Report on the Geology/Palaeontology of the Gavin Plaas Development

23 March, 2008

by

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and

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1. INTRODUCTION

The area in question (Figures 1 & 2) is hereafter referred to as ‘Gavin Plaas’ and is situated on the lower west coast, east of the town of Vredenburg. The region in general is highly sensitive in terms of the palaeontologically/archaeologically rich Cenozoic sedimentary strata (Table 1) which blanket the area (Coetzee and Rogers, 1982; Tankard, 1974; Hendey, 1981). Moreover, the area is situated adjacent to the world renowned West Coast Fossil Park (Figure 1). Therefore, it is essential to be aware of the distribution, thickness and depth below surface of the various Cenozoic formations where any undertaking involving subsurface disturbance is envisaged. Providing a geological framework of the area around Gavin Plaas facilitates an assessment of the likelihood of disturbing, damaging, or destroying invertebrate, vertebrate and trace fossils in the course of any excavation on the proposed site.

SANDVELD GROUP			
Formation	**Age**	**Lithology**	**Genesis**
Langebaan	Middle to Late Pleistocene	Calcarenites	Aeolian
Velddrif	Middle to Late Pleistocene	Shelly muds, sands and gravels	Shallow marine
Varswater	Early Pliocene	Sands and gravels	Marginal marine
Elandsfontyn	Miocene	Gravels, sands and carbonaceous sediments	Fluvio-estuarine

Table 1. Lithostratigraphy of coastal Cenozoic sediments of the southern west coast (Roberts et al., 2007).

2. Scope and Methodology

The Council for Geoscience and Iziko Museum, Cape Town were requested by New World Associates to conduct a geological/palaeontological sensitivity study as part of an Heritage Impact Assessmenton on Gavin Plaas, an area of some 1323 Ha situated mainly on the farm Langeberg (Figures 1 & 2). The *modus operandi* includes the acquisition and interpretation of borehole and field data, consultation of geological maps, as well as a field investigation. From these data a detailed geological map of Gavin Plaas and surrounds was compiled, further illustrated by cross-sections (Figures 2A, B & C).

3. STRATIGRAPHY AND PALAEONTOLOGY

3.1 Elandsfontyn Formation

3.1.1 Stratigraphy

The Elandsfontyn Formation is the oldest Cenozoic unit present in the region. Borehole G 30878 on the farm Elandsfontyn 349, Hopefield District, was chosen as the holostratotype for this formation (Rogers, 1982), since no surface occurrence was known. The formation occupies palaeo-depressions in neo-Proterozoic bedrock and is typically conformably to unconformably overlain by the Mio-Pliocene Varswater Formation (Roberts, 2006). The formation comprises upward-fining sequences of angular, fine- to coarse-grained, quartzose sand, gravel, clay, and lignite, recording meandering river sedimentation (Rogers, 1980, 1982; Dingle et al., 1983). Sedimentation relates mainly to the rising Miocene eustatic sea levels.

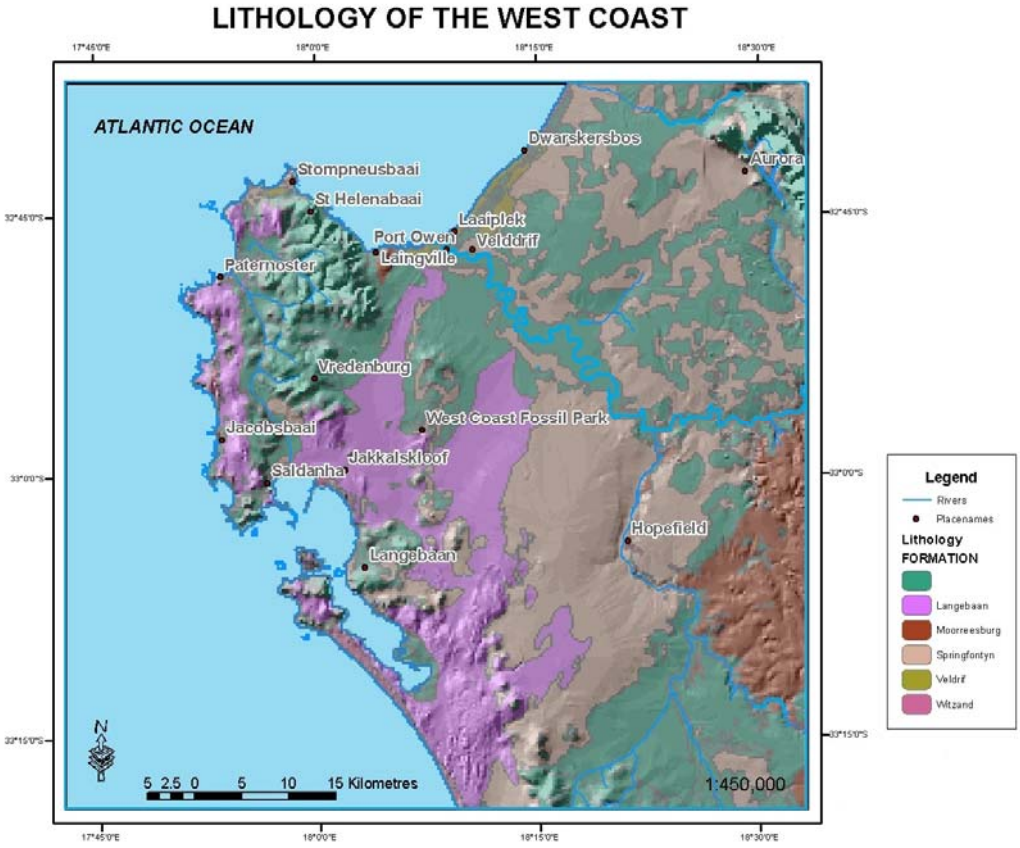

Figure 1. Locality and general geological map. Note the extensive dune plumes of the Pleistocene Langebaan Formation (purple), reaching to Gavin Plaas (red square)situated adjacent to the West Coast Fossil Park.

3.1.2 Palaeontological sensitivity

The formation occurs extensively on Gavin Plaas, reaching thicknesses of up to ~50 m. The carbonaceous horizons are polleniferous, indicating Middle to Late Miocene deposition in a subtropical climate where palms were well represented (Coetzee and Rogers, 1982; Coetzee, 1986; Cole and Roberts, 1996, 2000), and as such provides valuable windows into past vegetation and climates. Because it is deeply buried by younger formations, it is unlikely to be encountered in the

course of excavations on Gavin Plaas (Figs 2a, b).The palaeontological sensitivity of the Elandsfontyn Formation is regarded as moderate.

3.2 Varswater Formation

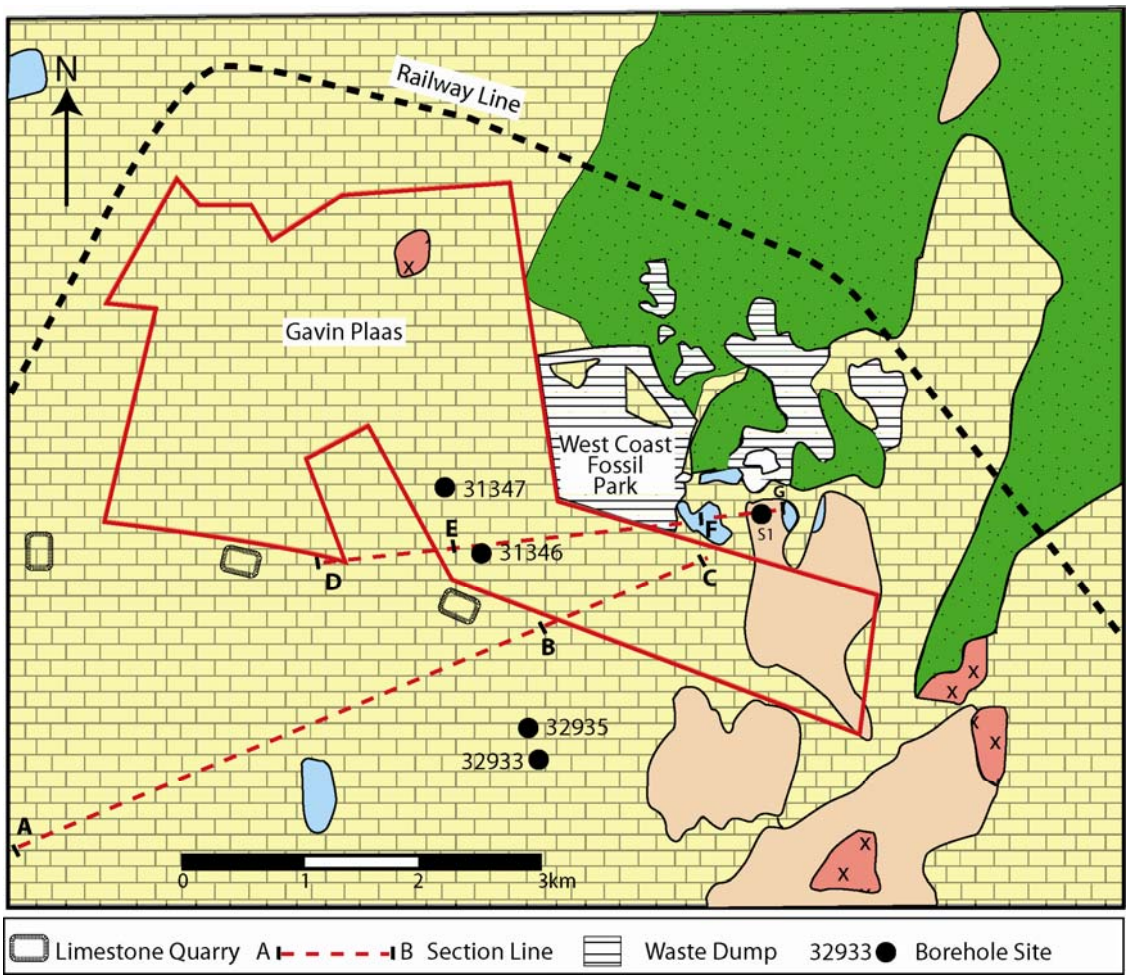

Figure 2A . Geological map of Gavin Plaas and surrounds. For regional context see Figure 1 and for the geological legend, see figure 2 B. Most of the area is underlain by the Quaternary Langebaan Formation aeolianites.

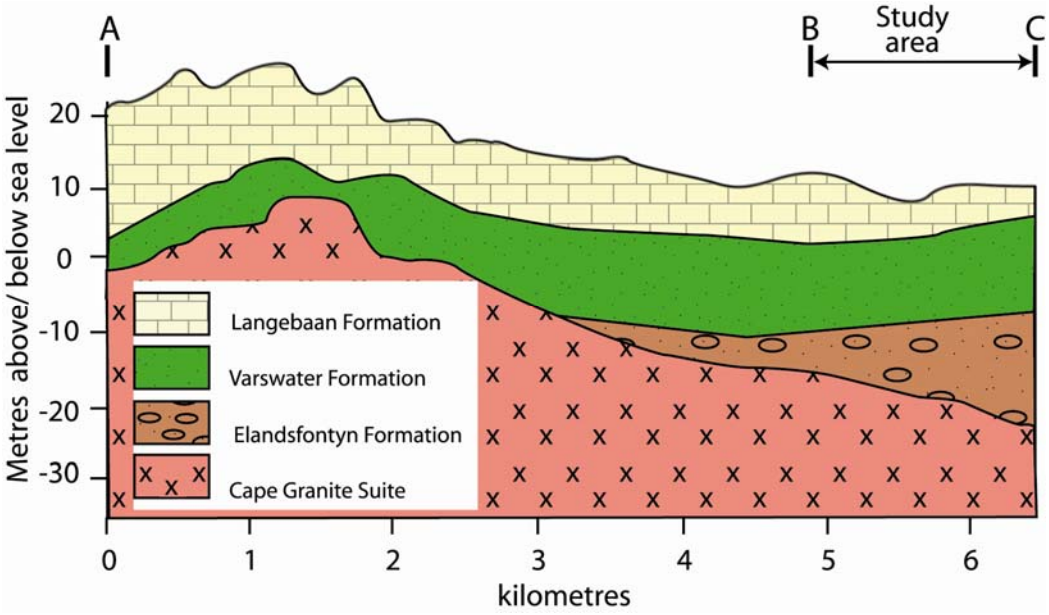

Figure 2B. Cross section showing the typical subsurface geology of Gavin Plaas. For location of the section, see Figure 2A.

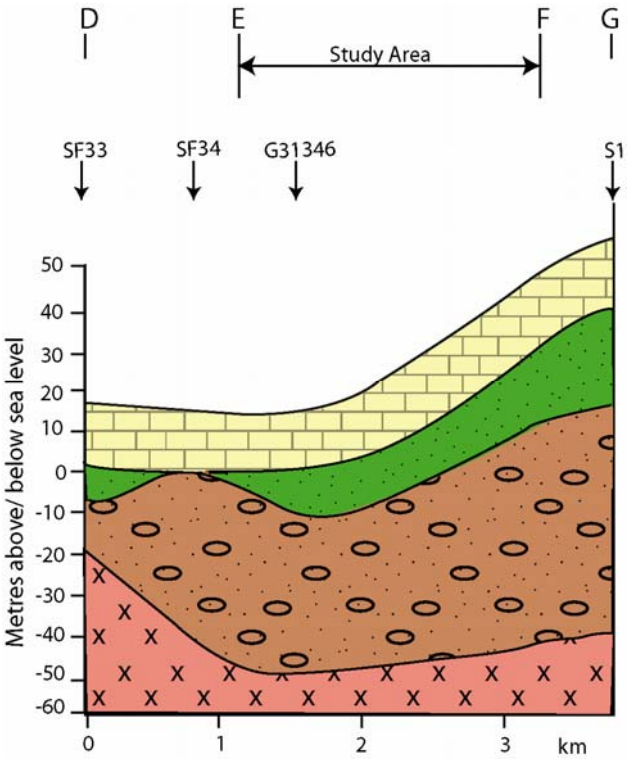

Figure 2C. Cross section showing the typical subsurface geology of Gavin Plaas. For location of the section, see Figure 2A.

3.2.1 Stratigraphy

The Varswater Formation was named by Hendey (1970) and the type section at New Varswater Quarry, Langebaanweg, was described by Tankard (1974). Further investigations have been made by Hendey (1976, 1981a, 1981b), Dingle et al. (1979) and Rogers (1980, 1982,), the latter making use of extensive borehole data. The Varswater Formation attains thicknesses of up to 60 metres and unconformably to conformably overlies older Miocene units (Elandsfontyn Formation) or pre-Cenozoic bedrock (Rogers, 1980). It is distinguished in cores by the presence of phosphate and rounded clasts (Rogers, 1980, 1982; Theron et al., 1992).

Descriptions of the four Members recognised in the Varswater Formation (Roberts, 2006), together with their probable age and thicknesses are provided in Figures 2 B, C and 3. The components of the formation include the Langeenheid Clayey Sand Member, Konings Vlei Gravel Member and Langeberg Quartzose Sand Member and Muishond Fontein Peletal Phosphorite Member (MPPM). These members cannot usually be distinguished in borehole logs and the general term Varswater Formation is embraces these units in cross-section A. Better borehole control is available for cross-section Gavin Plaas and members are shown here.

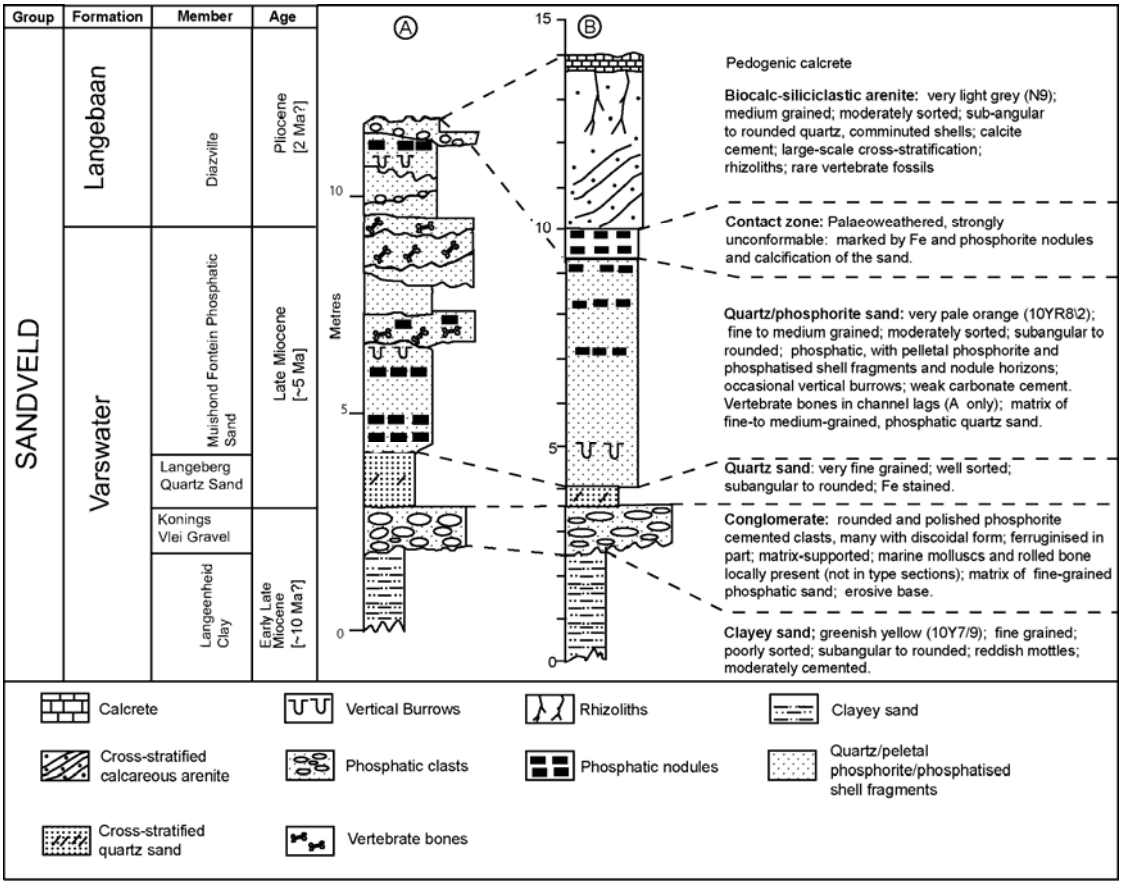

Figure 3 . Type sections of the Varswater Formation in the northern face of E Quarry. A) the section at the excavated fossil exposures; B) the section at the 'Highwall' 200 m west of the fossil exposures.

The Langeenheid Clayey Sand Member rests on the Neogene (fluvial) Elandsfontyn Formation and contains red ferruginous mottles suggestive of palaeoweathering prior to deposition of the overlying units. The member resembles estuarine deposits of the nearby Berg River and its stratigraphic context (overlying fluvial sediments) supports this interpretation.

The Konings Vlei Gravel Member (Fig. 3) comprises brownish, spherical to discoidal, mainly well-rounded and polished phosphorite clasts up to 0.6 m in diameter. It is partly ferruginised and the matrix comprises slightly silty sand with pelletal phosphorite and yellowish phosphatised shell fragments. Coquinite (shelly deposits) is present in the southwest of E Quarry and the member is

considered to a represent a high energy beach facies (Tankard, 1974; Dingle et al., 1979; Rogers, 1980, 1982; Hendey, 1981b). The Konings Vlei Gravel Member is probably early Late Miocene in age from sparse fossil evidence (Hendey, 1981) and since this unit rests unconformably on the lowermost unit of the formation (Langeenheid Member), the latter must be notably older.

The Langeberg Quartzose Sand Member is only 1-2 m thick (Figures 2 B & 3), but is laterally persistent, consisting of very fine- to medium-grained, moderately sorted quartzose sand. Phosphorite is generally absent and the unit is iron stained in part. Hendey (1981, a,b) considered the member to be fluvial in origin, but it may also have arisen from surficial leaching of phosphate.

The Muishond Fontein Peletal Phosphorite Sand Member comprises fine- to coarse-grained, moderately sorted, light brownish grey, phosphatic quartzose sand (Smith, 1971; Tankard, 1974). The sand has a pronounced bimodal size distribution with an angular to subangular fine sand component mixed with an angular to rounded, medium- to coarse fraction (Smith, 1971). The sand is generally massive, although fine laminae defined by variations in phosphate content occur sporadically (Fig. 4). The phosphatic material is of two kinds: (1) coarse-grained, amber-coloured shell fragments comprising carbonate apatite and (2) pelletal phosphorite (Smith, 1971; Rogers, 1980; 1982). The member is generally soft and weakly cemented by calcareous material but is locally hard and well cemented by phosphorite, forming lenses that extend laterally for up to 300 m. The member ranges up to ~8 m in thickness and is regarded as Mio-Pliocene in age based on fossil evidence (Figs 3 & 5).

The geological history of the fossil-bearing deposits at Langebaan Road is complex, involving repeated fluctuations in sea level. Consequently, multiple sedimentary settings are represented, including shallow marine, estuarine, marsh and fluvial. The Langeenheid Clayey Sand Member records the transition from fluvial to estuarine conditions during transgression, following the fluvial deposition of the Elandsfontyn Formation. The Konings Vlei Gravel Member represents a marine- reworked phosphatic horizon (itself recording an earlier transgression)

during a + 30 m stillstand of the Late Miocene regression (Hendey, 1981a, 1981b; Rogers, 1982).

The phosphate was produced authigenically as a result of upwelling within the cold Benguela Current system (Rogers, 1980) and the pelletal form probably represents phosphatisation of faecal pellets and precipitation in interstitial spaces between grains (Middleton, 2000, 2003). The contact between the Late Tertiary Varswater succession and the overlying Quaternary aeolianites is superbly revealed in the Highwall, ~200 m west of the fossil site (Fig. 6). The intense pedogenesis (soil forming processes) of the MPPM involving ferruginisation, calcification and phosphatisation witnesses the long time break (~5 Ma) in deposition of the two units.

3.2.2 Palaeontological sensitivity

The Late Tertiary Varswater succession formation occurs extensively on Gavin Plaas, reaching thicknesses of up to ~20 m, but is more typically a few meters thick. It probably pinches out in the vicinity of basement highs. It is everywhere blanketed by the Langebaan Formation and is seen only as exposures in old mine and prospecting excavations in the West Coast Fossil Park.

The prolific fossil site known as Langebaanweg (now within the West Coast Fossil Park) was discovered during phosphate mining operations which started at Baard's Quarry in 1943 and which later moved to "C' and "E" Quarries in the 1960's. Langebaanweg's importance as a fossil site was only realized by local and international scientists in 1958 (Hendey 1981a,b) when the first fossils discovered in Baard's Quarry were described. The prolific bonebeds of Langebaanweg 'E' Quarry soon established the site as a fossil site of world-wide significance. It offers one of the largest collections of Mio-Pliocene fossils in Africa and contains an extremely rich and diverse range of over 230 vertebrate and invertebrate taxa. Langebaanweg is capable of providing key information to

understanding the evolution of the present-day West Coast ecosystem as it is among the earliest sites from which fynbos pollen has been recovered. The site offers a unique insight into the evolution of modern fauna and flora during a period when many relict Tertiary taxa are found together with genera which inhabit the southwestern Cape, and southern Africa, today.

In the Western Cape, large gaps exist in our knowledge of climate change, its environmental impact over time, and its relationship to global events. Due to the excellent preservation and richness of the Langebaanweg site, comparative studies of ancient environments and biodiversity is possible over a 20 million year time interval providing information vital for reconstructing the evolution of West Coast ecosystems.

The palaeontological sensitivity of the Varswater Formation which occurs in the subsurface of Gavin Plaas is regarded as very high and should only be excavated under expert supervision.

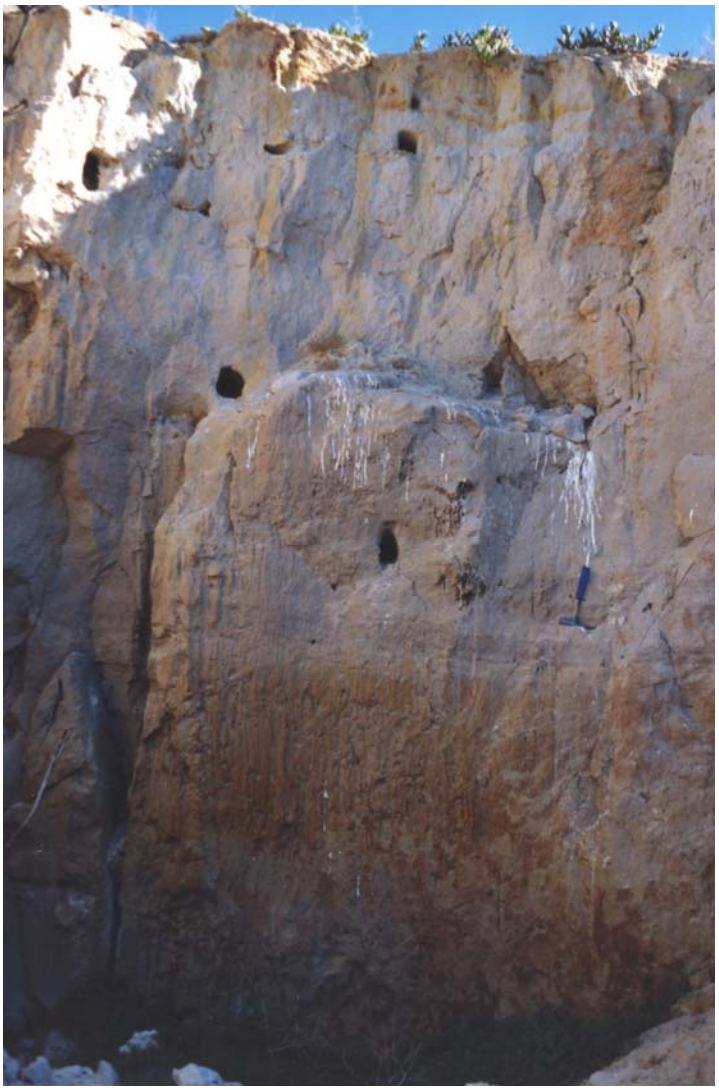

Figure 4. Fine laminae defined by variations in phosphate content are visible in the MPPM (below hammer). The upper part of the succession is leached of phosphate and mottled by meteoric waters. Birdhide, E Quarry.

Figure5. Sivathere (giraffid) fossils in the MPPM; fossil excavation, E Quarry (see Fig. 3 for stratigraphic context).

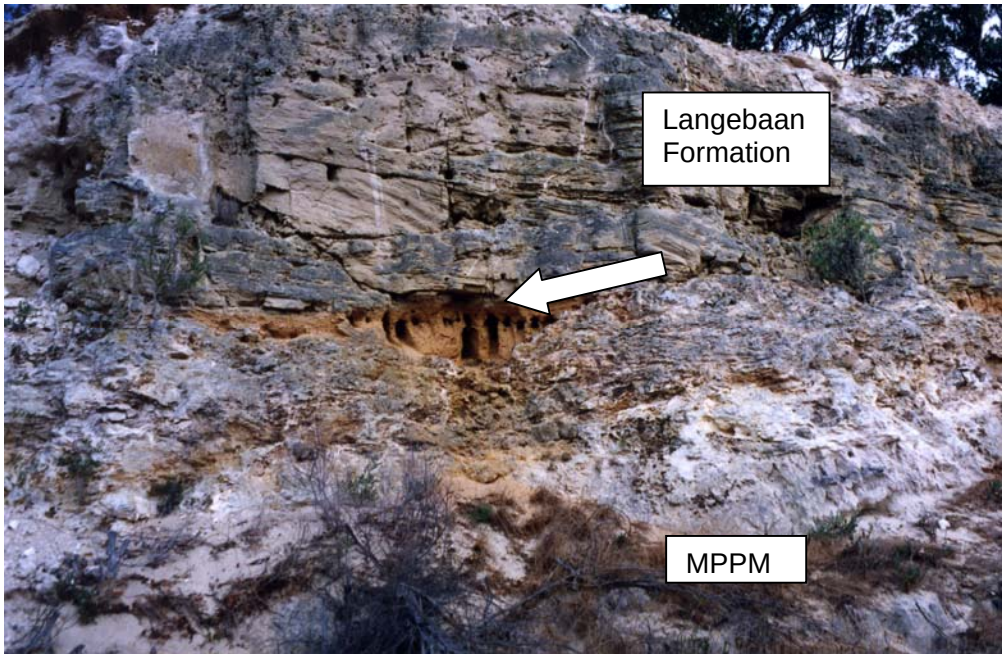

Figure 6. Intense pedogenesis (soil forming processes) in the MPPM involving ferruginisation (arrowed), calcification and phosphatisation, which took place prior to the influx of coastal calcareous sand dunes, now the cross-bedded Langebaan Formation.

The Varswater Formation was deposited in topographic lows, probably carved by fluvial activity during sea level lowstands. At Gavin Plaas, the highest elevation of the Varswater Formation is ~45 m above mean sea level (amsl), whereas at Elandsfontyn to the south it reaches ~80 m amsl. These high elevations may correlate with global sea levels. It may be that at Langebaanweg the Varswater Formation was truncated by a Pliocene highstand of ~50 m amsl.

It appears that the Varswater Formation is everywhere covered by Langebaan Formation aeolianites at Gavin Plaas and it is unlikely to be encountered in the course of shallow (< 4m) excavations on Gavin Plaas (Figs 2 A & B). However the possibility that it rises nearer the surface cannot be entirely discounted as surface/borehole control is sparse.

3.3 Langebaan Formation

3.3.1 Stratigraphy

Wybergh (1919) coined the term "coastal limestones" for the mantle of calcareous sands, calcretes and limestones in the Saldanha area. The latter author referred to the "Langebaan Limestone", but included all calcareous deposits within the unit regardless of age or origin. Tankard (1975a,b) formally proposed a "Langebaan Limestone Member", which has been raised in status to the "Langebaan Formation" (Roberts, 2006). Present usage of this term is now generally restricted to biocalc-siliciclastic aeolianites which occur sporadically along the coastline from False Bay to the Berg River (Cole and Roberts, 1995; Roberts, 2006).

The age of the Langebaan Formation ranges from Pliocene (Diazville Member) to Pleistocene and even Holocene (Kraal Bay Member). The Diazville Member is distinguished from the Kraal Bay Member by its micro- and macrofaunal content.

The Diazville Member is sparsely developed and is restricted to an area east of Gavin Plaas, whereas the Kraal Bay Member covers most of the area.

The Langebaan Formation aeolianites are generally buff coloured, fine-grained and calcareous in the area of the three maps, with bioclastic carbonate contents generally exceeding 50% and ranging up to 90 % (Martini, 1987). This relates to the absence of major rivers in this vicinity, which would have served to dilute the bioclastics with siliciclastics. Calcification of these dune sands may be rapid, occurring within a period as brief as 5 -10 ka, a consequence of the high bioclastic carbonate content (Roberts and Berger, 1997). Large scale cross-stratification is the dominant sedimentary structure, but widespread root bioturbation has obliterated such features in many exposures.

Most of the deposits take the form of dune plumes such as the Geelbek plume east of Langebaan Lagoon, which extends northwards from Yzerfontein (south of the map area) to Cloetes Kraal, a distance of some 47 km. Large palaeo-plumes also extend from the northeastern margin of Saldanha Bay to the Berg River and from Massenberg 298 to the Berg River; this river appears to have acted as a barrier to dune migration over a long period (Fig. 1). The thicker aeolianite sequences comprise multiple sand increments capped by pedogenic calcretes, which crops out extensively in the area.

The formation may attain appreciable thicknesses, reaching up to 65 m on Yzervarkensrug 127 just west of Gavin Plaas (Rogers, 1980). On Anyskop ~25 m were intersected in borehole S1 (Fig. 3B). The anomalous thickness of this deposit, in an area where the formation is genrally thin or absent, is due to accumulation on the flanks of the palaeotopographic high formed by the Varswater Formation deposits. In many areas, thin sheet-like deposits are more characteristic, as on Langeberg 189, Yzervarkensrug 129 and Uyekraal 189, where only 4-8 m of aeolianite is revealed in excavations and boreholes. The formation thins over granite domes in this area, the tops of which protrude

through the limestone, as in the north of Gavin Plaas and south of the area Figures 2 A, B, C. The limestones in these areas are also rather gritty due to proximity of the underlying bedrock. The formation rests with a pronounced unconformity on the Varswater Formation (Fig. 6)

3.3.2 Palaeontological sensitivity

The Late Tertiary Varswater succession formation occurs extensively on Gavin Plaas, reaching thicknesses of up to ~20 m, but is more typically a few meters thick (Figures 2A, B). It pinches out only in the vicinity of basement (granite) highs. Each calcrete-bounded sequence within the Langebaan Formation records episodes of dune mobility, followed by ingression of vegetation and pedogenesis. Dune snails abound in these palaeosols; apart from the very common *Trigonephrus globulus*, other species of terrestrial snails have been reported, including *Dorcasia, sp*., *Tomichia ventricosa, Phortion capense, Succinia delalandei, Burnupia capensis* and *Paludesstrina tristis* (Rogers et al., 1990). *T. globulus* is of normal size (~3 cm), notably smaller than in the Prospect Hill Formation.

A number of vertebrate fossils were recovered from the Diazville Member aeolianites at Prospect Hill, most of which are large bovid limb bones whose fragmentary character defied further identification. A metatarsal shaft fragment of a large, robust ruminant, possibly a heavily built bovid such as a giant form of buffalo, is probably of Pliocene to Pleistocene age. The only cranial remains were a partial mandible and some teeth of a tragelophine, possibly a small kudu, suggesting an age not older than Pliocene (Roberts and Brink, 2002). At Anyskop, aeolianites unconformably overlie the Varswater Formation and are well exposed around the margins of the old phosphate quarry. Mammalian fossils suggest an age of Late Pliocene (Hendey, 1981a,b) and these strata are included in the Diazville Member.

The aeolianites containing mammalian fossils at the Elandsfontyn fossil site on Elandsfontyn 349 are probably Mid-Pleistocene (400-600ka) in age. This dune plume extends as far as the Berg river in the north and may have a similar age throughout. Fragmentary mammalian fossils found by the author on Konings Vlei 138 near Gavin Plaas has similar taphonomic features as at the Elandsfontyn fossil site. The aeolianite exposed in the granite quarry at Besaansklip has a luminescence age of ~300 ka (Woodborne, pers. comm.).

In the Saldanha environs, the Langebaan Formation has proved to be richly fossiliferous, shedding much light on age relationships. In most instances, the fossiliferous deposits are carnivore dens thought to be those of hyaenas (Klein, 1983; Roberts, 1996). Hyaena den fossil occurrences are at Sea Harvest Factory, Saldanha Yacht Club, Hoedjies Punt and Saldanha Quarries. Since hyaenas are indiscriminate scavengers and hunters, a broad range of extinct and extant mammalian species, including herbivores and carnivores, are typically represented. The faunas range in age from Middle to Late Pleistocene and provide important insights into past climates and floras, but as they post -date dune deposition, provide only minimum ages. Wetter and drier cycles are indicated, relating to interglacial/glacial interludes.

The Late Pleistocene Langebaan fossil human footprints (Fig. 7) were discovered at Langebaan Laggon in the west Coast National Park. Human footprints are rare in the fossil record, only a few having been found worldwide and are of international significance (Roberts and Berger, 1997).

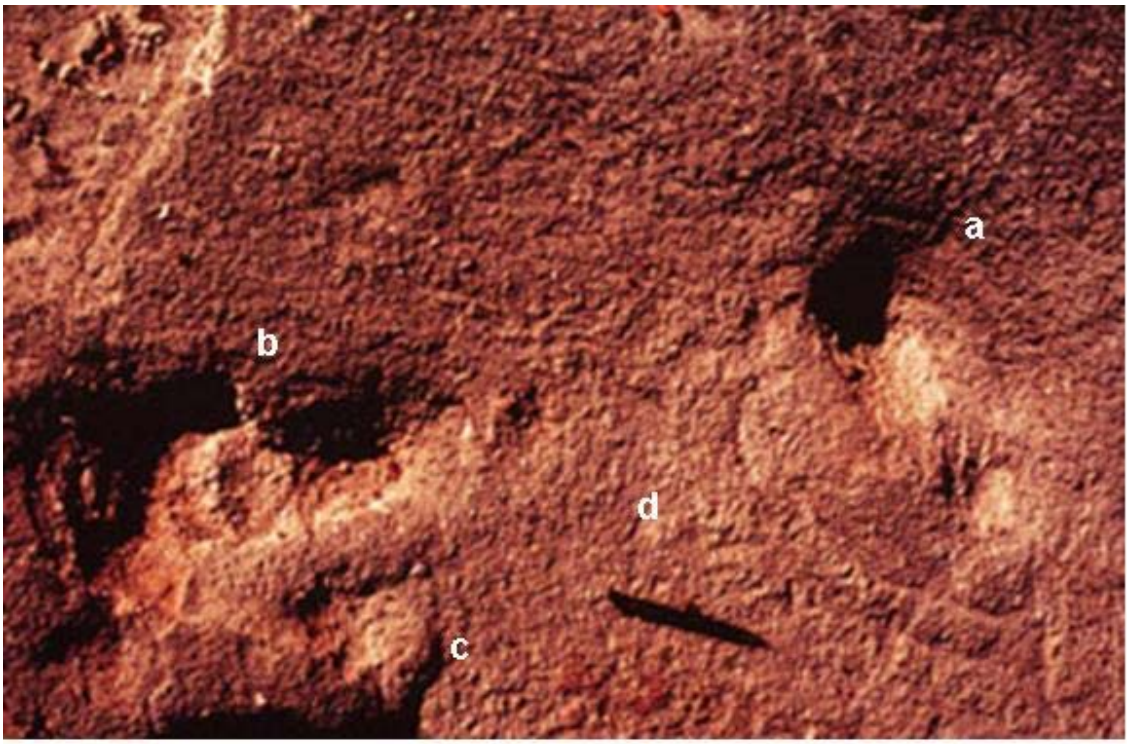

Figure 7. Langebaan fossil human footprints dated to the Last Interglacial Period (~120,000 years ago). Right (a) and left (b)feet are represented They are thought to have been made by an early anatomically modern human called 'Eve', since these people are thought to be ancestral to all modern humans (Roberts and Berger, 1997).

In view of the rich fossil archive contained within the Langebaan Formation and its extensive development on Gavin Plaas, there is a high risk of disturbing, damaging, or destroying highly significant invertebrate, vertebrate and trace fossils in the course of any excavation that disturbs the surface. The palaeontological sensitivity of the Langebaan Formation is regarded as very high.

4. RECOMMENDATIONS

It is clearly apparent from the foregoing discussion that the Cenozoic strata in area embraced by Gavin Plaas are highly sensitive in terms of their

palaeontological content. Therefore, the palaeontological impact of any developments is likely to be severe. Periodic monitoring of excavations by qualified personnel, appropriate mitigative steps such as rescue digs and archiving of recovered fossil materials are considered essential. Other possible actions include education of key workers to be able to recognize fossil material and to summon a specialist if need be. It is suggested that prior to commencement of any construction work in particular areas that test pits be dug to below the anticipated maximum depth of any excavation. This would facilitate evaluation of the impact of specific activities at various locations on the site. The costs incurred in all of these steps should be for the account of the developer. It is not envisaged that any further work be done at present, as borehole data and natural/artificial exposures

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