ECONOMIC GEOLOGY RESEARCH UNIT

University of the Witwatersrand
Johannesburg

BEDFORMS IN THE BRAIDED, ALGAL-COLONIZED SABI RIVER, SOUTHEASTERN RHODESIA

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by

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ABSTRACT

The Sabi River, in southeastern Rhodesia, is a braided, coarse-bedload river which flows over an alluvial floodplain up to 25 km wide. At low stage, the dominant bedforms in the braided channel are elongate linguoid bars. Green algae thrive in the river, being best developed in stagnant and semi-stagnant pools. Continuous shifting of channels erodes into such pools, liberating a constant supply of algal clots, which are an invariable component of the stream load. Algal clots are concentrated in the deeper water immediately in front of the avalanche faces of the bars. They become buried as the bar front migrates downstream. In the geologic record, the algal clots would be preserved as a carpet overlying a pebbly lag, and covered in turn by tabular cross-bedded sandstones. These observations may be put to practical use in the study of the gold- and uranium-bearing carbon seams of the Witwatersrand. They could also be used to predict the distribution of carbonized plant remains in coarse-grained braided stream deposits. Such remains frequently cause precipitation of uranium in peneconcordant, sandstone-uranium deposits.

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I. INTRODUCTION

The braided stream depositional environment is an economically important one, especially for gold-uranium in Precambrian quartz-pebble conglomerates and for peneconcordant uranium in sandstones. In both, carbon derived from plant material is intimately associated with mineralization. While braided streams are becoming increasingly well-documented (Miall, 1977), the behavior of fine plant debris is seldom mentioned.

The Sabi River in southeastern Rhodesia is a fine example of a coarse-bedload braided stream. In addition, at low stage, it is colonized by a luxurious growth of green algae. Algal clots are a part of the stream sediment load. The depositional behavior of the clots relative to other bedforms in the stream is described. The relationships can be used in the interpretation of ancient deposits, and in prediction of the location of carbonized plant remains.

The study is a preliminary one. Further work in the area has been made impossible by the continuing high level of military activity in the region.

II. LOCATION

The Sabi River is the major drainage feature of southeastern Rhodesia, rising in the east-central part of the country. It flows from north to south, more-or-less parallel to the eastern boundary of Rhodesia. The area studied (Figure 1) is located 24 km due south of Birchenough Bridge, and about 3 km south of the confluence of the Tanganda River with the Sabi. Access to the study reach is through the cultivated fields of the Sabi Tanganda Estate.

III. THE SABI RIVER

The Sabi is a perennial river, fed by permanent streams rising in the high-rainfall eastern highlands of Rhodesia. From a point some 50 km north of the study reach, the river flows over an alluvial fill, and is braided. At its widest, east and west of the study area, this alluvial valley is 25 km wide.

Within the alluvial valley, the Sabi River is confined to an entrenched channel, varying between 1,5 and 2 km in width. The banks of the channel are up to 5 m in height, and are composed mainly of silty sands. They are relatively stable, due to the heavy stand of bush and trees which line the riverbanks.

At low stage, the Sabi River is usually some 200 to 500 m wide, and no more than 1 m deep. The low-stage course is a subsidiary channel, confined between the main banks or the margins of stable, vegetated islands (Figure 1). Within this channel, unvegetated bars and banks are present. The balance of the river comprises an intermediate topographic level, which is covered by water only during floods. This level (left white on Figure 1) is either unvegetated or, in places, is lightly vegetated by reeds and small shrubs.

The gradient of the river over the study reach is 1:750, while the regional gradient within the alluvial valley is 1:800. These figures correspond to a slope of around 0,0013, slightly less steep than the Platte River of the U.S.A., with a gradient of 0,0015 (Miall, 1977).

The low stage discharge of the Sabi is of the order of 30m^3/sec (Rhodesia, hydrological office). The river is at low stage for most of the year. Flooding occurs periodically during the summer rainy season, from early November to April. This study was carried out intermittently over a two month period at the end of the dry season of 1975 (September and October).

IV. SEDIMENT LOAD

The drainage basin of the Sabi River consists mainly of Archaean granitoid basement of eastern Rhodesia. The sediment transported by the river comprises mainly granitic detritus (quartz

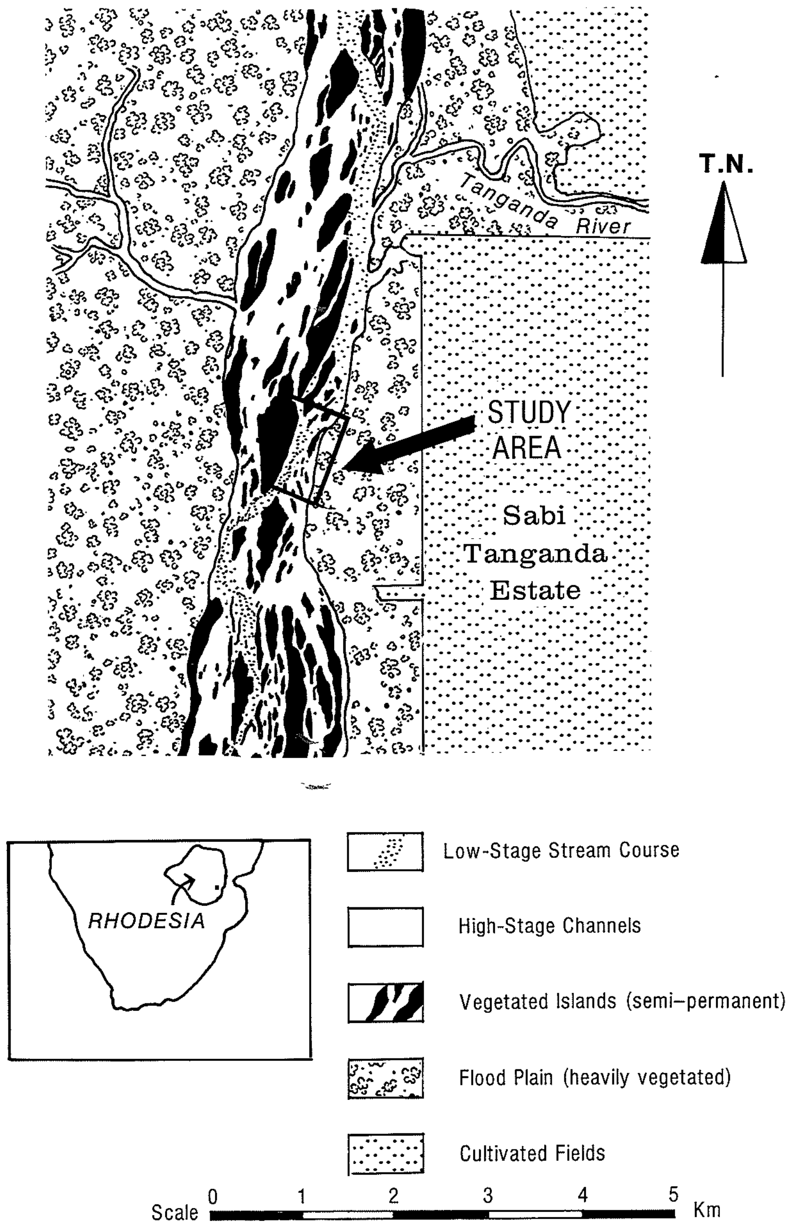

Figure 1 : The Sabi River, southeastern Rhodesia, showing location of the study reach.

and feldspar grains with some mica flakes). The detritus is mainly coarser than 1 mm, and averages some 2 mm. Granules (2-4 mm) and small pebbles (mainly 4-20 mm) are available for transport, and are mainly subangular white vein quartz clasts. During low-stage, the river runs clear, and the bedforms are easily visible. During floods, the water is turbid, carrying brown silty material, some of which is trapped on the islands due to the retarding effect of a dense growth of reeds.

V. THE STUDY REACH

The area studied measures about 1 km long (Figure 1). Here, the low stage channel of the stream is 300 to 400 m wide. The reach is situated between the stable bank of the Sabi River (to the east) and a stable vegetated island (to the west). Within this area, the relief is less than 2 m, from the deepest scour-pools to the tops of sand bars. Commonly, the channel floor and bar tops are no more than 0,5 m below and above the low-stage water level.

During low-stage, most of the water is carried in four or five braided threads, each 10-15 m wide. Within these threads, braid bars, mainly of the linguoid type, are developed. These bars are the dominant bedforms in the low-stage stream, and were mapped in detail during this study.

VI. MAPPING

Three threads of the river were mapped in detail, at a scale of 1:50. Mapping was done by plane table and alidade. In one of the map areas, a 1m grid was laid out by inserting thin reeds into the sand. Water depths and the direction of water movement were recorded at these locations. The direction of water movement could be easily monitored using a compass by noting movement of algal clots in the stream.

VII. RIVER BED MORPHOLOGY

The sand bars in the Sabi River can be easily mapped due to their colour contrast with the pools into which they build. The bars are composed of light coloured sand, while the floors of the pools are greenish, due to the film of green algae developed over them (Plate 1b). In addition, the bars are bounded by relatively steep avalanche faces, up to 0,5 m high.

In plan view, bars are elongate, their long axes being up to 10 times longer than their short axes (Figures 2a, b and 3). The fronts of the bars are acute (Figure 2a), tongue-shaped (Figure 2b) or lobate (Figure 3). Bars are frequently composite, with subsidiary bars riding up the back of the main bar (Figure 2b). They are similar to the "transverse bars" of Smith (1971a), but are more appropriately termed elongate linguoid bars.

The water depth on the bars decreases towards the avalanche face. In the example of Figure 3, the water depth decreases from over 20 to less than 5 cm as the bar front is approached. The shallowest parts of the bars are covered by a film of water, 2-3 cm deep.

There are a number of bedforms on the bar surfaces, which are controlled largely by water depth and velocity. The relative age of the bar surface appears to be important insofar as the distribution of lag deposits is concerned.

1. *Megaripples*

In the relatively deep and fast-flowing reaches, asymmetrical megaripples are the dominant bedforms (Plate 1a). The megaripples are characteristically some 10 cm high, and are spaced 0,5 to 1 m apart (Figure 3). Megaripple crests are discontinuous, displaying undulatory to lobate geometry (Reineck and Singh, 1975). On the margins of channels, the megaripple crests are not perpendicular to flow, being retarded near the bank margin by the slower flow of water.

2. *Ripples*

Small current ripples are rare in the Sabi River, due to its very coarse bedload. They have been seen in a few cases on the margins of active channels. Here, the sorting action of the stream has been responsible for concentration of finer sand, which has allowed the development of small current ripples, with 10 cm wavelength and 1 cm amplitude.

3. *Plane Bedding*

The shallowest parts of the bars, usually those near the avalanche faces, are plane-bedded (Plate 1b). In some instances the bar surface is perfectly plane, and is characterized by a thin film of water (1-3 cm deep) carrying a traction carpet of sand grains. A distinct streaming lineation, parallel to flow, can be made out (Plate 1c).

More commonly, these shallow bar surfaces are characterized by low amplitude (up to 5 mm) and long wavelength ripples (crests separated by up to 2 m). Similar features have been described by Smith (1971b) from the Platte River, U.S.A. As in the Platte example, coarser grains are concentrated at the fronts of the micro-foresets, while finer grains collect near the crestlines. Continued movement of these bedforms is likely to produce a discontinuous plane-bedded structure in the sand.

4. *Lag Surfaces*

In places, water velocity and sediment supply are such that the surface of the bar is weakly eroded (Figure 2a, b; Plate 1e). This normally occurs on the backs of bars, in relatively deep water. The effects of erosion are to concentrate small pebbles and granules in a lag sheet. Commonly, the lag sheet is elongate in the direction of water flow.

The pools in front of the linguoid bars are usually floored by a pebble-rich lag, frequently covered by a film of algae (Plate 1b). The lag is formed by the removal of finer sand grains from the depositional surface, presumably due to the fact that the water downstream of the avalanche face

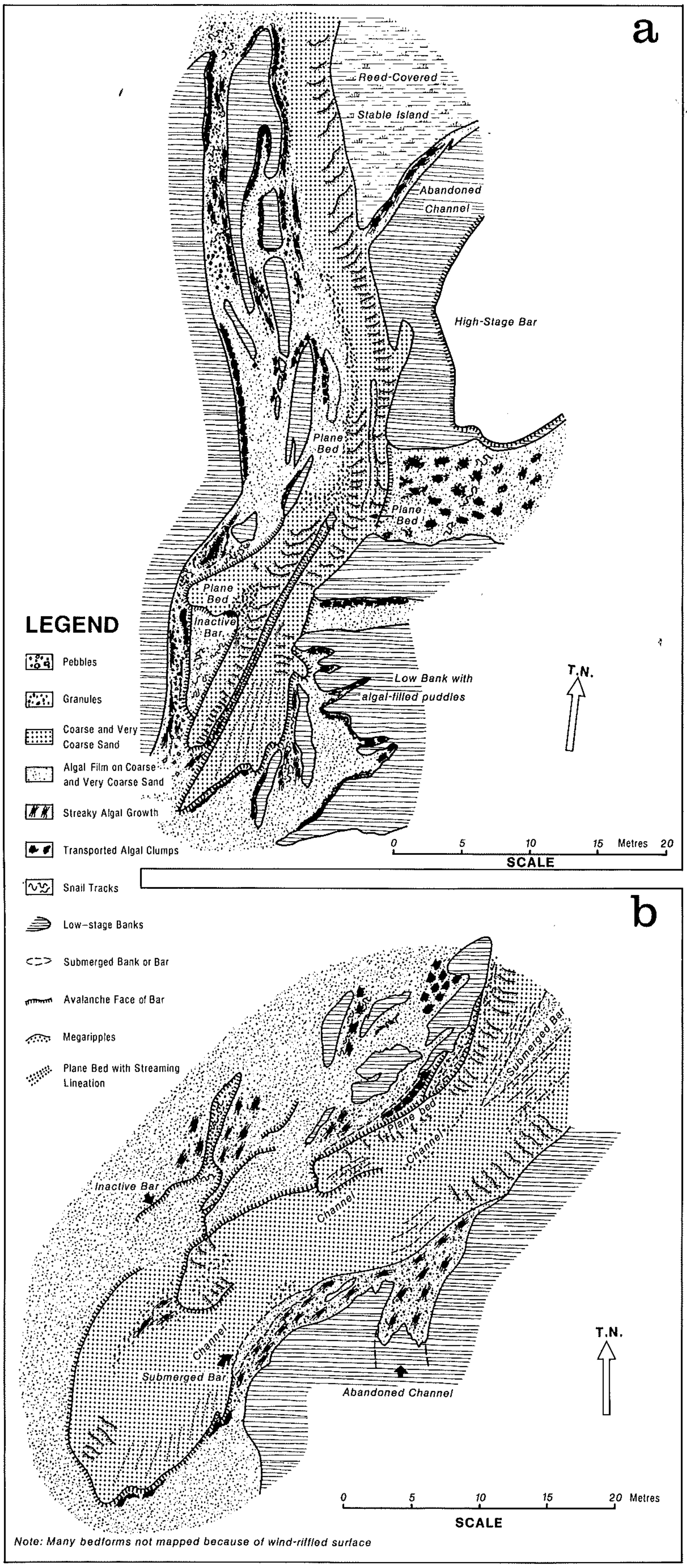

Figure 2a : *Bar geometry in part of the Sabi River.*

Figure 2b : *Composite linguoid bar, Sabi River.*

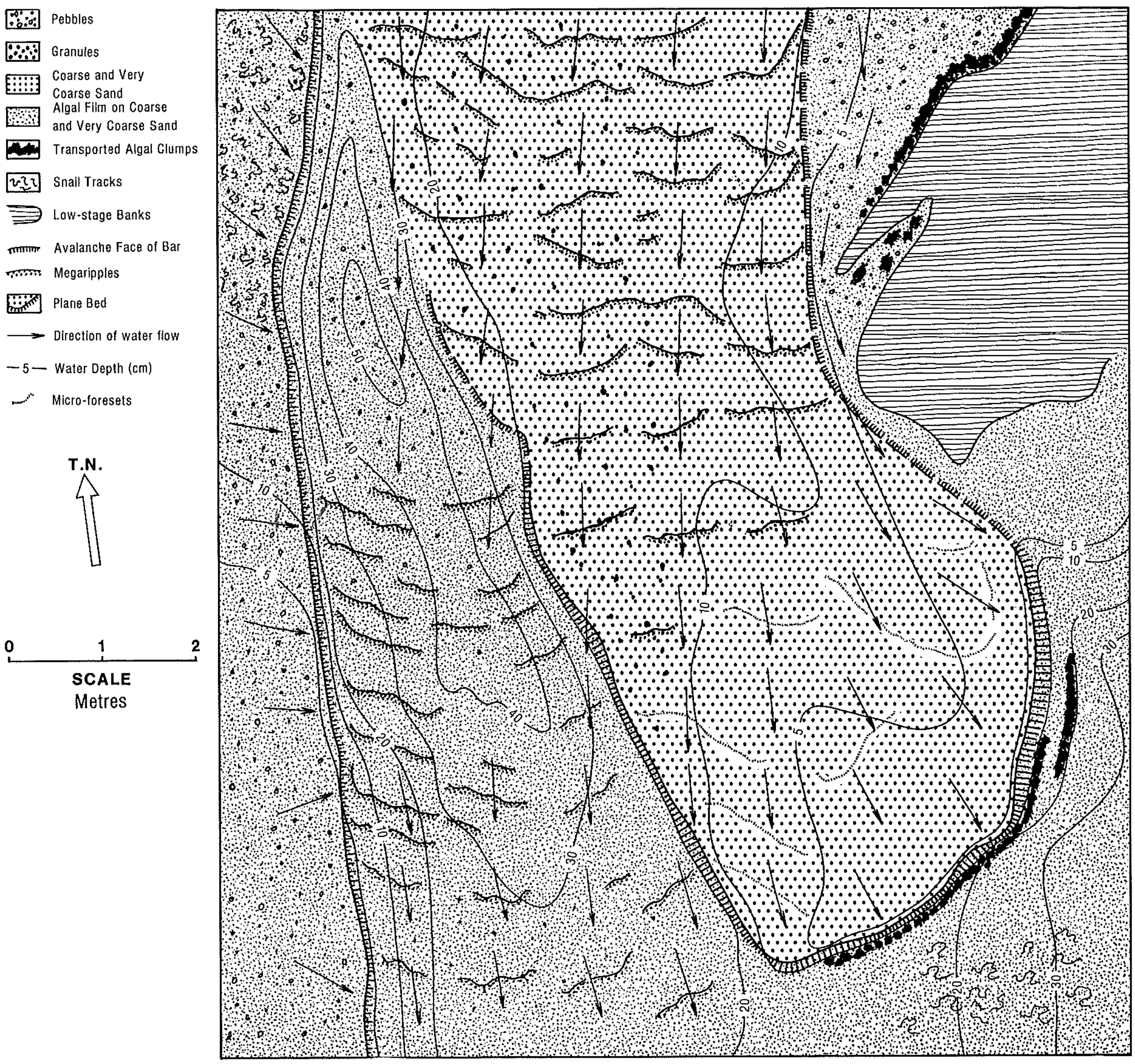

Figure 3 : *Lobate bar and scour-channel in part of the Sabi River (contours show water depth in cm; arrows show direction of water movement).*

is essentially sediment-free, having deposited its load at the slip-off face. The development of the algal film is possible since the pools are regions where little or no sand grains are available to bury the colony.

5. *Bar Fronts*

Avalance surfaces are developed around the margins of the bars, and are usually actively building out into deeper water. The bar height ranges from 5 to 50 cm, but is commonly only 10 to 20 cm (Plate 1b, c, d). Avalanche faces are normally smooth planar surfaces. However, small current ripples are, in places, worked onto the avalanche faces of inactive bars where these now form the margins of minor channels.

6. *Inactive Channels*

Channels which have become abandoned are either stagnant or carry a very sluggish flow of water. They are normally characterized by a film of green algae on the floor, which is often an old pebble lag. Snail grazing tracks usually criss-cross these channel floors. The tracks are regions where the algal film has been removed and the sand surface furrowed.

7. *Active Channels*

Active channels are up to 1 m deep, and are regions of relatively rapid flow. They are frequently located where flow is concentrated by an avalanche face growing obliquely towards a sand bank. The deepest parts of the channel are lag-floored (Plate 1e), but as flow widens and slows downstream, megaripples are developed (Figure 3).

The channel floors are relatively old features, and a green algal film has developed on them in all but the most erosive situations.

8. *Low Sand Banks*

Low banks stand a few centimetres above low-stage water level. They contain numerous stagnant pools, densely colonized by green algae. The floors of the pools are heavily grazed by snails. Where they lie adjacent to active and semi-active channels, the margins of the banks carry a heavy algal concentration, much of it transported and accreted onto the surface.

9. *High-Stage Bars*

The lobate fronts of high-stage bars are preserved in places. They stand up to 0,6 m above the low stage-water level, and are bounded by avalanche faces (Figure 2a). They are frequently partly destroyed by cattle tracks.

VIII. CONCENTRATION OF ALGAL MATERIAL

Small tufts or clumps of algal material are an integral part of the load of the low-stage Sabi River. The clumps are liberated upstream by erosion of an active channel into a stagnant, algae-lined pool.

The clumps move downstream, and are transported with a tumbling action across the shallow bar surfaces. On reaching the avalanche face, the algal clumps are frequently caught by the counter current in the zone of flow separation, and return to come to rest at the foot of the foreset. Here they become welded to the pile of algal material already accumulated (Plate 1b, c, d). This stable mass, which is a diaphenous, water-saturated accumulation of algal clumps with some leaves and twigs, is progressively covered as the avalanche face migrates. Particularly heavy concentrations of algal material are found in re-entrants along the bar avalanche face (Plate 1b, d).

In addition to transported algal clumps, an algal film grows *in situ* in pools, channels and abandoned channels. These films are relatively thin, but impart a greenish colour to the sand surface (Plate 1c, d). Where current action is fairly strong, the algal film is developed in a discontinuous streaky fashion (Figure 2a, b).

IX. GEOLOGIC SIGNIFICANCE

As the linguoid bars migrate, they can be expected to produce a characteristic vertical sequence of structures in the sand. The pools in front of the avalanche faces are usually lag surfaces, with a concentration of pebbles and heavy minerals. An algal film grows across this lag, and is sometimes bioturbated by snail grazing tracks. The algal clumps ahead of the bar are streamrolled into a carpet on this lag. Small waterlogged leaves and twigs are trapped in the algal mesh. The advancing bar will produce a planar cross-bed set. Some foresets will probably trap algal material, where major avalanche events cover a part of the clump. A plane-bedded interval can be anticipated across the top of the foreset, followed by an erosive lag surface and further planar cross-beds in the case of a composite bar as in Figure 2b. Trough-like cross-beds, produced by the migrating megaripples, will lie at the top of the cycle. Naturally, only parts of such cycles will be geologically preserved from the effects of erosion by later events.

In the 2 600-2 700 m.y. old Witwatersrand Basin of South Africa, carbon concentrations assocaited with pebbly lags have long been ascribed to algal activity (Minter, 1976). Here, carbon also occurs on the toes of foreset beds, and on the stoss side of small ripples (W.E.L. Minter, in press). The Sabi River provides a model which may partly explain this association. The Witwatersrand carbon seams could be regarded as algal films on a lag surface, possibly augmented by the transported algal clots formed at the fronts of transverse bars.

Secondly, uranium in post-Devonian fluvial sandstones is frequently fixed by carbon reductants in the arenites, usually carbonized plant remains. The Sabi River relationships provide some insight into the anticipated venue of concentration of carbon-rich matter. Uranium in low-gradient braided stream sandstones is likely to be precipitated by carbon concentrated on lag surfaces between sets of tabular cross-bedding.

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PLATE 1

a : Undulatory megaripples on back of bar. Machete handle 15 cm long.

b : Front of linguoid bar building into deeper water. Note darker, algal-colonized scattered pebble lag (in front of bar) and algal clots (around avalanche face). Pencil for scale.

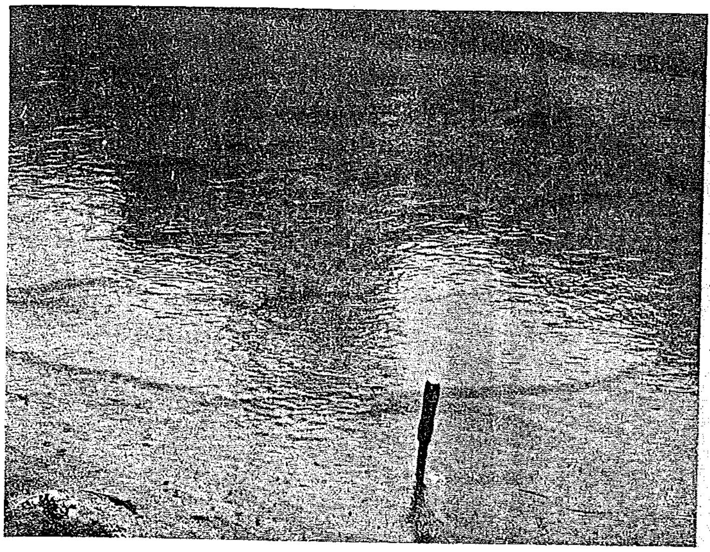
c : Streaming lineation on plane bed at front of small linguoid bar. Note darker, algal-colonized sand and algal clumps. Pencil for scale.

d : Algal clumps in front of avalanche face of linguoid bar. Machete handle 15 cm long.

e : Weakly algal-colonized pebble and granule-bearing lag in active channel on back of linguoid bar. Pencil for scale. (see right hand side of photograph).

PLATE 1

a



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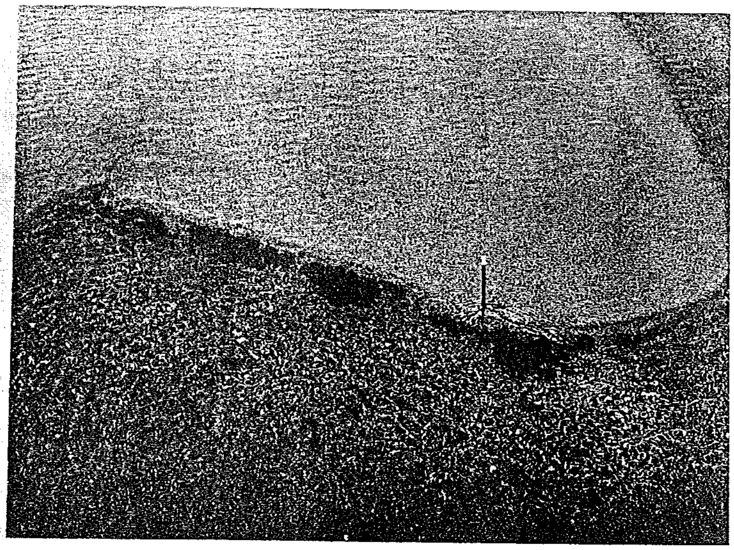

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