PALAEONTOLOGICAL HERITAGE ASSESSMENT: COMBINED DESKTOP & FIELD STUDY

Proposed SANRAL R61 (Section 6) Borrow Pit in the Engcobo Local Municipality, Chris Hani District Municipality, Eastern Cape Province

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1. EXECUTIVE SUMMARY

The SANRAL R62 (Section 6) borrow pit study area *c*. 9.4 km southwest of Engcobo, Eastern Cape, is underlain by Triassic continental sediments of the Burgersdorp Formation (Upper Beaufort Group / Tarkastad Subgroup, Karoo Supergroup) that are intruded by several Early Jurassic dykes of the Karoo Dolerite Suite. The Burgersdorp Formation in the Eastern Cape is well known for locally abundant fossil vertebrates (*e.g.* mammal-like reptiles, true reptiles) and trace fossils (*e.g.* invertebrate and vertebrate burrows) of the *Cynognathus* Assemblage Zone but very few fossils have been reported so far from this rock unit in the little-studied former Transkei region. Pleistocene mammalian remains and stone artefacts may be associated with the superficial sediments (possibly Masotcheni Formation) overlying the Karoo Supergroup bedrocks.

No vertebrate body fossils (*i.e.* bones, teeth) were recorded from the exceptionally well-exposed Burgersdorp Formation exposures at the Engcobo borrow pit site during a recent site visit. However, a small range of trace fossils – most of uncertain origin - are observed here within the thinly-interbedded sandstones and siltstones building the middle and upper portions of the exposed succession. Comparable trace fossil assemblages occur widely within the outcrop area of the Burgersdorp Formation, and none of the material observed in the SANRAL R62 (Section 6) borrow pit study area is considered to be of high conservation significance. There are therefore no objections on palaeontological heritage grounds to the authorisation of proposed borrow pit development.

The Environmental Control Officer (ECO) for the borrow pit project should be alerted to the potential for, and scientific significance of, new fossil finds during the construction phase of the development. Should important new fossil remains - such as vertebrate bones and teeth, petrified wood, plant-rich fossil lenses or dense fossil burrow assemblages - be exposed during construction, the responsible Environmental Control Officer should alert ECPHRA (*i.e.* The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible. This is so that appropriate mitigation action can be taken in good time by a professional palaeontologist at the developer's expense (Please refer to the Chance Fossil Finds Procedure appended to this report).

2. INTRODUCTION & BRIEF

As part of the upgrade of the R61 (Section 6) tar road between Queenstown and Ngcobo, SANRAL is proposing to exploit soft rock material from a borrow pit site on the northern outskirts of Mafusini Village, situated some 9.4 km SSW of the small town of Engcobo, Engcobo Local Municipality, Chris Hani District Municipality, Eastern Cape Province (Figs. 1 & 2). The borrow pit is located approximately 750 m east of the R61 (Section 6) at km 52.6 (Gaigher 2017).

Since this development will involve excavation into potentially fossiliferous bedrock of the Upper Beaufort Group (Karoo Supergroup), a combined desktop and field-based palaeontological heritage assessment of the pit area has been commissioned on behalf of SANRAL to supplement the recent Heritage Impact Assessment by G&A Heritage (Pty) Ltd, Louis Trichardt (Contact details: Mr Stephan Gaigher, Chief Executive Officer, G&A Heritage (Pty) Ltd, 38A Vorster Street, Louis Trichardt 0920, RSA. E-mail: stephan@gaheritage.co.za; Tel: 073 752 6583, 015 516 1561).

1.1. Legislative context of this palaeontological study

The borrow pit project is situated in an area that is underlain by potentially fossiliferous sedimentary rocks of Triassic to Late Caenozoic age (Sections 2 and 3). The pit excavation phase will entail surface clearance and substantial excavations into the superficial sediment cover as well as the underlying bedrock as well. The borrow pit development may adversely affect fossil heritage preserved at or beneath the surface of the ground within the development footprint by damaging, destroying or disturbing fossils that are then no longer available for scientific research or other public good.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act (1999) include, among others:

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

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:
(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.
(2) All archaeological objects, palaeontological material and meteorites are the property of the State.
(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.
(4) No person may, without a permit issued by the responsible heritage resources authority—
(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;
(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;
(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or
(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.
(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—
(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;
(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;
(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

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

1.2. Approach to the palaeontological heritage assessment

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity to development of each rock unit. Provisional tabulations of palaeontological sensitivity of all formations in Eastern Cape have already been compiled by Almond *et al.* (2008) (See also the SAHRIS Website). The potential 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 may occur during the construction, 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, *i.e.* the Eastern Cape Provincial Heritage Resources Agency, ECPHRA, for the Eastern Cape (Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; Email: smokhanya@ecphra.org.zaso). 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. Information sources

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

1. A Phase 1 Heritage Impact Assessment report for the project by Stephan Gaigher of G&A Heritage (Pty) Ltd (Gaigher 2017);

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations (Johnson 1984) as well as previous palaeontological assessment reports for the broader Confimvaba - Engcobo region (See References such as Almond 2010, 2015a, 2015b, 2017);

3. The author's database on the geological formations concerned and their palaeontological heritage (*cf* Almond *et al*. 2008);

4. Google Earth© satellite imagery.

5. A half-day site visit by the author and an experienced field assistant on 23 January 2018.

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. To the author's knowledge, there have been very few specialist palaeontological field-based studies in this particular part of the Eastern Cape (*cf* vertebrate palaeontology site map in Fig. 6 herein; Bordy & Krummeck 2016). Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, as in the present case, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

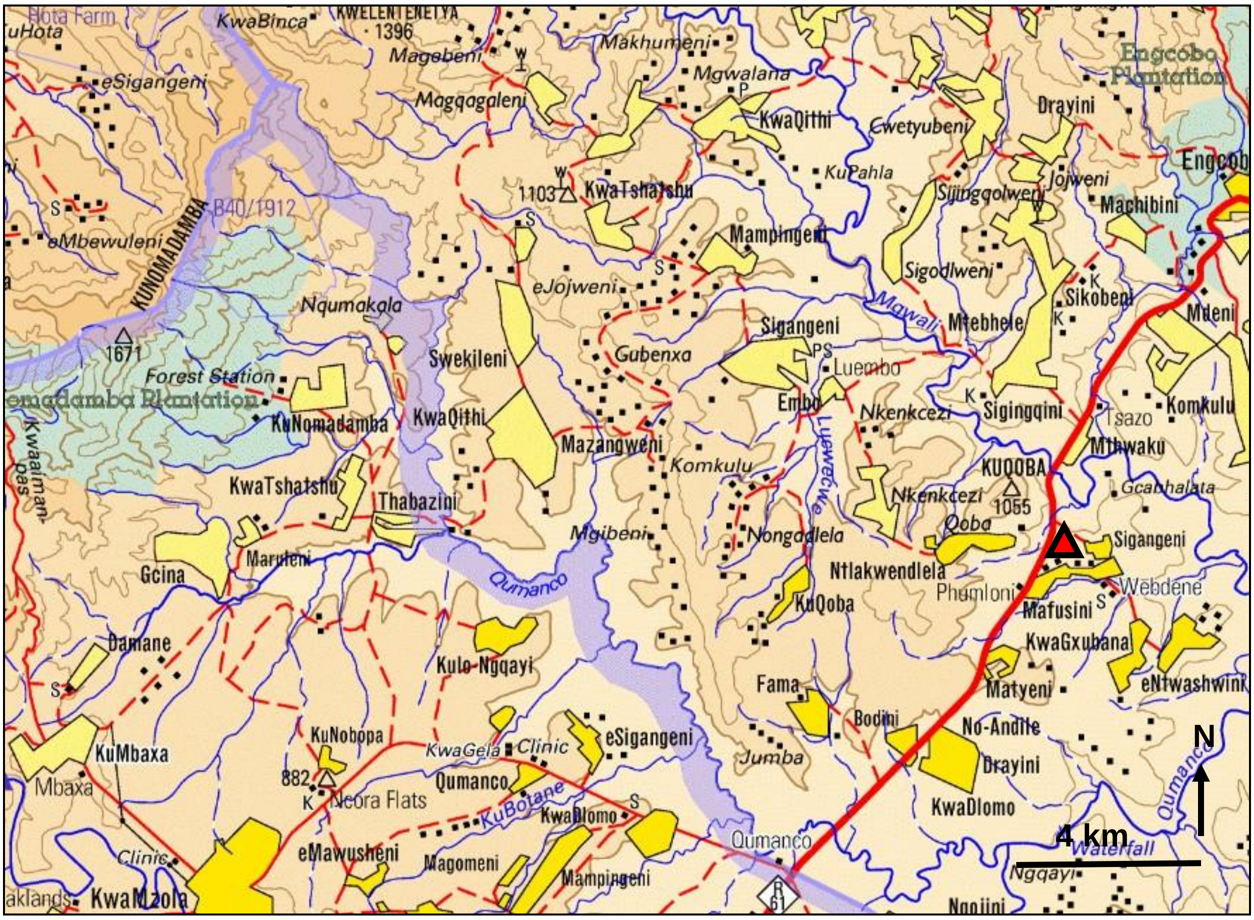

Figure 1. Extract from 1: 250 000 topographic map 3126 Queenstown (Courtesy of the Chief Directorate: National Geo-Spatial Information, Mowbray) showing the location (red triangle) of the proposed SANRAL borrow pit on the eastern side of the R61, *c*. 9.4 km SSW of Engkobo, Chris Hani District Municipality, Eastern Cape.

Figure 2. Google Earth© satellite image of the dissected hilly terrain to the southwest of Ngcobo, Eastern Cape showing the location (yellow triangle) of the proposed SANRAL borrow pit site, *c*. 1 km south of the Mgwali River.

Figure 3. Detailed satellite image of the borrow pit study area situated *c*. 750 m east of the R61 between Cofimvaba and Ngcobo and on the northern outskirts of Mafusini village. Reddish-brown and pale brown areas close to the pit site reflect mudrock and sandstone

facies of the Burgersdorp Formation (Karoo Supergroup). Pale buff areas to the north indicate erosion gulley exposures through Late Caenozoic superficial hillslope sediments (*cf* Masotcheni Formation) while rusty-brown areas close to the Mgwali River in the northeast are related to dolerite intrusions (Compare geological map, Fig. 4).

3. GEOLOGICAL BACKGROUND

The SANRAL R61 (Section 6) borrow pit study area (*c*. 31º 44' 59" S, 27º 57' 18" E) near Mafusini Village is situated *c*. 750 m east of the R62 at an elevation of *c*. 875 m amsl. It lies on a north-facing hillslope leading down to the meandering Mgwali River which flows approximately one kilometre to the north (Figs. 2 & 3). This hilly region lies close to the watershed between the Mgwali River in the north and the Qumanco River in the south. The geology of the study area is depicted on the 1: 250 000 geology map sheet 3126 Queenstown (Council for Geoscience, Pretoria; sheet explanation by Johnson 1984) (Fig. 4). The region is largely underlain at depth by Early to Middle Triassic fluvial sediments of the **Burgersdorp Formation** (Tarkastad Subgroup, Upper Beaufort Group, Karoo Supergroup) (TRb in Fig. 4). In the pit area recessive-weathering, maroon overbank mudrocks of the Burgersdorp Formation are locally well-exposed and sharply overlain by pale buff sandstones of the same stratigraphic unit (Fig. 6). Elevated hilly terrain to the northwest of the pit site, on the western side of the R61, shows clearly stepped hillslopes on satellite images due to prominent-weathering, subhorizontal channel sandstones of the Burgersdorp Formation as well as rusty-brown patches reflecting weathered dolerite intrusions (**Karoo Dolerite Suite**, Jd in Fig. 4) and associated lateritic soils. Lateritic patches are also seen to the northeast of the pit study area, close to the Mgwali River.

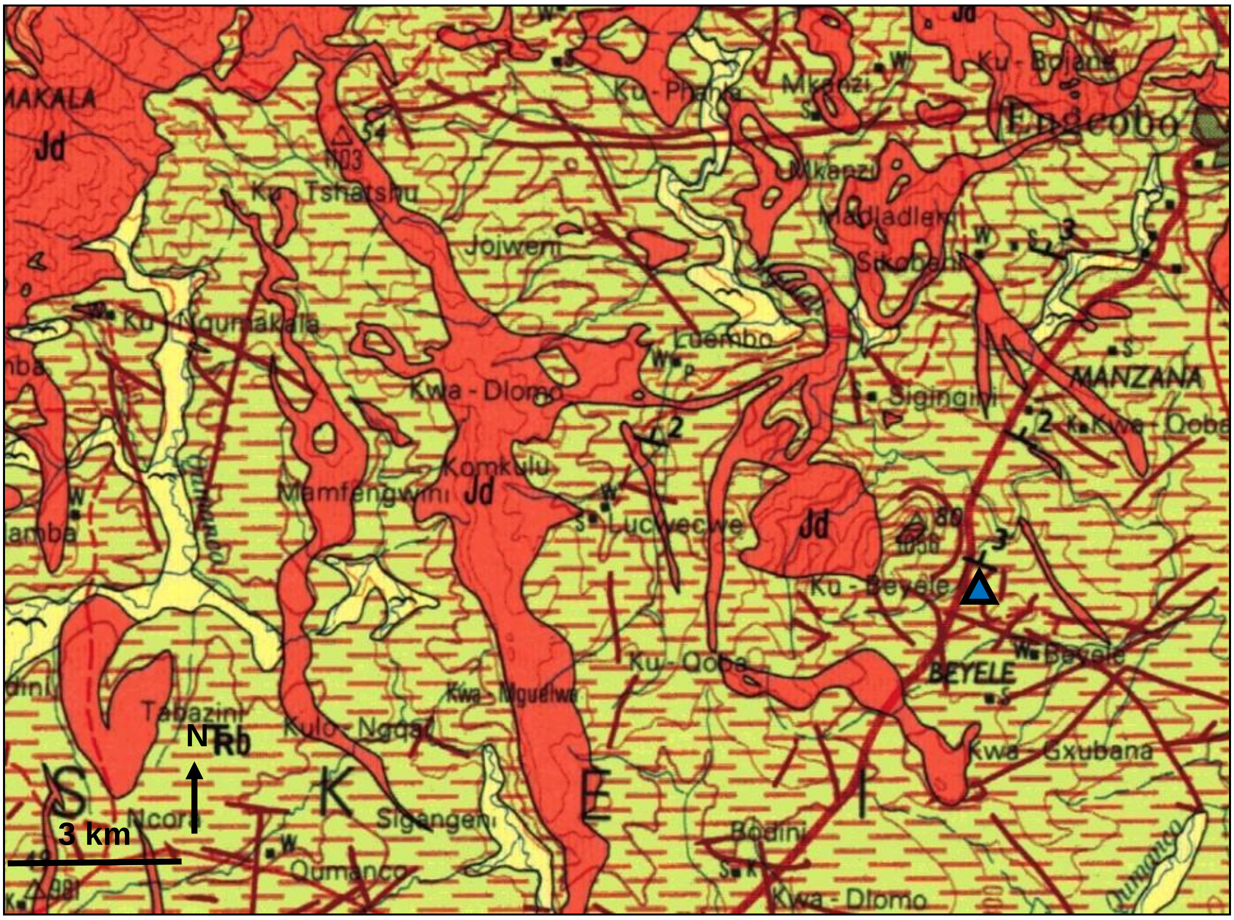

Fig. 4. Extract from 1: 250 000 geological map 3126 Queenstown (Council for Geoscience, Pretoria) showing the approximate location of the SANRAL R61 borrow pit study area southwest of Engcobo (blue triangle). TRb (greenish-yellow with dashes) = Early to Mid

Triassic Burgersdorp Formation; Jd (orange) = Early Jurassic intrusions of the Karoo Dolerite Suite; pale yellow areas = Late Caenozoic alluvium. Colluvial sediments of the Masotcheni Formation are not mapped separately here but occur extensively on hillslopes overlying the Burgersdorp Formation bedrocks where they are exposed in erosion gullies.

The **Burgersdorp Formation** represented in the study area 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 Middle Triassic age with a total thickness of some 900-1000 m 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. Geological descriptions of the formation are given by Dingle *et al.* (1983), Johnson (1976, 1984), Hiller & Stavrakis (1984), Johnson & Hiller (1990), Kitching (1995) Hancox (2000; see also extensive references therein) as well as Bordy and Krummeck (2016). Brief descriptions of the Burgersdorp beds in the Queenstown and Mthatha 1: 250 000 sheet areas are given by Johnson (1984) and Karpeta and Johnson (1979) respectively.

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 upward-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).

Surface exposure of fresh Beaufort Group rocks within or close to the Engcobo pit development area is unusually good, judging from satellite images and field reconnaissance, including steeper hillslopes, occasional stream beds, *dongas* and small dams (Fig. 3). The exposed Burgersdorp Formation succession in the borrow pit study area (Figs. 6 to 12) comprises, in stratigraphic order: (1) A thick lower package of massive, crumbly to hackly-weathering, reddish-brown mudrocks (distal floodplain); (2) A several m-thick, thin- to medium-bedded, locally bioturbated, heterolithic zone (proximal floodplain, levees and crevasse splays) with common, shallow to substantial, cross-cutting cut-and-fill channel structures, suggesting repeated aggradation and degradation of the proximal floodplain. Interbedded purple-brown to pale brown lithic sandstone and purple-brown mudrocks form upward-thinning as well as laterally-accreting channel-infill packages. The lower sandstones are erosive-based with thin mudflake breccio-conglomerates; thicker mudrock units contain zones of pale, curving or short, wedge-shaped shrinkage crack infills but well-developed pedogenic calcrete nodule horizons were not observed here; (3) An upper package of alternating massive purple-brown mudrocks and thin heterolithic units (upward-coarsening packages) passing upwards into thin-bedded mudrocks with very thin, pale sandstone interbeds (distal crevasse splays); (4) A several m-thick capping of prominent-weathering, pale brown channel sandstones with intermittent interbeds of mudrock intraclast breccias. The base of the channel sandstone package is sharp and locally gullied, with laterally-persistent, grey-green basal mudrock intraclast breccias but apparently no reworked calcrete concretions. This channel sandstone is one of several broadly tabular, laterally-persistent packages within the Burgersdorp Formation that weather prominently as a series stepped ridges on local hillslopes. The small stone quarry *c*. 200 m to the northwest of the borrow pit site is excavated into a lower-lying sandstone package.

The Burgersdorp sedimentary bedrocks are extensively intruded by dolerites of the Early Jurassic **Karoo Dolerite Suite** (Jd, orange in Fig. 4). Major sill-like dolerite intrusions surround the borrow pit development area on the southern, western and northern sides while several small-scale, steeply-inclined dykes cross-cut the Karoo bedrocks in the pit area itself (Fig. 6). Much of the Burgersdorp Formation outcrop immediately adjacent to the major intrusions is likely to be covered with doleritic colluvium (slope deposits) and lateritic soils, appearing rusty-brown on satellite images, and also to have been thermally metamorphosed (*i.e.* baked) as a result of dolerite intrusion. Thick accumulations of well-bedded, semi-conslidated, sandy, gravelly and bouldery alluvium of Late Caenozoic age (< 5Ma) can found in stream and river beds, as well seen in the deeply-incised stream *c*. 1 km to the NNW of the study site. These colluvial and alluvial deposits may be extensively calcretised (*i.e.* cemented with soil limestone or calcrete), especially in the neighbourhood of dolerite intrusions.

Hillslopes lateral to Karoo bedrock exposures in the pit area are mantled with saprolite, crumbly mudrock-rich soils and basal angular colluvial sandstone gravels. Pale yellowish-brown hillslope sediments of Late Caenozoic age are exposed in numerous *dongas* (erosion gullies), especially on the lower slopes of the Mgwali River Valley but also closer to the pit area itself (Fig. 13). The colluvial deposits are not mapped separately in Figure 4, but thick alluvium along the major water courses is shown here (yellow outcrop areas on the geological map). The semi-consolidated - and correspondingly readily-eroded - colluvial to alluvial gravels, sands, clays and palaeosols mantling hillslopes in the Engcobo region may be provisionally assigned to of the Late Pleistocene to Holocene **Masotcheni Formation**. This unit occurs widely within the northern KZN – Free State – Eastern Cape and is often well exposed within deep erosion gullies or *dongas* overlying the Karoo sedimentary bedrocks (*cf* Johnson & Verster 1994, Lindström 1981, Partridge *et al.* 2006). Sparse, downwasted flaked stone artefacts of dark grey hornfels overlie the semi-consolidated alluvium *c*. 1 km north of the borrow pit area but age-diagnostic stone tools were not recorded.

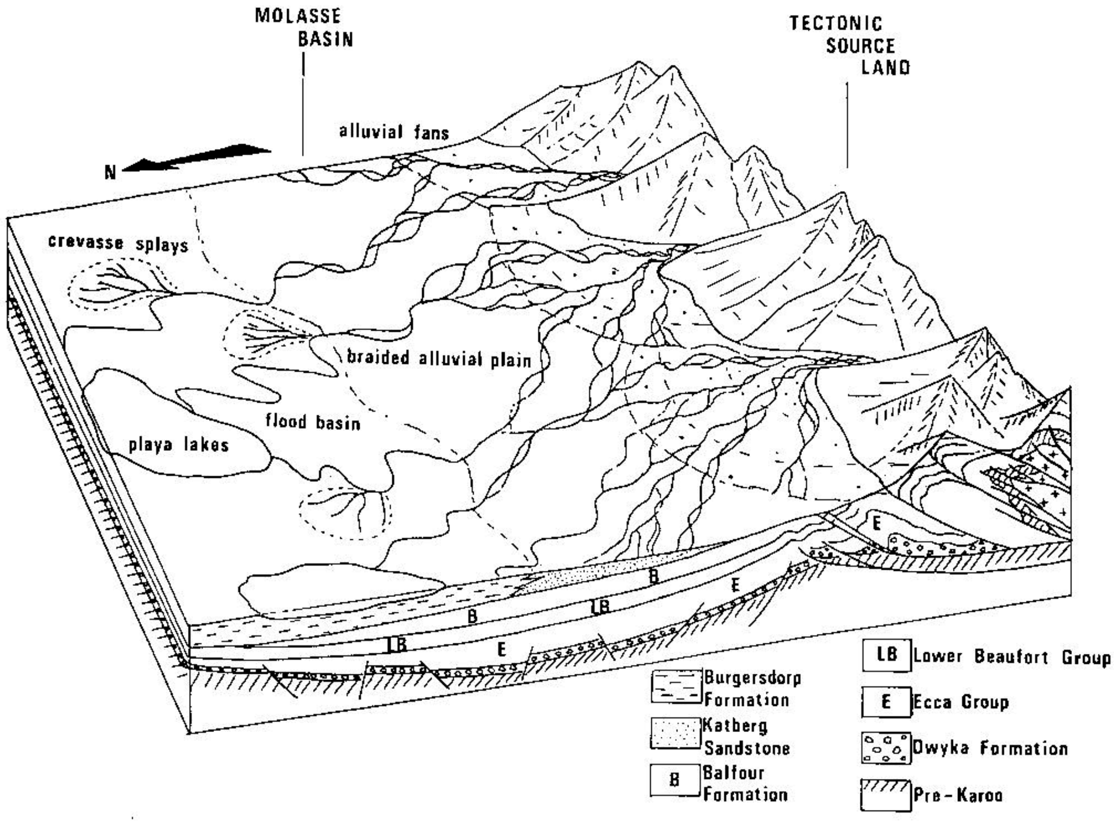

Figure 5. Reconstruction of the south-eastern Main Karoo Basin in Early Triassic times showing the deposition of the sandy Katberg Formation near the mountainous source area in the south. The mudrock-dominated Burgersdorp Formation was deposited on the distal floodplain where numerous playa lakes are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

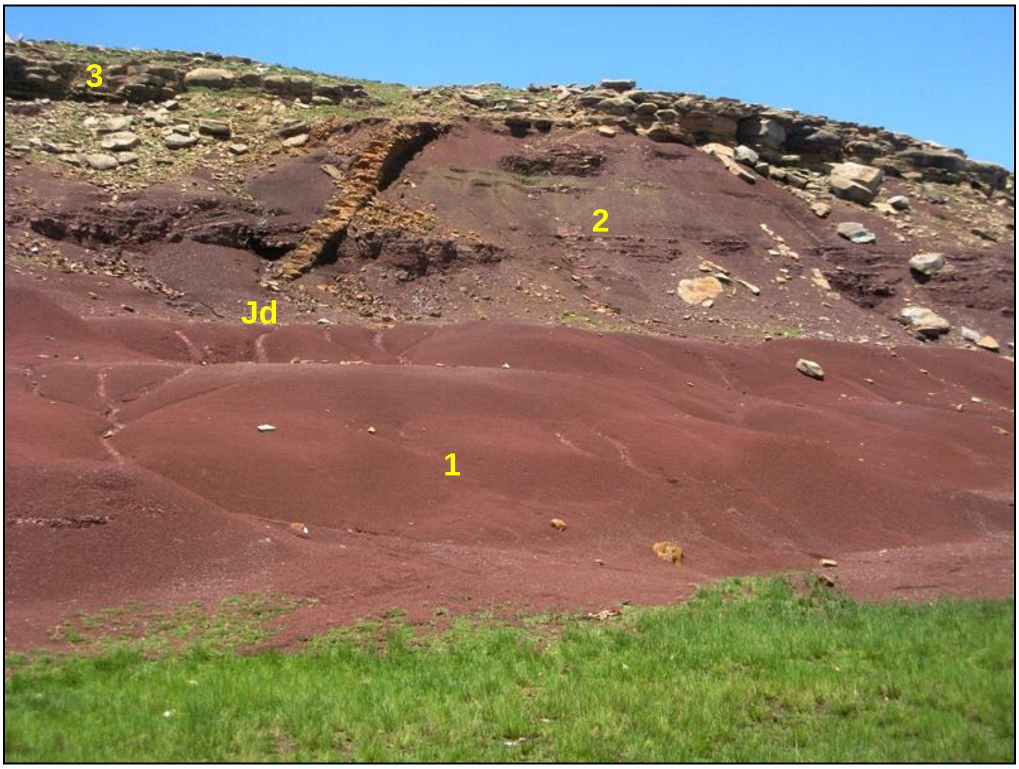

Figure 6. Burgersdorp Formation succession exposed in the Engcobo borrow pit: basal reddish-brown massive mudrocks (1) overlain by a purple-brown interval with upward-fining as well as upward-coarsening packages and wide cut-and-fill channel features (2) capped by a major channel sandstone package (3). Note also steeply inclined dolerite dyke (Jd).

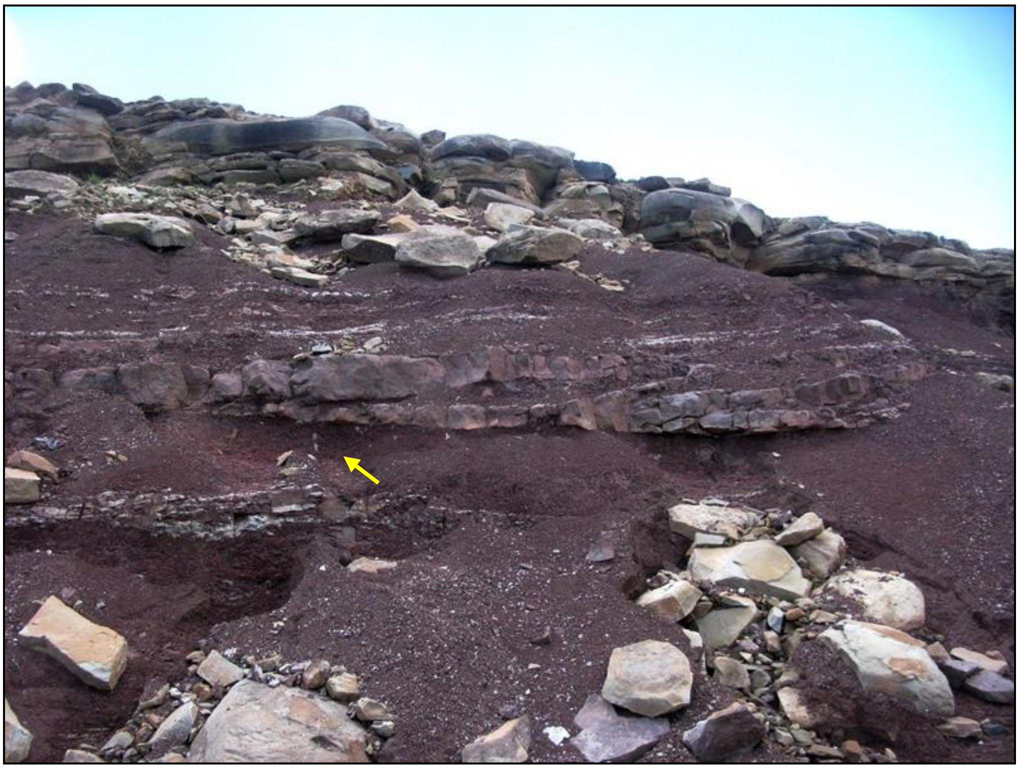

Figure 7. Small-scale incised channel within the central, heterolithic succession with lenticular, inclined, erosive-based, purple-brown sandstones at the base. Note subvertical trace fossils within underlying mudrocks (arrowed), shown close-up in Fig. 18 below.

Figure 8. Cross-cutting, markedly angular relationship between heterolithic, upward-thinning and –fining packages of purple-brown sandstones and siltstones in the central part of the exposed succession. Vigorous erosional degradation as well as aggradation of the proximal alluvial floodplain is indicated.

Figure 9. Upward-coarsening, conformable packages of purple-brown, thin-bedded to massive sandstone and mudrock within the upper part of the Burgersdorp succession in the Engcobo borrow pit.

Figure 10. Thinly bedded sandstones and siltstones at the top of the exposed purple-brown Burgersdorp Formation succession, sharply overlain by thick brown-weathering channel sandstones with a basal breccia of reworked mudrock intraclasts (greenish-grey).

Figure 11. Vertical section through the lower part of the upper channel sandstone package showing recessive-weathering, greenish-grey interbeds of mudrock intraclast breccia. Note the steeply-inclined dolerite dyke in the foreground on the right.

Figure 12. Stepped weathering profile of the major Burgersdorp channel sandstone package capping the maroon mudrocks at the borrow pit site. The sandstones are broadly tabular and massive to horizontally-laminated. Any interbedded mudrocks are not exposed on the plateau. The plateau is mantled by coarse, angular sandstone colluvium.

Figure 13. Gulley-eroded, reddish-brown colluvial sands and poorly-sorted basal gravels on the footslopes of the borrow pit site. These moderately- to poorly-consolidated deposits may belong to the Pleistocene Masotcheni Formation.

4. PALAEONTOLOGICAL HERITAGE

A compilation map of known fossil vertebrate sites from the Beaufort Group of the Main Karoo Basin (Nicolas 2007) emphasises the very small number of records from the former Transkei region between Queenstown and Umtata that includes the present study area (Fig. 14). Rather than simply a lack of fossils here, the main reasons are probably low levels of surface exposure (soil, colluvial, alluvial and vegetation cover), high levels of subsurface humid climate weathering, as well as the paucity of palaeontological field studies in the region. Burgersdorp Formation fossils from the Queenstown – Cofimvaba – Mthatha region have been briefly treated by Johnson (1984), Karpeta and Johnson (1979), Bordy & Krummeck (2016) as well as Almond (2011b, 2015a).

The Burgersdorp Formation is characterized by a diverse continental fossil biota of Early to Middle Triassic (Olenekian to Anisian) age, some 249 to 237 million years old (Kitching 1995, Hancox 2000, Rubidge 2005, Neveling *et al.* 2005, Smith *et al.* 2012). 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. 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.

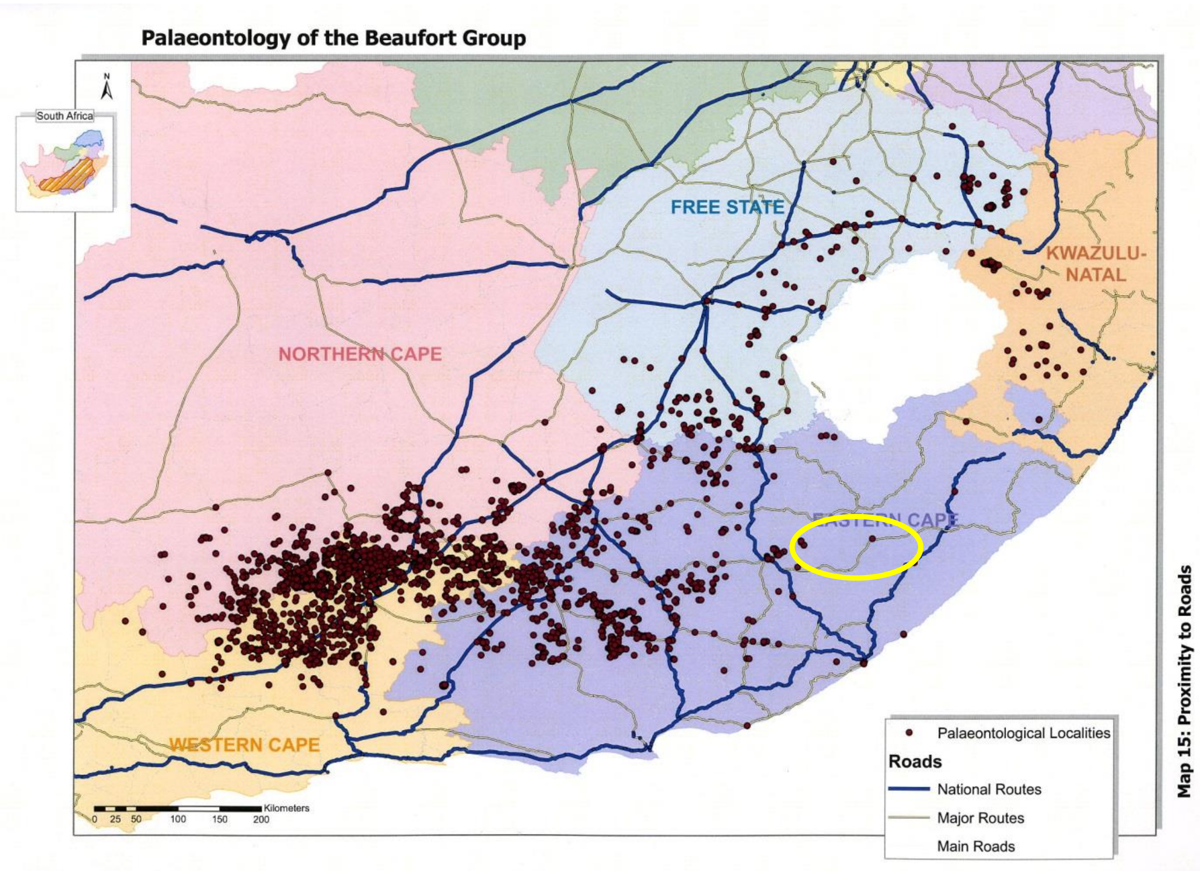

Figure 14. Distribution of recorded fossil vertebrate localities within the Beaufort Group (Main Karoo Basin) showing the lack of sites in the poorly-studied former Transkei region between Queenstown and Mtatha (yellow ellipse) (Map abstracted from Nicolas 2007).

Useful accounts of the palaeontological heritage of the Burgersdorp Formation – which has recently being recognised as yielding 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), Rubidge (2005) and Smith *et al.* (2012). 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 5 m, as well as the more gracile *Euparkeria* (Fig. 15). The therapsid fauna contains large herbivorous dicynodonts like *Kannemeyeria* (Fig. 16), 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. 16), 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; see also Bordy & Krummeck 2016) while a limited range of smaller-scale invertebrate burrows of uncertain origin are also known (Bordy & Krummeck 2016). 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).

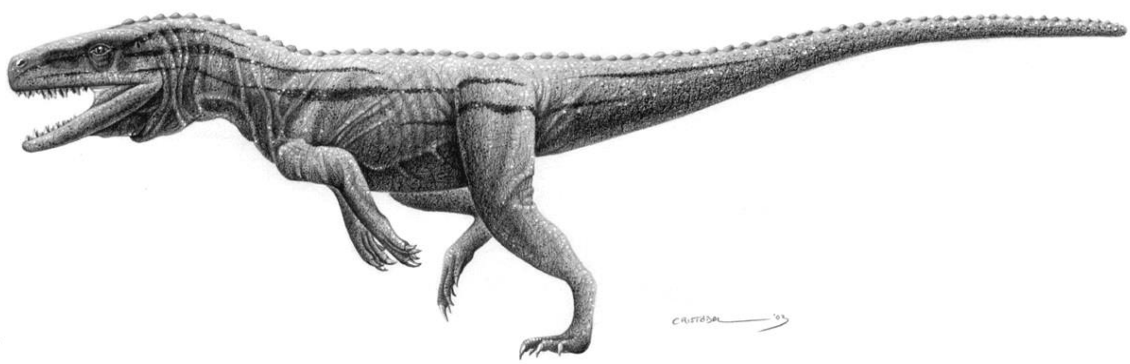

Figure 15. Reconstruction of the small (*c.* 0.5 m long) bipedal reptile *Euparkeria*, a primitive member of the archosaur group from which dinosaurs evolved later in the Triassic Period.

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).

The biostratigraphy of the Early–Middle 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).

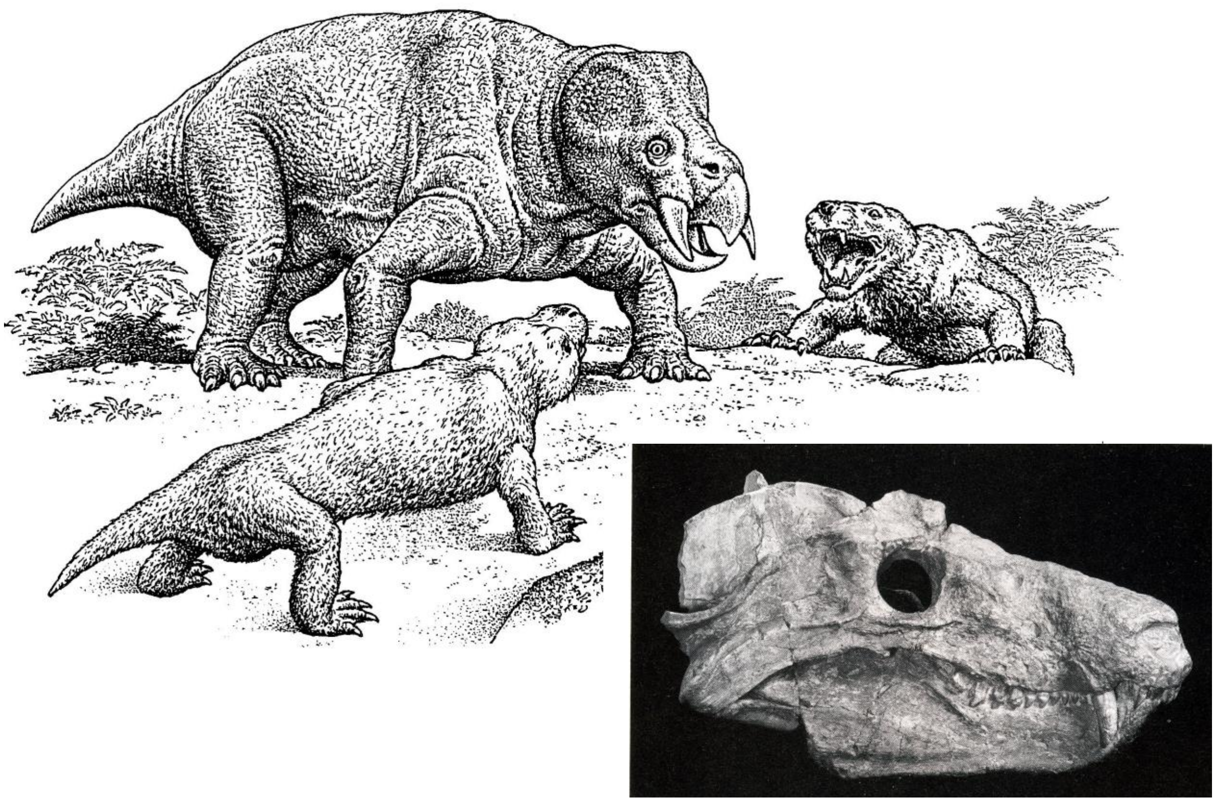

Figure 16. Reconstruction of typical therapsids of the Early Triassic *Cynognathus* Assemblage Zone - the large tusked herbivorous dicynodont *Kannemeyeria* and the predatory, bear-sized cynodont *Cynognathus*. The inset shows the heavily-built skull of *Cynognathus* (*c*. 30 cm long) in lateral view.

Previous vertebrate fossil records from the Burgersdorp Formation near Engcobo include armoured temnospondyl amphibians, kannemeyeriid dicynodonts and the cynodont *Diademodon* (Bordy & Krummeck 2016 and refs. therein). No vertebrate fossil bones or teeth were recorded from the Engcobo borrow pit study area during the site visit. It is notable that obvious palaeosol horizons marked be pedogenic calcrete nodules were not observed here. A small range of trace fossils – most of uncertain genesis – were recorded within the well-exposed, purple-brown, heterolithic central and upper portions of the exposed Burgersdorp succession, however. The commonest traces are bedding plane arrays of simple, cylindrical, vertical sandstone casts within both siltstone and sandstone facies that probably represent stem casts of reedy vegetation (*e.g.*

sphenophyte ferns) (Fig. 17). Moderately high intensity of proximal floodplain, in-channel and channel margins as well as distal floodplain bioturbation by invertebrates (possibly insects or worms) is best seen in colour-banded, thinly-bedded heterolithic zones where subvertical cylindrical burrows up to 2 cm across (but usually much less) rework sandstone into mudrock and *vice versa* (Fig. 24 & 25). Prominent-weathering, subvertical to oblique sandstone casts of subcylindrical to slightly compressed burrows into mudrock are 2 to 3 cm wide with a vaguely dimpled surface and often show reduction haloes (Figs 18 to 20). They resemble the enigmatic continental invertebrate burrows described in detail from the Burgersdorp Formation near Engcobo by Bordy and Krummeck (2016); the identity of the trace maker remains unknown. A few examples of possible small-scale (<10 cm diam.), gently-inclined vertebrate burrows with a broadly elliptical cross-section were also observed (Fig. 23) and may be compared with *Reniformichnus* of Krummeck & Bordy (2017). The >1 m-deep, 40-60 cm-wide, gutter-like sandstone cast with an expanded top shown in Figures 21 and 22 *might* be a large sloping vertebrate burrow, but this remains equivocal.

Late Caenozoic superficial deposits of the Karoo region are poorly studied in palaeontological terms but may contain local concentrations of fossil vertebrate, invertebrate and plant remains as well as trace fossils (*e.g.* mammalian bones, teeth, horncores, freshwater or terrestrial molluscs, coalified wood, palynomorphs, calcretised root casts and termitaria) (*cf* Skead 1980, Klein 1984, MacRae 1999, Brink *et al.* 1999, Brink & Rossouw 2000, Churchill *et al.* 2000, Partridge & Scott 2000). Key fossiliferous facies are mostly associated with extant or defunct drainage lines and include older consolidated alluvium and terrace gravels, lake, pan and *vlei* deposits (Partridge *et al.,* 2006). The Pleistocene to Holocene **Masotcheni Formation**, for example, is often characterised by concentrations of petrified fossil wood reworked from the Karoo Supergroup bedrocks as well as Early to Middle Stone Age stone artefacts. A sparse scatter of dark grey hornfels stone artefacts of uncertain age is seen overlying semi-consolidated alluvial deposits along a tributary of the Mgwali River, some 1 km north of the present study area. No reworked petrified wood, bone or teeth from the underlying Karoo bedrocks were recorded from the colluvial superficial deposits in the borrow pit area, however.

Figure 17. Vertical, cylindrical, pale sandstone-infilled casts – probably of reedy plant stems – within thin-bedded, purple-brown sandstone in the heterolithic channelled zone of the Burgersdorp succession (Scale in cm).

Figure 18. Subvertical to oblique sandstone casts (*c*. 2 cm wide) – probably invertebrate burrows – surrounded by pale reduction haloes and embedded within hackly-weathering purple-brown mudrocks (Scale = *c.* 15 cm).

Figure 19. Subcylindrical, bent sandstone cast of an invertebrate burrow (*c*. 3 cm wide) within massive purple-brown overbank mudrocks.

Figure 20. Weathered-out sandstone cast of a subcylindrical invertebrate burrow (2.7 cm wide) showing vaguely dimpled surface texture.

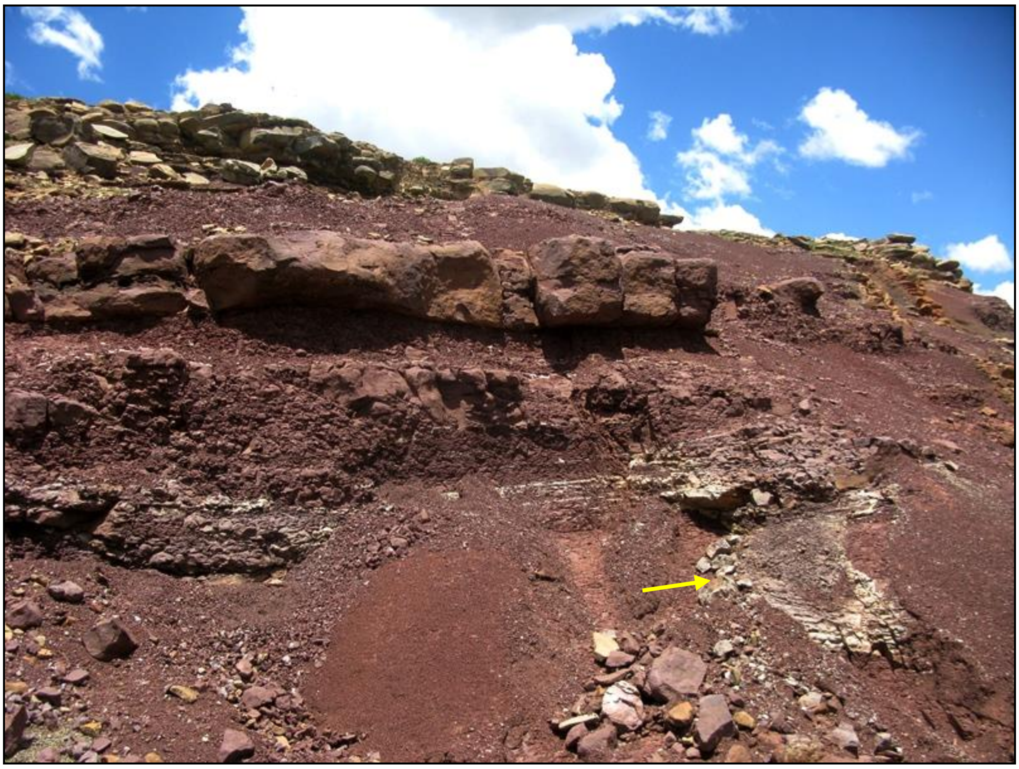

Figure 21. Sandstone cast of a large (*c*. 1 m-deep), gutter-shaped structure (arrowed), expanding towards the top and incised into massive mudrocks below, thin-bedded heterolithics above (possible upward-coarsening package). See also following figure.

Figure 22. Detail of the incised sandstone structure shown above. This enigmatic structure *might* be a vertebrate burrow cast (Hammer = 30 cm).

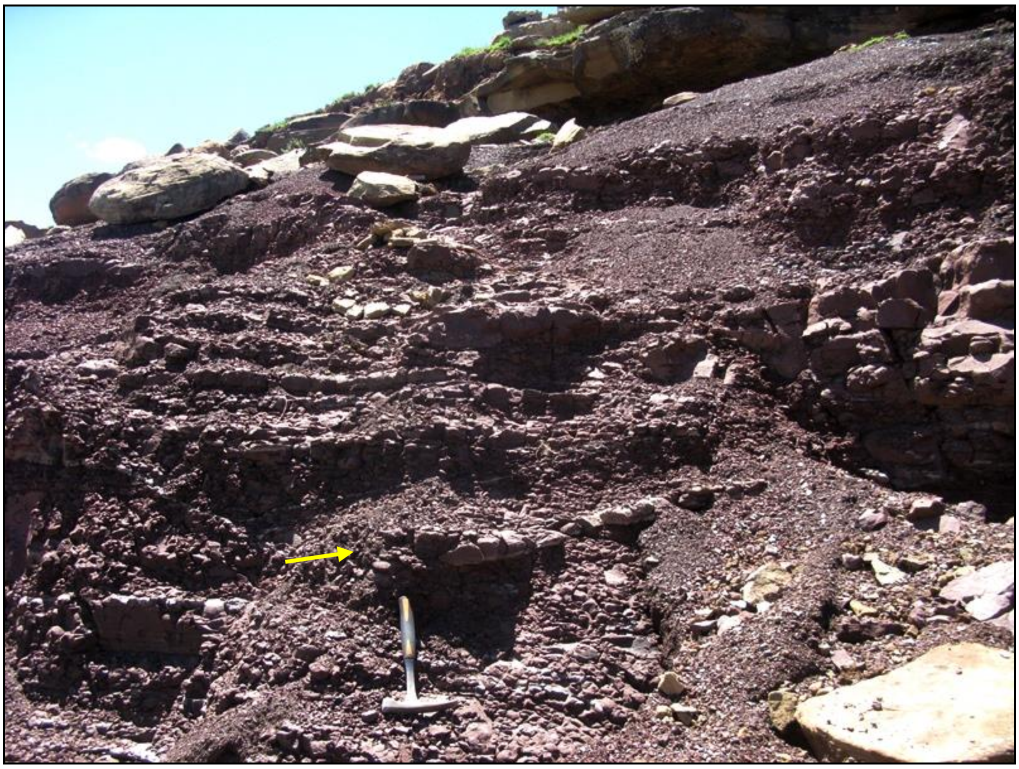

Figure 23. Possible sandstone cast of an inclined small vertebrate burrow (arrowed, *c.* 9 cm wide, elliptical cross-section) within the central heterolithic zone (Hammer = 30 cm).

Figure 24. Moderately dense bioturbation of interbedded Burgersdorp sandstones and purple-brown mudrocks within the central heterolithic zone. The subvertical, cylindrical burrows seen here are of very variable diameter (up to 1.5 cm); some of them might represent root structures.

Figure 25. Thinly-interbedded pale sandstones (distal crevasse splays) and purple mudrocks within the uppermost portion of the exposed Burgersdorp mudrock-dominated succession showing small-scale subvertical invertebrate burrows (< 2 cm wide) reworking mudrock into sandstone and *vice versa*.

5. CONCLUSIONS & RECOMMENDATIONS

The SANRAL R62 (Section 6) borrow pit study area near Engcobo is underlain by Early to Middle Triassic continental sediments of the Burgersdorp Formation (Upper Beaufort Group / Tarkastad Subgroup, Karoo Supergroup) and is cut by several small dykes of the Early Jurassic Karoo Dolerite Suite. The Burgersdorp Formation in the Eastern Cape is well known for locally abundant fossil vertebrates and trace fossils (*e.g.* invertebrate and vertebrate burrows) of the *Cynognathus* Assemblage Zone. So far, very few fossil vertebrate remains, or other palaeontological material, have been recorded from the Karoo Supergroup rocks in the Cofimvaba – Encobo area of the former Transkei. This may well be attributed in large part to (1) generally low levels of fresh bedrock exposure here, mainly due to the thick mantle of superficial deposits (colluvium / alluvium / soils) as well as seasonally dense vegetation cover and (2) the paucity of palaeontological field studies in the region. Deep weathering of bedrocks in humid, pluvial climates and baking of sedimentary country rocks by extensive dolerite intrusion may also have played a role. Pleistocene mammalian remains and stone artefacts may be associated with the superficial sediments (possibly belonging to the Masotcheni Formation) overlying the Karoo Supergroup bedrocks.

No vertebrate body fossils (*i.e.* bones, teeth) were recorded from the exceptionally well-exposed Burgersdorp Formation exposures at the borrow pit site during a recent site visit. However, a small range of trace fossils – most of uncertain origin - are observed here within the thinly-interbedded sandstones and siltstones building the middle and upper portions of the exposed succession. These traces include locally abundant stems casts of reedy plants, various small-scale invertebrate burrows, a few probable small (<10 cm-wide) vertebrate burrow casts as well as a possible – but equivocal – large vertebrate burrow cast (> 1 m deep, 50-60 cm wide). Several 2-3 cm wide subcylindrical sandstone casts resemble an unnamed invertebrate burrow type recently described from the Burgersdorp Formation near Engcobo by Bordy and Krummeck (2016). Comparable trace fossil assemblages occur widely within the outcrop area of the Burgersdorp Formation, and none of the material observed in the SANRAL R62 (Section 6) borrow pit study area near Engcobo is considered to be of high conservation significance.

There are therefore no objections on palaeontological heritage grounds to the authorisation of proposed borrow pit development.

The Environmental Control Officer (ECO) for the borrow pit project should be alerted to the potential for, and scientific significance of, new fossil finds during the construction phase of the development. Should important new fossil remains - such as vertebrate bones and teeth, petrified wood, plant-rich fossil lenses or dense fossil burrow assemblages - be exposed during construction, the responsible Environmental Control Officer should alert ECPHRA (*i.e.* The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible. This is so that appropriate mitigation action can be taken in good time by a professional palaeontologist at the developer's expense (Please refer to the Chance Fossil Finds Procedure appended below).

It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving fossiliferous bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

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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, Limpopo, Northwest, Mpumalanga, KwaZulu-Natal and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has previously served as a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed water development projects, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

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

APPENDIX: GPS LOCALITY DATA FOR SITES EXAMINED IN THE FIELD

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

Loc	GPS data	Comments
183	S31° 45' 05.1" E27° 57' 14.8"	SE end of hillslope exposure of Burgersdorp Fm. Exposed succession comprises in stratigraphic order (1) thick lower package of massive, crumbly to hackly-weathering, reddish-brown to dusky purple-grey mudrocks; (2) several m-thick, thin- to medium-bedded heterolithic zone with common shallow to major cross-cutting cut-and-fill channel structures, interbedded purple-brown to pale brown lithic sandstone and purple-brown mudrocks possibly forming upward-thinning as well as laterally-accreting packages; basal sandstones erosive; thicker mudrocks with pale, curving or short, wedge-shaped shrinkage crack infills; (3) upper package of alternating massive purple-brown mudrocks and thin heterolithic units passing upwards into thin-bedded mudrocks with very thin, pale sandstone interbeds; (4) several m-thick capping of prominent-weathering, pale brown channel sandstones with intermittent interbeds of mudrock intraclast breccias. Base of channel sandstone package is sharp and locally gullied with basal mudrock intraclast breccia but no reworked calcretes. Burgersdorp succession is cut by several steeply-inclined thin dolerite dykes. Hillslopes lateral to Karoo bedrock exposure mantled with saprolite, crumbly mudrock soils, angular colluvial sandstone gravels.
184	S31° 45' 05.2" E27° 57' 15.5"	Inclined (*c*. 30º) base of wide, shallow cut-and-fill structure with thinly-interbedded sandstone and siltstone. Local, convex-down linear sandstone thickenings possibly due to loading rather than vertebrate burrow casts. Washed out cast of 2.7 cm wide subcylindrical sandstone burrow cast with vaguely dimpled surface (*cf* unnamed Lower Triassic burrows of Bordy & Krummeck 2016). Float blocks of purple-brown siltstone and sandstone from middle heterolithic package (shallow channels, levees) with numerous, spaced, vertical sandstone casts with circular section (0.5-1 cm) – probably of reedy plant stems rather than invertebrates.
185	S31° 45' 04.7" E27° 57' 15.4"	*In situ* casts of subcylindrical sandstone burrow casts within purple-brown siltstone of middle heterolithic zone, beneath sharp base of clearly lenticular purple-brown channel sandstone. Burrows variously oblique, horizontal to subvertical. Stem casts of reedy plants as well as rounded grey-green and purple-brown mudrock intraclasts within sandstone float blocks.*Possible* gently inclined sandstone casts of a small vertebrate burrow (9 cm wide, elliptical cross-section) (requires confirmation).
186	S31° 45' 01.5" E27° 57' 18.2"	Mottled, highly-bioturbated purple-brown siltstones and pale thin sandstones of central heterolithic zone – probably due to intensive invertebrate burrowing and possibly rhizoturbation. Traces subcylidrical, subvertical to oblique, infilled with mudrock, up to 1.5 cm across but mostly smaller with range of diameters.
187	S31° 44' 59.8" E27° 57' 19.8"	Shortly below base of main channel sandstone capping, thinly interlayered sandstones and siltstones (possibly crevasse splays on distal floodplain) show intensive bioturbation with reworking of sand into mud and *vice-versa* (*not* plant root structures).
188	S31° 44' 58.7" E27° 57' 20.0"	*c*. 2 cm-wide subvertical to oblique pale sandstone casts with prominent reduction halos embedded within hackly, purple-brown siltstone. Possibly invertebrate burrows.
190	S31° 44' 57.6" E27° 57' 20.9"	Steeply-inclined, wall-like dolerite dyke, one of several forming a local swarm trending roughly N-S and cutting through Burgersdorp Fm succession.
191	S31° 44' 57.4" E27° 57' 21.6"	N end of main Burgersdorp mudrock exposures with *c.* 40-50 cm-wide, 1 m – deep, pale sandstone cast cuttings down into purple-brown siltstone, expanding laterally towards the top. Possibly a large vertebrate burrow cast or deep sandy gutter cast, but requires further study to determine origin. Also several oblique to curved, subcylindrical sandstone burrow casts (few cm wide) as seen at Loc. 184.
192	S31° 44' 57.8" E27° 57' 25.1"	Prominent overhang formed by resistant-weathering channel sandstones with gullied base and basal mudstone intraclast breccias overlying recessive-weathering purple-brown overbank mudrocks.
193	S31° 45' 02.2" E27° 57' 18.4"	Good sections through lower part of thick channel sandstone package showing tabular, medium-bedded, grey-green sandstones, variously amalgamated or

		interbedded with grey-green mudrock intraclast breccias. Channel sandstone base is regionally flat but locally gullied. Small dolerite dyke cuts through succession.
194	S31° 45' 01.8" E27° 57' 15.3"	Erosion gulley exposures through thick (sev. m) orange-brown colluvial soils with sandstone gravel-rich base overlying Karoo bedrocks. Possibly Masotcheni Formation. No petrified wood or other reworked fossil clasts observed.
195	S31° 44' 59.5" E27° 57' 10.1"	Small quarry excavated into tabular, thick-bedded, grey-green channel sandstone package of the Burgersdorp Fm, stratigraphically beneath main quarry section. Sandstones weather prominently as ledges along adjacent hillslopes with gullied Masotcheni Formation colluvial deposits below ledges.
196	S31° 44' 30.4" E27° 57' 03.1"	Gullied exposures of Masotcheni Formation well-consolidated gravelly sands with sparse downwasted anthropogenically flaked hornfels stone artefacts, *c*. 1 km NNW of borrow pit study area.
197	S31° 44' 29.2" E27° 57' 03.3"	Excellent vertical riverbank exposures of well-bedded Pleistocene or younger alluvial sediments overlying Burgersdorp Formation bedrocks.

<table>
<tr><td colspan="3">CHANCE FOSSIL FINDS PROCEDURE: SANRAL R61 (Section 6) borrow pit near Engcobo</td></tr>
<tr><td>Province & region:</td><td colspan="2">Eastern Cape, Engcobo Local Municipality, Chris Hani District Municipality</td></tr>
<tr><td>Responsible Heritage Management Authority</td><td colspan="2">ECPHRA (Contact: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600. E-mail: smokhanya@ecphra.org.za)</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Burgersdorp Formation (Early – Middle Triassic), Karoo Supergroup; Masocheni Formation (Pleistocene) colluvium</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Bones and teeth of therapsids, reptiles and other vertebrates; invertebrate and vertebrate burrows.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
• Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
• Context – describe position of fossils within stratigraphy (rock layering), depth below surface
• Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
• Alert Heritage Resources Authority and project palaeontologist (if any) who will advise on any necessary mitigation
• Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Authority for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
• Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
• Photograph fossils against a plain, level background, with scale
• Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
• Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
• Alert Heritage Resources Authority and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Authority, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Authority</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Authority. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Authority minimum standards.</td></tr>
</table>