Palaeontological Heritage Impact Assessment for Dubeni river crossing near Queenstown

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Background

The Project is located in northern Dubeni, 22km north east from Queenstown. Dubeni is reached by a gravel road which links a number of rural settlements situated along the banks of the Silver Stream and the White Kei Rivers. It is reached approximately 9.2 km from where the road connects to the R396 to Queenstown. The gravel road extends both north and eastwards beyond Dubeni. Where it crosses the Silver Stream, a small tributary of the White Kei River the approaches to the original bridge had been washed away in floods, leading to development of a temporary concrete causeway for vehicles as well as a concrete pedestrian pathway.

As a result Chris Hani District Municipality commissioned the construction of a new bridge with wider spans and less water resistance, requiring a slight realignment of the roadway. Two borrowpits were identified, to be exploited for aggregate required by the project.

An EMPR was prepared by Terreco Environmental, an East London-based environmental and geotechnical consulting firm. At this point a Heritage Impact Assessment was not called for.

As the project progressed the discovery of unforeseen graves led to a request for an HIA. Rob Gess Consulting was subcontracted to carry out a Palaeontological Impact Assessment as part of this process.
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Geology and Palaeontology

The River crossing is underlain by mudstone of the Burgersdorp Formation **(Tarkastad Subgroup, Beaufort Group, Karoo Supergroup)**, exposed where the White Kei and its tributaries have carved through a thick and regionally extensive sheet of dolerite (Figure 1). To the immediate west of the river crossing the Silver Stream emerges through a small notch, from an attractive pool carved into the dolerite. The stream course below the notch is thickly layered with large dolerite boulders bedded in coarse alluvium. Floodplain alluvium also mantles the bedrock on either of the crossing.

The two borrowpit sites, which have been previously exploited, penetrate the bedrock. Borrowpit pit one intercepts purple red mudstones congruent with those underlying the dolerite sill. Coarser sedimentary strata are exposed in borrowpit two. Despite this position having been mapped as being underlain by dolerite (Figure 1), field inspection reveals that it exploits remnants of the sedimentary strata that formerly overlaid the intrusion.

The mudstones and intermittent sandstones of the Burgersdorp Formation were laid down by meandering rivers on the broad floodplains of the Karoo Sedimentary basin during the early to mid Triassic Period, approximately 230 million years ago.

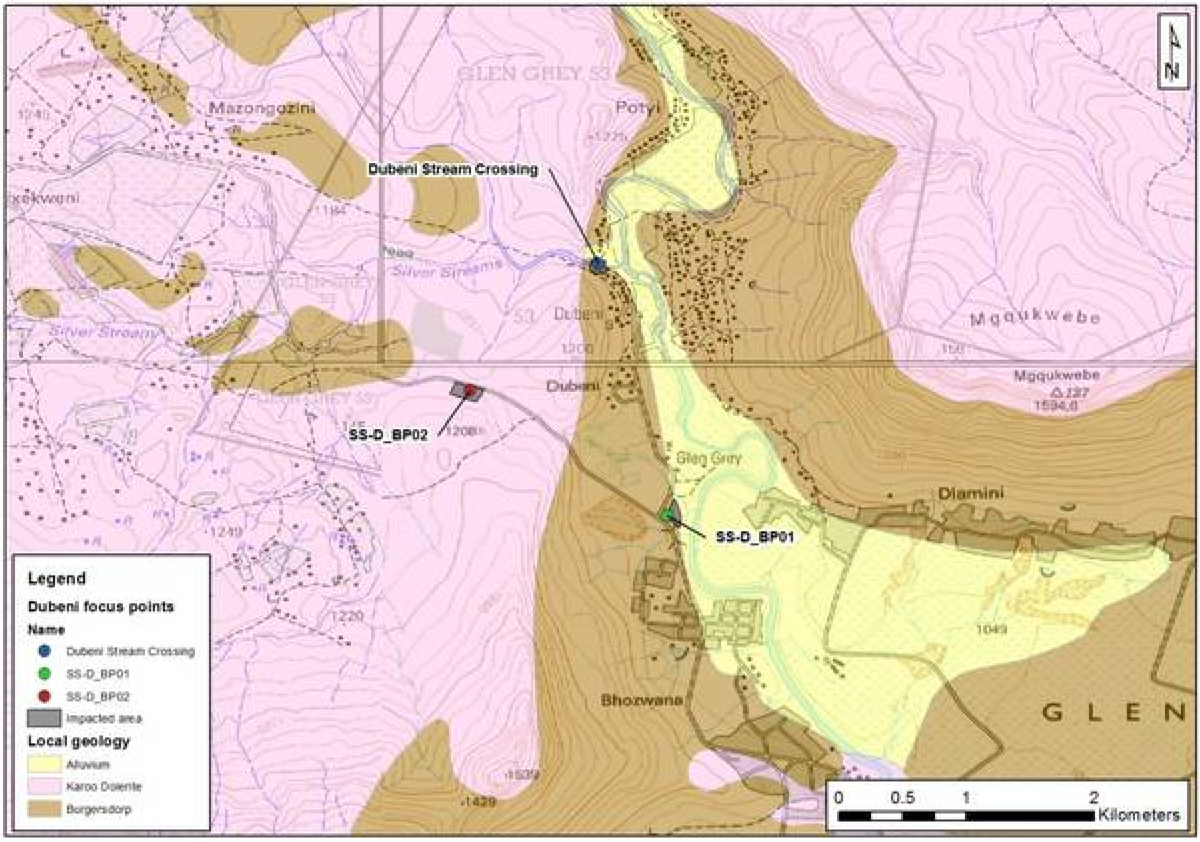

Figure 1: Geology of Dubeni and surrounding area taken from Geological survey data with river crossing impact area and borrowpits marked.

The strata of the **Karoo Supergroup** were deposited within the Karoo sedimentary Basin, which resulted from shortening and thickening of the southern margin of Africa, with coeval folding and uplift of the Cape Supergroup strata along its southern margin. The Karoo Supergroup strata are between 310 and 182 million years old and span the Upper Carboniferous to Middle Jurassic Periods. During this interval the basin evolved from an inland sea flooded by a melting ice cap, to a giant lake (the Ecca Lake) fed by seasonal meandering (and at times braided) rivers. This lake steadily shrank as it filled with sediment and the basin's rate of subsidence stabilised. The land became increasingly arid and was covered with wind blown sand towards the end of its cycle. Finally the subcontinent was inundated with basaltic lava that issued from widespread linear cracks within the crust, to form the capping basalts of the Drakensberg Group.

The beginning of the Triassic Period in South Africa was marked by a change in sedimentation, leading to the distinct sandstone dominated lithology of the Katberg Formation (Tarkastad Subgroup, Beaufort Group, Karoo Supergroup). Extensive sandy deposits resulted from multi channelled braided river systems that replaced the meandering rivers of the underlying Adelaide Subgroup. This change may have resulted from increased erosion of the landscape due to widespread extinction of plant groups during the end-Permian mass extinction. This was accompanied by widespread extinction of vertebrate taxa.

The **Burgersdorp Formation** (**Tarkastad Subgroup, Beaufort Group, Karoo Supergroup**) is more mudstone dominated than the Katberg Formation and the sediments represent a return to a meandering river system, presumably resulting from recovery of vegetation following the extinction event.

The floodplains of the **Beaufort Group (Karoo Supergroup)** provide an internationally important record of life during the early diversification of land vertebrates. Giant amphibians coexisted with diapsid reptiles (the ancestors of dinosaurs, birds and most modern reptiles), anapsids (which probably include the ancestors of tortoises) and synapsids, the dominant group of the time which included the diverse therapsids (including the ancestors of mammals). Rocks of the Beaufort Group provide the world's most complete record of the important transition from early reptiles to mammals

Therapsid diversity, along with that of most plants and animals was decimated during the end-Permian extinction event, a serious contender for the most severe extinction event to affect life on Earth. Ongoing research on the effects of this extinction event is facilitated by the detailed record, afforded by Beaufort Group strata, of life immediately before and after the event, as well as the gradual recovery of life afterwards.

The strata of the Beaufort Group are subdivided into a number of biostratigraphic units based on their changing suite of vertebrate fossils (Figure 2).

The most dramatic faunal change is evidenced near the boundary between the uppermost Adelaide Subgroup (the Balfour Formation) and the lower unit of the Tarkastad Formation (the Katberg Formation. This corresponds to the major extinction event associated with the Permo-triassic boundary. The Katberg Formation falls entirely within the *Lystrosaurus* Assemblage Zone, a depauperate zone lacking much of the higher taxonomic diversity of the underlying *Dicynodon* Assemblage Zone.The effects of the end Permian extinction event are also evident in the extensive and important record of fossil plants present in the rocks of the Karoo. Whereas faunas of Permian age are dominated by a wide range of early seed plants, the Glossopteridales (which probably include the ancestors of modern gymnosperms and ultimately angiosperms), this group appears to have gone entirely extinct during the end-Permian extinction

A return to a meandering river system, possibly as a result of a recovery of vegetation cover is reflected in the mudstone dominated strata of the **Burgersdorp Formation** (**Tarkastad Subgroup, Beaufort Group, Karoo Supergroup**). Though including the uppermost level of the *Lystrosaurus* Assemblage Zone, the Burgersdorp Formation largely corresponds to the *Cynognathus* Assemblage Zone. Synapsid therapsid diversity does not demonstrate recovery between the *Lystrosaurus* and *Cynognathus* assemblage zones. The Dicynodontia, *Lystrosaurus* and *Myosaurus* are replaced by *Kombuisia* and the giant *Kannemeyeria*. Therocephalia exhibit a turnover of taxa at generic level, but an overall reduction in diversity. Cynodontia (Therapsida, Synapsida) alone amongst synapsids demonstrate a slight increase in genera. These include the small advanced Cynodont, *Cynognathus*, which together with the Cynodont *Diademodon* and the Dicynodont *Kannemeyeria,* characterise this assemblage zone. Eosuchid and captorhinid Reptilia are moderately common, though showing no generic continuity with taxa of the underlying zone. Amphibia, which alone show increased diversity in the *Lystrosaurus* Assemblage Zone, remained diverse in the *Cynognathus* Assemblage Zone. They are, however,e not as generically diverse as in the *Lystrosaurus* Assemblage Zone, and likewise demonstrate no genus level continuity therewith. Fossil fish reach their greatest known Karoo Supergroup diversity in the Burgersdorp Formation (*Cynognathus* Assemblage Zone). Plants (*Dadoxylon*, *Dicroidium* and *Schizoneura*), trace fossils (including both vertebrate and invertebrate burrows) and a freshwater bivalve (*Unio karooensis*) have also been recovered.

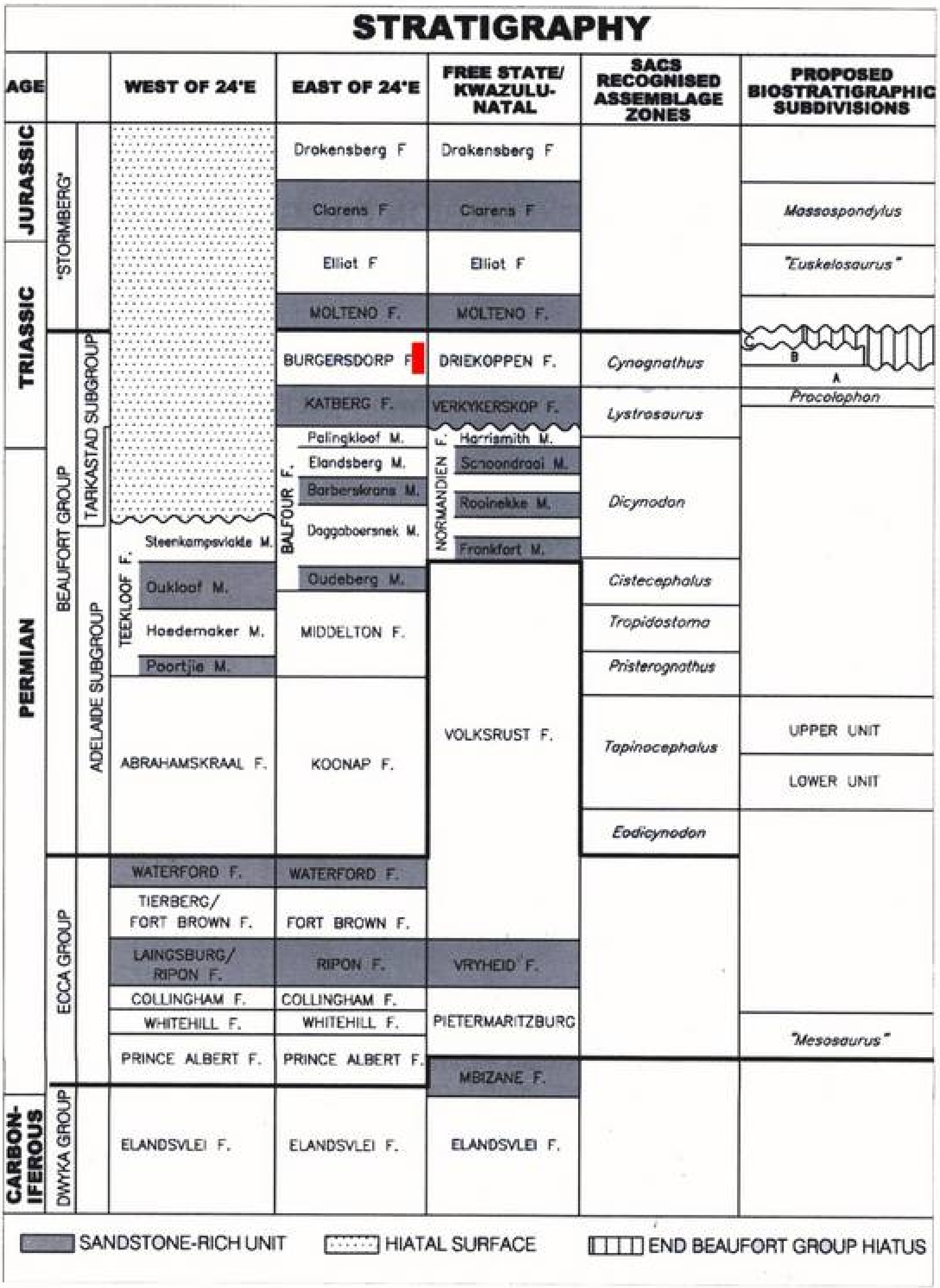

Figure 2: Karoo stratigraphy and biostratigraphy (after Smith *et al.*, 2012). Red line indicates approximate stratigraphic interval impacted by proposed development.

Dolerite within the area was intruded during the formation of the volcanic **Drakensberg Group (Stormsberg Group, Karoo Supergroup).** During the Jurassic, crack like fissures in the earth's crust became filled with molten lava that later cooled to form dolerite dykes. Other magma was injected under pressure between horizontal sedimentary strata and cooled to form extensive horizontal sills of dolerite. Dolerite, being an intrusive igneous rock, contains no fossils.

Site Visit

The Dubeni Stream crossing and two associated borrowpits were visited on the 14th of April 2014 and assessed for palaeontological sensitivity.

Although the area of the crossing is ultimately underlain by sediments of the Burgersdorp Formation these are not exposed in the immediate vicinity. The stream bed is filled with coarse boulders of dolerite and hard thermally altered sandstone, within a matrix of recent sandy alluvium (Fig. 3). The proposed new road course also crosses thick alluvium and it is unlikely that any bedrock will be disturbed during implementation at the site itself.

Figure 3: Dolerite and coarse sandstone boulders in a recent sandy matrix at the site of the new Silver Stream crossing at Dubeni.

Borrowpit 1 is a previously exploited borrowpit (Figs 4,5), the aggregate sourced from which consists of fine purplish mudstones with fine greenish sandstone interbeds - deposited as floodplain splays during the Triassic. Palaeomudcracks were observed, highlighted with greenish sediment, in the western wall of the borrowpit (Fig. 6). Although this is the type of deposit most associated with vertebrate fossils in the Burgersdorp Formation, none were observed during the site visit.


Figure 4: Borrow pit 1 looking south.


Figure 5: Borrow pit 1 looking west with fine sandstone layer visible near top of profile.

Figure 6: Palaeomudcracks (greenish) seen in cross section in western profile of borrowpit 1.
Despite being situated in an area mapped as dolerite by the geological survey, borrowpit 2 exploits rocks of sedimentary origin. These have however been severely thermally altered as they are situated immediately above the dolerite intrusion, the upper contact of which may be seen in the eastern wall of the borrowpit (Figure 7). They consist of a brittle olive green rock with fine vertical faulting and pale spherical areas of metamorphic alteration (Figure 8). Due to the extreme alteration of the rock it is not expected to yield useful palaeontological material.

Figure 7: Borrowpit 2 showing a wedge of thermally altered sedimentary rock in the foredound at right, underlain by pale weathered dolerite in the foreground at left. A dolerite comprised ridge is visible in the background.

Figure 8: Thermally altered sedimentary derived rock which provides the source of aggregate at borrowpit 2.

Conclusions and Recommendations

It is concluded that due to a thick cover of alluvium, including large boulders of dolerite and thermally altered sandstone, potentially fossiliferous Burgersdorp Formation sediments underlying the Silver Stream crossing at Dubeni are unlikely to be significantly affected.

Sedimentary derived rock is (despite geological survey information) the source of aggregate at borrowpit 2. Due to extreme thermal alteration this rock is not, however, likely to be of great palarontological interest,

Borrowpit 1 is intended to exploit floodplain derived fine mudstones of the Burgersdorp Formation. These have a high likelihood of containing Triassic vertebrate fossils. None were, however, observed during the initial site visit. It is recommended that **the ECO (or a designated on-site staff member) should carry out daily inspections of borrowpit 1**. Should any fossil bones be noted he should immediately contact the palaeontologist or a representative of ECPHRA and divert excavations to another part of the borrowpit. **Borrowpit 1 should also be inspected towards the end of its use, before rehabilitation occurs, by a qualified palaeontologist**.

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