OXISOLS

M. Latham
Office de la Recherchė Scientifique et Technique Outre-mer,
Noumea, New Caledonia.

Oxisols are red, yellow and occasionally grey soils of tropical or subtropical Regions. They are usually very deeply weathered and have undergone almost complete pedological transformation. Morphologically, apart from colour, they are characterised by sandy-loamy to clayey textures; medium to weakly developed blocky structures; in general, ferruginous and/or aluminous indurated elements; and by the absence of clear boundaries between horizons.

Weathering in removing the primary easily weatherable minerals has allowed formation of 1:1 clays of the kaolinitic family and of iron and aluminium oxihydrates. In addition, minerals resistant to weathering such as quartz and certain heavy minerals are commonly found.

Oxisols often develop on old geomorphological surfaces but they can also be found in relatively recent volcanic areas. They support forest or savannah vegetation. Their natural fertility is usually considered to be medium to poor.

1. Pedogenesis - Weathering

As Oxisols are generally linked with processes of deep weathering, examination of this process is appropriate. In hot, humid environments, (udic and ustic moisture regimes and isohyperthermic temperature regimes), the weathering process normally follows, schematically the following stages:

- the cations: sodium, potassium, magnesium and calcium as well as the more soluble elements of the rock are removed in solution simultaneously contemporaneously, silica from silicate minerals starts to be leached from the system; the silica, iron and aluminium which are liberated after the destruction of the primary minerals tend to reorganize in a more stable form - kaolinite, an aluminosilicate, with some iron substitution; as the silica continues to be progressively leached, some iron and eventually some aluminium (due to under-saturation in respect to silica) precipitate as oxides or hydroxides; and, the leaching of silica may progress, such that all silica is lost from the soil; at this stage only oxides and hydro-oxides of iron and aluminium remain in the soil.

This sequence of chemical change is very simplistic and in nature the processes operating are far more complicated. Some stages may be bypassed, for example, the formation of kaolinite or the sequence may never develop to the ultimate stage. Also, the paleo-climatic factors must be taken into account, for the formation of an Oxisol is a long process and it may have been initiated in a different climate than that prevailing at present. However, Oxisols by definition are soils which have reached the two last steps in the weathering process described.

2. The definition of the Oxic Horizon

This horizon is a deeply weathered subsurface horizon comprising a mixture of iron and aluminium oxihydrates, a variable amount of 1:1 lattice clays, with variable amounts of very insoluble minerals such as quartz or certain heavy minerals. It has neither an argillic nor a natric horizon.

In summary, the oxic horizon is defined as having:

- a minimum thickness of 30 cm;
- a fine earth fraction with 10 meq or less of bases (extractable with NH_4OAc plus aluminium extractable with 1N KCl) per 100g of clay;

- a CEC in the fine earth fraction of 16 meq or less per 100g of clay (by NH_4OAc at pH 7) unless there is an appreciable amount of aluminium interlayered chlorite;
- only traces of primary aluminosilicates such as feldspars, micas and ferromangnesium minerals;
- a texture finer than sandy loam and having more than 15% clay;
- less than 5% by volume that shows rock structure.

Classification of Oxisols:

Definition of the Order

Oxisols are mineral soils that meet one of these two requirements:

1. Have an aquic moisture regime and have plinthite that forms a continuous phase within 30 cm of the soil surface; or

2. Have an oxic horizon at some depth within 2 m of the soil surface but do not have a plaggen epipedon and do not have either a natric or an argillic horizon that overlies the oxic horizon.

Suborders

Five suborders are defined according to the key:

Aquox

Oxisols that have one or both of the following characteristics:

1. Plinthite that forms a continuous phase within 30 cm of the mineral surface of the soil and the soil is saturated with water within this depth at some time during the year; or

2. Either are saturated with water at some time during the year or are artificially drained, have an oxic horizon, and also have one or both of the following characteristics associated with wetness:

a. A histic epipedon; or

b. If free of mottles, immediately below any epipedon that has moist colour value of less than 3.5 there is dominant chroma of 2 or less; or if there are distinct or prominent mottles within 50 cm of the soil surface, the dominant chroma is 3 or less.

Torrox

Other Oxisols that have a torric moisture regime.

Humox

Other Oxisols that:

1. Have 16 kg or more organic carbon per square metre to a depth of 1 m, exclusive or organic surface litter;

2. Have a weighted average base saturation in the oxic horizon (by NH_4OAc) of <35 percent; and

3. Have an isothermic, thermic, or cooler temperature regime.

Ustox

Other Oxisols that have an ustic soil moisture regime and an isothermic, thermic, or warmer temperature regime.

Orthox

Other Oxisols.

Great Groups

Eight great groups have been defined in the different sub-orders (Table 1):

- Gibsi is defined for soils which have either cemented sheets containing 30% of gibbsite or have 20% or more by volume of gravel size aggregates containing 30% or more gibbsite within 1 m of the mineral soil surface, but do not have plinthite that forms a continuous phase within 30 cm of the soil surface.

- Plinth is the great group which relates to soils which have plinthite that forms a continuous phase within 1.25 cm of the soil surface.

- Ochr are soils with an ochric epipedon.

- Umbr are soils that have either an umbric epipedon or ochric epipedon that has more than 1% of carbon in all subhorizons to a depth of 75 cm or more below the mineral surface.

- Sombri are Oxisols with a sombric horizon.

- Acr are Oxisols that have in some subhorizon of the oxic horizon a cation retention capacity of 1.5 meq or less per 100g of clay (from NH_4Cl), but do not have discernable structure in the oxic horizon or have only weak blocky or prismatic peds.

- Eutr are Oxisols that do not have an anthropic epipedon and have a base saturation of 35% or more in the epipedon and in all the subhorizons of the oxic horizon to a depth of at least 1.25 m.

- Hapl which is the central concept of the suborder, and applied to the Humox, Ustox and Orthox suborders.

Like the suborders the great groups are defined according to a key (Table 1).

Subgroups

The central concept of oxisol subgroups is the Typic, all other subgroups being considered intergrades or extragrades. The latter are listed in Table 1.

Table 1. List of suborder and great groups of the Oxisol in the order of the key and of the main subgroups.

Suborders	Great Groups	Subgroup
	(Gibbsiaquox	
AQUOX	(Plinthaquox	
	(Ochraquox	
	(Umbraquox	
TORROX		
	(Sombrihumox	
HUMOX	(Gibbsihumox	
	(Haplohumox	(Typic
	(Acrohumox	(Perroferric
	(Sombriustox	
USTOX	(Acrustox	
	(Eutrustox	(Typic
	(Haplustox	(Tropeptic
	(Sombriorthox	
	(Gibbsiorthox	(Typic
	(Acrorthox	(Haplic
	(	(Plinthic
	(	
	(	(Typic
	(	(Haplohumic
ORTHOX	(Eutrorthox	(Sombrihumic
	(	(Tropeptic
	(	
	(	(Typic
	(	(Aquic
	(	(Epiaquic
	(Haplorthox	(Plinthic
	(	(Quartzipsammentic
	(	(Tropeptic
	(	(Ultic

In brief, subgroups are as follows:

- Tropeptic having an oxic horizon that extends to a depth of more than 1.25 m and have moderate subangular blocky or prismatic structures.

- Petroferric subgroups are those with a petroferric contact within 1.25 m of the soil surface.

- Haplic subgroups are those which have a net positive charge in some horizon within 1.5 m of the soil surface.

- Haplo-humic subgroups with more than 16 kg of organic carbon per m^2 to a depth of 1 m and do not fulfil the other requirements for a Humox.

- Plinthic subgroups have more than 5% or more by volume of plinthite or gravel-size aggregates that are cemented by gibbsite in all subhorizons within a depth of 1 m from the soil surface and a net positive charge in some subhorizon within 1.5 m of the soil surface.

- Sombric subgroups are those with a sombric horizon which meet all the requirements of the sombric except the base saturation and 16 kg of organic carbon/m^2 to a depth of 1 m.

- Aquic subgroups are those which do not meet the criteria for an Aquox but have mottles that have chroma of 2 or less accompanied by red or dark red mottles within 1.25 m of the soil surface.

- Epiaquic subgroups are those which have hues less red than 10 YR in all parts of the upper 75 cm and that have a colour value, moist, of less than 4.

- Quartzipsammentic subgroups have a texture that is coarser than sandy clay loam in all parts of the oxic horizon within 1.25 m of the mineral soil surface.

- Ultic subgroups are Oxisols with a regular clay distribution in the oxic horizons and discernable structure in the major part of the oxic horizon.

The subgroups are not listed according to the key for Oxisols.

4. Oxisols in the South West Pacific and Problems of Classification

In the islands of the South West Pacific the oxisol order is widely represented. They are found mostly on volcanic material undersaturated in quartz, in areas which are somewhat geomorphologically unstable. In this they differ from the majority of the Oxisols in Africa or in Latin America which develop in areas of 'old' stable granitic/gneissic rocks. Soil Taxonomy has made many improvements to the classification of Oxisols but many gaps and difficulties in classification remain.

(a) The creation of the Acr- great group has been an important step for the differentiation of the strongly weathered and oxidic rich Oxisols from the kaolinitic rich Oxisols. However, it is still incomplete and some differentiation at a high level of two categories within this great group appears necessary. These are:

(i) The soils with gibbsitic composition. These soils have been described in Lakeba, Fiji (Latham, 1978, and Leslie and Blakemore, 1978), in Vanuatu, Santo (Quantin, 1972-1978) and in Tahiti (Tercinier, 1974). They are deep red soils with a apparent non-existant CEC, a positive ΔpH and more than 40% of gibbsite. They cannot be clasified in the Gibbsi-great group because they have not gibbsitic sheets or gravels.

(ii) The soils with a ferritic composition which occur mainly on ultrabasic rocks. They are red (10 R), rich in hematite, to brown (7.5 YR), rich in geothite soils (Latham, 1981). They are found in New Caledonia but also in the Solomon Islands and Papua New Guinea.

These two categories of Oxisols are very different in regard to their characteristics and fertility status and should be differentiated at a higher level.

(b) The presence of very humiferous soils often with a mollic epipedon in a isohyperthermic temperature regime. These occur on the elevated atolls of the Loyalty Islands in New Caledonia (Latham, 1981). They are 40 to 80 cm thick overlying limestone and are very rich in calcium. The colour, carbon content, structure and base saturation related closely to the criteria defined for a mollic epipedon. However, they cannot be classified as a Humox because of their base saturation and their temperature regime. Similar soils have been observed by P. Quantin (1972-1978) in Vanuatu.

(c) The presence of halloysite and meta-halloysite in many of the oxisols with lattice clays in the South Pacific. These clays are of the same family as those with a kaolinitic mineralogy class but have a slightly higher CEC. The CEC's of these soils are greater than the 16 meq/100g clay limit. They are very widespread in Vanuatu (Quantin 1972-1978).

(d) The presence of oxidic soil material over the oxic horizon is a problem in classifying some of the Oxisols in Vanuatu.

(e) The lack of any provision for soils with iron gravels or pisolithes. This characteristic is very important for the soils formed on ultra-basic rocks in the Region, in particular, New Caledonia (Latham, 1975). A pisolithic horizon of thicknesses greater than 50 cm can be formed, which overlies fine soil material. At present this feature classifies the family level as a fragmental to skeletal particle size class. It cannot be differentiated from quartz gravel or anything else. This characteristic is particularly important in other parts of the world such as Africa.

(f) Concerning the Eutr- great group that is described in the Region as developing on limestone (Leslie and Blakemore, 1978) the question can be asked as to whether they can be compared with Eutrorthox found, for example, under Savanah vegetation in West Africa. It can be asked whether the presence of limestone gravel is compatible with the definition of an oxic horizon.

Conclusion

The classification of the Oxisols presented in Soil Taxonomy (Soil Survey Staff, 1975) represents an important step toward the differentiation and the ordering of a pedological group of soils as yet little understood. In the South Pacific Region the classification shows some deficiencies and difficulties in its application. Many completely different soils will, by definitions prescribed, fall into the same not very distinctive classes of Typic- Acr- or Hapl- great groups of Orthox or Ustox and will have to be differentiated at the family level. Since the publication of the Soil Taxonomy in 1975, ICOMOX (International Committee for Oxisols) has been established to test, evaluate and prepare proposals for revision of the Oxisols order. Two new proposals have been made (ICOMOX, 1980 and ICOMOX, 1981) which present new proposals for consideration that seem more satisfactory for the Oxisols of the Region. It is hoped that the incorporation of new knowledge to these proposals will help to refine and improve the system so that it will reflect still better the Oxisol entity.

References

ICOMOX, 1980. International Committee on the Reclassification of Oxisols: Circular No. 6/80.

ICOMOX, 1981. Status report on the International Committees.

Latham, M. 1975. Les sols dun massif de roches Ultrabasifus de la Gote Ovest de la Nouvels Caledonie: le Boulinda. Les sols a accumulation ferruginese relative. Cah. ORSTOM, Ser. Pedol., 13, 159-172.

Latham, M. 1978. The natural environment of Lakeba - UNESCO/UNFPA Fiji Island reports No. 5 (Canberra ANU for UNESCO). pp. 13-65.

Latham, M. 1981. Oxidisols in some island situations in the South Pacific: their characterisation, conditions of formation and fertility. Comm. to Soils with Variable Charge Conference, Palmerston North, New Zealand.

Latham, M., Quantin, P., Aubert, G. 1978. Etude des sols de la Nouvelle-Caledonie. ORSTOM, Paris, 138p. + 2 maps.

Leslie, D.M., Blakemore, L.C. 1978. Properties and classification of the soils from Lakeba, Lau group, Fiji. In Lau Tonga (1977), Royal Society of New Zealand Bulletin 17, Wellington, pp. 165-190.

Quantin, P. 1972-1978. Nouvelles Hebrides. Atlas des sols et de quelques donnees du milieu naturel. ORSTOM, Paris, 7 reports + maps.

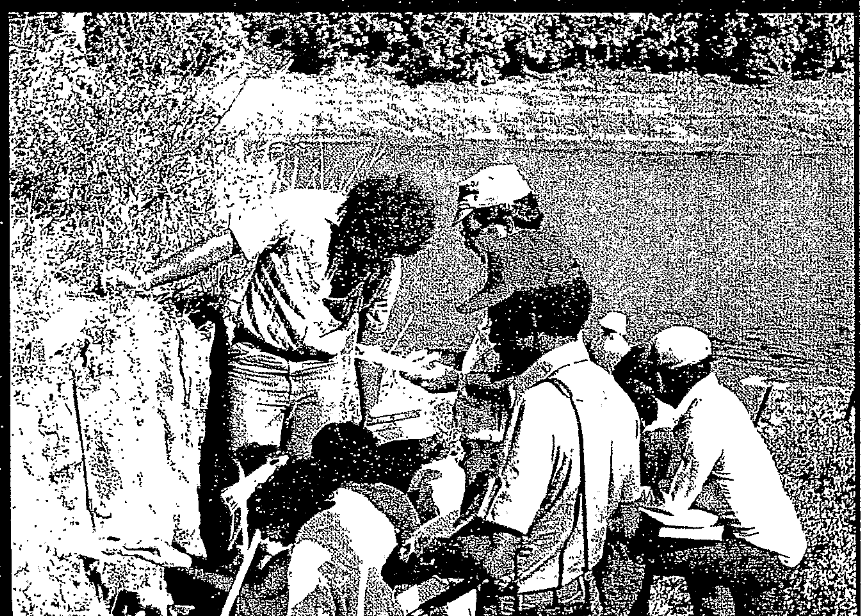
Tercinier, G. 1974. Cristallochimie des sols ferrallitiques totalement desilicifies d'une region tropicale tres humide de l'Oceanie intertropicale. Transactions Tenth International Soil Science Congress, Moscow, pp. 61-68.

Soil Survey Staff, 1975. Soil Taxonomy: A basic system of soil classification for making and interpreting soil surveys. U.S. Department of Agriculture Handbook 436, U.S. Government Printing Office, Washington, D.C., 754p.

R.J. MORRISON and D.M. LESLIE (Editors)

PROCEEDINGS OF THE SOUTH PACIFIC REGIONAL FORUM ON SOIL TAXONOMY

SUVA, NOVEMBER 1981



INSTITUTE OF NATURAL RESOURCES
THE UNIVERSITY OF THE SOUTH PACIFIC
SUVA, FIJI.