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MARGARET E. MARKER

The Geomorphological Significance of some Central Namib Materials[1]

(1 Table, 1 Figure)

1. Abstract

Surface materials associated with specific geomorphological sites are described, with a view to providing basic data for visiting scientists and other working in the Namib region. A fanglomerate overlying planed Palaeozoic and older rocks as well as an undescribed sandstone, is recognised as providing a datum and source of materials reworked during the Cenozoic evolution of the central Namib.

2. Introduction

Extreme aridity is characteristic of the central Namib of South West Africa. All geomorphological processes, including dune formation, are at present so reduced in intensity that it has been suggested that a period of arid stability now prevails (Rust & Wieneke 1974). Nevertheless evidence exists for past phases of humid activity in the form of incised tributary channels, incipient pedogenic profiles and carbonate surface crusts. Like most arid areas, the Namib is therefore of intrinsic interest to geomorphologists and to scientists investigating Cenozoic climatic changes. Some attempts have already been made to deduce sequences of climatic fluctuations (Korn & Martin 1955; Rust & Wieneke 1973; 1974; Wieneke & Rust 1973), but such hypotheses have advanced beyond available local detailed analyses. Although some geomorphological studies have been made (Barnard 1973; Besler 1976; Goudie 1972; Marker 1978; Spreitzer 1966), most Namib research has concentrated on biological aspects (as Koch 1960; 1961; Seely 1973 et al.), and the advance of geomorphological knowledge has been hampered by the scarcity of geomorphologists working in the area and by short fieldwork periods. This survey of some surface materials of the central Namib, in the vicinity of Gobabeb on the Kuiseb river, is envisaged as a contribution to information easily available for visiting scientists with limited time at their disposal. The problems raised may indicate future avenues of research.

The central Namib consists essentially of a plain surface above which rise inselbergs and seif dunes. The plain is incised by allogenic rivers, such as the Swakop, Khan, Kuiseb and Gaub with catchments in the better watered Khomas Highlands. Although seemingly constituting a single surface with a general westward gradient, the Namib plain is composed of a number of sub-surfaces resulting from reworking of the original surface under phases of renewed erosion. South of the Kuiseb river, red seif dunes inter-

rupt the continuity of the surfaces. Between Tsondab Vlei and Hudaob interdune flats exhibit incipient drainage lines clearly predating the advance of the seif dunes which now bar the drainage gradient. North of the Kuiseb river these surfaces are more clearly continuous. The significance of these surfaces for any reconstruction of Namib geomorphological history has been recognised (Goudie 1972; Spreitzer 1966). In fact, Wieneke and Rust (1973) have suggested that the lower surfaces can be related to Quaternary high marine stands and that duplication of the upper surfaces is the result of differential warping along the Khomas Highland front. River terraces at 42 m,[2] 20 m, 15 m and 6 m above Kuiseb river level between Homeb and Gobabeb have also been reported (Goudie 1972; Rust & Wieneke 1974). Each of these terraces is capped or composed of specific materials as are the higher surfaces. In all nine Cenozoic materials are described here (Table 1).

3. Cenozoic deposits

A. Calcrete Fanglomerate

The Kuiseb valley divides the stony Namib from the dune Namib to the south. North of the Kuiseb river the Namib surfaces are planed across steeply folded Proterozoic basement rocks of the Damara System intruded by Karoo age dykes. Isolated inselbergs such as Mirabib provide food for increased run-off so that shallow runnels interlace across the pedimented gravel plain. The entire surface, with the exception of rock outcrops, is mantled by a reg of angular gravel derived from local bedrock breakdown.

South of the Kuiseb river the same surfaces in part overlie a sandstone. At Hudaob above the Kuiseb Canyon where a 10 m calcrete caprock is being stripped, the altitude of the north and south bank surfaces may be compared. It is clear that the southern sub-calcrete bedrock bevelled surface is at the same altitude and is the continuation of the reg plain. The dissected gramadulla country fringing the Kuiseb valley discussed by Rust and Wieneke (1974) has originated during the stripping of the calcrete by streams incising to the allogenic Kuiseb Canyon during a wetter phase.

The Hudaob calcrete profiles show the massive calcrete to consist of a calcareous fanglomerate containing well-rounded fluvial quartz and other pebbles (Fig. 1). Although some pebbles are found throughout the profiles, bedded concentrations are localised. Most marked are those resting immediately on the planed and weathered schists and those near the top of the profiles. The upper pebble band is apparently a lag concentrate resulting from weathering down of the calcrete surface with concomitant recementation. Thus the degree of surface pebble density can be envisaged as a function of calcrete degradation. The calcrete formation is massively jointed but shows little evidence of soil development or of solution weathering by piping down the joints (Fig. 1).

At Ossewater the dunes overlie a calcrete similar to that exposed at Hudaob. Some 50 m below and along the slopes of the Kuiseb river valley, a closely-packed pebble conglomerate cemented by calcrete, represents the remnant of much later valley fill of pebbles derived from the older fanglomerate. Other massive pebble-studded calcretes cap the high terrace at Gobabeb where they overlie a sandstone with polygonal cracks. Both these pebble calcretes appear to be part of the same later valley fill. A calcrete

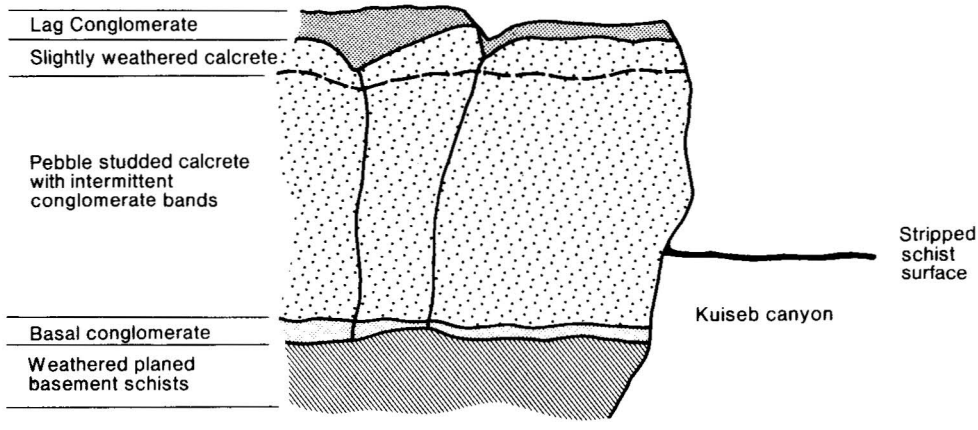

Fig. 1: Section at Hudaob (drawn from photograph)

caprock that occurs near the confluence of the Kuiseb and Gaub rivers can be traced west to Hudaob and it also rises gradually eastwards towards the mountain front. With increasing altitude large cobbles predominate over pebbles providing confirmation of the fanglomerate origin as a cemented fan deposit. Considerable seasonal discharge is thus implied during its formation. The lack of solution piping down marked vertical joints suggests that water surplus conditions sufficient to cause weathering have been absent since that time.

Rust and Wieneke (1974) comment on the duplication of scarps in the Hudaob calcretes and a similar stepping is visible south of Gobabeb. Break-up of the surface lag conglomerate and deflation of fine material accounts for localised variation in surface level.

Goudie (1972) has postulated a Pliocene age for the calcrete fanglomerate and equivalence with the Kalahari limestone exposed at Kalkrand. This view is supported by Martin (pers. comm.), but it should be emphasised that the precise age of the Kalahari limestones remains undetermined. They are believed to be Pliocene or earlier. The high level fanglomerate is undoubtedly a geological formation and an important geomorphological datum in the Namib. Its disintegration has released both rolled pebbles and calcium carbonate into the Namib environment.

Red Sandstones

The Kalahari Limestone also overlies indurated red sandstones that outcrop as cliffs in the vicinity of Tsondab Vlei, Diep Rivier and further south. These sandstones are another geological element within the dune Namib landscape. As a geological formation they have apparently not been described. Two types of sandstone at least can be distinguished. The older is a horizontally bedded massive red sandstone. It is impregnated with calcium carbonate along close joint and bedding planes to give a

reticulated appearance and it contains rolled calcrete cobbles. Lenses of calcrete concentration are also interbedded and are not always horizontal. There is no evidence for either pedogenic or vlei origins. Elsewhere the indurated red sandstone shows marked cross-bedding. In cliffs at Tsondab Vlei, cross-bedded sandstone overlies horizontal sandstone. The calcrete fanglomerate caps many of these cliff exposures. Elsewhere outlying ridges of sandstone show marked cross-bedding. Their morphology, location and bedding suggest that they are *in situ* Pleistocene fossil dunes. It is postulated that their sand and that of the present mobile dunes has been derived from the weathering of the massive sandstones (Besler 1976). Between Tsondab Vlei and Hudaob, the Namib surface is capped by the fanglomerate resting on planed sandstone overlying an irregular schist surface. Cross-bedded indurated sand ridges appear to rest on the calcrete surface. The sandstone is therefore of more than one age. Although some may represent indurated Pleistocene dunes, the older material may have been deposited under seasonally arid conditions (Selby 1976). As many bedded sandstones are overlain by fanglomerate material, the older sandstones predate the fan and may have been indurated during its formation. They are therefore of earlier Tertiary age than the fanglomerate.

Superficial calcretes

Two calcrete types other than the fanglomerate occur on lower interdune flats. Their calcium carbonate is likely to have been derived from the break-up and reworking of the fanglomerate caprock. Higher surfaces carry a lag of rounded hard, smooth recrystallised rubble which is occasionally associated with incipient brown soils. Lower levels support a lag of friable root cast calcrete under drought conditions. It appears as if the highest and original surface is preserved by the massive fanglomerate. The next surface level, lowered by fluvial action or by deflation, is associated with a protective lag of recrystallised calcrete rubble. Below this level a small amount of friable calcrete provides a lag and on the lowest interdune flats are ancient silt deposits such as those reported from Narabeb (Seely & Sandelowsky 1974). The silts are water-laid and have been partially calcretised and can show patchy soil formation. Some overlie sandstone and others rest on blown sand. Their existence indicates at least one phase of locally more humid conditions subsequent to the deposition of the massive fanglomerate.

Kuiseb river terrace deposits

In the vicinity of Gobabeb fluvial terraces, each with their own distinctive deposits occur. Their existence merely indicates increased discharge in the allogenic river and does not necessarily imply locally wetter conditions. As the Kuiseb river terraces have been discussed in detail elsewhere (Marker 1978), attention will here be focussed on the materials associated with each. North of the Kuiseb river, on the stony Namib the higher surface is a continuation of the reg Namib plain. It carries angular, fragmented gravel surrounding low rocky outcrops. At depth a calcareous gypsum crust cements sand and gravel and may be overlain by a brown sandy silt loam (Scholz 1972). Although this loam is not ubiquitous since it is vulnerable to deflation, its presence indicates sufficient surface water for chemical soil forming processes subsequent to the creation of the Namib surface. Shallow valleys drain from the surface onto a 6 m ter-

race and provide further evidence for locally wetter conditions prior to the final phase of incision.

The valleys are clogged with detritus derived from the reg material. There are no crusts at depth within the valley material, suggesting that infilling took place under arid conditions that did not favour mobilisation of carbonates by solution and their subsequent reprecipitation.

The 6 m terrace carries rounded pebbles of dominantly white quartz similar to those in the calcrete caprock and in the pebble conglomerate infill. The terrace is present on both sides of the Kuiseb channel and the pebbles are associated with a loose red sandy silt loam also having no pedogenic crust at depth. Although the present Kuiseb river bed-load consists of coarse sand and silt with no pebbles, the presence of pebbles on 6 m terrace does not necessarily imply a former greater discharge contemporaneous with the formation of the terrace. The pebbles probably emanated from the destruction of the fanglomerate or the derived infill and were emplaced by resorting. Subsequent soil formation occurred which may have been contemporaneous with the period of pedogenic crust formation on the higher terrace and the cutting of the shallow valleys.

Bedded Silts

Bedded sandy micaceous silts constitute the present 1 m flood plain of the Kuiseb River, but paler fine-grained calcareous silts also occur, up to 15 m above present river level within the incised valley (Goudie 1972; Rust & Wieneke 1974). These paler silts are largely confined to north bank tributary valleys in protected sites between a few kilometres west of Hudaob to Gobabeb, and reach their greatest exposure at Homeb/Ossewater. The deposit has been attributed to ponding behind a dune barrier (Scholz 1972; Marker & Müller 1978; Rust & Wieneke 1974). They are water-laid and largely horizontally bedded. Some of the upper beds are indurated with calcium carbonate, but the underlying layers are relatively soft. A duplicated glacis terrace at lower altitude has also been reported from Homeb (Rust & Wieneke 1974). However, the lower terraces are actually cut across silts and have overlying coarse sand and gravel layers all concealed by angular fragments derived from the reg surface. Incision with periods of stillstand to form terraces has therefore occurred subsequent to the ponding of the valley.

4. Additional information

Certain samples were subjected to an exploratory microscopic examination. Samples derived from material within interdune flats exhibit greater variation in composition and size than the well-sorted seif dune sands. In most samples, other than the paler silts, two main constituents can be detected. Larger and medium size sand grains are usually rounded to sub-rounded, well-polished and carry a red translucent patina. The smaller grains are more often angular and are clear or white with no trace of patina. They appear to be the product of chipping. Even in sandgrains from calcretes the basic division is maintained although wetting and drying reduces the tone of the patina. The indurated red sandstone itself is composed of rounded red patina-coated grains. Such samples show sorting but size is not constant from sample to sample. The sandstone seems to

have been sorted into a wide range of dominant grain sizes. Rounded to sub-rounded, polished grains with a red translucent patina are present in the red sandstone and compose the active red seif dunes. Such grains are also present in most of the other materials discussed. It is highly probable, as postulated by Besler (1976), that the mobile red Namib sands are derived from the red sandstone of unknown age and provenance. The two are almost co-extensive.

5. Summary

The central Namib exhibits a number of bevelled surfaces and fluvial terraces. The surfaces are cut across contorted basement rocks and an indurated red sandstone of postulated early Tertiary age. This planation was followed by the formation of 10 m thick limestone calcrete containing rolled pebbles diminishing in size with distance from the upland source area. The highly weathered nature of the sub-calcrete surface is indicative of deep weathering during planation and it is possible that the surface may be an etch plain (Thomas 1974). The date of this alteration is immaterial to a discussion of namib Cenozoic climatic fluctuations but it is noteworthy that present-day stripping is exposing a pre-weathered surface and that the granite weathering forms may result in part from pre-weathering enhanced by mist and salt weathering now.

Subsequent to the formation of the fanglomerate, a basic datum, seven distinct deposits have formed. South of the Kuiseb river, calcification is commonplace. Recrystallised calcrete nodules, friable root-cast calcrete and calcretised vlei silts are associated with progressively lower surfaces. North of the Kuiseb river occur angular gravel, reg, with crusts at depth. Within the Kuiseb valley there are pebble conglomerates, micaceous silts, sandy silts on the present flood plain, and the 6 m terrace with a lag of derived pebbles associated with red loam. The recognition and description of these materials is a first stage in the elucidation of Namib geomorphological sequences.

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TABLE I: THE MATERIALS OF THE CENTRAL NAMIB

Locality	*Type of deposit*	*Postulated origin*
OTHER ELEMENTS		
Kuiseb valley	Flood plain terrace sandy silts	Present-day fluvial action
Kuiseb valley	Rolled pebbles in loam matrix	6 m terrace reworked deposits: subsequent pedogenesis
South of Kuiseb	Interdune vlei silts	Water laid and partially calcretised
South of Kuiseb	Root-cast calcrete lag gravel	Degraded pedogenic calcium
Kuiseb valley	Micaceous silts	Lake or vlei deposits derived from canyon incision
North of Kuiseb	Angular reg gravels	Arid weathering residium
South of Kuiseb	Smooth hard rubble calcrete	Altered pedogenic horizon
South of Kuiseb	Red cross-bedded sandstone	Indurated Pleistocene dunes
BASIC ELEMENTS		
	Conglomeratic, calcrete	Fanglomerate
	Indurated, calcium impregnated sandstone	Primary deposit
	Planed and weathered Damara System rocks/ Salem granite/dolerite dykes	

[1] The research on which this paper is based was carried out during two visits to D.E.R.U. Gobabeb in 1975 and 1976. The assistance of Dr. Seely is acknowledged. The research was in part funded by grants from University of Witwatersrand and C.S.

[2] The postulated 42 m terrace at Gobabeb (Goudie 1972) in fact lies some 70 m above river bed datum.