PALAEONTOLOGICAL IMPACT ASSESSMENT: COMBINED FIELD ASSESSMENT & DESKTOP STUDY

Proposed Mont Rouge Golf Reserve near Vanwyksdorp, Kannaland Municipal Area, Western Cape Province

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

October 2011

1. SUMMARY

The company Assegaay Bosch Ranch (Pty) Ltd, Ladismith, is proposing to develop a nature reserve, known as the Mont Rouge Golf Reserve, approximately 9 400 hectares in area and situated just to the east of the village of Vanwyksdorp in the southeastern part of the Little Karoo region (Kannaland Municipal Area). It is proposed to develop up to 36 new housing units and an 18-hole golf course on the new reserve which extends from the slopes of the Rooiberg southwards across the Grootrivier. The Mont Rouge study area is underlain by an extensive series of sedimentary formations of Palaeozoic age that are assigned to the Table Mountain and Bokkeveld Groups (Cape Supergroup). Several of these rock units are known to be moderately to highly fossiliferous elsewhere in the Little Karoo region. However, in the study area the potentially fossiliferous mudrock-dominated formations are generally deeply-weathered and strongly cleaved so that their original fossil content has been largely destroyed. Furthermore, the Cape Supergroup bedrocks over much of the area are protected by a mantle of largely unfossiliferous superficial deposits such as colluvium (slope deposits), ancient and modern alluvial gravels (some silcretised), as well as silty alluvium and soil. The palaeontological sensitivity of the Palaeozoic bedrocks here is consequently low to very low in general. Highly sensitive post-glacial mudrocks of the Cedarberg Formation (Table Mountain Group) crop out on the southern face of the Rooiberg within the Mont Rouge development area. However, their outcrop is largely inaccessible and will not be directly impacted by the proposed development.

During palaeontological fieldwork fairly diverse and well-preserved shelly marine invertebrate assemblages were recorded from small exposures of less cleaved mudrocks and thin sandstones of the Early Devonian Gydo Formation (basal Bokkeveld Group) in the northern part of the study area, close to the existing Rooiberg guest lodge. However, most of the Gydo Formation is sparsely fossiliferous due to cleavage and weathering, and palaeontological impacts of the few proposed homestead developments within the Gydo outcrop area are regarded as of low significance.

The overall impact on fossil heritage of the proposed Mont Rouge golf reserve development - including the golf course by the Grootrivier as well as the homesteads scattered over the surrounding area - is assessed as LOW. It is concluded that no further specialist studies or mitigation are required for this development project on palaeontological grounds. Should rich fossil assemblages be exposed during construction, they should be reported to Heritage Western Cape. The impressive Assegaay Bosch manganese deposit on the southern slopes of the Rooiberg, some 1.4 km ENE of the Rooiberg lodge (33°43' 35.0" S 21°34' 26.0" E) is of significant historical / geological heritage interest and is therefore considered worthy of special protection on scientific heritage grounds.

2. INTRODUCTION & BRIEF

The company Assegaay Bosch Ranch (Pty) Ltd, Ladismith, is proposing to develop a nature reserve, known as the Mont Rouge Golf Reserve, of approximately 9 400 hectares just to the east of the village of Vanwyksdorp, Kannaland Municipal Area, in the southeastern part of the Little Karoo region (DEAD&DP REF: 12/2/1-ALI – 5485) (Fig. 1). The reserve is to occupy land previously zoned for agriculture and will be managed in conjunction with CapeNature *via* a Stewardship Agreement. It will comprise 36 nature reserve farms, one agricultural farm largely devoted to olive production, and an 18-hole golf course. The golf course is to be located on the northern and southern banks of the Grootrivier, close to an existing airstrip and agricultural lands (Figs. 2 & 4). It is proposed to develop up to 36 new housing units, one within each of the newly defined reserve portions, for which about 60 possible sites of *c.* 1000 m^2 have already been identified (Figs. 6, 10). Since all of the sites are located along or close to existing farm roads, which will be upgraded, at most only very short (<100 m) new access roads of 2 m width will be required. No new above ground electricity or telephone lines will be established, although some re-alignment of existing lines may be required.

The following project description has been provided by Sharples Environmental Services, George:

> The application will include the consolidation of 38 farms (Farms 178, 1/216, 2/216, 3/216, 4/216, 5/216, 6/216, 7/216, 8/216, 9/216, 10/216, 11/216, 12/216, 15/216, 16/216, Re/216, 179, 3/215, 6/215, 7/215, 8/215, 10/215, 11/215, 16/215, 18/215, Re/215, 2/228, 25/228, 1/227, 2/227, 3/227, Re/227, 1/226, Re/226, 5/218, 1/225, 1/223 and Re/225, Ladismith) totalling approximately 9289.715 ha and the resubdivision thereof into 38 farms, more or less equal in size. One of the newly created farms will be rezoned to Open Space Zone II and will be utilized for the construction of an 18-hole golf course. A second farm□s boundaries will be re-aligned and will accommodate all the cultivated agricultural land utilised for the production of lucern and olives. A portion of the aforementioned farm will be rezoned to accommodate an olive processing facility. The remaining 36 farms will collectively function as a nature reserve, with no inner fences with game fencing only on the outer boundaries to contain game in the reserve.

A palaeontological assessment of the existing airstrip development on Portion 1 of the Farm 216 Kleinvlakte, Assegaay Bosch, has recently been conducted by the author (Almond 2011) and has been accepted by Heritage Western Cape. The present combined field assessment and desktop palaeontological study covers the entire Mont Rouge development area, including the proposed new golf course development and new homestead developments. Fieldwork was carried out over a period of two days (1-2 October 2011) by the author and an experienced palaeontological field assistant (Ms Claire Browning, Council for Geoscience, Bellville). Since the southern part of the study area, south of the Rooiberg Pass - Vanwyksdorp dust road, was judged to be of low palaeontological sensitivity (*cf* previous desktop study by Almond 2011), fieldwork focused largely on the northern sector of the development area to the north of the Rooiberg Pass – Vanwyksdorp dust road where potentially fossil-rich bedrocks of the Lower Bokkeveld Group have been mapped.

The Mont Rouge reserve development, including the golf course itself, is underlain by potentially fossiliferous bedrocks of the Table Mountain Group and the Bokkeveld Group. A palaeontological assessment for the development has accordingly been commissioned on behalf of the developer, Mr. P. Coetzee of Assegaay Bosch Ranch (Pty.) Ltd., Ladismith, by Mr John Sharples of Sharples Environmental Services cc, George.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act of 1999 include, among others:

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

2.1. General approach used for palaeontological assessment 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 following preliminary field assessment 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, as in the present case, a field-based assessment study by a professional palaeontologist is usually warranted.

The focus of palaeontological fieldwork is *not* simply to survey the development footprint or even the development area as a whole (*e.g.* farms or other parcels of land concerned in the development). Rather, the palaeontologist seeks to assess or predict the diversity, density and distribution of fossils within and beneath the study area, as well as their heritage or scientific interest. This is primarily achieved through a careful field examination of one or more representative exposures of all the sedimentary rock units present (*N.B.* Metamorphic and igneous rocks rarely contain fossils). The best rock exposures are generally those that are easily accessible, extensive, fresh (*i.e.* unweathered) and include a large fraction of the stratigraphic unit concerned (*e.g.* formation). These exposures may be natural or artificial and include, for example, rocky outcrops in stream or river banks, cliffs, quarries, dams, dongas, open building excavations or road and railway cuttings. Uncemented superficial deposits, such as alluvium, scree or wind-blown sands, may occasionally contain fossils and should also be included in the field study where they are well-represented in the study area. It is normal practice for impact palaeontologists to collect representative, well-localized (*e.g.* GPS and stratigraphic data) samples of fossil material during field studies. All fossil material collected must be properly curated within an approved repository (usually a museum or university collection).

Note that while fossil localities recorded during scoping work within the study area itself are obviously highly relevant, most fossil heritage here is embedded within rocks beneath the land surface or obscured by surface deposits (soil, alluvium *etc*) and by vegetation cover. In many cases where levels of fresh (*i.e.* unweathered) bedrock exposure are low, the hidden fossil resources have to be *inferred* from palaeontological observations made from better exposures of the same formations elsewhere in the region but outside the immediate study area. Therefore a palaeontologist might reasonably spend far *more* time examining road cuts and borrow pits close to, but outside, the study area than within the study area itself. Field data from localities even further afield (*e.g.* an adjacent province) may also be adduced to build up a realistic picture of the likely fossil heritage within the study area. On the basis of the desktop and field studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*e.g.* HWC for the Western Cape). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

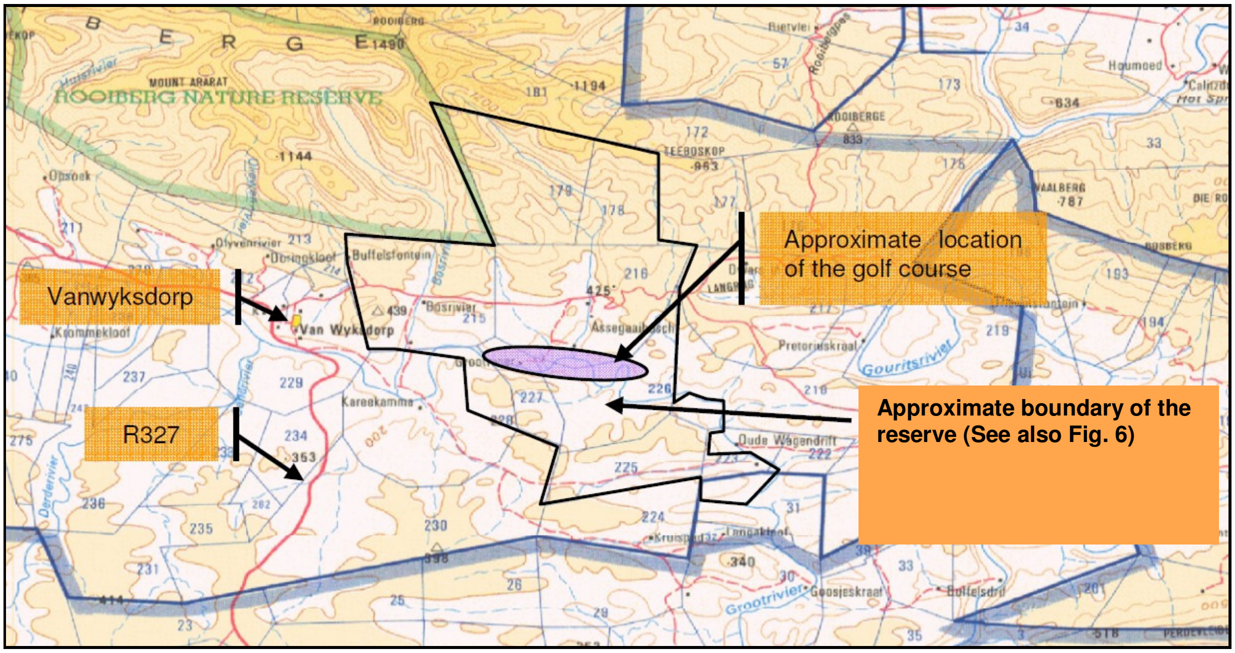

Fig. 1. Extract from 1: 250 000 topographical map 3320 Ladismith (Courtesy of the Chief Directorate: National Geo-spatial information) showing the boundary of the proposed 9 400 hectare Mont Rouge Golf Reserve (black line) spanning the Rooiberg Pass – Vanwyksdorp dust road and the Grootrivier to the east of Vanwyksdorp, southeastern Little Karoo (Map kindly provided by Sharples Environmental Services, George).

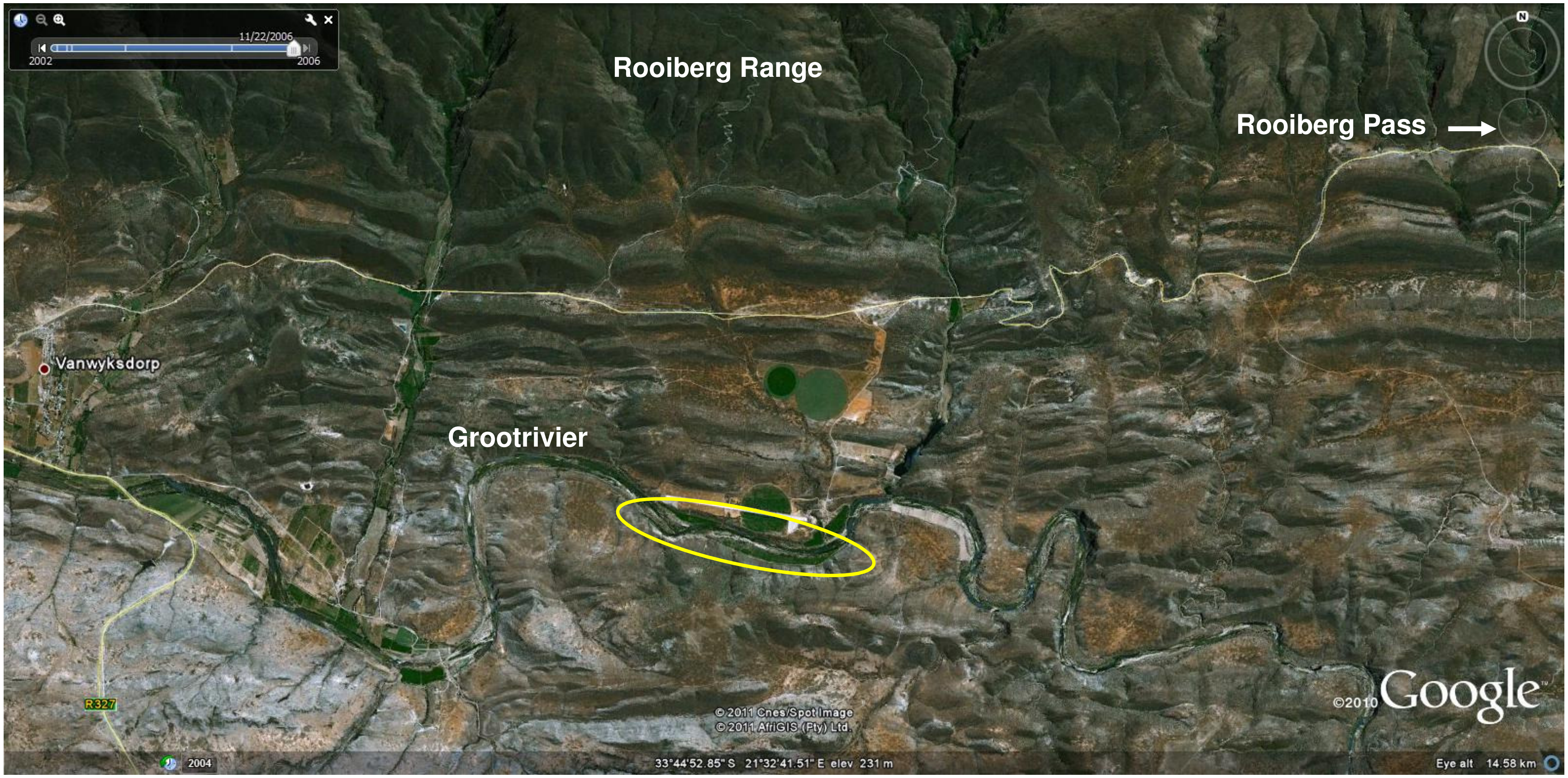

Fig. 2. Google Earth® satellite image showing the nature of the terrain within the Mont Rouge Golf Reserve study area on the southern flanks of the Rooiberg massif, *c*. 9 km to the east of Vanwyksdorp, Little Karoo. The location of the proposed golf course development either side of the Grootrivier is indicated by the yellow ellipse. See Fig. 4 below for a detailed plan of the proposed golf course development.

Fig. 3. Google Earth® satellite image of the northern and central sectors of the Mont Rouge Golf Reserve. See legend on following page.

Legend to Figure 3 on previous page:

Dg = Gydo Formation (Bokkeveld Group)
Dga = Gamka Formation (Bokkeveld Group)
Dv = Voorstehoek Formation (Bokkeveld Group)
Dh = Hexrivier Formation (Bokkeveld Group)
Dt = Tra Tra Formation (Bokkeveld Group)
Dbo + Dw = Boplaas Formation + Waboomberg Formation (Bokkeveld Group)
Dk = Karies Formation (Bokkeveld Group)
Tg = Grahamstown Formation (Tertiary silcretes)

Fig. 4. Plan of the proposed golf course development flanking the Grootrivier on Assegaay Bosch, near Vanwyksdorp, Little Karoo (Image kindly provided by Sharples Environmental Services, George).

2.2. Assumptions and limitations affecting the present study

In inferring the palaeontological sensitivity of rock units underlying a development from field and other data obtained outside the study area it is assumed that fossil heritage is fairly uniformly distributed throughout the outcrop area of a given formation. Experience shows that this assumption does not always hold. This is because the original depositional setting across a formation that may extend over hundreds of kilometres may vary significantly, with palaeoecological implications (*e.g,* from a shallow to deeper water environment), while fossils are often patchy in their occurrence. Furthermore, the levels of tectonic deformation (folding, cleavage development *etc*), as well as the intensity and nature of metamorphism and weathering experienced by a given formation may change markedly across its outcrop area. These factors may seriously compromise the preservation of fossil remains present within the original sedimentary rock so that the actual palaeontological sensitivity of a rock unit that is normally highly fossiliferous may be effectively very low in some areas.

Several factors limit and distort our current understanding of fossil distribution within the rocks of the Cape region, such as collection bias, poor locality details for older fossil collections, and restriction of bedrock exposure mainly due to cover by superficial sediments (*e.g.* alluvium, scree) or vegetation. A further limiting factor is that several of the 1: 250 000 geological maps are now out of date and do not differentiate between all the stratigraphic units that may be of palaeontological significance. This applies in the present case to the mapping of the Boplaas and Waboomberg Formations of the Bokkeveld Group, for example.

A major limitation affecting palaeontological assessment of the Assegaay Bosch area of the Little Karoo is the generally very low levels of exposure of the potentially-fossiliferous mudrock-dominated formations due to (a) dense vegetation cover and (b) extensive mantling of hillslopes by superficial deposits such as scree, alluvium and soil. The Table Mountain Group formations building the southern slopes of the Rooiberg are largely inaccessible. For these reasons, fieldwork for this project mainly focused on small bedrock exposures in borrow pits, road cuttings and hillslopes.

Fig. 5. Close-up satellite image of the proposed golf course development area on the Farm Kleinvlakte No 227/ on either side of the Grootrivier east of Vanwyksdorp (From Almond 2011). Note stepped topography as well as numerous patches of kaolinitised, chemically-weathered sediment (kaolinite / china clay) in the Bokkeveld Group outcrop area. The Bokkeveld sediments here have been mapped as the Boplaas Formation (Fig. 3) but may in part be equivalent to the Waboomberg Formation mapped further to the west within the Little Karoo.

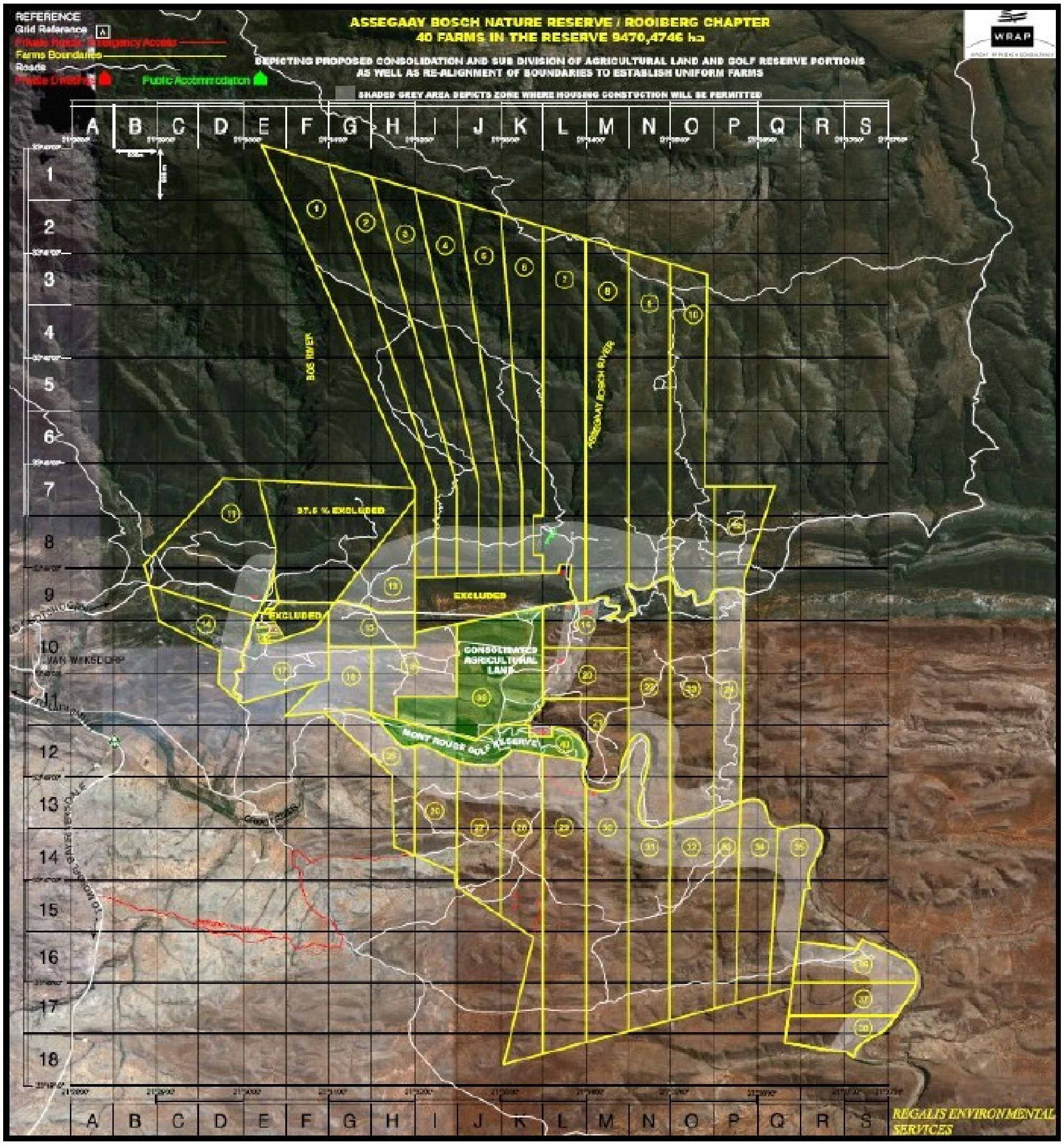

Fig. 6. Proposed subdivision of the Assegaay Bosch Nature Reserve into 38 small farms with the Golf Reserve in the centre (Image kindly provided by Sharples Enviornmental Services, George).

3. GEOLOGICAL BACKGROUND

The geology of the Assegaay Bosch study area east of Van Wyksdorp is outlined on 1: 250 000 sheet 3320 Ladismith (Theron *et al.* 1991) (Fig. 8). The area is entirely underlain by Early to Mid Palaeozoic sedimentary rocks of the Cape Supergroup (Fig. 9). The northern sector of the reserve lies on the southern flank of the Rooiberg massif which reaches heights of almost 1500m and is deeply dissected by steep-walled gorges that have been incised by north bank tributaries of the Grootrivier drainage system. The rugged mountain slopes here are largely built of quartzose sediments of the **Table Mountain Group** of Early to Middle Palaeozoic age (*i.e.* Ordovician to Early Devonian Periods) that were gently folded into an east-west trending mega-anticline (*i.e.* gigantic convex-upwards fold) during the formation of the Cape Fold Belt in Permo-Triassic times. Since these Table Mountain Group sediments are mostly fluvial and unfossiliferous, and furthermore will not be significantly impacted by the proposed development, they are not treated in any detail here. It should be noted that the marine, potentially fossil-rich **Cederberg Formation** (thin brown line in Fig. 8) is only accessible in deep *klowe* in this region. The uppermost rocks of the Table Mountain Group, known as the **Baviaanskloof Formation**, include marine beds with low diversity fossil shell assemblages that are well known elsewhere in the Rooiberg – Gamkaberg range. For more information the interested reader is referred to the detailed report on the geology and fossils of the Gamkaberg – Rooiberg massif presented by Almond (2005).

The greater part of the Mont Rouge development footprint is underlain by shallow marine sediments of the **Bokkeveld Group**, the mudrock-rich middle subdivision of the Cape Supergroup (Theron 1972, Theron & Loock 1988, Theron & Johnson 1991, Broquet 1992, Thamm & Johnson 2006). The Bokkeveld Group is a thick (*c*. 1.5 to 3.5km) succession of fossiliferous sedimentary rocks which was deposited in shallow marine to coastal settings during the Early to Middle Devonian Period, about 400 to 375 million years ago These sediments accumulated on an area of continental shelf – the Cape Basin – which then lay towards the southern edge of the supercontinent Gondwana at moderately high palaeolatitudes (*c*. 70°S). Bokkeveld Group sediments crop out extensively in lower lying portions of the Cape Fold Belt. In the eastern outcrop area of the Bokkeveld Group, near Port Elizabeth, it reaches a total thickness of *c*. 3.5km. However, in the Little Karoo region more modest thicknesses of around 1.5 to 2km are to be expected.

During the formation of the Cape Fold Belt the Bokkeveld Group rocks were intensely folded along west-east trending fold axes. The study area lies on the northern limb of a major east-west mega-syncline (down-fold) situated on the southern side of the Rooiberg – Gamkaberg mega-anticline. Several successive formations of the Lower Bokkeveld Group (**Ceres Subgroup**) and Upper Bokkeveld Group (**Traka Subgroup**) are represented here by narrow outcrop areas that run east-west across the reserve due to the dominant folding pattern (Figs. 3, 8). The weathering and erosion of recessive-weathering, mudrock-dominated formations (*e.g.* **Gydo**, **Voorstehoek** and **Tra Tra Formations**) alternating with prominent-weathering, more resistant sandstone-dominated formations (*e.g.* **Gamka**, **Hexrivier** and **Boplaas Formations**) is responsible for the distinctive hogsback topography of this part of the Vanwyksdorp Karoo, with its alternating east-west rocky ridges and narrow valleys (See satellite images in Figs. 2, 3 as well as Fig. 7).

It should be noted that the mapping on the 1: 250 000 geology map of the Upper Bokkeveld Group formations within the southern portion of the development area is open to reinterpretation. In particular, the very wide outcrop area assigned here to the Boplaas Formation appears exaggerated, even when the small-scale folding of this unit is taken into account. According to Theron *et al.* (1991, p. 28) the Boplaas Formation near the Rooiberg reaches a thickness of some 130m (only) and consists here of intercalated sandstones and "sandy grey shales". It seems likely that the "Boplaas" outcrop area shown on the map here is partially equivalent to the mudrock-rich Waboomberg Formation of the western Bokkeveld Group outcrop. The contact of the "Boplaas" beds and the overlying Karies Formation is also poorly defined. The latter is appears to be characterised on satellite images by subdued topography and pale colours, reflecting high levels of weathering and erosion (See bottom edge of Figs. 2, 3).

Short reviews of the geology of the various Bokkeveld Group formations represented within the Assegaay Bosch study area are given in the sheet explanation by Theron *et al.* (1991) as well as in the Gamkaberg – Rooiberg Nature Reserve report by Almond (2005a). A more detailed account of the Boplaas Formation that is mapped over much of the southern portion of the study area is given in the palaeontological assessment report for the Assegaay Bosch airstrip area by Almond (2011). This report applies equally to the proposed golf course development in the same area.

The Bokkeveld Group rocks in the study region tend to be highly deformed, as indicated by the moderately high dips (20-60°) and the presence of several smaller-scale synclinal and anticlinal axes within the context of the main mega-syncline. Tectonic cleavage is usually very well-developed, especially within finer-grained mudrock facies (claystones, siltstones). Furthermore, the Bokkeveld Group sediments have generally been subject to deep chemical weathering in post-Gondwana times, with the kaolinitisation of clay-rich successions. Such weathering is often associated with secondary mineralisation by ferriginous and manganese minerals, as well as leaching of sandstones. It is indicated, for example, by the numerous cream-coloured patches seen on aerial and satellite images (Figs. 2, 3 and 5) as well as the author's own fieldwork in the Little Karoo region (*e.g.* Almond 2005a, 2005b, 2009a, 2009b). Adjacent to major, ancient water courses such as Grootrivier the mantle of weathered bedrock or *saprolite* has been scoured away by river erosion so that locally younger (Late Tertiary or Quaternary to Recent) alluvial deposits may sit directly on fairly unweathered bedrock.

Relict, more gently sloping pediment surfaces (*i.e.* ancient land surfaces planed off by erosion) can be recognised along the Rooiberg mountain front), for example between 700 and 600m amsl. They are exploited by 4x4 tracks penetrating into the mountains in the northern part of the reserve (Fig. 6). Consolidated alluvial or colluvial gravels are mapped as N-S elongated "High Level Gravels" that are assigned to the **Grahamstown Formation** (Tg, small yellow areas in Fig. 8). The gravel layers cap southern extensions of the same pediment surfaces that cut across the Bokkeveld Group outcrop area. Road cuttings in the northern part of the reserve show excellent sections through slope deposits - notably a range of coarse **colluvial gravels** – that mantle the Palaeozoic bedrocks here, while bouldery, sandy and silty **alluvium** is associated with water courses including the Grootrivier and its tributaries.

Fig. 7. View of the southern foothills of the Rooiberg range in the northern sector of the Mont Rouge study area, looking towards the west. Ridges of south-dipping Bokkeveld sandstones alternating with easily-eroded mudrocks in the valleys are responsible for the distinctive hogsback topography here.

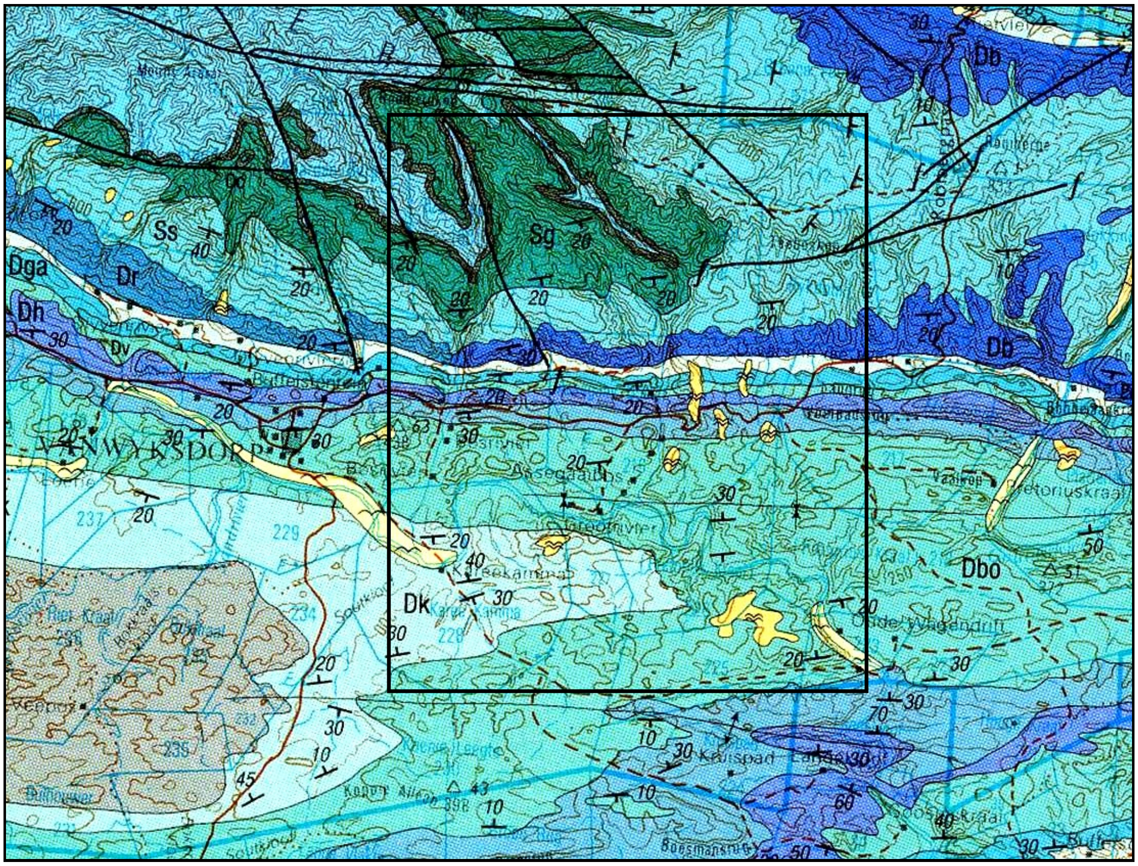

Fig. 8. Extract from 1: 250 000 geological map 3320 Ladismith (Council for Geoscience, Pretoria) showing the *approximate* extent of the broader study area for the Mont Rouge Golf Estate on the southern flanks of the Rooiberg, east of Vanwyksdorp (black rectangle). The following major geological units are represented within this area:

TABLE MOUNTAIN GROUP

Os (middle blue) = Peninsula Formation
Oc/Op (brown) = Cederberg plus Pakhuis Formation
Sg (green) = Goudini Formation
Ss (pale blue) = Skurweberg Formation
Db (dark blue) = Baviaanskloof Formation (equivalent to Rietvlei Fm in the west)

BOKKEVELD GROUP

Dg (pale blue) = Gydo Formation
Dga (sky blue) = Gamka Formation
Dv (greenish-blue) = Voorstehoek Formation
Dh (purple) = Hexrivier Formation
Dt (blue) = Tra Tra Formation
Dbo (greenish-blue) = Boplaas Formation plus Waboomberg Formation
Dk (pale blue) = Karies Formation

LATE CAENOZOIC SUPERFICIAL SEDIMENTS

Tg (yellow with double "flying bird" symbol) = Grahamstown Formation (silcretes) and other Tertiary High Level Gravels
Pale yellow with single "flying bird symbol" = Quaternary to Recent alluvium

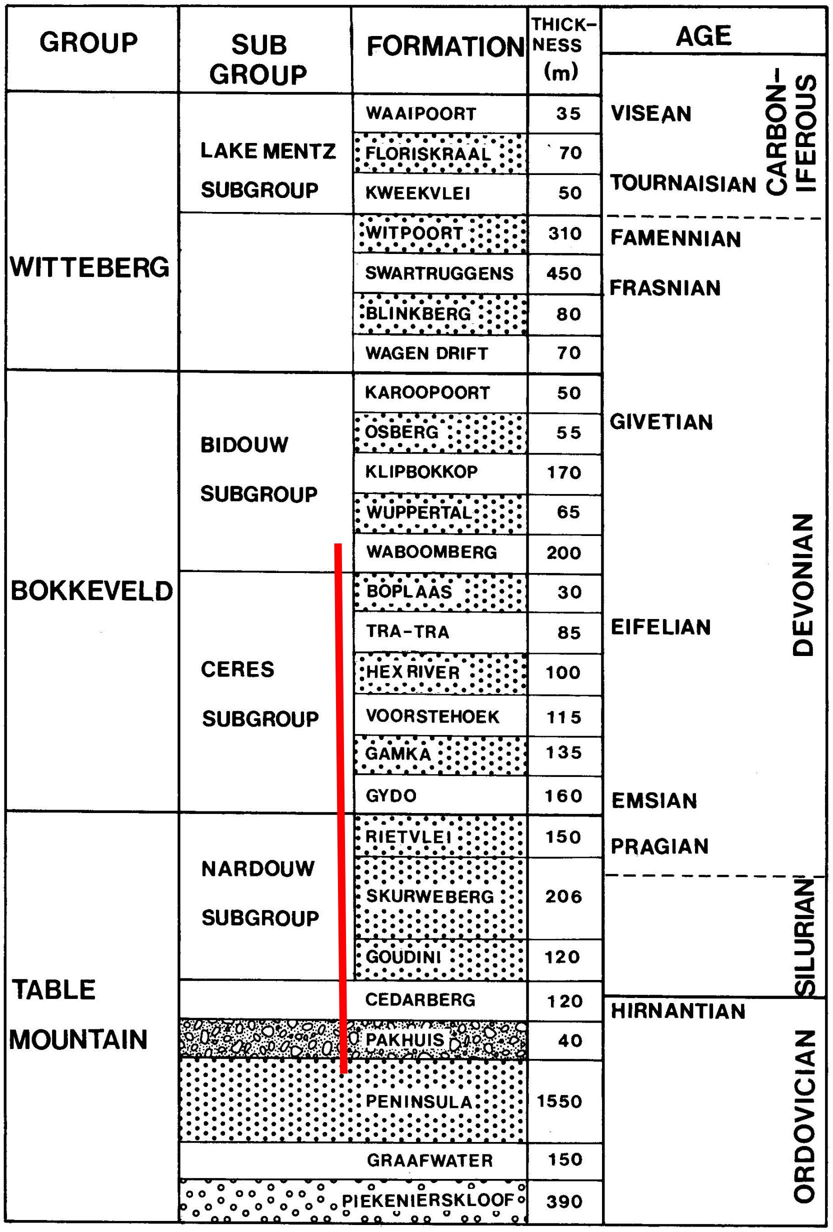

Fig. 9. Stratigraphic column for the Cape Supergroup succession in the Western Cape outcrop area (Modified from Theron & Thamm 1990) showing the numerous formations represented within the Assegaay Bosch study area (vertical red bar). Here, to the east of 21º E the Rietvlei Formation at the top of the Table Mountain Group is replaced by the Baviaanskloof Formation and the upper Bokkeveld Group is represented by the Traka Subgroup, including the Karies Formation, that interfingers laterally with the Waboomberg Formation of the Bidouw Subgroup.

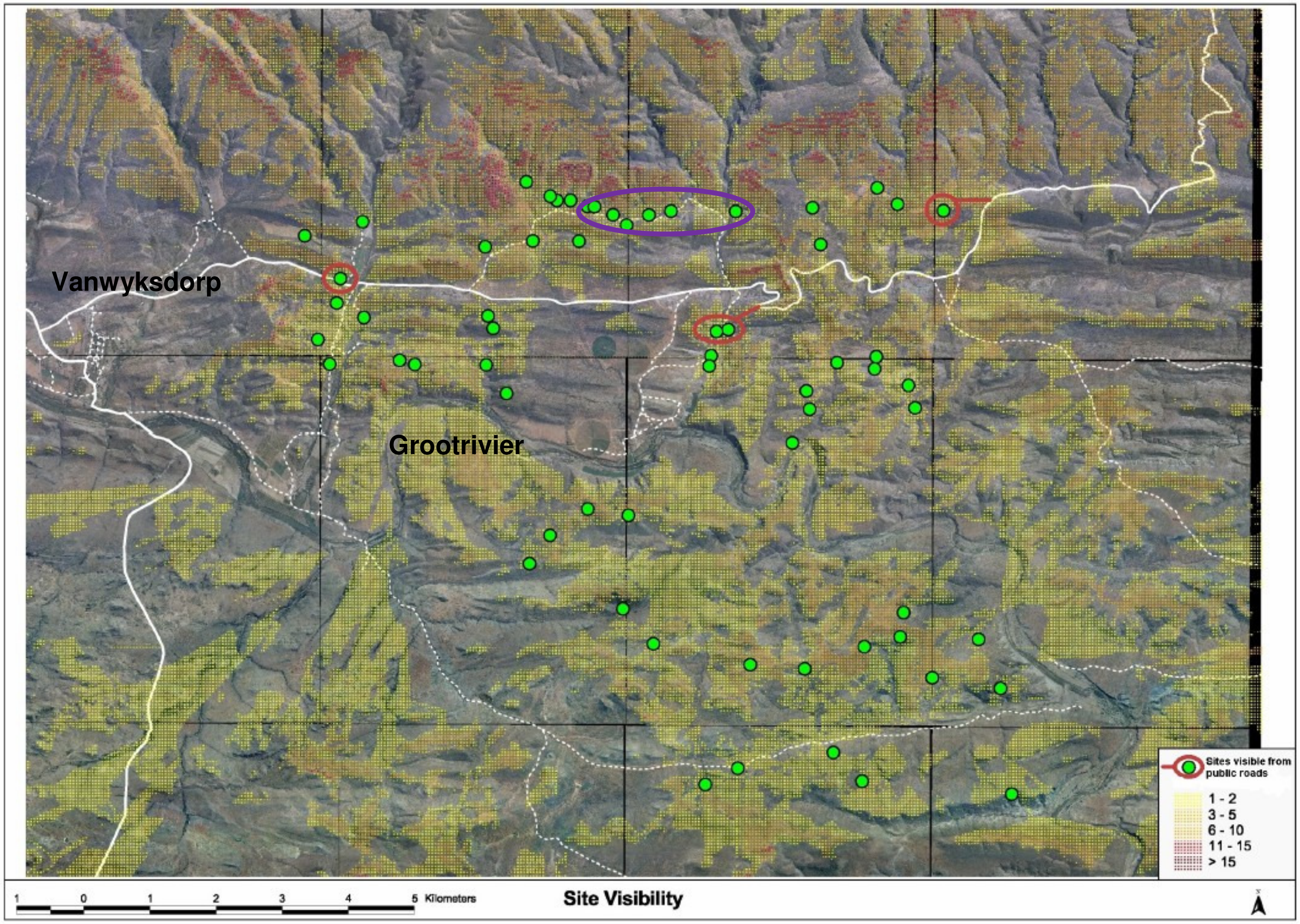

Fig. 10. Map of the Mont Rouge study area near Vanwyksdorp showing the location of the proposed homestead sites (green dots) (Image kindly provided by Sharples Environmental Services, George). Sites enclosed by the purple ellipse overlie potentially fossil-rich mudrocks of the Gydo Formation. The remaining sites are considered to be of low palaeontological sensitivity, largely due to high levels of cleavage and weathering that have destroyed most of the original fossil content, or cover by unfossiliferous superficial deposits.

4. PALAEONTOLOGICAL HERITAGE

The palaeontological heritage recorded within the various rock units represented within the Mont Rouge study area –*i.e.* formations of the Table Mountain Group and Bokkeveld Group as well as the Grahamstown Formation (silcretes, high level gravels) and a spectrum of younger superficial deposits – has been reviewed in the Ladismith geological sheet explanation by Theron *et al.* (1991) as well as in recent reports for conservation areas in the Little Karoo region by the author. Most relevant here are reports on the geology and fossils of the Rooiberg-Gamkaberg Nature Reserve (Almond 2005a), the Aardvark Nature Reserve (Almond 2005b), the Sanbona Nature Reserve (Almond 2009a) and the Warmwaterberg Spa (Almond 2009b).

Note that GPS details of all sites mentioned in the text are provided in Section 8.

4.1. Table Mountain Group

Significant palaeontological impacts on Table Mountain Group rocks of the Rooiberg massif are not anticipated since these are mostly inaccessible and contain only sparse fossils, while very few homestead sites are located in their outcrop area. Only the uppermost unit, the marine – influenced Baviaanskloof Formation, is considered in detail here. It is noted that the palaeontologically sensitive Cedarberg Formation will not be directly impacted by the proposed development.

4.1.1. Baviaanskloof Formation

A distinctive marine shelly invertebrate fauna of Early Devonian age characterises the upper, marine influenced portion of the Baviaanskloof Formation from the Little Karoo eastwards along the Cape Fold Belt. It is dominated by the globose, finely-ribbed articulate brachiopod *Pleurothyrella africana* (Fig. 12). Rare homalonotid trilobites, a small range of articulate and inarticulate brachiopods, nuculid and other bivalves, plectonotid “gasteropods” and bryozoans also occur within impure brownish-weathering wackes (Boucot *et al*. 1963, Rossouw *et al*. 1964, Johnson 1976, Hill 1991, Theron *et al.* 1991, Almond *in* Rubidge *et al*. 2008). In many cases fossil shells are scattered and disarticulated, but *in situ* clumps of preferentialy-orientated pleurothyrellid brachiopods also occur. This shelly assemblage establishes an Early Devonian (Pragian / Emsian) age for the uppermost Table Mountain Group (Nardouw Subgroup), based on the mutationellid brachiopod *Pleurothyrella* (Boucot *et al*. 1963, Theron 1972, Hiller & Theron 1988). Trace fossils include locally abundant, mud-lined burrows (*Palaeophycus*, *Rosselia*) and rare giant rusophycid burrows of Devonian aspect (*R. rhenanus*) that are attributed to homalonotid trilobites. Recently, dense assemblages of primitive vascular plants with forked axes and conical terminal “sporangia” that are provisionally ascribed to the genus *Dutoitia* have been collected from Baviaanskloof Formation mudrocks near Cape St Francis, Eastern Cape (Dr Mark Goedhart, Council for Geoscience, Port Elizabeth, pers. comm., 2008; Robert Gess pers. comm., 2011; *cf* Hoeg 1930, Anderson & Anderson 1985).

Distinctive impure sandstones (wackes) of the upper Baviaanskloof Formation crop out in rugged terrain along the northern edge of that portion of the Mont Rouge reserve within which the proposed homestead sites are located, *i.e.* along the southern edge of the Rooiberg range. This zone is densely vegetated, however, and no new fossil sites were recorded here (Fig. 11). Only a handful of development sites are proposed for this area, and the occurrence of marine fossils in this zone appears to be sporadic, so the significance of fossil heritage impacts on the Baviaanskloof Formation is rated as LOW.

Fig. 11. South-dipping beds of the Baviaanskloof Formation on the eastern bank of the Bosrivier. Exposure of the potentially fossiliferous uppermost Baviaanskloof beds in this region is very poor.

Fig. 12. Clusters of the distinctive Early Devonian brachiopod *Pleurothyrella*, preserved as internal and external moulds, within the Baviaanskloof Formation, Rietvlei (Gamkaberg Nature Reserve). Similar low-diversity shelly assemblages almost certainly occur at the same stratigraphic horizon within the Mont Rouge study area but have not yet been discovered there.

4.2. Bokkeveld Group

The lower part of the Bokkeveld Group in the Western Cape (Ceres Subgroup *plus* lowermost Bidouw Subgroup) contains rich 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 2008b). 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.

Bokkeveld shelly biotas are dominated by four main fossil groups: trilobites, brachiopods (lampshells), molluscs (bivalves, gastropods, nautiloids *etc*) and echinoderms (crinoids, starfish and relatives) (Fig. 13).

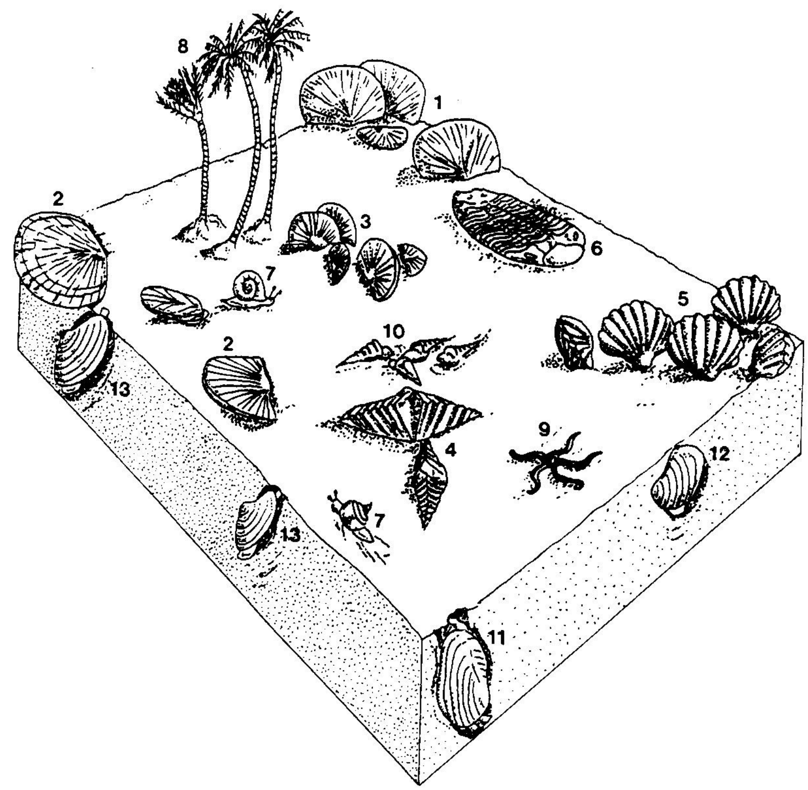

Fig. 13. Reconstruction of a typical shelly invertebrate community from the Lower Bokkeveld Group (Early - Mid Devonian). Taxa include the articulate brachiopods *Australostrophia* (1), *Schuchertella* (2), *Pleurochonetes* (3), *Australospirifer* (4), *Australocoelia* (5), the trilobite *Metacryphaeus* (6), the gastropod *Pleurotomaria* (7), crinoids (8), ophiuroids or brittle stars (9), hyoliths (10), and the bivalves *Sanguinolites* (11), *Palaeoneilo* (12) and *Nuculites* (13). From Hiller & Theron (1988).

A number of minor invertebrate groups are also represented here. Among these may be mentioned solitary and small colonial corals, colonial bryozoans, several types of conical shells whose zoological relationships are not well understood (*e.g.* hyolithids, tentaculitids or "screw shells" and conulariids), and various groups of microfossils such as ostracods (tiny bivalved crustaceans) and foraminiferans (protozoans with a skeleton of mineral grains or calcite). Vertebrate remains comprise rare, fragmentary remains of various marine fish groups, notably early sharks, armoured placoderms and "spiny sharks" or acanthodians (Almond, 1997, Anderson *et al*., 1999a, 1999b).

Rich invertebrate trace fossil assemblages (burrows, trackways *etc*) are recorded from nearshore, heterolithic successions in the northern outcrop area of the Ceres Subgroup (Almond 1998b, Almond *in* De Beer *et al.* 2002). Vascular plants of terrestrial origin are represented by drifted stem fragments of lycopods and primitive psilophytes (Anderson & Anderson 1985). The various invertebrate fossils establish the predominantly shallow marine depositional environment as well as the Early to Middle Devonian age of the Lower Bokkeveld succession (Emsian to Eifelian Stages, *c*. 410 – 390 million years ago), while a Middle Devonian (Givetian) age is established for the Bidouw Subgroup on the basis of non-marine fish remains and marine brachiopods at the top of the succession (Almond 2008b). The overall palaeontological sensitivity of the Bokkeveld Group is considered to be high to very high (Almond & Pether 2008).

To the author's knowledge there are no formal collections of fossils from the Lower Bokkeveld Group in the Van Wyksdorp area in institutional collections. The small collection of shelly fossils made from the Gydo Formation during the present field assessment (to be curated in the palaeontological collections of the Council for Geoscience, Bellville) is therefore of scientific value.

4.2.1. Gydo Formation

Dark, carbonaceous offshore shelf mudrocks towards the base of the Emsian age Gydo Formation (Dg) have yielded by far the most prolific and taxonomically diverse Malvinokaffric shelly invertebrate assemblages known from the Bokkeveld Group. The most productive localities are several road cuts and borrow pits (currently disused) in the stratotype section of the Gydo Fomation towards the top of the Gydo Pass near Ceres (Theron & Thamm 1990, Theron 1999). Well-preserved representatives of a majority of the Bokkeveld major taxa, as listed in the introductory palaeontological section above, are recorded from this formation. After over 150 years of collection useful new fossil specimens of previously-known species, as well as completely new taxa for the Bokkeveld Group, continue to be found at Gydo Pass and localities elsewhere in the region. Fairly comprehensive lists of Gydo fossils are provided by Oosthuizen (1984), Theron and Thamm (1990), Gresse and Theron (1992), and Theron (1999). Among the commonest taxa are articulate brachiopods (*Australoceolia, Australospirifer*, various chonetids), trilobites (*Burmeisteria, Bainella africana, Pennaia*), nuculid bivalves (*Palaeoneilo, Nuculites*) and various crinoids.

The Gydo Formation outcrop area was the focus of much of the fieldwork for the present palaeontological heritage assessment at Mont Rouge since this formation is often very fossil-rich and a number of proposed new homestead sites are located here (See sites within purple ellipses, Fig. 10). Most of the Gydo outcrop area is obscured by vegetation and soil, however, and the mudrocks within the lower part of the succession are generally highly cleaved. However, three fossiliferous sites within the middle to upper Gydo Formation were investigated in the neighborhood of the Rooiberg guest lodge (Fig. 14, Locs. 090, 093, 094, 095, 096). The most productive of these involves a succession of thin sandstones and siltstones exposed just to the south of the lodge, stratigraphically shortly below the base of the Gamka Formation sandstones.

Invertebrate fossils - preserved as moulds within micaceous, grey-green siltstones (usually cleaved) and thin, fine-grained sandstones - that were recorded from the Gydo Formation at Mont Rouge include the following taxa (Fig. 15):

Articulate **brachiopods** such as *Australospirifer*, *Australoceolia*, several chonetids, *Derbyina*, *Cryptonella, Schuchertella* and rarer *Ambocoelia*

Trilobites such as *Pennaia*, *Burmeisteria, Bainella,* and *Metacryphaeus*

Molluscs such as the bivalves *Palaeoneilo, Nuculites* and a possible pectinoid (*cf Pychopteria*), the bellerophontid *Plectonotus*, the gastropods *Loxonema* and a rare patelliform-like species (*cf Metoptoma*), small orthocone nautiloids

Echinoderms including locally abundant, well-articulated crinoids (*e.g.* long sections of stem ossicles, occasionally with attached cirri, intact feathery arms with pinnules), disarticulated crinoidal debris, an intact but poorly-preserved ophiuroid (brittle star)

Other shelly taxa including rare conical **hylolithids**, **tentaculitids**

Trace fossils including unidentified horizontal burrows ("*Palaophycus*") and larger, meniscate back-filled burrows ("*Planolites*").

In general, the Gydo fossil assemblages here are dominated by filter-feeding benthic invertebrate groups. Lenticular concentrations of strongly-ribbed brachiopods and crinoidal debris characterize storm accumulations (tempestites). The high degree of articulation shown by many of the echinoderms, with examples of exceptional preservation of crinoid arms, long stems with cirri and intact brittle stars, points towards obrution preservation (*i.e.* mud smothering). The high quality preservation combined with occasional rare taxa (*e.g.* hyolithids, patelliform gastropods) suggests that more intensive sampling of the Gydo Formation at Assegaay Bosch should prove palaeontologically worthwhile.

Because the greater part of the Gydo Formation is poorly exposed (due to vegetation and superficial sediment cover), deeply weathered and cleaved, while well-preserved shelly fossils do occur in less cleaved "windows" here and there, its palaeontological sensitivity here is rated as LOW overall but LOCALLY HIGH.

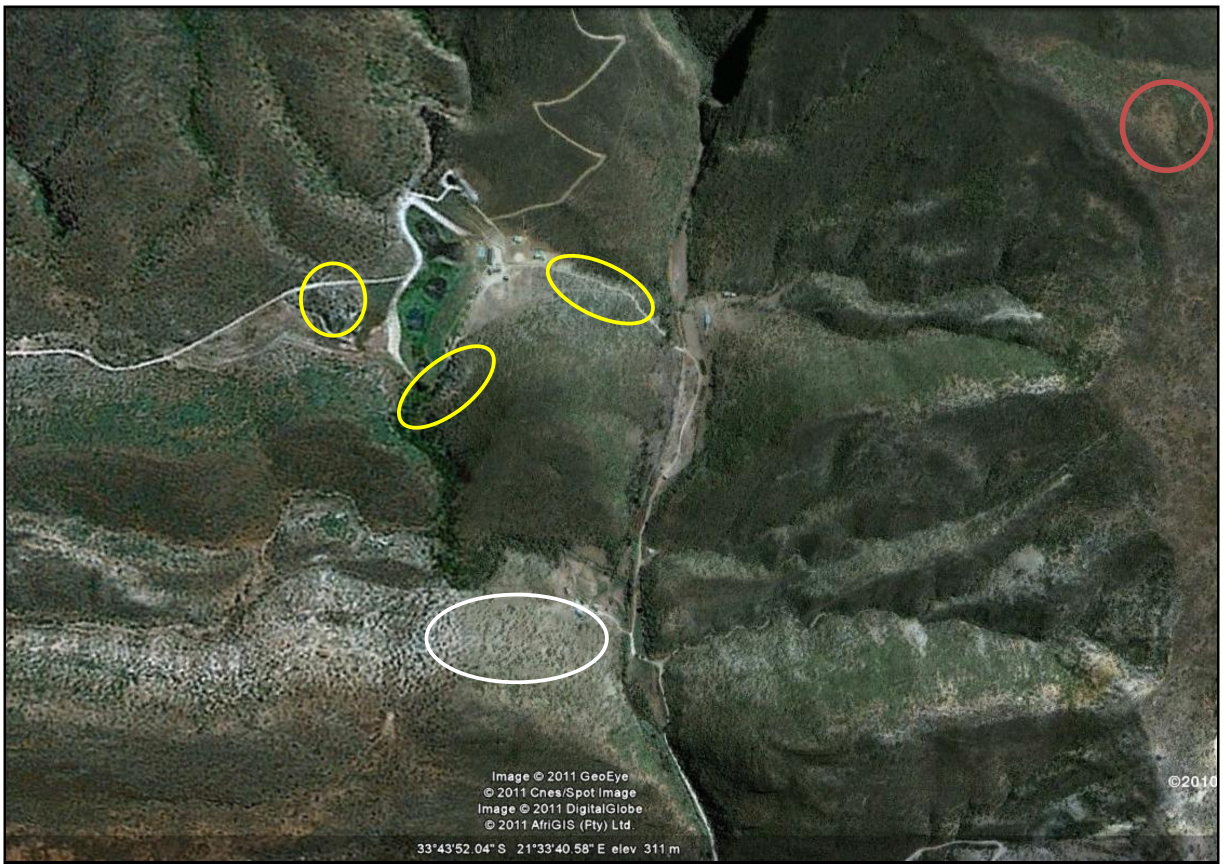

Fig. 14. Detailed Google Earth satellite image of the Rooiberg Lodge area, Assegaay Bosch, showing location of productive fossil sites in the Gydo Formation (Yellow ellipses). Sparsely fossiliferous, highly cleaved mudrocks of the Voorstehoek Formation are exposed in the next valley to the south (white ellipse). The gently-sloping, fairly flat surface seen to the east is a pediment surface capped with silcretised gravels of the Grahamstown Formation (Tg, See Fig. 23). Just to the east of this gravel capping is exposed a substantial deposit of manganese ore (purple circle, see Fig. 26).

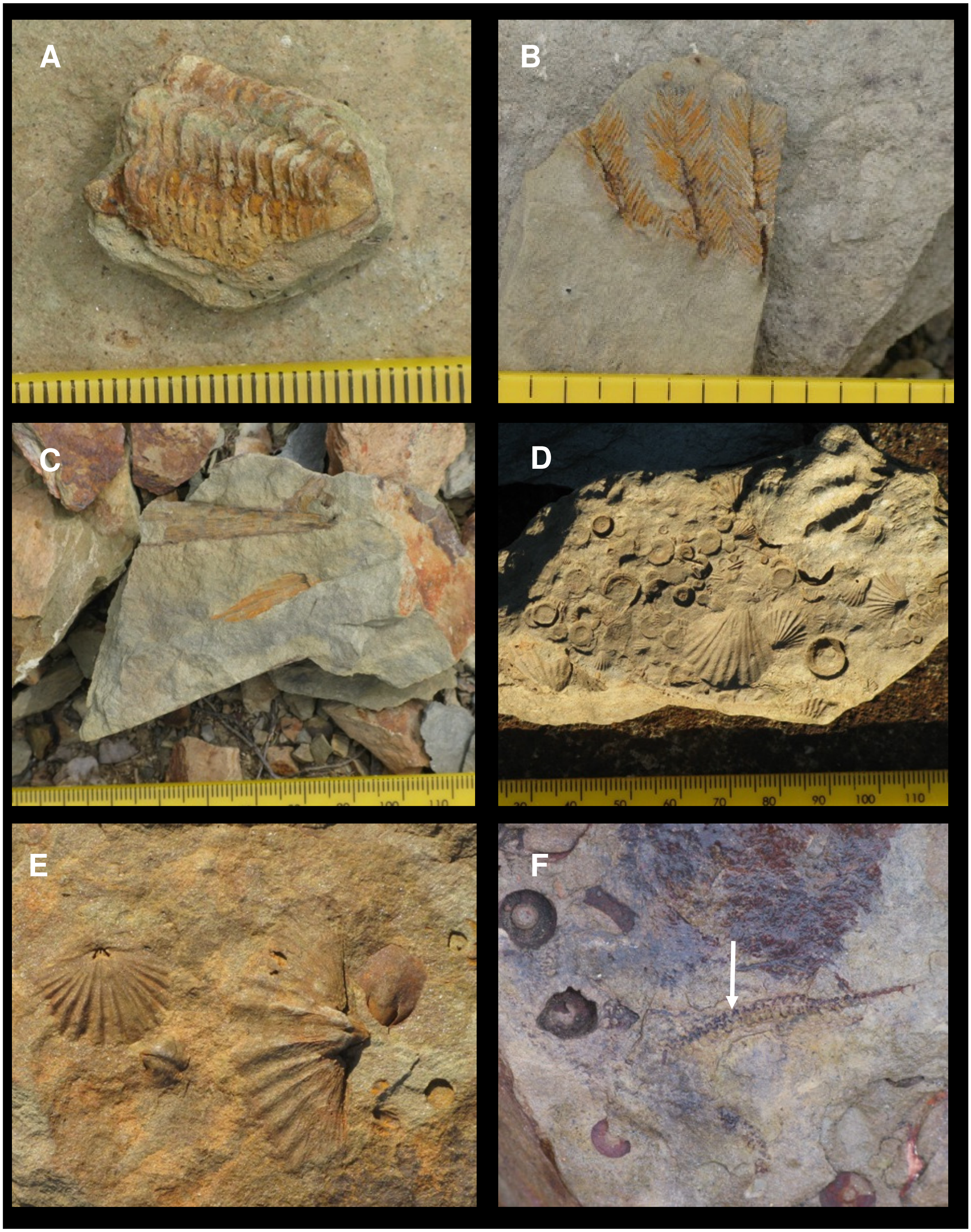

Fig. 15. Selection of Early Devonian shelly fossils from the Gydo Formation at Mont Rouge / Assegaaybosch. A – trilobite *Bainella*; B – exceptional preservation of crinoid filter-feeding arms with intact feathery pinnules; C – rare conical hyolithid tubes; D – storm-winnowed shell bed with disarticulated brachiopods and crinoidal debris; E – diverse articulate brachiopods, from left to right, *Australoceolia*, *Amboceolia*, *Australospirifer* and *Cryptonella*; F – intact but faintly preserved brittle star, a starfish relative (arm arrowed).

4.2.2. Gamka Formation

The sandstone-dominated Gamka Formation (Dga, Early Devonian, Emsian) is characterized by widespread sedimentological evidence for tempestite sedimentation (*e.g.* hummocky and swaley bedforms and cross-lamination) that is commonly associated with storm-generated lenticular *coquinas* of fossil shells. The coquinas are typically dominated by robust-shelled brachiopods *Australospirifer*, *Australocoelia* and *Cryptonella* as well as disarticulated crinoids (*e.g. Othozecrinus*), but more delicate taxa such as chonetids and tentaculitids are also found here. Trilobite fossils are rare, and usually very fragmentary (*e.g.* isolated trunk segments). These Gamka shelly assemblages appear to preferentially rework and concentrate the remains of suspension-feeding communities living in more turbulent, shallow settings on the sea bed (Hiller & Theron 1988, Theron & Thamm 1990). Useful lists of Gamka Formation fossil taxa are provided by Oosthuizen (1984), Theron and Thamm (1990), Gresse and Theron (1992) as well as Theron *et al.* (1995a).

Fig. 16. Prominent ridge of resistant-weathering sandstones of the Gamka Formation just south of the Rooiberg lodge.

The Gamka Formation forms steep-sided ridges and cliffs on the Assegaay Bosch reserve (Fig. 16). These will not be directly impacted by the proposed development of homesteads. Fossil occurrences were not recorded within the Gamka Formation during the present survey, but lenticular, storm-accumulated coquinas (shell beds) dominated by strongly-ribbed brachiopods are very likely to be present here, as recorded in other Little Karoo palaeontological studies, for example at Gamkaberg (Almond 2002) and the Warmwaterberg (Almond 2009a, 2009b).

4.2.3. Voorstehoek Formation

The fossil record of the mudrock-dominated Voorstehoek Formation (Dv, Middle Devonian / Eifelian) has been summarised by Oosthuizen (1984), Almond *et al.* (1996), Gresse and Theron (1992), Theron (2003) and Almond (2008). Generally fossil assemblages in this unit are much sparser and less diverse than in the underlying Gydo Formation, and they are correspondingly less well known. Prolific trace fossil assemblages in the northern outcrop area attest to the presence of a flourishing invertebrate fauna at the time (Almond *in* De Beer *et al*, 2002). Abundant shelly fossils are recorded from mudrocks in the lower half of this stratigraphic unit in the southwestern outcrop area including the Warm Bokkeveld, Matroosberg and Theronsberg Pass region (Theron 1972, Oosthuizen 1984, Gresse & Theron 1992, Theron 2003).

Voorstehoek shelly fossils have often been concentrated by storm winnowing and currents into thin shelly lenses or *coquinas*. Fossil biotas are dominated by shelly invertebrates such as trilobites, articulate brachiopods, crinoids, ophiuroids, bivalves, bellerophontid “gasteropods”, orthocone nautiloids, and problematic conical-shelled groups such as hyolithids and tentaculitids (Theron 1972, Oosthuizen 1984, Gresse & Theron 1992, Theron 2003, Almond 2008). Heterolithic, tempestite-dominated successions within the Voorstehoek Formation, especially in its northern outcrop area, have yielded rich shallow marine trace fossil assemblages of the *Cruziana* Ichnofacies (Almond 1998, Almond *in* De Beer et al. 2002, Theron 2003, Almond 2008).

The Voorstehoek Formation mudrocks in the Mont Rouge area are extensively cleaved and weathered, as seen in scattered exposures in the next valley due south of the lodge (Loc. 099, Figs. 14, 17). Fossils are present, but sparse and usually highly distorted. The few recognisable taxa recorded within grey-green siltstones here include crinoidal debris, large chonetid brachiopods, as well as probable *Australocoelia* brachiopods (Fig. 18). The palaeontological sensitivity of this formation in the Mont Rouge area is assessed as LOW.

Fig. 17. Grey-green siltstones of the Voorstehoek Formation south of Rooiberg lodge showing pervasive development of a steeply south-dipping cleavage that has distorted or destroyed most of the fossils originally present (Hammer = *c.* 30 cm).

Fig. 18. This lenticles of shelly debris – mainly moulds of disarticulated crinoids and brachiopods – from the Voorstehoek Formation (Loc 099).

4.2.4. Hexrivier Formation

The Hexrivier Formation (Dh) is the "second sandstone" of the Bokkeveld Group of early Middle Devonian (Eifelian) age, *c*. 390-380 Ma. Theron *et al.* (1995) give a detailed technical account of this unit. In general, fossil assemblages from the Hex River Formation tend to be sparser and much less diverse than those recorded from the Gamka Formation (Oosthuizen 1984, Gresse & Theron 1992, Theron *et al.* 1995) but the reason why is still unknown. Few shelly fossils, apart from disarticulated valves of the brachiopod *Australoceolia*, have been recorded from the western outcrop area. Monospecific assemblages of the small articulate brachiopod *Derbyina* are exposed in buff-weathering, impure sandstones of the Hexrivier Formation in the Little Karoo (Almond 2009a, 2009b). They may represent original "patch reefs" of filter-feeding shells on the seabed rather than storm-concentrated death assemblages, but more detailed taphonomic studies (*e.g.* of shell orientation and population structure) would be necessary to establish this. Most shells are preserved parallel to the bedding, not edge-on, and they are tightly packed to overlapping. The Hexrivier *Derbyina* shelly lenticles are probably the palaeoecological equivalent of the *Australospirifer* – dominated shell banks of the Gydo and Gamka Formations of the central and western Bokkeveld outcrop areas. Oosthuizen (1984) records a more diverse shelly faunule from the Hex River Formation at Warmwaterberg in the western Little Karoo, but the stratigraphic position of this assemblage requires confirmation. Taxa recorded here include the trilobite *Phacopina*, mutationellid brachiopods, tentaculitids and a possible crinoid stem. In the Cederberg the Hex River Formation has yielded a small range of trace fossils (vertical worm and bivalve burrows, *Skolithos* and *Lockeia*, as well as simple horizontal walled burrows, *Palaeophycus*) and primitive forking vascular plants or psilopsids (Oosthuizen 1984, Almond 2008).

No fossils were recorded within the Hexrivier Formation at Mont Rouge where it builds a prominent rocky ridge just north of the Vanwyksdorp – Rooiberg Pass road (Fig. 7, left hand side) . Shelly lenticles of *Derbyina* are probably present here, however, since they are reported from the northern slopes of the Gamkaberg (Almond 2005a). The palaeontological sensitivity of this formation in the Mont Rouge area is assessed as LOW, and there are no homestead sites proposed within its outcrop area.

4.2.5. Tra Tra Formation

Shelly fossils from the Tra Tra Formation are generally much more scarce and impoverished than in the Gydo and Voorstehoek Formations. The only area in the Western Cape where diverse marine invertebrate assemblages have been recorded from this unit is on or near the Wageboomberg / Theronsberg Pass near Ceres (Oosthuizen 1984, Gresse & Theron 1992). Some doubts remain, however, about the stratigraphic position of Oosthuizen's fauna which may actually come from lower down within the Bokkeveld succession (Almond 2008). A low diversity shelly invertebrate assemblage from the Tra Tra Formation of the Little Karoo (Sanbona Nature Reserve and Anysberg Reserve) has recently been recorded by Almond (2009a, *plus* unpublished observations, 2011). Fossil moulds here comprise a small range of bivalves (*Palaeoneilo Nuculites* and unidentified forms), plectonotid bellerophontids, orbiculoid inarticulate brachiopods, occasional articulate brachiopods, disarticulated crinoids, tentaculitids and simple, horizontal, mud-lined, secondarily-mineralised burrows. A small variety of trace fossils, including rare rusophycid burrows attributed to homalonotid trilobites, as well as fragmentary vascular plant remains are also recorded from the Tra Tra Formation in the Worcester sheet area (Gresse & Theron 1992, Almond unpublished. obs.).

There are extensive exposures of Tra Tra Formation mudrocks and thin sandstones in several borrow pits and roadcuttings along the Rooiberg Pass road; indeed, this is the best-exposed formation within the Bokkeveld Group in the study area. At all the localities visited the Tra Tra mudrocks were deeply weathered (pale grey to lilac hues) and cut by a steep south-dipping cleavage, destroying almost all traces of fossil remains within these rocks that were once mainly associated with the original bedding planes (Fig. 19). Numerous irregular-shaped, purplish ferruginous veins and concretions are present within the weathered mudrocks. At least some of these appear to be pseudomorphs after fossil burrows and infills of shell moulds. Rare examples of the latter include barely-recognisable remains of a homalonotid trilobite (probably *Burmeisteria*; Fig. 20) and possible articulated crinoids. The overall palaeontological sensitivity of this formation in the study area is LOW. Furthermore, the Tra Tra rocks have already been extensively disturbed by road development and no homestead sites have been proposed for their outcrop area.

Fig. 19. Typical roadcutting through the Tra Tra Formation on the Vanwyksdorp – Rooiberg Pass road showing the pervasive, steeply south-dipping cleavage and purplish ferruginous veins reflecting deep chemical weathering in Tertiary times (Hammer = *c.* 30 cm) (Loc. 085).

Fig. 20. Purplish ferruginous infill of a fossil mould – barely recognisable as the posterior trunk segments and tapering pygidium (tail shield) of a homalonotid trilobite – within deeply weathered mudrocks of the Tra Tra Formation (Loc. 084).

4.2.6. Boplaas Formation

Although these sediments were deposited in a shallow marine setting, the known fossil record of the Boplaas Formation is very sparse. Typical Devonian shelly invertebrates such as trilobites, brachiopods, crinoids *etc* are rare; the only Little Karoo fossil records are gastropods (snails) and brachiopods (lamp shells) from the uppermost Boplaas Formation east of Meiringspoort (Theron 1972, Basson *et al*. 1995). Trace fossils generated by infaunal (sediment-dwelling) invertebrates are common, including the ichnogenera *Teichichnus* and the gardening-burrow *Spirophyton* among others (Theron 1972, Oosthuizen 1984). High levels of bioturbation occur in the lower part of the formation, giving mottled, micaceous sandstones. Bedding planes covered with small fragments of primitive vascular plants, including lycopods (club mosses) and possibly psilopsids (primitive forked land plants), are recorded widely, especially in the west (*e.g.* Fig. 22 from the western Little Karoo; see also illustrations and descriptions in Plumstead 1967, pl. 3, Anderson & Anderson 1985, Basson *et al.* 1995, De Beer *et al*. 2002). Indeed, Basson *et al.* (1995) state that the Boplaas Formation outcrop south of 34°S is identified mainly on basis of the abundant fragmentary plant remains. This terrestrial plant material was presumably washed down rivers in flood from the continental hinterland, initially forming rafts of floating debris which eventually became waterlogged and sank to the sea bed, to be preserved in dense layers on sandy bedding planes. Given the widespread occurrence of this phenomenon throughout the formation outcrop area, huge influxes of plant debris from a well-vegetated continental hinterland are implied in Boplaas times, the cause as yet unknown.

Many of the proposed homestead sites in the southern sector of Mont Rouge, as well as the new golf course development, are located within the outcrop area of the Boplaas Formation (Figs. 3, 10). Examination of intermittent bedrock exposures (*e.g.* borrow pit at Loc. 091) shows that the mudrocks here are generally highly cleaved and weathered (see pale grey to lilac colours typical of kaolinitic weathering in Fig. 21), with irregular ferruginous inclusions that may represent replacements of trace or body fossils. Flatter-lying areas suitable for development are widely covered in a mantle of unfossiliferous High Level Gravels. The overall palaeontological sensitivity of this formation in the study area is assessed as LOW (*cf* also desktop report by Almond 2011).

Fig. 21. South-dipping succession of the Boplaas Formation (probably also in part equivalent to the Waboomberg Formation) showing alternation of pale, deeply-weathered mudrocks and darker cleaved sandstones. The pediment surface overlying Boplaas rocks in the foreground is mantled in quartzitic High Level Gravels.

Fig. 22. Boplaas Formation sandstones showing typical abundant, brownish-coloured rectangular impressions that are interpreted as fragmentary fossil plant stems (Sanbona Nature Reserve, Little Karoo).

4.2.7. Waboomberg Formation

The Waboomberg Formation is of early Middle Devonian age (Eifelian, *c*. 390-395 Ma) and resembles the marine-influenced Ceres Subgroup rather than the remainder of the Bidouw Subgroup in palaeontological terms. Unusually rich and well-preserved faunas of shelly invertebrates have been collected from dark, very fine-grained mudrocks of the lowermost Waboomberg Formation in the western branch of the Cape Fold Belt, for example in the Ceres Tafelberg area, Theronsberg Pass, south of Touwsrivier, and the Sanbona Nature Reserve in the Little Karoo (Theron 1972, Oosthuizen 1984, Gresse & Theron 1992, Almond 2009a). The excellent preservation here of fully-articulated trilobites (notably *Metacryphaeus venustus*), intact echinoderms (*e.g.* brittle stars, crinoids, carpoids) and several groups of delicate, rare invertebrates (*e.g.* ostracods, bryozoans) is attributed to sudden smothering of living seabed communities by a blanket of fine-grained, anoxic mud, a process technically known as *obrution*. The association of sparse, predominantly small-bodied invertebrates with black, highly pyritic mudrocks points to intermittent sea floor anoxia.

As discussed in Section 3 above, the large area in the southern part of the Mont Rouge reserve that is assigned to the Boplaas Formation is probably in part equivalent to the Waboomberg Formation. The potentially fossiliferous mudrocks seen here are generally highly cleaved and deeply weathered (See Fig. 21). Their palaeontological sensitivity if therefore considered to be LOW.

4.2.8. Karies Formation

Due in part to the normally poor exposure of these recessive-weathering mudrocks, the fossil record of the Karies Formation is very sparse. Some of the fossil vascular plants – notably lycopods and possible primitive psilopsids - described by Plumstead (1977) and Chaloner *et al.* (1980) from the Traka Subgroup probably came from the upper part of this unit. Anderson and Anderson (1985, p. 20) indicate marine invertebrates for the Karies Formation, but the source of this record is unclear and in this particular case it may be an error (perhaps a misinterpretation of non-marine bivalves). However, some marine fossils are certainly to be expected here, given the stratigraphic equivalence of the lower Karies and the fossiliferous Waboomberg Formations. Thin lenticels of storm-winnowed shelly marine fossils were recently recorded from beds assigned to the Karies Formation in the Klaarstroom area (southern margin of the Great Karoo) by Almond (2010). Apart from various trace fossils (vertical and horizontal burrows), faunal elements identified so far in the lowermost Karies beds here include: (a) small nuculid (deposit-feeding) bivalves of the genus *Nuculites*, (b) the larger nuculid *Palaeoneilo*, (c) snail-like plectonotid molluscs, and (d) small, finely-ribbed articulate brachiopods including possible examples of the genera *Rhipidothyris* and *Derbyina*. The occurrence of *Rhipidothyris* is of special interest since this brachiopod has previously only been recorded from the Karoopoort Formation (uppermost Bidouw Subgroup) in South Africa. The genus has been widely recorded from Givetian (Mid Devonian) shallow, relatively warm water, subtidal habitats in South and North America, North Africa, the Middle East and Australia. *Rhipidothyris* post-dates the end of the highly endemic, cool-water Malvinokaffric Faunal Realm that prevailed in southwestern Gondwana throughout the earlier part of the Devonian Period, belonging rather to the more cosmopolitan, warmer water Old World Faunal Realm of the later Devonian (Boucot & Theron 2001).

The Karies Formation sediments in the Mont Rouge area are highly weathered, cleaved and generally mantled with superficial deposits. Their palaeontological sensitivity is therefore considered to be LOW.

4.3. Late Caenozoic superficial deposits

Sparse fossil remains have been recorded from Tertiary or younger silcretes (*i.e.* silica-cemented pedocretes) of the **Grahamstown Formation** and equivalent deposits by Roberts (2003) and earlier authors. These include a small range of trace fossils (*e.g.* rhizoliths or plant root casts and invertebrate burrows such as *Skolithos*), charophyte algae (calcareous stoneworts), reed-like wetland plants resembling the extant *Phragmites* (*fluitjiesriet*), and reworked Late Permian silicified wood from the Beaufort Group (See also Adamson 1934, Du Toit 1954, and Roberts *et al.,* 1997). Silicified termitaria might also be expected here, although termite activity is inhibited by waterlogged soils that probably prevailed in areas where silcrete formation occured.

Laterally persistent cappings of well-cemented silcrete gravels are developed on some of the higher pediment surfaces in the Assegaay Boschstudy area, such as the gently-sloping surface some 1.5 km east of the Rooiberg lodge (Fig. 14). The silcretised, clast-supported gravels seen here are situated at elevations of some 450 to 420m amsl and up to 3 or more meters thick (In all likelihood they were originally substantially thicker) (Fig. 23). They are composed of grit to boulder-sized clasts of pale Table Mountain Group quartzite, varying from angular to well-rounded, embedded in a finer sandy matrix that may locally shows a prominent conchoidal fracture. Some of the larger clasts (including many down-wasted boulders on the plateau surface) show well-developed rounding and percussion marks indicative of fluvial transport, but there is probably a sizable contribution of more angular colluvial debris as well. Late Tertiary crustal uplift has been responsible for elevating these ancient river deposits some 200m higher than the present-day water courses in this area (Fig. 14). Typically the more chemically-reactive, clay-rich Bokkeveld Group bedrocks beneath the southern extensions of these gravel-capped pediment surfaces have been weathered to multi-hued, easily-eroded saprolite (= *in situ* weathered bedrock) within which well-preserved fossils are rarely found.

In fact, several terrace-like bevelled surfaces along the Rooiberg mountain front host similar mixed alluvial and colluvial gravels which have probably been reworked downslope during multiple phases of uplift and river incision as well as by gravity-driven processes (*e.g.* debris flows). Good examples of reworked coarse gravels infilling steep-sided gullies that have been cut into weak, weathered Bokkeveld bedrocks are seen in local road cuttings (Fig. 24). These poorly sorted, matrix- to clast-supported breccio-conglomerates composed largely of quartzitic clasts are probably of debris flow rather than fluvial origin. More angular colluvial breccias containing abundant cleaved Bokkeveld sandstone clasts as well as reworked quartzitic material are also observed in road cuttings (Fig. 25).

No fossil material was observed within the silcretised gravel cappings or channel-fill colluvial gravels on Assegaay Bosch. The palaeontological sensitivity of all of these coarse-grained superficial deposits is regarded as LOW.

Fig. 23. Sheet-like capping of coarse silcretised gravels capping a pediment surface *c.* 1.5 km east of Rooiberg lodge (Loc. 081) (Hammer = *c.* 30 cm). These ancient alluvial gravels are currently elevated some 200m above the present day drainage systems, reflecting substantial Late Tertiary crustal uplift in the region.

Fig. 24. Poorly-sorted, moderately well-cemented breccio-conglomerates of probable debris flow origin infilling small channels cut into weathered Bokkeveld mudrocks (Loc. 080). The basal gravels here are secondarily ferruginised (Hammer = *c.* 30 cm).

Neogene to Recent **alluvial deposits** may also contain fossil remains of various types. In coarser sediments (*e.g.* conglomerates) these tend to be robust, highly disarticulated and abraded (*e.g.* rolled bones, teeth of vertebrates) but well-preserved skeletal remains of plants (*e.g.* wood, roots) and invertebrate animals (*e.g.* freshwater molluscs and crustaceans) as well various trace fossils may be found within fine-grained alluvium. Human artefacts such as stone tools that can be assigned to a specific interval of the archaeological time scale (*e.g.* Middle Stone Age) can be of value for constraining the age of Pleistocene to Recent drift deposits like alluvial terraces. Ancient alluvial "High Level Gravels" tend to be coarse and to have suffered extensive reworking (*e.g.* winnowing and erosional downwasting), so they are generally unlikely to contain useful fossils.

A wide range of younger superficial deposits of probable Quaternary to Recent age are present in the Assegaay Bosch study area. Good sections through coarse-grained slope deposits (debris flows, scree, slope wash) are well seen in cuttings along the Vanwyksdorp – Rooiberg Pass road (Figs. 24, 25). Thick, well-bedded silty alluvial deposits are exposed in stream cuttings and dongas just north of the same road (Fig. 26) while coarse boulder alluvium is seen along the banks and bed of the Grootrivier as well as its tributaries such as the Bosrivier and Assegaayboschrivier (Fig. 11). Fossils have not been recorded from any of these superficial sediments.

Fig. 25. Poorly-sorted, coarse-grained colluvial breccias infilling an erosional gully cut into weathered Tra Tra Formation bedrocks, cutting on the Vanwyksdorp – Rooiberg Pass road (Loc. 088) (Hammer = *c.* 30 cm).

Fig. 26. Thick succession of well-bedded silty alluvium exposed by donga-erosion just north of the Vanwyksdorp – Rooiberg Pass road.

Of special note is a very substantial deposit of **manganese ore** on Assegaay Bosch, over 100m in N-S extent, that is exposed in an abandoned quarry on the southern slopes of the Rooiberg some 1.4 km ENE of the Rooiberg lodge (33°43' 35.0" S 21°34' 26.0" E). The ore deposit – which is not indicated on the 1: 250 000 Ladismith geological map - is located at *c*. 440m amsl on the eastern edge of an elongate, relictual patch of High Level Gravels (Fig. 14) and is partially capped by ferricretised quartzitic gravels (Fig. 26). The ore consists of the dense, metallic-grey mineral complex *psilomelane* that is actually a mixture of various manganese oxides and shows a range of habits, including massive, botroidal and stalactitic, all of which can be seen at the Assegaay Bosch quarry site. It is associated with a variety of ferruginous ores, including probable goethite and haematite, especially in the upper, weathered zone of the ore body. The quarry was apparently exploited during the Second World War but did not prove commercially viable (Mr P. Coetzee, pers. comm.). Clasts of manganese ore are also seen in surface gravels close to the Mont Rouge lodge to the west and it is quite possible that a number similar ore bodies are present on the southern flanks of the Rooiberg in this area. They are probably associated with local fault systems that channelled hot, mineral-rich ground waters to the surface in the past. Hotspring-related manganese sinters are well-known elsewhere in the Little Karoo, for example at Warmwaterberg and at Toorwater north of Uniondale (*cf* Almond 2002, 2009b).

The impressive Assegaay Bosch manganese deposit is of significant historical / geological heritage interest and is therefore considered worthy of special protection on scientific heritage grounds.

Fig. 26. View southwards along the quarry face cut into the large manganese ore deposit on Assegaay Bosch which is capped by well-cemented quartzitic pediment gravels of probable Tertiary age (Loc. 100).

5. CONCLUSION & RECOMMENDATIONS

The Mont Rouge study area is underlain by an extensive series of Palaeozoic sedimentary formations of the Table Mountain and Bokkeveld Groups (Cape Supergroup), several of which are known to be moderately to highly fossiliferous elsewhere in the Little Karoo. However, in the study area the potentially fossiliferous mudrock-dominated formations are generally deeply-weathered and strongly cleaved so that their original fossil content has been largely destroyed. Furthermore, the Cape Supergroup bedrocks over much of the area are protected by a mantle of superficial deposits such as colluvium (slope deposits), ancient and modern alluvial gravels (some silcretised) as well as silty alluvium and soil. The palaeontological sensitivity of the bedrocks here is consequently low to very low in general. Highly sensitive post-glacial mudrocks of the Cedarberg Formation (Table Mountain Group) crop out on the southern face of the Rooiberg within the Mont Rouge development area. However, their outcrop is largely inaccessible and will not be directly impacted by the proposed development.

During fieldwork fairly diverse and well-preserved shelly marine invertebrate assemblages were recorded from small exposures of less cleaved mudrocks and thin sandstones of the Gydo Formation (basal Bokkeveld Group, Early Devonian) in the northern part of the study area, close to Rooiberg guest lodge. These assemblages include a few rare taxa (*e.g.* hyolithids, patelliform gastropods) as well as specimens of unusually well-articulated echinoderms (*e.g.* crinoids with intact feeding arms, brittle stars) and should replay closer formal palaeontological study. However, most of the Gydo Formation is sparsely fossiliferous due to cleavage and weathering, and impacts of the few proposed homestead developments on fossil heritage in the Gydo outcrop area are regarded as of low significance.

The impact on fossil heritage of the proposed Mont Rouge golf reserve development - including the golf course by the Grootrivier as well as the homesteads scattered over the surrounding area - is consequently regarded as LOW. It is concluded that no further specialist studies or mitigation are required for this development project on palaeontological grounds. Should rich fossil assemblages be exposed during construction, they should be reported to Heritage Western Cape who may require mitigation at the developer's expense.

The impressive Assegaay Bosch manganese deposit on the southern slopes of the Rooiberg, some 1.4 km ENE of Rooiberg lodge (33°43' 35.0" S 21°34' 26.0" E) is of significant historical / geological heritage interest and is therefore considered worthy of special protection on scientific heritage grounds.

6. ACKNOWLEDGEMENTS

Ms John Sharples of Sharples Environmental Services, Cape Town, is thanked for commissioning this study and for providing the necessary background information. Mr Pieter Coetzee kindly took time to discuss the context of the Mont Rouge development and related projects in the Vanwyksdorp area, and generously arranged comfortable accommodation for our team during our field visit. I am especially grateful to Ms Claire Browning, palaeontologist at the Council for Geoscience, for her able assistance in the field and for discussions on Cape Supergroup palaeontology. We both very much enjoyed the hospitality of Jean and Yolanda Vermieren at the Rooiberg guest lodge.

8. REFERENCES

ADAMSON, R.S. 1934. Fossil plants from Fort Grey near East London. Annals of the South African Museum 31, 67-96.

ALMOND, J.E. 1997. Fish fossils from the Devonian Bokkeveld Group of South Africa. Stratigraphy. African Anthropology, Archaeology, Geology and Palaeontology 1(2): 15-28.

ALMOND, J.E. 1998. Trace fossils from the Cape Supergroup (Early Ordovician – Early Carboniferous) of South Africa. Journal of African Earth Sciences 27 (1A): 4-5.

ALMOND, J.E. 2005a. Geology of the Gamkaberg - Rooiberg Conservation Area, Little Karoo, 255pp. Unpublished report for Cape Nature, Natura Viva cc., Cape Town.

ALMOND, J.E. 2005b. Geology of the Aardvark Private Nature Reserve, Little Karoo, 80 pp (including figs.). Natura Viva cc, Cape Town.

ALMOND, J.E. 2008. Palaeozoic fossil record of the Clanwilliam sheet area (1: 250 000 geological sheet 3218). Unpublished report for the Council for Geoscience, Pretoria, 49 pp.

ALMOND, J.E. 2009a. Geology and fossils of the Sanbona Nature Reserve, Little Karoo, 244 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2009b. Proposed extension of the Warmwater Spa on Portions 5 and 8 of farm Uitvlucht 17 near Barrydale (Swellendam District): desktop study, 24 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011. Airstrip on Farm Kleinvlakte No 227 / Portion 1 near Vanwyksdorp, Kannaland Municipal Area, Western Cape Province: desktop study, 9 pp. Natura Viva cc, Cape Town.

ALMOND, J.E., THERON, J.N., ROBERTS, D.K., & AVERY, G. 1996. Fossils sites in the southwestern Cape. Excursion guide, 9th Biennial Conference of the Palaeontological Society of South Africa, 26-27 September, Stellenbosch, 47 pp.

ALMOND, J.E. & PETHER, J. 2008. Palaeontological heritage of the Western Cape (August 2008 draft), 125 pp. Unpublished palaeotechnical report for Heritage Western Cape, 19pp.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp, 226 pls. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

ANDERSON, M.E., ALMOND, J.E., EVANS, F.J. & LONG, J.A. 1999a. Devonian (Emsian-Eifelian) fish from the Lower Bokkeveld Group (Ceres Subgroup), South Africa. Journal of African Earth Sciences 29: 179-194.

ANDERSON, M.E., LONG, J.A., EVANS, F.J., ALMOND, J.E., THERON, J.N. & BENDER, P.A. 1999b. Biogeographic affinities of Middle and Late Devonian fishes of South Africa. Records of the Western Australian Museum, Supplement No. 57: 157-168.

BASSON, W.A., THERON, J.N. & HILL, R.S. 1995. Lithostratigraphy of the Boplaas Formation (Bokkeveld Group). South African Committee for Stratigraphy, Lithostratigraphic Series No.31, 10 pp.

BOUCOT, A.J., CASTER, K.E., IVES, D. & TALENT, J.A. 1963. Relationships of a new Lower Devonian terebratuloid (Brachiopoda) from Antarctica. Bulletins of American Paleontology 46 (No. 207): 81-123, pls. 16-41.

BOUCOT, A.J. & THERON, J.N. 2001. First *Rhipidothyris* (Brachiopoda) from southern Africa: biostratigraphic, paleoecological, biogeographical significance. Journal of the Czech Geological Society 46: 155-160

BROQUET, C.A.M. 1992. The sedimentary record of the Cape Supergroup: a review. In: De Wit, M.J. & Ransome, I.G. (Eds.) Inversion tectonics of the Cape Fold Belt, Karoo and Cretaceous Basins of Southern Africa, pp. 159-183. Balkema, Rotterdam.

CHALONER, W.G., FOREY, P.L., GARDINER, B.G., HILL, A.J. & YOUNG, V.T. 1980. Devonian fish and plants from the Bokkeveld Series of South Africa. Annals of the South African Museum 81: 127-157.

COOPER, M.R. 1986. Facies shifts, sea-level changes and event stratigraphy in the Devonian of South Africa. South African Journal of Science 82: 255-258.

COTTER, E. 2000. Depositional setting and cyclical development of the lower part of the Witteberg Group (Mid- to Upper Devonian), Cape Supergroup, Western Cape, South Africa. South African Journal of Geology 103: 1-14.

DE BEER, C.H., GRESSE, P.G., THERON, J.N. & ALMOND, J.E. 2002. The geology of the Calvinia area. Explanation to 1: 250 000 geology Sheet 3118 Calvinia. 92 pp. Council for Geoscience, Pretoria.

DU TOIT, A. 1954. The geology of South Africa. xii + 611pp, 41 pls. Oliver & Boyd, Edinburgh.

GRESSE, P.G. & THERON, J.N. 1992. The geology of the Worcester area. Explanation of geological Sheet 3319. 79 pp, tables. Council for Geoscience, Pretoria.

HILL, R.S. 1991. Lithostratigraphy of the Baviaanskloof Formation (Table Mountain Group), including the Kareedouw Sandstone Member. South African Committee for Stratigraphy, Lithostratigraphic Series No 12, 6 pp. Council for Geoscience, Pretoria.

HILLER, N. & THERON, J.N. 1988. Benthic communities in the South African Devonian. In: McMillan, N.J., Embry, A.F., & Glass, D.J. (Eds.) Devonian of the World, Volume III: Paleontology, Paleoecology and Biostratigraphy. Canadian Society of Petroleum Geologists, Memoir No. 14, pp 229-242.

HOEG, O.A. 1930. A psilophyte in South Africa. Det Kongelige Norske Videnskabers Selskab Forhandlinger Band III (24), 92-94.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo Sequences in the Eastern Cape Province. 336 pp. Unpublished PhD thesis, Rhodes University, Grahamstown.

JOHNSON, M.R. (Ed.) 1994. Lexicon of South African stratigraphy. 56 pp. Council for Geoscience / South African Committee for Stratigraphy, Pretoria.

MACRAE , C. 1999. Life etched in stone. Fossils of South Africa, 305 pp. The Geological Society of South Africa, Johannesburg.

OOSTHUIZEN, R.D.F. 1984. Preliminary catalogue and report on the biostratigraphy and palaeogeographic distribution of the Bokkeveld Fauna. Transactions of the Geological Society of South Africa 87: 125-140.

PLUMSTEAD, E.P. 1967. A general review of the Devonian fossil plants found in the Cape System of South Africa. Palaeontologia africana 10: 1-83, 25 pls.

PLUMSTEAD, E.P. 1977. A new phytostratigraphical Devonian zone in southern Africa which includes the first record of *Zosterophyllum*. Transactions of the Geological Society of South Africa 80: 267-277, pls. 1-2.

ROBERTS, D.L. 2003. Age, genesis and significance of South African coastal belt silcretes. Council for Geoscience Memoir 95, 61 pp. Pretoria.

ROBERTS, D.L., BAMFORD, M. & MILLSTEED, B. 1997. Permo-Triassic macro-plant fossils in the Fort Grey silcrete, East London. South African Journal of Geology 100, 157-168.

ROSSOUW, P.J., MEYER, E.I., MULDER, M.P. & STOCKEN, C.G. 1964. Die geologie van die Swartberge, Die Kangovallei en die Omgewing van Prins Albert, K.P. Explanation to Sheets 3321B (Gamkapoort) and 3322A (Prince Albert), with a summary in English. 96pp, 2 pls. Geological Survey / Council for Geoscience, Pretoria.

RUBIDGE, B.S., DE KLERK, W.J. & ALMOND, J.E. 2008. Southern Karoo Margins, Swartberg and Little Karoo. Palaeontological Society of South Africa, 15th Biennial Meeting, Matjiesfontein. Post-conference excursion guide, 35 pp.

TANKARD, A.J. & BARWIS, J.H. 1982. Wave-dominated deltaic sedimentation in the Devonian Bokkeveld Basin of South Africa. Journal of Sedimentary Petrology 52, 0959-0974.

THAMM, A.G. & JOHNSON, M.R. 2006. The Cape Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 443-459. Geological Society of South Africa, Marshalltown.

THERON, J.N. 1972. The stratigraphy and sedimentation of the Bokkeveld Group. Unpublished DSc thesis, University of Stellenbosch, 175pp, 17pls.
THERON, J.N. 1999. Lithostratigraphy of the Gydo Formation (Bokkeveld Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 33, 11 + 1 page erratum.

THERON, J.N. 2003. Lithostratigraphy of the Voorstehoek Formation (Bokkeveld Group). South African Committee for Stratigraphy Lithostratigraphic Series No. 38, 11 pp.

THERON, J.N. & LOOCK, J.C. 1988. Devonian deltas of the Cape Supergroup, South Africa. In: McMillan, N.J., Embry, A.F. & Glass, D.J. (Eds.) Devonian of the World, Volume I: Regional syntheses. Canadian Society of Petroleum Geologists, Memoir No. 14, pp 729-740.

THERON, J.N. & THAMM, A.G. 1990. Stratigraphy and sedimentology of the Cape Supergroup in the Western Cape. Guidebook, Geocongress '90, Geological Society of South Africa, PR2, pp1-64.

THERON, J.N. & JOHNSON, M.R. 1991. Bokkeveld Group (including the Ceres, Bidouw and Traka Subgroups). Catalogue of South African Lithostratigraphic Units 3: 3-5.

THERON, J.N., WICKENS, H. DE V. & GRESSE, P.G. 1991. Die geologie van die gebied Ladismith. Explanation to 1: 250 000 geology sheet 3320, 99 pp. Council for Geoscience, Pretoria.

THERON, J.N., BASSON, W.A. & HILL, R.S. 1995a. Lithostratigraphy of the Gamka Formation (Bokkeveld Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 29, 13 pp.

THERON, J.N., HILL, R.S. & BASSON, W.A. 1995b. Lithostratigraphy of the Hex River Formation (Bokkeveld Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 30, 9 pp.

8. GPS DATA FOR LOCALITIES

GPS locality data is given in the table below for all localities mentioned by number in the text.

Locality data was captured on a hand-held Garmin GPSmap 60CSx instrument to an accuracy of *c*. 3m.

GPS LOCALITY NO.	SOUTH	NORTH
80	33º 44' 15.5"	21º 34' 31.2"
81	33º 44' 07.3"	21º 34' 25.1"
84	33º 44' 21.9"	21º 35' 22.0"
85	33º 44' 16.1"	21º 35' 15.1"
88	33º 44' 18.5"	21º 34' 11.9"
90	33º 43' 44.4"	21º 33' 47.4"
91	33º 44' 45.9"	21º 31' 48.2"
93	33º 43' 42.3"	21º 33' 21.9"
94	33º 43'44.4"	21º 33' 23.0"
95	33º 43' 47.0"	21º 33' 31.9"
96	33º 43' 47.9"	21º 33' 31.9"
99	33º 44' 03.1"	21º 33' 32.5"
100	33º 43' 35.0"	21º 34' 26.0"

9. 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 APHAP (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 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
***Natura Viva* cc**