Palaeontological Impact Assessment for the upgrade of National Route 10 section 3 between Baviaans River (Km 20.1) and Rietvlei (Vrischgewaadg) (Km 45.1)

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Background

MPM Environmental Consultants were appointed by Worley Parsons RSA (incorporating KV3 Engineers) on behalf of the South African National Roads Agency Limited (SANRAL) as independent Environmental Assessment Practitioners (EAP) for the proposed upgrade.

The extent of the proposed upgrade (a linear development exceeding more than 300 m in length) falls within the ambit of section 38 of the South African Heritage Resources Act, Act No. 25 of 1999, which requires an archaeological impact assessment.

Rob Gess Consulting was subcontracted to conduct a Palaeontological Impact Assessment.

Geology

The route intersects members of the **Balfour Formation** (**Adelaide Subgroup, Beaufort Group, Karoo Supergroup**).

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.

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 planes. These in time came to form the interbedded sandstones and mudstones of the Permian **Koonap Formation**, **Middleton Formation** and **Balfour Formation** (**Adelaide Subgroup**, **Beaufort Group, Karoo Supergroup)**. Of these only parts of the Balfour Formation are intercepted by this road section.

These include the upper portion of the Ouderberg Member, The Baviaanskloof Member and the lowermost part of the Barberskrantz Member.

In the Cradock – Pearston- Adelaide area lacustrine conditions are indicated for much of the Balfour Formation (Johnson, 1976, PhD Rhodes Univ.). These would represent deposits within a localised water body.

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.

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 worlds 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. Though including the upper *Cistephalus* Assemblage Zone and possibly the lowermost *Lystrosaurus* Assemblage Zones, the **Balfour Formation** (**Adelaide Subgroup, Beaufort Group, Karoo Supergroup**) largely corresponds to the *Dicynodon* Assemblage Zone. Characterised by the co-occurence of *Dicynodon* and *Theriognathus* this zone demonstrates the Beaufort Groups greatest diversity of vertebrate taxa, including numerous taxa of dicynodont, biarmosuchian, gorgonopsian and therocephalian and cynodont therapsid Synapsida, together with diverse captorhinid Reptilia and less well represented eosuchian Reptilia, Amphibia and Pisces. *Glossopteris* flora plants and trace fossils have also been described.

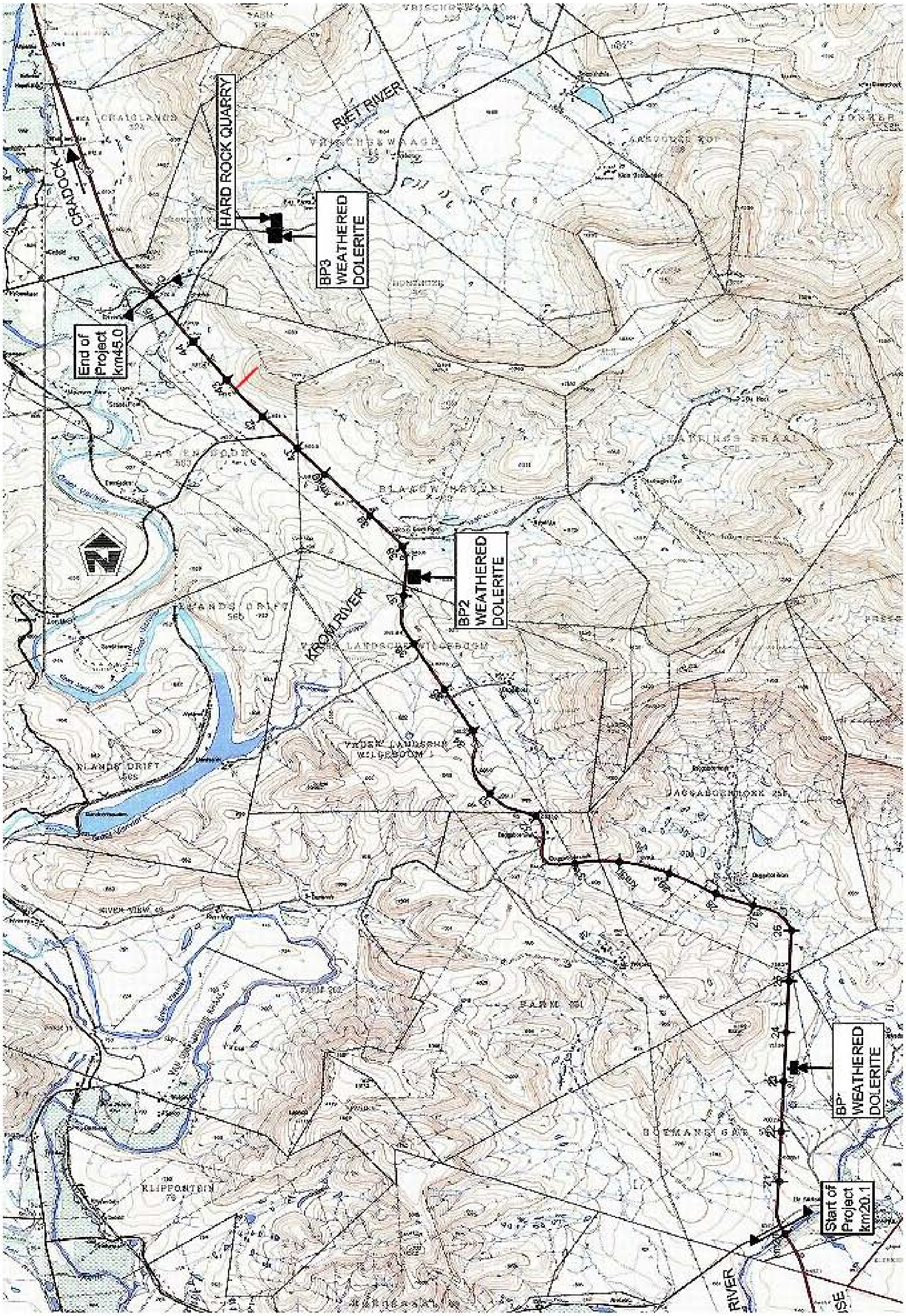

Figure 1. Map of the project area at Daggaboersnek south of Cradock showing sequential kilometer marks in black and position of *Glossopteris* leaf site in black.

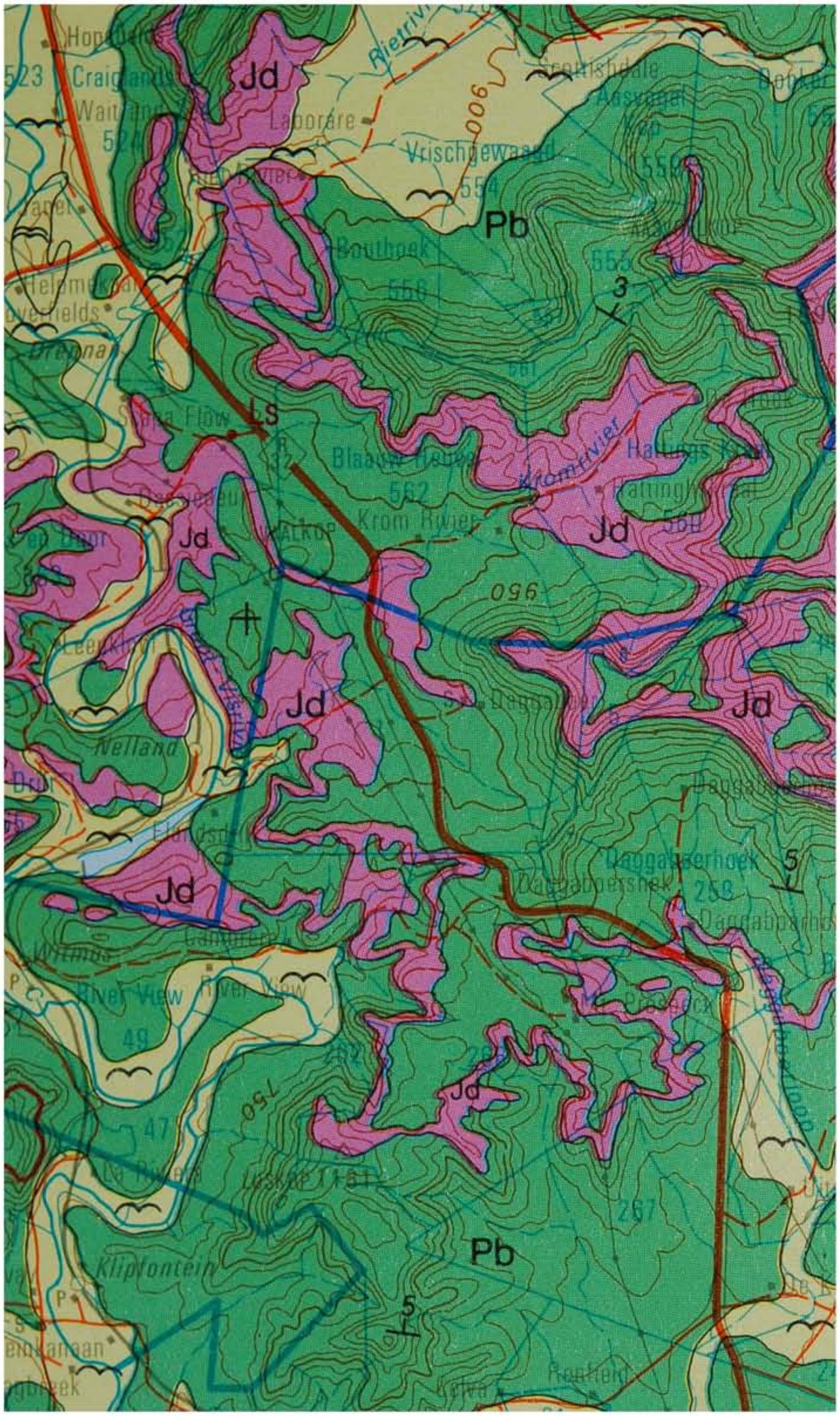

Figure 2. Geological map of the project area. Green (Pb) = Balfour Formation; Pink (Jd) = dolerite; Yellow = recent alluvium

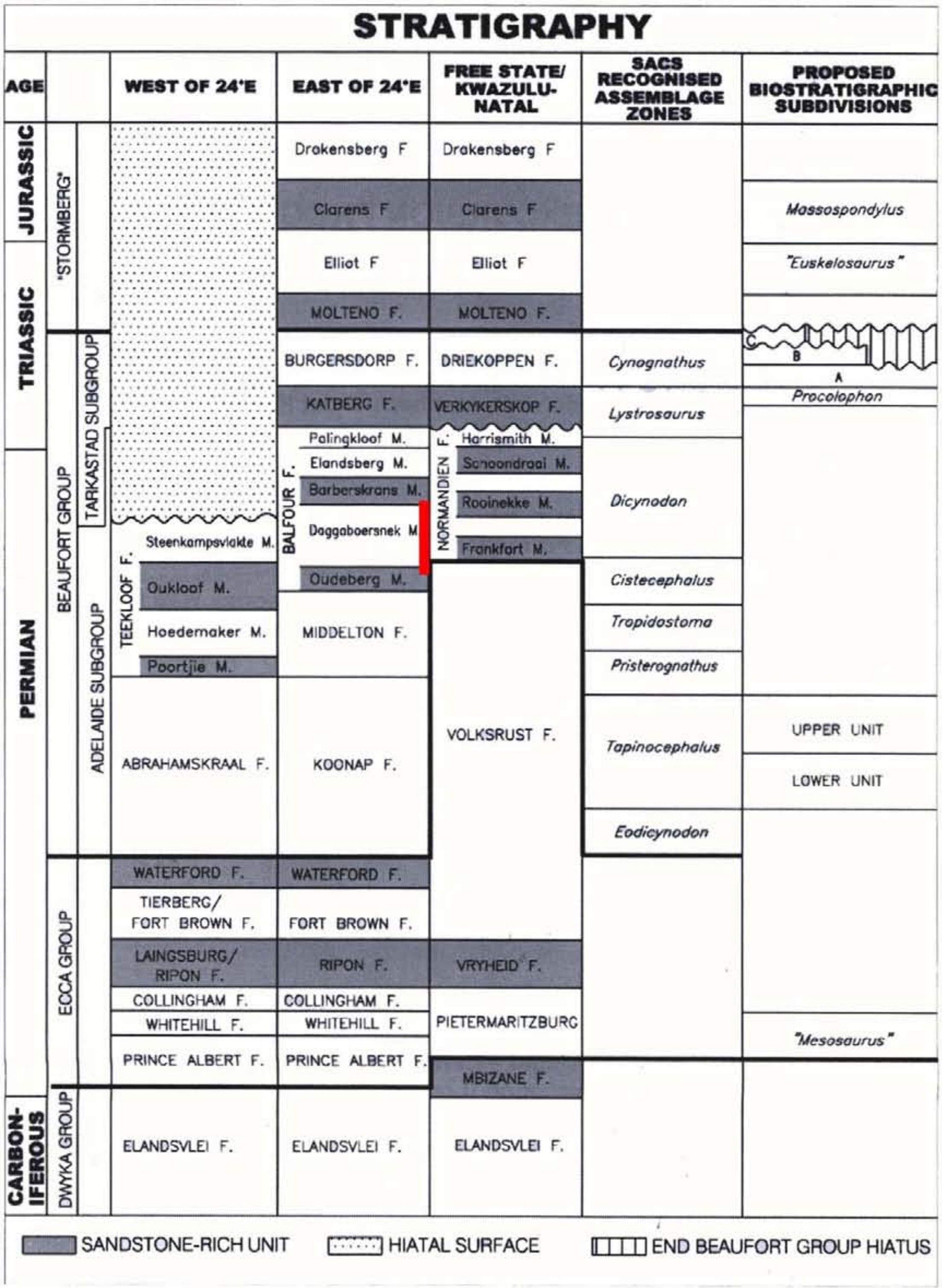

Figure 3. Stratigraphic column and corresponding biostratigraphy of the Karoo Supergroup (modified after Rubidge, B.S. 2005. *South African Journal of Science*. 108: 135-172). Red line indicates probable range of strata affected by the project.

Site visit

The site of the scheduled road works was fully surveyed on the 18th and 19th of August 2011. All roadcuttings were surveyed in detail on foot.

All borrow pits and the quarry are situated in dolerite and highly altered rock and will not affect palaeontological heritage.

Outcrops along the route between the kilometer 20 mark and the 22.4 kilometer mark consist of light olive green siltstone with interbedded sandstones, consistent with a fluvially deposited genesis. Small outcrops are encounted in a small roadcutting and sloot just before the 20.8 km mark, in a sloot just before the 21 km mark and in the right roadside gutter at the 21.7 km mark.

A more extensive roadcutting occurs between 22.1 km and 22.4 km. This roadcutting displayed impressions of mud cracks as well as plant fragments in the sandstones (Figure. 4) .

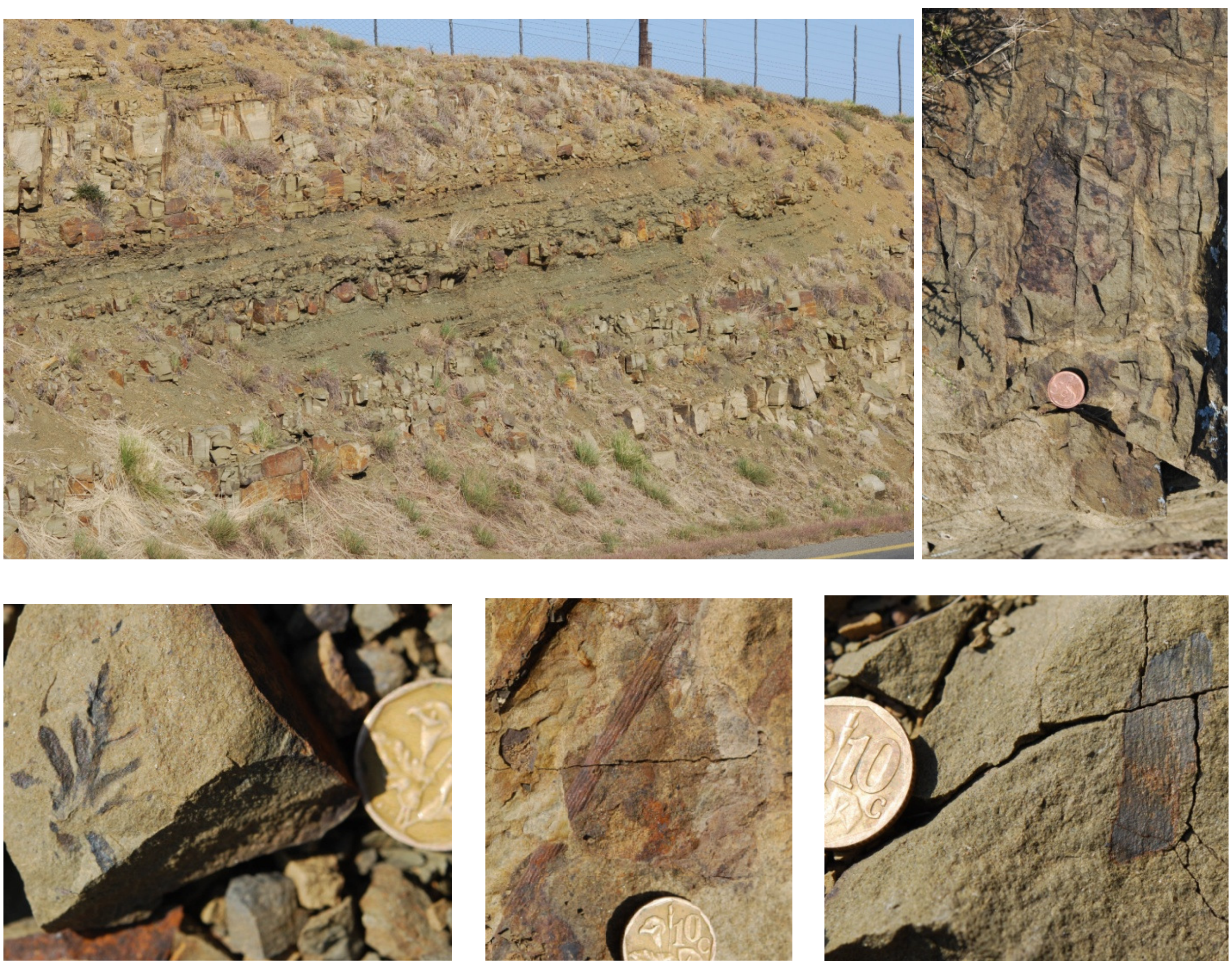

Figure 4. Roadcutting between 22.1 km and 22.4 km marks (top left), mud cracks preserved as pale sandstone infills in mudstone (top right), plant fragments (bottom).

Roadcuttings between 27.2 km and the 45 km, (with the exception of those between the 33.5 mark and the 36.6 km mark) consist, in general, of fine argillaceous mudstones and extensive thin sandstone interbeds, frequently topped by rippled surfaces (Figs 5-7). These strata are consistent with deposits formed in standing water. Some of these roadcuttings also reveal stacks of laterally extensive sandy units topped with rippled surfaces . Roadcuttings revealing sediments of this type occur between kilometers 26.5 and 26.9, 27.2 and 27.5, 27.8 and 28.2, 29.3 and 29.6, 30.0 and 30.4, 30.8 and 31.2, 31.6 and 31.7, 32.4 and 32.6, 33.0 and 33.2, 36.7 and 37.2, 42.6 and 43.2.

Although a faint impression of a *Glossopteris* leaf was observed in the cutting between 26.5 km and 26.9 km (Fig. 5), the last mentioned of this series of cuttings, that **between 42.6 and 43.2 proved the most palaeontologically productive as material was collected from a layer of exceptionally well- preserved *Glossopteris* leaves (Fig. 7).**

Figure 5. Road cutting between 26.5 km and 26.9 km. Argillaceous mudstones and sandstones (*above left*), *Glossopteris* leaf impression (*top right*), layered mudstones (*bottom left*) ripples (*bottom right*).

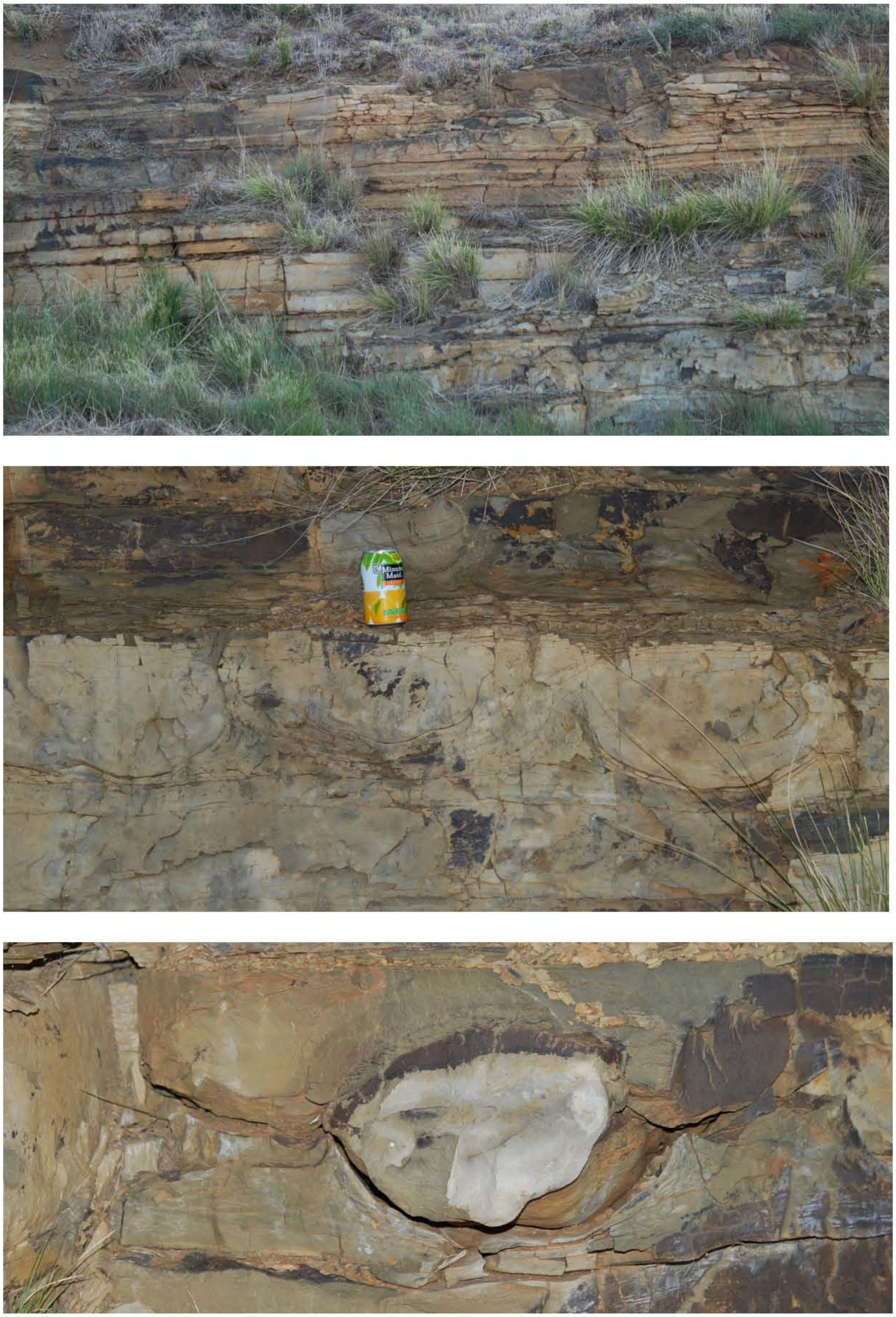

Figure 6. Sandstone layers that stratigraphically overlie argillaceous shales in roadcutting between 33.0 and 33.2 (*top*). Sandballs developed from loading of coarse sediment over semi-fluid underwater sediment. (*middle and bottom*).

Figure 7. Roadcutting between 42.6 km and 43.2 km marks. Ripples overprinted by invertebrate traces and plant drag marks (top left). Cutting at 42.781 km mark where exceptional *Glossopteris* leaf fossils were found (top right). *Glossopteris* leaf impressions (bottom).

On the top of the spur between the 33.5 mark and the 36.6 km mark road cuttings other strata are encountered (inc. roadcuttings between 36.3 and 36.6, 35.9 and 36, 35.5 and 35.8, 34.0 and 34.4 and 33.6 and 33.8) . A 2 meter thick sandtone layer with horizons of flaser ripples (Fig. 8) stratigraphically overlies the finely laminated mudstones. This in turn appears to be overlain in this area by mudstones and sandstones of an appearance consistent with a fluvial setting. These in places contain mud chip conglomerate layers (Fig. 9).

Figure 8. Flaser ripples in 2m thick sandstone bed above argillaceous beds near 36.7 km mark.

Figure 9. Road cutting between 36.3 and 36.6 km marks. Olive greenish mudstones and buff sandstones consistent with a fluvial setting (*left*). Mud chip conglomerate (*right*).

Conclusions and recommendations

1. This road section passes through a series of sedimentary packages of potential palaeontological interest. It is suggested that should roadcuttings be cleaned or cut back during these roadworks, they should be resurveyed by a palaeontologist following the completion of work and prior to any rehabilitation.

2. **An important layer containing abundant *Glossopteris* leaves is situated at 42.781 km at the southern end of the roadcutting dituated between 42.6 and 43.2. It is recommended that any cutting back or cleaning of this roadcutting should be monitored by a qualified palaeontologist**.

References

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