

## PALAEONTOLOGICAL SPECIALIST STUDY: FIELD ASSESSMENT

### PROPOSED EXTENSION OF A BORROW PIT ON THE FARM DRIEFONTEIN 26 NEAR MURRAYSBURG, CENTRAL KAROO DISTRICT MUNICIPALITY, WESTERN CAPE: REVISED FOOTPRINT

John E. Almond PhD (Cantab.)  
*Natura Viva* cc,  
PO Box 12410 Mill Street,  
Cape Town 8010, RSA  
naturaviva@universe.co.za

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#### 1. EXECUTIVE SUMMARY

The borrow pit site DR02404/8.5/0.3L near Middelvlei to the northeast of Murraysburg is 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 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 a previous field assessment (Almond 2012) several vertebrate and plant fossil sites - including therapsid skull material - were recorded within and on the margins of the adjacent, existing borrow pit (DR02404/8.5/0LR), notably on the eastern side of the DR2404.

Within the revised borrow pit footprint, some 50 m or more to the west of the DR2404, the Lower Beaufort Group bedrocks are for the most part mantled by gravelly colluvium and have been extensively baked by an adjacent dolerite intrusion, probably compromising much of the local fossil heritage. The only fossil remains recorded during field assessment are occasional fragments of weathered, reworked bone incorporated into Late Permian channel conglomerates. This may well be a reflection of poor bedrock exposure, however. Given the high density of fossil vertebrates within a small area of bedrock on the adjacent existing borrow pit site, it is likely that further fossil remains are present subsurface within the revised borrow pit footprint. It is concluded that the palaeontological sensitivity of the revised DR02404/8.5/0.3L borrow pit site is MODERATE.

The Environmental Control Officer (ECO) responsible for the borrow development should be aware of the possibility of important fossils (notably vertebrate bones and teeth) being present or unearthed on site and should monitor fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains. Bedrocks in the original borrow pit area to the east of the DR2404 should not be disturbed to protect fossil material already exposed on the pit floor. If such disturbance is unavoidable, it is recommended that the more scientifically valuable fossils in the existing pit area (*e.g.* cranial material) are fully recorded and collected by a professional palaeontologist *before* the new borrow pit to the west is developed.

In the case of any significant fossil finds made during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (Heritage Western Cape. Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za) so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer's expense. These recommendations should be incorporated into the Environmental Management Plan (EMP) for the borrow project.

## 2. INTRODUCTION

The Department of Transport, Western Cape, is applying to the Department of Mineral Resources for approval to exploit road material from a borrow pit site situated on the Farm Driefontein 26 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.

An initial desktop basic assessment of the original pit site by the author assessed its 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 pit 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).

A palaeontological heritage field assessment and short report (Almond 2012) were accordingly commissioned by Vidamemoria Heritage Consultants, Cape Town (Address: 3<sup>rd</sup> Floor, Guarantee House, 37 Burg Street, Greenmarket Square, Cape Town; tel: 021-424 8432; e-mail: Quahnita@vidamemoria.co.za). This was Vidamemoria pit no. 26 and NID ref. no. 10. Fieldwork for this project was carried out on 16 February 2012. The following comments and recommendations regarding palaeontological heritage at the site were made by Almond (2012):

*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 footprint of the proposed pit, now DR2404/8.5/0.3L, was subsequently revised to lie outside, and to the west of, the original pit area along the DR2404 which lay within the road reserve (Fig. 2). A further palaeontological field assessment of the revised borrow pit site was requested by Heritage Western Cape (Case number 14040408GT0409E, dated 23 April 2014) and duly commissioned by Vidamemoria Heritage Consultants. This is now Vidamemoria pit no. 305 and NID ref. no. 219. The second site visit was carried out on 18th August 2014.



Fig. 1. Extract from topographical sheet 3122 Victoria West (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the location of the revised borrow pit DR02404/8.5/0.3L near Middelvlei to the northeast of Murraysburg, Central Karoo District Municipality, Western Cape (blue dot).



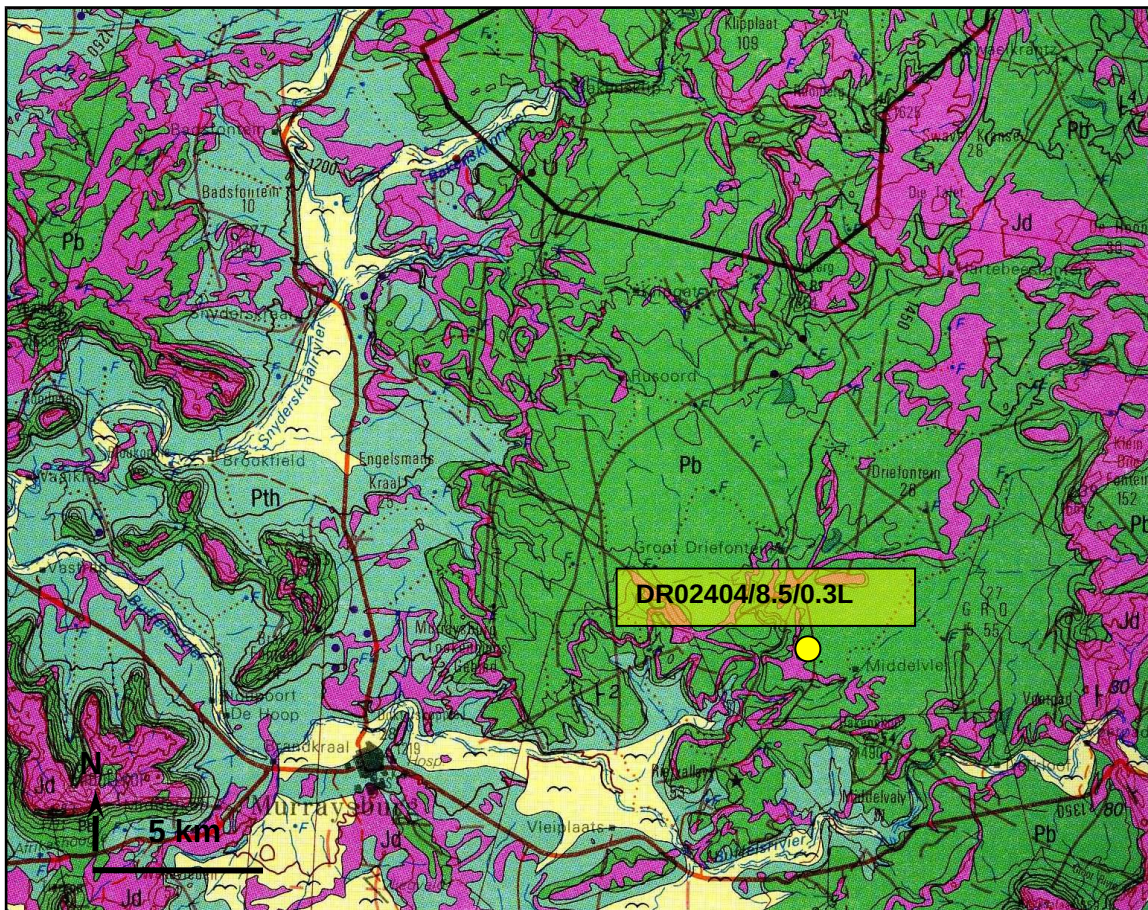
**Fig. 2. Google earth© satellite image of the revised DR2404/8.5/0.3L borrow pit study area (green area) which lies to just to the west of the original site proposed within the DR2404 road reserve (blue area), Farm Dreifontein 26 near Murraysburg. Several fossil vertebrates are exposed within the yellow ellipse.**

### 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. 3). 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 several, closely-spaced, pale yellow to greyish, medium-grained, multi-storey channel sandstones. These often have basal mudclast / calcrete conglomerates and 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)**. A dolerite intrusion is mapped just to the west of the present study area.

Given the paucity of bedrock exposure outside the existing borrow pit area, the geology and palaeontology of the latter as well as of the revised borrow pit area to the west are briefly outlined in this and the following section of the report (based in part on Almond 2012).





**Fig. 3. Extract from 1: 250 000 geology sheet 3122 Victoria West (Council for Geoscience, Pretoria) showing the locations of the proposed borrow pit DR02404/8.5/0.3L near Middelvlei to the northeast of Murraysburg, Central Karoo District Municipality, Western Cape (yellow dot). The pit site is underlain by sandstones and mudrocks within the lower part of the Balfour Formation (Adelaide Subgroup, Lower Beaufort Group) (Pb, green). The Beaufort Group rocks in this area are extensively intruded and baked by Early Jurassic dolerites of the Karoo Dolerite Suite (Jd, pink) such as shown just west of the borrow pit site.**

### **3.1. DR02404/8.5/0LR originally proposed borrow pit site**

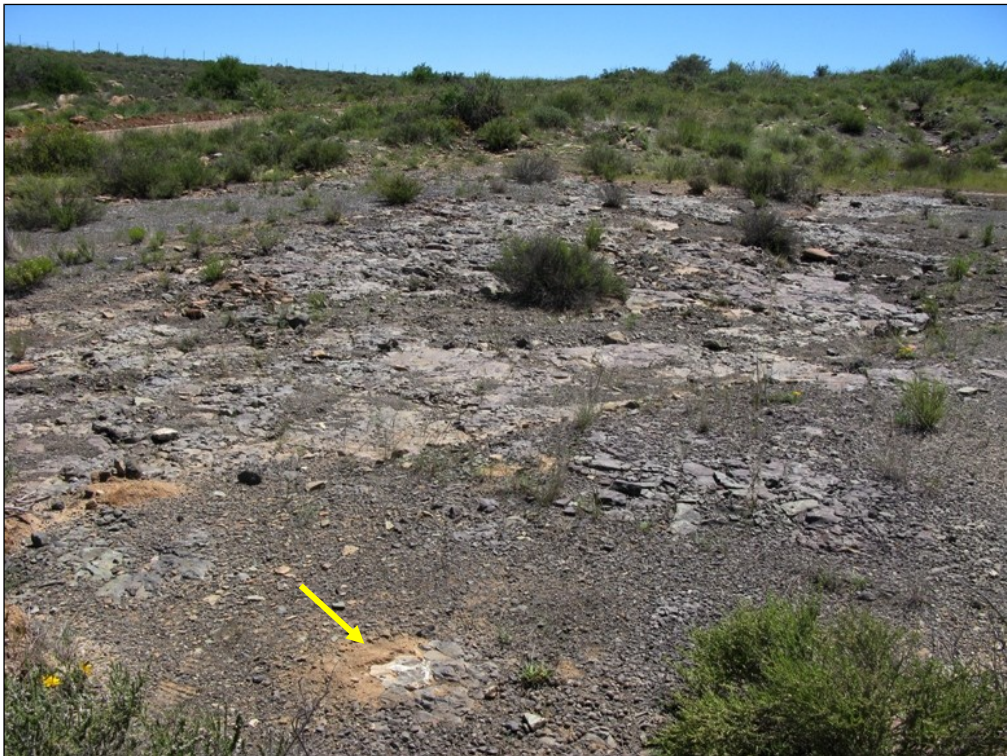
The existing DR02404/8.5/0LR borrow pit site (31° 56' 16.0" S, 23° 53' 48.7" E) is situated on either side of the DR2404 dust road at c. 1360 m amsl and 13 km ENE of Murraysburg (Fig. 2). The Middelvlei homestead lies about one kilometre to the east. A small stream gully cuts north to south through the 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. 5; Section 4.1). The siltstones are overlain by purplish, hackly-weathering mudrocks capped by a multi-storey channel sandstones (Fig. 4). 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. 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. 6).





**Fig. 4. Purplish-brown mudrocks and overlying channel sandstones (on the horizon) exposed on the south-eastern side of the original borrow pit site DR02404/8.5/0LR.**



**Fig. 5. Purplish siltstones exposed on the floor of original borrow pit site DR02404/8.5/0LR, looking towards the northwest. A partially-exposed fossil specimen is arrowed.**





**Fig. 6. Contact between a dolerite intrusion (rusty brown) and adjacent baked Beaufort Group sediments (grey-green) in the south-western portion of the original study area, west of the DR2404. The bedrocks are mantled with well-bedded, fine gravelly alluvium here.**

### **3.2. DR02404/8.5/0.3L revised borrow pit site**

The Lower Beaufort Group bedrocks within the revised borrow pit site, to the west of the existing roadside borrow pit (31° 56' 16.0" S, 23° 53' 45.8"), are for the most part extensively mantled by poorly-sorted, immature gravelly colluvial deposits that mainly comprise angular slabs of buff sandstone as well as mudrock gravels (Fig. 13). These deposits are up to several meters thick in places. Limited mudrock exposures show hackly-weathering overbank siltstones with horizons of greyish calcrete nodules, sometimes ferruginised (Fig. 9). Low banks of flaggy buff channel sandstones with ripple cross-laminated tops and striking SW-NE are seen in the western portion of the study area (Fig. 7). Local developments of thin (< 1m), lenticular channel conglomerates are dominated by fine reworked calcrete glaebules and small nodules in a ferruginised sandstone matrix, with occasional rolled bone (Figs. 8, 19 & 20; Section 4.2). The stream gully just south of the study area exposes baked Lower Beaufort mudrocks (greyish, brown-weathering hornfels) and sandstones (pale buff quartzites) with typical mineralised or hollow vugs (cavities) (Figs. 11, 12). Shortly to the west, a dolerite intrusion is exposed in the stream bed (Fig. 10).





**Fig. 7. Flaggy, well-jointed channel sandstones of the Balfour Formation, revised DR02404/8.5/0.3L borrow pit study area.**



**Fig. 8. Well-developed calccrete conglomerates towards the base of the channel sandstone package (Hammer = 30 cm). Some of these conglomerates contain rolled fossil bone (Figs. 19, 20).**





**Fig. 9. Limited exposure of hackly-weathering grey overbank mudrocks with horizons of greyish pedocrete nodules, revised borrow pit study area.**



**Fig. 10. Columnar-jointed dolerite intrusion exposed in stream bed near the southern edge of the revised study area (Hammer = 30 cm).**





**Fig. 11. Streambed exposure of baked Beaufort Group bedrocks just south of the revised study area. Note the thickness of the overlying gravelly colluvial deposits here.**



**Fig. 12. Detail of baked hornfels exposed in the stream bed shown in the previous figure (Hammer = 30 cm).**





**Fig. 13. Poorly-sorted colluvial deposits and downwasted surface gravels, dominated by slabby Beaufort Group sandstones, that mantle the Permian bedrocks over much of the revised study area.**

#### **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 original borrow pit site**

A scatter of nine fossil vertebrate sites was recorded within the original DR02404/8.5/0LR borrow pit site on the east side of the road (Fig. 2). The fossil bones are exposed in the quarry floor and are mostly disarticulated, although they include some articulated lower limb bones (Figs. 14 to 17). 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. 14) and skull (Fig. 17) 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 DR2404 road, contain compressions and moulds of reworked plant material, possibly stems or large branches (Fig. 18). 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. 14. Lower jaw (mandible) of a medium-sized dicynodont therapsid exposed on the floor of the original borrow pit site DR02404/8.5/0LR.**



**Fig. 15. Unidentified fossil bone exposed on the floor of the original borrow pit site DR02404/8.5/0LR.**





**Fig. 16. Articulated lower limb bones of a medium-sized therapsid exposed on the floor of the original borrow pit site DR02404/8.5/0LR.**



**Fig. 17. Palatal (ventral) view of the skull of a medium-sized dicynodont, possibly *Aulacephalodon*, exposed on the floor of the original borrow pit site DR02404/8.5/0LR.**





**Fig. 18. Large displaced slab of channel sandstone on the western side of the DR2404 showing current-orientated plant material associated with mudflakes and reworked bone fragments on the sole surface (Hammer = 32 cm).**

#### **4.2. Fossils at the DR02404/8.5/0.3L revised borrow pit site**

No fossil remains were observed in the limited exposures of Lower Beaufort Group bedrocks within the revised borrow pit study area with the exception of several pieces of rolled (*i.e.* river-reworked) bone within the channel conglomerates (Figs. 19 & 20). Such vertebrate fossil material is normally highly disarticulated, fragmentary and water-worn. The colluvial deposits overlying the Beaufort Group bedrocks are apparently unfossiliferous.

The highly fossiliferous overbank mudrocks exposed in the existing roadside borrow pit (See previous section) are likely to extend at depth westwards into the revised borrow pit study area. However, in the latter case they are extensively mantled by colluvium while substantial parts of the bedrocks have been baked by a dolerite intrusion just to the west, compromising its fossil heritage.

It is concluded that the palaeontological sensitivity of the revised DR02404/8.5/0.3L borrow pit footprint is MODERATE.





**Fig. 19.** Portion of the lenticular channel conglomerate seen in Figure 8 showing two reworked bone fragments (arrowed) (Scale = c. 15 cm).



**Fig. 20.** Close-up of sizeable fragment of reworked, weathered bone arrowed in the previous figure (Scale in cm). The ferruginised conglomeratic matrix consists largely of grey calcrete glaebules.



## 5. CONCLUSIONS & RECOMMENDATIONS

The borrow pit site DR02404/8.5/0.3L near Middelvlei to the northeast of Murraysburg is 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 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 a previous field assessment (Almond 2012) several vertebrate and plant fossil sites - including therapsid skull material - were recorded within and on the margins of the adjacent, existing borrow pit (DR02404/8.5/0LR), notably on the eastern side of the DR2404.

Within the revised borrow pit footprint, some 50 m or more to the west of the DR2404, the Lower Beaufort Group bedrocks are for the most part mantled by gravelly colluvium and have been extensively baked by an adjacent dolerite intrusion, probably compromising much of the local fossil heritage. The only fossil remains recorded during field assessment are occasional fragments of weathered, reworked bone incorporated into Late Permian channel conglomerates. This may well be a reflection of poor bedrock exposure, however. Given the high density of fossil vertebrates within a small area of bedrock on the adjacent existing borrow pit site, it is likely that further fossil remains are present subsurface within the revised borrow pit footprint. It is concluded that the palaeontological sensitivity of the revised DR02404/8.5/0.3L borrow pit site is MODERATE.

The Environmental Control Officer (ECO) responsible for the borrow development should be aware of the possibility of important fossils (notably vertebrate bones and teeth) being present or unearthed on site and should monitor fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains. Bedrocks in the original borrow pit area to the east of the DR2404 should not be disturbed to protect fossil material already exposed on the pit floor. If such disturbance is unavoidable, it is recommended that the more scientifically valuable fossils in the existing pit area (*e.g.* cranial material) are fully recorded and collected by a professional palaeontologist *before* the new borrow pit to the west is developed.

In the case of any significant fossil finds made during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (Heritage Western Cape, Protea Assurance Building, Green Market Square, Cape Town 8000. Private Bag X9067, Cape Town 8001. Tel: 086-142 142. Fax: 021-483 9842. Email: hwc@pgwc.gov.za) so that appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer's expense. These recommendations should be incorporated into the Environmental Management Plan (EMP) for the borrow project.

## 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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## 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)**