PALAEONTOLOGICAL SPECIALIST STUDY: FIELD ASSESSMENT

EXISTING BORROW PIT ALONG THE DR2182 ON FARM NO. 581 KEURBOS, CLANWILLIAM MAGISTERIAL DISTRICT, WESTERN CAPE

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August 2012

1. EXECUTIVE SUMMARY

The proposed extension of the DR2182/17.32/R/10/A borrow pit on the Farm No. 581 Keurbos, *c*. 10.5 km southeast of Clanwilliam, Clanwilliam District, Western Cape, will be excavated into (1) sandy glacial sediments of the Late Ordovician Pakhuis Formation that are of low palaeontological sensitivity, as well as (2) the overlying carbonaceous mudrocks of the Cederberg Formation (Table Mountain Group). At the Keurbos borrow pit site the finely laminated claystones of the Soom Member at the base of the Cederberg Formation have yielded a wealth of unique, well-preserved fossil invertebrate and vertebrate material since the mid-1970s, including specimens of water scorpions and primitive jawless fish with preserved soft tissues (muscles, gills, guts *etc*). **This site is therefore regarded as of EXCEPTIONALLY HIGH palaeontological sensitivity.**

The fossilferous "Soom shales" are currently poorly exposed in the pit and so further excavation should promote access to new fossil material. **Should the proposed pit extension along the Soom Member outcrop take place, it is ESSENTIAL that Heritage Western Cape be notified *well before* any excavation takes place and that a suitably qualified palaeontologist be consulted to consider appropriate mitigation actions both during and following development.** Mitigation is likely to involve the recording and sampling of fossil material as well as relevant geological data. Collaboration between the developer and palaeontologists should ensure that further invaluable specimens of the exceptional Soom Member fossil fauna are preserved for scientific analysis and future generations.

2. INTRODUCTION

The Department of Transport, Western Cape, is applying to the Department of Mineral Resources for approval to extend and exploit road material from an existing borrow pit along the unsealed road DR2182 in the Clanwilliam Magisterial District, Western Cape. Pit DR2182/17.32/R/10/A (31º 15' 02.4" S, 18º 57' 59.9" S) is located on the north side of a tight bend in the unsealed road on Farm No. 581 Keurbos, about 10.5 km southeast of Clanwilliam and 1.4 km north of Keurbos homestead (Figs. 1, 2). The pit will be extended substantially towards the northeast and eventually rehabilitated (Fig. 3).

A previous desktop basic assessment of the Keurbos pit by the author assessed its palaeontological heritage sensitivity as very high due to the presence here of proven fossiliferous sediments of the Soom Member (Cederberg Formation, Table Mountain Group). A palaeontological field assessment of the pit as part of an HIA was requested by Heritage Western Cape (HWC Case No. 111115JB26, Interim Comment 18 November 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 August 2012.

3. GEOLOGICAL CONTEXT

The DR2182/17.32/R/10/A pit (Fig. 6) is situated at c. 220m amsl in the northern Cederberg region on a hillslope facing southwards over the valley of the Rondegat River, a tributary of the Olifants River that flows some four kilometres to the west. A small southwest-flowing stream runs less than 100m to the southeast of the pit. The geology of the study area southeast of Clanwilliam is shown on 1: 250 000 geology sheet 3218 Clanwilliam, for which a revised sheet explanation has yet to be published (A very short explanation is printed on the sheet map) (Fig. 5). As seen on this map and satellite images (Fig. 2) the pit is excavated into northwest-dipping sediments of the **Winterhoek Subgroup** (**C1S2G**) in the middle of the Table Mountain Group succession. This subgroup consists of Late Ordovician sandy tillites (glacially deposited sediments) of the **Pakhuis Formation** that are overlain by post-glacial mudrocks and thin-bedded sandstones of the **Cederberg Formation**, also latest Ordovician in age (Figs. 4 & 6). The detailed stratigraphy of these successions is shown in Figure 4 below. Compared with the rugged-weathering quartzitic rocks of the rest of the Table Mountain Group, the Winterhoek Subgroup sediments are more readily weathered and show up clearly on satellite images as a smooth band striking NNE around the southern side of Platberg (Fig. 2). To the southwest these formations are truncated by a NW-SE fault that runs along the Rondegat River Valley (Fig. 5).

The Pakhuis Formation is a thin, laterally variable zone of Latest Ordovician glacial sediments (mainly sandy to sparsely pebbly tillites) immediately underlying the Cederberg Formation. The Pakhuis deposits record a pair of short-lived glacial episodes on the ancient southern supercontinent Gondwana some 440 million years ago (Thamm & Johnson 2006, Sutcliffe *et al*., 2000). The Cederberg rocks were deposited in cold, shallow seas that flooded the margin of Gondwana following the final melting of the Pakhuis continental ice sheets. This younger unit consists largely of much softer-weathering mudrocks (laminated claystones and siltstones) grading up into interbedded fine sandstones and mudrocks that tend to form gentle well-vegetated slopes and are widely known in the Cederberg area as "*Die Soom*" or "Upper Shale Band". The finer-grained lower portion of the Cederberg Formation is differentiated as the **Soom Member** from the overlying, more heterolithic **Disa Member** (Fig. 4), but fresh exposures of both these subunits are very rare due to pervasive deep weathering, extensive mantling by colluvial deposits (*e.g.* sandstone scree), and vegetation cover.

The floor and northeastern margins of the existing DR2182/17.32/R/10/A pit are cut into sandy diamictites of the Pakhuis Formation that weather reddish brown to greenish-grey (Figs. 6 & 7). They contain sparse polymict, subangular to well-rounded pebbles of quartzite, dark chert, granite and other exotic rocks types, some of which show glacial faceting and striation. The south-eastern portion of the proposed pit extension will be excavated into these poorly-sorted, sandy glacial rocks.

Most of the existing pit is cut back into the Soom Member and lower part of the Disa Member of the Cederberg Formation. The Soom Member is currently poorly exposed here, with only a small volume of finely-laminated, tabular-bedded claystones visible at present (Figs. 6 & 8). Due to weathering these display colour banding in various hues, but they are normally dark grey when fresh, weathering pale grey. The fine-grained claystones of the basal Soom Member grade upwards into siltstones and thin-bedded, tabular fine-grained sandstones of the Disa Member. These upper beds are very well exposed in cuttings along the DR2182 road to the southwest of the pit (Fig. 10). The micaceous fine-grained sandstones vary from massive to horizontally laminated and ripple cross-laminated and together with thin laminated mudrock interbeds occasionally display typical turbidite sedimentary features. Some float blocks show small-scale flutes, parallel tool marks associated with puckered microbial mats, and microloading features on their soles. They pass upwards into thicker-bedded sandstones, occasionally cross-bedded or flaggy, building the transitional contact with the overlying Goudini Formation (Fig. 4).

The Cederberg Formation bedrocks are mantled with colluvial slope deposits, including rubbly ferruginised gravels and downwasted platy sandstone gravels from the Disa Member outcrop area (Fig. 6). Within the proposed pit extension area deeply weathered Soom Member saprolite is exposed in erosion gullies and overlain by ferruginised shaley colluvium (Fig. 11).

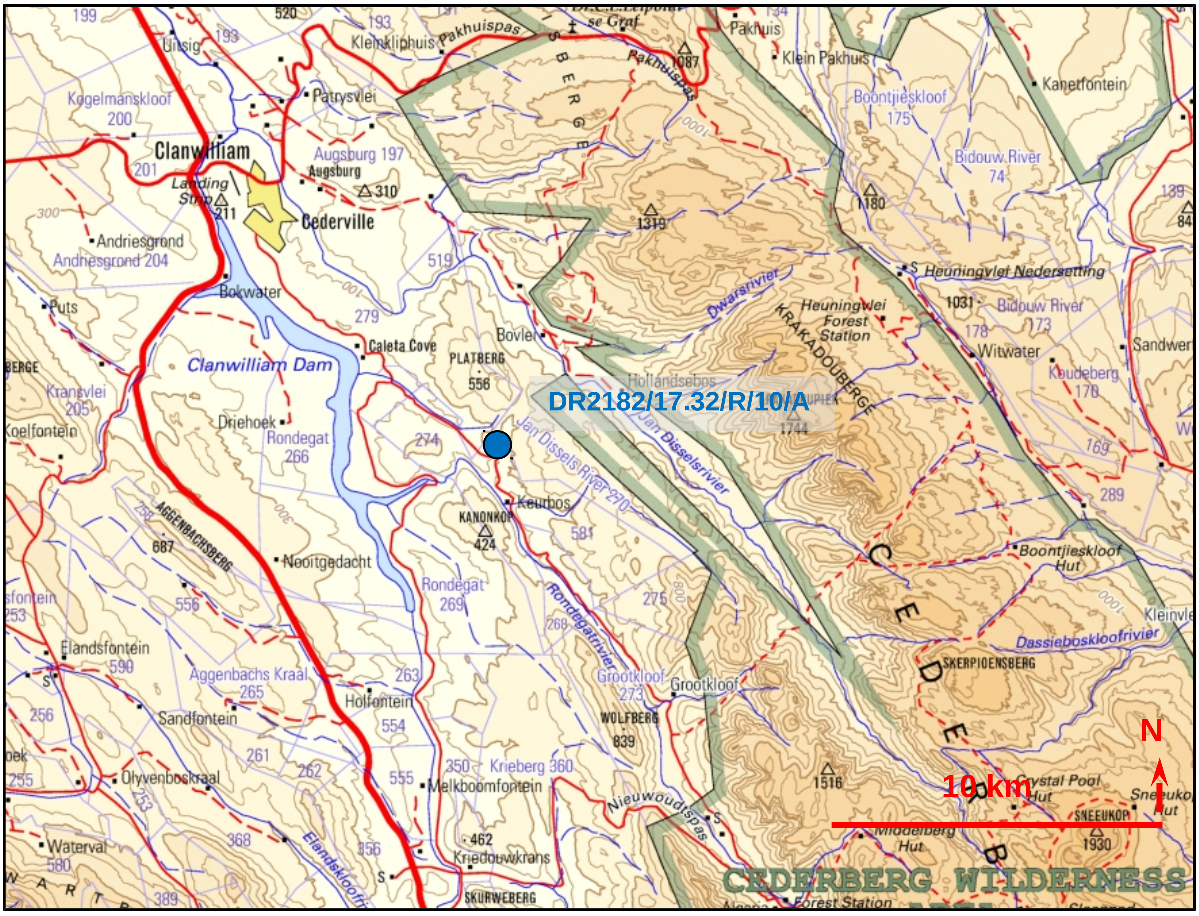

Fig. 1. Extract from 1: 250 000 topographical sheet 3218 Clanwilliam (Courtesy of the Chief Directorate: National Geo-spatial Information, Mowbray) showing the location of the DR2182/17.32/R/10/A borrow pit on the Farm Keurbos, *c*. 10.5 km southeast of Clanwilliam in the Clanwilliam Magisterial District, Western Cape (blue dot).

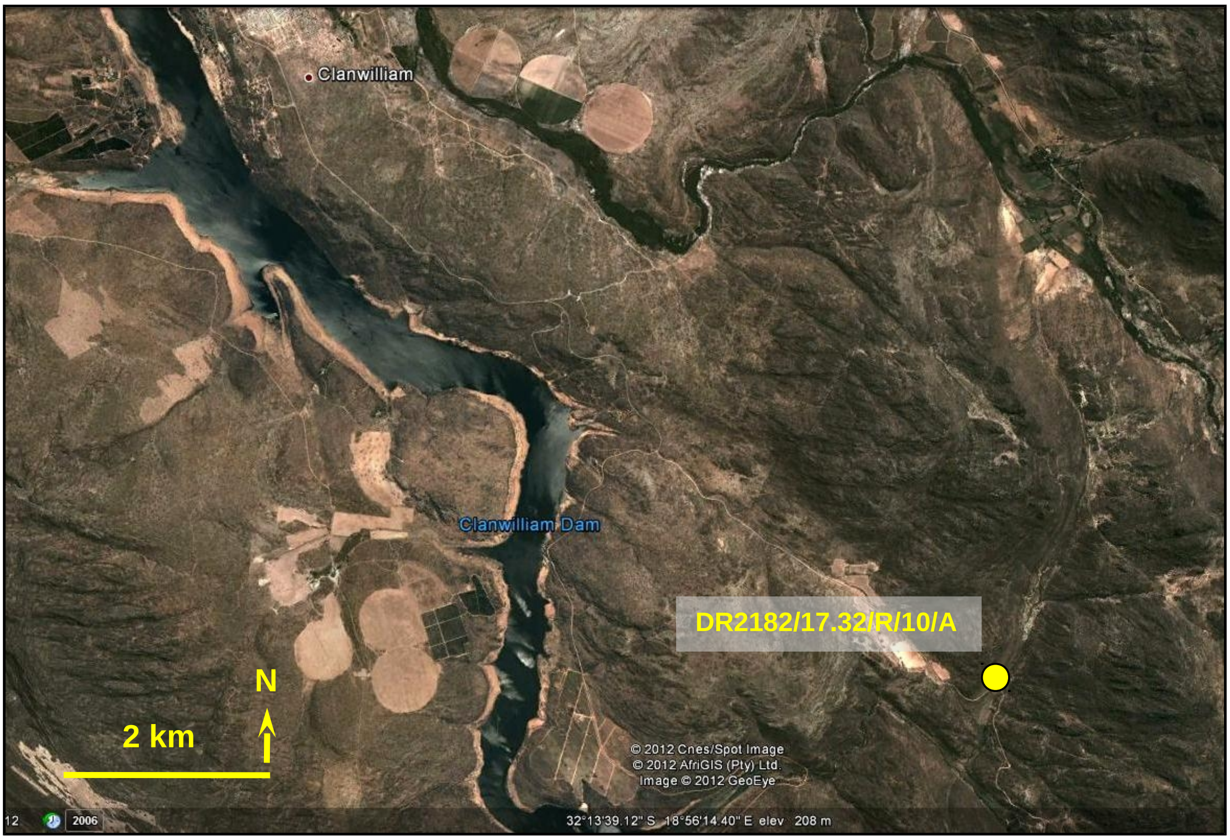

Fig. 2. 2006 Google earth© satellite image of the study area east of the Clanwilliam dam showing the location of the DR2182/17.32/R/10/A borrow pit (yellow dot). The comparatively smooth terrain extending NNE from the pit site is the outcrop area of the Cederberg Formation (Compare geological map in Fig. 4).

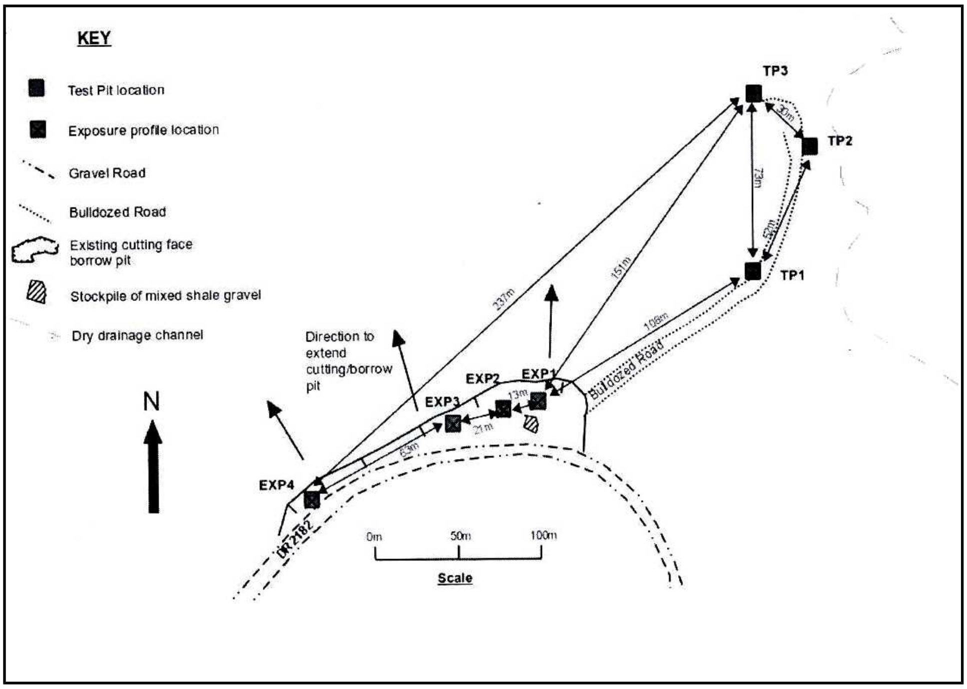

Fig. 3. Proposed north-eastwards extension of the DR2182/17.32/R/10/A borrow pit at Keurbos (Image abstracted from geotechnical report by Nadeson Consulting Services, 2011).

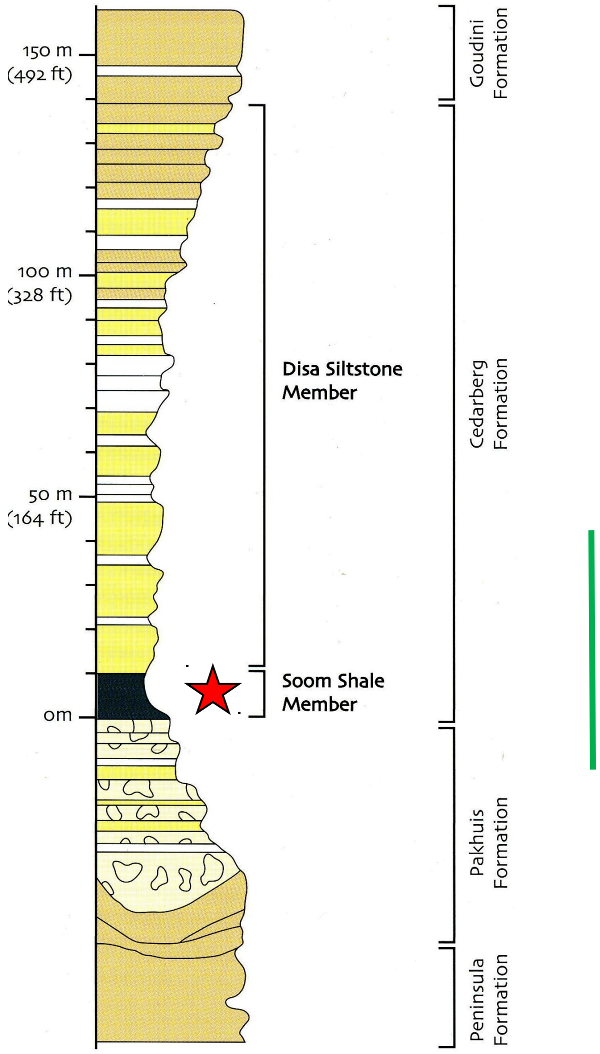

Fig. 4. Schematic section through the Late Ordovician Winterhoek Subgroup succession in the Cederberg region (From Selden & Nudds 2004). The vertical green bar indicates the portion of the sedimentary succession that will be directly affected by the proposed borrow pit extension. The most palaeontologically sensitive unit is the laminated claystones of the Soom Member (red star).

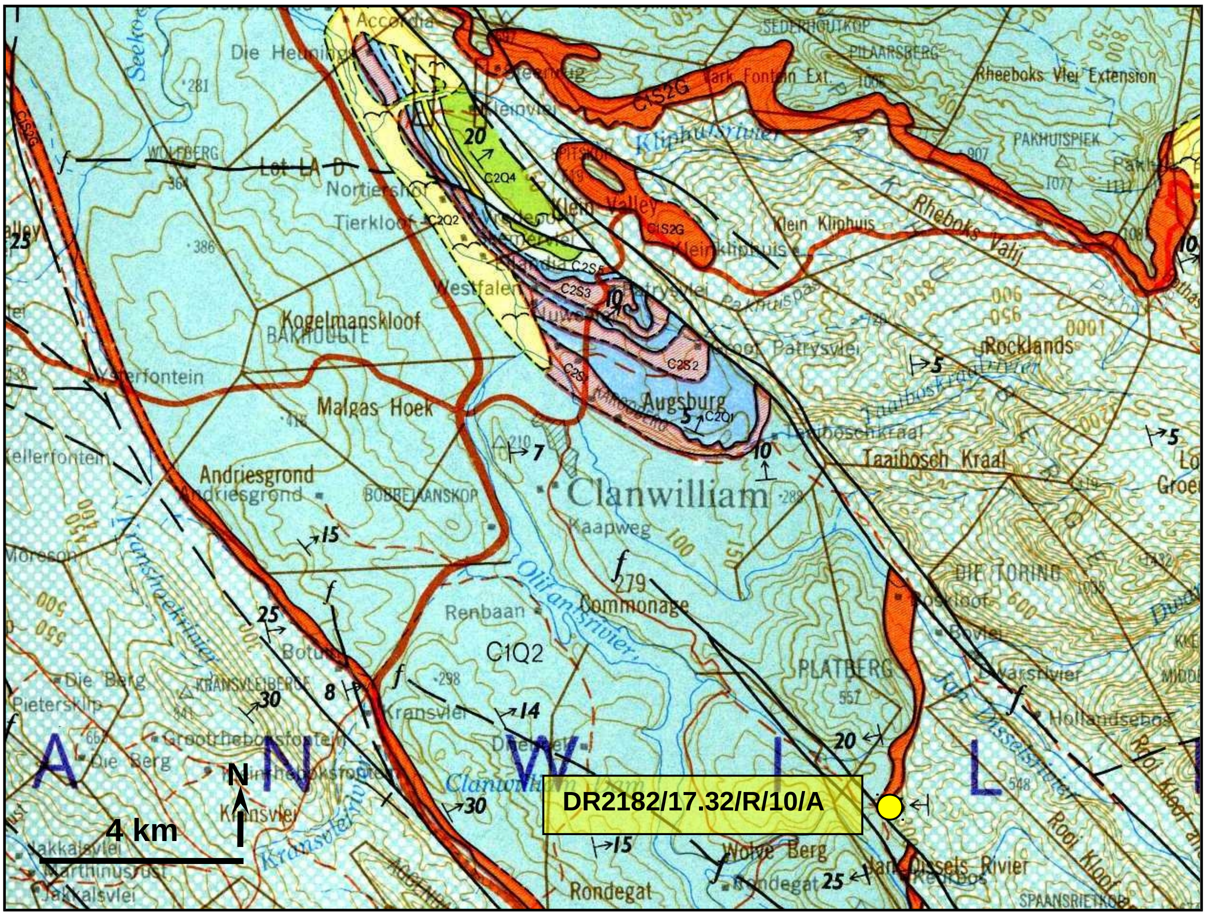

Fig. 5. Extract from 1: 250 000 geology sheet 3118 Calvinia (Council for Geoscience, Pretoria) showing location of the DR2182/17.32/R/10/A borrow pit along the DR2182 dust road *c*. 10.5 km SE of Clanwilliam. The existing pit is excavated into glacial tillites and postglacial marine mudrocks of the Winterhoek Subgroup (Pakhuis and Cederberg Formations (bright red, C1S2G) in the middle of the Table Mountain Group succession.

Fig. 6. View towards the northwest of the Keurbos borrow pit. The current small exposure of Soom Member mudrocks is arrowed (See Fig. 8). The right foreground is underlain by Pakhuis Formation tillites.

Fig. 7. Brown-weathering sandy tillite of the Pakhuis Formation with sparse angular to subrounded gravel clasts (Scale in cm and mm).

Fig. 9. Limited exposure of tabular bedded, finely-laminated claystones of the Soom Member (Hammer = 29 cm).

Fig. 10. Coarsening- and thickening-upwards succession within the upper Cederberg Formation (Disa Member) in road cutting southwest of the Keurbos pit.

Fig. 11. Weathered outcrop of the Soom Member within the proposed pit extension area (Hammer = 29 cm).

4. PALAEONTOLOGICAL HERITAGE

Apart from rare meniscate back-filled burrows, fossils are unknown from glacial deposits of the **Pakhuis Formation** (Almond, 2008). This unit is consequently regarded as having a very low palaeontological sensitivity. In contrast, the finely laminated basal mudrocks of the **Cederberg Formation** (**Soom Member**) are world-famous for their remarkable post-glacial fossil biota showing exceptional preservation of soft (*ie* unmineralised) tissues. This is one of only two so-called soft-body *Lagerstaette* of Late Ordovician age recorded worldwide (the other example was recently discovered in Canada; Young *et al.,* 2007). The macrofossils include a range of organic-walled microfossils (*e.g.* chitinozoans, spore tetrads, acritarchs), algae, shelly invertebrates (*e.g.* brachiopods, conical-shelled nautiloids and other molluscs, crustaceans, unmineralised naraoiid trilobites and eurypterids or "water scorpions"), and several groups of primitive jawless (*e.g.* undescribed *Jamoytius*-like anaspids, conodonts). A further interesting category of fossils recorded from the Soom Member are bromalites. These are the various fossilised products of ancient animal guts such as droppings (coprolites), regurgitates and stomach contents that sometimes contain the comminuted remains of recognisable prey animals such as conodonts or brachiopods (Aldridge *et al*., 2006). A low diversity shelly faunule, dominated by articulate and inarticulate brachiopods together with a small range of trace fossils is recorded from the overlying **Disa Member** of the Cederberg Formation.

An extensive account of the palaeontology of the Cederberg Formation, abstracted from Almond (2008), is provided in an appendix to this report. The interested reader is also referred to recent illustrated reviews by Aldridge *et al.* (1994, 2001) and Selden and Nudds (2004). **It should be noted that the Keurbos borrow pit is the main, but not the only, source of most of the key fossil material recorded so far from the Soom Member. The palaeontological sensitivity of this site is consequently regarded as EXCEPTIONALLY HIGH.**

5. CONCLUSIONS & RECOMMENDATIONS

The proposed extension of the DR2182/17.32/R/10/A borrow pit on the Farm Keurbos will be excavated into (1) sandy glacial sediments of the Late Ordovician Pakhuis Formation that are of low palaeontological sensitivity, as well as (2) the overlying carbonaceous mudrocks of the Cederberg Formation (Table Mountain Group). At the Keurbos borrow pit site the finely laminated claystones of the Soom Member at the base of the Cederberg Formation have yielded a wealth of unique, well-preserved fossil invertebrate and vertebrate material since the mid-1970s, including specimens of water scorpions and primitive jawless fish with preserved soft tissues (muscles, gills, guts *etc*). **This site is therefore regarded as of EXCEPTIONALLY HIGH palaeontological sensitivity.** The fossilferous "Soom shales" are currently poorly exposed in the pit. **Should the proposed pit extension along the Soom Member outcrop take place, it is ESSENTIAL that Heritage Western Cape be notified *well before* any excavation takes place and that a suitably qualified palaeontologist be consulted to consider appropriate mitigation actions during and following development.** Mitigation is likely to involve the recording and sampling of fossil material as well as relevant geological data. Collaboration between the developer and palaeontologists should ensure that further invaluable specimens of the exceptional Soom Member fossil biota are preserved for scientific analysis.

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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APPENDIX: PALAEONTOLOGY OF THE CEDERBERG FORMATION

Abstracted from the unpublished report prepared by J. Almond (2008) for the Council for Geoscience, Pretoria as part of the forthcoming Clanwilliam geology sheet explanation (Full references can be found in the original report).

An exceptionally important and interesting biota of soft-bodied and shelly invertebrates, primitive jawless vertebrates and microfossils has been recorded since the mid 1970s from finely laminated, black mudrocks of the Soom Member (lower Cederberg Formation). The "Soom Shale" is between 10-15m thick, and fossils occur sporadically throughout the succession, from 1m above the base upwards. This biota has been extensively reviewed by Aldridge *et al*. (1994, 2001) and Selden and Nudds (2004) and much new information remains to be published.

The majority of Soom fossils have been collected from a handful of localities, most of which lie on the Clanwilliam sheet within the central to northern Cederberg (Gray *et al*. 1986, Cocks & Fortey 1986, Theron *et al*. 1990, Aldridge *et al*. 1995). The most important are Kromrivier in the central eastern Cederberg, Keurbos 11.5 km south of Clanwilliam, Sandfontein 25km east of Citrusdal, as well as Buffels Dome in the Hex River Mountains (Worcester sheet area). New fossiliferous localities have recently been identified in the Clanwilliam area.

Two groups of primitive jawless vertebrates (agnathans) are recorded from the Soom Member: conodonts and naked anaspids. Conodonts are a major extinct group of small-bodied, eel-like, soft-bodied vertebrates characterised by a complex feeding apparatus of phosphatic toothed structures (conodont elements) that was probably used for predation. The Soom conodonts (*Promissum pulchrum plus* a second, smaller undescribed form) are remarkable for their gigantic size for this group, with individual conodont elements up to 2.2cm long and an estimated total body length of 40 to 100 cm. They are the only conodonts recorded south of the Sahara and were originally misinterpreted as primitive vascular plants (Theron & Kovács-Endrödy 1986, Kovács-Endrödy 1986, *cf* Rayner 1986). Intact conodont feeding apparatuses composed of 19 separate toothed elements are quite common in the Soom Shale (> 100 specimens), with occasional preservation of soft tissues such as muscle blocks in the trunk, and cartilaginous capsules protecting the huge, anteriorly positioned eyes (Theron *et al*. 1990, Gabbott *et al*. 1995, Aldridge & Theron 1993, Aldridge *et al*. 1995). The Soom conodonts have played a key role in the reconstruction of the hard- and soft-part anatomy and palaeobiology of the enigmatic conodont animals, as well as establishing their close relationship with other primitive jawless vertebrates such as the hagfish (Aldridge *et al*. 1994, Janvier 1995, Purnell *et al*. 1995, Donoghue *et al*. 2000). The Soom anapids (>5cm long), provisionally named *Soomichthys*, have well-developed eyes, gill slits, a round mouth with numerous tooth-like structures, and strap-like fins. Over twenty specimens have already been found, preserved as carbonaceous films (Aldridge & Purnell 2005, Aldridge *et al*. 2006b). *Soomichthys* resembles the well known "naked" anaspid *Jamoytius* from the Silurian of Scotland and may lie close to the ancestry of all living fish groups (*ie* stem group gnathostomes).

Among the largest Soom Shale invertebrate fossils are conical orthocone nautiloids up to 35cm long, some of which preserve impressions of the toothed radula (Gabbott 1999). Inarticulate brachiopods (conical orbiculoids / discinoids, flattened linguloids) are fairly common, many of them attached to orthocone shells, as also were rarer, finely-ribbed articulate brachiopods (rhynchonellids) and conical-shelled cornulitids. Soom trilobites include small (3cm) blind, uncalcified naraoiids (*Soomaspis*), a very primitive subgroup, as well as the more conventional dalmanitid *Mucronaspis* which is a typical cold-water Hirnantian form (Moore & Marchant 1981, Cocks & Fortey 1986, Fortey & Theron, 1994). Small (7cm) predatory onychopterellan eurypterids (water scorpions) show well-preserved muscle tissues, gills and a spiral gut structure (Braddy *et al*. 1995, 1999). Myodocopid ostracods (seed shrimps) are mainly found associated with orthocone cephalopod remains, and were presumably nektobenthic scavengers (Gabbott *et al.* 2003). Other rarer arthropods include planktic caryocaridids (probably a group of "phyllocarid" crustaceans; Whittle *et al*. 2007), a 40-cm long, many segmented arthropod (?tegopeltid; Aldridge *et al*. 2001) and various other undescribed forms. Molluscs have only been recorded from the Hex River area and include nuculanacean deposit-feeding bivalves and bellerophontid “gastropods” (Cocks & Fortey 1986). Several problematic soft-bodied invertebrates preserved as carbonaceous films, including possible medusoids and a lobopod, are currently being described, as are well-preserved scolecodonts (annelid worm jaw apparatuses).

Abundant hollow, organic-walled spines (*Siphonacis*) probably belong to some form of metazoan (Chesselet 1992); they were among the first Soom fossils to be discovered in the Cederberg by J.N. Theron and colleagues. Organic-walled microfossils from the Soom Member include spore tetrads of land plants, acritarchs (marine phytoplankton), and exceptionally well-preserved examples of chitinous, flask-shaped chitinozoans (Cramer *et al.* 1974, Gray *et al.* 1986, Gabbott *et al*. 1998). Some specimens of this last, problematic group are preserved as chains, in aggregates or within cocoon-like envelopes. They may represent egg-masses of nautiloids or even of conodonts.

Due to prevailing benthic anoxia (see below), many of Soom animals were active swimming forms (nekton) that probably lived in near-surface waters (Gabbott 1998, Whittle *et al*. 2007). Some animals may have been nectobenthic (swimming above the bottom), such as the eurypterids, trilobites, and ostracods, perhaps colonising the sea bed during intervals of improved oxygenation. The orbiculoid and rhynchonellid brachiopods, as well as the cornulitids, lived as attached epizoans (pseudoplankton) on living, floating or sunken nautiloid shells. Analysis of Soom bromalites (fossilised products of metazoan guts), including spiral and wrinkled coprolites, shows that more than one tier of predator was present (Aldridge *et al*. 2006). Bromalites containing comminuted conodont and brachiopod remains show that some Soom predators (perhaps as yet undiscovered) were quite capable of handling tough prey items.

The Soom Member is dated as latest Ordovician (Hirnantian Age of the late Ashgillian Epoch) on the basis of mucronaspid trilobites from the Hex River Mountains (Cocks & Fortey 1986, Theron *et al*. 1990). This is supported by global correlations of sea level curves and biotic events in the Late Ordovician (*e.g.* Sutcliffe *et al*. 2000). These place the final collapse of the Gondwana icesheets and concomitant deposition of post-glacial mudrocks within the late Hirnantian Age (*persculptus* biozone). The Soom Biota is a moderately high palaeolatitude, restricted representative of the so-called Hirnantian Faunas. These were impoverished, cold-adapted, fairly cosmopolitan shelly assemblages that flourished during and immediately following the Late Ordovician Gondwana glaciation and concomitant mass extinction episodes. Many of these specialised taxa were later eliminated by post-glacial warming at the end of the Ordovician (*e.g.* Cocks & Fortey 1986, Brenchley 2001).

The Soom Member biota is one of very few soft-bodied *Lagerstätte* (fossil “treasure troves”) known from Ordovician rocks, and is exceptional in its fairly high-latitude (*c* 30-45ºS), glacially-influenced setting. A comparable soft-bodied *Lagerstätte*, also with conodonts, has recently been recorded from the Middle Ordovician of Iowa, USA (Liu *et al*. 2006) and others of Late Ordovician (pre-extinction) age from Manitoba, Canada that contain eurypterids, scolecodonts, jellyfish and non-calcareous algae (Young *et al.,* 2007). The Soom fossils are generally highly compressed. Preservation here of soft tissues such as cartilage, muscles, gills and guts (*e.g.* in conodonts, eurypterids) is unusual in that it involves direct replacement of organic and calcareous skeletons by clay minerals (illite, with or without a kaolinite precursor), although carbonaceous film-like compressions of refractory organic materials also occur (Gabbott 1998, Gabbott *et al*. 2001). Solution of skeletal calcite and aragonite in acidic bottom waters was promoted by prevailing cold water conditions. Phosphatic skeletal elements (*e.g.* conodont elements, inarticulate brachiopod shells) have been replaced by silica.

The Soom biota contains fully marine elements such as nautiloids, articulate brachiopods and conodonts but is restricted compared with Late Ordovician shelly assemblages from lower palaeolatitudes. This is probably less so in the southern outcrop area, where benthic molluscs and “normal” trilobites also occur. Perhaps this restriction was due to cold, near-glacial waters and / or hypersaline salinities. The depositional environment of the Soom Member mudrocks is reconstructed as a shallow, cold sea or brackish embayment, perhaps partially ice-bound (drop stones are found in the lowermost Soom mudrocks), and situated close to the retreating Gondwanan icesheet. Fine-grained sediment may have been deposited as distal turbidites and / or even as wind-blown dust (loess) associated with denuded periglacial landscapes and strong winds. Poor mixing of saline seawater and fresh glacial meltwater may have led to salinity stratification of the water column, promoting bottom anoxia. Laterally persistent, fine paper-lamination of the carbonaceous mudrocks, the lack of disturbance or disarticulation of fossil remains such as delicate, multi-element conodont apparatuses by currents or scavengers, the absence of bioturbation, the paucity of benthic fauna as well as geochemical indicators all point to prevailing bottom anoxia in a quiet water setting. Incomplete decomposition of the abundant wispy organic material ("algae" or perhaps bacteria) also suggests bottom anoxia, and the seabed may have been further bound by microbial mats. Intermittent oxygenation is possibly indicated by ostracods, orbiculoid brachiopods and other benthos (Gabbott 1998).

A low diversity, brachiopod-dominated shelly faunule of cool water, Malvinokaffric aspect is recorded from nearshore, bioturbated fine sandstones and siltstones in the middle of the Disa Member of the Cederberg Formation. The best localities lie just outside the Clanwilliam sheet in the Porterville area (Rust 1967, Gray et al. 1986, Cocks *et al*. 1970, Cocks & Fortey 1986). The fauna comprises inarticulate brachiopods (?*Plectoglossa, Trematis, Orbiculoidea*), articulate brachiopods (*Heterorthella, Eostropheodonta, Plectothyrella*), a homalonotid trilobite, branching and frondescent bryozoans, crinoids, cricoconarids (tentaculitids) and crustaceans (Cocks & Fortey 1986, Wass 1970, unpublished honours thesis, John Decker, UCT). Most fossils are preserved as moulds, some showing casts of biogenic borings, while the phosphatic-shelled inarticulates appear to retain their original shelly material. The Disa assemblage is a typical representative of the post-glacial Hirnantian Fauna of latest Ordovician / Hirnantian age (Cocks & Fortey 1986, Theron *et al*. 1990) rather than Early Silurian as argued by some earlier authors (Cooper 1984, Gray *et al*. 1986).

In the northern Cederberg, "indistinct 3mm tubes" were recorded by Rust (1967) from the Disa Member near Klawer and the Bulshoek Barrage at Clanwilliam. Just north of the Clanwilliam sheet area burrows and arthropod trackways are found in the lower Disa Member at the Doring River Bridge (De Beer *et al*. 2002). A modestly diverse *Skolithos* / *Cruziana* ichnofacies ichnofauna has been collected from the thin-bedded, heterolithic portion of the Disa Member on the Farm Nardouw 1 in the same area (Almond 1998a, b). These traces were generated in a shoaling, storm-influenced nearshore setting and document the recovery of shallow marine endobenthos following the Hirnantian glacial / mass extinction episode before the resumption of braided fluvial sedimentation in this sector of Gondwana. The ichnofauna comprises several types of vertical burrows, including U-burrows (*e.g. Diplocraterion*), hypichnial casts of bivalves (*Lockeia*) as well as thick-walled mantled burrows, simple horizontal burrows (*Palaeophycus*), branching burrow networks (*cf Megagrapton*), sinuous epichnial furrows, small arthropod bilobites ("*Isopodichnus*"), and meniscate back-filled horizontal burrows of the *Scolicia* group that may be attributable to gastropods, as well as several other unnamed ichnogenera. No shelly fossils were recorded from this succession. Sinuous, possibly branching structures from the Disa Member (?) near De Doorns (Worcester sheet area) that were provisionally assigned to the "algal" genus *Tontalia* by Plumstead (1967) may also be trace fossils (possibly *Palaeophycus*) or even pseudofossils.

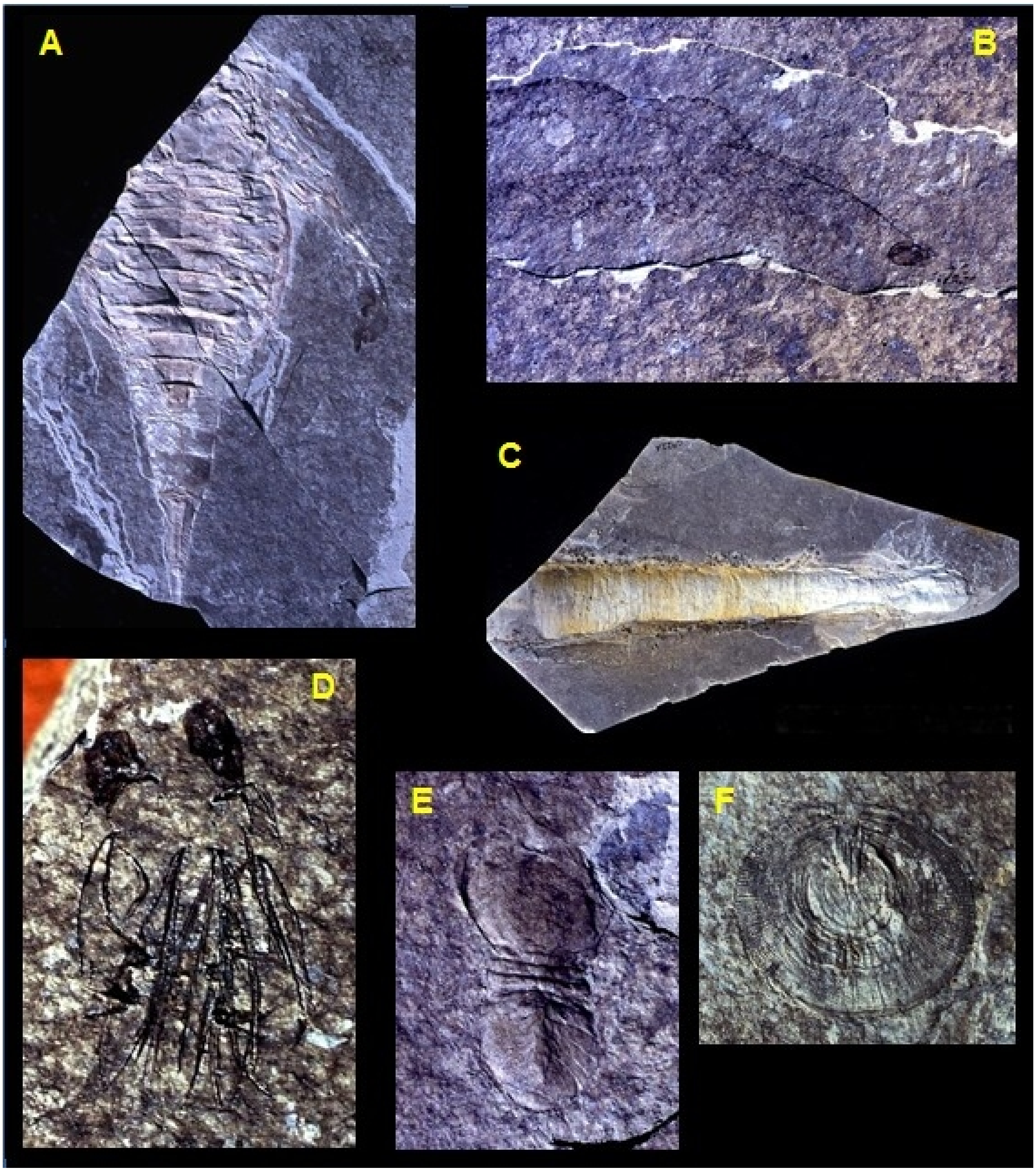

Fig. 1. Selected fossils from the Late Ordovician Soom Member (Cederberg Formation, Table Mountain Group) of South Africa, shown here at various scales. A. Onychopterellan eurypterid ("water scorpion"). B. Naked anaspid jawless fish Soomichthys. C. Orthocone nautiloid with epizoan inarticulate brachiopods. D. Large eye capsules and conodont apparatus of giant conodont animal *Promissum*. E. Soft-bodied naraoiid trilobite *Soomaspis*. F. Orbiculoid inarticulate brachiopod.

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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