PALAEONTOLOGICAL IMPACT ASSESSMENT

ARCELOR-MITTAL SA PROPOSED SALDANHA BAY LPG FACILITY SITE SELECTION

Vredenburg District, Saldanha Bay Municipality, Western Cape

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Prepared at the Request of
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SUMMARY

The proposed LPG Facility for ArcelorMittal SA in Saldanha Bay (Figure 1) is in the prefeasibility project stage and the goal is to exclude sensitive areas from the selected site as far as possible. This Palaeontological Impact Assessment (PIA) outlines the nature of palaeontological heritage resources (fossils) in the subsurface of the project area that are potentially affected by the making of excavations (bulk earth works) for the foundations of the installation.

Most of the project area is previous agricultural/grazing land, but in the west is a large, inactive quarry dug into the northern side of a palaeodune comprised of calcareous aeolianites with intercalated calcretes and other palaeosols. This is the **Langebaan Formation** and the area under consideration is primarily underlain by these palaeodune deposits. The quarry exposes subsurface section through the deposits, but is not sufficiently deep to penetrate the underlying marshland/vlei and marine deposits.

From the palaeontological perspective, the project area has a simple classification:

- The greater, eastern part where the subsurface has not been disturbed.
- The quarry area.

From the view that any site other than within the quarry will entail the disturbance and destruction of sequestered fossils, the quarry is the preferred site as the fossils that were in the excavated volume are already lost.

A new site (*i.e.* on undisturbed subsurface) will require monitoring during excavation of foundations *etc*. and fossils will inevitably be lost in spite of monitoring.

There are no criteria for palaeontological potentials to subdivide the undisturbed ground into more or less-favoured areas as the entire area is underlain by Langebaan Formation aeolianites of similar potential. Thus there are no "No-go" areas defined, other than that the undisturbed areas are not favoured.

This assessment has been prepared at the request of Ms Mariam January, consultant for Environmental Resources Management SA. The project is a proposed LPG Facility for ArcelorMittal SA in Saldanha Bay, Vredenburg Magisterial District, Western Cape.

The area under consideration for the project abuts the Transnet Saldanha Ore Terminal property (Figure 1). The project is in the prefeasibility stage and the goal is to exclude sensitive areas from the site as far as possible. Four potential subdivisions are shown in Figure 1.

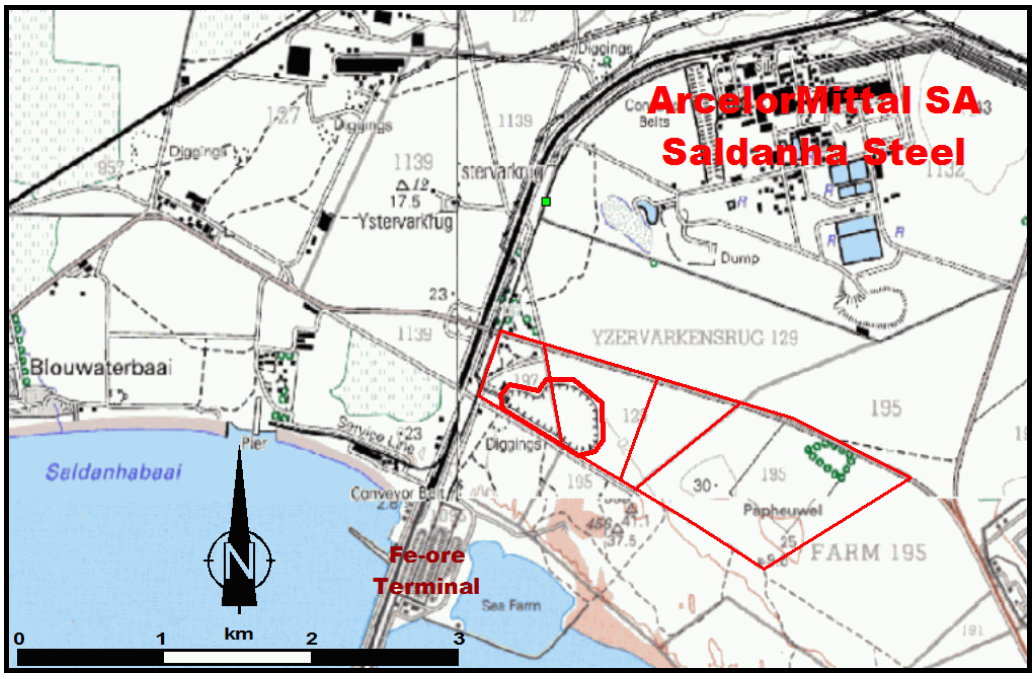

Figure 1. Location areas for the proposed LPG Facility for ArcelorMittal SA. Extracts of 1:50000 topo-cadastral maps. Chief Directorate: Surveys & Mapping.

The main purpose of this brief Palaeontological Impact Assessment (PIA) is to outline the nature of palaeontological heritage resources (fossils) in the subsurface of the project area that are potentially affected by the making of excavations (bulk earth works) for the foundations of the installation.

It is a contribution to the prefeasibility assessment of environmental sensitivities intended to inform the decision on the best location of the LPG Facility.

Most of the project area is previous agricultural/grazing land, but in the west is a large, inactive quarry dug into the northern side of a palaeodune comprised of calcareous aeolianites with intercalated calcretes and other palaeosols.

2 APPROACH AND METHODOLOGY

2.1 AVAILABLE INFORMATION

The baseline information for the area is Visser & Schoch (1973) and the accompanying geological map, the relevant part of which is reproduced as Figure 3. Other references are cited in the normal manner and included in the References section.

2.2 FIELD SURVEY

A cursory inspection of the subsurface strata exposed in the quarry in the western part of the project area was carried out on 11th September 2010. Aerial images show no other larger excavations with vertical exposure within the project area. An extensive survey of the surface of the project area was not performed. This was deemed not warranted due to the low probability and visibility of fossil material occurring on the surface. Surficial shells and bone are usually in an archaeological context.

2.3 ASSUMPTIONS AND LIMITATIONS

It is not possible to predict the buried fossil content of an area other than in general terms. In particular, the important fossil bone material is generally sparsely scattered in most deposits and much depends on spotting this material as it is uncovered during digging *i.e.* by monitoring excavations.

As of yet, the design details of the installation, particularly the dimensions of planned bulk earth works, have not been provided.

Figure 2. Simulated oblique aerial view of the setting of the proposed ArcelorMittal SA LPG Facility, looking from the south. From Google Earth.

3 PALAEONTOLOGICAL HERITAGE MANAGEMENT

The rescue of fossils or sampling of fossil content (palaeontological mitigation) cannot usually be done prior to the commencement of excavations for infrastructure and foundations.

Although fossils may be exposed on the surface in the vicinity of some of the sites, this material is usually disturbed and fragmentary. In most cases, such surficial or shallowly-buried material is in an archaeological context, to be dealt with by qualified archaeologists. The intent of palaeontological mitigation is to sample the *in situ* fossil content and describe the exposed, pristine stratigraphic sections. These palaeontological interventions thus happen once the EIA process is done, the required approvals have been obtained and excavation of the pits is proceeding.

The action plans and protocols for palaeontological mitigation must therefore be included in the Environmental Management Plan (EMP) for the project. Palaeontological mitigation is a longer-term process and generally does not *a priori* impede a project. It is possible, though generally unlikely, that during the course of works an exceptional occurrence could be uncovered that may require a more extended mitigation programme or perhaps conservation *in situ*. In such a case, the most feasible strategy to be adopted is a matter of consultation and agreement between the developers and the heritage authority.

4 GEOLOGICAL SETTING

4.1 LOCAL GEOLOGY

The area is primarily underlain by the **Langebaan Formation** (Figure 3, deep yellow, QC). These are old calcareous aeolianites (dune sandstones), beneath a capping calcrete crust. The old dune accumulation dominates the local topography, forming the low mounded hills that are evident in the coastal landscape and are covered with vegetation of darker-green hue (Figure 2). The old dunes were formed during a lower sea level, when Saldanha Bay was exposed. A considerable thickness accumulated, up to ~40 m asl. at the quarry site. At the coast these old dunes are now erosionally truncated by previous high shorelines and the present shoreline, forming a cliff that is partly covered by more recent sands. The 20 m asl. contour is thus close to the shore.

Between the low hills of outcropping "Langebaan Limestones" is a cover of pale Q1 sands with less dense vegetation (Figure 2). Encroaching from the coast are plumes of Unit Q5 sands (Figures 2 & 3).

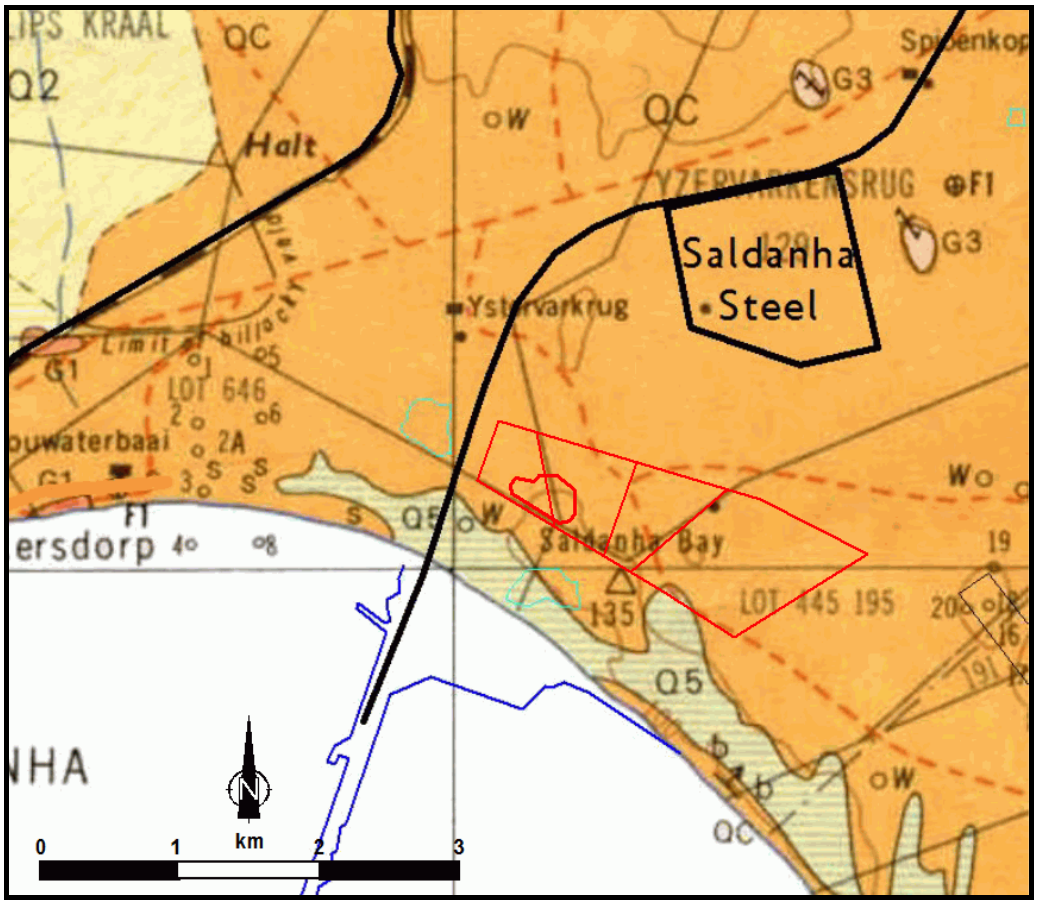

Figure 3. Geology in the vicinity of the proposed ArcelorMittal SA LPG Facility. From Visser & Schoch (1972), 1:125000 Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai). Contours 100 feet interval.

> ***Q5**: Recent windblown sands and dunes along the beaches.*
> ***Q1:** A widespread surface unit is the recent soil-unit Q1, white to slightly-reddish sandy soil, which is mainly stabilized sand sheet that locally covers Q2 and QC. It is thin in this area and is not specifically rendered on the map.*
> ***Q2:** An older surface soil-unit Q2, shallow sandy soil with heuweltjies (heuweltjiesveld), occurs inland the coast. It overlies the Langebaan "Limestone" Formation.*
> ***QC:** The **Langebaan "Limestone" Formation**, aeolianite, consisting of cemented fossil dunes, sandsheets and coastal marshes. It is underlain by marine deposits of Pliocene age (Varswater & Uyekraal fms). Closer to the coast, Quaternary beach deposits are interbedded in the aeolianites.*
> ***G1 & G3:** Granites of the Saldanha Batholith.*

Due to the erosional truncation of the Langebaan Formation at the present coast, it is exposed in the intertidal zone of the beach fringing the farm Spreeuwal, to the south of the project area (Figure 3). These beds are fossiliferous, with large mammal bones and some MSA artefacts (Avery & Klein, 2009). Small mammals, birds, reptiles, amphibians, freshwater gastropods and ostracods also occur. The preserved environment is a wetland or vlei. The larger mammal component includes extinct species and others not recorded historically in the Western Cape. These "Spreeuwal Beds" illustrate the palaeoenvironments that are a typically interbedded in the lower parts of the Langebaan Formation.

Beneath the Langebaan Formation are marine beds. At the coast these are expected to be not far beneath the aforementioned "Spreeuwal Beds". Further inland, beneath the project area, the marine deposits may be preserved at higher elevations, *e.g.* up to about 10 m asl. The marine formation that underlies the Langebaan Formation beneath the project area is not identified with certainty. It may be the outer edge of the mid-Pliocene (~3.4-3.0 Ma) marine sediments named the "**Uyekraal Shelly Sand**" by Rogers (1983). The Uyekraal farm near Saldanha Bay is the "type area" (Figure 4), but there is no type section exposed and the "Uyekraal Shelly Sand" is known there only from boreholes.

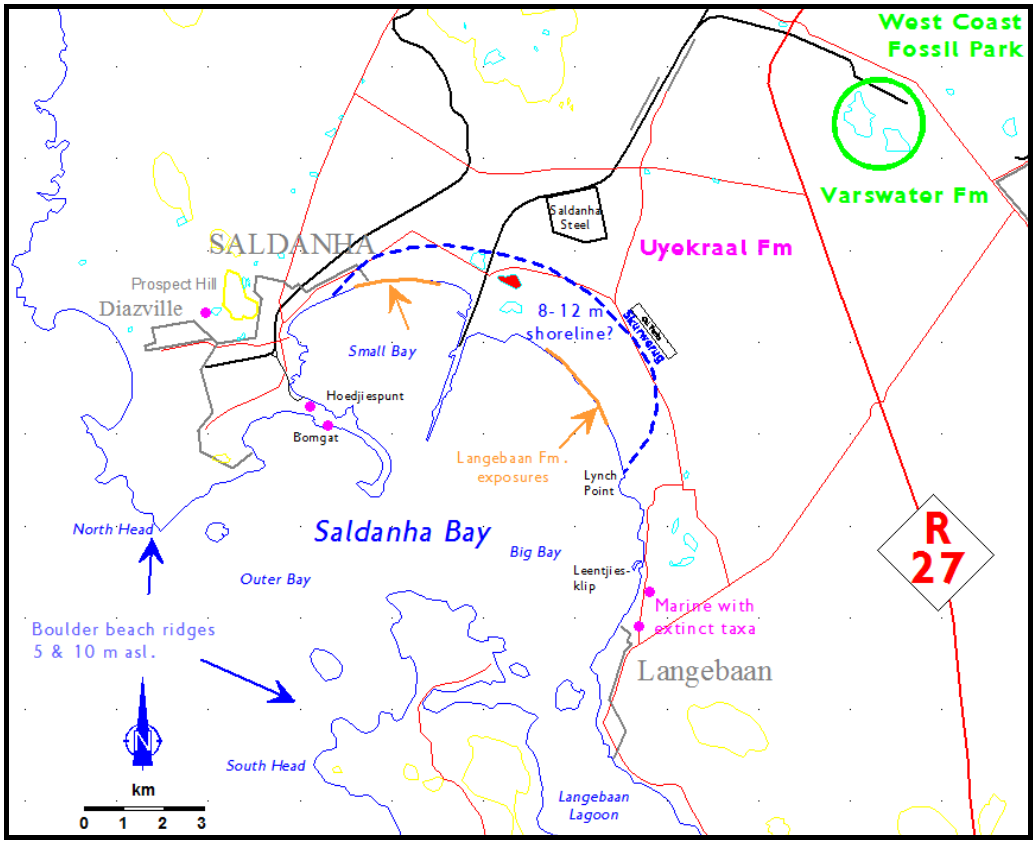

Figure 4. Aspects of the marine stratigraphy of the Saldanha Bay area.

Hendey & Cooke (1985) described a fossil suid skull (bushpig) found in the Skurwerug fossil dune plume, now the site of the "fuel oil tank farm" just east of the ore terminal (Figure 4). The Skurwerug suid dates the Langebaan Formation aeolianite there to the early Pleistocene ~1.2 Ma. This provides a minimum age for the underlying marine deposits beneath the Skurwerug area. Hendey & Cooke (1985) also argued that the Skurwerug dune plume may be associated with a palaeoshoreline at ~8-12 m asl. which is thus of similar early Pleistocene age. Should this be the case, then it is possible that the marine deposits at depth in the project area are this younger shoreline. According to the practical definition of the Velddrif Formation (Roberts, in Roberts *et al.*, 2006), these deposits would be the oldest member of the Velddrif Formation.

At still greater depth are river and marsh deposits infilling an ancient, buried valley that drained through Saldanha Bay. These **Elandsfontyn Formation** deposits are not likely to be encountered, except in boreholes.

4.2 EXPECTED PALAEONTOLOGY

The Langebaan Formation aeolianites do not appear to be very fossiliferous, but fossils from this formation and its correlates have been a prime source of information on Quaternary faunas and archaeology. Most of the fossils in the aeolianites are associated with particular contexts, particularly buried, stable surfaces (palaeosurfaces) where time has permitted bones to accumulate. The common fossils include shells of land snails, fossil tortoises, ostrich incl. egg fragments, sparsely scattered bones *etc*. "Blowout" erosional palaeosurfaces may carry fossils concentrated by the removal of sand by the wind. Hollows between dunes (interdune areas) are the sites of ponding of water seeping from the dunes, leading to the deposits of springs, marshes and vleis. Being waterholes, such are usually richly fossiliferous.

The calcrete top of the Langebaan Formation, beneath Q1 or Q2, usually has dissolution hollows formed by water locally ponding and dissolving of the calcrete. 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. These bone concentrations are "superimposed" into an older, cementing aeolianite.

The lairs of hyaenas, with concentrations of bones of antelopes and small carnivores, have proved a rich source of "stashed" bones of various ages. The calcretes have facilitated overhangs and crevices for use as lairs, super-imposing bone concentrations into an older, partly-cemented aeolianite.

Bone and shell concentrations related to buried Early and Middle Stone Age archaeological sites may occur in the aeolianite, particularly in its upper part.

The marine "Uyekraal Shelly Sand" formation, that could underlie the aeolianites, is poorly known and the fossil content and age is not adequately established. It has a capping hardpan calcrete, beneath which is green-hued shelly, gravelly sand with phosphatic casts (steinkerns) of molluscs and shark teeth (Rogers, 1982, 1983). It underlies the steelworks and an interesting fossil assemblage was obtained there (Roberts, 1997), but the mollusca did not include taxa that were useful for age determination (pers. obs.). However, at various places around Saldanha Bay are exposures of shelly marine deposits believed to be the "Uyekraal Formation" (Leentjiesklip, Hoedjiespunt peninsula, Diazville lower quarry) (Figure 4). On the basis of extinct fossil shells, the Uyekraal Fm. is correlated with the Hondeklip Fm. of Namaqualand, deposited during the mid-Pliocene 3.0-3.4 Ma, before the establishment of the modern, cool-upwelling Benguela regime and the extant fauna (Pether *et al*., 2000). Alternatively, should the marine formation be

younger, as suggested by Hendey & Cooke (1985), the ~1.2 Ma age indicated implies that the marine fossils present would be essentially a modern fauna.

4.3 FIELD OBSERVATIONS

The main purpose of the field inspection of the quarry (Figures 5 & 6) was to see if there was any indication, in its deepest part, of different beds underlying the main aeolianite. For instance, either Spreeuwal-type beds representing marsh or vlei deposits, or underlying marine beds.

The lowermost beds exposed on the quarry floor are aeolianites bearing abundant fossil *Trigonephrus* land snails (Figure 7). Fossil tortoises were also readily found (Figures 8 & 9). Although fragments of marine shell were seen, it was established that these are apparently contamination, as the numerous heaps dumped on the quarry floor are mixtures of cinder and marine shell-bearing sands sourced elsewhere. It is concluded that it is likely that a few more metres of aeolianite intervene between the quarry floor and the underlying, more fossiliferous formations.

The quarry faces were inspected cursorily in a number of more accessible places, mainly on the higher, south face (Figure 10). The purpose was to see if there were any obvious occurrences of fossil bone within or fallen out of the exposures. This brief "walkabout" is only likely to spot the more concentrated bone occurrences, such as hyaena accumulations. Although no bones were found, only a minor portion of the quarry was traversed. A more diligent and systematic search will almost certainly produce results, given the extent of the quarry exposure.

Figure 5. GPS trails in the quarry.

From the palaeontological perspective, the project area has a simple classification:

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Should the chosen site for the LPG Facility be in the quarry, there would be new opportunities for palaeontological finds arising from vegetation clearance and site preparation, providing that appropriate mitigation measures occur. Particularly, if the quarry floor is excavated further, there could be opportunity to sample the deeper part of the Langebaan Formation that is potentially more fossiliferous, as well as perhaps the underlying marine formation.

Figure 6. View of quarry floor.

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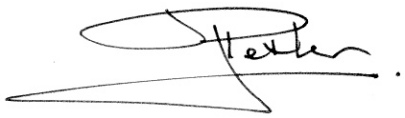

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Figure 7. Floor of quarry at Wpt 5 showing abundant Trigonephrus snails eroded out of the aeolianite. Red hue is veneer of iron-ore dust.

Figure 8. Floor of quarry at Wpt 5 showing fragmented fossil tortoise.

Figure 9. Floor of quarry at Wpt 5 showing intact fossil tortoise.

Figure 10. South face of quarry – looking for fossil bones.

~ (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.

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. Pedogenic types exhibit the micro-morphological features of soils, often include fossil roots (rhizoliths) and form by evapo-transpiration in semi-arid regions. Subdivisions are usually made on the basis of degree and type of cementation (*e.g.* powder, nodular, honeycomb, laminar and massive/hardpan).

Cenozoic: An Era in the Geological Time Scale (Annexure 2). The most recent era ongoing since about 65 million years ago.

Coversands: Aeolian blanket deposits of sandsheets and dunes.

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.

Fluvial deposits: Sedimentary deposits consisting of material transported by, suspended in 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 track or footprint of a fossil animal that is preserved in stone or consolidated sediment.

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.

Holocene: The most recent geological epoch commencing 11.7 ka till the present (Annexure 2).

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.

Karst: Landscape shaped by the dissolution of a layer or layers of soluble rock, usually carbonate rock such as limestone or dolomite.

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".

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.

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

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

Miocene: Epoch in the Geological Time Scale, from 23-5 Ma (Annexure 2).

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, but may be exhumed by erosion (*e.g.* wind erosion/deflation) or by mining.

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.*).

PIA: Palaeontological Impact Assessment.

Pleistocene: Epoch , from 2.6 Ma to 11.7 ka (Annexure 2).

Pliocene: Epoch in the Geological Time Scale, from 5.3-2.6 Ma (Annexure 2).

Quaternary: Period in the Geological Time Scale that includes both the Pleistocene and Holocene, *i.e.* 2.6 Ma to the present (Annexure 2).

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.

Velddrif Formation: Shallow marine and estuarine deposits of Quaternary age along the West Coast, found below 15 m asl. The most prominent of these "raised beaches" is of LIG age, ~125 ka.