

PALAEONTOLOGICAL SPECIALIST STUDY: FIELD ASSESSMENT

THREE EXISTING BORROW PITS AND ONE NEW PIT SITE ALONG THE MR0294 ROAD, MONTAGU DISTRICT, WESTERN CAPE

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1. EXECUTIVE SUMMARY

Three existing borrow pit sites and one proposed new site in the western Klein Karoo (Montagu District, Western Cape) are excavated into marine or non-marine mudrocks and impure sandstones of the Bokkeveld Group of Middle Devonian age. Existing pit MR00294/13.6/R/10/A/R3 (Portion 2 of Montagu Farm No. 217) is excavated into the Tra Tra Formation and existing pit MR00294/44.75/R/900 (Farm Ratelfontein No. 71) into the Waboomberg Formation. The new site MR00294/6.8/L/100 (Portion 7 of Farm Helpmekaar No. 147) and existing site MR00294/29.55/R/50/A/R74 (Montagu Farm No. 74) are both underlain by the Klipbokkop Formation. All these Bokkeveld rock units have yielded important fossil remains elsewhere in the western Klein Karoo region, including marine invertebrates as well as non-marine fish, vascular plants, molluscs and trace fossils. However, the bedrocks in all four of the study areas are highly weathered and cleaved, so their palaeontological sensitivity is LOW. Therefore, pending the discovery of substantial new fossil material such as shelly fossil, fish or plant remains, no further mitigation of fossil heritage for these borrow pit sites is recommended.

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, four existing or new borrow pit sites along the unsealed road MR0294 in the Montagu District, Western Cape (Fig. 1). These sites are:

- Pit MR00294/13.6/R/10/A/R3 on Portion 2 of Montagu Farm No. 217 (Kruispad 144) located c. 13.3 km ENE of Montagu (33° 45' 10.9" S, 20° 15' 26.9" E);
- Pit MR00294/29.55/R/50/A/R74 on Montagu Farm No. 74 (Papekuils Fontein) located c. 21.7 km NE of Montagu (33° 39' 14.2" S, 20° 17' 26.7" E);
- Pit MR00294/6.8/L/100 on Portion 7 of Farm Helpmekaar No. 147 located c. 8 km E of Montagu (33° 46' 46.4" S, 20° 10.1" E) (this is a new site);
- Pit MR00294/44.75/R/900 on Farm Ratelfontein No. 71 located c. 35 km NE of Montagu, close to the current western fence of the Sanbona Nature Reserve.

A previous desktop basic assessment of these pits by the author assessed their palaeontological heritage sensitivity as high due to the presence here of potentially fossiliferous sediments of the Bokkeveld Group. A palaeontological field assessment of the pits as part of an HIA was requested by Heritage Western Cape (HWC Case Ref. 111124JL18, Interim Comment 7 December 2011) in accordance with the requirements of the National Heritage Resources Act, 1999 (Section 38). The present palaeontological heritage field assessments 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). Fieldwork for this project was carried out on 18 to 20 August 2012.



Fig.1. Extract from topographical sheet 3320 Ladismith (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location of the four borrow pit sites in the western Klein Karoo to the east and northeast of Montagu, Montagu District, Western Cape (blue dot).

3. GEOLOGICAL BACKGROUND

The geology of the study area to the northeast of Montagu is shown on 1: 250 000 geology sheet 3320 Ladismith (Council for Geoscience, Pretoria; Theron *et al.* 1991) and is shown here in Fig. 2. This highly dissected, hilly region of the western Klein Karoo is underlain by marine to marginal marine / estuarine sediments of the Bokkeveld Group (Ceres and Bidouw Subgroups) of Early to Middle Devonian age. In this region the Bokkeveld rocks are often, but not invariably, intensely folded, faulted and cleaved. A number of major faults are shown on the geological map. It should be noted that the mapping here is often at reconnaissance level (based largely on photo interpretation) and field studies sometimes suggest – as discussed below - slightly different outcrop patterns for the various Bokkeveld Formations.

Existing pit site **MR00294/13.6/R/10/A/R3** on Portion 2 of Montagu Farm No. 217 (private nature reserve) is located on the south side of the MR0294 dust road and less than 100m north of a small stream. It is excavated into a gently south-sloping pediment surface at c. 420m amsl that is probably cut into the **Tra Tra Formation (Dt, Ceres Subgroup / Lower Bokkeveld Group)** rather than the Boplaas Formation as mapped on Fig. 2. Satellite images show pale, kaolinitised mudrock-dominated beds with subordinate sandstone-rich packages to the south and southwest, and these are also seen in the lower mountain slopes to the east (Fig. 3). Prominent-weathering sandstones capping these mountains represent the Boplaas Formation and so the pit area at a

lower elevation is inferred to be underlain by the slightly older Tra Tra Formation. This is a mudrock-dominated succession of shallow marine rocks of early Middle Devonian (Eifelian) age. Although micaceous mudrocks predominate, there are also several (around 4) sandstone-rich zones within the Tra Tra succession that give hillside outcrops a characteristic striped appearance (Theron *et al.* 1991, Almond 2009).

Sediments exposed in the MR00294/13.6/R/10/A/R3 pit comprise thin-bedded and laminated, pale grey to grey-green silty sandstones (wackes) and siltstones that are often micaceous, generally highly weathered and transected by veins of secondary ferruginous minerals. Secondary ferruginous concretions are also common. Some of the wackes display fine ripple cross-lamination (Fig. 4). The Bokkeveld bedrocks are sliced up by a pervasive, steep, east-west striking cleavage. The southern margins of the pit towards the stream are mantled by thick silty alluvium and alluvial gravels.

Existing pit site **MR00294/44.75/R/900** on Farm Ratelfontein No. 71 on the western side of the fenced-in portion of the Sanbona Nature Reserve is excavated at c. 750 m amsl into the north-eastern footslopes of a small *koppie* about 900m south of the MR0294 dust road (Fig. 5). The bedrocks here are assigned to the Klipbokkop Formation (Dkl) on the Ladismith geological maps (Fig. 2) but the thick succession of dark grey mudrocks with few sandstone event beds here is more typical of the slightly older **Waboomborg Formation (Dw)**. The thin sandstone package capping this and nearby koppies may belong to the Wuppertal Formation which underlies the Klipbokkop Formation *sensu stricto*.

The **Waboomborg Formation** is a mudrock-dominated unit overlying the Boplaas sandstones in the western Little Karoo. It is of early Middle Devonian age (Eifelian, c. 390-395 Ma). The succession includes intervals of claystone (fine-grained mudrock, including laminated shales) and siltstone, with occasional thin micaceous sandstones (Theron *et al.* 1991). Interbedded dark grey mudstones and siltstones occur towards the top of the succession, which is locally fossiliferous. The Waboomborg Formation mudrocks and overlying sandstones of the Wuppertal Formation form a single coarsening-upwards cycle reflecting shallowing of the Agulhas Sea in early Middle Devonian times. A thick succession of dark mudrocks at the base of the Waboomborg succession represents a significant sea level rise (high stand) in Mid Devonian times (Cooper 1986).

Mudrocks exposed in the existing MR00294/44.75/R/900 pit and adjacent hillslopes comprise hackly, grey-weathering siltstones that are dark grey to black when fresh. In some areas a well-developed cleavage is present. Spheroidal, pebble-sized (up to 4cm) ferruginous diagenetic nodules are common in the finer-grained mudrocks at the base of the hillslope (some showing cubical pseudomorphs after pyrite suggesting bottom anoxia) and there are also occasional cross-cutting veins of secondary ferruginous minerals. There are notably no sandstone event beds within the lower portion of the c. 25 to 30 meter – thick mudrock succession exposed here. Thin (1 to 2m) greyish-green to buff-weathering, wave-rippled sandstone packages, also extensively cleaved, occur within the upper middle and at the top of the succession (Fig. 6) suggesting that at least two shallowing-upwards parasequences are represented here. Pervasive steeply dipping cleavage within the Bokkeveld mudrocks in this region is best seen in stream cuttings some 150m to the west of the pit area (Fig. 7). Here can also be seen the thick mantle of well-bedded, gravely alluvial deposits that cover the Waboomborg sediments at the base of the *koppies* here.

The new pit site **MR00294/6.8/L/100** on Portion 7 of Farm Helpmekaar No. 147 is located on the northern side of the MR0294 dust road at c. 300 m amsl (Fig. 8). The gentle, south facing hill slopes here lie 350m north of a stream, a small tributary of which runs just east of the site. The pervasively cleaved, dull grey-green micaceous wackes here are very poorly exposed, with no available bedding surfaces and an impersistent veneer of downwasted to colluvial surface gravels (mainly platy wackes). No ferruginous diagenetic nodules were observed. Hill slopes on the opposite side of the valley to the south show extensive pale kaolinitic weathering of finer-grained facies. These rocks form part of a broadly upward – coarsening sequence and are assigned to the **Klipbokkop Formation (Dkl)** of Middle Devonian (Givetian) age (Fig. 2), an Upper Bokkeveld Group succession that crops out extensively in the western Klein Karoo (Almond 2009). It

comprises a thick succession of dark grey, ripple cross-laminated mudrocks and wackes that are often micaceous and contain fossiliferous ferruginous nodules towards the base (Theron *et al.* 1991). A restricted, non-marine depositional environment is inferred for most of the succession on the basis of the fossil biota (Section 4). The Klipbokkop Formation varies greatly in thickness, from 100 to 300m, increasing in thickness and the relative proportion of mudrocks towards the offshore part of the Bokkeveld Basin in the south. The mudrock-dominated parts of the succession are often poorly exposed, with good exposures mainly confined to stream valleys.

Existing pit site **MR00294/29.55/R/50/A/R74** on Montagu Farm No. 74 (Papekuils Fontein) lies at c. 860 m amsl on the southeast side of the MR0294 dust road and some 250 m west of a small stream. The pit is excavated into the northwest-facing slopes of a low ridge that is capped by highly cleaved, southeastwards dipping wackes (Fig. 10). Sediments exploited in the pit are assigned to the **Klipbokkop Formation** (Fig. 2) and comprise pale to dark grey, khaki and orange-weathering, thin-bedded micaceous wackes and siltstones with abundant small scale wavy lamination, lenticular lamination, local hummocky cross-stratification and bioturbation mottling (Fig. 11). Rusty brown ferruginous secondary concretions and veins are common. The bedrocks are pervasively cut by a steep, east-west striking tectonic cleavage. Deeply-weathered Klipbokkop sediments with varied pinkish, lilac and grey hues are exposed in the southeastern face of the pit (Fig. 12) where veins of large biconvex crystals of secondary gypsum were also observed. These last may have developed as a consequence of the weathering of pyrite within finer-grained mudrocks. The Bokkeveld bedrocks are mantled by ferruginous surface gravels, including locally well-developed ferricrete and blocky wackes downwasting from the ridge to the south. Along the crest of this ridge several prominent weathering beds or packages of buff, well-jointed and cleaved, horizontally-laminated and wave-rippled wackes are exposed. The latter probably represent the tops of upward-coarsening cycles or parasequences within the Klipbokkop succession, or may belong to the overlying Osberg Formation (The latter is mapped further to the southeast, however). A small *koppie* of Klipbokkop rocks just to the west of the pit site displays pale kaolinitic weathered slopes.



Fig. 3. View eastwards across pit MR00294/13.6/R/10/A/R3 that is probably excavated into the Tra Tra Formation. Note pale, kaolinitised mudrocks exposed on hillslopes in the background that are capped by sandstones of the Boplaas Formation.



Fig. 4. Finely cross-laminated, weathered wackes of the Tra Tra Formation in pit MR00294/13.6/R/10/A/R3 (Hammer = 29 cm).



Fig. 5. View of pit MR00294/44.75/R/900 and the adjacent *koppie* of Waboomberg Formation mudrocks seen from the northeast.



Fig. 6. Wavy-laminated tempestite sandstones capping the *koppie* seen in the previous figure (Hammer = 29 cm).



Fig. 7. Stream bank section c. 150 m to the west of pit MR00294/44.75/R/900 showing pervasively cleaved and ferruginous-veined grey mudrocks of the Waboomberg Formation overlain by a thick mantle of silty gravelly alluvium (Hammer = 29 cm).



Fig. 8. Poorly exposed, highly cleaved wackes of the Klipbokkop Formation at new pit site MR00294/6.8/L/100, viewed towards the northwest.



Fig. 9. Detail of the highly cleaved wackes at site MR00294/6.8/L/100 (Hammer = 29 cm).



Fig. 10. View southwards across the existing MR00294/29.55/R/50/A/R74 pit excavated into the weathered Klipbokkop Formation, with banded hillslopes of the lower Witteberg Group in the distance.



Fig. 11. Thinly interbedded, tabular to lenticular wackes and siltstones of the Klipbökkop Formation at site MR00294/29.55/R/50/A/R74 (Hammer = 29 cm).

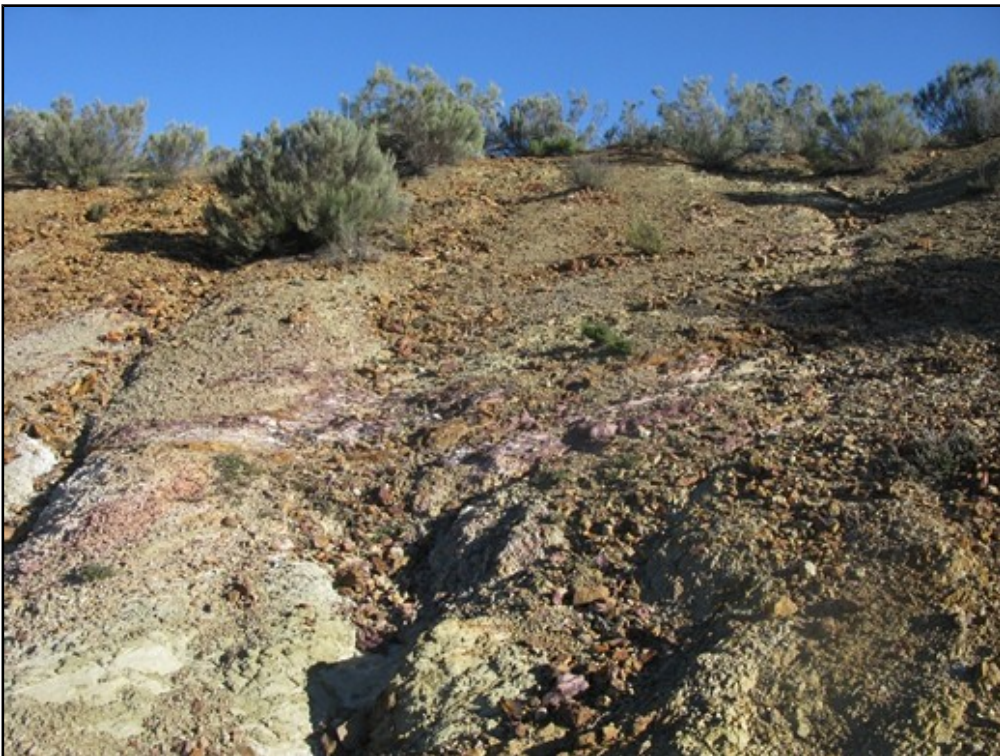


Fig. 12. Deeply-weathered, multi-hued siltstones and wackes of the Klipbökkop Formation on the southeastern face of pit MR00294/29.55/R/50/A/R74. Veins of large secondary gypsum crystals were observed here.

4. PALAEOONTOLOGICAL HERITAGE

4.1. Fossils in the Tra Tra Formation

Shelly fossils from the **Tra Tra Formation** in the Ladismith sheet area are generally scarce (*cf* Theron *et al.*, 1991, Table III, who only record *Australospirifer* from Bosluiskloof near Seweweekspoort, but also mention shell and crinoid remains in the more sandy beds). The only area in the Western Cape where diverse marine invertebrate assemblages have been recorded from this unit is on or near the Wageboomberg / Theronberg Pass near Ceres (Oosthuizen 1984, Gresse & Theron 1992). For this reason, the fairly abundant fossils from borrow pits within the lowermost Tra Tra Formation recently discovered on the Sanbona and Anysberg Nature Reserves in the western Klein Karoo are of considerable palaeontological interest (Almond 2009, unpublished observations 2011). Fossils moulds here are fairly well preserved and comprise a small range of bivalves (*Palaeoneilo*, *Nuculites* and unidentified forms), plectonotid bellerophonitids, orbiculoid inarticulate brachiopods, occasional articulate brachiopods, disarticulated crinoids, tentaculitids and simple, horizontal, mudlined, secondarily mineralised burrows.

No fossil remains were recorded from the Tra Tra sediments at pit site MR00294/13.6/R/10/A/R3. In general the Bokkeveld Group mudrocks here are highly cleaved and weathered and their palaeontological sensitivity is correspondingly LOW.

4.2. Fossils in the Waboomberg Formation

The palaeontology of the Middle Devonian (Eifelian) **Waboomberg Formation** in the Little Karoo region and elsewhere has been summarized by Almond (2009). Unusually rich faunas of shelly invertebrates have been collected from dark, very fine-grained mudrocks within this unit in the western branch of the Cape Fold Belt (Ceres area; Oosthuizen 1984, Gresse & Theron 1992). The excellent preservation here of fully-articulated trilobites, intact echinoderms (*e.g.* brittle stars, crinoids) and several groups of delicate, rare invertebrates (*e.g.* ostracods, bryozoans) is attributed to sudden smothering of living seabed communities by a blanket of fine-grained, anoxic mud, a process technically known as *obrution*. Comparable obrution faunas have not yet been identified in the Ladismith sheet area, where only a few fossiliferous localities within the Waboomberg Formation are known (Theron *et al.*, 1991). These include two localities near Prince Albert, another south of Touwsrivier, and a small shelly biota from the northern edge of the Sanbona Nature Reserve, about 14km to the north of the Warmwaterberg (Almond 2009).

At the last site, some 20 km to the east of the present borrow pit study area, the Waboomberg sandstones are cut through by an irregular, steeply-dipping, spaced cleavage so that preservation is generally poor. The fossils occur in thin (few cm) lentils and carpets of shells, often associated with mudflakes and metallic grey secondary manganese staining. The mudflakes (or rip-up clasts) indicate transport and sorting of shells by powerful currents or waves; most specimens are disarticulated. Small *pseudomorphs* of cubical pyrite minerals (*i.e.* replicas now converted to shiny brown iron minerals) are common. Since pyrite only forms in the absence of oxygen, this suggests that the seabed sediments were at least intermittently anoxic. Identifiable invertebrate fossils recorded from the Waboomberg Formation at Sanbona include:

brachiopods: *Australocoelia*, *?Derbyina*

bivalves : *Palaeoneilo*, *Nuculites*, *?Grammysioidea*, *?Cardiomorpha* and other forms

crinoids: *Ophiocrinus* and another form

others: tentaculitids

trace fossils: simple lined horizontal burrows (*Palaeophycus*)

The relative abundance of diversity of bivalves (mostly infaunal – *i.e.* burrowing into the seabed) compared with brachiopods (mostly epifaunal, living on the sea bed) is notable here. As with the

thicker coquinas in the Gamka Formation, the Waboomberg / Wuppertal shelly lenticles were probably accumulated during storms.

No fossil remains were recorded at the MR00294/44.75/R/900 pit site. The ferruginous diagenetic nodules seen here are apparently unfossiliferous. The very dark Waboomberg mudrocks may contain organic-walled microfossils such as acritarchs that would be of value for bistratigraphic (dating) purposes. In general the Bokkeveld Group mudrocks here are highly cleaved and weathered and their palaeontological sensitivity is correspondingly LOW.

4.2. Fossils in the Klipbökkop Formation

An important, albeit low-diversity, non-marine fossil biota has been recorded from the Bidouw Subgroup (Klipbökkop and upper Kanies Formations in the western Bokkeveld outcrop area) as well as from laterally equivalent Middle Devonian sediments to the east – *i.e.* the Adolphspoort Formation of the Traka Subgroup (Plumstead 1977, Chaloner *et al.* 1980, Anderson & Anderson 1985, Almond 1997, Anderson *et al.* 1999a, 1999b, Anderson *in* MacRae 1999, Almond 2008a, 2008b, 2009). The Klipbökkop / Adolphspoort fossil assemblages are mainly preserved as moulds and comprise:

- Fragmentary vascular plants, including several species of lycopods (the club mosses *Archaeosigillaria*, *Haplostigma*) plus possible psilopsids;
- Non-marine, thin-shelled bivalves (possibly unionids), often preserved in dense clumps;
- Rare marine invertebrates (*e.g.* the articulate brachiopod *Australospirifer*);
- A limited variety of trace fossils including rare trilobite burrows (*Cruziana*), and unusually small versions of the complex helical burrow *Spirophyton*;
- A low-diversity assemblage of bony and cartilaginous fish, including acanthodians (“spiny sharks”), several primitive sharks, bony-plated jawed fish known as placoderms (Fig. 13), and rare crossopterygians (lobe-finned bony fish). These important Middle Devonian fossil fish have been described and illustrated in detail by Chaloner *et al.* (1980), Almond (1997), Anderson *et al.* (1999a, 1999b) and Long *et al.* (in prep). General accounts of Devonian fish groups from Gondwana are given by Anderson *in* MacRae (1999) and Long (1995).

Klipbökkop / Adolphspoort fish fossils mainly consist of disarticulated placoderm plates as well as isolated teeth and fin spines of antarctilamnid sharks and acanthodians. The fossils are found scattered throughout the succession within silty mudrocks and occasionally within ferruginous carbonate-rich concretions. Thin conglomeratic layers of transported mudflakes mixed with fish teeth, spines and other skeletal elements are recorded from the mid to upper Klipbökkop Formation in the Cederberg region and elsewhere. Those parts of the succession with unionid-like bivalves, low-diversity trace assemblages dominated by small *Spirophyton*, vascular plants and fish fossils are considered to be non-marine in origin, perhaps accumulated on an extensive delta platform or prograding (advancing) shoreline zone. A mixture of fish originally from brackish to freshwater bodies near to the coastline (estuaries, lagoons, rivers, lakes) as well as salinity-tolerant marine forms may be represented in the fossil assemblages.

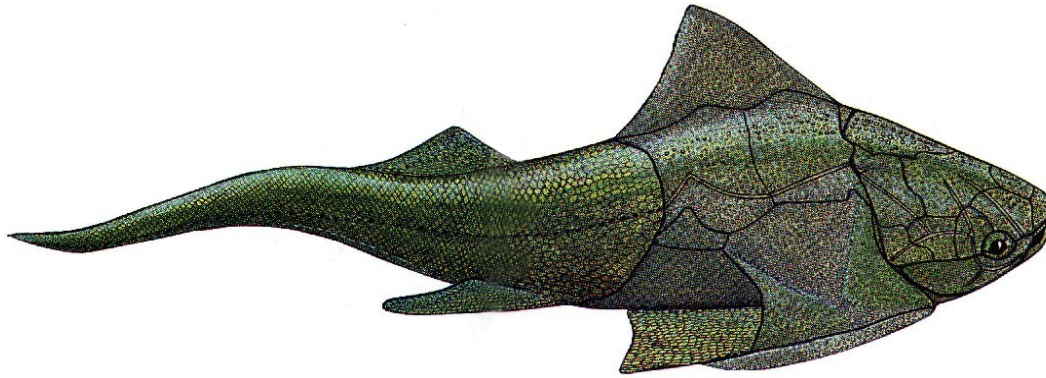


Fig. 13. Reconstruction of the armour-plated placoderm fish *Groenlandaspis*, which is recorded from Middle to Late Devonian sediments worldwide, including the Bidouw and Traka Subgroups of South Africa (From Long 1995).

Important assemblages of Middle Devonian fish, lycopods and non-marine bivalves have been recorded from the Klipbokkop Formation and equivalent beds on the Anysberg and Sanbona Nature Reserves in the western Klein Karoo (Almond 2009, unpublished observations 2011). However no body fossils were recorded within either the MR00294/6.8/L/100 or the MR00294/29.55/R/50/A/R74 borrow pit study areas. Potentially fossiliferous ferruginous nodules were not observed here. There is evidence for extensive bioturbation of some horizons, but discrete ichnogenera were not recognised. In general the Bokkeveld Group sediments here are highly cleaved and weathered and their palaeontological sensitivity is correspondingly LOW.

5. CONCLUSIONS & RECOMMENDATIONS

Three existing borrow pit sites and one new site in the western Klein Karoo (Montagu District, Western Cape) are excavated into marine or non-marine mudrocks and impure sandstones of the Bokkeveld Group of Middle Devonian age. Existing pit MR00294/13.6/R/10/A/R3 (Portion 2 of Montagu Farm No. 217) is excavated into the Tra Tra Formation and existing pit MR00294/44.75/R/900 (Farm Ratelfontein No. 71) into the Waboomberg Formation. The new site MR00294/6.8/L/100 (Portion 7 of Farm Helpmekaar No. 147) and existing site MR00294/29.55/R/50/A/R74 (Montagu Farm No. 74) are both underlain by the Klipbokkop Formation. All these Bokkeveld rock units have yielded important fossil remains elsewhere in the western Klein Karoo region, including marine invertebrates as well as non-marine fish, vascular plants, molluscs and trace fossils. However, the bedrocks in all four of the study areas are highly weathered and cleaved, so their palaeontological sensitivity is LOW. Therefore, pending the discovery of substantial new fossil material such as shelly fossil, fish or plant remains, no further mitigation of fossil heritage for these borrow pit sites is recommended.

6. ACKNOWLEDGEMENTS

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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 for SAHRA and HWC. Dr Almond is an accredited member of PSSA and AHP (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.



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