FRENCH SOIL CLASSIFICATIONS AND THEIR APPLICATION IN THE SOUTH PACIFIC ISLANDS

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The French soil classification (C.P.C.S.*, 1976) is derived from the genetic principles inherited from the early Russian pedologists, to which morphological and physico-chemical facts have been added in order to define taxonomic units. It is the result of several approximations of which the most important are the soil classification scheme of Aubert and Duchaufour (1956) and further modifications by Aubert (1965), Aubert and Segalen (1966) and Duchaufour (1970-1977). As there are still many unclarified areas in our pedological knowledge it exists only in mimeograph form. At present it is the subject of continuing discussions as to its rearrangement (work of the C.P.C.S.), the complete reconstruction (Soil Classification Scheme by Segalen et al., 1979) or statements about other ways of expressing pedological facts (Typology : Chatelin, Martin, 1972; Beaudou, Chatelin, 1976). In this paper the C.P.C.S. (1967) classification will be presented in as much detail as possible, together with the Segalen's soil classification scheme.

THE C.P.C.S. (1967) CLASSIFICATION AND ITS APPLICATION IN OCEANIA

The principle of this classification is "morphogenetic". The soils are classified after their morphological characteristics, according to their formation processes.

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*C.P.C.S.: Commission de Pédologie et de Cartographie des Sols.

The C.P.C.S. classification is subdivided into higher units : classes and subclasses, and lower units : groups, subgroups, families and series. The classes and subclasses express (Aubert, Boulaine, 1971) :

- the degree of soil evolution and profile development;
- the mode of weathering defined by the type and amount of free sesquioxides and by the abundance of certain types of clay;
- the type and the distribution of organic matter; and,
- certain fundamental evolutionary processes such as hydromorphy or soil development in the presence of salts.

The subclass characterizes the morphological features due to the pedo-climate. The groups and subgroups are defined according to morphological characters corresponding to soil development processes while the family is concerned with petrographic material and the series with edaphic characteristics.

The main field of application of the C.P.C.S. classification in the Region has been in Vanuatu where general maps on a scale of 1:50,000 and 1:100,000 have been made, and in New Caledonia where surveys on a scale of 1:1,000,000, 1:200,000, and 1:50,000 have been made. Apart from these, more limited studies have been conducted in Tahiti, Wallis, Fiji, Solomon Islands and Papua New Guinea.

The C.P.C.S. classification includes twelve classes :

1. Raw mineral soils:

Raw mineral soils are those which contain only a small trace of organic matter in the upper 20 cm of the profile, and in which the mineral horizons have not undergone any significant pedological development. A Regional example is furnished by the soils formed on very recent volcanic material (cinders, lava, and transported material) around the active volcanoes in Vanuatu (Quantin, 1975). These soils are uncommon in the humid tropics because of the rapidity and intensity of weathering. In Soil Taxonomy they are classified as Entisols.

2. Weakly developed soils

Weakly developed soils are those with a marked humiferous horizon but with little sign of geochemical alteration in the mineral matter or of pedological differentiation. This class contains four subclasses:

- weakly developed soils of glacial zones;
- weakly developed humiferous soils;
- weakly developed soils of dry zones;
- weakly developed soils of non-climatic origin.

In this Region, high altitude very humiferous alpine Rankers and non-climatic weakly developed soil, due to erosion or deposition, can be found.

Among the eroded soils, are classed those which have been truncated by erosion like those on altered basalt or schists in New Caledonia.

Deposition soils can be of two kinds:

- recent soils of river alluvium or colluvium. In this Region, these soils are common on all Holocene river terraces. They are very important because of their agricultural value, though they are not extensive. In Soil Taxonomy, they are classified as Fluvents;

- soils of recent volcanic deposits which are related to Vitrandepts (Vitritropands).

The concept of evolution and weathering in these soils is rather complicated, because the deposited material may have been subject to weathering before its deposition. Some eroded soils may have been deeply weathered under humid paleo-climates then truncated. Thus it is difficult to determine that part of the profile resulting from present processes of soil development,

and therefore the degree of pedological organisation of the profile appears to be a more suitable criterion.

3. Vertisols:

Vertisols are dark-coloured clay soils, dominated by swelling clays with a high exchange capacity (35-40 meq/100 g). They show shrinkage cracks in the dry season, obliquely striped slikensides indicating that they are affected by internal movements, which can produce a gilgai microrelief on the surface. The criteria for their classification are comparable to those used at the highest level (Vertisols) in Soil Taxonomy. For lower levels drainage capacity and the structure of the upper 15 cm in the profile are taken into account.

Typic Vertisols are common on the west coast of New Caledonia on the piedmont of basaltic hills and in the alluvial plains. Some vertic brown soils appear also on the west coast of the greatest and oldest islands of Vanuatu (Santo, Malekula). They are rare elsewhere in the Pacific Islands because the climate is too wet.

4. Andosols:

These soils constitute a group characterised by the dominance in the mineral fraction of the poorly ordered hydrated alumino-silicate called allophane associated with variable but often high percentage of organic matter. The classification of Andosols has been developed since the C.P.C.S. and at present provides for subclasses dichotomy between Andosols with weakly differentiated profiles and those with well differentiated profiles. The former corresponds in part to the separation of Vitrandepts from other Andepts. Andosols with a well differentiated profile are more common in the South Pacific islands and they include Eutrandepts, Dystrandepts and Hydrandepts. These soils are well represented in Vanuatu, Fiji, and Papua New Guinea.

5. Calcimagnesic soils:

These are the soils in which the morphological characteristics of the upper horizons are determined by the effect of alkaline earth ions (Ca, Mg). The lower part of the solum, where it exists, shows neither the characteristics of Vertisols nor those of Isohumic soils. The supply of bivalent ions is assured by a carbonate or other very basic types of underlying rocks.

In this Region the following soils are classified in this unit:

- Rendzinas on calcareous sand of coastal plains or atolls (French Polynesia, Fiji Loyalty Islands, Vanuatu);
- Brown calcareous soils with an aluminium rich facies;
- soils derived from volcanic pumice on uplifted atolls of Loyalty Islands, Kabara, and Niue.

These soils are classified in Soil Taxonomy as Mollisols under the suborder Rendolls.

6. Isohumic soils:

Isohumic soils are those which have a moderate or weakly differentiated profile, showing high percentages of organic matter at the surface that decreases slowly with depth. They are steppe soils: Brunizems, Chernozems, Chestnut soils, Brown soils, Maroon soils (cinnamonic). These soils are uncommon in the islands of the South Pacific. Certain soils with a calcareous crust on the west coast of New Caledonia (encrusted Maroon soils) can be classed among them. In Soil Taxonomy these Brown lime encrusted soils would be classified as Calciustolls.

7. Brown soils:

These soils are characterized by a humus of mull type in which the characteristics are similar to that defined for a mollic horizon, and by a well differentiated profile. Most of the iron liberated

by weathering is allied to the humus - clay complex. These soils would be classified in Soil Taxonomy as Mollisols, Inceptisols and Alfisols. In tropical environments eutrophic Brown soils, either weakly developed, or vertic, or ferruginised have been defined. These soils, which generally are not deep, have been observed in New Caledonia, Vanuatu, and Fiji, on volcanic uplands and on limestones. They are related to the Eutropepts described in Soil Taxonomy. Quantin, in order to take into account the incomplete mineral modification of some weakly developed acid soils in Vanuatu and New Caledonia,proposed that they should be classified as dystrophic or unsaturated Brown soils which could be related to Dystropepts.

8. Podzolized soils:

Podzolized soils are sometimes characterized by an A_2 horizon which is eluvial, very white and extremely impoverished in clay, iron and cations and always by an illuvial B horizon in which the characteristics are those of a spodic horizon rich in Al and Fe complexed humus. True Podzols are uncommon in this Region. They can be seen on very siliceous rocks, phtanites or siliceous alluvium in New Caledonia. On the other hand, the podzolisation with the formation of a bleached A_2 horizon is a common process in New Caledonia where it affects the upper fersiallitic part of ferallitic soils, also in Fiji in red and yellow podzolic soils and in Tahiti at high altitude.

9. Iron sesquioxide or fersiallitic soils:

These soils are characterised by the separation of iron or manganese sesquioxides which give a red-ochre or red colour to B horizons. In addition to kaolinite, their principal clay mineral, they contain a certain amount of 2:1 clay and are usually lacking in gibbsite. The concept of a fersiallitic soil, which has hitherto been restricted to ferruginous tropical soils and red or brown mediterranean soils, has been enlarged to include fersiallitic soils of low base saturation. In the Region such soils have been

observed in New Caledonia, Vanuatu and Fiji. These soils may undergo secondary podzolic evolution in the A_2 horizons. These low base saturation fersiallitic soils encountered in the Region would be classified in Soil Taxonomy as Ultisols or Alfisols for those leached in clay, or with Inceptisols, Eutropepts, Dystropepts for those which are not leached.

10. Ferrallitic soils:

Ferrallitic soils are characterized by an almost complete weathering of primary minerals except for quartz, muscovite and a few heavy minerals, and by the synthesis of kaolinite (or halloysite), aluminium hydroxides and iron sesquioxides. They are the typical soils of the humid tropics. They are subdivided at the level of subclass according to base saturation criteria. But in order to take into account the existence of soils composed uniquely of metallic sesquioxides the creation of a new subclass of oxidic soils has been proposed into which allitic soils rich in aluminium hydroxides, and ferritic soils, rich in iron sesquioxides, could be placed.

In Soil Taxonomy, ferrallitic soils correspond principally with Oxisols, but certain leached ferrallitic soils have been included among the Ultisols. Some halloysite rich ferrallitic soils, from volcanic materials, would be classified as Inceptisols (Tropepts, Andepts). These humid tropical soils are very common in Pacific Islands.

11. Hydromorphic soils

The class of Hydromorphic soils was created to characterize the soils in which pedogenesis is dominated by water saturation due to a temporary or permanent waterlogging of part or the whole of the profile. The following are classified as Hydromorphic soils:

- peats which in Soil Taxonomy are classified as Histosols. These soils are frequent in the subcoastal or inland marshes

which do not receive too much alluvium. They can be found in New Caledonia, Fiji, Vanuatu, Papua New Guinea, Tahiti and in many other areas;

- soils with moderate or small amounts of humus and with gley or pseudogley features, which correspond to the Aqu- suborders in Soil Taxonomy.

12. Sodic soils:

These are the soils in which the evolution is dominated by:

- the presence of soluble alkaline salts in solution of which the conductivity is above 7 mmhos.
- the presence of exchangeable sodium together with the appearance of a massive and diffuse structure.

They correspond mainly with Aridisols having a sodic or natric horizon. Limits in concentrations of soluble salts or exchangeable sodium are lower in the 1967 edition of C.P.C.S. than in Soil Taxonomy.

Within this Region these soils are uncommon, except in mangrove areas and on the west coast of New Caledonia where they are under the influences of a very dry climate, sodium rich parent rocks, and sea sprays, and where some solontchacks and solonetz are found.

Discussion

Thus, in the upper subdivisions of the French classification, most emphasis is placed on the major pedogenetic processes which are as follows:

- development under different types of humus (brunification, podzolization, iso-humization);
- ferruginization;
- andosolization;
- vertisolization;
- calcium-carbonate (or sulphate) illuviation;
- allitization, ferritization, ferralitization;
- waterlogging;
- alkalization;

In its principal features the French classification is logical and corresponds to the major world ecopedological units. However, it has been much criticized in recent years for various, sometimes contradictory, reasons. The following remarks have been made:

- It lacks precision. The absence of precise diagnostic features and well defined limits, sometimes leaving too much open to personal interpretation. But, this allows a certain flexibility in areas as yet unknown.
- It is incomplete. Numerous soils are not easily fitted into the system and it is therefore necessary to propose new taxa which then pile up over a number of years.
- Imprecise references are given to climate, which also do not account adequately for palaeoclimates.

However, the general principles of the system have apparently received the assent of the French Pedological community and a new edition of the C.P.C.S. following these principles is in progress.

SOIL CLASSIFICATION PROJECT (Segalen et al., 1979)

Other classification projects have been undertaken recently and among these the most complete by far, is that of a group of ORSTOM pedologists led by P. Segalen. This project marks a break

with the French genetic classification and attempts to be a more objective classification. Like Soil Taxonomy it classifies soils first by their own characteristics and according to diagnostic horizons. Two fundamental types of data are taken into consideration:

- mineral and organic constituents,
- soil morphology as expressed in the horizons.

The choice of the main mineral and organic constituents as primary taxa in the classification follows from the important properties that they have and from their permanent character. In addition the soil constituents summarize the effect of the factors and processes of their formation. But the morphological features are not undervalued, even though they are used at the second level.

Four levels of classification have been made:

- level I (class and subclass) is determined by the constituents or groups of main constituents;
- level II (groups to families) is determined by the diagnostic characteristics of the organic, humiferous, and mineral horizons;
- level III (genus, series) is determined by the chemical and edaphic characteristics of the horizons;
- level IV (phase, variant) is determined by special characteristics of the pedon and environmental data, relevant to land use or soil genesis explanation.

Ten classes are thus defined:

- primarosols which have no notable pedological development and where, if it is present, the organic horizon is less than 18 cm thick;
- organosols in which the organic horizon is more than 3/4 of the soil profile if that is less than 60 cm thick, or

more than 45 cm if the soil is more than 60 cm thick;

- selsols which contain chloride, sulphide, sulphate and carbonate salts;

- andosols in which the mineral matter is mainly composed of secondary amorphous and/or poorly ordered minerals which are very hydrated and form stable organo-mineral complexes with humic acids;

- bisialsols composed of 2:1 and 1:1 clay minerals, in variable proportions;

- ferbisialsols characterised by the presence of 2:1 clay minerals and iron oxides or hydroxides associated in variable proportions with 1:1 clay;

- monosialsols characterised by 1:1 clay minerals and possibly aluminium hydroxides;

- fermonosialsols in which the mineral horizons are constituted of 1:1 clays associated with metallic sesquioxides (iron, aluminium, titanium...);

- oxidisols are constituted mainly of iron, aluminium, titanium and other sesquioxides with very small amounts of clay minerals;

- podzols characterised by the degradation in the upper part of the pedon of clay minerals and iron and aluminium sesquioxides, and by the formation of more or less mobile complexes between organic matter and iron and aluminium hydroxides;

In the absence, as far as we know, of application, we may ask if this project can fulfil the aims of its subscribers, that is:

- comprehensive, allowing for all criteria to find their own place,

- natural, as it is based on naturally limited criteria,
- coherent, as it is based on a hierarchy of criteria where each criterion is treated at a special taxonomic level independently of the idea of the observer,
- universal, valuable for all times and in all countries allowing to add any new soil unit we can observe.

We may answer as follows:

- comprehensive: it includes morphological, chemical and mineralogical criteria;
- natural: the idea of natural limits is very often difficult to establish and much progress has still to be made towards their definition;
- coherent: the system's coherence need not be tested;
- universal: treating soil as an object in itself no external considerations are taken into account, for the high levels of classification, but they are, at the lower level, for land use evaluation or genesis explanation;

The main difficulty of the project is that much work is needed in the laboratory in order to define the main units. Therefore, there is some divergence between pedologists who prefer to classify their soils in the field with a minimum of analytic data because their laboratory support is limited, and those with access to good laboratory facilities who look for a more sophisticated system.

CONCLUSION

The 1967 edition of the French Soil Classification has served as a basis for most of the tropical soil surveys undertaken by ORSTOM during the last fifteen years. However, it has not always proved adequate for all the pedological units encountered and a revision of the classification is in progress. As well as the

studies in typological language (Beaudou, p.201), two different ways of thought have now emerged.

- one prefers to stay in the French morphogenetic tradition, revising the existing classification and making it more accurate;
- the other influenced by Soil Taxonomy prefers to build an entirely new, more objective and logical system. This project, conducted by a group of pedologists led by P. Segalen, is based on the definition of diagnostic horizons and on the creation of new units defined at the highest level by the organo-mineral constitution of the soil according to the main pedological processes.

If the C.P.C.S. members pursue and improve the first method of classification to a new edition, as it now appears, it is desirable that the authors should take into account the precise and logical concepts which Chatelin et al., and Segalen et al., have brought to pedology.

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