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The Seventh Approximation

A New Pedological Scheme of Soil Classification

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CLASSIFICATION IS THE first handmaiden of science. Perhaps more precisely it should be called the wet nurse of science, later becoming its consort, in some sciences being elevated to queen supreme. Without classification, knowledge would be factual chaos, difficult to retain and impossible to understand, like women, horse racing, and social studies.[2]

Actually, classification on the basis of need is one of our lower instincts, predating science by about the same amount that eyesight predates ophthalmology. For example, even the lowly worm will turn when he learns his two most pertinent categories of everything—can I eat it or will it eat me? In the case of parasitic worms the answers to both questions are yes, and the classification breaks down. Another instinctive classification is by sex, but the worm cannot make head nor tail of that either, being a bilateral opposed. Scientific classification relies not so much on use or general appearance as on objective observations and attention to detail.

At this point we interrupt with a brief comment on the purported subject of this article,[3] which is soils. The various engineering classifications of soils are rather closely allied with use. Or we can look more kindly and mumble that engineering soil classifications are based on properties which have engineering pertinence. As already implied, a use classification may be totally inept if the use should change. For example, a soil classification that works like a marvel for concocting a granular road base may be of only passing interest when strength comes from a chemical additive such as lime or portland cement.[4]

A hidden goal in classification is to provide something to revise, and soil scientists in the U. S. Department of Agriculture have been revising. Revision of the soil classification has been uniquely implemented with a number of "Approximations" submitted to soil scientists the world over for comments and revisions. The new pedological soil classification is currently in the Seventh Approximation, and in another three years or so should be fairly complete.

Most soil engineers will feel sorely wounded by all this, for it is only rather recently that we have become familiar with what the soil scientists were up to 20 years ago. At the present rate of acceptance the present revision may take a couple of centuries to assimilate. Let us first review.

> "The Entisols are those soils, exclusive of Vertisols, that have a plaggen horizon or that have no diagnostic horizon other than an ochric or anthropic epipedon, an albic horizon, an argic horizon, or, if the *N* value exceeds 0.5 in all horizons between 20 and 50 cm, a histic epipedon. . ."
>
> *The Seventh Approximation*, Chapter 8, "Entisols."

The Russian School

Any history of science always refers to this school or that school, further illustrating our exaggerated regard for degrees in education. In the 1870's a Russian scientist named V. V. Dokuchaiev created some rather enduring fallout; Dokuchaiev noted that the character of any soil appeared to be the result of five factors of soil formation: climate, organisms (especially vegetation), parent rock, relief, and time. Vary one factor such as climate, vegetation, or parent rock, and you find a different soil.

The heart of Dokuchaiev's soil classification is the "normal" or "zonal" soil, which primarily reflects climate and vegetation, that is, geographic zone. A comrade named Sibertsev then suggested the concepts of "intrazonal" and "azonal" soils. Intrazonal soils primarily reflect some local factor such as excess water or carbonates (which relate to relief and parent material). A particular intrazonal soil may occur in several geographic zones. Similarly, an azonal soil crosses zonal boundaries, and is essentially unweathered parent material.

The Russian classification based on genetic factors has been periodically modified, kicked out, hauled back, and barely tolerated by numerous later workers. The Americans G. N. Coffey and later C. F. Marbut maintained that a proper classification should rely on soil characteristics rather than on all these questionable inferences regarding origin. Marbut came closest to putting this goal into practice, but his classification had some serious loopholes that were not resolved. The Russian influence is shown in the USDA classification of 1938 modified in 1949, although division of orders into suborders, great soil groups, and ultimately into the basic soil-mapping unit, the soil series, follows a biological scheme. Relations of the

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[2] Classification lets the chaos be organized.

[3] Anything goes in a feature article.

[4] As a matter of fact, Portland Cement Assn. data show that cement requirements for soil-cement tend to correlate better with agricultural soil series than with engineering soil classes.

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zonal soils to climate are illustrated in Fig. 1.

Although each great soil group is defined on the basis of properties, the 1938–1949 classification is essentially genetic, and genesis invariably brings arguments. Some perfectly respectable soils have been left out because nobody knows which is the dominant factor. Furthermore, the Russo-American classification leaves no room for soil intergrades, which balks us liberals who look for answers in compromise. Nor is there provision for changes in soils due to cultivation or social climate, which provokes the Soviets who want it known that everything becomes better under Communism. Therefore, a new classification was needed—one based on soil properties (which relate to soil genesis) and not so closely oriented to prejudices regarding virginity. Any reasonable man knows one must love her for what she is, and not for what she used to be, even if her profile does look a shambles.

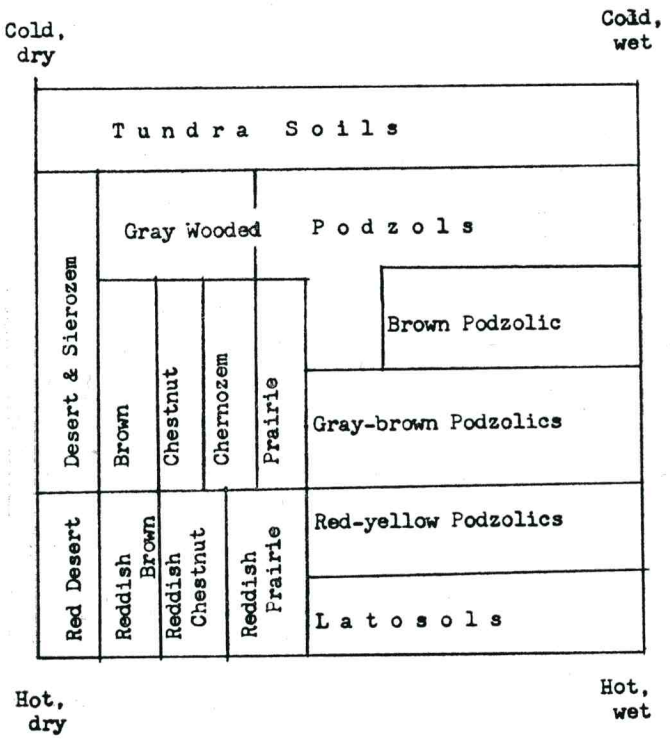


Fig. 1.—Idealized relationship of zonal great soil groups to climate.

The Soil Profile

Speaking of profiles, the most striking characteristic of soil is the tendency to form a layer cake, each layer being dubbed a "horizon." This is recognized in the vernacular in the terms topsoil and subsoil. Topsoil brings to mind dark, loamy material suited for raising tulips, wheat, corn, onions, and cool cash from the soil bank. Subsoil is the hard or sticky stuff located underneath, where it functions as a reservoir for moisture and for the dear-departed. Dirt is soil out of place, as on shoes, carpets, little boys, or pages of a two-bit novel. To a soil scientist or engineer dirt is a dirty word. It is not used.

A horizon.—Topsoil is more formally designated the A horizon. The A horizon may be either a dark-colored A_1, dark because of organic matter, or it may be a light-colored A_2, light because of loss of clay, iron, and aluminum. The A_2 is characteristic of podzols and podzolic soils, podzol coming from folk Russian meaning ashy soil. An A_3 is a transitional horizon to the underlying subsoil. The A horizon may be a foot or so thick, more or less, somewhat and depending.

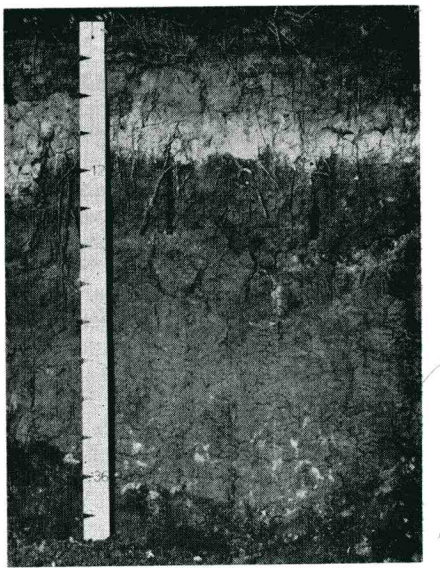
B horizon.—Subsoil is better termed the B horizon, and is even more variable than the A. It may be an accumulation zone of clay, iron, aluminum, humus, or a combination of these, or it may be a residual concentration of such materials. It may differ from other horizons mainly in color, but it usually shows a different structure such as tendency to break into small angular blocks or vertically oriented prisms. The zone of maximum whatever is called the B_2; B_1 and B_3 are upper and lower transitions.

Underneath the B is the C horizon, which usually displays some weathering but is below the zone of normal biological activity except for a few petroleum gophers. Salts such as calcium carbonate or gypsum may accumulate, making a C_{ca} or C_{cs}.

Other subscripts denote special topics; for example an A_p is a crazy mixed-up A horizon due to plowing. A subscript m means cemented, so a C_{cam} is a C horizon carbonate cemented into a hardpan, or duripan. The subscript x, as a B_x or C_x, indicates a "fragipan," or literally brittle pan, in other words a hard layer of high density. The x signifies what is known about its origin.

Progressive Education

Every soils man—engineer, scientist, shovel superintendent, or whatever, must dig these ABC's. Unfortunately the letters are not very completely descriptive; for example, they say nothing of the variability of different B horizons.



Courtesy William Johnson, USDA.

Fig. 2.—Gray Wooded soil (Typaltalf) on a Manitoba lake clay. The A horizon is white (A_2) and overlies a clayey, somewhat blocky B. Below 24 in. is the C horizon.

Therefore, a few supplemental terms have been defined in the Approximations. The terms are for diagnostic horizons pertinent to the new classification, and the names smack strongly of the new soil classes. Actually when one understands what these are about, the rest, like sin, is almost easy.

Pedon.—First we come head-on with the pedon, which rhymes. The pedon is considered to be the smallest volume which satisfactorily represents a soil, and is analogous to the unit cell in crystallography. The pedon is thus a hexagonal prism ordinarily 1 to 10 sq m in area and with a rather vague lower limit.

Epipedon.—The epipedon (overpedon) is loosely the A horizon plus any of the B darkened by organic matter. In the new classification six kinds of epipedon are recognized, from Molly to Manure. Only 1, 3, 4, and 5 (asterisk) are common in the U. S.:

*1. Mollic (= soft) epipedon, a thick, dark, organic A_1 horizon, Ca^{++} saturated, feels nice and loamy. Where the tall corn grows.

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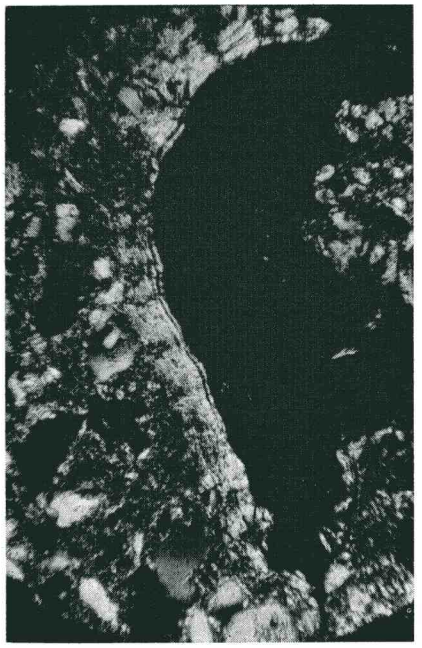


Courtesy Klaus Flach, USDA.

Fig. 3.—Clay skin (white banded area) enclosing a soil pore (black) as seen under a polarized light microscope.

2. Anthropic (man-ipulated) epipedon. Same as mollic but high in phosphate due to long cultivation and fertilization.

*3. Umbric (= shady or dark) epipedon. Same as mollic but H^+ saturated. An acid soil.

*4. Histic (= tissue) epipedon, a peaty or mucky horizon less than a foot thick, normally water-saturated.

*5. Ochric (= pale) epipedon, a light-colored A_2 or albic (white) horizon.

6. Plaggen (= meadow) epipedon, an A_p accumulated to more than 20 in. thick. Explanation for the thick A is long continued manuring.

To summarize, an A_1 is mollic, and A_2 is ochric, and a plaggen is B.S., M.S., and Ph.D.[5]

Subsurface New Words

*1. An argillic (= clayey) horizon is a B-horizon significantly enriched with clay from above. The soil may break into blocks or "peds" that must show "clay skins," which are thin coatings of oriented clay formed around soil pores, grains, or peds, giving a shiny appearance. Clay skins are most readily seen and verified under a microscope. Clay skinning has recently become a favorite outdoor and indoor sport among U. S. soil scientists.

2. Agric horizon. Same as argillic but modified from long cultivation.

*3. Natric (= sodium) horizon, same as argillic but with columnar or prismatic structure and over 15 per cent exchangeable sodium. Sodium disperses the clay, making for sticky problems. Southwest U. S.

*4. Spodic (= ashy) horizon, a B-horizon enriched with humus or sesquioxides such as Fe_2O_3 or both. No clay enrichment, no structure, no clay skins. May be cemented into a hard layer called an ortstein. Podzols.

*5. Cambic (= changed) horizon, a mildly weathered horizon between the A and the C with original rock structure gone. Little or no structure, no clay skins. Does not form in sands.

*6. Oxic (= oxide) horizon, a concentration of sesquioxides and kaolin clays due to removal of silica by strong weathering. Grows pineapple.

[5] This joke has peculiar academic franchise. M.S. = more of same; Ph.D. = piled higher and deeper.

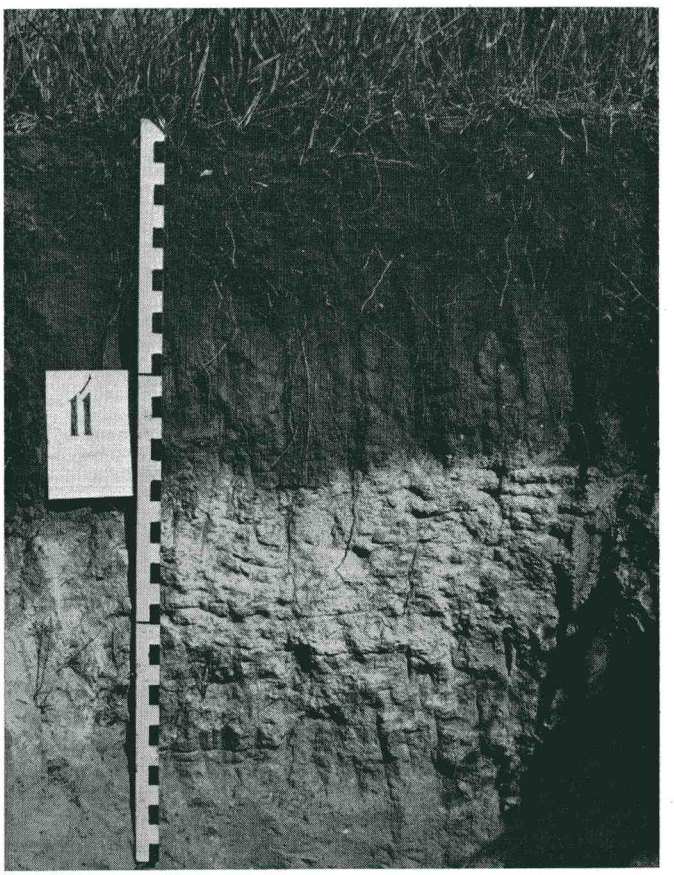
TABLE I.—PRESENT SOIL ORDERS AND APPROXIMATE EQUIVALENTS IN REVISED CLASSIFICATION OF BALDWIN, KELLOGG, THORP, AND SMITH, 1938–1949.

Order	Meaning	Approximate Equivalents
1...Entisols	Recent soil	Azonal soils, and some Low Humic Gley soils
2...Vertisols	Inversion soil	Grumusols
3...Inceptisols	Inception soil	Ando, Sol Brun Acide, some Brown Forest, Low Humic Gley, and Humic Gley soils
4...Aridisols	Arid soil	Desert, Reddish Desert, Sierozem, Solonchak, some Brown and Reddish Brown soils, and associated Solonetz
5...Mollisols	Mollic Epipedon	Chestnut, Chernozem, Brunizem (Prairie), Rendzinas, some Brown, Brown Forest, and associated Solonetz and Humic Gley soils
6...Spodonsol	Podzol (ashy)	Podzols, Brown Podzolic soils, and Ground-Water Podzols
7...Alfisols	Pedalfer (Al-Fe) soil	Gray-Brown Podzolic, Gray Wooded soils, Noncalcic Brown soils, Degraded Chernozem, and associated Planosols and some Half-Bog soils
8...Ultisols	Ultimate soil	Red-Yellow Podzolic soils, Reddish-Brown Lateritic soils of the U. S., and associated Planosols and Half-Bog soils
9...Oxisols	Oxide soil	Laterite soils, Latosols
10...Histosols	Tissue soil	Bog soils

Orders

One of the first inspirational things man did when he invented language was execute some orders, or was it order some executions? Anyway, we have a new language and a whole world to talk about, so let us sound off: Entisol, Vertisol, Inceptisol, Parasol! The first three are new names for soil orders. The last keeps off the sun.

Names of the soil orders are supposed to suggest vaguely the kind of soil. For



Courtesy William Johnson, USDA.

Fig. 4.—Chernozem ABC, North Dakota. The A is black, rooty, a mollic epipedon. The B is dark but weak, a cambic horizon. The white is a C_{ca}. New classification is Haplaltoll.

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example, Entisols are the exceptionally unweathered rec*ent* soils, formerly called Azonal. Vertisols include Black Cotton Soils or Grumusols, characterized by inversion, or vertical mixing due to sloughing into desiccation cracks. Our ultrarich prairie soils come under Mollisols, meaning they have a mollic epipedon (organic, calcium-saturated A-horizon). Alfisol looks like it might be rather good for alfalfa, but that would be a use classification so that's out. Actually it refers to "Pedalfer," an old tag for aluminum-iron soils.

The newly coined names are mainly from Latin and Greek, with a few German, French, and nonsense syllables thrown in. Therefore it helps to know the languages, and know your nonsense as well.

Whereas the old orders were genetic, the new ones are defined on the basis of measurable soil properties, such as thickness and kind of horizons, clay content, cation-exchange capacity, and conductivity of an extract. Particularly pertinent to engineers is the *N*-value, indicative of bearing capacity. *N* equals natural moisture content minus two, divided by per cent clay, plus three times the per cent organic matter. An *N*-value above 0.5 means tread softly or you'll sink.

Courtesy Guy D. Smith, USDA.

Fig. 5.—Inversion in the Vertisols tips fence posts and eucalyptus trees, South Australia

Suborders

As any pfc can tell you, each order gives rise to numerous suborders which can drive one to distraction. Whereas orders were three syllables (Ent-i-sol), suborders go by two. Furthermore, the last syllable indicates the order: Aquent (Aqu/ent = aqueous recent) is the hydromorphic suborder of Entisols. Similarly, there are Aqu*ert* (hydromorphic *Vert*isol), Aqu*ept* (Inc*ept*isol), Aqu*oll* (*Moll*isol), Aquo*d* (Spo*d*osol), Aqu*alf* (*Alf*isol), and Aqu*ult* (*Ult*isol). A major overhaul from the old classification is that hydromorphic soils fall under six suborders. Other suborders of Entisols are *Psamm*ent (sandy), *Ust*ent (hot climate), and *Ud*ent (humid climate).

Great Groups

There are so many great groups we'll not be able to call them all, but there are the New York Yankees, Elks, Young Republicans, ASTM, Laurel and Hardy, and the Mills Brothers, to name a few. Great groups of soils further divide the suborders, and are indicated by a third syllable tagged on the front. You may notice that names are beginning to have a rather foreign sound suggesting high Eskimo. Actually the resulting great group name is as easy as 1–2–3, only it's 3–2–1. For example, in Arctic cold the Aquent becomes a *Crya*quent, Cry meaning cold. Or an Aquoll (hydromorphic Mollisol) with an argillic or clayey horizon is an *Arg*aquoll.

Subgroups

Stop us if you've heard this before, but Albollic Argaquoll! What we mean is the soil is not just an ordinary Argaquoll (see above), in which case it would be an Orthic Argaquoll; it is Albollic, Albollic denoting the subgroup and indicating an intergrade character with an Alboll—whatever that is. If we take it apart we see Alb, meaning white horizon, and oll, meaning Mollisol. Starting at the back, an Albollic Argaquoll should have a dark A horizon (oll), wet conditions (aqu), an argillic or clayey B horizon (arg), and least of all a weak albic or A_2 horizon probably just above the B.

Finale

Beneath the subgroups remain as always the families and the basic mapping unit, the soil series. These still are named after a locality such as Ames, Boone, or Dubuque.

And that, friends, is the new pedological classification system in a nutshell and ready for roasting.

TABLE II.—GLOSSARY OF FORMATIVE ELEMENTS FOR ORDERS, SUBORDERS, GREAT GROUPS, AND SUBGROUPS.

acr.....most weathered	ert.....inversion	orth(ic)...true
agr.....agric horizon	ept.....inception	ox.....oxide
alb.....albic horizon	ferr.....iron	phan.....allophane
alf.....Pedalfer (Al-Fe)	frag.....fragipan	plac.....thin pan
alt.....high (cool)	fragloss = frag + gloss	plag.....plaggen horizon
and.....Ando (volcanic ash)	gloss.....tongued	plint.....plinthite (brick)
anthr.....man-modified	grum.....crumby	psamm...sandy
agu.....water-modified	hal.....salty	quarz.....quartz
arg.....argillic horizon	hapl.....min. horizon	rend.....on limestone
brun.....dark brown	hum.....humus	rhod.....dark red
calc.....calcic horizon	hydr.....wet	ruptic.....int. hor. intergrade
camb.....cambic horizon	id.....arid	sal.....salic horizon
crust.....crusting	ist.....tissue	thapto....in paleosol
cry.....cold	lithic.....on rock	therm.....warm
crypt.....deep horizon	maz.....massive	typ.....typical
cumulic...accumulating	nadur..= natr + dur	ud.....humid
dur.....duripan	natr.....natric horizon	ult.....strongly weathered
dystr.....low-base sat.	ochr.....ochric horizon	umbr.....umbric horizon
eutr.....high-base sat.	od.....spodic horizon	ust.....dry, hot
ent..... recent	oll.....mollic horizon	verm.....animal mixing

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