

# PALAEONTOLOGICAL SPECIALIST STUDY: FIELD ASSESSMENT

## PROPOSED EXTENSION OF AN EXISTING BORROW PIT WITHIN THE ROAD RESERVE ON THE FARM BELVEDERE 73 NEAR NELSPOORT, CENTRAL KAROO DISTRICT MUNICIPALITY, WESTERN CAPE

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

July 2015

### 1. EXECUTIVE SUMMARY

The MR00587/27,0/0,0R borrow pit site within the road reserve on Farm Belvedere 73, situated c. 14 km east of Nelspoort, Western Cape, is excavated into overbank mudrocks of the Teekloof Formation (Lower Beaufort Group / Adelaide Subgroup) of Late Permian age. The fluvial sediments of the Teekloof Formation in this region are assigned to the Hoedemaker Member and often highly fossiliferous, containing a range of reptiles, therapsids (“mammal-like reptiles”), plants and trace fossils (including large vertebrate burrows) that are assigned to the *Tropidostoma* Assemblage Zone. Numerous sandstone casts of straight, curved to helical burrows of small vertebrates (probably the dicynodont *Diictodon*) are exposed in the floor of the pit and the isolated skull of a small dicynodont was also recorded at the same stratigraphic level. This fossil material is of significant palaeontological interest.

**It is therefore recommended that a suitably qualified professional palaeontologist be commissioned to record and judiciously sample the fossil “warren” of vertebrate burrows currently exposed within the MR00587/27,0/0,0R it before any excavation or clearance work at the site takes place. All work should conform to international best practice for palaeontological fieldwork and the study (e.g. data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies published by SAHRA (2013).**

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. 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 MR00587/27,0/0,0R borrow pit project.

### 2. INTRODUCTION

The Department of Transport, Western Cape, is applying to the Department of Mineral Resources for approval to exploit road material from, and to extend, an existing borrow pit site situated within the road reserve on the Farm Belvedere 73 along the MR587 to the east of Nelspoort, Central

Karoo District Municipality, Western Cape. The existing pit MR00587/27,0/0,0R (32° 5' 42.37" S, 23° 9' 26.85" E) lies on the south side of a dust road c. 14 km east of Nelspoort (Fig. 1).

This is Vidamemoria pit no. 328 and NID ref. no. 242. 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. 15040123GT0422E, Interim Comment of 5 November 2015) in accordance with the requirements of the National Heritage Resources Act, 1999 (Section 38).

This palaeontological heritage field assessment and short report has accordingly been 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: yunus@vidamemoria.co.za). Fieldwork for this project was carried out on 14 June 2015.

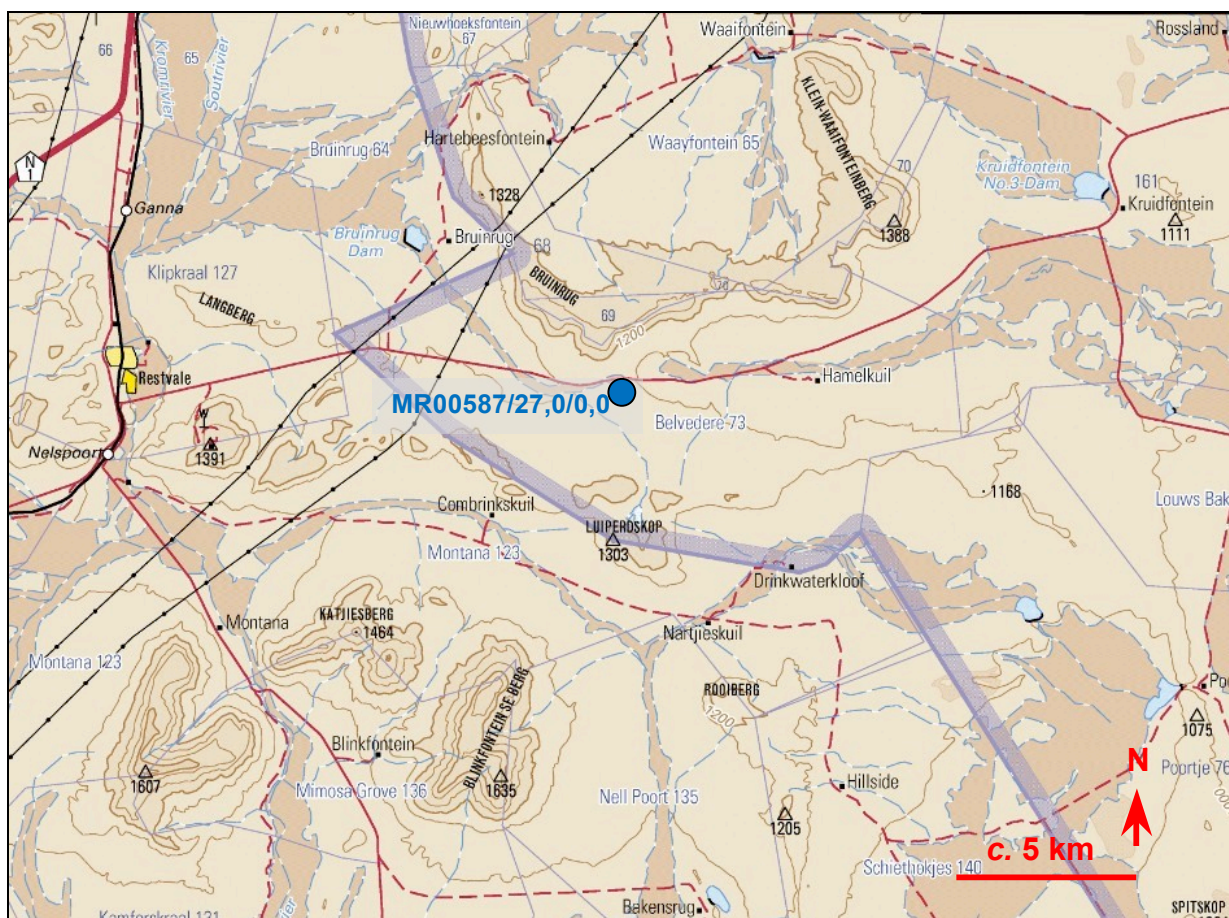
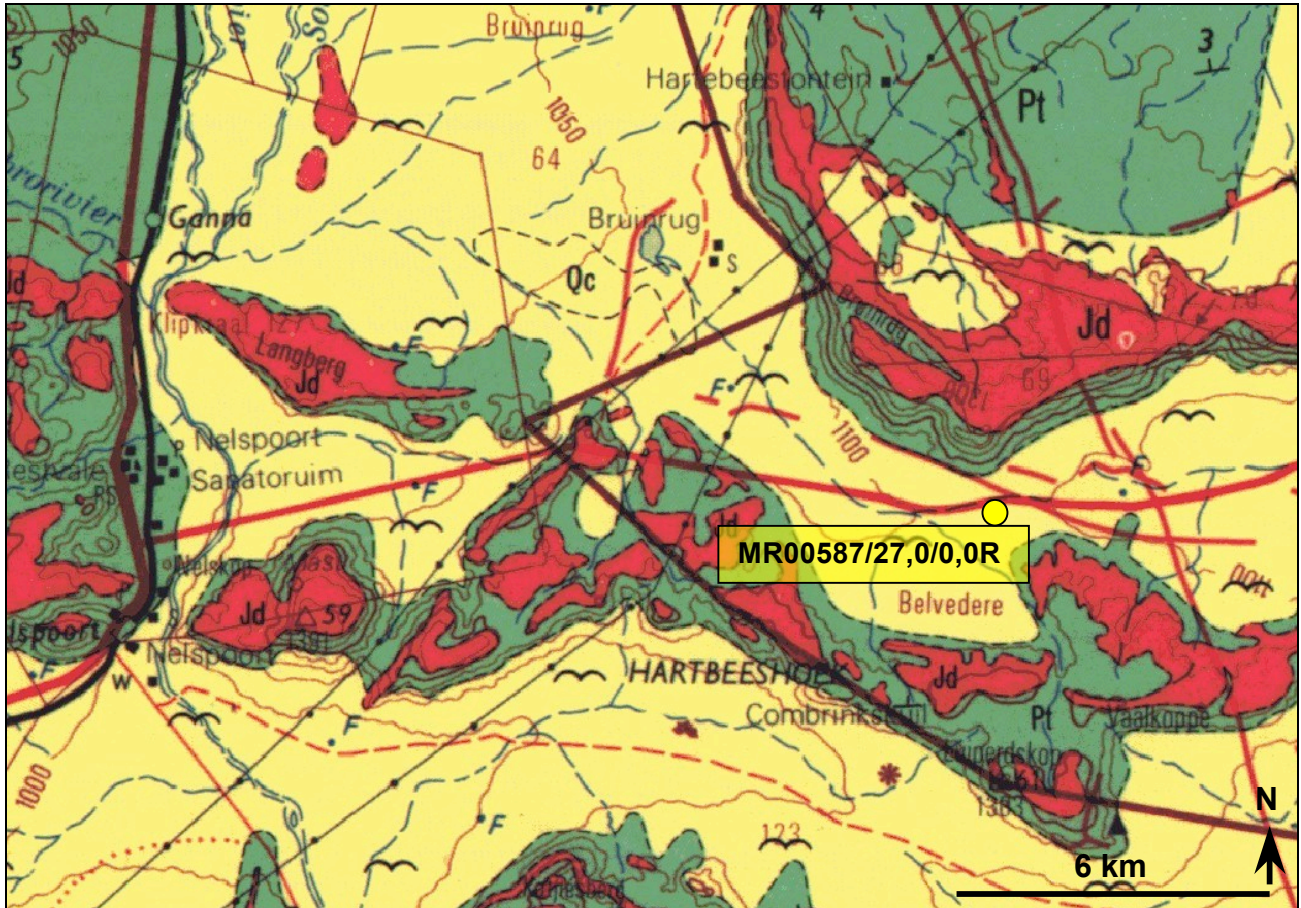


Fig. 1. Extract from topographical sheet 3222 Beaufort West (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the location of the existing MR00587/27,0/0,0R borrow pit on the road reserve on Farm Belvedere 73, located c. 14 km east of Nelspoort, Central Karoo District Municipality, Western Cape (blue dot).

### 3. GEOLOGICAL CONTEXT

The MR00587/27,0/0,0R borrow pit study area lies in semi-arid Karoo terrain at 1020 m amsl. just to the south of the Bruinrug escarpment (Fig. 1). The geology of the study area near Nelspoort is outlined on the 1: 250 000 geology sheet 3222 Beaufort West, for which a separate sheet explanation has not yet been published (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 fluvially-dominated **Teekloof Formation (Pt)** of Late Permian age, and specifically the mudrock-dominated **Hoedemaker Member** (Rubidge 1995). Bedding dips shown on the geological map are generally low, suggesting that the Beaufort Group succession here is largely flat-lying and undeformed. However, the Permian sediments are extensively intruded and thermally metamorphosed (baked) by sills and dykes of the Early Jurassic **Karoo Dolerite Suite (Jd)**. A major dolerite intrusion (sill) is mapped just to the north of the present study area (saucer-shaped sill of Bruinrug) and a NW-E trending dyke runs just north of the MR587 here.



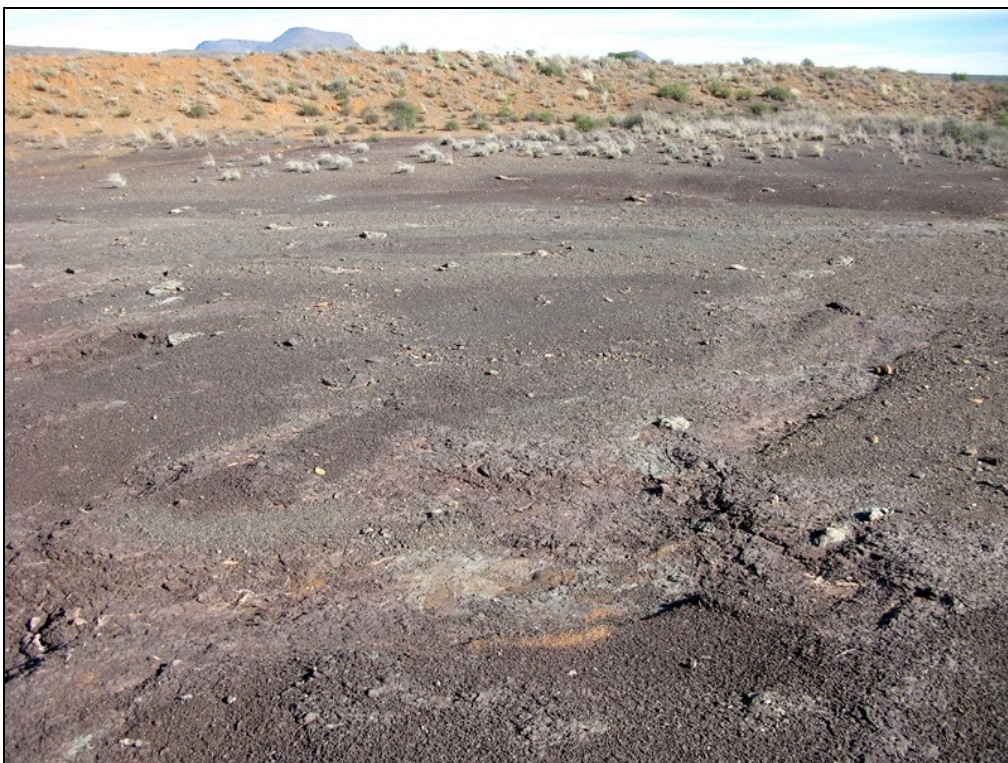
**Fig. 2. Extract from 1: 250 000 geology sheet 3222 Beaufort West (Council for Geoscience, Pretoria) showing the location of the MR00587/27,0/0,0R borrow pit located c. 14 km to the east of Nelspoort, Central Karoo District Municipality, Western Cape (yellow dot). The pit site is excavated into mudrocks within the lower part of the Teekloof Formation (Adelaide Subgroup, Lower Beaufort Group) (Pt, green) that are mantled here by Late Caenozoic alluvium and colluvium (pale yellow with flying bird symbol). The Beaufort Group rocks in this area are extensively intruded and baked by Early Jurassic dolerites of the Karoo Dolerite Suite (Jd, red), such as the NW-SE dyke just to the north of the borrow pit site as well as the dish-shaped dolerite sill of Bruinrug capping the escarpment to the north.**

The existing MR00587/27,0/0,0R borrow pit extends parallel to and south of the MR587 dust road; its lower eastern portion was partially flooded during the field assessment. Good bedding plane exposure of predominantly purple-brown and subordinate grey-green overbank mudrocks of the Teekloof Formation are seen on the pit floor, with occasional thin grey-green crevasse-splay sandstones (Figs. 3 to 5). Small rounded to irregular pedocrete nodules are common, as well as probable gypsum pseudomorphs and polygonal calcretised mudcrack infills, indicating periods of desiccation of the Late Permian floodplains. A striking feature of the site are abundant, sizeable sandstone-infilled burrows at several closely-spaced horizons within the pit (See Section 4). The Beaufort Group bedrocks are mantled with poorly-sorted stream alluvium to the west of the existing

pit (Fig. 6) as well as thick, gravelly orange-brown alluvial sands around the pit margin (Fig. 7). The alluvium directly overlying the Karoo bedrocks is locally calcretised and sometimes coarsely gravelly. Fine sheet wash gravels may be present at surface.



**Fig. 3. View south-eastwards across the existing MR00587/27,0/0,0R borrow pit area near Nelspoort.**



**Fig. 4. Predominantly purple-brown, hackly-weathering overbank mudrocks exposed on the borrow pit floor. Thick (partially displaced) alluvial sands and gravels are seen in the background.**



**Fig. 5. Thin crevasse-splay sandstone overlying the main burrow-rich overbank mudrock horizon (Hammer = 30 cm).**



**Fig. 6. Poorly-sorted angular to subrounded alluvial gravels in the stream bed just west of the existing borrow pit, looking towards the east.**



**Fig. 7. Thick-orange-brown alluvial sediments (partially displaced) overlying the Teekloof Formation bedrocks in the eastern portion of the borrow pit. Note gravelly horizon at the base (Hammer = 30 cm).**

#### **4. PALAEOLOGICAL HERITAGE**

According to the latest biostratigraphic map of the Main Karoo Basin published by Van der Walt *et al.* (2010) the MR00587/27,0/0,0R borrow pit study area lies within the ***Tropidostoma* Assemblage Zone** of Late Permian age that characterizes the Hoedemaker Member of the Teekloof Formation (Smith & Keyser, 1995). The following major categories of fossils might be expected within *Tropidostoma* AZ sediments in the study area (Kitching 1977, Keyser & Smith 1977-78, Anderson & Anderson 1985, Smith & Keyser 1995, MacRae 1999, Cole *et al.*, 2004, Smith *et al.* 2012):

- isolated petrified bones as well as rare articulated skeletons of **terrestrial vertebrates (tetrapods)** such as true **reptiles** (notably large herbivorous pareiasaurs, lizard-like archosauromorphs) and **therapsids** or “mammal-like reptiles” (e.g. diverse, small- to large-bodied herbivorous dicynodonts, flesh-eating gorgonopsians, carnivorous and insectivorous therocephalians, cynodonts);
- aquatic vertebrates such as large **temnospondyl amphibians** (*Rhinesuchus* spp., usually disarticulated), and **palaeoniscoid bony fish** (*Atherstonia*, *Namaichthys*, often represented by scattered scales rather than intact fish);
- freshwater **bivalves** (e.g. *Palaeomutela*);
- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings), fish swimming trails;
- **vascular plant remains** including leaves, twigs, roots and petrified woods (“*Dadoxylon*”) of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterid trees and arthropytes (horsetails).

There are several genera of toothed dicynodonts (e.g. *Emydops*, *Pristerodon*) as well as medium-sized forms like *Rachiocephalus* and *Endothiodon*. Carnivores are represented by medium-sized gorgonopsians (e.g. *Lycaenops*, *Gorgonops*) as well as smaller, insectivorous therocephalians

such as *Ictidosuchoides*. Among the large (2.3-3 m long), lumbering pareiasaur reptiles the genus *Pareiasaurus* replaces the more primitive *Bradysaurus* seen in older Beaufort Group assemblages.

The Hoedemaker Member mudrocks exposed in the MR00587/27.0/0.0R borrow pit feature numerous straight or curved, gently-inclined or even helical sections of dorso-ventrally compressed burrow casts (Figs. 8 to 11). They are embedded within the overbank mudrocks at several closely-spaced horizons and in some cases clearly underlie the thin crevasse-splay sandstones. The infill mainly comprises pale grey-green sandstone with dispersed small mudflakes. Sometimes it is laminated and thin upward-fining units terminating in mudrock may represent individual flood events. Swollen terminations or non-terminal portions of the burrows up to 22 cm wide probably represent living chambers. Similar straight to helical burrow casts associated with *Diictodon* skeletal material have been described from the Teekloof Formation (*Pristerognathus* and *Tropidostoma* Assemblage Zones) by Smith (1986, 1989) (Figs 13 & 14).

According to Smith and Keyser (1995) the tetrapod fauna of the *Tropidostoma* Assemblage Zone is dominated by the small communal burrowing dicynodont *Diictodon* that constitutes some 40% of the fossil remains recorded here. This animal was probably responsible for many of the vertebrate scratch burrows, including helical burrow casts, encountered in the Hoedemaker Member (e.g. Smith 1986, 1987, 1993). At least some burrows at the MR00587/27,0/0,0R borrow pit site were probably excavated by *Diictodon*. A small disarticulated skull, lying on its side, that is probably attributable to this genus was recorded at the same horizon as the numerous burrow casts (Fig. 12).



**Fig. 8. Numerous pale, prominent-weathering sandstone burrow casts weathering out of the purple-brown Hoedemaker Member mudrocks on the floor of the MR00587/27,0/0,0R borrow pit.**



**Fig. 9.** Close-up of gently-inclined, dorso-ventrally compressed sandstone burrow cast seen in the foreground of the previous figure (Scale is c. 15 cm long). Note the swollen section part-way along the burrow.



**Fig. 10.** Partially-exhumed sandstone cast of a helical vertebrate burrow (scale in cm), seen from above.





Fig. 11. Vertical section through a helical vertebrate burrow (pale grey structure, outlined) excavated into bedded overbank mudrocks beneath a thin crevasse-splay sandstone (Hammer = 30 cm).



Fig. 12. Isolated skull of a small dicynodont (lying on its side, beak towards the left) within a calcrete nodule embedded in mudrocks at the same level as numerous tetrapod burrow casts. The skull is probably of *Diictodon*.

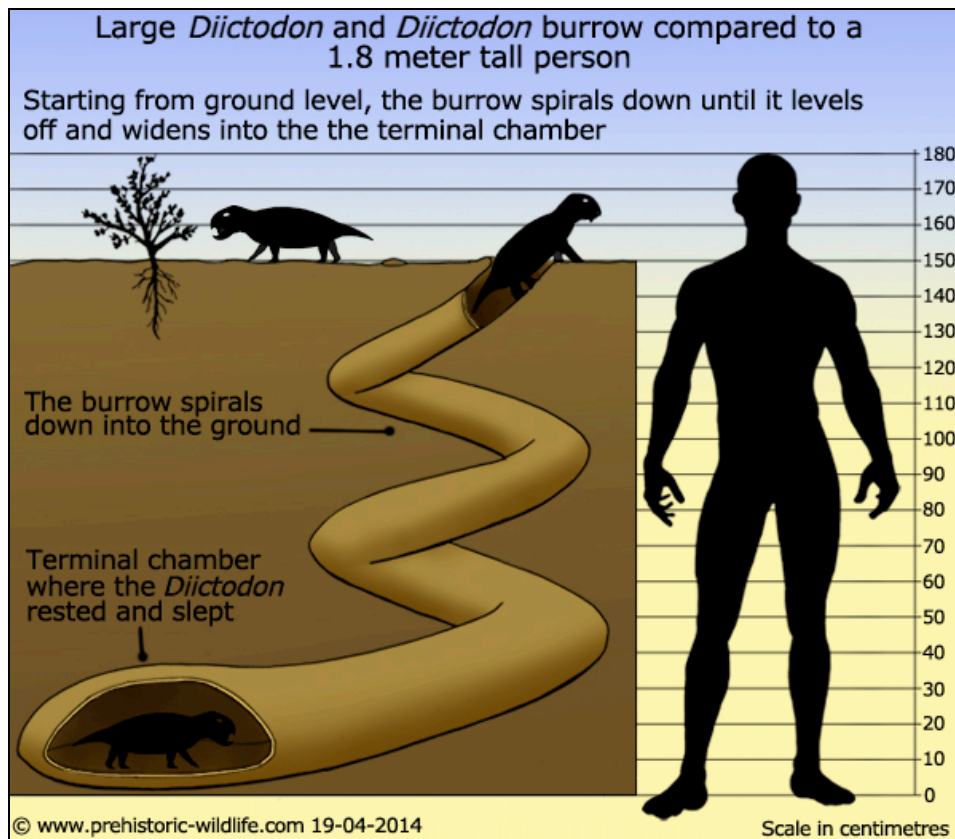


Fig. 13. Graphic reconstruction of helical burrows of *Diictodon* (www. Prehistoric-wildlife.com).



Fig. 14. Cast of a helical burrow from the Lower Beaufort Group together with a well-articulated small burrowing dicynodont (Figure of display from Iziko South African Museum Museum, Cape Town, sourced from the Internet).

## 5. CONCLUSIONS & RECOMMENDATIONS

The MR00587/27,0/0,0R borrow pit site within the road reserve on Farm Belvedere 73, situated c. 14 km east of Nelspoort, Western Cape, is excavated into overbank mudrocks of the Teekloof Formation (Lower Beaufort Group / Adelaide Subgroup) of Late Permian age. The fluvial sediments of the Teekloof Formation in this region are assigned to the Hoedemaker Member and often highly fossiliferous, containing a range of reptiles, therapsids (“mammal-like reptiles”), plants and trace fossils (including large vertebrate burrows) that are assigned to the *Tropidostoma* Assemblage Zone. Numerous sandstone casts of straight, curved to helical burrows of small vertebrates (probably the dicynodont *Diictodon*) are exposed in the floor of the pit and the isolated skull of a small dicynodont was also recorded at the same stratigraphic level. This fossil material is of significant palaeontological interest.

**It is therefore recommended that a suitably qualified professional palaeontologist be commissioned to record and judiciously sample the fossil “warren” of vertebrate burrows currently exposed within the MR00587/27,0/0,0R pit before any excavation or clearance work at the site takes place. All work should conform to international best practice for palaeontological fieldwork and the study (e.g. data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies published by SAHRA (2013).**

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. 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 MR00587/27,0/0,0R borrow pit project.

## 6. ACKNOWLEDGEMENTS

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

## 7. REFERENCES

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodrum of South African megaflores, Devonian to Lower Cretaceous, 423 pp. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

COLE, D.I., NEVELING, J., HATTINGH, J., CHEVALLIER, L.P., REDDERING, J.S.V. & BENDER, P.A. 2004. The geology of the Middelburg area. Explanation to 1: 250 000 geology Sheet 3124 Middelburg, 44 pp. Council for Geoscience, Pretoria.

DAY, M. & RUBIDGE, B. 2010. Middle Permian continental biodiversity changes as reflected in the Beaufort group of South Africa: An initial review of the *Tapinocephalus* and *Pristerognathus* assemblage zones. Proceedings of the 16<sup>th</sup> conference of the Palaeontological Society of Southern Africa, Howick, August 5-8, 2010, pp. 22-23.

- DAY, M., RUBIDGE, B., ALMOND, J. & JIRAH, S. 2013. Biostratigraphic correlation in the Karoo: the case of the Middle Permian parareptile *Eunotosaurus*. *South African Journal of Science* 109, 1-4.
- DAY, M.O., GÜVEN, S., ABDALA, F., JIRAH, S., RUBIDGE, B. & ALMOND, J. 2015. Youngest dinocephalian fossils extend the *Tapinocephalus* Zone, Karoo Basin, South Africa. *Research Letter, South African Journal of Science* 111, 5 pp.
- DAY M.O., RAMEZANI J, BOWRING S.A., SADLER P.M., ERWIN D.H., ABDALA F. & RUBIDGE B.S. 2015. When and how did the terrestrial mid-Permian mass extinction occur? Evidence from the tetrapod record of the Karoo Basin, South Africa. *Proceedings of the Royal Society B282: 20150834*. <http://dx.doi.org/10.1098/rspb.2015.0834>.
- HILL, R.S. 1993. The geology of the Graaff-Reinet area. Explanation to 1: 250 000 geology Sheet 3224 Graaff-Reinet, 31 pp. Council for Geoscience, Pretoria.
- JOHNSON, M.R., VAN VUUREN, C.J., VISSER, J.N.J., COLE, D.I., WICKENS, H. DE V., CHRISTIE, A.D.M., ROBERTS, D.L. & BRANDL, G. 2006. Sedimentary rocks of the Karoo Supergroup. Pp. 461-499 in Johnson. M.R., Anhaeusser, C.R. & Thomas, R.J. (eds.) *The geology of South Africa*. Geological Society of South Africa, Johannesburg & the Council for Geoscience, Pretoria.
- KEYSER, A.W. & SMITH, R.M.H. 1979. Vertebrate biozonation of the Beaufort Group with special reference to the Western Karoo Basin. *Annals of the Geological Survey of South Africa* 12: 1-36.
- KITCHING, J.W. 1977. The distribution of the Karoo vertebrate fauna, with special reference to certain genera and the bearing of this distribution on the zoning of the Beaufort beds. *Memoirs of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, No. 1*, 133 pp (incl. 15 pls).
- LE ROUX, F.G. & KEYSER, A.W. 1988. Die geologie van die gebied Victoria-Wes. Explanation to 1: 250 000 geology Sheet 3122, 31 pp. Council for Geoscience, Pretoria.
- MACRAE, C. 1999. Life etched in stone. *Fossils of South Africa*, 305 pp. The Geological Society of South Africa, Johannesburg.
- RESTALLACK, G.J., METZGER, C.A., GREAVER, T., HOPE JAHREN, A., SMITH, R.M.H. & SHELDON, N.D. 2006. Middle – Late Permian mass extinction on land. *GSA Bulletin* 118, 1398-1411.
- RUBIDGE, B.S. (Ed.) 1995. *Biostratigraphy of the Beaufort Group (Karoo Supergroup)*. South African Committee for Biostratigraphy, Biostratigraphic Series No. 1., 46 pp. Council for Geoscience, Pretoria.
- RUBIDGE, B.S. 2005. Re-uniting lost continents – fossil reptiles from the ancient Karoo and their wanderlust. 27th Du Toit Memorial Lecture. *South African Journal of Geology* 108, 135-172.
- SAHRA 2013. Minimum standards: palaeontological component of heritage impact assessment reports, 15 pp. South African Heritage Resources Agency, Cape Town.
- SMITH, R.M.H. 1993. Vertebrate taphonomy of Late Permian floodplain deposits in the southwestern Karoo Basin of South Africa. *Palaios* 8, 45-67.
- SMITH, R.M.H. 1986. Trace fossils of the ancient Karoo. *Sagittarius* 1 (3), 4-9.
- SMITH, R.M.H. 1987. Helical burrow casts of therapsid origin from the Beaufort Group (Permian) of South Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 60, 155-170.

SMITH, R.M.H. 1993b. Vertebrate taphonomy of Late Permian floodplain deposits in the southwestern Karoo Basin of South Africa. *Palaios* 8, 45-67.

SMITH, R.M.H. & KEYSER, A.W. 1995. Biostratigraphy of the *Tropidostoma* Assemblage Zone. Pp. 18-22 in Rubidge, B.S. (ed.) *Biostratigraphy of the Beaufort Group (Karoo Supergroup)*. South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R., RUBIDGE, B. & VAN DER WALT, M. 2012. Therapsid biodiversity patterns and paleoenvironments of the Karoo Basin, South Africa. Chapter 2 pp. 30-62 in Chinsamy-Turan, A. (Ed.) *Forerunners of mammals. Radiation, histology, biology*. xv + 330 pp. Indiana University Press, Bloomington & Indianapolis.

VAN DER WALT, M., DAY, M., RUBIDGE, B., COOPER, A.K. & NETTERBERG, I. 2010. A new GIS-based biozone map of the Beaufort Group (Karoo Supergroup), South Africa. *Palaeontologia Africana* 45, 1-5.

## 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)