PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

Borrow pit near Engcobo, Chris Hani District Municipality, Eastern Cape Province

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

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1. SUMMARY

An existing roadside borrow pit to the northeast of Engcobo in the Chris Hani District Municipality *c.* 56 km southeast of Elliot, Eastern Cape Province, is to be exploited for road construction material. The pit is excavated into Early Triassic fluvial sediments of the Burgersdorp Formation (Tarkastad Subgroup, upper Beaufort Group, Karoo Supergroup) that in this area are intruded by Early Jurassic dolerites of the Karoo Dolerite Suite. The Beaufort Group rocks are potentially fossiliferous, having yielded elsewhere a diverse biota of Early to Mid Triassic vertebrates (fish, amphibians, reptiles, therapsids), trace fossils and plants. However, in the study area these rocks are poorly exposed due to a widespread mantle of colluvium (*e.g.* doleritic scree) and alluvium. Furthermore, they have been thermally metamorphosed during dolerite intrusion, reducing their palaeontological heritage value. The igneous Karoo dolerites contain no fossils, and the palaeontological sensitivity of the Quaternary to Recent superficial sediments is generally low.

The proposed mining of road material will involve the excavation of substantial volumes of fresh bedrock of the Burgersdorp Formation that is potentially fossiliferous. However, the relatively small scale of the operation does not warrant monitoring or mitigation by a qualified palaeontologist. The responsible ECO should be alerted to the possibility of scientifically valuable fossil material being exposed by quarrying in the study area, for example through this report.

Should significant fossil remains (notably articulated vertebrate skeletons or skulls) be exposed during construction, however, the ECO should safeguard these - *in situ*, where feasible. SAHRA and / or a professional palaeontologist should then be alerted as soon as possible so that appropriate mitigation measures can be implemented.

2. INTRODUCTION & BRIEF

As part of a project to upgrade the gravel road network and storm water drainage system in the Eastern Cape town of Engcobo, located *c.* 56km southeast of Elliot on the R58 and *c.* 142km northeast of Queenstown on the R61, it is proposed to quarry road building material from an existing roadside borrow pit (Figs. 1 & 3, Borrow Pit 1) to the northeast of Engcobo (Borrow Pit 1 in Figs. 2, 4). The co-ordinates of the borrow pit are 31° 40' 12, 23.0" S, 28° 01' 19,20" E.

Since these developments will involve excavation into potentially fossiliferous bedrock of the Upper Beaufort Group, a palaeontological impact assessment for the project has been requested by SAHRA and commissioned on behalf of Engcobo Local Municipality by Biotechnology & Environmental Specialist Consultancy cc (BESC cc), East London, in accordance with the requirements of the National Heritage Resources Act, 1999. This report will form part of a Basic Assessment Report and Environmental Management Plan for the Engcobo borrow pit project.

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.

2.1. General approach used for palaeontological impact desktop studies

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 scoping 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 of the development itself, most notably the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field scoping study by a professional palaeontologist is usually warranted.

Fig.1. General view of Borrow Pit 1 to the northeast of Engcobo showing exposure of purplish-grey mudrocks and sandstones of the Burgersdorp Formation, Upper Beaufort Group (From BID document prepared by BESC cc).

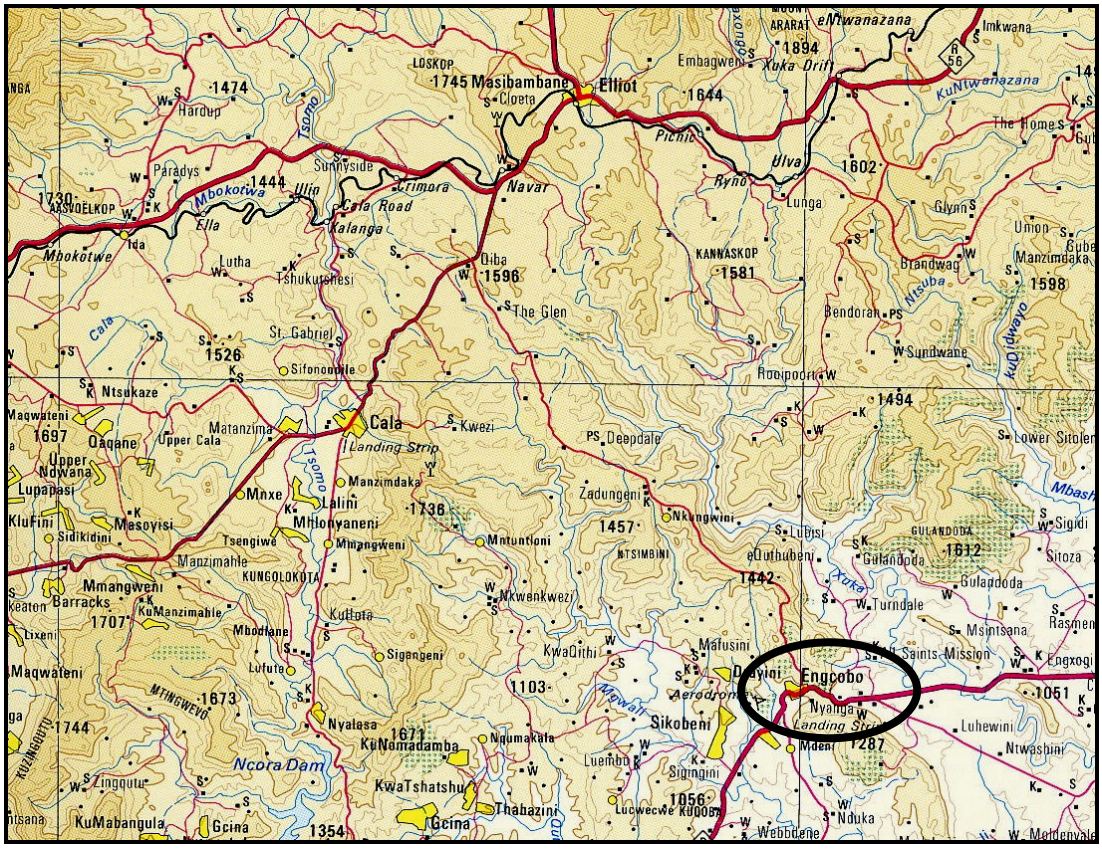

Fig. 2. Topographic map showing location (black ellipse) of the town of Engcobo *c.* 56km southeast of Elliot, Chris Hani District Municipality, Eastern Cape Province.

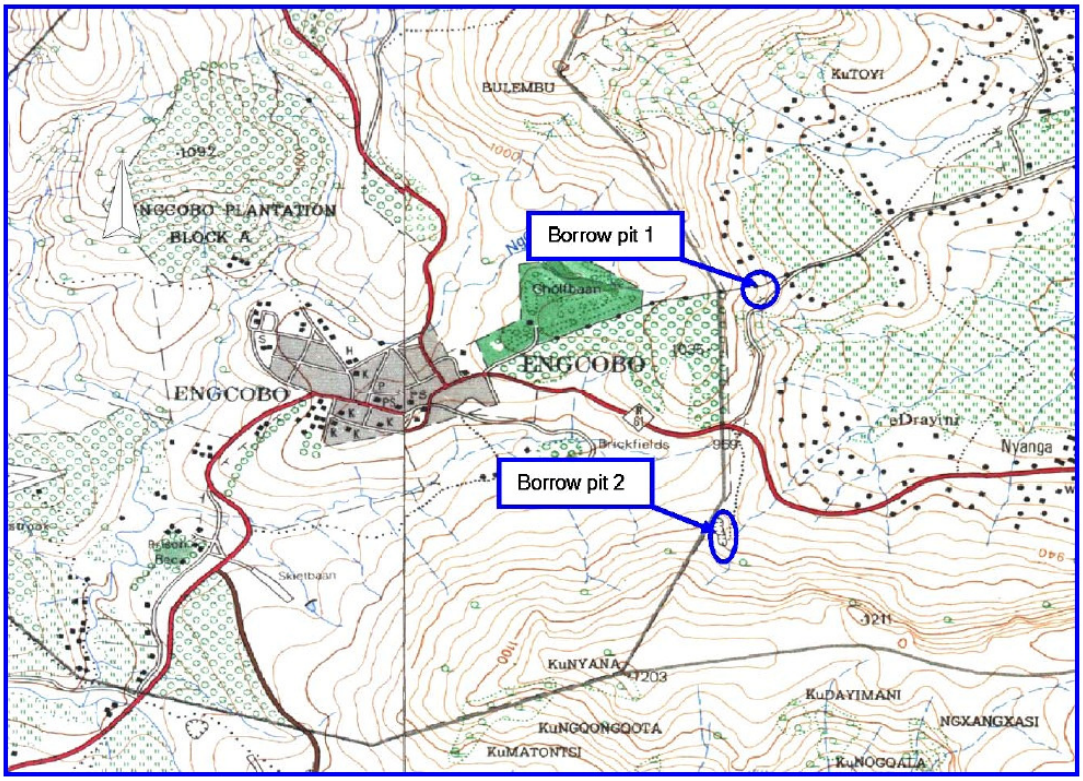

Fig. 3. Detailed map of the Engcobo area showing location of Borrow Pit 1 to the northeast of town (Abstracted from BID prepared by BESC cc).

3. GEOLOGICAL BACKGROUND

The geology of the Engcobo study area is depicted on the 1: 250 000 geology map sheet 3128 Umtata (Council for Geoscience, Pretoria; Karpeta & Johnson 1979) (Fig. 4). Borrow Pit 1 is situated on an east-facing slope looking towards the valley of the meandering Xuka River. The entire region is underlain by Early to Middle Triassic fluvial sediments of the **Burgersdorp Formation** (Tarkastad Subgroup, Upper Beaufort Group, Karoo Supergroup) (**TRb**, green in Fig. 4). These sediments are locally exposed on steeper hill slopes and stream banks, but some of the Burgersdorp outcrop here is obscured by dolerite scree in the mountainous uplands and by alluvium in the lowlands. Large sill-like bodies of resistant-weathering dolerite (pink, **Jd**) of the Early Jurassic **Karoo Dolerite Suite** (*c.* 183 Ma) intrude the Karoo sediments, including in the close neighbourhood of Borrow Pit 1, and form higher ground to the east of Engcobo. Patchy low-lying areas near river courses are mantled in **river alluvium** (pale yellow in Fig. 4) of Pleistocene to Recent age. Late Triassic sediments of the **Molteno Formation** (orange, TRm in Fig. 4) crop out in higher ground to the north of the study area.

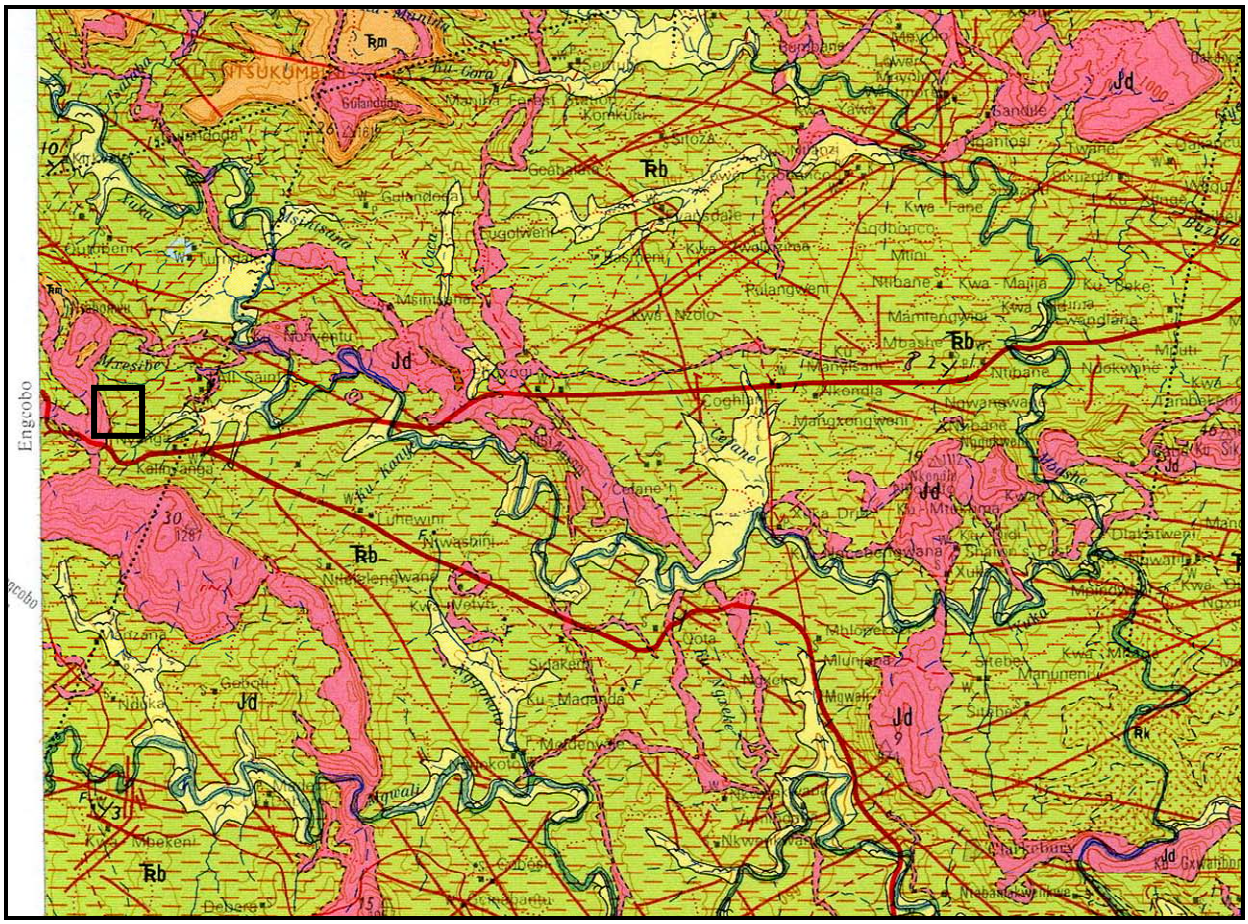

Fig. 4. Extract from 1: 250 000 geological map 3128 Umtata (Council for Geoscience, Pretoria) showing approximate location of the study area just northeast of Engcobo (black rectangle). TRb (green with dashes) = Early to Mid Triassic Burgersdorp Formation; TRm (orange) = Late Triassic Molteno Formation; Jd (pink) = Early Jurassic intrusions of the Karoo Dolerite Suite; Pale yellow areas = Late Caenozoic alluvium.

The Burgersdorp Formation is the youngest subunit of the Permo-Triassic Beaufort Group (Karoo Supergroup) and is paraconformably overlain by the Molteno and Elliot Formations of the Stormberg Group. It is a mudrock-rich succession of Early to Mid 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, west 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. 5). 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.* 1995, Hancox *et al.* 2010 and refs therein).

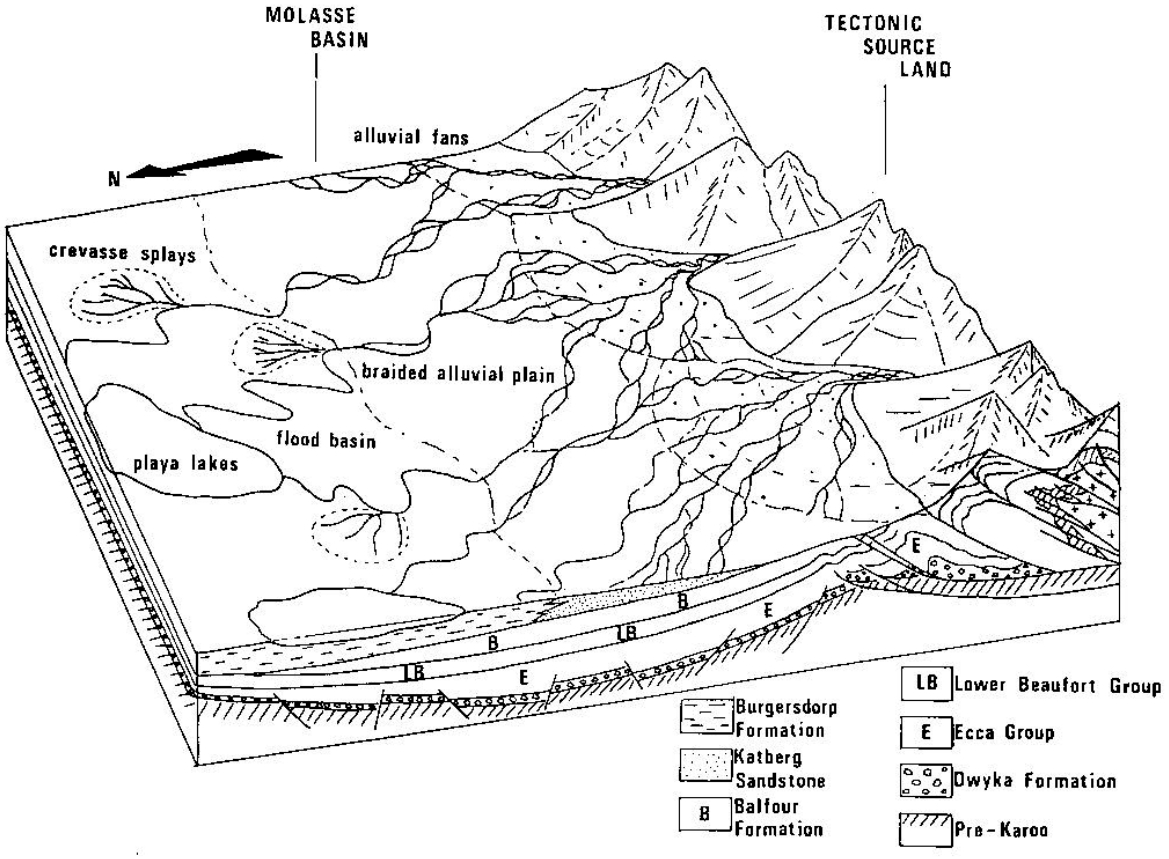

Fig. 5. Reconstruction of the southeastern Main Karoo Basin in Early Triassic times showing the deposition of the sandy Katberg Formation near the mountainous source area in the south. The mudrock-dominated Burgersdorp Formation was deposited on the distal floodplain where numerous playa lakes are also found (From Hiller & Stavrakis 1984).

The Burgersdorp sediments are extensively intruded by dolerites of the Early Jurassic **Karoo Dolerite Suite** (**Jd** in Fig. 4), including in the Engcobo region (Duncan & Marsh 2006). Much of the adjacent Burgersdorp Formation outcrop is likely to be covered with doleritic colluvium (slope deposits), appearing rusty-brown on satellite images, and also to have been thermally metamorphosed (*i.e.* baked) as a result of dolerite intrusion. In general, surface exposure of fresh Beaufort Group rocks within the development area is therefore likely to be poor, apart from occasional stream beds, dongas, steeper hillslopes as well as artificial excavations such as borrow pits. Thicker accumulations of sandy, gravelly and bouldery alluvium of Late Caenozoic age (< 5Ma) can found in stream and river beds. These colluvial and alluvial deposits may be extensively calcretised (*i.e.* cemented with soil limestone or calcrete), especially in the neighbourhood of dolerite intrusions.

4. PALAEONTOLOGICAL HERITAGE

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). Karoo fossil biotas of this age are of special interest in that they document the recovery of life on land following the catastrophic end-Permian mass extinction event (Benton 2003). 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. 5). The therapsid fauna contains large herbivorous dicynodonts like *Kannemeyeria* (Fig. 6), 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. 6), 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).

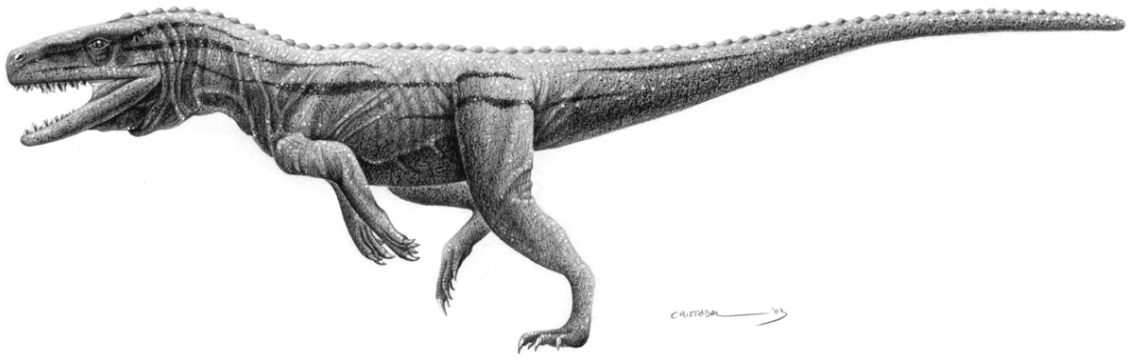

Fig. 5. Reconstruction of the small (*c.* 0.5m long) bipedal reptile *Euparkeria*, a primitive member of the archosaur group from which dinosaurs evolved later in the Triassic Period.

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. They include lycophytes (club mosses), ferns (including horsetails), "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).

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).

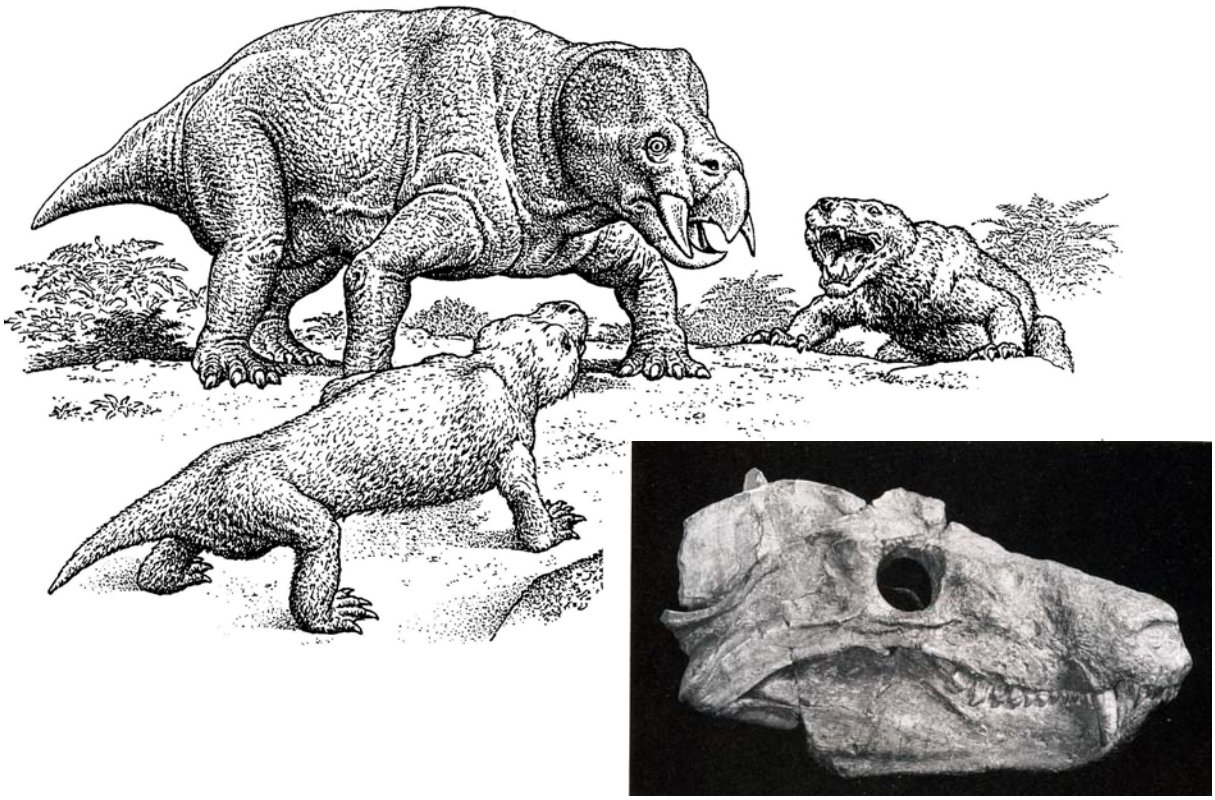

Fig. 6. Reconstruction of typical therapsids of the Early Triassic *Cynognathus* Assemblage Zone - the large tusked herbivorous dicynodont *Kannemeyeria* and the predatory, bear-sized cynodont *Cynognathus*. The inset shows the heavily-built skull of *Cynognathus* (*c.* 30cm long) in lateral view.

The biostratigraphy of the Early–Mid Triassic sediments of the Karoo Supergroup (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.,* 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 Karoo dolerites are igneous rocks, intruded at depth within the crust (Duncan & March 2006), and therefore do not contain fossils. The much younger superficial deposits (colluvium, gravels, silty alluvium *etc*) in the Karoo region as a whole have been comparatively neglected in palaeontological terms for the most part. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals (*e.g.* Skead 1980, Klein 1984, MacRae 1999, Partridge & Scott 2000, Partridge *et al.,* 2006). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods, rhizoliths), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens) in organic-rich alluvial horizons.

5. CONCLUSIONS & RECOMMENDATIONS

The Burgersdorp Formation sediments underlying the study area are potentially highly fossiliferous, having yielded elsewhere a diverse biota of Early to Mid Triassic vertebrates, trace fossils and plants. However, in the Engcobo area these rocks are often poorly exposed due to a mantle of colluvium (*e.g.* doleritic scree) and alluvium. Furthermore, they have been thermally metamorphosed during dolerite intrusion, reducing their palaeontological heritage value. The Karoo dolerites contain no fossils, and the palaeontological sensitivity of the superficial sediments is generally low.

The proposed mining of road material in Borrow Pit 1 will involve the excavation of substantial volumes of fresh bedrock of the Burgersdorp Formation that is potentially fossiliferous. However, the relatively small scale of the operation does not warrant monitoring or mitigation by a qualified palaeontologist. The responsible ECO should be alerted to the possibility of scientifically valuable fossil material being exposed by quarrying in the study area, for example through this report.

Should substantial fossil remains (notably articulated vertebrate skeletons or skulls) be exposed during construction, however, the ECO should safeguard these - *in situ*, where feasible. SAHRA and / or a professional palaeontologist should then be alerted as soon as possible so that appropriate mitigation measures can be implemented.

6. ACKNOWLEDGEMENTS

Ms Lee-Anne Proudfoot, Senior Environmental Consultant for Biotechnology & Environmental Specialist Consultancy cc, East London is thanked for commissioning this study and for kindly providing the necessary background information.

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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 road 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.

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