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THE QUATERNARY STRATIGRAPHY OF A SECTION OF THE SIBOWE RIVER, SOUTH-WEST SWAZILAND.

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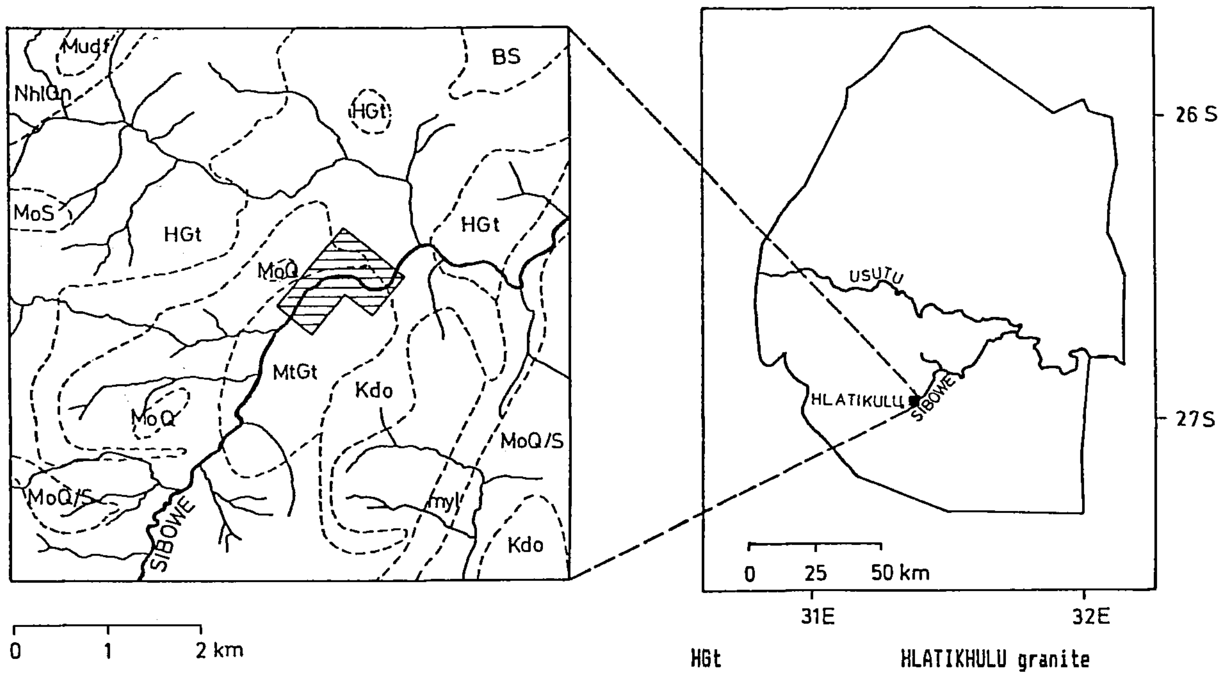
SUMMARY

In south-west Swaziland a river terrace along the Sibowe river is formed by active river incision. A complex profile along this terrace showing alluvial and colluvial deposits reflecting changes in environmental conditions since at least the last 30 000 years is exposed. Examination of soil characteristics, relative position of the composite strata as well as river dynamics leads to a stratigraphic interpretation which has been fitted into a time frame. The basal gravel, alluvial in nature, dates from before the deposition of the Mphunga colluvium which has been deposited between 30 300 and 8490 before present. On the colluvium occurs an alluvium most probably deposited during the Early Holocene. The incision of the terrace to its present level has occurred during the Late Holocene.

KEY WORDS: buried soil, colluvium, degradation, gravel deposits, lateral erosion, Swaziland



HGt	HLATIKHULU granite
MoS,MoQ,MoQ/S	MOZAAN shale, MOZAAN Quartzite
MtGt	MTOMBE granite
Mudf	Metamorphic suite, undifferentiated
myl	Mylonite
NhlGn	NHLANGANO gneiss

Source : Geological map, 1 : 50 000, PWD 24, 1980.

Figure 1 - Location and geology of the study area

1. INTRODUCTION

The Kingdom of Swaziland is located on and below the eastern escarpment of the southern African plateau. The four main geographical regions (from west to east: Highveld, Middleveld, Lowveld and Lubombo) coincide with dissected planation surfaces and are bounded by quite prominent scarps in some places but elsewhere the transition from one surface to another is much more difficult to identify. Most rivers just pass through the country as they have their upper catchment across the border in South Africa. However, as the annual precipitation over the country is relatively high, especially in the Highveld, a number of major tributaries contribute substantially to the total discharge of the trunk streams. One of the tributaries is the Sibowe river which drains into the Great Usuthu via the Mhlatuzane (see fig. 1).

Although Swaziland is an area of active river incision, Quaternary deposits have been preserved along the streams and on the gentle pediment slopes, especially in the Middleveld and the Lowveld, where investigations in the past have been concentrated. Riverbanks and numerous gullies - locally called "Dongas" - most probably formed since early nineteenth century (Goudie, 1984) by overgrazing and deforestation provide excellent exposures of the colluvial and alluvial deposits laid down since the Late Pleistocene.

In the Middleveld of south-west Swaziland, the Sibowe river has exposed a conspicuous soil profile. In broad terms, the following vertical "horizon" sequence may be seen: a gravel layer 50 to 100 cm thick at river level or slightly above overlain by a soil profile developed in colluvial material, 270 to 560 cm thick, itself buried by alluvial deposits 70 to 260 cm thick. Up and downstream variations of this basic pattern reveal the spatial diversity of this depositional environment. In 1989, the authors spent some time investigating this area. This exposure is of much interest since the different layers of the deposit reflect processes of erosion, sedimentation and stabilisation during past environmental conditions. The interpretation of the stratigraphy contributes towards a better understanding of the palaeoenvironmental history of Swaziland.

2. PHYSICAL ENVIRONMENT OF THE STUDY AREA

The drainage basin of the Sibowe river - a tributary of the Mhlatuzane - is situated in the upper Middleveld of south-west Swaziland (fig. 1).

The altitude within the drainage basin varies between 480 m and 1234 m. The site of interest lies at an altitude of about 792 m.

GEOMORPHOLOGY OF THE STUDY AREA - SIBOWE RIVER

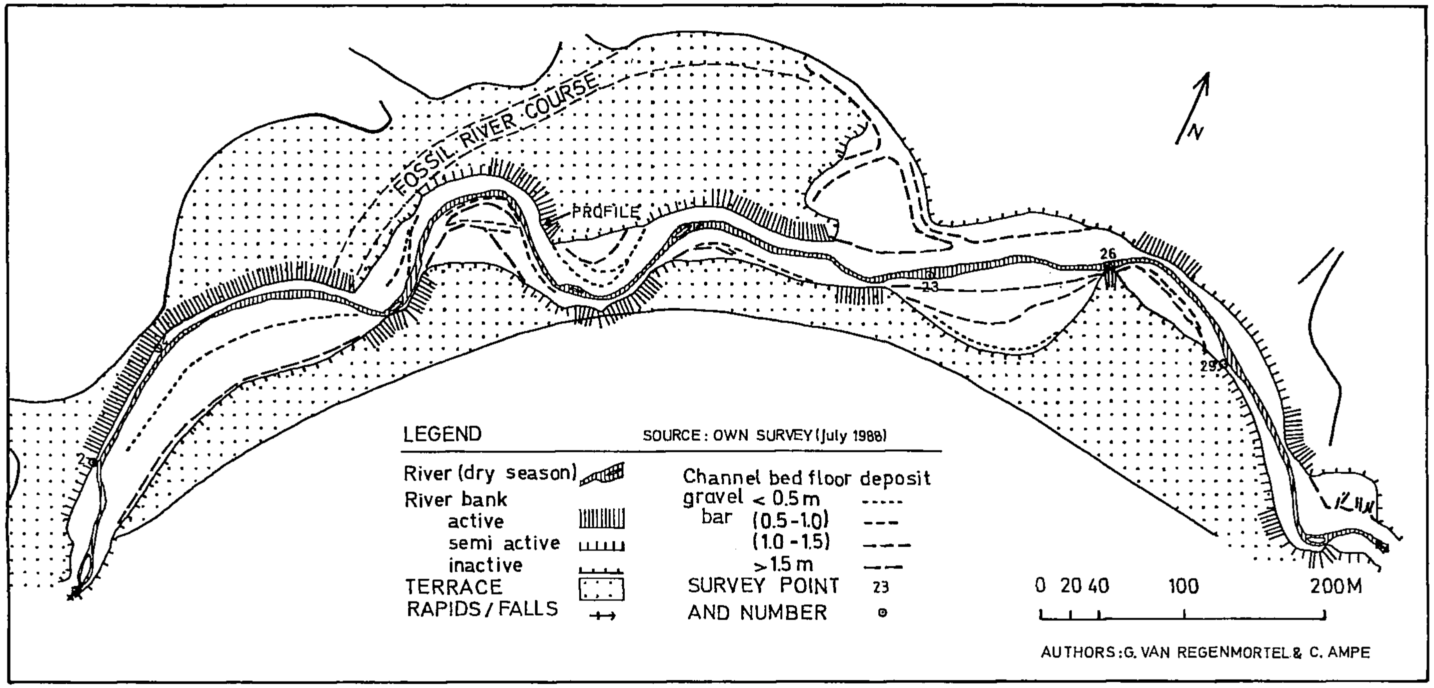


Figure 2

The nearest meteorological station is Hlatikulu about 4.5 km from the study site at an altitude of 1186 m which is about 400 m higher than the study area. Hlatikulu, located on the watershed of the Sibowe basin, receives a mean annual precipitation of 1122 mm and the mean annual temperature is 16.3°C. So the study area will be slightly hotter and less humid as temperature correlates inversely and precipitation directly proportional with altitude (Bootsman & Schmidt, 1983). The hottest month is January with a mean maximum temperature of 23.2°C, the coldest month is July with a mean minimum temperature of 8.0°C. The highest rainfall is recorded from October till March, small amounts of rainfall occur from May till August. When calculating the waterbalance small deficits are present from May till August but with the spring rains of September and October the soil storage is refilled and surplus occurs from November till April.

The site is underlain by coarse grained Mtombe granite with large crystals of microcline (2650 million years (m.y.) old) and bordered downstream by an intrusion of sheet-like bodies of dolerite sills of Karroo age (188 m.y. old). Within the drainage basin, upstream of the site, the most abundant rocktype is medium to coarse grained Hlatikulu granite (2650 m.y. old), outliers of Mozaan quartzite have been isolated from a more extensive outcrop representing a deposit in a basin of the Kaapvaal craton (2910 m.y. old) (Geological map, 1 : 125 000, Government of Swaziland, 1982).

The Sibowe long profile is fairly irregular as a result of the rather complex lithology of the area. The site of interest is located just upstream of a valley constriction which marks the position of the dolerite sill. The dolerite sill acts as a threshold delaying downcutting so the Sibowe's gradient upstream this narrow passage is low. Here a relatively large terrace at some 9 m above the present river level forms the study area.

The Sibowe river is undergoing lateral erosion. The terrace is being undercut at a considerable rate as Figure 2 shows. Taking into account the terrace area which has been removed during the last 3 decades, one is inclined to believe that this geomorphic activity took place in very recent times. Man-induced changes of the drainage parameters such as reduction in vegetation cover by overgrazing and deforestation causing an increase in run off and a higher discharge, disturbed the local(?) geomorphic equilibrium which was one of deposition (the terrace). This channel destabilization and subsequent adjustment must coincide with the gully-erosion phase which the entire region is currently undergoing.

RIVER DYNAMICS OF R. SIBOWE OVER 3 DECADES

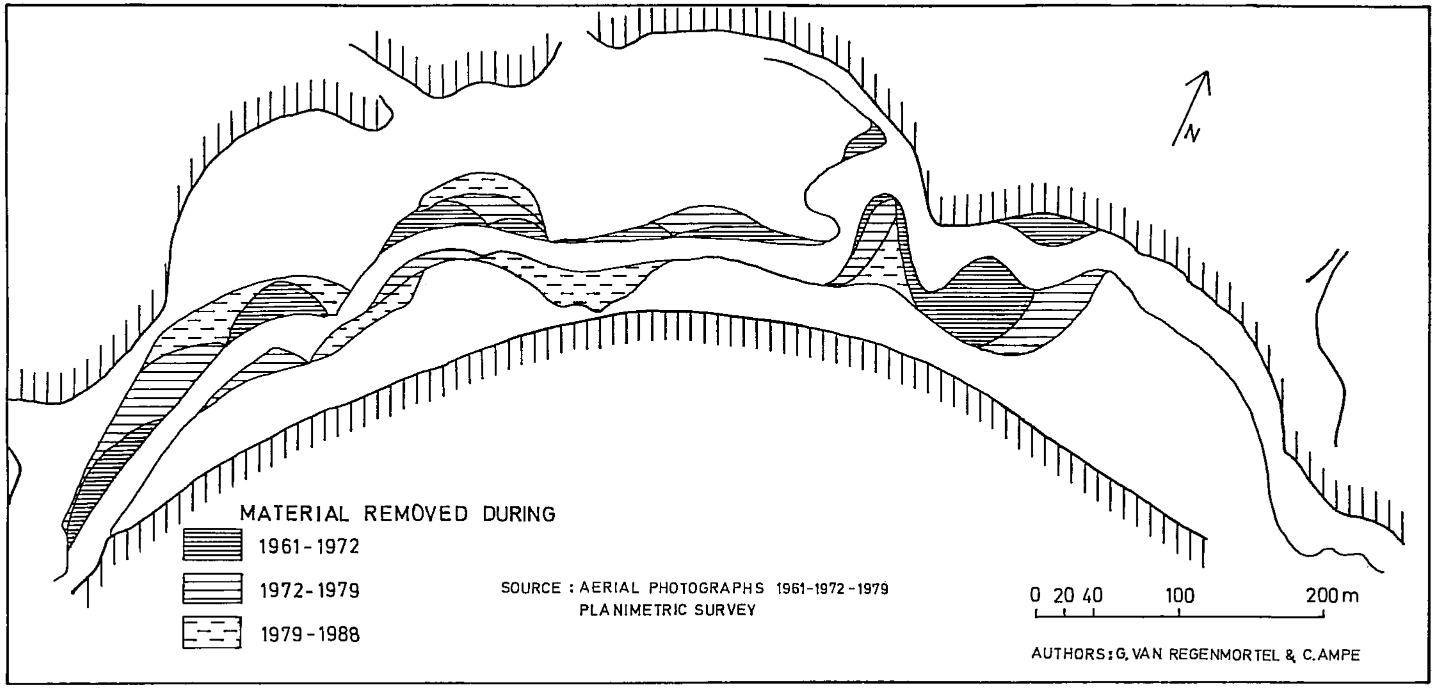


Figure 3

Figure 3 shows the morphology of the study area. The terrace surface is generally level but shows remnants of shallow river channels. The depth of the latter is restricted to the alluvial terrace material i.e. 130 cm. Sometimes, however, they are superimposed on fossil gulleys cut into the underlying colluvium. The channels pre-date the main river incision as the latter often truncates them and their gradient is mostly not much more than the terrace inclination itself indicating a base level higher than the present level of Sibowe. Moreover their degradation has not progressed very far as yet. This supports the fact that the incision of the Sibowe to its present level occurred very recently. The terrace alluvium itself thins towards the valley slopes.

The Sibowe river bed has sand and gravel deposits forming small gravel bars with a height from less than 0.5 m till more than 1.5 m. These represent depositions of a river with seasonally highly variable discharge. Much of this bed material is reworked material from the terrace alluvium and basal gravel below the colluvium and occasionally artefacts may be found exposed. At places where the sediments are protected from the river, stabilization has taken place (as between survey points 23 and 26 at the location of a cut-off river bend) and their relative positions reflect the flood history of Sibowe.

3. PROFILE DESCRIPTION

About 750 m from the bridge across the Sibowe river along the Hlatikulu - Mbulungwane road a representative soil profile is exposed along the river of which the description is given below (see fig. 3 : PROFILE). The top part from 0 to 130 cm is composed of alluvial material in which a succession of horizons with texture varying between gravelly sand and loam can be distinguished.

Soil genesis in this horizon is still in its initial stage as only an ochric epipedon could be identified. Stratification is recognisable and large amounts of mica are present. The soil was classified as Tropofluvent. At least two horizons (at 70-87 cm and 112-130 cm) show an increase in organic matter content suggesting periods of stability during which vegetation was established.

From 130 to 490 cm below the terrace surface, the profile of a buried soil developed in colluvium is exposed. According to Soil Taxonomy (7th Approximation, 1975) "a soil is considered to be buried if there is a surface mantle of new material that is 50 cm or more thick ...". The buried soil is formed on an ancient land surface, subsequently buried by younger deposits and generally far enough below the present surface that it is not affected by present pedogenic processes

Table 1: Soil Analysis

Depth (cm)	Texture (%)			Organic matter %	pHH_2O	Stratigraphy 1:2.5
	sand	silt	clay			
0-35	54.2	26.5	19.1	1.88	5.23	alluvial
35-48	63.9	25.0	11.2	1.72	5.47	alluvial
48-70	95.2	4.2	0.6	0.22	5.67	alluvial
70-87	70.4	16.5	13.2	1.00	5.54	alluvial
87-112	75.5	19.1	5.4	0.43	5.15	alluvial
112-130	30.8	41.1	28.1	2.12	4.93	alluvial
130-150	62.1	13.4	24.5	2.22	4.75	colluvial
150-310	55.3	11.4	33.3	0.50	5.01	colluvial
310-355	31.0	26.7	42.3	0.51	5.46	colluvial
355-410	40.6	27.8	31.7	0.16	4.89	colluvial
410-445	57.8	17.6	24.7	0.24	4.74	colluvial
445-490	55.2	22.0	22.9	0.13	5.98	colluvial
490-540	77.1	10.6	12.2	0.15	5.79	alluvial
+ 540	53.9	20.9	25.2	1.31	5.63	alluvial

Methods of analysis: texture: pipette method
organic matter: Walkley-Black
pH : 1 : 2.5 : 10 gr of soil for 25 ml of distilled water.

(Birkeland, 1984). However Gerrard (1981) points out that later soil formation may alter the characteristics of the buried soil making interpretation even more complex as the buried soil has been subjected to different cycles of soil formation (polygenetic).

The boundary between alluvial and colluvial material situated at 130 cm is abrupt and the A horizon evidenced through its higher organic matter content (2.22%) is still well preserved. Generally, however, the sharpness of the boundary indicates that an erosional phase has preceded the overlying alluvial deposition. The most striking features of the soil are its yellowish red colour (5YR5/8 measured with Munsell colour chart, American edition), sandy clay loam texture, very weak structure, diffuse boundaries between the horizons and the absence of rock or gravel fragments. With increasing depth (+355 cm) the colour becomes more brownish yellow (10YR6/8). The soil is extremely hard and structureless. Moderately thick cutans of iron and aluminium oxides align pores and old root canals.

Approximately 1 meter (+490 cm) above the basal gravel the soil colour becomes 2.5Y6/2, light brownish grey and 2.5Y3/1, very dark grey indicating reduction. Texture becomes coarser as evidenced by an increase in the sand fraction, indicating a change of parent material or depositional environment. The origin again is alluvial as lamination can be recognised in the coarse sand. The basal gravel at about 590 cm deep consists of about 50% subangular quartzite and 50% of weathered granite, the latter being more rounded.
The size distribution of the gravel is bimodal, two diameter classes being more abundant : (17-22 cm) and (1-5 cm). The high quartzite content of the gravel is quite surprising as outcrops of quartzite in the drainage basin upstream of the site cover only 6% of the area. This suggests that the gravel has been subjected to weathering for a substantial time before being covered by the colluvium, allowing for a relative enrichment of the quartzite gravel.

The profile described above varies laterally. Upstream (fig. 3, between nr 2 and 4) the colour of the colluvial layer varies between 10YR5/6 and 10YR5/1 (yellowish brown to grey). The main characteristic of the profile - alluvial material covering a buried soil, overlying the basal gravel - is preserved. Strong reducing conditions are responsible for the low chroma of the buried soil, a situation induced by the presence of a perching water table at about 190 cm below the surface - corresponding with a clay loam horizon, 10YR3/2, very dark greyish brown, 3.9 % organic matter - the water source being a spring about 20 m above terrace level.

Downstream at the left bank the profile shows a soil developed in colluvial material only (fig. 3, nr 29), immediately on top of dolerite. Here the valley slope is steep and no alluvium was ever deposited. Still further downstream at the right bank the alluvial cover disappears too, exposing a Plinthudult - a more or less freely drained soil with iron-rich, humus poor mixture of clay with quartz in the horizon with clay accumulation - on top of the basal gravel. The place where the transition takes place has been eroded so that a further interpretation is impossible.

4. INTERPRETATION AND DISCUSSION

The chronostratigraphical interpretation at the Sibowe river site was difficult as no methods were available for absolute dating of the different layers mentioned above. Nevertheless a literature review provided a time frame with which the present profile could be compared.

Price-Williams et al. (1982) used archaeological evidence to date to some approximation alluvial and colluvial materials in the country. They recognise five phases of alluvial deposition:

(1) Badzala gravel, usually situated 20 to 35 m above the current river level, composed almost exclusively of quartzites containing Archaic Early Stone Age (1.5 to 2 million years ago) artefacts, and are hence of Early Pleistocene age. Often the Badzala is cemented by iron minerals which is the reason why the gravel is so well preserved.

(2) Lizembe gravel, containing Acheulian material (is situated between 1.5 and 0.1 million years ago, for Swaziland no accurate datings are available) (Phillipson,1985).

(3) Shongololo gravel which they regarded as a rework of the Badzala gravels is not cemented containing Middle Stone Age artefacts (situated from 195 000 till 38 000 years ago at Border Cave). These three terraces consist of cobbles and pebbles.

Two Holocene river terraces which are mainly sandy were described as well:

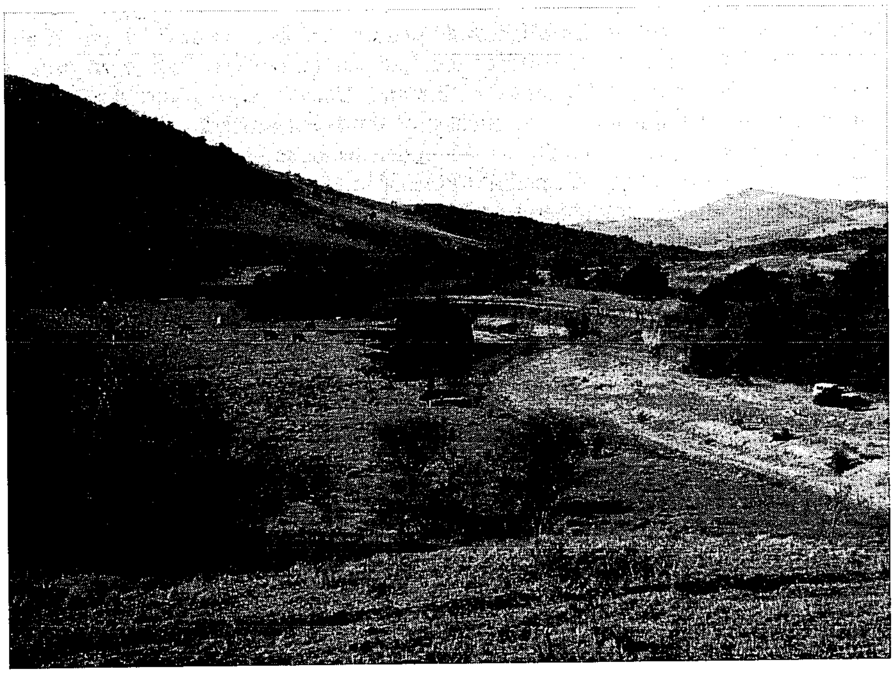
(4) Yebo terrace, constituting the modern floodplain and situated about 2 m above the present river level. Locally this terrace has been flooded during Cyclone Demoina (30 and 31 January 1984).

(5) Winn terrace found 2 to 10 m above the same reference level. The latter is thought to be an Early to Mid Holocene deposit as it is sandwiched between deposits containing Middle Stone Age artefacts and a cover with Late Stone Age tools (from about 30 000 years ago for Border Cave till about 1000 years ago, Phillipson, 1985).

Colluvia are preserved on the Middleveld pediment slopes (Price-Williams et al., 1982). The Bovu colluvium overlies the Badzala gravel.The former in turn is overlain by the younger Mphunga colluvium. Usually Bovu does not contain archaeological material but on the surface of the Bovu artefacts of Middle Stone Age were found and on one site an Acheulian handaxe was found in the Bovu. Based on C^{14} dating of $CaCO_3$ nodules present in Mphunga, Price-Williams et al. (1982) placed its deposition between 30 300 $\pm$ 30 years and 8490 $\pm$ 45 years before present (Late Upper Pleistocene). These results accord well with similar material excavated by Beaumont in the Sibebe cave which have been dated to 22 850 before present. Yet Dardis and Beckedahl (1988), using C^{14} dating from wood and organic detritus found in the Mphunga at a depth of 1.7 to 2.5 m below the surface, suggest that the upper part of the colluvium may be late Holocene in age or at least have been subjected to considerable late Holocene resedimentation so the colluviation should have continued at varying rates throughout the Holocene.

Price-Williams et al. (1982) hold climatic change responsible for this Pleistocene colluviation: dry phases leading to a reduction in vegetation cover cause landscape instability, mobilisation of weathered rock on the upper hill slopes and its deposition on the lower pediments.

The generation of the alluvial Badzala gravel is not explained in terms of climatic change. Watson et al. (1985) assigned the position of the Badzala gravel at 20 to 35 m above the present river level to tectonic uplift. They argued that only one widespread Pleistocene fluvial gravel is present, although several climatic fluctuations during the Pleistocene took place.
Evidence for Pleistocene climatic change in Swaziland can be found from two studies on cave deposits of the Lubombo Range. The deposits at Border Cave (Butzer et al., 1978) show four spall horizons, dated between 29 000 before present and 186 000 before present suggesting frost weathering during colder periods. A paleosol, dated between 154 000 and 145 000 before present, proves there was a humid warm climate during this period.
A study carried out by J. Prior (1983) is based on charcoal remains from Siphiso cave in Mlawula Nature Reserve. These remains were dated by C^{14} and have been identified by Scanning Electronic Microscope (SEM) techniques. From these data



The Sibowe river and terraces at Ebenezer, Swaziland she concluded that little climatic change occurred in the area of the shelter since about 4 000 before present. The Mid-Holocene around 6 000 before present was probably drier, whilst a warmer and moister phase occurred at about 9 000 before present preceded by a warm, dry period around 11 000 to 12 000 before present.

Across the divide in the adjacent drainage basin of the Ngwavuma at the same altitude as our site several gullies expose perfect examples of the colluvial stratigraphy as proposed by Price-Williams et al. (1982). However, the Sibowe profile itself does not simply fit into their model. The colluvial part of the profile does not allow a subdivision into 2 distinct colluvial phases. This suggests that it comprises one and the same phase. The most likely explanation then would be that Mphunga colluviation took place after the total removal by erosion of Bovu, supposing that the latter was present at the study site. The better preservation of both colluvia in the adjacent Ngwavuma drainage basin can be explained by the presence of a much wider and more gentle sloping pediment than at the Sibowe near the study area.

The question which arises now is about the identity of the basal gravel. Price-Williams et al. (1982) suggested that the chronological position of their "Shongololo" gravel is immediately above Bovu, thus below Mphunga. In a subsequent publication (Price-Williams and Watson, 1985) however it is stated that the Shongololo overlies the Mphunga. Furthermore the Lizembe gravel has been neglected in the literature. Whatever the basal gravel is - Shongololo or Lizembe - it is evident that if the Bovu at this site is removed by erosion as suggested then the basal gravel must be at least be 30 000 years old. The abraded Acheulian artefacts and Middle Stone age tools found in the present river bed most likely represent reworked material from older terrace gravels and in situ material, both mobilised from the basal gravel.

From the profile description presented above it is clear that different phases of erosion, deposition and pedogenesis have taken place starting from the deposition of the basal gravel. The geomorphic history (1) as exposed in this profile probably takes us back to at least 30 000 before present:

1. The basal gravel was deposited. This must have occurred after erosion of the Bovu colluvium (if it was ever present). Possibly during the same period Acheulian stone age tools became mixed with the bed load of Sibowe.

2. Colluviation corresponding with the Mphunga phase mainly on the SSE pediment slope resulted from environmental instability probably because of decreased water availability causing a reduction in vegetation cover. According

to Tyson (1986) it was drier and colder in Swaziland between 25 000 and 9 000 before present than nowadays. A sideways shift to the NNW of the Sibowe channel would explain the superposition of basal gravel and colluvium. That this happened may well have been possible as a fossil channel cut into the colluvium could be traced from the point where it leaves the present channel to where it joins again along a similar line as suggested for the pre-Mphunga Sibowe. However, a mere reduction of the river width as would have been most likely during a drier colluvial phase provides an explanation too. Colluviation could have come to a stand still at the end of the Pleistocene when geomorphic stability resulted in soil formation on the Mphunga parent material.

3. Increased Early Holocene runoff must have caused renewed channel incision and reduced vegetation cover relative to rainfall amount and/or intensity resulted in a subsequent infill. Tyson (1986) concluded that for Southern Africa as a whole the beginning of a reversion to a moister phase took place around 9 000 before present. For the study area however it is impossible to give an approximate age to this Holocene climatic changes as they have not yet been sufficiently documented.
There are remarkable textural differences between the fossil gully infill and the alluvial material which caused the terrace as such. Where the former has a uniform sandy composition, the latter exhibits a much wider textural range including massive boulders. These boulders are found quite a distance from any steeper slope. If they, on deposition, belonged to the bedload of Sibowe, the discharge must have been powerful indeed. The most likely identity of the terrace alluvium according to Price-Williams' model would be Winn. This would make it early to mid Holocene. The late Holocene then would have seen the incision of Sibowe to its present level, restricted by the local base level of the dolerite sill and strengthened by the degradation of the plant cover through the activities of the Iron Age (from 4th century after Christ, Phillipson, 1985) and modern time inhabitants of the Sibowe basin as the map of figure 2 shows.

5. CONCLUSION

If the interpretation is correct then it must be concluded that the dolerite sill downstream from the survey site has been a stable local base level for at least the last 30 000 years and lateral erosion by Sibowe as observed today is basically what the river has been doing since the same time period apart from the depositional phases as dictated by the environmental changes which have taken place.

The site is of particular interest as it was suited to the preservation, at least partial, of the colluvial and alluvial sedimentary deposits as they were laid down during the late Pleistocene and Holocene in a unique succession which elsewhere is seldom observed.

NOTES

(1) Just outside the mapped area about 15 m above the terrace level there is an outcrop of ferricrete which however could not be related to the time sequence below.

BIBLIOGRAPHY

Beaumont, P.B. (1973): Border Cave - a proper report. South African journal of Science 69: 41-46.

Birkeland, P.W. (1984): Soils and geomorphology. Oxford University Press.

Bootsman, C. & Schmidt, C. (1983): A spatial analogue of potential desertification in Swaziland. Desertification Control Bulletin, UNDP, p. 31-39.

Butzer, K.W.: Late Quaternary environments in South Africa. In J.C. Vogel (Ed.): Late caenozoic Palaeoclimates of the southern hemisphere. Sasqua, International Symposium, Swaziland: 235-264.

Butzer, K.W. & Beaumont, P.B. & Vogel, J.C. (1978): Lithostratigraphy of Border Cave, Kwazulu, South Africa. Journal of Archaeological science 5: 317-341.

Dardis, G.F. & Beckedahl, H.R. (1988): Late Holocene erosion and colluvium deposition in the Middle Highveld region of Swaziland. In Beckedahl, H.R. et al.: Southern African landscapes: a geomorphological field guide. Post-symposium field excursion guidebook: Symposium on the geomorphology of Southern Africa: 217-232.

Deacon, J. & Lancaster, I.N. (1988): Late quaternary Palaeo-environments of Southern Africa. Oxford University Press.

De Swardt, A.M.J. & Bennet, G. (1974): Structural and physiographic development of Natal since the late Jurassic. - Trans. Geol. Soc. S. Afr. 77: 309-322.

Finkl, Ch. W. (1980): Stratigraphic principles and practices as related to soil mantles. Catena 7, 2/3: 169-194.

Gerrard, A.J. (1981): Soils and landforms; an integration of geomorphology and pedology. Allen & Unwin, London.

Goudie, A. (1984): The Human Impact. Man's Role in Environmental Change. Basil Blackwell, England.

Moon, P.B. & Dardis, G.F. (ed) (1988): The geomorphology of Southern Africa. Southern Book Publishers.

Partridge, T.C. & Brink, A.B.A. (1967): Gravels and terraces of the Lower Vaal river basin. South African Geogr. J. 49: 21-38.

Partridge, T.C. & Maud, R.R. (1987): Geomorphic evolution of Southern Africa since Mesozoic. S. Afr. J. Geol. 90 (2): 179-208.

Phillipson, D.W. (1985): African Archaeology. Cambridge World Archaeology.

Price-Williams D., Watson A., Goudie A.S. (1982): Quaternary colluvial stratigraphy, archaeological sequences and palaeo-environment in Swaziland, Southern Africa. Geographical Journal, 148, part 1: 55-67.

Tyson, P.D. (1986): Climatic change and variability in Southern Africa. Oxford University Press, Cape Town.

USDA, Soil Conservation Service (1975): Soil Taxonomy, A basic System of Soil Classification for Making and Interpreting Soil Surveys, Agriculture Handbook, nr 436.

Yaalon, D.H. (1971): Soil forming processes in time and space. In Yaalon, D.H. (ed): Paleopedology - ISSS and Israel University Press, Jerusalem: 29-39.

Watson, A. & Price-Williams, D. (1985): Early Pleistocene river gravels in Swaziland and their geomorphological and structural significance. Z. Geomorph. N.F. 29,1: 71-87.