PALAEONTOLOGICAL HERITAGE ASSESSMENT: COMBINED DESKTOP & FIELD-BASED STUDY

PROPOSED UPGRADE OF NATIONAL ROUTE R63, SECTION 13, AND ASSOCIATED MINING APPLICATIONS FROM FORT BEAUFORT (KM 35,77) TO ALICE (KM 58,86), EASTERN CAPE

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EXECUTIVE SUMMARY

The South African National Roads Agency SOC Limited is proposing to upgrade Section 13 of the National Route R63 between the small towns of Fort Beaufort and Alice in the Eastern Cape. The road project will involve the development of six borrow pits and a hardrock quarry.

The study area for the proposed upgrade of the R63 (Section 13) is largely underlain by Late Permian continental sediments of the Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup) that are assigned to the Balfour Formation (Daggaboersnek Member). However, these potentially fossiliferous bedrocks are generally poorly-exposed, quite weathered and have been locally baked by major Karoo dolerite intrusions. Desktop and field assessment of the study area indicate that the sedimentary rocks of the Balfour Formation here contain very sparse vertebrate fossils, petrified wood and trace fossils (*e.g.* vertebrate burrows). No scientifically-valuable fossil remains were recorded from sedimentary rocks exposed within the development footprint itself, including the five sedimentary borrow pit localities (Sites C to G in Fig. 2 herein) and several road cuttings. A conservation-worthy warren of vertebrate burrows along the banks of the Mxelo River (red triangle in Fig. 2) lies 100 m *outside* the development footprint and so should not be directly impacted. Questionable vertebrate burrow and bivalve remains within the development footprint on the southern side of the R63 due north of Kwajoji village (orange triangle in Fig. 2) are not considered to be of conservation significance and no mitigation is recommended here. Superficial sediments of Late Pleistocene to Recent age - including thick sandy to gravelly alluvium, surface gravels and modern soils – are apparently fossil-poor. No vertebrate fossils, reworked petrified wood or other fossil remains were recorded within the superficial sediments during the present field assessment. Two proposed quarry excavations into a Jurassic dolerite sill on the north-eastern outskirts of Alice (Sites A & B in Fig. 2 herein) are of no palaeontological heritage significance.

The overall impact significance of the R63 (Section 13) road project, including the associated quarry / borrow pits, is evaluated as *very low* as far as palaeontology is concerned. Unless significant new fossil finds (*e.g.* well-preserved vertebrate remains, petrified wood) are made during the construction phase of the development, further specialist palaeontological studies or mitigation are not regarded as warranted for this project. The Environmental Control Officer (ECO) for the project should be alerted to the potential for, and scientific significance of, new fossil finds during the construction phase of the development. They should familiarise themselves with the sort of fossils concerned through museum displays (*e.g.* Amatole Museum, King William's Town, East London Museum) and accessible, well-illustrated literature (*e.g.* MacRae 1999).

Should important new fossil remains - such as vertebrate bones and teeth, 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 so that appropriate action can be taken in good time by a professional palaeontologist at the developer's expense.

Palaeontological mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as of associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy). The palaeontologist concerned with mitigation work will need a valid fossil collection permit from ECPHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological specialist work should 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 2 palaeontological studies recently developed by SAHRA (2013). These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the R63 (Section 13) road development.

1. INTRODUCTION & BRIEF

The South African National Roads Agency SOC Limited (SANRAL) is proposing to upgrade Section 13 of the National Route R63 between the small towns of Fort Beaufort (km 35,77) and Alice (km 58,86) in the Eastern Cape (Fig. 1). The following brief project outline is provided in the Background Information Document prepare by EOH Coastal and Environmental Services, East London:

> The project starts at the intersection between the R67 and the R63 on the section from Adelaide. The route follows the R63 in an easterly direction and continues through the town of

Fort Beaufort towards Alice for approximately 23km. The project ends at the Galloway Bridge just before the four-way stop entering the town of Alice. Key components include:

- Increasing the road reserve width from 30 m to a minimum of 50 m.
- General widening of the existing road cross section for climbing lanes and 2.5 m surfaced shoulders. The main carriageway is 6,4 m and needs to be increased to 12,4 m. The total width with the addition of passing lanes will be 14,6 m.
- Substantial vertical and horizontal geometric improvements from generally an 80 km/h to 100/120 km/h design speed.
- Rehabilitation of the pavement structure on existing alignment and construction of new pavement on the new alignment, for all of which suitable material will need to be sourced.
- Stabilisation of existing and new cut faces.
- Widening and / or new construction of existing bridges, agricultural underpass and drainage structures.
- Opening of a new hard rock quarry.
- Opening of 6 new borrow pits.

The proposed quarrying activities will require the submission of a mining application to the Department of Mineral Resources (DMR) as well as a separate Full Scoping and Environmental Impact Assessment which will be undertaken in accordance with Regulation 6 of the EIA Regulations (2014).

The quarry and borrow pit sites are designated A to G for the purposes of this report (See Fig. 2). The proposed road development and borrow pit / quarry footprints overlie potentially fossiliferous bedrocks of the Lower Beaufort Group (Karoo Supergroup) as well as Late Caenozoic superficial deposits. The present combined desktop and field-based palaeontological heritage study has therefore been commissioned on behalf of SANRAL by EOH Coastal & Environmental Services, East London (Contact details: Ms Thina Mgweba. EOH Coastal & Environmental Services. 25 Tecoma Street, Berea, East London. P.O Box 8145, Nahoon, East London, 5210. Tel: +27437267809. Fax: +27437268352. E-mail: t.mgweba@cesnet.co.za).

2. LEGISLATIVE CONTEXT FOR PALAEONTOLOGICAL ASSESSMENT STUDIES

The present combined desktop and field-based palaeontological heritage report falls under Sections 35 and 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the Environmental Management Plan for this project.

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

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

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

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

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

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

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

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(*b*) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(*c*) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

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

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

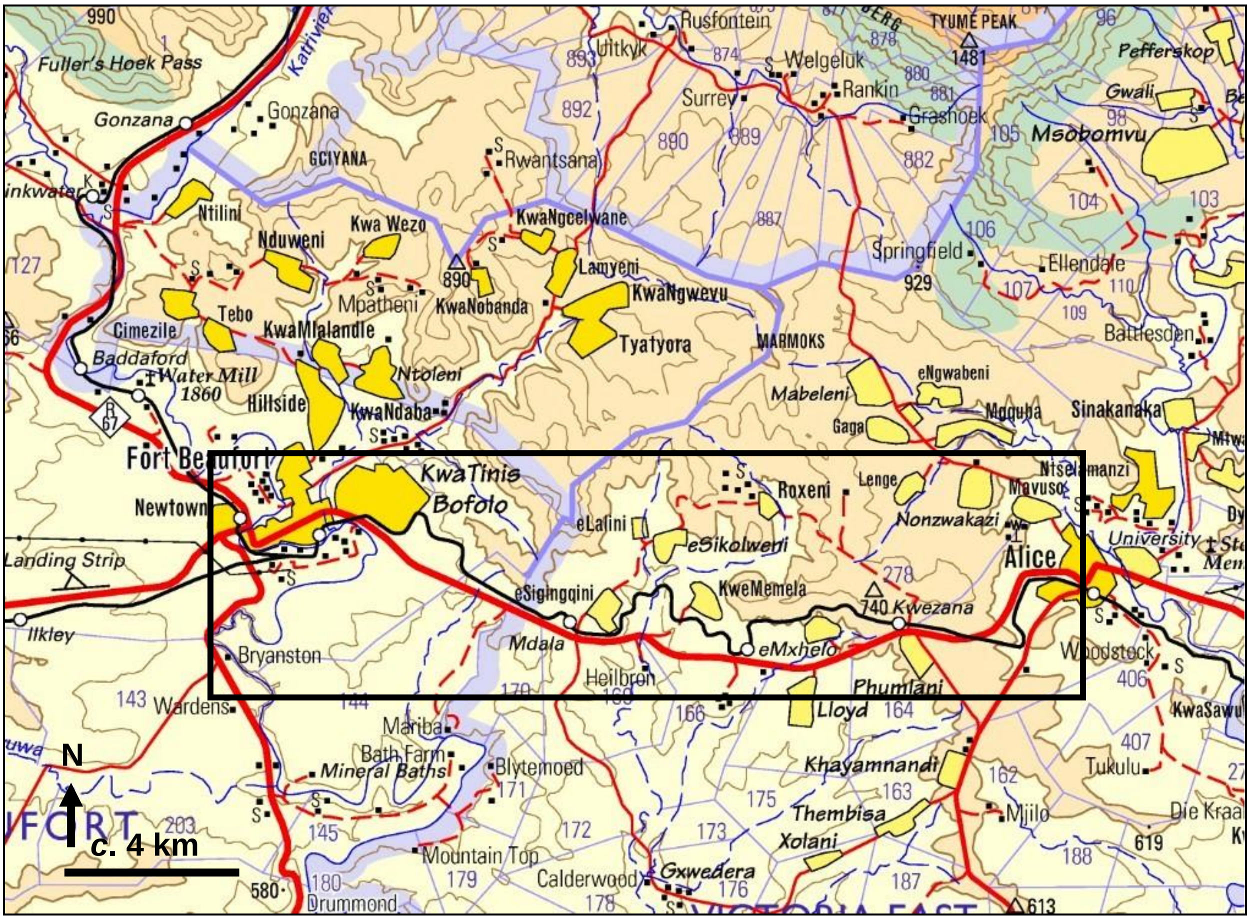

Fig. 1. Extract from 1: 250 000 topographical map 3226 King William's Town showing the *approximate* location (black rectangle) of the study area for the proposed R63 road upgrade between Fort Beaufort and Alice, Eastern Cape (Map courtesy of the Chief Directorate National Geo-spatial Information, Mowbray).

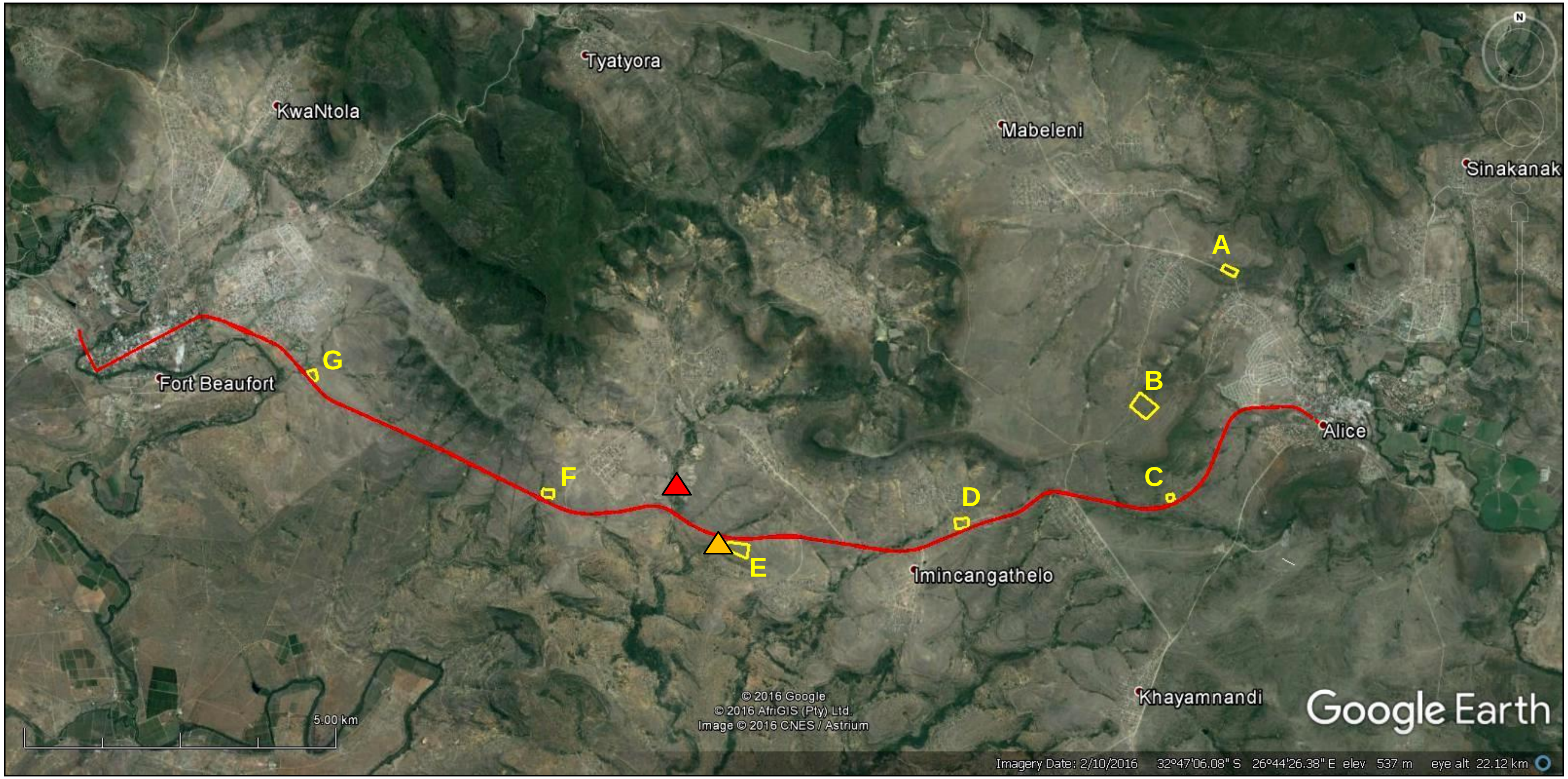

Fig. 2. Google earth© satellite image of the study area between Fort Beaufort and Alice, Eastern Cape. Section 13 of the National Route R63 is shown in red. The seven proposed borrow pits and quarries associated with the road upgrade are indicated by small yellow polygons (A-G). Sites A and B are excavated into dolerite, the remainder (C-G) into Balfour Formation sedimentary rocks. The red triangle shows the location of fossil vertebrate burrows on the west bank of the Mxelo River (c. 100 m N of road) that are conservations-worthy but will not be directly impacted by the proposed road development. The orange triangle indicates *unconfirmed* fossils of bivalves and a vertebrate burrow within the development footprint that are not considered to be of conservation significance – *i.e.* no mitigation recommended here (See Figs 33 and 28).

3. GENERAL APPROACH USED FOR THIS PALAEONTOLOGICAL IMPACT STUDY

This PIA report provides an assessment of the observed or inferred palaeontological heritage within the broader study area, with recommendations for specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, including previous palaeontological impact assessments in the region (*e.g.* Almond 2011a, 2011b, 2014, 2015a, 2015b), (2) published geological maps and accompanying sheet explanations (*e.g.* Mountain 1974, Hill 1993), and (3) a palaeontological field study in the project area between Alice and Fort Beaufort over the period 21-22 September, 2016.

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 scoping during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (The SAHRIS palaeosensitivity maps are also consulted on the SAHRA website). 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 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 assessment study by a professional palaeontologist is usually warranted.

The focus of palaeontological field assessment is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the field study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localized (*e.g.* GPS and stratigraphic data) samples of fossil material during field assessment studies. In order to do so, a fossil collection permit from SAHRA is required and all fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Note that while fossil localities recorded during field work within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or obscured by surface deposits (soil, alluvium *etc*) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area than within the study area itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area.

On the basis of the desktop and field 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. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological and taphonomic data) – is usually most effective 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, 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) and a suitably qualified palaeontologist so that specimens can be examined, recorded and, if necessary, professionally excavated. 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.

GPS locality data for numbered sites mentioned in the text are provided in the Appendix.

4. GEOLOGICAL BACKGROUND

The R63 road and quarry / borrow pit study area is situated between 400 and 800 m amsl in semi-arid, gently hilly terrain located some 10 km to the south of the Amatole Mountain Escarpment (Figs. 6 to 8). The area is drained by the meandering Kat River and several of its small, non-perennial tributaries. Close to the R63 much of the terrain is highly disturbed. Levels of bedrock exposure are generally very low, with the exception of road and rail cuttings, farm dams, stream and river banks and borrow pits. The local vegetation is mapped as Bhisho Thornveld with small areas of Bedford Dry Grassland.

The geology of the study area is outlined on 1: 250 000 geology sheet 3226 King William's Town (Fig. 3; Council for Geoscience, Pretoria). A very brief geological explanation for this sheet is printed on the map itself, and there is a separate report by Mountain (1974) on the geology of the East London area. An early account of the geology of Fort Beaufort has been published by Piers (1877) (not seen by this author) while Katemaunzanga (2009) has provided a useful detailed study of the Balfour Formation in the Fort Beaufort – Alice area (Fig. 4).

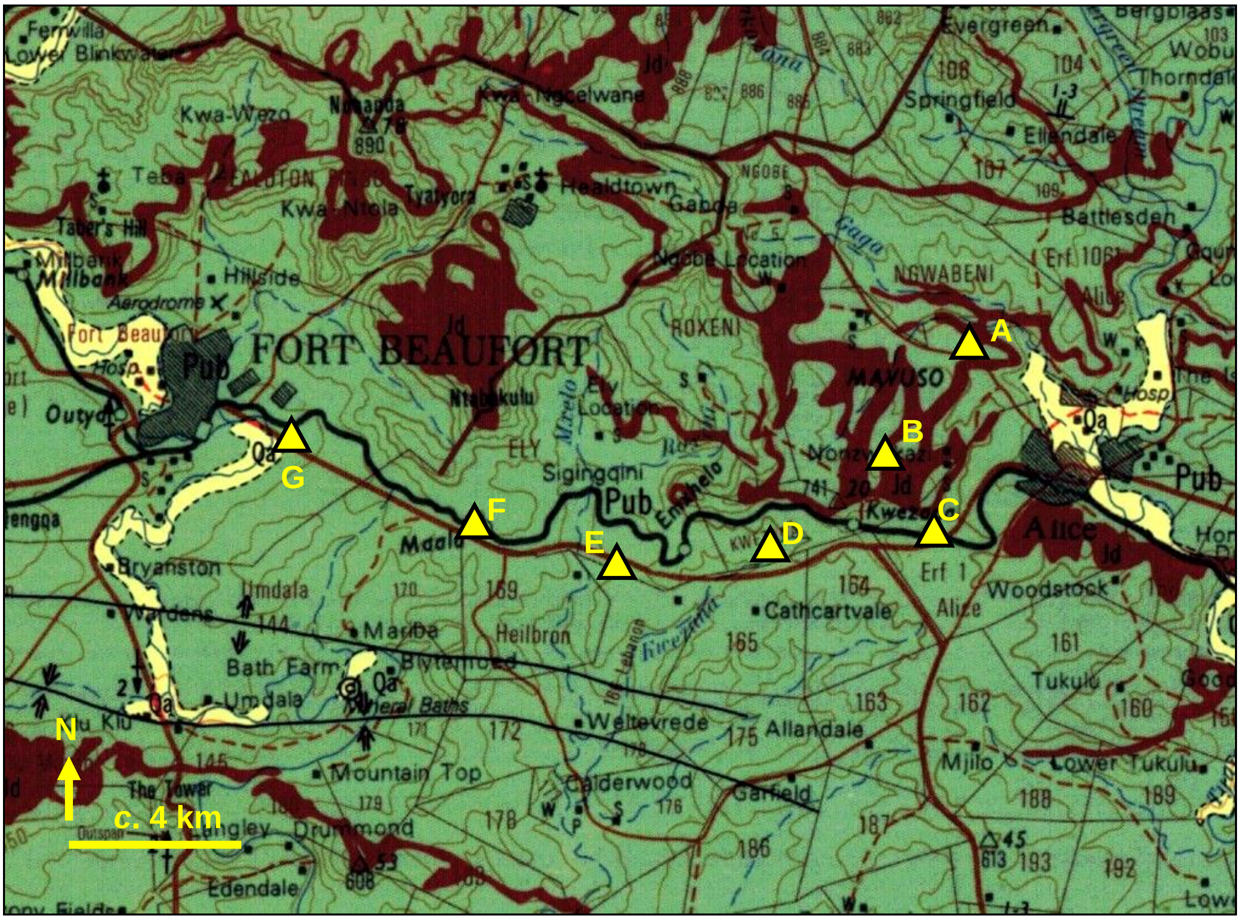

Fig. 3. Extract from 1: 250 000 geological map sheet 3226 King William's Town (Council for Geoscience, Pretoria) showing the R63 road and quarry / borrow pit study area between

Fort Beaufort and Alice in the Eastern Cape Province. The 7 quarry / borrow pit sites are indicated by yellow triangles (A, B into dolerite, C-G into Beaufort Group sediments).

KEY GEOLOGICAL UNITS: Dark brown (Jd) = Jurassic Karoo Dolerite Suite. Green = Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup), with Middleton Formation (Pum) south of the study area and Balfour Formation (Pub) within the area itself (See also Fig. 5). Note that this map does not clearly differentiate between these two formations. Superficial deposits such as Quaternary alluvium, colluvium and soils are also not shown separately here.

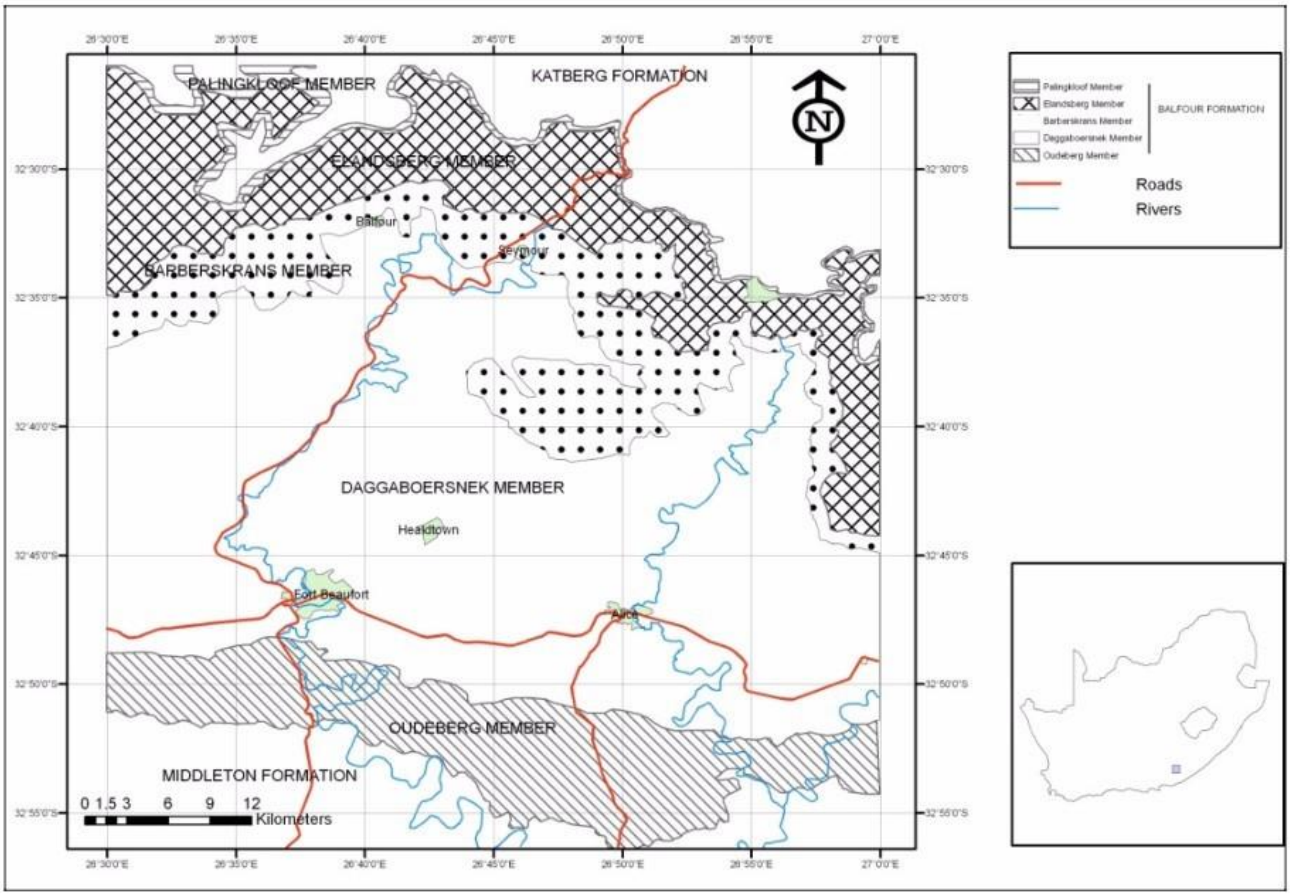

Fig. 4. Detailed geological map of the Fort Beaufort – Alice area by Katemaunzanga (2009). The R63 study area between Fort Beaufort and Alice falls entirely within the outcrop area of the mudrock-rich Daggaboersnek Member of the Balfour Formation (Lower Beaufort Group / Adelaide Subgroup).

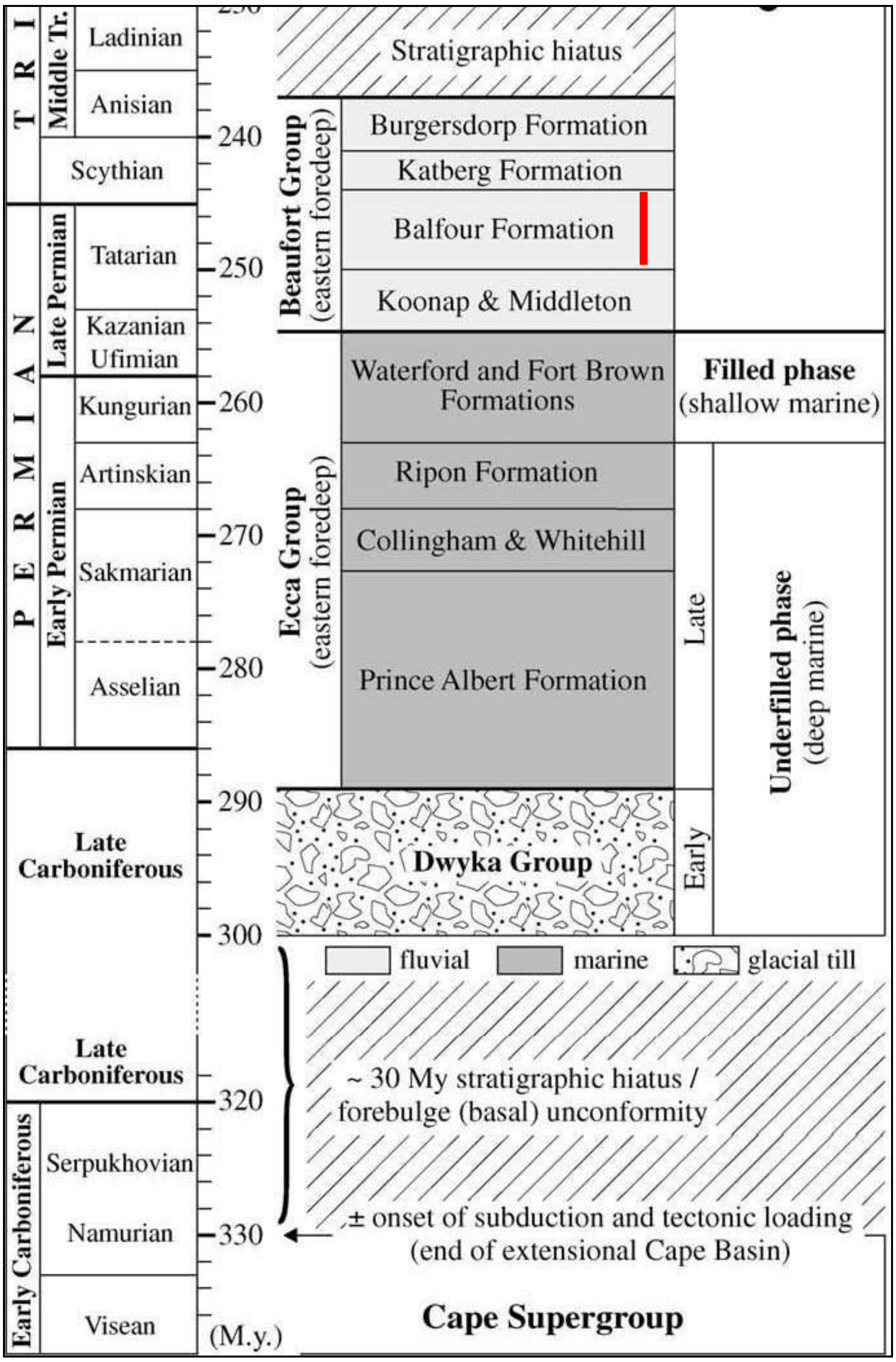

Fig. 5. Stratigraphic subdivision of the Carboniferous and Permian portions of the Karoo Supergroup in the Main Karoo Basin (From Catuneanu *et al.* 2005). The Late Permian Balfour Formation at the top of the Lower Beaufort Group (= Adelaide Subgroup) succession that underlies the present R63 study area is emphasized by the thick red bar.

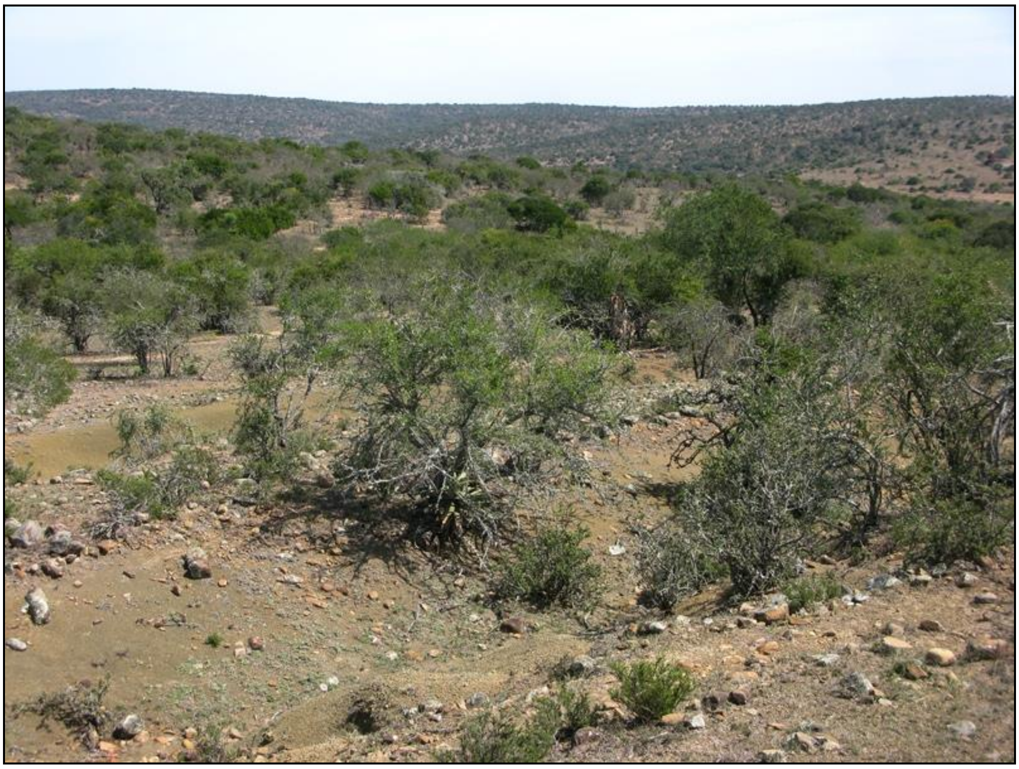

Fig. 6. Typical semi-arid, gently hilly terrain of the R63 project area between Fort Beaufort and Alice showing shrubby Bhisho Thornveld vegetation and gullied hillslopes.

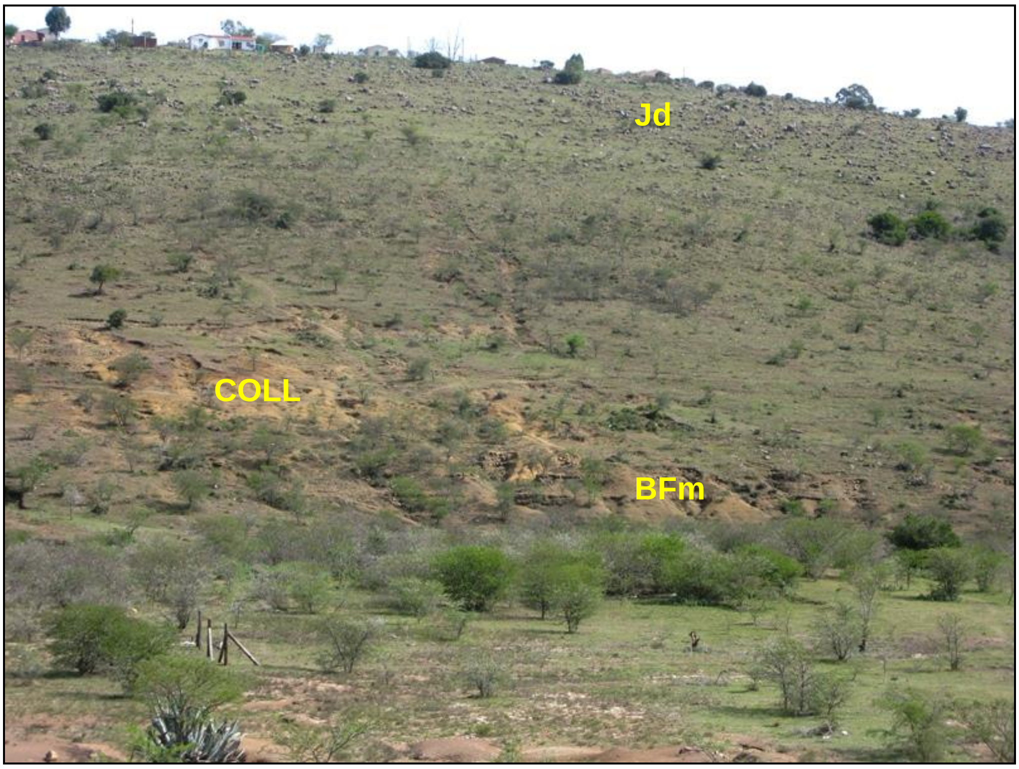

Fig. 7. Valley slopes on the NW outskirts of Alice, close to Mavuso village, with limited exposure of Balfour Formation bedrocks towards the valley floor (BFm), gullied, calcretised colluvial deposits on valley slopes (COLL) and dolerite corestones (Jd) along the valley crest (Loc. 317).

Fig. 8. Dolerite-dominated landscape to the north of the R63 near Alice, littered with rounded corestones, with uplands of the Amatole Mountains in the background (Quarry site B; Loc. 316).

4.1. Lower Beaufort Group (Adelaide Subgroup)

The present study area is largely underlain by Late Permian continental (fluvial) sediments of the Lower Beaufort Group (**Adelaide Subgroup, Pa**) (See map Figs. 3 and 4 as well as stratigraphic column, Fig. 5). Due to poor exposure, the Adelaide Subgroup outcrop area has not been clearly subdivided at the formational level in this region (Mountain 1974, Johnson & Caston 1979). According to the 1: 250 000 geological map (Fig. 3), the **Balfour Formation** (**Pub**) is underlies the Fort Beaufort – Alice study area but the contact with the Middleton Formation to the south is not clearly delineated. The more recent and detailed mapping by Katemaunzanga (2009) shows that the study area lies within the recessive-weathering, mudrock-dominated **Daggaboersnek Member** of the Balfour Formation (Fig. **). The sandstone-rich Oudeberg and Baberskrans Members of this formation build the low hilly country to the south and north respectively.

A representative vertical section through the Beaufort Group in this region of the Eastern Cape is given by Johnson *et al*. (2006, Fig. 16 therein). Dips of the Beaufort Group beds in the broader study region are generally very shallow so low levels of tectonic deformation are expected. Brief descriptions of Adelaide Subgroup sediments in the Eastern Cape are given in sheet explanations for geology sheets King William's Town (printed on 1: 250 000 geology map), Kei Mouth (Johnson & Caston 1979) and Grahamstown (Johnson & Le Roux 1994). In this area of the Eastern Cape the contact between the Balfour and the underlying Middleton Formation is often difficult to map, given the scarcity of good outcrops and their broadly similar lithologies. Satellite images of the region show that in general relief is low and few natural exposures of the Beaufort Group bedrock are present. The Beaufort Group bedrocks, especially the potentially fossil-bearing mudrock component, are often deeply weathered here in view of the long-prevailing warm, humid climatic regime.

The fluvial **Balfour Formation** (**Pub**) comprises recessive weathering, grey to greenish-grey overbank mudrocks with subordinate resistant-weathering, grey, fine-grained channel sandstones deposited by large meandering river systems in the Late Permian Period (Johnson *et al.* 2006). Thin wave-rippled sandstones were laid down in transient playa lakes on the flood plain. Reddish mudrocks are comparatively rare, but increase in abundance towards the top of the Adelaide Subgroup succession near the upper contact with the Katberg Formation. The base of the Balfour succession is defined by a sandstone-rich zone, some 50 m thick, known as the Oudeberg Member.

Key recent reviews of the Balfour Formation fluvial succession have been given by Visser and Dukas (1979), Catuneanu and Elango (2001), Katemaunzanga (2009), Katemaunzanga & Gunter (2009) and Oghenekome (2012). Catuneanu and Elango (2001) identified six upward-fining depositional sequences within the Balfour succession that are separated by subaerial unconformities and lasted on average about 0.7 Ma (million years). The sequences were generated by tectonic processes within the Cape Fold Belt. Fluvial deposition by sandy braided rivers in the early part of each sequence was followed by more mixed channel sandstones and overbank mudrocks laid down by meandering rivers higher in the sequence. Sedimentological data, such as the rarity of palaeosols (fossil soils, desiccation cracks, red beds), suggest that palaeoclimates during this period were predominantly temperate to humid and water tables were generally high.

Exposure of the Lower Beaufort Group bedrocks – and especially the potentially fossiliferous mudrock facies - within the study area is very limited due to thick superficial sediment cover and grassy vegetation (Figs.**). Bedrock exposure is mainly confined to the deeper parts of several erosional gullies or dongas, stream banks, borrow pits or quarries, road and railway cuttings and patchy exposures on steeper hillslopes. Balfour Formation exposures examined during the present field survey are very briefly described in the Appendix with GPS locality data. Road cuttings are generally biased towards the resistant-weathering channel sandstone facies (Fig. 9), with very poor representation of the more readily-weathered mudrocks that actually form the majority of the Daggaboersnek Member. The best exposures of this member were seen along the Mxelo River (Figs. 10 to 13) and in the large quarry (Site G) on the eastern outskirts of Fort Beaufort (Figs. 16 & 17). Good mudrock exposure was also seen at borrow pit sites E and F as well as just south of the R63 at Loc. 325 (Figs. 14 & 15). Well-developed palaeosols marked by horizons of palaeocalcrete concretions are frequently encountered within the overbank mudrocks (Figs. 13, 17 & 18); they are an important focus for fossil vertebrate recording. Many of the calcrete concretions have a secondarily ferruginised cortex, perhaps related to regional dolerite intrusion (Fig. **). Basal channel breccio-conglomerates of reworked mudflake and calcrete intraclasts were not commonly encountered within the Daggaboersnek Member in the study area, with the exception of small lenses at Site G (Loc. 19). This facies may be associated with disarticulated bones and teeth as well as reworked woody pant material in the Lower Beaufort Group.

Fig. 9. Road cuttings along the R63 are biased towards the resistant-weathering sandstone packages of the Balfour Formation, as seen here close to Fort Beaufort (Loc. 328), rather than the softer-weathering mudrocks.

Fig. 10. Good exposure of medium-bedded sandstone package of the Balfour Formation exposed in the banks of the Mxelo River (Loc. 326) (Hammer = 30 cm).

Fig. 11. Thinly tabular-bedded, dark grey overbank mudrocks of the Balfour Formation capped by channel sandstones along the banks of the Mxelo River (Loc. 326) (Hammer = 30 cm).

Fig. 12. Stream gulley exposure of Balfour Formation mudrocks on the western side of the Mxelo River (Loc. 326). Such exposures are ideal for fossil-finding.

Fig. 13. Exhumed calcretised palaeosol (fossil soil horizon) within the Balfour Formation showing densely-packed, greyish calcrete concretions (Loc. 326) (Scale in cm).

Fig. 14. Package of weathered, tabular-bedded sandstones of the Balfour Formation overlying equally weathered, khaki mudrocks (Loc. 326) (Hammer = 30 cm). These beds contain possible freshwater bivalve moulds (See Fig. 33).

Fig. 15. Weathered, khaki-hued overbank mudrocks of the Balfour Formation near Mdala village (borrow pit F site). The arrow indicates a *possible* vertebrate burrow cast with an elliptical section.

Fig. 16. Excellent exposures of Balfour Formation sandstone and mudrock facies in the quarry cut face on the eastern outskirts of Fort Beaufort (Site G) (Loc. 329).

Fig. 17. Well-developed calcretised palaeosol (fossil soil) marked by pale calcrete concretions at the level of the hammer head, shortly beneath a thin, brownish sandstone palaeosurface (Loc. 329) (Hammer = 30 cm). Such calcrete nodule horizons are a focus for palaeontological recording and collection.

Fig. 18. Freshly-broken calcrete concretion (*c*. 8 cm long) showing calcite-rich, dark grey core and rusty cortex (Loc. 315). The latter may be a consequence of regional dolerite intrusion.

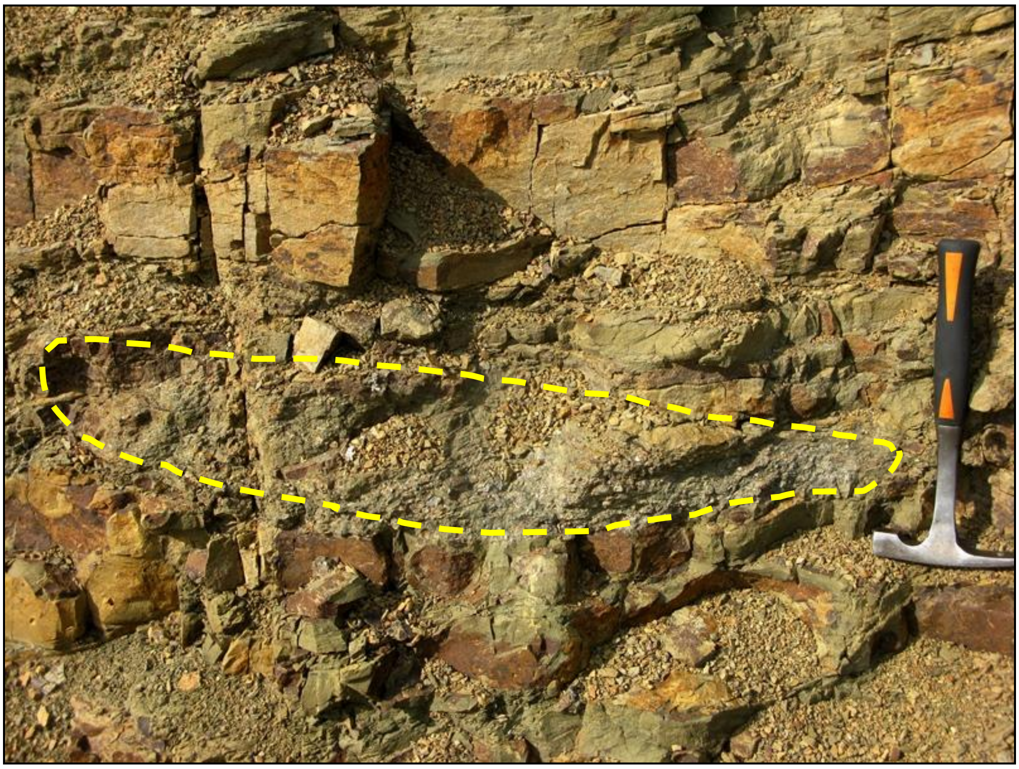

Fig. 19. Small lens of fine conglomerate within the Balfour Formation, largely composed of reworked, small pebble-sized calcrete nodules *plus* mudflake intraclasts (Hammer = 30 cm). Such Beaufort Group channel conglomerates may also contain reworked vertebrate bones and teeth or petrified wood (not seen here).

4.2. Karoo Dolerite Suite

To the north of the R63 n the Fort Beaufort – Alice region the Balfour Formation sediments have been extensively intruded and baked by dolerite sills in the Early Jurassic (183 Ma) **Karoo Dolerite Suite** (**Jd**) (Duncan & Marsh 2006) (Fig. 3). Such major intrusions have thermally metamorphosed (baked and recrystallised) the country rock for a considerable distance on either side of their edges. The fresh to weathered dolerites are exploited locally for road material. Weathered-out, well-rounded dolerite corestones embedded in friable *sabunga* are well seen at quarry / borrow pit sites A and B (Figs. 20 and 8 respectively), located to the north of the R63 near Alice.

Fig. 20. Roadside quarry (Site A) between the villages of Mavuso and Nkobonkobo on the NW outskirts of Alice. Note large, prominent-weathering dolerite corestones embedded in deeply-weathered, orange-brown *sabunga*.

4.2. Late Caenozoic superficial deposits

Various types of **superficial deposits** of Late Caenozoic (Miocene / Pliocene to Recent) age occur widely throughout the Karoo study region (*e.g.* Holmes & Marker 1995, Cole *et al.* 2004, Partridge *et al.* 2006). They include pedocretes (*e.g.* calcretes, ferricretes), colluvial slope deposits (scree, hillwash), down-wasted surface gravels, river alluvium, wind-blown sands as well as spring and pan sediments. This mantle of superficial deposits obscures the Palaeozoic bedrock geology in most parts of the study area. Furthermore, deep chemical weathering in the Late Cretaceous to

Tertiary interval has converted some of the near-surface bedrocks to *in situ* weathered saprolite. Useful geological overviews of talus deposits, alluvium and calcrete occurrences in a semi-arid Karoo region are given by Cole *et al.* (2004).

Older alluvial deposits, represented by semi-consolidated High Level Gravels as well as calcretised and ferricretised sands – are exposed along the banks of the Mxelo River (Fig. 21) as well as other incised streams in the study area (*e.g.* Loc. 323 near borrow pit D) (Fig. 22). These older deposits may be of Quaternary age. Unconsolidated younger silty, sandy and gravelly alluvium is also seen along these water courses (Fig. 23). Angular surface gravels, dominated by Beaufort Group sandstone as well as minor dolerite, occur widely within the study area, especially in the vicinity of channel sandstones (Fig. 24); they sometimes contain an admixture of better-rounded fluvial cobbles and pebbles. Valley slopes are mantled by sandy to gravelly colluvium (sometimes calcretised) which is exposed in areas of *donga* erosion (Fig. 7).

Fig. 21. Semi-consolidated High Level Gravels (ancient alluvium) overlying a bedrock bench of Balfour Formation sediments several meters above present river level, banks of the Mxelo River (Loc. 326) (Hammer = 30 cm).

Fig. 22. Several meters of pale buff, calcretised older sandy alluvium overlying Balfour Formation bedrocks, stream banks near Kwezana Village (Loc. 323).

Fig. 23. Streambank exposure near Kwezana Village of thick sandy to silty alluvial deposits with porly-sorted basal gravels (Loc. 323) (Hammer = 30 cm).

Fig. 24. Coarse surface gravels of angular to moderately well-rounded sandstone clasts of probable mixed alluvial and colluvial origin overlying Balfour Formation bedrocks (Loc. 324).

5. PALAEONTOLOGICAL HERITAGE

Palaeontological heritage reported elsewhere within the main rock units represented in the study area between Fort Beaufort and Alice as well as further afield is outlined here, largely based on previous desktop and field-based studies in the region by Almond (2011a, 2011b, 2014, 2015a, 2015b).

The overall palaeontological sensitivity of the Beaufort Group sediments is high (Almond *et al*. 2008). These continental sediments have yielded one of the richest fossil records of land-dwelling plants and animals of Permo-Triassic age anywhere in the world (MacRae 1999, Rubidge 2005, McCarthy & Rubidge 2005). A chronological series of mappable fossil biozones or assemblage zones (AZ), defined mainly on their characteristic tetrapod faunas, has been established for the Main Karoo Basin of South Africa (Rubidge 1995). Maps showing the distribution of the Beaufort assemblage zones within the Main Karoo Basin have been provided by Kitching (1977), Keyser and Smith (1979) and Rubidge (1995, 2005). An updated version based on a comprehensive GIS fossil database has been published by Van der Walt *et al*. (2010).

Most maps showing the distribution of the Beaufort Group assemblage zones within the Main Karoo Basin show that their boundaries remain uncertain in the near-coastal region of the Eastern Cape (Rubidge 1995, 2005), although some of these ambiguities have been resolved by the latest map of Van der Walt *et al.* (2010). GIS databases show that the density of fossil sites recorded within the East London area remain very low (Nicolas 2007, Fig. 25 herein). This is probably due to factors such as low levels of bedrock exposure, deep bedrock weathering, and extensive dolerite intrusion, although palaeoenvironmental factors may also have played a significant role here. Given the current paucity of palaeontological data from the East London region, any new well-localized, identifiable fossil finds here are of considerable scientific value.

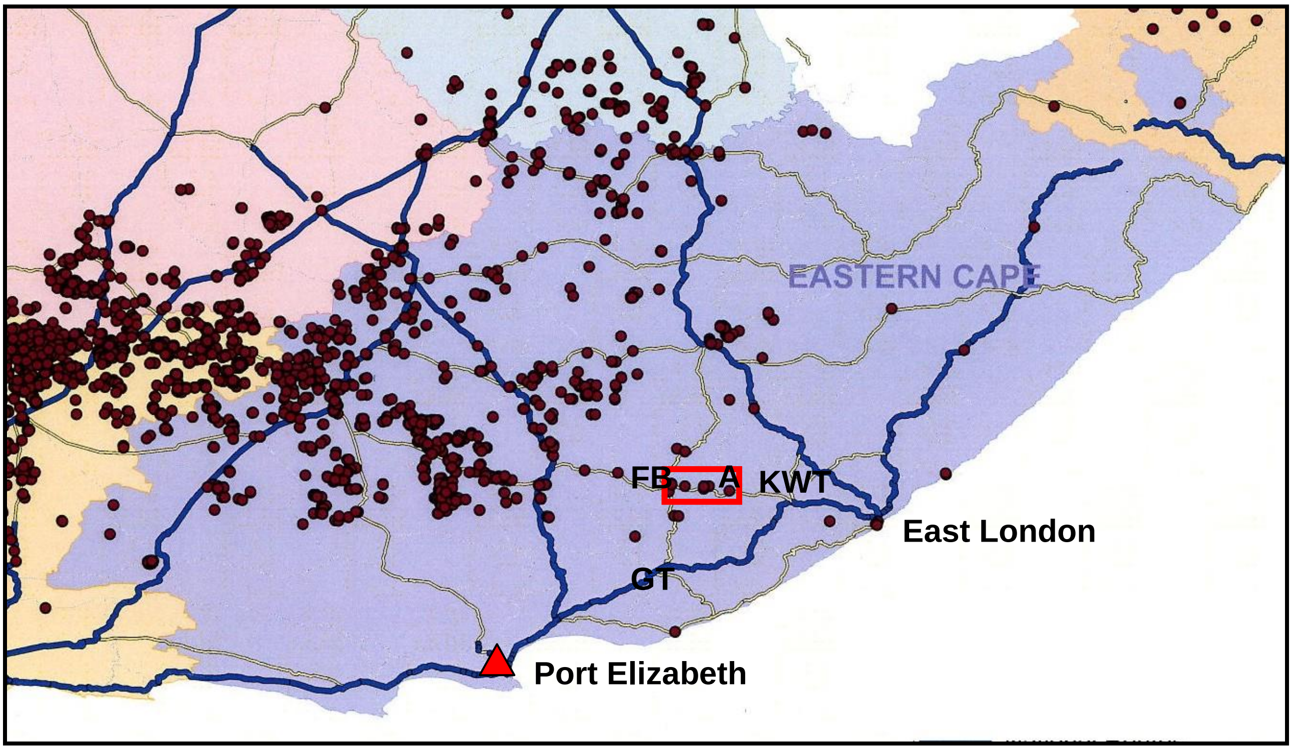

Fig. 25. Distribution of vertebrate fossil sites in the Beaufort Group in the Eastern Cape (Modified from Nicolas 2007). Note the general scarcity of sites recorded in the eastern portion of the Main Karoo Basin, with a concentration of localities between Alice (A) and Fort Beaufort (FB) (red rectangle). Permian vertebrates have been recorded from the Fort Beaufort area in particular since the 1840s. KWT = King William's Town. GT = Grahamstown.

5.1. Balfour Formation

The biostratigraphic placement of the Daggaboersnek Member at the base of the Balfour Formation has been, until recently, rather equivocal. Le Roux and Keyser (1988) report *Cistecephalus* AZ fossils from this member in the Victoria West sheet area, whereas the

Daggaboersnek Member on the Middelburg sheet area is assigned to the *Dicynodon* Assemblage Zone and this certainly applies to the greater part of the Balfour Formation (Rubidge 1995, Cole *et al*., 2004 p. 21). This younger biozone has been assigned to the Changhsingian Stage (= Late Tartarian), right at the end of the Permian Period, with an approximate age range of 253.8-251.4 million years (Rubidge 1995, 2005). Recent biostraigraphic analysis by Viglietti *et al.* (2015) places the Daggaboersnek Member firmly in the **Lower *Daptocephalus* Assemblage Zone**, below the incoming of distinctive dicynodonts of the Genus *Lystrosaurus* (Fig. 26).

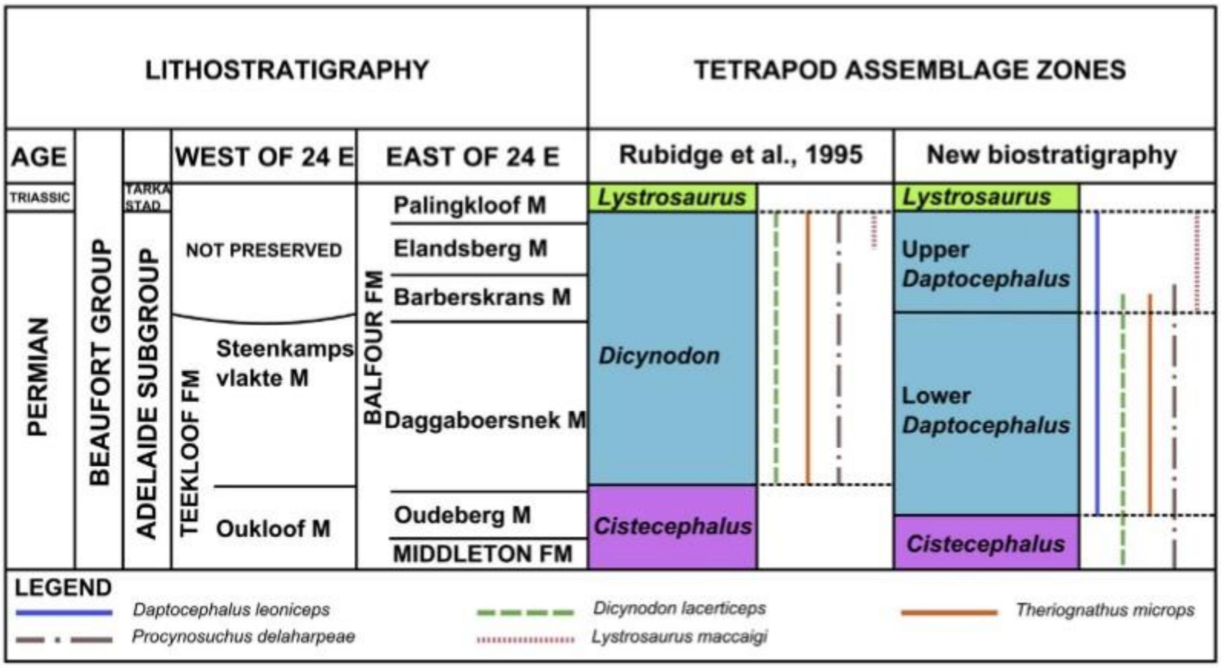

Fig. 26. Revised subdivision of fossil assemblage zones (AZ) represented within the Balfour Formation (From Viglietti *et al.* 2015). The present study area in the Dagggaboersnek Member is now assigned to the Lower *Daptocephalus* AZ.

Good accounts, with detailed faunal lists, of the rich Late Permian fossil biotas of the *Daptocephalus* (previously *Dicynodon*) Assemblage Zone have been given by Kitching (1995) and by Cole *et al*. (2004). There are also useful illustrated reviews by Cluver (1978), MacRae (1999), McCarthy & Rubidge (2005) and Smith *et al.* (2012). An authoritative revision has recently been published by Viglietti *et al.* (2015). In general, the following broad categories of fossils might be expected within the Balfour Formation in the Eastern Cape study area:

- isolated petrified bones as well as articulated skeletons of terrestrial vertebrates such as true **reptiles** (notably large herbivorous pareiasaurs, small lizard-like millerettids and younginids) and **therapsids** (diverse dicynodonts such as *Daptocephalus*, *Dicynodon* and the much smaller *Diictodon*, carnivorous gorgonopsians, therocephalians such as

Theriognathus (= *Whaitsia*), primitive cynodonts like *Procynosuchus*, and biarmosuchians) (See Fig. 27 herein).

- aquatic vertebrates such as large, crocodile-like temnospondyl **amphibians** like *Rhinesuchus* (usually disarticulated), and palaeoniscoid **bony fish** (*Atherstonia*, *Namaichthys*)
- freshwater **bivalves** (*Palaeomutela*)
- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings)
- **vascular plant remains** including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterids and arthrophytes (horsetails)

The abundance and variety of fossils within the *Dicynodon* Assemblage Zone decreases towards the top of the succession according to Cole *et al*. (2004); however, Viglietti *et al.* (2015) argue that the Upper and Lower *Daptocephalus* AZ do not differ significantly in faunal diversity. From a palaeontological viewpoint, these diverse *Daptocephalus* AZ biotas are of extraordinary interest in that they provide some of the best available evidence for the last flowering of ecologically-complex terrestrial ecosystems immediately preceding the catastrophic end-Permian mass extinction (*e.g.* Smith & Ward, 2001, Rubidge 2005, Retallack *et al*., 2006).

As far as the biostratigraphically important tetrapod remains are concerned, the best fossil material within this AZ is generally found within overbank mudrocks, whereas fossils preserved within channel sandstones tend to be fragmentary and water-worn (Rubidge 1995, Smith 1993). Many fossils are found in association with ancient soils (palaeosol horizons) that can usually be recognised by bedding-parallel concentrations of calcrete nodules.

Petrified (siicified) wood material showing well-developed seasonal growth rings occurs fairly frequently in the Beaufort Group in the King William's Town – East London region. It has been provisionally referred to the basket-genus *Dadoxylon* and is probably of gymnospermous affinities for the most part (*cf* Bamford 1999, 2004). Therapsid remains from the King William's Town region displayed at the Amatole Museum, King William's Town include an unidentified backbone from Sunnyvale Farm near Berlin and another from Stutterheim, some 35 km north of King William's Town (Almond 2011b).

The Fort Beaufort region was the locus of several of the earliest fossil vertebrate finds from the Main Karoo Basin of South Africa, made in the 1840s by pioneer local amateur collectors such as Andrew Geddes Bain and Johannes Borcherds. Accounts of the first discoveries of dicynodont therapsids ("bidentals") and pareiasaur reptiles, such as the famous the "Blinkwater Monster", have been given by A.G. Bain (1844, letter to the Geological Society of London republished in Lister 1949) and more recently by MacRae (1999; *cf* also Piers 1877). The precise localities of the finds are often uncertain but it is clear they came from both the Middleton and Balfour Formation outcrop areas, respectively south and north of Fort Beaufort itself.

Sparse vertebrate skeletal remains were recorded from the Balfour Formation in the Nxuba WEF study area near Bedford, some 60 m west of Fort Beaufort, by Almond (2015a). They include isolated dicynodont tusks as well as partial, semi-articulated skeletons (probably therapsid) variously embedded within mudrocks or calcrete concretions. Other fossil remains seen here include rare sandstone burrow casts as well as reworked fossil wood associated with channel sandstones. The Balfour Formation cropping out in the Nojoli WEF project area slightly further to the west has yielded abundant, well-preserved silicified wood, some material showing insect borings (Almond 2014). A sizeable chunk of a petrified log showing seasonal growth rings but without provenance is displayed in the Fort Beaufort Museum; it probably also comes from the Balfour Formation.

The *possible* molds of small, non-marine bivalves (Fig. 33) as well as a *possible* sandstone vertebrate burrow cast (Fig. 28) were recorded from Loc. 325, due north of Kwajoji village, within Balfour Formation bedrocks that are likely to be disturbed by the proposed road development (See orange triangle on satellite image Fig. 2). This poorly-preserved material of uncertain identity is not considered as worthy of collection or other mitigation.

No new fossil vertebrate skeletal material or petrified wood was recorded within the R63 project area between Fort Beaufort and Alice during the present study. Several vertebrate burrows were recorded at Loc. 326 within a heavily-calcretised palaeosol (fossil soil horizon) exposed on the western banks of the Mxelo River, some 8 km ESE of Fort Beaufort (Figs. 29 to 32; see also red triangle on Fig. 2). They are variously infilled with indurated mudrock or are partially weathered-out to appear as furrows within the calcretised palaeosol horizon. They include numerous straight to sinuous, looping or locally-confluent burrow casts and furrows from 7 cm up to *c*. 20 cm wide. The furrows are interpreted as components of an exhumed vertebrate burrow warren within the Daggaboersnek Member. Calcrete pedogenesis may have mainly occurred *after* burrowing, preferentially affecting the mudstone matrix between the burrow infills rather than the burrow infills. The burrowed horizon is overlain by crumbly, fine-grained, grey-green mudrocks. This locality of scientific interest and merits protection; however, it lies over 100 m NE of the road and should not be directly affected by the proposed road development.

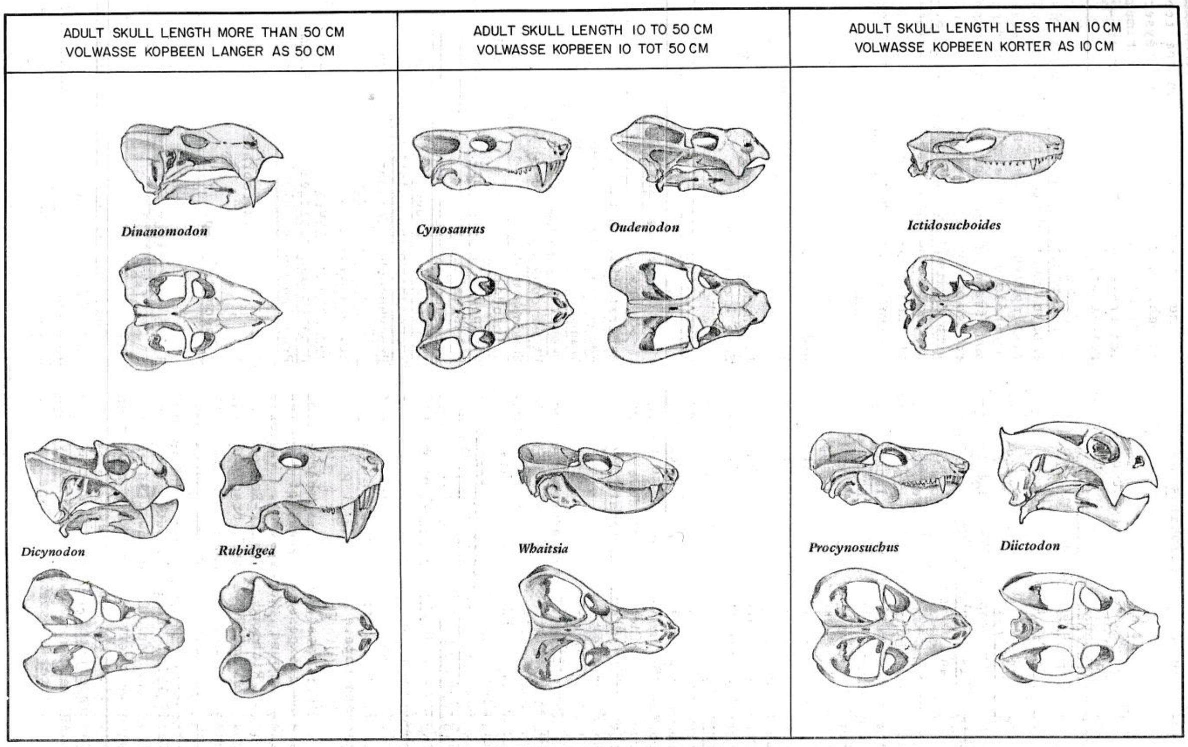

Fig. 27. Skulls of characteristic fossil vertebrates – all therapsids - from the *Daptocephalus* (previously *Dicynodon*) Assemblage Zone (From Keyser & Smith 1977-1978). Among the dominant therapsids ("mammal-like reptiles"), *Rubidgea* and *Cynosaurus* are carnivorous gorgonopsians, *Whaitsia* (now *Theriognathus*) is a predatory therocephalian while *Ictidosuchoides* is a small insectivorous member of the same group, *Procynosuchus* is a primitive cynodont, and the remainder are large- to small-bodied dicynodont herbivores.

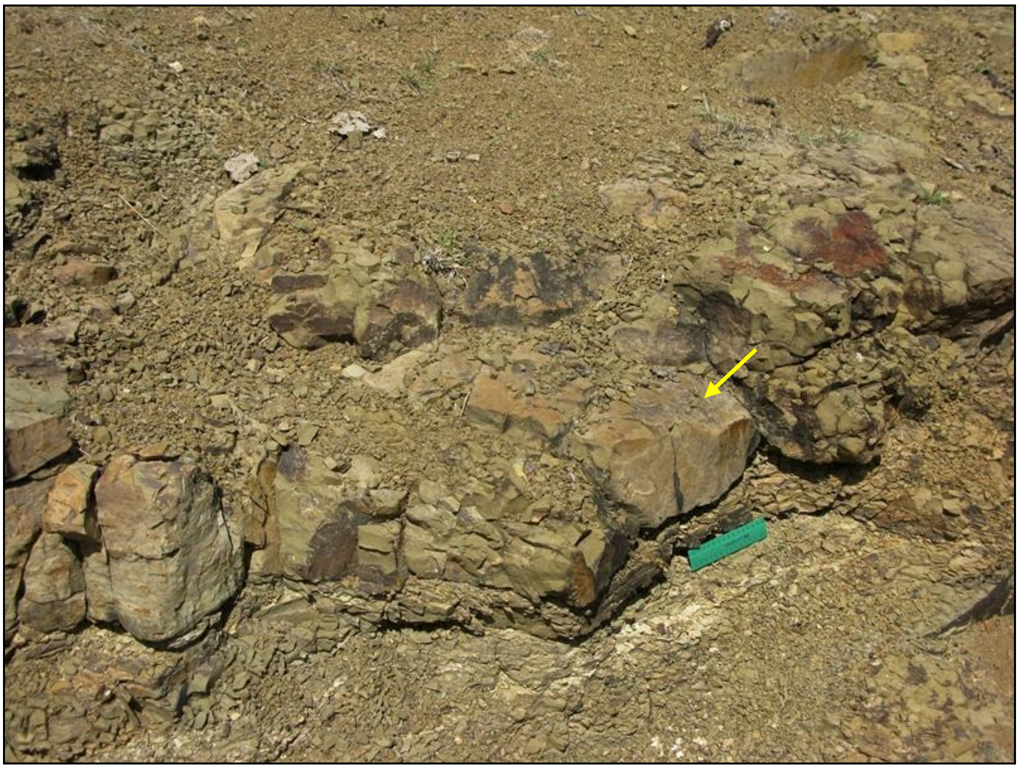

Fig. 28. ***Possible*** **sandstone vertebrate burrow cast with elliptical cross-section (arrowed), Balfour Formation due north of Kwajoji village (Loc. 325) (Scale = 15 cm).**

Fig. 29. Gently-dipping, calcretised mudrock horizon on the western bank of theMxelo River showing anastomosing network of paler furrows – possibly a vertebrate warren – overlain by dark grey overbank mudrocks (Loc. 326).

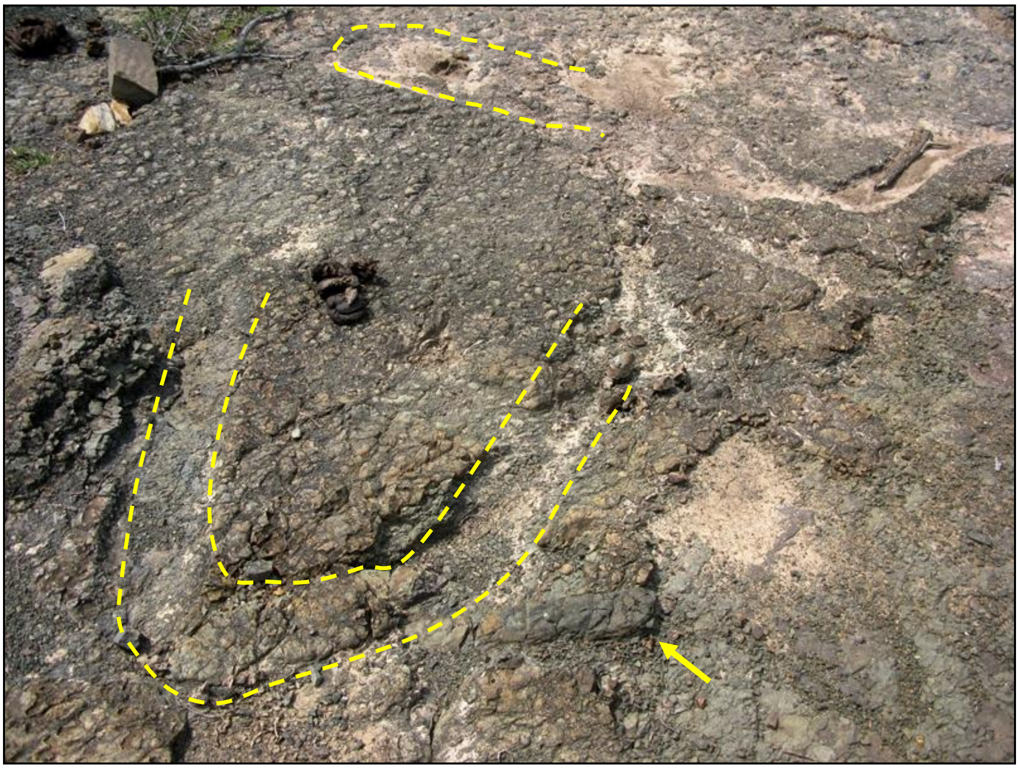

Fig. 30. Detail of surface seen in previous figure showing straight to strongly-curving furrows (re-exhumed burrows) surrounded by heavily-calcretised mudrock matrix (See also Fig. 13). The arrowed small burrow cast is shown below.

Fig. 31. Close-up of small, straight burrow cast indicated by the yellow arrow in the previous figure (Scale in cm).

Fig. 32. Hairpin-shaped, tightly-looped large burrow (partially retaining infill) within calcretised palaeosol seen in Fig. 29 (Loc. 326) (Hammer = 30 cm).

Fig. 33. Sandstone upper bedding plane showing dispersed, small bean-shaped moulds, possibly reworked non-marine bivalves (Loc. 325) (Scale in cm and mm).

5.2. Karoo Dolerite Suite

The dolerite outcrops in the Eastern Cape study region are in themselves of no palaeontological significance since these are high temperature igneous rocks emplaced at depth within the Earth's crust. As a consequence of their proximity to large dolerite intrusions in the East London – King Williams Town – Fort Beaufort area, the Beaufort Group sediments here often been thermally metamorphosed or "baked" (*i.e*. recrystallised, impregnated with secondary minerals). Embedded fossil material of phosphatic composition, such as bones and teeth, is frequently altered by baking - bones in the East London area are typically black, for example - and may be very difficult to extract from the hard matrix by mechanical preparation (Smith & Keyser, p. 23 *in* Rubidge 1995). Thermal metamorphism by dolerite intrusions therefore tends to reduce the palaeontological heritage potential of Beaufort Group sediments.

No fossiliferous baked country rocks were encountered at dolerite quarry / borrow pit sites A and B near Alice.

5.3. Late Caenozoic superficial deposits

The central Karoo "drift deposits" have been comparatively neglected in palaeontological terms. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon in the 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, Meadows & Watkeys 1999, Churchill *et al*. 2000 Partridge & Scott 2000). 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 peats or palynomorphs (pollens, spores) in organic-rich alluvial horizons (Scott 2000) and siliceous diatoms in pan sediments. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein). Stone artefacts of Pleistocene and younger age may additionally prove useful in constraining the age of superficial deposits such as gravelly alluvium within which they are occasionally embedded.

Locally abundant petrified wood reworked from the Balfour Formation is preserved within coarse alluvial gravels near Cookhouse (Almond 2014); a similar provenance may probably be ascribed to the large chunk of petrified wood displayed in the Fort Beaufort Museum. Also displayed in the museum are several subfossil mammalian teeth, including portions of large elephant molars, found – probably at or near-surface - in the Fort Beaufort area (Fig. 34). No new fossil material was recorded from the various superficial deposits in the present R63 study area between Alice and Fort Beaufort, however.

Fig. 34. Subfossil teeth of large mammals, including elephant molars, recorded from the Fort Beaufort region, displayed in the Fort Beaufort Museum (*plus* exotic walrus tusks in the centre).

6. EVALUATION OF IMPACTS ON PALAEONTOLOGICAL HERITAGE

The R63 (Section 13) road project is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Late Palaeozoic and younger, Late Tertiary or Quaternary, age as described in Sections 4 & 5 of this report. The construction phase of the proposed road improvements and associated quarry / borrow pits will entail ground clearance as well as substantial excavations into the superficial sediment cover and locally into the underlying bedrock. All these developments may adversely affect potential fossil heritage within the project footprint by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good.

The inferred impact of the proposed road development and associated borrow pits / hard rock quarry on local fossil heritage resources is evaluated in Table 1 below. This assessment applies only to the construction phase of the infrastructure since further impacts on fossil heritage during the operational and decommissioning phases of the facilities are not anticipated.

Potential impacts on fossil heritage during the construction phase are generally negative, direct and restricted to the development footprint (*site*). They are *permanent* and cannot be reversed (*irreversible*). Where rare, well-preserved fossils such as vertebrate skeletons are concerned, losses may be irreplaceable. Given (1) the highly-weathered and locally baked nature of the many of the Palaeozoic sediments in the study area, (2) the small footprint of the proposed development as well as (3) the scarcity of scientifically-important fossil records during the present field assessment of the study footprint, the severity of anticipated impacts is rated as *low (negative)* while the probability of scientifically significant impacts is low (*unlikely*). Palaeontological impacts are *partially mitigatable*, as outlined below. The overall impact significance of the R63 (Section 13) road project, including the associated quarry / borrow pits, is evaluated as *very low* as far as palaeontology is concerned.

Table 1: Evaluation of impacts on fossil heritage resources due to the construction phase of the proposed upgrade of National Route R63 Section 13 and associated mining applications (No further impacts are anticipated in the operational phase).

POTENTIAL IMPACTS	Nature	Type	Extent	Duration	Severity	Reversibility	Irreplaceable Loss	Probability	MITIGATION POTENTIAL	IMPACT SIGNIFICANCE		MITIGATION MEASURES
										Without Mitigation	With Mitigation	
CONSTRUCTION PHASE												
Impacts on Palaeontology	Negative	Direct	Site	Permanent	Low Negative	Irreversible	Resource may be partially destroyed	Unlikely	Partially mitigatable	Very low (negative)	Moderate (positive – due to new palaeontological data)	Chance finds of fossils such as vertebrate bones & teeth, petrified wood to be safeguarded by ECO & reported to ECPHRA for recording & sampling by professional palaeontologist

7. SUMMARY & RECOMMENDATIONS

The study area for the proposed upgrade of the R63 (Section 13) between Alice and Fort Beaufort, Eastern Cape, is underlain by Late Permian continental sediments of the Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup) that are assigned to the Balfour Formation (Daggaboersnek Member). However, these potentially fossiliferous bedrocks are generally poorly-exposed, quite weathered and have been locally baked by major Karoo dolerite intrusions. Desktop and field assessment of the study area indicate that the sedimentary rocks of the Balfour Formation here contain very sparse vertebrate fossils, petrified wood and trace fossils (*e.g.* vertebrate burrows). No scientifically-valuable fossil remains were recorded from sedimentary rocks exposed within the development footprint itself, including the five sedimentary borrow pit localities (Sites C to G in Fig. 2 herein) and several road cuttings. A conservation-worthy warren of vertebrate burrows along the banks of the Mxelo River (red triangle in Fig. 2) lies 100 m *outside* the development footprint and so should not be directly impacted. Questionable vertebrate burrow and bivalve remains within the development footprint on the southern side of the R63 due north of Kwajoji village (orange triangle in Fig. 2) are not considered to be of conservation significance and no mitigation is recommended here. Superficial sediments of Late Pleistocene to Recent age - including thick sandy to gravelly alluvium, surface gravels and modern soils – are apparently fossil-poor. No vertebrate fossils, reworked petrified wood or other fossil remains were recorded within the superficial sediments during the present field assessment. Two proposed quarry excavations into a Jurassic dolerite sill on the north-eastern outskirts of Alice (Sites A & B in Fig. 2 herein) are of no palaeontological heritage significance.

The overall impact significance of the R63 (Section 13) road project, including the associated quarry / borrow pits, is evaluated as *very low* as far as palaeontology is concerned. Unless significant new fossil finds (*e.g.* well-preserved vertebrate remains, petrified wood) are made during the construction phase of the development, further specialist palaeontological studies or mitigation are not regarded as warranted for this project. The Environmental Control Officer (ECO) for the project should be alerted to the potential for, and scientific significance of, new fossil finds during the construction phase of the development. They should familiarise themselves with the sort of fossils concerned through museum displays (*e.g.* Amatole Museum, King William's Town, East London Museum) and accessible, well-illustrated literature (*e.g.* MacRae 1999).

Should important new fossil remains - such as vertebrate bones and teeth, 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 so that appropriate action can be taken in good time by a professional palaeontologist at the developer's expense.

Palaeontological mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as of associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy). The palaeontologist concerned with mitigation work will need a valid fossil collection permit from ECPHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological specialist work should 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 2 palaeontological studies recently developed by SAHRA (2013). These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the R63 (Section 13) road development.

8. ACKNOWLEDGEMENTS

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10. 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 and the Free State under the aegis of his Cape Town-based company *Natura Viva* cc. He has 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 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.

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APPENDIX: GPS LOCALITY DATA FOR NUMBERED SITES MENTIONED IN TEXT

All GPS readings were taken in the field using a hand-held Garmin GPSmap 62sc instrument. The datum used is WGS 84. Only those localities mentioned by number in the text are listed here.

Loc No.	GPS data	Comments
314	32 48 01.7 S 26 48 32.2 E	Balfour Fm R63 road cutting 200 m east of Borrow Pit C. Khaki-hued, massive to thin-bedded, weathered mudrocks and brownish, unistorey, medium-grained, lenticular channel sandstones, thin- to medium-bedded. Channel sandstones with sharp erosive bases, upward-fining tops.
315	32 48 02.1 S 26 48 22.7 E	Existing extensive, shallow borrow pit (Pit C) excavated into Balfour Fm grey-green, hackly overbank mudrocks and dark brown-weathering, fine-grained, sharp-based channel sandstones. Mudrocks speckled with small angular claystone intraclasts and thin, pale greyish elongate, sometimes branched structures – *possibly* plant rootlet traces. Cobble-sized palaeocalcrete concretions mineralised to rusty-brown, friable material – probably due to dolerite intrusions nearby.
316	32 47 10.8 S 26 48 04.7 E	Site of proposed dolerite quarry B with test pits at head of SW-NE trending valley on western outskirts of Alice, *c*. 1.6 km N of R63. Large (boulder-sized), rounded dolerite corestones weathering out at surface. Weathered dolerite (*sabunga*) exposed from test pit excavations. Dark reddish-brown, lateritic soils. No baked country rocks observed.
317	32 46 38.1 S 26 48 49.0 E	Viewpoint across valley to SE of Mavuso village showing limited exposure of grey-green Balfour Fm mudrocks and thin sandstones near stream bed on valley floor, pale brown, sandy alluvial / colluvial soils exposed by gulley erosion on valley sides. Crest of valley slopes capped by extensive dolerite sill, marked by corestones.
318	32 46 38.1 S 26 48 49.0 E	Existing roadside quarry (Site A) between villages of Mavuso and Nkobonkobo on NW outskirts of Alice. Quarry excavated into deeply-weathered dolerite sill, showing impressive, prominent-weathering, rounded corestones with onionskin weathering embedded in friable *sabunga*, thinly capped by dark reddish-brown, gravelly lateritic soils. Baked country rocks not seen.
319	32 48 00.4 S 26 47 04.9 E	R63 road cutting through Balfour Fm just west of Phumulani village. Package of brown-weathering, lenticular, medium-grained channel sandstones. Low angle cross-bedding with palaeocurrents towards the NW, sharp erosive bases (no intraclast breccias). Interbedded thin-bedded grey-green overbank siltstones and massive, hackly-weathering siltstones structured into thin (few dm) upward-coarsening packages.
320	32 48 14.1 S 26 46 16.0 E	Shallow existing borrow pit D into Balfour Fm to SE of Kwezana village. Friable, weathered, grey-green, massive to thin-bedded mudrocks with secondarily ferruginised, cobble-sized palaeocalcrete concretions marking palaesols, thin pale yellowish-brown sandstone interbeds, locally flaggy. Angular colluvial sandstone surface gravels.
321	32 48 08.9 S 26 46 10.0 E	Stream bank exposures of coarse, angular, poorly-sorted blocky alluvial gravels (Balfour wackes, minor dolerite) overlain by pale brown sandy to silty alluvium on southern outskirts of Kwezana village.

322	32 48 08.6 S 26 46 09.7 E	Stream bank exposure of dark, hackly-weathering, grey-green Balfour Fm overbank mudrocks with thin channel sandstone and possible crevasse splay sandstones. Brownish palaeocalcrete nodules (sometimes vuggy, secondarily ferruginised) within mudrocks mark palaeosols.
323	32 48 09.3 S 26 46 12.7 E	Steep banks of incised stream to SE of Kwezana village showing several meters of pale buff, calcretised fine-grained older alluvium (rounded calcrete glaebules up to 5 cm across, concentrated by downwasting towards top of section), local patches of ferricrete, capped by sandstone-dominated surface gravels. Alluvium overlies mudrock-dominated Balfour Fm mudrocks. Good stream banks sections nearby through pale brownish, non-calcretised younger sandy to silty alluvium with blocky coarse basal gravels.
324	32 48 31.4 S 26 43 54.7 E	Borrow pit site E to south of R63 and NW of Kwajoji village. SW-facing hillslope exposure of hackly-weathering, khaki to grey-green Balfour Fm mudrocks with thin lenticular to tabular sandstone interbeds. Upper hillslopes mantled by coarse, rounded to angular colluvial and alluvial sandstone gravels.
325	32 48 22.3 S 26 44 12.8 E	Extensive, gullied hillslope exposures of weathered Balfour Fm to south of R63 due N of Kwajoji village. Hackly-weathering khaki overbank mudrocks with pale grey to rusty-brown calcrete concretions up to 30 cm across, calcretised desiccation cracks. Heterolithic packages of thin-bedded, tabular sandstones and grey-green to khaki mudrocks. Possible moulds of small (*c*. 5 mm long) oval to bean-shaped non-marine bivalves on sandstone bedding surfaces. Small lenticular channel features. Isolated elongate sandstone bodies with oval cross-section (*c*. 30 cm wide) – *possibly* vertebrate burrow casts (equivocal). Blocky, brown-weathering sandstone surface gravels on upper hillslopes and streaming down gullies.
326	32 48 06.3 S 26 43 15.0 E	Good riverbank and erosion gulley exposures of Balfour Fm on western banks of Mxelo River, just N of R63. Thin-bedded grey-green overbank mudrocks with dense horizons of grey, subrounded pedogenic calcrete concretions. One palaeosol horizon features numerous straight to sinuous, looping or locally confluent burrow casts and furrows from 7 cm up to *c*. 20 cm wide, locally infilled with indurated mudrock, and interpreted as part of an exhumed vertebrate burrow warren. Calcrete pedogenesis may have mainly occurred after burrowing in matrix between burrow infills. Burrowed horizon overlain by crumbly fine-grained grey-green mudrocks capped by tabular, erosive-based channel sandstones and thin-bedded heterolithic packages. Semi-consolidated, poorly-sorted, pale yellowish-brown High Level Gravels (sandstone clasts, angular to subrounded) perched several meters above river bed on west side. Good cut bank sections through pale brown sandy to silty younger alluvium with gravel lenses further upstream.
327	32 47 50.3 S 26 47 04.0 E	Borrow Pit F site adjacent to railway line just west of Mdala village. Extensive strike exposure of weathered, khaki to olive-green Balfour Fm overbank mudrocks, thin-bedded, tabular *plus* thin, sharp-based sandstones (probably crevasse splay deposits). Horizons of rusty ferruginised calcrete nodules. Possible mudrock-infilled vertebrate burrows (requires confirmation).
328	32 47 39.9 S 26 41 04.2 E	R63 road cutting through tabular-bedded packages of brown-weathering Balfour Fm - interbedded thin- to medium-bedded, sharp-based sandstones and grey-green mudrocks.
329	32 46 58.4 S	Large quarry into Balfour Fm crevasse splay and thin channel

	26 39 33.2 E	sandstones with blue-grey to grey-green overbank mudrocks on eastern outskirts of Fort Beaufort, just north of R63. Speckled silty mudrocks with small mudflakes and possible plant rootlet traces. Well-developed palaeosol horizons of rounded to irregular, pebble- to cobble-sized, pale grey to rusty-brown palaeocalcrete nodules. Flat to gently undulose, thin sandstone palaeosurface, Small, thin (*c*. 10 cm) lenticles of greyish reworked calcrete nodule and mudflake channel breccio-conglomerate (no fossil bones or teeth observed).