ANNALS OF THE SOUTH AFRICAN MUSEUM
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

Volume 95 Band
April 1985 April
Part 2 Deel

THE FAUNAL DEPOSITS OF A LATE PLEISTOCENE RAISED BEACH AT MILNERTON, CAPE PROVINCE, SOUTH AFRICA

By

BRIAN KENSLEY

Cape Town Kaapstad

The ANNALS OF THE SOUTH AFRICAN MUSEUM

are issued in parts at irregular intervals as material becomes available

Obtainable from the South African Museum, P.O. Box 61, Cape Town 8000

Die ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

word uitgegee in dele op ongereelde tye na gelang van die beskikbaarheid van stof

Verkrygbaar van die Suid-Afrikaanse Museum, Posbus 61, Kaapstad 8000

OUT OF PRINT/UIT DRUK

1, 2(1–3, 5–8), 3(1–2, 4–5, 8, t.–p.i.), 5(1–3, 5, 7–9), 6(1, t.–p.i.), 7(1–4), 8, 9(1–2, 7), 10(1–3), 11(1–2, 5, 7, t.–p.i.), 14(1–2), 15(4–5), 24(2), 27, 31(1–3), 32(5), 33, 36(2), 45(1)

ISBN 0 86813 065 6

Printed in South Africa by The Rustica Press, Pty., Ltd., Court Road, Wynberg, Cape

In Suid-Afrika gedruk deur Die Rustica-pers, Edms., Bpk., Courtweg, Wynberg, Kaap

THE FAUNAL DEPOSITS OF A LATE PLEISTOCENE RAISED BEACH AT MILNERTON, CAPE PROVINCE, SOUTH AFRICA

By

BRIAN KENSLEY

Smithsonian Institution, Washington, D.C.

(With 2 figures and 3 tables)

[*MS accepted 21 March 1984*]

ABSTRACT

The faunal content of a Late Pleistocene raised beach exposed on the north shore of Table Bay is examined. The deposit has been correlated with the Velddrif Shelly Sand Member of the Bredasdorp Formation. The deposit contained mainly molluscan shells (78 species), with occasional crustacean, echinoderm, and elasmobranch fish remains. The molluscs represent rocky-shore, sandy-shore, and calm-water and/or estuarine species. It is hypothesized that this mixed assemblage is due to a kill-off (perhaps because of a cut-off from the sea and rising salinity and temperatures) in a nearby lagoonal area (the Rietvlei Basin), with the dead shells eventually being washed out to sea, and then thrown up at the top of the beach, along with the remains of sandy-beach and rocky-shore forms. The deposit contains two extinct species, *Nuculana bicuspidata* and *Crepidula capensis praerugulosa*, as well as 12 species now confined to the warmer waters of the east coast.

CONTENTS

INTRODUCTION

In June 1974, during the heavy winter weather experienced in Table Bay, a north-west storm coincided with a spring-tide. The resultant exceptionally high and powerful wave action eroded a section of the beach and fringing sand-dunes just below the Milnerton lighthouse, and exposed a sedimentary deposit dominated by molluscan shells. In May 1983, a short stretch of an old beach-line, about 0,5 km south of the lighthouse on the Cape Town side of the Milnerton Lagoon mouth, was exposed. Superficial inspection of the deposits revealed several features that pointed to a Pleistocene age. These included a very obvious concentration of molluscan shells, the brown colour of what was obviously the common black mussel *Choromytilus meridionalis*, and the presence of species that do not now occur alive in Table Bay or on the west coast of southern Africa. The object of this paper is to place the deposits and their probable age on record, and to speculate on their history.

Ann. S. Afr. Mus. **95** (2), 1985: 111–122, 2 figs, 3 tables.

METHODS

To determine species composition, selective manual collecting was done along the deposit, and a faunal list drawn up.

In an attempt to gain a rough idea of the quantitative composition, a cubic metre of deposit was collected, washed in water to separate the fossils, and species and specimens sorted, identified and counted.

From molluscan shells supplied to Teledyne Isotopes of New Jersey, a radiocarbon date was obtained (sample number I–8372).

DESCRIPTION OF THE DEPOSIT

The major exposed deposit is situated about 100 m to the north of Milnerton lighthouse on the shore of Table Bay (33°53′S 18°27′E) (Figs 1, 2A–B). At the Low Water of Springs level the beach was scoured away to expose a bed of ferricrete that showed a characteristic nodular and cellular structure (Fig. 2C). Into the irregularities of this ferricrete, shells and coarse sediment had become cemented. Where the shells actually touched the ferricrete, they were stained a rusty brown. It is possible that this ferricrete layer is homologous with the 'iron-stained gravelly sands' described by Tankard (1975*a*: 261) from a late Tertiary deposit at Ysterplaat about 4 km away. In places in the lower part of the deposit, patches of black peat-like material were exposed. Shells were not present in this peat (Fig. 2E).

The whole area of the beach between Low Water of Springs and the exceptionally high High Water of Springs revealed shell remains (Fig. 2F). In places, the consolidating sediment seemed harder or more firmly cemented than in others, and here lumps of the deposit that had eroded more slowly than the softer sediments protruded above the more level 'beach' surface. At the top of the beach, which normally is a gentle sand slope running into low sand-dunes, the sea had cut a cliff into the bases of these dunes, exposing a vertical face in the deposit of about 1 m in thickness. In places, this face of the deposit was interrupted by gulleys of black non-fossiliferous sand (Fig. 2D). Both shell deposit and black sand were overlain by modern, white, calcareous, littoral sand. Three weeks after the sudden exposure of this deposit, all sign of it had vanished, having been covered by white sand moved in by sea and wind.

The length of the major deposit exposed along the beach was 64 m. The horizontal width of the beach from LWS to the top of the sand-dune cliff was 13 m. The vertical distance from LWS to the top of the deposit was 2,5 m.

The deposit consisted of coarse sand grains and shell debris, with occasional angular rounded pebbles, and a few scattered pieces of calcrete. There was some bedding, with especially the bivalve shells oriented horizontally, but this was not everywhere apparent.

The 1983 beach-line exposure south of the lagoon mouth consisted of a 40–50 cm-thick layer of calcrete containing sparsely scattered shells showing no obvious bedding. Thin lenses of shells about 20 cm below the limestone could

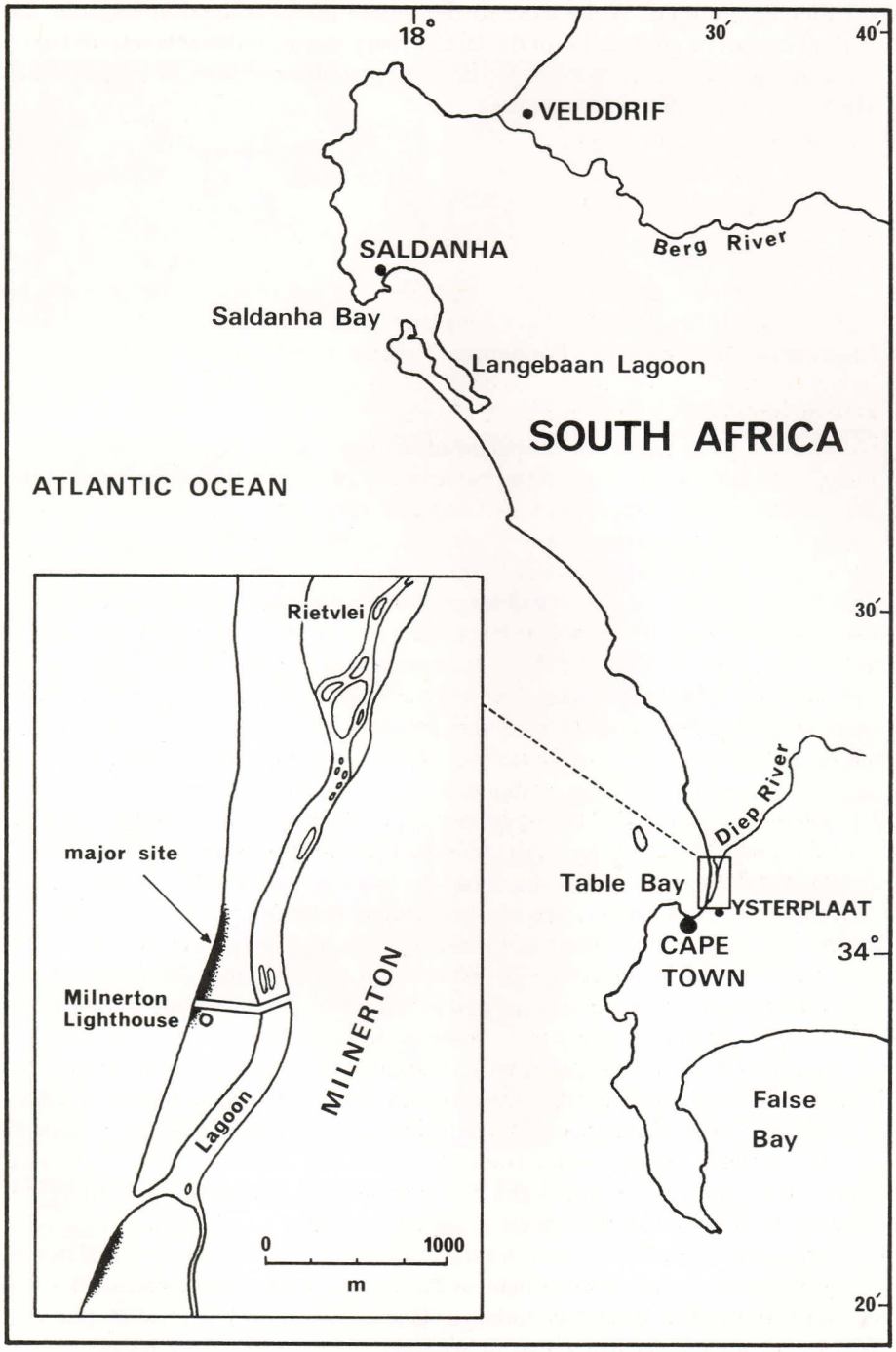

Fig. 1. Map showing location of Milnerton beach deposit.

occasionally be seen. While close to the mouth of the Milnerton Lagoon, this deposit cannot be confused with the late Tertiary marine sediments referred to by Tankard (1975*a*: 262) as 'submerged deposits just offshore from Milnerton which are below normal wave erosion base . . .'.

RESULTS

AGE OF THE DEPOSIT

A radiocarbon date of 33 750 ± 1 780 years BP was obtained, but this may be a minimum age. The deposits have been correlated with the Velddrif Shelly Sand Member of the Bredasdorp Formation (Tankard 1976) by Rogers (1982).

FAUNAL ANALYSIS

Table 1 gives the list of 78 species of molluscs, five other invertebrates, and two vertebrates, found both in the cubic metre of deposit and in material hand-collected at random. Records of the Quaternary occurrences of the species as well as the present distribution are given, along with a rough indication of the ecological habitat of each species.

The habitat types of the species may be sorted roughly into rock-dwelling forms, sand or mud-dwellers, and estuarine and/or calm-water forms. (This latter group is not more stringently divided for reasons both of definition, and because little is known of the biology of several of the living forms.) From Table 1 it can be seen that of these habitat-types, the greatest number of species as well as specimens belong to the rock-dwelling group. The majority of these are forms that occur to varying degrees of abundance in the intertidal zone. Seven species of the estuarine and/or calm-water group, representing 7,6 per cent of the total sample, were present. The most abundant species was an extinct *Crepidula*, closely followed by an extant species of the same genus (see Table 2). The next ten most abundant species are all living forms found on the west coast. Five species are typical rock-dwelling forms, five species are sand or mud-dwellers, and amongst these latter are forms that occur in sandy habitats exposed to strong wave action, e.g. *Bullia digitalis*, as well as forms that occur in either sublittoral or calm water, e.g. *Bullia laevissima, Nassarius speciosus*.

Species that do not occur living at the present on the west coast are also represented in the deposit. This gives a list of 12 species, all typical inhabitants of the warmer waters of the south-east and east coasts (see Table 3). Of these 12 species, six have been recorded from the Pleistocene deposits of the west coast, mainly from the Elands Bay–Velddrif–Saldanha Bay area (see Tankard 1975*b*; Schalke 1973; Visser & Schoch 1973; Barnard 1962).

Given the probable Eemian Interglacial age for the deposit, it would not be unreasonable to expect (in the light of Pleistocene molluscan extinctions) a few extinct forms in the present assemblage. One extinct species is present, plus one species no longer occurring live in southern Africa. *Nuculana bicuspidata*, a

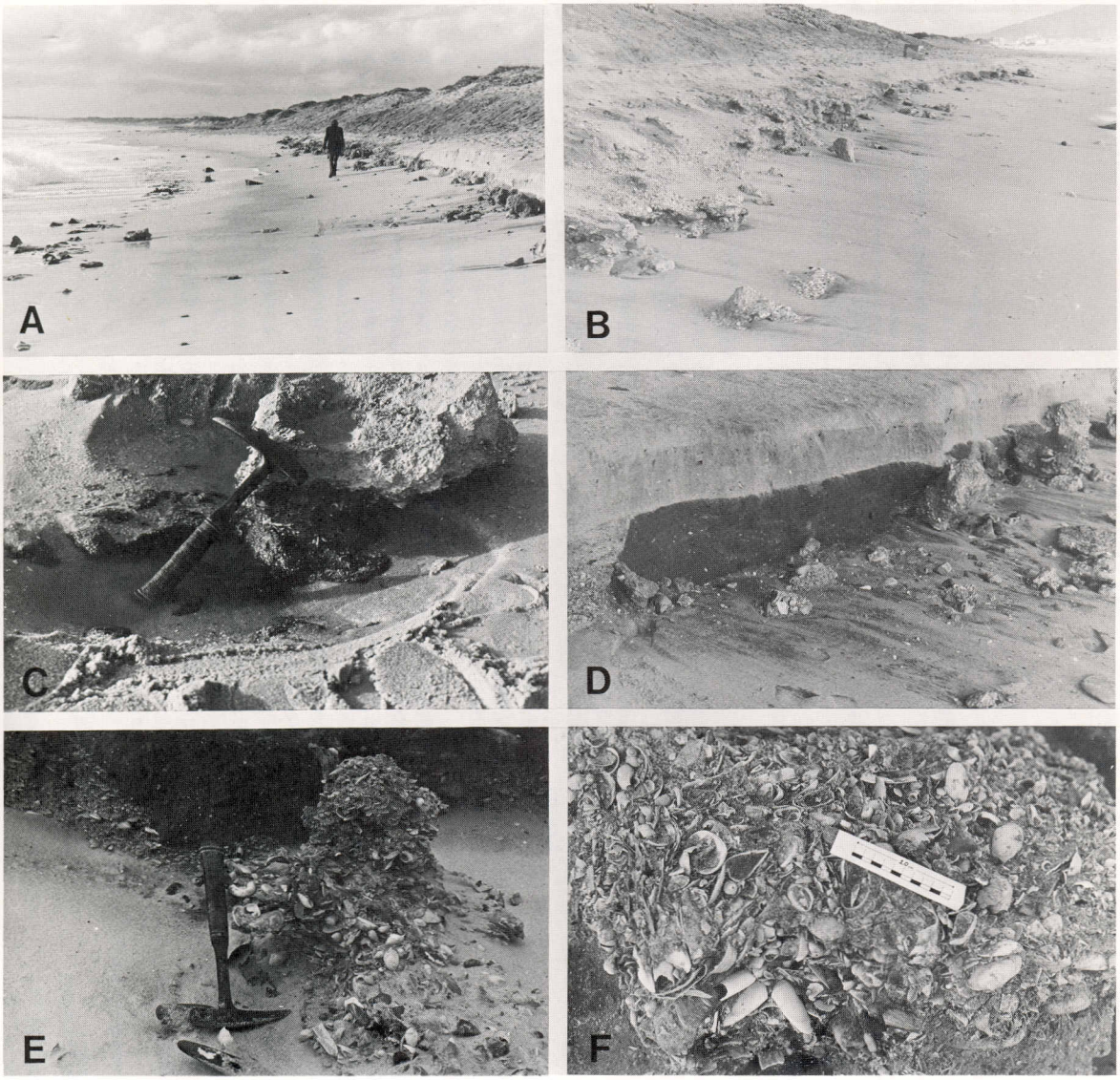

Fig. 2. A. Milnerton beach, looking north, showing shell deposit and overlying sand dunes at right. B. Milnerton beach, looking south towards Cape Town, showing shell deposit. C. Ferricrete exposed at lower level of beach. D. Non-fossiliferous dark sand below white dune sand. E. Peat-like material in shell deposit. F. Close-up of shell deposit.

TABLE 1

Faunal list, Milnerton Late Pleistocene raised beach.
E—estuarine; M—mud dweller; R—rocky-shore dweller; S—sand dweller; W—weed-bed dweller; †—extinct species

Species	Quaternary records	Living distribution	Habitat
MOLLUSCA, BIVALVIA			
Aulacomya ater (Molina)	Lüderitz, Orange River, Velddrif, Saldanha, Rietvlei	Namibia to Natal	R
Barnea truncata Say	Table Bay	Senegal to Angola	R
Choromytilus meridionalis (Krauss)	Orange River, Sedgefield, Durban	Namibia to Natal	R in S
Donax serra (Chemnitz)	Lüderitz, Orange River, Velddrif, Saldanha, Langebaanweg, Sedgefield	Namibia to Port Alfred	S
Dosinia lupinus Linnaeus	Cape Cross, Saldanha, Velddrif, Bredasdorp, Sedgefield, Port Elizabeth	Walvis Bay to East London	S & M
Loripes liratula (Sowerby)	Saldanha, Little Brak River, Sedgefield, Knysna	Still Bay to Port Alfred	S
Lutraria lutraria (Linnaeus)	Lüderitz, Saldanha, Velddrif, Sedgefield	Lüderitz to Port Alfred	S
Mactra glabrata Linnaeus	Saldanha, Little Brak River, Sedgefield, Port Elizabeth, Durban	Saldanha to Natal	S
Melliteryx mactroides (Hanley)	—	False Bay to Port Alfred	S
Nuculana biscuspidata (Gould)	Cape Cross, Velddrif	Mauritania to Angola	S
Ostrea algoensis Sowerby	Elands Bay, Velddrif, Knysna	False Bay to East London	R
Parvicardium turtoni (Sowerby)	Sedgefield, Knysna, Port Elizabeth, Durban	False Bay to Natal	S
Petricola bicolor Sowerby	—	Namibia to Zululand	R
Psammotellina capensis Sowerby	Elands Bay, Velddrif, Saldanha, Rietvlei, Sedgefield	False Bay to Port Alfred	E
Scissodesma spengleri (Linnaeus)	Velddrif, Saldanha, Port Elizabeth	False Bay to Port Alfred	S
Solen capensis Fischer	Lüderitz, Elands Bay, Velddrif, Saldanha, Rietvlei, Sedgefield, Port Elizabeth	Olifants River to East London	M, E
Tellimya trigona Barnard	Elands Bay, Velddrif, Saldanha, Rietvlei	Lüderitz to False Bay	S
Tellina trilatera Gmelin	Orange River, Velddrif, Saldanha, Little Brak River, Knysna	Saldanha to Port Alfred	S
Theora ovalis Smith	—	Saldanha to Port Alfred	S
Tivela compressa (Sowerby)	Velddrif, Saldanha, Bredasdorp, Little Brak River	False Bay to Natal	S
Venerupis corrugata (Gmelin)	Orange River, Elands Bay, Velddrif, Saldanha, Little Brak River, Sedgefield	West Africa to Natal	S, R

MOLLUSCA, GASTROPODA

Afrocominella capensis (Dunker)	—	Namibia to Cape Agulhas	R
Amblychilepas scutellum (Gmelin)	Velddrif, Saldanha, Little Brak River, Sedgefield, Inhambane	Angola to Natal	R
Argobuccinum pustulosum (Lightfoot)	Lüderitz, Orange River Mouth, Velddrif, Saldanha	Namibia to East London	R
Assiminea globulus Connolly	—	Olifants River to Keiskamma River	M, E
Bullia annulata (Lamarck)	Saldanha, Port Elizabeth	Saldanha to Mozambique	S
Bullia digitalis Meuschen	Lüderitz, Orange River, Velddrif, Saldanha, Port Elizabeth	Namibia to Transkei	S
Bullia laevissima (Gmelin)	Cape Cross, Lüderitz, Velddrif, Saldanha, Sedgefield, Port Elizabeth	Namibia to Transkei	S, M
Burnupena cincta (Röding)	Elands Bay, Velddrif, Saldanha	Angola to Transkei	R
Burnupena lagenaria (Lamarck)	Lüderitz, Orange River, Saldanha, Port Elizabeth	Namibia to Natal	R
Burnupena papyracea (Bruguière)	Velddrif, Saldanha	Namibia to Walker Bay	R
Calyptraea chinensis (Linnaeus)	Velddrif, Saldanha, Port Elizabeth	Saldanha to East London	R
Clionella confusa (Smith)	—	Mossel Bay to Port Alfred	R
Cinysca granulosa (Krauss)	—	Namibia to Transkei	R
Conus mozambicus Hwass	Orange River, Saldanha	Namibia to East London	R
Crepidula capensis praerugulosa Kilburn & Tankard	Elands Bay, Velddrif, Saldanha	†	?R
Crepidula porcellana Lamarck	Lüderitz, Orange River, Velddrif, Saldanha, Knysna, Port Elizabeth	North-west Africa to Natal	R
Crepidula rugulosa Dunker	Lüderitz	Lamberts Bay to Still Bay	R
Cymatium cutaceum africanum (Adams)	Velddrif, Saldanha, Little Brak River, Sedgefield, Knysna, Port Elizabeth, Durban	Namibia to Mozambique	R
Cythara amplexa (Gould)	Velddrif, Saldanha	Lüderitz to East London	R
Epitonium kraussi (Nyst)	—	Namibia to Natal	R
Fissurella mutabilis Sowerby	Saldanha, Rietvlei, Little Brak River, Port Elizabeth	Lüderitz to Natal	R
Gibbula capensis (Gmelin)	Saldanha	Saldanha to Agulhas	R
Gibbula cicer (Menke)	Bredasdorp	Namibia to Transkei	R
Helcion dunkeri (Krauss)	—	Namibia to Natal	R
Lippistes cornu (Gmelin)	—	Table Bay, East London	?
Littorina knysnaensis (Philippi)	Elands Bay, Saldanha, Knysna	Namibia to Natal	R
Marginella rosea Lamarck	—	Saldanha to Agulhas	R, in S

Species	Quaternary records	Living distribution	Habitat
Marginella sp.	—	—	—
Nassarius capensis (Dunker)	Port Elizabeth	Table Bay to Transkei	S
Nassarius kraussianus (Dunker)	Velddrif, Saldanha, Bredasdorp, Little Brak River, Sedgefield, Knysna, Port Elizabeth, Durban	Namaqualand to Mozambique	E, M
Nassarius speciosus (Adams)	Velddrif, Saldanha	Orange River to Transkei	M
Natica saldontiana Bartsch	Velddrif, Saldanha	Saldanha to Agulhas	S
Natica tecta Anton	Velddrif, Saldanha, Little Brak River, Sedgefield, Knysna, Port Elizabeth	Namibia to East London	E, M, S
Nucella cingulata (Linnaeus)	Lüderitz, Orange River, Velddrif, Saldanha	Namibia to False Bay	R
Nucella dubia (Krauss)	Orange River, Saldanha, Velddrif, Little Brak River, Sedgefield, Port Elizabeth	Namibia to Natal	R
Nucella squamosa (Lamarck)	Lüderitz, Orange River, Velddrif, Saldanha, Rietvlei	Namibia to Transkei	R
Ocenebra scrobiculata (Philippi)	—	Lüderitz to Transkei	R
Oxystele tigrina (Chemnitz)	Elands Bay, Saldanha, Port Elizabeth	Saldanha to Transkei	R
Oxystele variegata (Anton)	Elands Bay, Saldanha, Port Elizabeth	Angola to Natal	R
Patella argenvillei Krauss	Lüderitz, Orange River, Velddrif, Saldanha, Port Elizabeth	Namibia to Transkei	R
Patella barbara Linnaeus	Lüderitz, Orange River, Velddrif, Saldanha	Namibia to Zululand	R
Patella granatina Linnaeus	Lüderitz, Orange River, Velddrif, Saldanha	Namibia to Walker Bay	R
Patella miniata Born	Orange River, Velddrif, Saldanha	Namibia to Natal	R
Protomella capensis (Krauss)	Velddrif, Saldanha, Rietvlei, Little Brak River, Sedgefield, Knysna	Lamberts Bay to East London	E, S

Pseudoraphitoma alfredi (Smith)	—	Table Bay to Durban	S
Pteropurpura uncinaria (Lamarck)	—	False Bay to Natal	R
Retusa truncatula (Bruguière)	Knysna	Agulhas to Port Alfred	E, W
Rissoa capensis Sowerby	Elands Bay, Velddrif, Saldanha	Still Bay, Port Alfred	R
Siphonaria sp.	—	—	R
Tricolia capensis (Dunker)	Rietvlei	Namibia to Mozambique	R
Tricolia neritina (Dunker)	—	Namibia to Port Elizabeth	R
Turbo sarmaticus Linnaeus	Port Nolloth, Saldanha	Table Bay to Transkei	R
Turritella carinifera Lamarck	Orange River, Saldanha, Little Brak River, Sedgefield, Knysna	Port Nolloth to Mozambique	R in S
Vermetus sp.	—	—	R
Volvarina capensis (Krauss)	Velddrif, Saldanha, Rietvlei	Lüderitz to Agulhas	S
MOLLUSCA, AMPHINEURA			
2 species represented by loose valves	—	—	R
CRUSTACEA, CIRRIPEDIA			
Balanus maxillaris Gronovius	Velddrif	Lamberts Bay to Port Elizabeth	R
Balanus sp.	—	—	R
CRUSTACEA, DECAPODA			
Callianassa kraussi Stebbing	—	Olifants River to Natal	E
Ovalipes punctata (de Haan)	—	Namibia to Natal	S
ECHINODERMATA, ECHINOIDA			
cf. *Parechinus angulosus* (Leske)	—	Namibia to Zululand	R
PISCES, ELASMOBRANCHIATA			
Myliobatis sp.	—	—	S
Odontaspis acutissima Agassiz	Saldanha, Milnerton	†	—

TABLE 2

Ten major components of the Milnerton beach deposit, as percentages of the total number of specimens.

Species	Percentage
Crepidula capensis praerugulosa	25,1
Crepidula porcellana	8,7
Bullia laevissima	8,4
Bullia digitalis	5,5
Choromytilus meridionalis	5,1
Tricolia capensis	4,8
Nassarius speciosus	3,9
Nucella squamosa	3,8
Rissoa capensis	2,9
Venerupis corrugata	2,8

palaeotaxodont bivalve, has been reported as a Pleistocene fossil from Velddrif, Cape Province, and Cape Cross, South West Africa (Namibia), but living from Angola to Mauritania and the Cape Verde Islands (Tankard 1975*b*). The animal lives in sand or mud, probably infratidally, as it has been recorded from the same sediments as *Panopea glycymeris* (Kensley 1974). *Crepidula capensis praerugulosa* Kilburn & Tankard, 1975, the most abundant species from the deposit, is also known from an older Late Pleistocene site near Langebaan (9,5 m a.s.l.). Kilburn & Tankard (1975) note that *C. c. praerugulosa* has a regularly curved ventral margin, and speculate that the animals were often attached to mytilid mussels,

TABLE 3

Typical south-east and east-coast species occurring in the Milnerton deposit, with Pleistocene records where known.

Species	Pleistocene records
Clionella confusa	—
Loripes liratula	Elands Bay, Velddrif, Saldanha, Rietvlei, Little Brak River, Keurbooms, Knysna
Nassarius capensis	Algoa Bay
Ostrea algoensis	Elands Bay, Velddrif, Knysna
Parvicardium turtoni	Sedgefield, Knysna, Algoa Bay, Durban
Psammotellina capensis	Elands Bay, Velddrif, Saldanha, Rietvlei, Sedgefield
Pseudoraphitoma alfredi	—
Pteropurpura uncinaria	—
Retusa truncatula	Knysna
Rissoa capensis	Elands Bay, Velddrif, Saldanha
Scissodesma spengleri	Velddrif, Saldanha, Port Elizabeth
Tivela compressa	Velddrif, Saldanha, Bredasdorp, Little Brak River

also an occasional habitat for *C. porcellana*. As this latter species was the second most abundant in the Milnerton deposit, it seems unlikely that they shared a common habitat. Quite possibly, *C. porcellana* was more frequently attached to large gastropods or to rocky substrates and, with the extinction of *C. c. praerugulosa*, came to live on mussels as well. A third extinct form is the elasmobranch fish *Odontaspis acutissima* represented by a single unworn tooth. This species is well recorded from the Pleistocene (Darteville & Casier 1943), but little significance can be attached to its presence in the Milnerton deposit, as this single shark tooth could be a reworked entity of earlier age.

Several features concerning the actual state of the shells in the deposit give rise to comment, e.g. the concentration of shells, the condition of the shells, and the abundance of shells less than 10 cm in length. The cubic metre of deposit yielded 4 908 recognizable specimens comprising 82 species. While worn and broken specimens were present, the majority were unworn and in perfect condition, including many shells of small species or delicate juvenile shells.

DISCUSSION

At the time of deposition of the Milnerton accumulation, there must have been an estuarine and/or calm-water environment nearby, supporting a more diverse molluscan population than does the present-day Milnerton lagoon–estuary complex (cf. Millard & Scott 1954). This was probably the Rietvlei Basin, which during the Pleniglacial opened north of both the present mouth and the beach deposit under discussion (Schalke 1973). (Although from the faunal list the Milnerton deposit appears richer and more diverse than Schalke's Rietvlei fauna, his sampling by means of bore-holes was obviously limited, and the two deposits cannot usefully be compared.)

Also in the vicinity there must have been an extensive intertidal rocky-shore area to support the relatively high numbers of rocky-shore forms, as well as a sandy infra- and intertidal area.

The 12 species from the deposit now found living only on the east coast seem to indicate that the sea temperature at the time of deposition was somewhat higher than is presently experienced in Table Bay. Nine of the 12 species range from False Bay eastwards, indicating a minimum sea temperature of 14 °C. The present temperature regime in Table Bay has minima of 9–10 °C. That Pleistocene sea temperatures were at times higher than those of the present on the west coast has already been well documented (Tankard 1975*b*). As a typical west-coast fauna was already established at the time of the Milnerton deposition, it seems probable that the 12 east-coast species listed in Table 3 were either ecologically more tolerant than many of the west-African and east-coast forms, which had already died out, or they represented the tail-end of populations dying out on the southern west coast.

Schalke (1973) postulated a fluctuating rainfall pattern at about the time of the deposition of the shells under discussion. A series of events that could lead to

the inclusion of numerous estuarine forms in the beach deposit would involve a dry period resulting in a drying up and an increased temperature and salinity regime of the estuary and/or calm-water area (assuming a temporary cut-off from the sea, as during neap tides), which in turn would lead to large-scale mortality of many of the physiologically less tolerant molluscs. With the advent of strong rains, these dead shells would then be washed out to sea, to be deposited along with the purely marine forms. This series of events has been witnessed on the South West African coast (Kensley 1978), and could account to some degree for the mixed nature of the Milnerton faunal assemblage.

ACKNOWLEDGEMENTS

I am grateful to Dr Q. B. Hendey, South African Museum, and Dr J. Rogers, C.S.I.R. Marine Geology Unit, University of Cape Town, for their advice and comments. My thanks are due to the Director and Trustees of the South African Museum for permission to work on the material described during my 1983 visit.

REFERENCES

BARNARD, K. H. 1962. Revised list of South African Late Tertiary and Pleistocene marine Mollusca. *Trans. R. Soc. S. Afr.* **36**: 179–196.

DARTEVILLE, C. & CASIER, E. 1943. Les poissons fossiles du Bas-Congo et des régions voisines (1e partie). *Ann. Mus. Congo Belge* (A) **2**: 257–268.

KENSLEY, B. 1974. The status of the Plio-Pleistocene *Panopea* in southern Africa (Mollusca, Bivalvia, Hiatellidae). *Ann. S. Afr. Mus.* **65**: 199–215.

KENSLEY, B. 1978. Interaction between coastal processes and lagoonal fauna, between Walvis Bay and Lüderitzbucht, South West Africa. *Madoqua* **11**: 55–60.

KILBURN, R. N. & TANKARD, A. J. 1975. Pleistocene molluscs from the west and south coasts of the Cape Peninsula, South Africa. *Ann. S. Afr. Mus.* **67**: 183–226.

MILLARD, N. A. H. & SCOTT, K. M. F. 1954. The ecology of South African estuaries. Part VI. Milnerton Estuary and the Diep River, Cape. *Trans. R. Soc. S. Afr.* **34**: 279–324.

ROGERS, J. 1982. Lithostratigraphy of Cenozoic sediments between Cape Town and Elands Bay. *Palaeoecol. Afr.* **15**: 121–137.

SCHALKE, H. J. W. G. 1973. The Upper Quaternary of the Cape Flats area (Cape Province, South Africa). *Scripta Geol.* **15**: 1–57.

TANKARD, A. J. 1975*a*. The marine Neogene Saldanha Formation. *Trans. geol. Soc. S. Afr.* **78**: 257–264.

TANKARD, A. J. 1975*b*. Thermally anomalous Late Pleistocene molluscs from the south-western Cape Province, South Africa. *Ann. S. Afr. Mus.* **69**: 17–45.

TANKARD, A. J. 1976. Pleistocene history and coastal morphology of the Ysterfontein–Elands Bay area, Cape Province. *Ann. S. Afr. Mus.* **69**: 73–119.

VISSER, H. N. & SCHOCH, A. E. 1973. The geological and mineral resources of the Saldanha Bay area. *Mems geol. Soc. S. Afr.* **63**: 1–150.