PALAEONTOLOGICAL SPECIALIST STUDY: FIELD ASSESSMENT

TWO EXISTING BORROW PITS ALONG THE DR01445, LAINGSBURG MAGISTERIAL DISTRICT, WESTERN CAPE

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1. EXECUTIVE SUMMARY

It is proposed to re-excavate and extend two existing borrow pits along the DR01445, situated some 30-35 km southeast of Laingsburg, Western Cape, for road material. Both pits are excavated into mudrocks of the Gydo Formation (Lower Bokkeveld Group) that is well known for its rich fossil heritage – especially shelly invertebrates – from the Early Devonian Period.

The palaeontological sensitivity of the uncleaved Gydo Formation mudrocks at pit DR01445/17.15/0.01R is HIGH, and this locality has yielded fossils of a number of rare fossil invertebrate groups in the past. It is very likely that newly-excavated mudrock from this pit will yield rich assemblages of well-preserved shelly fossils, including examples of groups and species that are poorly represented elsewhere. It is therefore recommended that the developer should commission a professional palaeontologist *in good time* to record and sample fossil material from the pit during the early stages of excavation when abundant fresh (*i.e.* unweathered) mudrock is available for examination, and *before* most of this material is employed for road construction.

The Bokkeveld mudrocks in pit DR01445/13.9/0.0L are highly cleaved and their palaeontological sensitivity is correspondingly LOW. No further studies or mitigation are recommended in this case.

2. INTRODUCTION

The Department of Transport, Western Cape, is applying to the Department of Mineral Resources for approval to exploit road material from two existing borrow pits along the unsealed road DR01445, as well as to extend these pits. The two pits (DR01445/17.15/0.01R and DR01445/13.9/0.0L) are situated some along the northern margin of the Klein Swartberg range some 30-35 km southeast of the town of Laingsburg (Fig. 1). The material obtained from the pits would be used to re-gravel portions of the DR01445 near Rouxpos and Vleiland.

A desktop basic assessment of the two DR01445 pits by Almond (2011) assessed their palaeontological heritage sensitivity as high due to the presence here of potentially fossiliferous mudrocks of the Lower Bokkeveld Group. A palaeontological field assessment of the pits as part of an HIA was requested by Heritage Western Cape (HWC Case No. 110928JB25, Interim Comment 7 October 2011) 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 13 February 2012.

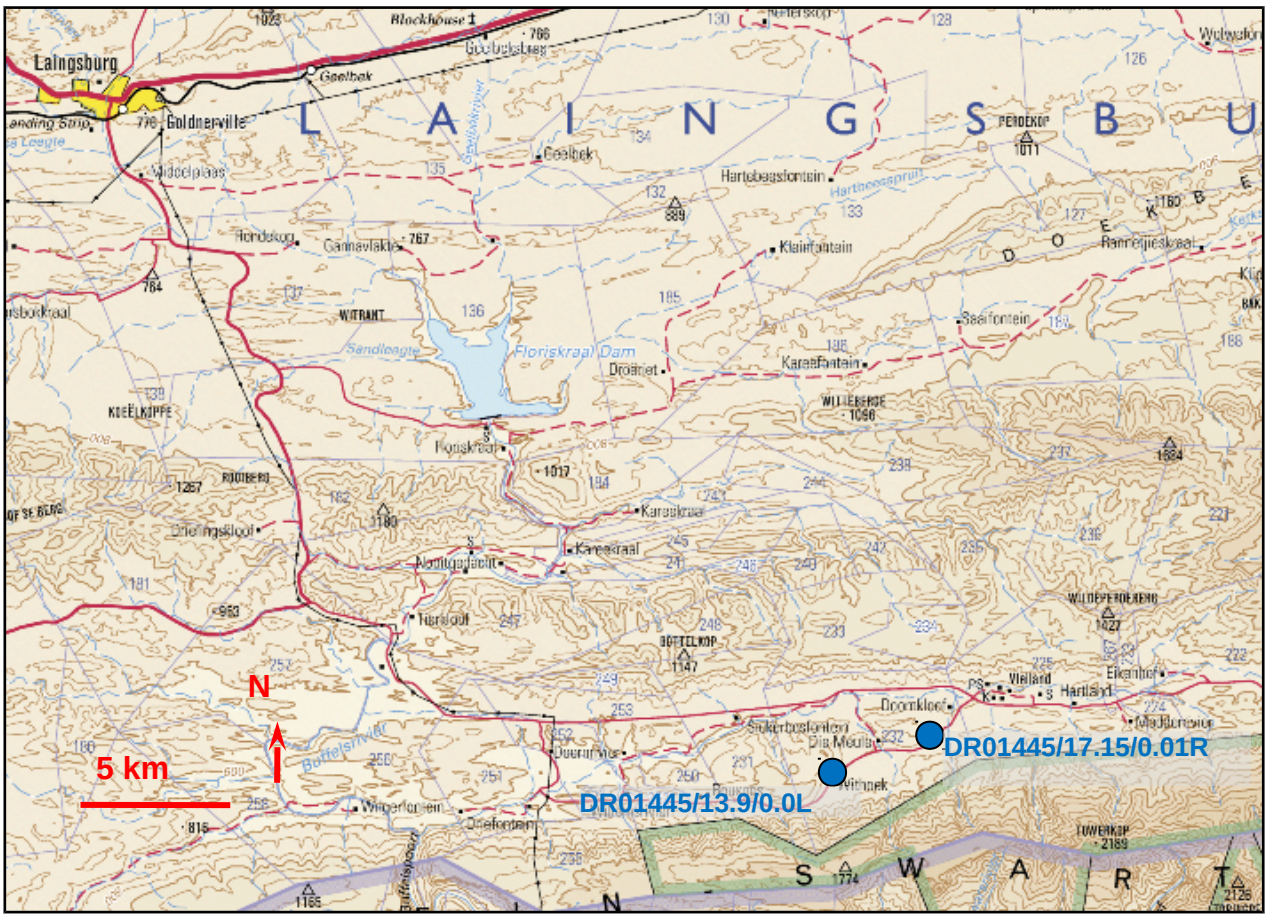

Fig. 1. Extract from topographical sheet 3320 Ladismith (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the approximate location of the two DR01445 borrow pits some 30-35 km southeast of Laingsburg, Western Cape (blue dots).

3. GEOLOGICAL CONTEXT

The geology of the borrow pit study area is shown on 1: 250 000 sheet 3320 Laingsburg (Council for Geoscience, Pretoria) (Fig. 2). Both pits lie along the foot of steep, south-east facing scarp slopes underlain by mudrocks forming the lower portion of the **Gydo Formation** (**Dg**) (Lower Bokkeveld Group, Cape Supergroup) of Emsian or Early Devonian age, some 400 million years old (Theron 1999, Theron & Johnson 1991, Thamm & Johnson 2006). This formation, which reaches thicknesses of about 180 m at Gamkapoort, some 50 km to the east of the study area, consists of an upward-coarsening, shallowing succession of dark grey to black mudrocks, fine-grained sandstones and medium-grained wackes (dark, impure sandstones). These sedimentary rocks were deposited in a cool shallow seaway, the Agulhas Sea, on the south-western margins of Gondwana some 400 million years ago. Offshore mudrocks were deposited in quiet, deeper waters and may be massive or well-laminated. Pyrite-rich horizons indicate episodes of anoxia at or shortly below the sea floor. Near-shore sandstones were laid down in more turbulent settings and often show the influence of major storms (*e.g.* well-developed wave ripples, hummocky cross-stratification). The Gydo Formation is consistently the most fossil-rich formation within the Bokkeveld Group (Section 4). The overlying sandstone-dominated **Gamka Fm** (**Dga**) is more resistant weathering and forms a steep cliff or *kranz* at the top of the slope above the borrow pits (Fig. 4).

The broadly east-west trending subunits of the Lower Bokkeveld Group running along the northern margin of the Klein Swartberg mega-anticline show gentle to high dips towards the north, further complicated by minor parasitic folds (Fig. 2). Dips may be especially high close to the mountain front itself, where the underlying TMG beds may be subvertical. As a result of the high levels of

tectonic deformation within this sector of the Permo-Triassic Cape Fold Belt the clay-rich mudrocks of successions such as the Gydo Formation have often been subjected to intense cleavage (*e.g.* Fig. 5) that has in turn promoted chemical weathering. These weathering processes have operated over long time intervals beneath ancient pediments, such as represented by the relict pediment gravels and land surfaces preserved at intervals along the west-east trending ridges and valleys within the Bokkeveld outcrop area.

The intact hill slopes surrounding the existing borrow pits are mantled with coarse colluvial gravels and skeletal, often reddish-brown, ferruginous soils. The gravel clasts vary from angular to subrounded and consist mainly of poorly sorted Bokkeveld *wackes* (*i.e.* impure sandstones), but subordinate clasts of Table Mountain Group (TMG) quartzite and vein quartz also occur. Large rounded boulders of TMG quartzite adjacent to pit DR01445/13.9/0.0L show well-developed conchoidal exfoliation scars (Fig. 6). They have been downwasted from a pre-existing High Level Gravel pediment extending across the valley from the Klein Swartberg range to the south, relicts of which can still be seen some 1.5 km southeast of the pit.

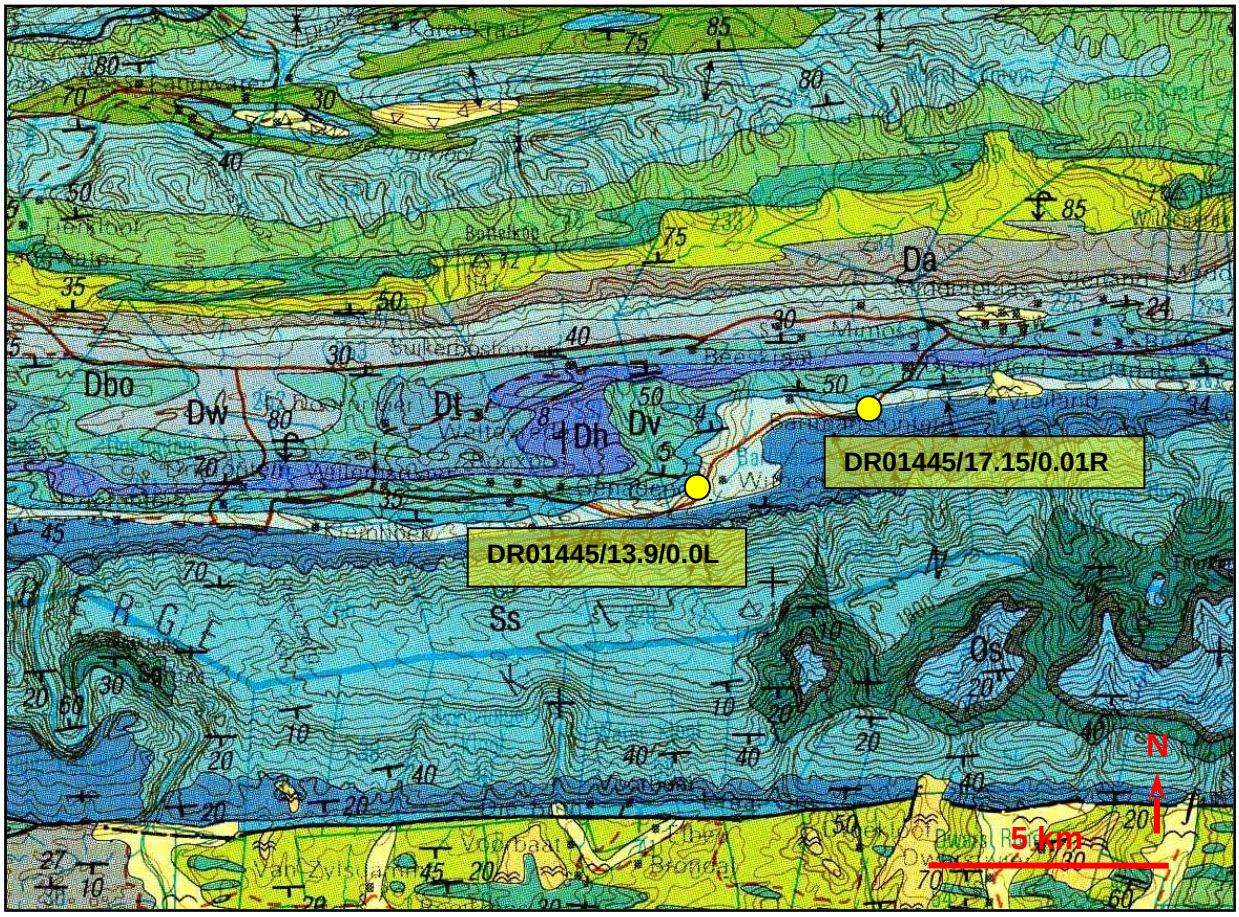

Fig. 2. Extract from 1: 250 000 geology sheet Laingsburg (Council for Geoscience, Pretoria) showing location of the two borrow pits along the DR01445 dust road along the northern margin of the Swartberg. Both pits under consideration are excavated into offshore marine mudrocks of the Early Devonian Gydo Formation (Dg, pale blue-grey) at the base of the Bokkeveld Group.

Fig. 3. General view towards the NW of Pit DR01445/17.15/0.01R showing pale grey, weathered Bokkeveld Group mudrocks (Gydo Formation) overlain by orange-brown, slightly ferruginous colluvial gravels.

Fig. 4. North-western edge of Pit DR01445/13.9/0.0L showing weathered and highly cleaved Bokkeveld mudrocks (Gydo Formation) overlain by orange-brown colluvial gravels (Hammer = 30 cm). Note steep cliff of Gamka Formation sandstones capping the slope behind.

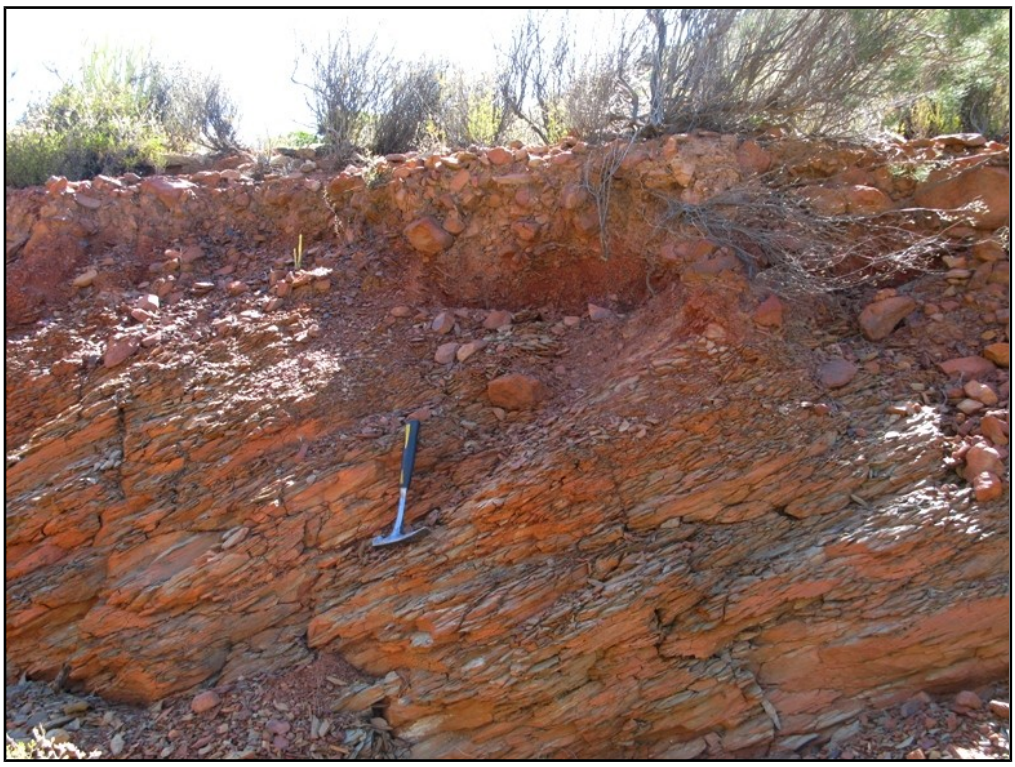

Fig. 5. Close-up of weathered and highly cleaved Gydo Formation mudrocks in Pit DR01445/13.9/0.0L (Hammer = 30 cm). The original bedding here is subhorizontal while the superimposed cleavage dips steeply to the left. Note capping of ferruginous skeletal soils and colluvial gravels.

Fig. 6. Thick mantle of colluvial gravels showing sedimentological evidence for debris flow processes and an outsized, downwasted boulder of TMG quartzite, south-western end of Pit DR01445/13.9/0.0L study area (Hammer = 30 cm).

4. PALAEONTOLOGICAL HERITAGE

The lower part of the **Bokkeveld Group** in the Western Cape (Ceres Subgroup *plus* lowermost Bidouw Subgroup) – and in particular the **Gydo Formation** - is known for its rich fossil assemblages of shallow marine invertebrates of the Malvinokaffric Faunal Province of Gondwana (Cooper 1982, Oosthuizen 1984, Hiller & Theron 1988, Theron & Johnson 1991, MacRae 1999, Almond *in* De Beer *et. al*. 2002, Thamm & Johnson 2006, Almond 2008). Key fossil groups here include trilobites, brachiopods, various subgroups of molluscs (bivalves, gastropods, nautiloids *etc*), and echinoderms (starfish, brittle stars, crinoids, carpoids, sea cucumbers *etc*), with several minor taxa including corals, conulariids, tentaculitids and rare fish remains, among others (Almond 1997, Anderson *et al.* 1999). These shelly fossil assemblages – generally preserved as impressions or moulds, but occasionally in the Gydo Formation also embedded within phosphatic or siliceous nodules – are especially abundant within the mudrock-dominated units such as the Gydo, Voorstehoek and Waboomberg Formations in their more distal (offshore) outcrop areas. Thin lenticles of shelly debris, known as *coquinas*, have been concentrated by storm activity and mainly consist of disarticulated specimens.

Fossils from various localities in the Gydo Formation within the broader Swartberg – Little Karoo study region have been treated by Oosthuizen (1984), Theron *et al.* (1991) and Almond (2005), among others. Of particular note are rare, well-preserved echinoderm fossils from borrow pits in the Vleiland area are mentioned by Jell and Theron (1999). Also previously collected here are several specimens of fossil sea cucumbers (holothuroids). These are among the very few fossils of this extant invertebrate group known anywhere in the world, as well as some of the oldest articulated examples known (unpublished data).

4.1. Fossil heritage at DR01445/17.15/0.01R

This extensive borrow pit has not been re-excavated for some time, but a few heaps of weathered, pale grey Gydo mudrocks are still present, especially towards the north-eastern end of the quarry (Fig. 3). The mudrocks here are more massive and distinctly less cleaved than those at Pit DR01445/13.9/0.0L, only 2.75 km to the WSW (see below), favouring good fossil preservation. Local concentrations of moulds of articulated to disarticulated shelly invertebrate fossils – mostly small individuals - are common within these heaps. These fossil inverebrates include (Fig. 7):

- bivalve molluscs, especially the nuculids *Palaeoneilo*, *Nuculites*
- monospecific clumps of the tall-spired gastropod *Loxonema*
- the bellerophontid *Plectonotus*
- articiulate brachiopods (*Australoceolia*, *Derbyina*, chonetids, *Metaplasia**) and inarticulates (*Orbiculoidea*)
- rare articulated crinoids* (sea lilies) with intact calyx and arms, together with more abundant disarticulated specimens (*e.g.* stem ossicles)
- several types of tiny ostracods* (seed shrimps)
- small trilobites (juvenile *Burmeisteria*, probable *Metacryphaeus*)
- hyolithids* and tentaculitids (conical shells of uncertain affinity)

Taxa marked with an asterisk* above are generally rare, or rarely as well-preserved, in Lower Bokkeveld fossil assemblages elsewhere. This pit is probably also the original source of the very rare fossil holothuroids* (sea cucumbers) mentioned earlier, as well as important specimens of Bokkeveld echinoderms described by Jell and Theron (1999).

The palaeontological sensitivity of this site is therefore rated as HIGH.

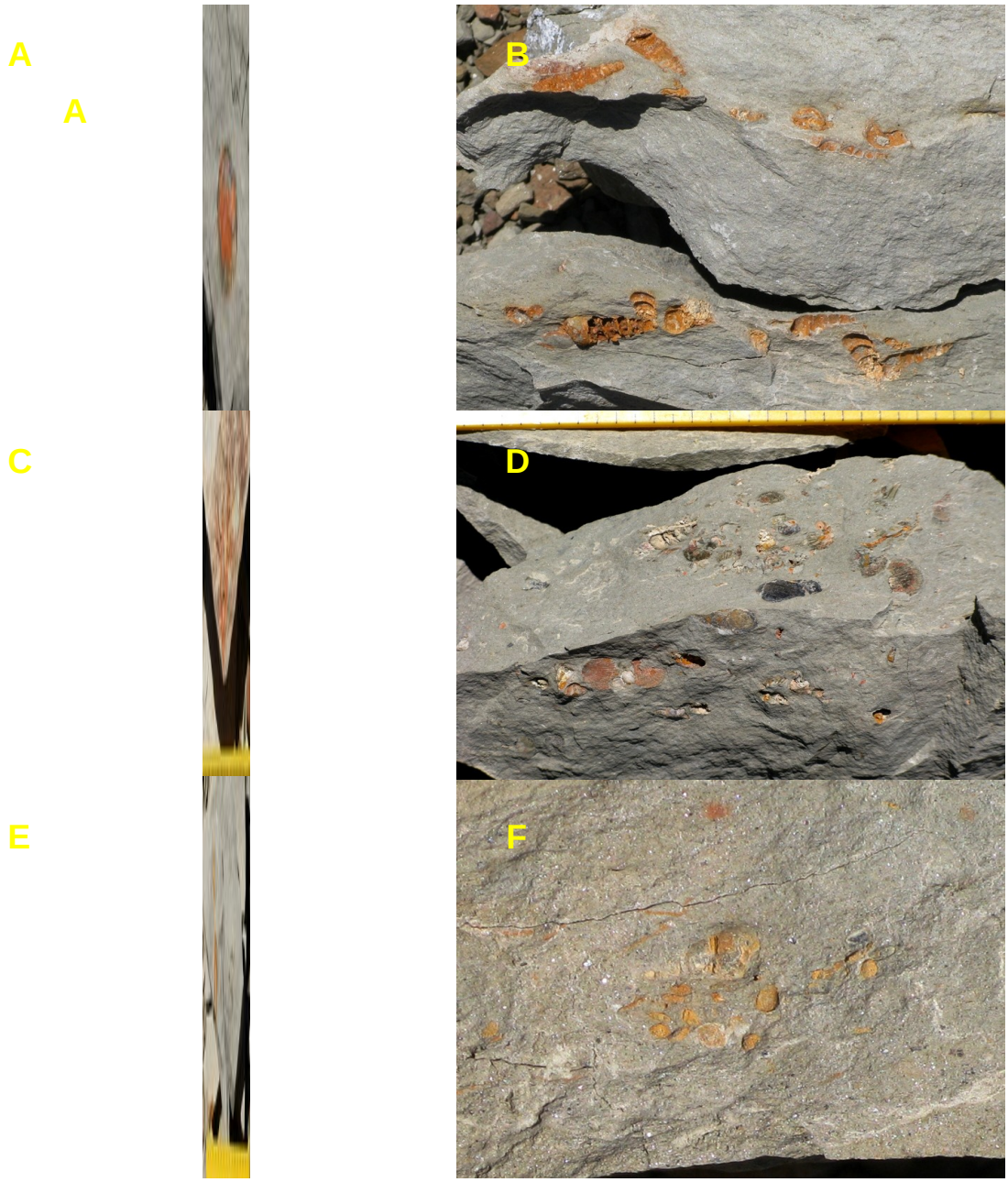

Fig. 7. Shelly fossil moulds from Gydo Formation mudrocks in Pit DR01445/17.15/0.01R, shown at various magnifications. These include: (A) the nuculid bivalve *Palaeoneilo* (3 cm across), (B) concentrations of tall-spired gastropods *Loxonema* (shells *c*. 1.5 cm long), (C) articulated calyx and arms of a crinoid (calyx 6mm across), (D) diverse shelly assemblage, including articulate brachiopods (field of view *c.* 10 cm wide), (E) the trilobite *Metacryphaeus* (scale in cm), and (F) concentration of ostracods (oval seed shrimps, 1 to 2 mm long) and other small shells.

4.1. Fossil heritage at DR01445/13.9/0.0L

The Gydo Formation mudrocks within this pit are not only weathered near-surface but, more significantly, are intensely cleaved at a high angle to the original bedding (Figs. 4 & 5). This cleavage not only promotes surface penetration of water (and hence chemical weathering, which destroys fossils) but also cuts across potential fossil-bearing bedding planes. Fossils that may have originally been present are now usually highly distorted or have been completely destroyed. Remaining fossils are difficult to observe and collect because bedding planes are not accessible or well-exposed.

The only fossils observed in this pit were rare specimens of chonetid brachiopods and articulated trilobites (Fig. 8). A single ferruginised *Steinkern* (internal mould) of an enrolled juvenile burmeisteriid trilobite was also noted among surface gravels on the pit margin.

The overall palaeontological sensitivity of this site is rated as LOW.

Fig. 8. Shelly fossils from the Gydo Formation in Pit DR01445/13.9/0.0L. Left – chonetid brachiopod (*c*. 3 cm across). Right – internal mould of an enrolled juvenile burmeisteriid trilobite (max. width 3.5 cm).

5. CONCLUSIONS & RECOMMENDATIONS

Both the DR01445 pits under consideration are excavated into mudrocks of the lower Gydo Formation that is well known for its rich fossil heritage – especially shelly invertebrates – from the Devonian Period.

The palaeontological sensitivity of the uncleaved Gydo Formation mudrocks at pit DR01445/17.15/0.01R is high, and this locality has yielded well-preserved fossils of a number of rare fossil groups in the past. It is very likely that newly-excavated mudrocks from this pit will yield rich assemblages of well-preserved shelly fossils, including examples of groups and species that are poorly represented elsewhere. It is therefore recommended that the developer should commission a professional palaeontologist *in good time* to record and sample fossil material from the pit during the early stages of excavation when abundant fresh (*i.e.* unweathered) mudrock is available for examination, and *before* most of this material is employed for road construction.

The Bokkeveld mudrocks in pit DR01445/13.9/0.0L are highly cleaved and their palaeontological sensitivity is correspondingly low. No further studies or mitigation are recommended in this case.

6. ACKNOWLEDGEMENTS

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

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8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape, Gauteng, Limpopo and Free State for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Assessment Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed borrow pit project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

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