PALAEONTOLOGICAL ASSESSMENT
(Desktop Study)

PROPOSED ESKOM BLOUWATER – UIEKRAAL 132kV D/C LINE AND UIEKRAAL 132/11kV 3x40MVA SUBSTATION

By

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For

ESKOM HOLDINGS SOC LIMITED
Western Operating Unit
Distribution Division

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CONTENTS

SUMMARY

Frontier Rare Earths Ltd (Frontier) has applied to **ESKOM** for an electricity power supply point for its proposed REE Separation Plant, involving a powerline link to the national electricity grid and a local sub-station at the proposed Frontier RE plant. Accordingly, ESKOM proposes to construct a 5km double circuit 132kV Kingbird line from the Blouwater-Aurora 1 132kV line to the proposed new Uiekraal substation at the Frontier plant (Figure 1. The ESKOM Distribution Division has appointed **Landscape Dynamics** to undertake the Basic Assessment (BA) process for the environmental and other impacts associated with the construction of the proposed powerline and the Uiekraal Substation.

For the evaluation of the palaeontological impact it is the extent/scale of the deeper excavations to be made that are the main concern. The dimensions of the footings (foundations) for the powerline pylons are not specified in available information. The footings vary according to the size of the pylon and the geotechnical characteristics at each pylon site. In this instance the thin surficial sands are closely underlain by hard calcrete. Consequently, footings about 1 X 1 m are not expected to exceed depths of ~2 m. The flat terrain enables the deployment of relatively fewer and smaller pylons. Foundation slabs for the new Uiekraal substation are not expected to exceed about 0.6 m in depth. Although the amount of subsurface disturbance is relatively limited, the affected subsurface of the area has a distinct probability of containing fossils that will be exposed during earth works.

Beneath a thin cover of sand, the project site is underlain by calcareous aeolianites (old dune sands) and calcretes ("surface limestones") of the **Langebaan Formation**. These strata do not appear to be very fossiliferous to the cursory eye, but the fossils that have been found are of profound scientific value, raising international interest in the region. The Langebaan Formation aeolianites have been a prime source of information on Quaternary faunas and archaeology. Notably, some fossil finds have been made in the nearby area.

It is recommended that the material excavated from the holes made for the pylon footings be monitored for the occurrence of archaeological material and possible fossils, particularly fossil bones. Appendices 1 and 2 outline monitoring by construction personnel and general Fossil Find Procedures.

Given the nature of the deposit, fossil bone is expected to be found as broken bone exposed in chunks of calcrete. All bone-bearing pieces of calcrete should be collected and set aside. The contracted or standby palaeontologist must be contacted and provided with information on the nature of the possible fossil find (e.g. images).

It is suggested that the West Coast Fossil Park be approached to play a role in the mitigation exercise. Due to their proximity, WCFP personnel are able to react quickly to potential fossil finds and take custody of found material.

The author is an independent consultant/researcher and is a recognized authority in the field of coastal-plain and continental-shelf palaeoenvironments and is consulted by exploration and mining companies, by the Council for Geoscience, the Geological Survey of Namibia and by colleagues/students in academia pursuing coastal-plain/shelf projects.

Expertise

- Shallow marine sedimentology.
- Coastal plain and shelf stratigraphy (interpretation of open-pit exposures and on/offshore cores).
- Marine macrofossil taxonomy (molluscs, barnacles, brachiopods).
- Marine macrofossil taphonomy.
- Sedimentological and palaeontological field techniques in open-cast mines (including finding and excavation of vertebrate fossils (bones).

Membership of Professional Bodies

- South African Council of Natural Scientific Professions. Earth Science. Reg. No. 400094/95.
- Geological Society of South Africa.
- Palaeontological Society of Southern Africa.
- Southern African Society for Quaternary Research.
- Heritage Western Cape. Member, Permit Committee for Archaeology, Palaeontology and Meteorites.
- Accredited member, Association of Professional Heritage Practitioners, Western Cape.

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1 INTRODUCTION

Frontier Rare Earths (Frontier) Limited is proposing to build a Rare Earth Element (REE) Separation Plant near Vredenburg, on Portion 6 of the property Langeberg 188, near Saldanha Bay in the Vredenburg Magisterial District. Frontier has therefore applied to ESKOM for an electricity power supply point for the proposed REE Separation Plant, involving a powerline link to the national electricity grid and a local sub-station at the proposed Frontier RE plant. Accordingly, ESKOM proposes to construct a 5km double circuit 132kV Kingbird line from the Blouwater-Aurora 1 132kV line to the proposed new Uiekraal substation at the Frontier plant (Figure 1.

The ESKOM Distribution Division has appointed **Landscape Dynamics** to undertake the Basic Assessment (BA) process for the environmental and other impacts (i.e. Heritage, Aquatic, Botanical, Avifaunal, Faunal) associated with the construction of the proposed powerline and the Uiekraal Substation.

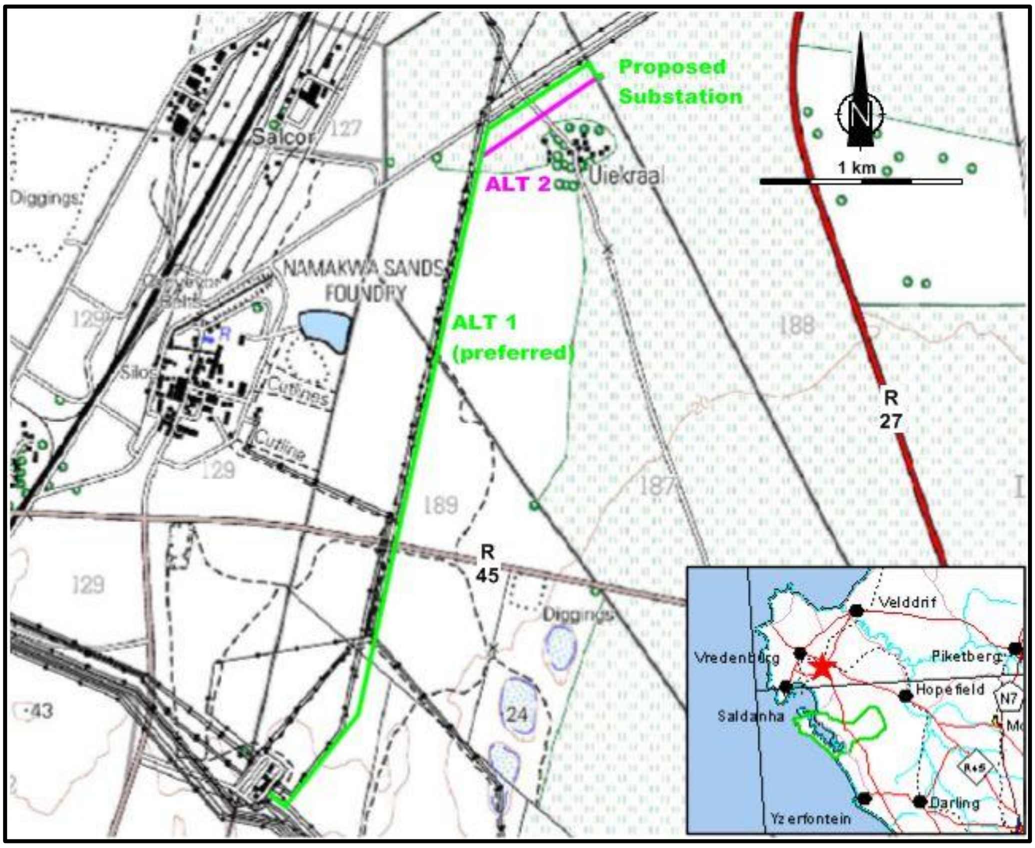

Figure 1. Location of the proposed new ESKOM powerline from the Blouwater-Aurora powerline to the new Uiekraal Substation at the proposed Frontier REE Separation Plant. Extract from 3218CA_CC_2003_ED5_GEO.TIF 1:50000 topo-cadastral sheet (Chief Directorate: Surveys and Mapping).

This Palaeontological Impact Assessment (PIA) is part of the Heritage Impact Assessment (HIA). Its subject is fossils and because fossils are usually found buried in the ground, palaeontological interventions mainly happen once fossil material is exposed at depth, *i.e.* once the EIA process is done, the project is approved and construction commences.

The purposes of this palaeontological assessment are to:

- Outline the nature of possible palaeontological/fossil heritage resources in the subsurface of the study area.
- Suggest the mitigatory actions to be taken with respect to the occurrence of fossils during bulk earth works.

The action plans and protocols for palaeontological mitigation must therefore be *included in the Environmental Management Plan (EMP) of the proposed project*. Appended to this PIA is a general fossil-finds procedure for the appropriate responses to the discovery of palaeontological materials during construction of the powerline footings and Uiekraal substation.

2 APPLICABLE LEGISLATION

The National Heritage Resources Act (NHRA No. 25 of 1999) protects archaeological and palaeontological sites and materials, as well as graves/cemeteries, battlefield sites and buildings, structures and features over 60 years old. The South African Heritage Resources Agency (SAHRA) administers this legislation nationally, with Heritage Resources Agencies acting at provincial level. According to the Act (Sect. 35), it is an offence to destroy, damage, excavate, alter or remove from its original place, or collect, any archaeological, palaeontological and historical material or object, without a permit issued by the South African Heritage Resources Agency (SAHRA) or applicable Provincial Heritage Resources Agency, *viz*. Heritage Western Cape (HWC).

Notification of SAHRA or the applicable Provincial Heritage Resources Agency is required for proposed developments exceeding certain dimensions (Section 38). If the extent of subsurface disturbance and exposure exceeds 300 m in linear length and 5000 m^2 (NHRA 25 (1999), Section 38 (1)), it must be assessed for heritage impacts that include assessment of potential palaeontological heritage (a PIA).

3 THRESHOLDS

For the evaluation of the palaeontological impact it is the extent/scale of the deeper excavations to be made that are the main concern. The dimensions of the footings (foundations) for the powerline pylons are not specified in available information. The footings vary according to the size of the pylon and the geotechnical characteristics at each pylon site, with more substantial footings required in soft or yielding sands and soils. However, in this instance (see below) the thin surficial sands are closely underlain by hard calcrete. Consequently, footings about 1 X 1 m are not expected to exceed depths of

~2 m. The flat terrain enables the deployment of relatively fewer and smaller pylons. Foundation slabs for the new Uiekraal substation are not expected to exceed about 0.6 m in depth.

Although the amount of subsurface disturbance is relatively limited, the affected subsurface of the area has a distinct probability of containing fossils that will be exposed during earth works, as elucidated below.

4 APPROACH AND METHODOLOGY

4.1 AVAILABLE INFORMATION

The point of departure is the geological map of the area *viz*. 1:125000 Sheet 255 and the accompanying explanation (Visser & Schoch (1972, 1973). The relevant part of the geological map is reproduced as Figure 2. Since then, ongoing research has added various refinements of the geology, but the map remains essentially valid. The later research contributions relevant to this assessment are cited in the normal manner as references in the text and are included in the References section.

Quarries, borrow-pits and erosional blowouts in the surrounding area have shown the nature of the underlying substrata and their fossil potential. The most well-known is the old Chemfos phosphate quarry that now incorporates the West Coast Fossil Park. This large quarry has exposed deeper-lying strata that are locally highly fossiliferous, *viz*. the early Pliocene Varswater Formation, but this formation will not be intersected by the shallow excavations for the proposed powerline and substation.

The affected formations are the overlying calcareous aeolianites of the Langebaan Formation and quartzose coversands of the Springfontyn Formation. Natural coastal exposures, numerous shallow quarries/borrow pits, and ephemeral exposures in infrastructure excavations for developments (e.g. Namakwa Sands, SALKOR, Saldanha Steel) have informed the abundances and contexts of fossil in these formations (Pether, 2009, 2010).

4.2 ASSUMPTIONS AND LIMITATIONS

The assumption is that the fossil potential of the formation underlying the site (Langebaan Formation) will be typical of that found in the region and more specifically, similar to that already discovered nearer to the site. Scientifically important fossil bone material is expected to be sparsely scattered in these deposits and much depends on spotting this material as it is uncovered during digging *i.e.* by monitoring excavations.

A limitation on predictive capacity exists in that it is not possible to predict the buried fossil content of an area or formation other than in such general terms.

Certain processes/agents can produce significant concentrations of fossil bones, but the possibility of these specific buried palaeoenvironments being present is only hinted at by the general setting of a site.

5 GEOLOGICAL AND PALAEONTOLOGICAL SETTING

5.1 ASPECTS OF THE REGIONAL GEOLOGY

The bedrock of the region consists of **Malmesbury Group** shales that along the coast have mostly been eroded away to below sea level. Their origin dates from over 560 Ma (Ma: million years ago, Mega-annum). The Malmesbury shales are intruded by the crystalline "**Cape Granites**" that are now exposed as hills around Vredenburg and Darling. These bedrock formations are not of palaeontological interest.

The bedrock is overlain by formations that make up the **Sandveld Group** of coastal deposits. The **Elandsfontyn Formation** is the oldest formation of the **Sandveld Group** and consists of fluvial (river) deposits that infill old valleys eroded into the soft Malmesbury shales. It has peaty beds that contain fossil pollen indicative of yellowwood forest vegetation with palm trees. The depositional environments are those of meandering rivers under humid climatic conditions.

The coastal plain was inundated during periods of high sea level and marine and estuarine deposits form a major part of the Sandveld Group. The richly-fossiliferous, phosphatic **Varswater Formation** is exposed in the phosphate quarry at the West Coast Fossil Park (WCFP). There the fossils from the upper part show that the age of the deposits is about 5 Ma and that the origin of the deposits is related to the early Pliocene sea-level highstand.

West of the WCFP the flat plain that extends towards the coast is underlain at depth by younger marine deposits of middle Pliocene age ~3 Ma. This is the "**Uyekraal Formation**" and it is the youngest marine formation that has a warm-water shell fauna and a significant number of extinct shell species. Although it underlies the Study Area, it will not be intersected by the shallow excavations that the proposed project entails.

Aeolianites or "dune rocks/fossil dunes" overlie the marine deposits of the coastal plain. The calcareous aeolianites are evident in the coastal landscape as the ridges, low hills and mounds beneath a capping calcrete crust, or "surface limestone" in old terminology. This is the **Langebaan Formation** or "Langebaan Limestones". It is depicted in a yellow hue on the geological map and it underlies the entire Study Area, as is shown in the excerpt in Figure 2.

The considerable extent of the Langebaan Formation aeolianites attests to the persistence of strong southerly winds and the availability of sand on beaches. The "fossil" dune plumes that make up the Langebaan Formation accumulated episodically, under the influences of climate (windiness, rainfall) and available sand source areas (sea-level position, sediment supply). Periods of dune formation are separated by periods of stability and soil formation. Erosion and re-deposition of previous dunes also took place in some areas. The most favourable sand supply conditions seem to have prevailed at sea levels below present, in the range of 10-40 m bsl. Cliffs and steep seaside slopes mark where the older dune plumes are eroded by the modern, higher sea level. The oldest parts of the Langebaan Formation just postdate the ~3 Ma marine Uyekraal Fm., the youngest parts postdate the "~125 ka raised beach" of the Velddrif Formation at the modern coast and are as young as ~60 ka.

Much of the aeolian sand is tiny fragments of shell. The cementing of this sand to form aeolianite is generally quite weak, but much denser cementing has taken place in the uppermost part of the fossil dunes in the form of a "carapace" or capping of calcrete (Figure 3). The calcrete is a type of cemented soil called a pedocrete, formed in the near-surface by evapo-transpiration after the dunes became inactive and became vegetated. The aeolianites contain further calcretes and leached *terra rosa* soils at depth, attesting to a number of periods of reduced rates of sand accumulation, surface stability and soil formation.

In the flatter, lower parts of the Langebaan Formation landscape, such as the Study Area, the net accumulation of aeolian sands has been less. Evidently the sands have accumulated in smaller increments as sand sheets and/or there have been more marked breaks between periods of sand accumulation, or periods of erosion (wind deflation). Very thick, multiple calcretes have formed over a long time in the flatter areas.

The **Springfontyn Formation** is an informal category that accommodates the mainly non-calcareous, windblown sand sheets and dunes that have covered parts of the landscape during the Quaternary. Visser & Schoch (1972, 1973) differentiated the coversand by its surface appearance into 2 surficial units, **Q2** (older cover) and **Q1** (younger cover) (Figure 2). The Springfontyn Fm. consists of the sequences beneath these "coversands", *i.e*. SubQ2 and SubQ1. On the geological map (Figure 2) these coversands are depicted transparently, so as not to obscure the extent of the closely-underlying Langebaan Fm.

Unit Q2 is characterized by its surface manifestation as the distinct "heuweltjiesveld", the densely dot-patterned landscape of low hillocks that are termitaria made by harvester termites. It is also apparent that Q2 underlies large areas now covered by the younger Q1 coversand. The dot-patterned "heuweltjiesveld" is merely the surface-soil characteristic of Unit Q2. Not much detail is known about Unit Q2 at depth (Sub-Q2). Pedogenic layers of ferruginous concretions, clayey beds and minor calcretes occur among sandy-soil beds. Clearly Q2 will differ from place to place according to the local setting. In this area, in addition to mainly windblown sands from the south, Sub-Q2 will likely comprise the local colluvial/hillwash/sheetwash deposits, small slope-stream deposits, alluvium in the lower valleys and vlei and pan deposits.

Surface **Unit Q1** is a younger "coversand" geological unit and is "white to slightly-reddish sandy soil" (Visser & Toerien, 1971; Visser & Schoch, 1973).

These are patches of pale sand deposited in geologically-recent times. In places these sands are undergoing semi-active transport and locally have been remobilized into active sandsheets and dunes.

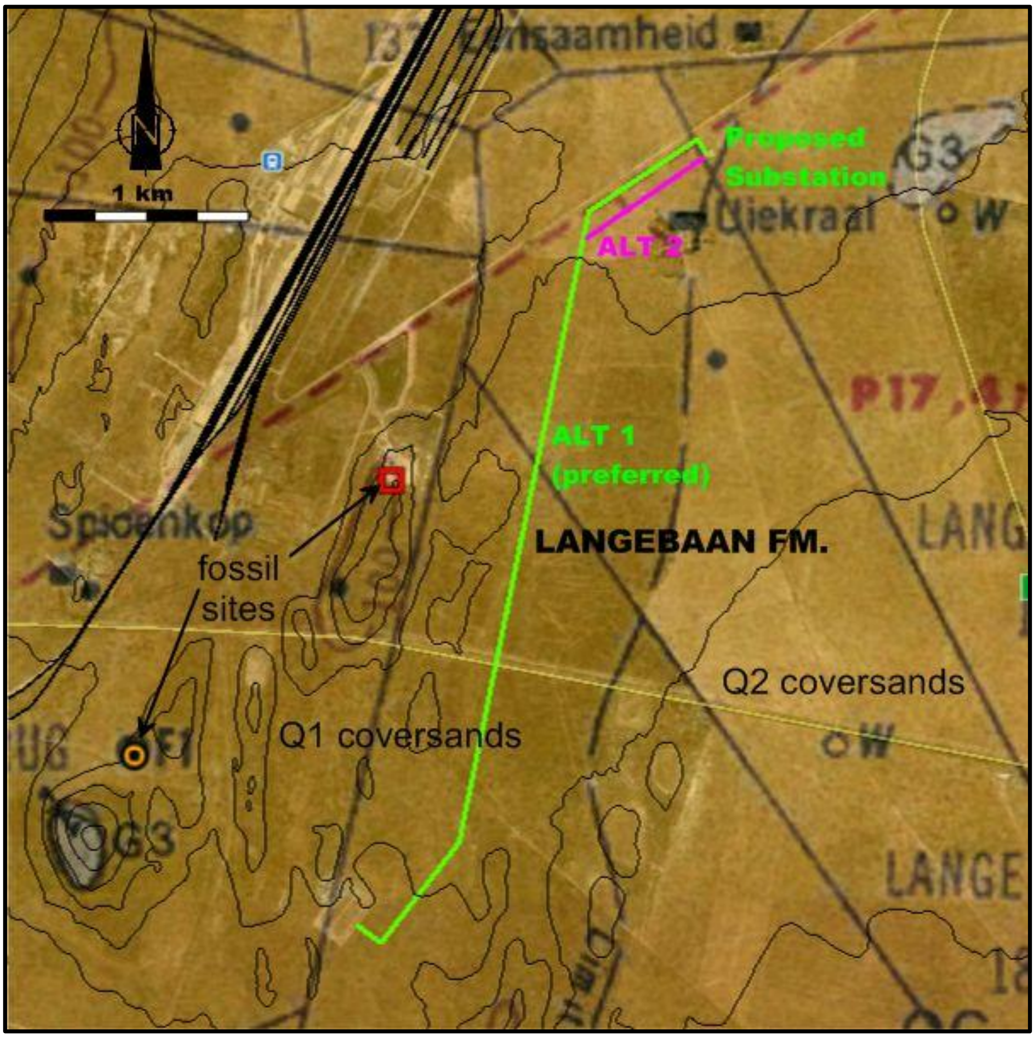

Figure 2. . Geology of the Study Area. Extract from Visser & Schoch (1972), 1:125000 Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai).

5.2 GEOLOGY OF THE STUDY AREA

The powerline route extends north from ~20 m asl (Blouwater SS) and traverses the very low gradient for ~4.2 km towards the proposed new Uiekraal substation site at ~27 m asl. (Figure 2). The route crosses over **Springfontyn Formation** coversand unit **Q1** which is underlain by the calcrete capping of the **Langebaan Formation**. To the west is a low ridge of aeolianite wherein fossil bones have been discovered (Figure 2). To the east of the route is **Q2** "heuweltjiesveld".

5.3 EXPECTED PALAEONTOLOGY

5.3.1 Fossils in aeolian settings

Many fossils are associated with old, buried surfaces in the aeolianites (palaeosurfaces), usually formed during wetter or less windy periods, with reduced rates of sand accumulation and with soil formation showing the surface stability. Trace fossils such as plant roots (rhizoliths), insect burrows and mole burrows are very common. The common fossils include shells of extinct land snails, fossil tortoises, ostrich incl. egg fragments and generally sparsely scattered bones. Conversely "blowout" erosional palaeosurfaces may carry fossils concentrated by the removal of sand by the wind.

Of particular interest are fragments of the fossil eggshells of ostriches. The fossil fragments differ from modern eggs by having the pores concentrated in clumps or pore complexes. Different pore arrangements occur in eggshells from units of different ages. This sequence of fossil eggshells is already proving useful in correlations with eggshell finds in Africa and as far afield as Arabia. The local example is the finding of *Diamantornis wardi* eggshell in "Langebaan Fm" aeolianites north of Saldanha Bay, now separated as the **Prospect Hill Formation** aeolianite with an indicated age of 12-9 Ma (Roberts & Brink, 2002).

Figure 3. Fossil bone concentration (circled) in the infill of a cavity below the calcrete capping of the Langebaan Formation.

The bone concentrations most commonly found are due to hyaenas. The bones often occur in the lairs of hyaenas, such as tunnels made into the softer material beneath a calcrete "roof" (Figure 3). These most often occur on slopes where some erosion of the calcrete, producing overhangs and crevices, has facilitated the making of a burrow. Burrows made by aardvarks are also exploited by hyaenas. Hyaena lairs can be found at depth in the aeolian deposits, where they relate to buried palaeosurfaces.

Dissolution hollows formed by water locally ponding and dissolving the calcrete are another site of local fossil trapping. These can also be exploited to make burrows and lairs. These dissolution features are called “karst” and surprisingly deep “pipes” can form in this manner, usually filled with reddened sediment. Such dissolution pipes can directly trap small animals and accumulate fossils. The fossil concentrations in animal lairs and dissolution features are “superimposed” into an older, cementing aeolianite.

Hollows between dunes (interdune areas) are the sites of ponding of water seeping from the dunes, leading to the deposits of springs and small vleis. These are usually muddy, with plant fossils, but being waterholes, are usually richly fossiliferous, with concentrations of large mammal bones due to predator activity, including Stone Age hunters.

In low-lying areas when rainfall is sufficient, the dense, thick calcrete can impede drainage to the extent that wide, shallow pans form. These accumulate pan deposits consisting of windblown dust and re-precipitated carbonate. Such pan carbonates cement onto the top of the calcrete and superficially resemble it, but they are distinguished by abundant, small, fossil aquatic snails and no doubt contain the remains of other pan life such as frogs, birds, etc. and occasional mammal remains. Such pan deposits occur on the “flats” west of the Langebaan Road/R27 intersection (John Almond, pers. comm.).

Figure 4. Example of fossil antelope jaw from a shallow trench into the calcrete capping of the Langebaan Formation at SALKOR. Image courtesy André Carstens.

More specifically, trial pits made prior to the excavation of the second slimes dam at Namakwa Sands Smelter revealed that a particularly thick, multiple calcrete underlies the area. Notably, sporadic fossil bone finds are a feature of this SALKOR railyard area and apparently occur on palaeosurfaces hidden in the calcrete. Fossils in the calcretes are quite difficult to spot as they are usually coated with white limey deposit (Figure 4) and do not stand out well amongst the nodules and general bumpiness of a fresh exposure.

The Q1 Springfontyn Formation coversands have lower fossil potential, but fossil bones may well occur on the buried surface of the underlying calcrete.

5.4 BURIED ARCHAEOLOGICAL MATERIAL

It is possible that archaeological material may occur locally within the thin, loose sand cover covering the capping calcrete of the aeolianite. This is indicated by "out of place' marine shell (limpets, mussels), pottery pieces and quartz or silcrete stone tools. Buried archaeological material may also occur on top of the calcrete or in crevices and solution pits in it. Early and Middle Stone Age artefacts and associated fossil bones are found within and below the capping calcretes.

6 NATURE OF THE IMPACT OF BULK EARTH WORKS ON FOSSILS

Fossils are rare objects, often preserved due to unusual circumstances. This is particularly applicable to vertebrate fossils (bones), which tend to be sporadically preserved and have high value w.r.t. palaeoecological and biostratigraphic (dating) information. Such fossils are non-renewable resources. Provided that no subsurface disturbance occurs, the fossils remain sequestered there.

When excavations are made they furnish the "windows" into the coastal plain depository that would not otherwise exist and thereby provide access to the hidden fossils. The impact is positive for palaeontology, provided that efforts are made to watch out for and rescue the fossils. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss. The loss of the opportunity to recover them and their contexts when exposed at a particular site is irreversible.

The status of the potential impact for palaeontology is not neutral or negligible.

Although coastal dunes and coversands are not generally very fossiliferous, it is quite possible that fossiliferous material could occur. The very scarcity of fossils makes for the added importance of watching for them.

There remains a medium to high risk of valuable fossils being lost in spite of management actions to mitigate such loss. Machinery involved in excavation may damage or destroy fossils, or they may be hidden in "spoil" of excavated material.

7 SIGNIFICANCE

The fossils that have been found in the Langebaan Fm. aeolianites are of profound scientific value, raising international interest in the region. The Langebaan Fm. aeolianites have been a prime source of information on Quaternary faunas and archaeology.

At the Diazville lower quarry, Langebaan Fm. aeolianite overlying the mid-Pliocene, marine Uyekraal Formation enclosed vertebrate material indicative of a late Pliocene or younger age (Roberts & Brink, 2002) (Diazville Member). The fossil suid (bushpig) from Skurwerug dates the fossil dune-plume there to the early Pleistocene ~1.2 Ma (Hendey & Cooke, 1985).

At Elandsfontein a fossil interdunal vlei was exposed by deflation, the large number of fossil bones and ESA tools indicate an age of ~600 ka (Klein et al., 2007). Notably, prior to the wind erosion of coversands at Elandsfontein, there would have been no indication of the fossil wealth just below, which included a cranium of the pre-modern human *Homo heidelbergensis*.

At Geelbek Dunefield the deflation hollows located between the wind-blown, actively-mobile sand dunes are a source of mammalian fossils and Stone Age tools, with more being constantly exposed (Kandel *et al*., 2003). The older aeolianites surrounding Geelbek dunefield exhibit three sequential calcretes which are dated at ~250, ~150 and ~65 ka, *i.e*. stability/soil formation during glacial periods (Felix-Henningsen et al., 2003).

At Spreeuwal on the shore of Saldanha Bay, fossil vlei deposits are exposed in the intertidal zone and contain large mammal bones and some MSA artefacts (Avery & Klein, 2009). The larger mammal component includes extinct species and others not recorded historically in the Western Cape. Small mammals, birds, reptiles, amphibians, freshwater gastropods and ostracods also occur.

At Kraalbaai the aeolianite with human tracks preserved in it (Kraal Bay Member) is dated to 117-79 ka (Roberts & Berger, 1997). Dating of aeolianites near Cape Town by luminescence methods shows accumulation during MIS 7 and MIS 5 (interglacials), with calcrete formation in the intervening glacial (ice age) periods (Roberts *et al*., 2009).

Examples of hyaena bone accumulations in dens within the partly-lithified dune rocks are the Sea Harvest and Hoedjiespunt sites in Saldanha Bay. Hoedjiespunt is the find site of fossil teeth of a hominid in deposits 200-300 ka old. The Sea Harvest site produced an essentially modern human tooth that is older than 40 ka. Both sites provided considerable samples of the faunas of those times, thanks to the brown hyaenas.

The general significance of coastal-plain fossils involves:

- The history of coastal-plain evolution.
- The history of past climatic changes, past biota and environments.

- Associations of fossils with buried archaeological material and human prehistory.
- For radiometric and other dating techniques (rates of coastal change).
- Preservation of materials for the application of yet unforeseen investigative techniques.

8 RECOMMENDATIONS

Note that the probable presence of fossils in the subsurface does not have an *a priori* influence on the decision to proceed with the installation. However, mitigation measures are essential. The potential impact has a moderate influence upon the proposed project, consisting of implemented mitigation measures recommended below, to be followed during the Construction Phase.

It is recommended that the material excavated from the holes made for the pylon footings be monitored for the occurrence of archaeological material (See 5.3.2) and possible fossils, particularly fossil bones.

Appendices 1 and 2 outline monitoring by construction personnel and general Fossil Find Procedures.

Given the nature of the deposit, fossil bone is expected to be found as broken bone exposed in chunks of calcrete. All bone-bearing pieces of calcrete should be collected and set aside. The contracted or standby palaeontologist must be contacted and provided with information on the nature of the possible fossil find (e.g. images).

It is suggested that the West Coast Fossil Park be approached to play a role in the mitigation exercise. Due to their proximity, WCFP personnel are able to react quickly to potential fossil finds and take custody of found material.

In the event of significant occurrences of fossils, a professional palaeontologist must be appointed to supervise their excavation and to record their contexts. Said palaeontologist/sedimentologist must also undertake final inspections, the latter involving the sampling of ambient fossil content, the recording of the stratigraphy and sedimentary geometry of the exposures and the compilation of the report to Heritage Western Cape and the IZIKO S.A. Museum.

8.1 MONITORING

Table 1. Basic measures for the Construction EMP

OBJECTIVE: To see and rescue fossil material that may be exposed in the various excavations made for pylon installation and substation foundations.	
Project components	Pylon footings & foundation excavations, spoil from excavations.
Potential impact	Loss of fossils by their being unnoticed and/ or destroyed.

Activity/ risk source	All bulk earthworks.	
Mitigation: target/ objective	To facilitate the likelihood of noticing fossils and ensure appropriate actions in terms of the relevant legislation.	
Mitigation: Action/ control	**Responsibility**	**Timeframe**
Inform staff of the need to watch for potential fossil occurrences.	ESKOM, Environmental Site Officer (ESO), contractors.	Pre-construction.
Inform staff of the procedures to be followed in the event of fossil occurrences.	ESO/palaeontology specialist.	Pre-construction.
Monitor for presence of fossils	Contractor personnel and ESO.	Construction.
Liaise on nature of potential finds and appropriate responses.	ESO and palaeontology specialist.	Construction.
Excavate main finds, inspect pits & record selected, key/higher-risk excavations.	Palaeontology specialist.	Construction.
Obtain permit from HWC for finds.	Palaeontology specialist.	Construction
Performance Indicator	Reporting of and liaison about possible fossil finds. Fossils noticed and rescued.	
Monitoring	Due effort to meet the requirements of the monitoring procedures.	

It is probable that sparse, valuable fossil bones and other fossils will go undetected, even with the most diligent mitigation practicable. On the other hand, the finding and recovery of fossils will have a positive impact ranging from local to international in extent, depending on the nature of the finds

9 APPLICATION FOR A PALAEONTOLOGICAL PERMIT

A permit from Heritage Western Cape (HWC) is required to excavate fossils. The applicant should be the qualified specialist responsible for assessment, collection and reporting (palaeontologist).

A permit has not been applied for prior to the making of excavations. Should fossils be found that require rapid collecting, application for a retrospective palaeontological permit will be made to HWC immediately.

The application requires details of the registered owners of the sites, their permission and a site-plan map.

All fossil finds must be recorded and the fossils and their contextual information (a report) must be deposited at a SAHRA-approved institution.

10 REPORTING

Should fossils be found a detailed report on the occurrence/s must be submitted. This report is in the public domain and copies of the report must be supplied to the IZIKO S.A. Museum and Heritage Resources Western Cape. It must fulfil the reporting standards and data requirements of these bodies.

The report will be in standard scientific format, basically:

- A summary/abstract.
- Introduction.
- Previous work/context.
- Observations (incl. graphic sections, images).
- Palaeontology.
- Interpretation.
- Concluding summary.
- References.
- Appendices

The draft report will be reviewed by the client, or externally, before submission of the Final Report.

11 REFERENCES

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12 GLOSSARY

~ (tilde): Used herein as "approximately" or "about".

Aeolian: Pertaining to the wind. Refers to erosion, transport and deposition of sedimentary particles by wind. A rock formed by the solidification of aeolian sediments is an aeolianite.

AIA: Archaeological Impact Assessment.

Alluvium: Sediments deposited by a river or other running water.

Archaeology: Remains resulting from human activity which are in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures.

asl: above (mean) sea level.

Bedrock: Hard rock formations underlying much younger sedimentary deposits.

bsl: below (mean) sea level.

Calcareous: sediment, sedimentary rock, or soil type which is formed from or contains a high proportion of calcium carbonate in the form of calcite or aragonite.

Calcrete: An indurated deposit (duricrust) mainly consisting of Ca and Mg carbonates. The term includes both pedogenic types formed in the near-surface soil context and non-pedogenic or groundwater calcretes related to water tables at depth.

Clast: Fragments of pre-existing rocks, *e.g.* sand grains, pebbles, boulders, produced by weathering and erosion. Clastic – composed of clasts.

Colluvium: Hillwash deposits formed by gravity transport downhill. Includes soil creep, sheetwash, small-scale rainfall rivulets and gullying, slumping and sliding processes that move and deposit material towards the foot of the slopes.

Coversands: Aeolian blanket deposits of sandsheets and dunes.

Duricrust: A general term for a zone of chemical precipitation and hardening formed at or near the surface of sedimentary bodies through pedogenic and (or) non-pedogenic processes. It is formed by the accumulation of soluble minerals deposited by mineral-bearing waters that move upward, downward, or laterally by capillary action, commonly assisted in arid settings by evaporation. Classified into calcrete, ferricrete, silcrete.

ESA: Early Stone Age. The archaeology of the Stone Age between 2 000 000 and 250 000 years ago.

EIA: Environmental Impact Assessment.

EMP: Environmental Management Plan.

ESO: Environmental Site Officer

Fluvial deposits: Sedimentary deposits consisting of material transported by water in suspension and by traction and laid down by a river or stream.

Fm: Formation.

Fossil: Mineralised bones of animals, shellfish, plants and marine animals. A trace fossil is the disturbance or structure produced in sediments by organisms, such as burrows and trackways.

Heritage: That which is inherited and forms part of the National Estate (Historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999).

HIA: Heritage Impact Assessment.

LSA: Late Stone Age. The archaeology of the last 20 000 years associated with fully modern people.

LIG: Last Interglacial. Warm period 128-118 ka BP. Relative sea-levels higher than present by 4-6 m. Also referred to as Marine Isotope Stage 5e or “the Eemian”.

Midden: A pile of debris, normally shellfish and bone that have accumulated as a result of human activity.

MSA: Middle Stone Age. The archaeology of the Stone Age between 20-300 000 years ago associated with early modern humans.

Palaeontology: The study of any fossilised remains or fossil traces of animals or plants which lived in the geological past and any site which contains such fossilised remains or traces.

Palaeosol: An ancient, buried soil whose composition may reflect a climate significantly different from the climate now prevalent in the area where the soil is found. Burial reflects the subsequent environmental change.

Palaeosurface: An ancient land surface, usually buried and marked by a palaeosol or pedocrete, but may be exhumed by erosion (*e.g.* wind erosion/deflation) or by bulk earth works.

Peat: partially decomposed mass of semi-carbonized vegetation which has grown under waterlogged, anaerobic conditions, usually in bogs or swamps.

Pedogenesis/pedogenic: The process of turning sediment into soil by chemical weathering and the activity of organisms (plants growing in it, burrowing animals such as worms, the addition of humus *etc.*).

Pedocrete: A duricrust formed by pedogenic processes.

PIA: Palaeontological Impact Assessment.

SAHRA: South African Heritage Resources Agency – the compliance authority, which protects national heritage.

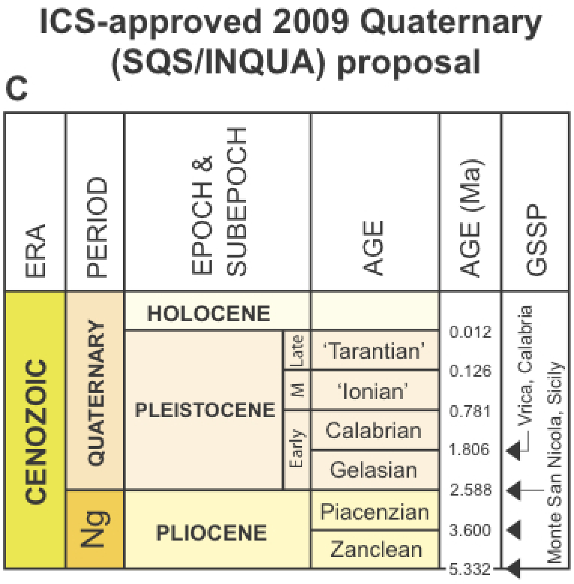
Stone Age: The earliest technological period in human culture when tools were made of stone, wood, bone or horn. Metal was unknown.

Type locality: The specific geographic locality where the stratotype of a layered stratigraphic unit is situated. The name also refers to the locality where the unit was originally described and/or named.

12.1 *GEOLOGICAL TIME SCALE TERMS (YOUNGEST TO OLDEST).*

ka: Thousand years or kilo-annum (10^3 years). Implicitly means "ka ago" *i.e.* duration from the present, but "ago" is omitted. The "Present" refers to 1950 AD. Generally not used for durations not extending from the Present. Sometimes "kyr" is used instead.

Ma: Millions years, mega-annum (10^6 years). Implicitly means "Ma ago" *i.e.* duration from the present, but "ago" is omitted. The "Present" refers to 1950 AD. Generally not used for durations not extending from the Present.



Holocene: The most recent geological epoch commencing 11.7 ka till the present.

Pleistocene: Epoch from 2.6 Ma to 11.7 ka. Late Pleistocene 11.7–126 ka. Middle Pleistocene 135–781 ka. Early Pleistocene 781–2588 ka (0.78-2.6.Ma).

Quaternary: The current Period, from 2.6 Ma to the present, in the Cenozoic Era. The Quaternary includes both the Pleistocene and Holocene epochs.

Pliocene: Epoch from 5.3-2.6 Ma.

Miocene: Epoch from 23-5 Ma.

Oligocene: Epoch from 34-23 Ma.

Eocene: Epoch from 56-34 Ma.

Paleocene: Epoch from 65-56 Ma.

Cenozoic: Era from 65 Ma to the present. Includes Paleocene to Holocene epochs.

Cretaceous: Period in the Mesozoic Era, 145-65 Ma.

Jurassic: Period in the Mesozoic Era, 200-145 Ma.

Precambrian: Old crustal rocks older than 542 Ma (pre-dating the Cambrian).

13 APPENDIX 1 – MONITORING FOR FOSSILS

A regular monitoring presence over the period during which excavations are made, by either an archaeologist or palaeontologist, is generally not practical.

The field supervisor/foreman and workers involved in digging excavations must be encouraged and informed of the need to watch for potential fossil and buried archaeological material. Workers seeing potential objects are to report to the field supervisor who, in turn, will report to the Environmental Site Officer (ESO). The ESO will inform the archaeologist and/or palaeontologist contracted to be on standby in the case of fossil finds.

To this end, responsible persons must be designated. This will include hierarchically:

- The field supervisor/foreman, who is going to be most often in the field.
- The Environmental Site Officer (ESO) for the project.
- The Project Manager.

Should the monitoring of the excavations be a stipulation in the Archaeological Report, the contracted Monitoring Archaeologist (MA) can also monitor for the presence of fossils and make a field assessment of any material brought to attention. The MA is usually sufficiently informed to identify fossil material and this avoids additional monitoring by a palaeontologist. In shallow coastal excavations, the fossils encountered are usually in an archaeological context.

The MA then becomes the responsible field person and fulfils the role of liaison with the palaeontologist and coordinates with the developer and the Environmental Site Officer (ESO). If fossils are exposed in non-archaeological contexts, the palaeontologist should be summoned to document and sample/collect them.

Other alternatives could be considered, such as the employment of a dedicated monitor for the construction period. For instance, a local person could be detached from or trained by personnel at the West Coast Fossil Park.

13.1 CONTACTS FOR REPORTING OF FOSSIL FINDS.

West Coast Fossil Park

- Pippa Haarhoff: 083 289 6902, 022 766 1606, pippah@iafrica.com

Iziko Museums of Cape Town: SA Museum, 021 481 3800.

- Dr Romala Govender: 021 481 3895, 083 441 0028.

Heritage Western Cape

- Troy Smuts: 021 483 9543

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14 APPENDIX 2 - FOSSIL FIND PROCEDURES

In the context under consideration, it is improbable that fossil finds will require declarations of permanent “no go” zones. At most a temporary pause in activity at a limited locale may be required. The strategy is to rescue the material as quickly as possible.

The procedures suggested below are in general terms, to be adapted as befits a context. They are couched in terms of finds of fossil bones that usually occur sparsely, such as in the aeolian deposits. However, they may also serve as a guideline for other fossil material that may occur.

In contrast, fossil shell layers are usually fairly extensive and can be easily documented and sampled (See section 15.5).

Bone finds can be classified as two types: isolated bone finds and bone cluster finds.

14.1 ISOLATED BONE FINDS

In the process of digging the excavations, isolated bones may be spotted in the hole sides or bottom, or as they appear on the spoil heap. By this is meant bones that occur singly, in different parts of the excavation. If the number of distinct bones exceeds 6 pieces, the finds must be treated as a bone cluster (below).

Response by personnel in the event of isolated bone finds

- **Action 1:** An isolated bone exposed in an excavation or spoil heap must be retrieved before it is covered by further spoil from the excavation and set aside.
- **Action 2:** The site foreman and ESO must be informed.
- **Action 3:** The responsible field person (site foreman or ESO) must take custody of the fossil. The following information to be recorded:
    - Position (excavation position).
    - Depth of find in hole.
    - Digital image of hole showing vertical section (side).
    - Digital image of fossil.
- **Action 4:** The fossil should be placed in a bag (*e.g.* a Ziplock bag), along with any detached fragments. A label must be included with the date of the find, position info., depth.
- **Action 5:** ESO contacts the standby archaeologist and/or palaeontologist. ESO to describe the occurrence and provide images asap. by email.

Response by Palaeontologist in the event of isolated bone finds

The palaeontologist will assess the information and liaise with the developer and the ESO and a suitable response will be established.

14.2 BONE CLUSTER FINDS

A bone cluster is a major find of bones, *i.e*. several bones in close proximity or bones resembling part of a skeleton. These bones will likely be seen in broken sections of the sides of the hole and as bones appearing in the bottom of the hole and on the spoil heap.

Response by personnel in the event of a bone cluster find

- **Action 1:** Immediately stop excavation in the vicinity of the potential material. Mark (flag) the position and also spoil that may contain fossils.
- **Action 2:** Inform the site foreman and the ESO.
- **Action 3:** ESO contacts the standby archaeologist and/or palaeontologist. ESO to describe the occurrence and provide images asap. by email.

Response by Palaeontologist in the event of a bone cluster find

The palaeontologist will assess the information and liaise with ESKOM and a suitable response will be established. It is likely that a Field Assessment by the palaeontologist will be carried out asap.

It will probably be feasible to "leapfrog" the find and continue the excavation farther along, or proceed to the next excavation, so that the work schedule is minimally disrupted. The response time/scheduling of the Field Assessment is to be decided in consultation with developer/owner and the environmental consultant.

The field assessment could have the following outcomes:

- If a human burial, the appropriate authority is to be contacted. The find must be evaluated by a human burial specialist to decide if Rescue Excavation is feasible, or if it is a Major Find.
- If the fossils are in an archaeological context, an archaeologist must be contacted to evaluate the site and decide if Rescue Excavation is feasible, or if it is a Major Find.
- If the fossils are in a palaeontological context, the palaeontologist must evaluate the site and decide if Rescue Excavation is feasible, or if it is a Major Find.

14.3 RESCUE EXCAVATION

Rescue Excavation refers to the removal of the material from the "design" excavation. This would apply if the amount or significance of the exposed material appears to be relatively circumscribed and it is feasible to remove it without compromising contextual data. The time span for Rescue Excavation should be reasonably rapid to avoid any or undue delays, *e.g*. 1-3 days and definitely less than 1 week.

In principle, the strategy during mitigation is to "rescue" the fossil material as quickly as possible. The strategy to be adopted depends on the nature of the occurrence, particularly the density of the fossils. The methods of collection would depend on the preservation or fragility of the fossils and whether in loose or in lithified sediment. These could include:

- On-site selection and sieving in the case of robust material in sand.
- Fragile material in loose/crumbly sediment would be encased in blocks using Plaster-of Paris or reinforced mortar.

If the fossil occurrence is dense and is assessed to be a "Major Find", then carefully controlled excavation is required.

14.4 MAJOR FINDS

A Major Find is the occurrence of material that, by virtue of quantity, importance and time constraints, cannot be feasibly rescued without compromise of detailed material recovery and contextual observations.
A Major Find is not expected.

Management Options for Major Finds
In consultation with ESKOM and the environmental consultant, the following options should be considered when deciding on how to proceed in the event of a Major Find.

Option 1: Avoidance

Avoidance of the major find through project redesign or relocation. This ensures minimal impact to the site and is the preferred option from a heritage resource management perspective. When feasible, it can also be the least expensive option from a construction perspective.

The find site will require site protection measures, such as erecting fencing or barricades. Alternatively, the exposed finds can be stabilized and the site refilled or capped. The latter is preferred if excavation of the find will be delayed substantially or indefinitely. Appropriate protection measures should be identified on a site-specific basis and in wider consultation with the heritage and scientific communities.

This option is preferred as it will allow the later excavation of the finds with due scientific care and diligence.

Option 2: Emergency Excavation

Emergency excavation refers to the "no option" situation wherein avoidance is not feasible due to design, financial and time constraints. It can delay construction and emergency excavation itself will take place under tight time constraints, with the potential for irrevocable compromise of scientific quality. It could involve the removal of a large, disturbed sample by excavator and conveying this by truck from the immediate site to a suitable place for "stockpiling". This material could then be processed later.

Consequently, emergency excavation is not a preferred option for a Major Find.

14.5 EXPOSURE OF FOSSIL SHELL BEDS

Response by personnel in the event of intersection of fossil shell beds

- **Action 1:** The site foreman and ESO must be informed.
- **Action 2:** The responsible field person (site foreman or ESO) must record the following information:
    - Position (excavation position).
    - Depth of find in hole.
    - Digital image of hole showing vertical section (side).
    - Digital images of the fossiliferous material.
- **Action 3:** A generous quantity of the excavated material containing the fossils should be stockpiled near the site, for later examination and sampling.
- **Action 4:** ESO contacts the standby archaeologist and/or palaeontologist. ESO to describe the occurrence and provide images asap. by email.

Response by Palaeontologist in the event of fossil shell bed finds

The palaeontologist will assess the information and liaise with ESKOM and a suitable response will be established. This will most likely be a site visit to document and sample the exposure in detail, before it is covered up.

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