## PALAEONTOLOGICAL ASSESSMENT: COMBINED FIELD ASSESSMENT AND DESKTOP STUDY

# Proposed development of Portion 3 of Farm 695 (Clippety Clop), Kwelera, East London, Great Kei Municipality, Eastern Cape.

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## 1. SUMMARY

The proposed holiday housing development on Portion 3 of Farm 695 (Clippety Clop), Kwelera, East London, is situated on the northern banks of the tidal Kwelera River, some 20 km northeast of East London, Eastern Cape. The development footprint is largely underlain by Late Permian continental sediments of the Adelaide Subgroup (Lower Beaufort Group, *c*. 253-251 million years old). These rocks are overlain by Early Triassic sandstones of the Katberg Formation (Tarkastad Subgroup) that build the cliffs and higher ground to the northeast. South of the river the Beaufort Group sediments are intruded and baked by Early Jurassic igneous intrusions of the Karoo Dolerite Suite.

The Balfour Formation fluvial sediments are potentially fossiliferous, having yielded elsewhere a wide range of terrestrial vertebrates (bones and teeth of pareiasaurs, therapsids, amphibians *et al*.), bivalves, trace fossils and vascular plants. The overall impact of this project on local palaeontological heritage is likely to be very minor, however, because the potentially fossiliferous Beaufort Group sediments here are (a) deeply weathered, (b) sparsely fossiliferous, (c) have probably been extensively baked by nearby dolerite intrusions, and (d) are mostly covered with a thick (> 3m) mantle of fossil-poor alluvium. No fossils were observed within good exposures of the Balfour Formation rocks at the coast and in excellent roadcuts inland.

Reworked clasts of well-preserved silicified wood occur within the Katberg Formation sandstones and have been concentrated by erosion and weathering into overlying thin gravels on the coastal plateau, as seen in the northeastern sector of Clippety Clop. However, these younger rocks will not be directly impacted by the proposed holiday home development while good coastal exposures of the Katberg Formation at the nearby coast show that fossils are very rare in this succession.

For these reasons, further specialist studies or mitigation by a professional palaeontologist is not regarded as necessary for this development. However, the responsible ECO should be alerted to the possibility of important fossil finds, especially in new exposures of fresh (unweathered) Beaufort Group sediments (*e.g.* in and freshly excavated borrow pits for road or building material).

Should substantial fossil remains be found, the ECO should carefully record and safeguard these, preferably *in situ*, and alert SAHRA or a professional palaeontologist at the earliest opportunity so that the fossils can be examined and, if necessary, properly excavated.

## 2. INTRODUCTION & BRIEF

The company Clippety Clop Property Holdings cc is proposing to develop up to 12 holiday homes on Portion 3 of Farm 695, „Clippety Clop" adjacent to the Kwelera River and some 20 km northeast of East London, Great Kei Municipality, Amathole District Municipality, Eastern Cape Province (Figs. 1 & 2). The Areena River Resort lies on the western boundary of the property which is bounded on the south side by the Kwelera River and is approximately 28 hectares in area. As shown in the site development plan (Fig. 3), the new holiday homes will be developed on low-lying ground on the inside of a major bend of the Kwelera River and southwest of a major sandstone escarpment that dominates the northeastern half of the property. According to the Basic Information Document prepared by Terreco Environmental Consultants:

> The holiday homes have been situated inland from the 1:100 year floodline for the Kwelera River and form a cluster close to the distinctive ridgeline which bisects the property in a north-west to south-east direction. Each holiday home will have a footprint of approximately 120m$^2$. There will be no fencing between the holiday homes. Services to be provided include a gravel access road to each unit, a single conservancy tank to receive sewage from every home and a combined borehole/rainwater collection water supply…The topography of the Project focus area is characterised by a flat to gently sloping floodplain associated with the Kwelera River and which gently rises in a northerly direction from the river to approximately 29m above mean sea level.

In order to apply for environmental authorisation for the proposed resort development in terms of the National Environmental Management Act 107 of 1998, a Basic Assessment Report (BAR) is being prepared by Terreco Environmental cc whose contact details are as follows:

Terreco Environmental cc
P O Box 19829, Tecoma, EAST LONDON, 5214
Phone: (043) 721 1502 Fax (043) 721 1535
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The study region is largely underlain by potentially fossiliferous sedimentary rocks of the Beaufort Group of Late Permian to Early Triassic age. A present combined desktop and field-based study of the potential impact of the proposed development on palaeontological heritage was commissioned by Terreco Environmental cc, East London, in accordance with the National Heritage Resources Act, 1999. Fieldwork at Clippety Clop as well as nearby coastal sites and roadcuts took place on 20th September.

GPS data for all numbered localities mentioned in the text are given in Section 8 of this report.

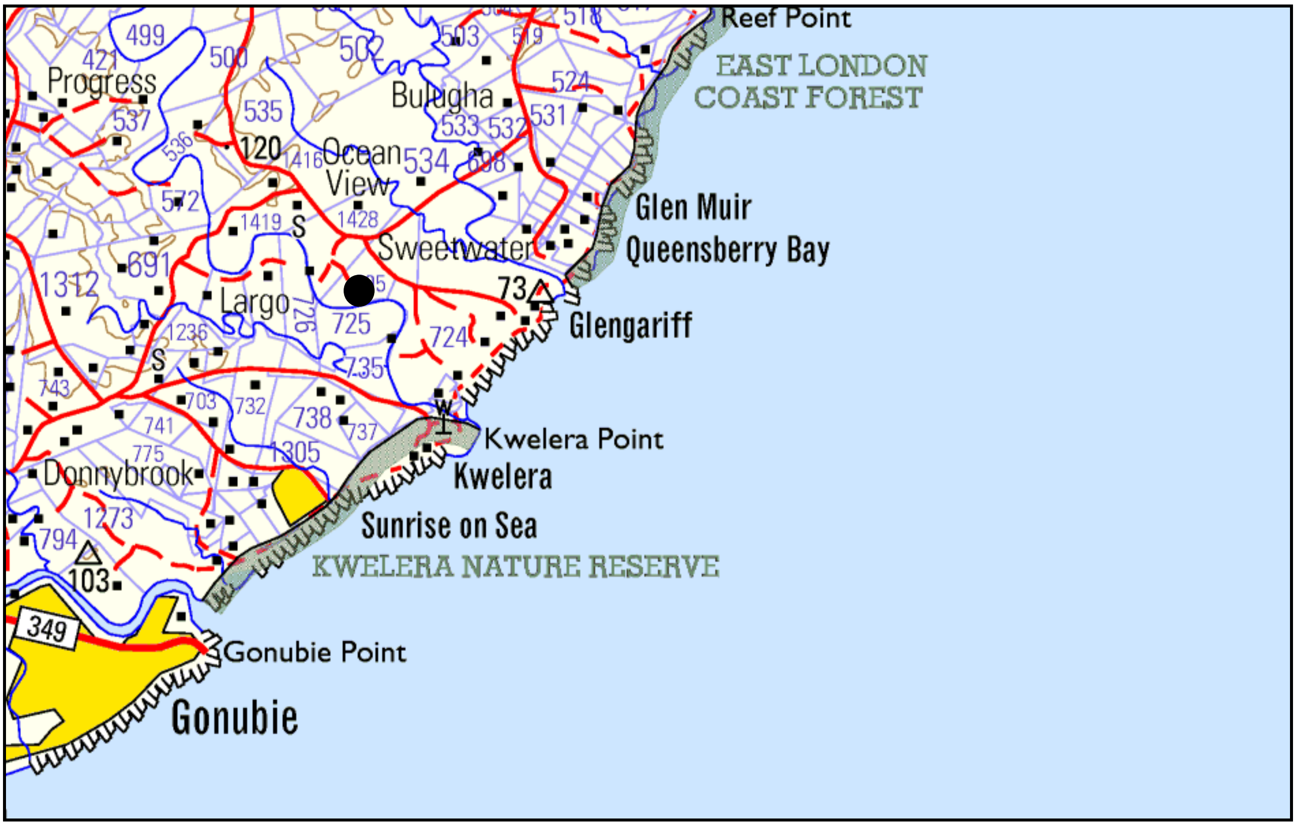


**Fig. 1. Location (black spot) of the Clippety Clop Resort on the northeastern banks of the Kwelera River, some 20 km northeast of East London, Eastern Cape Province (Extract from 1: 250 000 Map 3228 Kei Mouth, Courtesy of Chief Directorate of Surveys and Mapping, Mowbray).**

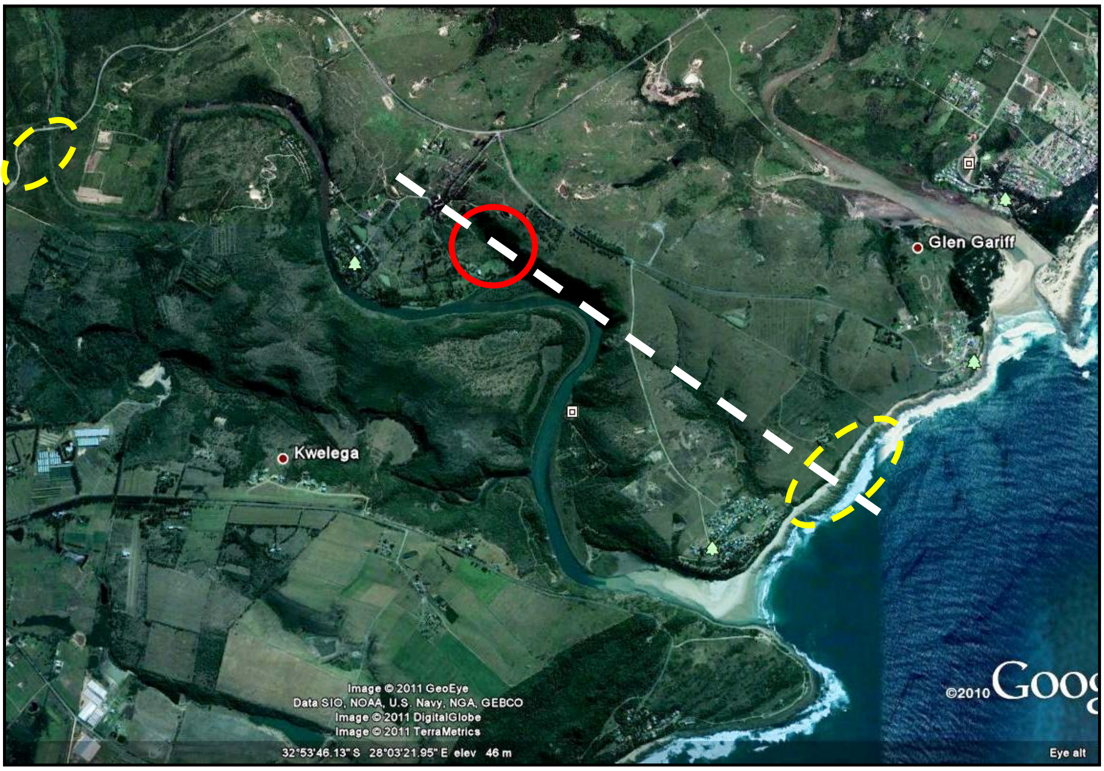


**Fig. 2. Google Earth® satellite image of the lower reaches of the Kwelera River showing the location of the Clippety Clop Resort development area on low-lying ground on the inside of a meander bed (red circle). The white dashed line indicates the approximate course of the normal (*i.e.* unfaulted) sedimentary contact between (1) the more recessive-weathering, mudrock-dominated Adelaide Subgroup succession that underlies the greater part of the low-lying study area to the SW and (2) the more resistant-weathering, sandstone-dominated Katberg Formation that builds the higher-lying plateau and cliffs to the NE. Good, accessible coastal exposures of the Adelaide and Katberg beds are seen along the coast southwest of Glengariff and roadcuts just south of the Kwelera River (yellow ellipses).**

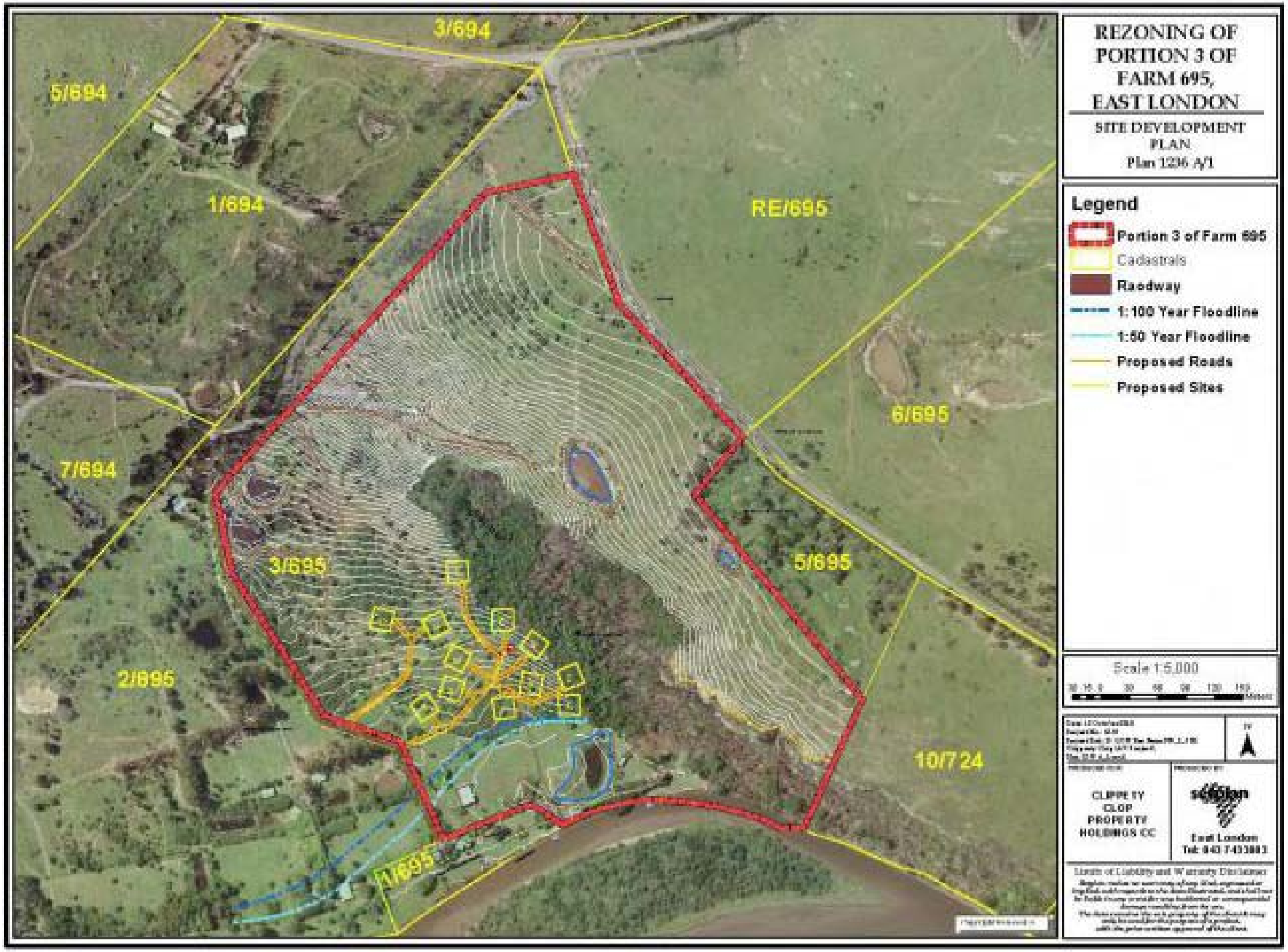


**Fig. 3. Site Development Plan for the proposed Clippety Clop resort development on Portion 3 of Farm 695, Kwelera, East London (From BID prepared by Terreco Environmental cc, East London).**

## 3. GEOLOGICAL BACKGROUND

The proposed development area lies on low-lying ground on the inside of a large, incised meander bend along the northern banks of the tidal Kwelera River, some 2.2 km from the Indian Ocean. The ground slopes gently upwards to the north, from 7m amsl at the river"s edge to *c*. 30m amsl inland. A steep sandstone escarpment underlies higher ground in the northeast at *c*. 60-90m amsl. (Fig. 4). Bedrock exposure within the low-lying area near the river is negligible due to substantial alluvial cover, as well as dense vegetation inland. The sandstone cliffs show good exposure of the Katberg Formation but are well-vegetated and largely inaccessible. Sporadic bedrock exposures are found along the track up to and over the sandstone plateau as well as around a number of small dams here as well as along the plateau edge (Fig. 3). Good, accessible exposures of the Adelaide and Katberg rocks underlying the study area are present along the nearby coast to the south-west of Glengariff as well as in roadcuts inland (Fig. 2) and were also visited during this study.

**Fig. 4. View of Clippety Clop study area looking towards the northeast showing Kwelera River and adjacent low-lying alluvial plain in the foreground with sandstone cliffs of the Katberg Formation in the background.**

According to the 1: 250 000 geology sheet 3228 Kei Mouth (Council for Geoscience, Pretoria) (Fig. 5) the bedrock in the study region at Kwelera comprises Late Permian to Early Triassic continental (fluvial) sediments of the **Beaufort Group** (Karoo Supergroup). These comprise recessive-weathering sediments of the **Lower Beaufort Group** (**Adelaide Subgroup, Pa**) beneath the holiday home development footprint close to the Kwelera River. Due to generally poor exposure (as seen here), the Adelaide Subgroup outcrop area has not been subdivided at formational level on the Kei Mouth sheet (Mountain 1974, Johnson & Caston 1979).

The higher-lying, north-eastern portion of the Clippety Clop Resort is underlain by the more resistant-weathering, sandstone-dominated succession of the **Katberg Formation** (**Upper Beaufort Group / Tarkastad Subgroup**; **Trk** on geological map). These sediments of Early Triassic age form the southern edge of the partially fault-bound Kwelera Outlier along the Eastern Cape coast (Dingle *et al*., 1983, map p.20). The southern edge of the Kwelera Tarkastad Outlier is mapped as a normal sedimentary contact - *i.e.* a fault-bound contact is *not* inferred here. It is therefore concluded that the lower, south-western part of the study area is underlain by the uppermost Adelaide Subgroup – *i.e.* equivalents of the **Balfour Formation** (**Pb** of adjacent 1:

250 000 geological maps) - that are of latest Permian age. The white dashed line in Figure 2 indicates the approximate course of the normal sedimentary contact between (1) the mudrock-dominated Adelaide Subgroup succession that underlies the greater part of the low-lying study area to the SW and (2) the more resistant-weathering, sandstone-dominated Katberg Formation to the northeast.

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, column 1). Dips of the Beaufort Group beds in the study region are generally very shallow (10-15º NE), so low levels of tectonic deformation are expected.

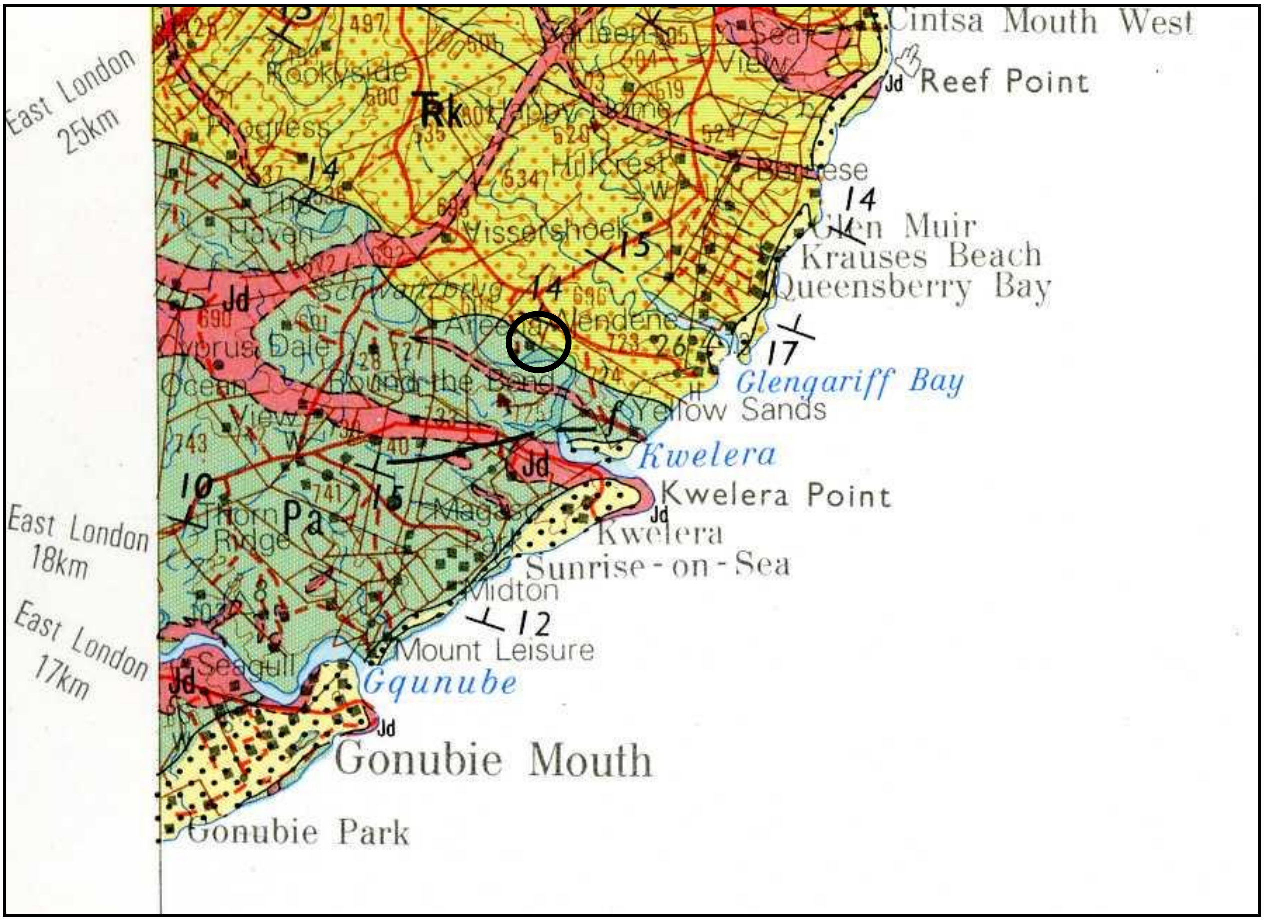


**Fig. 5. Extract from 1: 250 000 geological map 3228 Kei Mouth (Council for Geoscience, Pretoria) showing location (black circle) of the Clippety Clop Resort on the northern banks of the Kwelera River.**

**The main rock units in the study region are:**

**Pa (pale green) – Late Permian fluvial sediments of the Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup)**

**TRk (greenish-yellow) – Early Triassic fluvial sediments of the Katberg Formation (Upper Beaufort Group / Tarkastad Subgroup, Karoo Supergroup)**

**Jd (pink) – Early Jurassic dolerite intrusions of the Karoo Dolerite Suite**

***N.B.* Quaternary to Recent alluvial sediments along the Kwelera River are not separately mapped here.**

## 3.1. Adelaide Subgroup

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, but – as discussed earlier, the Adelaide beds in the study area can be assigned to the Balfour Formation.

The fluvial Balfour Formation succession 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. Thin wave-rippled sandstones were deposited 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 (Johnson & Caston 1979).

Apart from a few scrappy exposures of buff, ripple cross-laminated sandstones within tracks (*e.g.* Loc. 041), the Adelaide beds are not seen at surface within the study area due to pervasive cover by alluvial sediments. However, good exposures of equivalent beds are seen along the coast south-west of Glengarrif, below the sandstone-dominated Katberg succession (Loc. 054). The Adelaide succession here comprises thick, hackly-weathering, grey-green to purple-brown mudrocks with subordinate brown-weathering lenticular sandstones. Compared with the Katberg sandstones, those in the Lower Beaufort Group are less tabular, finer-grained and better-sorted. Tabular foresets indicate palaeocurrents to the north-east. Thick mudflake breccias occur at intervals, but well-developed calcrete horizons are not seen here.

Excellent, long roadcut exposures through the same rocks are present just southeast of the Kwelera River some 2.7 km WNW of the Clippety Clop study area (Fig. 2, Loc. 055). Thick, dark-grey to olive-green hackly-weathering mudrocks, including massive to thick-bedded siltstones, are seen here dipping down towards the river. Channel sandstones lower in the succession are widely-spaced, thin (c. 1m), buff, fine-grained and well-sorted. Some are disrupted into series of load balls (ball-and-pillow structure / pseudonodules) due to collapse into underlying "soupy" mudrocks. Higher-lying sandstones form multi-storey packets of medium- to thick-bedded channel fills with erosional, channelled bases. Climbing ripple lamination suggests rapid rates of deposition. Thin-bedded channel levee deposits and mud-filled abandoned channels are also present. Undoubted pedocrete horizons are not seen, although rusty-coloured blobs may be diagenetically altered calcretes. The thick, often massive mudrocks, load structures and lack of well-developed calcrete nodule horizons perhaps suggest a moist, swampy setting for these beds.

## 3.2. Katberg Formation

Useful geological descriptions of the Katberg Formation are given by Johnson (1976), Hancox (2000), Johnson *et al.* (2006), Smith *et al.* (2002) and for the Middelburg sheet area in particular by Cole *et al.* (2004). The more detailed sedimentological accounts by Stavrakis (1980), Hiller and Stavrakis (1980, 1984), Haycock *et al.* (1994, 1997), Groenewald (1996) and Neveling (1998) are also relevant to the present study area.

The Katberg Formation forms the regionally extensive, sandstone-rich lower portion of the Tarkastad Subgroup (Upper Beaufort Group) that can be traced throughout large areas of the Main Karoo Basin. The predominant sediments are (a) prominent-weathering, pale buff to greyish, tabular or ribbon-shaped sandstones up to 60m thick that are interbedded with (b) recessive-weathering, reddish or occasionally green-grey mudrocks. Up to four discrete sandstone packages can be identified within the succession. Katberg channel sandstones are typically rich in feldspar and lithic grains (*i.e.* lithofeldspathic). They build laterally extensive, multistorey units with an erosional base that is often marked by intraformational conglomerates up to one meter thick consisting of mudrock pebbles, reworked calcrete nodules and occasional rolled fragments of bone. The basal Katberg succession is often marked by a major cliff-forming sandstone unit, as in the present study region. Internally the moderately well-sorted sandstones are variously massive, horizontally-laminated or cross-bedded and heavy mineral laminae occur frequently. Sphaeroidal carbonate concretions up to 10 cm across are common. The predominantly reddish Katberg mudrocks are typically massive with horizons of pedocrete nodules (calcretes), and mudcracks. Mudrock exposure within the study area is limited by extensive mantling of these recessive-weathering rocks by superficial sediments.

Sandstone deposition was mainly due to intermittently flooding, low-sinuosity braided river systems flowing northwards from the rising Cape Fold Belt mountains in the south into the subsiding Main Karoo Basin (Fig. 6). Mudrocks were largely laid down by suspension settling within overbank areas following episodic inundation events, while other fine-grained sediments are associated with lakes and temporary playas in lower-lying areas on the arid floodplain, especially in the northern Katberg outcrop area and its lateral correlatives in the Burgersdorp Formation. Palaeoclimates inferred for the Early Triassic Period in the Main Karoo Basin were arid with highly seasonal rainfall and extensive periods of drought. This is suggested by the abundant oxidised ("rusty red") mudrocks, desiccation cracks, and palaeosols associated with well-developed calcretes. Arid settings are also supported by taphonomic and behavioural evidence such as pervasive carbonate encrustation of fossil bones, mummification of postcrania, bone-bed death assemblages associated with water holes and the frequency of burrowing habits among tetrapods, including large dicynodonts like *Lystrosaurus* (Groenewald 1991, Smith & Botha 2005).

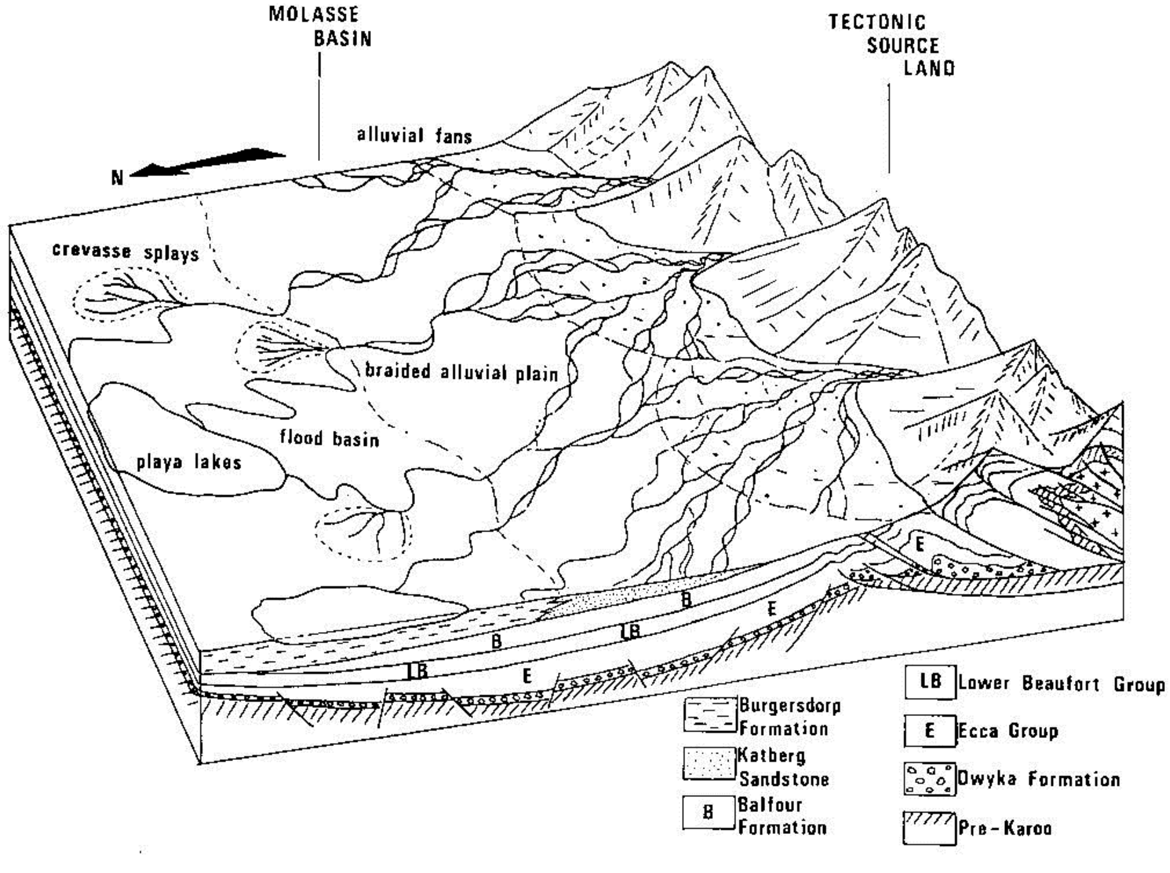


**Fig. 6: Reconstruction of the south-eastern part of the Main Karoo Basin in Early Triassic times showing the deposition of the sandy Katberg Formation near the mountainous source area in the south. The mudrock-dominated Burgersdorp Formation was deposited on the distal floodplain where numerous playa lakes are also found (From Hiller & Stavrakis 1984).**

According to Johnson (1966) and Johnson and Caston (1979) the Katberg Formation in the south-western corner of the Kei Mouth sheet is approximately 900m thick and consists largely of fine- to medium-grained lithic sandstones that are pale reddish-grey in colour and contain pebbles. There is very little mudrock within the succession here which is attributed to deposition within braided river systems. The occurrence of sparse, scattered pebbles - rather than pebbly conglomerates - of varied lithologies and diameters up to 12-15cm within the Katberg beds ("Middle Beaufort Stage") east of Grahamstown, including the Kwelera outcrop area, was noted by Mountain (1939, 1946, 1974; see also Theron 1975, Dingle *et al.* 1983, Stavrakis 1980, Hiller & Stavrakis 1980, Cole & Wipplinger 2001). Pebble types mentioned include quartzite, granite, quartz porphyry and fossil wood, among others, all of which were seen during the present field study. Bordy *et al.* (2010) have additionally noted pebbles of sandstone, conglomerate, mudstone and rhyolite in the East London area. Ongoing basin analysis and provenance studies by Bordy *et al.* (2010) suggest a transition between braided to meandering fluvial styles in semi-arid climatic settings for the Tarkastad Group in the Eastern Cape. Palaeocurrents here are directed towards the north-northwest. Analysis of pebble clasts and litharenites indicate a recycled orogenic provenance, *i.e.* the southern branch of the Cape Fold Belt / Agulhas Plateau region (Theron 1975, D. Cole pers. comm. 2011 and Bordy *et al.* 2010; see Fig. 6 herein).

Katberg sandstones are exposed on Clippety Clop adjacent to the track climbing up the escarpment as well as in good cliff-top exposures (Locs. 043, 044, 045, 050). Here are seen thick-bedded, massive to horizontally laminated, medium- to coarse-grained, gritty sandstones with sparsely scattered, well-rounded pebbles. They are pale buff when fresh, and often show a pitted surface or even honey-comb weathering, probably due to impurities such as feldspars or lithic clasts. Dolerite-like sphaeroidal weathering into rounded, exfoliating boulders is also seen, overlain by a thin crumbly regolith (Figs. 7, 8).

Excellent coastal exposures of the sandstone-dominated lower Katberg Formation are seen southwest of Glengariff (Fig. 10; Loc. 052). The rocks here are medium- to thick-bedded, brown-weathering, massive to horizontall- laminated sandstones with almost no interbedded mudrocks. Sedimentary structures include cut-and-fill channels, trough cross-bedding, and occasional flat-laminated, thin-bedded sandstones with well-developed primary current lineation. Palaeocurrents are consistently towards the north or northeast. Sparse scattered pebbles of various lithologies, including rare silicified wood clasts, are seen here. Horizons of diagnetically-modified, silicified calcrete nodules associated with pebbles and (often ferruginised) mudflakes are common (Fig. 11). Several lenticels of coarse breccias composed of reworked blocks of laminated sandstone and honeycomb-weathered calcareous siltstone up to 20cm in diameter within a coarser sandstone matrix were also observed; these may reflect channel collapse and early pedogenic cementation of some bank sediments.

**Fig. 7. Pinkish-brown weathering Katberg sandstones at Loc. 043 dipping gently to the northeast.**

**Fig. 8. Katberg sandstones in roadcut (Loc. 044) showing sphaeroidal-like weathering pattern (Scale = 16 cm).**

**Fig. 9. Exposure of Katberg sandstones along NE edge of large dam on plateau (Locs. 045-046). The Triassic bedrock here is overlain by thin ferruginous gravels and *c*. 1m of silty soil.**

**Fig. 10. Excellent coastal exposure of gently-dipping, tabular sandstones of the Katberg Formation looking northwards towards Glengariff.**

**Fig. 11. Secondarily silicified calcrete nodules within the coastal Katberg sandtone outcrop. Note also well-rounded quartzite pebble (Scale marked in cm) (LOc. 052).**

### 3.3. Karoo Dolerite Suite

In the East London region the Balfour and Katberg Formations have been extensively intruded and baked by dolerite sills in the Early Jurassic (183 Ma) **Karoo Dolerite Suite** (**Jd**; *cf* Duncan & Marsh 2006). A narrow WNW-ESE dolerite intrusion (sill or dyke) transects the broader study region south-west of the Kwelera River, and a parallel, larger intrusion extends out to Kwelera Point to the SE (Fig. 5). However, no dolerites are mapped within the study area itself.

### 3.4. Late Caenozoic superficial deposits

A range of superficial deposits of probable Quaternary to Recent age mantle most of the Beaufort Group bedrocks within the study area. According to the preliminary geotechnical investigation by Dr GV Price of Terreco Geotechnical cc alluvial sediments mantle the inside bend of the Kwelera River "extending virtually to the river"s intersection with the cliff scarp". Deep soils are present on the gentle pediment slopes at the foot of the Katberg scarp, and deep to very deep clayey and silty soils along the estuarine edge of the river. It is likely that the Beaufort Group bedrock, especially the potentially fossil-bearing mudrock component, is deeply weathered here. A geotechnical report for an adjacent development project prepared by Walters and Associates of East London (See Almond 2011) shows that the Beaufort Group bedrock in low-lying area close to the Kwelera River is mantled in a thick (>3.3m at 100m distance from the riverbanks) layer of alluvial deposits, as expected on the inside of a meander bend. These deposits comprise silty-clay with rounded sandstone cobbles overlain by finer-grained silty and sandy alluvium.

Thick silty soils and dark estuarine to alluvial muds are exposed around the margins of several small dams and in the banks of the Kwelera River in the lower portion of the Clippety Clop study area (Fig. 4). Bouldery colluvium mantles the forested footslopes of the Katberg escarpment. The more gently-sloping parts of the Katberg outcrop are mantled in one or more meters of silty, grey-brown soil with embedded gravels and boulders of sandstone as well as thin lenticles or layers of ferruginous gravels (Loc. 042). These gravels are better exposed around the edge of the dams on the plateau (Locs. 045, 048, 049; Fig. 9) as well as along dirt tracks (Loc. 051). They typically contain well-rounded to fractured pebbles of various exotic, extra-basinal lithologies (granite, gneiss, quartzite, silicified wood) that have weathered out of the underlying Katberg sandstones and that have then been reworked or down-wasted on the coastal platform (See discussion of and references to Katberg pebbles above) (Figs. 14, 15). Some of the finer-grained pebbles have been flaked into stone artefacts.

# 4. PALAEONTOLOGICAL HERITAGE

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. A chronological series of mappable fossil biozones or assemblage zones, 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 show that their boundaries remain uncertain in the near-coastal region of the Eastern Cape (Rubidge 1995, 2005). Without further fossil collecting, it is therefore not yet possible to positively identify the specific Beaufort fossil assemblage zone(s) involved at many study sites in this region, and therefore the particular fossil remains (species, genera) that might be encountered there during development.

## 4.1. Fossils in the Adelaide Subgroup

The Beaufort sediments close to the Katberg sandstone contact in the northeastern part of the study area can be assigned to the Balfour Formation, the greater part of which (above the basal sandstone-dominated Oudeberg Member) is characterised by Late Permian fossil biotas of the ***Dicynodon* Assemblage Zone**. 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).

The generally very low levels of exposure of Lower Beaufort Group seen in the East London area is due to deep post-Gondwana weathering as well as extensive soil development and high levels of vegetation cover in modern humid, pluvial climates. Roadcuts (*e.g.* along the N2 freeway) and steep-sided river valleys (*e.g.* in East London itself) mainly feature the more resistant dolerites and channel sandstones while the potentially more highly fossiliferous Beaufort Group mudrock horizons are very poorly exposed (Almond 2011a). For these reasons alone, the Late Palaeozoic fossil record of the East London area is very poorly known, with most records coming from the better exposed coastal zone (*e.g.* Mountain 1974, Nicolas 2007).

Older data on Lower Beaufort Group fossil records in the East London area has been provided by Mountain (1974, p. 12) and Kitching (1977, pp. 53, 62). It is notable that many of these early records explicitly refer to badly preserved specimens. Poorly preserved therapsids, mostly dicynodonts referable to the *Cistecephalus* Assemblage Zone, as well as unidentified plant remains were collected near East London (on the left bank of the Buffalo River and on the shore) in the eighteenth century by George Gordon McKay. The dicynodont *Oudenodon*, which ranges through the *Cistecephalus* and *Dicynodon* Assemblage Zones, is recorded from close to the Qolora River Mouth, some 60km north-east of East London (Rogers & Schwarz 1902, p. 54).

Unnamed tetrapod fossils were recorded from the Morgans Bay area (just southwest of the Kei Mouth) to the north-east of East London by Plumstead (Mountain 1974, p.12). A *Cistecephalus* Assemblage Zone fossil biota including the dicynodonts *Dicynodon* (this genus ranges down below the *Dicynodon* AZ itself; Rubidge 1995) and *Oudenodon* as well as other, unidentified small- and medium-sized dicynodonts, the gorgonopsian *Lycaenops* and plant fossils of the *Glossopteris* flora (*Glossopteris* spp., sphenophytes) was collected by Kitching from intertidal coastal exposures intruded by dolerite at Morgans Bay, Komga in 1954 (Mountain 1974, p. 12; Kitching 1977, p. 62). Kitching (1977, p. 53) records the following therapsid genera from "small, scanty exposures next to the Nahoon River towards Arnoldton and Kidd"s Beach", *i.e.* along the coast to the southwest of East London: the dicynodonts *Aulacephalus* [= *Aulacephalodon*?], *Pristerodon* and *Oudenodon* as well as an indeterminate theriodont ("*Lycosuchus*"). Kitching referred this biota to "strata below the *Cistecephalus* band. The "*Cistecephalus* Band" is a potential acme zone that occurs high up within the *Cistecephalus* Assemblage Zone and so Kitching"s fauna may well belong the latter assemblage zone. 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 (Almond 2011a). It has been provisionally referred to the basket-genus *Dadoxylon* and is probably of gymnospermous affinities for the most part (*cf* Bamford 1999, 2004).

Much of the fossil material mentioned above is probably curated in the collections of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg. Small displays of local Beaufort Group and other fossils are also presented at the Amatole Museum (previously Kaffrarian Museum), King William"s Town, and the East London Museum.

Good accounts, with detailed faunal lists, of the fossil biotas of the *Dicynodon* Assemblage Zone have been given by Kitching (*in* Rubidge 1995) and by Cole *et al*. (2004). See also the reviews by Cluver (1978), MacRae (1999), McCarthy & Rubidge (2005) and Almond *et al*. (2008). In general, the following broad categories of fossils might be expected within the Balfour Formation near East London:

- isolated petrified bones as well as articulated skeletons of terrestrial vertebrates such as true **reptiles** (notably large pareiasaurs, small millerettids) and **therapsids** (diverse dicynodonts such as *Dicynodon* and the much smaller *Diictodon*, gorgonopsians, therocephalians such as *Theriognathus*, primitive cynodonts like *Procynosuchus*, and biarmosuchians) (See Fig. 12 herein);
- aquatic vertebrates such as large temnospondyl **amphibians** like *Rhinesuchus* (usually disarticulated), and palaeoniscoid **bony fish** (*Atherstonia*, *Namaichthys*);
- freshwater **bivalves;**
- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites;
- **vascular plant remains** including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterids and arthrophytes (horsetails).

From a palaeontological viewpoint, these diverse *Dicynodon* 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*., 2003, 2006).

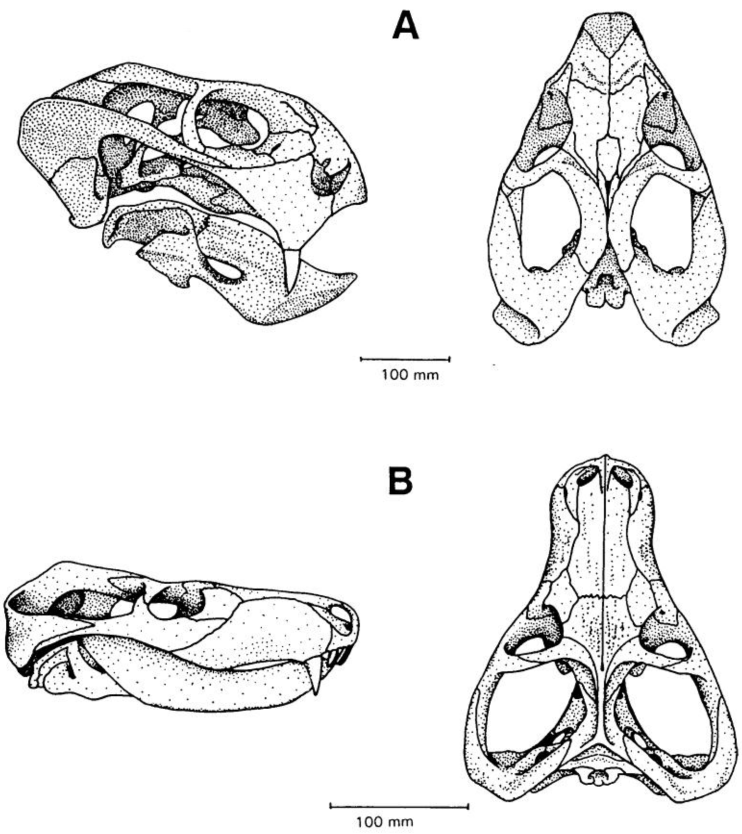


**Fig. 12. Skulls of key therapsids ("mammal-like reptiles") from the Late Permian *Dicynodon* Assemblage Zone: the dicynodont *Dicynodon* and the therocephalian *Theriognathus* (From Kitching *in* Rubidge 1995).**

As far as the biostratigraphically important tetrapod remains are concerned, the best fossil material 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. The abundance and variety of fossils within the *Dicynodon* Assemblage Zone decreases towards the top of the succession (Cole *et al*., 2004).

As a consequence of their proximity to large dolerite intrusions in the East London – King Williams Town / Bisho area, the Beaufort Group sediments here often been thermally metamorphosed or "baked" (*ie*. 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. The neighbouring dolerite intrusions are themselves of no palaeontological significance since these are high temperature igneous rocks.

No fossils were observed within the Adelaide Subgroup rocks exposed on Clippety Clop, along the nearby coast, or in extensive roadcuttings in the Kwelera River area (Loc. 055). The sedimentological evidence for moist, swampy substrates here may suggest that the environment was somehow unsuitable for terrestrial tetrapods, but this is highly speculative. The lack of well-developed pedocrete horizons, with which fossilized skeletal remains are frequently associated in the Beaufort Group, may be significant and suggest a possible taphonomic control of fossil abundance and distribution.

### 4.2. Fossils in the Katberg Formation

The Katberg Formation is known to host a low-diversity but palaeontologically important terrestrial fossil biota of Early Triassic (Scythian / Induan - Early Olenekian) age, *i.e.* around 250 million years old (Groenewald & Kitching 1995, Rubidge 2005). The biota is dominated by a small range of therapsids ("mammal-like reptiles"), amphibians and other tetrapods, with rare vascular plants and trace fossils, and has been assigned to the ***Lystrosaurus* Assemblage Zone** (**LAZ**). This impoverished fossil assemblage characterizes Early Triassic successions of the upper part of the Palingkloof Member (Adelaide Subgroup) as well as the Katberg Formation and - according to some earlier authors – the lowermost Burgersdorp Formations of the Tarkstad Subgroup. Recent research has emphasized the rapidity of faunal turnover during the transition between the sand-dominated Katberg Formation (*Lystrosaurus* Assemblage Zone) and the overlying mudrock-dominated Burgersdorp Formation (*Cynognathus* Assemblage Zone) (Neveling *et al.* 2005). In the proximal (southern) part of the basin the abrupt faunal turnover occurs within the uppermost sandstones of the Katberg Formation and the lowermost sandstones of the Burgersdorp Formation (*ibid*., p.83 and Neveling 2004). This work shows that the *Cynognathus* Assemblage Zone correlates with the entire Burgersdorp Formation; previous authors had proposed that the lowermost Burgersdorp beds belonged to the *Lystrosaurus* Assemblage Zone (*e.g.* Keyser & Smith 1977-78, Johnson & Hiller 1990, Kitching 1995). It should also be noted that the dicynodont *Lystrosaurus* has now been recorded from the uppermost beds of the Latest Permian *Dicynodon* Assemblage Zone but only becomes super-abundant in Early Triassic times (*e.g.* Smith & Botha 2005, Botha & Smith 2007 and refs. therein).

Useful illustrated accounts of LAZ fossils are given by Kitching (1977), Keyser and Smith (1977-1978), Groenewald and Kitching (1995), MacRae (1999), Hancox (2000), Smith *et al.* (2002), Cole *et al*. (2004), Rubidge (2005 *plus* refs therein) and Damiani *et al.* (2003a), among others. These fossil biotas are of special palaeontological significance in that they document the recovery phase of terrestrial ecosystems following the catastrophic end-Permian Mass Extinction of 251.4 million years ago (*e.g.* Smith & Botha 2005, Botha & Smith 2007 and refs. therein). They also provide interesting insights into the adaptations and taphonomy of terrestrial animals and plants during a particularly stressful, arid phase of Earth history in the Early Triassic.

Key tetrapods in the *Lystrosaurus* Assemblage Zone biota are various species of the medium-sized, shovel-snouted dicynodont *Lystrosaurus* (by far the commonest fossil form in this biozone. contributing up to 95% of fossils found), the small captorhinid parareptile *Procolophon*, the crocodile-like early archosaur *Proterosuchus*, and a wide range of small to large armour-plated "labyrinthodont" amphibians such as *Lydekkerina* (Fig. 13). Botha and Smith (2007) have charted the ranges of several discrete *Lystrosaurus* species either side of the Permo-Triassic boundary. Also present in the LAZ are several genera of small-bodied true reptiles (*e.g.* owenettids), therocephalians, and early cynodonts (*e.g. Galesaurus, Thrinaxodon*). Animal burrows are attributable to various aquatic and land-living invertebrates, including arthropods (*e.g. Scoyenia* scratch burrows), as well as several subgroups of fossorial tetrapods such as cynodonts, procolophonids and even *Lystrosaurus* itself (*e.g.* Groenewald 1991, Damiani *et al.* 2003b, Abdala *et al.* 2006, Modesto & Brink 2010, Bordy *et al.* 2009, 2011). Vascular plant fossils are generally rare and include petrified wood ("*Dadoxylon*") as well as leaves of glossopterid progymnosperms and arthrophyte ferns (*Schizoneura*, *Phyllotheca*). An important, albeit poorly-preserved, basal Katberg palaeoflora has recently been documented from the Noupoort area (Carlton Heights) by Gastaldo *et al.* (2005). Plant taxa here include sphenopsid axes, dispersed fern pinnules and possible peltasperm (seed fern) reproductive structures. Pebbles of reworked silicified wood of possible post-Devonian age occur within the Katberg sandstones (Hiller & Stavrakis 1980). Between typical fossil assemblages of the *Lystrosaurus* and *Cynognathus* Assemblage Zones lies a possible *Procolophon* Acme Zone characterized by abundant material of procolophonids and of the amphibian *Kestrosaurus* but lacking both *Lystrosaurus* and *Cynognathus* (Hancox 2000 and refs. therein).

Most vertebrate fossils are found in the mudrock facies rather than channel sandstones. Articulated skeletons enclosed by calcareous pedogenic nodules are locally common, while intact procolophonids, dicynodonts and cynodonts have been recorded from burrow infills (Groenewald and Kitching, 1995). Fragmentary rolled bone is found in the intraformational conglomerates at the base of some the channel sandstones.

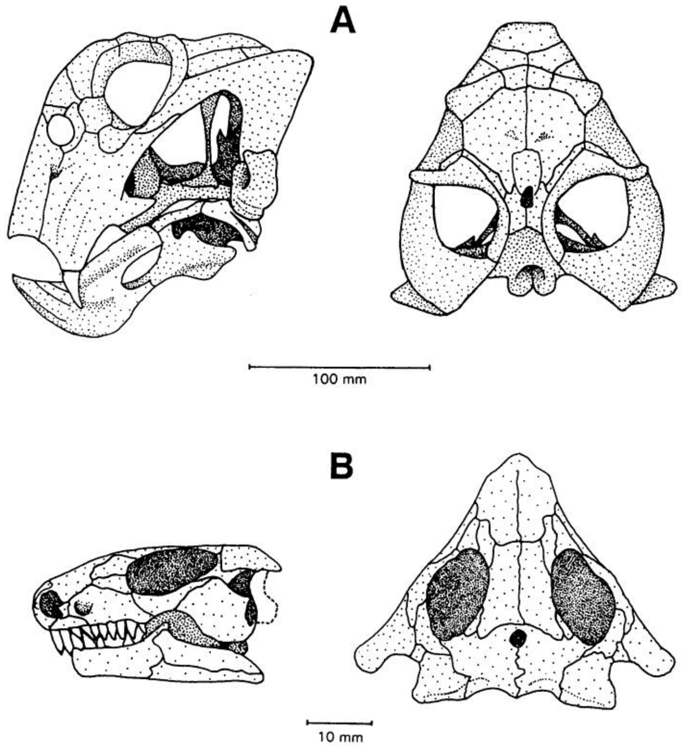


**Fig. 13: Skulls of two key tetrapod genera from the Early Triassic *Lystrosaurus* Assemblage Zone of the Main Karoo Basin: the pig-sized dicynodont *Lystrosaurus* (A) and the small primitive reptile *Procolophon* (B) (From Groenewald and Kitching, 1995).**

No *in situ* fossils were observed within the Katberg Formation sandstones on Clippety Clop, and only rare silicified wood clasts were seen *in situ* in the much better coastal exposures near Glengariff (Fig. 16). However, it is clear from the frequency of fossil wood clasts concentrated within downwasted *remanié* gravels on the coastal platform north of East London that significant woody material is indeed scattered through the Katberg sandstones here, as has been observed by a number of previous authors (See discussion and references in Section 3.2 above, including Mountain 1939, Mountain 1974, Hiller & Stavrakis 1980, Dingle *et al.* 1983, Cole & Wipplinger 2001, Bordy *et al.* 2010). This is notable in view of the marked paucity of Early Triassic plant fossils within the Katberg Formation (Gastaldo *et al.* 2005; see above). Also of interest is the occurrence of significant quantities of silicified gymnospermous woods within weathering profile silcretes at Fort Grey, some 15km west of East London. Microscopic analysis shows that these woods have been reworked from the nearby Beaufort Group rocks and are not Tertiary in age as previously supposed (Adamson 1934, Roberts *et al.* 1997). On the basis of their detailed morphology a Triassic rather than Permian age was preferred for at least some of these fossil woods by Bamford *et al.* (1997, p. 165), although only Lower Beaufort Group rocks currently crop out in this area.

Hiller and Stavrakis (1980) suggest only a “possible post-Devonian” age for the fossil woods preserved as pebbles within the Katberg Formation of the Eastern Cape (Note that the first woody trees, the progymnosperm *Archaeopteris*, appeared in Late Devonian times. This genus is represented in the Witpoort Formation of the Eastern Cape, though not as perminalised woods; Anderson *et al.* 1995). Some of the Katberg reworked woods show well-developed growth rings, resembling highly seasonal Lower Beaufort woods in this respect. Others fragments are, at least superficially, homogeneous in appearance and look like chert; they can only be recognised as of plant origin using a hand lens, when the beautiful cellular preservation becomes apparent. Careful examination of pediment gravel occurrences overlying the Katberg outcrop in the coastal platform area around East London should yield more and better-preserved fossil material.

The petrified wood fragments found at Clippety Clop are all small (few cm maximum dimensions) and are mainly to be found in ferruginous gravels of probable Late Tertiary or Quaternary age (since they also contain stone artefacts). They are associated here with polymict well-rounded pebbles (Figs. 14-15). The latter – like the tough petrified wood clasts themselves, some of which are also well-rounded – are clearly down-wasted from the underlying Katberg sandstone outcrop which contains sparse *in situ* pebbles of various exotic (extra-basinal) lithologies. The impression is that the woods were *already* silicified by the time they were incorporated into the Katberg fluvial sandstones, and are therefore of pre-Katberg (pre-Early Triassic) age, but this requires confirmation. They may have been eroded out of Permian Lower Beaufort beds that were probably exposed in the southern provenance area in Early Triassic times (D. Cole, pers. comm., 2011; Fig. 6 herein) but an older, pre-Permian age is also possible. The age and stratigraphic provenance of the reworked fossil woods may be resolved by microscopic examination (M. Bamford, pers. comm., 2011).

### 4.3. Fossils within the superficial deposits

The only fossils observed within the Clippety Clop study area are small pieces of silicified woods reworked from the Katberg Formation into thin, ferruginous gravels of probable Quaternary age, where they are associated with stone artefacts. These interesting fossil remains have been discussed in the previous section of this report.

**Fig. 14. Well-rounded polymict pebbles (RHS), stone artefacts (centre) and fragments of silicified wood (LHS) from ferruginous gravels overlying Katberg sandstones at Loc. 047. The pebble clasts and fossil wood material have eroded out of the underlying Katberg sandstones (Scale in cm).**

**Fig. 15. Detail of fragments of silicified woods shown in previous figure. Note that some clasts are well-rounded.**

**Fig. 16.** ***In situ*****, well-rounded clast of silicified wood embedded within Katberg sandstones along the coast southwest of Glengariff (Loc. 052) (Scale in cm). These fossil wood fragments are inferred to have been eroded out of pre-Triassic sediments within the provenance area of the Katberg Formation to the south of the present-day African coastline.**

## 5. CONCLUSIONS & RECOMMENDATIONS

The proposed Clippety Clop development footprint overlies the outcrop area of the Late Permian Adelaide Subgroup (= Lower Beaufort Group). Higher ground to the northeast is built of Katberg Formation sandstones (Early Triassic Tarkastad Subgroup = Upper Beaufort Group). Petrified fossil wood, eroded from the underlying Katberg sandstones, occurs within thin gravels of probable Quaternary age overlying the plateau. However, this area will not be directly impacted by the holiday home development. The overall impact of the proposed resort project on local palaeontological heritage is likely to be very minor because the potentially fossiliferous Lower Beaufort Group sediments affected are (a) deeply weathered, (b) sparsely fossiliferous, (c) may have been extensively baked by nearby dolerite intrusions, and (d) are mostly covered with a thick mantle of fossil-poor alluvium. Further palaeontological specialist studies or mitigation of this development is therefore not regarded as necessary.

Nevertheless, deep excavations into fresher (unweathered) Beaufort Group bedrock during the proposed development may reveal palaeontologically useful fossil material of Late Permian or Early Triassic age. Fossil vertebrates from these beds would be of particular interest because there has been little formal collection in this area and new finds may well help resolve current ambiguities regarding the Beaufort Group biostratigraphy in the Eastern Cape coastal region.

It is therefore recommended that any substantial, fresh exposures of Beaufort Group sediments created during construction (*e.g.* in newly excavated borrow pits for road or building material) should be inspected at intervals by the responsible Environmental Control Officer (ECO). It is also strongly recommended that the ECO for this development visit a Karoo palaeontological display (*e.g.* at the Albany Museum, Grahamstown, or East London Museum) before the start of operations so that they acquire some familiarity with the appearance of typical Beaufort Group and younger fossil material. Well-illustrated and accessible accounts of Karoo fossils that may help in the recognition of Beaufort Group fossils have been published by Cluver (1978), MacRae (1999) and McCarthy and Rubidge (2005).

Should fossils be encountered during excavations, they should be carefully recorded (aerial photo, 1: 50 000 map or GPS reading) and safeguarded by the ECO, if possible *in situ*. Specimens without locality information are of limited scientific value. The fossils should be reported to SAHRA and submitted for inspection by a professional palaeontologist at the earliest opportunity. Some of this material may be of scientific interest - in which case it should be deposited ultimately in an approved repository (*e.g.* Albany Museum, Grahamstown or East London Museum) – while other specimens may be of educational value and might be donated for display purposes.

If well-articulated skeletons or other substantial fossil remains are encountered during construction, they should *NOT* be informally excavated since this will almost invariably lead to damage and loss of useful contextual information (*e.g.* taphonomy – data on mode of death and burial of animals). If feasible, they should be photographed (with scale), covered with a protective layer of loose sediment, and the site marked and carefully recorded (GPS / 1: 50 000 map / aerial photograph). The Environmental Control Officer should immediately inform SAHRA or the responsible palaeontologist at the Albany Museum (Dr Billy de Klerk, 046-622 2312; b.deklerk@ru.ac.za) so that specimens can be examined and, if necessary, professionally excavated.


## 6. ACKNOWLEDGEMENTS

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## 8. GPS DATA FOR LOCALITIES

GPS locality data is given in the table below for all localities mentioned by number in the text.

Locality data was captured on a hand-held Garmin GPSmap 60CSx instrument to an accuracy of *c*. 3m.

| GPS LOCALITY NO. | SOUTH | NORTH |
|---|---|---|
| **041** | 32º 53" 22.2” | 28º 03" 39.6” |
| **042** | 32º 53" 12.7” | 28º 03" 31.3” |
| **043** | 32º 53" 13.3” | 28º 03" 34.2” |
| **044** | 32º 53" 13.2” | 28º 03" 35.3” |
| **045** | 32º 53" 15.3” | 28º 03" 43.9” |
| **046** | 32º 53" 15.4” | 28º 03" 44.0” |
| **047** | 32º 53" 15.4” | 28º 03" 44.2” |
| **048** | 32º 53"13.9” | 28º 03" 42.9” |
| **049** | 32º 53" 18.0” | 28º 03" 49.1” |
| **050** | 32º 53" 24.2” | 28º 03" 51.9” |
| **051** | 32º 53" 20.7” | 28º 03" 48.7” |
| **052** | 32º 53" 40.9” | 28º 05" 26.7” |
| **054** | 32º 53" 53.3” | 28º 05" 04.0” |
| **055** | 32º 53" 09.9” | 28º 01" 57.4” |

## 8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

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

John E. Almond

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