KALAGADI MANGANESE SMELTER, COEGA IDZ, EASTERN CAPE PROVINCE: DESKTOP PALAEONTOLOGICAL ASSESSMENT

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1. SUMMARY

The Kalagadi Manganese Smelter site in Zone 6 of the Coega IDZ, Eastern Cape overlies richly fossiliferous marine sediments of the Sundays River Formation (Early Cretaceous Uitenhage Group) and Alexandria Formation (Miocene-Pliocene Algoa Group). Surface deposits ("Bluewater Bay Formation"), averaging about 1m thick, are of low palaeontological significance. Given the high to very high palaeontological sensitivity of the underlying bedrock, a comprehensive palaeontological monitoring programme is required to record and sample fossils exposed by deeper excavations (> 1m) during development. A realistic monitoring and sampling programme should be negotiated between the professional palaeontologist appointed to undertake mitigation and the developer before deep excavations are made. The responsible ECO should also be educated about the sorts of fossils likely to be encountered and a protocol for handling fossil material exposed during development should be developed by the palaeontologist responsible. The Kalagadi Smelter development at Coega is likely to have a *positive* impact on palaeontological heritage *provided that* adequate mitigation is followed through.

2. INTRODUCTION & BRIEF

Kalagadi Manganese (Pty) Ltd are proposing to develop a manganese alloy smelter on a 209 hectare site within Zone 6 (Heavy Metal Cluster) of the Coega Industrial Development Zone (Coega IDZ) near Port Elizabeth, Eastern Cape.

The Coega IDZ overlies highly fossiliferous sediments of Cretaceous to Neogene (late Tertiary) age within the Algoa Basin. Palaeontological heritage in South Africa is protected by the National Heritage Resources Act of 1999 (Act 25 of 1999). A desktop palaeontological impact assessment for the Kalagadi Manganese Smelter project has therefore been commissioned on behalf of Kalagadi Manganese (Pty) Ltd by Coastal and Environmental Services based in Grahamstown. The main brief of the desktop PIA involves -

- Determination of the likelihood of palaeontological remains of significance on the proposed site within the Coega IDZ
- Assessment of the likely sensitivity and significance of palaeontological remains on the site
- Suggested measures to mitigate any negative impacts to palaeontological remains during the construction and operational phases of the proposed project
- Preparation of a written report on the above.

3. OUTLINE OF GEOLOGICAL CONTEXT

The Coega IDZ, situated some 25km NNE of Port Elizabeth (Eastern Cape Province) lies just inland of Algoa Bay within a south-central portion of the Cretaceous Algoa Basin known as the Sundays River Trough (1: 250 000 geology sheet 3324 Port Elizabeth, Council for Geoscience, Pretoria; Toerien & Hill 1989). This trough is a downfaulted depression to the southwest of the WNW-ESE Colchester Fault that contains a thick succession of Early Cretaceous terrestrial to marine shelf sediments of the **Uitenhage Group** (**Kirkwood** and **Sundays River Formations**; see geological sections and maps in McMillan 2003 and refs. therein). These older fossiliferous sediments are truncated by a major erosional hiatus that is overlain by a thin, but palaeontologically significant, veneer of Neogene (Miocene-Pliocene) shallow marine, coastal and estuarine sediments of the **Algoa Group** (**Alexandria Formation**) (Le Roux 1990a, Maud & Botha 2000, Roberts *et al*. 2006). Geologically-recent karstic (*ie* solution) weathering of the lime-rich Alexandria Formation has led to the development of an extensive pebbly, reddish-brown surface deposit over much of the inland outcrop area of the formation (Maud & Botha 2000). This was formerly identified as a separate, bipartite fluvial unit of Plio-Pleistocene age with calcrete horizons called the **Bluewater Bay Formation** (Le Roux 1987c, 1989) and is mapped as such on the 1: 250 000 Port Elizabeth geology sheet. Incised channels cutting into the Alexandria Formation and infilled with cross-bedded coarse "Bluewater Bay" gravels are illustrated by Le Roux (1989). They suggest that these contested surface deposits may well comprise a composite of *in situ* karstic weathering products (including coarse solution-hollow infills) as well as fluvial sediments of late Neogene age.

The superficial "Bluewater Bay" deposits average 1.2m in thickness, but this varies greatly due to the presence of occasional incised channel-fill and solution pipe structures up to 7m deep (Le Roux 1987c, 1989). The Alexandria Bay Formation ranges from 3 to 13m in thickness, with an average of 9m (Le Roux 1987b). Maud & Botha 2000 record a maximum thickness of 18m, while Robert Gess (undated heritage report) reports a average thickness of 7m for the Alexandria Formation in the Coega region. The majority of deep excavations into the Kalagadi Smelter Site at Coega (*eg* for foundations) are therefore unlikely to intersect the underlying Sundays River Formation sediments. However, this possibility cannot be entirely excluded on the basis of the very limited subsurface geological information available. Therefore the potential impact of developments within the Coega IDZ on palaeontological heritage within this Early Cretaceous formation will also be briefly considered in this report. The underlying Kirkwood Formation crops out along the banks of the Coega River west of the study area, but is too deeply buried beneath the surface within Zone 6 of the Coega IDZ to be affected by developments there.

Recent independent archaeological heritage scoping studies within Zone 6 at Coega IDZ by Dr Lita Webley of the Albany Museum (unpublished report, 2007) and Jonathan Kaplan of ACRM (pers. comm., August 2008) revealed a surface cover of recent sands or soil underlain by a layer of quartzite cobbles above an irregular calcrete surface, with some surface exposure of calcrete. Mollusc shells (marine or freshwater?) embedded within surface calcrete lumps were also observed. A photo of a vertical trench section some few metres deep provided by Mr Kaplan appears to show dark soil overlying a thin layer of poorly-consolidated, calcretised surface material (Bluewater Bay Formation?) which is underlain by more consolidated, well-bedded pale sediments. These last may be calcareous beds of the Alexandria Formation, or alternatively (Webley, 2007 report) thick subsurface calcretes.

4. SUMMARY OF PALAEONTOLOGICAL HERITAGE

An outline of the palaeontological heritage recorded from each of the three near-surface geological units represented at Zone 6, Coega IDZ is given here, together with an estimate of the overall palaeontological sensitivity of each unit, following the ongoing review of the palaeontological heritage of the Eastern Cape by Almond *et al*. (2008)

4.1. Early Cretaceous Sundays River Formation (Overall palaeontological sensitivity: HIGH)

The Sundays River Formation is of Early Cretaceous (Valanginian-Hauterivian) age, *ie* between 130-140 Ma (million years old). It comprises a thick (up to 2km) succession of grey sandstones, siltstones and finer mudrocks that are often highly fossiliferous (Shone 2006). Depositional settings range from estuarine through littoral to outer shelf (McMillan 2003). In palaeontological terms it contains one of the most prolific and scientifically important marine biotas of Mesozoic age in southern Africa.

Fossils have been recorded from these beds in the Algoa Basin since the early nineteenth century (1837) and there has been a long history of palaeontological publications dealing with the Sundays River fauna since then (see especially Cooper 1981 for early literature). Among the key papers and reviews are those by Sharpe (1856), Kitchin (1908), Spath (1930), Du Toit (1954), Engelbrecht *et al*. (1962), Haughton (1969), McLachlan & McMillan (1976, 1979), Klinger & Kennedy (1979), Cooper (1981, 1991), Dingle *et al*. (1983), McMillan (2003) and Shone (2007). An accessible, well-illustrated account of Sundays River fossils has been recently given by MacRae (1999).

The main invertebrate fossil groups recorded from the Sundays River Formation include a rich variety of molluscs (ammonites, nautiloids, belemnites, gastropods and many genera of bivalves), corals, serpulid polychaetes, echinoids, and crustaceans. There are also plant remains (*eg* bored wood, amber), rare vertebrates (*eg* marine plesiosaur reptiles and isolated dinosaur bones and teeth), diverse and abundant trace fossils, and a wide spectrum of microfossils, notably foraminiferans, ostracods, dinoflagellates and land-derived pollens and spores. Among all these the ammonites and microfossils are of particular biostratigraphic importance, while the foraminiferans are useful for palaeo-environmental analysis (See extensive discussion in McMillan 2003).

Despite the long history of palaeontological work on Sundays River fossils there has been little systematic collection of fossils – especially macrofossils - from these beds in recent decades, and most taxa remain poorly studied (*eg* most invertebrate groups, apart from the ammonites and trigonid bivalves). The Coega area – notably the Coega Brick Pits just west of the Coega IDZ – has been sampled extensively over the years for micro- and macrofossil remains, although much remains to be done even here and much palaeontologically interesting material is being destroyed through neglect. Any deeper excavations made during development within the Coega IDZ that intersect the Sundays River beds should therefore be systematically sampled for fossil remains by a qualified palaeontologist.

4.2. Miocene – Pliocene Alexandria Formation (Overall palaeontological sensitivity: HIGH)

This estuarine to coastal marine formation, consisting of a basal conglomerate rich in oyster shells overlain by calcareous sandstones, shelly coquinas and thin conglomerates, is a composite product of several marine transgression / regression cycles across the south coastal plain in Late Miocene-Pliocene times, *ie* roughly around 7-5 Ma ago (Maud & Botha 200 Roberts *et al.* 2006). It overlies a series of marine terraces incised into older (mainly Cretaceous) rocks in the hinterland of the Algoa Basin (Ruddock 1968). The unit is highly fossiliferous, but good vertical exposures in the interior are usually limited by cover of younger sediments of the Algoa Group (*eg* Nanaga Formation aeolianites) or weathered surface material of the "Bluewater Bay" facies. A wide range of marine fossils – mainly molluscs (bivalves, gastropods), but also sea urchins (the "sea pansy" *Echinodiscus*), corals, bryozoans, brachiopods, sharks' teeth, benthic foraminifera and trace fossils (*eg* pellet-walled burrows of *Ophiomorpha*) – have been recorded from the Alexandria Formation since the early twentieth century (*eg* Newton 1913, Du Toit 1954, Barnard 1962, Engelbrecht *et al*. 1962, King 1973, Dingle *et al*., 1983, Le Roux 1987a,b, 1990b, 1993, McMillan 1990). Robert Gess (undated heritage report for Coega development) also mentions mammal bones found in this unit. One of the reference stratotype sections for the Alexandria Formation (Stratotype D of Le Roux 1987b, pp. 11-13) is situated at near Coega, northeast of the Coega River and close to the study area. Here the unit is some 7-8m thick and richly fossiliferous. It is highly likely that new excavations intersecting the Alexandria Formation during development will also prove fossil-rich and sampling by a professional palaeontologist would be of scientific value, especially given the limited surface outcrop of this unit in the interior of the Algoa Basin.

4.3. Pliocene – Pleistocene "Bluewater Bay Formation" (Overall palaeontological sensitivity: LOW)

The contested geological origins of this - probably composite – superficial unit have been emphasised in Section 3 above. In any case, a late Neogene (Plio-Pleistocene) age is likely, *ie* < 5 Ma, and probably much younger (Le Roux 1987c, 1989). In contrast to the relatively unweathered Alexandria Formation beneath, the Bluewater Bay unit is characterised by the absence of fossil marine shells. Depending on the geological origins of the deposits, this may variously reflect the extensive dissolution of derived calcareous shelly material during karstic weathering of the fossiliferous (Alexandria Formation) parent rock and / or a fluvial (and often high-energy) setting. Stratotype sections for this unit were established by Le Roux (1889) at Bluewater Bay and Swartkop Salt Pan some 15-20km SW and WNW of the Coega IDZ respectively. This author records the presence of occasional freshwater molluscs (*eg* unionids) and fragmentary "terrestrial shells", presumably land snails (*eg Achatina*; *cf* Le Roux 1987b, p. 13). As with any such superficial terrestrial deposits of late Neogene age, especially in areas or horizons where calcareous layers (*eg* calcretes) abound, a wide range of other fossil animal and plant material might be encountered here. This may include: carapaces and bones of tortoises, ostrich egg shells, insect traces (*eg* calcretised termitaria), bones and teeth of small to large mammals (such as moles, bovids, elephant) as well as calcretised root casts (rhizoliths, rhizocretions). Scoping of new exposures of and new sections through these deposits for palaeontological remains during development is therefore recommended.

5. SIGNIFICANCE STATEMENT

The CES impact rating scheme is applied in the following table to assess the potential impact of the Kalagadi Manganese Smelter project on palaeontological heritage at the site and beyond.

Impact	Effect			Risk or Likelihood	Total Score	Overall Significance
	Temporal Scale	Spatial Scale	Severity / Benefit of Impact			
Without Mitigation	Permanent (-4)	Study area (-2)	Severe (-4)	Definite (-4)	-14 (detrimental)	**HIGH NEGATIVE IMPACT**
With Mitigation	Long Term (+3)	National (+3)	Beneficial (+2)	Probable (+3)	+11 (beneficial)	**MODERATE POSITIVE IMPACT**

Please note that *positive* values used above for impacts following mitigation are intended to show that this mitigation should convey positive benefits for palaeontological heritage, both locally and nationally. In contrast, failure to mitigate would entail the permanent loss of potentially rich palaeontological heritage "sealed in" below the development site.

6. CAUSE & COMMENT

Excavations made during the course of building the Kalagadi Smelter and associated developments will expose potentially fossiliferous sediments that are currently buried beneath the land surface. Study and sampling of these sediments and their enclosed fossils by a qualified palaeontologist while they are still exposed is necessary, before they are permanently sealed in by further development and thereby lost to science. If appropriate mitigation is carried out, as outlined below, this will usefully contribute to our understanding of the rich palaeontological heritage of the Coega region.

Essential palaeontological heritage mitigation for this project should involve -

- the appointment of a qualified palaeontologist *before* the commencement of excavations to undertake specialist mitigation work for this project. Before mitigation work begins, the palaeontologist involved will need to obtain a fossil collection permit from SAHRA and make arrangements with an approved repository (*eg* museum, university) to store and curate any fossil material collected.
- development of a provisional schedule and protocol for field inspection, study and sampling of exposed fossiliferous sediments by the appointed palaeontologist, in advance of construction and in collaboration with managers responsible for construction. The frequency and extent of palaeontological inspection and sampling undertaken will necessarily depend on the richness and scientific importance of any fossils revealed during excavation, which is not predictable in detail. Therefore the provisional mitigation schedule may well need to be modified accordingly as development proceeds. If important fossil deposits are encountered, intermittent mitigation is likely to be necessary as long as excavations are accessible.
- basic training of the responsible environmental control officer regarding the nature of fossil heritage that may be affected by the development (*eg* major fossil groups

concerned) and the establishment of an agreed protocol for the protection and handling of fossils material exposed while the palaeontologist is not on site.

7. SUMMARY & RECOMMENDATIONS

The overall palaeontological sensitivity of the Coega IDZ is high to very high, since it is underlain near-surface by two of the most richly fossiliferous marine formations in the South African rock succession, *viz*. the Early Cretaceous Sundays River Formation (Uitenhage Group) and the Miocene-Pliocene Alexandria Formation (Algoa Group). Some, perhaps even most, excavations much over one metre deep may well encounter fossiliferous sediments of the Algoa Group, while only deeper excavations (>9m) are likely to intersect the underlying Cretaceous beds. Surface deposits assigned to the "Bluewater Bay Formation" are of limited palaeontological interest, but they should also be inspected for possible fossil material such as vertebrate bones, teeth and non-marine molluscs.

It is therefore essential that adequate opportunity to record and sample fossil biotas from new subsurface rock exposures within the Kalagadi Smelter Site is afforded to a professional palaeontologist during the course of excavations and before these sediments are permanently "sealed in" by development. This work should involve detailed recording of sedimentary facies, fossil distribution and other palaeontologically relevant information as well as fossil collection. The palaeontologist involved will be required to obtain a palaeontological mitigation permit from SAHRA which will also involve designating an approved depository for fossil material collected during the course of the study.

A comprehensive and realistic palaeontological monitoring programme should be negotiated between the developers and the professional palaeontologist concerned *before* development (and especially deep excavation) commences. As part of this monitoring programme, the responsible ECO should receive instruction from a palaeontologist concerning the nature and types of fossils likely to be encountered, and the protocol to be followed should fossils be encountered while the palaeontologist is not on site.

It should be emphasised that, *provided adequate palaeontological mitigation is guaranteed and undertaken*, developments in the Coega IDZ are likely to make a *positive* contribution to our understanding of fossil heritage within the fossil-rich Algoa Basin.

Given the scale and scientific value of the fossil collections that may well be acquired through palaeontological mitigation at the Coega IDZ over the coming years, it would be appropriate for an informative, educational display to be set up either at Coega itself and / or a nearby educational institution such as the Albany Museum, Grahamstown or the Port Elizabeth Museum.

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