Palaeontological impact assessment for Proposed upgrade of the N10 section 4, immediately north of Cradock

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Background

SRK Consulting, on behalf of SANRAL conducted a Basic Assessment for the upgrading of the N10 Section 4: Cradock (Km 1.6) to Knutsford (Km 29) (Figure 1).

It is proposed that the existing in-situ base of the road prism will be re-worked and stabilized. Widening of the road shoulders is not anticipated. However two intersections along the road will be widened to accommodate a refuge lane and slip lane. This widening will however remain within the existing road reserve (which is generally about 25 m wide). Between these two intersections a climbing lane will require widening of the road. An agricultural underpass is proposed at Km 24.9, requiring elevation of the road by approximately 2 m. For this, a substantial volume of sub-base material, and therefore a borrow-pit, will be required. A second borrow pit will also be required for roadworks. An application will be submitted to the Department of Mineral Resources for the development of this borrow pits.

As this road section crosses strata of the highly fossiliferous Balfour Formation a phase 1 field assessment was carried out on the first of June 2012.

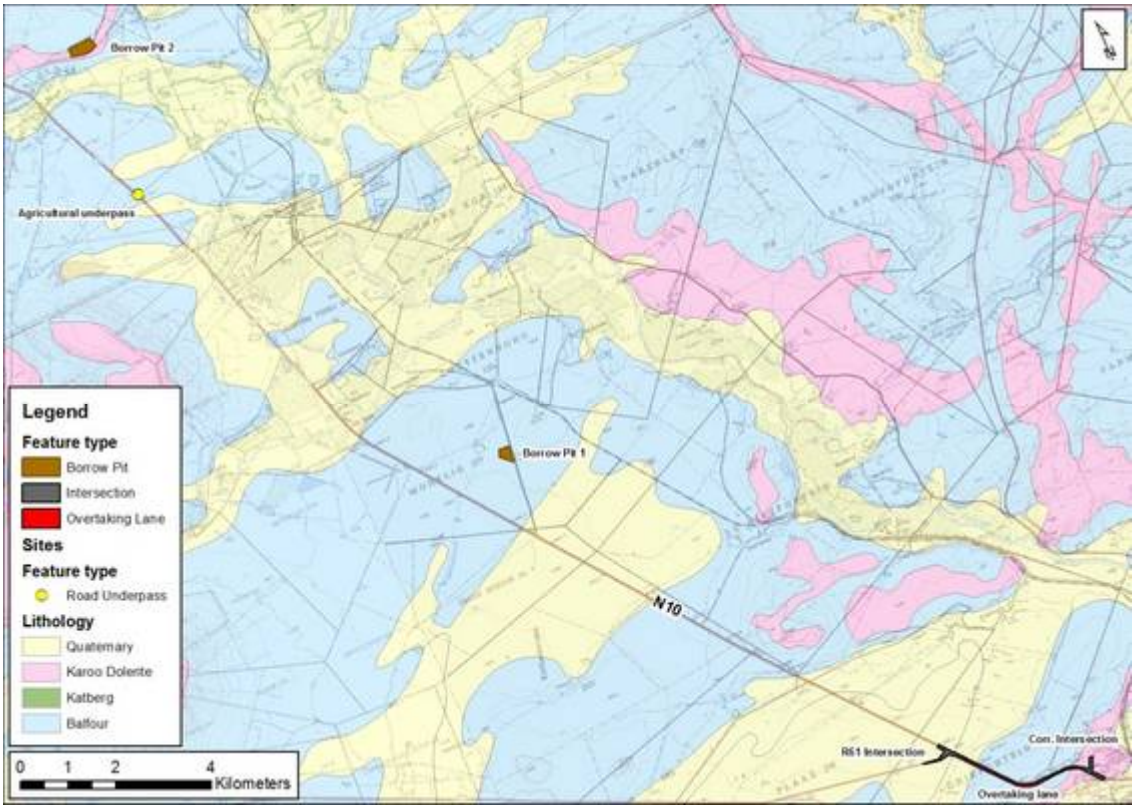

Figure 1. Upgrade of N10 section 4 features superimposed on topographic and geological survey data.

Geology and Palaeontology

The entire study area is underlain by strata of the middle to upper **Balfour Formation (Adelaide Subgroup, Beaufort Group, Karoo Supergroup**), including the Daggaboesnek Member, the sandstone dominated Barberskrantz Member and the greyish mudstone dominated Elandsberg Member. These are intruded by dolerite dykes and sills implaced 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. As the lake shrank the plains behind the shoreline grew. Rivers crossing the plains deposited sediment as channel fills and overbank flood deposits. 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 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 world's most complete record of the important transition from early 'reptiles' to mammals.

The Beaufort Group is subdivided into a series of biostratigraphic units on the basis of its faunal content. The Barberskrantz and Elandsberg Members of the Balfour Formation fall within the *Dicynodon* Assemblage Zone (Figure 2).

The *Dicynodon* Assemblage Zone is characterised by the co-occurrence of two therapsids, *Dicynodon* and *Theriognathus.* It demonstrates the Beaufort Groups greatest diversity of vertebrate taxa, including numerous genera and species of dicynodont, biarmosuchian, gorgonopsian and therocephalian and cynodont therapsid Synapsida, together with diverse captorhinid Reptilia and less well represented eosuchian Reptilia, Amphibia and Fish. Trace fossils of invertebrates and vertebrates as well as *Glossopteris* flora plants have also been described.

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.

Much of the area is covered in a thick deposit of Quaternary alluvium some of which has been calcretised. This is unlikely to contain palaeontologically sensitive material

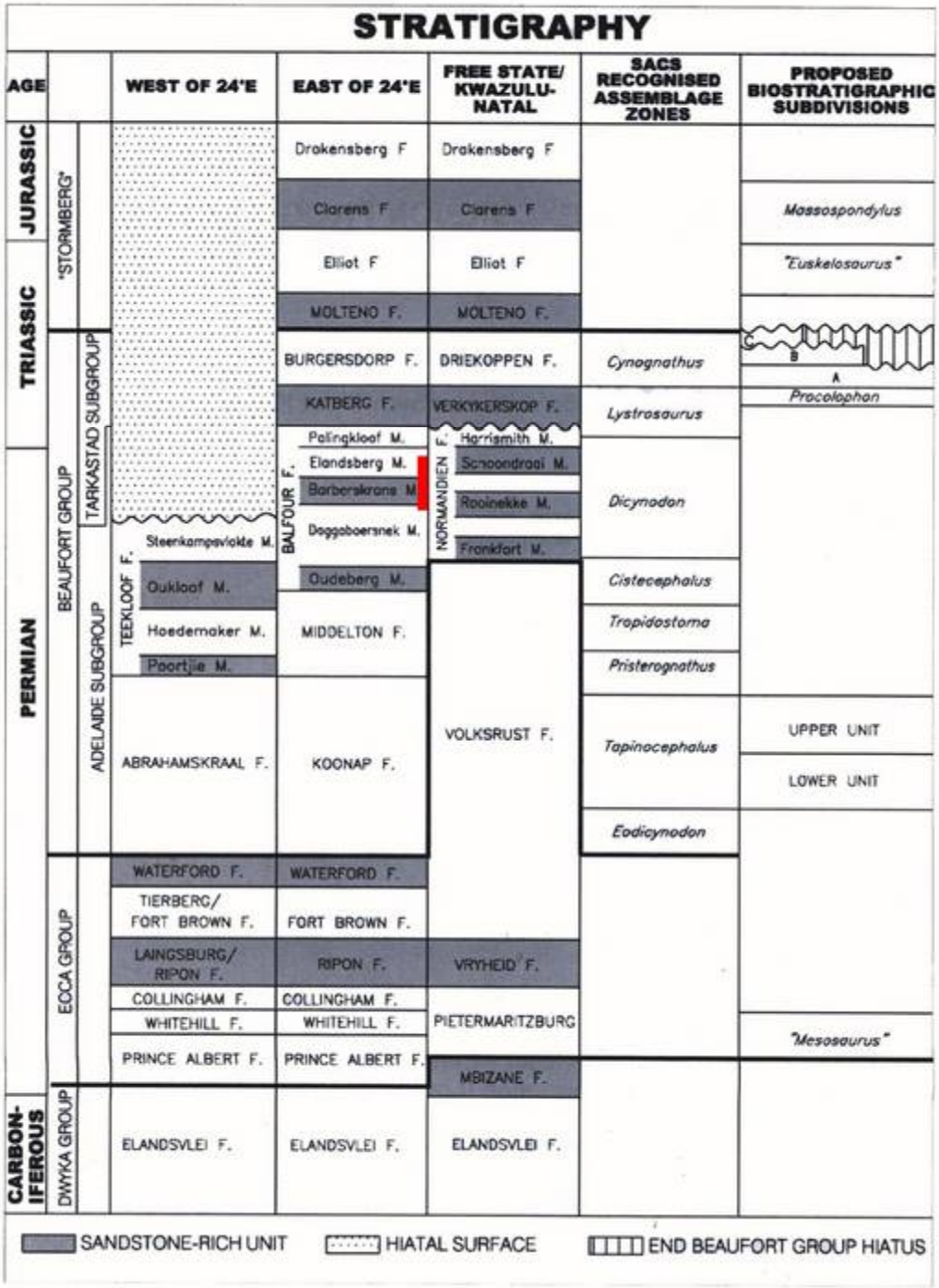

Figure 2. : Karoo stratigraphy and biostratigraphy (after Smith *et al*., 2012). Red line indicates stratigraphic interval impacted by proposed development.

Site Visit

A phase 1 field assessment was carried out on the first of June 2012. Most of the proposed upgrade will be sited along an existing raised roadbed and is not therefore of any palaeontological concern. A field assessment was however required for two new intersections, a climbing lane that will require cutting back of an existing road cutting, an agricultural underpass and two borrow pits.

The correctional services intersection is situated where a large dolerite sill underlies the land surface (Fig. 3) and is therefore of no palaeontological sensitivity. The small roadcutting to the north of the intersection, which will be affected by its upgrade, is part of the same sill. It exhibits microfaulting during cooling, towards the top of the sill. The resultant cracks have been filled with residual pegmatitic melt depleted in dark mafic minerals (Fig. 4).

Figure 3. Dolerite immediately to the south of the correctional services intersection.

Figure 4. Pegmatitic veins in dolerite in roadcutting to the north of the correctional services intersection.

Development of the proposed climbing lane will require cutting back of Balfour Formation strata exposed in a lengthy existing roadcutting (Fig. 5). This roadcutting is comprised largely of fairly coarse grained sediments including coarse siltstones and sandstones (Figs5-8). These include sandstones with stacked ripple cross lamination which were probably subaqeously deposited (Fig. 6). Calcium coated roundish structures within certain strata may represent sandballs created by soft sediment deformation which have been subsequently remineralised. Strata are generally altered to some extent due to their situation above an unusually large dolerite sill and in some cases remobilised minerals have crystalised out in vertical cracks (Fig. 9). The roadcutting was minutely examined but was not found to contain fossils bar some very poorly preserved plant stems (Fig. 8).

Figure 5. Southern end of the climbing lane cutting showing coarse siltstones and sandstones. The small roadcutting in the middle distance is that composed of dolerite north of the correctional services intersection.

Figure 6. Stacked ripple cross bedding in sandstone in climbing lane roadcutting. Scale bar = 5cm.

Figure 7. Alternating thin sandstone and mudstone ripple layers near the top of the climbing lane roadcutting (towards the northern end of the cutting).

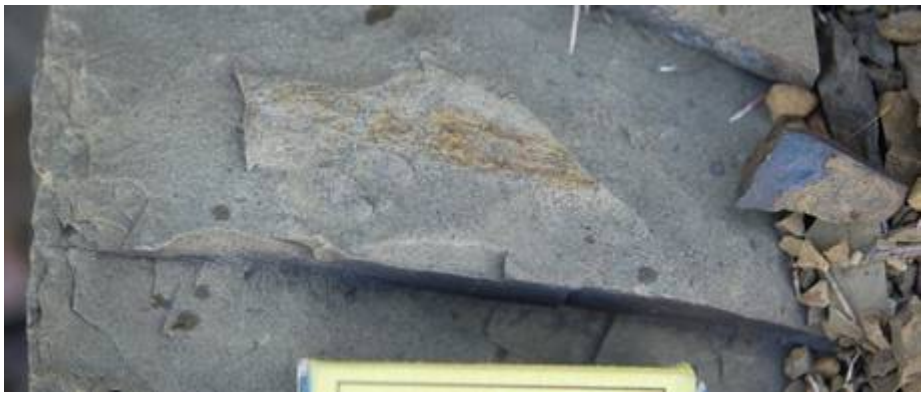

Figure 8. Poorly preserved plant stem from near the bottom half of the climbing lane cutting sequence.

Figure 9. Minerals that have crystalised in vertical cracks in sedimentary strata in the climbing lane roadcutting, resulting from the large underlying dolerite sill.

The R61 intersection is at a point where the road bed is raised and underlain by alluvium (Fig.10). This in turn is underlain by a Quaternary (geologically recent) conglomerate of chunks of Balfour Formation rock embedded in a calcrete matrix (Fig. 11). Neither the alluvium nor the calcretised conglomerate, which is unlikely to be impacted, are expected to produce important palaeontological material.

Figure 10. Intersection between N10 and R61 – built up on alluvial plain.

Figure 11. Quaternary calcrete containing reworked chunks of Balfour Formation rock, underlying alluvium beside the R61 to the west of the intersection with the N10.

The proposed agricultural underpass site is also of minimal sensitivity as here too the road is underlain by thick alluvium and the road bed is already raised point.

Figure 12. Site of the proposed agricultural underpass showing road bed raised on alluvial surface.

Borrow pit one is a greenfields development and the intended aggregate is entirely covered by alluvium (Fig. 13). In places small steps in the surface are marked by weathered sandstone fragments, indicating the presence of thin sandstone interbeds within mudstone (Fig.14). A nearby borrowpit exhibited a coarse greenish mudstone which was not found to be fossiliferous (Fig. 15). Evaluation of this site will not be possible until after works have proceeded.

Figure 13. Proposed site of Borrow Pit One showing alluvial cover.

Figure 14. Accumulations of weathered sandstone chunks that form bands on the gently sloping surface of the proposed site of Borrow Pit One, indicating presence of thin sandstone interbeds in mudstone.

Figure 15. Greeny grey fluvial mudstones of the Balfour Formation exposed in an abandoned Borrow pit to the east of the proposed new Borrow Pit One site.

The second borrowpit site (Bprrow Pit Two), which is intended to be the more extensive, extends back from a smaller existing borrowpit. Although the geological survey data indicates that this locale is entirely underlain by dolerite, only the north west corner in fact is. This borrowpit exhibits a thick bed of fine greenish mudstone (Fig. 16) which contains shallow water ripple planes (Fig. 18). This is in part overlain by a coarser layer within which

a horizon containing well-preserved sphenophyte stems was located (Fig. 16, 18). These Balfour Formation sediments underlie the dolerite sill marked on the map

The intention is to extend the borrowpit backwards to exploit aggregate contained in a small spur. This spur is topped by a loose pavement of weathered sandstone and alluvium (Fig. 19), except in the north west corner of the proposed site where dolerite caps the strata (Fig. 20).

Although no fossils of high significance were located during the survey, this site has the potential to contain important fossils.

Figure 16. Greenish mudstones and mudstones exposed at back of existing borrow pit at Borrow Pit Two site. Field assistant pointing out position of fossil sphenophyte layer.

Figure 17. fossil sphenophyte plant stems at Borrow Pit Two site. Scale bar = 2cm

Figure 18. Shallow water palaeoripples in mudstones at Borrow Pit Two site.

Figure 19: Pavement of weathered sandstone capping spur behind existing borrowpit at Borrow Pit Two site.

Figure 20. Dolerite outcropping in north west corner of Borrow Pit Two site.

Conclusions and Recommendations.

Most of the proposed upgrade will be sited along an existing raised roadbed and is not therefore of any palaeontological concern.

The correctional services intersection is situated where a large dolerite sill underlies the land surface and is therefore of no palaeontological sensitivity. Likewise the R61 intersection is of extremely low or no sensitivity as at this point the road bed is raised and underlain by alluvium. This in turn is underlain by a geologically recent conglomerate of chunks of Balfour Formation rock embedded in a calcrete matrix.

The proposed agricultural underpass site is also of minimal sensitivity as it is underlain by thick alluvium and the road bed is already raised at this point.

Development of the climbing lane may require cutting back of Balfour Formation strata exposed in a lengthy existing roadcutting. This roadcutting was minutely examined but was not found to contain fossils bar some very poorly preserved plant stems. In addition these strata are all altered to some extent due to their situation above an unusually large dolerite sill. This outcrop is not considered palaeontologically sensitive.

Borrow Pit One is a greenfields development and the intended aggregate is entirely covered by alluvium. A nearby borrowpit exhibited a coarse greenish mudstone which was not found to be fossiliferous. Evaluation of this site will not be possible until after works have proceeded

Borrowpit two, which is intended to be the more extensive, extends back from a smaller existing borrowpit. This borrowpit exhibits a thick bed of fine mudstone which contains shallow water ripple planes. This is in part overlain by a coarser, sandy layer within which a horizon containing well preserved sphenophyte stems was located. Although no fossils of high significance were located during the survey, this site has the potential to contain important fossils.

For this reason it is recommended that:

1. the EO is notified to look out for fossil plants and bones during excavation of the two borrowpits.
2. **The two borrowpits are inspected by a palaeontologist towards the end of their exploitation, but prior to back filling and rehabilitation.**

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