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NEW ZEALAND SOIL CLASSIFICATION by A. E. Hewitt
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Development

The publication of 'New Zealand Soil Classification' by Dr Alan Hewitt this year (Hewitt 1992a) represents a major milestone in New Zealand soil science. That it was one of the final publications of the now defunct DSIR is somehow appropriate because, as classification systems should, it provides (in a mere 133 pages) a synthesis of much of what has been learnt about the soils of New Zealand over the past 60 years or more. The new classification was officially launched at the New Zealand Society of Soil Science Conference in Rotorua on 16 November, 1992.

The new classification is the culmination of about ten years of work by Hewitt and others, particularly Ben Clayden, that began in 1983 when the New Zealand Soil Bureau decided not to adopt 'Soil Taxonomy' as its principal means of classification (Leamy et al. 1983). Soil Taxonomy, used on a trial basis from 1977-1983 (Miller 1978), had met with a mixed reception and there had been call to give the New Zealand Genetic Classification of Taylor and Pohlen (1962, 1968) at least "parity of study with Soil Taxonomy" (Gibbs 1979). Soil Taxonomy was seen as having serious shortcomings for New Zealand purposes even though protagonists acknowledged that it had the capacity to change to make better provision for international needs — the chief problem was its slow pace of evolution (Leamy et al. 1983).

[As an aside, it is perhaps ironical that the Soil Conservation Service of USDA recognised this problem at around the same time and formed international soil classification committees to provide a mechanism for handling and publishing approved amendments in successive issues or editions of 'National Soil Taxonomy Handbook' and 'Keys to Soil Taxonomy' (Kinloch & Clayden 1983; Witty & Eswaran 1990). Moreover, New Zealand soil scientists went on to make major contributions to the revisions of Soil Taxonomy through the 1980s, culminating in publication of the Andisol order in 1990.]

Thus, against a background of disquiet and debate, Hewitt set to work on the New Zealand Soil Classification (NZSC). Version 1 was published in 1987, Version 2 in 1989, and Version 3 in 1991, essentially the basis of NZSC as published this year. At all stages, draft copies were sent to interested soil scientists thoughout New Zealand for comment and trial, and specialists (e.g., in allophanic volcanic ash soils) were asked to help set limits in defining diagnostic horizons and so on for specific orders. At the same time, the principles and objectives of the new system, how it was to be developed, and how it was shaping up, were systematically documented in a series of commendable seminars and progress reports (e.g., Hewitt 1984, 1987, 1990, 1991). In a review article describing the 'legacy and lessons' of the entire exercise (Hewitt 1992b), Hewitt noted that perhaps the main legacy arising from the Soil Taxonomy trial was the development of a large computer data base of soil profiles (series) throughout New Zealand. This data base facilitated the construction of the new classification from the 'bottom up' in the taxonomic hierarchy, i.e. in an inductive fashion. The higher taxa, broadly known from the groups of Taylor and Pohlen's (1968) system, enabled concomitant construction from the 'top down', i.e. in a deductive fashion. A feature of the NZSC that breaks from the old Genetic Classification is the use of diagnostic horizons and other differentiae (some in common with Soil Taxonomy) to establish the classes. Such use of diagnostic horizons, and other factors, resulted in the development of revised systems of soil horizon notation (Clayden & Hewitt 1989), soil description (Milne et al. 1991), and land evaluation systems (Hewitt 1990). These revisions together with the NZSC thus constitute a new soil survey and classification package.

Similar developments in national classifications have also taken place in recent times in other countries including South Africa (Soil Classification Working Group 1991) and Australia (Isbell 1992; Lowe 1992).

The New Zealand Soil Classification

Presentation and introduction

The classification is presented in a orange-covered A5-sized (210 x 148 mm) book with soft covers. Three colour photographs of soil profiles representative of the Papakauri, Oamaru, and Lismore series adorn the front cover. Inside, the layout is attractive and clear. Short titles at the bottom of each page next to the page number are essential in helping readers find the appropriate sections. A plasticised cover would be useful to help keep the book field proof.

The text begins with a foreword (p. 4) listing references for technical terms not defined in the classification itself. This is followed by an introduction (pp. 5-14) in which initially the objectives and principles of the system are spelt out very clearly. The principles include the statements that (1) the classification should be hierarchical; (2) the grouping of soils into classes should be based on similarity of measureable soil properties rather than presumed genesis; (3) classes must be designed to allow the maximum number of accessory statements to be made about them; (4) differentiae should where possible allow field assignment of soils to classes; (5) the nomenclature of higher categories should be based where possible on connotative English words chosen for their acceptability to non-specialists; (6) where possible, continuity with successful parts of the New Zealand Genetic Classification should be maintained; and (7) the classification applies to the main islands of New Zealand and classes must be correlated with Soil Taxonomy for international comparison. The 'soil individual' is then defined, the pedon of Soil Taxonomy (Soil Survey Staff 1975) being recommended rather than the polypedon, although it is recognised that assignments are often made from soil profile slices assumed representative of a pedon.

Then follow useful subsections on how to use the classification keys to assign a soil to subgroup level (this section includes a figure illustrating the hierarchical relationships between the three highest levels of orders, groups, and subgroups), what to do if soils are found that do not readily fit the appropriate class as allocated by the key (misclassification), how to justify the addition of a new subgroup if new data warrant such additions (the specification of 'subgroup' in this section implies that more substantial changes to higher taxa, i.e. at group or order level, are perhaps less likely to happen for a considerable time), and finally a summary of general correlations with Soil Taxonomy and the New Zealand Genetic Classification systems in the form of a table covering six pages.

Diagnostic horizons

The next section defines 35 diagnostic horizons and other differentiae (pp. 15-34) including horizons, pans, layers, soil materials, contacts, profile forms, and other features. These are documented alphabetically after a summary table and are used to provide precise definitions in the keys to the orders, groups, and subgroups. Some of the horizons or features are based largely on Soil Taxonomy (e.g., argillic horizon, duripan, placic horizon) but most have a New Zealand emphasis and are considerably simpler than approximate equivalents in Soil Taxonomy. For example, the definition of 'allophanic soil material' in NZSC (p. 16) does not require the laboratory determinations of acid-oxalate-extractable Al and Fe, bulk density, P retention, or glass content that are essential for 'Andic soil properties' of Soil Taxonomy (Soil Survey Staff 1990). Instead, in accordance with the field assignment principle noted above, the definition is largely based on field-determined properties of sensitivity, unconfined soil strength, stickiness, and reaction to NaF ('reactive-aluminium test'), which are defined in the soil description handbook (Milne et al. 1991) and are reasonably reproducible (NaF test classes are also listed in the NZSC). P retention is available as a more precise alternative to the morphological differentiae when the morphological properties are marginal (Hewitt 1990). Bulk density measurements, needed in addition to the morphological (or P retention) properties for defining allophanic material (< 0.9 Mg/m^3), require only simple equipment and can be measured in a field office.

Some of the diagnostic horizons, when met in the field for the first time, may cause some uncertainty until experience with their use is gained. These include the argillic, cutanic, cutanoxidic, and oxidic horizons which have specific features for their recognition and differentiation. For example, argillic horizons may have clay coatings with a waxy lustre when dry, cutanic horizons have coatings without a waxy lustre when dry, and cutanoxidic peds have aggregates of iron oxide crystallites giving them a dusty appearance when dry. Such distinctions, often fairly subtle, become important for determining some of the soil orders — for example, distinguishing Ultic Soils, Oxidic Soils, and Granular Soils. One or two other features may also raise eyebrows when first encountered. For example, a 'weathered-B horizon' is normally taken as a Bw horizon but the definition (p. 34) additionally notes that it may also meet the requirements of various other sorts of B horizons including a redox-mottled horizon, argillic horizon, cutanic horizon, or brittle-B horizon. The insertion of such qualifications, however, becomes clear when the classification is actually used. All in all, the diagnostic horizons are comprehensive and wide ranging.

Key
The key to the 15 soil orders occupies six pages (pp. 35-40) and is obviously a critical part of the classification. It would be helpful if these pages in future editions were perhaps of a different colour so that they can easily be picked out from the rest of the text. In the opening paragraph of the section, Hewitt specifies that any surface mantle of new material (e.g., fresh alluvium) less than 30 cm thick is not considered as part of the soil for assignment to the various classes except for some cases (Recent, Raw, or some Gley Soils), and that any soil with an overthickened A horizon 45 cm or more thick, and not mottled within 30 cm of the mineral soil surface, should be entered directly at Recent Soils. The keys proper then follow, beginning with Organic Soils and ending with Raw Soils.

In general, the keys are reasonably clear and straightforward to follow once the diagnostic horizons are mastered. Typically, the diagnostic horizon definitions are repeatedly referred to until sufficient familiarity with the definitions is attained. It is essential to have copies of both the horizon notation and soil description handbooks in order to work though the keys (for both the orders and the lower levels in the classification) with 'yes-no' questions and answers because some critical features are not defined in the NZSC — for example, soil texture groups or soil sensitivity classes. It would be worth considering combining at least the soil horizon notation booklet (Clayden & Hewitt 1989) into the NZSC in future editions (probably at the back as done in the Keys to Soil Taxonomy). Occasionally, soil pH is used to make taxonomic chops at both order level (e.g., Ultic Soils have pH <5.5) and below (e.g., Acid Brown Soils have a pH of 4.8 or less, or a placic horizon). The final page of the keys includes a useful figure summarising colour criteria used in part to separate Brown Soils from Pallic Soils and Recent Soils.

Orders, groups, subgroups
The main part of the book (pp. 41-127) is devoted to descriptions of each of the orders which are listed alphabetically from Allophanic Soils to Ultic Soils. Each order is systematically documented. There are subsections describing the concept of the order (it typically summarises the salient properties, usual parent materials and sometimes conditions of genesis), its correlation with the Genetic Classification and Soil Taxonomy, its occurrence, and then a list of usually quite precise accessory properties of the order (usually around ten or a dozen statements). These accessory properties relate not only to the utility of the classes but also to the grouping decisions made during their establishment (Hewitt 1990). Then follows a table summarising the hierarchy of the order and associated groups and subgroups. Examples of series (geographical names) are also listed, and are helpful for teaching purposes. This summary leads into the keys to the groups and subgroups. As with the key to the orders, these keys can be followed step by step by essentially answering 'yes' or 'no' to the definitions for the groups or subgroups until the endpoint (subgroup) is reached.

Nomenclature
The name given to a soil assigned to a subgroup is always made up of three elements in the sequence, namely subgroup-group-order (e.g., Fragic Allophanic Brown Soils). In some cases, the group or, more usually, subgroup element may be hyphenated (e.g., Argillic-calcareous Orthic Melanic Soils; Duric Perch-gley Pumice Soils; Humose-ortstein Perch-gley Podzols). Note that the first letter in all elements of the name is always capitalised. This is because they are (1) proper names, and (2) to avoid confusion with simple descriptive terms that are technically unrelated to the classification — for example, a 'Yellow Ultic Soil' versus a 'yellow soil', an 'Allophanic Soil' versus an 'allophanic soil', and so on. The nomenclature is clearly important and Hewitt has attempted to keep the names connotative yet simple. Some names have met with criticism, particularly the use of Semiarid Soils (the soil climate rather than the soil itself is being described), Brown Soils (what is 'brown'?), and Granular Soils (what is 'granular'?). As well, the use of 'Podzols' rather than 'Podzol Soils' is the exception of the order names which otherwise all end in

'Soils'. A few names sound rather similar and are potentially confusing (e.g., Humus-pan Pan Podzols versus Humose Pan Podzols). But, despite some mouthfuls, the majority of names at subgroup level are quite reasonable to write or say and, very importantly, are connotative (even though lacking the simple interlocking elegance of Soil Taxonomy). Many classifications, to my mind, encapsulate the properties and genesis rather neatly, as exemplified in Fig. 1.

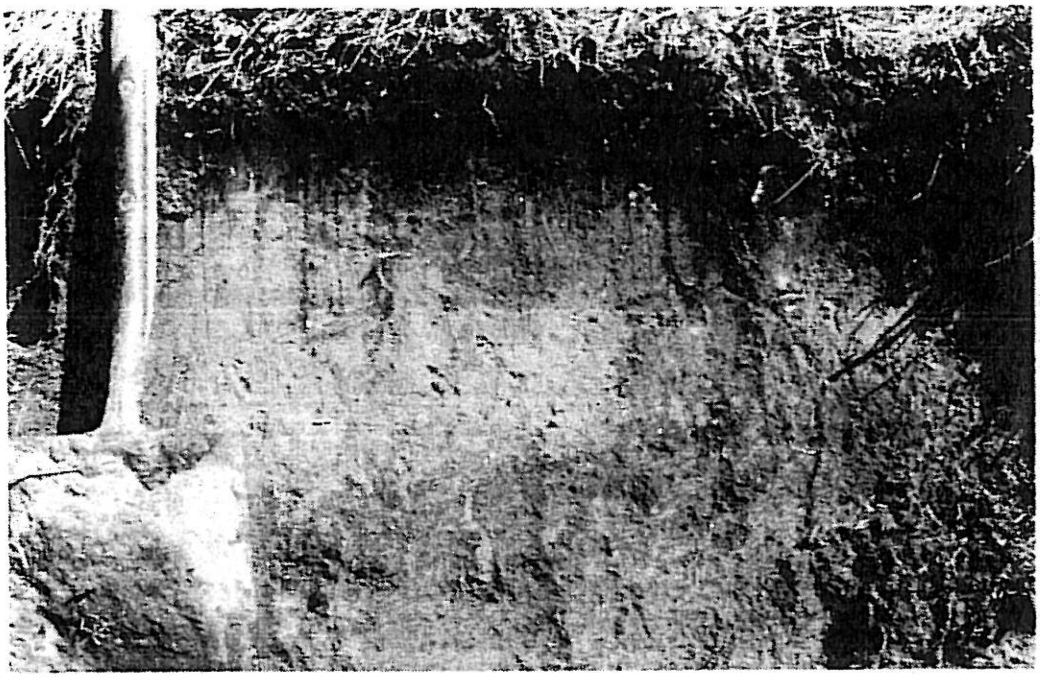

Fig. 1. A composite soil developed in Taupo Tephra on late Quaternary tephra deposits in the King Country. It is classed as a Buried-allophanic Orthic Pumice Soil in the NZSC. In the Genetic Classification it is a composite Yellow-brown pumice soil on Yellow-brown loam. *Photo:* J.D. McCraw.

Each of the groups and subgroups has been assigned a two,three, or four letter code. Some of these make interesting reading. For example, Peaty Orthic Gley Soils are appropriately designated GOO (p. 68), Acidic-mafic Allophanic Brown Soils are coded as BLAM (p. 56), and Mottled-pallic Orthic Recent Soils are coded as ROMP (p. 116). Even a famous (or should it be infamous?) Lincoln pedologist is represented with PJT being a Typic Argillic Pallic Soil (p. 95). At Waikato, RFA is an Acidic Fluvial Recent Soil (p. 115).

Series

It should be noted that the NZSC comprises three hierarchical levels — order, group, subgroup — but is designed to accommodate a fourth category, that of series. Criteria for the definition of soil series in the NZSC have recently been presented separately by Clayden (1991). He proposes to distinguish within subgroups according to three main criteria: nature of parent material or substrate, particle-size characteristics, and permeability profile. The idea is that each soil series defined on this basis will have a unique definition based on its subgroup, parent material, particle-size grouping, and permeability class. Thus the soil shown in Fig. 1 is likely to be classed at series level as a Buried-allophanic Orthic Pumice Soil, Sandy/silty, tephric-rhyolitic, rapid/moderate, the last three elements being particle size, parent material, and permeability profile features, respectively. This level of the classification seems similar to the family category of Soil Taxonomy, and it may be that this term is resurrected (it was originally planned as such by Hewitt in 1984), thereby leaving the series essentially as the geographic name of a soil meeting the definitions of the four hierarchical levels (A.E. Hewitt, pers. comm. 1992). Thus the Papakauri and Tirau soils, for example, are likely to have identical classifications to subgroup level (Typic Orthic Allophanic Soils) but are separated at the fourth level ('family' or series, or both).

The assignment of parent material and particle size features to series level resulted in some significant changes between version 2.0 (1989) and the NZSC (1992). One example is that shown on the front cover, a representative of the Lismore series. In version 2.0, this was rather appropriately keyed out as a Pan Stony Brown Soil but in version 3.0 (NZSC) the Stony group has descended to series level. Texture is still used at group or subgroup level in a few cases, however. For example, in Sandy Brown Soils and Sandy Recent Soils, and Silt-mantled Perch-gley Podzols.

Relation to Genetic Classification

To a general degree, many of the new orders approximate soil groups in the old Genetic Classification. For example, Semiarid Soils roughly match brown-grey earths, Pallic Soils match yellow-grey earths, Podzols match podzols, Granular Soils match brown granular loams, Allophanic Soils match yellow-brown loams, Pumice Soils match yellow-brown pumice soils, and Gley Soils match gley soils. This general continuity will help in users making the transition from the old to the new system. However, all of the old groups have been reshaped to a certain extent, and some have been dismembered completely. Residual bits may appear in several new orders, as in the following examples. (1) Soils in the old red and brown loams group now appear in the Allophanic Soils (e.g., Papakauri series) or in the Oxidic Soils (e.g., Okaihau, Kerikeri series). (2) Allophanic members of the upland and high country yellow-brown earths may appear in Allophanic Soils but where the allophanic soil material is too thin they are usually intergrades in the Brown Soils, namely Allophanic Brown Soils (e.g., Craigieburn series). (3) One order that brings together soils that might previously have been regarded as unlikely partners is the Melanic Soils order, made up of soils with high base saturations, well structured and very dark A horizons, and weakly alkaline or weakly acid subsurface horizons. These soils have parent materials rich in calcium or magnesium, or both, and include the old rendzinas or rendzic intergrades (e.g., Oamaru series) and some of the brown-granular loams and clays (e.g., Dun series). (4) An interesting split is the separation of the strongly weathered and leached northern yellow-brown earths from the rest of the yellow-brown earth group into the Ultic Soils. Such a split was suggested many years ago by Guerassimov (1969). (5) That the Pumice Soils have been maintained as a separate entity, rather than being lumped into the Allophanic Soils as occurs with the Andisols in Soil Taxonomy, is a good feature because of their special nature and recent age. (6) Perhaps the most diverse order in the NZSC is the Brown Soils order, the most extensive in New Zealand, which contains soils previously classed in yellow-brown earths, yellow-brown sands, southern brown granular loams and clays, and numerous others.

There are several orders that have no real equivalent in the Genetic Classification, namely the Raw Soils (lacking topsoil development) and Anthropic Soils. The latter order keys out just before Recent and Raw Soils at the end of the keys (p. 40) and so soils that have been drastically disturbed but restored to the extent that they will meet the requirements of orders other than Recent or Raw Soils will not be assigned to Anthropic Soils.

Final pages

The last pages of the NZSC (pp. 128-133) contain acknowledgements, references, and an appendix explaining the letter codes and meanings for different levels of the classification.

Conclusions

L. I. Grange began his paper on the classification of soils of Rotorua County (Grange 1929) with the remark: "The classification of soils is by no means easy" (p. 219). This is no less true today. Therefore, the NZSC surely represents an outstanding achievement. It is a modern classification system designed specifically for New Zealand conditions, is both comprehensive and generally easy to use in the field with a minimum of supporting laboratory data, and is a great advance on the Genetic Classification. It is also correlatable with Soil Taxonomy. Its flaws are few, its attributes are many, and it works. Apart from minor adjustments and the inclusion of new groups or subgroups as new data arise, there are unlikely to be major structural alterations to the framework for some time. The suggestion of Tonkin et al. (1992) at the Rotorua conference that multisequal (or 'composite') soils should be considered for inclusion in future editions of NZSC was generally well supported. Such inclusions should not seriously disrupt the current NZSC framework, however.

The NZSC is easy to teach. At Waikato University, we have been teaching it to postgraduates since version 1.0 was published and to undergraduates since 1990. The new terms are now routine.

Alan Hewitt was brave enough to state, in 1987, that the New Zealand Soil Classification "will deliver the goods to those concerned for the stewardship of New Zealand soils" (Hewitt 1987, p. 243). In my view, it has delivered the goods. The obvious question that now arises from his statement, however, might be, "Who are the stewards of New Zealand soils in 1992"? Certainly, Soil Bureau and its DSIR successors have gone but, as so eloquently and passionately put by Dr Phil Tonkin at the Rotorua conference, there are still scientists and others who study, manage, and appreciate soils in New Zealand: they are the stewards and they must use the legacy of previous generations — the New Zealand Soil Classification.

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