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CAINOZOIC MAMMALS FROM COASTAL NAMAQUALAND, SOUTH AFRICA

by

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ABSTRACT

Fossil mammals from various stratigraphic levels in coastal Namaqualand reveal that the littoral marine deposits, hitherto correlated to the Plio-Pleistocene, range in age from Early Miocene to Pleistocene and Holocene. The faunal assemblages, described in stratigraphic order, consist predominantly of large mammals, but most of the faunas also contain marine vertebrates and invertebrates. Faunas of Early Miocene (ca 17 Ma), Middle Miocene (ca 13-12 Ma), Late Miocene (ca 6-5 Ma), Plio-Pleistocene (ca 3-2.5 Ma) and younger age are documented.

KEYWORDS: Namaqualand, Miocene, Pliocene, Pleistocene, Mammals, Biostratigraphy

INTRODUCTION

Scanty remains of Miocene and younger fossil mammals have previously been recorded from Northern Cape Province, but the material is so fragmented and rare that previous authors (Hendey 1981 1984; Pether 1986) were only able to estimate a broad Miocene age for the sites at which they occurred (Bosluis Pan, Ryskop, Hondeklip Bay). Recent surveys carried out by the Palaeontology Expedition to South Africa (PESA), a collaborative French-South African project, has resulted in the collection of additional mammal specimens at several localities (Table 1) (Senut *et al.* 1996) which permit refined estimates to be made of the ages of the deposits. In the Miocene horizons, there are three main suites of mammals, 1) an assemblage comprising Early Miocene and basal Middle Miocene species, 2) a late Middle Miocene assemblage, and 3) a younger association consisting of Late Miocene to basal Pliocene species. Overlying these deposits are Pleistocene to Recent strata which have yielded abundant terrestrial mammal fossils and artefacts (Tables 2-5).

GEOLOGICAL SETTING

The Namaqualand coastal plain is bounded on the west by the Atlantic Ocean and it backs onto the Great Escarpment to the east. It is a strip of land 50-60 km wide by 300 km long lying parallel to the coast, extending from the Orange River in the north to the Olifantsrivier in the south (Figure 1). Much of the coastal plain is covered by sands and other sediments which support a rich vegetation consisting principally of succulents comprising the fynbos vegetation of Namaqualand. These plants flower profusely during the winter rainfall months (August-October). Palaeoclimatic evidence indicates that the region was sub-tropical during most of the Miocene, in strong contrast to the modern climatic regime. There is little surface water in the region at present, the area falling into the southern part of the Namib Desert which extends some 2000 km from the Olifantsrivier, South Africa, in the south to the Carunjamba River in Angola in the north.

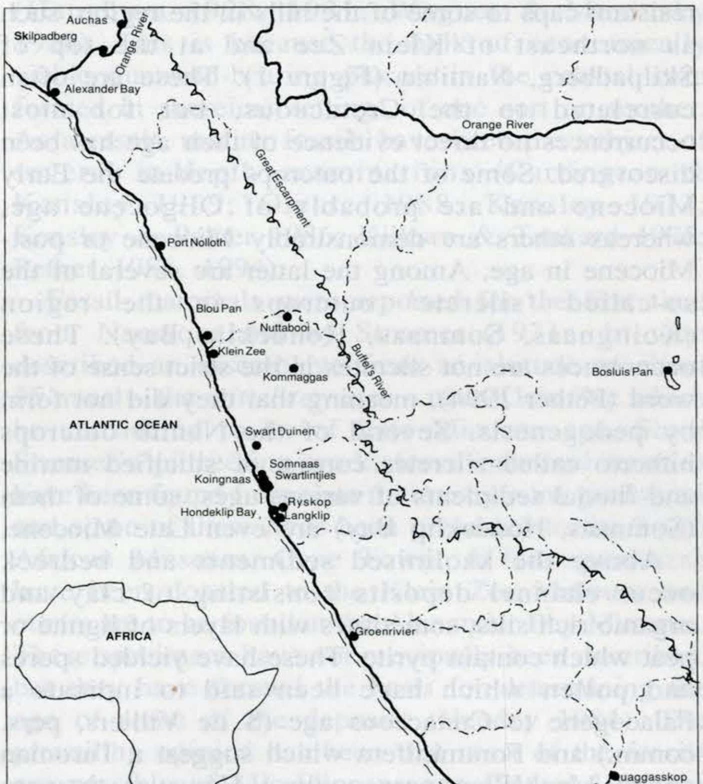

Figure 1: Locality map, Namaqualand, South Africa, showing the position of sites mentioned in the text and the approximate orientation of the great escarpment.

The sediments of the coastal plain overlie an eroded surface of gneisses and other bedrock types. The eroded surface of the gneisses has appreciable relief, even near the coast, with bedrock channels cutting several metres into the general surface.

Over large extensions of the coastal plain there are thick weathering profiles consisting predominantly of kaolinised basement and pre-Miocene sediments. These weathered profiles occur extensively from Cape Town northwards as far as Lüderitz, and they drape the landscape, rising over hills and descending into valleys, except where they have been eroded away during post-Middle Miocene erosion. Kaolinised bedrock extends seawards into the Atlantic, suggesting that the weathering which produced it took place during a pre-Miocene low sea stand. The most likely correlation is to the Oligocene period which worldwide was a period of low sea levels (Haq *et al.* 1987).

The oldest known sediments in Namaqualand, of pre-Miocene age, which occur in bedrock channels near the coast, are unfossiliferous due to extensive kaolinisation that has greatly affected them and the bedrock. The only common rock types that have escaped alteration in these kaolinised profiles are quartz and diamonds.

The next youngest sediments in the coastal plain remain undated because of an absence of fossils. So-called surface quartzites (or 'silcretes') form resistant caps to some of the hills in the region, such as northeast of Klein Zee and at the top of Skilpadberg, Namibia (Figure 1). These are often correlated to the Cretaceous, but for most occurrences no direct evidence of their age has been discovered. Some of the outcrops predate the Early Miocene and are probably of Oligocene age, whereas others are demonstrably Miocene or post-Miocene in age. Among the latter are several of the so-called 'silcrete' outcrops in the region (Koingnaas, Somnaas, Hondeklip Bay). These occurrences are not silcretes in the strict sense of the word (Pether 1994), meaning that they did not form by pedogenesis. Several of the Namib outcrops hitherto called silcretes consist of silicified marine and fluvial sediments of various ages; some of them (Somnaas, Hondeklip Bay) are even Late Miocene.

Above the kaolinised sediments and bedrock occur channel deposits consisting of clay and organic rich silts, sometimes with layers of lignite or peat which contain pyrite. These have yielded spores and pollen which have been said to indicate a Palaeogene to Cretaceous age (S. de Villiers, pers. comm.) and Foraminifera which suggest a Turonian age (I. MacMillan, pers. comm.). However, they are more likely to be Late Oligocene in age because they are younger than the kaolinised rocks which themselves are possibly Oligocene. The upper parts of the channel deposits consist of sands, often with cobbles and intraformational conglomerates. Lenses of sandstone have been ferruginised, and these have been reworked and are found as boulders of ferruginous sand in the Early Miocene diamondiferous gravels at Ryskop.

Stratigraphically above these channel fillings, there are various Miocene to Recent sediments. Near the coast these are dominantly of littoral facies rich in marine fossils assigned to the Alexander Bay Formation (Gresse 1988), which is a composite unit comprising deposits assigned to 90, 50 and 30 m sediment packages by Pether (1994). For a detailed explanation of the concept of littoral sediment packages, the reader is referred to Pether (1994), as the subject is complex and has often caused confusion. The altitudinal label refers to the height of maximal transgression following which regression occurred, which in turn led to accumulation of sediments over a range of altitudes. Confusion has arisen in some readers' minds because sediments of the '90 m package' underlie those of the '50 m package', and these underlie those assigned to the '30 m package' – which at first glance seems to be a contradiction.

The Namaqualand littoral sediment packages include lagoonal deposits containing terrestrial plant fossils, such as at Swartlintjies (Block 9) of Late Miocene to Early Pliocene age. *In situ* and reworked phosphorite blocks which contain abundant marine fossils, principally molluscs, are common at the base of the so-called 50 m and 30 m packages, but are not known to occur at the base of the Early Miocene 90 m package. Phosphorite genesis in Namaqualand thus appears to have begun after the Early Miocene and before the Late Miocene (Figure 4).

Several widely represented wave-cut 'terraces' have been mapped in Namaqualand because of their economic interest. On land, these have been related to sea levels as high as 90 m above modern sea level. From above to below these have been labelled the Grobler, Upper, Middle and Lower terraces, but the number, altitude and naming of terraces reported in the literature vary from author to author (Carrington & Kensley 1969; Gresse 1988; Hallam 1964; Keyser 1972, 1976) and from place to place. De Villiers & Sönghe (1959) recognised four terraces at Alexander Bay, as did Keyser (1972), but the naming of the terraces by various authors is inconsistent.

Approximate altitude	De Villiers & Sönghe (1959)	Keyser (1972)
84m	Not recognised	Grobler Terrace
44m	145 ft terrace	Upper Terrace
33-38m	Upper Terrace	Middle Terrace
10-25m	Middle Terrace	Middle Terrace
0-8m	Lower Terrace	Lower Terrace

Offshore, several terraces have been recognised as far down as 45 m below modern sea level (Gresse 1988).

Pether (1986 1994) proposed that the deposits lying on the subaerially exposed terraces represent three sedimentary packages, the so-called 90mP, 50mP and 30mP packages. These sediment packages are considered to have formed when sea levels were respectively at 90, 50 and 30 m above modern sea level, and consist of a variety of facies which accumulated simultaneously in four main depositional settings which differ in altitude – (from below upwards) lower shoreface, upper shoreface, foreshore and terrestrial environments. Furthermore, the packages accumulated during regressive episodes, so that sea-level was dropping during deposition of each package. For this reason, present altitude alone is insufficient to determine to which package a body of sediment belongs. One needs to determine which facies is represented and to relate this to the ancient sea level which pertained at the time of its deposition. In addition, to complicate matters, Pether (1986) recognised several other depositional environments including nearshore shelfs, and back-barrier and barrier complexes.

Gresse (1988) and Pether (1994) considered that the 90, 50 and 30 m packages, which contain warm water molluscan species, range in age from latest Miocene to Late Pleistocene, but the new biostratigraphic evidence indicates that all of them are older than previously thought. Later in time than these three sedimentary packages is a series of low level raised beaches containing cold water molluscan species.

Inland from the coastal deposits there are fluviatile sediments in the Buffels River valley (Figure 1) (Buffels Bank (=Kommaggas), Nuttabooi) but the age of these deposits is unknown. They are probably of Tertiary age because they repose on bedrock from which the kaolinised profile has been eroded. Dingle *et al.* (1983) cited Hendey (1981) to the effect that at Kommaggas there is a fossiliferous beach deposit containing shark teeth. This would mean that sea level would have been at least at an altitude of ca. 140 m above modern sea level. Hendey (1984) suggested an Early Tertiary or Middle Miocene age for Buffels Bank, citing vertebrate evidence but giving no details of the fossils concerned. It is now known that the fossil assemblage to which he was referring, and which was said to have come from Buffels Bank (or Kommaggas) did not come from this inland locality, but from the Buffels Bank Mine at Hondeklip Bay, and is thus not pertinent to estimating the age or geomorphological setting of the inland deposits.

Lamont (1947) cited Rogers (as a personal communication) concerning the presence of shark teeth and other marine fossils at Quaggaskop (Figure 1) in the Knersvlakte north of Van Rhynsdorp at an altitude of about 120 m above sea level. He failed to find additional vertebrate fossils despite recognising the supposedly fossiliferous outcrops from photographs handed to him by Rogers, but claims to have found a doubtful coral fossil. He also reported the possible occurrence of oysters in the bed of the Sout Rivier on the Farm Douse the Glim a few km upstream from Quaggaskop, about 190 m above sea level, based on conversations with the former owner of the land. Dingle *et al.* (1983, Figure 156) correlated these putative occurrences with those further north in the Sperrgebiet, Namibia, although they noted that the age of the Namaqualand deposits was equivocal and that they could be Neogene. Recent surveys in the area by PESA failed to find any marine strata in the Quaggaskop area – all the sediments seen, including the diamondiferous gravels, are of fluviatile origin overlying kaolinite, and until demonstrated otherwise, previous notices regarding the putative occurrence of marine fossils at Quaggaskop and Douse the Glim should be discounted.

Younger than all the sediments mentioned above is a series of aeolianites and other terrigenous deposits of Pleistocene to Recent age, some of which have been affected by calcrete pedogenesis and other types of pedogenesis such as the formation of murram nodules. Above the calcrete, which is of Pleistocene age, occurs a horizon of unindurated sands and mobile dunes.

PREVIOUS PALAEONTOLOGICAL WORK IN NAMAQUALAND

Ever since diamonds were first discovered in Namaqualand, fossils have played an important role in all studies regarding genesis of the deposits (Haughton 1928, 1931; Wagner & Merensky 1928). This is because the bulk of economically viable diamond-bearing placers in the coastal strip formed in shoreline settings of one sort or another. As a result, marine fossils have been the subject of several in-depth examinations (Carrington & Kensley 1969; Gresse 1988; Kensley 1977; Kensley & Pether 1986; Kilburn & Tankard 1975; Pether 1986, 1994).

Fossil mammals were reported for the first time from Namaqualand by Stromer (1931a, b) who described an assemblage from an altitude of about 35 m asl – the *mittel-terrasse* – near Klein Zee which he considered to be of Late Miocene age. Since Stromer's pioneering work, fossil mammal remains have been found from time to time by mine geologists and some of these have been presented to the South African Museum, Cape Town. A few specimens have been donated to the Klein Zee Museum and others are to be found at the Alexander Bay Museum. These specimens have not previously been described, but they have formed the basis for determining the age of some of the deposits (Hendey 1984). The prevailing opinion has been that most of the fossils are possibly of Mio-Pliocene age (Pether 1986) or even of Late Pliocene age (Hendey 1981). Only one fossil, a carnivore carnassial from Hondeklip Bay collected by M. Mittelmeyer (Pether 1986), was labelled as being of Miocene age, but this specimen has not previously been described. In fact, it belongs to a Late Middle Miocene species of amphicyonid

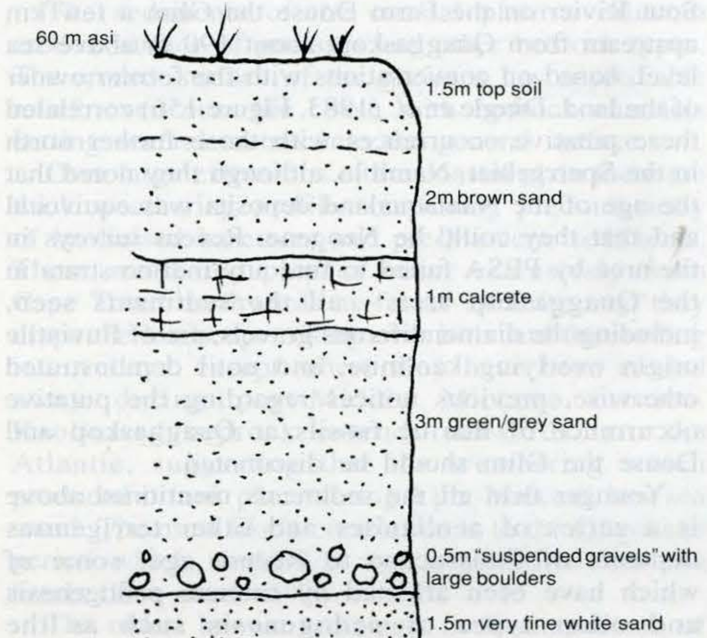

Figure 2: Stratigraphic section at Ryskop, Namaqualand, Northern Cape Province, showing the pre-Miocene channel deposits overlying kaolinised bedrock, and overlain successively by deposits of the 90 m package (Early Miocene diamondiferous gravels with fossils and white sand), the 50 m package (the "suspended gravels" and green/grey sand of Late Miocene age), calcrete of Pleistocene age, brown sand (Middle Pleistocene) and topsoil (Holocene).

(*Agnotherium* sp.), similar to a species known from Ngorora, Kenya and Beglia, Tunisia (ca 13-12 Ma).

LITTORAL MARINE BIOSTRATIGRAPHY

All four littoral marine sediment packages that have been mapped along the Namaqualand coast have yielded marine fossils (Carrington & Kensley 1969; Gresse 1988; Hallam 1964; Haughton 1928, 1931; Kensley & Pether 1986; Pether 1994; Wagner & Merensky 1928). The three older packages yield warm water molluscan faunas, while the youngest one contains a cold water mollusc assemblage. Until recent work at Ryskop, the 90 m package had yielded few fossils. The 50 m package contains the index fossil *Donax haughtoni*, while the 30 m package yields the extinct species *Donax rogersi* (Pether 1994). The sub-10 m raised beaches, unlike the three older deposits, are characterised by cold water molluscan faunas of which *Donax serra* is a member.

The diamond-bearing gravels at Ryskop, 50-52 m above sea-level (Figure 2), yield abundant marine fish and shark teeth and rarer terrestrial mammal fossils. The latter assemblage is characteristic of Early Miocene sediments of East Africa aged about 18 Ma or marginally younger (Faunal Set II of Pickford 1981) and they provide good evidence as to the age of these deposits. PESA correlated these strata to the 90 m package, and J. Pether, who was present at the time of the PESA survey, concurred with this correlation after examining the sections exposed in the Ryskop Mine. At this mine, the deposits assigned to the 90 m package are overlain by sediments of the 50 m package (locally called the "suspended gravels" (Figure 2)) which have yielded a large bovid tooth identified as *Simatherium demissum* and a fragment of rhinocerotid tooth

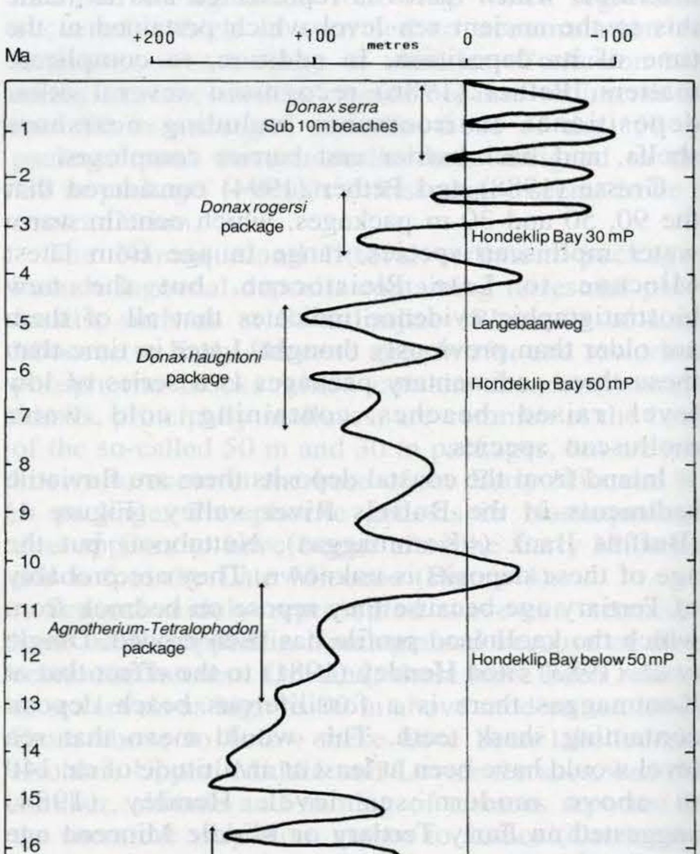

Figure 3: Correlations of Namaqualand and Namib coastal fossil sites with the eustatic curve of Haq *et al.*, 1987, reveals a broad tendency for fossiliferous sediments to accumulate during periods of high sea stand. The *Kenyasus/Nguruwe* package (= 90 m package) is late in the Early Miocene, the *Agnotherium/Tetralophodon* package is late in the Middle Miocene, the *Donax haughtoni* package (= 50 m package) is at the summit of the Late Miocene and basal Pliocene, the *Donax rogersi* package (= 30 m package) is Plio-Pleistocene in age, while the *Donax serra* packages (= sub 10 m beaches) are all Mid- to Late Pleistocene and Holocene.

similar to specimens from Langebaanweg (7-6 Ma). Thus at Ryskop and Hondeklip Bay, the 50 m package is probably latest Miocene to basal Pliocene in age.

Gresse (1988), following Pether (1986), concluded that the extinct index fossil, *Donax haughtoni*, of the 50 m package was an Early Pleistocene species, because it was considered to occur in the same strata as the equid *Equus capensis*. These authors were consequently forced to place the extinct species found in the 30 m package, *Donax rogersi*, into the Middle Pleistocene. Our own findings at Hondeklip Bay and Swartlintjies, indicate that the equids come from terrigenous deposits which overlie the marine packages in which these marker fossils occur. Gresse (1988) also found *Equus* in association with what he labelled the 50 m terrace deposits, but noted that they were from below the uppermost calcrete horizon and not within the marine succession. These subaerial deposits are certainly younger than their underlying littoral sediments. In contrast, mammals in the 50 m package suggest that it is of Late Miocene or basal Pliocene age, which would mean that *Donax haughtoni* is of this age rather than Pleistocene. This means that the younger species *Donax rogersi* could be older than previously thought, possibly Pliocene or Early Pleistocene (Figure 3).

MAMMALIAN AND AVIAN BIOSTRATIGRAPHY

The sedimentary succession in coastal Namaqualand has yielded faunas of various ages (Tables 2-5) ranging in age from Early Miocene to Holocene. The oldest fossiliferous sediments observed in the region crop out at Koingnaas and at Ryskop (on the farm Avontuur). They consist of clays and silts rich in organic material. No mammal fossils were found in these levels – the depositional environment appears to have been too acid - but the spores, pollen and foraminiferans are alleged to indicate a possible Turonian age for these sites (S. de Villiers, pers. comm., I. MacMillan, pers. comm.). These deposits are unconformably underlain by kaolinised sediments and bedrock from which no fossils have been found.

At Ryskop and Koingnaas the organic-rich clays and silts are overlain by sandstones which have been heavily ferruginised in places. At Ryskop (Figure 2), these sandstones were eroded prior to or during the Early Miocene, because they are overlain unconformably by a poorly sorted boulder bed containing reworked ferruginised sandstone cobbles which outcrops some 50 m above modern sea level. This unit has yielded Early Miocene mammals. The same bed yields abundant fish and shark teeth. Nearby, at Hondeklip Bay, a late Middle Miocene carnivore (*Agnotherium* sp.) and a tetralophodont proboscidean (*Tetralophodon* sp.) were found. Pether (1986) concluded that the sediments from which these fossils came are low elevation parts of the 90 m package – i.e. that they accumulated below contemporary sea level. However, the same package was said to have yielded Mio-Pliocene fossils, suggesting that some of the strata currently assigned to the 90 m package represent a composite deposit containing both Early Miocene and Mio-Pliocene faunal elements.

The next youngest mammalian fossils found in the region come from the so-called 50 m package (Pether 1986). This lot of sediments has been correlated to the Late Pliocene and Early Pleistocene (Gresse 1988; Pether 1986, 1994). Deposits assigned to this package accumulated when sea level was some 50 m higher than it is today. Consequently, it is rich in marine fossils, but from time to time fossil mammals of Late Miocene to Early Pliocene aspect have been found in it at various quarries, including Ryskop, Hondeklip Bay, Swartlintjies, Somnaas and Langklip (Pether 1986). Fossil bovids from Groenrivier shown to the expedition members are of similar age, being close in morphology and size to *Simatherium demissum* from Langebaanweg. Indeed, most of the fossil mammals from the 50 m package in Namaqualand are similar to material from Langebaanweg (Table 4). In particular, a fine unabraded mandible of the suid *Nyanzachoerus kanamensis australis* provides good evidence for a Mio-Pliocene age (7-5 Ma) for this package.

Pether (1986) reported that he had found *Equus* teeth in these sediments, which would indicate a Pleistocene to Recent age – younger than 2.6 Ma – for its deposition. The sediments currently assigned to the 50 m package may thus represent a complex of basal Pliocene and Pleistocene deposits. Our own feelings on the matter after finding additional equid specimens at Hondeklip Bay and Swartlintjies are that the Late Miocene to basal Pliocene sediments with marine fossils are overlain by Pleistocene terrigenous deposits of considerably younger age.

Although the Langebaanweg fauna has not been dated by geophysical methods, our comparisons with fossils from East Africa suggest that it is of Late Miocene age, ca. 7-5.5 Ma (Senut & Pickford 1994). There is a slight possibility, however, that these South African sites could be of Early Pliocene age – ca. 5 Ma. The findings of the PESA thus indicate that the so-called 50 m package contains fossils of Mio-Pliocene age.

Much of Namaqualand is covered by dune sands and terrigenous deposits which are generally poorly fossiliferous. However, mammals have been found at Swartlintjies (Table 3) and Hondeklip Bay and ostrich (*Struthio camelus*) egg shell fragments at Bloupan and near Port Nolloth. These levels have also yielded good assemblages of Acheulean and Middle Stone Age artefacts. All the fossils and artefacts found in these aeolianites indicate that they accumulated in the Middle to Late Pleistocene and Holocene. However, the basal parts of the dune succession have not yielded fossils, and they could conceivably be as old as the Late Pliocene. Parts of the aeolianite succession have been subjected to calcrete pedogenesis. Fossil mammals and bird eggs found in this calcrete at Swart Duinen (Table 2) and Bloupan are of Late Pleistocene to Holocene aspect.

In conclusion, in the coastal strip of Namaqualand, fossil vertebrates indicate that sediment

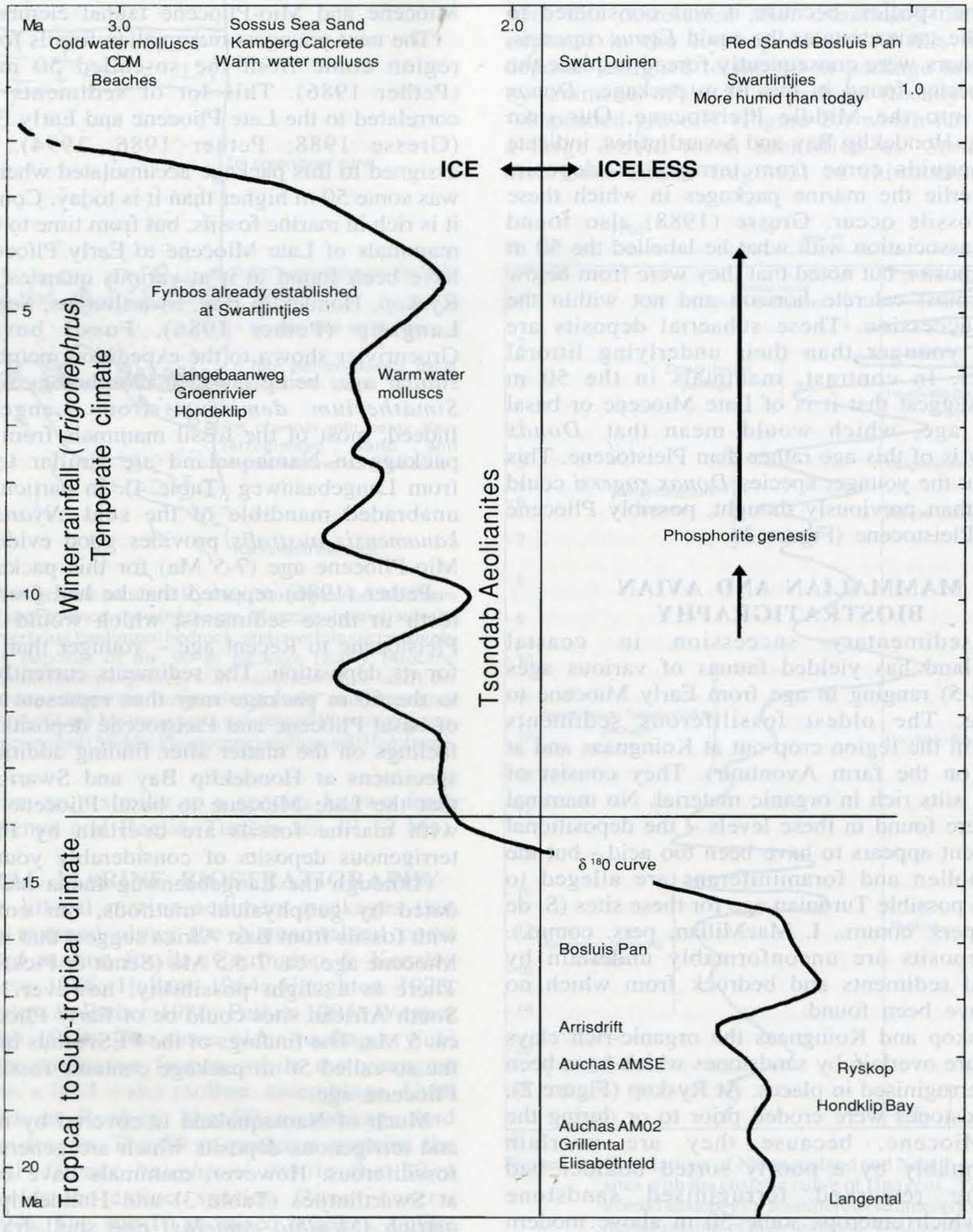

Figure 4: Correlations of Namaqualand and Namib fossil sites and geological and palaeoenvironmental events with the δ^{18}O curve of Miller & Fairbanks (1985). Prior to the mid-Miocene temperature plunge (15-13 Ma) the climate in Namaqualand and the Namib was tropical to sub-tropical. After this event the Namib became hyperarid, but the coastal waters remained warm, as revealed by the composition of the marine molluscan faunas. During this period phosphorite genesis was widespread in the region. The coastal waters finally became as cold as they are today after the second temperature plunge (3-2 Ma).

packages of at least five different ages are present in the Cainozoic succession – Early Miocene (ca 18-17.5 Ma), late Middle Miocene (ca 12-11 Ma), Late Miocene (ca 7-5 Ma), Early Pleistocene (ca 2-3 Ma) and Late Pleistocene to Holocene (ca 0.5-0 Ma) (Table 6). It is clear that, in Namaqualand, periods of high sea level (Figure 3) correspond to periods of preservation of fossil mammals.

Figure 3 correlates the southwest African sites with the eustatic curve of Haq *et al.* (1987). This shows a broad agreement between periods of littoral sedimentation and fossil preservation with periods of high sea-level in Namaqualand and neighbouring Namibia.

Figure 4 correlates the Namaqualand sites with the $\delta^{18}O$ curve of Miller & Fairbanks (1985). A major palaeoenvironmental episode occurred in southwestern Africa about 15 Ma when the climate changed from sub-tropical with summer rainfall before, to temperate with winter rainfall afterwards. During the Early and basal Middle Miocene, vegetation in southern Namibia and upland Namaqualand was of sub-tropical affinities (Pickford *et al.* 1996a; Senut *et al.* 1996; de Wit & Bamford, 1993) but by Late Miocene times fynbos was established in coastal Namaqualand (fossil plants at Swartlintjies Block 9). This change, which is best documented in Namibia, correlates closely in time with a major cooling plunge in the $\delta^{18}O$ record of the world's oceans. Nevertheless, warm water molluscs continued to thrive along the coast of Namaqualand and Namibia until the Pleistocene, after which they were replaced by an influx of cold water forms (Haughton 1928, 1931; Kensley & Pether 1986).

COMMENTARY ON STROMER'S 1931 PAPERS

According to Stromer (1931a, b), the fossils collected by F. Beetz at an altitude of little over 35 m above msl, immediately north of the Buffels River at Klein Zee, belong to Late Miocene species. The fossils were reported to be from a fluviatile sandstone lying above the marine diamond-bearing terrace deposits.

Elsewhere in the Namaqualand deposits, sediments at the 35 m mark are usually considered to be of Middle Pleistocene age (Gresse 1988), or Early Pleistocene if the new evidence is taken into account. However, altitude alone is insufficient to identify to which sediment package any strata belong, and Stromer's fossils are of Late Miocene to Early Pliocene taxa. It would thus appear to be difficult to reconcile a Late Miocene age for the Klein Zee mammals found above terrace deposits which are elsewhere considered to be considerably younger. It seems clear that the mammal fossils were not reworked from a pre-existing deposit. Two possibilities present themselves : either Stromer was in error about the age of the fossils presented to him, or a small deposit of Late Miocene strata escaped reworking during the high sea levels of the Pliocene and Pleistocene (Gresse 1988). The latter scenario is not impossible considering that most of the fossil mammals from the area – from the 50 m package – are of Late Miocene age.

Examination of most of the original fossils from Klein Zee is not possible since much of the collection was destroyed during the 2nd World War (Hendey 1984), but study of the illustrations suggests that some of the fossils might be of Pleistocene age. The murid rodent in particular appears to have molar morphology reminiscent of Pleistocene to Recent species (P. Mein, pers. comm.). Hendey (1984) considered three of the carnivore species described by Stromer (1931a) to be conspecific with material from Langebaanweg, in which case the Klein Zee fossils would indeed be of Late Miocene age. Further work needs to be done to solve this conundrum.

SYSTEMATIC DESCRIPTIONS

Early Miocene Mammal Assemblage

Order Primates Linnaeus, 1758

Superfamily Hominoidea Simpson, 1931

Genus indeterminate cf. *Kenyapithecus* Leakey, 1962

Species indeterminate

Material: SAM PQ RK 1402 is half of an upper left molar of a large bodied hominoid (Figure 5). The paracone and much of the metacone are missing, but the protocone and hypocone are complete and little worn – only the tips of the cusps have small lakelets of exposed dentine. The protocone is bordered on its anterior and lingual sides by a prominent cingulum. Anteriorly, there is an anterior accessory cusplet attached to the cingulum, but separated from the protocone by shallow grooves. A crest runs distolabially from the tip of the protocone, reaching towards the metacone, of which only the lingual portion is preserved. The hypocone is separated from the trigone by an oblique valley running from the mesiolingual edge of the tooth to the distal end, where it is blocked off by the distal cingulum. The hypocone sends a low crest from its apex labially

Figure 5: SAM PQ RK 1402, Hominoidea upper molar fragment, occlusal view : late Early Miocene (scale = 1 cm).

towards the metacone. The anterior and posterior surfaces of the crown have been lightly abraded, but each surface has a slight depression which may represent interstitial wear facets, suggesting that the tooth is either a first or second molar. In its overall morphology, the specimen recalls the genus *Kenyapithecus* and *Samburupithecus* from Samburu Hills, Kenya, rather than any of the other known Early and Middle Miocene hominoids from East Africa.

The enamel thickness can be measured near the tip of the metacone, where it is exposed in a naturally broken section. Even though the exposure is not at the tip of the cusp, the enamel is 1.6 mm thick, measured at right angles to the dentine-enamel junction. The tooth is 13.2 mm long. If this tooth is a first molar it is larger than any known Early or Middle Miocene hominoid. If it is considered to be a second upper molar, then it falls into the range of size variation of *Proconsul major* from Chamtwara, Napak and Songhor (Bosler 1981). It is appreciably larger than the two known species of *Kenyapithecus* (Pickford 1985), but is smaller than the Late Miocene hominoid from the Samburu Hills (Ishida *et al.*, 1984). This tooth provides convincing evidence of the existence of a large bodied hominoid, intermediate in body size between *Pan* and *Gorilla*, in southern Africa at the end of the Early Miocene or onset of the Middle Miocene.

Order Rodentia Bowdich 1821
Family indeterminate

Material: An isolated lower incisor, SAM PQ RK 1403 (Figure 6), has a rounded section and size akin to incisors of *Diamantomys luederitzi*. The entire surface of the tooth has been abraded so that the finely rugose surface structure has been polished off, meaning that it is not possible to identify the specimen below the ordinal level. It does show that relatively large rodents survived in the region at the time of deposition of the diamondiferous strata.

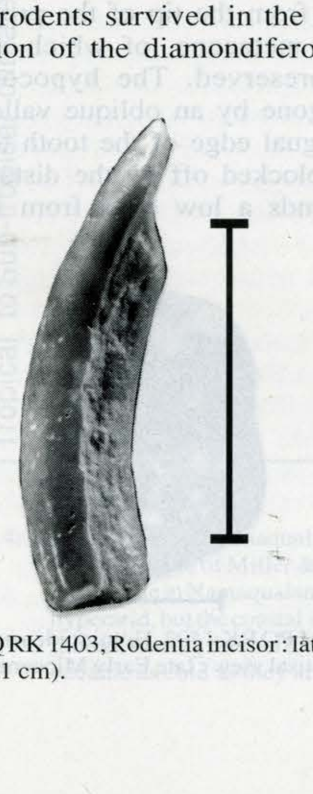

Figure 6: SAM PQ RK 1403, Rodentia incisor : late Early Miocene (scale = 1 cm).

Suborder Pinnipedia Illiger, 1811
Family Phocidae Gray, 1825
Genus cf. *Mirounga* Gray, 1827
Species indeterminate

Material: Four isolated peg-like teeth with roots appreciably more voluminous than the crowns closely resemble the cheek teeth of *Mirounga*, the elephant seal (Figures 7a-d). The crowns are simple pegs covered in enamel which has grooves running from cervix to tip all round the teeth. The apices of the crowns are slightly bent over. The roots have a "swollen" appearance and are almost twice as long as, and 1.5 times the diameter of, the crowns. The teeth have the following dimensions in mm:-

	Specimen			
	1	2	3	4
Figure 7	a	b	c	d
Dimension (in mm)				
Total height (root + crown)	26.3	24.0	19.2	21.3
Crown diameter	5.1	6.1	4.5	---
Root diameter	8.4	8.3	6.3	5.0
Crown height	10.4	10.0	7.4	8.0
Root length	18.2	16.9	15.9	15.0

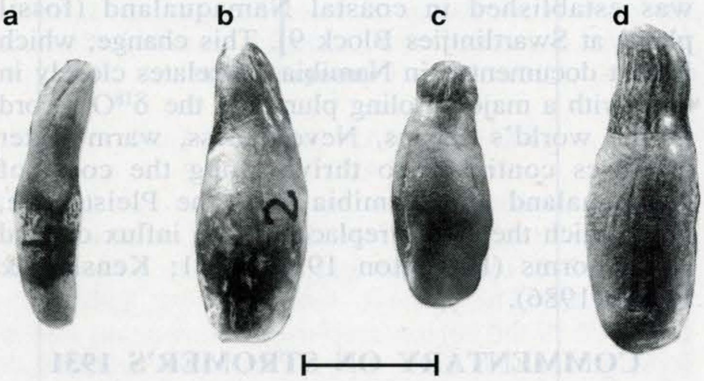

Figure 7: a-d.- RK, cf. *Mirounga* sp. Cheek teeth, side views : late Early Miocene (scale = 1 cm).

Suborder Deinotherioidea Osborn, 1921
Family Deinotheriidae Bonaparte, 1845
Genus *Prodeinotherium* Ehik, 1930
Species *Prodeinotherium hobleyi* (Andrews, 1911)

Material: Two enamel fragments (Figures 8a-b) are assignable with confidence to deinotheres on the

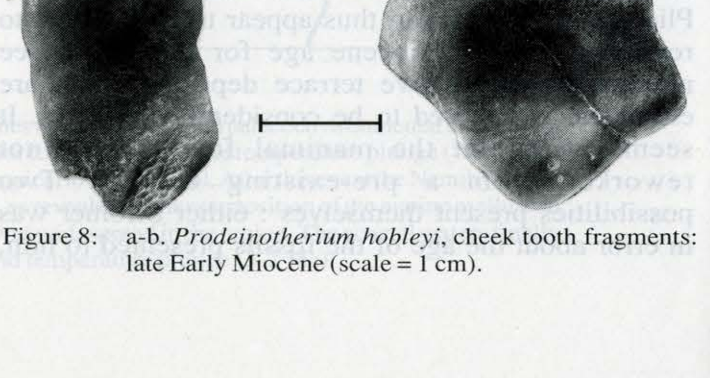

Figure 8: a-b. *Prodeinotherium hobleyi*, cheek tooth fragments: late Early Miocene (scale = 1 cm).

basis of their size, loph-like shape and the characteristic wear pattern on the occlusal edges of the lophs. Judging from their size, these fragments could belong to the small species *Prodeinotherium hobleyi*, which is known widely in Africa from Early and Middle Miocene sediments.

Suborder Elephantoidea Gray, 1821
Family Gomphotheriidae Cabrera, 1929
Genus indeterminate

Material: Numerous enamel fragments of gomphotheres occur at Ryskop. These cannot be identified precisely, but their abundance suggests that gomphotheres were a common element in the Miocene fauna of coastal Namaqualand.

Order Perissodactyla Owen, 1848
Family Rhinocerotidae, Owen, 1845
Genus indeterminate

Material: At Ryskop, many fragments of rhinocerotid enamel have been found, but most of them are not possible to identify beyond the family level. There is one specimen, a premolar ectoloph, which possesses a strong basal cingulum (Figures 9a-b) comparable to that of the genus *Brachypotherium*, but it would be unwise to go further than this. The relative abundance of material suggests that rhinocerotids were a common element in the Early Miocene fauna of the region.

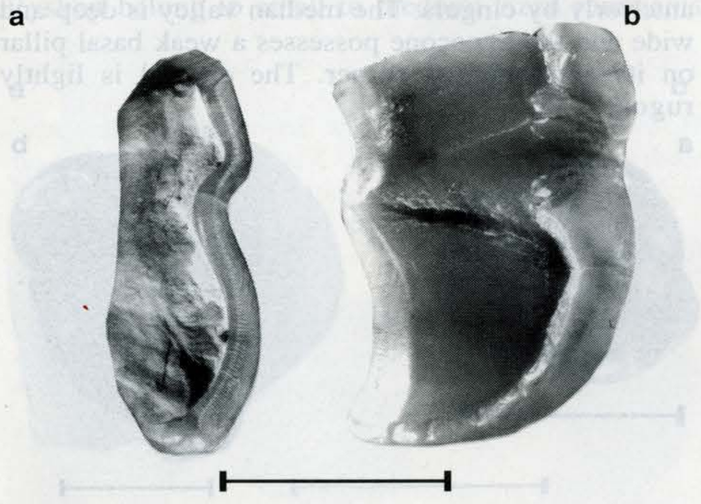

Figure 9: a-b. RK, Rhinocerotidae lower premolar fragment, occlusal and buccal view : late Early Miocene (scale = 1 cm).

Order Artiodactyla Owen, 1848
Family Suidae Gray, 1821
Genus *Nguruwe* Pickford, 1986
Species *Nguruwe kijivium* (Wilkinson 1976)

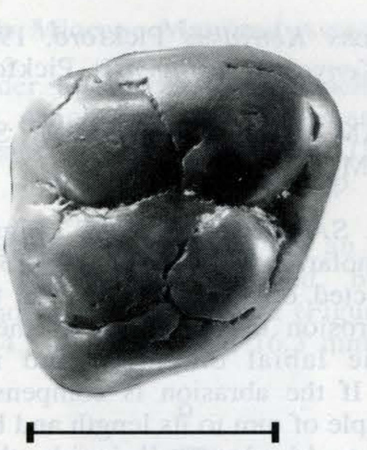

Figure 10: SAM PQ RK 1396, *Nguruwe kijivium*, upper left third molar, occlusal view : late Early Miocene (scale = 1 cm).

Material: A left upper third molar from Ryskop (SAM PQ RK 1396) is typical of *Nguruwe kijivium*, even though the specimen is rolled and polished (Figure 10). RK 1396 is 15.1 mm long by 13.7 mm wide, but would originally have been larger. It is heavily rolled and polished, to the extent that the median accessory cusp is confluent with the hypocone. There are four main cusps, and an anterior cingulum which reaches round the lingual side of the protocone. Labially there is a cingulum, as in East African material. Distally the hypoconule is small and lingually positioned. In the lingual end of the median transverse valley there is a basal pillar, and the median valley itself is narrow.

This tooth is close in size and morphology to the Kenyan sample of *Nguruwe kijivium* (Pickford 1986) (Figure 11) which has also been recorded from basal Middle Miocene deposits at Arrisdrift (Pickford 1995; Pickford *et al.* 1996a, b), for which an age of ca 17.5 Ma has been suggested.

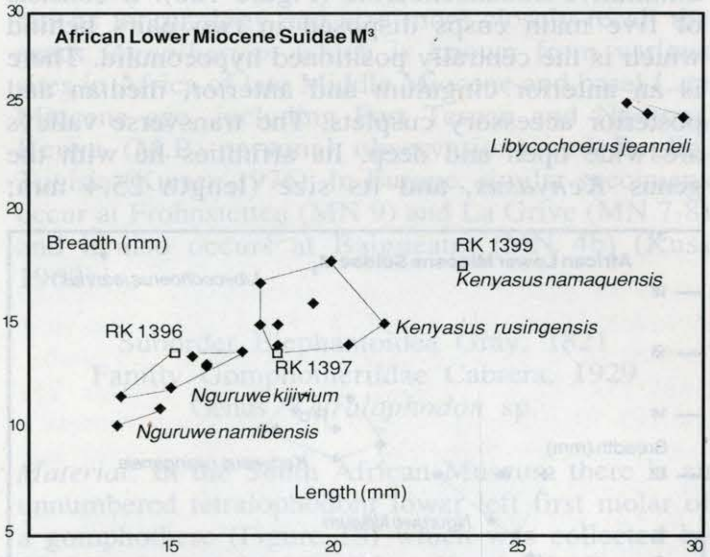

Figure 11: Bivariate plot of suid upper third molars from Ryskop and East Africa. Such data not only show that Ryskop is roughly contemporary with late Early Miocene localities in East Africa, but that it contains a species (*Kenyasus namaquensis*) hitherto not recorded from East Africa.

Genus *Kenyasus* Pickford, 1986
Species *Kenyasus rusingensis* Pickford, 1986

Material: SAM PQ RK 1397, right M^3; SAM PQ RK 1393, right M_3.

Description: SAM PQ RK 1397 (Figure 12a) an upper third molar, is 18.0 mm long by 13.7 mm wide. It is constructed on the same plan as the previous tooth, but erosion of the edges of the crown has removed the labial cingulum and reduced its dimensions. If the abrasion is compensated for by adding a couple of mm to its length and breadth, then this tooth would plot well inside the range of variation of *Kenyasus rusingensis* (Figure 11).

Figure 12: a-b.- a) SAM PQ RK 1397, *Kenyasus rusingensis*, upper left third molar, occlusal view and b) SAM PQ RK 1393, *Kenyasus rusingensis*, lower right third molar, occlusal view : late Early Miocene (scale = 1 cm)

An isolated lower right third molar from Ryskop, SAM PQ RK 1393, has been rolled and abraded, but is complete enough to reveal that it belongs to a diminutive kubanochoerine (Figure 12b). It consists of five main cusps disposed in two pairs behind which is the centrally positioned hypoconulid. There is an anterior cingulum and anterior, median and posterior accessory cusplets. The transverse valleys are wide open and deep. Its affinities lie with the genus *Kenyasus*, and its size (length 25.4 mm; breadth 14.1 mm) is compatible with the Early Miocene species from Kenya (Pickford 1986). When unabraded this tooth would have been somewhat larger and if the abrasion is compensated for by adding a couple of mm to its length and breadth, the specimen still plots within the range of variation of *Kenyasus rusingensis* (Figure 13).

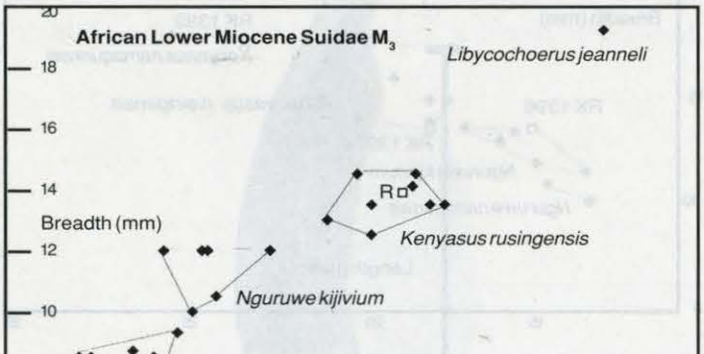

Figure 13: Bivariate plot of suid lower third molars from Ryskop and East Africa.

Species *Kenyasus namaquensis* sp. nov.

Diagnosis: A species of *Kenyasus* intermediate in size between *Kenyasus rusingensis* and *Libycochoerus jeanneli*.

Holotype: SAM PQ RK 1399, unworn left upper molar (Figure 14b).

Paratype: SAM PQ RK 1398, right P^4 (Figure 14a)

Derivatio nominis.- The species name is for the Namaqua region, Northern Cape Province, South Africa.

Description: The upper left molar, SAM PQ RK 1399 (Figure 14b), the holotype of the species, is 23.2 mm long by 17.7 mm wide, and is larger than the known sample of *K. rusingensis* from Kenya (Figure 11). The crown is relatively unused and not heavily rolled. It consists of four main cusps with anterior, median and distal accessory cusplets. The hypoconule is lingually positioned and is flanked anteriorly by cingula. The median valley is deep and wide and the hypocone possesses a weak basal pillar on its anterolingual corner. The enamel is lightly rugose.

Figure 14: a-b. SAM a) PQ RK 1398, *Kenyasus namaquensis* sp. nov., right upper fourth premolar, occlusal view and b) SAM PQ RK 1399, *Kenyasus namaquensis* sp. nov., left upper third molar, occlusal view : late Early Miocene (scale = 1 cm)

An isolated right upper fourth premolar (SAM PQ RK 1398) (Figure 14a) is 11.5 mm long by 11.7 mm wide, which is significantly larger (Figure 15) than material from Kenya assigned to *Kenyasus rusingensis*. It possesses two labial cusps and a single, large, lingual cusp which is surrounded by a cingulum. The sagittal valley is wide open, but is blocked off anteriorly and posteriorly by cingula.

The Ryskop suid specimens as an assemblage suggest an age younger than Rusinga (17.8 Ma) but perhaps equivalent to Arrisdrift (17.5 Ma). In any case, the fossils are of late Early Miocene or early Middle Miocene age.

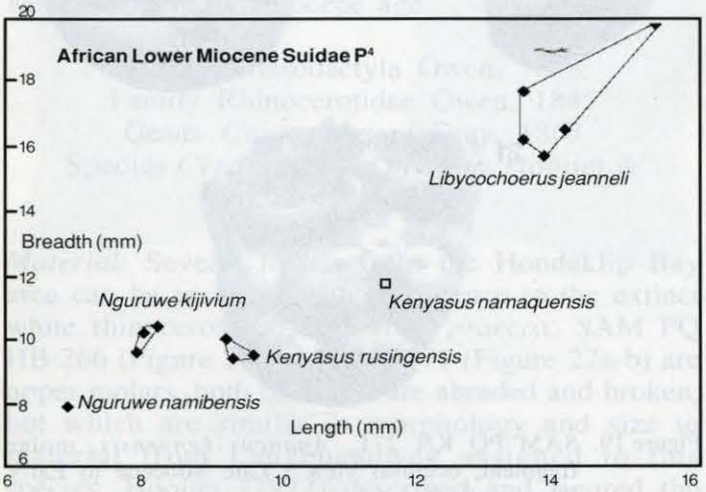

Figure 15: Bivariate plot of suid upper fourth premolars from Ryskop and East Africa showing the presence of a large species of *Kenyasus* (*K. namaquensis*) at Ryskop.

Suborder Ruminantia Scopoli, 1777
Genus indeterminate

Material: Two small fragments of upper molars from Ryskop belong to small to medium sized ruminants (Figures 16a-b). They are too fragmented to be identifiable beyond the level of ruminant.

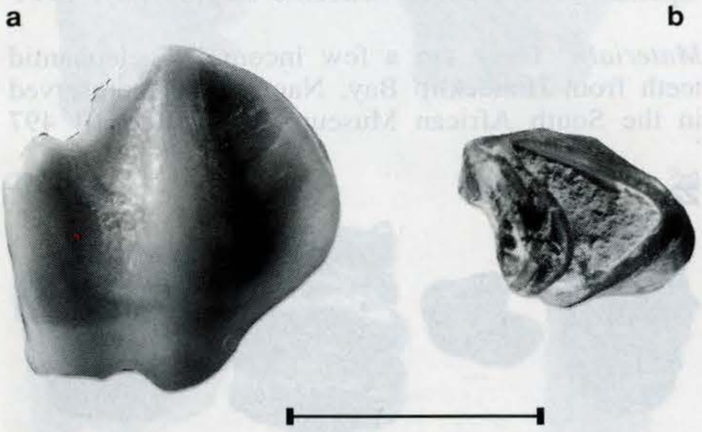

Figure 16: a-b. a) RK, ruminant upper molar ectoloph, buccal view and b) RK, ruminant molar fragment, occlusal view (scale = 1 cm).

Middle Miocene Mammal Assemblage

Suborder Fissipedia Blumenbach, 1791
Family Amphicyonidae Trouessart, 1885
Genus *Agnotherium* Kaup, 1833
Species *Agnotherium* sp.

Material: SAM PQ HB 504, is an upper right carnassial, rolled and polished, but in good condition and practically unworn (Figure 17a-c), 27 mm long, 14.3 mm wide and 16.3 mm high.

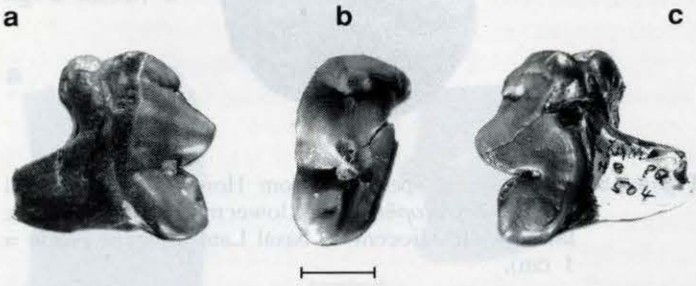

Figure 17: a-c.- SAM PQ HB 504, *Agnotherium* sp. Upper right carnassial, labial, occlusal and lingual views: late Middle Miocene to basal Late Miocene (scale = 1 cm)

Description: The following description was kindly supplied by Dr Jorge Morales, Madrid. This tooth is an upper right amphicyonid carnassial which is long and narrow (sectorial). The protocone is broken but was located low and in an anterior position and would have been very reduced in size. The parastyle is well developed.

This tooth is larger than material from Arrisdrift, Namibia (Morales *et al.* in press) described as a new species of the genus *Ysengrinia*, a genus also known from basal Middle Miocene sites in Europe (MN 04), but its morphology and size more closely recall the genus *Agnotherium* which is known from various sites in Africa of late Middle Miocene and basal Late Miocene age, including Fort Ternan and Ngorora, Kenya (M.P. personal observation) and Beglia, Tunisia (Kurten 1976). In Europe, similar specimens occur at Frohnstetten (MN 9) and La Grive (MN 7-8) and it also occurs at Baigneaux (MN 4b) (Kuss 1962).

Suborder Elephantoidea Gray, 1821
Family Gomphotheriidae Cabrera, 1929
Genus *Tetralophodon* sp.

Material: In the South African Museum there is an unnumbered tetralophodont lower left first molar of a gomphothere (Figure 18) which was collected by M. Mittelmeyer in 1984/85 at Hondeklip Bay from

Figure 18: Unnumbered specimen from Hondeklip Bay, basal gravels, *Tetralophodon* sp., lower molar, occlusal view: late Middle Miocene to basal Late Miocene (scale = 1 cm).

the basal gravels below the 50 m package. It has four and a half lophs, the last one being composed of a central pillar bordered laterally and lingually by low beaded cingula. It is ca 119 mm long by ca 57 mm wide and the enamel is ca 4.5-5 mm thick.

It recalls material from Ngorora (Tassy 1986) and Samburu Hills, Kenya (Nakaya *et al*. 1984) Sinda-Mohari, Zaire (Madden 1977) and from the Maghreb (Bergounioux & Crouzel 1956) all of late Middle Miocene to early Late Miocene age (faunal sets V and VI (Pickford 1981)). The most likely age of the Hondeklip Bay material is between 12 and 9 Ma.

Late Miocene Mammal Assemblage

Suborder Elephantoidea Gray, 1821
Family Gomphotheriidae Cabrera, 1929
Genus *Anancus* Aymard, 1855
Species *Anancus kenyensis* (MacInnes, 1942)

Material: There are several specimens from Namaqualand that can be assigned with some confidence to the genus *Anancus*. Even though the fossils are abraded and often incomplete, the characteristic offset between the labial and lingual cusps is present in most specimens. Material includes SAM PQ KN 271 (Figure 19), the mid portion of a molar comprising parts of 2.5 lophs, SAM PQ HB 431 (Figure 20), HB 432 (Figure 21) and HB 501 (Figure 22), the distal portions of molars from Hondeklip Bay. The molar enamel is thick and the crowns bunodont.

Even though the material is variable in morphology, all of it can be subsumed into *Anancus kenyensis*, and it is comparable to material from Langebaanweg, South Africa (Hendey 1981). The material is probably Latest Miocene to Early Pliocene in age.

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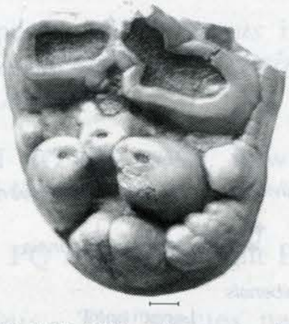

Figure 19. SAM PQ KN 271, *Anancus kenyensis*, molar fragment, occlusal view : Late Miocene to Early Pliocene; (scale = 1 cm).

Figure 20. SAM PQ HB 431, *Anancus kenyensis*, molar fragment, occlusal view : Late Miocene to Early Pliocene;(scale = 1 cm).

Figure 21. SAM PQ HB 432, *Anancus kenyensis*, molar fragment, occlusal view : Late Miocene to Early Pliocene (scale = 1 cm).

Family Elephantidae Gray, 1821
Genus *Loxodonta* Cuvier, 1827
Species *Loxodonta* sp. Lukeino stage Tassy, 1994

Material: There are a few incomplete elephantid teeth from Hondeklip Bay, Namaqualand preserved in the South African Museum. SAM PQ HB 497

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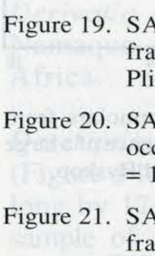

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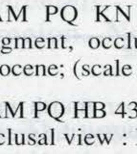

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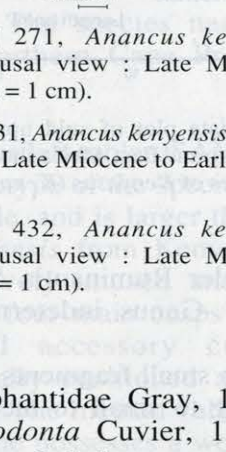

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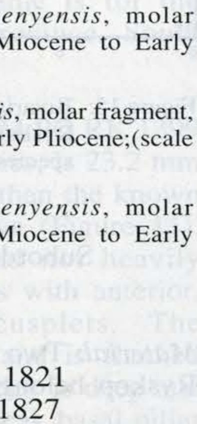

Figure 22: SAM PQ HB 501, *Anancus kenyensis*, upper molar, occlusal view : Late Miocene to Early Pliocene (scale = 1 cm).

Figure 23: SAM PQ HB 497, *Loxodonta* Lukeino stage, molar fragment, occlusal view : Late Miocene to Early Pliocene (scale = 1 cm).

Figure 24: SAM PQ HB 429, *Loxodonta* Lukeino stage, molar fragment, occlusal view : Late Miocene to Early Pliocene (scale = 1 cm).

Figure 25: SAM PQ HB 502, *Loxodonta* Lukeino stage, molar fragment, occlusal view : Late Miocene to Early Pliocene (scale = 1 cm).

(Figure 23), HB 429 (Figure 24), and HB 502 (Figure 25) are characterised by thick enamel, wide interloph valleys, the presence of cementum and distinct loxodont sinuses. These fossils resemble early loxodonts from Lukeino (Kenya) and the Western Rift Valley, Uganda (Tassy 1994) of Late Miocene to Early Pliocene age.

Order Perissodactyla Owen, 1848
Family Rhinocerotidae Owen, 1845
Genus *Ceratotherium* Gray, 1867
Species *Ceratotherium praecox* Hooijer & Patterson, 1972

Material: Several fossils from the Hondeklip Bay area can be assigned with confidence to the extinct white rhinoceros *Ceratotherium praecox*. SAM PQ HB 266 (Figure 26) and KN 1771 (Figure 27a-b) are upper molars, both of which are abraded and broken, but which are similar in morphology and size to material from Langebaanweg assigned to this species. Hooijer (1972) described and figured the specimen from Swartlintjies (KN 1771). There is also a metacarpal lacking the distal extremity, SAM PQ HB 985 (Figure 28), which conforms to specimens of the same species known from Langebaanweg and East Africa.

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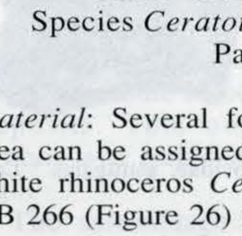

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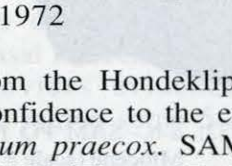

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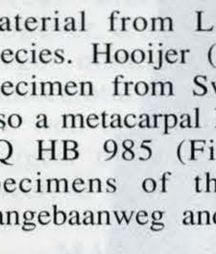

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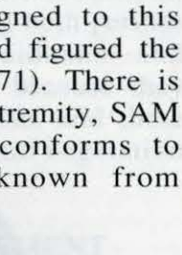

Figure 26: SAM PQ HB 266, *Ceratotherium praecox*, upper molar, occlusal view : Late Miocene to Early Pliocene (scale = 1 cm).

Figure 27: a-b.- SAM PQ KN 1771, *Ceratotherium praecox*, upper molar, a) occlusal and b) mesial views : Late Miocene to Early Pliocene (scale = 1 cm).

Figure 28: SAM PQ HB 985, *Ceratotherium praecox*, metacarpal, dorsal view : Late Miocene to Early Pliocene (scale = 1 cm).

Family Equidae Gray, 1821
Genus *Hipparion* de Christol, 1832
Species *Hipparion* cf. *sitifense* Pomel, 1897

Material: An isolated upper cheek tooth, SAM PQ HB 498, from Hondeklip Bay (Figure 29), recalls the North African species *Hipparion sitifense* by its diminutive size and curved, rather low crown. The protocone is also relatively rounded, and in these respects the Namaqualand fossil resembles material from the Albertine Rift, Uganda (Eisenmann 1994), aged about 6-7 Ma.

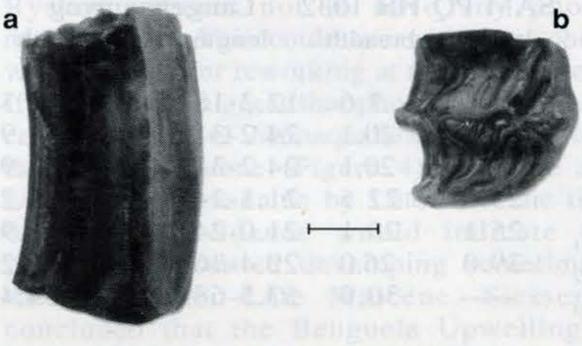

Figure 29: a-b. SAM PQ HB 498, *Hipparion* cf. *sitifense*, upper molar a) side and b) occlusal views : Late Miocene (scale = 1 cm).

Order Artiodactyla Owen, 1848
Family Suidae Gray, 1821
Genus *Nyanzachoerus* Leakey, 1958
Subspecies *N. kanamensis australis* Cooke & Hendey, 1992

Material: A partial right mandible, SAM PQ HB 1032, with P_2 to half M_3, from the 50 m package at Hondeklip Bay (Pether 1994), is unabraded, but rather broken (Figure 30). The mandible is accompanied by isolated left P_3, right and left

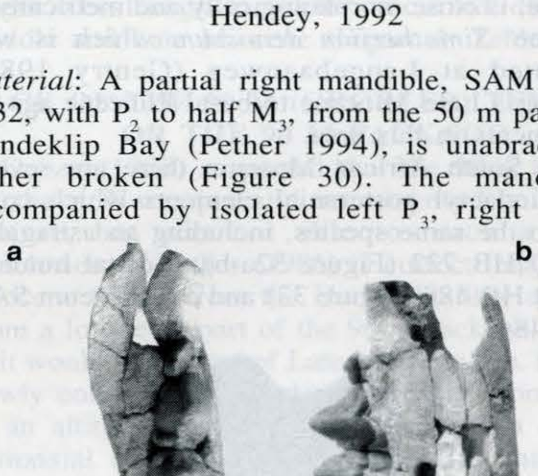

Figure 30: a-b. SAM PQ HB 1032, *Nyanzachoerus kanamensis australis*, right mandible with P_2-front half of M_3, a) occlusal and b) labial views : Late Miocene to Early Pliocene (scale = 1 cm).

incisors and both canines. The dentition is in good condition, except for the first molar which is heavily worn. The specimen is close in morphology to specimens from Langebaanweg (Cooke & Hendey 1992) but its molars are slightly longer than the largest specimens from this site. It is also similar in morphology and size to material from the Late Miocene of Nkondo, Uganda (Pickford 1994).

Measurements of SAM PQ HB 1032 (in mm) compared with range of variation in *Nyanzachoerus kanamensis australis* from Langebaanweg (own measurements).

	SAM PQ HB 1032		Langebaanweg	
Tooth	length	breadth	length	breadth
Right P_2	15.3	7.6	12.2-18.0	7.6-9.3
Right P_3	27.5	20.1	24.2-31.0	18.5-23.9
Left P_3	27.6	20.1	24.2-31.0	18.5-23.9
Right P_4	25.5	22.5	21.1-24.2	21.2-24.2
Right M_1	25.1	20.1	21.0-24.2	16.5-21.9
Right M_2	39.0	26.0	29.4-36.9	22.0-28.2
Right M_3	-----	30.9	53.5-68.0	26.3-34.4

Suborder Ruminantia Scopoli, 1777
Family Bovidae Gray, 1821
Genus *Simatherium* Dietrich, 1941
Species *Simatherium demissum* Gentry, 1980

Material: An isolated lower molar lacking the ectoloph, found at Groenrivier (Figure 31a-b), and currently preserved at Namaqualand Mines Ltd, Klein Zee, is close morphologically and metrically to the bovine *Simatherium demissum* which is well represented at Langebaanweg (Gentry 1980), suggesting a Late Miocene to basal Pliocene age for the sediments in this area.

In the South African Museum there are several large artiodactyl postcranial elements which could belong to the same species, including an astragalus, SAM PQ HB 722 (Figure 32a-b), a distal humerus SAM PQ HB 488 (Figure 33) and a calcaneum SAM PQ HB 484.

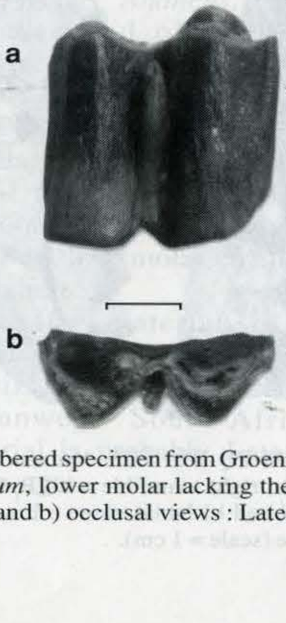

Figure 31: Unnumbered specimen from Groenrivier, *Simatherium demissum*, lower molar lacking the lingual portion, a) buccal and b) occlusal views : Late Miocene (scale = 1 cm).

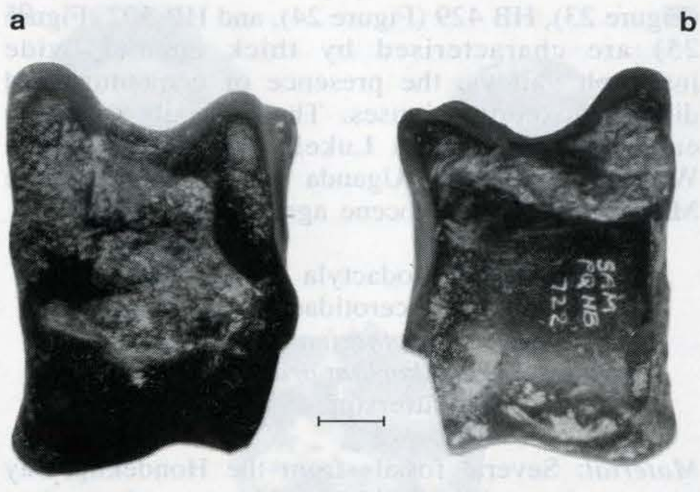

Figure 32: a-b.- SAM PQ HB 722, Bovidae, astragalus : Late Miocene (scale = 1 cm).

Figure 33: SAM PQ HB 488, large artiodactyl, distal humerus: Late Miocene (scale = 1 cm).

TERRESTRIAL PALAEOENVIRONMENT

At present coastal Namaqualand forms the southern part of the Namib Desert. It is a cool desert with an important vegetation cover comprised mainly of fynbos succulents. Rainfall occurs principally in the winter months. There is little surface water on account of the sandy substrate that covers much of the coastal strip. Nevertheless the vertebrate fauna is relatively diverse – large, medium and small antelopes, hyaenas, jackals, bat-eared foxes and meerkats, lagomorphs, rodents, insectivores, ostriches, tortoises, lizards and snakes. The acavid landsnail *Trigonephrus* is ubiquitous and often of large size.

Fossil equids and giraffids have been found at several Pleistocene sites in the region, suggesting that the climate may have been more humid during the Middle Pleistocene than it is today. It may also have been subjected to summer rainfall during this period (Figure 4). At this time early humans lived in the region, leaving behind abundant implements of Acheulean typology. The area was also attractive to humans during the Middle Stone Age and subsequent periods.

At Swartlintjies (Block 9) green clays in a bedrock channel yield abundant remains of vegetation, including leaves of various succulents and monocotyledons (grass, reeds). The same succession yielded a tooth of *Anancus* which suggests a Late Miocene to basal Pliocene age for the deposits. This outcrop provides evidence that fynbos was established in the region some 5-7 m.y. ago.

The assemblage of fossil mammals from Early Miocene and Late Miocene times is too poor to reveal much about the palaeoenvironment. However, it should be noted that during both periods large mammals such as proboscideans and rhinocerotids were probably common because they are well represented by tooth fragments, and these suggest the presence of an important vegetation cover, at least in parts of the area.

MARINE PALAEOENVIRONMENT

Several authors have noted that marine fossils associated with the 90, 50 and 30 m sediment packages of Namaqualand are either extinct or occur today in warm waters of the Atlantic Ocean off the West African coast (Gresse 1988; Haughton 1928, 1931; Pether 1986; Tankard & Rogers 1978) or in the Indian Ocean. Molluscs from the youngest – post-calcrete – marine deposits in the region, in strong contrast, comprise cold water forms still found in the area today. At present, the Agulhas Current interacts with the Benguela Current at the latitude of Cape Town, and sends large warm water eddies or rings northwestwards into the Atlantic (Cohen *et al.* 1992) before being retroflexed back towards the Indian Ocean. During the Miocene, however, the littoral waters of south western Africa appear to have been derived from the north, which would suggest that the warm Angola Current penetrated considerably further south than it does today. Offshore sediments have yielded evidence that the cold Benguela Current was established off the southwestern coast of Africa by Late Miocene times (Siesser 1980). The detailed interaction between the various ocean currents requires further study in view of this apparent contradiction.

PHOSPHORITES

Phosphorite nodules and *in situ* blocks of phosphorite occur commonly throughout the area between Klein Zee and Langklip. Phosphorite nodules occur in the 50 m and 30 m packages, but usually not in primary depositional context, suggesting that they have been reworked from pre-existing deposits. Pether (1986) considered the *in situ* phosphorite at Hondeklip Bay to be remnants of the seaward extension of the 90 m package, but this seems unlikely because no phosphorite occurs in the Ryskop section correlated to this unit. In the same 50 m package phosphatic internal casts of gastropods and bivalves are common. Similar occurrences have been noted between Port Nolloth and Alexander Bay (Gresse 1988), in the Walvis Bay region of Namibia (Ward 1987), and in the south near Cape Town (Tankard 1975).

The sediment with Early Miocene mammals at Ryskop appears not to have any phosphorite nodules in it. This could mean that no phosphorite was available for reworking at the time of deposition. If so it would suggest that phosphorite genesis in the coastal waters of Namaqualand occurred later than the Early Miocene (Figure 4). Because abundant nodules were available by Late Miocene times, the balance of evidence would indicate that the phosphorites started developing sometime during the Middle or Late Miocene. Siesser (1980) concluded that the Benguela Upwelling System began operating early in the Late Miocene, some 10 m.y. ago. It is probable that upwelling along the coast brought in the nutrient-rich raw materials from which the phosphorites were ultimately derived (Tankard 1975).

Although much of the contextual evidence has been destroyed by mining activities, it would appear that the main period of phosphorite genesis in the Klein Zee-Langklip sector occurred during the Middle and Late Miocene (Figure 4; Table 6).

AGE OF THE 90 M (GROBLER) TERRACE OR THE 90 M PACKAGE

Gresse (1988) suspected that the 90 m terrace of northern Namaqualand represented a Miocene feature, but was not able to reach a definite conclusion. If Pether (1986) is correct that the Mio-Pliocene fossils from the Hondeklip Bay area came from a low level part of the 90 m package, then this unit would be at least of Late Miocene age. However, newly collected suid and other fossils from Ryskop at an altitude of 50 m above msl and a carnivore carnassial collected at Hondeklip Bay many years ago and said to be from the 90 m package (Pether 1986) belong to Early Miocene (18-17.5 Ma) and late Middle Miocene species (ca 13-12 Ma).

It has long been postulated that the Arrisdrift fossil locality (ca 17.5 Ma) in the proto-Orange accumulated as a result of a rise in sea level at the end of the Early Miocene (Hendey 1978). The presence of calcareous tubes of serpulid worms at Arrisdrift has been taken to indicate that sea level was some 40 m higher at that time than it is today. The evidence for high sea levels from the Orange River Valley accords with that from Ryskop, both in terms of timing and of the sea levels attained.

CONCLUSIONS

Judging from fossils collected by the PESA during the 1995 and 1996 field seasons and from studies of collections in the South African Museum, there were four principal periods during which mammalian fossils were preserved in Namaqualand coastal sites. The earliest of these is late in the Early Miocene (ca 17.5-18 Ma), evidence coming from the Avontuur Mine at Ryskop, near Hondeklip Bay. These are the first fossil faunas of Early Miocene age recognised in South Africa and as such are the most southerly occurrence of mammals of this age in Africa (30°S latitude versus 27°S for the site of Langental in Namibia). The tropical aspect of this fauna suggests that the disposition and latitudinal extent of the tropics during the Early Miocene was very different from what it is today.

There is evidence at Buffles Bank Mine, Hondeklip Bay, of fossil preservation during late Middle Miocene times (ca 12-11 Ma), based on carnivore and proboscidean fossils found in phosphate bearing gravels below the 50 m package.

Much of the coastal plain sediment in Namaqualand is of Late Miocene age, being more or less the same age as the famous locality of Langebaanweg. These fossils are about 7-5.5 m.y. old, samples having been found at Hondeklip Bay, Groenrivier, Swartlintjies, Langklip and Somnaas. By this time the climate in the region was already temperate, as evidenced by the presence of fossil plants resembling fynbos at Swartlintjies 2. Nevertheless, the coastal waters at this time were still relatively warm as shown by the molluscan assemblages.

Middle and Late Pleistocene as well as Holocene fossil mammals occur sparsely in aeolian sands and calcrete horizons overlying marine strata. Deposits at Swartlintjies contain Acheulean artefacts and Middle Pleistocene fossils while at Swart Duinen a rich fossil site in calcrete has yielded a Late Pleistocene to Holocene assemblage. The temperature of the coastal waters off southwestern Africa changed from warm during the Early Pleistocene to cold in the Middle to Late Pleistocene, as revealed by major changes in the composition of the littoral molluscan faunas.

These results of the PESA modify many of the previous conclusions concerning the ages of diamondiferous strata in coastal Namaqualand, and of the timing of faunal and palaeoclimatic events in the vicinity of the south west African coast.

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TABLE 1

Geographic location of fossiliferous localities in Coastal Namaqualand sampled by PESA in 1995-1996. (Co-ordinates taken with GPS on graticule WGS 84 and rounded up or down to the nearest second.)

SITE	FARM	GPS COORDINATES
Swart Duinen 1	Schulpfontein 472	30°02'26"S 17°14'43"E
Swart Duinen 2	Schulpfontein 472	30°02'31"S 17°14'52"E
Swart Duinen 3	Schulpfontein 472	30°02'18"S 17°14'48"E
Somnaas 1	Somnaas 474	30°09'52"S 17°13'42"E
Somnaas 2	Somnaas 474	30°10'06"S 17°14'05"E
Koingnaas	Koingnaas 475	30°09'51"S 17°13'43"E
Swartlintjies 1	Swartlintjies 484 (S20)	30°16'07"S 17°16'56"E
Swartlintjies 2	Swartlintjies 484 (Block 9)	30°17'06"S 17°17'24"E
Langklip	Langklip 489	30°21'33"S 17°19'42"E
Ryskop	Avontuur	30°19'28"S 17°19'16"E

TABLE 2

Fauna recovered by PESA from Late Pleistocene calcareous aeolianites below the mobile dunes at Swart Duinen.

The fauna from this site is close to the modern fauna of Namaqualand.

(PESA collections and identifications)

Insecta	?Coleoptera	Cocoons
Mollusca	Acavidae	*Trigonephrus* sp.
Amphibia	?Ranidae	
Chelonia	Testudinidae	
Ophidia	?Viperidae	
Aves	Struthionidae	*Struthio camelus*
Carnivora	Viverridae	*Suricata suricata*
Lagomorpha	Leporidae	*Pronolagus* sp.
Insectivora	Chrysochloridae	
Rodentia	Bathyergidae	*Bathyergus* sp.
	Thryonomyidae	*Petromus* sp.
	Muridae	*Parotomys* sp. *Mystromys* sp. *Gerbillurus* sp. *Mastomys* sp. *Rhabdomys* sp.
Perissodactyla	Equidae	*Equus* sp.
Artiodactyla	Giraffidae	*Giraffa* sp.
	Bovidae	*Raphicerus campestris*

TABLE 3

Fauna collected by PESA from Middle Pleistocene deposits at Swartlintjies Acheulean site.

Note the presence of elephants, zebras and sivatheres, suggesting the former presence of a more sub-tropical climate in what is now a winter rainfall area covered in fynbos.

(PESA collections and identifications)

Chelonia	Testudinidae	
Ophidia	?Viperidae	
Primates	Hominidae	*Homo* sp. (Acheulean artefacts)
Lagomorpha	Leporidae	*Pronolagus* sp.
Rodentia	Sciuridae	*Paraxerus inuus*
	Bathyergidae	*Cryptomys* sp.
Proboscidea	Elephantidae	*Loxodonta* sp.
Perissodactyla	Equidae	*Equus* sp.
	Rhinocerotidae	indet.
Artiodactyla	Giraffidae	*Sivatherium maurusium*

TABLE 4

Composite faunal list of Late Miocene mammals collected over the years at Groenrivier, Hondeklip Bay, Swartlintjies 2, Somnaas 2 and Langklip in Namaqualand.

These faunal elements are characteristic of Late Miocene to Early Pliocene sites in eastern Africa, ranging in age from 7-5 Ma. Cetacea and pinnipeds are common in these sites, but are not discussed in the text because most of the remains are virtually unidentifiable vertebrae, ribs and isolated teeth. (PESA collections and identifications)

Aves	Struthionidae	*Struthio oldawayi*
Cetacea		Indet.
Pinnipedia	Phocidae	Indet.
Proboscidea	Gomphotheriidae	*Anancus kenyensis*
	Elephantidae	*Loxodonta* Lukeino stage (Tassy, 1994)
Perissodactyla	Rhinocerotidae	*Ceratotherium praecox*
	Equidae	*Hipparion* cf. *sitifense*
Artiodactyla	Suidae	*Nyanzachoerus kanamensis australis*
	Bovidae	*Simatherium demissum*

TABLE 5

Mammalian fauna recovered by PESA from Early Miocene deposits at Ryskop.

The assemblage as a whole compares reasonably well with late Early Miocene localities of East Africa, such as Rusinga, and Ryskop is thus likely to be of Early Miocene age, but the hominoid and *Kenyasus namaquensis* suggest a slightly younger age, perhaps basal Middle Miocene (ca 17.5-16 Ma).

(PESA collections and identifications)

Primates	Hominoidea	cf. *Kenyapithecus* sp.
Rodentia		indeterminate
Pinnipedia	Phocidae	cf. *Mirounga* sp.
Proboscidea	Deinotheriidae	*Prodeinotherium hobleyi*
	Gomphotheriidae	indeterminate
Perissodactyla	Rhinocerotidae	indeterminate
Artiodactyla	Suidae	*Nguruwe kijivium* *Kenyasus rusingensis* *Kenyasus namaquensis* sp. nov.
	Ruminantia	indeterminate

TABLE 6

Chronological position of various faunal localities in coastal and upland Namaqualand together with a summary of the main biostratigraphic, palaeoclimatic and geological events that occurred during the Cainozoic. The main period of phosphogenesis is also depicted.

Age Ma	Faunal localities	Geological, Biostratigraphic and Palaeoclimatic events
0	Red Aeolianites at Bosluis Pan	Active dunes, Extant cold water molluscs
		Swart Duinen Sub 10 m beaches, Cold coastal waters (*Donax serra* packages)
1	Swartlintjies 1, Hondeklip Bay	
		Calcrete pedogenesis
2		Onset of aeolianite deposition in coastal plain
	Hondeklip Bay	Sea level +/- 30 m above msl (*Donax rogersi* package)
3		
4		
5		
	Hondeklip Bay, Swartlintjies 2	Warm coastal waters (*Nyanzachoerus*)
6	Groenrivier, Langklip, Somnaas	Sea level +/- 50 m above msl (*Donax haughtoni* package)
7		
8		
9		
10		Phosphorite genesis
11		
	Hondeklip Bay	Sea-level ca 50 m above msl.
12		(*Agnotherium*/*Tetralophodon* package)
13		
		Phosphorite genesis
14		
15		
16	Bosluis Pan	
17		
18	Ryskop	Sea level +/-90 m above msl (*Nguruwe*/*Kenyasus* package)
19		
20		
21+		
		Koingnaas & Ryskop ferruginised sandstones
		Koingnaas & Ryskop lignitic sediments
		Kalinisation of bedrock and sediments, 'Surface Quartzite'