PALAEONTOLOGICAL SPECIALIST STUDY: FIELD ASSESSMENT

EXPANSION OF AN EXISTING BORROW PIT IN THE PRINCE ALBERT TOWNLANDS, PRINCE ALBERT DISTRICT, WESTERN CAPE

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1. EXECUTIVE SUMMARY

The large DR01725/0.6/0.02R borrow pit site located in the Prince Albert Townlands, Prince Albert District, Western Cape, is excavated into Early Permian sediments of the lower Ecca Group (Prince Albert, Whitehill and Collingham Formations). These basinal mudrocks have yielded important assemblages of fossil fish, marine shelly invertebrates, mesosaurid reptiles, non-marine crustaceans, petrified wood and trace fossils in the Prince Albert area and elsewhere along the margins of the Main Karoo Basin. Large fragments of petrified driftwood have been recorded from the study area, probably from the Collingham Formation. The unusually well-exposed bedding planes of this succession seen along the northern edge of the existing quarry display very dense but low diversity assemblages of trace fossils (invertebrate burrows). For the most part, the Lower Ecca rocks have been high deformed by tectonism (folding, cleavage formation) and are often highly weathered and fractured. No body fossils were observed in the Ecca Group during field assessment and, with the exception of the well-developed trace fossil assemblages in the Collingham Formation, the overall palaeontological sensitivity of the site is low. The overlying colluvial and alluvial gravels are not palaeontologically sensitive.

It is recommended that the trace fossil assemblages currently exposed in the Collingham Formation along the northern edge of the existing DR01725/0.6/0.02R pit should be recorded and judiciously sampled by a professional palaeontologist *before* further excavation takes place. Otherwise there are no objections on palaeontological heritage grounds to the proposed borrow pit extension.

2. INTRODUCTION

The Department of Transport, Western Cape, is applying to the Department of Mineral Resources for approval to exploit rock material from a large existing borrow pit along the unsealed road DR1725 in the Prince Albert District, Western Cape. Pit DR01725/0.6/0.02R is situated on the Prince Albert Townlands on the southern edge of North End township and *c*. 500 m west of the R328 tar road through Prince Albert (33º 12' 48.3" S, 22º 01' 25.0" E) (Figs. 1 & 2).

A previous desktop basic assessment of the pit by the author assessed its palaeontological heritage sensitivity as high due to the presence here of known fossiliferous sediments of the Lower Ecca Group. A palaeontological field assessment of the pit as part of an HIA was requested by Heritage Western Cape (HWC case 1808 - 1845 ref 120502JL02, Interim Comment 16 May 2012) 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). This is Vidamemoria pit number 148 and NID reference number 80. Fieldwork for this project was carried out on 28 September 2012.

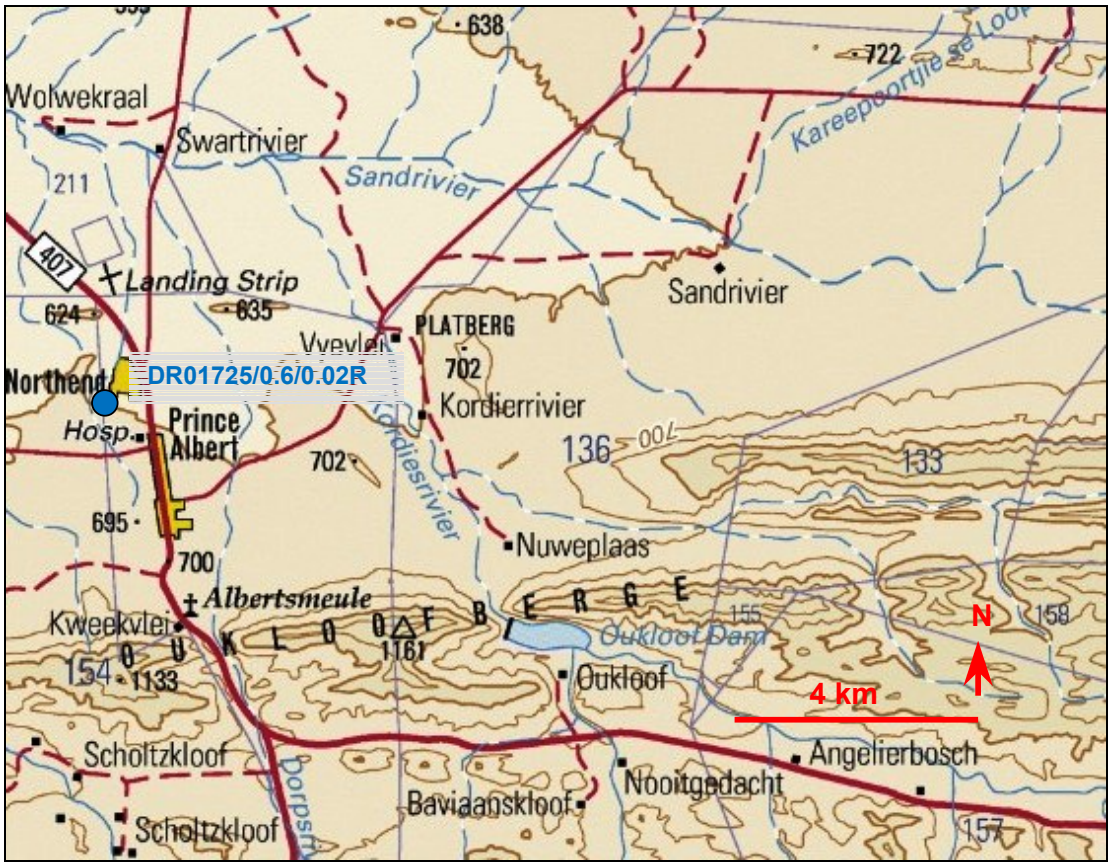

Fig.1. Extract from topographical sheets 3322 Oudtshoorn (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location of the existing DR01725/0.6/0.02R pit on the northwestern outskirts of Prince Albert, Central Karoo District Municipality, Western Cape (blue dot).

Fig. 2. 2005 Google earth© satellite image of the study area in the Prince Albert Townlands showing the location of the large existing DR01725/0.6/0.02R borrow pit along the DR1725 (yellow symbol). Note the east-west striking outcrop areas of the Dwyka (C-Pd), Prince Albert (Pp), Whitehill (Pw) and Collingham Formations (Pc) as well as the minor stream running N-S on the western side of the pit.

3. GEOLOGICAL HERITAGE

The geology of the Prince Albert study area is outlined on 1: 250 000 geology sheet 3322 Oudtshoorn (Council for Geoscience, Pretoria) and is shown here in Fig. 3. A very short sheet explanation has been published by Toerien (1979). Also relevant is the explanation to the adjacent 1: 250 000 Ladismith sheet by Theron *et al.* (1991).

The borrow pit study area lies on the northern limb of an E-W trending anticline in sediments of the Karoo Supergroup on the southern margin of the Main Karoo Basin at Prince Albert. Here several formations within the lowermost **Ecca Group** show subvertical to northwards-overturned bedding to the north of the anticlinal core formed by underlying Dwyka Group rocks. Marine sediments of the Ecca Group (Karoo Supergroup) were deposited within the Ecca Sea, an extensive salty to freshwater, largely land-locked water body located on the south-western margins of Gondwana in Early to Middle Permian times (Johnson *et al.* 2006).

The southern edge of the existing pit is excavated into dark basinal mudrocks of the **Prince Albert Formation**. The main area of the pit is excavated into pale-weathering mudrocks of the **Whitehill Formation**, while the northern edge of the pit is cut into subvertical beds of the **Collingham Formation**. This last unit is more resistent-weathering and forms a low ridge between the present pit and the southern edge of the North End township. On satellite images the west-east striking outcrop areas of these various stratigraphic units can be clearly seen (Fig. 2). The proposed

borrow pit development will involve excavation of material from all three Ecca formations, with a northward extension into the Collingham ridge

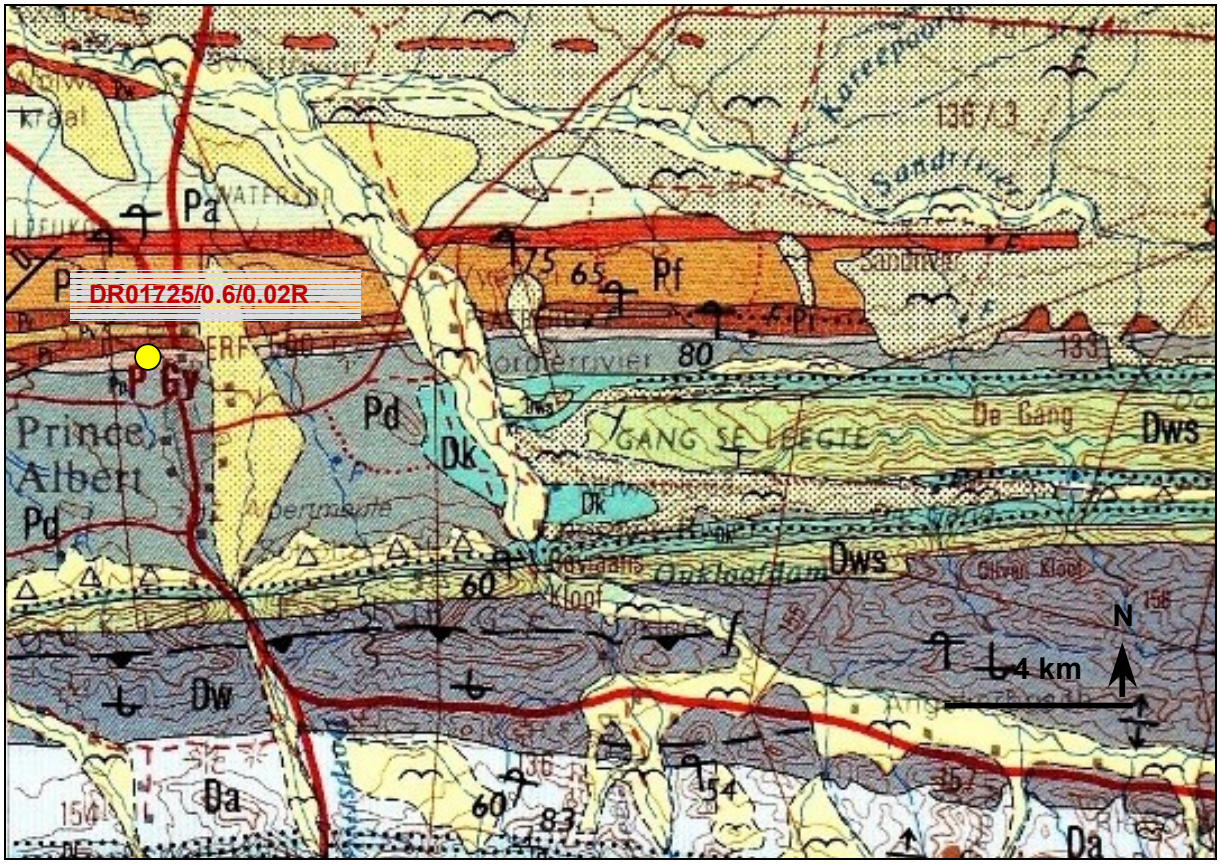

Fig. 3. Extract from 1: 250 000 geology sheet 3322 Oudtshoorn (Council for Geoscience, Pretoria) showing the location of the DR01725/0.6/0.02R borrow pit in the Prince Albert Townlands, Western Cape (yellow dot). The large existing pit is excavated into steeply-dipping beds of the Prince Albert, Whitehill and Collingham Formations of the lower Ecca Group (all grouped here as Pp). P = phosphate. Gy = gypsum.

The post-glacial basinal mudrocks of the **Prince Albert Formation** (**Ppr / Pp**) form the lowermost subunit of the Ecca Group. This thin-bedded to laminated mudrock-dominated succesion of Early Permian (Asselian / Artinskian) age was previously known as "Upper Dwyka Shales". Key geological accounts of this formation are given by Visser (1992) and Cole (2005). The Prince Albert succession consists mainly of tabular-bedded mudrocks of blue-grey, olive-grey to reddish-brown colour with occasional thin (dm) buff sandstones and even thinner (few cm), soft-weathering layers of yellowish water-lain tuff (*i.e.* volcanic ash layers). Extensive diagenetic modification of these sediments has led to the formation of thin cherty beds, pearly- blue phosphatic nodules, rusty iron carbonate nodules, as well as beds and elongate ellipitical concretions impregnated with iron and manganese minerals. The brittle rocks are well-jointed and often display a well-developed tectonic cleavage that results in sharp, elongate cleavage flakes ("pencil cleavage"). Extensive bedding planes are therefore rarely encountered.

Dark Prince Albert mudrocks are poorly exposed along the southern edge of the existing DR01725/0.6/0.02R pit (Figs. 4 & 5). They are steeply north-dipping, tectonically disturbed and include prominently pale cream-weathering tuff (volcanic ash) layers up to several cm thick. These include unusually coarse-grained tuffs (Fig. 6). The dark grey-green to metallic grey mudrocks

show well-developed pencil cleavage and extensive bedding surfaces are not seen. Ferruginous diagenetic nodules and secondarily mineralised beds are common.

The **Whitehill Formation** (**Pw**) is a thin (*c*. 30m) succession of well-laminated, carbon-rich mudrocks of Early Permian (Artinskian) age that forms part of the lower Ecca Group. These sediments were laid down about 278 Ma in an extensive shallow, brackish to freshwater basin – the Ecca Sea – that stretched across southwestern Gondwana, from southern Africa into South America (McLachlan & Anderson 1971, Oelofsen 1981, 1987, Visser 1992, 1994, Cole & Basson 1991, MacRae 1999, Johnson *et al*. 2006). Fresh Whitehill mudrocks are black and pyritic due to their high content of fine-grained organic carbon, probably derived from persistent or seasonal phytoplankton blooms that promoted anoxic conditions on the Ecca Sea bed. Near-surface weathering of the pyrite leads to the formation of gypsum, lending a pale grey colour to the Whitehill outcrop (hence informally known as the "*Witband*") (This is clearly seen in satellite images; Fig. 2). Large (meter-scale) diagenetic nodules and lenses of tough, greyish dolomite are common and often display a stromatolite-like fine-scale banding.

Good witness sections through the upper part of the Whitehill Formation are seen at the western end of the DR01725/0.6/0.02R pit. The lower Whitehill succession is not well seen due to previous quarrying but appears to be tectonically deformed. The beds here are weathered pale grey to pinkish hues and dip steeply southwards (*i.e.* overturned). There are several tuff horizons within the upper Whitehill Formation close to the contact with the Collingham. Whitehill bedding is largely obscured by a pervasive, widely-spaced tectonic cleavage and / or jointing that runs subhorizontally (Fig. 7). Large *ex situ* excavated boulders of dark grey cherty dolomite from the Whitehill Formation at the western end of the pit show a complex, brecciated internal fabric and are up to 3 m across (Fig. 8). Black dolomite nodules with a stromatolite-like internal lamination, as recorded to the east of Prince Albert, were not observed here.

The tabular-bedded **Collingham Formation** is characterized by the regular "striped" alternation of thin-bedded, well-jointed siliceous mudrocks and soft-weathering pale yellow tuffs (*i.e.* volcanic ash layers) (Viljoen 1992, 1994). These tuffs have been radiometrically dated to 270 Ma or Mid Permian. Basinal mudrocks and tuffs deposited by suspension settling in the lower part of the Collingham give way higher up to thicker, tabular-bedded turbidite units deposited by sediment gravity flows. A prominent-weathering *c*. 60 m thick bed of chert (cryptocrystalline silica) within the lower part of the Collingham Formation is known as the Matjiesfontein Member and extends for several hundred kilometers along the southern margin of the Great Karoo. This used to be considered as the marker bed indicating the contact between the Dwyka Group (Upper Dwyka Shales, now Prince Albert Formation) and the Ecca Group, but this is no longer stratigraphic practice.

Tabular, regularly interbedded dark mudrocks and thin, crumbly, yellow-weathering tuff layers (the latter up to 6 cm thick) of the Collingham Formation form the wall-like northern edge of the existing DR01725/0.6/0.02R borrow pit where they dip very steeply to the south (*i.e.* are overturned towards the north) (Fig. 9). The *c*. 60 cm thick, pale grey Matjiesfontein Member chert bed is well exposed striking E-W along the crest of the Collingham ridge (Fig. 10). The brittle bedrocks here are extensively fractured by joints and cleavage, with some evidence for bedding plane slip in the form of mineral lineation. Common secondarily mineralized (ferruginised) beds show distinctive snuffbox weathering. Exposure of the upper Collingham beds is not good on the northern slopes of the ridge.

The north-facing slopes of the Collingham ridge as well as the lower lying area surrounding the DR01725/0.6/0.02R borrow pit are mantled with poorly-sorted, polymict downwasted gravels, including many artificially flaked clasts derived from the Matjiesfontein Member, occasional quartzite boulders derived from relict High Level Gravels in the area as well as a wide range of exotic rock types (*e.g.* amygdaloidal lavas) that have weathered out of the Dwyka outcrop area to the south (Fig. 11). These gravels are reworked as coarse alluvium in the shallow stream to the west of the pit area.

Fig. 4. View eastwards along the length of the large existing DR01725/0.6/0.02R borrow pit in the Prince Albert townlands. Dark mudrocks in the south (RHS) belong to the Prince Albert Formation. The main pit area is excavated into pale Whitehill Formation mudrocks (centre). The ridge in the north is built of more resistant sediments of the Collingham Formation (LHS).

Fig. 5. View eastwards along strike of the Prince Albert Formation exposure along the southern margin of the DR01725/0.6/0.02R pit. The pale stripes are thin tuff (volcanic ash) horizons.

Fig. 6. Close-up of unusually coarse-grained tuff from an ash layer within the Prince Albert Formation. The block on the left is *c*. 7 cm across.

Fig. 7. Cut face of weathered and highly cleaved, pale grey mudrocks of the Whitehill Formation (Hammer = 27 cm). The bedding here dips very steeply north (towards the observer) while the more prominent cleavage is subhorizontal.

Fig. 8. Large dolomitic nodule with a brecciated fabric excavated from the Whitehill Formation (Hammer = 27 cm). Some Whitehill dolomite nodules in Prince Albert region are highly fossiliferous (*e.g.* crustaceans).

Fig. 9. Tabular, subvertical beds of the Collingham Formation exposed along the northern face of the existing DR01725/0.6/0.02R pit. The succession comprises alternating beds of silicified mudrock and pale yellow, crumbly tuff (volcanic ash).

Fig. 10. View westwards along the crest of the ridge running along the northern edge of the existing DR01725/0.6/0.02R borrow pit. The prominent-weathering tabular bed seen here is the well-known Matjiesfontein Member chert band within the lower Collingham Formation. The bedding here is overturned towards the north.

Fig. 11. Downwasted gravels mantling the lower Ecca mudrock outcrop area. The poorly-sorted polymict gravels consist of quartzite, sandstone, vein quartz and a wide range of exotic rock types weathered out from the Dwyka Group tillites (Hammer = 27 cm).

4. PALAEONTOLOGICAL HERITAGE

The following brief account of the known fossil record of the lower Ecca Group formations represented at Prince Albert is largely abstracted from Almond (2010a, 2010b). Brief palaeontological data for the Lower Ecca beds near Prince Albert can also be found in Rossouw *et al.* (1964).

4.1. Fossil heritage of the Prince Albert Formation

The fossil biota of the postglacial mudrocks of the Prince Albert Formation is usefully summarized by Cole (2005). Epichnial (bedding plane) trace fossil assemblages of the non-marine *Mermia* Ichnofacies, dominated by the ichnogenera *Umfolozia* (arthropod trackways) and *Undichna* (fish swimming trails), are commonly found in basinal mudrock facies of the Prince Albert Formation throughout the Ecca Basin. These assemblages have been described by Anderson (1974, 1975, 1976, 1981) and briefly reviewed by Almond (2008a, b). A small range of simple, horizontal to oblique endichnial burrows forming dense monospecific ichnoassemblages have been recorded from the Ceres Karoo, especially from those parts of the Prince Albert succession containing thin volcanic tuffs (Almond 2010a). The presence of more diverse, but incompletely recorded, benthic invertebrate fauna in the Early Permian Ecca Sea is suggested by the recent discovery of complex arthropod trails with paired drag marks in the Prince Albert Formation near Matjiesfontein, southern Great Karoo margins (Almond 2010b).These trackways might have been generated by small predatory eurypterids (water scorpions), but this requires further confirmation.

The Dwyka / Ecca boundary beds have yielded some of the most important marine-influenced fossil assemblages within the Ecca Group but these lowermost Prince Albert Formation beds are probably not directly impacted by the present development.

Diagenetic nodules containing the remains of palaeoniscoids (primitive bony fish), sharks, spiral bromalites (coprolites, spiral gut infills *etc* attributable to sharks or temnospondyl amphibians) and petrified wood have been found in the Ceres Karoo (Almond 2008b and refs. therein). Rare shark remains (*Dwykaselachus*) are recorded near Prince Albert on the southern margin of the Great Karoo (Oelofsen 1986). Microfossil remains in this formation include sponge spicules, foraminiferal and radiolarian protozoans, acritarchs and miospores.

No fossils were recorded within the Prince Albert beds in the DR01725/0.6/0.02R borrow pit at Prince Albert. Fossil heritage here has probably been largely destroyed here by tectonism and weathering.

4.2. Fossil heritage of the Whitehill Formation

In palaeontological terms the Whitehill Formation is one of the richest and most interesting stratigraphic units within the Ecca Group (Almond 2008a and refs. therein). In brief, the main groups of Early Permian fossils found within the Whitehill Formation include:

- small aquatic mesosaurid reptiles (the earliest known sea-going reptiles)
- rare cephalochordates (ancient relatives of the living lancets)
- a variety of palaeoniscoid fish (primitive bony fish)
- highly abundant small eocarid / notocarid crustaceans (bottom-living, shrimp-like forms)
- insects (mainly preserved as isolated wings, but some intact specimens also found)
- a low diversity of trace fossils (*e.g.* king crab trackways, possible shark coprolites / faeces)
- palynomorphs (organic-walled spores and pollens)
- petrified wood (mainly of primitive gymnosperms)
- other sparse vascular plant remains (*Glossopteris* leaves, lycopods *etc*).

The stratigraphic distribution of the most prominent fossil groups – mesosaurid reptiles, palaeoniscoid fishes and notocarid crustaceans – within the Whitehill Formation has been documented by several authors, including Oelofsen (1987), Visser (1992) and Evans (2005). Petrified wood from the Whitehill near Prince Albert is recorded by Rossouw *et al.* (1964).

No crustacean, mesosaurid or other fossil remains were observed during the present field assessment of the Prince Albert DR01725/0.6/0.02R borrow pit site. Grey diagenetic nodules in the Whitehill outcrop area to the east of Prince Albert have yielded well-preserved, three dimensional crustacean fossils (pygocephalomorphs) but these have not been recorded from Prince Albert site itself. The Whitehill beds here are highly cleaved, tectonised and weathered, so their fossil content has probably been largely destroyed.

4.3. Fossil heritage of the Collingham Formation

The palaeontology of the **Collingham Formation** has been reviewed by Viljoen (1992, 1994) and Almond (2008a). Transported, water-logged plant debris and tool marks generated by logs are often associated with thicker turbidite beds, especially within the upper part of the Collingham Formation. Substantial blocks of silicified wood are known from the Laingsburg area. The heterolithic character of this succession favours trace fossil preservation, with very high levels of bioturbation recorded locally. The abundance of fossil burrows indicates that oxygenation of bottom waters and the sea bed had improved substantially since Whitehill times. Abundant, moderately diverse trace fossil assemblages have been recorded from the Collingham Formation (Anderson 1974). They include horizontal, 2 cm-wide epichnial grooves with obscurely segmented levees ("*Scolicia*", possibly generated by gastropods), narrow, bilobate arthropod furrows ("*Isopodichnus*"), reticulate horizontal burrows (perhaps washed out *Megagrapton*-like systems), densely packed horizontal burrows with a rope-like surface texture covering selected bedding planes (*cf Palaeophycus*), narrow branching burrows, rare arthropod trackways (*Umfolozia*) and fish swimming trails (*Undichna*). The trackway of a giant sweep-feeding eurypterid has been identified from the upper Collingham Formation near Laingsburg, and fragmentary body fossils of similar animals are known from coeval sediments in South America (Almond 2002). At over two metres long, these bottom-feeding predators are the largest animal so far known from the Ecca Sea.

The Collingham Formation exposure in the DR01725/0.6/0.02R borrow pit site is unusual in showing several extensive bedding planes, which are rare elsewhere due to the prevalence of jointing within this brittle rock unit (Fig. 9). Dense assemblages of horizontal burrows of two contrasting diameters are revealed on freshly broken dark mudrock surfaces within the lowermost Collingham Formation (Fig. 12). Bedding plane soles showing the interface between mudrock and tuff facies also display dense networks of horizontal burrows preserved as positive hyporeliefs (Fig. 13). No giant eurypterid trackways were seen here. The trace fossil assemblages within the Collingham Formation at pit site DR01725/0.6/0.02R warrant detailed study before they are destroyed by further quarrying activity. The Roy Oosthuizen fossil collection (now housed at Iziko: South African Museums, Cape Town) contains a piece of large silicified log which was collected from the study area. This probably came from the Collingham Formation here, but may also belong to the Whitehill Formation as claimed by Mr Oosthuizen himself (*cf* Rossouw *et al*, 1964).

Fig. 12. Close-up of freshly broken surfaces within mudrocks of the Collingham Formation showing dense assemblages of horizontal endichnial burrows at two different scales (Pale larger burrows are *c*. 1 cm across).

Fig. 13. Bedding plane (sole surface) exposure within the Collingham Formation showing dense assemblages of horizontal burrows (*c*. 1 cm across) at the interface of pale yellowish tuff and dark grey mudrock.

5. CONCLUSIONS & RECOMMENDATIONS

The large DR01725/0.6/0.02R borrow pit site located in the Prince Albert Townlands, Prince Albert District, Western Cape, is excavated into Early Permian sediments of the lower Ecca Group (Prince Albert, Whitehill and Collingham Formations). These basinal mudrocks have yielded important assemblages of fossil fish, marine shelly invertebrates, mesosaurid reptiles, non-marine crustaceans, petrified wood and trace fossils in the Prince Albert area and elsewhere along the margins of the Main Karoo Basin. Large fragments of petrified driftwood have been recorded from the study area, probably from the Collingham Formation. The unusually well-exposed bedding planes of this succession seen along the northern edge of the existing quarry display very dense but low diversity assemblages of trace fossils (invertebrate burrows). For the most part, the Lower Ecca rocks have been high deformed by tectonism (folding, cleavage formation) and are often highly weathered and fractured. No body fossils were observed in the Ecca Group during field assessment and, with the exception of the well-developed trace fossil assemblages in the Collingham Formation, the overall palaeontological sensitivity of the site is low. The overlying colluvial and alluvial gravels are not palaeontologically sensitive.

It is recommended that the trace fossil assemblages currently exposed in the Collingham Formation along the northern edge of the existing DR01725/0.6/0.02R pit should be recorded and judiciously sampled by a professional palaeontologist *before* further excavation takes place. Otherwise there are no objections on palaeontological heritage grounds to the proposed borrow pit extension.

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 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.

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