PALAEONTOLOGICAL DESKTOP STUDY FOR BANTAMSKLIP (W. CAPE) AND THYSPUNT (E. CAPE) REACTOR SITES

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1. SUMMARY

The overall palaeontological sensitivity of both the Bantamsklip and Thyspunt nuclear power station sites is only moderate to low, certainly compared with the Koeberg option, and there are no serious palaeontological grounds for choosing between them. The bedrock platforms beneath these two south coast sites are built of Table Mountain Group sediments of Early Palaeozoic age. These are moderately to highly deformed and unlikely to yield well-preserved fossil material; at most, sparse trace fossil assemblages are expected. A thin cover of Late Caenozoic / Neogene coastal sediments belonging to the Bredasdorp Group (Bantamsklip) or Algoa Group (Thyspunt) is also present. The palaeontological sensitivity of these younger sediments ranges from low to high. The Neogene units are poorly- to well-consolidated and mainly consist of sparsely fossiliferous aeolianites (wind-blown sands) of Quaternary age (<1.8 Ma), with occasional subsurface calcrete horizons. A limited range of terrestrial fossils, such as snail shells, rare vertebrate bones, teeth (perhaps associated with hyaena dens) and even trackways, as well as organic-rich peats or mudrocks might be encountered subsurface within these aeolianites, especially along palaeosol horizons. Thin pebbly layers directly overlying the Palaeozoic bedrock and buried beneath the aeolianites probably represent shallow marine to estuarine units of Mid to Late Pleistocene (and even Mid Holocene) age, such as the Klein Brak Formation (Bantamsklip) and Salnova Formation (Thyspunt). These last units are often characterised by a rich fossil fauna of shelly invertebrates ("Swartkops Fauna") that is of considerable palaeontological and palaeoenvironmental interest. In all cases, regular monitoring of all substantial excavations into Caenozoic coastal sediments by a qualified palaeontologist, with ample opportunity to sample fossiliferous units and record relevant sedimentological data, is strongly recommended. Possible impacts on older palaeontologically sensitive horizons present subsurface beyond the immediate reactor footprints will have to be assessed in more detail if one or other of these sites is finally chosen for a nuclear power plant.

Sensitive units within the Site Vicinity (40 km radius) include the Cederberg Formation (Late Ordovician invertebrates and fish), Baviaanskloof Formation (Early Devonian invertebrates, trace fossils and possible primitive vascular plants) as well as the De Hoopvlei and Alexandria Formations (Mocene / Pliocene marine invertebrates, possible vertebrates).

2. INTRODUCTION

A brief desktop study of palaeontological heritage beneath the proposed Nuclear 1 reactor sites at Bantamsklip (Western Cape) and Thyspunt (Eastern Cape) is undertaken here, largely based on unpublished geological reports commissioned by Eskom, geological maps and sheet explanations published by the Council for Geoscience, Pretoria, as well as the extensive palaeontological literature. Excavations for the proposed Nuclear 1 reactor(s) would cut back the entire Caenozoic cover down to the underlying bedrock. Only the immediate footprint (Site Location, ie ≤ 1km radius) of the two reactor sites has been considered in detail at this stage. However, brief reference is also made to highly fossiliferous formations within the broader region (Site Area, ie 8km radius, or Site Vicinity ie 40km radius) that may well be affected by peripheral development. More comprehensive reviews of regional palaeontological heritage will be necessary once the site or sites for new nuclear reactors are finally chosen and the entire development footprint is defined.

3. BANTAMSKLIP

The geological setting for the Bantamsklip Nuclear 1 site on the coast southeast of Gansbaai is summarised in the geological report by De Beer (2007a). This report includes a recently compiled 1: 50 000 scale geological map. The broader geological context is shown on the published 1: 250 000 Worcester sheet and outlined in the accompanying sheet explanation (Gresse & Theron 1992).

The site is located on top of a wave-cut platform incised into tough quartzitic bedrock of the Peninsula Formation (lower Table Mountain Group). Apart from at the rocky coastline itself, where a modern gravel and boulder beach as well as coarse beach sands are found, the platform is mantled with a thin (11m or less) veneer of less well consolidated late Caenozoic sediments of the Bredasdorp Group. Logs of borehole cores through the Caenozoic cover beneath the site location are given in a report on the subsurface geology by De Beer (2001). The site has been cored more recently (C. De Beer, P. Siegfried, pers. comm. 2008) but borehole logs were not available at the time of writing.

3.1. TABLE MOUNTAIN GROUP

3.1.1. Peninsula Formation

Continuous, gullied rocky outcrops of Peninsula Formation, dipping at 18º to 30º, are seen at the coast at Bantamsklip and extend at shallow depths as a buried wave-cut platform around 0 to 4m amsl underneath the entire site location. The Peninsula succession is dominated by quartzites (ie well-cemented sandstones) and less well-cemented quartzitic sandstones, but there are also thin mudrock horizons which, being more susceptible to weathering and erosion, are generally poorly exposed, even at the coast.

The Peninsula Formation is a predominantly fluvial succession of Early to Late Ordovician age with minor shallow marine to estuarine intercalations ((Broquet 1992, Hiller 1992, Thamm & Johnson 2006). Age-diagnostic organic-walled microfossils (eg acritarchs) are likely to occur in finer mudrocks within the marine-influenced, heterolithic parts of the succession, but these fossils have yet to be successfully isolated. Body fossils are unknown from this formation, although impressions of rounded mudflakes have occasionally been misinterpreted as moulds of shells. So far only a modest range of trace fossils have been recorded from the Peninsula Formation, mostly in association with heterolithic subunits that are attributed to shallow marine or estuarine settings. They include Ordovician forms of the trilobite burrow Cruziana (Rugosa Group) recorded, for example, from Bettys Bay (Potgieter & Oelofsen 1983), arthropod trackways attributed to trilobites and water scorpions (eurypterids), complex annulated "worm burrows" of the ichnogenus Arthrophycus, a small range of horizontal burrows (Palaeophycus etc), Skolithos-dominated "pipe rock", and the large (up to 25cm wide) cyclindrical burrow Metaichna (See review in Almond 2008).

The palaeontological sensitivity of the Peninsula Formation as a whole is considered to be low. According to De Beer (2001, 2007b) the Peninsula Formation bedrock at Bantamsklip shows high levels of deformation (shearing, brecciation, quartz veining, extensive jointing). The Palaeozoic bedrock here is therefore unlikely to yield palaeontologically significant trace fossils or other palaeontological material.

3.2. BREDASDORP GROUP

The Caenozoic cover at Bantamsklip varies from 3m (to the SE) to 11m (to the NE) in depth, with an average thickness of 5-9m (De Beer 2001). Preliminary borehole investigations within the reactor site location, all within 300m of the modern coastline, show that these superficial deposits mainly consist of unconsolidated to semi-consolidated aeolian sands underlain by thin, laterally impersistent horizons of calcretised sands and marine gravels. Note that the various sedimentary units recognised in these earlier borehole cores were defined lithologically and were not assigned to recognised formations of the Bredasdorp Group. In the absence of age-diagnostic data, such as fossils, the lithostratigraphic correlations proposed below for these subsurface units are necessarily tentative.

Comprehensive reviews of the Bredasdorp Group succession, including palaeontology of the various formations, are given by Malan (1986, 1989, 1990), Malan and Viljoen (1990), Maud and Botha (2000) as well as Roberts et al. (2006). Recent dating information is given in the unpublished report for Eskom by Roberts (2006). Detailed lithostratigraphic, palaeoenvironmental and palaeontological discussions for each formation are provided in the Lithostratigraphic Series publications published by the South African Committee for Stratigraphy (SACS; eg Malan 1989b, c, 1991a,b).

3.2.1. Pre-Pleistocene units

Pre-Pleistocene sediments of the Bredasdorp Group do not appear to be present at the Bantamsklip site location. This situation is to be expected for a site overlying such a low-elevation (2-4m amsl), rocky coastal platform, since older Neogene units were generally completely scoured off during transgressive events of later, Quaternary age. Note, however, that within the wider development footprint of the reactor site (Site Vicinity) fossiliferous sediments of the Late Miocene / Early Pliocene De Hoopvlei Formation are likely to be encountered subsurface at elevations over 18m amsl (above mean sea level). The fossil biota of this nearshore marine / estuarine unit has been reviewed by Spies et al. (1963) and Malan (1991b) and mainly comprises bivalve and gastropod molluscs, flat-shelled irregular sea urchins (Echinodiscus) and a range of foraminiferan microfossils. Terrestrial and aquatic vertebrate remains may well also occur here. Although they have not been widely recorded so far from Neogene sediments along the south coast, important vertebrate fossils are known from contemporary units of comparable facies along the west coast (eg Hendey 1984, Pether et al. 2000, Roberts et al. 2006). Late Pliocene / Early Pleistocene dune sands of the Wankoe Formation overlying the 18m amsl coastal erosion surface, including the De Hoopvlei deposits, contain sporadic fossil shells of terrestrial gastropods (snails) such as Dorcasia, Tropidophora and Achatina (Malan 1989b).

3.2.2. Klein Brak Formation

This heterogeneous subunit of the Bredasdorp succession comprises a range of shallow marine, beach, estuarine and lagoonal deposits, both cemented and uncemented, that are related to a number of successive Pleistocene transgressions. These include the MIS 11 as well as the MIS5e (Eemian Interglacial) packages of c. 400 000 and c.120 000 BP that overlie wave-cut platforms along the south coast at elevations below 18m amsl (Malan, 1991a, Roberts 2006).

Thin gravel horizons overlying Peninsula Formation bedrock and mantled by unconsolidated sands (but apparently in no case by heavily calcretised sands) were intersected by boreholes at Bantamsklip at elevations of –3m to +2m with respect to modern sea levels (De Beer 2001). The gravels are variable in thickness and elevation, reflecting irregular bedrock topography such as buried gullies. They average less than 1m in thickness but reach up to 2.4m closer to the coastline in the southern part of the site. The level of cementation and shell content of the gravels are not recorded in the available borehole logs. These buried gravels are provisionally interpreted here as erosional relicts of the Klein Brak Formation, although at such low elevations, at least close to the modern shoreline, they might also (if only in part) date from the Mid Holocene sea level high (See Section 3.2.5. below).

In the NE corner of the Bantamsklip site a 2.2m thick layer of clay directly overlying Peninsula Formation bedrock was intersected by a single borehole (BK5, 300-400m from the present coastline). The clay underlies calcretised aeolianites (unlike the gravels described above) and is tentatively interpreted as a back-barrier lagoon or coastal lake deposit referable to a Late Pleistocene age marine highstand (ie part of the Klein Brak Formation).

The Klein Brak Formation is often highly fossiliferous, being characterised by the predominantly estuarine to shallow marine “Swartkops Fauna” of Pleistocene age (Martin 1962, Barnard 1962, Davies 1972, Kilburn & Tankard 1975, Malan 1991, Le Roux 1990a, 1993, Viljoen & Malan 1993). Excellent fossiliferous exposures are found in the Mossel Bay area and good coastal outcrops are also seen north of Gansbaai closer to Bantamsklip. Rich Klein Brak shelly assemblages are dominated by a variety of gastropods and bivalves. Among these is the spectacularly large (30cm) bivalve Panopea glycimeris that suggests warmer Pleistocene sea temperatures than recorded at present along the south coast (Tankard 1975, Pether 1987, 1988). Trace fossils include pelleted-walled burrows of the ichnogenus Ophiomorpha (Malan et al. 1994). Fossil plants, including wood and pollens of Fynbos Biome angiosperms (eg Stoebe, Polygala, Anthospermum) are also known from the Klein Brak succession (Malan 1991, Malan et al. 1994). The thin clay horizon detected c. 9m subsurface in the northeast portion of the Bantamsklip site may well contain well-preserved plant material (including palynomorphs) as well as non-marine molluscs, and perhaps even freshwater vertebrate remains.

3.2.3. Waenhuiskrans Formation

Small, scattered surface exposures of consolidated coastal aeolianites up to 1.5m thick at Bantamsklip are well-cemented on top but poorly cemented below (De Beer 2001). Partially- to well-calcretised sands with thin calcrete layers, lying beneath unconsolidated sands and immediately above Peninsula Formation bedrock, were intersected by boreholes at elevations of 4 to 7m amsl. They are thickest (up to 4m) in the northern portion of the site area and occur widely at elevations below 7m amsl along this stretch of coastline, overlying an erosional surface of probable Late Pleistocene (Eemian) age. These calcrete-rich, semi- to well-consolidated aeolianites are provisionally assigned here to the Late Pleistocene Waenhuiskrans Formation (cf De Beer 2007a, p.12 who refers to Wankoe Formation aeolianites at Bantamsklip). Similar semi-consolidated aeolianites mantling almost the entire width of the coastal plain here are mapped as Waenhuiskrans Formation on the 1: 250 000 Worcester sheet (also on recent 1: 50 000 geology map given in De Beer 2007), though relicts of Wankoe dune sands might well be preserved below surface at higher elevations (above 18m amsl) inland.

The Waenhuiskrans Formation has so far only yielded a sparse range of body fossils. These are mostly terrestrial gastropods of the genera Achatina, Dorcasia, Tropidophora, Trigonephrus and Ferissia – all snails except for the last, which is an extant brackish-water slug (Malan 1989c, Roberts et al. 2008). Allochthonous marine fossils include wind-blown foraminiferans and sand-worn shell fragments. Fascinating assemblages of Late Pleistocene last interglacial vertebrate trackways, ascribed to African elephants, antelopes, equids, carnivores and tortoises, as well as rhizoliths (plant root traces, cf Klappa 1980) and calcretised termitaria, have recently been recorded from well-dated (MIS 5e to 5b) Waenhuiskrans aeolianites at Still Bay by Roberts (2003) and Roberts et al. (2008).

Comparable consolidated Late Pleistocene aeolianites of the Sandveld Group (Langebaan Formation) on the SW Cape coast have yielded a wide range of terrestrial vertebrate fossils, especially mammals, from pre-historic hyaena dens (NB the dens and associated fossils are much younger than the aeolianites themselves). The most famous site is at Swartklip on the False Bay coast, but sparse vertebrate remains have also been recorded from consolidated dunes further east (eg.Spies et al. 1963). At Swartklip the Florisian mammal fauna from the last "glacial " (c. 110 000 BP) includes bones and teeth of a wide range of carnivores such as lion, leopard, brown hyaena and black-backed jackal as well as herbivores such as extinct giant long-horned buffalo, hippo, white rhino, zebras and various antelope. Hyaena coprolites and ostrich remains also occur (Singer & Fuller 1962, Hendey & Hendey 1968, Klein 1975, 1980, 1983, 1984, 1986). Modern human footprints dated to 117 000 BP (late MIS 5e) are recorded from Langebaan Formation aeolianites on the West Coast (Roberts & Berger 1997, Pether et al. 2000).

Given the similar depositional setting, a wide range of terrestrial body fossils, such as listed for the Langebaan Formation above and for Holocene aeolianites below, may also be present if searched for in the Waenhuiskrans succession. However, the overall palaeontological sensitivity of this unit can be provisionally rated as low.

3.2.4. Strandveld Formation

Inside the modern gravel and boulder beach at Bantamsklip the site is mantled with unconsolidated sands which grade inland into stabilised, partly vegetated dunes of the Holocene Strandveld Formation. An active dune field with barchanoid dunes up to 30m high is present to the north (Pearly Beach Nature Reserve) and east of the site (De Beer 2001).

Unconsolidated superficial sands in borehole cores at Bantamsklip attain a maximum thickness towards the interior of 11m. The sands are fine, with a coarser component of comminuted (finely ground) shell material and minor silt. They are provisionally assigned to the aeolian Strandveld Formation but relicts of older, Pleistocene dunes (Waenhuiskrans Formation, discussed above) may also be represented within this unit. The interface between these two similar aeolian sand successions may be hard to detect, although it is often marked by a pronounced pedogenic horizon (Roberts et al. 2008).

An authoritative and useful review of the palaeontological potential of Quaternary coastal sands is provided by Pether (2007b) and appended with this report. Categories of potentially valuable fossils mentioned by Pether (ibid.) that may be preserved in, and recovered from, these sands include:

rare fossil bones, teeth and other remains of mammals (eg rhino, elephant, bovids, moles), reptiles (eg tortoises, lizards), and ostriches (eg egg shells)
terrestrial gastropods
plant remains such as charcoal, decayed plant roots
calcareous and siliceous microfossils (foraminiferans, ostracods, diatoms)
organic-walled microfossils (pollen, spores) from mudrocks deposited in interdune ponds and vleis, which may also contain fossil frogs, fish, aquatic snails and plant macrofossils (reeds, leaves, seeds, roots etc)
trace fossils (eg mole and arthropod burrows, vertebrate tracks)

3.2.5. Mid Holocene Sea Level High marine deposits

Marine gravels and cobble-beds with a thin covering of shelly marine or aeolian sand, in part grass-covered, are situated between the modern beach and stabilised dunes (De Beer 2001). Some of these nearshore deposits are probably attributable to the Mid Holocene sea level highstand that reached up to 2-3m amhsl around 3-4000 BP (Miller et al., 1993, Roberts 2006). These Mid Holocene beds, which in some cases may have been cast high onto the beach during major storms, contain subfossil shells of potential interest for palaeoenvironmental reconstructions (eg for palaeotemperature, palaeosalinity and archaeological studies). Examples of such deposits further east along the South Coast that have been dated to the Mid Holocene to Recent are assigned by Roberts (2006) to local equivalents of the Klein Brak Formation (ie the Salnova Formation of the Algoa Group). A distinct topographic step in the landscape observed by D. Roberts (pers. comm.) may represent the inner edge of a Mid Holocene raised beach, in which case there would probably be useful palaeontological material at its base (currently mantled with Recent sands).

4. THYSPUNT

The proposed Nuclear 1 reactor site at Thyspunt, on the coast southwest of Humansdorp, is situated on top of a low-lying coastal platform that has been carved by wave action into resistant, quartzite-dominated sediments of the Nardouw Subgroup (upper Table Mountain Group / TMG). The TMG platform surface mostly lies between 4 to 8m amsl, rising to a maximum of 10m amsl, and is mantled with a thin veneer of late Caenozoic coastal sediments of the Algoa Group.

An outline of the geological setting and subsurface geology at Thyspunt is given in several Eskom technical reports by De Beer (2001, 2007) and Goedhart (2007). The site lies on the published 1: 250 000 Port Elizabeth geological sheet (See also sheet explanation by Toerien and Hill 1989). Detailed 1: 50 000 geological maps for the study area have now been compiled but were not available at the time of writing. Borehole cores through the Caenozoic cover are briefly described and discussed by De Beer (2001) and Goedhart (2007). Later borehole core data has since been obtained (De Beer pers. comm.) but were also not available for this report.

4.1. TABLE MOUNTAIN GROUP

The Thyspunt reactor site overlies the WNW-ESE striking contact between the Goudini Formation (in the NE) and Skurweberg Formation (in the SW) of the Nardouw Subgroup, as proven by borehole coring (De Beer 2001). These units were previously known as the Tchando and Kouga Formations respectively, and the older terms appear in some earlier geological reports. The lithostratigraphy and sedimentology of the Nardouw Subgroup are reviewed by Malan and Theron (1989), Broquet (1992), De Beer (2002) and Thamm and Johnson (2006), and the palaeontology of these beds has been reviewed by Almond (2008).

In terms of the wider development footprint (Site Area), it is noted that the Late Ordovician Cederberg Formation of the Table Mountain Group underlies the coastal plain to the east within 2km of the site location. This is a highly sensitive “red flag” unit in palaeontological terms, internationally famous for its unique post-glacial biota of invertebrates and primitive jawless fish showing soft tissue preservation (Almond, 2008 and refs. therein). Peripheral developments associated with the proposed nuclear reactor might well involve excavations into the mudrock-dominated lower Cederberg Formation (Soom Member), in which case intensive palaeontological mitigation would be necessary.

Recent geological reconnaissance to the NW of Thyspunt has yielded fossil material of possible early vascular plants (Rhyniopsida?) from silty mudrocks of the Early Devonian Baviaanskloof Formation which lies at the top of the Table Mountain Group sequence (Mark Goedhart, pers. comm., 2008). Hitherto the Baviaanskloof Formation has yielded a small faunule of marine shelly invertebrates - predominantly articulate brachiopods (eg Pleurothyrella), with rarer bivalves, homalonotid trilobites, tentaculitids and bryozoans – as well as low diversity ichnoassemblages (eg Rosselia, Palaeophycus, rare Ruzophycus; Almond, 2008).

4.1.1. Goudini Formation (= Tchando Fm.)

At Thyspunt this succession of shallow marine to braided fluvial sediments of Early Silurian age (Malan et al. 1989) comprises dark grey quartzitic sandstones with a higher proportion (5-7%) of mudrock interbeds than seen within the younger Skurweberg Formation. The palaeontology of this formation is dealt together with that of the Skurweberg Formation below.

4.1.2. Skurweberg Formation (= Kouga Fm.)

The Skurweberg Formation, which crops out along the modern coast, consists of well-bedded, often massive grey quartzitic sandstones with rare (1%), thin (< 1m) mudrock interbeds (De Beer 2001). These last increase in frequency downwards in the succession towards the base of the formation. Some of the darker, more impure quartzites are intensely bioturbated. The Skurweberg sediments are Silurian in age and were deposited on a braided alluvial flood plain subject to occasional, transient marine incursions (Theron et al. 1989, Almond 2008).

Body fossils have not been recorded so far from the Goudini and Skurweberg Formations. However, a small range of shallow marine, estuarine and perhaps even freshwater trace fossils are known from low diversity (often monospecific) ichnoassemblages. These have mainly been recorded from the western outcrop area (western Cape Fold Mountains) and mostly from the more heterolithic (mudrock-rich and marine-influenced) parts of the Nardouw succession. The ichnofossils include rare trilobite scratch burrows (Cruziana) and arthropod tracks, annulated sediment-feeder burrows (Arthrophycus allehganiensis), and commoner sandstone horizons of “pipe rock” that are riddled with the simple vertical tube burrows (Skolithos) of suspension feeding invertebrates (Malan et al., 1989, Theron et al., 1989, Almond 2008). Vertical tube burrows with a petaloid array of horizontal lobes surrounding the aperture (possibly bivalve siphon traces) were reported from Table Mountain sandstone float blocks (well-rounded beach boulders) at St Francis Bay (Tom Barry, pers. comm.. 2006). However, their precise stratigraphic provenance within the Table Mountain Group has not yet been established. A widespread marker bed of bioturbated siltstone occurs within the upper Goudini Formation in the Bredasdorp area (Malan et al. 1989) and may extend further east.

De Beer (2001) describes moderately high levels of deformation (eg ubiquitous jointing) as well as ferruginous weathering down to several meters within Nardouw Subgroup quartzitic rocks at Thyspunt. The mudrocks are strongly foliated, with some slickensides, and locally they are extensively weathered to white kaolinitic clay. These features suggest that well-preserved fossils of any sort are unlikely to be present within the Nardouw succession as a whole. The overall palaeontological sensitivity of these Palaeozoic TMG quartzites is in any case low.

4.2. ALGOA GROUP

The Nardouw platform at Thyspunt is mantled by Neogene coastal sediments of the Algoa Group that vary in depth from 12m in the SE to about 20m in the NW. Twenty-two boreholes, straddling the Goudini / Skurweberg contact in the underlying bedrock, were drilled through these superficial sediments, all situated within 250m of the current shoreline (De Beer 2001). The lithostratigraphic interpretation of the available core data given below is necessarily provisional, but essentially follows the analysis by Goedhart (2007).

The stratigraphy, palaeontology and sedimentology of Late Caenozoic coastal sediments of the Algoa Group along the south-eastern coast of South Africa have been reviewed by Le Roux (1986, 1987a,b, 1989a, 1990a, b. 1993), Maud and Botha (2000), as well as most recently by Roberts et al. (2006). New chronostratigraphic data is provided by Roberts (2006).

4.2.1. Pre-Pleistocene units

Since the wave cut platform at Thyspunt lies less than 10m above present sea level (and mostly below 8m amsl), it is unlikely that substantial relicts of pre-Pleistocene sediments of the Algoa Group are preserved below surface close to the modern coastline. It can be expected that these older coastal sediments would have been entirely or largely eroded away during the Mid to Late Pleistocene transgressions (MIS11, MIS5e) that reached up to 9-10m amsl (cf Roberts 2006).

The shallow marine to estuarine Alexandria Formation does in fact occur widely in the subsurface above 18m amsl in the Oyster Bay – Humansdorp – Cape St Francis area (Site Vicinity). However, this is not reflected on published maps at 1: 250 000 scale (Goedhart 2007). A wide range of Miocene-Pliocene marine fossils – mainly molluscs, but also sea urchins (the "sea pansy" Echinodiscus), corals, bryozoans, brachiopods, sharks' teeth, benthic foraminifera and trace fossils – have been recorded from the Alexandria Formation since the early twentieth century (eg Newton 1913, Du Toit 1954, Engelbrecht et al., 1962, King 1973, Dingle et al., 1983, Le Roux 1987a-c). These richly fossiliferous beds may well be affected by excavations into the interior coastal plain as part of the broader Nuclear 1 development footprint.

Pliocene to Early Pleistocene aeolianites of the Nanaga Formation also occur extensively at elevations above 18m amsl on the coastal plain inland of Thyspunt (see 1: 250 000 Port Elizabeth geological map), where their preservation has been promoted by Pliocene uplift in the Algoa region of some 30m (Roberts 2006). Older dunes up to 50m high amsl occur just 300m from the coast at Thyspunt and may belong to the Nanaga Formation. The sparse palaeontology of the Nanaga Formation is summarised by Le Roux (1992). The fossil biota consists of fragmentary marine shells, foraminifera (cf McMillan 1990), and a small range of terrestrial snails (eg Achatina, Tropidophora, Trigonephrus, Natalina).

4.2.2. Salnova Formation

Occasional thin (1.2-1.6m) pebble beds with clasts up to 5cm and a sandy matrix (degree of cementation not recorded) were intersected by two boreholes at Thyspunt (DP1, PP4) at 2-6m amsl, where they probably infilled gullies in the bedrock directly beneath. These boreholes are situated some 200m inland of the present shoreline. Their low elevation suggests that they may be marine deposits of the last interglacial of Late Pleistocene age (Eemian transgression, MIS 5e) and are consequently assigned here to the Salnova Formation.

The Salnova Formation, which now incorporates marine deposits of several Mid to Late Pleistocene transgressions, is characterised by a rich, shallow marine to estuarine “Swartkops” fossil biota (Le Roux 1990b, 1991, 1993; see also palaeontological references for the co-eval Pleistocene Klein Brak Formation in section 3.2.2. above). Fossil assemblages are dominated by a wide range of molluscs (especially gastropods and bivalves). Compared with the older, Miocene / Pliocene Alexandria Formation of the Algoa Group, crab and sea urchin remains are also typically abundant in the Salnova Formation, while corals, brachiopods (lamp shells) and sharks’ teeth are generally absent (Le Roux 1991). Trace fossils include pellet-walled arthropod burrow systems of the ichnogenus Ophiomorpha and bivalve burrows, among others (ibid.). Vertebrate remains (rare bones, teeth) may also be present but are not well recorded.

Close to the modern shore, such pebbly beds, often admixed with shells, could be attributed to the Mid Holocene sea level highstand when they lie below about 3m amsl (see discussion in 3.2.5. above). Recent, dated cobbly deposits occurring up to 2.5m amsl at Cape St Francis were attributed by Roberts (2006) to storm waves and were also assigned to the Salnova Formation, whose definition has evidently been broadened to include near-coastal marine deposits of Holocene as well as Pleistocene age.

4.2.3. Nahoon Formation

Up to 16m of semi-consolidated sands overlying Nardouw bedrock are recorded in borehole cores from Thyspunt (De Beer 2001, Goedhart 2007). Directly above the bedrock the sands sometimes contain large shell fragments. Vegetated sand dunes up to 25m high with abundant shelly material are seen in the study area, while older dunes (Nanaga Formation?) reach 50m amsl only 300m from the coast. Since the near-coastal sands at the Thyspunt site location apparently overlie a Late Pleistocene / Eemian wave-cut platform, these aeolianites are provisionally assigned here to the Mid to Late Pleistocene Nahoon Formation. The Nahoon dune sandstones are typically better consolidated than otherwise closely comparable aeolianites of the younger Schelm Hoek or older Nanaga Formations of the Algoa Group (Le Roux 1989b). No calcretes are recorded in the borehole logs, however.

The palaeontology of the Nahoon Formation has been briefly summarised by Le Roux (1989b). As with the broadly co-eval Waenhuiskrans Formation (Section 3.2.3 above), the biota is dominated by terrestrial gastropods that are commonest in palaeosol horizons. Cominuted shell debris, foraminiferans and rhizocretions (plant root casts) are also common (ibid., and McMillan 1990). Near East London mammal and bird trackways, including early human footprints, occur in Nahoon aeolianites dated to 200 000 BP (Mountain 1966, Roberts et al. 2006, Roberts in press, 2006). Occasional bone accumulations are attributed to much younger hyaena dens, as at Swartklip (See Section 3.2.3 above). Peat horizons are also recorded (Le Roux 1989b) and should yield useful data on contemporary vegetation and palaeoclimates (cf Carr et al., 2006).

4.2.4. Schelm Hoek Formation

Thin, calcareous, shelly and largely unconsolidated surface sands at Thyspunt can be assigned to the Holocene Schelm Hoek Formation (cf Illenberger 1992). These Holocene deposits may be semi-consolidated at depth, and difficult to distinguish from the generally better cemented Nahoon Formation aeolianites. Active dunes are not present in the study area, but E-W striking modern dune fields are present to the north (Qw on 1: 250 000 Port Elizabeth geological map).

The palaeontology of superficial sands along the Cape coast is summarised by Pether (2008) as outlined in Section 3.2.4. above. IIlenberger (1992) records fragmentary remains of molluscs, calcareous algae, and sea urchins as well as foraminiferans, terrestrial shales (eg Achatina) and root casts from the Schelm Hoek Formation in particular.

5. RECOMMENDATIONS

Detailed and comprehensive recommendations for palaeontological mitigation of coastal Caenozoic sites such as these have been given in the unpublished heritage reports for Koeberg by John Pether (2008) and Tim Hart (2008), as well as in the information document by Pether (2007a). In the case of Bantamsklip and Thyspunt regular monitoring of all deeper excavations into Caenozoic coastal sediments by a qualified palaeontologist, with ample opportunity to sample fossiliferous units and record relevant sedimentological data, is likewise strongly recommended.

Palaeontological mitigation of Table Mountain Group bedrock is not necessary since the sensitivity of the Table Mountain quartzite-dominated successions is generally low. However, should interesting Palaeozoic fossils be revealed during excavations, these should be sampled by the responsible palaeontologist.

Possible impacts beyond the immediate reactor footprint on older palaeontologically sensitive horizons such as the Cederberg Formation (Late Ordovician invertebrates and fish), Baviaanskloof Formation (Early Devonian invertebrates, trace fossils and possible primitive vascular plants), as well as the De Hoopvlei and Alexandria Formations (Mocene / Pliocene marine invertebrates, possible vertebrates) will have to be assessed in more detail should either site be finally chosen for a nuclear power plant.

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