PALAEONTOLOGICAL SPECIALIST STUDY: DESKTOP ASSESSMENT

Proposed Maskam limestone mine near Vanrhynsdorp, Matzikama Municipality, Western Cape Province

John E. Almond PhD (Cantab.)
***Natura Viva* cc, PO Box 12410 Mill Street,**
Cape Town 8010, RSA
naturaviva@universe.co.za

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EXECUTIVE SUMMARY

Cape Lime (Pty) Ltd, Vredendal, is proposing to develop a high grade limestone mine on the Remainder of the farm Welverdiend 511, some 8 km SSW of Vanrhynsdorp in the Matsikama Municipality, Western Cape Province. No processing plant will be located on site and all excavated limestone material will be transported to the applicant's existing plant at their Vredendal site some 12 km away.

The study area is largely mantled by a range of Late Caenozoic superficial deposits (wind-blown sands, soils, alluvium) that are up to 2m thick and all of low palaeontological sensitivity. The underlying Late Precambrian bedrocks of the Gifberg Group, notably the carbonate target rocks of the Widouw Formation, are metamorphosed, recrysallised and highly deformed, and hence unlikely to contain any fossils.

The overall impact significance of the proposed mining development is inferred to be LOW because most of the study area is mantled by superficial sediments of low palaeontological sensitivity and the Precambrian bedrocks are almost certainly unfossiliferous. No further specialist studies or mitigation regarding fossil heritage are considered necessary for this project.

Should substantial fossil remains (*e.g.* vertebrate teeth, bones, petrified wood, stromatolites, shells, trace fossils) be exposed during mining, however, the ECO should safeguard these, preferably *in situ*, and alert Heritage Western Cape as soon as possible so that appropriate action (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist at the developer's expense.

1. INTRODUCTION

The company Cape Lime (Pty) Ltd, Vredendal, is proposing to develop a mine for high grade limestone on a 321.11ha portion of the Remainder of the farm Welverdiend 511 (total area 3 495.8ha) in the Matsikama Municipality, Western Cape Province. The study site is situated approximately 1 km east of the N7 tar road between the towns of Klawer and Vanrhynsdorp, just north of the Wiedou River and about 8 km SSW of Vanrhynsdorp itself (Figs. 1, 2). An abandoned marble mine (Jumaqua Marble) is located 2.76 km to the NE.

The proposed operation entails the mining of some 1.2 million cubic meters of high grade limestone (> 97% $CaCO_3$) over an area of approximately 300 x 175m and to an average depth of 24 m. This will be a hard rock drill and blast open cast mine. Topsoil and subsoil are to be removed in advance of excavation and the latter will be used to backfill the main excavation. The estimated depth of overburden to be removed (mainly subsoil) varies from 0 to 2m in thickness. No processing plant will be located on site and all excavated limestone material will be transported to the applicant's existing plant at their Vredendal site some 12km away. Facilities to be located on site at Maskam comprise the following:

• Office, Store and Restroom (one building);
• Toilets (conservancy tank);
• Domestic and Industrial Waste Temporary storage facility.

Most of the proposed mining development area is covered by a thin veneer of Late Caenozoic superficial sediments that are underlain by ancient Precambrian rocks (including the target limestone body), some of which may contain fossil remains. The extent of the proposed development (over 5000 m^2) falls within the requirements for a Heritage Impact Assessment (HIA) as required by Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance
- palaeontological sites
- palaeontological objects and material, meteorites and rare geological specimens

Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated May 2007.

A desktop palaeontological assessment of the study area has been commissioned by Site Plan Consulting, Strand, as a contribution to a comprehensive EMP for this mining project. This EMP is being compiled as part of the requirements for the application of a mining right in terms of the Mineral & Petroleum Resources Development Act 28 of 2002 (MPRDA).

2. APPROACH & METHODOLOGY

2.1. Details of specialist

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, Free State and Mpumalanga 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 Practitioners – Western Cape).

2.2. General approach used for palaeontological impact desktop studies

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature of the development itself, most notably the extent of fresh bedrock excavation envisaged.

When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a field-based assessment by a professional palaeontologist is usually warranted. Most detrimental impacts on palaeontological heritage occur during the construction phase when fossils may be disturbed, destroyed or permanently sealed-in during excavations and subsequent construction activity. Where specialist palaeontological mitigation is recommended, this may take place before construction starts or during the construction phase while fresh, portentially fossiliferous bedrock is still exposed for study. Mitigation usually involves the judicious sampling, collection and recording of fossils as well as of relevant contextual data concerning the surrounding sedimentary matrix. It should be emphasised that, *provided* appropriate mitigation is carried out, many developments involving bedrock excavation actually have a *positive* impact on our understanding of local palaeontological heritage. Constructive collaboration between palaeontologists and developers should therefore be the expected norm.

2.3. Information sources

The information used in this fossil heritage screening study was based on the following:

1. A draft environmental management plan (EMP) prepared by Site Plan Consulting, Strand (June 2011);

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations as well as recent palaeontological impact studies in the same region (notably Almond 2010, 2011a, 2011b, 2011c);

3. The author's previous field experience with the formations concerned and their palaeontological heritage.

2.4. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have *never* been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little

or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information;

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g.* of commercial mining companies) - that is not readily available for desktop studies;

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting field assessments these limitations may variously lead to either:

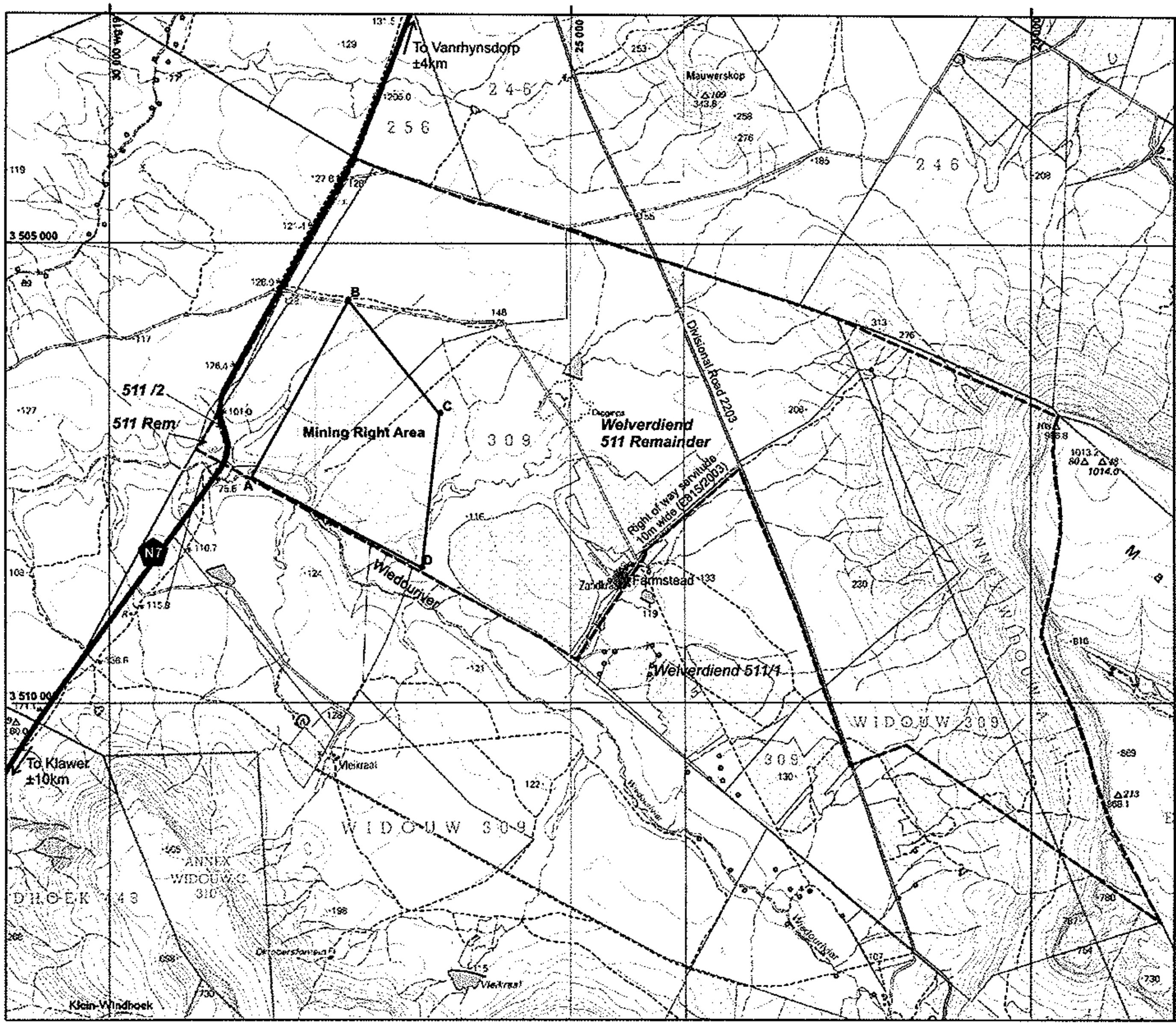
(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the present case the main factor constraining the reliability of the assessment of fossil heritage within the study area as a whole is uncertainty concerning the age and distribution of the alluvial deposits along the Widouw River (These are not shown on the available 1: 250 000 geological map). However, these alluvial sediments are probably geological young, poorly fossiliferous, and mostly lie outside the mining footprint, so any direct impacts on local fossil heritage here by the proposed development are likely to be small.

Fig. 1 (following page). Map showing the location (yellow polygon) of the proposed Maskam limestone mine on the eastern side of the N7 and north of the Wiedouw Rivier, about 8 km SSW of Vanrhynsdorp, Western Cape Province (Image kindly provided by Site Plan Consulting).



Plan as contemplated in Regulation 2(2) to accompany an Application for a Mining Right in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No 28 of 2002)

The area A to D to A measures 321.11 ha and represents the proposed mining right area on the Remaining Extent of the farm Welverdiend 511 in the Magisterial District of Vanrhynsdorp.

Coordinates of the Mining Right Area

Point	Y	X
A	28434.66	3507528.86
B	27420.00	3505605.00
C	26420.00	3506825.00
D	26625.00	3508515.00

Central Meridian: 19°E
Projection: WGS84
Datum: WGS84

Applicant:
Cape Lime (Pty) Ltd
Co Reg No:99/02171/07

APPLICANT SIGNATURE

DESIGNATION

DATE:

Property Boundary
Farm Welverdiend 511 Rem

Contours @20m intervals

Prepared for:
CAPE LIME (Pty) Ltd.
PO Box 400 Vredendal 8160
Tel: (027) 213 3090 Fax: (027) 213 3095

Prepared by:
Site Plan Consulting
PO Box 28, Strand 7139
Tel:021 854 4260 Fax:021 854 4321

Maskam Limestone Deposit

REG 2(2) Drawing

Date: June 2011 | Scale: 1: 40 000 | Figure 2

0 0.4 0.8 1.2 1.6 2 2.4km

3. DESCRIPTION OF THE STUDY AREA

3.1. Location and brief description of study area

The Maskam limestone mine site is located on the southern edge of the Namqualand region and on the eastern edge of the west coastal plain, about 8 km SSW of Vanrhynsdorp (Figs. 1,2). The terrain within the study site lies between 95 and 115m amsl and falls within a dissected region in the western foothills of the prominent Matsikammaberg Range. The proposed mining excavation is located less than one kilometre east of the N7 on the south-western edge of a spur between tributaries of the small, intermittently flowing Wiedou River.

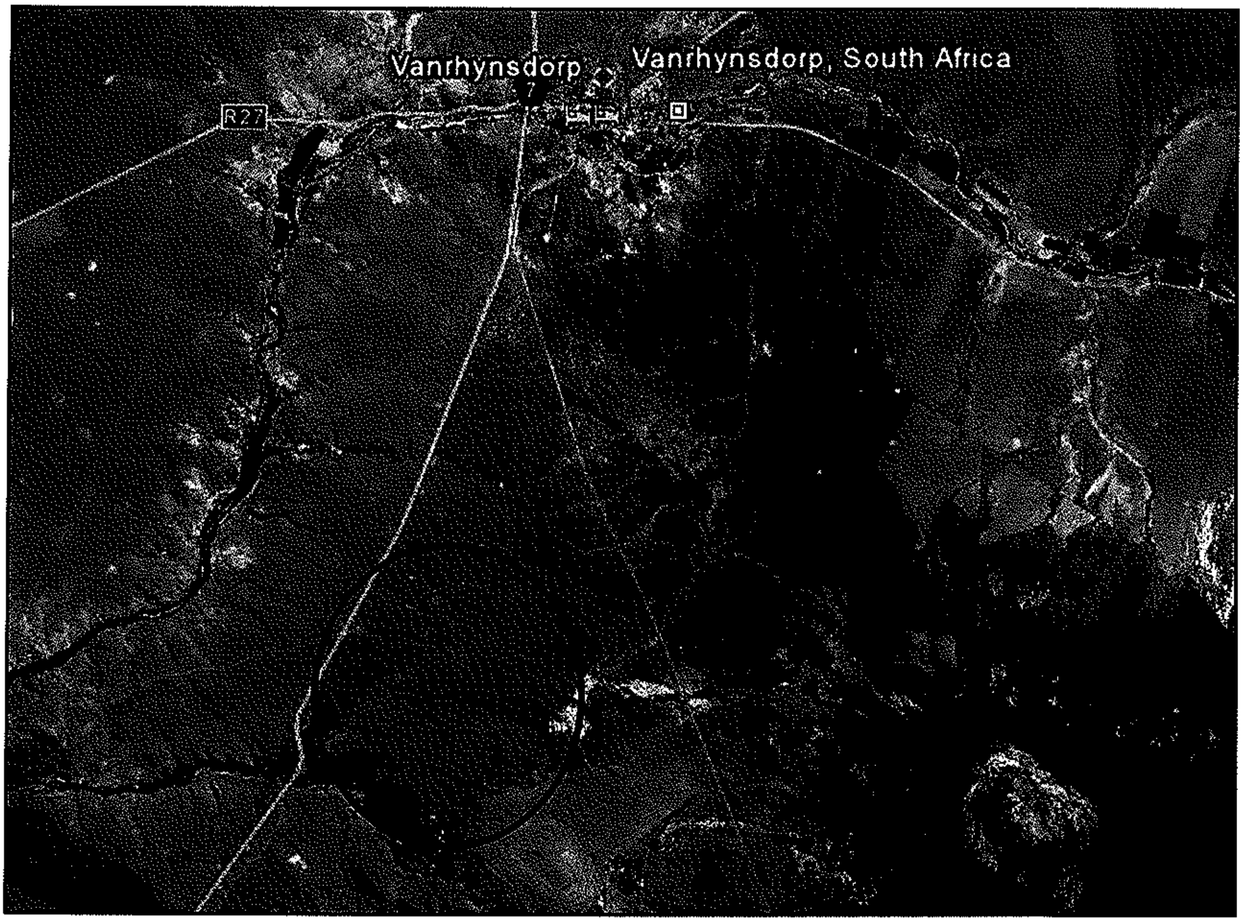


Fig. 2. Google Earth® satellite image of the Maskam mine study region on the eastern side of the N7 *c.* 8km SSW of Vanrhynsdorp, Western Cape Province, showing dark Gariep limestone bedrocks exposed in the banks of the Wiedouwrivier and gently sloping, semi-arid, soil-covered terrain to the north (black oval). The northwestern tip of the Matsikammaberg is visible in the southeastern corner.

3.2. Geology of the study area

The geology of the study area near Vanrhynsdorp is shown on the 1: 250 000 geology map 3118 Calvinia (Council for Geoscience, Pretoria; Fig. 3 herein). A comprehensive sheet explanation for this map has been published by De Beer *et al.* (2002). The older sheet explanation to the 1: 125 000 geology sheet Doring Bay & Lambert's Bay by Visser and Toerien (1971) is also relevant (but not seen by author).

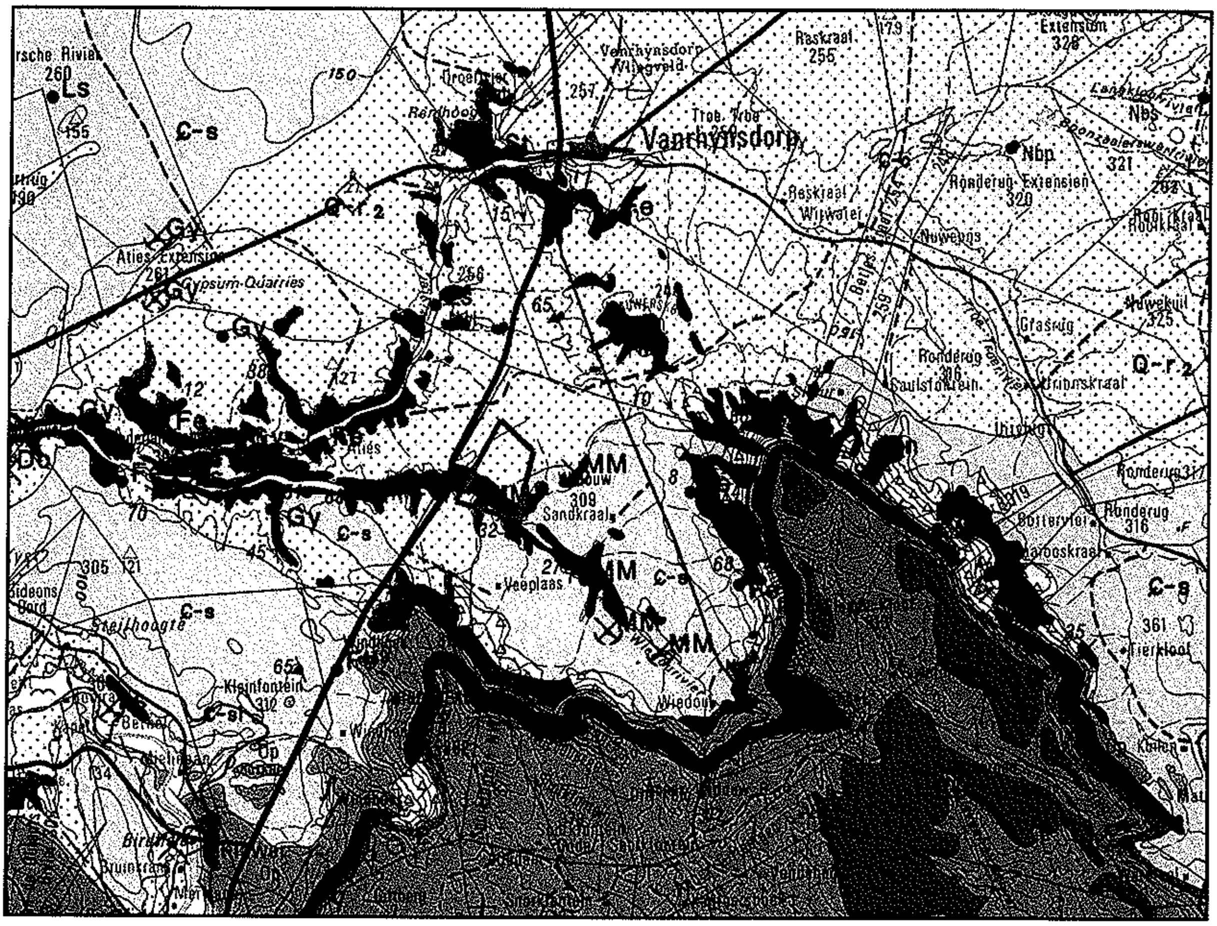


Fig. 3. Extract from 1: 250 000 geological map 3118 Calvinia (Council for Geoscience, Pretoria) showing the *approximate* location (orange polygon) of proposed Maskam limestone mine study area *c.* 8 km SSW of Vanrhynsdorp, Western Cape Province (black polygon).

Late Caenozoic rock units mapped within the study region include:
Q-s (buff) = red aeolian (wind-blown) sand
Q-r2 (yellow + dots) = calcareous and gypsiferous soil
Alluvial deposits of the Wiedouw River occur along the southern margin of the study area but are not separately mapped on this scale.

Late Precambrian (Proterozoic) metamorphic bedrocks of the Gifberg Group (Gariep Supergroup) include:
Nwi (pale blue) – recrystallized carbonates of the Widouw Formation underlain at depth by
Nat (grey-green) – pyrite-rich schists of the Aties Formation
Nbp (dark purple) – carbonates (some stromatolitic) of the Bloupoort Formation

According to the 1: 250 000 geology map (Fig. 3) the study area of the proposed new limestone mine largely mantled by superficial sediments of Late Caenozoic - *i.e.* Late Tertiary or Neogene to Recent - age. The thickness of superficial sediment overburden overlying Precambrian bedrocks here varies from zero to two meters. A small area in the east is covered by fine-grained **aeolian sands (Q-s)** that cover large portions of the coastal plain to the north and south of Vanrhynsdorp, where they are often underlain by older calcareous or loamy soils, and that often appear distinctly orange on satellite images. The reddish sands are derived from pale alluvial sands that were accumulated near the coast by the palaeo-Olifants River system and then blown inland by prevailing southwesterly winds. They are mainly of Pleistocene to Recent age. A majority of the study area is mantled by **calcareous and gypsiferous soils (Q-r2)** that cover large areas of the Knersvlake region around Vanrhynsdorp and are often capped by a reddish, well-consolidated calcareous or siliceous hardpan or *dorbank*. The soils comprise a spectrum of gravally conglomerates, grit, sand and finer sediment showing a variable degree of calcretisation (*i.e.* pedogenic limestone formation typical of semi-arid climates). Pleistocene to Holocene **alluvial deposits** such as silts and gravels occur along the Widouw River but these are small in extent and are not separately mapped at 1: 250 000 scale.

Late Precambrian metasediments of the **Gifberg Group** forming the Vredendal Inlier of the Neoproterozoic Gariep Supergroup crop out along the bed and banks of the Widouw River. Within the study area just to the east of the N7 these comprise metamorphosed, deformed carbonate and other metasedimentary rocks of the **Widouw Formation (Nwi)**. The Widouw succession, here in its type area, mainly consists of recrystallized, greyish limestones (marbles) and dolostones but also includes subordinate bodies of meta-greywacke, quartzite and phyllite (De Beer *et al.*, 2002, Gresse *et al.*, 2006, Frimmel 2008). The carbonate rocks can reach over 200m in thickness, but this has probably been exaggerated by tectonic reduplication. According to the draft EMP the target carbonate rock for the Maskam mine is a light grey, massive, fine- to medium/coarse-grained, crystalline, exceptionally homogenous, very high grade calcium carbonate / marble rock. The "limestone" ore body at the Maskam site dips gently eastwards at between 5 and 15° and is overlain by schistose, often highly pyritic metasediments of the **Aties Formation (Nat)** (Fig. 4). The latter subunit of the Gifberg Group is not mapped at surface in the study area but is well-exposed to the west of the N7 as well as in road cuts along the Olifants River Valley.

The following useful description of the Maskam limestone ore body as well as Fig. 4 below have been abstracted from the draft EMP (Site Plan Consulting, June 2011) which is in turn based on a report entitled "*Geological Report of the Maskam Limestone Deposit on the farm Welverdiend 511 in the Vanrhynsdorp District*" (DW Rees in July 2008):

> The ore body [to the north of current proposed excavation area] is covered by 5-20m of overburden which comprises clay, stiff silt and sand as well as hard silcrete bands. The suboutcrop is uniformly flat with no karsts penetrating into the ore body. The body does not outcrop but on the central western side it lies 1-2m below the land surface. The entire western part of the body is overlain by low-grade carbonate-rich hanging wall rock which gradually deepens eastward [Fig. 4 below]. The body is underlain by siliceous graphitic and phyllitic waste rock and the contact between the body and foot-wall schist is sharp. The true thickness of the deposit varies between 20m in the west and 66m in the east. The ore body has been identified for 1000m along the strike. The southern part terminates in deep weathering adjacent to the Wiedou River but the body extends northwards along strike over its full width beyond the prospected area. No obvious faults, discontinuities or abnormalities were encountered in any of the boreholes. A unique feature of the deposit is the consistent high calcium carbonate values obtained in the boreholes along strike, down-dip and in vertical depth from the sub-outcrop to the foot-wall contact. No lenses of dolomite or siliceous limestone were encountered in the 1532 one metre samples taken from the 39 boreholes which were drilled into the ore body. The western margin of the ore body shows some weathering and clay and silt filled cavities do occur with limestone float (i.e. large limestone boulders suspended in the overburden). The overburden gradually increases in thickness in a northerly direction to 20m at borehole MR7. Only minor water intersections were encountered particularly when the foot-wall contact was intersected. No water fissures or solution channels were intersected.

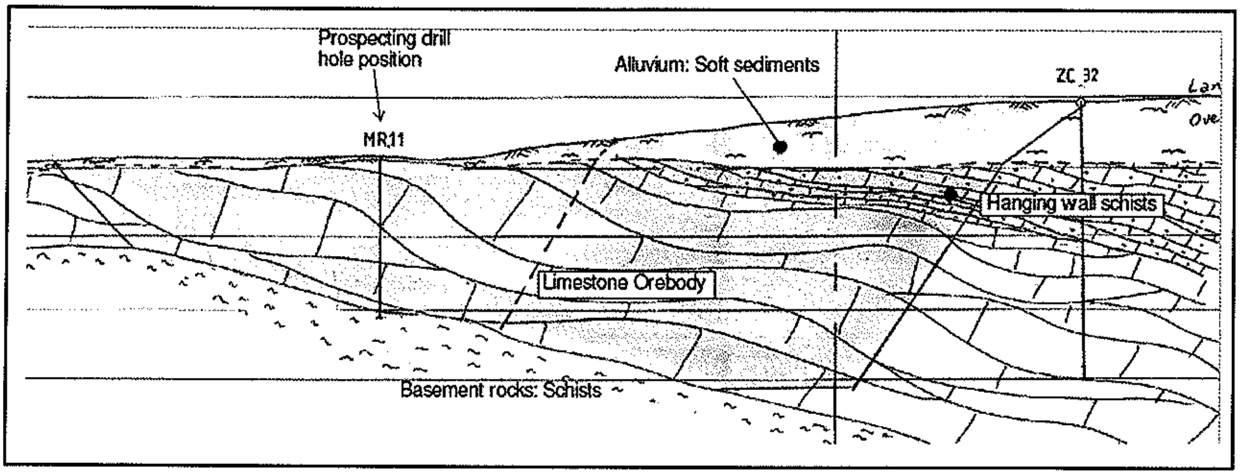


Fig. 4. West-East section through the Maskam limestone ore body (Abstracted from the draft EMP prepared by Site Plan Consulting, June 2011).

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4. PALAEONTOLOGICAL HERITAGE

The main Late Caenozoic fossils mentioned in the 1: 250 000 Calvinia sheet explanation by De Beer *et al.* (2002) are calcretised subfossil termitaria (termite mounds or *heuweltjies*) that may be several thousand years old and reflect past, more pluvial (*i.e.* rainy) climatic episodes. Recent carbon dating gives dates in the range of 30-40 000 years BP for fossil termitaria in the West Coast region, *i.e.* preceding the last glacial maximum (Midgley *et al.* 2002, Potts *et al.* 2009 and refs. therein). Examples of these complex calcareous structures embedded within the Quagga's Kop Formation to the north of Vanrhynsdorp have probably been mistaken in the past as fossil corals, while freshwater unionid bivalves have been erroneously taken to be marine mussel shells (*ibid.*, p. 79, and Lamont 1947). There are vague reports of Late Tertiary skeletal remains of terrestrial mammals within diamondiferous deposits of the Quagga's Kop Formation, including the type area of the formation north of Vanrhynsdorp (*e.g.* Hendy 1984, p. 88). Lamont (1947) apparently recorded marine sharks teeth from the same area but this record seems unlikely, given the high elevation above sea level, and has not been confirmed (De Beer *et al.* 2002, p.79). The Late Tertiary Olifants River Gravels at Vredendal have yielded a range of silicified woods of tropical angiosperms that are referred to the Miocene Epoch (Bamford 1999).

Younger (Quaternary – Holocene) **alluvial deposits** along the Widouw River are likely to be at most sparsely fossilferous. While older alluvial gravels of the Quagga's Kop succession are *not* mapped in the study area, the possibility of comparable, fossil-bearing alluvial deposits associated with the Widouw River system should be borne in mind (*N.B.* This is considered unlikely given the different provenance and age of the Widouw River compared to the older drainage systems to the north). Residual gravels within the **calcareous and gypsiferous soils** (Q-r2) that are probably in part derived from the Quagga's Kop Formation might contain derived (reworked) fossil remains such as resistant mammalian teeth or bones as well as Early Stone Age (Pleistocene) artefacts (De Beer *et al.* 2002, p. 81).

The sparse fossil record of unconsolidated Quaternary **wind-blown sands** (**Q-s**) in southern Africa also includes calcretized rhizoliths (root casts), invertebrate burrows including termitaria, ostrich egg shells (*Struthio*) and shells of land snails such as *Trigonephrus* (Partridge *et al.* 2006, Almond 2008a, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands. Underlying calcretes might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways.

In conclusion, the Late Caenozoic "drift" deposits mantling almost the entire study area are generally of low overall palaeontological sensitivity (De Beer *et al.* 2002, Almond & Pether 2008, Almond 2008a, b). However, sparse mammalian bones, teeth and horn cores as well as remains of fish, amphibians, tortoises (or even crocodiles), petrified wood, freshwater molluscs and trace fossils might occur in association with any older alluvial sediments of the Widouw system along the southern margin of the proposed development area. Some of these river-transported fossil or subfossil remains may have been eroded out of older alluvial gravels upstream.

As far as known, the highly deformed and metamorphosed sediments of the Late Precambrian Gifberg Group mapped within or beneath the study area – principally the **Widouw** Formation (the target rock for limestone mining) and **Aties Formations** – are not fossiliferous (De Beer *et al.* 2002, Gresse *et al.* 2006, Frimmel 2008). The Neoproterozoic Widouw shelf carbonates were probably originally fossiliferous; primitive shelly fossils, stromatolites, trace fossils as well as organic-walled microfossils might be expected in sediments of this age and facies, as seen for example in comparable carbonate successions of the slightly younger Bloupoort Formation (Nbp) at the top of the Gifberg Group that crops out less than 10 km to the east of the study area (Fig. 3). However, any fossils once present in the Widouw carbonates have almost certainly been destroyed by subsequent intense tectonic deformation and metamorphism, including recrystallization to form marbles. No fossils have been observed by the author good exposures along and close to the N7, for example, and none are mentioned in the recent geological literature (See references listed above).

The overall palaeontological sensitivity of the broader study area is therefore rated as LOW.

5. DISCUSSION & CONCLUSIONS

The study area for the proposed limestone mine near Vanrhynsdorp is mantled by a range of Late Caenozoic superficial deposits that are up to 2m thick and all of low palaeontological sensitivity. The underlying Late Precambrian bedrocks of the Gifberg Group, notably the carbonate target rocks of the Widouw Formation, are metamorphosed and highly deformed, and hence unlikely to contain any fossils.

Alluvium of the Widouw River is likely to be at most sparsely fossiliferous and will be directly impacted by the proposed mining only to a small extent. Older alluvial gravels of possible Late Tertiary to Recent age (Karoo Kop Formation) that are associated with river courses in the Knersvlakte region are not mapped within the Maskam study area.

The overall impact significance of the proposed mining development is inferred to be LOW because most of the study area is mantled by superficial sediments of low palaeontological sensitivity and the Precambrian bedrocks are almost certainly unfossiliferous. No further specialist studies or mitigation regarding fossil heritage are considered necessary for this project.

Should substantial fossil remains (*e.g.* vertebrate teeth, bones, petrified wood, stromatolites, shells, trace fossils) be exposed during mining, however, the ECO should safeguard these, preferably *in situ*, and alert Heritage Western Cape as soon as possible so that appropriate action (*e.g.* recording, sampling or collection) can be taken by a professional palaeontologist at the developer's expense.

6. ACKNOWLEDGEMENTS

Mr Craig Donald of Site Plan Consulting, Strand, is thanked for commissioning this study and for kindly making available all the necessary background information. The excellent maps and geodata provided were especially appreciated.

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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 mining 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.

Dr John E. Almond
Palaeontologist
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