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SEDIMENTOLOGICAL STUDY OF THE HILLSLOPE PEDIMENT OF THE FEBE AREA (SOUTH-CAMEROON)

Etude sédimentologique des dépôts dus à la micropédimentation sur les versants. Région de Fébé (Sud Cameroun).

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RESUME

Dans la région du Mont Fébé, la pédimentation de versant de colline *a été active. Les fractions sableuses des sols de la région sont relativement peu affectées par les processus pédogénétiques postérieurs à cette pédimentation. Les indices de similarité calculés sur la fraction sableuse indiquent l'absence de discontinuités ligholologiques marquées dans le pédisédiment. L'indice de similarité calculée sur la fraction gravillonnaire par contre, indique une discontinuité lithologique très évidente entre la nappe de gravats et la couverture fine.*

La population de traction fine est limitée par les diamètres de 2 mm (-1 phi) et de 250 µm (2 phi). L'évolution en profondeur des paramètres sédimentologiques de la population de traction fine dans le pédisédiment et l'évolution en fonction de la position géomorphologique confirment les observations de terrain.

ABSTRACT

In the Fébé area hillslope pedimentation *has been active. The sand fractions of the soils in the area are relatively little affected by post-pedimentation pedogenetical processes. The similarity indices calculated on the sand fraction do not provide evidence for the presence of clear lithological discontinuities in the pedisediment. The similarity indices calculated on the gravel fractions on the contrary indicate a lithological discontinuity be-*

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tween the stoneline and the hillwash cover.

The fine traction population is bounded by the grain sizes of 2 mm (-1 phi) and 250 µm (2 phi). The evolution in depth of the sedimentological parameters of the fine traction population in the pedisediment and the evolution in function of the geomorphological position confirm the conclusions of the field study.

INTRODUCTION

The pedimentation process in the Fébé area has been described by EMBRECHTS & DE DAPPER (1986). The authors found that during the last important dry climatic phase of the Quaternary (12,000 - 30,000 Y.B.P.) a particular form of *valley floor pedimentation* (ROHDENBURG, 1982) - referred to as *hillslope pedimentation* - was active. Under the influence of hillslope pedimentation valley sides act as pedimentation scarps. They retreat on the hillslopes until the watershed (hilltop) is reached. The hillslopes are transformed into pediments with gradients exceeding 40 % in the area.

MOSS & WALKER (1978) and MOSS *et al.* (1979) proved that the manner in which particles are transported by overland water flows is analogous to the one in which rivers transport solid particles. This even occurs in water flows not deeper than 1 mm and under the impact of raindrops.

Tropical pedimentation is essentially an overland transportation process of solid particles by water. In the present paper the pedimentation process in the Fébé area is analysed from a sedimentological point of view.

MATERIALS

Physical Environment

The studied area is situated between the top and the foot of the Fébé hill. This bornhardt forms the boundary between the hilly area north-west of the town of Yaoundé and the South-Cameronian plateau. The area is bounded by the latitudes of 3° 55' and 3° 58' N and of 11° 29' and 11° 32' E (fig. 1). The altitude ranges between 1,060 m a.s.l. at the top of the Fébé hill and 740 m a.s.l. at the bottom of the valleys developed at the foot of the hill.

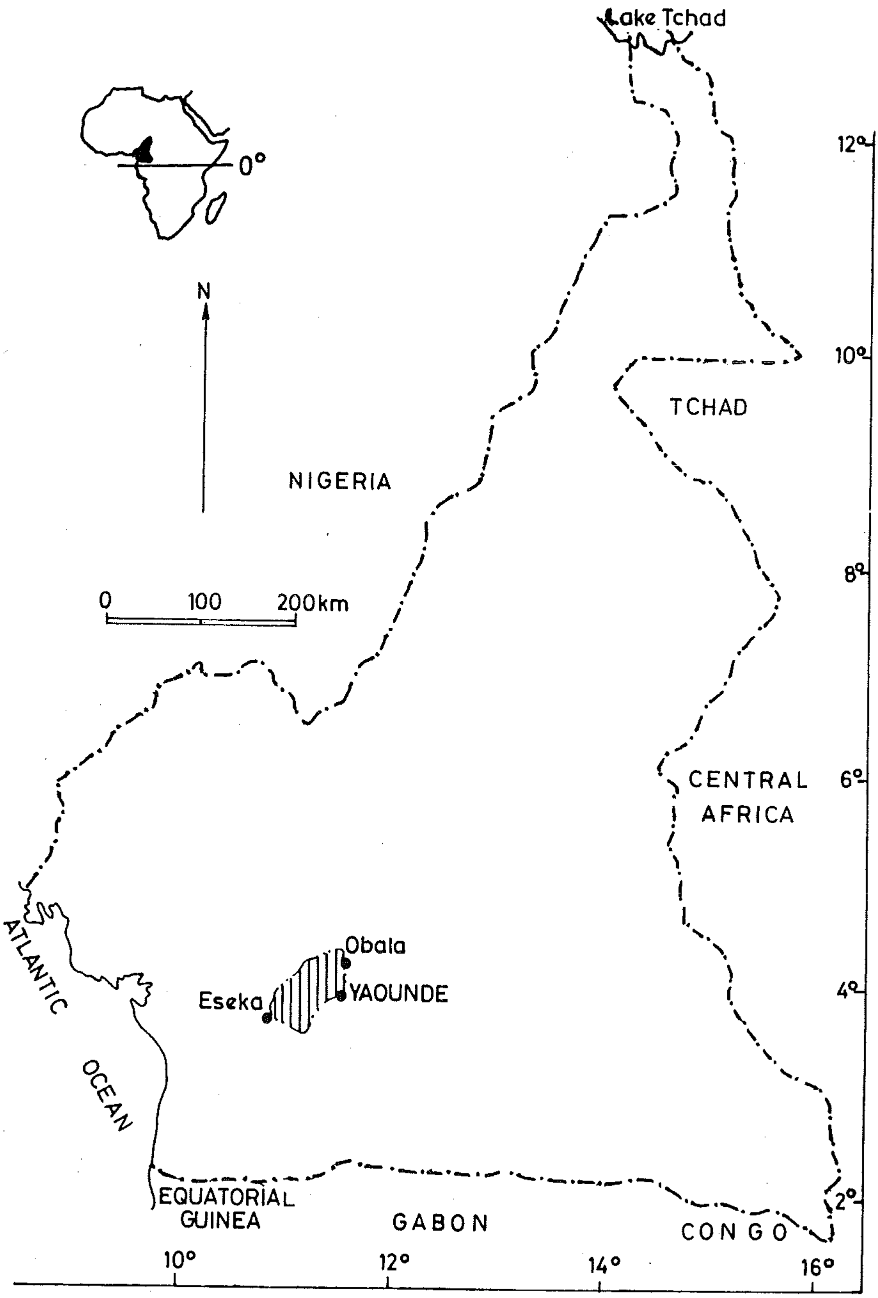

Fig. 1 : Localisation of the hilly area in Cameroon.

The geological substratum is a weakly migmatised gneiss (CHAMPETIER DE RIBES & AUBAGUE , 1956). The present climate was classified as continental subequatorial by SUCHEL (1972). This corresponds to an Aw"i type of climate according to Köppen (TREWARTHA, 1954).

The study area is situated at only 250 km E of the Cameronian Atlantic coast. This area was indicated by AUBREVILLE (1962) and by HAMILTON (1976) as one of the possible rainforest survival areas during the dry climatic phases of the Quaternary. It may therefore be accepted that the climate in the study area was of a relatively wet type allowing for a dense savannah vegetation.

The top of the Fébé hill is probably a relict of the Post-Gondwana (Cretaceous) surface, whereas the plateau at the foot of the hill belongs to the Africa I (Under to Middle Tertiary) erosion surface (SEGALEN, 1967) (fig. 2).

Near the hilltop Humitropepts (Soil Survey Staff, 1975) occur, the hillslopes are characterised by the presence of Tropohumults and of Palehumults and at the footslope Haplorthoxes are present (EMBRECHTS & DE DAPPER, 1986).

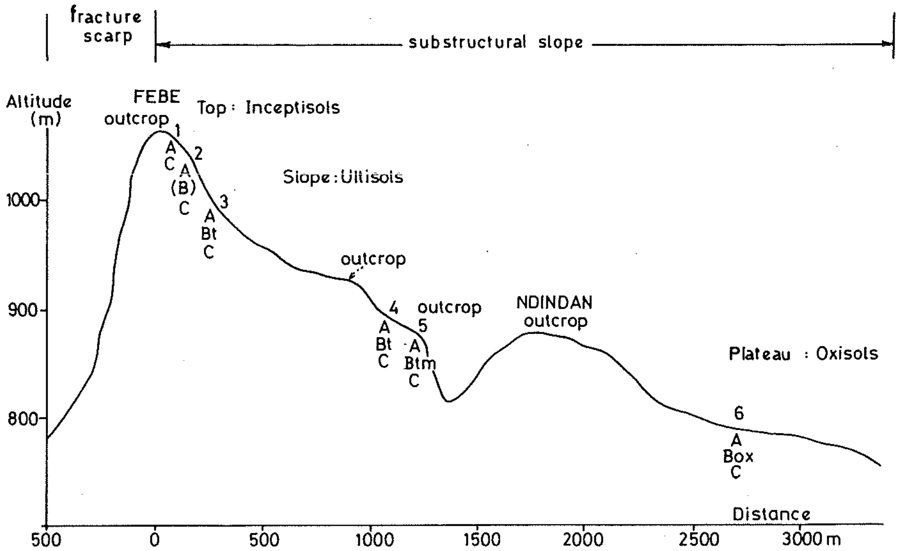

Fig. 2 : Localisation of the pedons on the substructural slope (vertical exaggeration 5/1).

METHODS

Roundness and Shape of Quartz Grains

Petrographic sized thin sections (50 X 30 mm) were prepared out of undisturbed soil samples. Classification of the quartz grains in the relative scale of POWERS (1953) was carried out using a magnification of 40x. 125 to 150 quartz grains were classified per thin section.

Grain Size Analysis

Grain size distributions have been determined with the pipet method after pretreatments with H_2O_2 and HCL 0,2N and using Na-metaphosphate as dispersing agent. The sand has been fractionated using standard sieves of 47, 105, 250, 500, 1000 and 2000 µm sieve opening.

Similarity Index

For a chosen grain size fraction (*in casu* the sand fraction) the similarity index (LANGOHR *et al.*, 1976) is the sum of the minimum values of the weight percentages of corresponding grain size classes of two soil samples. The similarity index equals 100 if both samples have identical grain size distributions and equals 0 if the grain size classes present in one sample are totally absent in the other sample. In intermediary situations the values of the similarity index range between those two extremes.

The similarity index calculated on the grain size distribution of two adjacent horizons is a measure for the relationship between those horizons, low values indicating lighological discontinuities. The similarity index has also been calculated between a reference horizon and other horizons at increasing distance from the reference horizon. Decreasing values of the index indicate gradual changes in the grain size distribution rather than real lithological discontinuities.

Analysis of Grain Size Curves

KRUMBEIN (1938) found that the granulometric composition of a sediment often corresponds approximately with a logarithmic-normal distribution. DOEGLAS (1946) and SPENCER (1963) showed that most of the sediments are composed of two or more subpopulations, each of them exhibiting a logarithmic-normal distribution. Each normally distributed subpopulation, plotted cumulatively on a probability scale is characterised by a straight section on the probability graph. The characteristics of the subpopulations and hence the positions of the individual sections on the graph, are determined by their way of hydraulic transport.

According to VISHER (1969) a subpopulation is characterised by the mean, standard deviation, skewness and kurtosis of its normal distribution. VISHER (1969) found that the intersection of the traction and the saltation populations is usually situated around 250 µm (2 phi). The intersection between the saltation and the suspension populations is normally situated around 100 µm (3.3 phi).

RESULTS AND DISCUSSION

Morphology of the Sand Fraction

It is generally accepted that tropical pedogenesis mainly acts upon the clay and silt fractions rather than affecting the sands and gravels. However, the formation of nodules, physical fragmentation *in situ* or chemical weathering may also affect the coarser fractions.

Quartz grains constitute 85 to 95 % of the sand fractions of both the saprolite and the pedisediment. The remaining minerals of the sand fraction are by large resistant to chemical and physical alteration. Only a few (iron) nodules are present in the sand fractions of the studied pedons.

Classification of the quartz grains according to their roundness and shape proves that fragmentation in horizons close to the soil surface is negligeable (Tab. I). Furthermore the classification does not indicate rounding of quartz grains due to transportation or chemical weathering. It may be concluded that the grain size distribution of the sand fraction is relatively little affected by the pedogenetical processes acting upon the pediment.

Similarity Index of the Saprolite

The similarity index calculated in the saprolite is a measure for the variation caused by the stratification of the parent rock and by the alteration gradient (Tab. II).

The greatest differences between adjacent layers are observed in the immediate vicinity of the fresh parent rock (ca. 5 m depth). The index calculated between the first subhorizon and tne other subhorizons decreases to a value of approximately 80, but can still attain high values at relatively great depths.

Pedon	Horizon	Depth (cm)	Shape	Roundness (%) *		
				very angular	angular	somewhat angular
Typic Humitropept	A11	0–21	spherical	2	49	1
			oblong	3	45	0
	C2	84–160	spherical	0	56	0
			oblong	0	44	0
Orthoxic Palehumult	A12	5–16	spherical	1	42	3
			oblong	1	49	4
	B33Cn	160–250	spherical	0	40	4
			oblong	0	55	1
Tropeptic Haplorthox	A12	4–16	spherical	0	48	5
			oblong	0	46	1
	B24Cn	225+	spherical	0	53	0
			oblong	0	46	1

Tab. I : Roundness and shape of quartz grains of the sand fraction of some representative horizons (classification according to POWERS, 1953).

* Somewhat rounded and rounded quartz grains are absent.

Depth (cm)	108–152	152–190	235–250	275–290	315–325	390–400	420–430	460–475	490–500
Index between adjacent subhorizons		93.4	94.9	92.1	88.8	90.0	91.7	88.7	83.7
Index between the 1st subhorizon and the other subhorizons	100	93.4	94.1	92.6	81.4	84.2	87.2	95.0	82.2

Tab. II : Similarity indices calculated on the sand fraction of the saprolite of an Orthoxic Tropohumult.

Similarity Index Calculated in the Pedisediment

The similarity index calculated on the *gravel fraction* of a horizon belonging to the hillwash cover (no coarse fragments) and a horizon of the stoneline will have a value of 0. This indicates a lithological discontinuity between the two materials.

The similarity index calculated on the *sand fractions* of adjacent horizons (fig. 3) proves the existence of several horizons with a lower granulometric relationship. However, clear lithological discontinuities characterised by values of the similarity index much lower

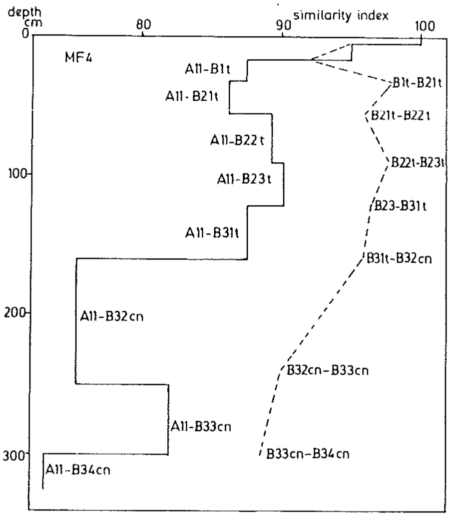

Fig. 3 : Similarity indices calculated on the sand fractions between adjacent horizons and between the top horizon and subsequently deeper lying horizons of an Orthoxic Palehumult.

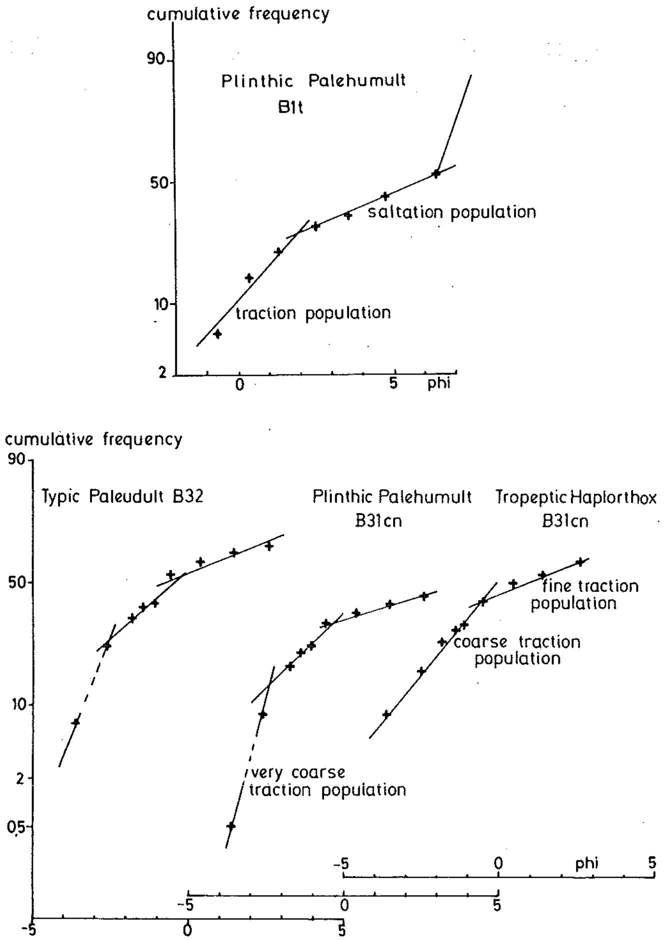

Fig. 4 : Boundaries of the fine traction population

a) without coarse elements
b) coarse elements included.

than the values found between adjacent horizons of the saprolite have not been detected.

A gradual decrease is noticed of the similarity index of the sand fractions, calculated between the top horizons and horizons of increasing depths (fig. 3). This evolution proves the existence of a *gradual shift* in the grain size distribution of the sand fractions of the parent material of the soils.

Sedimentological Parameters of the Traction Fraction

Delimitation of the traction fraction

The grain size distribution of the hillwash cover (fig. 4a) exhibits a break-point around 250 µm (2 phi). This point marks the lower limit of the traction population.

In the horizons of the *hillwash cover* the upper limit of the fine traction population corresponds to the upper limit of the very coarse sand. In the horizons of the *stoneline* the upper limit of the fine traction population is determined by the onset of a coarser population (fig. 4b). In both cases 2 mm (-1 phi) is an acceptable upper limit of the fine traction population.

The fine traction population is the coarser part of the sand fraction (diameters between 250 µm and 2 mm) and is as such only weakly influenced by soil forming processes.

Mean diameter and sorting

The relation between the mean diameter and the sorting is shown in fig. 5. In the pedisediment the mean diameter decreases from the bottom (stoneline) to the top (surface horizons). The sorting is more or less constant in the stoneline but increases from the bottom to the top in the hillwash cover.

The finest and the best sorted horizons are found near the surface of the profiles situated at the greatest distances from the watershed (fig. 2), regardless their degree of weathering. The deposition circumstances of the pedisediment are presented in fig. 6.

According to FOLSTER (1969) a differentiation takes place in the stoneline between the stoneline s.s. and the pediment gravel. In the field this differentiation was not clearly visible. Calculations of the mean diameter of the traction populations of the stoneline indica-

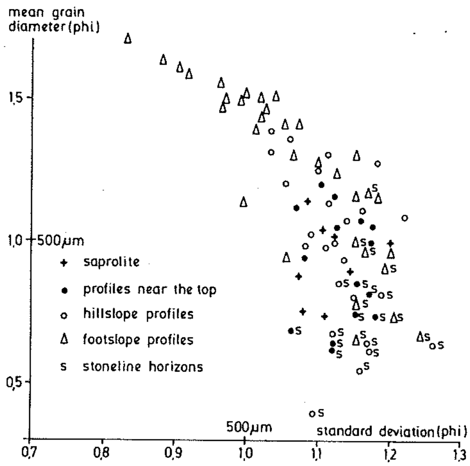

Fig. 5 : Relation between the mean grain diameter in the traction fraction and the standard deviation.

te that the coarsest material is present in the deepest horizons of the stoneline (Tab. III).

Horizon	A1	A3cn	B21cn	B22cn	B23cn	B24cn	B31cn
Depth (cm)	0-11	11-30	30-44	44-68	68-90	90-140	140-200
Mean (phi)	0.97	1.16	0.99	0.97	0.91	0.78	0.65

Tab. III : Mean diameter of the traction population of the stoneline of a Tropeptic Haplorthox (all horizons except A1 belong to the stoneline).

This observation leads to the conclusion that the material at the bottom of the stoneline has been transported over a shorter distance than the material higher in the profile.

Skewness and kurtosis

The relationship between skewness and kurtosis is shown in fig. 7. Fig. 8 illustrates the evolution of the shape of the distribution curve during the pedimentation process.

The traction population of the stoneline contains more coarse sand grains than the corresponding fraction of the saprolite. The relative amounts of coarse sand grains are highest in the stoneline near

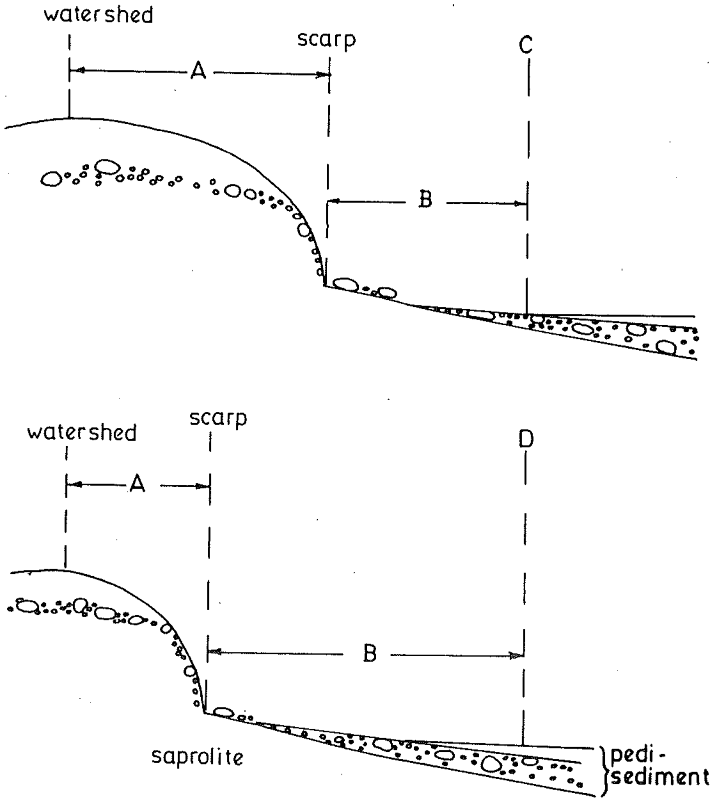

Fig. 6 : Deposition of the stoneline with retreating scarp

A. transportation by sheet-wash and gully-erosion
B. transport over the stoneline without deposition or important take up of material
C. starting deposition of the hillwash cover after transportation over a short distance over the stoneline
D. end of the deposition of the hillwash cover after transportation over a long distance over the stoneline and the hillwash cover and consequently after a relative increase of the amount of fine grains and an improvement in the sorting with regard to situation C.

the contact with the saprolite.

With regard to the saprolite the amounts of fine and medium components of the traction population of the pedisediment increase. This enrichment becomes more important from the bottom to the top in the pedisediment and with increasing distances from the watershed.

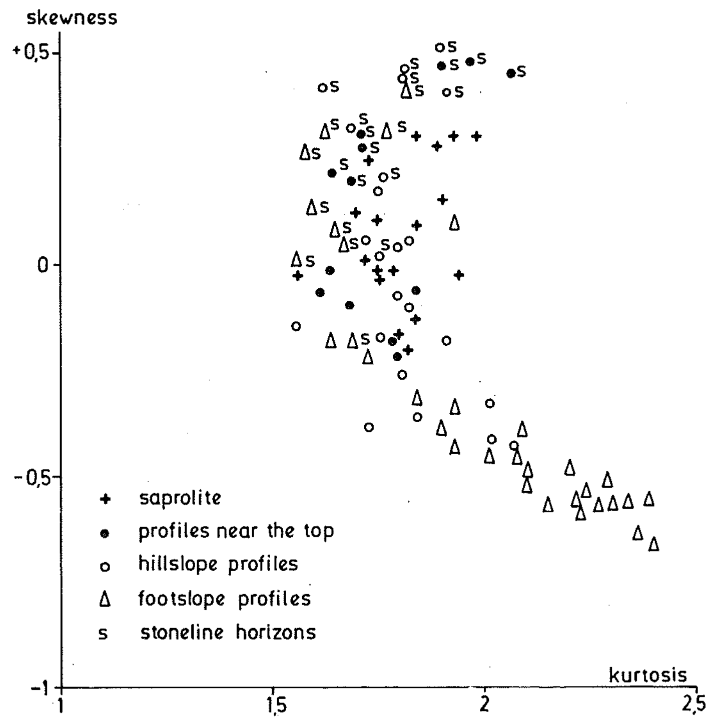

Fig. 7 : Relationship between skewness and kurtosis in the traction fraction.

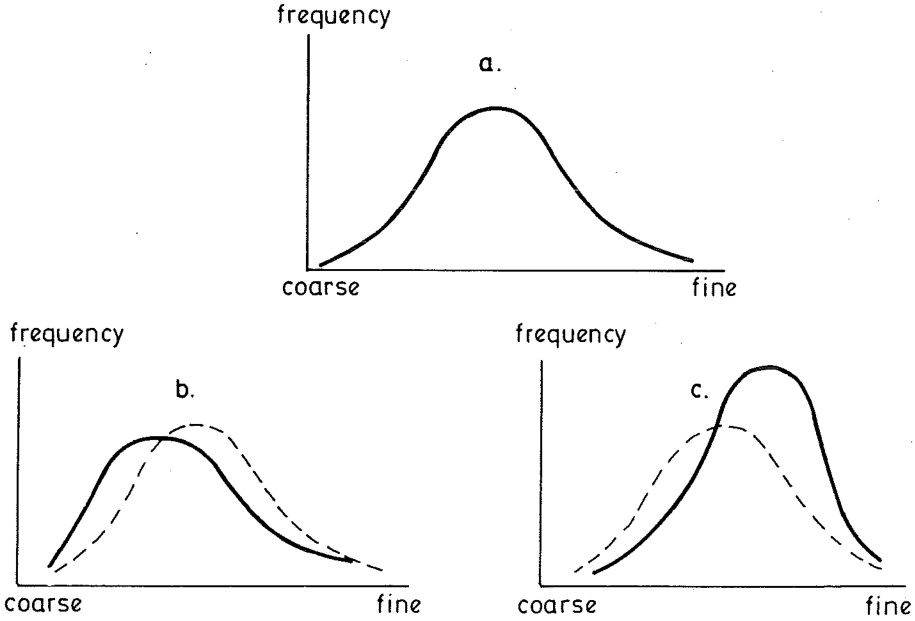

Fig. 8 : Evolution of the distribution curve of the traction population during hillslope pedimentation a) before pedimentation; b) stoneline : relative increase of the amount of coarse sand grains; c) hillwash cover : relative increase in the amount of medium and fine sans grains.

CONCLUSION

The similarity index calculated on the sand fraction and the sedimentological parameters of the traction population are important indicators for the study of the sedimentological aspects of pedimentation.

The study of the evolution of the sedimentological parameters of the traction population of the pedisediment, both in function of the position in the landscape and in function of the depth in the pedisediment itself confirms the results of the field observations in the area. The results are in agreement with the pedimentation theories of FOLSTER (1969) and ROHDENBURG (1969, 1982).

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