

Fluvio-marine deposits south-east of Swakopmund, South West Africa

by

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ABSTRACT

Up to two conglomerate layers carrying specimens of *Striostrea margaritacea* are interbedded in a layered deposit of unconsolidated and gypsum-cemented sand which occurs up to 50 m above sea-level. Size distribution analysis of the sand and surface characteristics of the sand grains indicate sheet-flood action and rapid burial, but aeolian and marine reworking is evident and mixing of fluvial, aeolian and marine sand populations occurred in a fluvio-marine environment. The littoral fauna suggests freely circulating sea water during periods of limited detrital supply. At other times complete restriction of the depository led to evaporation and the precipitation of gypsum. Final burial took place in an embayment or tidal lagoon which was periodically isolated from the open sea. The association of sheet-flood action and evaporite minerals strongly suggests that an arid environment existed at the time of deposition.

1 INTRODUCTION

A previously unknown, 18-km long deposit of horizontally bedded unconsolidated sand, gypsum-cemented sand and conglomerate containing up to two fossiliferous layers (Plate 1), was exposed by trenching south-east of Swakopmund. The deposit

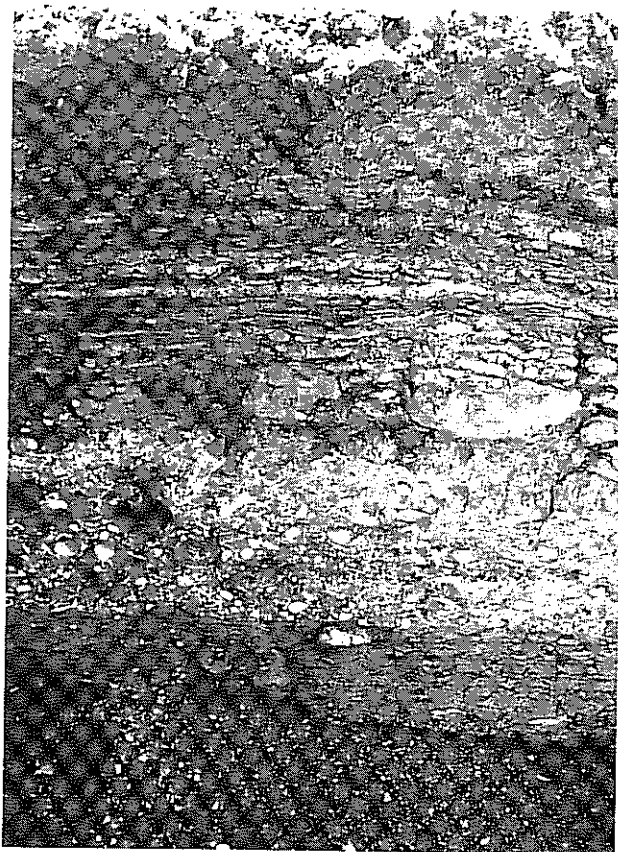
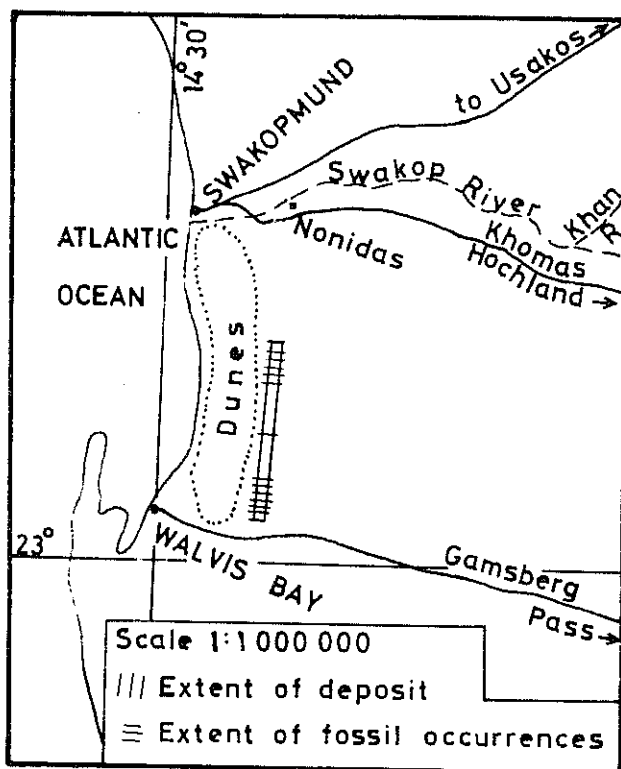


Plate 1. Layered fluvio-marine deposit of unconsolidated and gypsum-cemented sand with conglomeratic layers that contain specimens of *Striostrea margaritacea*.

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Map 1. Locality map of deposit.

occurs at an elevation of between 35 and 50 m above sea-level and the most northerly fossil occurrences are 17 km from the main Swakopmund — Usakos road (Map 1). The deposit is described and a mechanical analysis of the sand has been carried out in an attempt to establish its origin.

A similar deposit which occurs between Haigamchab and Nonidas on the Swakop River has been described by Gevers and Van der Westhuysen (1931). This contains a 60 cm thick layer of halite but lacks fossils.

2 LITHOLOGY

Lithological characteristics of measured sections located 26 and 29 km south of the main Swakopmund — Usakos road respectively are shown in figure 1. The deposit is composed largely of sand but conglomerate and clayey layers are also present. Individual beds persist over considerable distances. In the 29-km section the contact between layers 7 and 8 is paraconformable. Local lens-shaped cross bedded layers occur.

Halite and gypsum are present in all but layer 4 of the 26-km section. Layer 2 of the same section contains only a trace of halite. Gypsum forms a cement and occurs as isolated crystals, as patches of crystals either in the form of "desert roses" or thin irregular root-like columns, and as solid masses cementing complete layers. Crystals are all less than 5 mm in diameter and all enclose sand grains. The gypsum-cemented layers are coloured red by disseminated

hematite. Most of the halite occurs as separate crystals but in layer 8 of 29-km section there are small crystal aggregates. The latter enclose only very few sand grains. The fossiliferous layers vary in thickness from 4 to 45 cm and are all conglomeratic.

2.1 The sand layers

A meaningful size-distribution analysis could only be carried out on layer 4 of the 26-km section as the other layers contain evaporate minerals.

The histogram and cumulative curve of layer 4 are given in figure 2. The sand is fairly well sorted and has a distinct negative skewness. Plots of skewness versus mean, standard deviation and kurtosis (figure 3) show that the sand falls within the regions where characteristics of dune, beach and river sands overlap.

Although all sand grains of layer 4 are frosted a gradation from slightly to highly frosted occurs.

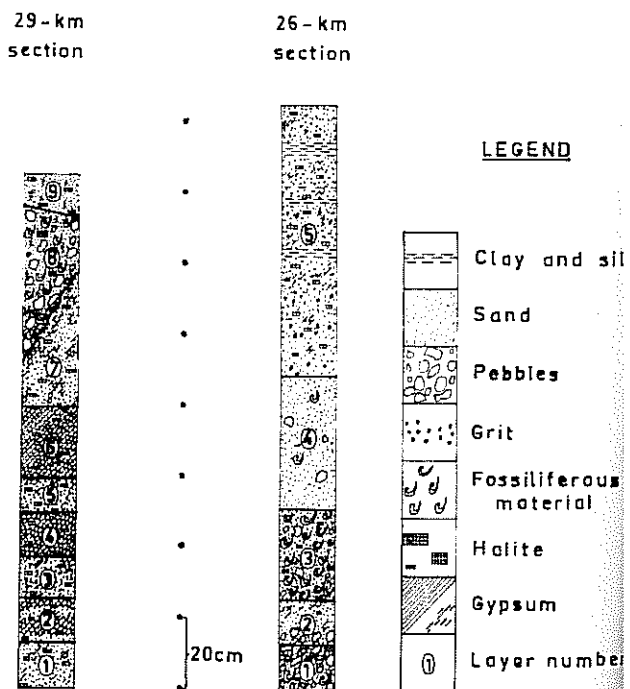


Figure 1. Lithology of measured sections 29 and 26 km south of the main Swakopmund — Usakos road.

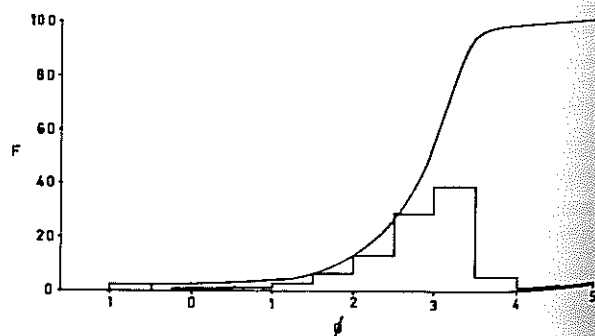


Figure 2. Histogram and cumulative curve of sand from layer 4 of the 26-km section.

few subrounded and only slightly frosted grains are present in the 45 to 80-mesh range.

In sands from all the other layers minor proportions of both rounded and angular grains show no frosting at all. These are most abundant in the 45 to 120-mesh range (figure 4). Many of the angular unfrosted grains are in the form of distinctive sharp-edged flakes. The typical decrease in the degree of rounding with decrease in grain size is shown by all samples (figure 4). Heavy minerals (biotite, hornblende, garnet, apatite, zircon, tourmaline, rutile, sphene and epidote) are well rounded, highly frosted and are concentrated in the 170 to 325-mesh range. Micaceous minerals are relatively abundant in all fractions.

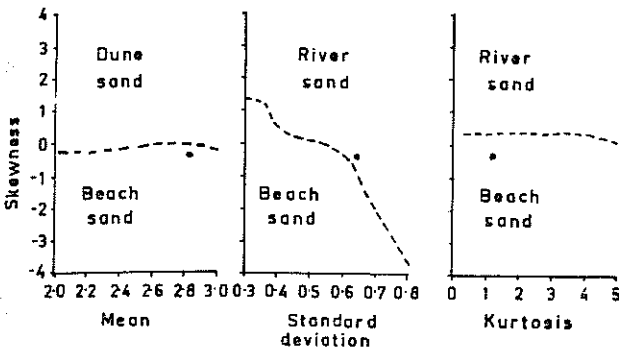


Figure 3. Textural characteristics of sand from layer 4 of the 26-km section (ϕ scale). Dune, river and beach sand characteristics after Friedman (1961).

2.2 The pebbles

The maximum pebble diameter is 10 cm. All pebbles are well rounded and sphericity varies from good to poor. Rock types present are schist, calc-silicate rock, marble (all from the Damara Group), shale (Karoo Sequence), granite, quartzite and quartz.

Sample No.	Mesh range	> 25	25-35	35-45	45-60	60-80	80-120	120-170	170-230								
		r	z	r	z	r	z	r	z								
Layer 4 26-km section	Roundness																
	Frosted (f)	87	13	90	10	88	12	85	15	81	19	63	36	59	41	58	42
	Unfrosted (uf)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Layer 1 29-km section	Roundness																
	Frosted (f)	82	17	70	18	55	20	56	17	58	27	34	58				
	Unfrosted (uf)	0.5	0.5	3	9	6	19	4	23	2	13	2	6				

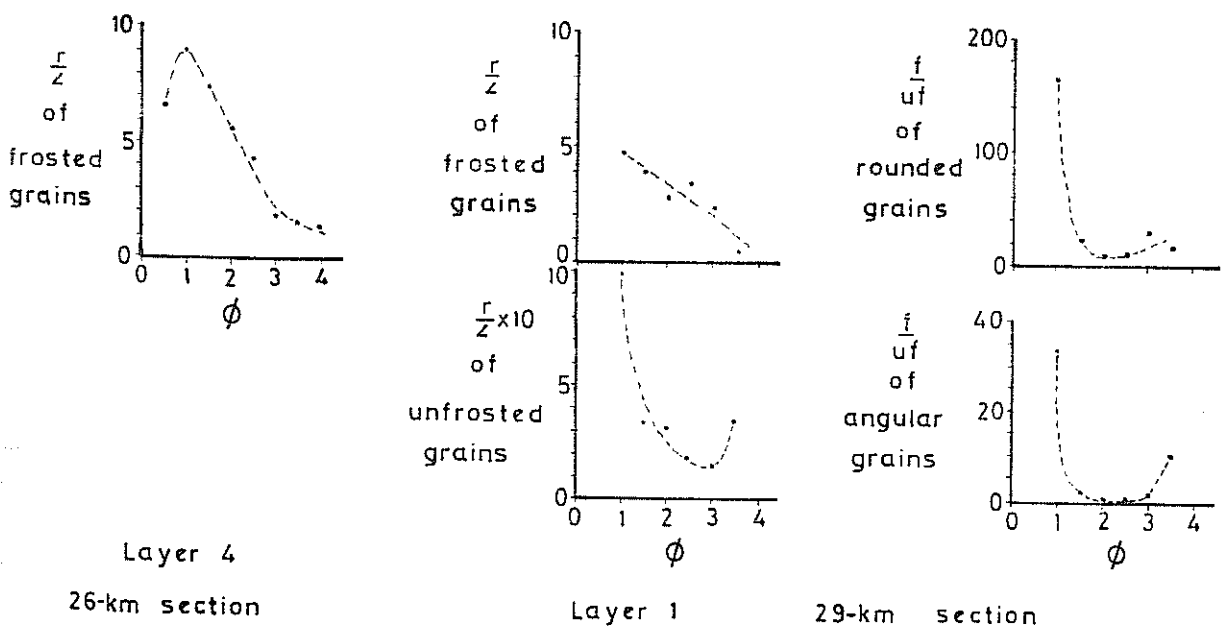


Figure 4. Rounding and frosting characteristics of sand fractions between 25 and 230-mesh (0.5-4 ϕ). Figures in per cent. r = well rounded, rounded, subrounded; z = angular, subangular.

3 FOSSILS

Specimens of *Striostrea margaritacea* occur in all the fossiliferous layers. Most of the left valves (attached valve) are fragmented, soft and extremely friable. In contrast the right valves are rather sturdy and many are unbroken. The specimens show scarcely any signs of abrasion and broken shells are all sharp edged.

In addition, fish vertebrae, crustacean and barnacle fragments and two gastropod specimens (as yet unidentified) have been found.

4 DISCUSSION

Consideration of the data provided by microscopic examination and by figures 3 and 4 indicates that the samples are composed of several populations.

Evidence for a fluvialite sand population is provided by relatively abundant mica in all sieve fractions, by unfrosted angular quartz flakes which indicate very limited transport and rapid burial, and by pebbles of Karoo shale. The nearest present-day outcrops of these rocks are 150 km inland at Erongo. All the other pebbles are not sufficiently diagnostic as possible source areas cover large tracts inland and along the coast.

A beach or lagoon sand population is indicated by the distinct negative skewness of layer 4 of the 26-km section (dune sand is positively skewed, Allen, 1970, p. 103), by the good sorting and lack of angular unfrosted grains in this layer, and by the lateral extent of beds. Marine conditions are indicated by the oyster valves and by the presence of halite and gypsum. The characteristic fauna points to periods when there was scarcely any supply of detritus, to a fairly free circulation of sea water and to possible warmer water temperatures than prevail at present along the coast. *S. margaritacea* requires a minimum summer water temperature of 25° C (Korringa, 1956). Association of the fauna with conglomeratic horizons (see figure 1) suggests a littoral environment.

In a littoral environment some reworking by wind is to be expected so that frosting of grains is not particularly diagnostic. However, spherical, highly frosted grains indicate intense wind action. Such grains are common in the coarser fractions indicating that at least some of the clastic material has been derived from an aeolian environment.

The alteration of gypsum-rich and gypsum-poor layers suggests that periodically during deposition a restricted environment developed preventing circulation of sea water. Evaporation led to precipitation of gypsum as a cement. Such conditions of temporary isolation could occur in local basins isolated temporally in a shallow deltaic environment or in a coastal embayment or tidal lagoon. The latter environment appears to be the most probable because the unabraded shells indicate that even when water was able to circulate freely the littoral zone was protected from strong wave action.

No exposure connects the deposits with the gravel and salt deposits occurring between Haigamchab and Nonidas on the Swakop River (Gevers and Van der Westhuysen, 1931). However, since the deposit occurs at the same elevation as the gravels at Nonidas and as the intervening bedrock outcrops are only small and sporadic it is probable that the two deposits can be correlated.

5 CONCLUSIONS

The sequence is probably mainly fluvialite in origin, having been formed by sheet flood action of the Swakop River. Depositional conditions appear to have varied considerably during accumulation of the deposit. For the most part burial was rapid but aeolian and marine reworking is evident and mixing of fluvialite, aeolian and marine fractions occurred in a fluvio-marine environment. Periods of rapid supply of material were interspersed with periods during which very limited deposition took place. During the latter periods sea water either circulated freely enabling a littoral fauna to thrive, or was not able to circulate at all and accompanying slow evaporation in the depository led to the precipitation of gypsum. Final burial took place in an embayment or tidal lagoon which was periodically isolated from the open sea.

The association of sheet-flood action and evaporite minerals strongly suggests that an arid environment existed at the time. This is further substantiated by the probable correlation of the deposit with a sand and gravel sequence on the south bank of the Swakop River which contains beds of pure halite.

6 ACKNOWLEDGEMENTS

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