PALAEONTOLOGICAL HERITAGE ASSESSMENT: COMBINED DESKTOP & FIELD-BASED STUDY

PROPOSED UPGRADE OF NATIONAL ROUTE R63 (SECTION 16) AND ASSOCIATED MINING APPLICATIONS, BETWEEN N6 BRIDGE AND THE N2 PAST KOMGA IN THE AMATHOLE DISTRICT MUNICIPALITY, EASTERN CAPE PROVINCE

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EXECUTIVE SUMMARY

The South African National Roads Agency SOC Limited is proposing to upgrade Section 16 of the National Route R63 between Kei Road and the N2 near Komga, Amathole District, Eastern Cape. The road project will involve the development of eight new or existing borrow pits and quarries.

The study area for the proposed road upgrade is underlain by Late Permian continental sediments of the Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup) that are assigned to the Balfour Formation. However, these potentially fossiliferous bedrocks are generally poorly-exposed, deeply-weathered and have been locally baked by major Karoo dolerite intrusions. Desktop and field assessments of the study area indicate that the sedimentary rocks of the Balfour Formation in this region contain, at most, very sparse vertebrate fossils, non-marine bivalves, petrified wood and trace fossils (*e.g.* large vertebrate burrows). No fossil remains of any sort were recorded from sedimentary rocks exposed within the development footprint itself, including the eight associated quarry and borrow pit localities and several road cuttings along the R63. Superficial sediments of Late Pleistocene to Recent age - including thick sandy to gravelly alluvium, surface gravels, ferricrete hardpans and modern soils – are apparently unfossiliferous. No vertebrate fossils, reworked petrified wood or other fossil remains were recorded within the superficial sediments during the present field assessment. Four proposed quarry / borrow pit excavations into a Jurassic dolerite sill *c*. 12 km to the west of Komga are of no palaeontological heritage significance.

The overall impact significance of the R63 (Section 16) road project, including the eight 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, 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 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 16) road and quarry / borrow pit development.

1. INTRODUCTION & BRIEF

The South African National Roads Agency SOC Limited (SANRAL) is proposing to upgrade Section 16 of the National Route R63 between N6 Bridge (km 1.0) and the N2 past Komga (km 43.64), Amathole District, Eastern Cape (Figs. 1 & 2). The following brief project outline is provided in the Background Information Document prepared by EOH Coastal and Environmental Services, East London:

- The upgrade of the portion of R63 Section 16 between km 1.0 and km 43.64, including vertical and horizontal alignment, and re-surfacing thereof;
- Widening of the current road prism to a SANRAL design standard and to a standard cross section up to 13.4 m;
- Lengthening of major and minor drainage structures, widening of four bridge structures;
- Construction of one new bridge structure;
- Upgrading of a major intersection at R63 / N2 T-junction (± km 43,64);
- Replacement of concrete-lined drains to suit new design levels;
- Investigation of a void / sinkhole which extends some 3 m beneath the road near km 18.4;

- Exploitation of hard and soft rock road materials from four borrow pit sites and four quarry sites (See Table 1).

The EIA process required for the road upgrade component of the project is a BAR. SANRAL is exempted from submitting a full mining application to the Department of Mineral Resources (DMR) as per Section 106 of the MPRDA. They are only required to submit an Environmental Management Programme (EMPr) as part of their application. This can only be done after obtaining an Environmental Authorization from the DMR.

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 Programme 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 been published by SAHRA (2013).

Fig. 1. Extract from 1: 250 000 topographical map 3226 King William's Town showing the study area for the proposed R63 Section 16 road upgrade between the N6 near Kei Road and the N2 east of Komga, Amathole District, Eastern Cape (Map courtesy of the Chief Directorate National Geo-spatial Information, Mowbray). Also indicated are the eight associated borrow pit (BP) and quarry (Q) sites (Table 1).

Fig. 2. Google earth© satellite image of the R63 Section 16 study area (red line) between the N6 and the N2 near Komga, Eastern Cape. The eight proposed borrow pits and quarries associated with the road upgrade are also indicated (See Table 1). Quarries 11 and 12 and Borrow Pits 22 and 25 are excavated into Karoo dolerite while the remaining sites are excavated into Late Permian sedimentary rocks of the Balfour Formation (Lower Beaufort Group).

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 broader region (*e.g.* Almond 2011a, 2011b, 2014, 2015a, 2015b, 2016, 2017a, 2017b, Gess 2011a, 2011b, 2012, Groenewald 2011, Prevec 2014), (2) published geological maps and accompanying sheet explanations (*e.g.* Mountain 1974, Hill 1993), and (3) a palaeontological field study of the project area between Kei Road and the N2 near Komga over the period 21-22 June, 2017. GPS locality data for numbered sites mentioned in the text are provided in the Appendix.

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.

4. GEOLOGICAL BACKGROUND

The R63 (Section 16) road and quarry / borrow pit study area between Kei Road and the N2 near Komga is situated at elevations between *c*. 550 and 770 m amsl in dissected, hilly terrain located to the southeast of the main Amatole Mountain Escarpment and some 50 km inland from East London (Figs. 1 & 2). This region is characterised by relicts of the Pan African 1 land surface of Early Miocene age according to Maud (2008). The area is drained to the southeast by the Gqunube, Tanga and Kwelera Rivers as well as their numerous small, non-perennial tributaries. Levels of bedrock exposure in the area are generally very low, with the exception of road and railway cuttings, farm dams, stream and river banks, quarries and borrow pits. The rolling uplands are grassy or transformed for agriculture while steeper slopes and valley sides are often wooded (Figs. 3 to 5). The geology of the study area is outlined on 1: 250 000 geology sheet 3226 King William's Town (Fig. 6; 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. The geological context for the study region has been covered in previous palaeontological assessment reports by the author (*e.g.* Almond 2017a, 2017b). The region is underlain by Late Permian continental sediments of the **Balfour Formation** (Lower Beaufort Group, Karoo Supergroup) that are locally intruded by major Early Jurassic dolerite sills and dykes of the **Karoo Dolerite Suite**. These bedrocks are mantled with a range of Late Caenozoic **superficial deposits** such as alluvium, colluvium (slope deposits) and soils.

Fig. 3. View north-eastwards along the R63 (Section 16) to the east of the Gqunube River showing hilly terrain and low cuttings into weathered Beaufort Group bedrock (Loc. 303).

Fig. 4. View south-westwards towards the Gqunube River Valley and the R63 from Loc. 304 showing well-vegetated hillslopes.

Fig. 5. Undulating upland terrain just east of the BP23 study site (east of Komga) showing grassy hill slopes and wooded valley bottoms.

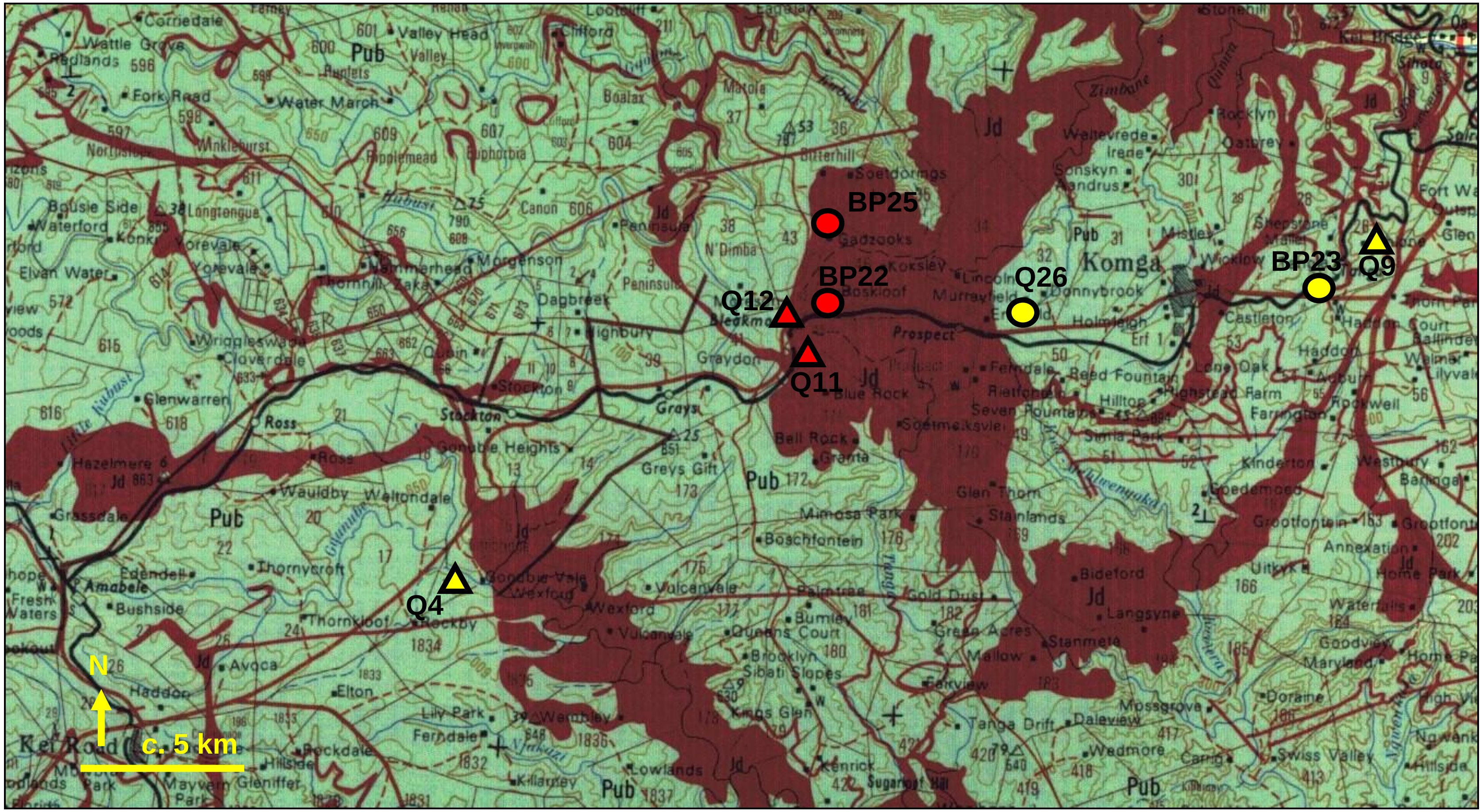

Fig. 6. Extract from 1: 250 000 geological map sheet 3226 King William's Town (Council for Geoscience, Pretoria) showing the R63 Section 16 road and quarry / borrow pit study area between the N6 and the N2 near Komga, Eastern Cape Province. The 8 quarry / borrow pit study sites are indicated by yellow triangles and circles (red = Karoo dolerite; yellow = Lower Beaufort Group sediments) (See also Table 1).

KEY GEOLOGICAL UNITS: Dark brown (Jd) = Jurassic Karoo Dolerite Suite. Green (Pub) = Balfour Formation, Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup). Superficial deposits such as Quaternary alluvium, colluvium and soils are also not shown separately here.

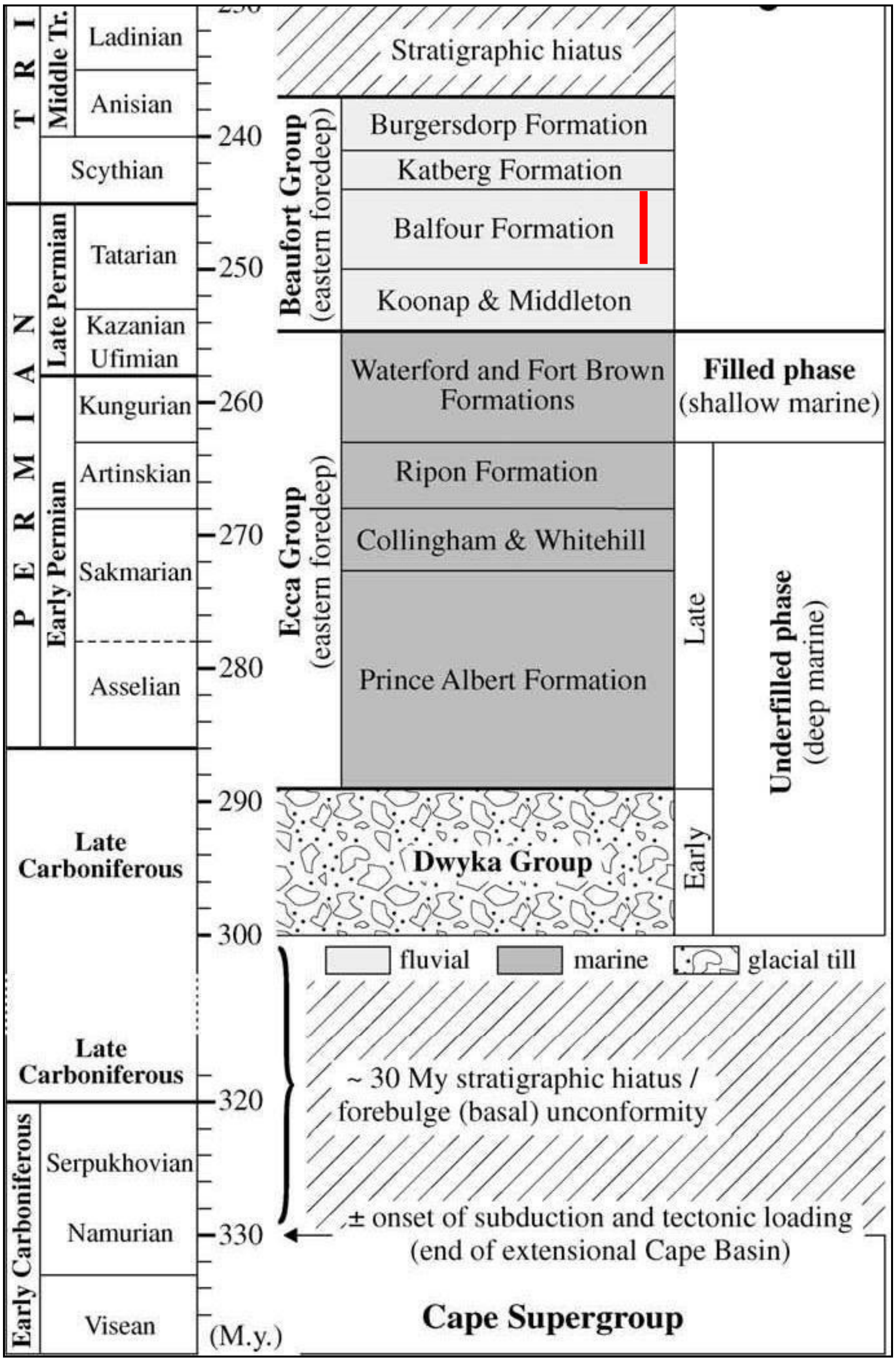

Fig. 7. Stratigraphic subdivision of the Carboniferous and Permian portions of the Karoo Supergroup in the Main Karoo Basin (From Catuneanu *et al.* 2005). The Late Permian Balfour Formation at the top of the Lower Beaufort Group (= Adelaide Subgroup) succession that underlies the present R63 Section 16 study area is emphasized by the thick red bar.

4.1. Lower Beaufort Group (Adelaide Subgroup)

The present study area is largely underlain by Late Permian continental (fluvial) sediments of the **Balfour Formation** that here forms the uppermost portion of the Lower Beaufort Group / Adelaide Subgroup (green, **Pub** on geological map Fig. 6; see also stratigraphic column Fig. 7). Due to generally poor bedrock exposure, the various sandstone- and mudrock-dominated members of the Balfour Formation mapped further to the west within the Main Karoo Basin (*cf* Katemaunzanga 2009) have not yet been recognised within the present study area.

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 past warm, humid climatic regime that probably prevailed during most of the Tertiary interval.

The fluvial Balfour Formation 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. 3 to 5). Bedrock exposure is mainly confined to the deeper parts of several erosional gullies or dongas, river and 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 strongly biased towards the resistant-weathering channel sandstone facies, with very poor representation of the more readily-weathered mudrocks that actually form the majority of the Balfour Formation succession.

The best exposures of comparatively fresh Balfour Formation channel sandstone facies were seen in road cuttings along the N2 just north of the R63 turnoff to Komga as well as in the cut face of the existing Quarry 4 study site (Figs. 8 & 9). Bedding varies from tabular to lenticular, with occasional tabular cross-bedding. Mudrock interbeds as well as basal intraclast breccias are noticeably absent within or below major sandstone packages. In the vicinity of major dolerite intrusions the sandstones have been baked to pale-weathering, well-consolidated quartzites with locally common infilled vugs (cavities) and possible evidence of country rock remobilisation (possible xenoliths, disturbed lamination) (Figs. 10 to 12). A distinctive weathering feature shown by thick sandstone units is the generation of boulder-sized, well-rounded corestones controlled by joints (*cf* Almond 2017a). The sphaeroidal corestones typically show a dark brown surface patina and often weather-out along ridge crests as striking boulder accumulations (*N.B.* some of the boulders may have been displaced during road construction) (Figs. 14 to 16). Deeply-weathered sandstone saprolite is pale to yellowish brown and friable due to leaching of silica cements, locally resembling unconsolidated alluvial sands or sandy soils (Fig. 13).

Balfour Formation overbank mudrocks are generally very poorly exposed and almost never fresh within the study area. They are predominantly siltstones, grey green but weathering khaki-brown, and variously massive or thick to thin bedded (Figs. 17 to 21). Small scale (several dm) upward-fining cycles can be discerned in some road cutting exposures (Fig. 21). *In situ* pedogenic calcrete horizons (palaeosols) were not recognised during this study, although occasional leached palaeocalcrete nodules reworked into surface gravels were seen.

Fig. 8. Thick package of tabular, pale brown, cross-bedded channel sandstones of the Balfour Formation exposed in an N2 road cutting just N of the junction with the R63 Komga road (Loc. 318).

Fig. 9. Vertical section through a thick, tabular-bedded channel sandstone package exposed at the Quarry 4 site. Note absence of mudrock interbeds here.

\Fig. 10. Road cutting through pale grey-weathering, quartzitic channel sandstones of the Balfour Formation that have been baked by nearby dolerite intrusion (Loc. 305).

Fig. 11. Close-up of previous channel sandstone exposure showing numerous darker inclusions – possibly intraclasts, or perhaps xenoliths related to remobilisation of the sandy package during nearby dolerite intrusion (Hammer = 30 cm).

Fig. 12. Dark grey, baked quartzitic channel sandstones showing several irregular infilled vugs or cavities – probably a consequence of nearby dolerite intrusion (Scale in cm) (Loc. 305).

Fig. 13. Deeply-weathered, friable Balfour Formation channel sandstone with vague relict cross-bedding and occasional thin calcrete veins (Loc. 304) (Hammer 30 cm).

Fig. 14. Well-jointed channel sandstone in road cutting showing typical dark brown weathering patina, open joints and incipient corestone formation (Hammer = 30 cm) (Loc. 298).

Fig. 15. *In situ*, subrounded corestones within a deeply-weathered sandstone package overlain by crumbly sandstone saprolite and orange-brown gravelly soils (Hammer = 30 cm) (Loc. 298).

Fig. 16. Concentration of large, well-rounded sandstone boulders with a dark brown patina representing downwasted corestones from a deeply-weathered major sandstone package (Loc. 295).

Fig. 17. Isolated lenticular, upward-fining Balfour Formation channel sandstone showing a sharp lower contact with the underlying overbank mudrocks, borrow pit near Kei Road (Loc. 294).

Fig. 18. Weathered thin, upward-fining channel sandstone body overlain by thick saprolite and soil, road cutting just east of Komga (Loc. 315) (Hammer = 30 cm).

Fig. 19. Deep road cutting through crumbly, weathered channel sandstone package (Loc. 308).

Fig. 20. Package of khaki-hued, hackly-weathering overbank mudrocks and fine-grained sandstones of the Balfour Formation exposed in a road cutting (Loc. 300).

Fig. 21. Small-scale, upward-fining cycles within hackly-weathering overbank mudrocks (Hammer = 30 cm) (Loc. 300).

4.2. Karoo Dolerite Suite

To the west and east of Komga 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. 6). Such major intrusions have thermally metamorphosed (baked and recrystallised) the country rock for a considerable distance on either side of their edges, as described for the channel sandstones at Loc. 305 above (Figs. 10 to 12). Low, rounded and pitted surface exposures of a major dolerite sill are seen at the two quarry sites (Q11, Q12) some 12 km west of Komga (Figs. 22 & 23). In the nearby borrow pits (BP22, BP25) thick, friable *sabunga* and corestones represent *in situ* dolerite saprolite. The latter occasionally shows layering and superficially resembles bedded sediment (Figs. 24 & 25). Overlying soils are typically dark grey rather than reddish-brown.

Fig. 22. Low rounded and pitted surface exposures of a major sill-like dolerite intrusion at the Q11 study site (Loc. 309) (Hammer = 30 cm).

Fig. 23. Similar whale-back surface exposures of dolerite at the Q12 study site.

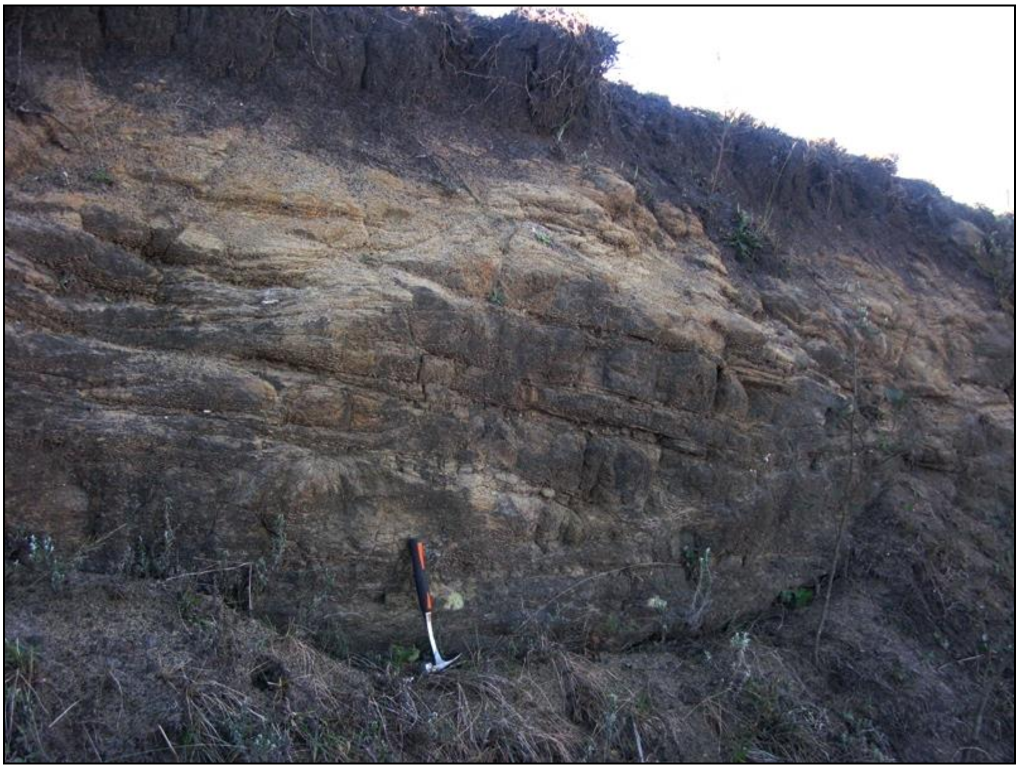

Fig. 24. Deeply-weathered, friable dolerite *sabunga* showing pseudobedding exposed in the walls of an existing borrow pit (Loc. 312, BP22 study site) (Hammer = 30 cm).

Fig. 25. Friable dolerite *sabunga* overlain by thick dark grey soils and corestones, BP 25 study area (Loc. 311).

4.3. 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).

Comparatively few good sections or exposures of superficial sediments were encountered in the Komga study area; close to the road and quarry / borrow pit sites, these younger sediments are often disturbed. The deeply-weathered Beaufort Group saprolite grades up into, or is sharply overlain by sandy to loamy soils, with or without gravels (Figs. 30 to 33). A laterally-extensive, prominent-weathering ferricrete hardpan up to several dm thick occurs along the soil / saprolite contact in several road cuttings (Fig. 29). Exposures of the rusty-brown glaebular ferricrete often show a dark, almost black surface patina. Colluvial sandstone clasts downwasting from a weathered sandstone channel package have mixed with weathered clay and soil to form a rubbly, diamictite-like deposit locally (Fig. 26). Poorly-sorted alluvial gravels of local sandstone are exposed in the banks of the Gqunube River (Fig. 27). In dolerite areas surface gravels contain abundant subrounded dolerite corestones (Fig. 28).

Fig. 26. Downwasted colluvial rubble of leached, ferruginised sandstone accumulated above and on the periphery of a deeply-weathered channel sandstone body (Hammer = 30 cm) (Loc. 313)

Fig. 27. Poorly-sorted, coarse alluvial gravels of subangular sandstone clasts overlying channel sandstone bedrock, banks of the Gqunube River (Loc. 302 (Hammer = 30 cm).)

Fig. 28. Poorly-sorted, bouldery colluvial gravels – mainly sandstone, with occasional dolerite clasts - overlying Balfour Formation saprolite (Hammer = 30 cm) (Loc. 299).

Fig. 29. Persistent, dark rusty-brown ferricrete hardpan developed at base of soils overlying weathered saprolite (Balfour Formation overbank mudrocks) (Loc. 297).

Fig. 30. Small farm dam (site of BP 26) excavated into sandy soils and weathered Balfour Formation bedrocks, including channel sandstones (Loc. 314).

Fig. 31. Close-up of weathered, cross-bedded Balfour Formation sandstones overlain by pale, sparsely-gravelly soils (Loc. 314) (Hammer = 30 cm).

Fig. 32. View eastwards across the existing quarry at the Q9 study site (Loc. 317). Note lack of bedrock exposure here due to rehabilitation.

Fig. 33. Fresh, greyish channel sandstone bench and rusty-brown, downwasted sandstone corestones at the base of the existing Q9 quarry site (Hammer = 30 cm) (Loc. 317). The slopes behind have been rehabilitated.

5. PALAEONTOLOGICAL HERITAGE

Palaeontological heritage reported elsewhere within the main rock units represented in the study area along the R63 near Komga as well as further afield is outlined here, largely based on previous desktop and field-based studies in the region by the author and others (*e.g.* Almond 2011a, 2011b, 2014, 2015a, 2015b, 2016, 2017a, 2017b, Gess 2011a, 2011b, 2012, Groenewald 2011, Prevec 2014).

The overall palaeontological sensitivity of the Beaufort Group sediments within the Main Karoo Basin 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 broader East London region remain very low (Nicolas 2007, Fig. 34 herein). This is probably due to factors such as low levels of bedrock exposure, deep bedrock weathering, and extensive dolerite intrusion, although palaeoenvironmental factors as well as research neglect 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.

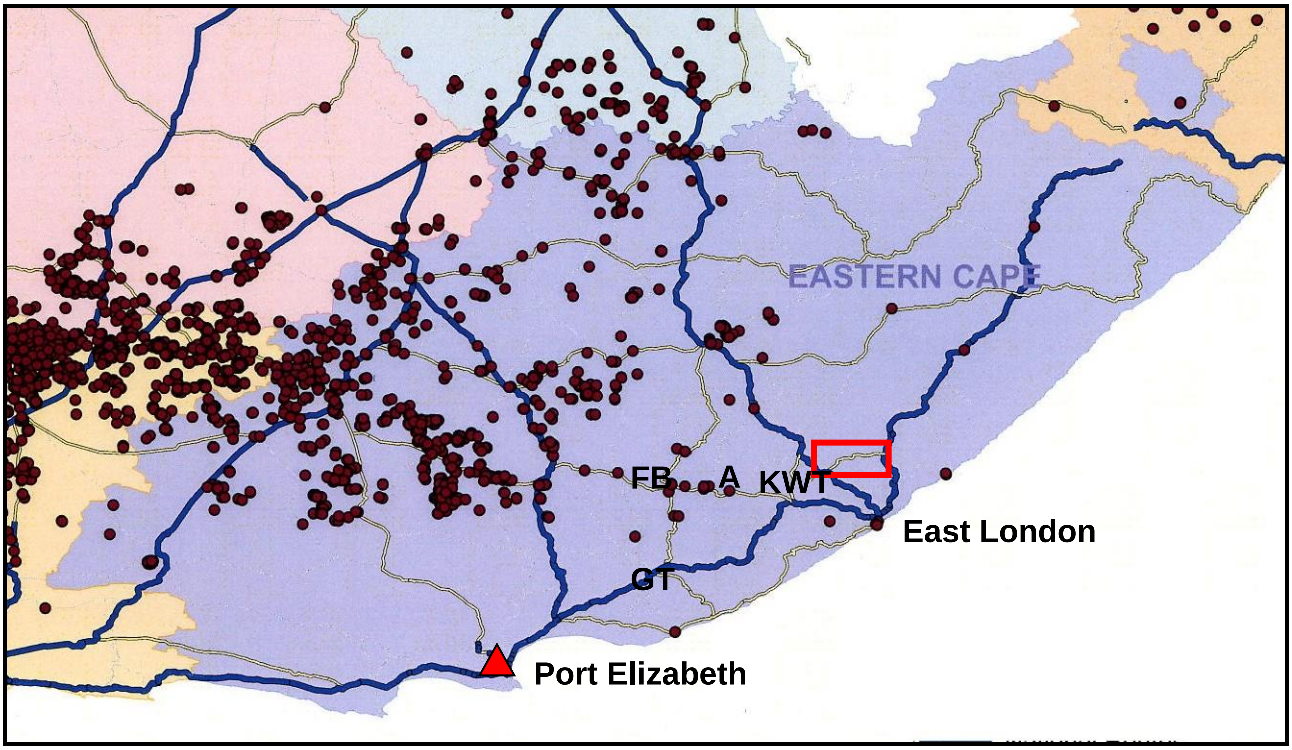

Fig. 34. Distribution of vertebrate fossil sites in the Beaufort Group in the Eastern Cape (Modified from Nicolas 2007). Note the general scarcity of sites recorded in the eastern portion of the Main Karoo Basin. Permian vertebrates have not yet been recorded from the present R63 (Section 16) study area near Komga (red rectangle). KWT = King William's Town. GT = Grahamstown. FB = Fort Beaufort. A = Alice.

5.1. Balfour Formation

The majority of the Late Permian Balfour Formation succession, with the exception of the basal sandstones and the uppermost mudrocks, is assigned to the *Dicynodon* Assemblage Zone, recently renamed the ***Daptocephalus* Assemblage Zone** (Rubidge 1995, Cole *et al*., 2004, Viglietti *et al.* 2015) (Fig. 35). This 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).

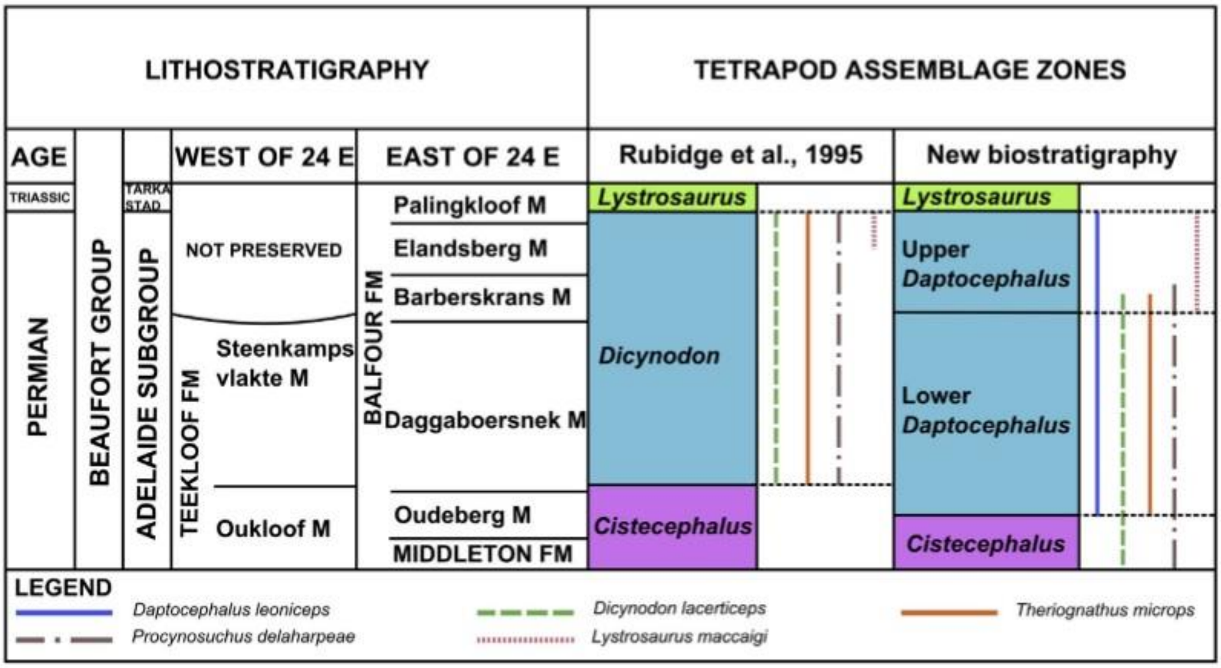

Fig.35. Revised subdivision of fossil assemblage zones (AZ) represented within the Balfour Formation (From Viglietti *et al.* 2015). The formation has not been subdivided into members in the Komga study area due to poor bedrock exposure levels.

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. 36 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 (silicified) 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. Occasional vertebrate burrows, including a possible fossil warren, as well as possible non-marine bivalves were described from the Adelaide Subgroup along the R63 between Fort Beaufort and Alice by Almond (2016).

Recent field-based palaeontological assessments in the East London – Komga – Kei Mouth area have generally confirmed that vertebrate fossil remains are scarce within the Lower Beaufort Group bedrocks, but this may be in part attributable to low exposure levels, pervasive deep weathering as well as a historical neglect of the region by palaeontologists. Gess (2012) noted unidentified fossil bone material in a N2 road cutting just NE of East London (possibly Balfour Fm) as well as in the upper Balfour Formation in the Mbashe River Pass (Indutywa District). Invertebrate trace fossils and plant debris were recorded east of the Kei River (Gess 2011a). A palaeontological field study for the small Chaba WEF (now operational) to the southeast of Komga did not yield any notable fossil remains (Groenewald 2011). The much more extensive Great Kei WEF project area, spanning the N2 to the southeast of Komga, also yielded no vertebrate fossils but low diversity invertebrate trace fossils as well as plant remains (especially sphenophyte debris) were recorded here by Prevec (2014). Most or all of these fossil occurrences were referred to the Balfour Formation by the authors concerned. No fossil vertebrate remains were recorded from the Lower Beaufort Group in the Haga Haga WEF study area, situated *c*. 30 km to the southeast of Komga, by Almond (2017a, 2017b). While locally abundant concentrations of well-preserved Beaufort Group petrified wood blocks were noted here, these were not observed *in situ* but as reworked blocks within unconsolidated superficial sediments (*ibid*.).

No petrified wood, vertebrate remains or other fossil material was recorded during the present field assessment of the R63 (Section 16) near Komga. This is probably due largely to the deep weathering of the Beaufort Group bedrocks as well as the low bedrock exposure levels.

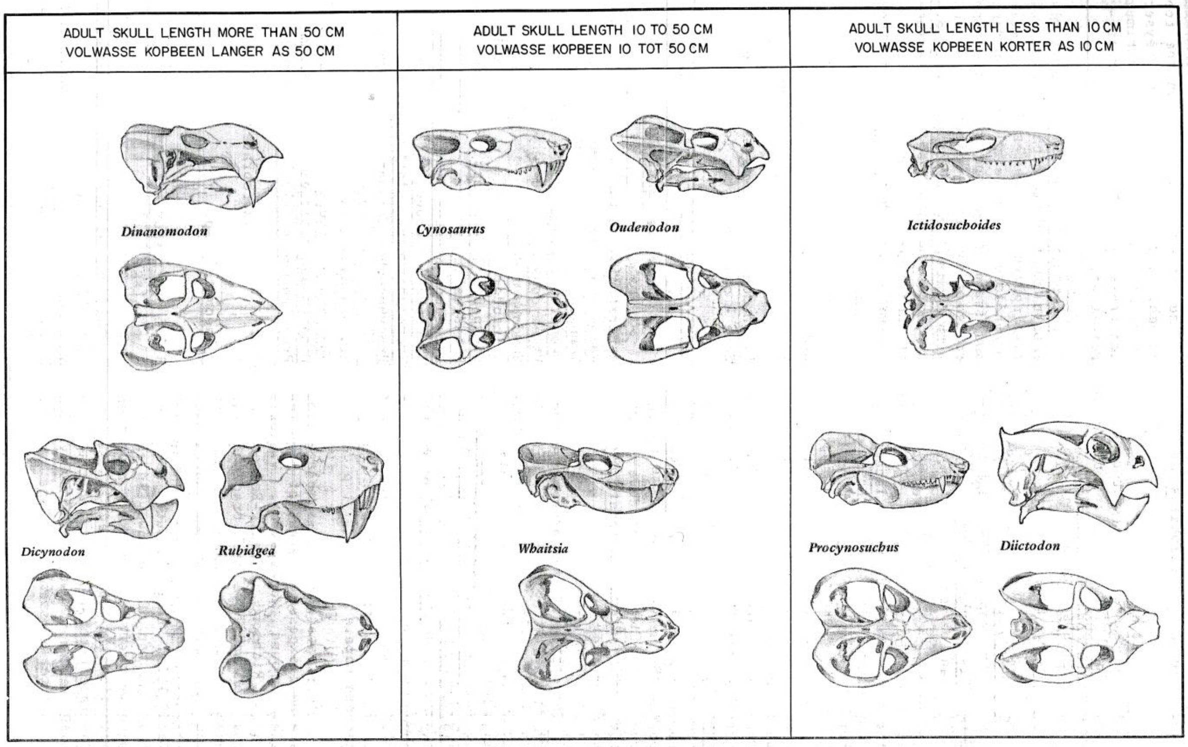

Fig. 36. Skulls of characteristic fossil vertebrates – all therapsids - from the *Daptocephalus* (previously *Dicynodon*) Assemblage Zone (From Keyser & Smith 1977-1978). Among the dominant therapsids ("mammal-like reptiles"), *Rubidgea* and *Cynosaurus* are carnivorous gorgonopsians, *Whaitsia* (now *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.

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 the various dolerite quarry / borrow pit study sites during the present field assessment.

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 has been recorded from coarse alluvial gravels near Cookhouse (Almond 2014) and in the Haga Haga WEF study area *c*. 30 km southeast of Komga (Almond 2016); 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. No new fossil material was recorded from the various superficial deposits in the present R63 study area near Komga, however.

6. EVALUATION OF IMPACTS ON PALAEONTOLOGICAL HERITAGE

The R63 (Section 16) 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 2 below. This assessment applies only to the construction phase of the project since further impacts on fossil heritage during the operational phase and rehabilitation phases of the road and quarries / borrow pits 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 comparatively small footprint of the proposed road developments as well as (3) the absence of new fossil records made 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 16) road project, including the associated quarry / borrow pits, is evaluated as *very low* as far as palaeontology is concerned.

Table 1: Eight borrow pit and quarry sites associated with the R63 Section N16 road upgrade, Eastern Cape (See map Figs. 1 & 2)

SITE	GPS	GEOLOGY	PALAEONTOLOGICAL HERITAGE	RECOMMENDED MITIGATION
Quarry 4	32 39 22.6 S 27 38 50.3 E	Balfour Formation channel sandstone package	No fossils recorded	**NONE**
Quarry 11	32 35 42.4 S 27 45 50.9 E	Karoo Dolerite Suite – major sill	No fossils recorded	**NONE**
Quarry 12	32 35 12.6 S 27 45 45.0 E	Karoo Dolerite Suite – major sill	No fossils recorded	**NONE**
Borrow Pit 25	32 33 35.2 S 27 46 03.5 E	Karoo Dolerite Suite – weathered saprolite (*sabunga*)	No fossils recorded	**NONE**
Borrow Pit 22	32 35 03.8 S 27 46 11.0 E	Karoo Dolerite Suite – weathered saprolite (*sabunga*)	No fossils recorded	**NONE**
Borrow Pit 26	32 35 16.5 S 27 50 20.1 E	Balfour Formation sandstone & mudrock	No fossils recorded	**NONE**
Borrow Pit 23	32 34 36.2 S 27 56 00.8 E	Balfour Formation sandstone & mudrock	No fossils recorded	**NONE**
Quarry 9	32 33 51.0 S 27 57 40.1 E	Balfour Formation sandstone & mudrock	No fossils recorded	**NONE**

Table 2: Evaluation of impacts on fossil heritage resources due to the construction phase of the proposed upgrade of National Route R63 (Section 16) and associated mining applications (No further impacts are anticipated in the operational & rehabilitation phases).

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: Damage, destruction of fossil remains at or beneath the ground surface within the development footprint	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 16)near Komga, 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. However, these potentially fossiliferous bedrocks are generally poorly-exposed, deeply-weathered and have been locally baked by major Karoo dolerite intrusions. Desktop and field assessments of the study area indicate that the sedimentary rocks of the Balfour Formation in this region contain, at most, very sparse vertebrate fossils, non-marine bivalves, petrified wood and trace fossils (*e.g.* large vertebrate burrows). No fossil remains of any sort were recorded from sedimentary rocks exposed within the development footprint itself, including the eight associated quarry and borrow pit localities and several road cuttings along the R63. Superficial sediments of Late Pleistocene to Recent age - including thick sandy to gravelly alluvium, surface gravels, ferricrete hardpans and modern soils – are apparently unfossiliferous. No vertebrate fossils, reworked petrified wood or other fossil remains were recorded within the superficial sediments during the present field assessment. Four proposed quarry / borrow pit excavations into a Jurassic dolerite sill *c*. 12 km to the west of Komga are of no palaeontological heritage significance.

The overall impact significance of the R63 (Section 16) road project, including the eight 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, 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 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 16) road and quarry / borrow pit development.

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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, KwaZulu-Natal 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.	GPS DATA	COMMENTS
294	32 41 42.2 S 27 34 05.6 E	Small borrow pit adjacent to R63, just east of Kei Road. Balfour Formation sharp-based, lenticular channel sandstone, fine- to medium-grained, grey to pale yellow, medium-bedded, locally tabular cross-bedded with current ripples on bed tops. Fines upward into grey-green, hackly-weathering overbank mudrocks and grey soils. No basal breccio-conglomerates seen.
295	32 40 44.3 S 27 36 15.6 E	Farm 24, south of Fernkloof homestead, N. side of R63 road. Concentration of dark brown, well-rounded boulders of fine-grained Beaufort Group sandstone (not dolerite). Flat bedding places occasionally visible. Downwasted corestones resulting from deep chemical weathering of Beaufort Group channel sandstones; mainly seen along upland ridge crests. May have been displaced in part during road construction.
296	32 40 20.1 S 27 36 57.4 E	Farm 24, SE of Fernkloof homestead, S of road. Concentration of large, well-rounded corestones of Beaufort Group sandstone.
297	32 39 41.4 S 27 37 53.5 E	R63 road cutting along both sides of R63 to NW of Rockby homestead. Beaufort Group beds dipping eastwards towards Gqunube River valley. Medium-grained, well-sorted channel sandstones, thin- to medium-bedded., grey patina, with sandstone corestones towards east. Khaki-hued, thin-bedded, tabular, highly-weathered overbank mudrocks, crumbly siltstones and thin fine-grained sandstone interbeds. Brownish domical termitaria in grey-brown soil horizon. Well-developed, laterally-persistent, dense ferricrete pedocrete horizon overlying Beaufort Group saprolite (20-40 cm thick, rusty-brown with black patina, small glaebules).

298	32 39 28.1 S 27 38 13.7 E	R63 road cutting along both sides of R63, *c*. 1 km SW of Gqunube River. Section through highly-weathered, well-jointed Beaufort Group yellowish-brown channel sandstone package with occasional *in situ* rounded, dark brown-patinated corestones (some showing onionskin weathering). Freshly-broken sandstone surfaces pale grey-green, speckled, medium- to coarse-grained, friable with kaolinitised feldspars, some brown mica platy grains. Sandstone bedrocks overlain by brown soils (not terra rossa).
299	32 39 26.6 S 27 38 15.8 E	Eastern section of same road cutting as above. Thin- to medium-bedded, highly-weathered Beaufort Group sandstones with *in situ* and weathered-out corestones, thick brown soils containing rock rubble, local development of ferricrete hardpan at base of soils. Occasional reworked dolerite boulders among rock rubble (speckled dark grey-green, dense, well-rounded, coarse-grained).
300	32 39 12.0 S 27 38 38.5 E	R63 road cutting *c.* 370 m west of bridge across Gqunube River. Package of tabular-bedded, highly-weathered, hackly, khaki-hued Beaufort Group overbank siltstones, massive or structured into thin (up to few dm), upward-fining packages. Thin lenticular channel sandstone. Pale brown soils with ferricrete development towards base.
301	32 39 22.6 S 27 38 52.5 E	Quarry 4, Farm 2152 – moderately large existing NE-facing quarry site on SW banks of Gqunube River. Quarry excavated into thick Lower Beaufort channel sandstone package (base not seen). Sandstones pale brown, well-jointed, with local corestone weathering near surface. Fresh sandstone is medium- to thick-bedded, tabular, grey-green, speckled, well-sorted, medium- to coarse-grained sandstones and wackes with horizons of ripple cross-lamination, flat lamination. Fresh mudrock interbeds and basal breccio-conglomerates not seen.
302	32 39 20.6 S 27 36 52.7 E	Lower portion of same sandstone package exposed in bed and banks of Gqunube River. Thick-bedded channel sandstones overlain by coarse , rubbly boulder-rich alluvium, poorly-sorted, subangular sandstone gravels and thick (0.5 – 1 m) brown sandy alluvial soils in riverbanks.
303	32 38 33.0 S 27 39 18.6 E	Long R63 road cuttings due E of Weltondale homestead. Weathered, highly-jointed,tabular-bedded, yellow-brown, fine-grained Beaufort Group channel sandstone and grey-green overbank siltstones. Rubbly orange-brown soils (local dolerite influence).
304	32 38 10.5 S 27 39 39.2 E	Steep sandy embankment on N side of R63 compose of deeply- and highly-weathered, pale brown Beaufort Group channel sandstones, coarse / gritty, friable, with local development of cross-bedding, corestones, soft platy calcrete (probably Quaternary) along fractures and bedding planes. Occasional coarse-grained, creamy kaolinitic or calcrete clasts (possibly granitoid, from basement provenance, or reworked calcrete concretions). Fresher sandstone in corestones grey-green, medium- to coarse-grained, speckled, impure and kaolinitic wackes.
305	32 38 09.6 S 27 39 51.0 E	R63 road cutting through thick Beaufort Group channel sandstone package, pale grey-weathering, well-jointed and consolidated with dark grey speckled fresh rock surfaces, massive to horizontally-laminated. Solid, quartzitic appearance and several scattered vugs (infilled cavities) suggest baking by dolerite intrusion (sill) that is mapped in this area. Several angular to subrounded, greyish, internally laminated “intraclasts” also present as well as anomalous subvertical lamination within sandstone in matrix – these phenomena possibly related to mobilisation of sandstone by dolerite intrusion (*cf* xenoliths)
306	32 36 54.0 S 27 40 00.1 E	R63 road cutting SE of Rangerton homestead showing poorly-exposed section through khaki-coloured, deeply-weathered Lower Beaufort Group overbank siltstones (saprolite) with yellowish, fine-grained sandstone interbeds. Overlying grey soils with laterally-persistent ferricrete hardpan (sev. dm) at base and downwasted ferricrete blocks close to road level in the cutting.
307	32 36 36.5 S 27 41 20.3 E	Deep R63 road cutting on Farm 9. Poor exposure of deply-weathered Lower Beaufort Group khaki overbank mudrocks and fine-grained, yellow-brown sandstone saprolite
308	32 36 27.4 S 27 41 37.7 E	Deep R63 road cutting through weathered Lower Beaufort Group sandstone package: crumbly, pale yellowish brown, tabular to lenticular, thin – to

		medium-bedded. Occasional cross-bedded sandstone units.
309	32 35 42.7 S 27 45 50.1 E	New Quarry 11 site, *c*. 250 m east of R63. Low rounded (whaleback) and pitted surface exposures of major dolerite sill showing jointing, large-scale exfoliation, grey-green speckled, coarse-grained dolerite.
310	32 35 12.5 S 27 45 44.8 E	New Quarry 12 site just N of R63. As above – to be excavated into the same major dolerite sill.
311	32 33 35.5 S 27 46 02.7 E	Borrow Pit 25 – existing small borrow pit excavated into friable, grey-green weathered dolerite (*sabunga*) with corestones, onionskin exfoliation, minor platy calcrete veneers, overlain by dark brown soils.
312	32 35 03.2 S 27 46 09.1 E	Borrow Pit 22 site – existing extensive elongate (W-E) shallow pit just N of R63 excavated into deeply-weathered dolerite *sabunga* with corestones, laminated weathered rocks (pseudobedding).
313	32 35 20.4 S 27 49 54.7 E	Roadcutting on N side of R63 *c*. 700 m ESE of Endfield homestead. Deeply-weathered, brownish Beaufort Group channel sandstone package with blackish surface patina, showing joints opened by solution weathering, collapse features (probably karstified). Grades eastwards into poorly-sorted, slightly ferruginised, rubbly colluvium of downwasted sandstone blocks in a clay-rich matrix – material splaying laterally from prominent sandstone rise.
314	32 35 17.5 S 27 50 18.7 E	Borrow Pit 26 site surrounding existing small farm dam excavated into weathered Beaufort Group channel sandstones (locally cross-bedded, ripple cross-laminated or flat-laminated with primary current lineation) and overbank mudrocks. Bedrock saprolite overlain by thick, pale brown to greyish soils with sparse sandstone gravels, reworked ferricrete glaebules, occasional ochreous blocks of fragmented, leached palaeocalcrete nodules.
315	32 34 38.6 S 27 54 42.2 E	Long R63 road cutting just E of Komga with khaki-coloured weathered Beaufort Group thin- to medium-bedded (locally cross-bedded) sandstones and overbank siltstones, capped by grey soils.
316	32 34 36.3 S 27 55 59.3 E	Borrow Pit 23 site – existing deep pit N of R63, *c*. 2.3 km west of N2, excavated into weathered Lower Beaufort Group grey-green mudrocks and intermittently exposed fine-grained, greyish wackes. Latter locally show well-developed subvertical spaced cleavage.
317	32 35 51.0 S 27 57 38.6 E	New Quarry 9 site – large quarry excavated into weathered Lower Beaufort Group sandstones and siltstones. Bedrock exposure poor due to rehabilitation. Probable that thick overbank mudrock package is present here. Base of quarry shows low bench of grey speckled channel sandstone with horizontal lamination, rusty-brown sandstone corestones.
318	32 34 36.5 S 27 57 24.3 E	Road cuttings along both sides of N2 just N of Komga turnoff showing good sections through thick package of Lower Beaufort Group channel sandstones, medium tabular-bedded, cross-bedded, well-jointed, pale grey with dark brown patina.