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TRENDS IN SOIL EROSION ON SLOPES IN SOUTHEASTERN GHANA

by

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RESUME

Un bassin du quatrième ordre situé dans le Sud-ouest du Ghana (6°02' N., 0°05' W) a été sélectionné pour évaluer les processus qui agissent à long terme sur les versants et dans les fonds de vallée d'un région tropicale. Ce bassin est couvert d'une forêt dégradée où domine une association *Antiaris-Chlorophora*. La nature du substratum et du sol est uniforme. Le site, jadis soumis aux cultures itinérantes, n'a plus été modifié par l'homme depuis lors. Une partie des versants ont d'ailleurs une pente trop forte pour encore être utilisés.

Un réseau de tiges en acier a été planté en 1964-65 sur les pentes et dans les fonds de vallée de 11 grandes parcelles afin d'effectuer des mesures de l'érosion et de l'accumulation en tenant compte du site. Une nouvelle visite en 1974 a permis de faire des observations relatives aux modifications survenues pendant les dix ans écoulés. En voici les principaux résultats :

1. Sur un versant convexe orienté vers le nord, couvert d'une forêt secondaire de taille moyenne, avec une pente générale comprise entre 8 et 12° et une longueur variant entre 70 et 130 m, apparaît une légère érosion (3 à 5 cm) sur le tiers supérieur ; cette érosion qui tend à diminuer la pente générale, apparaît d'une façon uniforme sur toute la largeur de la parcelle (500-700 m).
2. Sur des parcelles orientées vers le sud et l'est, de même végétation, de même pente moyenne et de même longueur que la première, l'érosion est également confinée au tiers supérieur du versant mais avec des intensités plus élevées (jusqu'à 12 cm) et plus localisées ; une telle disposition semble favorable au ravinement.
3. Sur des parcelles de même orientation et de même pente que les précédentes mais avec une végétation moins haute et une longueur moindre (25-70 m), une érosion faible affecte les deux tiers amont de la pente, sans grande variation latérale.

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4. Sur des pentes faibles (4 à 8°) tournées vers le nord, de faible longueur et où la forêt secondaire n'est pas encore bien développée, aucun départ appréciable n'apparaît à la surface du sol.
5. Sur des pentes semblables aux précédentes mais orientées vers le sud et l'est, il se produit sur toute la largeur de la parcelle (800 m) une érosion dans les deux tiers supérieurs (3 à 7 cm– avec une accumulation nette (2 à 4 cm) en contrebas.
6. Enfin, sur des pentes fortes, de 12° et plus, avec un couvert forestier dense, l'érosion reste assez faible (2 à 4 cm) et limitée à la partie moyenne du versant légèrement convexe, tendant ainsi à le rendre concave.

En conclusion, l'action géomorphologique qui a été observée dans ces parcelles a permis de juger de l'importance, dans un milieu intertropical, des quatre facteurs qui avaient été retenus :

a) *l'orientation des versants* a un effet remarquable, lié très probablement lui-même à l'orientation des pluies et de l'insolation ;
b) *le degré de développement de la forêt* secondaire est également important, car il contrôle la protection du sol contre les effets de la pluie ;
c) *la longueur de la pente* montre une influence moins notoire que les précédents, tandis que
d) *la pente générale* semble n'avoir que peu d'effets.

INTRODUCTION

Erosion and mass wasting processes have been dealt with much less in the Tropics than in other zones of the globe, even though the last two decades have witnessed a great deal of progress in this area. The contributions of TRICART (1965), ROUGERIE (1960), RUXTON and BERRY (1961), VAN DIJK and EHRENCRAN (1949), and SAVIGEAR (1960), to name a few, serve as vivid illustration of the recent attention which advance the understanding of such endeavours several steps forward.

The nature of field work in such environments and the poor accessibility to them have been a major drawback in collecting firsthand data. The state of knowledge today still remains at the pioneer stage when it comes to rates of removal or deposition, sediment yields, and volume approximations under different environmental conditions. On the other hand, the pressure on the land is mounting rapidly with no guidelines to help in regulating that pressure and to direct land exploitation to safer locations where harm to the land would be minimized through its wise management. Such guidelines can be established when there is precise understanding of the intensity of processes as related to grade and other environmental conditions. Therefore, such a body of knowledge is urgently needed in all varieties of environmental settings in the Tropics if such guidelines are to be locally established for conserving the delicate ecological balance.

It is within the purpose and spirit of obtaining such data that this work was initiated in southeast Ghana, under the local environmental conditions of the Akwapim-Togo ridges. It is intended to contribute to the slowly but surely accumulating knowledge of processes in the Tropics which, in turn, may be used for guidelines serving the welfare of the land and its peoples.

The area used for long-term observation of present-day processes was selected purposely within the domain of man's influence. The site is located next to a Ghanaian village and adjoins scattered farms on lands occupied in the past by farmers using traditional practices.

The site was first surveyed in 1964 with a field party from the Geography Department of the University of Ghana–and that was after an understanding reached with the elders of the village, to whom the purpose of the work was explained. In the early survey a few basic profiles were selected, along which steel rods were installed, leaving 15 cm protruding at 90° to the surface level. Following that, subsidiary profiles were established, as described in subsequent sections, to complete grid networks on slope fronts.

A resurvey was done in the field in november 1974, the results of which are described in this paper. Resurvey of the site is intended at 10-year intervals in the future.

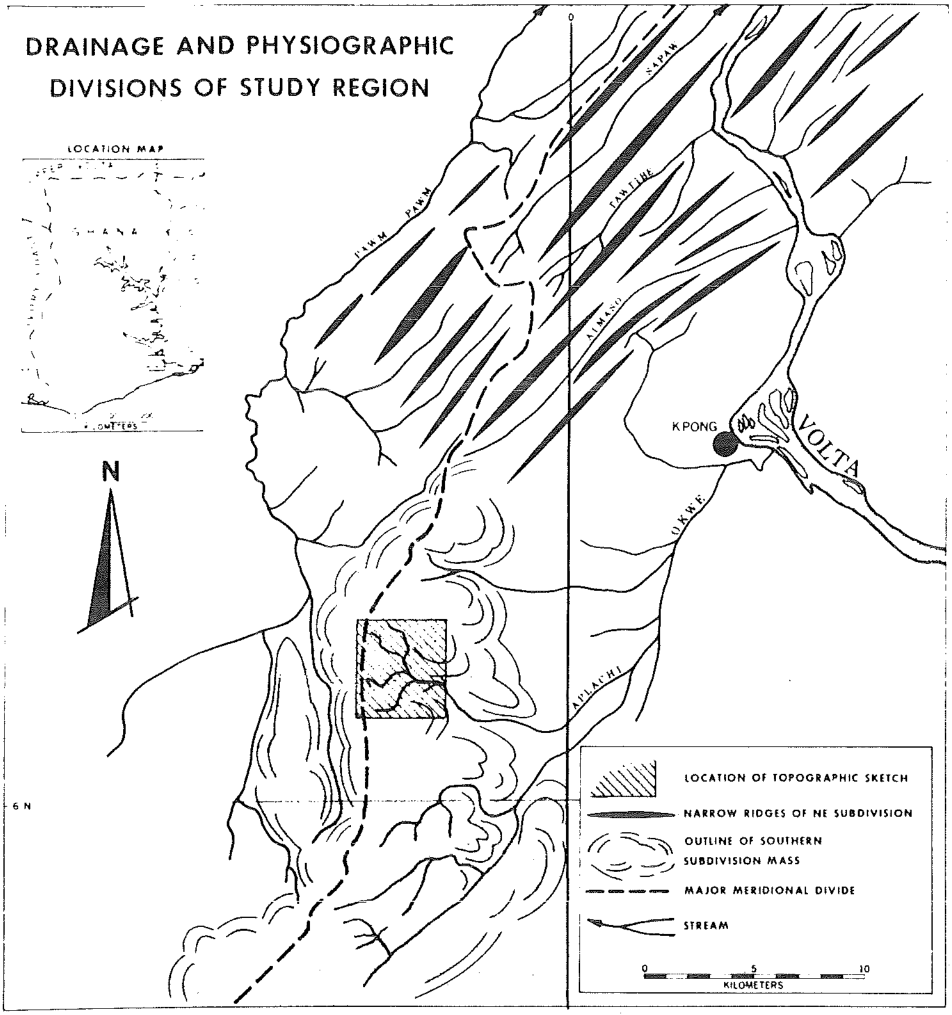
THE SITE'S BASIC CHARACTERISTICS

I. Location and physiography.

The site under observation is located at 0°05'W longitude and 6°02'N latitude, just east of the major divide of the southern part of the Akwapim-Togo region. The site falls totally within the eastern flank of the main range, and is well confined within a small fourth order basin draining to the Volta River through the Aplachi and the Okwe (Fig. 1).

At this area the Akwapim-Togo ridges differ in their nature, and can be looked at as two separate subdivisions, a Northeastern and a Southeastern. The distinctions between the two are as follows :

1. The Northeastern subdivision is typified by 5-6 parallel, narrow ridges (1-2 km wide), which run NNE and are separated by subsequent valleys. All of these ridges are interrupted northwards by the Volta River, which flows through several gaps separating the ridges from their cross-Volta extensions.
2. The Southwestern section, which extends along a similar directional trend (NNE), lacks the parallel ridge nature and is rather a broad elongated dissected mass (Fig. 1). This provides for one direct major divide along the crest line and several transversal stream basins draining east and west, one of which was selected for this work.



DRAINAGE AND PHYSIOGRAPHIC
DIVISIONS OF STUDY REGION
LOCATION MAP
GHANA
N
PAWM PAWM
SAPAW
TAWTIHE
AIMASO
KPONG
VOLTA
OKWE
APLACHI
6 N
0
LOCATION OF TOPOGRAPHIC SKETCH
NARROW RIDGES OF NE SUBDIVISION
OUTLINE OF SOUTHERN SUBDIVISION MASS
MAJOR MERIDIONAL DIVIDE
STREAM
0 5 10
KILOMETERS

Figure 1

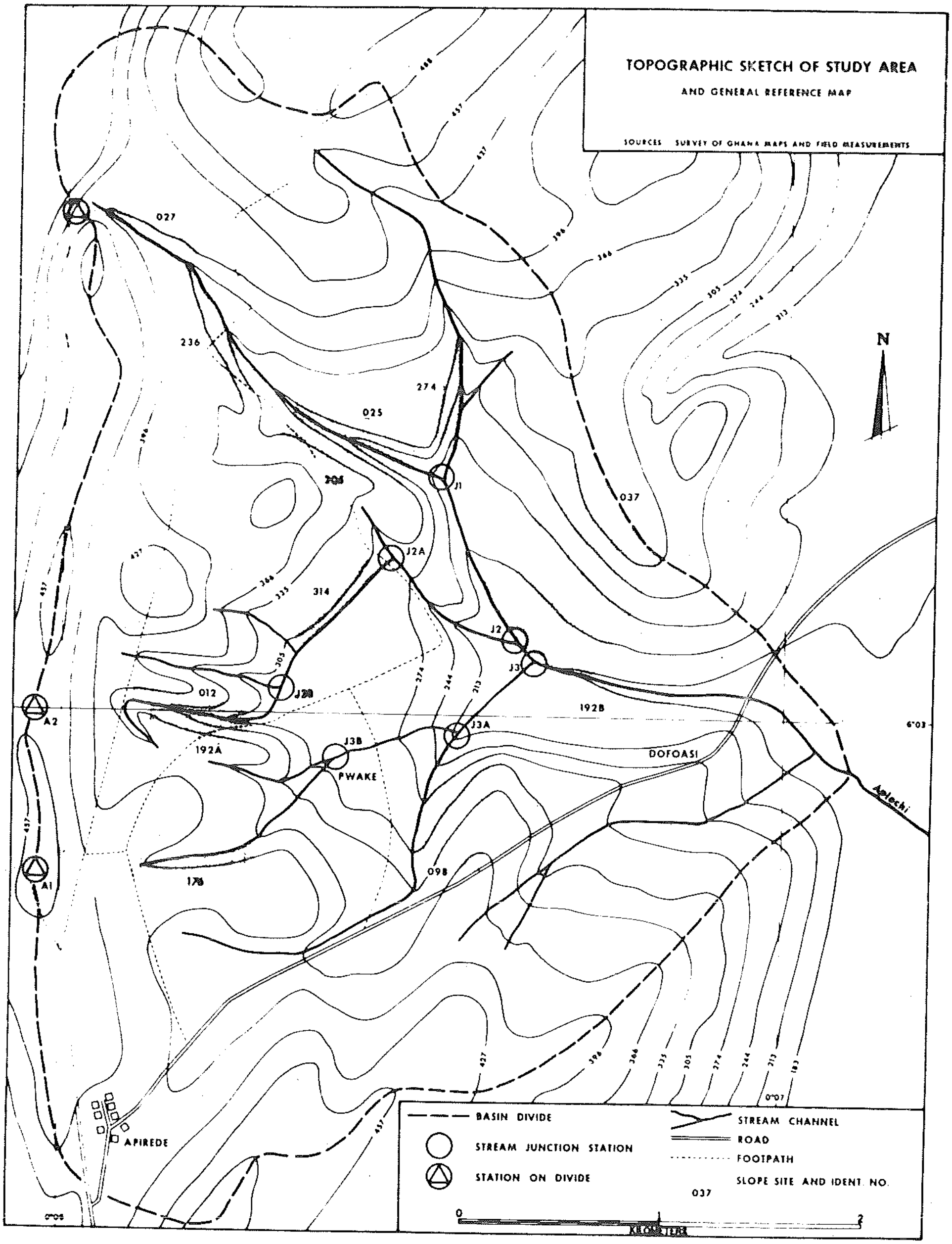


Figure 2 : (elevations in meters)

II. Topography

A topographic sketch of the basin (Fig. 2) illustrates its major features. The basin area has a total relief of 324 meters, the highest spot being at 495 m and lowest at 171 m. The depth of dissection exceeds 150 meters at the major stream and its northwestern tributary, while at most other tributaries it remains between 100-120 meters. At the western part of the basin, several lithological benches exist (Fig. 3), some of which are either flat or with a marked westerly inclination, contrary to the general slope of the basin. The profile in Figure 4 exemplifies some of these surfaces, one of which is so broad (about 700 m) that several farms are located on it. Such benches exist elsewhere in the basin, too, but not to the same extent as in the western part, causing the drainage texture to be very heterogeneous, as are the dissection depth and frequency. Fortunately, on the other hand, this phenomenon provides for a variety of slope lengths and angles within the basin, which would have been difficult to find otherwise.

III. Lithology and soils

The rock makeup of the site is basically crystalline and metamorphic, belonging to the Togo Series or the Akwapimian (N.R. JUNNER, 1940) of about middle pre-Cambrian age. Orogenies and metamorphic phases have rendered rocks of this series highly jointed and, in places, readily available for weathering and erosion. The arrangement of the different members of the series is in bands which follow the original folding trends of the Atakora from SSW to NNE (*R*. FURON, 1950; UNESCO-ASGA, 1968). Actually, today's structure and form represent the roots of that orogenetic belt after several phases of erosion have removed most of the original mountains. Differential weathering and erosion left the more resistant quartzites and phyllites to make the parallel ridges, while metamorphosed shales and the like, being less resistant, formed the valleys, both ridges and valleys following the band pattern of NNE trend.

The soils of the site belong broadly to the Forest Lithosol group in some parts, and to the Forest Ochrosol group in others (Portfolio of Ghania maps; R.P. MOSS, 1969). The dominance of quartzites and steep slopes enhances the occurrence of lithosols as expected. However, soil depth on slopes, even those which exceed 8° in overall angle, is still more than 30 cm, as concluded from field experience while installing the steel rods.

Figure 3 : A lithological bench located on spur between slope 025 and 274 as viewed from south.

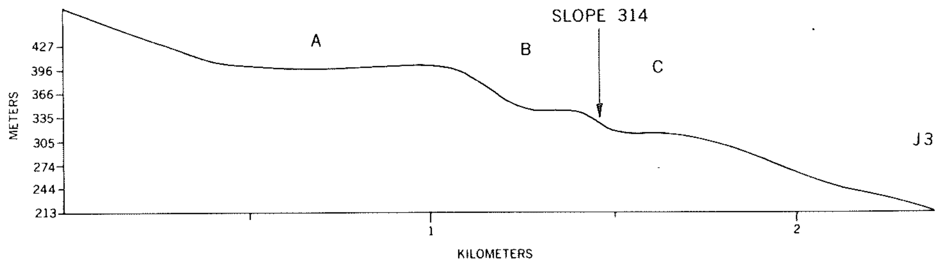


Figure 4 : Cross profile from divide on west to station J 3 illustrating lithological benches at A, B and C.

IV. Climate and vegetation

The site falls within the Tropical Continental Climatic Zone, with a well marked dry winter (W.G. KENDREW, 1964). However, due to its elevation, local climate is orographically modified, temperatures running lower and rainfall higher than the surrounding area (about 1200 mm). A sharp contrast can be observed between this area and the immediate adjoining plain to the east as a result of this factor ; there is moist tropical forest on the Akwapim (R.W. KEAY, 1959), and only savanna type vegetation on the plain. The forest of this zone is dominated by the *Antiaris-Chlorophora* Association, which forms a distinct band along the Akwapim to the northeast and extends northwestwards along the Mpraeso-Mampong Scarp area.

METHODOLOGY

I. Field Work

Initially, following selection of the area, village elders were consulted to obtain permission for using the slopes. After a full explanation of the work purpose, consent was obtained and a party of students from the University of Ghana's Department of Geography began establishing profiles as well as reference stations. The reference stations were important landmarks with measured distances and bearings to starting points on profiles, providing for somewhat easier finding of sites upon resurveying. Auxiliary profiles on the slope were added parallel to the original profiles, and by the end of fall of 1964 all field work was completed.

II. Measurement Procedure

It was felt that relying on a single slope profile may not always be satisfactory, since denudational processes may selectively act on parts of the slope, either affecting the area outside the profile or affecting that profile and not the rest of the slope. Therefore, it was decided to cover every slope with several parallel profiles. Profiles were spaced at about 100 meters from each other, and a fixed magnetic bearing was followed on all profiles of the same slope. The slopes were also labeled by that magnetic heading followed during measurements. Profile measurement began at channel level and continued from there uphill with a planimetric equi-distance of 6 m from one station to the other, using a tape and two abney levels. The 6 m distance was found to be workable, since in many instances vegetation hampers the use of longer distance by obstructing the direct line of vision. Steel rods were placed at every second point on the profile, that is at every 12 m starting from the slope base (1).

The steel rods, measuring about 45 cm of length, were pounded into the slope at about 90° to the surface, leaving 15 cm protruding above ground. The resulting network of parallel profiles with planimetric equidistance of 6 m stations makes a grid which covers the whole slope and helps to depict the geometry of the slope form and to estimate the quantities of materials displaced in its different parts.

The profiles were first plotted at a large scale without vertical exaggeration, and angles were figured from original plots. A vertical exaggeration of X2 became necessary when scales were reduced on slope samples included in this paper, in order to accentuate angle changes between slope segments (2).

DESCRIPTION AND EVOLUTION OF SLOPES

In the following sections, six sample slopes, and trends in their 1964-1974 evolution are considered. It is clearly evident that such a short period cannot as yet provide a satisfactory answer to actual slope evolution ; nevertheless, it can point out certain trends in the process. Besides, as long-term observation continues, every ten-year situation becomes an important stage which helps in understanding the evolutionary sequence, and therefore should be recorded and carefully looked at.

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(1) The steel rods were prepared at the University of Ghana's Blacksmith Workshop.

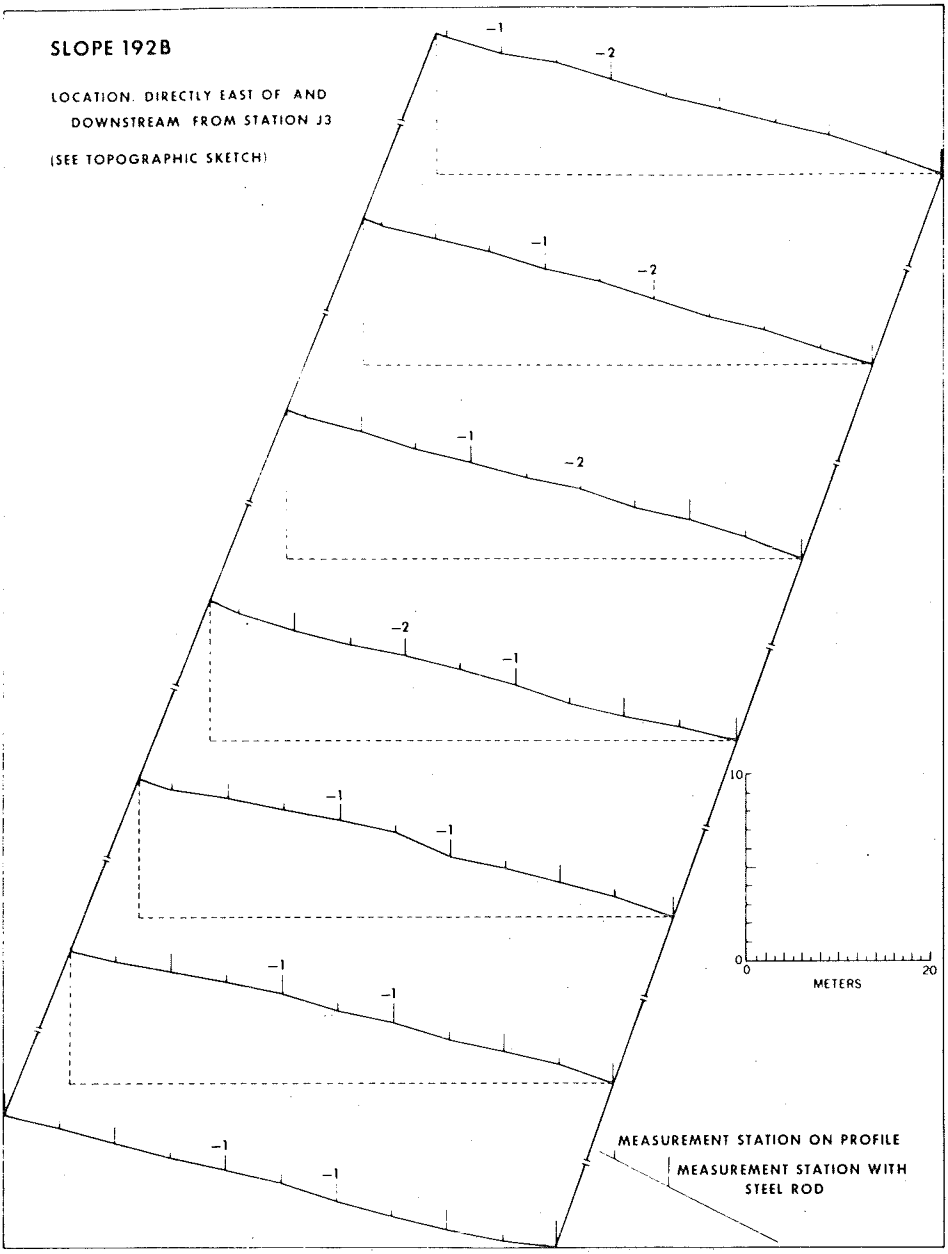

Figure 5 : Slope 192 B profiles.

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(2) This excludes Slope 098, being long and steep enough to make vertical exaggeration unnecessary.

I. Slope 192B

Slope 192B is located in the lowest part of the basin and drains directly to the Aplachi in the east-central section of the area (Fig. 2). The slope faces north and has an average overall angle of 7°. Variations from the overall angle are minimal, and do not exceed one degree on different slope segments. The total planimetric slope length varies from 55 m to 60 m, the eastern section being slightly longer (bottom profile on Fig. 5).

The six profiles established on the slope begin at the Aplachi bank, and end at the break in slope where a litho-structural bench occurs at about 8 m above the bank level.

The slope is covered by a secondary growth, as of the initial survey of 1964. Some local people recall the site having been under cultivation 20-30 years prior to the initial survey. However, it is now abandoned, and looks as if it will remain so for the few coming decades the soil there having lost its fertility.

Looking at the 10-year period changes here, very minimal removal can be recorded, amounting to 2 cm as the highest value. This slope shows the lowest rate of removal among all those studied. However, there is a clear tendency for that removal to occur, mostly in the middle third of the slope, as shown by most profiles (Fig. 5), with the exception of the westernmost profile (top of Fig. 5), where removal is greater towards the upper part of the slope.

II. Slope 314

Slope 314 is located in the central section of the drainage basin, immediately upstream from Station J2A (Fig. 2). It drops from a slight divide at the edge of a lithological bench to a large second order stream (Fig. 4). It is a southeast facing slope, with overall average angle just above 7°. Variation from overall angle and different slope segment is little and does not exceed 1°. The total planimetric length is about 60 m and varies slightly across an 800 m front. Only seven profiles were taken on that slope which are spaced at the regular 100 m interval, except for the three profiles at the top of Figure 6, where the distance between them had to be stretched to 200 m due to difficulties of access.

Basically, Slope 314 is very similar to Slope 192B in overall angle and total length, and differs from it mainly by exposure direction and the

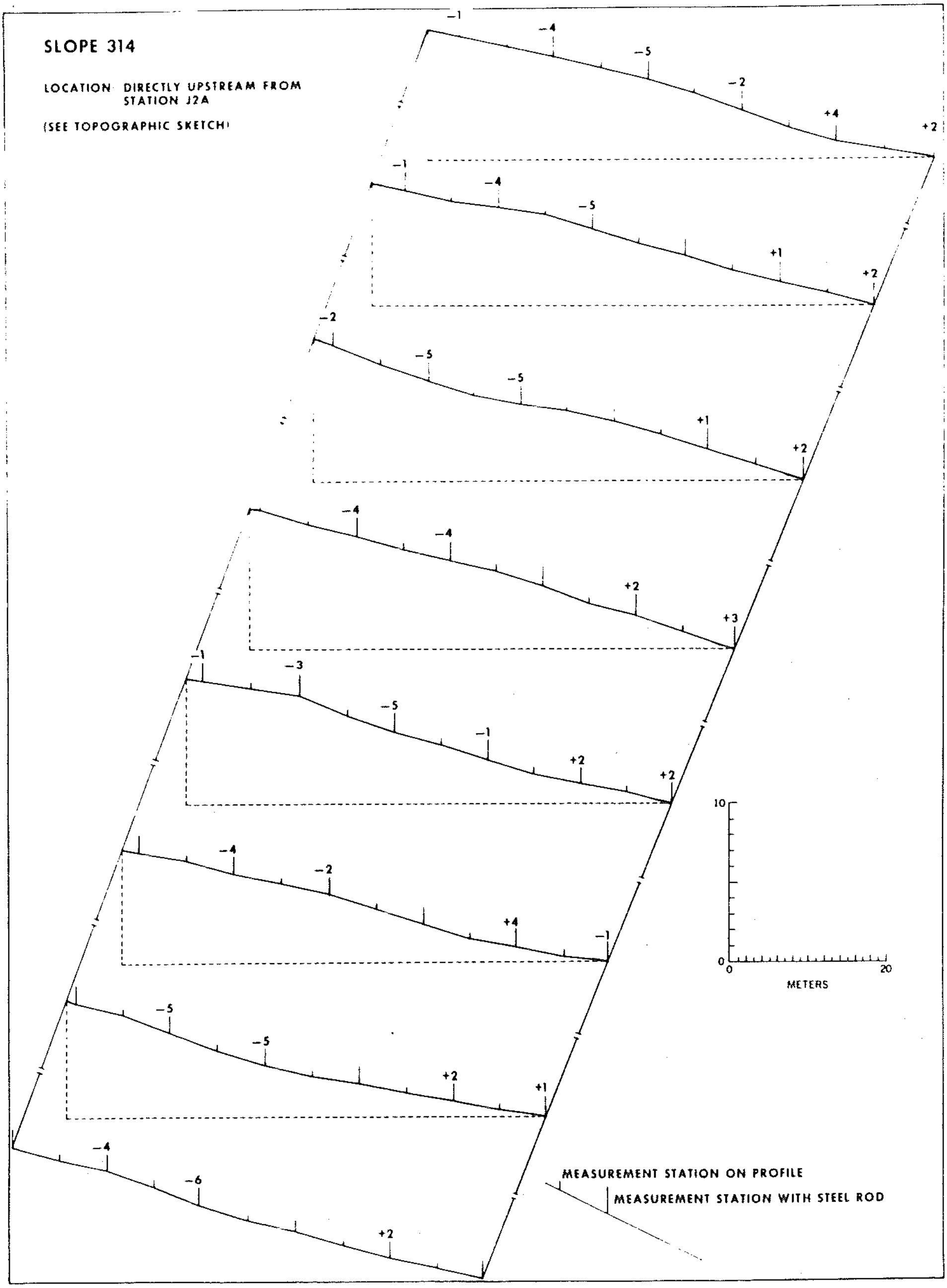

Figure 6 : Slope 314 profiles.

density of vegetation growth. Slope 314 was under farming for one decade prior to the initial survey, and its "recovery" has not had enough time to reach the "medium" secondary growth as in Slope 192 B. There is a "thin" secondary growth on most of the previously cleared parts of the slope and deposition at the lower third. In contrast with Slope 192B rates of removal are quite important, reaching up to 5 cm and, equally important, are the rates of deposition (up to 5 cm).

Slopes 314 and 192B are of similar angle and length, yet a great deal of removal and deposition occurs on Slope 314 and almost none on Slope 192B. One might find the reason for such contrasting difference in factors other than slope length and angle. It seems reasonable to look at vegetation and exposure direction as possible factors influencing that difference. One other slope (027), not discussed in this paper but having same length, angle, and vegetation cover as 314, exhibits very similar results, having an exposure direction to SSW (instead of SE as in 314). All this seems to strengthen the possibility that both vegetation and aspect have contributed to the difference in the rate of change between Slopes 192B and 314.

III. Slopes 192A

Slope 192A is located in the western part of the basin between Station Al on the major divide and Station J2B at the tributary junction (Fig. 2). It is north-facing slope, which drains into a first-order tributary.

The overall angle of this slope averages 10° from most profiles. However, being basically a convex type, variation from overall angle is high, especially in lower slope segments where the slope steepens considerably (Fig. 7).

The planimetric length of this slope is about 110 m and tends to remain equal along a 600 m front, as represented by seven profiles across the whole slope.

The slope is covered by a medium secondary growth. There is no recollection among local people of its being farmed within the past 3-5 decades, and there is no apparent intention of its usage in the forseeable future as understood from their reactions.

Examining the nature of change on this slope within the first 10 years period reveals a tendency for removal in the upper third to upper half of the slope. Removal rates are as high as 5 cm, and no accumulation is evident at any segment.

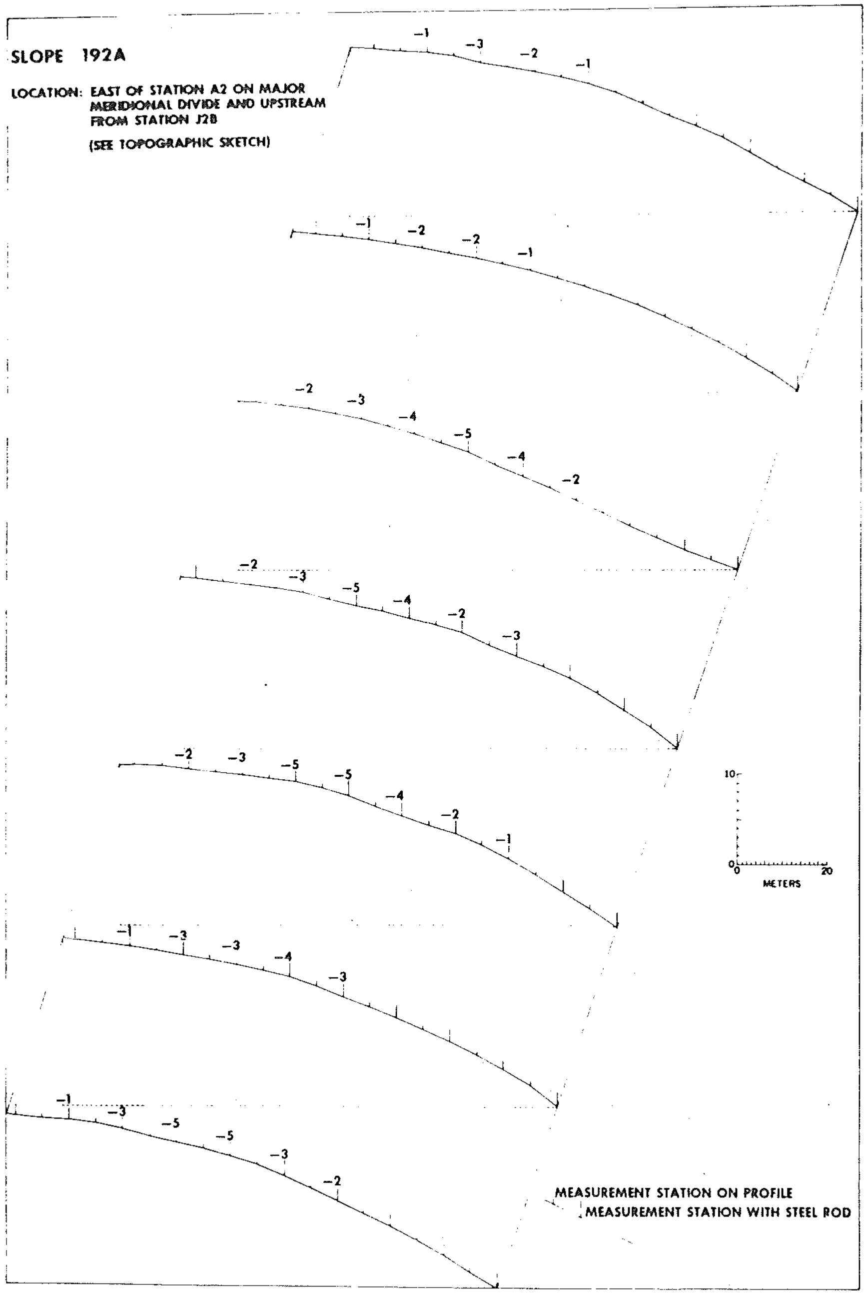

Figure 7 : Slope 192 A profiles.

It is worthwhile mentioning the remarkable lack of removal in the lower third of the slope, and this in spite of the predominantly higher angles at the lower slope segments. One possible explanation could be the nature and size of the first-order tributary, as related to its very close proximity to the local divide which is right at the top of the slope.

IV. Slope 012

Slope 012 is located at the west central section of the basin between Station A2 on the major meridional divide and Station J2B at the first-order streams junction. The slope faces to the south, and its average overall angle is of medium value-just a little below 10°. Variations between the overall angle and individual slope segments angle occurs often, and can reach up to 2°.

Planimetric length of Slope 012 is of short range (70 m), and gradually becomes shorter (60 m) on the eastern profiles (top of Fig. 8).

Thin secondary forest growth covers the slope, which was farmed in patches; local farmers reported this, but were unable to estimate how long ago (Fig. 9). They did not seem to forsee exploitation of the slope in the near future.

Upon examination of the change which occured on the profiles during the 10-year period, removal was the only result on this slope, and all removal was observed on the upper two-thirds of the slope profile with no deposition anywhere. Also, rates of removal are quite similar on all seven profiles in amounts of up to 3 cm, which falls within low to medium range as compared with other values experienced in this study. Data obtained from Slope 274 (not discussed in this paper, but having similar environmental conditions of angle, length and vegetation coverage) tend to exhibit the same rates of removal on similarly located slope segments. The only difference between the two slopes remains within the exposure direction (012 faces south and 274 faces east), which at this stage seems to be of no consequence in this area. Exposure to south and east seems to have a similar effect, and contrast seems to occur with north-facing slopes versus south and east-facing ones.

V. Slope 025

Slope 025 is located in the northwestern quarter of basin, directly upstream from Station J1 on a long second order stream which originates close to Station A3 on the main meridional divide (Fig. 2). It is a south-facing slope, having a marked upper convexity and lower concavity. Its upper part begins on a break-in-slope, which occurs at the rounded edge of a small litho-structural bench.

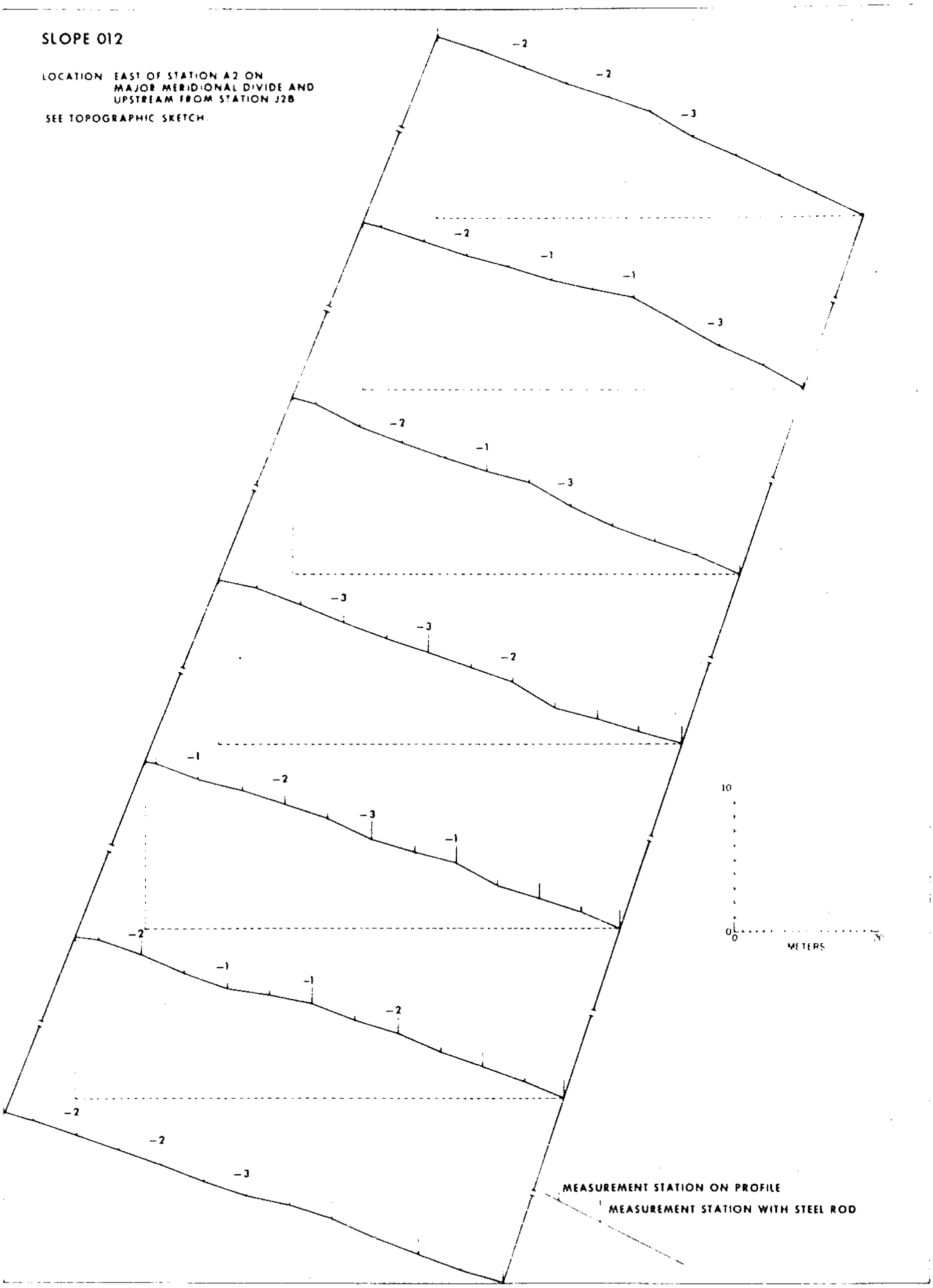

Figure 8 : Slope 012 profiles.

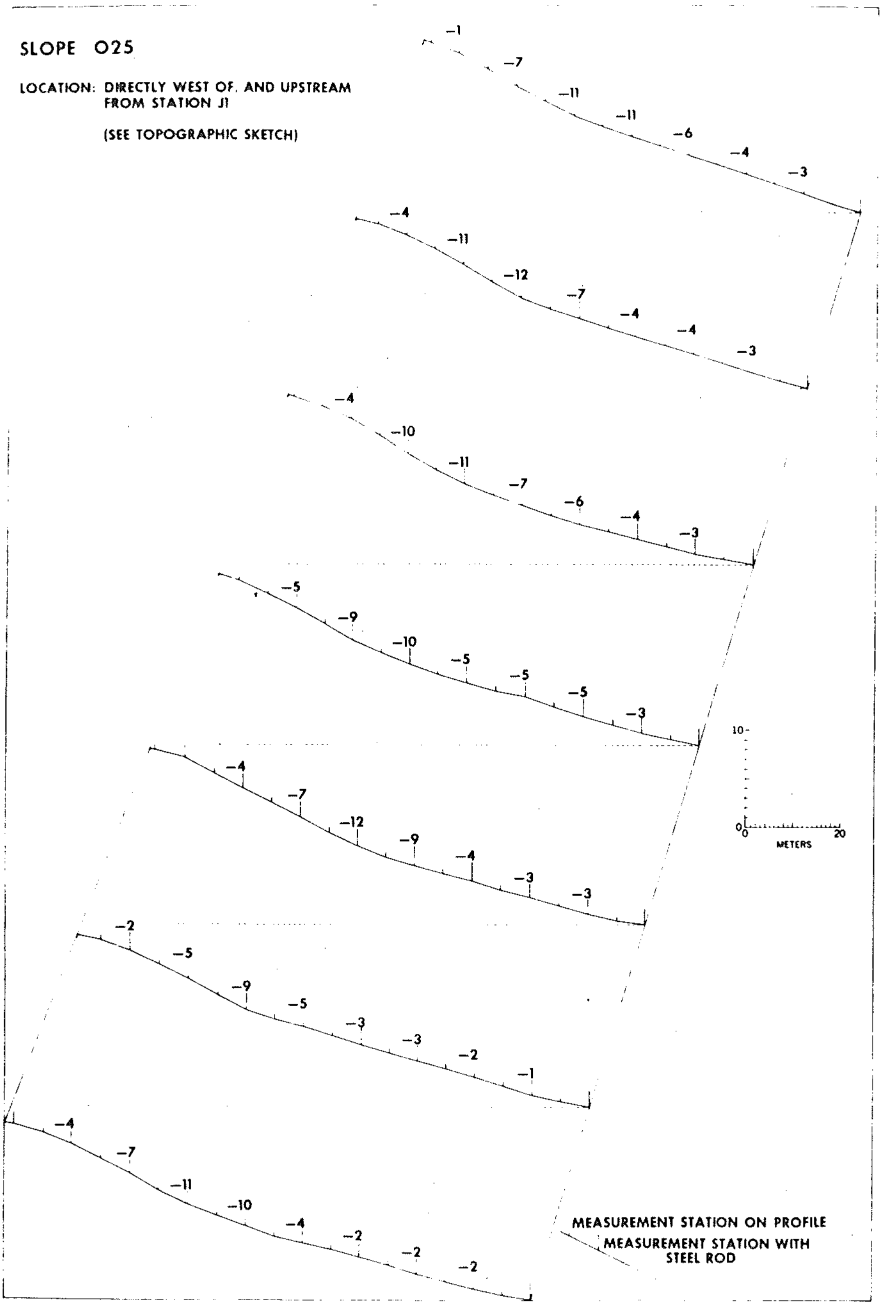

Figure 10 : Slope 025 profiles.

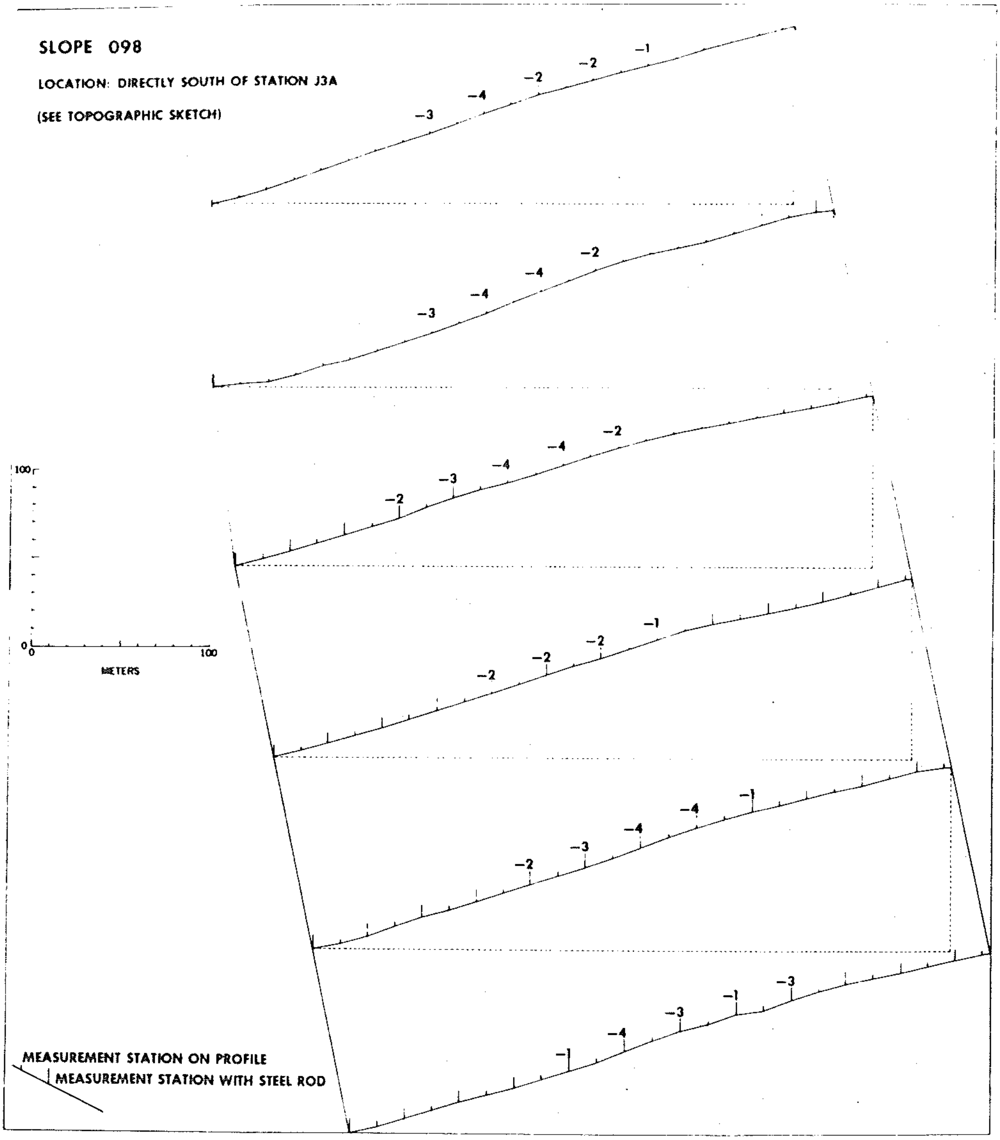

Figure 11 : Slope 098 profiles.

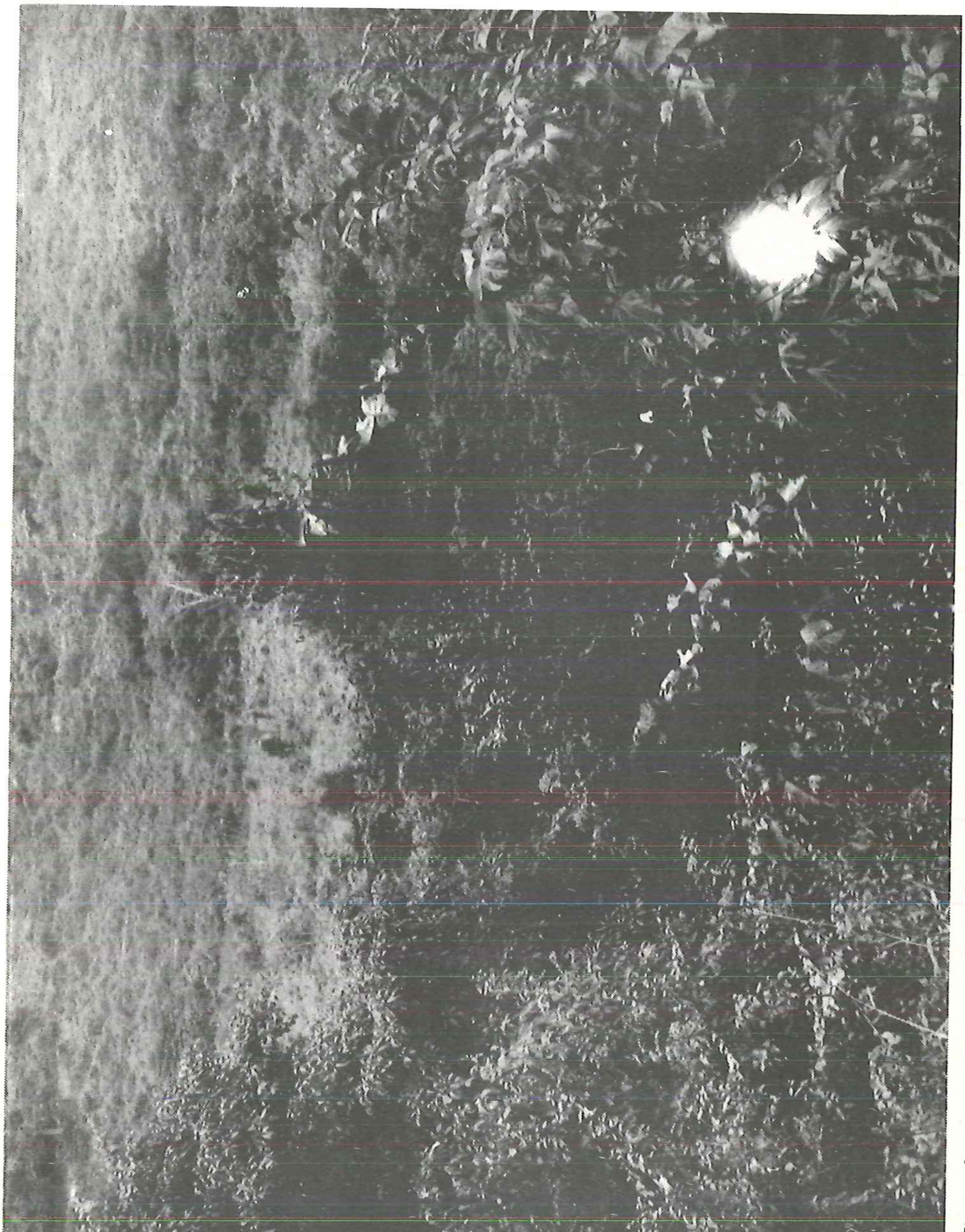

Figure 9 : Slope 012 as viewed from east (upper middle left of photo) showing thin secondary growth.

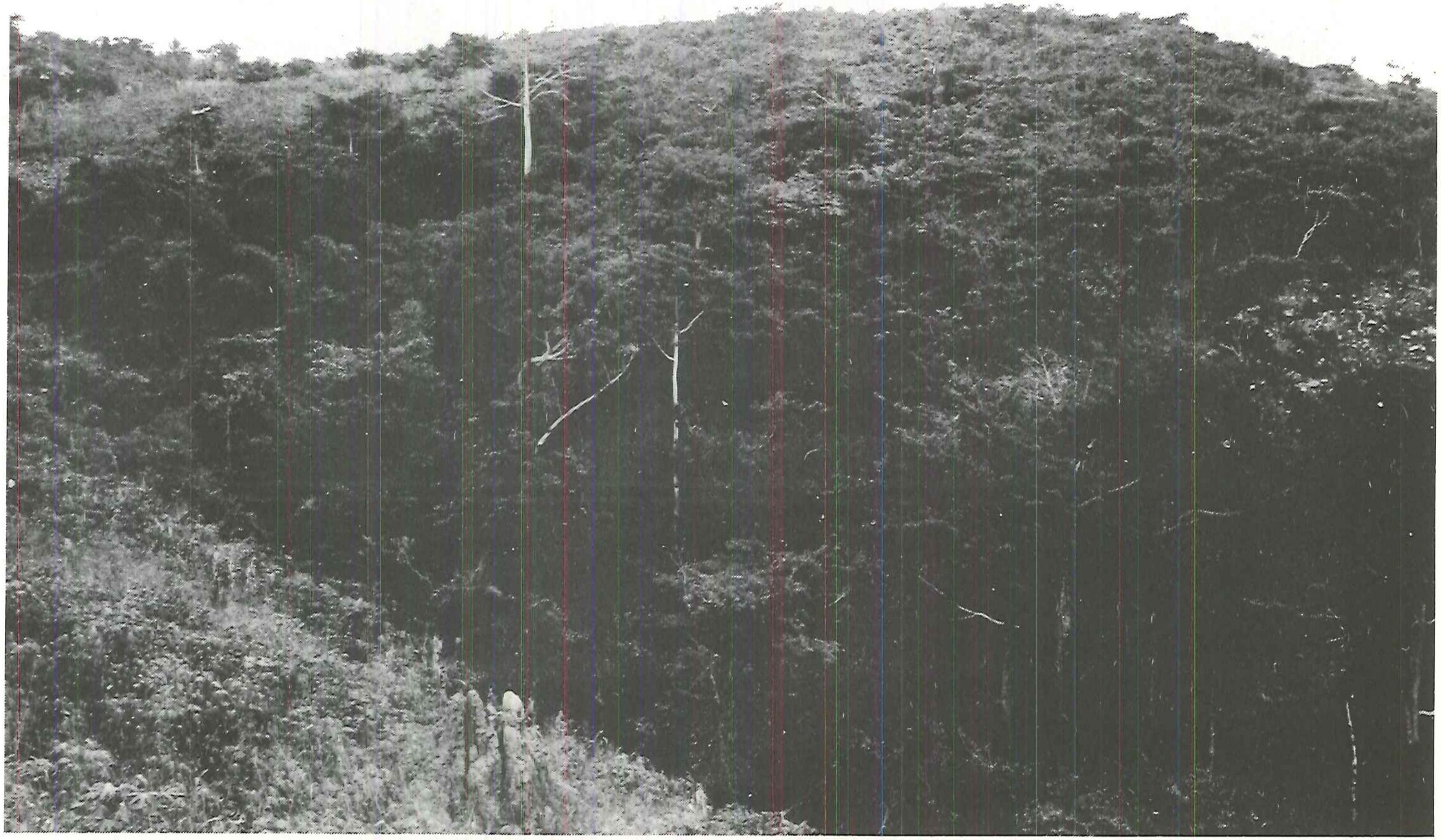

Figure 12 : View of slope 098 looking from north, note the slight convexity of the profile.

The average overall angle of Slope 025 is slightly above 10°, and high variations exist between the overall angle and that of a particular slope segment in amounts of up to 3°. The planimetric length varies between 100 m in the east (bottom profiles on Fig. 10) and 90 m in the west.

The slope is covered with medium secondary forest growth, cleared in a few sections by past agricultural patches. No farmed sections exist now over the whole slope and no information could be obtained with regard to past activities and future intentions for use of this location.

In examining the nature of the change which occurred after the 10-year period, the following observations are of notable interest :

(1) Rate of removal is among the highest experienced throughout the study area ; rates up to 12 cm have been encountered upon resurveying in 1974 and, if such rates are to continue in the next decade, several steel rods will have to be changed or replaced since their buried part will become too short to keep them stable.

(2) Great variations exist between the seven profiles in the rate of removal, which has not been uniform accross the whole slope front. This may lead to the possible beginning of gullying if it continues along the same trend, since selective removal is taking place along the slope. The phenomenon seems tojustify the establishment of multiple profiles across the slopes, without which such a tendency would have gone unnoticed.

(3) Removal exhibits its highest values somewhere between the upper third of the slope and the lower two-thirds. If this is to continue, a change of the profile to a total concavity is quite conceivable, as this effect combines with the possible gullying to come.

VI. Slopes 098

Slope 098 exemplifies the longer and steeper type of slopes looked at within in this framework. It is located in the south-central section of the area directly upstream from Station J3A (Fig. 2).

Slope 098 faces west and has an average overall angle of 16°. Variations are moderate between the overall angle and that of individual slope segments, amounting to a maximum of 2°.

The slope's total planimetric length varies from 140 m in the south (bottom profile on Fig. 10) to 128 m in the north. The slope's upper part begins on a small spur, which makes a secondary divide between two second order streams.

Slope 098 has a slight convexity which is apparent on all six profiles, as can be observed on Figures 11 and 12. The slope is covered by a thick secondary forest growth. It does not seem likely that any kind of agricultural occupancy occurred here in the past for an extended period of time ; neither does it look practical in the forseeable future. The phenomenon noted both on this slope and on Slope 037[1] is a thin undergrowth which makes for better accessibility than other slopes, rendering field work much easier in spite of the steeper grades and longer profiles.

Examining the 10-year changes which occurred on these slope profiles, removal seems to be very little considering the steep angles prevailing here (up to 4 cm only). Most of that removal tends to concentrate on the middle third of the profile, a situation which, if continued, may change the nature of the profile from slight convexity to a slight concavity, but that looks very remote at the present slow rate.

A very similar tendency is exhibited by the previously mentioned Slope 037, which has comparable controls in terms of overall angle, vegetation coverage and exposure.

CONCLUSIONS

It must be reiterated here that the following conclusions are only of interim nature, limited to a relatively short period and presented with all the reservations warranted in such a situation. This is also, at this stage, the reason for not including any geometrical derivations of volumes removed or deposited which are feasible in utilizing the grid network of profiles. The following conclusions are formulated on the basis of the six slopes described earlier, in addition to five other slopes not discussed in the paper to avoid repetition of similar conditions and outcome.

(1) North-facing slopes in general seem to be much less susceptible to removal than slopes facing east or south. This tendency is dominant regardless of other environmental controls considered within this work, namely overall angle, length, and vegetation cover. If this tendency proves to be consistent in future resurveys, the weather-making factors of this area should be scrutinized to find the possible combination of reasons : whether it lies within prevailing local winds at times of heavy rainfalls or the condition of the sun's rays, or any combination of these with other factors.

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[1]Not discussed in this paper.

(2) Vegetation cover ranks second in importance, since removal tends to become greater with thinner growth. This occurs under almost all varieties of environmental controls. This factor seems so important, since it defies the steep angles in several slopes (098, 037). It also defies the slope length, but is still influenced by slope exposure to a certain degree. "Canopy" sheltering could be the possible reason and not necessarily the effect of root systems, since field observation finds surface wash most responsible for removal.

(3) The third ranking factor influencing removal seems to be the slope length and not always with any interdependence on angle. As a general observation, the longer the slopes the higher the rate of removal.

(4) The least important factor seems to be the overall angle of the slope at this stage. However, several indications point to the effect of angle in individual cases of slope segments. Some interdependence which exists between overall angle and segment angles should be looked into after future resurveys, for a possible elucidation of the role of angles on removal.

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DISCUSSION

L.K. Jeje : With regard to your concluding observations about the effect of aspect on slope erosion, this appears very unlikely to me as rainfall cannot vary much on any side of a particular hill in the area of study except of course the relief is exceptionally high.

J. Aghassy : Observations made at this stage are temporary in view of the relatively short period of ten years. However, results compiled from all eleven slopes seem to favor exposure direction. No explanation to the reasons for that can be advanced until data on wind affecting possible rainfall impact on slopes can be obtained. The meteorological station to be installed on the site may give some clues to reasons. The fact remains though that the 10-year findings favor exposure importance.

G.E.K. Ofomata :

1) When you speak of "degraded forest", what in fact do you mean, especially when you state you were not interested in the causes of slope removal but in the ultimate form ?
2) What is the population density in the area of your study and what part do you think this would have played in the observations you have made ?
3) Was there no cultivation in your area of study for the entire ten years covered by your observations ? Did you, in fact, find all your stakes in place when you revisited the area after ten years ? Such a situation, if it existed, would be very surprising indeed.

J. Aghassy :

1) Degraded forest is used here to mean partial clearings made by farmers for cultivation purposes, subsequently abandoned after losing fertility.
2) The Akwapian-Togo area seems to have been rather stable in the last few decades in terms of population density. It does not appear to consider that changes in such density were important in affecting this experiment result.
3) Since understanding was reached with the village elders about this experiment and slopes were selected under their guidance and consent, we were led to such places where no future utilization of land was contemplated. The steel rods were not tampered with and it is reasonable to assume they may not be tampered with in the future given the traditional respect village elders hold in the area.

J. Dresch :

1) Demande comment ont été faites les mesures à l'intérieur du réseau de cordes.
2) Il souhaiterait qu'elles soient complétées par des mesures méso- ou microclimatiques qui permettraient d'expliquer le rôle de l'orientation : celui-ci dépend, à ces latitudes, non de la radiation solaire mais de l'orientation des vents pendant la saison des pluies. Le rôle de la pente n'est pas sensible parce que celle-ci, inférieure à 12°, est trop faible et pas assez irrégulière.

J. Aghassy :

1) Les mesures ont été faites avec deux personnes chacune mesurant l'angle de pente avec un clinomètre l'une vers l'autre tout en maintenant entre elles une équidistance planimétrique de six mètres.

2) Il faut, en effet, considérer la direction des vents pluvieux plus que celle du rayonnement pour expliquer la relation qui existe entre l'érosion des versants et leur orientation. Des données météorologiques locales seront bientôt disponibles, une station météorologique allant être installée près des parcelles expérimentales.

M.F. Thomas : If human disturbance has been discounted from the experiment can you equally eliminate possible effects of movement (including rotation) of the rods by soil creep or similar mass movement ?

J. Aghassy : Human disturbance is discounted following the 1974 resurvey. As to possible mass movements, they can be measured as they occur especially rotational types and the like : rods were installed at 90° to slope surface guided by a triangle which was used in the resurvey procedure. There was no apparent angle change in rods at this stage.

M.A. Stocking : Your conclusions are very interesting and as you said somewhat at variance into what may be expected and what others have found. You are dealing with what are really very small amounts of removal especially on the lower slope. What is the statistical significance of your results ?

J. Aghassy : The results reported are of interim nature, they are considered as a step in a more extended evolution which may reach some validity in a few decades. They show trends which may not continue in the same way or even may be reversed.

A. Jahn : I do not understand relationship between slope orientation and the rate of degradation in the tropical area. This kind of relationship is typical only for the high latitude zones, which is an evident fact.

J. Aghassy : It is agreed that this relationship can be understood only over high latitude zone and is rather difficult to explain for the tropics. But this is what these interim results show so far. An explanation must be found through an investigation of wind intensities and directions at time of rain, if such trend is to continue. Installing a meteorogical station is contemplated for the purpose of obtaining the necessary data. Hopefully the personnel in the village school may take care of such a station.