PALAEONTOLOGICAL SPECIALIST STUDY: FIELD ASSESSMENT

EXISTING BORROW PIT AND ROAD CUTTINGS ALONG THE DR1380, BREEDEVALLEI DISTRICT, WESTERN CAPE

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August 2012

1. EXECUTIVE SUMMARY

The large DR01380/16.0/R/50/A/W7 borrow pit situated on the northern side of the DR1308 some 18 km southeast of Worcester, Breedevallei District, is excavated into Early Permian carbonaceous non-marine mudrocks of the Whitehill Formation (Ecca Group). This site – the palaeontologically well-known Scherpenheuwel Quarry - has yielded important fossil material of crustaceans, insects and aquatic mesosaurid reptiles (including well-articulated adult skeletons and juveniles) over the past three decades. The quarry furthermore represents one of the best exposures of the Whitehill Formation succession known and is of considerable geological significance in terms of Ecca Group stratigraphy and sedimentology. Unfortunately the quarry has recently been extensively re-excavated as part of a local road improvement programme without providing an opportunity to mitigate palaeontological and geological heritage. It is likely that significant fossil material that might otherwise have been recovered is now lost.

Thin-bedded siliceous mudrocks and tuffs (volcanic ash layers) of the lowermost Collingham Formation exposed at the top of the quarry face contain low diversity trace fossil assemblages.

New road cuttings (*c*. 520 m long) into the underlying Prince Albert Formation (Ecca Group, Early Permian) along the southern side of the DR1308 to the east of the quarry expose dark basinal mudrocks, volcanic tuffs and phosphatic nodules. Sparse trace fossil assemblages recorded here include complex meniscate backfilled burrows and arthropod trackways. Extensive development of pencil cleavage here precludes the extensive recording and recovery of representative fossil material.

Since the proposed excavation work has already been completed, no further mitigation of fossil heritage for this site is recommended. It is likely that this scientifically important quarry will continue to receive sporadic attention from palaeontologists and geologists in future. Should the Department of Transport plan to re-excavate Ecca Group rocks in this area, Heritage Western Cape should be advised well in advance so that a professional palaeontologist can be commissioned to advise on, and carry out, appropriate mitigation measures.

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 DR1380 in the Breedevallei District, as well as from a section some 520m long and up to 15m wide along the southern side of the DR1380 to the east of the pit. Pit DR01380/16.0/R/50/A/W7 (33º 45’ 25.5” S, 19º 35’ 07.5” E) on Portion 12 of Farm 481 Kenmoor (Farm Scherpenheuwel 481 in Fig.

1) is situated at *c*. 235m amsl on the north side of the DR1380 road about 18 km southeast of the town of Worcester in the Breede River Valley region.

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 Whitehill Formation (Ecca Group). A palaeontological field assessment of the pit as part of an HIA was requested by Heritage Western Cape (HWC Case No120130JL08, Interim Comment 15 February 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). Fieldwork for this project was carried out on 20 August 2012.

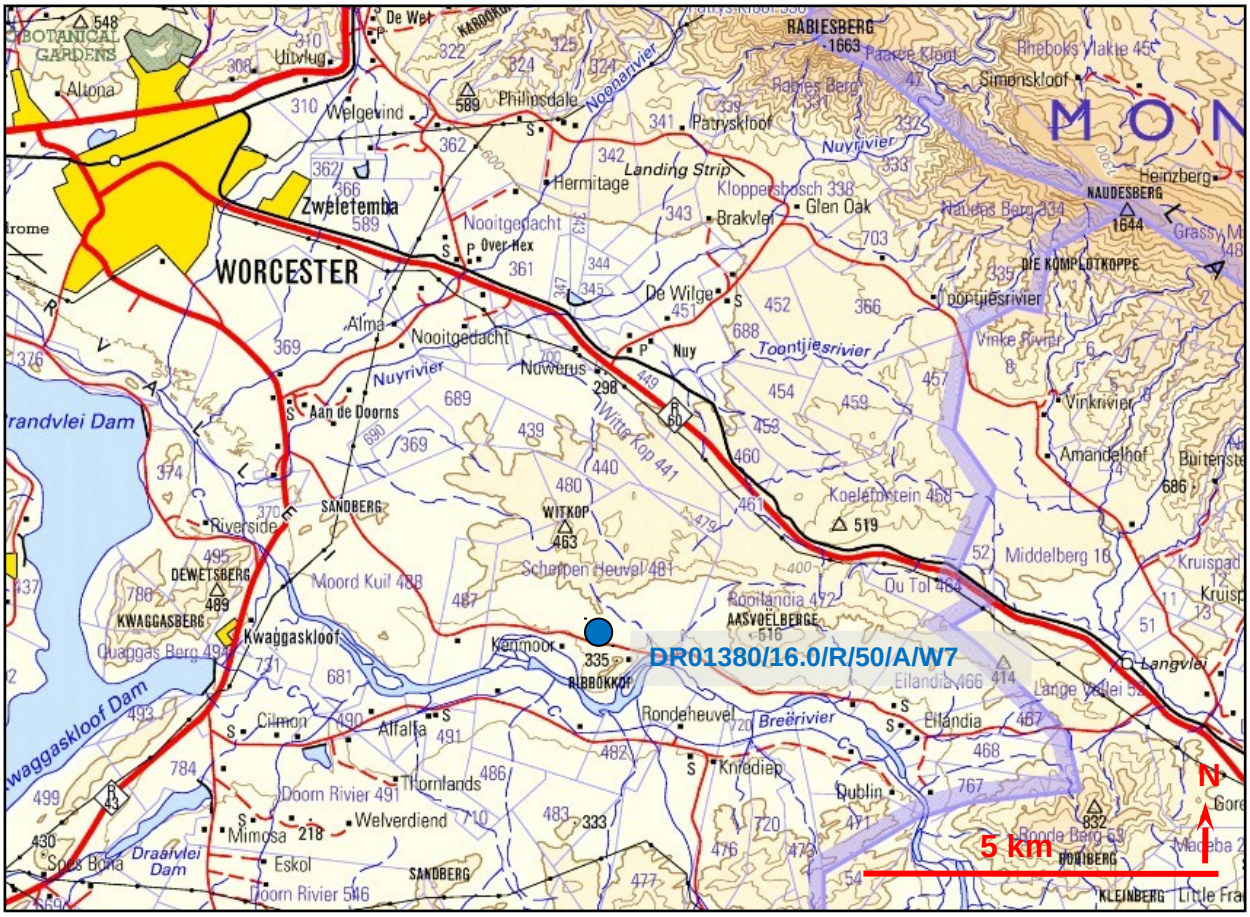

Fig. 1. Extract from topographical sheets 3119 Worcester (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location of the existing DR01380/16.0/R/50/A/W7 pit *c*. 18 km SE of Worcester in the Breedevallei Magisterial District, Western Cape (blue dot).

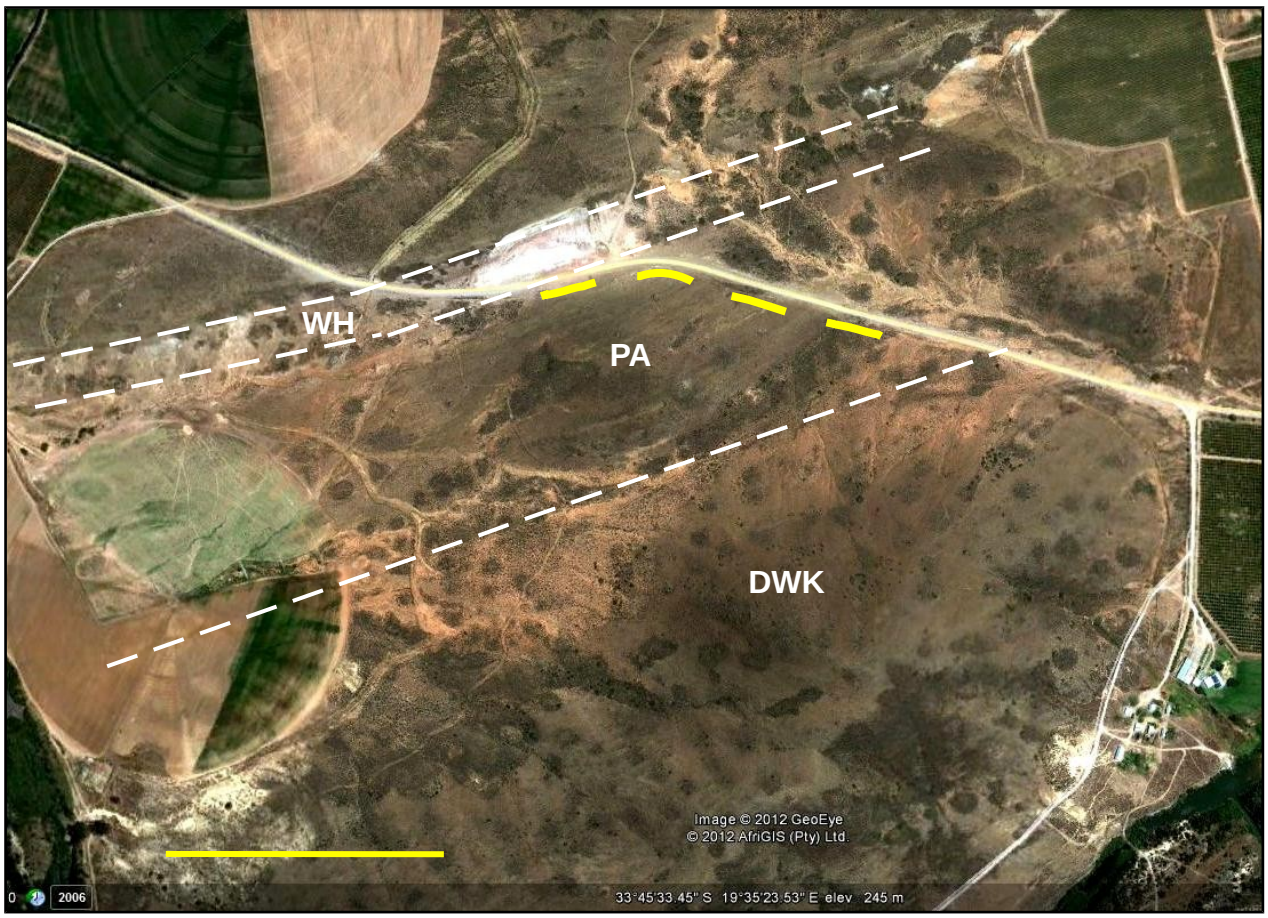

Fig. 2. 2006 Google earth© satellite image of the Scherpenheuwel study area showing the large existing DR01380/16.0/R/50/A/W7 pit (since further excavated) north of the DR1380 (white area) and the road section where new road cuttings have now been made (yellow dashed line). The outcrop area of the Whitehill (WH), Prince Albert Formation (PA) and Dwyka Group (DWK) are indicated by the dashed white lines. The Breede River channel is seen in the bottom corners of the image. The yellow scale bar = *c.* 300m.

3. GEOLOGICAL HERITAGE

The geology of the Scherpenheuwel study area is shown on 1: 250 000 geology sheet 3319 Worcester (Council for Geoscience, Pretoria) and is shown here in Fig. 3. A short sheet explanation has been published by Gresse & Theron (1992; see also the older 1: 125 000 Worcester- Hermanus map and sheet explanation by De Villiers *et al.* 1964). The study area lies within the Worcester-Robertson outlier, an erosionally-isolated patch of Karoo Supergroup sediments embedded within the outcrop area of much older Cape Supergroup rocks in the heart of the Cape Fold Belt. The present road project area is underlain by marine sediments of the **Ecca Group** (Karoo Supergroup) that 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 lower Ecca Group rocks here, comprising the Prince Albert, Whitehill and Collingham Formations, lie on the southern limb of a SW-NE trending syncline and dip to the northwest.

The large quarry at Scherpenheuwel (Pit DR01380/16.0/R/50/A/W7) (Figs. 5 to 7), also referred to as the Eilandia Quarry in the literature, is well known as exposing one of the best sections through almost the entire **Whitehill Formation** succession in the Worcester-Robertson Outlier (Gresse and Theron 1992), or indeed anywhere within South Africa; normally this readily-weathered formation is very poorly exposed. Pale grey to pinkish weathering, finely laminated mudrocks of the Whitehill Formation are seen in the main quarry face where they are capped with more resistant-weathering,

silicified, tabular-bedded mudrocks and pale yellow tuffs (volcanic ashes) of the **Collingham Formation**. An outline of the geology and palaeontology of the Scherpenheuwel Quarry by Almond (1996) is given in an appendix to this report, and will not be repeated here. Since this account was written, the quarry face has been cut back considerably to the northwest, and the **Prince Albert Formation** mudrocks along the DR1380 to the east (previously poorly exposed) have also been excavated to form extensive road cuttings.

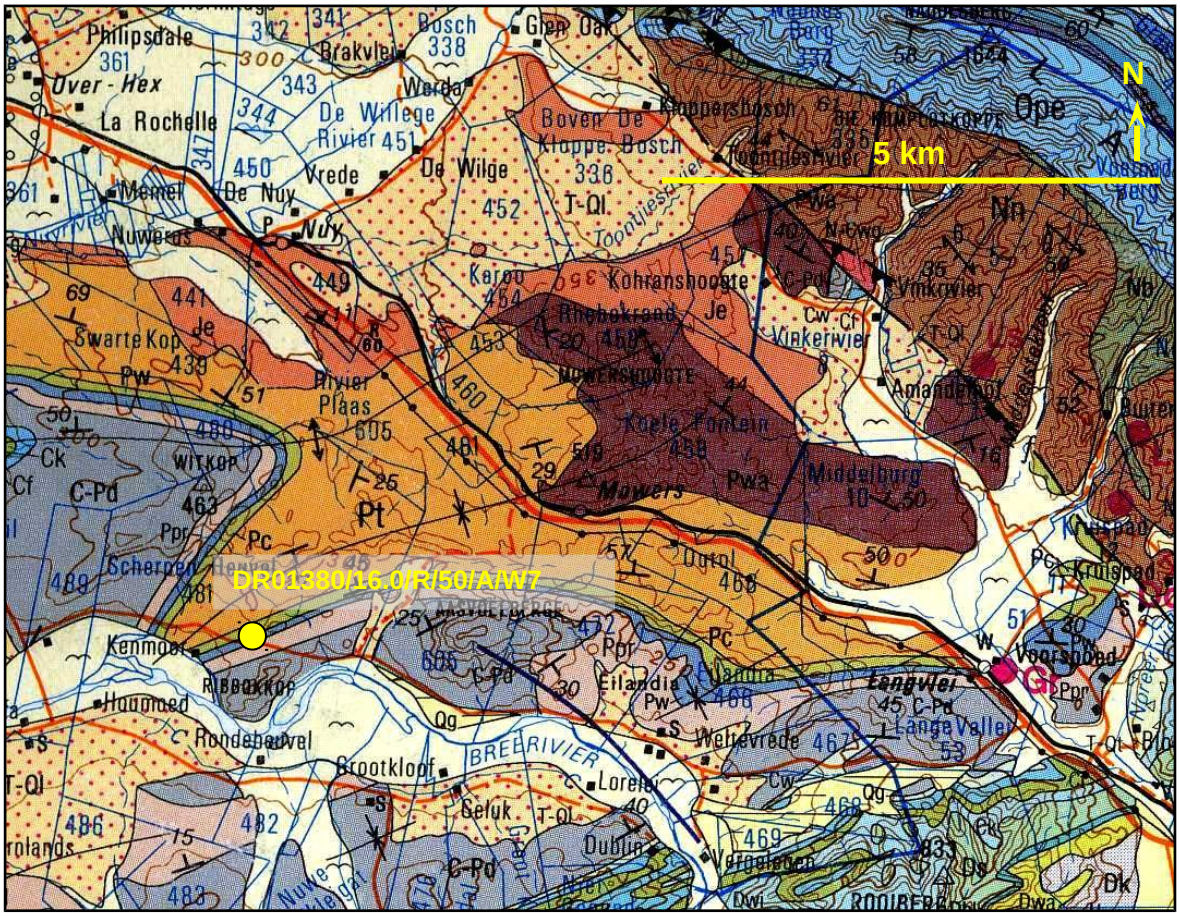

Fig. 3. Extract from 1: 250 000 geology sheet 3119 Worcester (Council for Geoscience, Pretoria) showing location of the DR01380/16.0/R/50/A/W7 borrow pit *c*. 18 km SE of Worcester. The existing pit is excavated into finely laminated carbonaceous mudrocks of the Whitehill Formation (Pw, Ecca Group), indicated here by the thin blue line, capped by alternating mudrocks and volcanic tuffs of the Collingham Formation (Pc, Ecca Group, thin green line). The new road cuttings to the east of the pit are incised into basinal mudrocks and tuffs of the Prince Albert Formation (Pa, Ecca Group, greyish brown band). The hill Ribbokkop to the south of the road development is built of glacial sediments of the Dwyka group (C-Pd, dark grey).

The post-glacial basinal mudrocks of the **Prince Albert Formation** (**Ppr**) 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. This applies to the new road cutting exposures

near Scherpenheuwel quarry (Fig. 4) that do not extend into the Dwyka Group below the Prince Albert Formation. The outcrop area of the Prince Albert Formation here can be clearly distinguished on satellite images by the SW-NE trending bedding from the massive (*i.e.* unbedded) Dwyka outcrop area to the southeast (Fig. 2).

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 (Fig. 8). The Scherpenheuwel quarry is one of the best known exposures of the Whitehill Formation succession in South Africa and warrants formal sedimentological description (*e.g.* as a reference stratotype). The rocks here are described in the appendix (From Almond *et al.* 1996).

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. Only the lowermost part of the Collingham succession, below the Matjiesfontein Chert marker bed, are exposed along the upper edge of the cut face of the Scherpenheuwel quarry (Fig. 6).

Fig. 4. Northwest-dipping tabular mudrocks with thin interbedded tuffs (volcanic ashes) of the Prince Albert Formation along the southern side of the DR1380.

Fig. 5. Pinkish- and grey-weathering mudrocks of the Whitehill Formation in the main Scherpenheuwel Quarry, viewed towards the northeast.

Fig. 6. Highest portion of the Scherpenheuwel quarry cut face showing grey laminated mudrocks of the uppermost Whitehill Formation (main fossil zone) overlain by prominent-weathering tabular silicified mudrock beds at the base of the conformably overlying Collingham Formation.

Fig. 7. Close–up view of laminated mudrocks of the upper Whitehill Formation within the main fossil zone (Hammer = 27 cm). This horizon has yielded fossils of mesosaurid reptiles, insect wings and pygocephalomorph crustaceans in the Scherpenheuwel quarry.

Fig. 8. Large boulder-sized nodules of grey diagenetic dolomite excavated from the Scherpenheuwel quarry and moved to the south side of the adjacent road.

4. PALAEONTOLOGICAL HERITAGE

The fossil record of the Ecca Group outlier in the Worcester-Robertson area is still poorly known (Gresse & Theron 1992) and much of the available data is unpublished (Almond *et al.* 1996, Almond, pers. obs.). The following brief account of the known fossil record of the lower Ecca Group formations represented at Shcerpenheuwel is largely abstracted from Almond (2010a, 2010b).

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.

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.

The paucity of well-preserved bedding planes in the new Prince Albert Formation roadcuts at Scherpenheuwel precludes the comprehensive recording of trace fossil biotas. Low diversity ichnoassemblages recorded within the uppermost Prince Albert beds here (33º 45’ 25.1” S, 19º 35’ 14.1” E) include moderate-sized meniscate backfilled burrows (so-called “*Scolicia*”, possibly a form of *Psammichnites*) (Fig. 9) as well as 3 cm wide arthropod trackways with large, rounded track impressions (Fig. 10) and dense networks of fine horizontal burrows. 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 not directly impacted by the present development.

Fig. 9. Winding meniscate back-filled burrows ("*Scolicia*") from the uppermost Prince Albert Formation at Scherpenheuwel. The traces are approximately 1.25 to 1.5 cm wide.

Fig. 10. Trackway of an unidentified arthropod from the uppermost Prince Albert Formation at Scherpenheuwel. The trackway is approximately 3 cm wide.

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). Fossils recorded from the upper part of the Scherpenheuwel Whitehill quarry exposure include several mesosaurid reptiles (some possible juveniles), locally super-abundant compressions of notocarid crustaceans, rare insect remains (mainly wings) as well as possible ferruginised network burrows (See Appendix abstracted from Almond *et al.* 1996; also Geertsema *et al*. 2002 and refs. therein in for insect fossils). The main crustacean beds in the quarry have been extensively cut back in recent times and are no longer readily identifiable. No crustacean, mesosaurid or other fossil remains were observed during the present field assessment of the site. In general fossils within the Whitehill Formation are rare but often well-preserved. Grey diagenetic nodules elsewhere in the Whitehill outcrop area (*e.g.* near Prince Albert) have yielded well-preserved, three dimaensional crustacean fossils but these have not been recorded from the Worcester – Robertson Karoo exposures, including Scherpenheuwel.

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, 2cm-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.

Sparse trace fossils occur within the tabular bedded lowermost Collingham Formation at Scherpenheuwel and elsewhere in the Worcester-Robertson Karoo.

5. CONCLUSIONS & RECOMMENDATIONS

The large DR01380/16.0/R/50/A/W7 borrow pit – the palaeontologically well-known Scherpenheuwel Quarry site - on the northern side of the DR1308 is excavated into Early Permian carbonaceous mudrocks of the Whitehill Formation (Ecca Group). This site has yielded important fossil material of crustaceans, insects and aquatic mesosaurid reptiles (including well-articulated adult skeletons and juveniles) over the past three decades. The quarry furthermore represents one of the best exposures of the Whitehill Formation succession known and is of considerable geological significance in terms of Ecca Group stratigraphy and sedimentology. Unfortunately the quarry has recently been extensively re-excavated as part of a local road improvement programme without providing an opportunity to mitigate palaeontological and geological heritage. It is likely that significant fossil material that might otherwise have been recovered is now lost.

Thin-bedded siliceous mudrocks and tuffs (volcanic ash layers) of the lowermost Collingham Formation exposed at the top of the quarry face contain low diversity trace fossil assemblages.

New road cuttings into the underlying Prince Albert Formation (Ecca Group, Early Permian) along the southern side of the DR1308 to the east of the quarry expose dark basinal mudrocks, volcanic tuffs and phosphatic nodules. Sparse trace fossil assemblages recorded here include complex meniscate backfilled burrows and arthropod trackways. Extensive development of pencil cleavage here precludes the extensive recording and recovery of representative fossil material.

Since the proposed excavation work has already been completed, no further mitigation of fossil heritage for this site is recommended. It is likely that this scientifically important quarry will continue to receive sporadic attention from palaeontologists and geologists in future. Should the Department of Transport plan to re-excavate Ecca Group rocks in this area, Heritage Western Cape should be advised well in advance so that a professional palaeontologist can be commissioned to advise on, and carry out, appropriate mitigation measures.

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. I am also very grateful to Ms Madelon Tusenius for logistical support and assistance with these borrow pit projects.

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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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