

# Relict vlei silts of the middle Kuiseb River valley, South West Africa

by

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## ABSTRACT

Relict fine-grained sediments have been preserved within erosion gullies (gramadullas) of the middle Kuiseb river valley in the Namib desert. These deposits are divisible into a conspicuous higher terrace and a concealed, eroded low level type. Discontinuous remnants, commonly yellowish-grey silts containing subsidiary sands, have been traced from Gobabeb 40,5 km upstream. The diverse mineralogy of the deposits reflects their metamorphic rock source. Bedding is distinct but sand and silt units are irregular in form. Sedimentary structures include cross-stratification and sun cracks. Four terrestrial gastropod species have been collected from the sparsely fossiliferous sequences. Alternation of low energy flooding and desiccation permitted fine sediment accumulation. Subsequent renewed fluvial activity incised the deposit into a double terrace. A late Quaternary age is postulated for the sediments.

## 1 INTRODUCTION

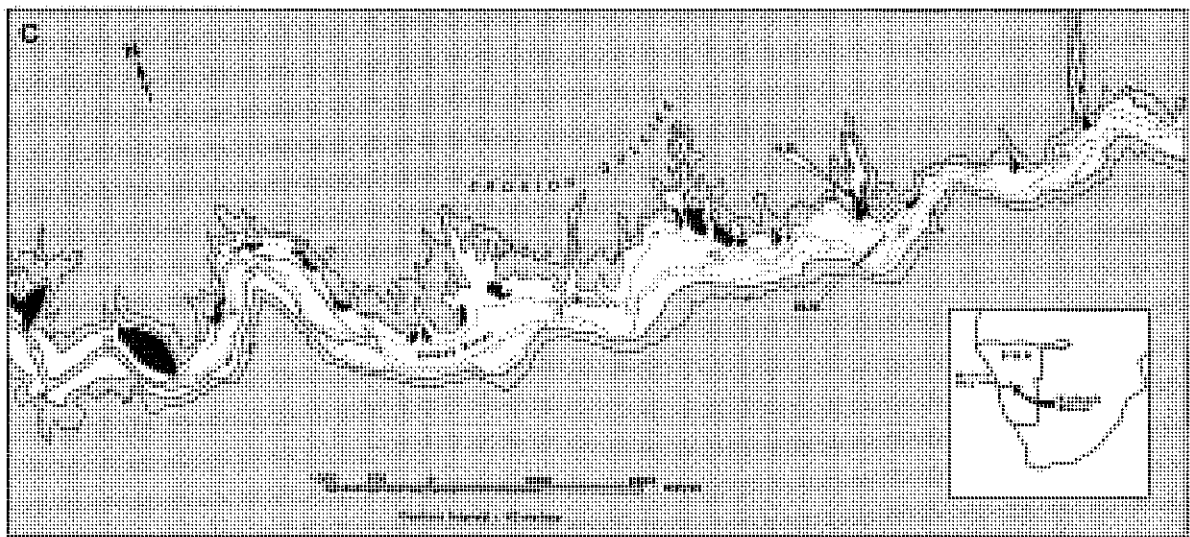
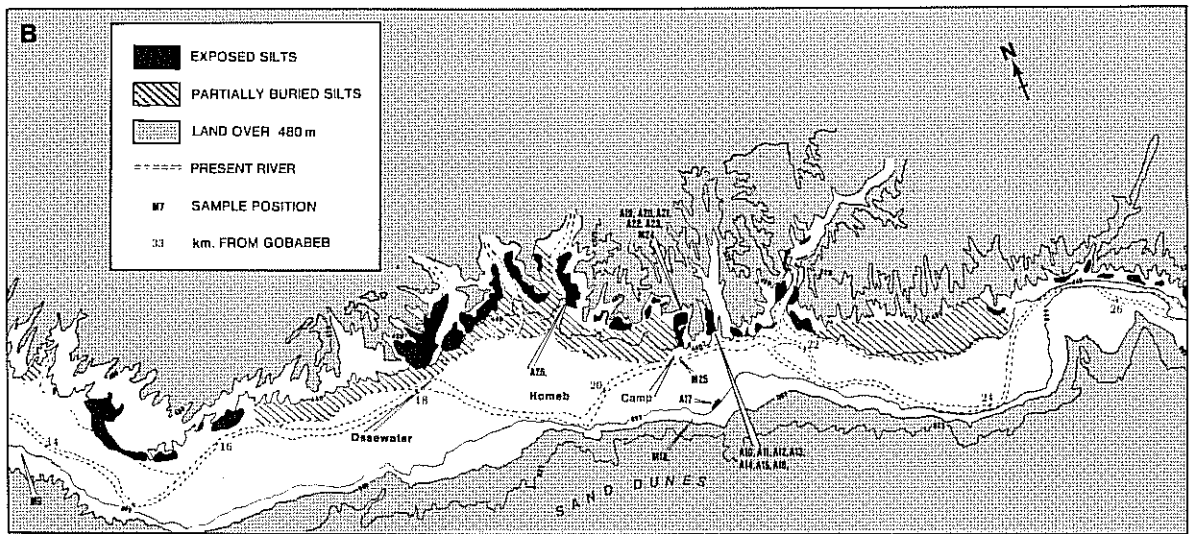
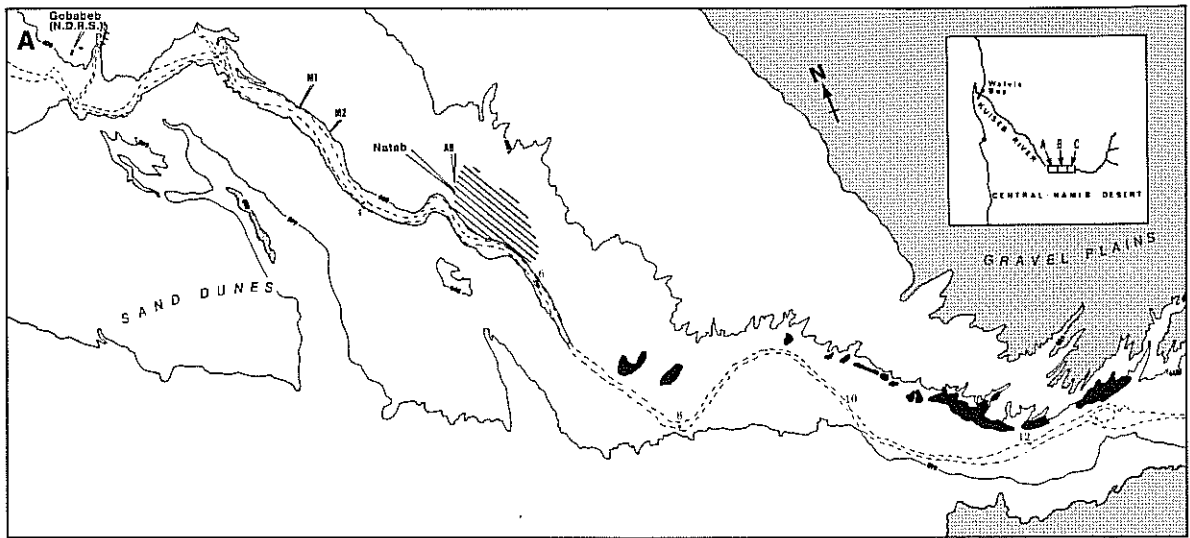
Relict silt-rich deposits of substantial but variable depth constitute one component of central Namib Cenozoic geomorphology, occurring in the Tsauchab, Tsondab and Kuiseb river basins. This paper discusses the location, constituents, characteristics and sedimentary history of the relict silts preserved in the middle Kuiseb valley. No details of this series have previously been published although mention has been frequent (Besler, 1972; Goudie, 1972; Rust & Wienecke, 1974; Scholtz, 1972).

The Kuiseb deposits are best preserved in the vicinity of Ossewater-Homeb, where they occur as a double terrace, the lower partially concealed by younger sands and gravels. Their present distribution is governed by factors favouring preservation from modern fluvial erosion so that the majority of silts are banked against and fill erosion gullies in the north wall of the lower Kuiseb canyon (map 1). Previous work (Goudie, 1972; Scholtz, 1972) has concentrated on the Ossewater-Homeb sediments although similar deposits have been noted at Natab (Scholtz, 1972) whilst Rust & Wienecke (1974) considered that the deposits ceased about 4 km upstream of Natab. The silts deposits are now shown to occur over a 40,5 km distance upstream of Gobabeb, isolated occurrences being believed to represent remnants of a former extensive valley fill (map 1).

These alluvial deposits are localised where the Kuiseb canyon widens into a valley incised into a basement plateau of folded, metamorphosed and faulted rocks of the Damara supergroup which have been invaded by granite and pegmatites (Martin, 1965). The basement composition is such that a very diverse mineral suite is available for incorporation into younger sediments. A further source of fines is provided by

## CONTENTS

Abstract .....	151
1 Introduction .....	151
2 The deposits .....	153
2.1 Composition and stratification .....	153
2.2 Minor sedimentary structures .....	153
2.3 Evaporites and calcretes .....	157
2.4 Palaeontology .....	157
2.5 Sampling data characteristics .....	160
3 Conclusions .....	160
4 Acknowledgements .....	161
5 References .....	161



MAP 1: The distribution of relict silts in the middle Kuiseb River valley.

Cretaceous to Holocene calcrete, gypsum and gravel and dune sand overlying the Damara rocks to the south of the Kuiseb valley.

The Kuiseb River, which rises in the better watered Khomas Highlands south of Windhoek, carries discharge in this section of its course in most years. As a result it removes blown sands emanating from the Namib dune-sea and serves to separate the dune Namib to the south from the gravel Namib to the north. The climate is hyper-arid with an annual rainfall at Gobabeb of only 16,5 mm (Seely & Stewart, 1976). Rainfall is variable and occasionally of great intensity. Fog is another source of moisture. Weathering processes are thus characteristic of desert environments with, in addition, chemical processes due mainly to the action of salt and sea mists (Scholtz, 1972).

The remnant silts are described in terms of their environment in order to add to information relating to sediment source and mode of emplacement. Demonstration of local provenance and emplacement by processes similar to the present has significance for the interpretation of the Cenozoic history of the area.

## 2 THE DEPOSITS

The terraced sequences of Ossewater-Homeb provide the type locality (map 1). Thick deposits preserved in north-bank erosion gullies have been incised and provide vertical sections (fig 1, plate 1). Their relatively level surface has previously been accepted as representing the level of infilling. However traces of similar materials adhering to bed-rock above the main terrace level suggest infilling may have reached a higher level (plate 1a). A lower terrace partially concealed by fan gravels of a later date forms the riverwards extension of the deposit. Such partially concealed silts are the most frequent type both upstream and downstream. The stratigraphy, even of the higher terrace, is further obscured by an external capping of hard, fine-grained material deposited by contemporary wash from material carried in suspension. These '*mud drapes*' and the intermittent preservation of the deposit complicate section correlation (plate 2a).

### 2.1 Composition and stratification

The most abundant sediments are yellowish-grey silts but subsidiary sands, probably of dune provenance, and darker biotite-rich silts are also incorporated. Stratification of the sediments is generally horizontal, although certain units show steeper dips ( $5^{\circ}$  –  $15^{\circ}$ ) unrelated to cross-stratification or tectonic deformation, their random orientation being an expression of basement irregularity. In contrast to such initial dips imposed during sedimentation, are the variable attitudes of large remnants that have collapsed following

erosional undercutting. Other minor irregularities have been imposed by differential compaction and by modern creep processes. No structures of tectonic origin were observed.

Bedding is variable (fig 1 and plate 2). The best-ordered units are the dominant, laterally uniform, yellowish-grey silt beds. These vary from 10 cm to 300 cm in thickness. The darker silt beds vary from 1 cm to about 30 cm in thickness and from 10 to 60 cm in length, tending to pinch out entirely. Fine sands occur mainly in variable lenses or in thin, 1 to 3 cm beds. Rarely small sand lenses occur intermixed with finer sediments. Basal conglomerates and schist-derived sands occur as highly irregular 1 to 200 cm wedges and display poor to well-developed pebble or sand grain imbrications dipping towards the valley walls.

Bed form ranges from massive to laminated. Many massively bedded yellowish-grey silts have a well-developed fissility, indicative of micro-lamination. The darker silts are also frequently fissile and commonly display parting lineations. Their fissility may be attributed to the proportion of included platy minerals. Much of the lamination, however, results from small scale alternation of coarser silty sand with finer silt material. Graded bedding is a minor feature of the sedimentary sequences.

Although the sections are generally well-stratified, no ordered repetition of units has been recognised and it is doubtful whether the deposits can be attributed to sedimentation of a regular cyclic nature. Apart from the basal conglomerates, no preferred stratigraphic position is displayed by any particular sediment type. The irregular, non-continuous nature of the subsidiary sediments (darker silts, sands and conglomeratic schist-rich sands) seems to indicate deposition under relatively uniform conditions with local variation. The texture, good stratification, lamination and bedding variability indicates an origin within a vlei situation such as prevails at Sossus or Tsondeb today, where discharge is insufficient to permit exoreic discharge.

### 2.2 Minor sedimentary structures

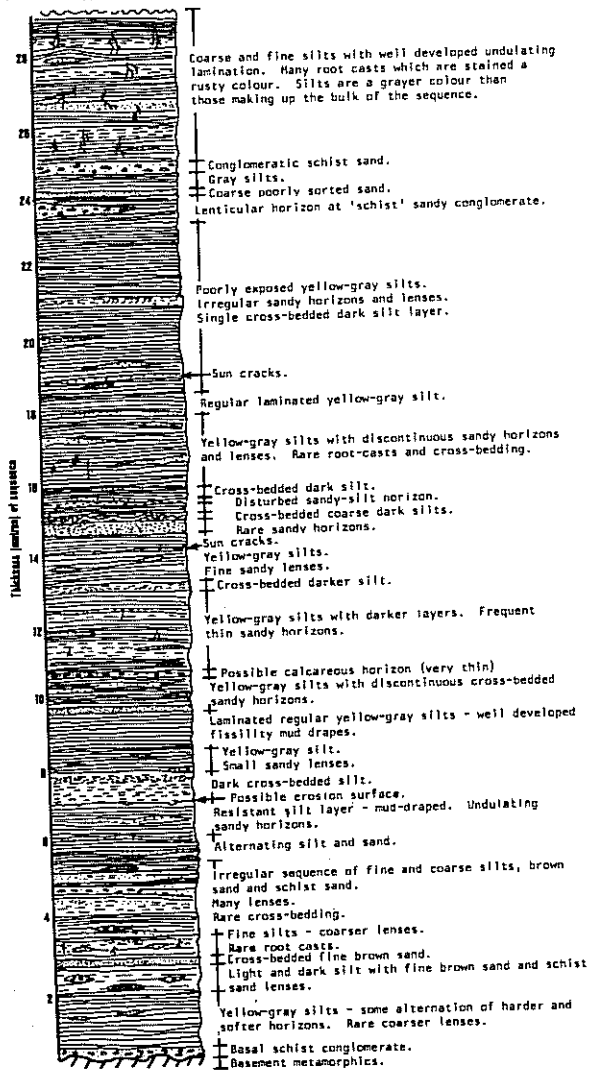
True cross-stratification is almost entirely limited to the darker silts and fine brown sands although the schist sands display a poorly developed cross-stratification (plate 3b). Cross-stratified horizons have no preferred stratigraphic position and are almost always lenticular. They appear to have resulted from ripple action in shallow waters containing a high load of suspended material. Absence of other types of cross-stratification and of directional control indicates a paucity of strong currents and of vigorous fluvial deposition. Strata in the Ossewater-Homeb area show no directional sedimentary control.

Convolute bedding caused by gravity sliding and foundering is of minor importance and occurs only

SECTION 1

(Illustrating some aspects of the relict sediment sequence in a valley 21 km from Gobabeb. Due to the nature of the exposure this is a composite section)

Silt remnants cling to valley side for a further 2 metres (approx.)

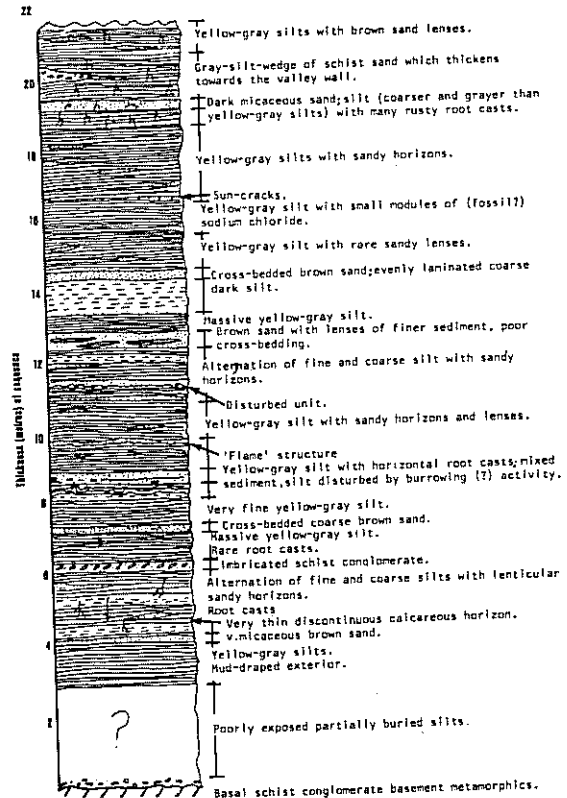


Start of sequence ~ 7 metres above present river level.

SECTION 2

(Illustrating some aspects of the relict sediment sequence in a valley near Ossewater. Due to the nature of the exposure this is a composite section).

Silt remnants cling to valley side for a further 10 metres (approx.) and are covered by scree.



Start of sequence ~ 11 metres above present river level.

- CROSS BEDDING
- LENSES OR LENTICULAR HORIZONS
- ROOT CASTS
- EROSION CHANNELS
- SUN CRACKS
- SCHIST SAND HASAL CONGLOMERATE
- SAND
- DARK SILT (USUALLY CLAYEY SILT)
- YELLOW / GRAY SILT (USUALLY CLAYEY SILT)

FIG. 1: Composite sedimentary sequences: (a) from Ossewater (b) from Homeb.

in silt and silty-sand beds a few centimetres thick, where it is restricted to internal bed laminations. Slump structures causing mildly deformed beds, 3 to 12 cm thick, probably arose from response to the influence of gravity on sediments deposited on a slight slope or to differential compaction over a basement high. Small faults are often associated with and restricted to these slumped beds (plate 3).

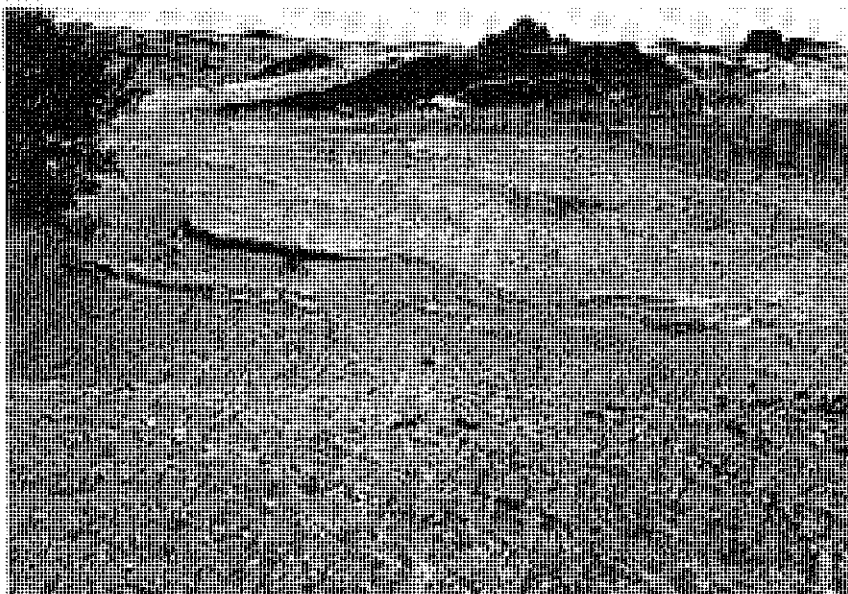
Organic structures, such as root casts, are widespread, at times transgressing up to 15 to 20 cm of silts and sands (fig 2). Most casts are weakly calcified, vertical to sub-vertical tubes 5 to 20 mm in diameter but some are uncalcified. Down-dragging of laminations in the vicinity of the root casts is ascribed to plant growth in a plastic sediment. In the upper layers

many root casts are associated with an oxidised zone. Lack of oxidation in the lower layers may be due to reducing conditions at the time of deposition.

The most significant of the lesser structures are clearly discernible desiccation cracks which exhibit no preferential stratigraphic position. Crack patterns create irregular polygons varying in diameter from 10 to 100 cm, larger polygons being frequently subdivided by small cracks. The cracks are usually filled with material texturally distinct from the fine material comprising the cracked surface. Sometimes cracks are restricted to homogenous thin layers but others show well-developed fine laminations and thus transgress layers. Most cracked surfaces are overlain by very thin fine sand layers. Occasionally the presence of cracks

PLATE 1: Silt location:

- a) terraced sediments at Homeb (note the level surface denoting the probable floor of the deposit, the silt patches adhering to basement rocks above that level and gully incision into the silts,
- b) preservations of terraced silts in erosion gullies,
- c) Natab concealed silts.





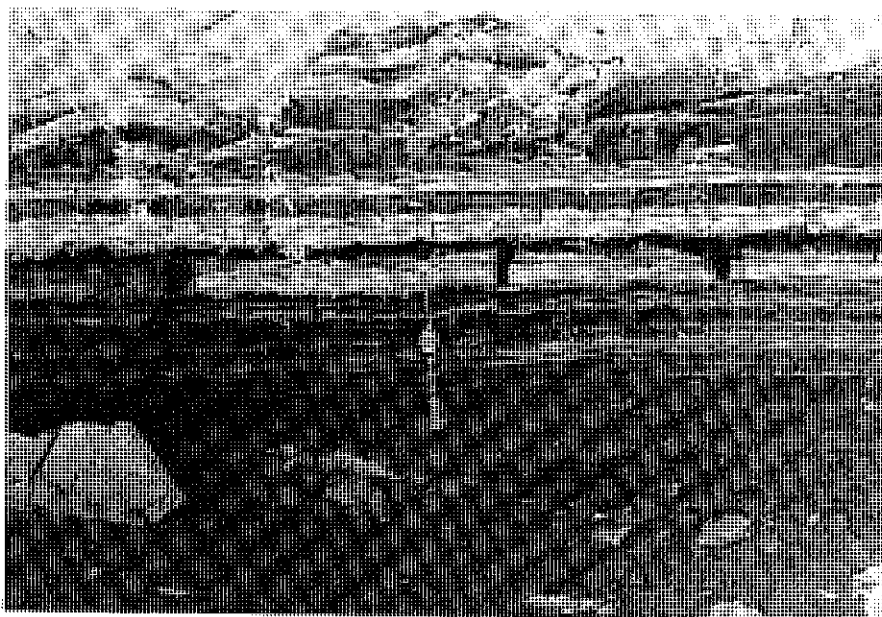
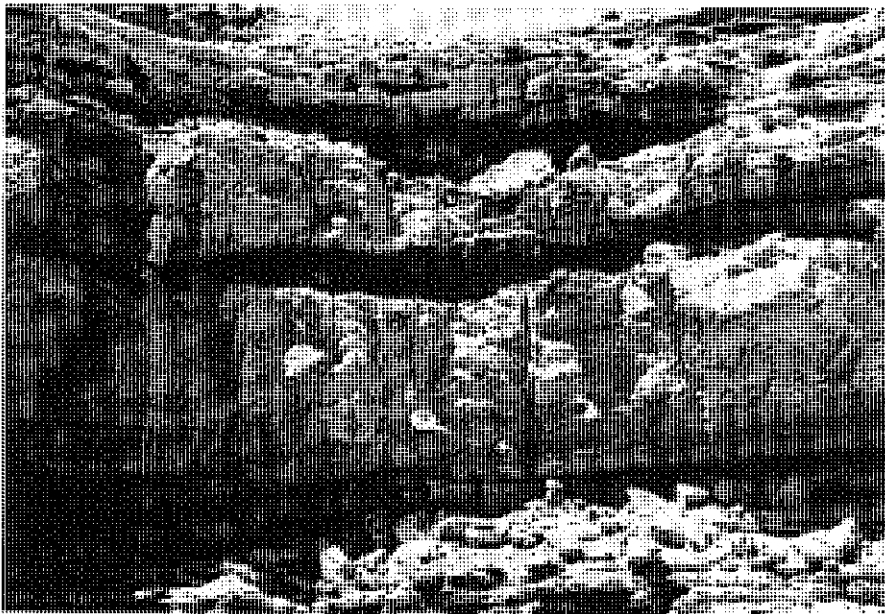


PLATE 2: Sedimentary sequences:

- a) showing effect of coarse and fine layers with mud drapes,
- b) relict fine-grained silts showing slumping.

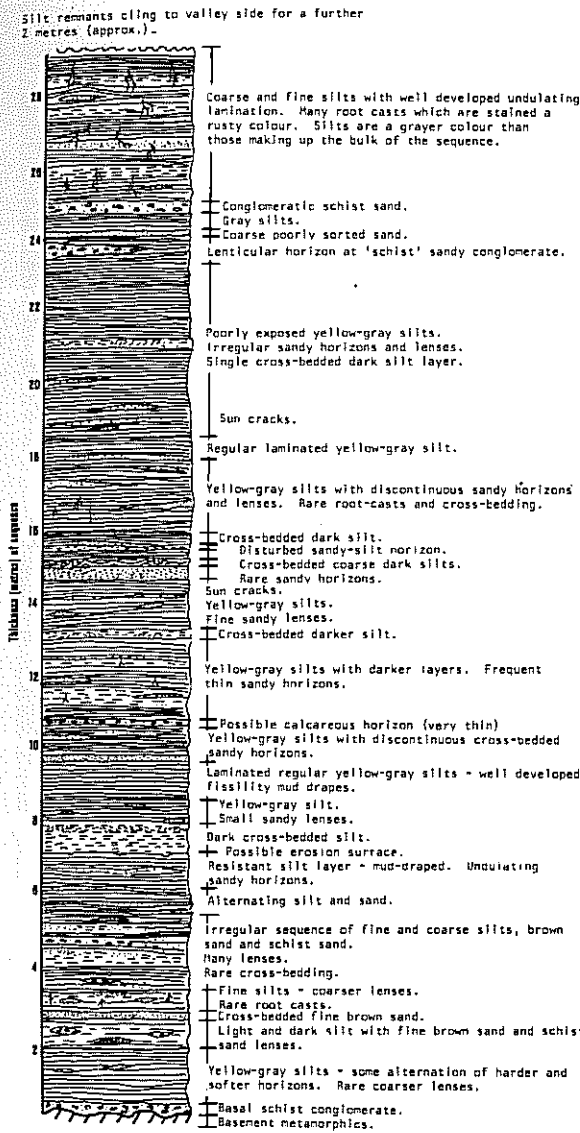
is detected only from positive casts on the bottom of overlying clayey silt beds. The cracks resemble those found in fine-grained modern sediments.

The presence of desiccation cracks implies periodic drying. The overlying sandy layer is believed to be dune-derived and is interpreted as a dry period deposit incorporated when the deposit was subsequently re-flooded. Dune-derived material may also have been incorporated during flood stages to form sandy layers and lenses. Relict erosion channels are further evidence that the deposit was intermittently dry (plate 3e). The

channels are all small, up to 10 to 20 cm across and 6 to 12 cm deep, and truncate any laminations in the underlying yellowish-grey silts. Channels cut into sands or pebble conglomerate were not observed. Characteristically the channels are filled with fine brown sand or darker coarse silt which may be either cross-stratified or horizontally bedded. The channels are interpreted as resulting from erosion by braided channel rivulets active when the deposit was almost dry. Sudden flooding appears not to have occurred since coarser sediments akin to the sands of the present river-bed are not found.

SECTION 1

(Illustrating some aspects of the relict sediment sequence in a valley 21 km from Gobabeb. Due to the nature of the exposure this is a composite section)



SECTION 2

(Illustrating some aspects of the relict sediment sequence in a valley near Ossewater. Due to the nature of the exposure this is a composite section).

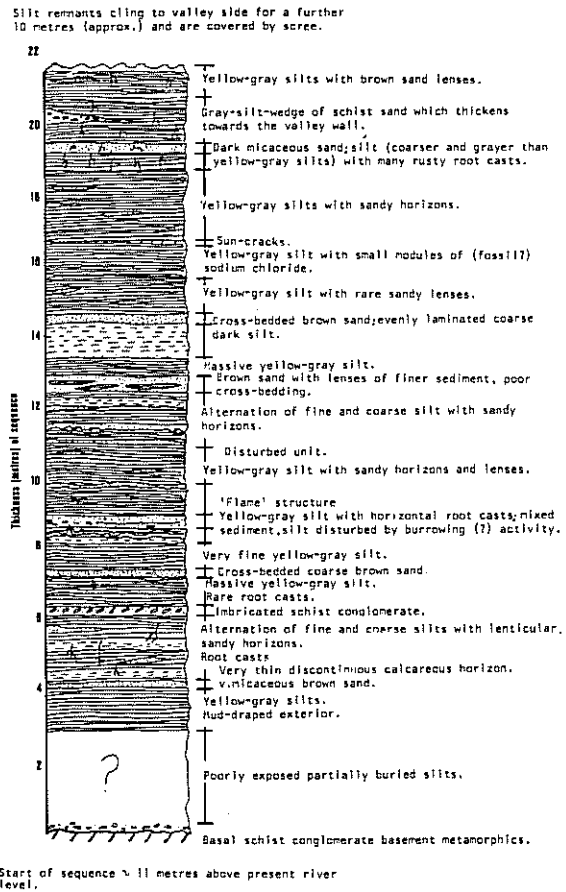


FIG. 2: Root disturbance in relict yellowish-grey silts.

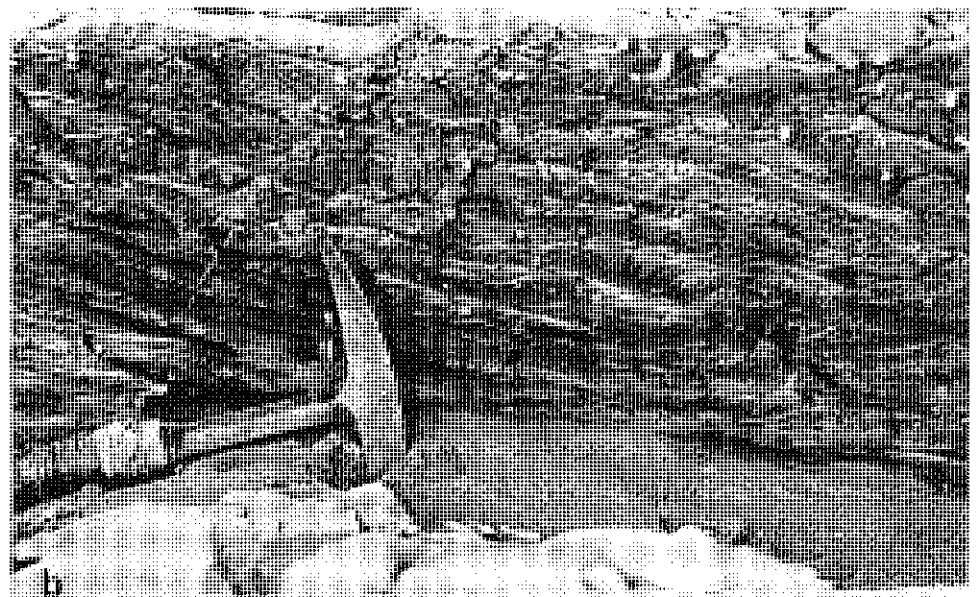
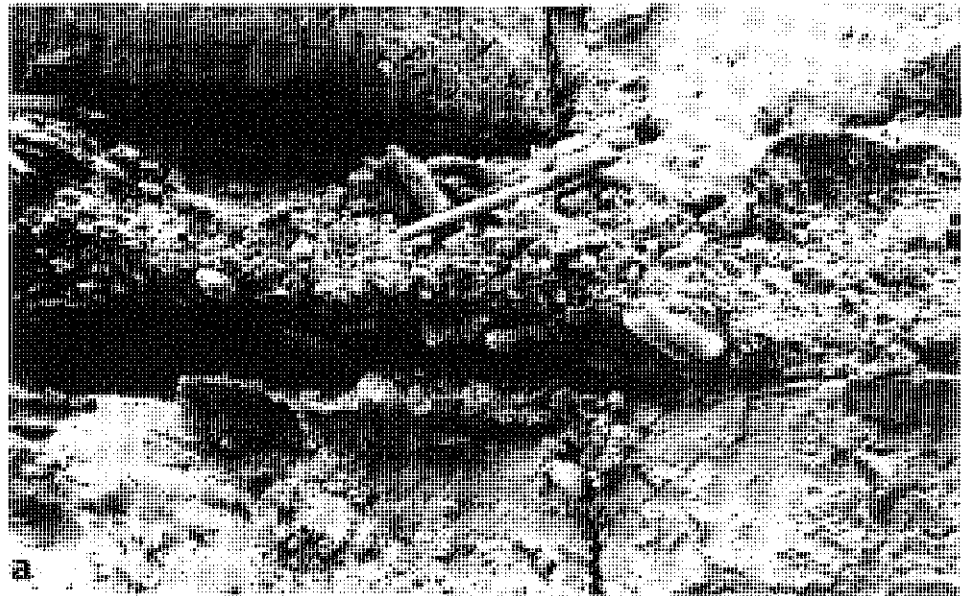
2.3 Evaporites and calcretes

Most arid depositional environments favour the formation of evaporites which become incorporated into the depositional sequence. The Kuiseb valley sediments are distinguished by a relative lack of evaporites, with the exception of calcretes cementing and capping the sequence. These occur mainly as hard, dark brown fragments of irregular shape and size, sometimes joined to form continuous cappings. They never exceed a few metres in extent or 2 to 5 cm in thickness. Most

of the sequences are partially cemented by carbonates with some gypsum and salt content in addition.

2.4 Palaeontology

Although the silt sequences are poorly fossiliferous, four species of gastropod have been collected. Positive identification has not yet been possible. *Bulinus (Bulinus) tropicus* and *Biomphalaria pfeifferi* were identified by Oberholzer (Institute of Zoological Re-





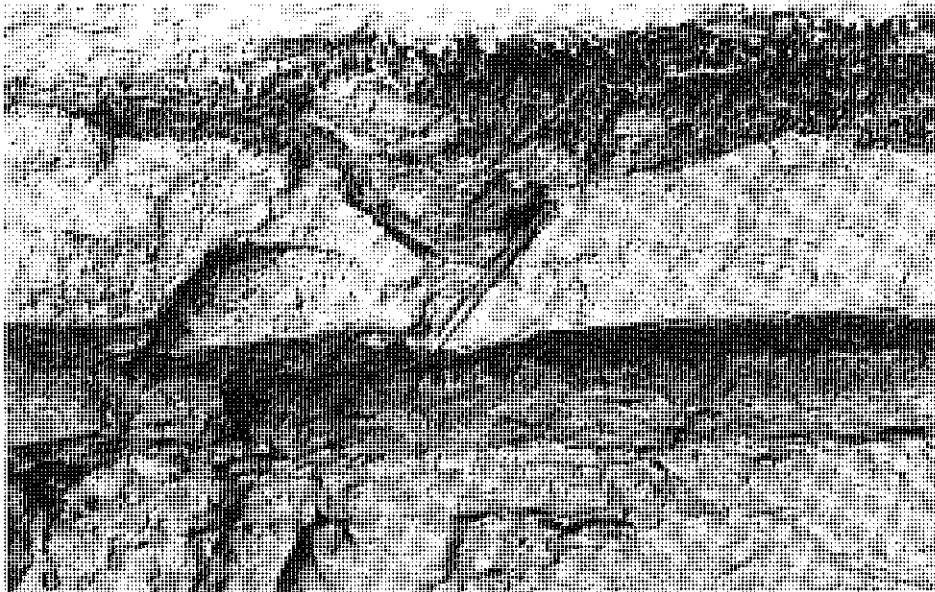
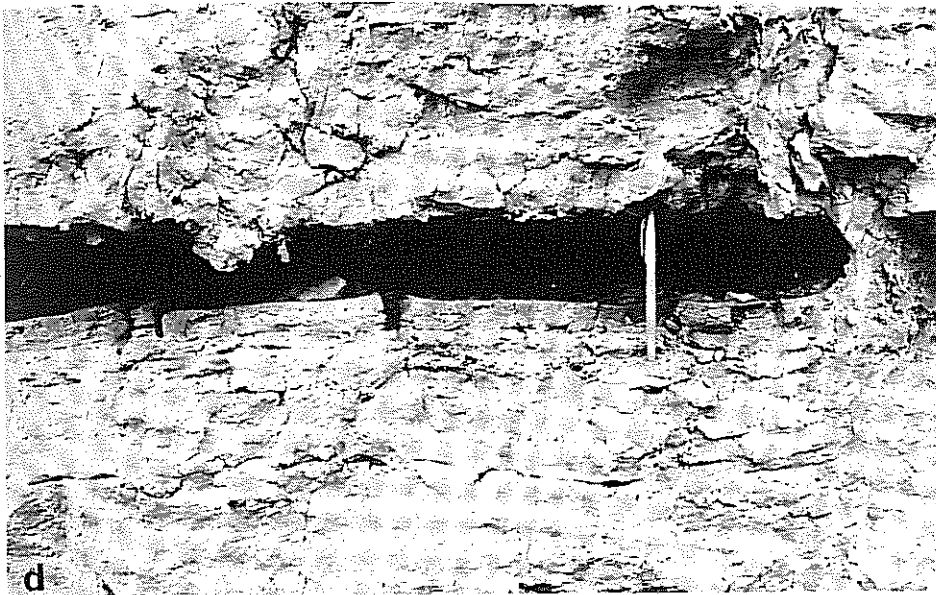


PLATE 3: Evidence of disturbance in silt sequences:

- a) pebble imbrication in schist conglomerate bed
- b) cross-stratification of a ripple origin
- c) excellent example of flame structures
- d) dessication cracks
- e) erosion channel indicative of hiatus in sedimentation.

search, Potchefstroom University)\* but the same specimens were classified as *Xerocerastus sp.* and as *Sculptaria sculptuici* respectively by the South African Museum. Of the other species, the South African Museum suggests *Isodora sp.* for one (fig 3). *Biomphalaria sp.* fossils have also been collected from the surface of eroding silts, 3 and 10 km west of Tsondab Vlei. All are fresh water sub-fossil snails and correspond to others collected from the Kalahari (Oberholzer, pers. comm.). Within the Kuiseb valley spatial distribution of fossils is random. No preferred stratigraphic position is apparent and fossils can be found

throughout the sequences, usually embedded in yellowish-grey silts although occasional specimens occur in the coarser, darker silts. Specimens usually

\* The only information regarding biological requirements, habitat and age of the gastropods comes from comments provided by Oberholzer with his identification:  
 (1) *Bulinus (Bulinus) tropicus* This species is a master of aestivation and reproduction over a short period. For this reason it is frequently found in temporary water-holes.  
 (2) *Biomphalaria pfeifferi* Although sometimes able to survive temporary drought by sheltering in crevices and other suitable spots, drying out of the habitat adversely affects the number of individuals in that particular habitat, since this species seems to require a relatively long period in which to reproduce successive generations.

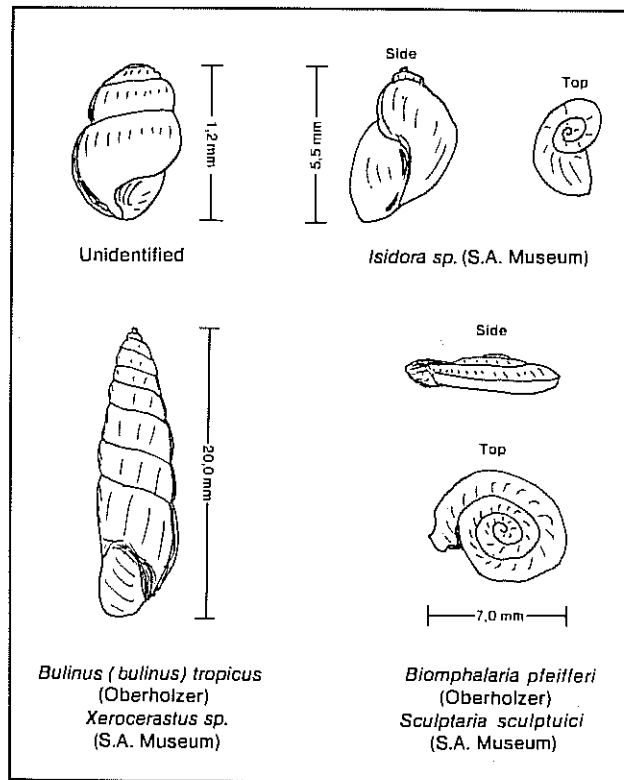


FIG. 3: Gastropods from the relict silts.

occur singly but groups of up to 5 individuals have been found. Only rarely are different species associated. The fossils are presumed to be late quaternary in age as modern forms exist and a tentative carbon fourteen date of 12 000 years Before Present has been obtained (Vogel, pers. comm.).

### 2.5 Sampling data characteristics

Samples taken from the deposit and from modern river sediments have been compared. Similarity in mineralogy and texture between the brown relict sands and present day-dune material is marked. The dune material is coarser and better sorted than the sands from the deposit lenses but this could be due to reworking and subaqueous mixing of the relict sediments. If the relict sands are derived from dunes, it implies that the depositional environment was then similar to that at present.

A rather tenuous size and mineralogic correlation between modern channel sands and other sand lenses of the relict deposit is also apparent. Again mixing has affected the relict deposit. The modern flood plain over bank sediments and the dark biotite rich relict silts are also similar. Bearing in mind the range within each category, there is no appreciable difference between past and present sediments. The relict sediments tend to be less sorted, probably reflecting differences in depositional environment. Modern sediments are laid down by river floods whereas the relict

sediments seem to have had a quiet water environment subject to seasonal drying, and been deposited from low energy river regimes. The broad similarities between the relict sediments and the modern deposits suggest that the processes were not radically different and that those differences that exist can be explained by the difference in environmental energy.

### 3 CONCLUSIONS

The characteristics of the relict vlei silts of the middle Kuiseb River valley indicate a localised deposit suggestive of a vlei environment with restricted river channel and aeolian deposition. Since only minor sands occur within the dominantly silt deposit, it is deduced that the Kuiseb River then had a regime of lower energy than at present. To account for such an accumulation of still-water sediments a barrier to impede downstream flow has previously been invoked but a tectonic barrier has not been envisaged since the silts were laid down when the river was already close to or at its present base level. A model whereby dunes migrated across the river channel under conditions of greater aridity has been suggested. However under conditions of low flow, a river regime has lower energy and only suspended sediment would reach the river end-point. No dune barrier causes silt accumulation in Sossus or Tsonab Vlei today. Flow is merely insufficient to proceed further downstream. Dunes cross the river valleys following cessation of river flow.

The thickest silt deposits, up to 50 m above present channel level, are preserved in the vicinity of Ossewater-Homeb. At Gobabeb, however, the deposit appears to have a maximum thickness of only 15 m. Deposition seems to have thinned downstream. This may have resulted from progressive desiccation as the river end-point migrated upstream. No more complicated explanation is required. The following sedimentary history can thus be postulated:

1. Incision to form the Kuiseb valley and side gullies.
2. Slight climatic shift to aridity in the headwater region to reduce flow.
3. Formation of a vlei in the lower canyon with subsequent dune migration across the former river channel downstream of Gobabeb.
4. Discontinuous seasonal sedimentation with repeated flooding, depositing fine material in shallow quiet waters. Some contribution from aeolian sources and from rare local sheet wash may have occurred. Preponderance of silt would have been favoured by lower fluvial energy.
5. A return to wetter conditions with greater fluvial energy removed the dune barrier and caused incision into the sediments as the Kuiseb River cut down to its present level in two stages.

The precise date of the development of the vlei and thus the age of the sediments has not yet been determined. A late Quaternary age is postulated since the silt terraces post-date canyon re-incision through

the pebble conglomerate infill (Marker, 1977). The tentative carbon fourteen date of 12 000 years Before Present provides a terminal date.

#### 4 ACKNOWLEDGEMENTS

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TABLE 1: Sample data: size and colour characteristics (designation after Folk, 1969; and US Geol. Surv.)

DESCRIPTION	NO	COLOUR	M2	G1	Sk1	Kg	VERBAL DESCRIPTION
"Typical silts form the the bulk of the relict sediments.	A 4	Yellowish grey 5 YR 7/2	5,34	1,45	0,41	1,26	"Sandy silt" poorly sorted, fine skewed, leptokurtic
	A13	Yellowish grey 5 YR 7/1	6,76	1,92	0,08	0,78	Clayey silt, poorly sorted, near symmetrical, platykurtic
Darker than the above but otherwise similar in form of occurrence. Are important components mainly of the basal glacial deposits, but also occur less frequently interbedded with yellow grey silts.	A 8	Dusky grey 5 YR 6/2	5,68	1,70	0,19	0,97	Sandy silt, poorly sorted fine skewed, mesokurtic
	A16	Dusky olive grey 5 YR 6/1	5,59	2,12	0,17	0,91	Sandy, silt, very poorly sorted, fine skewed, mesokurtic
	A17	Dusky olive grey 5 YR 6/1	5,23	1,90	0,40	1,12	Sandy silt, poorly sorted, strongly fine skewed, leptokurtic
Coarse silts - subsidiary in volume to yellow grey silts and finer dark silts. Occur in lenses as well as irregular beds. Often display good ripple cross-stratification.	A10	Dusky grey 5 YR 6/2	4,56	1,31	0,45	1,09	Sandy silt, poorly sorted, strongly fine skewed, mesokurtic
	A11	Dusky grey 5 YR 6/2	4,02	0,83	0,20	1,29	Silty sand, strongly sorted,skewed, moderately fine, leptokurtic
	A19	Dusky grey 5 YR 6/2	4,78	1,46	0,49	1,60	Sandy silt, poorly sorted, strongly fine skewed, very leptokurtic
Fine sands of darker colour - similar to the darker, coarser silts in form and also often cross-stratified.	A 5	Moderate yellow- ish brown 10 YR 5/2	3,77	1,02	0,44	2,51	Silty sand, poorly sorted, strongly fine skewed, very leptokurtic
	A22	Dusky grey 5 YR 6/2	3,26	0,71	0,17	1,31	Very fine sand, moderately sorted, fine skewed, leptokurtic
Fine brown sands limited almost entirely to lenses.	A12	Moderate yellow- ish brown 10 YR 5/5	3,49	0,81	0,29	1,53	Very fine sand, moderately sorted, fine skewed, very leptokurtic

Probably of dune (i.e. aeolian) origin, later reworked and mixed with aqueously deposited components.	A15	Light brown 5 YR 6/4	2,84	0,76	-0,32	1,82	Fine sand, moderately sorted, strongly coarse skewed, very leptokurtic
	A26	Pale brown 5 YR 5/4	3,23	0,65	0,25	2,11	Very fine sand, moderately well sorted, fine skewed, very leptokurtic.
Local basement derived deposits — can be likened to scree deposits and are very immature. Termed "schist" sands.	A21	Brownish grey 5 YR 4/1	1,50	1,52	0,07	0,76	Medium sand, poorly sorted, near symmetrical, platykurtic
	A23	Brownish grey 5 YR 4/1	1,92	1,51	-0,06	0,99	Medium sand, poorly sorted, near asymmetrical, mesokurtic
Samples from obviously "mixed" lenses — represent reworked material from different sources.	A14	Moderate yellowish brown 10 YR 5/5	2,17	1,80	-0,63	1,55	Fine sand, poorly sorted, strongly coarse skewed, very leptokurtic
	A20	Yellowish grey 5 YR 7/2	3,41	1,39	0,44	2,43	Very fine sand, poorly sorted, strongly fine skewed, very leptokurtic
Modern river overbank deposits — sometimes laminated, very frequently cross-stratified. Are similar to the other fine sands and coarser silts of the relict sequences.	M 1	Moderate yellowish 10 YR 5/2	3,22	0,79	0,14	0,99	Very fine sand, moderately sorted, fine skewed, mesokurtic
	M 2	Moderate yellowish brown 10 YR 5/2	4,46	0,87	0,20	1,06	Sandy silts, moderately sorted, fine skewed, mesokurtic
	M 7	Pale yellowish brown 10 YR 6/2	2,62	0,74	0,21	1,25	Fine sand, moderately sorted, fine skewed, leptokurtic
Modern river channel sediments. (M6 is upstream of M25 which is slightly better sorted and finer).	M 6	Pale yellowish brown 10 YR 6/4	2,32	0,73	0,14	0,93	Fine sand, moderately sorted, fine skewed, mesokurtic
	M25	Greyish brown	2,43	0,56	0,15	1,02	Fine sand, moderately well sorted, fine skewed, mesokurtic
Modern gramadulla bed load material.	M24	Dusky yellow 5 YR 6/4	0,96	1,71	0,12	0,74	Coarse sand, poorly sorted, fine skewed, platykurtic
Dune sands cascading over lip into river valley at present.	M 9	Pale brown 5 YR 6/6	2,05	0,38	0,38	0,97	Fine sand, well sorted, strongly fine skewed, mesokurtic
	M18	Pale brown 5 YR 6/6	1,53	0,61	0,74	1,17	Medium sand, moderately sorted, strongly fine skewed, leptokurtic

- M2 = graphic mean (phi units)  
 GI = inclusive graphic standard deviation (phi units)  
 Sk I = inclusive graphic skewness  
 Kg = graphic kurtosis (Folk 1969)

Sample number prefix A: relict sediment

B: modern sediment