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TOWARDS AN INTERNATIONAL REFERENCE BASE FOR SOIL CLASSIFICATION

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The US "Soil Taxonomy" system of soil classification (Soil Survey Staff, 1975) is right now the most widely used and quoted system. This because it is a detailed catagorical system that has minutely defined quantitative boundary values for each unit, at whatever catagorical level. Such a system is attractive for those students and scientists that are satisfied with straightforward keying out of any particular soil (pedon), and do not want to be bothered by reservations on pedogenetic soundness, local utilization relevance, or assimilation by non-soil scientists. The system is also very actively propagated the world over, particularly in developing countries, through substantial funding by the USAID technical cooperation programme.

Drawbacks are a clear geographical bias to the soil patterns in mainland USA (including the prevailing soil moisture/soil temperature regimes) and a machinery for updating and improvement (Guthrie, 1984) for use elsewhere that in practice is very sluggish: the system remains the intellectual property/copyright of the Soil Survey Staff of the US Soil Conservation Service. Any change proposed internationally has to proceed through a lengthy process of discussions and testing, at which the US conditions remain the main criteria. The system has the "series" of the traditional US soil surveys as its basic building stones, and these are historically mapping units rather than classification units. Any approved change in the classification system may therefore require renewed mapping, and understandably US regional and state soil surveyors are quite wary to do so just to satisfy the queries and wishes of a few pedologists in New Zealand, India, Tunesia or Venezuela. Many of the apparent inconsistencies in the presentday US system (as regards its structure or the definition of diagnostic elements) are in fact related to the mix-up between soil mapping unit and soil classification unit. In this connection, too, reference be made to Dudal (1978) and Sombroek & Van de Weg (1980) on the difference between, and the relevance in view of interpretation, of respectively soil taxonomic units (soil individuals: pedons or polypedons), soil mapping units (soil communities: covers, associations, complexes, catena's, ensembles, or pedochoren), and land mapping units (soil/land physionomic units: land structures, land systems, landscapes, physiographic regions).

The other main international "system" of soil classification is the Legend of the FAO-Unesco Soil Map of the World at 1:5 million (FAO-Unesco, 1974). This system, used in quite a number of countries, especially of Europe and Africa, tries to give equal weight to occurrences the world over. It is quantitative in its definition of class limits, and has simple naming that has moreover clear connotations with older systems of classification and pedogenetic concepts. Moisture and temperature regimes are covered more precisely, but separately, through FAO's agroclimatological zonification approach ("length of growing season" in relation to rainfall; temperature classes in relation to plantgrowth). The main disadvantage is, of course, that it has only a two-level subdivision (though the agroclimatological units can in fact be taken to represent a third level), and that officially it cannot be denoted as a classification system.

There are many other systems of soil classification, partly purely national, partly with an international reach (see list of references). Some are very traditional, with little or no updating, while others are in full development (Camargo et al., 1985, for Brazil; Segalen et al., 1979, for ORSTOM; Fitzpatrick, 1983). They are used side by side with the US Soil Taxonomy and/or the FAO-Unesco legend, and cater to local specificity of occurrences and the needs or wishes of local users (agronomists, planners, extension officers etc.) who do not want to part with traditional systems and names.

A number of them, such as the USSR system (e.g. Egorov et al 1977), the French CPCS system (Aubert et al., 1967), and the middle-European Kubiena-Mückenhausen system (Mückenhausen, 1977), are more concerned with soil genetic theories then with precisely defined class limits, and therefore give rise to confusion and equivocal placing of any particular pedon. This is partly due to a different orientation of soil science at both sides of the Atlantic: in Europe, research and teaching in pedology is often organized in departments/institutions of "soil science and geology" while in the USA it is as "soil science and agronomy ".

A rather elegant and practical solution to the controversy between soil genesis prevalence and soil characteristics/properties prevalence is given in Segalen's approach, and the Northcote (1979) system now widely used in Australia.

The growing awareness that local differences, both as pedogenetic peculiarities and in their importance for management, can never be completely encompassed in one international quantitative and detailed system of soil classification, has led to an initiative by FAO, Unesco and ISSS Commission V to arrive at a so-called International Reference Base (IRB) for soil classification. Three international meetings were already held to devise such a "system" (Sofia 1980, 1981, 1983) and at present a special ISSS Working Group is trying to elaborate criteria and keys for subdivision of the 16 groups distinguished at the highest level (see Table 1; Schlichting, 1982). The philosophy behind this effort is described shortly in the various ISSS Bulletins (no's 57, 59, 61, 63, 64, 65): An international soil classificaton system is to be organized, in only four catagories at different levels of generalization. The subdivision in catagories at even lower levels can vary and will depend on the soil cover in the various countries. However, a methodology and criteria can be developed for making these lower-level separations. It is not the intention that existing (national) systems be replaced, but rather that a reference system be established through which these different detailed systems can be correlated and harmonized, starting with the highest catagories.

The FAO-Unesco Legend was taken as basis for discussion and advantage is taken of international soil correlation already achieved through that project (and through the US Soil Taxonomy international committees).

Unfortunately, neither the FAO and Unesco soil sections, nor the ISSS Working Group has as yet secured any significant financial resources to make much headway with the elaboration of IRB. A well-equiped technical secretariat and the organisation of a few workshops in key regions in the tropics and subtropics are prerequisites. UNEP has held out promises for financial support over the past five years, but this UN organisation has not yet "delivered the goods" (March 1985).

In this situation, and in view of the pressing need for an adequate classification guide at regional small-scale mapping in developing countries, in particular West, Southern and Eastern Africa, FAO recently decided to employ the consultancy services of Dr. A. Pécrot, who, together with Dr. R. Dudal of Leuven University and ISRIC staff in Wageningen, should revise the Legend of the Soil Map of the World for updating and use at country level, as follows:

a. identify which units need to be changed
b. indicate what amendments have already been suggested for each unit
c. write a new definition for as many units as possible
d. develop a third level for the principal soils
e. give priority to soils important for Africa, but with the new legend to have worldwide application

Good progress has already been made on this and it is expected that the revision will be complete before the fall of this year. Hopefully this initiative will merge smoothly into the longer-term IRB effort.

The slowness of progress of IRB is partly related to the difficulty of obtaining general agreement between all principal "schools" - USA, France, Australia, Brasil, Japan/China, Eastern Africa, etc. - on a compromise between the "central concept" approach and quantitative rigidity, as well as on the principles for subdivision below the first level. Elements of this could be:

- thickness of the soil, c.q. the total amount of fine earth or "active" material (shallow or very stony soils versus deep soils; predominance of sterile quartz sand versus clay-humus complexes)
- properties related to the nature of the parent material (for instance acid versus basic pyroclastics in the case of Andosols)
- properties related to the degree of weathering (the nature of the amorphous or crystalline clay fraction: types of diagnostic subsurface horizons).

- properties related to the degree and location of humus accumulations (for instance pachy-sombric, sombric, ochric)
- properties related to the type and degree of vertical redistribution of soil constituents - secondary minerals - in the profile (silicate clay minerals, sesquioxides, salts, humic substances, in a subsoil horizon)
- properties related to the degree of base saturation (calcaric, base saturated, base unsaturated, allic)
- properties related to the type and degree of (de)hydration (frozen, dehydrated, hydrated, perhydrated, water-stagnated)
- permanent properties related to intensive human influence (artificial humus enrichment, anthraquic features (paddy), homogenisation, etc.).

All these properties are important, but no agreement yet exists on which sets of properties should function as "overriding" principles at each categoric level.

Other bottlenecks are the definition or subdivision of some diagnostic horizons, e.g. the argillic horizon (see proposition Sombroek in Table 2); andic properties (the range from vitric to humophanic); the various activity-levels of the mineral constituents in the clay fraction (from high-activity down to akric); and of course the soil moisture/soil temperature regimes (in terms of "overhead" climatic parameters, or as their expression in other measurable soil parameters like permafrost layers; mottling or dye-tested reducing conditions in gleyic units; carbonate accumulations in desertic climates, etc.). Here the question of priority to the inherited permanent characteristics versus the actuarian behaviour of the soils is still not fully solved (the marks of influence of former climates being much stronger in Australia and parts of East and West Africa than in the largely post-glacial regions of USA and Northern Europe).

Gradually, however, a consensus is emerging, and this pedologist at least has not given up hope that in a few years' time some scheme will emerge that is acceptable to most, if not all soil scientists the world over. It may finally take away the still growing waryness among soil-management oriented specialists over the repeated changes in names and definitions, and haggling among pedologists.

Some form of soil classification scheme will always remain necessary, even with the advance of computerized soil data storage and its eventual combination with remote sensing imagery in the establishment of soil geographic information systems. The latter will probably make use of a system of coding of diagnostic surface and subsoil characteristics and features (cf. Northcote's system), and their lateral variation. Both for teaching purposes and to "label" the soil component at agrotechnology transfer and ecosystem studies one still will need to give names to the main units.

One can in fact envisage a kind of periodic table of soil classification units, with the elements listed on page 4/5 as principal guides (Buol and Sombroek, in preparation). Everything important for soil classification combined on one multicoloured and coded wall chart! In this way, too, one can combine elements of a hierarchical system with a network system and even a relational system of classification.

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Table 1 -

IRB-Proposals for Soil Classification at different levels
(February 1982, New Delhi Congress)

1st	2nd	(tentative name, FAO-equivalent)	3rd	4t
1. shallow weakly developed	on hard parent m.	Lithosols	=	
	" coarse p.m.	Arenosols	=	
	" medium p.m.	Regosols	= (medium)	
	" alluvial p.m.	Fluvisols	=, most	
2. swelling/shrinking	clayey, low kf	Vertisols	=	
	" " "	Pelosols		
3. surface water		Pseudogleys		
	+albic	Stagnogleys,		
	"	Planosols	=	
4. ground water		Gleysols	=	
	+thionic	Thiosols	thionic Fluvi	
5. saline and/or alkaline		Solonchaks	=	
		Solonetz	=	
6. aridic	calcic	Calcisols	Xero	
	gypsic	Gypsisols	Yermo	
7. mollic (humus saturated)	+Ca-redistribution	Kastanozems	=	
	"	Chernozems	=	
	-Ca redistribution	Greyzems	=	
	"	Phaeozems	=	
	"	Rendzinas	=	
8. umbric (humus unsaturated)		Rankers	=	
	+cambic	Umbrisols	humic Cambi	
9. sialic (CEC>24, $Fe_d < 4$)		Cambisols	=, most	
	+argillic	Luvisols	=, most	
			Podzoluvi, Acri	
10. fersialic (CEC>24, $Fe_d > 4$)		Chromosols	chromic Cambi	
	+argillic		" Luvi	
11. ferralic (CEC<24)		Ferralsols	=	
	+argillic	Nitosols	=	
	"	Ferluvisols	ferric Luvi	
	"	Feracrisols	" Acri	
12. andic		Andosols	=	
13. FeAl/humus-B		Podzols	=	
14. organic		Histosols	=	
15. permafrost		Gelisols	gelic groups	
16. anthropogenic		Anthroposols		

from: Sombroek, W.G. 1984. "Identification and use of subtypes of the argillic horizon" (International Symposium on Red Soils, Nanjing, China, November 1983)

Table 2 - Characteristics that may be used for the definitions of subtypes of the argillic horizon

		Akric (~oxydon)	Oxic (~ferraliton)	Argillic (sensu-latu) Nito- (brillant-lulgique)	Lixo- (~kandic)	Luvo- (ortho)	Abrupto- (~pale pp)	Plano- (~epiaquic/ stagno)	Natro- (~natric)
	depth of profile (A+B)	(>>100 cm)	(>>100 cm)	(>150 cm)	(>100 cm)	(<100 cm)	(<100 cm)	(<100 cm)	(<100 cm)
mineralogy	SiO_2/Al_2O_3 ratios	(<1.0)	(1.0-2.2)	(2.0-2.5)	(>2.2)	(>2.5)	(>2)	(>3.0)	(>3.0)
	clay-mineralogy	oxidic (gibbsitic)	oxidic-kaolinitic	kaolinitic + halloysite	kaolinitic	mixed-illitic	varying	(illitic)	(smectitic)
	free-iron (dithionite)	<<8% (<1?)	<8%	>8%	<8%	---	---	---	---
	specific surface (EGME)/clay	<<150m²/g (<50?)	<150m²/g	>150m²/g	<150m²/g	(>100m²/g)	(>100m²)	(>100m²)	>100m²
	CEC-clay (NH_4OAc; pH 7)[2]	<1.5	<16	(<24)	<24	(>24)	(>24)	(>24)	(>24)
	ECEC-clay		<12	(<16)	<16	(>16)	(>16)	(>16)	(>16)
		$pH_{KCl} > pH_{H_2O}$							>15% Na/>50% Na+Mg
weathering	weatherable minerals in fine sand fraction	<3%	<3%	(<10%)	<10%	(>10%)	(>10?)	(>10%)	(>10%)
	silt/clay ratio	<0.25	<0.25	<0.40	>0.25 (<0.6?)	>>0.25 (>0.6?)	(>0.6)	(>0.6)	(>0.6)
illuviation textural differentiation	textural increase[3]	(<1.2)	<1.2, over >12 cm	<1.2, over >12 cm	>1.2 (>1.4?), within 12 cm	>1.4, within 30 cm	>2.0, within 2.5 cm	>2.0, within 7.5 cm	>2.0, within 7.5 cm
	horizon boundary A-B[4]	(diffuse)	diffuse-gradual	diffuse-gradual	gradual-clear	clear-gradual	abrupt	clear to abrupt	clear to abrupt
	argillans (micromorphological), percentage and position	<1 ----	<1 (in the fabric)	variable (in the fabric)	<5 (in fabric and on peds)	>5 (on peds and in pores)	>5 (on peds and in pores)	(1-5) (on peds)	(1-5) (on peds)
org.matter differentiation	bleaching in A	none	none	none	bleached sand grains	bleached sand grains	bleaching even or absent	mottled bleaching (E)	(often bleached)
	org. matter decrease A to B	gradual	gradual	gradual	clear (blotchy)	clear	clear	abrupt (or inverse E-B)	abrupt
structure	macro structure, strength			moderate to strong	weak to moderate	moderate	moderate to strong	moderate to strong	(moderate)
	macro structure, shape[5]	(pm)	wc pm (floury)	abk-sp (lower part)	sbk-sc pm	abk-pr	abk-pr	pr	cpr
	micro structure (plasmic fabric)	isotic/asepic	asepic	asepic/insepic	insepic	masepic	masepic	masepic	masepic/omnisepic
	bulk density	<1.4	<1.4	<1.4	>1.4	>1.6	>1.6	>1.6	>1.6
	structure index[6]	(<90)	>90	>90	<90	<80	(>60?)	(<60)	(<50)
physical management properties	consistency moist	very friable	very friable	(very) friable	friable	firm	firm	very firm	very firm
	consistency dry	slightly hard (raw)	soft	hard	hard-very hard	hard-very hard	hard	extremely hard	extremely hard
	root penetration	(everywhere)	(everywhere)	(within peds)	(within peds)	around peds mainly	within peds?	around peds	around peds
	water penetration	very easy	very easy	very easy	rather easy	restricted	somewhat restricted?	very restricted	very restricted

[1]underlined: leading criteria; non-underlined: complementary criteria ("sway" criteria within flexibility range of leading criteria; between parentheses: non-systematically co-varying accessory properties.

[2]CEC-clay: meq/100 g; organic matter-corrected, by Brazilian graphical method.

[3]textural increase: ratios for the intermediate textures, with absolute percentages as defined in Soil Taxonomy and elsewhere.

[4]horizon boundary diffuse if change over > 12 cm, gradual if within 7.5-12 cm, clear if within 2.5-7.5 cm, abrupt if within < 2.5 cm.

[5]macro structures: wc pm = weakly coherent porous massive; sc pm = strongly coherent porous massive; sbk = subangular blocky; abk = angular blocky (scalloppy); sp = strong polyhedric (nutty); pr = prismatic; cpr = columnar.

[6]structure index: aggregate stability as measured by the fraction (in %) of the total clay that cannot be dispersed by simple shaking with water.