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THE TROPICAL GREY EARTHS OF THE ACCRA PLAINS, GOLD COAST

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THE TROPICAL GREY EARTHS OF THE ACCRA PLAINS
GOLD COAST

Tropical Black Earths in the Gold Coast were described by the authors in a previous paper (1). Adjoining these soils under similar environmental conditions on the Accra Plains occur solonetzic soils which it is considered might be named Tropical Grey Earths.

These soils are associated with Dahomeyan (Archaean) acid igneous rocks, mainly muscovite-biotite gneisses and schists in which plagioclase is the dominant feldspar.* A trend towards the development of similar profile morphology has been observed, however, in certain terrace and lacustrine alluvia in the region. The soils enjoy a seasonally-distributed rainfall of 25-45 inches per annum and occur on gently-undulating topography with slopes generally less than 2 per cent. To the west of the Black Clays belt, the soils occupy the lower half of the topography in association with sandy or gravelly soils on the uplands. A similar distribution occurs in the north-centre of the eastern belt, but elsewhere here the soils occupy the whole topography from summits to bottoms. They support sparse short grassland with widely scattered clumps of thicket confined to old termite mounds. The major grasses are *Monocymbium ceresiiforme* Stapf and *Andropogon canaliculatus* Schum., and a number of dwarf sedges are common. Altogether, the soils cover approximately 200 square miles on the Accra Plains. Similar soils probably occupy some 125 square miles on the Ho-Keta Plains east of the river Volta. These soils provide the major grazing areas on the Accra Plains but they are uncultivated at present. Preliminary fertilizer trials on the University College Farm, Nungua, indicate that phosphorus deficiency is the limiting factor, cereals failing to mature unless phosphorus is added; nitrogen is also deficient.

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*Although the soils are very closely tied to these rocks, they cannot be regarded as truly sedentary in development since there is almost invariably a stone-line of quartz gravel or transported ironstone concretions at a depth of 3-4 feet separating the soil from the rock. It appears probable that the soil parent material is derived from the parent rock by mound-building termites. This material then weathers further and is redistributed by surface sheet-flow during rainfall.

The topsoil consists of 2-3 inches of grey (10YR 5/1), slightly humus-stained sand or sandy loam grading into a few inches of pale brownish grey (10YR 6/2) sand or sandy loam. This layer is firm and porous in situ, but crumbles loose when disturbed. There is an abrupt break to the subsoil at 6-12 inches. This horizon consists of 9-12 inches of very hard and compact sandy clay which cracks into prismatic blocks 2-6 inches in diameter when dry. In well-developed profiles, the surfaces of the blocks are varnished dark brown with humus for 3-4 inches near their top, but are weakly mottled grey and ochre internally and in their lower portion; in other profiles, humus stains the whole of the upper portion of the subsoil dark grey-brown (10YR 4/2), but there is usually weak mottling, too, and root-channels are ironstained. This compact layer grades at 15-24 inches into a less hard and compact, more cloddy and plastic clay containing hard calcareous nodules and small manganese dioxide concretions. This layer varies in colour in different areas from pale grey (10YR 7/1) to pale yellowish brown (2.5YR 6/4), and is usually weakly mottled with ochre. Embedded in the base of this layer is a stone-line varying in composition from a thin, discontinuous line of transported ironstone pisoliths to 12 or more inches of ironstained, subangular, vein-quartz gravel. The underlying, steeply-dipping gneiss or schist is usually moderately to highly weathered and commonly contains nodular calcium carbonate in the cleavage planes.

Several profiles have been completely analysed. Data for a typical profile are shown in Table 1. This profile was sampled in detail, subdividing the morphological horizons into several layers. 0-11 inches represents the topsoil, 11-24 inches the hardpan layer, 24-60 inches the weathered parent material containing a stone-line at 48-60 inches overlying the weathered parent rock, 60-72 inches.

Profiles normally consist entirely of fine earth down to the stone-line where gravel and stones may vary in amount from less than 5 to over 70 per cent. Clay contents are low in the topsoil but suddenly increase to around 30 per cent. in the subsoil and remain fairly constant thereafter down to the stone-line and weathered rock. $CaCO_3$ may occasionally exceed 30 per cent., but usually there is less than 5 per cent.; it must be pointed out, however, that where hard concretions occur they may be removed with the coarse fraction in mechanical analysis.

Depth in inches	Coarse material > 2 mm. per cent.	Mechanical analysis of fine earth, fraction size in mm., per cent[1]								Organic matter per cent[2]				Moisture equivalent per cent.
		2-.625	.625-.2	.2-.02	.02-.002	<.002	$CaCO_3$	Loss on solution	Total	Org. C	Total N	C/N	Org. matter	
0-3	nil	.80	33.34	50.13	5.36	7.34	nil	2.33	99.30	.92	.048	19.17	1.58	10.3
3-6	nil	4.09	33.68	49.28	4.43	6.34	nil	1.45	99.27	.53	.036	14.72	.91	8.3
6-11	nil	7.26	38.53	43.96	3.39	5.31	nil	1.22	99.67	.33	.026	12.69	.57	6.6
11-18	nil	7.79	29.23	26.29	3.21	30.42	nil	3.43	100.37	.83	.061	13.61	1.43	Pool form.
18-24	nil	9.61	25.26	29.96	4.27	28.81	.02	2.33	100.26	.37	.036	10.28	.64	-
24-29	.5	7.34	25.04	31.81	4.91	29.04	.02	2.31	100.47	.22	.024	9.17	.38	-
29-37	.2	6.10	25.44	33.31	4.88	27.18	1.33	1.55	99.80	.07	.011	6.36	.12	-
37-48	.2	5.64	31.18	35.63	4.11	20.58	1.12	1.43	99.69	-	-	-	-	-
48-60	73.7	15.49	18.08	25.69	6.69	30.94	.61	1.84	99.34	-	-	-	-	-
60-72	32.5	21.13	22.81	32.36	5.61	15.54	.30	2.23	99.98	-	-	-	-	-

Depth in inches	pH[3]	Exchange complex m.e./100 g[4]						Ca/Mg	Na in complex per cent.	Water-soluble salts per cent[5]			Total P p.p.m[6]	Truog P p.p.m.
		C.E.C.	H	Ca	Mg	K	Na			NaCl	Na_2SO_4	$NaHCO_3$		
0-3	6.2	7.74	2.18	3.10	2.05	.26	.14	1.51	1.8	-	-	-	73	7
3-6	6.1	5.43	1.75	2.11	1.53	.13	.10	1.38	1.8	-	-	-	54	2
6-11	6.2	3.55	1.68	1.12	1.12	.18	.10	1.00	2.8	-	-	-	51	2
11-18	5.9	19.42	3.67	7.89	5.80	.20	2.09	1.36	10.8	-	-	-	95	-
18-24	6.9	17.50	.85	8.21	6.62	.13	1.64	1.24	9.4	.055	-	.046	73	-
24-29	7.4	19.78	nil	8.50	7.38	.24	2.54	1.29	12.8	.094	-	.040	-	-
29-37	8.2	19.68	nil	8.93	8.03	.14	2.58	1.11	12.8	.148	.055	.096	-	-
37-48	8.2	15.19	nil	7.43	6.19	.12	1.45	1.20	9.5	.128	.045	.098	-	-
48-60	8.0	24.36	nil	9.64	9.84	.19	4.47	1.03	18.3	.188	.055	.087	-	-
60-72	8.3	13.50	nil	5.82	5.27	.06	1.75	1.01	13.0	.105	.040	.086	-	-

[1]Beaker method; $CaCO_3$ Scheibler-Passon, 10 per cent. $HClO_4$ used instead of HCl.
[2]C wet combustion, Walkley-Black, nitrogen Kjeldahl. [3]Glass electrode, soil-water ratio 1:2.

[4]Cation exchange capacity (C.E.C.) and exch. H: Ba-acetate, exchangeable cations N ammonium acetate. Ca and Mg by the versenate method, K as cobaltinitrite, Na as $Mg-UO_2$ acetate. Corrected for salts and $CaCO_3$.
[5]Determined in 1:5 water extract. [6]Vanadomolybdate method, extracted with $HClO_4$.

Table 1. Analytical data for a typical profile of the Tropical Grey Earths. (Profile No.APA 675).

Clay contents in the hardpan are not significantly higher than in lower layers and the compaction in the former is due to the dispersing effect of sodium in the exchange complex; lower layers are better structured because of the presence of electrolytes. The hardpan is absolutely impervious under field conditions, and pool formation occurs during moisture equivalent determinations on samples from this horizon.

An exchange capacity of 60-70 m.e. per 100g clay suggests that montmorillonite is the predominant clay mineral; kaolinite is likely to be the only other clay mineral present (2). Actual exchange capacities are less than 10 m.e. per 100g soil in the topsoil and 15-25 m.e. in lower layers. Lateral drainage of water over the hardpan slightly leaches the topsoil and upper subsoil, but lower layers quickly become alkaline, although reaction values rarely exceed pH 8.5. Calcium and magnesium, in roughly equal proportions, generally account for 80-90 per cent. of the bases present. There is little sodium in the topsoil, but this element accounts for 10-15 per cent. of the total bases in the hardpan and lower layers, and sometimes for 20-30 per cent. at the base of the profile. Potassium contents vary, a few profiles possessing 0.5-1.0 m.e. throughout, but most having less than 0.2 m.e. Phosphorus contents are very low, with 50-100 p.p.m. total P and usually less than 5 p.p.m. acid soluble P (Truog).

Soluble salt contents are low in the topsoil and upper subsoil, but increase to 0.2-0.4 per cent. in lower layers. NaCl predominates, followed by $NaHCO_3$; Na_2SO_4 contents are low and never exceed 0.1 per cent. The pattern of distribution is similar in all soils analysed, the maximum of chlorides occurring rather below the bottom of the hardpan with the bicarbonate maximum occurring slightly lower down the profile; a second chloride peak sometimes occurs in the stone-line.

Organic matter contents are low. There is characteristically a secondary maximum in the upper part of the subsoil. This feature may not be due to downward leaching since sodium contents are low in the topsoil, but probably arises from the fact that plant roots concentrate in the cracks between the structural units in the hardpan and decompose under less aerobic conditions than in the topsoil. C/N ratios are high and may show a secondary maximum in the upper subsoil.

When soils as different as the Tropical Black Earths and these Grey Earths are developed side by side under similar environmental conditions — fully developed profiles of each sometimes being present within a yard or two of each other at the boundary — the differentiating determining factor must be the parent rock from which they are developed. The presence of significant amounts of sodium in the exchange complex determines the development of the Grey Earths and its importance is satisfactorily accounted for by the weathering of plagioclase feldspar in the parent rock. Plagioclase feldspar is also present in the hornblende gneiss giving rise to the Black Earths, however, but here it must be assumed that the amount of sodium released is small in proportion to that of calcium and magnesium released by the weathering of this rock and is insufficient to influence profile development.

The importance of chlorides in the Grey Earths is more difficult to account for. It might be supposed that the chlorides are derived from sea spray, but a red earth examined from a site close to the shore contained no NaCl down to 3 feet and less than 0.01 per cent. below this, and there are only infinitesimal amounts present throughout Black Earths profiles. The distribution of chlorides in the Grey Earths suggests that they have not been leached down from above but are derived by capillary rise from moisture moving through the stone-line where such exists. It seems unlikely that chlorides are released by weathering of the parent rock, and it may be that they are derived from fossil water held in these rocks since Tertiary or Quaternary times when they were below sea-level. Chlorides derived in a similar way in the Black Earths would perhaps be more readily leached because of the slightly greater permeability of these calcium dominated soils.

The profile morphology is undoubtedly that of the solonetz, and one of the authors is familiar with similar soils in the eastern parts of the Hungarian plains (3) where, however, the two-peak distribution of organic matter characteristic of the Accra Plains' soils is not present. Milne's ibambasi soils of Tanganyika (4) appear to be similar soils, but no other references to such soils in the tropics are known to the authors. Their mode of formation from the parent rock would seem to distinguish them from the solonetz of temperate latitudes and it seems desirable, for the present at least, to regard them as a distinct world group. For classificatory purposes in the Gold Coast, these soils are placed in the Sodium Planosols (5).

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Summary

Grey solonetzic soils on the Accra Plains are developed over acid igneous rocks on savannah-covered, peneplain landforms under a subarid to subhumid climate. Grey sandy topsoils overlie a compact, prismatic hardpan which is humus-stained near the top and grades down into pale-coloured clay containing $CaCO_3$ concretions; a stone-line separates the parent material from the weathered rock. The topsoil and upper subsoil are slightly acid; lower layers are moderately alkaline. 10-15 per cent. sodium in the exchange complex accounts for the development of the hardpan. 0.2-0.4 per cent. soluble salts, predominantly NaCl, occur below the hardpan. Organic matter is low in amount; it characteristically shows a secondary maximum in the upper subsoil. Phosphorus and nitrogen contents are very low.

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