PALAEONTOLOGICAL IMPACT ASSESSMENT FOR PROPOSED BORROW PITS NEAR WITTLESEA, EASTERN CAPE

Prepared for: SRK consulting

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Background

The Eastern Cape Department of Roads and Public Works proposes to apply for permits for 5 borrow pits in the Whittlesea area near Queenstown in the Lukhanji Local Municipality. SRK Consulting has been appointed by Goba Consulting Enginers as the independent consultants to assess the environmental impacts in terms of the Mineral and Petroleum Resources Development Act (MPRDA 2002). The development requires authorisation from the Department of Minerals Resources.

The borrow pits are proposed for general maintenance of the provincial roads, in particular the gravel roads, in the vicinity. It is proposed that 20,000 to 25,000 m^3 of gravel wearing course be mined from each borrow pit over an extended period.

To determine the fossil record for the local area affected by the proposed borrow pits, a Phase I assessment was conducted.

Rob Gess Consulting was contracted to conduct a phase one Palaeontological Impact Assessment. The borrow pits were examined on the 24th of April 2012.

Geology

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. Lowermost Karoo strata of the Dwyka and lower Ecca Groups were affected by folding in the vicinity of the Cape Fold Belt. Deposition was shifted from the northern edge of the Agulhas Sea to the increasingly freshwater, inland Karoo Basin. 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 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.

As the Ecca Lake silted up a subaerial (exposed) shoreline began to develop, initially in the south east of the basin. The lake steadily shrank towards the centre of the basin, leaving behind flat silty plains across which long rivers meandered from the Cape Mountains towards the much reduced lake. Sands were deposited along the river channels whereas periodic flooding deposited muds on the broad flood plains. These in time came to form the interbedded sandstones and mudstones of the Koonap, Middleton and Balfour formations of the Adelaide Subgroup, (**Beaufort Group,** Karoo Supergroup) and the Katberg and Burgersdorp Formations of the Tarkastad Subgroup (Beaufort Group, Karoo Supergroup), within the Eastern Cape. Of these only the **Katberg** and **Burgersdorp Formations** are represented in these borrow pits (Figure 1).

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** (lower **Tarkastad Subgroup**, 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).

These strata are intruded by dykes (vertical sheets) and sills (horizontal sheets) of **dolerite** implanted during eruption of basalts belonging to the Jurassic Drakensberg Group.

The rocks into which the dolerite is intruded is often altered (metamorphosed) adjacent to intrusions.

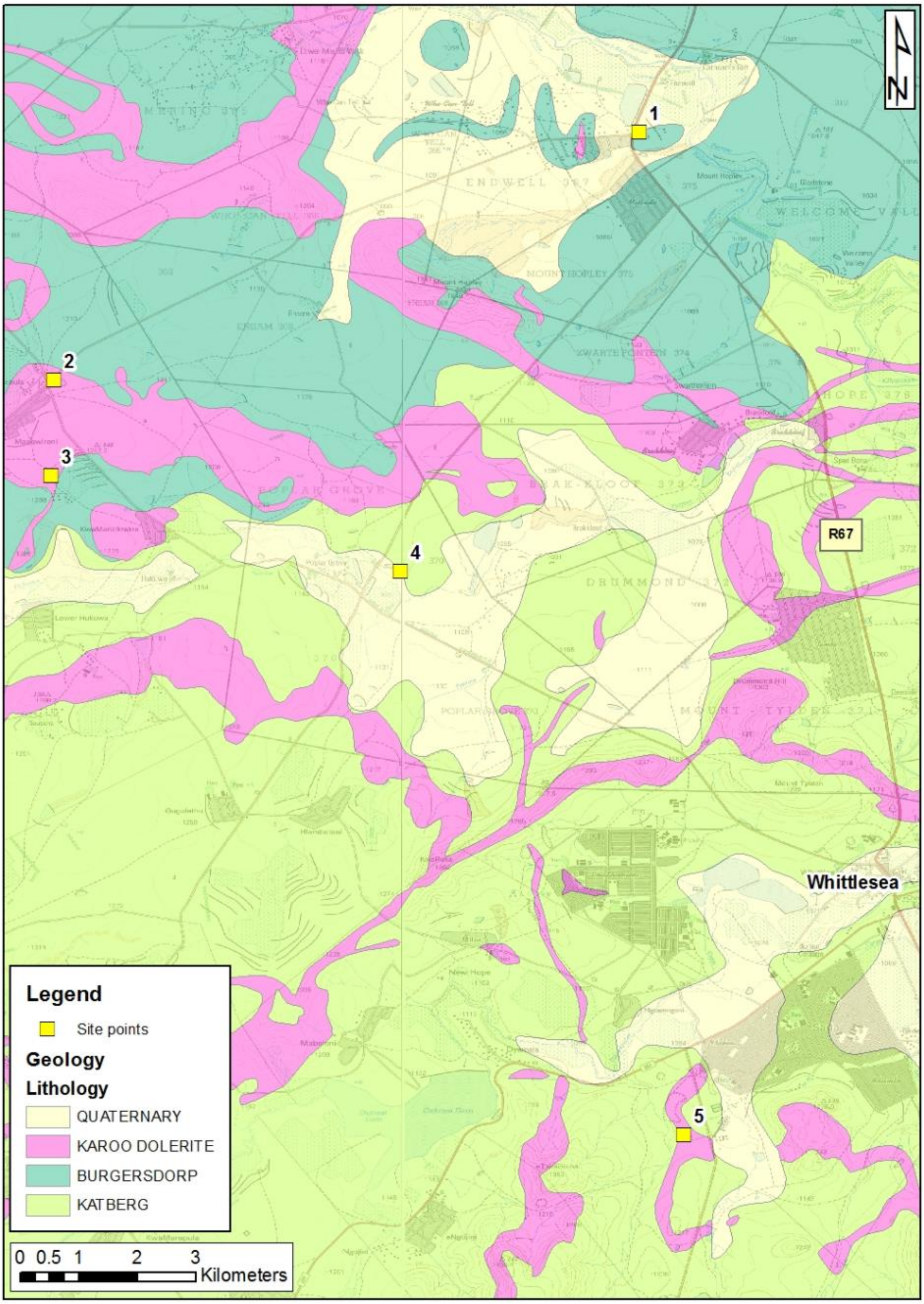

Figure 1: Geological Survey data superimposed on topographic map with borrow pits positions added.

Palaeontology

The flood planes 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 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 lowermost zones not represented in this area (figure 2).

A marked faunal change occurs between the *Dicynodon* and *Lystrosaurus* Assemblage Zones approaching the top of the Balfour Formation, corresponding with the major extinction event associated with the Permo-triassic boundary. The ***Lystrosaurus*** **Assemblage Zone** spans the uppermost (Palingkloof) member of the Balfour Formation, the **Katberg Formation (Tarkastad Subgroup, Beaufort Group, Karoo Supergroup)** and the lower part of the **Burgersdorp Formation (Tarkastad Subgroup**, **Beaufort Group, Karoo Supergroup).**

The *Lystrosaurus* Assemblage Zone is dominated by a single genus of dicynodont, *Lystrosaurus,* which together with the captorhinid reptile, *Procolophon*, characterise this zone. Biarmosuchian and gorgonopsian Therapsida do not survive into the *Lystrosaurus* Assemblage Zone, though therocephalian and cynodontian Therapsida exhibit moderate abundance. Captorhinid Reptilia are reduced, however an unprecedented diversity of giant amphibians characterises this interval.

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. The rocks of the Karoo provide an unrivalled sequential record of these changes and the diversification of other groups of plants in the aftermath of the extinction. The strata of the Karoo basin have also yielded fossil insects and insect leaf damage of a range of ages.

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 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.

Dolerite, being an intrusive igneous rock, contains no fossils.

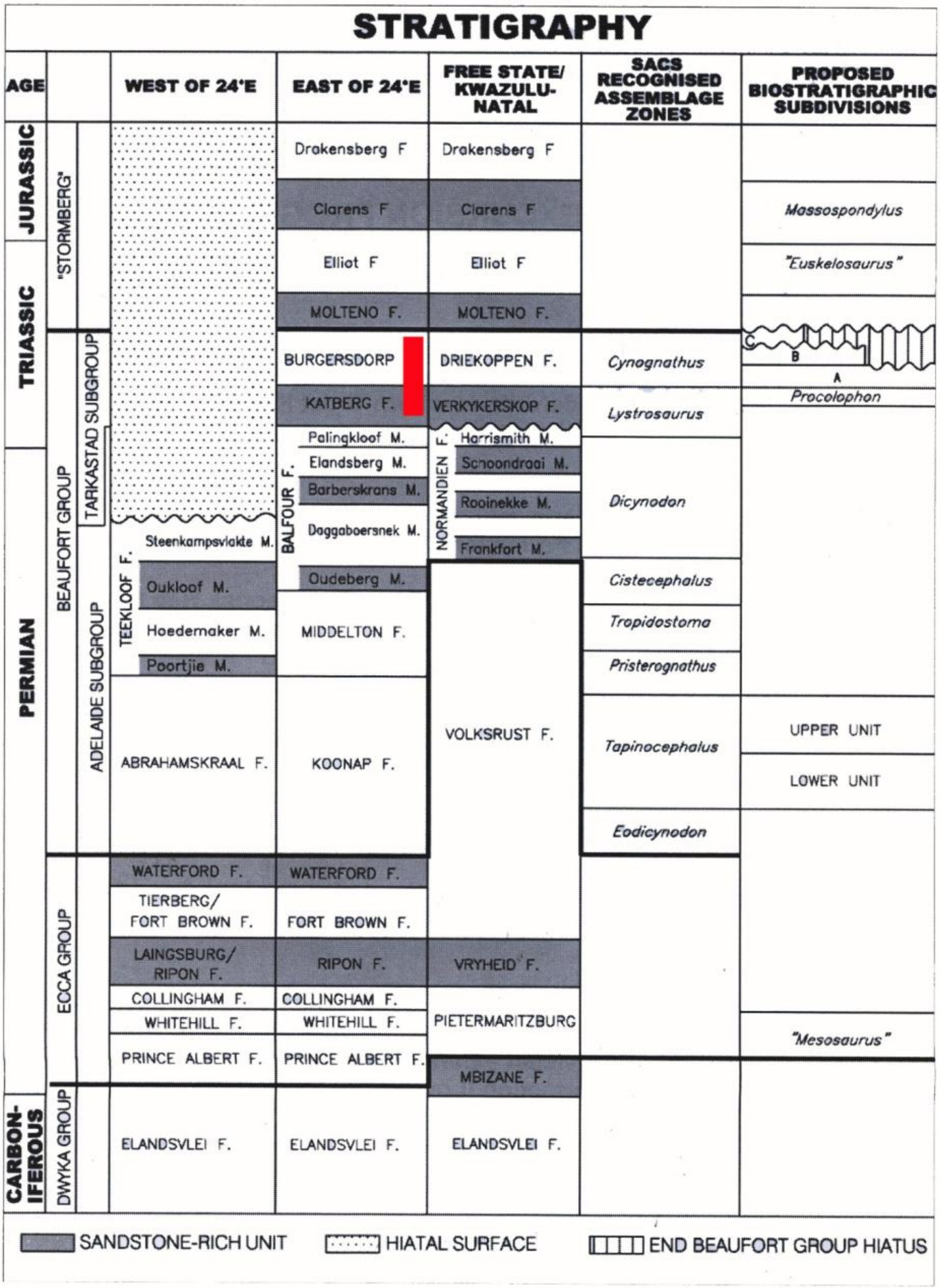

Figure 2: Karoo stratigraphy and biostratigraphy (after Smith *et al*., 2012). Red line indicates stratigraphic interval impacted by proposed development.

Site Visit

All five borrow pits were investigated on the 24th of April 2012.

Borrow pits 2 (fig. 3) and 5 (fig 4) consist of dolerite – exclusively in the case of borrow pit 2 and predominantly in the case of borrow pit 5. Borrow pit 5 exploits a weathered dolerite sill that outcrops around the base of a small hill capped with baked Katberg Formation sandstone. A small amount of this baked sandstone is incidentally exposed towards the back of the quarry, however it is unlikely to yield palaeontological material.

Figure 3: Borrow pit 2 showing exploitation of dolerite.

Figure 4. Metamorphosed Katberg Formation sandstones overlying a dolerite sill, exposed at the back of borrow pit 5.

Katberg Formation (Tarkastad Subgroup, Beaufort Group) mudstones underlying sandstones that caps a ridge are exploited in borrow pit 4. The lowermost sandstone (fig. 5) has an erosional base which exhibits casts of scouring of the dessicated underlying muds (fig. 6). Somewhat below this the mudstones include a layer characterised by mudcracks cast by infill with a pale sandy sediment (fig. 7). Above this layer a large probable invertebrate burrow cast was noted (fig. 8). Small invertebrate burrow casts as well as surface feeding traces were also noted within the mudstones (fig. 9).

Figure 5: Borrow pit 4 – uneven based sandstone overlying mudstones.

Figure 6: Borrow pit 4: underside of sandstone revealing cast of water scoured dessication cracked mud surface. Scale bar = 4cm.

Figure 7: Borrow pit 4- cross section of mudcracked surface within mudstones.

Figure 8: Borrow pit 4 – large probable invertebrate burrow cast in mudstones. Scale = 4cm.

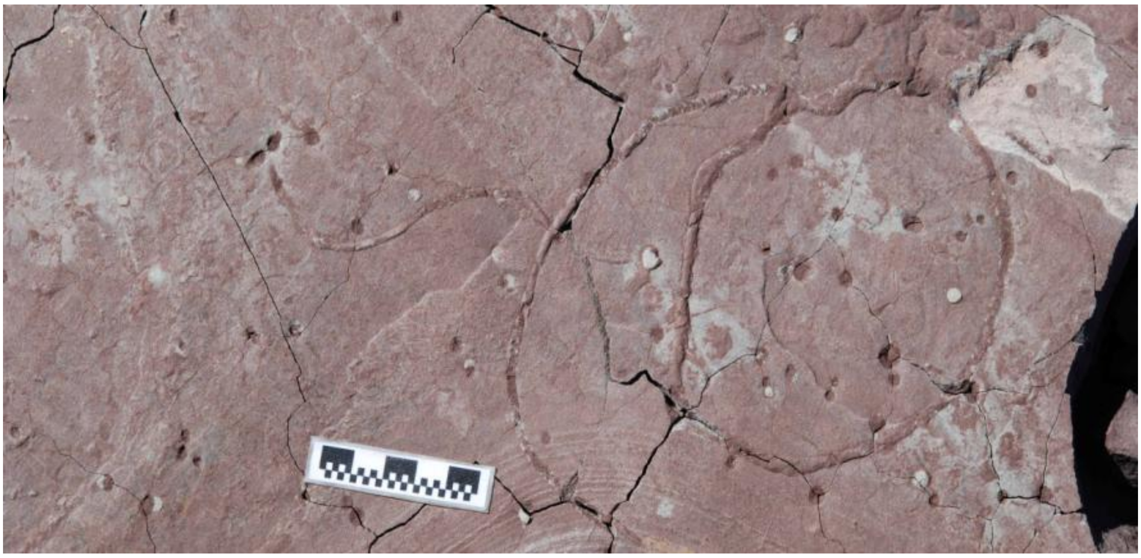

Figure 9: Borrow pit 4: Mudstone layer exhibiting abundant small invertebrate burrows and invertebrate surface feeding traces. Scale bar = 4cm.

Mudstones belonging to the Burgersdorp Formation (Tarkastad Subgroup, Beaufort Group) are the source of aggregate in borrow pits one and three.

Borrow pit three is excavated into mudstone underlying a dolerite sill (fig. 10). These mudstones have been altered to a bluish colour as a result of proximity to the magmatic intrusion (fig. 11).

Figure 10: Borrow pit 3 excavated into mudstone underlying a dolerite sill.

Figure 11: Burgersdorp Formation mudstone altered to bluish colour by metamorphism at borrow pit 3.

Borrow pit 1 exposes Burgersdorp Formation mudstones with thin interbedded sandy layers.

Small invertebrate burrows were noted (fig. 13). In geologically recent times the strata have been faulted by a series of curved fractures approximately 3 meters deep that are revealed in cross section in the quarry, disrupting strata. These are filled with calcretised pebbly sub-soil that overlies the mudstone (fig. 12).

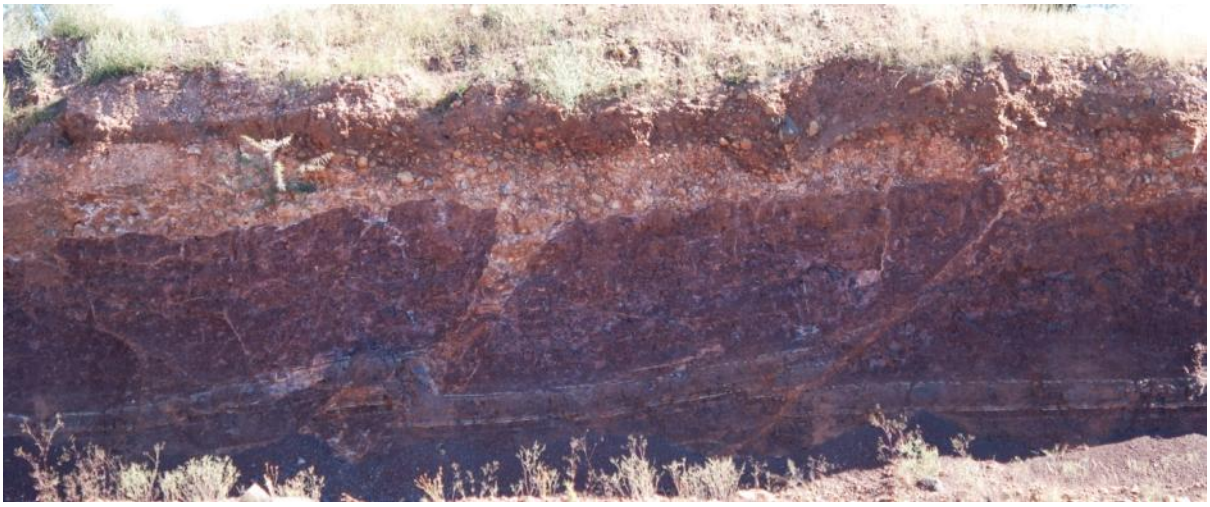

Figure 12: Borrow pit 1: Burgersdorp Formation mudstones showing 3 metre deep faults filled with geologically recent calcretised pebbly deposit.

Figure 13: Borrow pit 1: impressions of small invertebrate burrows. Scale bar = 4 cm.

Conclusions and Recommendations

All borrow pits were investigated, however no significant palaeontological resources were observed. No further palaeontological work is therefore required before the beginning of works.

There is virtually no chance of fossils being disturbed during further exploitation of borrow pits 2 and 5.

It is possible that fossil vertebrate bones might be disturbed during excavations at borrow pits 1, 3 and 4. The ECO should be instructed to look out for any fossil bones and to contact a palaeontologist in the event of fossil bones being uncovered.

The geology at borrow pit 4 suggests a depositional environment in which fossil bones may be expected to be found. **Borrow pit 4 should therefore be revisited by a palaeontologist at the end of excavation but prior to rehabilitation**.

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