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C. F. CHARTER'S INTERIM SCHEME FOR THE CLASSIFICATION OF TROPICAL SOILS

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Introduction

At the 5th International Congress of Soil Science at Leopoldville in 1954, C. F. Charter staunchly defended the traditional genetical system of soil classification against those attempting to have it superseded by 'formula' types of classification. At short notice, he prepared during the course of the conference a brief paper outlining his view which he presented at a special symposium on soil classification held towards the end of the Congress. A summary of the paper was published in the Proceedings (1).

Following the Leopoldville Congress, he continued to work on this classification scheme, more particularly in relation to tropical soils, and he had intended to have collected sufficient field and analytical material to be able to present a comprehensive scheme at the 6th Congress in 1956. However, a lengthy visit to the United States during the spring and summer of 1955, followed by various international conferences in England, the Gold Coast and the Belgian Congo in the autumn, interrupted these studies; then rapidly failing health and his untimely death in January, 1956, prevented their completion.

The scheme presented below has been compiled from the notes he left. It is recognized that it is incomplete. Charter himself recognized that a great deal of work remained to be done on it, and that it might in the event be impossible to collect material sufficient to present more than an interim scheme at the 6th Congress. The terminology proposed is in some cases provisional only, and Charter was known to be dissatisfied with some of the more generally accepted terms although he had not in every case replaced them by names and definitions he considered more satisfactory. There are parts of the scheme, too, with which the present writer is not in complete agreement. It seems preferable, however, to present the scheme as it stood at the time of his death rather than attempt to add material which he did not himself scrutinize and assess or to modify views which, with his wide experience and keen intelligence, he had obviously good grounds for holding.

As it stands, the scheme treats mainly of West African conditions. The compilation and correlation of data from other tropical regions had been commenced, but this had made so little progress that it is impossible to incorporate the information in the present paper.

Scheme of classification

Order

The classification is based on Neustrev's formula

Soil = $\int$ climate, vegetation, relief and drainage, parent material and age.

Soils are grouped at the order level according to the predominating action of one or, usually, two of these factors, viz.-

I. Climatophytic Earths - with characteristics predominantly determined by climate and vegetation. This order is equivalent to that formerly termed Zonal.

II. Topoclimatic Earths - with characteristics predominantly determined by relief and climate. This order is designed to include soils of high altitudes (c. 3,000 m. and over) within the tropics*

III. Topohydric Earths - with characteristics predominantly determined by relief and drainage. This order includes the majority of the soils formerly included in the Intrazonal order.

IV. Lithochronic Earths - with characteristics predominantly determined by parent material and/or age. This order incorporates the former Azonal order as well as certain former Intrazonal soils.

Suborder

I. Climatophytic Earths.- This is simply divided according to whether the profile is through-leached or not, viz.-

*The present writer is not convinced that these soils should be separated at the order level. They have not developed in response to relief as such but rather to the special climatic conditions obtaining at high altitudes in the tropics and the vegetation associated with this environment. They might accordingly be regarded as Climatophytic Earths.

A. Hygropeds - soils in which precipitation connects with a groundwater-table. This suborder is equivalent to that formerly termed Pedalfer. These soils provide the major problem in classifying tropical soils since they probably account for 80-90 per cent of the upland soils in this zone.

B. Xeropeds - soils in which precipitation does not connect with a groundwater-table. This suborder is equivalent to that formerly termed Pedocal. These soils are probably of very limited importance in the tropics since, although the rainfall total may be low, this may be made up of a few heavy precipitations which provide enough water to penetrate to the groundwater-table. Moreover, it appears that, as the desert is approached, sedentary upland soils become scarcer and lowland, seasonally poorly drained soils become more common. Also, higher rainfall experienced during previous climatic cycles may have left behind leached red earths.

II. Topoclimatic Earths.- Insufficient material is yet available for a satisfactory classification of the soils of tropical mountain regions and they will not be further discussed below. Groups associated with mountain tundra, mossy forest, montane rain forest, etc. presumably occur.

III. Topohydric Earths.- In this order, suborders are differentiated mainly according to the relief-form with which the poorly drained soils are associated, viz.-

A. Planopeds - developed on peneplain topography or on marine or river terraces. Such soils may occupy entire landform units. They are of widespread occurrence in the older tropical land masses.

B. Clinopeds - developed on slopes where seepage occurs and various substances are precipitated from solution. Such soils are of restricted importance.

C. Depressiopeds - developed in poorly drained depressions. Moisture supplies are generally augmented by run-off or seepage from soils of other orders or suborders developed in topographical association on adjoining slopes. Such soils may be of great economic importance, actually or potentially, but they generally cover only a relatively small proportion of the landscape.

D. Hydropeds - developed under water in lagoons or permanent rice paddies. Under natural conditions such soils are generally of small importance. However, large areas of soils which under natural conditions might have been classifiable as Depressiopeds have through their development for rice-cultivation been converted into Hydropeds.

E. Cumulopeds - developed in depressions where peat has accumulated. Such soils are only locally of importance in the tropics.

IV. Lithochronic Earths.- Suborders are differentiated according to the particular factor retarding profile development, viz.-

A. Lithopeds - soils in which profile development is restricted by the resistant nature of the parent rock or the rapid erosion of products of rock-weathering on steep slopes. (At one time, Charter had included certain soils developed over limestones and basic igneous rocks in this suborder, but latterly was considering classifying them with the Climatophytic Earths*).

B. Regopeds - soils in which profile development is restricted by the inert nature of the parent material, loose sands.

C. Alluviopeds - soils in which profile development is restricted by the extreme youth of the parent materials, volcanic ash or river alluvium.

Great Soil Group** and Subgroup

I. Climatophytic Earths

A. Hygropeds.- The characteristic Climatophytic Earths of the tropics are the red or yellow, friable, porous, thoroughly weathered, kaolinitic or gibbsitic earths which Kellogg has termed Latosols (2). This term has been retained (as a Great Soil Group Family) in the present classification.

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*See footnote on page 6.

**Although there is no authority for the step in Charter's notes, the present writer finds a need in compiling this classification to introduce a grouping (not a separate category) intermediate between Suborder and Great Soil Group. This he has tentatively termed Great Soil Group Family.

Great soil group families and great soil groups and subgroups will not be described in detail below except in so far as it may be necessary to explain the identity of particular soils or justify their place in the classification.

Amongst the groups recognized, the soils are arded as possessing AC profiles; soils with genuine tural, consistency or structural B horizons would be ssified in separate groups. No authentic B horizons [illegible] been discovered in Gold Coast Latosols, however, and ir development elsewhere may perhaps be regarded as an dication of senescence leading ultimately to a change o Topohydric Earths on peneplain topography.

The groups recognized are differentiated according to the nature of the associated vegetation (forest, savannah or thorn-thicket) and, <u>inter alia</u>, the intensity of profile leaching. Red and yellow soils occurring in topographical association are differentiated at the subgroup level since, except for the difference in degree of hydration of the ferric iron present, their major physical and chemical properties appear to be essentially similar.

The groups recognized are as follows:-

1. Forest Oxysol
2. Savannah Oxysol?
3. Forest Ochrosol
4. Savannah Ochrosol
5. Thorn-thicket Ochrosol

<u>Oxysols</u> are associated with high rainfall areas (c. 70-80+ inches p.a.). Profiles are strongly leached, with reaction values lowest at the surface, viz. pH 4.0-4.5 in the topsoil gradually increasing to 4.5-5.0 in lower horizons until weathering rock is reached. Compared with Ochrosols, organic matter in Oxysols tends to be higher in amount, to have a higher carbon/nitrogen ratio, to be dispersed more deeply down the profile and to have a lower cation exchange capacity. Sedentary upland Oxysols are brown or orange-brown compared with red or reddish brown in upland Ochrosols. Although Oxysols are normally developed under forest, it seems probable that as a result of human interference some soils will now be found to occur under derived savannah vegetation.

<u>Ochrosols</u> are associated with moderate to low rainfall areas. Those under forest receive c. 40-70 inches p.a.; those under broad-leaved savannah woodland receive c. 30-50 inches; thorn-thicket soils may receive from as little as 10-15 inches up to 30 inches. In Ochrosols, there is a marked concentration of organic matter and bases in the upper topsoil;

lower horizons are strongly leached. Typical reaction values, under forest, are pH 6.0-7.0 in the upper topsoil and 5.5-6.5 in the lower topsoil, below which values fall rapidly to 4.5-5.0 throughout the main body of the solum until weathering rock is reached. Under savannah, pH values in the upper topsoil are similar, but there is a less rapid fall with depth and values usually remain around pH 5.5 throughout the subsoil. There is less information on thorn-thicket soils, but those seen in low-rainfall areas of Tanganyika appear to have rather more acid topsoils (pH 5.0-6.0); lower horizons probably have reaction values around pH 5.0-5.5. Forest, savannah and thorn-thicket groups are differentiated on the morphology of the humous horizons.

Oxysol-Ochrosol intergrades are of widespread occurrence in the Gold Coast forest zone.

Basisols* include relatively young soils developed over parent materials from which bases are released sufficiently quickly to replace those lost by leaching. Profiles are consequently neutral to only slightly acid in reaction throughout. These soils appear mainly to occur under moderate to low rainfalls. (Under high rainfalls (c. 80+ inches p.a.), Latosols seem to develop directly from basic rocks;

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*Originally, Charter had classified these soils, together with Rendzinas and Brown Forest soils, in the Lithochronic order. However, the fact that such soils have a well developed profile morphology - i.e. they are not immature in the sense of skeletal soils - seemed to require that they be separated from this order, and, latterly - only a month or so before his death - he had decided to include the Basisols at least, because of the influence of climate on their development, with the Climatophytic Earths, although there is no indication in his notes exactly at what level he intended classifying them.

Because of their base-rich nature, and perhaps also the presence to some extent of illitic or montmorillonitic clay minerals, such soils are typically highly plastic and structured, the units varying in size from crumb to large blocky or cloddy. This characteristic, together with their relatively unleached profile, gives these soils markedly different properties from true Latosols and seems to require that they be classified separately.

To the present writer, a possible solution to the problem seems to be to classify in a separate order all those soils in which the development of the appropriate Climatophytic Earth is retarded by the too-plentiful supply of bases in the parent material. Since climate also determines which particular soil group will develop, the order might be termed Lithoclimatic, it being implied in this case that the prefix refers to basic parent materials. In general, soils developed from basic rocks in any particular area tend to show the characteristics of Climatophytic Earths belonging to a more arid climate. Formerly, such soils would have been regarded as zonal-intrazonal.

Latosols are also characteristically found over basic rocks where these underlie old peneplain surfaces, in which case bauxitic crusts are often developed.)

The groups recognized are differentiated according to the nature of the associated vegetation (forest, savannah or thorn-thicket) and the colour of the solum, red or brown. As in the Latosols, yellow soils are only differentiated at the subgroup level. The following groups are recognized:-

1. Forest Rubrisol
2. Savannah Rubrisol
3. Thorn-thicket Rubrisol
4. Forest Brunosol
5. Savannah Brunosol.

Rubrisols are characteristically dark red (on the uplands) and show large, firm or hard, structural units, particularly in the subsoil. Brunosols are dark brown and the structural units appear to be smaller and less firm than in the red soils. The reasons for the development of the one soil rather than the other are not fully understood, although Brunosols appear generally to occur in drier areas than Rubrisols; the latter soils, however, may also be tied to rocks inherently richer in iron.

Intergrades between Basisols and Ochrosols and between Basisols and Oxysols also occur.

B. Xeropeds.- No attempt has been made to re-assess the classification of great soil groups within this suborder, and the conventional grouping - Reddish Prairie, Reddish Chestnut, Reddish brown, Red Desert and Desert - is provisionally retained.

Although, ideally, Xeropeds should possess an illitic-montmorillonitic clay complex, it seems possible that soils with kaolinitic-ferrallitic clays also occur. The latter property, however, is to be regarded as a characteristic inherited from a previous, more humid, climatic cycle.

II. Topoclimatic Earths

Not further subdivided.

III. Topohydric Earths

Each of the suborders comprising the Topohydric Earths is subdivided into great soil group families according the nature and reaction of the groundwaters influencing pedogenesis. In most suborders, acid, neutral, calcareous and saline group families have been recognized; in some, it seems desirable to recognize very acid group families also.

Within the group families, great soil groups are generally differentiated according to the colour of the solum, black, brown and grey groups usually being recognized. Further differentiation into forest and savannah groups is sometimes required.

A. Planopeds.- Very acid, acid, calcium and sodium Planosols occur.

Groundwater Podsols seem best classified as Very Acid Planosols, and Groundwater Laterites as Acid Planosols. Most Groundwater Podsols occur under forest, but it seems possible that a savannah group of these soils also occurs. Both Forest and Savannah Groundwater Laterites occur.

Calcium Planosols comprise Tropical Black Earths and Tropical Brown Earths.* These soils typically occur under savannah, but minor occurrences of both are known under forest in West Africa and it again seems necessary to recognize forest and savannah groups.

Soils provisionally named Tropical Grey Earths seem to be associated with conditions under which sodium accumulates in significant amounts or is inadequately leached from the weathering parent material, giving rise to profiles with hardpan or claypan horizons.** These soils have been tentatively allocated to the Sodium Planosols, therefore. They seem invariably to occur under savannah conditions. Milne's imbambasi soils of Tanganyika appear to belong to this group (3).

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*Charter regarded these soils as developing primarly in response to relief and drainage; parent material was a contributory factor but not a determinant. The present writer is not in entire agreement with this view since these soils are invariably closely tied to basic rocks or sediments under subhumid to subarid conditions. They might be included with the other lithogenic soils in the suggested Litho-climatic Order (c.f. footnote p. 6).

**To some extent, these soils also might be regarded as Lithoclimatic Earths since they seem mainly to be developed under subhumid to subarid conditions over rocks containing abundant sodium-bearing minerals (usually albite).

B. Clinopeds.- No subdivisions of this suborder have yet been made.

C. Depressiopeds.- Very acid, acid, neutral, calcareous and saline group families are recognized. Neutral to acid soils in which reducing conditions obtain for at least a part of the year are termed Gleisols; bottom soils in which calcium or sodium salts accumulate are termed Vleisols. Black, brown and grey great soil groups are recognized within the group families, and forest and savannah groups are recognized in some cases, too.

Very Acid Gleisols are characterised by the presence of an acid type of humus and reaction values of pH 4.5-5.0 or less throughout the profile. Two great soil groups only have been recognized: Forest and Savannah Grey Very Acid Gleisols. Some soils of these groups are strikingly mottled dark red below the humous layer.

Acid Gleisols differ from the Very Acid Gleisols in being rather less acidic in reaction near the surface and becoming markedly less acidic with depth: typical reaction values are pH 4.8-5.8 at the surface gradually increasing to 6.0-7.0 below about 3 feet. Black, brown and grey great soil groups occur. These soils seem most commonly to occur in savannah regions in bottoms receiving large amounts of surface run-off from impervious soils up-slope, but Forest Grey Acid Gleisols are also developed. In the Black Acid Gleisols, the clay mineral appears to be predominantly montmorillonitic; in the brown soils, montmorillonite is present but is mixed with other clay minerals; in the grey soils, illite seems likely to predominate in some soils and kaolinite in others. Black and brown soils show only slight mottling, but the grey soils are usually strongly mottled.

Neutral Gleisols show a more normal reaction profile, with pH values of 6.0-7.0 in the topsoil and 5.5-6.5 in the subsoil. Only Forest and Savannah Grey Neutral Gleisol great soil groups are known at present, although it seems probable that brown groups will also be discovered in the Gold Coast. The clay mineral seems likely to be largely illitic, although there seem to be large amounts of kaolinite in certain series attributed to this group family.

Calcium Vleisols are associated with more arid conditions than any of the Gleisols. Profiles may be slightly acid near the surface but all show calcium carbonate accumulation at a moderate depth. Black, brown and grey groups occur. The soils appear typically to occur under grassland, often swamp grassland, but it is possible that there are small occurrences under forest or thorn-thicket which would require the differentiation of appropriate great soil groups. The clay mineral in the Black Vleisols seems typically to be montmorillonitic; montmorillonite seems also to be present in the Brown Vleisols, although mixed with other clay minerals not yet specified; Grey Vleisols seem more likely to be illitic or to contain illite-kaolinite mixtures.

Sodium Vleisols occupy depressions in regions more arid than those where Calcium Vleisols occur, but they may also margin coastal lagoons in rather more humid regions. The terms Solonchak and Solonetz are retained for the two great soil groups recognized.

D. Hydropeds.- Only neutral and saline group families are recognized for the present, although acid and calcareous members may also be expected to occur. Some of the soils support only acquatic herbs; others carry swamp or marsh grasses or sedges; yet others carry swamp or mangrove forest. There are inadequate data available at present, however, to permit the subdivision of the group families into great soil groups on the basis of differences in the morphology of the organic matter layers, although Sodium Hydrosols under *Rhizophora racemosa* (Red mangrove) forest obviously form a distinct group.

E. Cumulopeds.- Very acid, acid, neutral, calcareous and saline group families are provisionally recognized although little information seems to be available on peat soils in the tropics. Very Acid Cumulosols would have a reaction of pH 4.5-5.0 or less at the surface, Acid Cumulosols, pH values c. 5.0-6.0 at the surface, perhaps increasing with depth; Neutral Cumulosols, pH values 6.0-7.5 at the surface, remaining constant or falling slightly with depth; Calcium Cumulosols, pH values 6.5-7.5 at the surface increasing to 8.0-8.5 with depth. Sodium Cumulosols developed in mangrove peat would likely show high reaction values *in situ* but would become extremely acid if oxidation were permitted to occur.

Bog and Half-Bog great soil groups presumably occur within each of the group families, but they have not for the present been differentiated.

IV. Lithochronic Earths

Lithopeds, Regopeds and Alluviopeds are not further subdivided.

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ORDER	SUBORDER	GREAT SOIL GROUP FAMILY	GREAT SOIL GROUP
CLIMATOPHYTIC EARTHS	HYGROPED	Latosol	Forest Oxysol Savannah Oxysol Forest Ochrosol Savannah Ochrosol Thorn-thicket Ochrosol
		Basisol	Forest Rubrisol Savannah Rubrisol Thorn-thicket Rubrisol Forest Brunosol Savannah Brunosol
	XEROPED	?	Reddish Prairie Reddish Chestnut Reddish brown Red Desert Desert
TOPOCLIMATIC EARTHS	Not further subdivided at present	-	-
TOPOHYDRIC EARTHS	PLANOPED	Very Acid Planosol	Groundwater Podsol
		Acid Planosol	Groundwater Laterite
		Calcium Planosol	Tropical Black Earth Tropical Brown Earth
		Sodium Planosol	Tropical Grey Earth
	CLINOPED	Not further subdivided at present	-
	DEPRESSIOPED	Very Acid Gleisol	Forest Grey Very Acid Gleisol Savannah Grey Very Acid Gleisol
		Acid Gleisol	(Savannah) Black Acid Gleisol (Savannah) Brown Acid Gleisol Forest Grey Acid Gleisol Savannah Grey Acid Gleisol
		Neutral Gleisol	Forest Grey Neutral Gleisol Savannah Grey Neutral Gleisol Savannah Brown Neutral Gleisol?
		Calcium Vleisol	(Savannah) Black Vleisol (Savannah) Brown Vleisol (Savannah) Grey Vleisol
		Sodium Vleisol	Solonchak Solonetz
	HYDROPED	Acid Hydrosol? Neutral Hydrosol Calcium Hydrosol? Sodium Hydrosol	Not further subdivided at present
	CUMULOPED	Very Acid Cumulosol Acid Cumulosol Neutral Cumulosol Calcium Cumulosol Sodium Cumulosol	Not further subdivided at present but Bog and Half-Bog members presumably occur.
LITHOCHRONIC EARTHS	LITHOPED REGOPED ALLUVIOPED	Not further subdivided at present	Lithosol Regosol Alluviosol

Table 1. C.F. CHARTER'S INTERIM CLASSIFICATION OF TROPICAL SOILS

The use of ? after a name indicates that there is some doubt as to whether soils of such groups or group families in fact exist. Names underlined are those of groups which have not yet been closely investigated and for which the generally-accepted name is therefore retained.