

PALAEONTOLOGICAL HERITAGE ASSESSMENT: COMBINED DESKTOP & FIELD-BASED STUDY

PROPOSED EXPANSION OF THE AMAHLEKE WATER SUPPLY SCHEME NEAR DIMBAZA OUTSIDE OF KING WILLIAMS TOWN, BUFFALO CITY METROPOLITAN MUNICIPALITY, EASTERN CAPE

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December 2015

EXECUTIVE SUMMARY

Buffalo City Metropolitan Municipality are proposing to expand the existing Amahleke Water Supply Scheme located near Dimbaza outside of King Williams Town in the Eastern Cape. The proposed works involves the upgrading of the existing water pipelines and rising main as well as an expansion of two of the reservoirs in the area. The upgrade of the pipeline includes the construction of a pipeline bridge over the Mngqesha River.

The study area for the proposed upgrade of the Amahleke Water Supply Scheme north of Dimbaza is underlain by Late Permian continental sediments of the ILwer Beaufort Group (Adelaide Subgroup, Karoo Supergroup). However, these potentially fossiliferous bedrocks are generally highly weathered and have been baked by major Karoo dolerite intrusions. Consequently their palaeontological sensitivity is low. This is also the case for the overlying superficial sediments of Late Pleistocene to Recent age, including thick sandy to gravelly donga infill deposits, ferricrete hardpans, sandy to gravelly alluvium and modern soils. No vertebrate fossils, petrified wood or other fossil remains were recorded within the bedrock or superficial sediments during the present field assessment. The overall impact significance of the Amahleke Water Supply Scheme project is evaluated as *negligible* 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) and accessible, well-illustrated literature.

Should important new fossil remains - such as vertebrate bones and teeth, plant-rich fossil lenses or dense fossil burrow assemblages - be exposed during construction, the responsible Environmental Control Officer should alert ECPHRA (*i.e.* The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible so that appropriate action can be taken in good time by a professional palaeontologist at the developer's expense.

Palaeontological mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as of associated geological data (*e.g.* stratigraphy, sedimentology, taphonomy). The palaeontologist concerned with mitigation work will need a valid fossil collection permit from ECPHRA and any material collected would have to be curated in an approved depository (*e.g.* museum or university collection). All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies recently developed by SAHRA (2013). These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the expansion of the Amahleke Water Supply Scheme.

1. INTRODUCTION & BRIEF

Buffalo City Metropolitan Municipality are proposing to expand the existing Amahleke Water Supply Scheme located near Dimbaza outside of King Williams Town in the Eastern Cape. The proposed works involves the upgrading of the existing water pipelines and rising main from a 110 /140 mm to a 250 mm diameter pipeline as well as an expansion of two of the reservoirs in the area. The larger reservoir is being upgraded from 500 KL to a 3,5 ML and the smaller one from 150 KL to 1,5ML. The upgrade of the pipeline includes the construction of a pipeline bridge over the Mngqesha River that runs between Dimbaza in the south and Pirie Mission in the north (Figs. 1 & 2).

The proposed pipeline and reservoir 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 by TERRECO Environmental cc (Contact details: Shaun Saker, TERRECO Environmental cc, East London 57 Jarvis Road East London 5241, Eastern Cape, South Africa. Tel: 043 721 1502. Fax: 043 721 1535. Cell: 083 377 1130) according to 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 National Heritage Resources Act, 1999 include, among others:

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

Fieldwork for the palaeontological heritage assessment was carried out over two days on 3 to 4 December 2015.

2. LEGISLATIVE CONTEXT FOR PALAEONTOLOGICAL ASSESSMENT STUDIES

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

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- palaeontological sites;
- palaeontological objects and material, meteorites and rare geological specimens.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

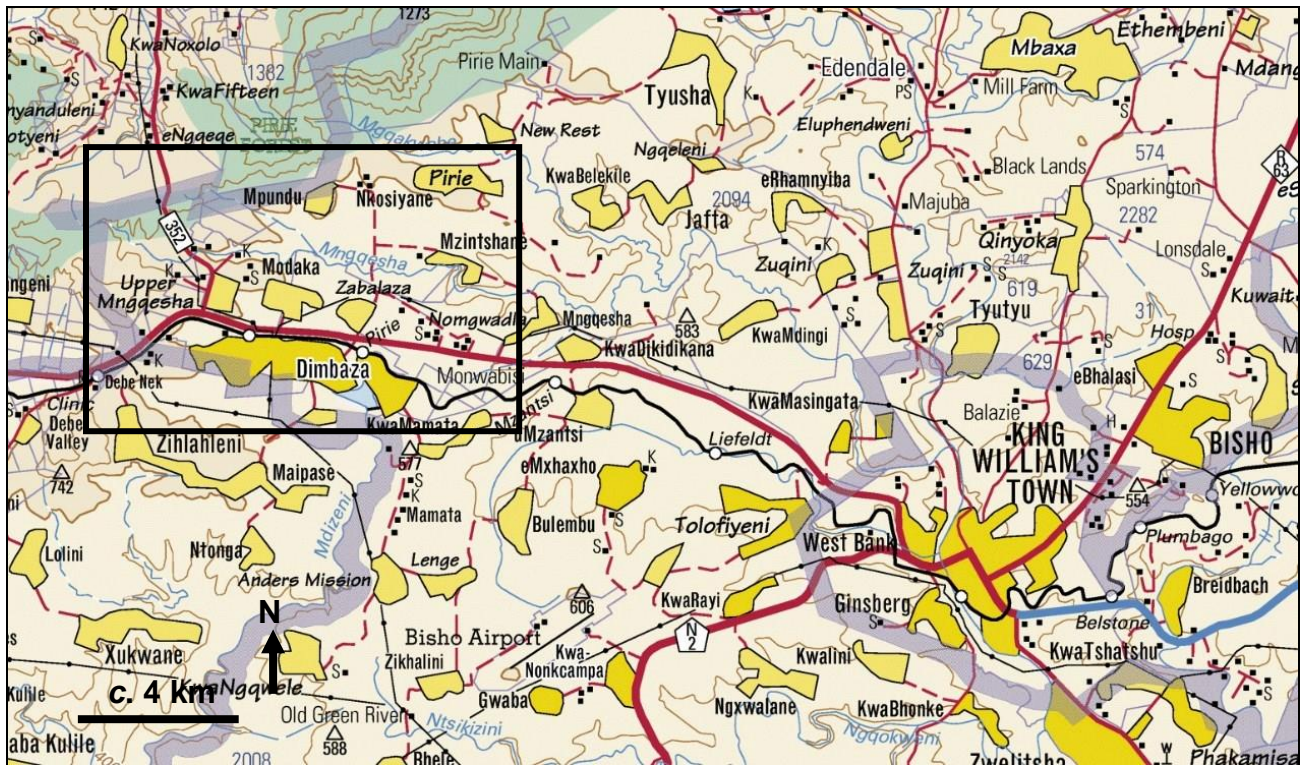


Fig. 1. Extract from 1: 250 000 Map 3226 King William's Town showing the *approximate* location (black rectangle) of the study area for the Amahleke Water Supply Scheme to the north of Dimbaza and c. 18 km WNW of King William's Town, Buffalo City Metropolitan Municipality, Eastern Cape (Map courtesy of the Chief Directorate National Geo-spatial Information, Mowbray).



Fig. 2. Google earth© satellite image of the study area near Dimbaza showing the water pipeline route between Debe Nek in the west and Pirie Mission in the northeast (blue, purple lines), two existing reservoirs (R1, R2) and the proposed location of a pipeline bridge across the Mngqesha River (yellow circle).

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 area (e.g. Almond 2011a, 2011b), (2) published geological maps and accompanying sheet explanations (e.g. Mountain 1974), (3) a field study in the project area near Dimbaza (3-4 December, 2015).

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following scoping during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (The SAHRIS palaeosensitivity maps are also consulted on the SAHRA website). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most notably the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field assessment study by a professional palaeontologist is usually warranted.

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

required and all fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

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

On the basis of the desktop and field studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological and taphonomic data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority, ECPHRA (*i.e.* The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) and a suitably qualified palaeontologist so that specimens can be examined, recorded and, if necessary, professionally excavated. It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

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

4. GEOLOGICAL BACKGROUND

The study area near Dimbaza comprises gentle hilly, grassy terrain between Debe Nek in the west and Pirie Mission Station in the northeast, some 4 km north of the R63 and c. 18 km WNW of King William's Town, Eastern Cape (Figs. 1, 2, 5 & 6). The area lies between 600 and 630 m amsl and is drained by the Mngqesha River as well as several smaller tributaries. Close to the R63 the terrain is highly disturbed. Levels of bedrock exposure are generally very low. The geology of the study area is outlined on 1: 250 000 geology sheet 3226 King William's Town (Fig. 3; Council for Geoscience, Pretoria). A very brief geological explanation for this sheet is printed on the map, and there is a separate report by Mountain (1974) on the geology of the East London area.

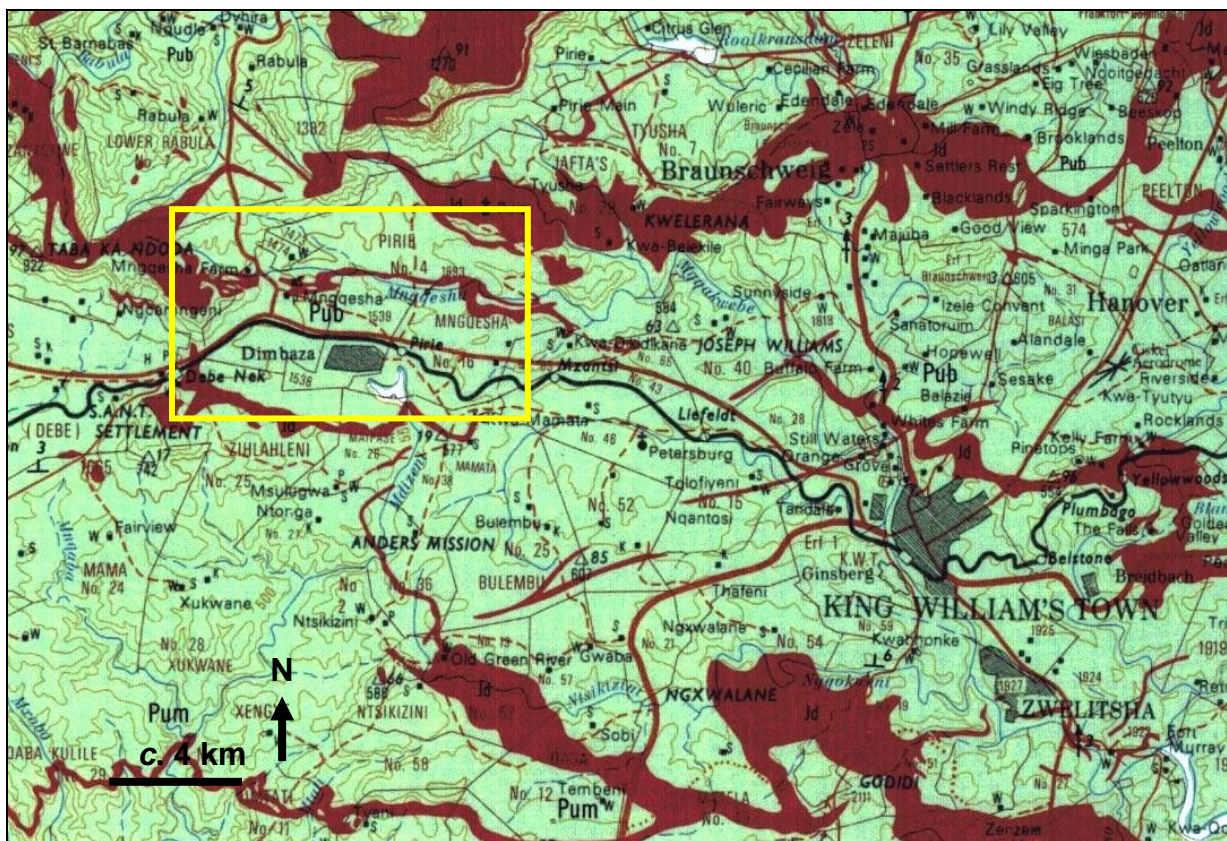


Fig. 3. Extract from 1: 250 000 geological map sheet 3226 King William's Town (Council for Geoscience, Pretoria) showing approximate location (yellow rectangle) of the study area for the Amahleke Water Supply Scheme near Dimbaza, Buffalo City Metropolitan Municipality, Eastern Cape Province. KEY GEOLOGICAL UNITS: Dark brown (Jd) = Jurassic Karoo Dolerite Suite. Pale green = Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup), with Middleton Formation (Pum) towards the south and Balfour Formation (Pub) towards the north. Note that this map does not clearly differentiate between these two formations. Superficial deposits such as Quaternary alluvium, colluvium and soils are also not shown separately here.

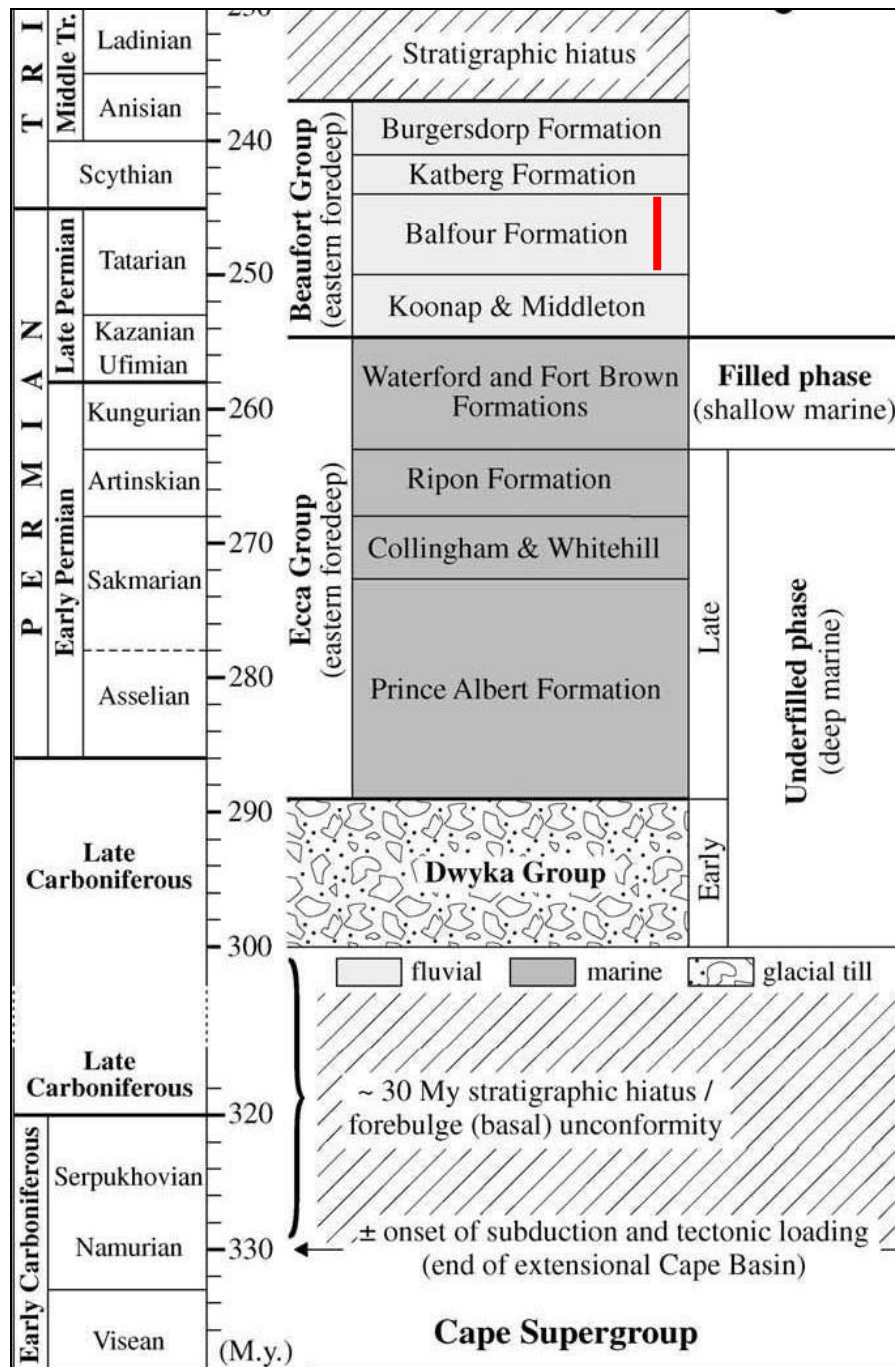


Fig. 4. Stratigraphic subdivision of the Carboniferous and Permian portions of the Karoo Supergroup in the Main Karoo Basin (From Catuneanu *et al.* 2005). The Late Permian Balfour Formation at the top of the Lower Beaufort Group (= Adelaide Subgroup) succession that underlies the present study area is emphasized by the thick red bar.



Fig. 5. View southward towards Dimbaza from the sandstone ridge underlying Pirie Mission. Note the distinctive dimpled *Kommetjievlaakte* terrain in the middle ground.



Fig. 6. View northwards from Zabalaza settlement towards the Mngqesha River which is marked by trees. The rise beyond the river is underlain by baked Lower Beaufort sediments intruded by Karoo dolerite. Dark mountain slopes clothed by the Pirie Forest are seen in the background.

4.1. Lower Beaufort Group (Adelaide Subgroup)

The study area is largely underlain by Late Permian continental (fluvial) sediments of the Lower Beaufort Group (**Adelaide Subgroup, Pa**) (See map Fig. 3 and stratigraphic table Fig. 4). Due to poor exposure, the Adelaide Subgroup outcrop area has not been clearly subdivided at the formational level in this region (Mountain 1974, Johnson & Caston 1979). According to the 1: 250 000 geological map (Fig. 3), the **Middleton Formation (Pum)** crops out to the south of King William's Town and the overlying **Balfour Formation (Pub)** is mapped to the north of town but the junction between the two is not clearly delineated. Only the Balfour Formation is represented in the Dimbaza – Pirie Mission study area itself.

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 (6 ° 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) 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, is often deeply weathered here in view of the long-prevailing warm, humid climatic regime.

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

Key recent reviews of the Balfour Formation fluvial succession have been given by Visser and Dukas (1979), Catuneanu and Elango (2001), Katemaunzanga (2009) 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. 5 & 6). Bedrock exposure is mainly confined to the deeper parts of several erosional gullies or dongas, the banks of the Mngqesha River, a few small borrow pits or quarries and patchy exposures on steeper hillslopes.

Several subparallel, closely-spaced ridges or scarps running WNW-ESE to the south of Pirie Mission represent a package of resistant-weathering channel sandstone bodies (Fig. 2). The sandstones are exposed in a small building stone quarry besides the track between Nkosiyané settlement and Pirie Mission (Fig. 10). South-dipping, medium-grained, blocky-weathering, yellowish-brown, impure channel sandstones (wackes) are also seen within some of the deeper dongas (Fig. 8) and on south-facing slopes north of the Mngqesha River (Fig. 13). Buff-weathering, greyish, fine-grained baked sandstones are exposed on the floor and lower cut faces in the currently-active stone quarry to the south of Nkosiyané (Fig. 12).

The best exposures of Lower Beaufort Group mudrocks occur in the southern, lower stretches of dongas south of Pirie Mission (Fig. 7), in a shallow borrow pit just east of Nkosiyané (Fig. 9) as well as in the walls of the stone quarry to the south (Fig. 11). Small exposures of grey-green to yellow-brown mudrocks were also examined just north of the Mngqesha River, in the vicinity of the R1 reservoir site and on the margins of a small dam just south of the R63 near Debe Nek (Fig. 14). In general, the Lower Beaufort Group sediments appear to be highly weathered near-surface and in addition they have locally been baked by nearby dolerite intrusions as seen, for example, from the tough splintery quartzites and dark silt hornfels exposed in the active quarry at Loc. 160. The friable mudrock packages show low dips and contain thin crevasse-splay sandstones as well as occasional palaeosol horizons marked with dark grey calcrete horizons (a major focus for palaeontological collection).



Fig. 7. Exposure of gently-dipping, weathered grey-green mudrocks and thin sandstones of the Balfour Formation in the walls of a deep *donga* south of Pirie Mission (Loc. 154).



Fig. 8. Balfour Formation channel sandstone exposed by gulley erosion, associated with coarse rubbly colluvium and ferricretised subsurface gravels, donga south of Pirie Mission (Loc. 153).



Fig. 9. Hackly-weathering, grey-green Balfour Formation mudrocks exposed in a borrow pit just east of Nkosiyane (Loc. 158) (Hammer = 30 cm).



Fig. 10. Well-jointed channel sandstones of the Balfour Formation exposed in a small quarry to the west of Pirie Mission (Loc. 159) (Hammer = 30 cm).



Fig. 11. Hackly-weathering, grey-green, massive mudrocks of the Balfour Formation capped by sandy soils, quarry cut face north of the Mngqesha River (Loc. 160) (Hammer = 30 cm).



Fig. 12. Tough baked quartzites overlying a dolerite intrusion exposed on the floor of an active quarry north of the Mngqesha River (Loc. 160) (Hammer = 30 cm).



Fig. 13. Hillslope exposure of baked Balfour Formation sandstones and mudrocks just north of the Mngqesha River (Loc. 163).



Fig. 14. Channel sandstone package of the Balfour Formation exposed on the margins of a small dam near Debe Nek (Loc. 168).

4.2. Karoo Dolerite Suite

In the East London – King William’s Town region the Balfour Formation sediments have been extensively intruded and baked by dolerite sills in the Early Jurassic (183 Ma) **Karoo Dolerite Suite (Jd)** (Duncan & Marsh 2006). Of particular relevance to the present study is a major sill-like dolerite intrusion the crops out in an E-W band extending from northwest of King William’s Town as far east as East London. Such major intrusions have thermally metamorphosed (baked and recrystallised) the country rock for a considerable distance on either side of their edges (Fig. 12).

Olive-green, gritty weathered dolerite (*sabunga*) is exposed towards the bottom of deep dongas south of Pirie Mission Station (Fig. 15). The gullies extend several meters down into the friable *sabunga* and may be re-exhumed erosional features formed on the deeply-weathered upper surface of a now-buried dolerite sheet.

The broadly west-east trending ridge or platform on the northern side of the Mngqesha River is formed by (1) a sheet-like dolerite intrusion (Fig. 16) that is probably connected subsurface with the larger dolerite outcrop mapped at the latitude of Pirie Mission as well as (2) by adjacent baked country rocks of the Lower Beaufort Group (notably tough quartzites).



Fig.15. Deeply-weathered, friable dolerite bedrocks (*sabunga*) exposed in a donga south of Pirie Mission Station (olive green material in left foreground) (Loc. 151).



Fig. 16. Boulder-sized, lichen-encrusted corestones overlying the outcrop of a dolerite intrusion building the W-E ridge north of the Mngqesha River (Loc. 161) (Hammer = 30 cm).

4.2. Late Caenozoic superficial deposits

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

The Palaeozoic and Mesozoic bedrocks in the study area are largely mantled by thin to locally very thick sandy soils with angular sandstone gravels and fine ferricrete glaebules in the subsoil. Deep sections through the superficial deposits overlying weathered Lower Beaufort Group and Jurassic dolerite bedrocks are seen in the walls of several extensive dongas to the south of Pirie Mission Station (Figs. 15, 17 & 18). At the northern (upslope) end of the dongas some 10 m of pale buff, semi-consolidated, sandy to silty alluvial (or mixed alluvial – colluvial sheetwash) deposits overlies the bedrocks and contains sparse, dispersed, angular gravels of sandstone. The deposits are

crudely bedded, with a gentle dip towards the south (downslope). Their considerable thickness may indicate that they represent the infilling of pre-existing, “re-exhumed” erosion gullies into deeply-weathered, friable bedrock and are probably not sheet-like in geometry. Coarse sandstone, dolerite corestone and dense glaebular ferricrete gravels along the base of the modern gully may have in part downwasted from above and also represent a basal lag deposit at the interface of the *donga* deposits and the underlying bedrocks. The thick buff *donga* deposits contain a brownish, incipiently ferricretised horizon towards the top and are overlain by darker brown to greyish modern soils. The stratigraphic provenance of rare flaked artefacts in dolerite (MSA) recorded along the *donga* base is equivocal. They may have downwasted from a horizon at the base of the modern soils or from within the thick *donga* infill deposits. Alternatively, they may overlie a dense finely-nodular ferricrete hardpan at the interface between the bedrocks and the *donga* infill.

Several good vertical sections through Quaternary alluvial deposits can be seen along the banks of the Mngqesha River (Figs. 20-21). At Loc. 166 on the south bank of the river pale buff, sandy older alluvium is sharply overlain by a thin (≤ 30 cm) gritty to gravelly horizon containing numerous stone artefacts made of greyish dolerite (Fig. 22). The artefacts are not patinated and the edges show little rounding due to water transport. The comparatively large size of the blades and occasional denticulate edges suggest an assignation to the early Middle Stone Age (MSA), *i.e.* early part of the Late Pleistocene (~ 120 -80 000 BP) (Dr Lita Webley, Dr Sarah Wurz pers. comm., 2015). This provides an approximate upper age limit to the overlying darker brown alluvial sediments and soils, *i.e.* Late Pleistocene. The lower portion of this younger alluvium contains dispersed calcrete nodules suggesting episodes of semi-arid climates.

A striking feature of the well-grassed, gently-hilly *veld* to the north of Dimbaza is the occurrence of countless, closely-spaced small, rounded depressions that are a few meters wide and 1-2 m deep (Figs. 5 & 23). These are well-seen on satellite images (Fig. 24) and have inspired the name *Kommetjievlaakte* for the region between Debe Nek and King William’s Town (Pickford 1926, Kopke 1980, Dold & McKenzie 2010). The depressions occur within the soil horizon and extend down onto an underlying ferricrete horizon composed of rusty-brown, rounded glaebules that may be up to a meter or more thick. The ferricrete zone is well see along local *donga* and stream sections (Fig. 18). Not all the *kommetjie* depressions are rounded; some are elongate and confluent downslope. The origin of the curious *kommetjies* remains unresolved, but may be related somehow to the burrowing activities of local populations of giant earthworms combined with high rainfall and local soil properties (Dold & McKenzie 2010). Extensively ongoing bioturbation of the modern soils by vibrant populations of giant earthworms is demonstrated by the density of outsized worm casts are scattered through the grassy *veld*. In addition large, domical *termitaria* constructed of greyish soil dot the *veld* and can be observed in section along the margins of steams and dongas (Fig. 19).



Fig. 17. Thick (c. 10 m), south-dipping, sandy donga-infill deposits exposed by renewed gulley erosion on hillslopes to the south of Pirie Mission Station (Loc. 151).



Fig. 18. Semi-consolidated, sandy hillslope or donga-infill deposits overlain by a resistant-weathering ferricrete horizon and greyish-brown modern soils, southwest of Pirie Mission.

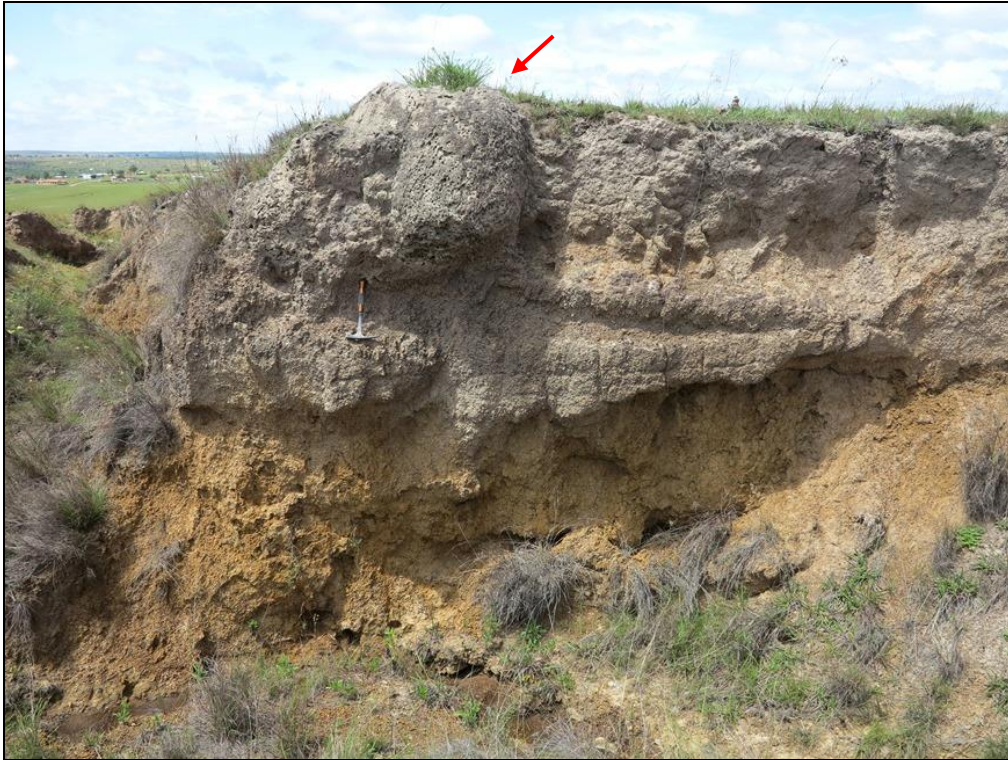


Fig. 19. *Donga* incision through thick greyish-brown modern soils exposing a large domical termitarium (arrowed) (Loc. 155) (Hammer = 30 cm).



Fig. 20. Thick Late Quaternary alluvial deposits along the north bank of the Mngqesha River (Loc. 165).



Fig. 21. South bank of the Mngqesha River showing pale buff, sandy older alluvium overlain by a thin gravelly horizon and c. 1.5 m of darker-hued younger alluvium and soils (Loc. 166) (Hammer = 30 cm).



Fig. 22. Close-up view of the gravelly alluvial unit seen in the previous figure showing weathered-out MSA doleritic stone artefacts (arrowed) as well as other examples still embedded in the deposit (Loc. 166) (Scale is c. 15 cm long).



Fig. 23. Typical subrounded *kommetjie* with a central mound in the grassy *Kommetjievlaakte* southwest of Pirie Mission Station.



Fig. 24. Google earth© satellite image of the *Kommetjievlaakte* to the southwest of Pirie Mission Station clearly showing the distinctive rounded to linear depressions that characterise the area.

5. PALAEONTOLOGICAL HERITAGE

Palaeontological heritage reported elsewhere within the main rock units represented in the study area near King William's Town is outlined here, largely based on previous desktop and field-based studies in the region by Almond (2011a, 2011b).

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

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

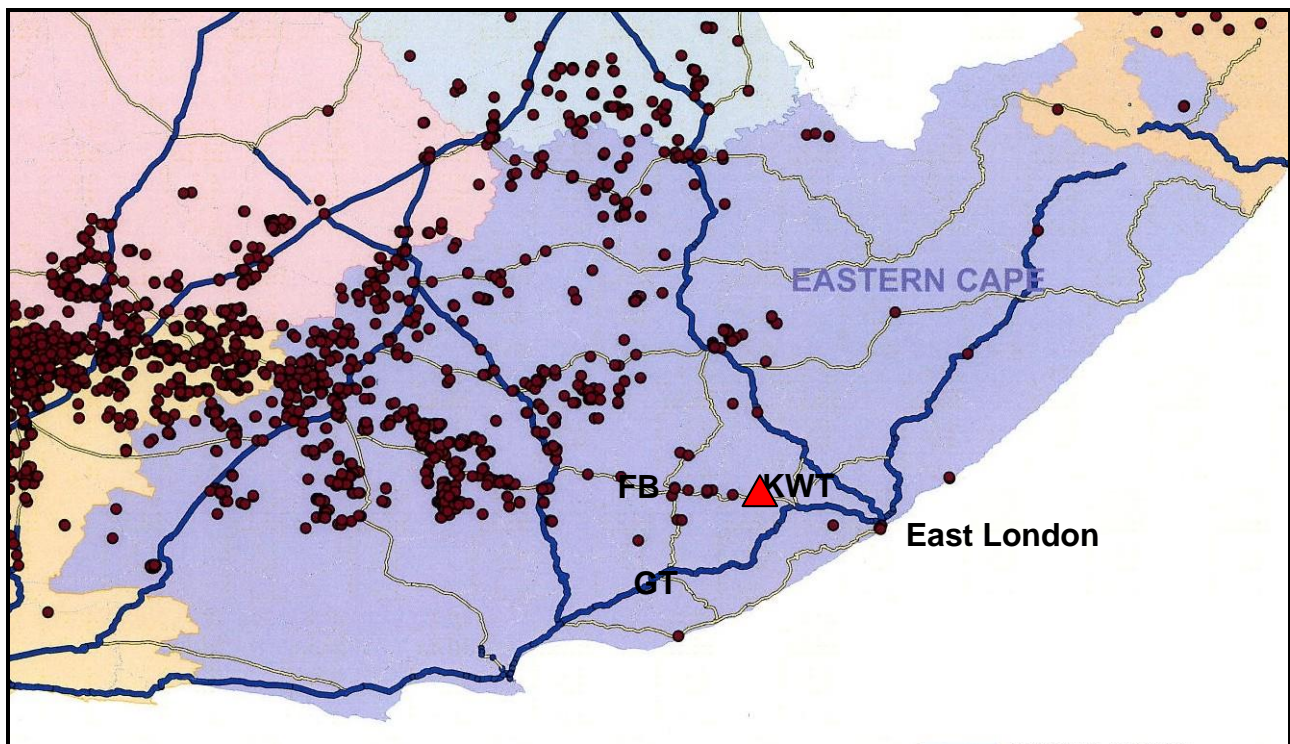


Fig. 25. Distribution of fossil sites in the Beaufort Group in the Eastern Cape (Modified from Nicolas 2007). Note the scarcity of sites recorded in the East London area and further west towards and beyond King William's Town, including the Dimbaza area (red triangle). KWT = King William's Town. FB = Fort Beaufort. GT = Grahamstown.

5.1. Balfour Formation

The biostratigraphic placement of the Daggaboersnek Member at the base of the Balfour Formation is equivocal. Le Roux and Keyser (1988) report *Cistecephalus* AZ fossils from this member in the Victoria West sheet area, whereas the Daggaboersnek Member on the Middelburg sheet area is assigned to the ***Dicynodon* Assemblage Zone** and this certainly applies to the greater part of the Balfour Formation (Rubidge 1995, Cole *et al.*, 2004 p. 21). This younger biozone has been assigned to the Changhsingian Stage (= Late Tartarian), right at the end of the Permian Period, with an approximate age range of 253.8-251.4 million years (Rubidge 1995, 2005).

Good accounts, with detailed faunal lists, of the rich Late Permian fossil biotas of the *Dicynodon* Assemblage Zone have been given by Kitching (1995) and by Cole *et al.* (2004). See also the reviews by Cluver (1978), MacRae (1999), McCarthy & Rubidge (2005) and Smith *et al.* (2012). 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 *Dicynodon* and the much smaller *Diictodon*, carnivorous gorgonopsians, therocephalians such as *Theriongnathus* (= *Whaitsia*), primitive cynodonts like *Procynosuchus*, and biarmosuchians) (See Fig. 26 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).

Older data on Lower Beaufort Group fossil records in the East London area has been provided by Mountain (1974) and Kitching (1977). 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 60 km north-east of East London (Rogers & Schwarz 1902). 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). 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, Kitching 1977). Kitching (1977) 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. Previously referred to the “Endothiodon” Zone”. 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.

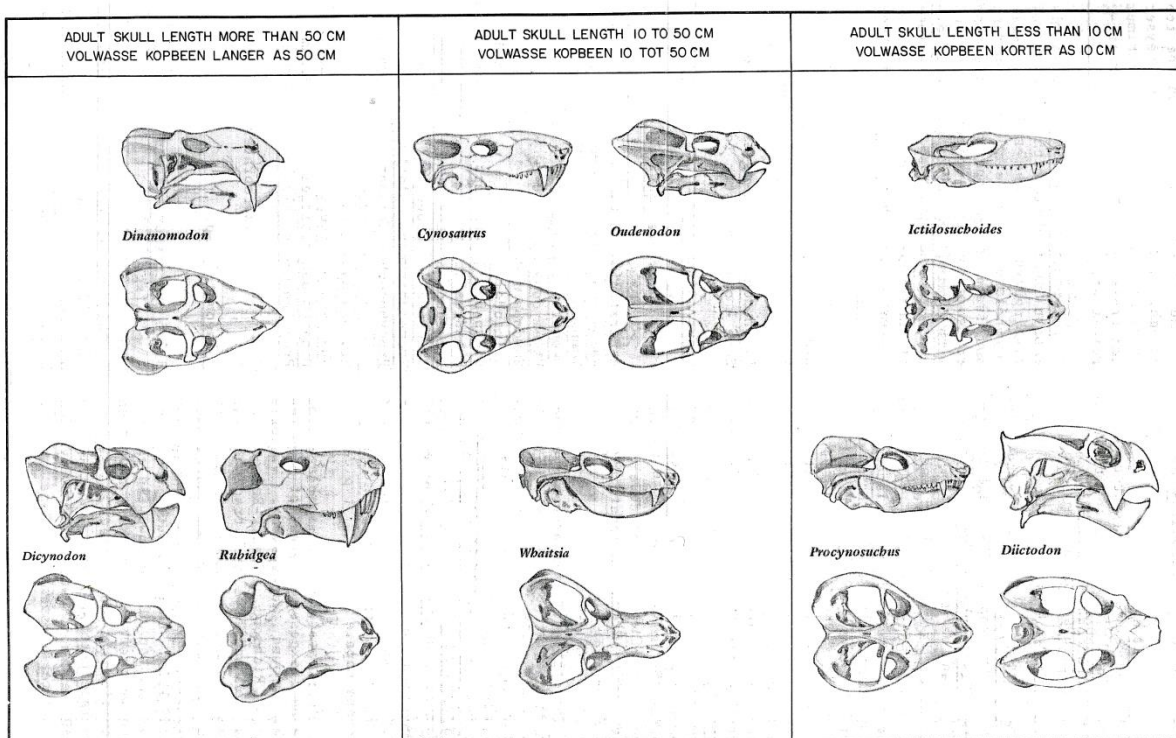


Fig. 26. Skulls of characteristic fossil vertebrates – all therapsids - from the *Dicynodon* Assemblage Zone (From Keyser & Smith 1977-1978). Among the dominant therapsids (“mammal-like reptiles”), *Rubidgea* and *Cynosaurus* are carnivorous gorgonopsians, *Whaitsia* (now *Theriognathus*) is a predatory 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.

Petrified (siicified) wood material showing well-developed seasonal growth rings occurs fairly frequently in the Beaufort Group in the King William's Town – East London region. It has been provisionally referred to the basket-genus *Dadoxylon* and is probably of gymnospermous affinities for the most part (*cf* Bamford 1999, 2004). Therapsid remains from the study 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).

No fossil vertebrate material was recorded within the weathered, baked bedrocks of the Lower Beaufort Group in the present study area north of Dimbaza. Possible small vertebrate burrows associated with thin crevasse splay sandstones at Loc. 164 just north of the Mngqesha River are considered to be dubious.

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 / Bisho 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.

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.

No fossil material was recorded from the various superficial deposits in the present study area north of Dimbaza.

6. EVALUATION OF IMPACTS ON PALAEONTOLOGICAL HERITAGE

The Amahleke Water Supply Scheme 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 pipelines and reservoirs 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 development on local fossil heritage resources is evaluated in Table 1 below. This assessment applies only to the construction phase of the infrastructure since further impacts on fossil heritage during the operational and decommissioning phases of the facilities are not anticipated.

Potential impacts on fossil heritage during the construction phase are generally negative, direct and restricted to the development footprint (*site*). They are *permanent* and cannot be reversed (*irreversible*). Where rare, well-preserved fossils such as vertebrate skeletons are concerned, losses may be irreplaceable. Many fossil groups (e.g. trace fossils, petrified wood) are well-represented elsewhere within the outcrop area of the formations concerned; in their particular case, loss of unique palaeontological resources is not envisaged. Given (1) the highly-weathered and baked nature of the Palaeozoic sediments in the study area, (2) the small footprint of the proposed development as well as (3) the absence of fossil records during the present field assessment, 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 Amahleke Water Supply Scheme project is evaluated as *negligible* as far as palaeontology is concerned.

Table 1: Evaluation of impacts on fossil heritage resources due to the construction phase of the proposed expansion of the Amahleke Water Supply Scheme near Dimbaza (No further impacts anticipated in the operational phase).

POTENTIAL IMPACTS	ASPECT	Nature	Type	Extent	Duration	Severity	Reversibility	Irreplaceable Loss	Probability	MITIGATION POTENTIAL	IMPACT SIGNIFICANCE		MITIGATION MEASURES
											Without Mitigation	With Mitigation	
CONSTRUCTION PHASE													
Impacts on Palaeontology		Negative	Direct	Site	Permanent	Low Negative	Irreversible	Resource may be partially destroyed	Unlikely	Partially mitigatable	Negligible	Moderate (positive – due to new palaeontological data)	Chance finds of fossils such as vertebrate bones & teeth to be safeguarded & reported to ECPHRA for recording & sampling by professional palaeontologist (Tel: 043 745 0888)

7. SUMMARY & RECOMMENDATIONS

The study area for the proposed upgrade of the Amahleke Water Supply Scheme north of Dimbaza is underlain by Late Permian continental sediments of the ILwer Beaufort Group (Adelaide Subgroup, Karoo Supergroup). However, these potentially fossiliferous bedrocks are generally highly weathered and have been baked by major Karoo dolerite intrusions. Consequently their palaeontological sensitivity is low. This is also the case for the overlying superficial sediments of Late Pleistocene to Recent age, including thick sandy to gravelly donga infill deposits, ferricrete hardpans, sandy to gravelly alluvium and modern soils. No vertebrate fossils, petrified wood or other fossil remains were recorded within the bedrock or superficial sediments during the present field assessment. The overall impact significance of the Amahleke Water Supply Scheme project is evaluated as *negligible* 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) and accessible, well-illustrated literature.

Should important new fossil remains - such as vertebrate bones and teeth, plant-rich fossil lenses or dense fossil burrow assemblages - be exposed during construction, the responsible Environmental Control Officer should alert ECPHRA (i.e. The Eastern Cape Provincial Heritage Resources Authority. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za) as soon as possible so that appropriate action can be taken in good time by a professional palaeontologist at the developer's expense.

Palaeontological mitigation would normally involve the scientific recording and judicious sampling or collection of fossil material as well as of associated geological data (e.g. stratigraphy, sedimentology, taphonomy). The palaeontologist concerned with mitigation work will need a valid fossil collection permit from ECPHRA and any material collected would have to be curated in an approved depository (e.g. museum or university collection). All palaeontological specialist work should conform to international best practice for palaeontological fieldwork and the study (e.g. data recording fossil collection and curation, final report) should adhere as far as possible to the minimum standards for Phase 2 palaeontological studies recently developed by SAHRA (2013). These recommendations should be incorporated into the Environmental Management Programme (EMPr) for the expansion of the Amahleke Water Supply Scheme.

8. ACKNOWLEDGEMENTS

Mr Shaun Saker of TERRECO Environmental cc, East London, is thanked for commissioning this report and for providing the necessary background information. I am grateful to Dr Lita Webley (ACO Associates, Cape Town) and Ms Madelon Tusenius for companionship, logistical back-up and useful discussions on heritage-related matters in the field. Dr Webley and Dr Sarah Wurz (Wits, Johannesburg) gave useful comments on the likely age of the stone artefacts within the superficial sediments.

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10. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

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

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape, Limpopo, Northwest and the

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

Declaration of Independence

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



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APPENDIX: GPS LOCALITY DATA FOR NUMBERED SITES MENTIONED IN TEXT

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

Loc No.	GPS data	Comments
150	S32° 47' 52.1" E27° 14' 52.8"	Thick greyish-brown, gravelly soils on hillslopes south of Pirie Mission Station. Dispersed ferricrete glaebules, mudrock chips in subsurface. Giant earthwork casts at surface.
151	S32° 47' 56.3" E27° 14' 52.1"	Northern end of deep donga / erosion gully S of Pirie Mission Station incised through thick superficial sediments down to weathered dolerite and Beaufort Group bedrocks.
152	S32° 47' 56.9" E27° 14' 52.4"	Large MSA flake of dolerite exposed along base of erosion donga.
153	S32° 47' 57.7" E27° 14' 52.4"	Weathered, yellowish-brown Lower Beaufort sandstones exposed at base of donga. Capped by rusty-brown ferricrete hardpan. Possible re-exhumed erosional gully through Lower Beaufort Group channel sandstone. Colluvial sandstone blocks abundant.
154	S32° 47' 59.8" E27° 14' 52.1"	Donga exposure of deeply-weathered, grey-green, hackly-weathering Lower Beaufort Group mudrocks within thin, baked pale buff crevasse-splay sandstone horizons. Succession subhorizontal, overlain by ferricretised fine colluvium/ sheetwash and modern soils.
155	S32° 48' 00.5" E27° 14' 39.1"	Section through thick greyish modern soils along margin of donga showing vertical exposure of large domical termitarium.
156	S32° 47' 45.7" E27° 14' 05.7"	Small stream bed and bank exposures of rusty-brown ferricrete hardpan, modern soils with large domical termitaria.
158	S32° 47' 42.6" E27° 13' 51.6"	Shallow borrow pit excavated into grey-green, hackly-weathering Beaufort Group mudrocks capped by ferricrete soils and domical termitaria. Dispersed small calcrete glaebules. Small-scale horizontal burrows. Fine massive diamictite facies with small mudrock angular chips in a silty matrix.
159	S32° 47' 34.3" E27° 14' 05.0"	Small building stone quarry excavated into pale brown, well-jointed, quartzitic channel sandstones of Lower Beaufort Group, medium-grained, speckled, showing horizontal lamination and low-angle cross-bedding. Capped by thin sandy to gravelly soils with ferricrete subsoil.
160	S32° 48' 35.5" E27° 13' 51.8"	Exposure of massive, hackly, weathered, grey-green to buff mudrocks and tough, splintery, well-jointed pale grey quartzite (baked wackes), darker hornfels in cut face and floor of active quarry overlying dolerite intrusion. The thick rubbly overburden overlying the horizontally-bedded Lower Beaufort Group and dolerite bedrocks may have been artificially displaced during quarrying activity. Reddish-brown lateritic soils overlie dolerite on quarry margins.
161	S32° 48' 41.0" E27° 13' 49.1"	Boulder-sized dolerite corestones overlying dolerite intrusion forming ridge on north side of Mngqesha River. Rounded corestones have a grey, lichen-encrusted surface patina but no desert varnish.
162	S32° 48' 48.0" E27° 13' 49.7"	Hillslope exposure of weathered, baked Lower Beaufort Group sandstones and mudrocks to N of Mngqesha River overlain by ferricretised gravelly soils.

163	S32° 48' 48.3" E27° 13' 50.7"	Hillslope exposure of weathered, buff Lower Beaufort Group channel sandstones and mudrocks to N of Mngqesha River overlain by ferricretised gravelly soils, colluvial sandstone rubble.
164	S32° 48' 49.0" E27° 13' 51.8"	Shallow gulley (or borrow pit) exposure of crumbly, weathered grey-green to khaki Lower Beaufort Group mudrocks on hillslope N of Mngqesha River. Thin crevasse splay sandstones associated with possible (but doubtful) small subhorizontal vertebrate burrows.
165	S32° 48' 51.0" E27° 13' 51.3"	Thick (4-5 m) pale buff silty alluvium with sparse dispersed gravel clasts exposed along N bank of Mngqesha River. Angular blocky coarse gravels of Beaufort Group sandstone in river bed.
166	S32° 48' 55.8" E27° 13' 46.5"	Vertical section along S bank of Mngqesha River through pale buff, sandy older alluvium overlain by thin (≤ 30 cm) gritty gravel horizon with numerous stone artefacts (dolerite, probably early MSA) and c. 1.5 m of darker brown younger alluvial soils. Lower portion of younger alluvium contains dispersed calcrete nodules.
167	S32° 49' 39.8" E27° 13' 29.9"	Low relief surface exposures of hackly-weathering Lower Beaufort Group mudrocks in vicinity of R1 reservoir with overlying ferricrete and thin gravelly soils..
168	S32° 50' 01.6" E27° 09' 56.9"	Hackly-weathering grey-green mudrocks with dark palaeocalcrete nodules, medium-bedded channel sandstones around margins of small dam near Debe Nek.