

PALAEONTOLOGICAL SPECIALIST STUDY: FIELD ASSESSMENT

TWO BORROW PIT SITES NEAR MURRAYSBURG, CENTRAL KAROO DISTRICT MUNICIPALITY, WESTERN CAPE

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1. EXECUTIVE SUMMARY

It is proposed to develop two borrow pit situated to the northeast of Murraysburg, Central Karoo District Municipality, Western Cape, for road material. Borrow pit sites DR02404/8.5/0LR near Middelvlei and DR02404/29.3/0.5L near Swaelkranz to the northeast of Murraysburg are both excavated into mudrocks within the lower part of the Balfour Formation (Lower Beaufort Group / Adelaide Subgroup) of Late Permian age. The fluvial sediments of the Balfour Formation in the Murraysburg area are highly fossiliferous, containing a range of reptiles, therapsids ("mammal-like reptiles"), plants and trace fossils (including large vertebrate burrows) that are assigned to the *Cistecephalus* Assemblage Zone. During field assessment a substantial number of vertebrate and plant fossil sites were recorded both within and around the margins of the two borrow pit sites.

Given the density of fossil vertebrate and plant material (including therapsid skull material) within a small area of bedrock within and around borrow pit site DR02404/8.5/0LR, the palaeontological sensitivity of this area is assessed as HIGH. It is recommended that the more scientifically valuable fossils already exposed in the pit area (e.g. cranial material) are fully recorded and collected by a professional palaeontologist *before* further excavation takes place.

The Lower Beaufort mudrocks in the DR02404/29.3/0.5L borrow pit study area are also highly fossiliferous (*i.e.* HIGH palaeontological sensitivity) but the fossil sites currently exposed lie outside the area proposed for exploitation. Fossil remains will undoubtedly be exposed, damaged and destroyed by excavation within the proposed pit area. However, the fossils here are likely to be very fragmented and dirt-covered following excavation, compared with naturally weathered-out material, reducing the value of scientific collecting. Further specialist studies or mitigation are not considered warranted in this case.

2. INTRODUCTION

The Department of Transport, Western Cape, is applying to the Department of Mineral Resources for approval to exploit road material from two borrow pit sites situated along the DR2404 to the northeast of Murraysburg, Central Karoo District Municipality, Western Cape. The existing pit DR02404/8.5/0LR (31° 56' 7.80" S, 23° 53' 48.48" E) lies either side of the road one kilometre east of Middelvlei farmstead and 13 km ENE of Murraysburg. Pit locality DR02404/29.3/0.5L (31° 46' 54.71" S, 23° 58' 2.46" E), currently a shallow farm dam, is located about half a kilometre west of the historical Swaelkranz homestead and 28 km northeast of Middelburg (Fig. 1).

A previous desktop basic assessment of the pit sites by the author assessed their palaeontological heritage sensitivity as high due to the presence here of potentially fossiliferous sediments of the Lower Beaufort Group. A palaeontological field assessment of the two pits as part of an HIA was requested by Heritage Western Cape (HWC case ref. no. 110928JB27, Interim comment 3

October 2011) in accordance with the requirements of the National Heritage Resources Act, 1999 (Section 38).

The present palaeontological heritage field assessment and short report were accordingly commissioned by Vidamemoria Heritage Consultants, Cape Town (Address: 3rd Floor, Guarantee House, 37 Burg Street, Greenmarket Square, Cape Town; tel: 021-424 8432; e-mail: Quahnita@vidamemoria.co.za). These are Vidamemoria pit nos. 26 and 30 and NID ref. no. 10. Fieldwork for this project was carried out on 16 February 2012.

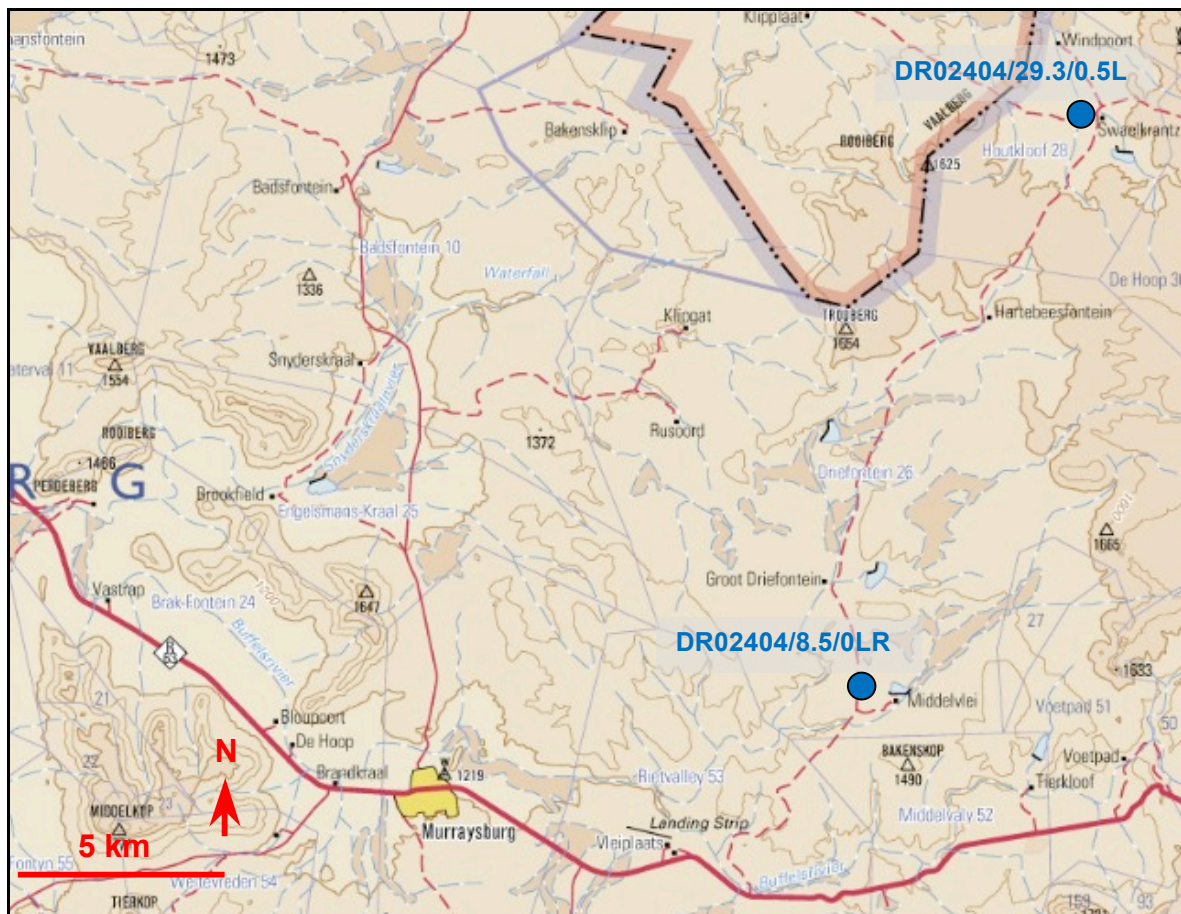


Fig. 1. Extract from topographical sheet 3122 Victoria West (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the location of the two borrow pits DR02404/8.5/0LR near Middelvllei and DR02404/29.3/0.5L near Swaelkranz to the northeast of Murraysburg, Central Karoo District Municipality, Western Cape (blue dots).

3. GEOLOGICAL CONTEXT

The geology of the study area near Murraysburg is outlined on the 1: 250 000 geology sheet 3122 Victoria West (Le Roux & Keyser 1988) (Fig. 2). The area is largely underlain by Late Permian continental sediments of the **Lower Beaufort Group** (Adelaide Subgroup, Karoo Supergroup). A useful overview of this internationally famous rock succession has been given by Johnson *et al.* (2006). The bedrocks in the study area are assigned to the **Balfour Formation (Pb)** of Late Permian age, and in particular to the c. 70 m-thick sandstone-rich basal subunit known as the **Oudeberg Member** (= "Richmond Sandstone" of Le Roux and Keyser 1988). This member is characterised by pale yellow to greyish, medium-grained multi-storey channel sandstones, often with basal mud clast conglomerates, that are interbedded with grey-green to purple-brown overbank mudrocks. The sandstone component decreases in importance towards the north,

grading laterally into thinly-interbedded mudrock and sandstone horizons. Bedding dips are not indicated on the Victoria West sheet, suggesting that the Beaufort Group succession is largely flat-lying and undeformed. However, these Permian sediments are extensively intruded and thermally metamorphosed (baked) by sills and dykes of the Early Jurassic **Karoo Dolerite Suite (Jd)**.

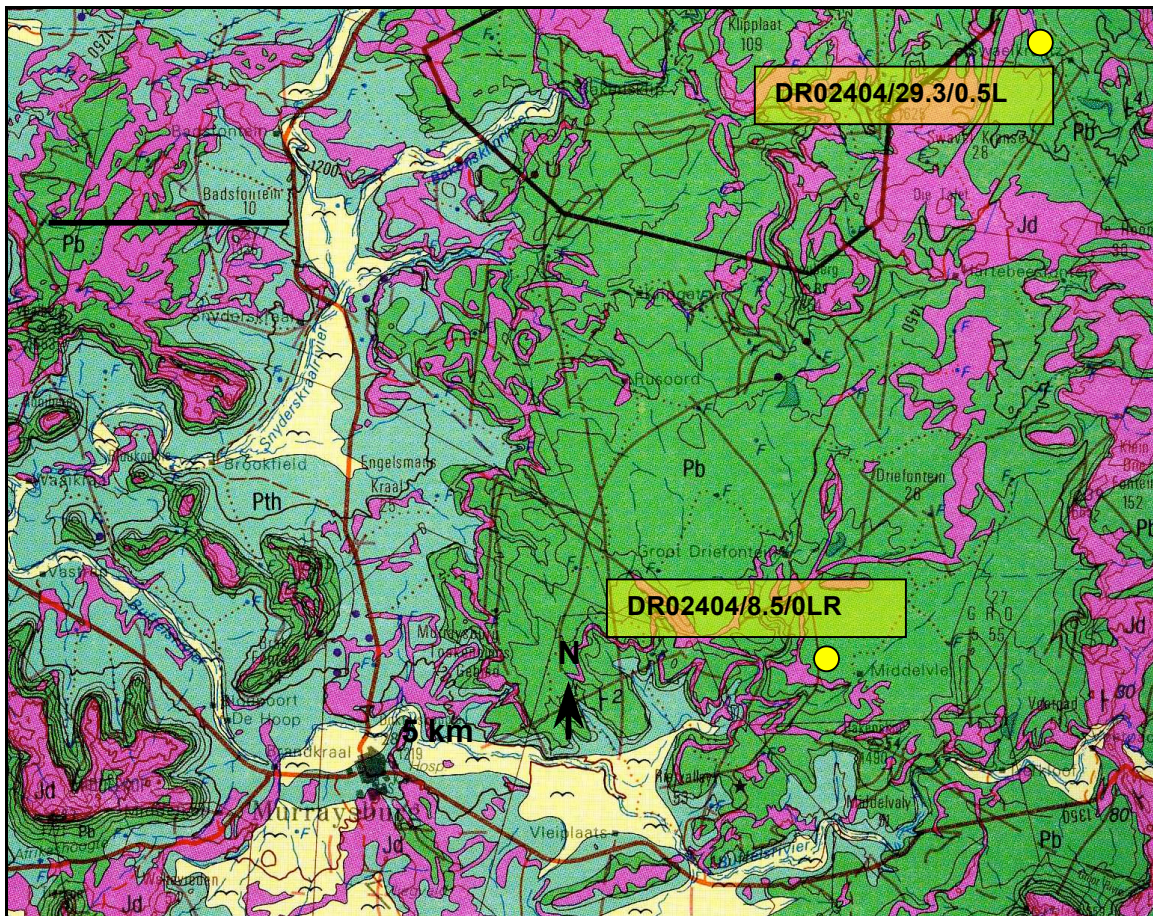


Fig. 2. Extract from 1: 250 000 geology sheet 3122 Victoria West (Council for Geoscience, Pretoria) showing the locations of the two borrow pits DR02404/8.5/0LR near Middelvlei and DR02404/29.3/0.5L near Swaelkranz to the northeast of Murraysburg, Central Karoo District Municipality, Western Cape (yellow dots). Both pit sites are underlain by mudrocks in the lower part of the Balfour Formation (Adelaide Subgroup, Lower Beaufort Group) (Pb, green). The Beaufort Group rocks in this area are extensively intruded by Early Jurassic dolerites of the Karoo Dolerite Suite (Jd, pink).

3.1. DR02404/8.5/0LR borrow pit site

The existing DR02404/8.5/0LR borrow pit site is situated on either side of the DR2404 dust road at c. 1360 m amsl and 13 km ENE of Murraysburg. The Middelvlei homestead lies about one kilometre to the east. A small stream gully cuts north to south through the pit area on the west side of the road.

The Lower Beaufort succession exposed on the pit floor east of the road mainly comprises purple-brown, well-consolidated siltstones with horizons of rusty-weathering pedogenic calcrete nodules associated with scattered fossil bones (Fig. 4; Section 4.1). The siltstones are overlain by purplish, hackly-weathering mudrocks capped by a multi-storey channel sandstones (Fig. 3). The latter are variously flaggy to cross-bedded and ripple cross-laminated, and contain concentrations of transported plant material. On the west side of the road the Beaufort Group sediments are mantled by a thick layer of gravelly alluvium and soils, incised by the modern stream gully here (Fig. 5). The edge of a dolerite intrusion and adjacent baked Beaufort rocks are exposed in the stream bed on the south-western side of the study area.



Fig. 3. Purplish-brown mudrocks and overlying channel sandstones (on the horizon) exposed on the south-eastern side of borrow pit site DR02404/8.5/0LR.

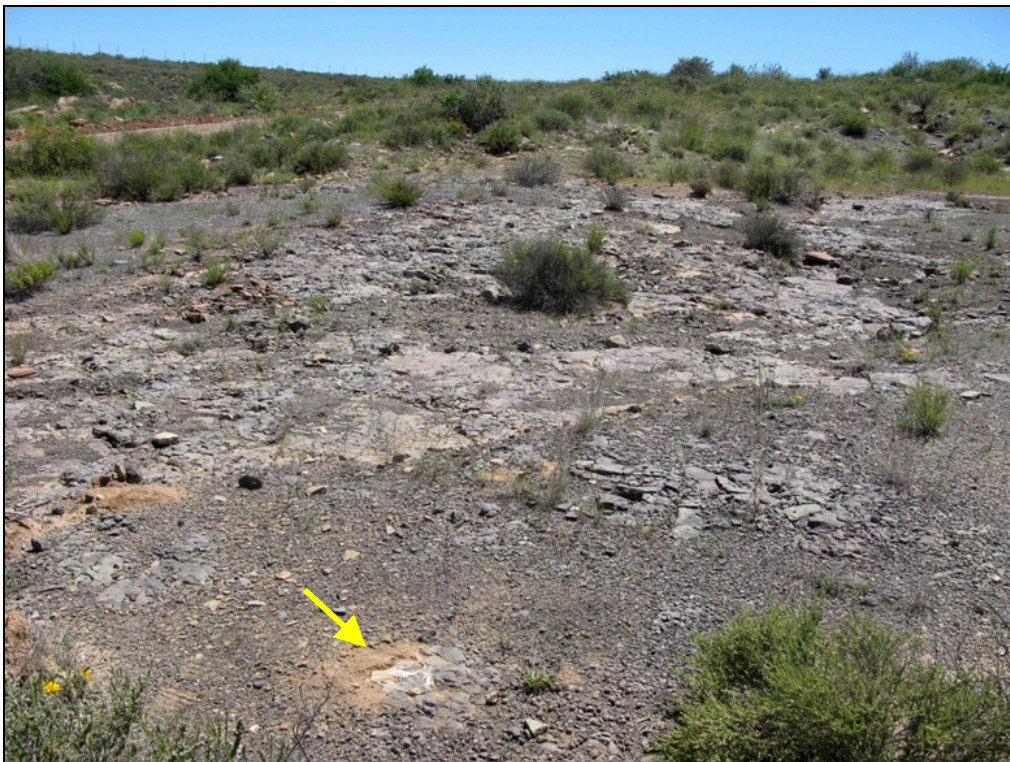


Fig. 4. Purplish siltstones exposed on the floor of borrow pit site DR02404/8.5/0LR, looking towards the northwest. A partially-exposed fossil specimen is arrowed.



Fig. 5. Contact between a dolerite intrusion (rusty brown) and adjacent baked Beaufort Group sediments (grey-green) in the south-western portion of the study area. The bedrocks are mantled with well-bedded, fine gravelly alluvium here.

3.2. DR02404/29.3/0.5L borrow pit site

The DR02404/29.3/0.5L borrow pit site is located about half a kilometre west of the historical Swaelkranz homestead and 28 km northeast of Middelburg. The site is an extensive shallow dam lying at c. 1450 m amsl on the southern side of a channel bend in a NW-flowing tributary of the Bakenskliprivier. Exposure of Beaufort Group sediments within the dam area is generally poor, since they are covered with fine alluvium and a sparse veneer of sheetwash gravels (dolerite, hornfels, sandstone) (Fig. 6). However, there are excellent Beaufort Group sandstone and mudrock exposures along a low, sandstone-capped ridge running south of an irrigation furrow along the southern side of the study area, as well as on the north side of the river. Both these areas were inspected for fossil remains in order to assess the palaeontological sensitivity of the proposed borrow pit site. A densely vegetated area just east of dam site may also be exploited for road material but here the Beaufort bedrocks are deeply buried beneath muddy alluvium and spring sediments (Mr M. Hesselink, pers. comm.).

The low ridge to the south of the study area is capped by a c. 1.5 m thick channel sandstone showing cross-bedding, subordinate channels, ripple cross-lamination and other sedimentary features (Figs. 7, 8). The sole of the sandstone body often features a well-developed ferruginous basal conglomerate dominated by reworked calcrete glaebules with occasional fragments of fossil bone. The underlying grey-green mudrocks contain several horizons of pedogenic calcrete nodules, some of which are richly fossiliferous (Fig. 15).



Fig. 6. View south-eastwards across borrow pit site DR02404/29.3/0.5L showing mantle of fine-grained alluvium and sheetwash gravels in the dam area in the foreground and the low sandstone-capped ridge towards the south where several fossil sites are located.



Fig. 7. View along the sandstone-capped ridge showing good exposure of fossiliferous Lower Beaufort mudrocks just south of the DR02404/29.3/0.5L borrow pit study area.



Fig. 8. Pinkish-brown, speckled lens of calcrete conglomerate at the base of the channel sandstone shown in the previous photograph (Hammer = 32 cm). These basal conglomerates often contain rolled fossil bone fragments.

4. PALAEOLOGICAL HERITAGE

The sandstone-rich Oudeberg Member of the Balfour Formation is characterised by fossil tetrapods of the *Cistecephalus* Assemblage Zone (= upper *Cistecephalus* Biozone or *Aulacephalodon-Cistecephalus* Assemblage Zone of earlier authors). The following major categories of fossils might be expected within *Cistecephalus* AZ sediments in the study area (Kitching 1977, Keyser & Smith 1977-78, Anderson & Anderson 1985, Smith & Keyser 1995, MacRae 1999, Cole *et al.*, 2004, Rubidge *et. al.* 1995, 2005):

- isolated petrified bones as well as rare articulated skeletons of terrestrial vertebrates such as true reptiles (e.g. large herbivorous pareiasaurs like *Pareiasaurus*, small insectivorous owenettids) and therapsids or “mammal-like reptiles” (e.g. diverse herbivorous dicynodonts, notably *Cistecephalus*, *Oudenodon* and *Aulacephalodon*, a wide range of flesh-eating gorgonopsians such as *Lycaenops*, and insectivorous therocephalians like *Ictidosuchoides*);
- aquatic vertebrates such as large temnospondyl amphibians (*Rhinesuchus*, usually disarticulated), and palaeoniscoid bony fish (*Atherstonia*, *Namaichthys*); these are often represented by scattered scales rather than intact fish;
- freshwater bivalves (*Palaeomutela*);
- trace fossils such as worm, arthropod and tetrapod burrows and trackways (e.g. of the large dicynodont *Aulacephalodon*), coprolites (fossil droppings), plant roots;
- vascular plant remains including leaves, twigs, roots and silicified woods (“*Dadoxylon*”) of the *Glossopteris* Flora, especially glossopterid trees and arthropytes (horsetails). Plant remains are usually sparse and fragmentary.

Authoritative lists of vertebrate genera and species recorded so far from the *Cistecephalus* Assemblage Zone are given by Smith and Keyser (1995). Faunal lists for fossil sites in the Victoria West map area are given by Kitching (1977). The marked increase in fossils of the small dicynodont *Cistecephalus* at the top of the AZ in the Victoria West area and elsewhere is noted by these authors. Vertebrate fossils recorded in the Oudeberg Member in particular include the dicynodont genera *Cistecephalus* (the commonest form), *Aulacephalodon* and *Oudenodon* (Le Roux & Keyser 1988).

As far as the biostratigraphically important tetrapod remains are concerned, the best fossil material is generally found within overbank mudrocks. In contrast, fossils preserved within channel sandstones (e.g. channel lag breccio-conglomerates of reworked mudflakes and calcrete nodules) tend to be fragmentary and water-worn (Smith & Keyser 1995, Smith 1993). Many fossils are found in association with ancient soils (palaeosol horizons) that can usually be recognised by bedding-parallel concentrations of calcrete nodules. The fossil bones are isolated and disarticulated for the most part, and are typically permineralised and encrusted in a mantle of calcrete (often brown-weathering). Fossil bone embedded in mudrocks adjacent to major dolerite intrusions may be modified by thermal metamorphism; for example, bones in the Graaff-Reinet District may acquire a smooth, white “porcellanite” pallor, while bones recorded near Bedford may be black (Smith & Keyser 1995).

4.1. Fossils at the DR02404/8.5/0LR borrow pit site

A scatter of nine fossil vertebrate sites was recorded *within* the DR02404/8.5/0LR borrow pit site on the east side of the road (Fig. 4). The fossil bones are exposed in the quarry floor and are mostly disarticulated, although they include some articulated lower limb bones (Figs. 9 to 12). They are largely embedded in grey-green to purplish siltstone and are associated with a palaeosol (fossil soil) horizon, as indicated by abundant pedogenic calcrete nodules at this level. A few bone fragments were also noted within the overlying purple-brown mudrocks. Most of the remains observed are postcranial, but at least one lower jaw (Fig. 7) and skull (Fig. 9) are present. The fossils have not yet been firmly identified, but at least some of them probably belong to a medium-sized dicynodont therapsid such as *Aulacephalodon*. It is possible that several of the fossils are parts of the same animal whose skeletal remains were dispersed on the floodplain surface after death. However, floods may also have concentrated the bones of several different animals here.

In situ channel sandstones on the south-eastern edge of the pit site, and even more so displaced blocks of sandstone on the west side of the road, contain compressions and moulds of reworked plant material, possibly stems or large branches (Fig. 10). Mudflake conglomerates on the soles of these sandstones contain further fossil plant material as well as scattered bone fragments and moulds of small intact bones.



Fig. 9. Lower jaw (mandible) of a medium-sized dicynodont therapsid exposed on the floor of borrow pit site DR02404/8.5/0LR.



Fig. 10. Unidentified fossil bone exposed on the floor of borrow pit site DR02404/8.5/0LR.



Fig. 11. Articulated lower limb bones of a medium-sized therapsid exposed on the floor of borrow pit site DR02404/8.5/0LR.



Fig. 12. Palatal (ventral) view of the skull of a medium-sized dicynodont, possibly *Aulacephalodon*, exposed on the floor of borrow pit site DR02404/8.5/0LR.



Fig. 13. Large displaced slab of channel sandstone showing current-orientated plant material associated with mudflakes and reworked bone fragments on the sole surface (Hammer = 32 cm).

4.1. Fossils at the DR02404/29.3/0.5L borrow pit site

Few fossils were noted within the DR02404/29.3/0.5L borrow pit study area itself due to low exposure of bedrock here. However, mudrocks excavated from a test pit towards the western end of the dam contain several bone fragments (Fig. 14), suggesting that the bedrock here may well be highly fossiliferous. Exposures of Beaufort Group mudrocks north of the river also yielded several fossil bone fragments.

The mudrocks underlying the low sandstone ridge along the southern side of, but outside, the borrow pit study area proved to be richly fossiliferous. Several fossil sites with well-preserved bone were noted during a survey of this portion of the broader study region lasting some two hours in total, and undoubtedly a more thorough search would reveal many more fossil occurrences. Fossils recorded here were usually associated with, or entirely enclosed by, pedogenic calcrete nodules reflecting ancient soil horizons (Figs. 15-17). They include the fairly intact skull of a medium-sized, large-tusked dicynodont (Fig. 18, possibly *Aulacephalodon*) as well as several isolated or semi-articulated vertebrae, ribs and limb bones of therapsids and / or reptiles. Rolled bone fragments were also recorded within the well-developed ferruginous basal conglomerate of the overlying channel sandstone (Fig. 8).

No fossils were observed in the densely vegetated area to the east of the dam. Since this is apparently the site of a spring, it is quite possible that skeletal remains (e.g. bones, teeth) of Quaternary to Recent mammals and other wildlife attracted to the spring in the past, especially during times of drought, might be buried here.



Fig. 14. Bone fragments embedded in grey-green Beaufort mudrocks excavated from a test pit in the western part of the dam area.



Fig. 15. Ancient soil horizon marked by pinkish calcrete nodules. Note concentration of disarticulated fossil bone a few cm above the calcrete zone.



Fig. 16. Freshly broken calcrete nodule showing white fossil bones embedded inside (Scale in cm).



Fig. 17. Disarticulated or semi-articulated vertebrae of a medium-sized reptile or therapsid that have eroded out of the Beaufort mudrocks and been concentrated in gullies (Scale in cm).

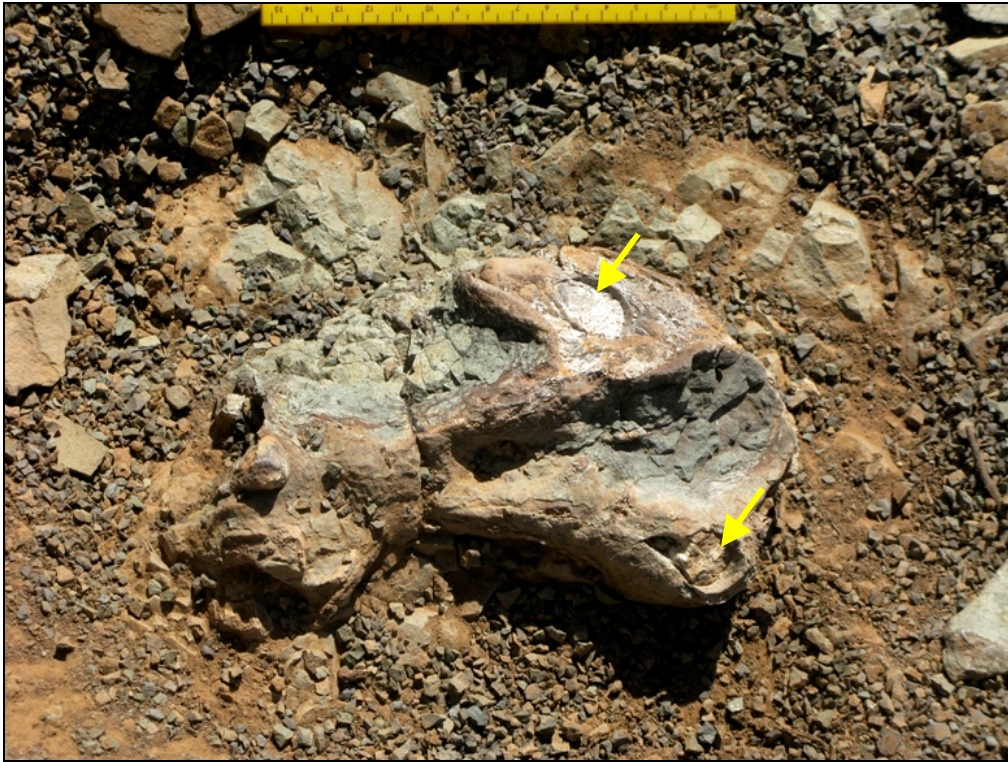


Fig. 18. Skull of a medium-sized, large-tusked dicynodont therapsid, possibly *Aulacephalodon*, seen in palatal (ventral) view (tusks arrowed). The snout of the animal is facing to the right. Scale in cm.

5. CONCLUSIONS & RECOMMENDATIONS

Borrow pits sites DR02404/8.5/0LR near Middelviei and DR02404/29.3/0.5L near Swaelkranz to the northeast of Murraysburg are excavated into mudrocks within the lower part of the Balfour Formation (Lower Beaufort Group / Adelaide Subgroup) of Late Permian age. The fluvial sediments of the Balfour Formation in the Murraysburg area are high fossiliferous, containing range of reptiles, therapsids (“mammal-like reptiles”), plants and trace fossils (including large vertebrate burrows) that are assigned to the *Cistecephalus* Assemblage Zone. During field assessment substantial number of vertebrate and plant fossil sites were recorded both within and around the margins of the two borrow pits sites under consideration.

Given the density of fossil vertebrate and plant material (including therapsid skull material) within a small area of bedrock within and around borrow pit site DR02404/8.5/0LR, the palaeontological sensitivity of this area is assessed as HIGH. It is recommended that the more scientifically valuable fossils already exposed in the pit (e.g. cranial material) are fully recorded and collected by a professional palaeontologist *before* further excavation takes place.

The Lower Beaufort mudrocks in the DR02404/29.3/0.5L borrow pit study area are also highly fossiliferous (*i.e.* HIGH palaeontological sensitivity) but the sites currently exposed lie outside the area proposed for exploitation. Fossil remains will undoubtedly be exposed, damaged and destroyed by excavation within the proposed pit area. However, the fossils here are likely to be very fragmented and dirt-covered following excavation, compared with naturally weathered-out material, reducing the value of scientific collecting. Further studies or mitigation are not considered warranted in this case.

6. ACKNOWLEDGEMENTS

Ms Quahnita Samie of Vidamemoria Heritage Consultants, Cape Town, is thanked for commissioning this specialist study and for kindly providing the necessary background information.

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APPENDIX: GPS LOCALITY DATA FOR FOSSIL SITES

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx instrument. The datum used is WGS 84.

LOC	GPS	COMMENT
040	S32 53.447 E28 03.699	Fossil bone occurrences on floor of pit DR02404/8.5/0LR
041	S32 53.369 E28 03.659	
042	S32 53.212 E28 03.521	
043	S32 53.222 E28 03.570	
044	S32 53.220 E28 03.588	
045	S32 53.255 E28 03.731	Series of large vertebrate burrows along river bank between borrow pit sites
046	S32 53.257 E28 03.734	Rare rolled bone fragments among sheetwash gravels, & within mudrocks from test pit at site DR02404/29.3/0.5L
048	S32 53.231 E28 03.715	Large tusked dicynodont skull
049	S32 53.300 E28 03.818	Ribs within calcrete nodule
050	S32 53.404 E28 03.865	Fossil bones weathering out of ferruginous calcrete horizon
051	S32 53.345 E28 03.812	Bone fragments within mudrock slopes north of river

8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape, Gauteng, Limpopo and Free State for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Assessment Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed borrow pit project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.



Dr John E. Almond (Palaeontologist, *Natura Viva* cc)