PALAEONTOLOGICAL IMPACT ASSESSMENT: DESKTOP STUDY

PROPOSED HOUSING DEVELOPMENT IN CENYU VILLAGE / CENYULANDS AREA, STUTTERHEIM, EASTERN CAPE

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1. SUMMARY

The proposed Cenyu Village / Cenyulands housing development footprint on Erf 8012 on the north-eastern outskirts of Stutterheim, Eastern Cape, is underlain by (1) a major intrusion of Jurassic dolerite (Karoo Dolerite Suite) in the north and by (2) mudrock-dominated fluvial sediments forming the upper part of the Late Permian Balfour Formation (Lower Beaufort Group, Karoo Supergroup) in the south. The dolerites are entirely unfossiliferous. The adjacent Balfour Formation rocks might contain a range of Late Permian vertebrate fossils (reptiles, therapsids, amphibians and fish), trace fossils, non-marine bivalves and plant remains (*e.g.* petrified wood). There are several records of Beaufort Group vertebrate fossils from the Stutterheim area, including medium-sized therapsids ("mammal-like reptiles"). Fossil assemblages within the uppermost Balfour Formation are of special palaeontological interest in that they document the catastrophic mass extinction episode at the end of the Permian Period, *c*. 251 million years ago.

The impact significance of the proposed housing development in terms of local palaeontological heritage is rated as LOW, however, because:

- Much of the footprint is underlain by unfossilferous dolerite;
- the potentially fossiliferous bedrocks are mantled in thick soils and are highly weathered;
- baking of sediments during dolerite intrusion has probably compromised their fossil content;
- fossil abundance is generally low within the upper part of the Balfour Formation.

Fresh exposures of Beaufort Group sediments created during the construction phase of the development should be inspected at intervals by the responsible Environmental Control Officer (ECO). Should *loose* fossils be encountered during excavations, their location should be recorded, they should be carefully collected, with adherent matrix where necessary, given a provisional reference number (*e.g.* marked on masking tape) and carefully wrapped in newspaper. The fossils should be 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 *in situ,* articulated skeletons or other substantial fossil remains are encountered during excavation, 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 a suitably qualified palaeontologist so that specimens can be examined, recorded and, if necessary, professionally excavated.

2. INTRODUCTION & BRIEF

The Eastern Cape Department of Housing is proposing a housing development (Cenyu Village / Cenyulands) on Erf 8012 on the north-eastern outskirts of the town of Stutterheim, situated about 80 km northwest of East London, Eastern Cape (Figs. 1 & 2). The housing project comprises 450 erven of which 442 have been earmarked as residential erven. 330 of these are in a greenfield area while the remaining 112 are within an existing housing area.

According to the Draft Scoping Report prepared by Arcus Gibb Engineering & Science, East London, the proposed development will also involve the following main infrastructural components:

- Construction and/or rehabilitatation of approximately 8.0km of internal gravel roads (3 to 5 m wide) and approximately 6km of stormwater drainage;
- Installation of 6.0km of new uPVC internal water supply reticulation, including 20 new standpipes, 23 gate valves, 18 fire hydrants and all associated couplings and fittings;
- Construct of 375 new ventilated improved pit latrine (VIP) toilets, *i.e.* one per erf;
- Rehabilitatation of 67 existing VIP toilets;
- Construction of a new water pump station complete together with a 1.4km rising main;
- Construction of a new 81 Kilolitre elevated reservoir including all pipes and fittings.

The proposed development footprint overlies dolerite (an unfossiliferous igneous rock) and potentially fossiliferous sedimentary rocks of the Lower Beaufort Group (Adelaide Subgroup) of Late Permian age. A desktop study of the potential impact of the proposed development on palaeontological heritage has therefore been commissioned on behalf of the developer by Arcus Gibb Engineering & Science, East London, as part of a comprehensive EIA for this housing project, in accordance with the requirements of the National Heritage Resources Act, 1999. The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

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

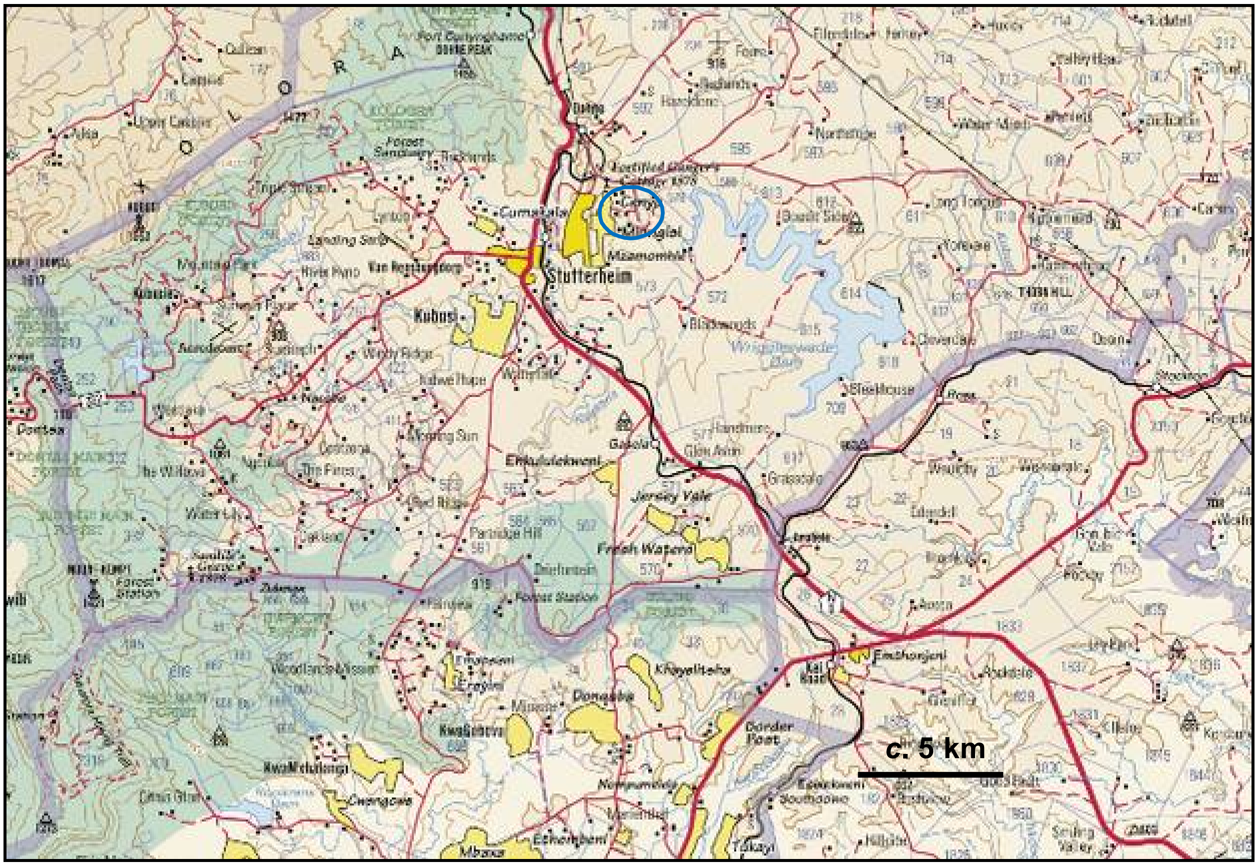

Fig. 1. Extract from 1: 250 000 topographical map 3226 King William's Town (courtesy of the Chief Directorate: National Geo-spatial Information) showing approximate location of the Cenyu development site on the northeastern outskirts of Stutterheim (blue ellipse).

Approach to this desktop palaeontological assessment (PIA)

This desktop PIA report provides an assessment of the observed or inferred palaeontological heritage within the 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 earlier palaeontological impact assessments for the East London – Stutterheim region; (2) published geological maps and accompanying sheet explanations, as well as (3) the author's field experience with the formations concerned and their palaeontological heritage. In addition, a brief site visit was made by the author on 8th December 2011 to supplement data from the desktop study.

When preparing a palaeontological desktop assessment the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The currently recorded fossil heritage within each unit is determined from the published scientific literature and the author's field experience. This data is then used to asses the palaeontological sensitivity of each rock unit to development (*N.B.* A tabulation of palaeontological sensitivity of all formations in the Eastern Cape has already been compiled by Almond *et al*., 2008).

The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the rock units concerned and (2) the nature of the development itself, most notably the extent of fresh bedrock excavation envisaged. Adverse palaeontological impacts normally occur during the construction rather than operational phase. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological 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 (*e.g.* SAHRA for the Eastern Cape). 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.

Assumptions made for the PIA desktop study

Note that while fossil localities recorded within the study area itself are obviously highly relevant, most fossil heritage is buried beneath the land surface or obscured by surface deposits (soil, alluvium *etc*) and vegetation cover. The hidden fossil resources therefore have to be inferred from palaeontological observations made within the same formations elsewhere in the region, or even further afield (*e.g.* an adjacent province). Here it is assumed that fossil heritage is fairly uniformly distributed throughout the outcrop area of a given formation. Experience shows that this assumption does not always hold. This is because the original depositional setting across a formation that may extend over hundreds of kilometres may vary significantly, with palaeoecological implications (*e.g.* from a shallow to deeper water environment), while fossils are often patchy in their occurrence. Furthermore, the levels of tectonic deformation (folding, cleavage development *etc*), as well as the intensity and nature of metamorphism and weathering experienced by a given formation may change markedly across its outcrop area. These factors may seriously compromise the preservation of fossil remains present within the original sedimentary rock.

Fig. 2. Aerial image of the Cenyu Village / Cenyulands area on the north-eastern outskirts of Stutterheim showing location of proposed new housing developments (red polygons) (Image kindly provided by Arcus Gibb Engineering & Science, East London).

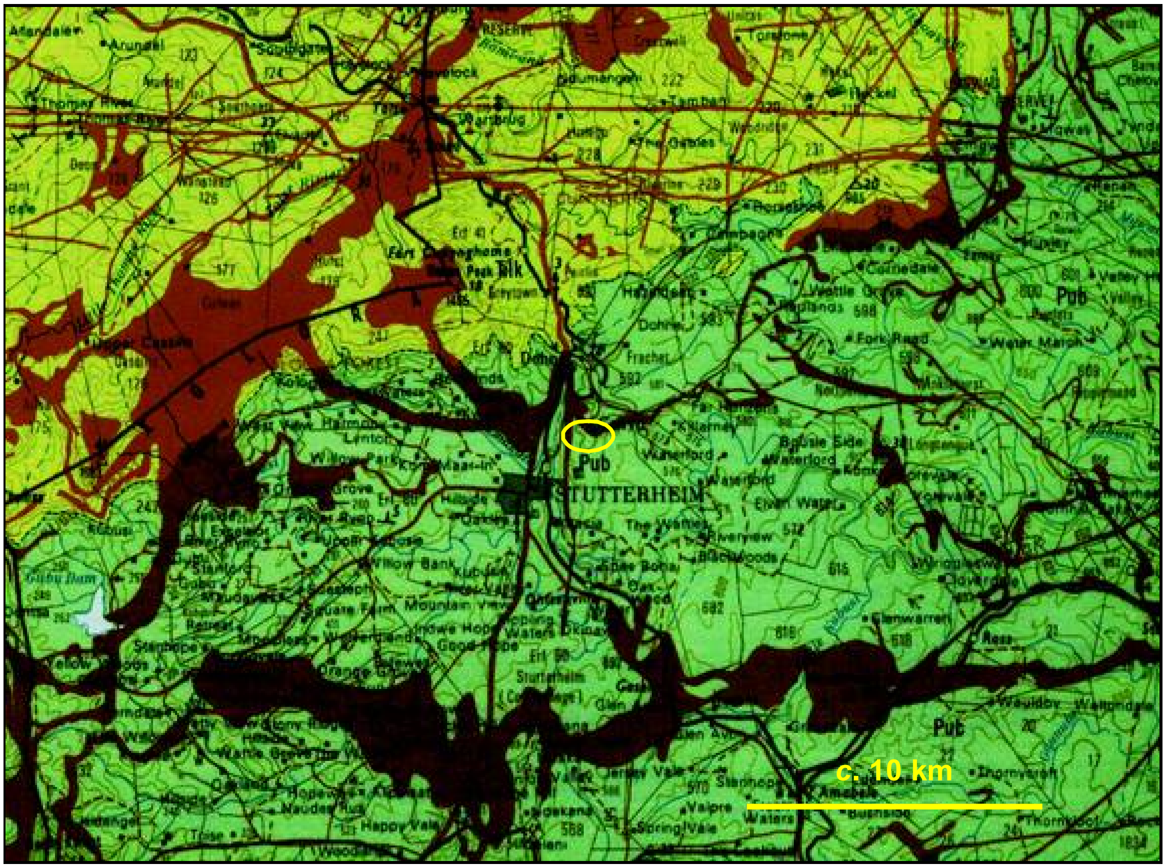

Fig. 3. Extract from 1: 250 000 geological map sheet 3226 King William's Town (Council for Geoscience, Pretoria) showing approximate location (yellow ellipse) of the proposed Cenyu Village / Cenyulands housing development near Stutterheim, Eastern Cape Province.

KEY GEOLOGICAL UNITS:

Dark brown (Jd) = Jurassic Karoo Dolerite Suite
Green (Pub) = Balfour Formation of the Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup
Yellow-green (Trlk) = Katberg Formation of the Upper Beaufort Group (Tarkastad Subgroup, Karoo Supergroup)
Superficial deposits such as Quaternary to Recent colluvium, alluvium are not shown here.

3. GEOLOGICAL BACKGROUND

The study area north-east of Stutterheim, east of the N6 East London to Queenstown tar road and west of the Wriggelswade Dam, comprises gently-sloping ground either side of and across a low, south-facing escarpment founded on an extensive, resistent-weathering dolerite sill (Figs. 2, 3). Elevations range from 930m amsl in the north (northern edge of the Cenyu Village area) down to around 775m amsl in the southeastern corner of the Cenyulands area. The latter is traversed by several small south-eastwards-flowing streams draining the dolerite escarpment. Densely vegetated steeper slopes just below the escarpment edge are seen to the east of the study area. In general, levels of bedrock outcrop – especially Karoo mudrocks - in the region are poor.

The geology of the Stutterheim area is outlined on 1: 250 000 geology sheet 3226 King William's Town (Fig. 3; Council for Geoscience, Pretoria). A very brief geological explanation for this sheet is printed on the map, and there is a useful separate report by Mountain (1974) on the geology of the East London area. The study area is largely underlain by Late Palaeozoic continental (fluvial) sediments of the **Lower Beaufort Group** (**Adelaide Subgroup**). Due to poor exposure, the Adelaide Subgroup outcrop area has not been clearly subdivided at the formational level over much of the broader East London region (Mountain 1974, Johnson & Caston 1979). However the mudrock-dominated uppermost Adelaide Subgroup succession near Stutterheim, close to the contact of the sandstone-rich **Katberg Formation** (Trlk) of Early Triassic age, clearly belongs to the upper part of the Late Permian **Balfour Formation** (**Pub**), as shown on the geological map. Good exposures through the overlying buff-coloured Katberg Formation sandstones are seen along the N6 just to the north of Stutterheim (See also PIA report on these rocks by Groenewald 2011).

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 study region are generally very shallow (5º or less), 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), Grahamstown (Johnson & Le Roux 1994) as well as the more detailed report by Mountain (1974) for the East London area. In this subregion 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 bedrock, especially the potentially fossil-bearing mudrock component, is often deeply weathered here.

The fluvial **Balfour Formation** (**Pub**) comprises recessive weathering, grey to greenish-grey overbank mudrocks with subordinate resistant-weathering, grey, fine-grained channel sandstones deposited by large meandering river systems in the Late Permian Period (Johnson *et al.* 2006). Thin wave-rippled sandstones were laid down in transient playa lakes on the flood plain. Reddish mudrocks are comparatively rare, but increase in abundance towards the top of the Adelaide Subgroup succession near the upper contact with the Katberg Formation. The base of the Balfour succession is defined by a sandstone-rich zone, some 50m thick, known as the Oudeberg Member. Because of the predominance of recessive-weathering mudrocks, the Balfour Formation erodes readily to form low-lying *vlaktes* and gently hilly terrain, while extensive exposures of fresh (unweathered) bedrock are generally rare. Most of the Cenyulands area beneath the dolerite escarpment is underlain by Balfour Formation mudrocks. However, these are likely to be deeply weathered and according to the available geotechnical data (Draft Scoping Report, Arcus Gibb Engineering & Science) they are mantled with deep colluvial and residual, clay-rich soils. Fresh exposures of Balfour bedrocks are likely to be very rare here.

In the East London - Stutterheim region the Balfour Formation sediments have been extensively intruded and baked by dolerite sills of the Early Jurassic (183 Ma) **Karoo Dolerite Suite** (**Jd**) (Duncan & Marsh 2006). The west-east trending trace of an extensive dolerite sheet cuts across the Balfour Formation outcrop area just north of Stutterheim and underlies much of the present study area, particularly around Cenyu Village. Such major intrusions are likely to have thermally metamorphosed the country rock for a considerable distance on either side of their margins.

Weathered dolerite and large corestones of fresher dolerite are well seen in the large quarry (now in part rehabilitated as a sportsfield) inside the village area (Fig. 4). Dolerite also crops out on steeper slopes on the western edge of the village, while deep, reddish-brown ferruginous soils derived from weathered dolerite cover the plateau area around Cenyu (Fig. 5).

Fig. 4. Large dolerite corestones showing well-developed onion-skin weathering in the northern part of the main quarry at Cenyu Village.

Fig. 5. Reddish-brown ferruginous soils overlying weathered dolerite, with floating dolerite corestones, north-western outskirts of Cenyu village (Hammer = 30 cm).

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 (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 is currently in press (Van der Walt *et al*. in press).

Most 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), although some of these ambiguities may be resolved by the latest map of Van der Walt *et al.* (in press). GIS databases show that the density of fossil sites recorded within the East London region remain very low on the whole. This is probably due to factors such as low levels of outcrop, deep bedrock weathering, and extensive dolerite intrusion, although palaeoenvironmental factors may also have played a significant role here. However, there is a cluster of fossil Karoo vertebrate records from the neighbourhood of Stutterheim, though at this scale it is unclear if they refer to the Balfour or Katberg Formation (Nicolas 2007, Fig. 6 herein). Fossil remains from the uppermost Balfour Formation here, close to the contact with the overlying Katberg sandstones, belong to the latest Permian *Dicynodon* Assemblage Zone (Rubidge 1995). Given the current paucity of palaeontological data from the East London - Stutterheim region, any new, well-localized, identifiable fossil finds here are of considerable scientific value.

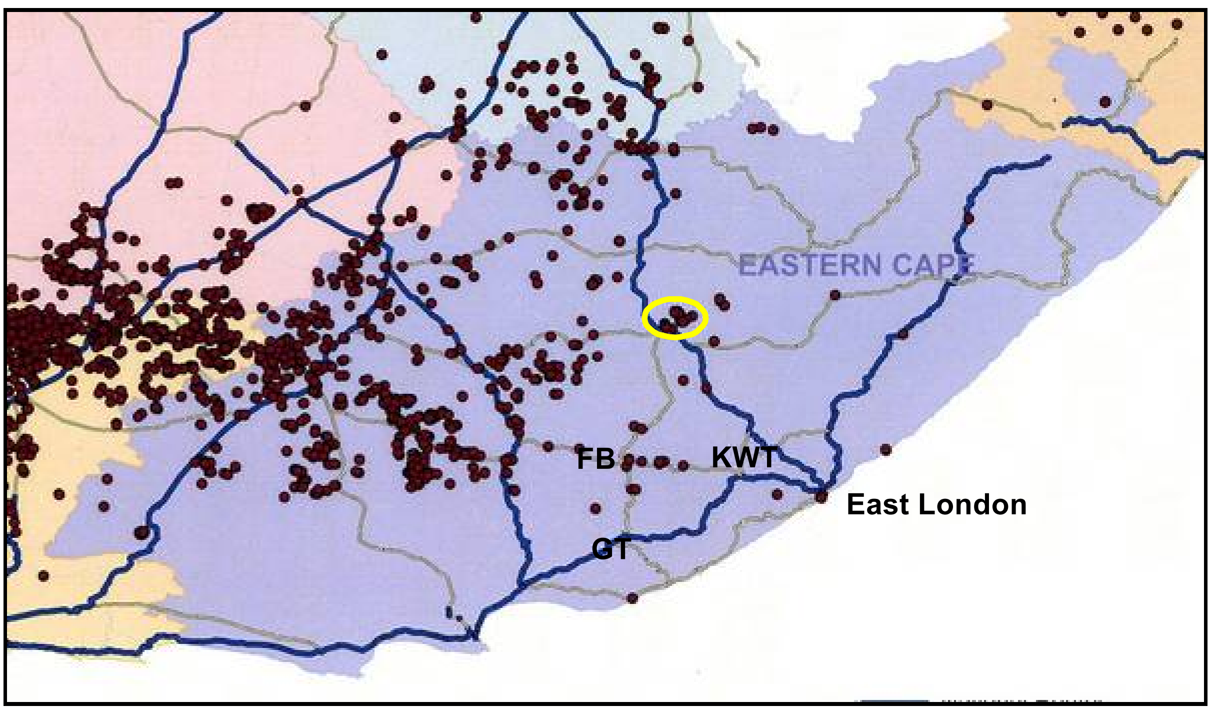

Fig. 6. Distribution of fossil sites in the Beaufort Group in the Eastern Cape (Modified from Nicolas 2007). Note that several fossil sites are recorded from the Stutterheim area to the east of the N6 (yellow ellipse). KWT = King William's Town. FB = Fort Beaufort. GT = Grahamstown.

4.1. Balfour Formation

The sandstone-dominated Oudeberg Member at the base of the Balfour Formation is assigned to the *Cistecephalus* Assemblage Zone (Rubidge 1995). The Assemblage Zone to which the overlying mudrock-dominated Daggaboersnek Member should be assigned is less clear (Cole *et al*., 2004). Le Roux and Keyser (1988) report *Cistecephalus* AZ fossils from this member in the Victoria West sheet area, whereas the Daggaboersnek Member in the Middelburg sheet area is assigned to the ***Dicynodon* Assemblage Zone** and this certainly applies to the greater part of the Balfour Formation, including the beds exposed close to the Katberg contact near Stutterheim (Rubidge 1995, Cole *et al*., 2004). This younger biozone has been assigned to the Changhsingian Stage (= Late Tartarian), right at the end of the Permian Period, with an approximate age range of 253.8-251.4 million years (Rubidge 1995, 2005).

Good accounts, with detailed faunal lists, of the rich Late Permian 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), Almond *et al*. (2008) and Nicolas & Rubidge (2010). In general, the following broad categories of fossils might be expected within the Balfour Formation in the East London to Stutterheim 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 *Dicynodon* and the much smaller *Diictodon*, carnivorous gorgonopsians, therocephalians such as *Theriognathus* (= *Whaitsia*), primitive cynodonts like *Procynosuchus*, and biarmosuchians) (See Figs. 7 and 8 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 (Cole *et al*., 2004). 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*., 2006).

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).

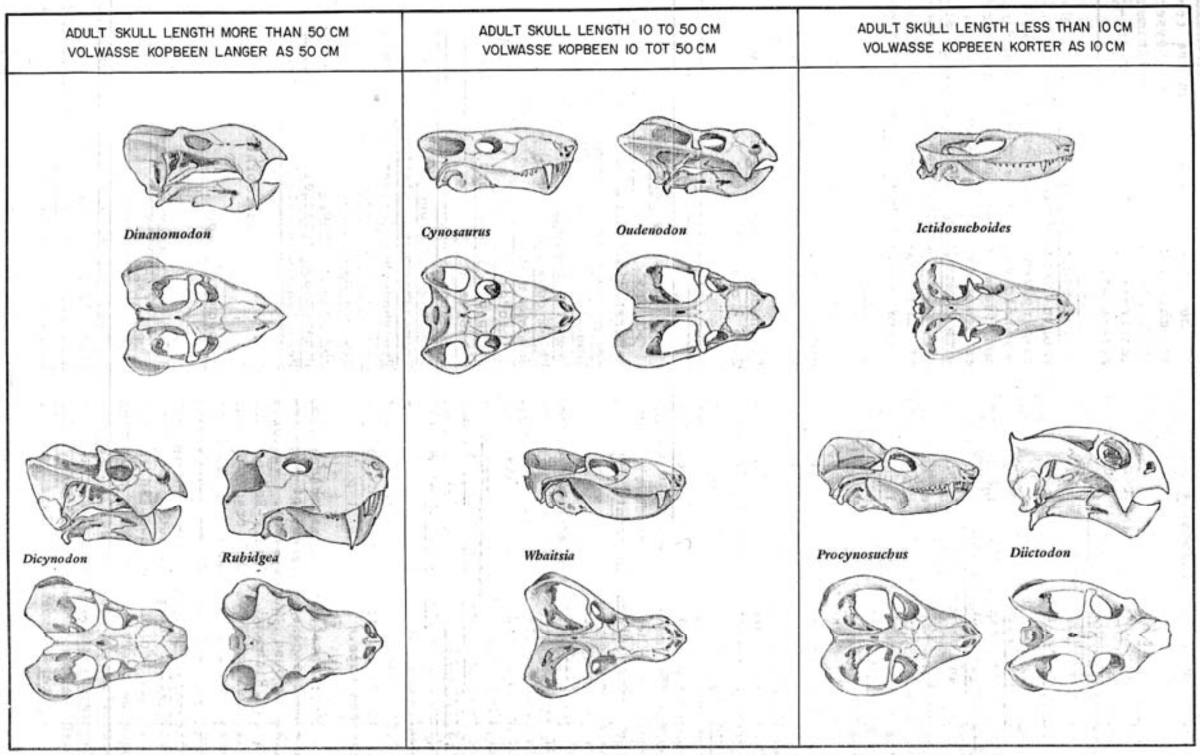

Fig. 7. Skulls of characteristic fossil vertebrates – all therapsids - from the *Dicynodon* Assemblage Zone (From Keyser & Smith 1979). Among the dominant therapsids ("mammal-like reptiles"), *Rubidgea* and *Cynosaurus* are carnivorous gorgonopsians, *Whaitsia* (now *Theriognathus*) is a predatory therocephalian while *Ictidosuchoides* is a small insectivorous member of the same group, *Procynosuchus* is a primitive cynodont, and the remainder are large- to small-bodied dicynodont herbivores.

Fig. 8. Backbone and ribs of an unidentified medium-sized therapsid, Lower Beaufort Group in the Stutterheim area (East London Museum, fossil display).

4.3. 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 – Stutterheim 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 neighbouring Beaufort Group sediments. This may well apply to the Balfour Formation beds in the Cenyulands area near Stutterheim, for example.

5. PALAEONTOLOGICAL SENSITIVITY & RECOMMENDATIONS

The proposed Cenyu / Cenyulands housing development footprint near Stutterheim is underlain by a major intrusion of Jurassic dolerite in the north and by mudrock-dominated fluvial sediments in the uppermost part of the Late Permian Balfour Formation (Lower Beaufort Group, Karoo Supergroup) in the south. The dolerites are entirely unfossiliferous. The Balfour Formation rocks might contain a range of Late Permian vertebrate fossils (reptiles, therapsids, amphibians and fish), trace fossils, non-marine bivalves and plant remains (*e.g.* petrified wood). There are several records of Beaufort Group vertebrate fossils from the Stutterheim area, including medium-sized therapsids ("mammal-like reptiles"). Fossil assemblages within the uppermost Balfour Formation are of special palaeontological interest in that they document the catastrophic mass extinction episode at the end of the Permian Period, *c*. 251 million years ago.

The potential impacts of the proposed housing development are briefly assessed in Table 1 below according to the scheme developed by Arcus Gibb Engineering and Science. The impact significance of the development is rated here as LOW because:

- Much of the footprint is underlain by unfossilferous dolerite;
- the potentially fossiliferous bedrocks are mantled in thick soils and are highly weathered;
- baking of sediments during dolerite intrusion has probably compromised their fossil content;
- fossil abundance is generally low within the upper part of the Balfour Formation.

Negative impacts on local fossil heritage can be effectively mitigated by appropriate ECO monitoring and – where necessary – by professional palaeontological mitigation. Fresh exposures of Beaufort Group sediments created during the construction phase of the development 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 the 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 *loose* fossils be encountered during excavations, they should be carefully collected, with adherent matrix where necessary, given a provisional reference number (*e.g.* marked on masking tape) and carefully wrapped in newspaper. It is *essential* that the locality where the fossil is found be accurately marked on a 1: 50 000 map or recorded by GPS. Specimens without locality information are of limited scientific value. The fossils should be 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 *in situ,* articulated skeletons or other substantial fossil remains are encountered during borrow pit excavation, 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 a suitably qualified palaeontologist so that specimens can be examined, recorded and, if necessary, professionally excavated.

It should be noted that provided appropriate mitigation measures are implemented, the professional recording and collection of new fossil material represents a *positive* impact in terms of our understanding of Eastern Cape fossil heritage.

CRITERIA	**RATING**
Nature & type of impact	Negative, direct Disturbance, damage or sealing-in of fossil material at surface or beneath the ground during the construction phase of the development (notably through excavations into fresh sedimentary bedrock)
Extent	Site (development footprint)
Duration	Permanent
Probability	Improbable to probable
Degree to which impact can be reversed	Low
Irreplaceable loss of resources	Low
Confidence level	Medium (due to lack of surface exposure of bedrocks)
Degree of mitigation	Moderately mitigated (Monitoring for fossil material by ECO; recording and sampling by professional palaeontologist if substantial fossil remains are found)
Significance	LOW

Table 1. Assessment of impacts on local palaeontological heritage of the proposed Cenyu / Cenyulands housing development, Stutterheim

6. ACKNOWLEDGMENTS

Ms Mary-Anne Crocker of Arcus Gibb Engineering & Science, East London, is thanked for commissioning this report and for providing the necessary background information.

7. REFERENCES

Almond, J.E., De Klerk, W.J. & Gess, R. 2008. Palaeontological heritage of the Eastern Cape. Draft report for SAHRA, 20 pp. *Natura Viva* cc, Cape Town.

Anderson, J.M. & Anderson, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

Cluver, M.A. 1978. Fossil reptiles of the South African Karoo, 54pp. South African Museum, Cape Town.

Cole, D.I., Neveling, J., Hattingh, J., Chevallier, L.P., Reddering, J.S.V. & Bender, P.A. 2004. The geology of the Middelburg area. Explanation to 1: 250 000 geology Sheet 3124 Middelburg, 44 pp. Council for Geoscience, Pretoria.

Dingle, R.V., Siesser, W.G. & Newton, A.R. 1983. Mesozoic and Tertiary geology of southern Africa. viii + 375 pp. Balkema, Rotterdam.

Duncan, A.R. & Marsh, J.S. 2006. The Karoo Igneous Province. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 501-520. Geological Society of South Africa, Marshalltown.

Groenewald, G. 2011. The proposed Thomas River Wind Eneregy Facility, Stutterheim, Eastern Cape Province, South Africa: palaeontological impact assessment report, 11 pp. Metsi Metseng Geological Services cc, Bethlehem.

Hill, R.S. 1993. The geology of the Graaff-Reinet area. Explanation to 1: 250 000 geology Sheet 3224 Graaff-Reinet, 31 pp. Council for Geoscience, Pretoria.

Johnson, M.R. & Caston, D.L. 1979. The geology of the Kei Mouth area. Explanation to 1: 250 000 geology Sheet 3228 Kei Mouth, 7 pp. Council for Geoscience, Pretoria.

Johnson, M.R. & Le Roux, F.G. 1994. The geology of the Grahamstown area. Explanation for 1: 250 000 geology sheet 3326 Grahamstown, 40 pp. Council for Geoscience, Pretoria.

Johnson, M.R., Van Vuuren, C.J., Visser, J.N.J., Cole, D.I., De V. Wickens, H., Christie, A.D.M., Roberts, D.L. & Brandl, G. 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 461-499. Geological Society of South Africa, Marshalltown.

Keyser, A.W. & Smith, R.M.H. 1979. Vertebrate biozonation of the Beaufort Group with special reference to the western Karoo Basin. Annals of the Geological Survey of South Africa 12, 1-35.

Klein, R.G. 1984. The large mammals of southern Africa: Late Pliocene to Recent. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 107-146. Balkema, Rotterdam.

MacRae, C. 1999. Life etched in stone. Fossils of South Africa. 305pp. The Geological Society of South Africa, Johannesburg.

McCarthy, T. & Rubidge, B. 2005. The story of Earth and life: a southern African perspective on a 4.6-billion-year journey. 334pp. Struik, Cape Town.

Mountain, E.D. 1974. The geology of the area around East London, Cape Province. An explanation of sheet map 3227D (East London), 3228 (Kei Mouth), 29 pp. Geological Survey / Council for Geoscience, Pretoria.

Nicolas, M.V. 2007. Tetrapod diversity through the Permo-Triassic Beaufort Group (Karoo Supergroup) of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg.

Nicolas, M. & Rubidge, B.S. 2010. Changes in Permo-Triassic terrestrial tetrapod ecological representation in the Beaufort Group (Karoo Supergroup) of South Africa. Lethaia 43, 45-59.

Partridge, T.C., Botha, G.A. & Haddon, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

Partridge, T.C. & Scott, L. 2000. Lakes and pans. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.145-161. Oxford University Press, Oxford.

Retallack, G.J., Metzger, C.A., Greaver, T., Hope Jahren, A., Smith, R.M.H. & Sheldon, N.D. 2006. Middle-Late Permian mass extinctions on land. GSA Buletin 118, 1398-1411.

Rubidge, B.S. (ed.) 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). 46pp. South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

Rubidge, B.S. 2005. Re-uniting lost continents – fossil reptiles from the ancient Karoo and their wanderlust. South African Journal of Geology 108: 135-172.

Skead, C.J. 1980. Historical mammal incidence in the Cape Province. Volume 1: The Western and Northern Cape. 903pp. Department of Nature and Environmental Conservation, Cape Town.

Smith, R.M.H. 1993. Vertebrate taphonomy of Late Permian floodplain deposits in the southwestern Karoo Basin of South Africa. Palaios 8: 45-67.

Smith, R.H.M. & Ward, P.D. 2001. Pattern of vertebrate extinction across an event bed at the Permian-Triassic boundary in the Karoo Basin of South Africa. Geology 29, 1147-1150.

Van der Walt, M., Day, M., Rubidge, B., Cooper, A.K. & Netterberg, I. In press, 2010. Utilising GIS technology to create a biozone map for the Beaufort Group (Karoo Supergroup) of South Africa. Palaeontologia Africana.

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, Limpopo, Gauteng and the Free State 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 development project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.