Karoo foreland basin, South Africa. Journal of African Earth Sciences 24, 79-94.

HILLER, N. & STAVRAKIS, N. 1980. Distal alluvial fan deposits in the Beaufort Group of the Eastern Cape Province. Transactions of the Geological Society of South Africa 83, 353-360.

HILLER, N. & STAVRAKIS, N. 1984. Permo-Triassic fluvial systems in the southeastern Karoo Basin, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 34, 1-21.

HOLMES, P.J. & MARKER, M.E. 1995. Evidence for environmental change from Holocene valley fills from three central Karoo upland sites. South African Journal of Science 91: 617-620.

HOPSON, J. 1984. Late Triassic traversodont cynodonts from Nova Scotia and southern Africa. Palaeontologia africana 25, 181-201.

HUXLEY, T.H. 1866. On some remains of large dinosaurian reptiles from the Stormberg Mountains, South Africa. Geological Magazine 3, 563.

HUXLEY, T.H. 1867. On some remains of large dinosaurian reptiles from the Stormberg Mountains, South Africa. Quarterly Journal of the Geological Society 23, 1-6.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape province. Unpublished PhD thesis, Rhodes University, Grahamstown, 336 pp.

JOHNSON, M.R. 1984. The geology of the Queenstown area. Explanation to 1: 250 000 geology Sheet 3126 Queenstown, 21 pp. Council for Geoscience, Pretoria.

JOHNSON, M.R. & HILLER, N. 1990. Burgersdorp Formation. South African Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 2, 9-10. Council for Geoscience, Pretoria.

JOHNSON, M.R., VAN VUUREN, C.J., HEGENBERGER, W.F., KEY, R. & SHOKO, U. 1996. Stratigraphy of the Karoo Supergroup in southern Africa: an overview. Journal of African Earth Sciences 23, 3-15.

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. Pp. 461-499 *in* Johnson. M.R., Anhaeusser, C.R. & Thomas, R.J. (eds.) The geology of South Africa. 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. 1963. Notes on some fossil pockets and bone beds in the *Cynognathus*-Zone in the Burghersdorp and Lady Frere Districts. Palaeontologia Africana 8, 113-118.

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).

KITCHING, J.W. 1995. Biostratigraphy of the *Cynognathus* 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.

KITCHING, J.W. & RAATH, M A. 1984. Fossils from the Elliot and Clarens Formations (Karoo Sequence) of the Northeastern Cape, Orange Free State and Lesotho, and a suggested biozonation based on tetrapods. Palaeontologia africana 25, 111-125.

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.

KNOLL, F. 2004. Review of the tetrapod fauna of the "Lower Stormberg Group" of the main Karoo Basin (Southern Africa): implication for the age of the Lower Elliot Formation. Bulletin de la Societe Geologique de France 175, 73-83.

LE ROUX, F.G. 1993. Die geologie van die gebied Colesberg. Explanation to 1: 250 000 geology Sheet 3024 Colesberg, 14 pp. Council for Geoscience, Pretoria.

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.

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.

NEVELING, J., RUBIDGE, B.S. & HANCOX, P.J. 1999. A lower *Cynognathus* Assemblage Zone fossil from the Katberg Formation (Beaufort Group, South Africa). South African Journal of Science 95, 555-556.

NEVELING, J. 2004. Stratigraphic and sedimentological investigation of the contact between the *Lystrosaurus* and the *Cynognathus* Assemblage Zones (Beaufort Group: Karoo Supergroup). Council for Geoscience, Pretoria, Bulletin, 137, 164pp.

NEVELING, J., HANCOX, P.J. & RUBIDGE, B.S. 2005. Biostratigraphy of the lower Burgersdorp Formation (Beaufort Group; Karoo Supergroup) of South Africa – implications for the stratigraphic ranges of early Triassic tetrapods. Palaeontologia Africana 41, 81-87.

NICOLAS, M.V. 2007. Tetrapod diversity through the Permo-Triassic Beaufort Group (Karoo Supergroup) of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg.

NICOLAS, M. & RUBIDGE, B.S. 2010. Changes in Permo-Triassic terrestrial tetrapod ecological representation in the Beaufort Group (Karoo Supergroup) of South Africa. Lethaia 43, 45-59.

OLSEN, P.E. & GALTON, P.M. 1984. A review of the reptile and amphibian assemblages from the Stormberg of southern Africa, with special emphasis on the footprints and age of the Stormberg. Palaeontologia africana 25, 87-110.

ORTIZ, D., LEWIS, P.J., KENNEDY, A.M., BHULLAR, B.S. & HANCOX, J. 2010. Preliminary analysis of lungfish (Dipnoi) tooth plates from Driefontein, South Africa. Proceedings of the 16th Conference of the PSSA, Howick, Umgeni Valley Nature Reserve, 72-74.

PARTRIDGE, T.C. & SCOTT, L. 2000. Lakes and pans. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.145-161. Oxford University Press, Oxford.

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.

RAATH, M.A. 1996. Earliest evidence for dinosaurs from central Gondwana. Memoirs of the Queensland Museum 39, 703-709.

RAATH, M.A., KITCHING, J.W., SHONE, R.W. & ROSSOUW, G.W. 1990. Dinosaur tracks in Triassic Molteno sediments: the earliest evidence of dinosaurs in South Africa? Palaeontologia Africana 27, 89-95.

RAY, S. & CHINSAMY, A. 2002. A theropod tooth from the Late Triassic of southern Africa. J. Biosci. 27, 295-298.

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.

SCOTT, L. 2000. Pollen. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.339-35. Oxford University Press, Oxford.

SEELEY, H.G. 1894. On *Euskelosaurus browni* (Huxley). Annals and Magazine of Natural History (6) 14, 317-340.

SELDEN, P.A., ANDERSON, J.M., ANDERSON, H.M. & FRASER, N.C. 1999. Fossil araneomorph spiders from the Triassic of South Africa and Virginia. The Journal of Arachnology 27, 401-414.

SELDEN, P.A., ANDERSON, H.M. & ANDERSON, J.M. 2009. A review of the fossil record of spiders (Araneae) with special reference to Africa, and description of a new specimen from the Triassic Molteno Formation of South Africa. African Invertebrates 50, 105-116.

SHONE, R.W. 1978. Giant *Cruziana* from the Beaufort Group. Transactions of the Geological Society of South Africa 81, 327-329.

SIDOR, C.A. & HANCOX, P.J. 2006. *Elliotherium kersteni*, a new trithelodontid from the Lower Elliot Formation (Upper Triassic) of South Africa. Journal of Paleontology 80, 333-342.

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., ERIKSSON, P.G. & BOTHA, W.J. 1993. A review of the stratigraphy and sedimentary environments of the Karoo-aged basins of Southern Africa. Journal of African Earth Sciences 16, 143-169.

SMITH, R. & KITCHING, J. 1997. Sedimentology and vertebrate taphonomy of the *Tritylodon* Acme Zone: a reworked palaeosol in the Lower Jurassic Elliot Formation, Karoo Supergroup, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 131, 29-50.

SMITH, R. M.H.., TURNER, B.R., HANCOX, P.J., RUBDIGE, B.R. & CATUNEANU, O. 1998. Trans-Karoo II: 100 million years of changing terrestrial environments in the main Karoo Basin. Guidebook Gondwana-10 International Conference, University of Cape Town, South Africa, 117 pp.

SMITH, R.M.H., HANCOX, P.J., RUBIDGE, B.S., TURNER, B.R. & CATUNEANU, O. 2002. Mesozoic ecosystems of the Main Karoo Basin: from humid braid plains to arid sand sea. Guidebook 8th International Symposium on Mesozoic Terrestrial Ecosystems, Cape Town, South Africa, 116 pp.

STAVRAKIS, N. 1980. Sedimentation of the Katberg Sandstone and adjacent formations in the south-eastern Karoo Basin. Transactions of the Geological Society of South Africa 83, 361-374.

STOW, G.W. 1871. On some points in South African geology. Quarterly Journal of the Geological Society of London 27, 497-548.

TANKARD, A.J., JACKSON, M.P.A., ERIKSSON, K.A., HOBDAY, D.K., HUNTER, D.R. & MINTER, W.E.L. 1982. Crustal evolution of southern Africa – 3.8 billion years of Earth history, xv + 523 pp., pls. Springer Verlag, New York.

TURNER, B.R. 1975. The stratigraphy and sedimentary history of the Molteno Formation in the Main Karoo basin of South Africa and Lesotho. Unpublished PhD thesis, University of Witwatersrand, Johannesburg, 314 pp.

TURNER, B.R. 1978. Trace fossils from the Upper Triassic fluviatile Molteno Formation of the Karoo (Gondwana) Supergroup, Lesotho. Journal of Paleontology 52, 959-963.

VAN DER WALT, M., DAY, M., RUBIDGE, B., COOPER, A.K. & NETTERBERG, I. In press, 2010. Utilising GIS technology to create a biozone map for the Beaufort Group (Karoo Supergroup) of South Africa. Palaeontologia Africana.

VAN HEERDEN, J. 1979. The morphology and taxonomy of *Euskelosaurus* (Reptilia: Saurischia; Late Triassic). Navorsinge van die Nasionale Museum 4, 21-84.

VAN HOEPEN, E.C.N. 1920. Contributions to the knowledge of the reptiles of the Karoo Formation, 6, Further dinosaurian material in the Transvaal Museum. Annals of the Transvaal Museum 7, 93-141.

VISSER, J.N.J. 1984. A review of the Stormberg Group and Drakenberg Volcanics in southern Africa. Palaeontologia Africana 25, 5-27.

VISSER, J.N.J. & BOTHA, B.J.V. 1980. Meander channel, point bar, crevasse splay and aeolian deposits from the Elliot Formation in Barklay Pass, North-eastern Cape. Transactions of the Geological Society of South Africa 83, 55-62.

VON HEUNE, F. 1932. Die fossile Reptil-Ordnung Saurischia, ihre Entwicklung und Geschichte. Monographien zur Geologie und Palaeontologie 1(4), 361 pp.

WARREN, A.A. & DAMIANI, R.J. 1999. Stereospondyl amphibians from the Elliot Formation of South Africa. Palaeontologia africana 35, 45-54.

WELLS, L.H. & COOKE, H.B.S. 1942. The associated fauna and culture of Vlakkraal thermal springs, O.F.S.; III, the faunal remains. Transactions of the Royal Society of South Africa 29: 214-232.

WELMAN, J., GROENEWALD, G.H. & KITCHING, J.W. 1991. Confirmation of the occurrence of *Cynognathus* Zone (*Kannemeyeria – Diademodon* Assemblage-Zone) deposits (uppermost Beaufort Group) in the northeastern Orange Free State, South Africa. South African Journal of Geology 94, 245-248.

WYLEY, a. 1856. Geological report upon the coal in the Stormberg and adjoining districts, Cape of good Hope. Parliamentary repo rt G6, Cape Town, 1-6.

YATES, A.M. 2003. A definite prosauropod dinosaur from the Lower Elliot Formation (Norian: Upper Triassic) of South Africa. Palaeontologia africana 39, 63-68.

YATES, A.M. 2007a. Solving a dinosaurian puzzle: the identity of *Aliwalia rex* Galton. Historical biology 19, 93-123.

YATES, A.M. 2007b. The first complete skull of the Triassic dinosaur *Melanorosaurus* Haughton (Sauropodomorpha: Anchisauria). Special Papers in Palaeontology 77, 9-55.

YATES, A.M. 2008. A second specimen of *Blikanasaurus* (Dinosauria: Sauropoda) and the biostratigraphy of the lower Elliot Formation. Palaeontologia africana 43, 39-43.

YATES, A.M. & KITCHING, J.W. 2003. The earliest known sauropod dinosaur and the first steps towards sauropod locomotion. Proceedings of the Royal Society of London B270, 1753-1758.

8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

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

Declaration of Independence

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