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RELATION BETWEEN LANDFORM PARAMETERS AND SOIL PROPERTIES IN SOME SELECTED LANDSCAPES IN SOUTH-WESTERN NIGERIA

Relations entre différents éléments de la topographie et certaines propriétés des sols dans quatre toposéquences du Nigéria du Sud-Ouest

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RESUME

Les relations existants entre certaines propriétés des sols et différents éléments de la topographie, ont été étudiées selon quatre toposéquences dans la zone d'affleurement du complexe de base dans les régions d'Ife et d'Ilesha.

Les paramètres topographiques pris en considération sont les suivants : direction et longueur de la pente, distance du sommet local, rayon de courbure de la pente, et hauteur ont été relevés en même temps que les profils des sols, c-à-d. épaisseur des couches superficielles,profondeurs de l'horizon bariolé, de l'horizon d'argile sableuses du hardpan, pourcentage de cailloux et des concrétions à 50 cm ainsi que la profondeur à partir de laquelle apparaît une coloration rougeâtre (2,5 YR).

Les relations existant entre des différents paramètres de la topographie d'une part, et entre certaines caractéristiques des sols et ces mêmes paramètres d'autre part, ont été approchées à l'aide des coefficients de correlation simple.

Il a été observé qu'un changement dans certaines caractéristiques des pentes correspond à un changement dans les niveaux observés dans le sol. En règle générale, la courbure et la direction sont les deux paramètres les mieux corrélés aux propriétés mesurées dans le sol. Toutefois, une grande partie des variations des caractéristiques pédologiques restent "inexpliquées".

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ABSTRACT

The relations between various relief elements and soil properties over Basement Complex rocks in the Ife and Ilesha areas were studied across four landscape segments.

Landform parameters of : slope gradient, length of slope, slope length direction, distance from local summit, slope length curvature and elevation were recorded with soil profile observations, viz : thickness of surface layers, depth to mottles, depth to sandy clay horizon, depth to hardpan, percent rock fragments at 50 cm, percent concretions at 50 cm and depth of distinct reddish colouration (Hue 2.5 YR).

Simple regression and correlation analyses were used to examine the relationship between : each soil property and the landform parameters and the landform parameters.

It was observed that changes in certain slope characteristics correspond with changes in soil boundaries. Generally slope length curvature and slope length direction were the parameters most strongly related to the soil properties measured. However, considerable soil variations remained unaccounted for.

INTRODUCTION

Early workers in soil genesis and classification applied the classic ideas of geology and physiography to explain differences in soils and therefore grouped them on geographic basis. This was illustrated by the publications of COFFEY (1912) and MARBUT *et al.* (1913) in which soils were discussed by physiographic regions. Modern soil scientists also discuss soils in relation to slopes, thus MILNE (1935) in his original article on the catena noted that the profiles changed along the traverse from the ridge crest to the stream in accordance with the topography and its influence on drainage.

The study of soil-geomorphic relations have been approached from several view points by different authors. In the temperate regions, WEBSTER (1962), CURTIS (1962), TROEH (1964), JORDAN & DANIELS (1966), WALKER *et al.* (1968 a, 1968 b), and WHITFIELD & FURLEY (1971) studied the relationships between landform and soils of varying drainage characteristics using slope gradient and other relief parameters. Such detailed geomorphic studies are not common in South-Western Nigeria. However, MOSS (1965), ASHAYE (1967), and ASHAYE & OJO-ATERE (1972) indicated some broad relationships between soils and slopes on sandstone parent materials in this area. The main objective of this paper is to correlate some soil properties with associated geomorphic parameters on the

Basement Complex rocks in the humid rain forest area of South-Western Nigeria and to evaluate their importance as a basis for delineating soil boundaries.

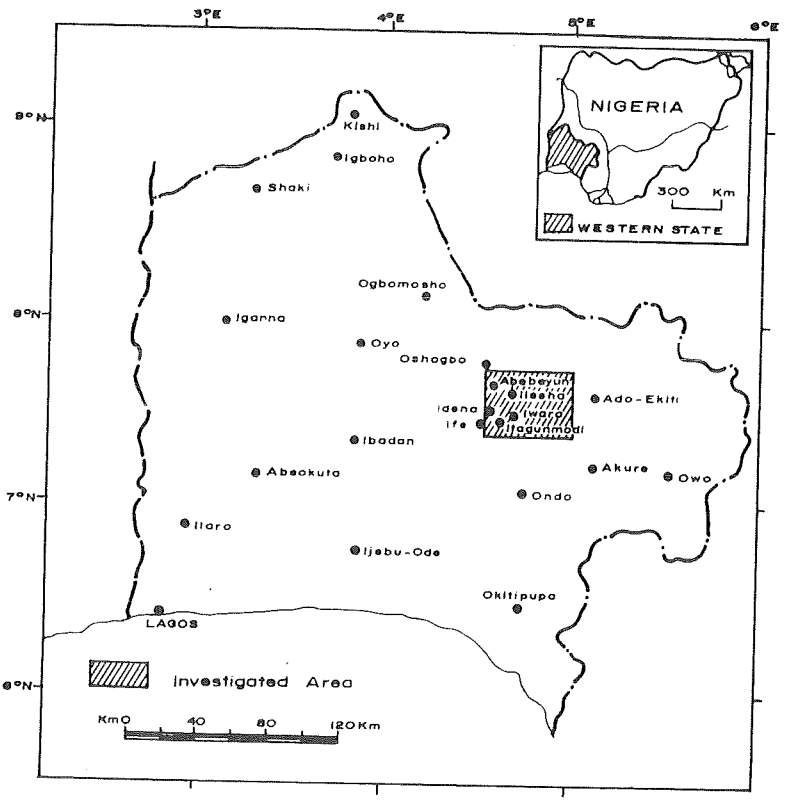
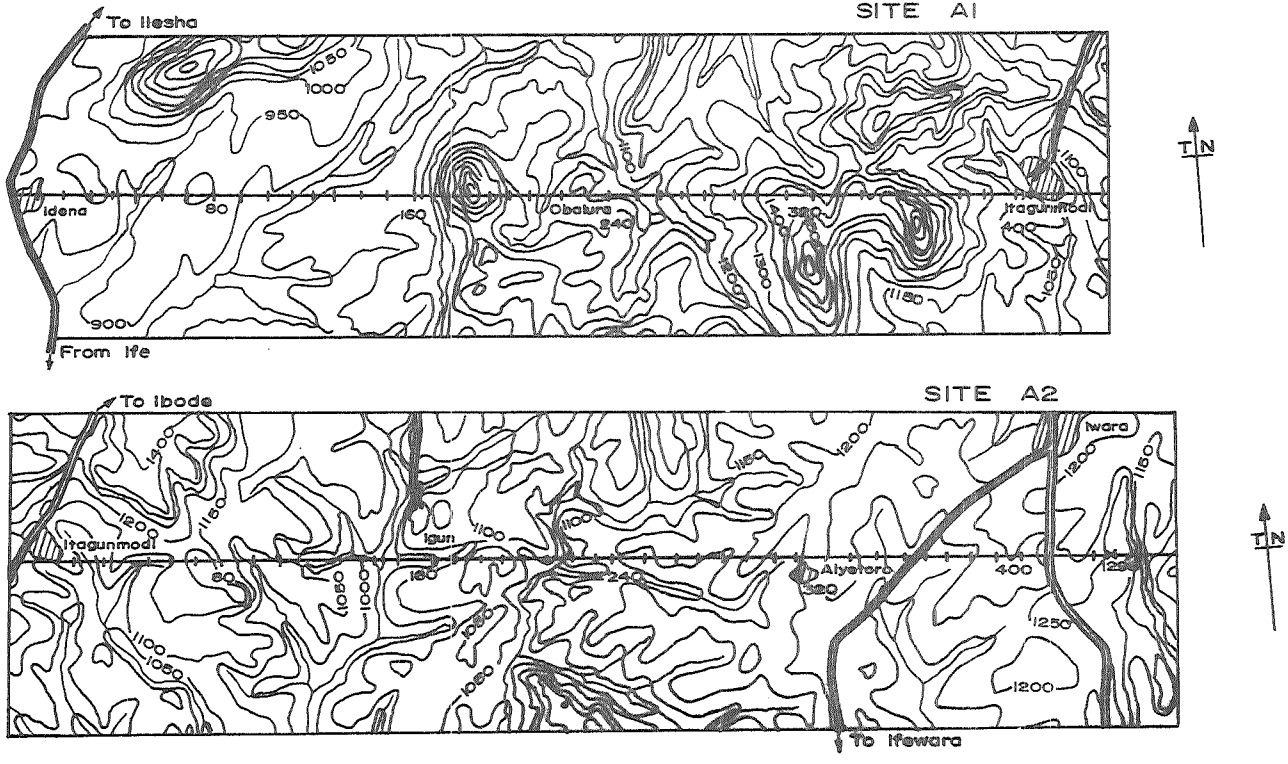


Fig. 1 : Location map of the investigated area.

METHOD

Soil properties were measured at grid point intervals of 201 metres, across four selected soil landscapes on the Basement Complex rocks in the Ife and Ilesha areas (Fig. 1 a and 1 b). Soil profile observations were made at each grid point. In all the profiles, thickness of surface layers (YS) depth to mottles (YM), depth to sandy clay horizon (YT), depth to hardpan (YH), percent rock fragments at 50 cm (YG) percent concretions at 50 cm (YC) and depth of distinct reddish colouration (Hue 2.5 YR) (YR) were measured.


SITE A1
To Ilesha
From Ife
Idena
Obalura
Itagunmodi
SITE A2
To Ibode
To Ifewara
Itagunmodi
Igun
Aiyetoro
Iwara
N

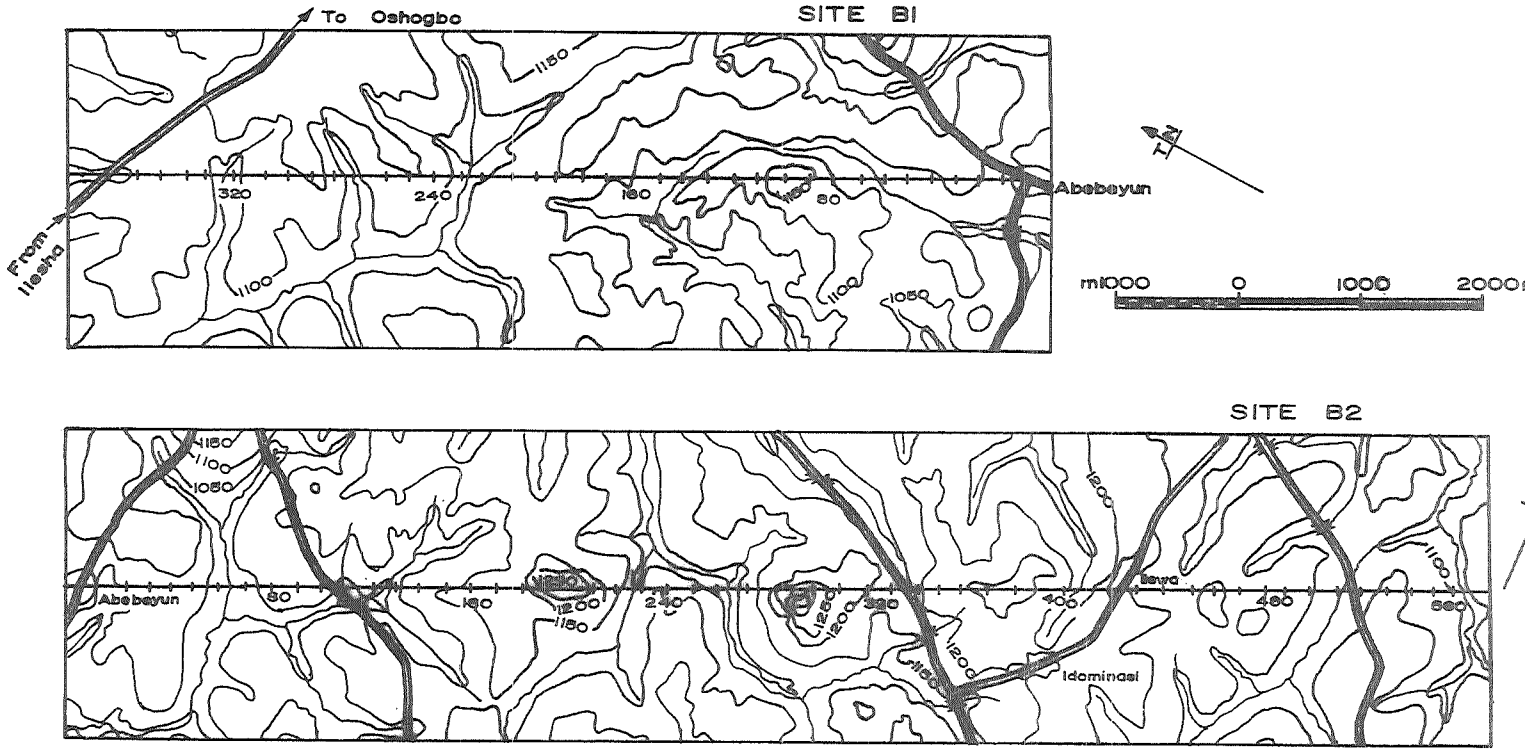
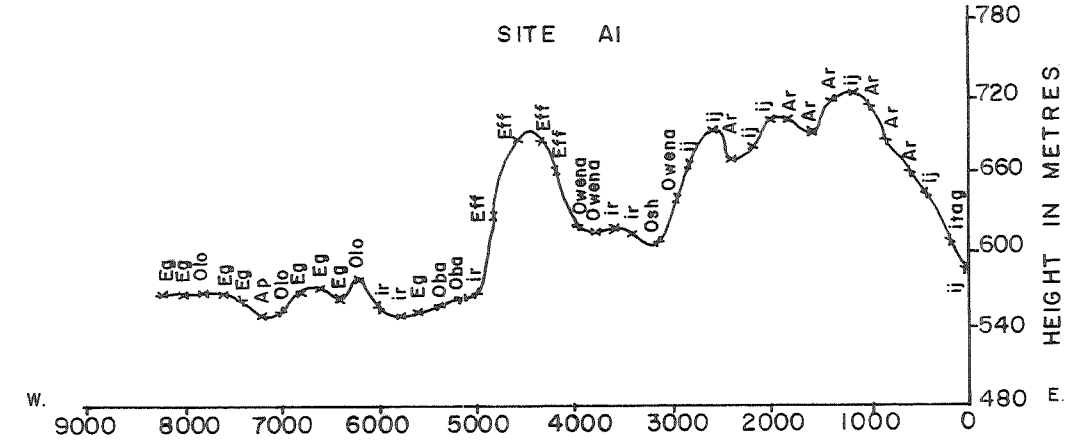
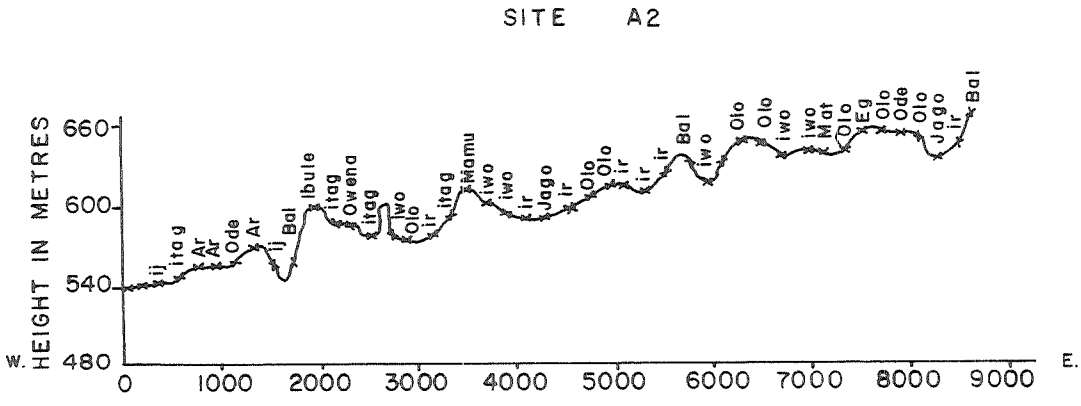


Fig. 2 a : Sample grids across landscapes on basement complex (A1, A2, B1 and B2) in Ife-Ilesha area of South-West Nigeria.





SOIL SERIES LEGEND

itag — itagunmodi
ij — ijare
Ar — Araromi
ir — iregun
Eg — Egbeda
Gamb — Gambari
Olo — Olorunda
Mat — Matako
Bal — Balogun
Ode — Odeyinka
Ap — Apomu
Eff — Effon

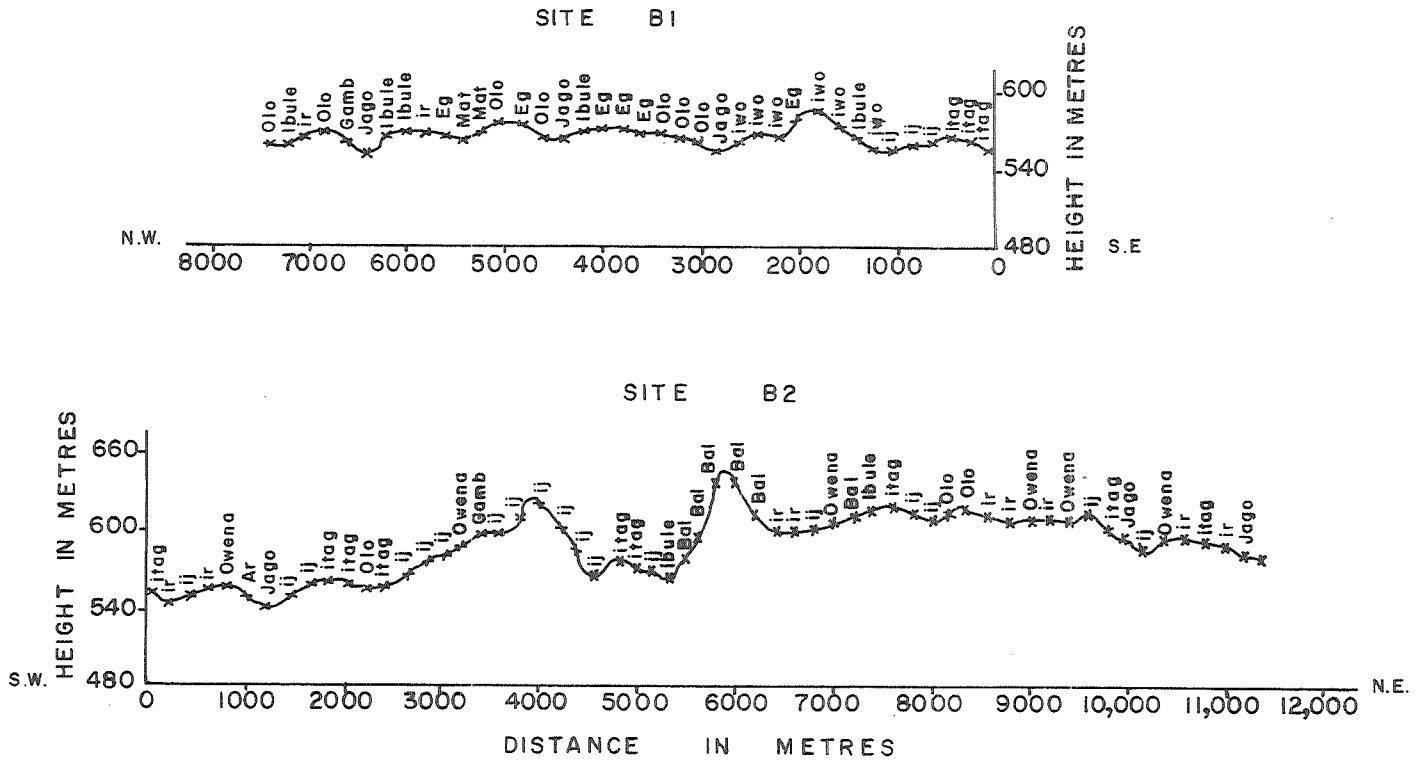


Fig. 2 b : Diagrammatic representation of the selected landscapes (A1, A2, B1 and B2) used in determining landform parameters about each sampling point.

Elevation (XG) data were obtained for each grid point by levelling with the Dumpy level and values were given in metres relative to standard reference points which in all cases were the local valley floors. Other geomorphic parameters like slope gradient, length of slope, slope length direction, slope length curvature and distance from local summit were determined at each grid point (Fig. 2 A_1, A_2, B_1 and B_2) as follows :

(i) Slope gradient (XS) was measured in the field with an Abney level and values were expressed in percentages.

(ii) Slope length direction (XD) was measured following the method used by WALKER *et al.* (1968 a) as the angle between chosen reference direction and the downslope projection of the slope length direction line.

(iii) Slope length curvature (XC) was measured as the value of the ratio of the slope gradient at a grid point to the slope gradient at an adjacent downslope grid point. Values of slope length curvature greater than unity indicate concavity, and the values less than unity indicate convexity.

(iv) Distance from local summit (XDE) was measured as the distance of grid point from the nearest local summit.

(v) Length of slope (XDL) was a direct measure in metres of the slope length from a grid point to the nearest points of slope break or curvature up and downslope.

The geomorphic parameters were then fitted to soil data in simple regression and correlation analyses. Also simple correlation analyses among the various geomorphic parameters were examined. The major soil types observed in the study area are briefly described in what follows : the locations of the soil series are shown in Fig. 2 a and 2 b.

Major soil types

The soils comprise of sedentary types like the *Itagunmodi*, *Araromi*, *Olorunda*, *Iwo*, *Egbeda* and *Ibadan* series which show close association with their underlying geology, and hill creep - *Iregun* series, and hill wash - e.g. *Jago* series which develop on migratory slope material.

Itagunmodi series (typic Paleustalf)

A well-drained profile with a reddish brown (5 YR 4/3) sandy clay loam surface layer and red (2.5 YR 5/6) sandy clay subsoil.

Araromi series (Lithic Paleustalf)

The profile is well-drained with dark reddish brown (2.5 YR 3/4) sandy clay surface layer and dark red (10 YR 3/6) sandy clay subsoil.

Ijare series (Plinthic Paleustalf)

A well-drained shallow profile with reddish brown (5 YR 4/3) sandy clay loam surface layer and dark red (10 YR 3/6) sandy clay subsoil. Iron-rich nodules increases down the profile, giving rise to a continuous hardpan at depth (50 cm).

Olorunda series (Typic Haplustalf)

A well-drained profile, with a dark brown (7.5 YR 3/2) sandy loam surface layer and reddish yellow (7.5 YR 5/8) sandy clay subsoil. Many iron-rich nodules occur at about 60 cm. Faint yellowish brown (10 YR 5/8) and red (2.5 YR 4/8) dry mottlings occur at depth.

Iwo series (Typic Haplustalf)

A well-drained profile with a dark brown (10 YR 3/4) sandy loam surface layer and reddish brown (2.5 YR 4/4) sandy clay subsoil. Faint strong brown (7.5 YR 5/8) and red (2.5 YR 5/8) dry mottlings occur at depth.

Egbeda series (Typic Haplustalf)

The soil is well-drained with dark brown (7.5 YR 3/2) sandy loam surface layer and reddish brown (5 YR 4/4) sandy clay subsoil. Common, diffuse, brownish yellow (10 YR 6/8) and strong brown (7.5 YR 5/8) mottles are restricted to the subsoil.

Ibadan series (Typic Haplustalf)

A well-drained profile with a dark brown (10 YR 3/3) gravelly loamy sand surface layer and strong brown (7.5 YR 5/8) gravelly sandy clay subsoil.

Hill-creep soils

Iregun series (Aquic Haplustalf)

A fairly well-drained profile with very dark greyish brown (10 YR 3/2) loamy sand surface layer and brownish yellow sandy clay loam subsoil. Faint, strong brown (7.5 YR 5/6) mottles occur at depth. Few, iron-rich nodules occur at depth.

CORRELATION OF SOIL PROPERTIES AND LISTED PARAMETERS

Soil series	Soil properties	Geomorphic parameters					
		XS	XE	XD	XDL	XDE	XC
Itagunmodi	YS	- 0.08	- 0.28	0.03	0.06	0.26	0.43
	YT	0.17	0.36	0.37	0.06	-	0.01
	YR	- 0.23	- 0.19	0.08	- 0.28	- 0.23	0.14
Araromi	YS	- 0.08	- 0.48	- 0.50	- 0.13	- 0.22	- 0.22
	YT	- 0.45	- 0.40	- 0.26	- 0.31	- 0.50	0.46
	YG	- 0.17	- 0.20	- 0.39	- 0.08	- 0.16	- 0.38
	YC	0.03	0.50	0.36	0.43	0.43	- 0.14
	YR	- 0.17	- 0.33	- 0.40	- 0.10	- 0.23	- 0.14
Ijare	YS	-	- 0.16	0.22	0.21	-	-
	YT	- 0.16	- 0.28	- 0.26	-	- 0.20	- 0.09
	YG	- 0.03	- 0.15	-	- 0.12	- 0.31	- 0.13
	YC	0.13	- 0.06	0.16	0.33	0.24	- 0.40
	YR	0.18	0.31	0.55**	0.08	0.01	- 0.03
Olorunda	YS	0.65**	0.04	- 0.13	0.30	- 0.09	- 0.04
	YT	0.10	0.16	- 0.29	- 0.11	- 0.20	0.02
	YG	0.18	0.17	0.18	0.11	- 0.03	- 0.10
	YC	- 0.21	0.46	-	- 0.60	- 0.16	0.24
Iwo	YS	0.06	- 0.17	- 0.53	- 0.14	0.42	- 0.12
	YT	0.25	0.02	- 0.35	0.44	- 0.12	- 0.44
	YG	- 0.08	0.05	0.14	- 0.42	0.17	0.30
	YC	- 0.11	0.56	0.07	0.01	- 0.28	- 0.15
Egbeda	YS	- 0.11	- 0.62	0.76**	- 0.30	0.16	- 0.16
	YT	0.13	0.12	- 0.32	- 0.38	- 0.50	-
	YG	- 0.14	- 0.22	0.20	- 0.10	-	- 0.29
	YR	0.33	- 0.46	0.22	- 0.36	- 0.08	- 0.34
Ibadan	YS	-	-	-	-	-	-
	YT	0.66	0.15	0.26	0.41	- 0.56	0.93**
	YG	0.55	0.44	- 0.07	0.41	- 0.21	0.21
	YC	- 0.41	0.23	0.43	0.15	0.68	- 0.57
	YR	0.24	0.51	0.24	- 0.41	- 0.14	0.41
Hill-Greep soils (*Iregun*, etc...)	YS	0.12	0.03	- 0.26	0.02	- 0.11	- 0.32
	YT	- 0.01	- 0.30	0.13	- 0.40	0.27	0.53**
	YG	- 0.11	- 0.30	0.20	0.03	0.22	0.52**
	YC	- 0.25	0.08	- 0.05	0.04	- 0.05	0.07
	YR	- 0.16	0.01	- 0.03	0.10	- 0.11	0.03
Hill-wash soils (*Jago*, etc ...)	YS	- 0.20	0.42	0.16	0.03	- 0.08	0.30
	YM	0.40	- 0.48	- 0.01	- 0.46	0.67**	- 0.41
	YT	- 0.28	0.60	- 0.12	0.30	- 0.54	0.16
	YG	- 0.47	0.30	- 0.18	- 0.41	0.02	0.78**
	YC	0.59	- 0.50	- 0.48	0.05	- 0.53	- 0.20

Tab. I : Correlations between soil properties and geomorphic parameters of some soils along the selected landscapes.

Tab. II *(next page)* : Correlations among geomorphic parameters associated with some soils across the selected landscapes.

Significant levels of correlation coefficients for each soil type and for each site (0.05 level* significant; 0.01 level** highly significant.

Soil series	Geomorphic parameters	XS	XE	XD	XDL	XDE	XC
Itagunmodi	XS	1.00	-	-	-	-	-
	XE	- 0.22	1.00	-	-	-	-
	XD	0.77**	0.08	1.00	-	-	-
	XDL	0.62**	0.20	0.42	1.00	-	-
	XDE	0.75**	- 0.07	0.63**	0.70**	1.00	-
	XC	0.26	0.13	0.41	0.35	0.07	1.00
Araromi	XS	1.00	-	-	-	-	-
	XE	0.14	1.00	-	-	-	-
	XD	0.54*	0.42	1.00	-	-	-
	XDL	- 0.24	0.42	0.25	1.00	-	-
	XDE	0.38	0.52	0.13	- 0.07	1.00	-
	XC	0.15	0.22	0.16	- 0.25	0.18	1.00
Ijare	XS	1.00	-	-	-	-	-
	XE	0.42	1.00	-	-	-	-
	XD	0.39	0.49**	-	-	-	-
	XDL	- 0.10	- 0.29	0.05	-	-	-
	XDE	0.13	0.14	0.42*		0.22	1.00
	XC	0.06	0.39*	0.31	- 0.29	0.06	1.00
Olorunda	XS	1.00	-	-	-	-	-
	XE	0.17	1.00	-	-	-	-
	XD	- 0.07	0.08	1.00	-	-	-
	XDL	- 0.12	- 0.43	0.02	1.00	-	-
	XDE	- 0.03	- 0.18	0.06	0.34	1.00	-
	XC	- 0.33	0.23	0.05	- 0.03	- 0.30	1.00
Iwo	XS	1.00	-	-	-	-	-
	XE	- 0.41	1.00	-	-	-	-
	XD	- 0.54	0.60*	1.00	-	-	-
	XDL	- 0.03	- 0.25	- 0.42	1.00	-	-
	XDE	0.29	0.06	- 0.30	- 0.02	1.00	-
	XC	- 0.44	0.15	0.21	0.15	- 0.14	1.00
Egbeda	XS	1.00	-	-	-	-	-
	XE	0.02	1.00	-	-	-	-
	XD	- 0.04	- 0.84**	1.00	-	-	-
	XDL	- 0.03	0.04	0.09	1.00	-	-
	XDE	- 0.14	0.34	0.06	0.08	1.00	-
	XC	- 0.60	0.40	- 0.22	0.31	0.25	1.00
Ibadan	XS	1.00	-	-	-	-	-
	XE	0.05	1.00	-	-	-	-
	XD	- 0.37	0.47	1.00	-	-	-
	XDL	0.52	- 0.44	0.02	1.00	-	-
	XDE	- 0.83	0.45	0.62	- 0.51	1.00	-
	XC	0.79	- 0.16	- 0.02	0.63	- 0.79	1.00
Hill-Creep soils (*Jago*, etc ...)	XS	1.00	-	-	-	-	-
	XE	- 0.16	1.00	-	-	-	-
	XD	0.02	- 0.66	1.00	-	-	-
	XDL	0.01	0.04	0.12	1.00	-	-
	XDE	0.22	- 0.07	0.02	0.08	1.00	-
	XC	- 0.18	- 0.32	0.18	- 0.02	0.56**	1.00
Hill-Wash soils (*Jago*, etc ...)	XS	1.00	-	-	-	-	-
	XE	- 0.59	1.00	-	-	-	-
	XD	- 0.59	0.14	1.00	-	-	-
	XDL	0.16	0.31	0.36	1.00	-	-
	XDE	0.38	- 0.39	0.52	- 0.47	1.00	-
	XC	- 0.11	0.01	0.14	- 0.40	0.22	1.00

Hill-wash soils (Tropaqualfs)

The soils are poorly-drained, with very dark brown (10 YR 2/2) sandy clay loam or dark grey (10 YR 4/1) loamy sand surface layers and yellowish red (10 YR 5/3) sandy clay or light grey brown (2.5 YR 6/2) sandy subsoils. Distinct gleyed mottles of reddish brown (5 YR 4/5) or faint mottles of brownish-yellow (10 YR 6/1) occur at depth.

RESULTS

Soil properties and geomorphic parameters

The relationship between soil properties and individual landform parameters are shown in table I. In the *Itagunmodi* and *Araromi* series, there was no significant correlation between the soil properties and associated geomorphic parameters. Slope length direction (XD) is very strongly correlated with (i) the depth of distinct reddish colouration (Hue 2.5 YR) in *Ijare* series, and (ii) the thickness of surface layer (YS) in *Egbeda* series. The slope gradient (XS) is very strongly correlated with thickness of surface layer (YS) in *Olorunda* series. Elevation (XE) is strongly correlated with percent concretions at 50 cm (YC) in *Olorunda* and *Iwo* series. In the *Ibadan* series, the depth to sandy clay horizon (YT) is very strongly correlated with the slope length curvature (XC). In the hill-creep soils, the depth to sandy clay horizon (YT) and the percent rock fragments at 50 cm (YC) are very strongly related to the slope length curvature (XC). In the hill-wash soils, the depth to mottles (YM) is very strongly correlated with distance from local summit (XDE) and the percent rock fragments at 50 cm (YG) is very strongly correlated with slope length curvature (XC).

Correlations among geomorphic parameters

The relationship among geomorphic parameters at each inspection point is shown in table II. In some cases, highly significant correlations occur between the parameters, but in the areas associated with *Olorunda*, *Egbeda*, *Ibadan* and the hill-wash soils, there was no significant correlation among the various geomorphic parameters.

In the *Itagunmodi* sites, the slope gradients (XS) are very strongly correlated with the slope length direction (XD); the length of slope (XDL) and the distance from local summit (XDE). Also, the distance from local summit (XDE) is very strongly correlated with slope length direction

(XD) and the length of slope (XDE). In the Akomi sites, the slope length direction (XD) is strongly correlated with the slope gradient (XS). In the *Ijare* sites, the slope gradient (XS) is strongly related to the elevation (XE) and the slope length direction (XD). Also, elevation (XE) is very strongly related to slope length direction (XD) and strongly related to slope length curvature (XC). And the slope length direction (XD) is also strongly related to the distance from local summit (XDE). In the *Iwo* sites, elevation (XE) is strongly correlated with the slope length direction (XD). In the hill-creep soil sites, the distance from local summit (XDE) is very strongly correlated with the slope length curvature (XC).

DISCUSSIONS

Correlations analysis has been used as a means of evaluating the relationship between certain geomorphic parameters and soil properties. Generally, it was observed that slope length curvature and slope length direction were most strongly related to some soil properties measured. Elevation, slope gradient and distance from local summit were also important parameters for percent concretions at 50 cm; thickness of surface layer and depth to mottle respectively. Nevertheless, considerable soil properties remained unaccounted for. A possible conclusion would be that the changes in soil properties are a true reflection of the effect of slope, and this indicates the importance of slope in soil boundary delineation. It also conforms with the catenary sequence established in south western Nigeria by SMYTH & MONTGOMERY (1962), MOSS (1965) and MURDOCH *et al.* (1976).

Also, correlation analysis has been used to evaluate the relationships among individual geomorphic parameters. Generally, it was observed that slope gradient was most strongly related to slope length direction, length of slope and distance from local summit. As well, slope length direction, distance from local summit and elevation were important parameters, which were strongly correlated. But, considerable geomorphic parameters remained unrelated.

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