Palaeontological Impact Assessment for proposed upgrade of Route R61 section 6

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Background

The proposed project includes the rehabilitation and upgrade of the Route R61 Section 6 between Cofinvaba and Ngcobo from 2.35 km west of the Qumanco River in the west to Ngcobo in the east - to provide a 20 year design life and to bring it up to National Roads Standards. The western limit of this project is at km 41.655 with the eastern limit being at km 68.2 also including the main road in Ngcobo town. This section of road is situated in the Eastern Cape Province between the towns of Cofinvaba and Ngcobo and forms part of the important link between the Eastern Cape, Free State, and Gauteng. In the west the R61 joins the N6 at Queenstown and in the east links with the N2 at Mtata towards KwaZulu Natal.

The existing road is a single carriageway and stretches along rolling mountainous terrain and has an average surfaced width of 6.2m comprising of 2 x 3.1m lanes and a gravel shoulder. This road traverses though the Town of Ngcobo.

The proposed road will be upgraded to 12.4m (two lanes at 3.7m and two shoulders of 2.5m of which 0.8 m must be surfaced). It is proposed to increase the reserve width to 50m. Right turn refuge lanes will be incorporated in the three major intersections. The road will be fenced and livestock crossings will incorporated with road accesses.

The proposed scope of works is to include the following:

- Rehabilitation and widening of approximately 26.5 km of the existing R61 Section 6;
- Four Bridges to be widened and strengthened as necessary;
- Upgrading of culverts if necessary to accommodate hydraulic load and changes to road width and/or grade line.

Assessments will also be done for the utilisation and development of a maximum of six borrow pits (existing and new) and one hard rock quarry along the road. An application will be submitted to the Department of Mineral Resources.

Rob Gess consulting was contracted on 17th March 2011 to conduct a phase one Palaeontological Impact Assessment for this Project. The entire route and proposed borrow pits and quarry were surveyed.

Geology and Palaeontology

The entire study area is underlain by strata of the Burgersdorp Formation (middle Tarkastad Subgroup, Beaufort Group, Karoo Supergroup). These are cut by dolerite dykes intruded during the Jurassic.

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 Triassic Burgersdorp Formation was deposited in the latter half of the Karoo Basin's evolution. Life in the Karoo basin had been decimated during the Permotriassic extinction event, reflected in a change in lithology from the mudstone dominated upper Balfour Formation (Adelaide Subgroup, Beaufort Group, Karoo Supergroup) to the sandstone dominated lithology of the Katberg Formation (lower 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.

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). The Burgersdorp Formation is characterised by maroon, blue-green and greyish green with subordinate intercalated fine to medium grained felspathic sandstones. Sandstones are lenticular and often widely separated.

The flood planes of the **Beaufort** Group (Karoo Supergroup) provide an internationally important record of life during the early diversification of land vertebrates. During its deposition 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 worlds most complete record of the important transition from early reptiles to mammals

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Therapsid diversity, along with that of most plant 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 Beaufort Group is subdivided into a series of biostratigraphic units on the basis of its faunal content. The Burgersdorp Formation may include the uppermost *Lystrosaurus* Assemblage Zone in addition to the entire *Cynognathus* Assemblage Zone.

The *Lystrosaurus* Assemblage Zone contains a limited fauna surviving immediately after the Permotriassic extinction event. It is dominated by a single genus of dicynodont, *Lystrosaurus*, which together with the captorhinid reptile, *Procolophon*, characterise this zone. Therocephalian and cynodontian Therapsida were moderately abundant. Small numbers of Captorhinid Reptilia survived the biotic turnover. An unprecedented diversity of giant amphibians characterises this interval and fish have also been recorded. Fossil millipedes, a range of plants and diverse trace fossils have also been recorded.

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 remain diverse, though they are not as gererically diverse as in the *Lystrosaurus* Assemblge 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.

During the formation of the volcanic **Drakensberg Group (Stormsberg Group, Karoo Supergroup)**, during the Jurassic, crack like fissures in the earths 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.

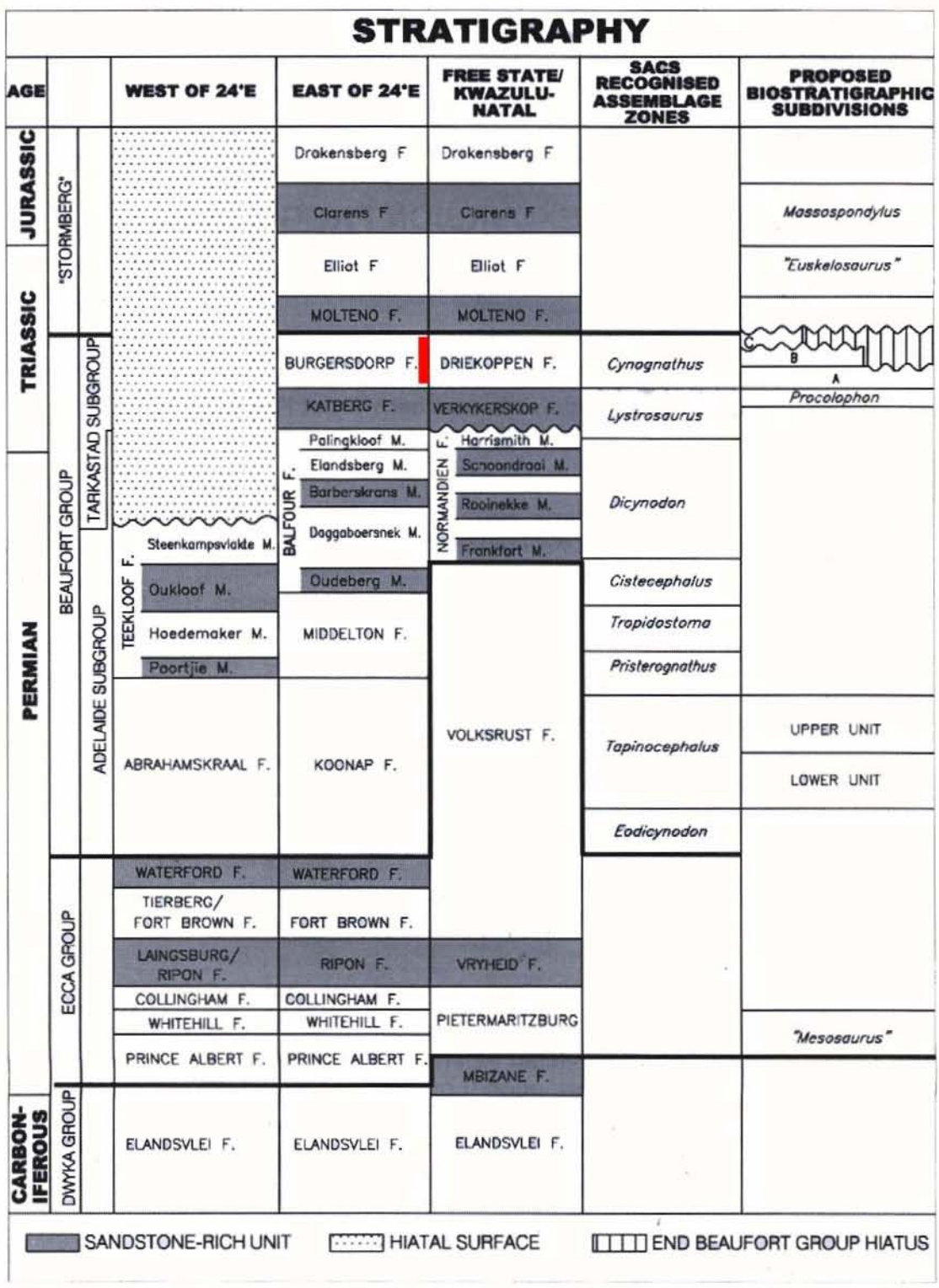


Figure 1: Karoo stratigraphy and biostratigraphy (after Rubidge, B.S. 2005, S.A. Journal of Science), with Burgersdorp Formation highlighted in red.

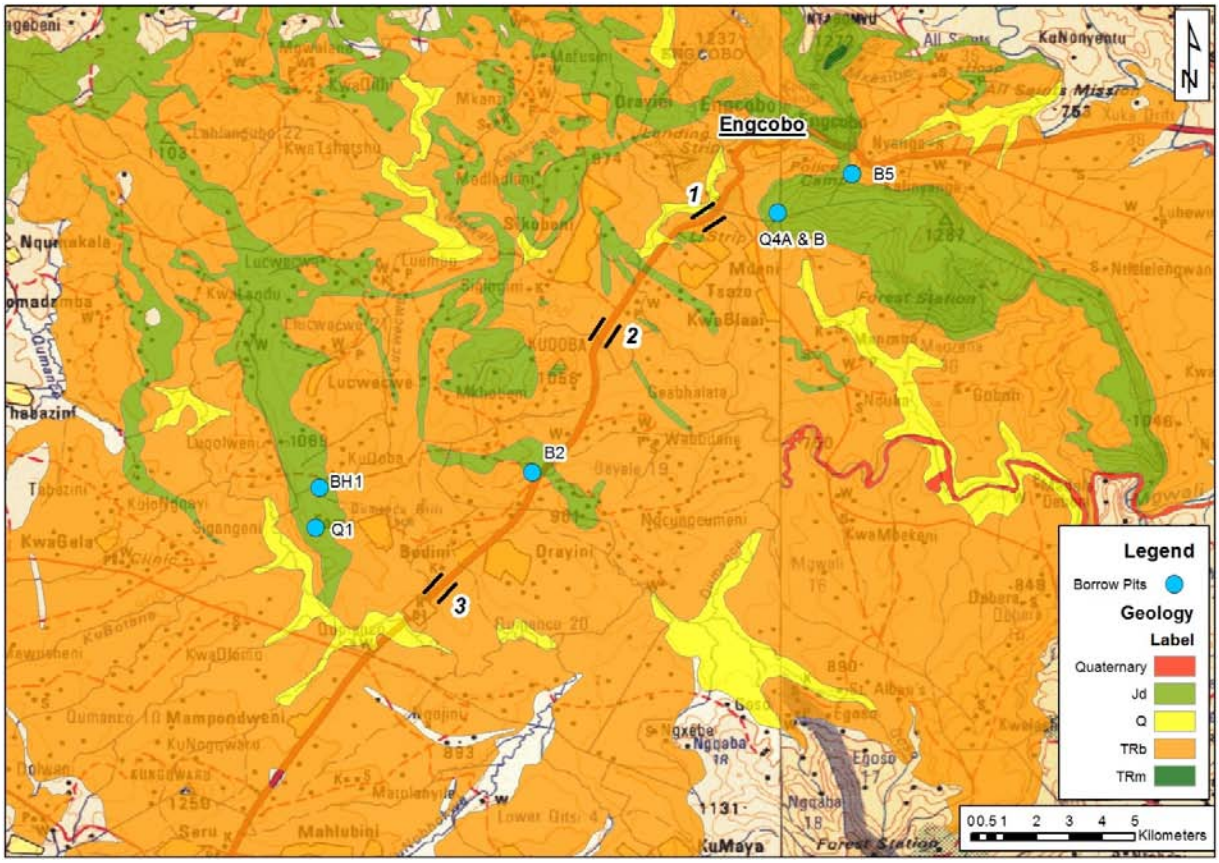


Figure 2: Geological map of the study area, Trb = Burgersdorp Formation, Jd = dolerite, Q = Quaternary cover. 1,2 and 3 refer to areas of Palaeontological interest.

Site Visit

The route was rigorously surveyed on the 21st and 22nd July, with extensions and additional borrow pits being surveyed on 19th November. It was confirmed that all borrow pits and quarries are situated in dolerite.

Figure 3: Borrow pits 2 (above) and 5 (below) showing deeply weathered and fresher dolerite respectively

The route followed by the road itself does pass a number of roadcuttings containing buff to maroon mudstones of the Burgersdorp Formation. These are situated immediately north of the

Qumanco River; where the road skirts the eastern flank of (Mount) Kuqoba; where it passes up the northern bank of the Mgwali River (which at this point flows around the northern slopes of Kuqoba); and approaching the Mgwali's northern flowing tributary (which rises around Encobo) from the south.

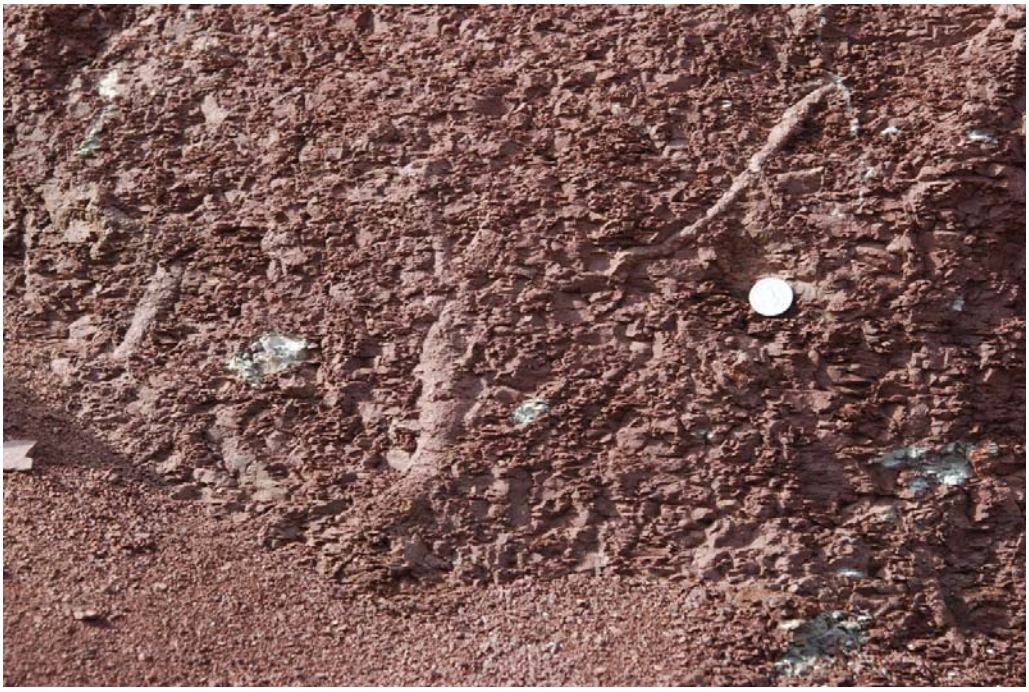
These roadcuttings were minutely examined. No vertebrate or plant fossils were found. A number of trace fossils are noted below as they will be destroyed by widening of the road.

On the northern side of the Mgwali River (Fig. 2, pt. 2) the road passess between tall road cutting. Here, shale with small sandstone interbeds is overlain by dolerite, which has at some point been mined for aggregate.

Within the mudstone there are two horizons featuring palaeomudcracks, which are particularly clearly represented in the eastern roadcutting. Both of these (though the stratigraphically higher of the two in particular) are associated with numerous invertebrate burrows, vertical, inclined and of varying orientation. These are roughly 1cm in diameter and the natural casts of some appear to have a "nobbly" surface (Figs. 4-6)

Identical burrows are also preserved in a cutting immediately north of the Qumanco River (Fig. 2 pt. 3) (Fig. 7).

Figure 4: Trace fossil rich roadcutting to the immediate north of the Mgwali River (see Fig 2, pt.2)



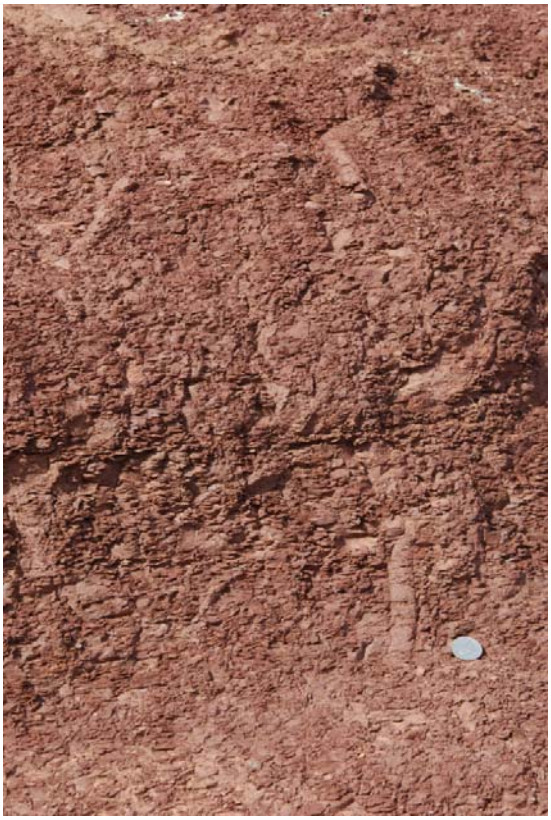


Figure 5: Vertical and inclined invertebrate burrows in roadcutting north of the Mgwali River. Scale = R5 coin

Figure 6: Details of vertical burrows exposed in roadcutting north of Mgwali River.

Figure 7: Vertical burrows exposed in roadcutting north of Qumanco River (Fig.2, pt.3)

On the southern side of the Mgwali's northern tributary (Fig. 2 pt. 1) the road is also lined on both sides by roadcuttings that expose promising outcrops of purplish mudstone. These contain paler bioturbated layers and thin sandstone interbeds. An isolated horizontal burrow of approximately 1cm diameter was also observed (Fig. 8).

Figure 8: Road cutting south of Mgwali Rivers northern tributary (Fig. 2, pt. 1) (above) and cast of horizontal burrow (below).

Conclusions and Recommendations

1. As all borrow pits and quarries intended for use in this project are only impinging on dolerite, they will in no way impact on palaeontological resources.

2. Potentially palaeontologically sensitive cuttings through mudstones and thin interbedded sandstones of the Burgersdorp Formation occur on both sides of the road to the north of the Qumanco River, to the north of the Mgwali River, and south of its northern tributary (Fig. 2, pts 1-3) . Although no vertebrate or plant fossils were discovered during the survey, these may be exposed when the road is widened.

   It is therefore recommended that these cuttings should be re-inspected after completion of the construction phase and before any vegetation or other rehabilitation is conducted. This should form part of the Environmental Management Plan.