PALAEONTOLOGICAL MITIGATION IN THE ENVIRONMENTAL MANAGEMENT PLAN

GECKO FERT (PTY) LTD MINING RIGHT APPLICATION
DMR REF: WC 30/5/1/2/2/10019MR

PHOSPHATE MINING ON FARM LANGEBERG 185/7 AND FARM 1043
NEAR LANGEBAANWEG, SALDANHA MUNICIPALITY, VREDENBURG DISTRICT

by

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SUMMARY

The context of this document is the application for a mining right by Gecko Fert (Pty.) Ltd. on the properties Farm Langeberg 185/7 and Farm 1043, near Langebaanweg and adjacent to the West Coast Fossil Park situated in the Varswater E Quarry (Figure 1). It is proposed to exploit a shallowly-buried resource of phosphatic sediments in the reworked and pedogenically-altered zone that caps the underlying Varswater Formation. The crushed and screened phosphatic material is a slow-release, soil-conditioning fertilizer. Site Plan Consulting is conducting the application process on behalf of Gecko Fert.

Mining of phosphatic rock on Langeberg 185/7 has previously taken place at Baard's Quarry (Figure 2), starting in 1943 and continuing until the early 1960s, when the Varswater quarries were opened and Baard's Quarry was backfilled. In 1958 fossils that were collected by a mine employee came to the attention of visiting scientists. Thereafter an effort was made to obtain more material and the small assemblage acquired dates from the early Quaternary, between 2.6 – 2.0 million years ago (Ma). Few early Quaternary mammal faunal assemblages have been found and are of considerable interest as that was a time of considerable climate change and faunal turnover, as the planet's ice-age mode set in. In the previous mining, a great deal of the fossils were crushed up along with the phosphatic rock. The renewed mining provides the opportunity to obtain a much larger sample of the Baard's Quarry assemblage, provided that mitigation is effectively carried out.

A detailed review of the geology, fossil content and context of the Baard's Quarry-type deposits is provided herein, based on the literature and observations made during the prospecting programme.

The deposit poses challenges for mitigation as adhering, clayey matrix material obscures the mainly fragmentary fossil bones and the important teeth. It is important that as many fossils as possible are spotted when they are still *in situ* or nearly so, in the sides and floors of the quarries. Diligent searching is required. In general, the fossils are more visible in quarry faces that have "aged" and been cleaned up by weathering away of matrix. Fossils could be fortuitously seen during the excavation, moving and stockpiling of the deposits. The visibility of fossils will be enhanced after rainfall, when surface material is washed cleaner. The drying of stockpiled deposit, with crumbling away of matrix and some wind erosion is very effective at disclosing the fossil content. Careful inspection of quarry faces and stockpiles after these conditions is bound to yield finds.

The excavated material is being dry-screened and crushed at an unknown off-site location. Nevertheless, it is at this processing facility that the fossil bones and teeth are very likely to be seen. It is therefore a priority that for effective mitigation a means of monitoring and rescuing fossils in this process be set up.

It is impossible for a specialist to routinely monitor the quarries and mined material. Routine monitoring can only be achieved by the co-operation of the people on the ground. A monitoring presence is critical for immediately

spotting a major “strike” of fossils and stopping further damaging excavation. Background information in the form of some training should be provided to mine personnel. There must be guidelines to be followed for finds and a reporting/action protocol in place when finds are uncovered during monitoring. A “Fossil Finds Procedure” is provided in Section 8.

Section 9 of this report presents “Draft Procedures for the Mitigation of Mining Impacts on Palaeontological Resources at the Gecko Fert (Pty) Ltd Quarries”. It is a preliminary document for negotiation between involved parties, to be more specifically adapted to circumstances/issues arising and incorporated into the EMP for the mine.

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1 INTRODUCTION

The context of this document is the application for a mining right by Gecko Fert (Pty.) Ltd. on the properties Farm Langeberg 185/7 and Farm 1043, near Langebaanweg, Saldanha Municipality, Vredenburg District (Figure 1). It is proposed to exploit a shallowly-buried resource of phosphatic sediments in the reworked and pedogenically-altered zone that caps the underlying Varswater Formation. The crushed and screened phosphatic material is a slow-release, soil-conditioning fertilizer. Site Plan Consulting is conducting the application process on behalf of Gecko Fert.

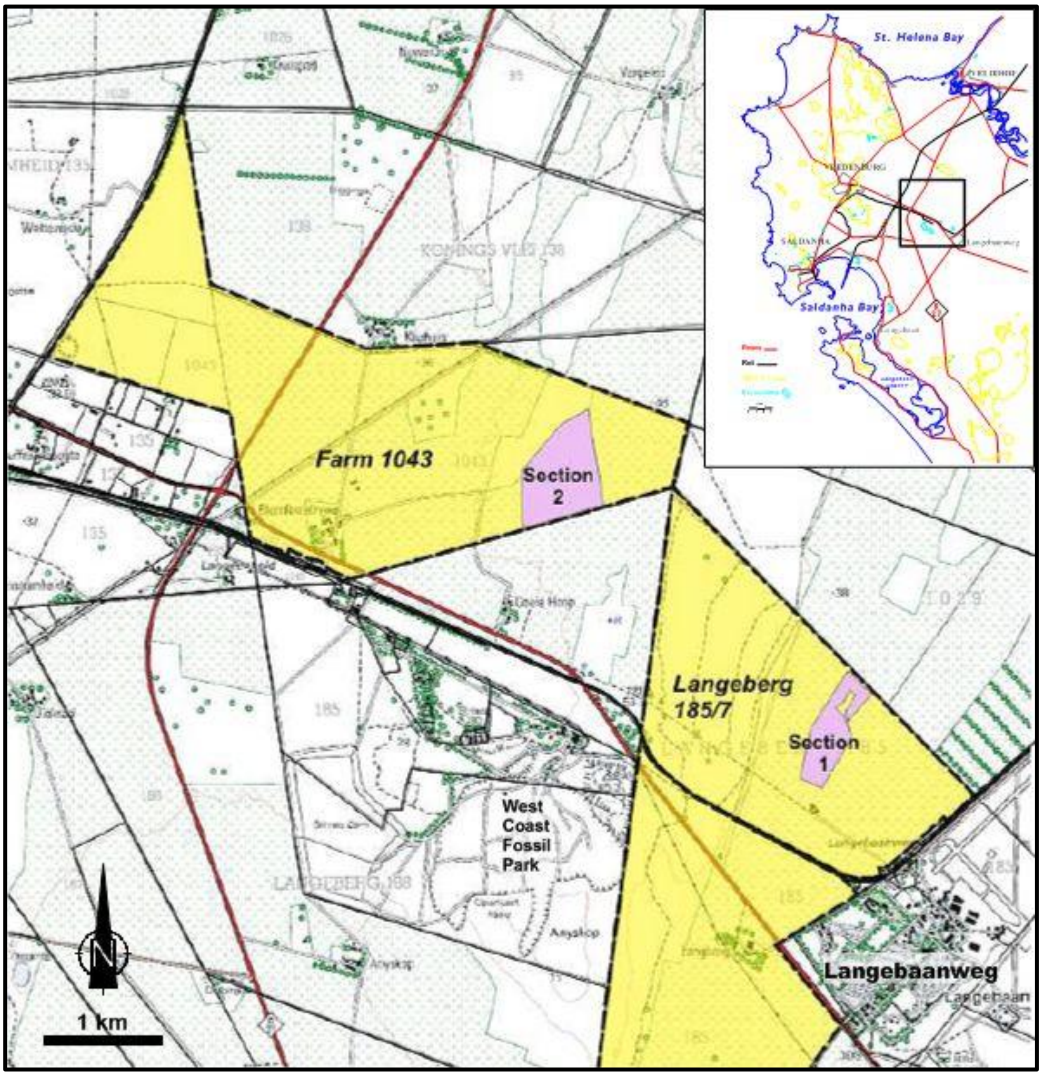

Figure 1. Location of the mining right application areas. Adapted from figure 2 of the application Scoping Report (Site Plan).

This mining right application follows on from a prospecting programme and trial mining. A Palaeontological Impact Assessment (PIA) was prepared for the prospecting application (Pether, 2009a) that outlined the potential palaeontological heritage resources in the subsurface of the prospecting area. This was followed up with a document setting out procedures for mitigation, for inclusion in the EMP for the prospecting (Pether, 2009b). Palaeontological monitoring was carried out on the 16th September 2009, when the prospecting trenches were inspected for possible fossil content. A Palaeontological Mitigation Report was subsequently compiled (Pether, 2009c).

Following from the prospecting, two mining areas have been defined, Section 1 and Section2 (Figure 1). Section 1 includes two quarries, with the northern one partially exploited during trial mining (Figure 2).

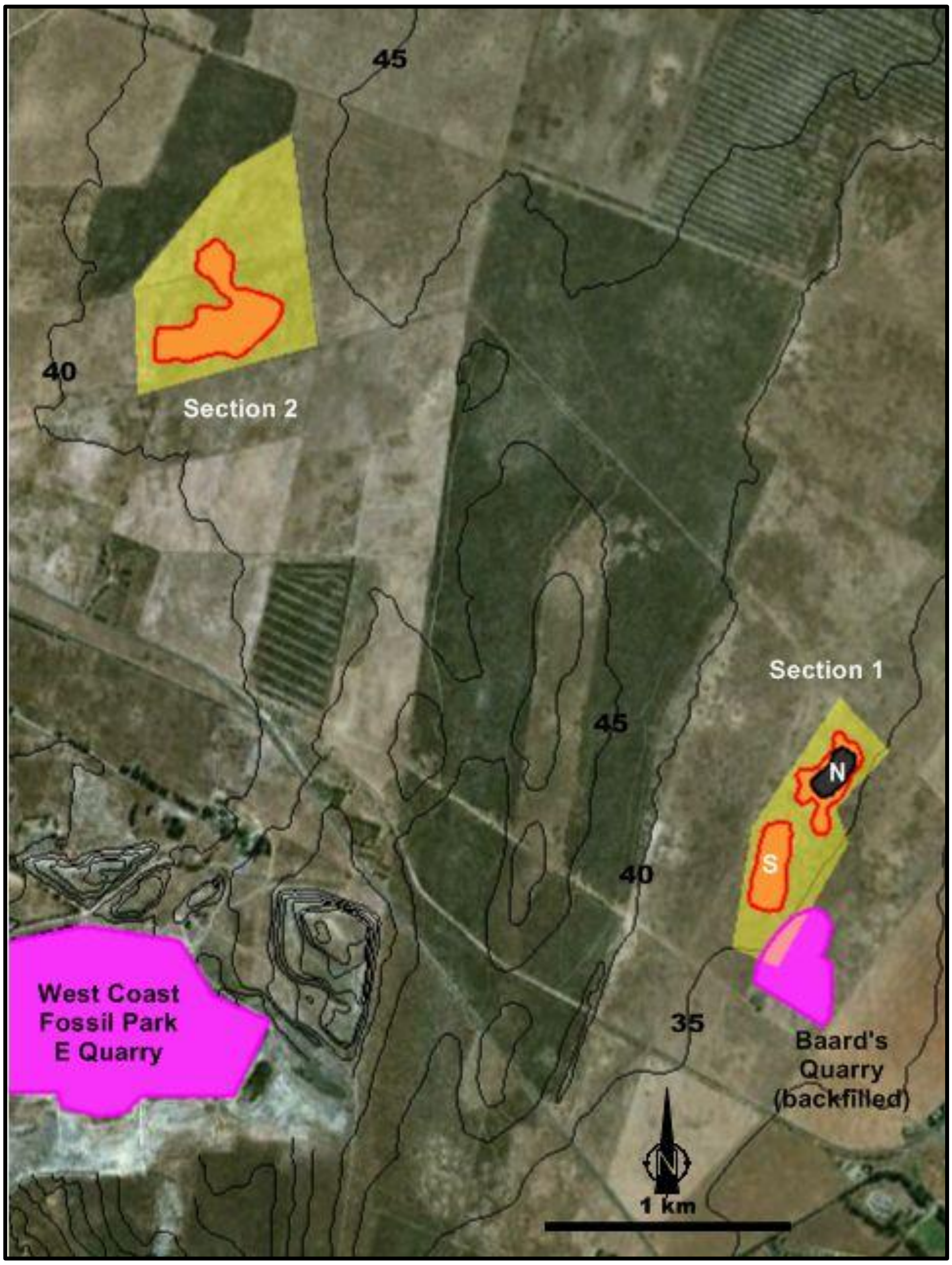

Figure 2. The mining right application areas (yellow) and proposed quarries (orange), with the trial mining indicated (Sect. 1 N – black). Magenta – previous phosphate quarries.

The application is for mining of the phosphatic material in the shallow subsurface only, as revealed and sampled in the small cuts made during prospecting with an excavator. Thus the maximum depth of intended mining is 2.5 - 3.0 m, which is the depth of phoscrete formation in the pedogenically-altered zone. Originally it was intended to also mine the underlying phosphatic sediments, but these are clayey sands that require extensive washing and processing, leading to increased costs and potential environmental impacts. The phoscrete will thus be mined to a depth determined by the underlying clay-rich sediment. Due to the discontinuous nature of cementing, blasting is not necessary. The processing of the phoscrete material by crushing and screening takes place off site.

2 GEOLOGICAL SETTING

The regional geological setting and stratigraphy has been summarised in the PIA for the prospecting programme (Pether, 2009a) and is not recounted herein. For the purposes of this document it is apt to focus on the deposits that will be encountered during the shallow mining, namely the uppermost beds of the **Varswater Formation**, the **Baard's Quarry Fluviatile Deposits** (BQF deposits) and the overlying **Springfontyn Formation** sands. The Palaeontological Mitigation Report (Pether, 2009c) included more information on the poorly-known Baard's Quarry Fluviatile Deposits that were not in the original PIA and, for the sake of completeness, such is also included herein.

The mining right applications occur in an area of elevated phosphate occurrences (Figure 3, red **P**s) found beneath the coversands. The areas mapped as **QP** (Figure 3) reflect outcropping phosphatic sediments which indicate that the phosphatic, early Pliocene (~5 Ma) **Varswater Formation** closely underlies those areas.

To the south, west and east of the QP areas, the eroded top of the Varswater Formation is overlain by ancient calcareous aeolianites of the **Langebaan Formation** (**QC**, Figure 3) in the form of palaeo-duneplumes. The hill of Anyskop just south of the E Quarry of the West Coast Fossil Park (WCFP) is formed of Langebaan Formation aeolianite and a further, small aeolianite ridge forms higher ground between the two application areas (Figures 2 & 3). The Langebaan Fm. aeolianites were derived from calcareous beaches and span an age range from at least the late Pliocene to the late Quaternary.

The **Springfontyn Formation** is represented by its uppermost deposits in the form of coversands Q2 and Q1 (Figure 3). The older soil **Q2** is the "heuweltjiesveld" that has formed on coversands deposited on the older formations as sandsheets and local dune fields/plumes during the middle Quaternary before ~130 ka. The Springfontyn Formation thus overlaps in age with the Langebaan Fm. aeolianites, but these coversands are mainly quartzose and poorly calcareous and reflect mobilization and redeposition of local sand sources. The coversand **Q1** is "white to slightly-reddish sandy soil", a pale sand deposited episodically during the last ~100 ka as sand sheets and dunes. In places these sands are undergoing semi-active transport.

2.1 GEOLOGY OF THE AFFECTED DEPOSITS

In places in the QP areas, dark-brown phosphatic rock resembling ferricrete/laterite is exposed, both as a variably cemented layer and as nodular material. Less common are outcrops of phosphatic sandstone, in varying hues from whitish, grey, brown and greenish. The latter underlies the former, separated by a sharp contact. These cemented lithologies have formed within pale clayey sands with low phosphate content (Visser & Schoch, 1973). This phosphatic rock material was the targeted ore at Baard's Quarry, where mining commenced in 1943. The quarry was closed and backfilled in the early 1960s.

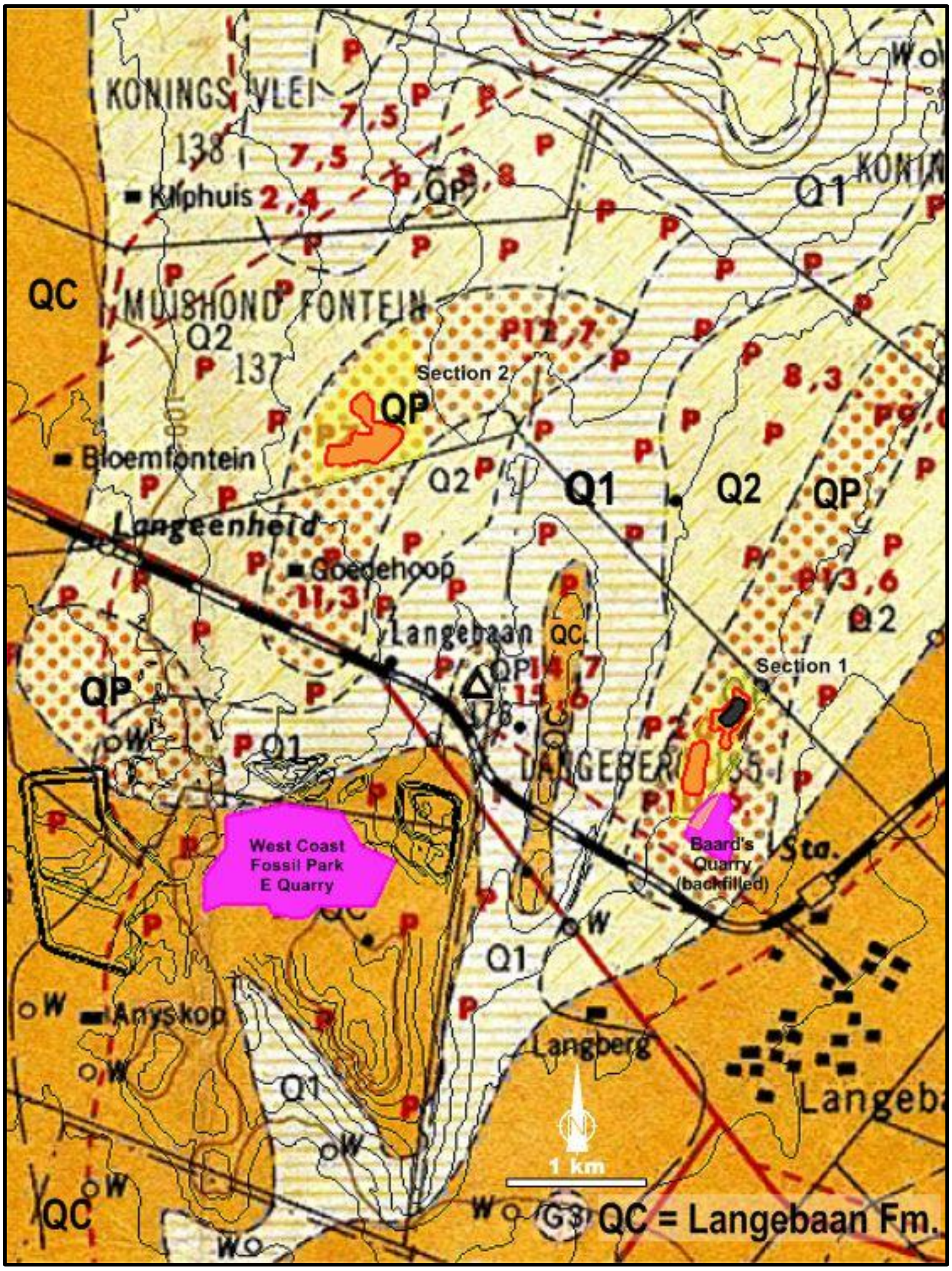

Figure 3. Geology of the project area. From Visser & Schoch (1972), 1:125000 Map Sheet 255: 3217D & 3218C (St Helenabaai), 3317B & 3318A (Saldanhabaai). Legend below in order of youngest to oldest formations.

Q1: A recent soil-unit, white to slightly-reddish sandy soil, which blankets much of the surrounding area and locally covers units Q2 and QC.

Q2: Older surficial cover of light reddish-brown, sandy soil of the "heuweltjiesveld".

QC: Langebaan Formation aeolianite limestones. These are surface outcrops of old, cemented calcareous dunes. Underlain by Pliocene and Quaternary marine deposits 5 - 0.4 Ma.

QP: Varswater Formation: Consolidated and unconsolidated sand, clay and shelly gravel.

Bedrock

G3: Saldanha Granite.

Tankard (1974) reproduced a diagram recorded during prospecting on Muishond Fontein (Farm 1043) in the northern QP area near the Section 2 mine application (Figure 3). This indicated lower deposits of pale-green clayey sands that were locally incised by donga-like, small-scale channels with multiple cut & fill structures Figure 4) and a general north-south orientation. The diagram indicates 3 periods of erosion, the last preceding deposition of the surface sands.

Hendey (1978) reconstructed the following geological section for Baard's Quarry deposits:

- **Unit 4.** Surface aeolian sands, with some unmineralized (subfossil) bones.
- **Unit 3.** Ferricrete/laterite and other duricrusts in unconsolidated sand matrix. The source of a minor assemblage of ferruginized fossil material termed the "**Upper Level Assemblage**". Isolated teeth and tooth fragments. Most material indeterminate fragments.
- **Unit 2.** Deposits, some in river channels, of phosphatic sandstones and quartz-porphyry cobbles in clayey sand matrix. The phosphatic sandstones were the ore material at Baard's Quarry. This unit was the main source of the fossils. The bones are phosphate-mineralized. Termed the "**Lower Levels Assemblage**". Also mainly bone fragments and teeth, many abraded during fluvial transport. A portion may have been eroded from underlying Unit 1.
- **Unit 1.** Greenish-white clayey sands. Source of a minor quantity of unphosphatized bones of terrestrial taxa included with the "Lower Levels Assemblage".

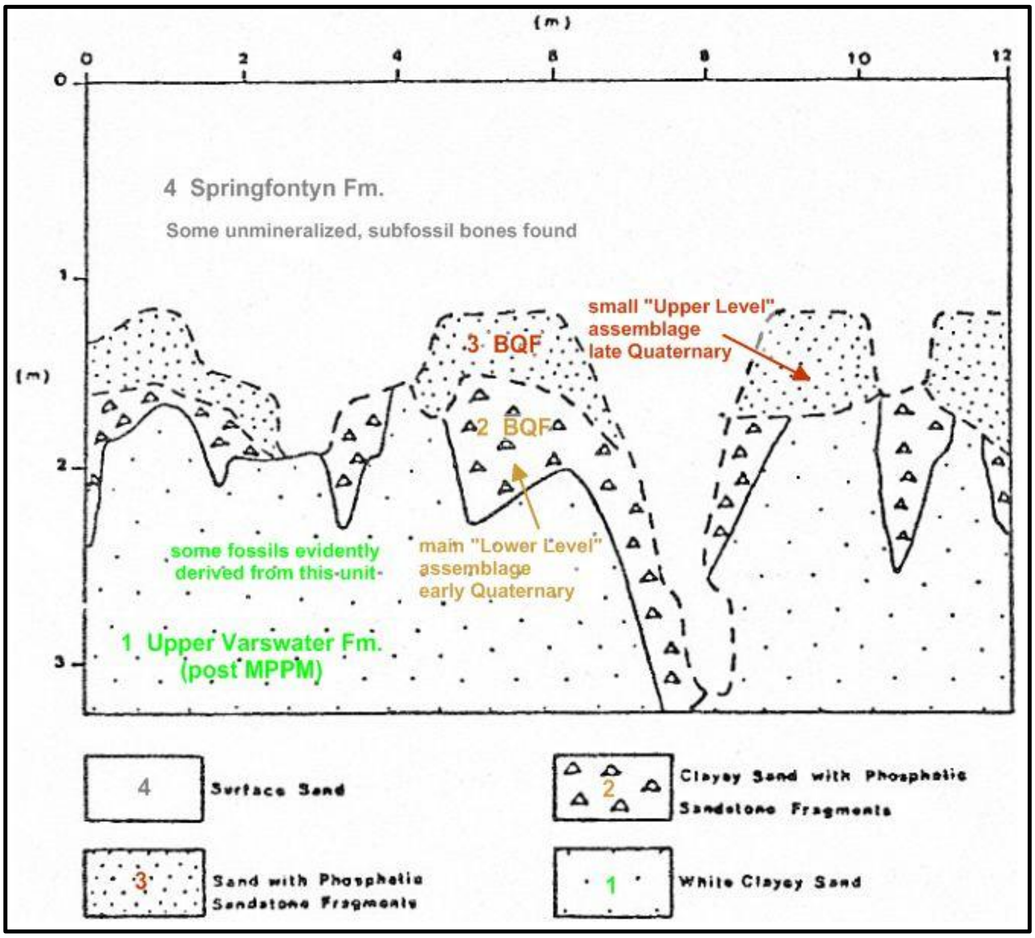

Figure 4. Schematic section of Baard's Quarry-type deposits observed on Muishond Fontein.. Adapted from Tankard, 1974.

Tankard's (1974) figure (Figure 4) was reproduced from mine records, as the quarry had already been backfilled. It shows 4 units that presumably correlate with the 4 units recognized by Hendey (1978), although the lateritic nature of "Unit 3" was not specifically indicated.

2.1.1 Unit 1

The lowermost unit exposed in the prospecting trenches is quartzose sand with intergranular, mainly pale-green, clay content, locally mottled yellow. This is taken to be the same "white clayey sand" recorded by Tankard (Figure 4) and the clayey sands called "Unit 1" by Hendey (1978). Although this clayey material is the "footwall" of the intended ore, it contains fossils that will probably be exposed at some point during mining.

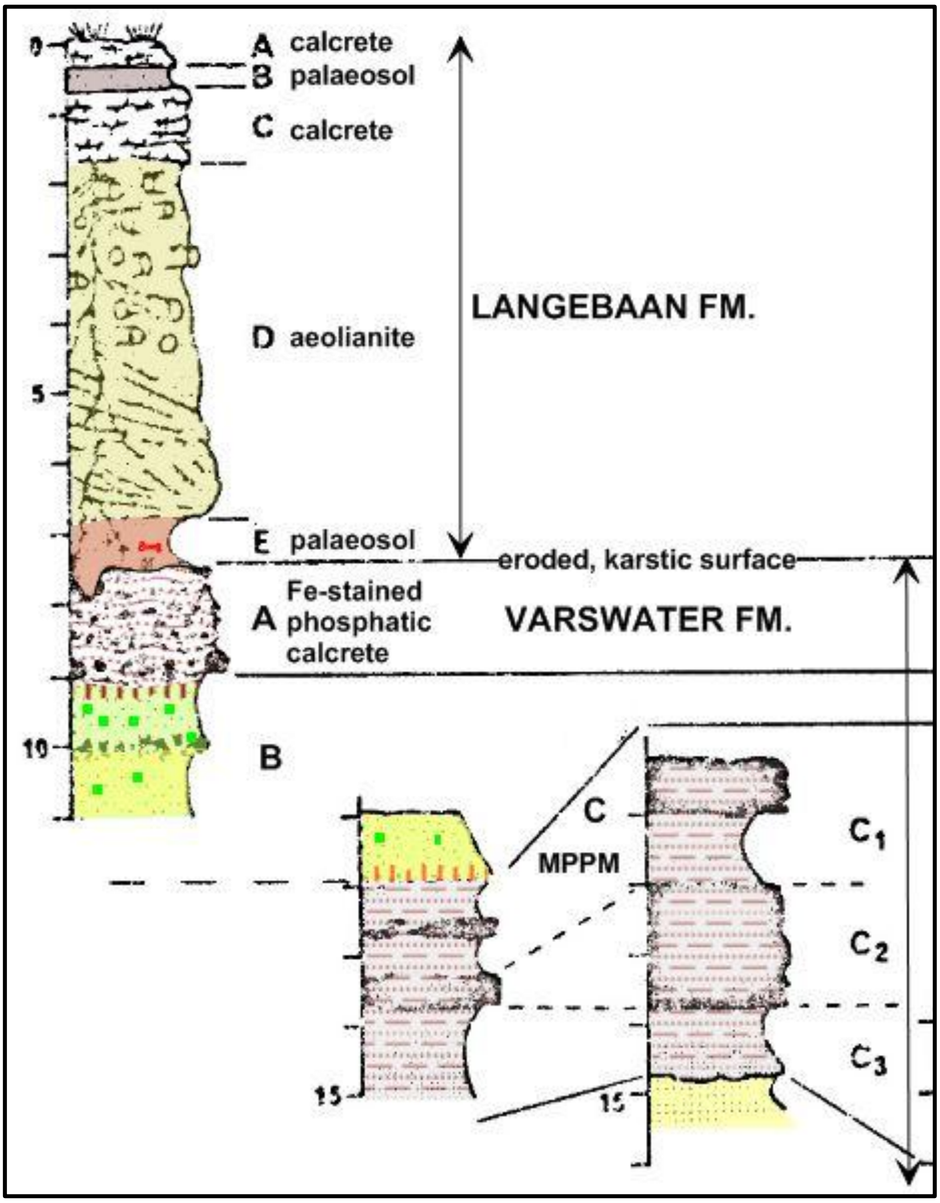

Figure 5. Measured section from Dingle et al. (1979) showing Unit B in E Quarry: ~3 m of greenish-white or yellowish quartz sand overlying the MPPM.

The sand varies from poorly-sorted with significant coarse grain content, to well-sorted medium and fine sand. Phosphatic grains are most evident in coarser sand, as red-brown, resinous grains and what appears to be phosphatized fish skeletal debris. The clay content is evidently postdepositional and the unit is mottled yellow-brown by Fe-oxides. Cementing is quite variable, parts excavating as boulder-like chunks, other parts more friable and other parts soft. No primary sedimentary structures could be clearly discerned.

Unit 1 is ostensibly the uppermost part of the Varswater Formation, *i.e.* the Muishond Fontein Phosphatic Sand Member (the MPPM) (previously called the "undifferentiated" Pelletal Phosphorite Member or PPM). The MPPM is the main phosphatic-sand bearing unit of the Varswater Formation. Its formation reflects the increasing inundation of the area by rising sea level. Deposition took place in an expanded estuarine system; seals and fishes reflect the aquatic estuarine habitat. The MPPM becomes more open-marine in the upper part, with marine microfossils, fish teeth and shell fragments, but very few bones, and evidently reflects deposition in a deepening embayment (Hendey, 1981).

However, Unit 1 differs lithologically from the "classic" MPPM as seen in the upper parts of E Quarry, which is compact, distinctly-bedded, reddish-brown, generally well-sorted sand comprised of quartz and phosphatic grains. Phosphatic sandstone rock has formed by *in situ* lithification of the sands (Dingle *et al*., 1979). The BQ Unit 1 does not resemble the "classic" upper MPPM and is therefore an unlikely correlate of it.

Happily, the observations made by Dingle *et al*. (1979) include a description of the transition between the Varswater Formation and the overlying aeolianites of the Langebaan Formation, as seen in the NW corner of E Quarry (EQ). There the "classic" MPPM is overlain by ~3 m of white, greenish-white or yellowish, compact quartz sand in which the quantity of phosphatic grains is much reduced (Figure 5, their Layer B of the Varswater Fm.). The transition from the MPPM seems well-defined and marked by a horizon of hard, phosphatic nodules and orange Fe-oxide staining. A layer of very irregular, black nodules occurs at ~10 m subsurface, beneath which the sand is yellowish. Green clasts, apparently more clay-rich, are a feature of the unit, particularly in the upper half. Underneath the capping Layer A phosphatic calcrete is a zone of intense Fe-oxide mottling.

Layer A caps the Varswater Fm. and is a well-developed, phosphate-enriched, iron-oxide-stained pedocrete. Although Dingle *et al*. (1979) suggest that this layer continued to calcify in the subsurface of the overlying Langebaan Fm. calcarenites, its inescapable feature is its eroded and solution-pitted surface. At least this indicates that pre-existing soil was removed and the underlying "hardpan" was exposed. The overlying reddish-brown soil contains numerous land snail shells, thus dissolution in an aquifer perched on the pedocrete evidently has not been serious. Fossil bone also occurs in this palaeosol.

From the description of EQ Unit B (Figure 5) it is feasible that it is the lateral equivalent of the very similar sediments exposed as Unit 1 in shallow sites ~3 km to the north and east.

The origin of this unit has apparently not been addressed in previous work. Significantly, in the summary geological column presented by Dingle *et al*. (1979) (their figure 6), the units A and B are not included in the Varswater Formation, but are shown separately above a solid line on top of Unit C (the MPPM) together with the remark "no evidence of age".

An important aspect of the interpretation of the succession exposed in E Quarry is that final regression deposits are not recognized. For instance, it can be predicted that when sea level receded from the early Pliocene transgression maximum of ~50-60 m asl., the shoreline would have built out seawards (prograded), covering the previous MPPM with shallow shoreface and beach deposits (a regressive sequence). It is possible that the basal contact of the regressive sequence is still unrecognized in the upper MPPM. However, this seems unlikely in view that no major breaks in deposition have been seen in the upper MPPM.

Nevertheless, the subaerially-exposed marine sediments of the prograded shoreline would then have been subjected to erosion by streams and wind, reducing the original thickness substantially and perhaps removing the regressive deposits altogether.

Notably, in early Pliocene coastal sequences exposed in Namaqualand diamond mines, the green-hued marine sands are capped by a well-developed pedocrete. The 2-3 m of poorly-structured sand deposits underlying the pedocrete appears marine to casual inspection, but contains sparse terrestrial fossils overlying a cryptic palaeosurface produced by aeolian erosion. The uppermost few metres of the formation thus consists of reworked marine sands that have been redeposited as aeolian sand sheets and local dunes. This reworking involved the erosion of foreshore and upper shoreface deposits that are thus missing from the marine section.

It is suggested that Unit B (Unit 1) may represent a similar reworked unit on top of the MPPM. It contains clasts of green sediment. Furthermore, the matrix adhering to the *Antidorcas* fossils suggests that they were in Unit 1, *i.e.* the unit evidently contains terrestrial fossils. The *Antidorcas* material was probably skimmed from the top of Unit 1 as, like the presently-proposed mining, Unit 1 was "footwall" and not mined.

2.1.2 Unit 2

In the prospecting trenches, the upper contact of BQ Unit 1 is sharp and eroded and locally overlain by rounded clasts and boulders of Unit 1 material. It is generally near flat and the only indication of a channel-like feature was at trench AB where a steeply-dipping plane separates pallid Unit 1 lithology and material of irregular and altered appearance. It seems the dongas illustrated in Visser & Schoch (1973) and Tankard (1974) are only locally developed. (Refer to Pether 2009c Mitigation Report for trench locations mentioned).

Unit 2, described as "phosphatic sandstone and quartz-porphyry cobbles in a clayey sand matrix" seems to involve both fragmented phosphatic sandstone and further phosphatic cementing. Except for one possible instance, the prospecting trenches did not intersect Unit 2 in donga-channel infills and a distinct Unit 2 layer or bed is not apparent on the upper contact of Unit 1.

It is suggested that Unit 2 can only be recognized when it occurs as infills of channels incised into Unit 1, or when it overlies a clear contact formed on Unit 1 and forms a distinct entity below Unit 3. Where such is absent, the events that gave rise to Unit 2 are "condensed" on the erosion surface on Unit 1.

The “Lower levels” assemblage (Table 1) is mainly fragmentary and much is clearly transported. The material is also strongly phosphate-mineralized, with the exception of the *Antidorcas* specimens. The presence of *Equus* (horse/zebra) indicates an age younger than 2.6 Ma, which is the current “*Equus* Datum” for the entry of the horse into Africa (Martin Pickford, pers. comm.) Other taxa suggest an age >2 Ma. This places the age in the early Quaternary. (NB the boundary between the Quaternary and the end of the Pliocene has been moved from ~1.8 Ma to 2.6 Ma, so that the beginning of the Quaternary corresponds to the global climatic changes consequent on the onset of major Northern Hemisphere glaciation (Ice Ages)).

Table 1. The “Lower Levels” Assemblage

Orycteropus sp., aardvark
Canis sp., jackal
Mellivora cf. *capensis*, honey badger
Panthera sp., lion or leopard
Hyaena cf. *bellax*, extinct large hyaena
+?*Homiphoca capensis*, extinct seal – only marine element.
+*Mammuthus subplanifrons*, earliest known ancestor of mammoths
+Gomphotheridae, ancestral elephant
Diceros bicornis, black rhino
Ceratotherium sp., *cf*. white rhino
+*Hipparion baardi*, extinct three-toed horse
+*Equus cf*. *capensis*, similar to extinct Cape zebra
Hippopotamus sp.
+*Sivatherium* sp., short-necked giraffid
+*Mesembriportax acrae*, *cf*. nilgai or "blue cow" of India
Reduncini, "reedbuck"
Alcelaphini 2 spp., hartebeest-like antelopes
+*Gazella cf*. *praethomsoni*, gazelle
Antidorcas sp., springbok – could be from Unit 1.
Raphicerus sp., steenbok/grysbok

Few early Quaternary mammal faunal assemblages have been found and further discoveries of these fossils from BQF-type deposits would be highly significant.

2.1.3 Unit 3

Overlying Unit 1 is the phosphatic ,dark-brown “ferricrete” of previous workers. The sharp contact seen on Unit 1 is consistent with this and shows that Unit 3 is indeed also a depositional layer and not a lateritic pedocrete formed within the preceding deposits. This lateritic material exhibits the considerable lateral variation remarked upon by previous workers and usually varies between 0.2 to ~1 m thick, but may be practically absent (Trench AA). Large lumps of white and yellow, less-altered Unit 1 material are present. They are polyphase, being comprised of amalgamations of earlier nodules. More discrete boulders are coated with dark-brown rinds and appear to be more “evolved”, with more noticeable vivid green mineralization. In places the unit has a graded appearance, with pisoliths of decreasing size fading out upwards.

The fossil material in Unit 3 (Table 2) is also fragmentary and it is "ferruginized" and stained with Fe-oxides. The assemblage has elements in common with late Quaternary fossil sites such as Swartklip. It is unlikely to be older than late in the middle Quaternary. The fossil evidence indicates that Unit 3 was deposited or thoroughly reworked late in the Quaternary.

Table 2. The "Upper Level" Assemblage

+*Equus capensis*, extinct Cape zebra
+*Hippotragus gigas* or *Oryx gazella* (gemsbok)
Hippotragus leucophaeus, blue antelope
Alcelaphini 2 spp., hartebeest-like antelopes
Raphicerus sp., steenbok/grysbok

2.1.4 Unit 4

The capping sandy soil that is mainly loose, grey sand, varying in thickness from just several cm to ~ 1 m thick. In places a more advanced soil occurs on top of Unit 3 (trenches AD and AA) and is distinguished by weak cementing and its brown colour. This indicates that Unit 4, the Springfontyn Formation coversands, accumulated in at least two phases. It is speculated that the older, semi-indurated soil underlies Q2 "heuweltjiesveld". The latter seems somewhat obscured in the QP areas by overlying Q1 grey sands. Perhaps the "subfossil" bones found in Unit 4 came from the palaeosurface separating the older soil from grey coversand.

2.2 DISCUSSION

The "supergene" phosphate enrichment and cementing of Unit 1 and the formation of the Unit 3 lateritic soil suggests that the "QP" areas have been persistent surfaces. It is instructive to return to the E Quarry section where the apparent equivalent of Unit 1 (Unit B) has a thick, capping, evolved pedocrete (Unit A) which was later subaerially exposed before being sequestered beneath aeolianites (Figure 5). The age of these aeolianites is estimated to be latest Pliocene/earliest Quaternary, as the microfossil content indicates the sands were derived from the marine Uyekraal Formation, deposited ~3 Ma and which extends seawards from just west of the WCFP. The pedocrete (Unit A), an advanced palaeosol was most probably buried and preserved beneath aeolianite somewhere between 3 - 2 Ma.

As mentioned, no age-diagnostic fossils have come from the EQ Units A and B. A pedocrete similar to EQ Unit A has evidently not been preserved in the QP areas. Accepting that the *Antidorcas* material was in the upper part of BQ Unit 1 provides a maximum age for the burial of the fossils. *Antidorcas* evolved in East Africa ~3 Ma or slightly earlier, but is not known from early Pliocene contexts. Thus a palaeosurface involving the uppermost part of BQ Unit 1 could be as old as ~3 Ma, but is probably a bit younger. Speculatively, a pedocrete that had formed in the top of BQ Unit 1 (equiv. to EQ Unit A) could have been removed by erosion prior to incorporation of the *Antidorcas* fossils.

An episode of localized landscape dissection took place between ~2.6 – 2.0 Ma, flushing fragmentary fossil material into small-scale drainages (Unit 2) and reworking the “phoscrete sandstones” that had formed in Unit 1, as well as its fossil content.

Further erosion preceded deposition of Unit 3, as Unit 2 seems now to be preserved mainly in donga-like channels. As mentioned, the fossil evidence indicates that Unit 3 was deposited or thoroughly reworked late in the Quaternary, probably younger than ~0.2 Ma. Thus a considerable lapse of time intervenes between Unit 2 and Unit 3. Unit 3 can thus be regarded as the terrestrial equivalent of the marine “condensed sequence” or “hardground”, a long-exposed “sediment omission surface” subject to ongoing diagenetic processes and reworking. It is more of a residue than a deposit.

3 NATURE OF THE IMPACT OF MINING

Mining will result in a negative direct impact on the fossil content of the affected subsurface. Fossils and significant observations will be lost in the absence of management actions to mitigate such loss. This loss of the opportunity to recover fossils and their contexts when exposed at a particular site is irreversible.

Conversely, mine pits and construction excavations 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. There remains a medium to high risk of valuable fossils being lost in spite of management actions to mitigate such loss. These aspects are summarised in Table 3.

Table 3 – Impact Table - Mining

Locale	**Quarries**	
	Without mitigation	**With mitigation**
Extent	Local/regional	Local/regional
Magnitude	High	Medium
Duration	Long	Long
SIGNIFICANCE	**HIGH (-)**	**MED-HI (- & +)**
Probability	Definite	Definite
Confidence	Certain	Certain
Reversibility	Irreversible	Irreversible
Status	Negative	Positive
Irreplaceable loss of resources?	Yes	Partly
Can impacts be mitigated?	Partly	
Mitigation:	Monitoring and inspection of excavations.	

4 *ASPECTS OF MITIGATION*

As a working hypothesis, it is suggested that BQ Unit 1 (=EQ Unit B) may be the "missing" early Pliocene regressive unit and may actually be subaerially-reworked marine deposits. Neither EQ Unit B nor BQ Unit 1 have been studied in any detail hitherto. Sparse terrestrial fossils apparently occur in BQ Unit 1. Although BQ Unit 1 is not the target of mining, its uppermost part will be extensively exposed in the "footwall" of the phosphate quarries, affording the opportunity to verify the suspected presence of fossil vertebrate bones. The unit could also be exposed to greater depth in trenches and sumps for quarry drainage.

BQ Unit 1 also has a sparse, "ambient" content of enigmatic, phosphatized, skeletal material, probably of fish origin, but micromammalian material could potentially also occur. This should be sampled and investigated more thoroughly, for its potential to elucidate aspects of the poorly-known upper parts of the Varswater Formation.

Although the BQ Unit 2 channel infills were not convincingly exposed in the prospecting trenches, they are bound to be encountered at some stage during mining. As the main source of previously-recovered fossils, special effort should be directed at obtaining more potentially-identifiable specimens from the channel fills.

No major finds of fossil material were encountered during the inspection of the prospecting trenches. Given the historical finds in the area, it is very likely that fossils were unearthed, but they are not easily seen due to the wet, clayey, nodular and stained nature of the deposits. It is thought likely that the previous finds were mainly revealed during washing and screening of the deposits and were collected on an *ad hoc* basis by Baard' Quarry mine personnel.

In an ideal world it is preferable that the fossils are spotted when they are still *in situ* or nearly so, in the sides and floors of the quarries. Given that the fossils are usually obscured to various degrees by adhering matrix material, such finds are fortuitous and the spotting of the fossils can only be improved by a deliberate alert for them, with diligent checking of possibilities. Fossils could be fortuitously seen during the excavation, moving and stockpiling of the deposits.

The visibility of fossils will be enhanced after rainfall, when surface material is washed cleaner. In general, the fossils are more visible in quarry faces that have "aged" and been cleaned up by weathering away of matrix. The drying of stockpiled deposit, with crumbling away of matrix and some wind erosion is very effective at disclosing the fossil content. Careful inspection of quarry faces and stockpiles after these conditions is bound to yield finds.

According to the mining application Scoping Report, wet screening (washing) of the excavated phosphatic material will not be done. It is being dry-screened and crushed at an unknown off-site location. Nevertheless, it is at this processing facility that the fossil bones and teeth are most likely to be seen. It is therefore a priority that for effective mitigation a means of monitoring this process be set up. The details of a fossil monitoring and recovery plan depend on the plant setup and the practicalities of observing the material and being able to obtain or "snatch" fossils from the process. Safety considerations will have to be taken into account.

A vital part of the mitigation process is the recording of the context of the fossils and the nature of the deposits in detail. However, it is clear that ascertaining the source bed of a fossil found in excavated deposits present difficulties, previously "overcome" by placing emphasis on the state of the fossil, whether Fe-stained (BQ Unit 3) or strongly mineralized (Unit 2). Some caution must apply, as the deposits are influenced by a fluctuating water table and pedogenic/diagenetic processes are likely continuing today. It can only be hoped that at some stage *in situ* fossils will be spotted and can be examined in the quarry faces.

It is impossible for a specialist to routinely monitor the quarries and mined material. Routine monitoring can only be achieved by the co-operation of the people on the ground. By these are meant personnel in supervisory/inspection roles, such as the geologist, surveyor, pit foremen, *etc*., who are willing and interested to look out for occurrences of fossils. A monitoring presence is critical for immediately spotting a major "strike" of fossils and stopping further damaging excavation.

Background information in the form of some training should be provided to mine personnel. There must be guidelines to be followed for finds and a reporting/action protocol in place when finds are uncovered during monitoring. A "Fossil Finds Procedure" is provided in Section 8.

5 PALAEONTOLOGICAL MITIGATION IN THE EMP

It is recommended that a long term mitigation plan be formulated for the quarrying operation. The inevitable loss of valuable fossils as a consequence of mining operations would be counterbalanced by the acquisition of a fossil archive which may otherwise have remained concealed indefinitely; the proviso here is that adequate mitigatory measures are implemented, involving:

- **Access**. Ready access to the site by specialists/mitigators and associated personnel should be permitted by the mining company.
- **Training**. Gecko Fert staff should be adequately trained in the detection and in certain instances, collection of fossil material.
- **Communication**. The mitigators should be timeously informed of important fossil discoveries.
- **Motivation**. Successful mitigation will largely hinge on the voluntary cooperation of Gecko Fert staff. The mitigators should motivate personnel via lectures, feedback on the significance of fossil finds and their publicization.

- **Documentation**. Gecko Fert should assist in the onsite documentation of fossil finds. This could involve provision of mine plans, work area and temporary storage facilities, materials and labour.
- **Costs**. The underlying philosophy is that the need to create an artificial fossil archive is precipitated by the destruction of the natural *in situ* archive. The mining company should therefore be liable for the costs incurred in the creation of the new archive. As a general guide, the costs of onsite mitigatory measures and preliminary curation at scientific institutions should be borne by Gecko Fert. The costs of subsequent study of the fossils should be the responsibility of the scientific organisation concerned.

It is envisaged that the IZIKO S. A. Museum, HWC, the Council for Geoscience and the West Coast Fossil Park will all be involved in some way at various times in the monitoring and rescue of fossil material during the quarrying operations. The personnel of the adjacent WCFP are well situated to respond to fossil finds, for the reasons of expertise, reduced response times and reduced costs of travel.

Section 9 of this report presents “Draft Procedures for the Mitigation of Mining Impacts on Palaeontological Resources at the Gecko Fert (Pty) Ltd Quarries”. It is a preliminary document for negotiation between involved parties, to be more specifically adapted to circumstances/issues arising and incorporated into the EMP for the mine.

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7 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.

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.

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 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.

Laterite: Soils in which iron oxides are concentrated and segregated in the form of mottling, nodules/pisoliths and cementation. Distinctive by various reddish, dark-brown to yellow-brown hues. The name laterite is derived from Latin - *later* = brick, which alludes to the brick-like hues. Also called plinthite (Greek *plinthos* = brick). Also known as ferricrete, iron pan, “ouklip” or “koffieklip”, ngubane and murram. A warm, sub-humid to humid climate with a distinct dry season and a wet season is commonly associated with laterite formation. Intermittent wetness from a fluctuating water table gives rise to the reduction and mobilization of iron and its migration and reprecipitation

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.

OSL: Optically stimulated luminescence. One of the radiation exposure dating methods based on the measurement of trapped electronic charges that accumulate in crystalline materials as a result of low-level natural radioactivity from U, Th and K.

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.

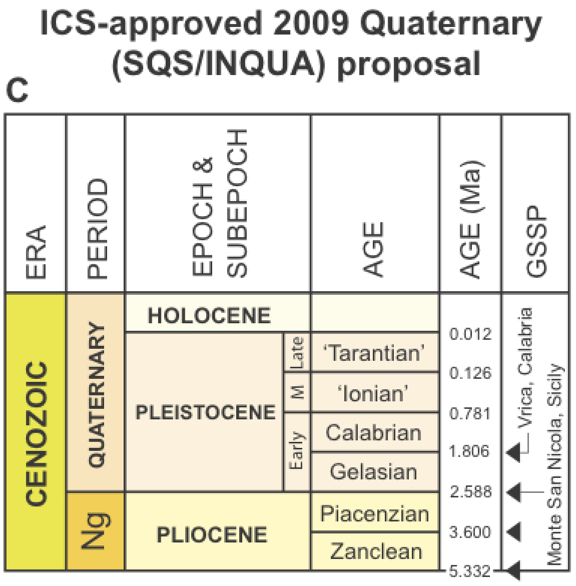
7.1 GEOLOGICAL TIME SCALE TERMS (YOUNGEST TO OLDEST).

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. The terms early, middle or late in reference to the Quaternary should only be used with lower case letters because these divisions are informal and have no status as divisions of the term Quaternary. The sub-divisions 'Early', 'Middle' or 'Late' apply only to the word Pleistocene. As used herein, early and middle Quaternary correspond with the Pleistocene divisions, but late Quaternary includes the Late Pleistocene and the Holocene.

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).

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8 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. However, they may also serve as a guideline for other fossil material that may occur.

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

8.1 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 ECO must be informed.
- **Action 3:** The responsible field person (site foreman or ECO) 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:** ECO to inform the developer, the developer contacts the standby archaeologist and/or palaeontologist. ECO 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 ECO and a suitable response will be established.

8.2 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 ECO.
- **Action 3:** ECO to inform the developer, the developer contacts the standby archaeologist and/or palaeontologist. ECO 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 the developer and the ECO 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 (see AIA). 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 an palaeontological context, the palaeontologist must evaluate the site and decide if Rescue Excavation is feasible, or if it is a Major Find.

8.3 RESCUE EXCAVATION

Rescue Excavation refers to the removal of the material from the just 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.

8.4 *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 developer/owner 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.

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 mining 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.

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9 DRAFT PROCEDURES FOR THE MITIGATION OF MINING IMPACTS ON PALAEONTOLOGICAL RESOURCES AT THE GECKO FERT (PTY) LTD QUARRIES

9.1 CONTACT PERSONS

Gecko Fert (Pty) Ltd.

Co Reg #: 2008/01296/07.
P O Box 218, Paarl, 7620.

Physical/ residential address
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Applicant's Contact
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Alternative contact's name
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jpether@iafrica.com MWeb faxmail 0866 890 732

Should the contact persons not be available, another alternate must be designated. At least 2 weeks notice of any change of contact person(s) must be given.

9.2 ACCESS TO SITE

1. Gecko Fert, or their representative, will allow the appointed mitigation specialist and any other academic specialists, approved or nominated by Heritage Western Cape or the South African Museum, access to the site to monitor the exposure of fresh sections and to conduct sampling.
2. Site visits must be arranged at least 48 hours in advance with the contact person for the mine.
3. All visitors to the site must be fully conversant with and adhere to all safety regulations and procedures of the mine.
4. Gecko Fert will ensure effective liaison and regular reporting of mining progress to the appointed specialist.

9.3 MITIGATION OF MINING IMPACT ON PALAEONTOLOGICAL RESOURCES

1. Mitigation of palaeontological material must begin as soon as possible as “trial mining” has already taken place. The appointed specialists must acquaint themselves with the operation and determine feasible mitigation strategies.
2. A plan for systematic sampling, recording, preliminary sorting and storage of palaeontological and sedimentological samples will be developed during the early stages of the project, in collaboration with the South African Museum and West Coast Fossil Park.

3. Mitigation will involve the attempt to capture all rare fossils and systematic collection of all fossils discovered. This will take place in conjunction with descriptive, diagrammatic and photographic recording of exposures, also involving sediment samples and samples of both representative and unusual sedimentary or biogenic features. The fossils and contextual samples will be processed (sorted, sub-sampled, labelled, boxed) and documentation consolidated, to create an archive collection from the excavated sites for future researchers.

9.4 FUNCTIONAL RESPONSIBILITIES OF GECKO FERT

1. Ensuring, at their cost, that a representative archive of palaeontological samples and other records is assembled to characterise the palaeontological occurrences affected by the mining operation.
2. Provide field aid, if necessary, in the supply materials, labour and machinery to excavate, load and transport sampled material from the mine areas to the sorting areas, removal of overburden if necessary, and the return of discarded material to the mine area or crushers.
3. Facilitate systematic recording of the stratigraphic and palaeoenvironmental features in exposures in the fossil-bearing excavations, by described and measured geological sections, by providing aid in the survey in of positions.
4. Provide safe storage for fossil material found routinely during mining by mine personnel. In this context, isolated fossil finds in disturbed material qualify as "normal" fossil finds.
5. Provide covered, dry storage for samples and facilities for a work area for sorting, labelling and boxing/bagging samples.
6. Costs of basic curation and storage in the sample archive at the South African Museum (labels, boxes, shelving and, if necessary, specifically-tasked temporary employees).

9.5 DOCUMENTARY RECORD OF PALAEONTOLOGICAL OCCURRENCES

1. The mine will make the mining plan available to the appointed specialist, in which the following information will be indicated on the plan by the mine in conjunction with the appointed specialist:
2. Initially, all known specific palaeontological information will be indicated on the plan. This will be updated throughout the mining period
3. Locations of samples and measured sections will be pegged and routinely accurately surveyed. Sample locations, measured sections, etc., must be recorded three-dimensionally.

9.6 FUNCTIONAL RESPONSIBILITIES OF THE APPOINTED PALAEONTOLOGIST

1. Establishment of a representative collection of fossils and an contextual archive of appropriately documented and sampled palaeoenvironmental and sedimentological geodata at the South African Museum

2. Undertake an initial evaluation of potentially affected areas and of available exposures in excavations.
3. On the basis of the above, and evaluation during the early stages of quarry development, develope, in collaboration with Gecko Fert management, more detailed practical strategies to deal with the fossils encountered routinely during mining, as well as the strategies for major finds.
4. Informal on-site training in responses applicable to "normal" fossil finds must be provided for Gecko Fert staff by the appointed specialist (see Section 8).
5. Respond to significant finds and undertake appropriate mitigation.
6. A quarterly? visit to "touch base" with the monitoring progress, process and document interim "normal" finds and to undertake an inspection and documentation of new mine faces.
7. Transport of material from the mine to the South African Museum.
8. Reporting on the significance of discoveries, as far as can be preliminarily ascertained. This report is in the public domain and copies of the report must be deposited at the IZIKO S.A. Museum and Heritage Resources Western Cape. It must fulfil the reporting standards and data requirements of these bodies.
9. Reasonable participation in publicity and public involvement associated with palaeontological discoveries.

9.7 EXPOSURE OF PALAEONTOLOGICAL MATERIAL

1. In the event of mining exposing new palaeontological material, not regarded as normative/routine as outlined in the initial investigation, such as a major fossil bone finds, the following procedure must be adhered to:
2. The appointed specialist or alternates (WCFP, South African Museum) must be notified by the responsible officer (*e.g.* the ECO or mine geologist), of major or unusual discoveries during mining, found by the mine geologist or other personnel.
3. Should a major *in situ* occurrence be exposed, mining will immediately cease in that area so that the discovery is not disturbed or altered in any way until the appointed specialist or scientists from the South African Museum, or its designated contractor, have had reasonable opportunity to investigate the find. Such work will be at the expense of Gecko Fert.
4. Section 8 of this report is a more detailed Fossil Finds guideline.

9.8 FUNCTIONAL RESPONSIBILITIES OF THE WEST COAST FOSSIL PARK

1. Assist in the training of Gecko Fert personnel in the recognition of fossil material.
2. Provide a rapid response in the event of significant finds.
3. Monitor the "normal" fossil finds at suitable intervals and take temporary custody of such at the WCFP.

Subject to agreement.

9.9 *FUNCTIONAL RESPONSIBILITIES OF THE IZIKO SOUTH AFRICAN MUSEUM*

1. Labelling, sorting, boxing, shelving, storage and cataloguing of physical and documentary material in the sample archive at the South African Museum. Eventual storage in an electronic data base of the catalogued and documentary material.

2. Maintenance of the Gecko Fert palaeontological archive at the South African Museum.

9.10 *PERMITS*

1. The specialist contracted by Gecko Fert will possess the required excavation permit from the Heritage Western Cape (HWC) in respect of palaeontological sites.
2. The mine officer with responsibility for fossil discoveries must also possess a HWC permit.

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