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Full Length Research Paper

Lithologic discontinuity and pedogenetic characterization on an aberrant toposequence associated with a rock hill in South Western Nigeria

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Pedons formed from hill creep and hill wash soils along an aberrant toposequence associated with a rock hill were studied to understand the morphogenetic properties influencing soil formation in Ile-Ife area, South Western Nigeria. Soil morphology, physical (including sand fractions), and chemical properties were used to characterize and classify the soils. The results showed that lithologic discontinuities were expressed by presence of stone lines, abrupt changes in soil texture/sand sub-fractions and accumulation of cations in surface than sub-surface pedons. The active pedogenic processes influencing soil formation include, transportation and deposition, cummulation and homogenization. Regolith types formed include" colluvio-residuum, colluviums and alluvium underlaid with soil residuum. Pedons 1 and 2 were classified as dystrochrepts (Dystric Cambisols). Pedon 3 was classified as Ultic Udarents (Lixic Arenosols) pedons 4 and 5 are Typic Rhodudults (Rhodic Lixisol) and Plinthudults (Plinthosols) while Pedon 6 was classified as Anthropic Quartzipsamments.

Key words: Lithologic discontinuity, morpho-genetic characterization, soil classification, rock hill, regolith types.

INTRODUCTION

Differences in the mode of formation of the parent material give rise to differences in soil morphology. This in turn are distinctly different from those in the parent rock. Such examples are unconsolidated glacial and loess (wind blown silt) in the temperate regions. As well as unconsolidated coastal plain sediments along the Gulf and Atlantic coasts of North America and West Africa (Moss, 1965). Smyth and Montgomery (1962) recognized four types of parent material in Central Western Nigeria as hill creep; sedentary (in situ), hill wash and alluvial deposit. On steep slopes, several geomorphic processes that may be active are debris avalanche, soil creep, slope wash and solution (Graham et al., 1990).

Debris avalanches may range from a few meters in length to 1,500 m. Regolith or soil materials transported by debris avalanche accumulate on lower slope position as colluviums. Soil creep is the slow, almost imperceptible non-accelerating down-slope movement of superficial soil or rock debris (Selby, 1982). Soil creeps or hill creeps are the products of large boulders (Smyth and Montegomery, 1962) which add to accumulation of colluvium on lower slope position thus create a thin blanket of colluviums over most of the landscape (Graham et al., 1990). Soils developed in such materials tend to be loose because of their coarse texture as observed in Balogun series (Smyth and Montgomery, 1962). Slope or hill wash has been defined by Young (1972) as the downslope transport of regolith materials through the effect of raindrop impact and overland waterflow. Soils formed under this condition are made up of finer colluvial particles which accumulate in lower slope sites. An example of this is Oba series (Smyth and Montgomery, 1962). Alluvial parent material is formed by the re-deposition of material carried in suspension by streams and rivers. It may therefore be composed of materials derived from a variety of rock types and is often very variable in composition. Ionic products of regolith weathering (or pedogenesis) may be precipitated as secondary minerals or as amorphous materials, absorbed by clays, or removed in solution by leaching. All these slope processes are responsible for the distribution of various kinds of regolith on hill slopes.

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Graham et al. (1990) described soil residuum as different from saprolite in the sense that pedogenic processes have destroyed the continuity of the original rock structure (in residuum). They reported that soil residuum may be massive or have soil structure and that fragments of saprolitic material may persist within the soil. It is however distinct from colluvium in that it has not been transported laterally, although rock structure has been distrupted. The nature and the distribution of regolith on slopes have been used in soil genesis studies and in predicting soil distribution on landscapes.

Soil profile variation therefore occurs due to landform processes of transformation and deposition. These have led to non-uniformity and discontinuity in parent materials. Such additions (deposition) include volcanic ash, loess or variations in the sedimentation conditions of alluvial materials and colluvium. Stone lines have often been found to be indicators of discontinuity in cases of colluvial overlays as part of landscape evolution processes (Ahn, 1970). Furthermore, unconformity between the overlying materials and that below may also be marked by mottles or an indurated zone (Ahn, 1970). Stoneline is an evidence of non - uniformity of parent materials due to past erosion (Ojanuga, 1978). It is often possible to prove that the stoneline came from an old land surface which contained an indurated and hardened laterite layer. Different soil types were formed due to different exposure to morphogenesis processes such as eluviation, illuviation, deposition, cementation of pedo-sediments and multiple stratification as determined by the position of the pedon on the landscape. This has necessitated this study with the aim of assessing the pedogenic characteristic associated with lithologic discontinuity.

MATERIALS AND METHODS

Description of the study area

The area of study lies approximately within longitude 4° 30´E and 4°50´E and latitude 7°21´N and 7°30´N.

The landscape selected was an arable farm land located below North west hills of Obafemi Awolowo University Ile-Ife. The landscape is a gently undulating terrain. The land use is a mixture of bush regrowth and arable crops. The area has been under cultivation for more than ten years. The crest was cultivated to cassava. Mid-slope section was previously cultivated to maize, the stumps of which were seen during the time of study. Along the river course were sugar cane stands, scattered oil palm (*Elaeis guineensis*) and Cola (*kola nitida*) trees.

The area of study is humid tropics with distinct dry and wet seasons of about 4 and 8 months respectively. The climatic data recorded about 2 km away put annual rainfall at 1300 mm. The mean air temperature is 13℃. The area of study is specifically underlain by coarse/medium grained granite gneisses (Boesse and Ocan, 1988). This terrain is unique being below a rock hill. Hence hill creep soils are expected to dominate the area especially on the upper slope position.

Field work

Reconnaissance Survey of the area of study was done prior to site selection. Minipits were dug at 50 m apart to select sites for profile pits and for better understanding of soil distribution along the landscapes. Profile pits were subsequently established based on variabilities at different slope facets which are the summits, upper slopes, mid slopes, break of slopes and lower slopes positions above the valley bottom. The horizons designations of Soil Survey Staff (2003) were used. Bulk soil samples were collected from each horizon.

Samples were collected from each horizon for bulk density determination by core method. The morphological characteristics of soil were described. The gradient of the slope on which each profile was sited were measured.

Laboratory analyses

Samples were prepared and routinely analysed following the guidelines of International Institute of Tropical Agriculture (IITA) (1979).

Soil classification

Soil were identified and classified according to Smyth and Montgomery (1962) at series level and Soil Taxonomy (Soil Survey Staff, 2003) and FAO/UNESCO (1994).

RESULTS AND DISCUSSION

Soil morpho-genetic characterization

Six pedons were identified on the slope facets from rock hill to the lower slope. Their morphological description is shown in Table 1. Pedon 1 (in Table 1) contains weathered rock fragment in the subsoil layers. The first 3 layers seem to be concurrently formed in washed-in materials because of the drastic change in soil texture compared to those formed in the subsoil horizons. The soils of this profile are in bands with identical mineral fabric (structures) as observed in the weathered rock. This probably indicates that the rate of weathering is faster than the rate of transportation. Therefore, the rock boulders are seen weathered in their original sites and forming bands. Carson and Kirkby (1972) reported a similar result in their study of slope development processes. The soil was identified as Balogun series (Smyth and Montgomery, 1962)

Pedon 2 (in Table 1) is located almost at the foot of the rock hill. The top material is like “a heap” on top of residual materials showing cumulative effects of deposition.. This is separated by a stone line made up of smoky quartz cobbles. The residuum consists of weathered feldspars within the stone line. The weathered rock contains ageing iron. This probably explains further the differences in composition of surface and subsurface materials. Such stone lines had been used by Ojanuga (1978) to identify lithologic discontinuity. The soil has been identified as Asejire series.

Pedon 3 (in Table 1) is located on the pedo-sediment around the rock hill. The profile has eight different. The profile has eight different horizons. The first four are

Table 1. Morphological properties of the soils on a rolling landscape associated with a rock hill.

Pedon 1. Balogun series

Hor	Depth(cm)	Colour	Mottle	Textures	Structure	Consistency		Root	Mineral	boundary
						(Moist)	(Wet)			
A1	0-4	10YR3/2	-	SL	cr	fr	ns sp	-	-	sc
A2	4-18	10 YR3/4	-	SL	cr	fr	ns,np	-	-	wd
A3	18-43	10 YR5/4	-	gSL	cr	fr	s,p	-	-	sc
BA	43-53	7YR4/6	-	S/gSCL	sbk		s,p	-	f	cs
Bt	53-90	7YR8/6	-	C	mabk		s,p	f	f	gd
2BW	90-134	7YR4/4 /7YR6/8		C	mabk	f		-	m	cs
2BC1	134-150	2YR5/4 /2.5YR5/8	-	SCL	abk	f		-	-	
		2.5YR5/8	-		mabk				-	
2BC2	150-205	5YR8/1		SCL	cabk	f	s,p			

Pedon 2. Asejire series

Hor	Depth(cm)	Colour	Mottle	Textures	Structure	Consistency		Root	Mineral	boundary
						(Moist)	(Wet)			
A1	0-6	10YR2/2		L	cr	fr	s/ sp	f	-	gs
A2	6-22	10YR4/3		SCL	cr	fr	s/sp	m	-	gs
A3	23-34	10YR4/4		gL	cr	fr		fm	G	gs
B	34-77	7.5YR4/4		gCL	cabk	fr	vsp	f	fe	cw
2BW1	77-120	7.5 4/6		CL	cabk	f	svp	f	(felds)	cs
X	120-134(x)	2.5YR6/4		gC	abk	f			vc,fe	ci
		10YR6/4							vc, fe	
3BW	134-160	5YR4/8		gC	abk	f	sp		co	ci
		10YR8/8							vc	
Bcr	160-205	10YR2/1		gC	abk	vf	sp		vc	

Pedon 3. Akure series

Hor	Depth (cm)	Colour	Mottle	Textures	Structure	Consistency		Root	Mineral	boundary
						(Moist)	(Wet)			
AP	0-19	10YR2/2	L	gr	fr	p.s	fm	-	-	gs
A1	19-30	10YR4/4	L	sb/c	fr	s/sp	ff	-	-	cs
A2	30-45	YYR4/6	gCL	cr	fr	s/sp	ff	fe	-	cs
2Bt	45-65	5YR4/4	CL	sbk	fr	vs,p	ff	-	-	as
3BW1	64-126	5YR 4/6	C	sbk	f	sp	fm	fe	-	
		10YR5/4								
X	146-153	2YR4/0	gL		f	-		-	-	as
		10YR5/4								
4BCr	153-200	2YR4/6	L	pabk	-	s/s,p		-	-	-
		YB10YR								

Pedon 4. Oba series

Hor	Depth(cm)	Colour	Mottle	Textures	Structure	Consistency		Root	Mineral	Boundary
						(Moist)	(Wet)			
A	0-11	5YR3/2	-	L	cr	fr	s/s/sp	ff	-	gw
BA	11-22	5RY3/4	-	L	cr	fr	sp	fm,c	-	c
B	22-89	2.5YR3/6	-	C	sbk	f	s/sp	fm	-	ss
B	89-114	2.5YR3/6	-	CL	sbk	af	s/sp	ff	-	cw
2CB	114-180	10YR6/6	-	CL	abk	vf	s/sp	cf	-	

Table 1. Contd.

Pedon 5. Gambari

Hor	Depth(cm)	Colour	Mottle	Textures	Structure	Consistency (Moist)	Consistency (Wet)	Root	Mineral	Boundary
A	0-15	7.5YR4/4	-	SL	cr	fr	ns sp	-	cf	dw
BA	15-27	10YR4/4	-	SL	cr	fr				
B	27-50	5YR4/4	-	SL	cr	fr	-	-	Fe	cs
	50+	10YR6/6	-	g Cl	bk	fr	vsp			cs
		10YR6/8	-						Fe	

Pedon 6. Iregun series

					Consistency		Root	Mineral	Boundary
Depth(cm)	**Colour**	**Mottle**	**Textures**	**Structure**	**(Moist)**	**(wet)**			
AP	0-20	10YR3/2	L	g	l	ns sp	-	cfm	ds
A1	20-40	10YR4/3	SL	sbk	fr	ns sp	-	m	cs
(X)	40-50	10YR4/3	gCL	sbk	fr	ns	-	f	cs sp
2Bt	50-70	10YR4/3	S/gC	sbk	f	sp	-	-	cs
2C	70-150	2.5YR5/2	SL	sbk	fr	ns sp	-	-	

deposited loosely on one another and seem to be under active creep movement. They are therefore considered as colluvial. Graham and Boul (1990) observed such colluvial deposit on the Blue Ridge Front in North Carolina. The next two horizons have higher clay content, some of which might have been originated from elluvial-illuvial processes as evidenced by patch clay skins on ped surfaces (Appendix 2). The presence of a stone line probably separates these outwash fans from the colluvial soil below. The pedon description matches the soils of Akure series (Smyth and Montgomery, 1962).

Pedon 4 (Table 1) is located on the mid-slope position. The pedon is reddish with uniform homogenous horizons which appear to be sitting on the sedentary variegated layer at 89 cm depth. Water seepage was observed during profile digging at 85 cm depth. This is considered as an additional evidence of different layers of different permeability that established a discontinuity in lithology. The soil was described as Oba series.

Pedon 5 is shallow (120 cm) and is located at the break of slope. The top part of the regolith is loose and has fine texture compared to the hard subsoil section of there golith. The profile has scattered iron concretions. The pedon has been identified as Gambari series (concretional variation).

Pedon 6 is at the lower slope position at about 75 cm from the valley bottom. A very gravelly layer of 10 cm separates the surface horizons from the B horizon. This stone line is an indication of a break in lithology between the subsoil forming *in situ* and surface outwash particles since the stone line was recorded in the BA which is transition horizon. Stone lines formation are peculiar to soil formation in almost all the profiles described.

Physical properties

The surface horizons of pedons 1 - 6 have coarse texture which range from sandy loam to clay loam. The subsurface horizons of the upland pedons and those of mid-slope position (pedons 1 - 5) have finest textures dominating compared to other pedons. These range from clay loam to clay. The textures of the subsurface horizons in the lowland pedons vary between sandy loam to sandy clay loam.

Where major breaks were recorded as in Pedons 1 and 2 there is a shift in fine sand distribution for Pedon 1 and in medium and fine sand distribution for Pedon 2 (Table 2).

In pedons 3 which is Akure series, there is almost uniform distribution of sand subfractions. This is also in conformity with uniform morphology characteristics described as in Table 1. In pedon 4 the biogenetic nature is described by random distribution of sand subfractions in the surface horizons and with clear boundary with the clay sub soil underneath. The fine sand is randomly distributed in the surface colluviuum and increase down the profile in the residuum.

There is no specific pattern of distribution of sand subfractions in pedons 5 and 6 except for fine sand. The fine sand has higher values in the surface horizons. Generally, medium sand has the highest values in quantity in all the pedons with maximum value of 35.67% recorded in pedon 1.

Silt content is very high in the soil pedons. It varies from about 18 to 30%. This is a pointer to stage of development of the soils. High silt content is a pointer to low degree of weathering. Pedon 5 (Shanroji series) has high silt content formed after the surface soils has been washed away and replaced by new hill wash materials over paralithic contact at a depth less than 100 cm. This distinguished this soil from the common Gambari series in the South Western Nigeria from the classification of Smyth and Montgomery (1962).

Clay content increases generally with increasing depth

Table 2. Particle size distribution on a rolling landscape associated with a rock hill.

Horizon	Depth (cm)	Very CS %	CS (%)	M (%)	F (%)	VF (%)	Sand (%)	Silt (%)	Clay (%)	Sand + Silt (%)	BD	Texture
						P 1						
A_1	0 – 4	8.40	17.80	28.40	12.90	0.80	68.20	16.09	15.20	84.80	.95	SL
A_2	4 – 18	10.0	15.00	25.20	17.40	0.20	68.20	21.00	10.80	89.20	1.47	SL
A_3	18 –43	13.4	16.40	5.00	17.90	1.90	69.70	13.11	18.20	81.80	1.37	SL
B_1	43 –53	13.2	13.90	18.50	7.10	0.10	52.80	19.50	27.70	72.30	1.34	SCL
$2B_t$	53 –90	9.20	9.50	11.50	4.90	0.10	35.20	24.40	40.40	59.60	1.37	C
$3B_{wt}$	90 134	3.80	5.70	10.50	8.00	0.50	28.50	23.30	48.70	51.80	1.35	C
4BC	134-150	2.40	8.50	15.30	8.40	0.40	35.00	18.60	46.40	53.60	1.36	C
5BC	150-205	0.65	6.20	24.30	11.00	3.60	51.60	18.20	30.20	69.80	1.34	SCL
	$205\text{-}230^+$	0.60	6.30	24.90	17.90	1.87	51.60	18.20	20.30	69.80		SCL
						P2						
A_1	0 – 6	5.20	9.30	18.60	9.60	0.30	43.00	31.50	25.50	74.5	1.30	L
A_2	6 – 22	7.50	11.30	23.70	9.40	0.10	52.00	28.50	19.50	80.5	1.33	SCL
A_3	22 – 34	9.50	11.20	20.00	8.90	0.70	50.30	29.71	20.00	80.00	1.46	L
B	34 – 77	7.50	9.40	14.00	5.80	0.90	36.79	25.21	38.00	62.00	1.46	CL
$2B_{w1}$	77-120	9.10	7.70	7.90	8.10	0.72	33.50	28.48	38.00	62.00	1.58	CL
$2B_{w2}$	120-134	6.30	7.90	12.30	4.30	0.00	30.80	27.20	42.00	58.00	1.60	C
$3B_w$	134-160	7.40	8.40	12.10	4.10	0.10	32.10	25.90	42.00	58.00	1.59	C
$4BC_r$	160-205	6.30	7.90	12.30	2.60	0.10	29.20	28.80	42.00	58.00	1.61	C
						P3						
AP	0 – 10	2.80	9.90	22.80	11.70	0.30	47.50	32.10	20.40	79.60	1.04	L
A_1	10 –30	3.50	9.90	18.10	7.60	0.10	39.20	20.20	34.60	65.40	1.53	CL
AB	30 –70	4.86	10.87	22.40	11.50	0.08	49.70	25.90	24.40	75.60	1.61	SCL
2B	70 .100	2.56	4.70	11.20	6.70	.01	25.20	34.60	40.20	59.80	1.58	C
$2BW_1$	100.135	2.74	8.20	16.70	6.60	.38	34.70	25.25	40.10	59.90	1.42	C
$3BW_1$	135.200	3.09	8.01	16.00	6.90	.10	37.10	27.30	38.60	64.40	1.43	CL
$3BW_2$	200.206	4.30	8.00	15.30	6.70	0.10	34.40	27.20	38.20	61.60	ND	CL
----	206^+	5.30	8.50	15.20	6.60	0.10	35.10	26.7	38.20	61.80	ND	CL
						P 4						
A	0 -11	1.87	7.17	17.96	10.10	0.10	37.20	44.40	18.40	81.60	1.10	L
AB	11 –42	5.40	12.90	30.10	4.80	0.10	53.30	28.30	18.40	81.60	1.71	L
B	42 -89	3.90	7.64	14.60	6.70	1.10	32.00	26.57	41.40	58.60	1.51	C
$2BW_1$	89 114	5.39	9.31	15.50	5.30	0.10	37.40	25.20	37.40	62.60	1.53	CL
2CB	114180	6.70	10.30	15.50	6.00	0.20	38.40	22.60	38.70	61.30	1.67	CL
2CB	180^+	6.00	9.70	14.90	6.40	0.40	37.40	24.20	28.40	61.60	ND	CL
						P 5						
A	0 15	6.20	13.90	26.00	16.10	1.90	64.10	27.00	8.90	91.10	1.41	SL
BA	12 –27	10.78	14.70	23.10	9.80	0.20	58.60	25.20	16.20	83.80	1.50	SL
2B	27- 50	6.80	11.70	17.10	6.10	0.20	41.90	23.40	34.70	65.30	1.56	CL
2CE	50 –70	12.60	15.40	17.70	5.40	0.20	61.30	18.50	30.20	69.80	1.73	SCL
2C		17.10	16.40	16.20	5.20	0.20	55.10	17.40	25.50	72.50	1.68	SCL
						P6						
AP	0 –20	9.49	14.30	24.30	10.40	0.40	50.90	26.40	14.70	84.40	1.21	SCL
A_1	20-40	7.10	21.90	21.10	13.90	1.00	65.00	20.30	14.20	85.30	1.67	SL
BA	40 -50	11.98	13.10	24.00	11.70	0.70	61.50	23.80	14.70	85.30	1.76	SL
$2B_t$	50-70	13.97	14.40	21.50	7.60	0.20	57.80	15.70	26.60	73.40	1.75	SCL

Table 2. Contd.

2C	70 -150	28.20	14.10	10.60	5.40	0.40	58.70	18.40	22.90	77.10	1.65	SCL
	150^+	29.40	14.20	11.70	6.40	0.50	62.20	19.40	18.40	81.60	1.55	SL

VCS -very coarse sand; CS-coarse sand; M- medium; F-fine; VF-very fine; BD-bulk density; P- Pedon.

to a maximum and then decreases in the C horizon of all the soil profiles. Similar finding was recorded by Ojanuga (1978) except in Pedon 2. This could be due to its position on the toposequence which leads to fast colluvium accumulation. The mass accumulation of colluvium probably prevents the expression of residuum observed in the subsoil. Cutans formation is weak, which indicate low pedogenetic process of illuviation especially on the upland soils. However there is formation of argillic horizons in Pedons 1, 3 and 4.

In Pedon 1, the bulk density is also almost uniform (about 1.35 g/cm^3). The bulk density values increase with increasing depth for pedons which have colluvium top (e.g. pedons 2 and 5) while others which are basically colluvium have variable values (e.g. pedons 3 and 6). However, there is a general increase in bulk density for pedons in Oba series (pedons 5) which has alluvium surface over soil residuum.

Chemical properties

Table 3 shows the chemical composition of the soils; pH is neutral to slightly acidic in almost all the pedons. This is probably due to the release of clay and nutrient from colluvial deposited minerals when they further get transformed (Graham, 1990). Calcium and Mg are also dominant cations in these soils. Surface horizons have more variable composition being area of active depositional processes and the distribution tends to be uniform in the saprolite but probably differs according to the degree of weathering it has undergone. Sodium ion and k^+ are also very low in all the pedons (<0.06 cmol/kg). The parent mineral are probably poor in minerals rich in K and Na. Exchangeable acidity is generally low especially in the colluvial deposits (0.3 - 0.7 cmol/kg). The collivium has probably lost A1 bearing minerals during pedogenesis. Base saturation is generally high, >40% in the residuo-colluvium sub-regolith (partially decomposed saprolite).

Base saturation decreases concomitantly with increase in exchangeable acidity. Aluminum saturation is very variable in pedon 1. However, in other upland colluvium, the A1 saturation is also narrowly variable.

Lithologic discontinuity

Generally, in upper pedon positions due to outwash and eluviations, gravel has accumulated in the upper horizons forming stone lines. Stone lines are therefore common features and either separate different colluvial materials or separate colluvium from residuum. They occur in all soil profiles at all observed slope positions except in pedon 5. Coarse materials (rocks / cobbles / boulders) are characteristic features of pedons close to the rock hill and these gradually decrease downslope. This conforms with findings of Bitrot (1960) that initial materials near the mountain range contained more coarse and angular materials than areas farther away from the mountain range. Therefore, the characterizing features of soil bodies depend on the intensity of pedogenic activities they have passed through. The more intense the soil forming activities, the finer the features (except structure). The soil formed from rock in zones of deposition gives characteristics similar to *in situ* soil development. However, the colluvial origins of these different bands of rock are established by their different texture (Table 2). Weathering, transportation and deposition are active at upper slope positions such that the processes of nodules and concretion formation are excluded. However, (Pedon1, 2 and 3), the soil formed *in situ* are either "colluvio-residuum", totally in residuum or colluvium underlaid with residuum. "Colluvio-residuum" is the term used in this study to describe rock boulders that are deposited and later weathered in zone of deposition. This has been explained by Carson and Kirkby (1972) that the rate of weathering being faster than the rate of transportation because of the large size of boulders. This colluvio-residuum have variegated saprolite until further pedogenic activities take place to homogenize them characterized the pedon (Table 2).The Pedons have clear boundary (Tables 1 and 2). The boundaries are also smooth showing distinct and separate layers of horizons of different origin. This is unlike soils totally formed *in-situ* where the boundaries are not easily discerned being either diffuse or gradual and either irregular or wavy (Ande, 1995). The contrast in horizon boundaries indicates different mode of formation, or time of deposition which are directly related to process of soil formation or weathering. Loose and weak structures characterized colluvial soils on the surface horizons while, uniform sub soils in Pedons 2 and 3 might have been developed due to homogenization of colluvium deposit over time.

Soil classification

Following Soil Survey Staff (2003) classification, Pedons1 and 2 are classified as Inceptisols and further classification put them into the dystrochrepts (Dystric

Table 3. Chemical characteristics of the pedons.

Horizon	Depths	pH H_20	pH KCL	$A1^{+3}$ Acidity	H^+ Acidity	Exch. bases	Ca^{2+}	Mg^{2+}	k^+	Na+	Sum of ECEC	%Base	A1Sat%	Org.C. %	(cm)
Pedon 1. Balogun series															
A1	0-4	6.55	6.05	0.10	0.30	.40	6.25	4.29	0.23	.01	11.28	11.68	96.58	.86	7.98
A2	4-18	6.05	5.35	0.20	0.80	1.00	15.00	0.92	0.03	.01	15.96	16.96	94.10	1.18	0.88
A3	18-43	6.35	4.95	0.30	0.20	0.50	1.25	1.33	0.03	.01	2.62	2.67	98.13	11.24	0.62
BA	43-53	5.85	4.70	0.20	0.20	0.40	1.25	4.29	0.04	.01	5.59	5.99	93.32	3.34	0.70
2Bat	53-90	5.25	4.10	0.50	0.40	0.90	1.25	4.29	0.06	.02	5.62	9.52	59.03	5.25	.82
3BW	90-134	4.70	3.65	4.40	-0.80	3.60	1.25	1.46	0.05	.02	2.78	5.78	48.1	76.12	0.62
4Bc	134-150	4.65	3.65	8.40	-0.40	8.00	1.25	1.46	0.05	.01	2.77	10.77	25.72	77.99	0.43
5Bc	150-205	4.55	3.50	11.20	-3.20	8.00	1.25	1.29	0.04	.01	2.59	10.59	24.46	105.76	0.43
Pedon 2. Asejire series															
A1	0-6	8.00	6.40	0.20	0.50	0.70	20.00	1.96	0.0	0.02	22.03	22.73	96.92	.88	3.9
A2	6-22	7.40	6.20	0.10	0.30	0.40	7.50	1.08	0.02	.01	8.61	9. 01	95.56	1.09	2.57
A3	22-34	6.70	5.65	0.20	0.20	0.40	4.50	.79	0.02	.01	5.32	5.72	93.01	3.50	0.68
B	34-77	6.55	5.60	0.00	0.30	0.30	5.00	1.42	0.06	.02	6.50	6.80	95.50	0.00	.43
2Bw1	77-120	5.40	4.40	0.20	0.50	0.70	2.50	1.96	0.05	.01	4.52	5.22	86.59	3.83	.62
2B2	120-134	4.80	4.10	0.40	0.80	1.20	5.00	4.08	0.04	.01	9.13	10.33	88.38	3.87	.48
3Bc	134-160	5.10	4.20	0.30	0.50	0.8	4.50	2.63	0.05	.02	7.2	8.0	90.00	3.76	.76
4Bcr	160-205	5.80	3.80	0.70	0.60	1.3	2.50	1.79	0.09	.01	4.34	5.64	76.95	12.41	.57
Pedon 3. Akure series															
AP	0-19	7.00	5.30	0.30	0.40	0 .70	10.00	4.29	0.04	.01	14.34	14.41	99. 51	2.08	1.56
A1	19-30	7.30	5.00	0.10	0.30	0.40	3.00	0.96	0.02	.01	3.99	4.39	90.89	2.28	1.17
A2	30-45	6.25	4.60	0.10	0.30	0.40	1.25	1.13	0.02	.01	2.41	2.87	85.77	3.56	1.0
2B t	45-65	6.50	4.50	0.10	0.20	0.30	2.50	1.96	0.03	.01	4.50	4.80	93. 7	2.08	0.9
3Bw1	65-126	6.70	4.90	0.30	0.50	0.80	5.00	1.33	0.03	.01	6.37	7.17	88. 84	4.18	0.62
3BW	126-146	6.45	4.50	0.10	0.30	0.40	5.00	1.79	0.03	.01	6.83	7.23	94.47	1.38	0.56
4BWC1	146-153	6.25	4.60	0.20	0.40	0.60	5.00	2.13	0.03	.01	7.1	7.77	92.28	2.57	.47
4Bc2	153-200	7.20	4.70	0.20	0.30	0.50	5.00	1.46	0.03	.01	6.50	7.00	92.86	2.86	.84
Pedon 4. Oba series															
A	0-11	6.85	6.65	0.10	0.40	0.50	11.25	5.13	0.12	.02	16.52	17.02	97.06	0.59	6.94
AB	11-22	5.95	5.15	0.10	0.30	0.40	1.25	0.79	0.22	.01	2.07	2.47	83.81	4.05	0.92
B	22-89	5.05	4.25	0.30	0.40	0.70	2.50	1.46	0.04	.01	4.01	4.71	85.13	6.37	0.53
2BW1	89-114	5.10	3.80	1.40	0.60	2.00	1.25	0.83	0.02	.01	2.11	4.11	51.34	34.06	0.92
2CB	114-180	6.85	6.65	1.30	0.50	1.80	1.25	0.71	0.01	.01	1.98	3.78	57.38	34.39	0.30
2CB	180-200	7.05	6.65	1.70	0.40	2.10	1.25	0.67	0.01	.01	1.94	4.04	48.42	42.08	0.37
Pedon 5. Gambari (Concretional variation)															
A	0-13	6.35	5.65	0.10	0.30	0.40	5.00	3.46	0.33	.01	8.50	8.40	95.51	1.12	2.95
BA	13-27	5.50	4.80	0.10	0.30	0.40	1.25	0.75	0.02	.01	2.03	2.73	83.54	4.12	0.47
2B	27-50	5.55	4.80	0.10	0.40	0.50	2.50	1.08	0.03	.01	3.62	4.12	87.86	2.43	0.70
2CB	50-85	4.50	4.15	0.40	0.80	1.20	1.25	0.96	0.02	.01	1.34	2.54	52.75	15.75	0.18
2C	85-120	4.60	4.15	0.20	0.80	2.00	1.25	1.00	0.01	.01	2.27	4.27	53.16	4.68	0.12

Table 3. Contd.

Pedon 6. Iregun series.

Horizon	Depth (cm)	pH $A1^{+3}$	pH H^{+}	Exch. Bases	Ca^{2+}	Mg^{2+}	k^{+}	Na+	Sum of ECEC	%Base	AlSat %	Org.C. %	(cm)	H2O	KCl
		Acidity													
Ap	0-20	6.95	6.65	0.00	0.40	0.40	11.25	3.75	0.88	.02	15.10	15.50	97.42	0.00	1.56
A1	20-40	6.50	6.05	0.10	0.20	0.30	1.25	1.29	0.02	.01	2.57	2.87	89.55	3.48	0.43
B	40-50	6.80	6.05	0.10	0.30	0.40	1.25	1.17	0.03	.01	2.96	2.86	86.01	3.50	0.31
2B	50-50	6.70	5.85	0.10	0.30	0.40	5.00	1.33	0.05	.02	6.39	6.79	91.12	1.47	0.27
2C	70-150	6.65	5.97	0.10	0.40	0.50	5.00	1.46	0.10	.02	6.58	7.08	92.94	1.41	0.20
2C	150-175	6.55	5.50	0.10	0.20	0.30	2.50	0.88	0.06	.02	3.46	3.76	92.02	2.60	0.16

Cambisols). Pedons 3 was classified as Ultic Udarents (Lixic Arenosols) due to their loose texture and recent development from outwash fans of the rock hill. While pedons 4 and 5 are Udults and at subgroup level are classified as Typic Rhodudults (Rhodic Lixisol) and Plinthudults (Plinthosols) respectively. This is due to their udic soil moisture regime, and the reddish colour of the former and the presence of plinthite in the latter. Pedon 6 was classified as Anthropic Quartzipsamments. This is due to human influence as described in Table 1 and also the quartz build up and sandy horizons which

CONCLUSION

This study revealed that the direction of setting down of the pebbles and gravels and their shapes aided the identification and differentiation of the transported materials from the residual regolith. Rock fragments were oriented roughly parallel to the slope direction. Soil creep and slope wash have produced different soil types. Pedons 1, 2 and 3 are hill creep soils while pedon 4 is a hill wash soil. Therefore, soil might have been formed in colluvial materials that were deposited at different times. The differences in textures and stratification attained are probably indications of time factors and different multi-erosion activities. Bedrock slabs are oriented down slope; surficial debris accumulates against slope sides of rock debris except on the nearly level surface close to the hill. These are parts of the conditions that have been considered as evidence of soil creep by Young (1972). Moreover, the pebbles which are quartz gravels often formed from stone lines. These give rise to abrupt soil boundary between adjacent horizons. For examples, in Pedons 2, 3, and 6, these stones appear to be the demarcating layers between different colluvial deposits and/or demarcating layers between surface alluvium and residual subsurface soils.

Upland Pedons are typically colluvial from their morphology. This can be corroborated with the particle size distribution. The subsurface horizons are made up of colluvial boulders weathering *in situ*. The different bands of weathering rock are displayed clearly and separately according to the deposition times since their degree of weathering or decomposition is different as indicated morphologically.

The discontinuity in pedon 5 is further confirmed by the difference between the upper surface layers and sedentary ones below. Pedon 6 depicts the character of a sedentary soil overlaid by colluviums. It contains sandy top separated from subsoil horizons by a layer of concretionary materials. In Pedon 6 surface horizons are coarser than the subsurface horizons which were morphologically confirmed by contrasting texture of sandy loam and sandy clay loam. The upper horizons are probably derived from materials from upper slope positions and the subsoil is sedentary as described earlier from the morphology.

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