5 Soil classification

5.1 Purposes

The broad concept of acid sulphate soils encompasses unripe saline soils that will become acid if they are drained, unripe, severely acid soils, and ripe aluminium-saturated soils that are severely acid or potentially acid only in the deep subsoil. Each characteristic may be exhibited over a wide range of intensity and in combination with other properties that are common to all alluvial soils. In some cases, soil limitations are so severe that amelioration and cultivation are impracticable; in other cases, the limitations are slight or easily rectified; so it is useful to distinguish a range of categories of acid sulphate soils.

A soil classification serves two purposes:

- It enables us to order our own observations and ideas;
- It enables us to communicate with other people who need to use this information.

Soil survey involves grouping together soils that will behave in the same way, for the purpose in hand, and separating those soils that will behave differently. So classification is an integral part of soil survey. The two activities cannot be separated.

To be useful for management and land-use planning, a classification should be based on soil properties that are important to land use. The properties should also be measurable in the field or, failing this, measurable quickly and cheaply in the laboratory. Characteristics of acid sulphate soils that fulfil both criteria include:

- Acidity or potential acidity;
- Salinity;
- Composition and texture;
- Ripeness;
- Profile form, especially the depth and thickness of limiting horizons;
- Depth and seasonal variation of the watertable;
- Duration and depth of flooding.

None of the established international soil classifications considers these properties in combination, or in sufficient detail for land reclamation, management, or land-use planning. A new classification is therefore presented here, based on the first five of these properties. Two levels of classification are defined: the profile form – for detailed soil mapping and site characterisation – and a higher category classification – to group soils which present similar kinds of management problems. Correlation between this purely technical classification, Soil Taxonomy (1975), the ORSTOM classification (1982), and the FAO/Unesco legend (1974) is presented in Section 5.5.

5.2 Criteria of the ILRI classification

5.2.1 Acidity and potential acidity

Acidity is easily measured in the field (see Section 7.3). In mineral soils, severe acidity is usually associated with yellow mottles of jarosite; but in peat, muck, and clay rich in organic matter, the oxidation of pyrite may generate severe acidity without visible deposition of jarosite. (In peat, acidity may also develop independently of the occurrence of pyrite.)

Acidity generated by the oxidation of pyrite is associated with the production of soluble sulphate, iron, and aluminium. Soluble aluminium severely impairs crop growth at low concentrations. Crop response (for example Williams 1980), and measurements of pH and soluble aluminium on acid sulphate soils by Metson (1977) in New Zealand and by Allbrook (1973) in Malaysia, suggest that a pH value of 4 in the field, or with a dried sample in 0.01 M $CaCl_2$ (1:2.5 suspension), is low enough to cause acid sulphate problems. A pH value of less than 4 is therefore adopted here as the primary criterion of an acid sulphate soil. More severe acidity may be distinguished at phase level. In the absence of jarosite, a water-soluble sulphate content of at least 0.05 per cent serves to distinguish acid sulphate soils from other severely acid soils. This is a broader definition than that adopted by the USDA Soil Taxonomy (Soil Survey Staff 1975), which defines a diagnostic sulfuric horizon by a pH (1:1 in water) of less than 3.5 and jarosite mottles.

A prime distinction must be made between soils that are acid sulphate soils now, and soils that *will become* severely acid if they are drained. A *potential acid sulphate soil* is at present waterlogged and not severely acid, but contains so much pyrite that it will become severely acid if this pyrite is oxidised. The best criterion of potential acidity is a fall of pH to less than 4 during three months moist incubation. Soil Taxonomy defines sulfidic material as waterlogged material containing 0.75 per cent or more sulphur, and less than three times as much carbonate ($CaCO_3$ equivalent). Apart from requiring the determination of sulphur and carbonates, this definition does not make allowances for variations in the buffering capacity of clay minerals and exchangeable cations. It is better to let the soil 'speak for itself' with its pH after moist incubation.

A further distinction that is critical to management is between acid sulphate soils that still have a reserve of pyrite and those that do not. The term *raw acid sulphate soils* is proposed for those with a reserve of pyrite within the rooting zone. They can be identified by a fall in pH of at least 0.2 during incubation. The lime requirement to bring raw acid sulphate soils to a pH suitable for arable crops is normally prohibitive, and the pyrite will continue to generate acidity over many years. In contrast, soils that no longer have reserves of pyrite respond to normal applications of lime and fertilizer.

5.2.2 Salinity

Crop growth on tidal soils and on recently reclaimed land is limited by soluble salts. Because of the wide variation in crop tolerance of salinity, critical values for specific purposes should be selected according to the proposed management system. Production of grassland, rice, and many other arable crops is severely impaired by salinity (EC_e) greater than 4 mS cm^{-1}, so this value has been adopted as the standard. Phases may be distinguished according to the scale of the U.S. Salinity Laboratory (USDA 1954):

EC_e (mS cm^{-1} at 25° C)	Proposed classification
0–2	Non-saline
2–4	Slightly saline
4–8	Moderately saline
More than 8	Very saline

5.2.3 Soil composition and soil texture

Peat soils and mineral soils each have their own unique characteristics, and they respond differently to management in many ways. According to Soil Taxonomy, *peat* has more than 20 per cent organic matter by mass (if the mineral component has no clay) to more than 30 per cent organic matter by mass (if the mineral component is 50 per cent or more clay).

In mineral soils, the distinction between sandy and clayey materials is important because of their contrasting geotechnical properties, notably bearing strength, shear strength, ripening characteristics, and permeability. The 'Unified Soil Classification (U.S. Army Corps Eng. 1953; U.S. Dept. Defense 1968), which is widely used by engineers, makes a useful distinction between *clayey soils*, where more than half of the material less than 60 mm is smaller than 0.06 mm – i.e. more than half silt + clay – and *sandy soils* that are less than half silt + clay. Marine and estuarine sediments are nearly always well sorted, falling clearly into either the clayey or the sandy category. Layers of borderline texture are limited, except along river levees, but where this situation is extensive, a loamy category may be introduced.

5.2.4 Degree of ripening

The ripening of clay and peat soils critically influences drainage and mechanical strength (see Section 3.5). The categories defined by Pons and Zonneveld (1965) find wide application (for example de Bakker and Schelling 1966; Dent 1980):

Class	n-value	Remoulded shear strength (kPa)
Ripe	Less than 0.7	More than 20
Nearly ripe	0.7–1.0	7–20
Half ripe	1.0–1.4	4–6
Practically unripe	1.4–2.0	1–3
Unripe	More than 2.0	0

5.3 Profile form

The depths and thicknesses of limiting horizons, and their arrangement in the soil profile, are just as important as the degree of acidity, salinity, and ripening. Limiting depths of 20, 50, and 80 cm have been chosen to define ripeness categories in The Netherlands. These depths also correspond well with different degrees of management problems in respect of acidity and salinity for temperate soils and management systems.

The effects on crop growth of limiting horizons depend very much on the severity of the dry season. For dryland crops in the tropics, where there is a dry season longer than one month or a soil water deficit in excess of 150 mm, limiting depths of 20, 60, and 100 cm are more appropriate. Soil water deficit is defined as the maximum cumulative difference between rainfall and potential evaporation (see for example FAO 1977).

For special surveys, single properties may be mapped separately: for example, presence/absence of and depth to potentially acid material (Figure 6.6) or pH (Figure 6.15). For systematic, detailed soil surveys, different categories of acidity, potential acidity, salinity, composition or texture, and degree of ripeness can be combined in a shorthand *profile form*. Table 5.1 lists the limiting values applied to each property.

The profile form is written, for example, as:

$a_2s_0Cw_1$ or a_2Cw_1

where:

a_2 = severely acid at a depth of between 20 and 50 cm;
s_0 = not saline within 80 cm;
C = clay;
w_1 = ripe to at least 20 cm over an unripe subsoil.

Although there are a great many possible combinations of soil characteristics, those that distinguish acid sulphate soils and related alluvial soils are often closely related (for example, residual salinity in a polder is commonly associated with an unripe subsoil). So in practice, a manageable number of useful categories can be distinguished and only a few mapping units are required for soil survey in any particular locality (see Figures 6.5, 6.6, 6.10, and 6.12).

Soil series and phases of series can be established to encompass groups of profile forms that have distinct management requirements, for example:

a_2Cw_1	Omanaia Series	Ripe clay with unripe acid subsoil
$a_2s_2Cw_1$	Omanaia Series	Saline subsoil phase
$p_1s_1Cw_3$ $p_2s_1Cw_2$	Takahiwai Series	Unripe and half ripe saline sulphidic clay
$p_2s_1Cw_2$	Takahiwai Series, shallow phase	Sand within 65 cm

Table 5.1 Limiting values for individual characteristics of acid sulphate soils and related soils

Note that limiting depths are governed by the length and severity of the dry season. The lower values are applicable where the soil water deficit remains below 150 mm.

Acidity

Acid sulphate (pH < 4 and soluble sulphates)

within 20 cm	a_1
within 50/60 cm	a_2
within 80/100 cm	a_3

Very severe acidity may be distinguished as a separate phase

Potential acidity

Potentially acid (sulphidic) material

within 20 cm	p_1
within 50/60 cm	p_2
within 80/100 cm	p_3

Where an acid sulphate horizon has already developed in the upper part of the profile, this takes precedence in classification over sulphidic material at greater depth

Salinity

Saline ($EC_e > 4$ mS cm^{-1})

within 40/50 cm	s_1
within 80/100 cm	s_2
Not saline within 80/100 cm	(s_0)

Texture and composition

Clay	clay or silty clay more than 40 cm thick. Where a peaty surface horizon is present, this is less than 20 cm thick	C
Peat	peat more than 40 cm thick	O
Sand	sand to sandy loam more than 40 cm thick. Where a peaty surface is present, this is less than 20 cm thick	S
Muck	interlayered peat and mineral soil not fulfilling the above thickness criteria	
	organic topsoil	O/C
	mineral topsoil	C/O, S/O

Shallow phases may also distinguish clay or sandy topsoils that do not meet the thickness requirements of clay or sandy soils

Ripeness

In clay, peat, or muck

	n-value Depth 0-20 cm	Depth 20-50/60 cm	Depth 50/60-80/100 cm	
Unripe	>0.7	>1.4		w_3
Half ripe	>0.7	0.7-1.4		w_2
Ripe with unripe subsoil	<0.7	>0.7 and/or >1.0		w_1
Ripe with ripe subsoil	<0.7	<0.7	<1.0	(w_0)

Soil series should be established only by national soil survey organisations, because they have the facilities for correlation and characterisation of mapping units. For this reason, the soil maps shown in Section 6 refer to acid sulphate soils only in terms of their profile form and higher category classification.

5.4 Higher category classification

Hierachical soil classifications are not well suited to the needs of land-use planning, land reclamation, or the transfer of detailed management experience from one place to another. Particular soil characteristics assume a different relative importance according to the climate, crop, or system of management. For example, the presence of potentially acid material below 60 cm is of no significance to irrigated rice or to grassland under high watertable management, but it is a severe limitation to dryland crops which rely on soil water storage.

Admitting that no single ordering of soil characteristics will serve all purposes equally well, it is still useful to distinguish a manageable number of categories of acid sulphate soils according to the nature of the problems they present and their distinct responses to management. A grouping of major categories of potential acid sulphate soils and acid sulphate soils is presented in Table 5.2.

5.4.1 Organic soils

Organic soils vary in density, hydraulic conductivity, degree of decomposition, available nutrients, mineral content, and thickness. Nevertheless, they form a distinct group. Organic soils may be separated from mineral soils on the basis of an organic matter content greater than 20 per cent dry mass, where the mineral component contains no clay, to greater than 30 per cent dry mass where the mineral fraction is 50 per cent or more clay. This corresponds to an organic matter content of well over 50 per cent by volume.

So far as reclamation and management are concerned, a further distinction should be made between, on the one hand, deep *peat* of low mineral content and, on the other hand, shallow peat (less than 40 cm thick), thin interlayers of peat and mineral soil (less than 40 cm mineral alluvium in the upper 60 cm of the soil profile), and organic soils of relatively high clay content (mineral content between 40 and 70 per cent dry mass). The three last categories behave in much the same way when cultivated and are here termed *muck*. Management problems common to all organic soils – low mechanical strength; massive shrinkage when drained, followed by continued loss by oxidation and erosion; low available nutrients; and trace element deficiences – are typically most severe in peat.

For the purposes of land reclamation and management, three classes of organic acid sulphate soils may be distinguished according to the long-term problems they present:

- *Unripe sulphidic peat and muck*: Unripe, sulphidic soils that are at present waterlogged but which will become severely acid when drained. They are unripe, with n-values more than 0.7 within 60 cm of the surface and more than 1.0 within 100 cm*;
- *Raw acid sulphate peat and muck*: Acid sulphate conditions, with pH less than 4 and with jarosite mottles or more than 0.05 per cent soluble sulphate, within 60

*Limiting soil depths are 50 and 80 cm under humid, temperate conditions; 60 and 100 cm under tropical conditions with a dry season longer than one month. See Table 5.1. All following definitions refer to seasonally dry tropical conditions.

Table 5.2 Major categories of potential acid sulphate soils and acid sulphate soils

	Organic soils		Sandy soils	Clayey soils			
Undrained not potentially acid	Unripe peat and muck		(Saline) sand	Unripe (saline) clay			
Potential acid sulphate soils	Unripe sulphidic peat and muck		Sulphidic sand	Unripe saline sulphidic clay			
Acid sulphate soils	Raw acid sulphate peat and muck	Ripe acid sulphate peat and muck	Raw acid sulphate sand Acid sulphate sand	Raw saline acid sulphate clay	Ripe acid sulphate clay with raw subsoil	Ripe acid sulphate clay	
Associated non acid sulphate soils	Peat and muck with unripe subsoil	Ripe peat and muck	Sand		Ripe clay with unripe subsoil	Ripe clay	Ripe acid aluminium clay

cm of the soil surface. Typically the subsoil remains unripe with n-values greater than 0.7 between 20 and 60 cm and greater than 1.0 between 60 cm and 100 cm. This subsoil contains a reserve of pyrite so that its pH will fall below 4 on incubation;
- *Ripe acid sulphate peat and muck*: Acid sulphate conditions, with pH less than 4 and with jarosite mottles or more than 0.05 per cent soluble sulphate, within 60 cm of the surface. The soil is ripe, with n-value less than 0.7 to a depth of 60 cm and less than 1 between 60 cm and 100 cm. There is no reserve of pyrite in the upper 100 cm; pH will not fall further on incubation.

5.4.2 Sandy soils

Sandy soils are mineral soils in which more than half of the material less than 60 mm is greater than 0.06 mm diameter, i.e. more than 50 per cent sand and gravel. Sandy soils are not cohesive but, except under exceptional conditions of water upwelling, they have great frictional strength. They do not shrink when drained. Sandy alluvial soils are of moderate or high permeability. They have a low available water capacity.

In addition to the physical differences between all sandy soils and all clayey soils, sulphidic sands are always low in pyrite, generally less than 1 per cent S by mass but, unless they are shelly, they have a low neutralising capacity, so that very severe acidity rapidly follows drainage. However, acidity and salinity are readily leached and, once oxidation of pyrite is complete, the lime requirement of acid sulphate sand is low.

Three classes of sandy acid sulphate soils may be distinguished. These are potential acid sulphate sands, severely acid sands with reserves of pyrite, and severely acid sands without significant reserves of pyrite:
- *Sulphidic sand*: pH greater than 4, but potentially acid (incubated pH less than 4) within 100 cm;
- *Raw acid sulphate sand*: pH less than 4 and jarosite mottling or more than 0.05 per cent soluble sulphate within 100 cm. The pH of some horizon within 100 cm falls to less than 4 and by at least 0.2 during incubation;
- *Acid sulphate sand*: pH less than 4 and either jarosite mottles or more than 0.05 per cent soluble sulphate within 100 cm. There is no further fall of pH during incubation.

5.4.3 Clayey soils

Clayey soils have more than half the mineral fraction finer than 0.06 mm (silt + clay). They have little frictional strength and their cohesive strength depends critically on their water content – unripe clays are fluid or soft, ripe clays are firm and tough. Permeability depends on structure. In well-structured clay, water drains readily so long as fissures between peds remain open. Even in unripe, structureless clays, permeability can be high if there are many coarse pores.

Clays exhibit the widest range of acid sulphate characteristics and offer a correspondingly great variety of possibilities for reclamation. It is useful to recognise several

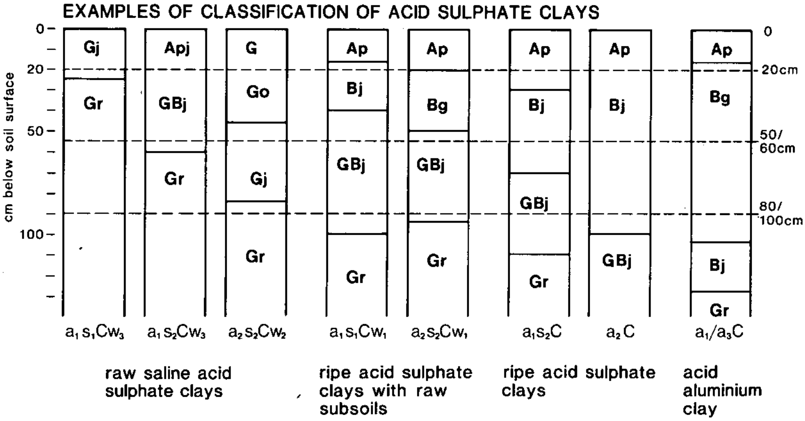

Figure 5.1 Classification of profile forms of sulphidic (potentially acid) clays

classes of clayey soils. The primary distinction is made between potential acid sulphate soils (sulphidic clays), acid sulphate soils that still have reserves of pyrite (raw acid sulphate clays), and those that do not. The same rules are followed as in the case of sandy soils and organic soils. Further distinctions are made according to physical ripeness and salinity:

- *Unripe saline sulphidic clay*: These soils are at present waterlogged, but contain pyrite that will oxidise following drainage and produce acidity in excess of the soil's neutralising capacity. The depth at which sulphidic material occurs and the total reserve of pyrite are critical characteristics for reclamation and must be distinguished by soil surveys. In tidal soils, ripening of clays does not proceed beyond the half-ripe stage so long as the soil profile remains almost continuously waterlogged.

  Figure 5.1 depicts a range of profile forms within the class of unripe saline sulphidic clays and proposed sub-classes based on the thickness of the more-ripened, more-oxidised horizons over the unripe sulphidic subsoil. Field identification of thick Go and Gro horizons can be interpreted as not potentially acid; Gr horizons are potentially acid unless rich in shell.

  The characteristics of unripe saline sulphidic clays are:
  - pH greater than 4, but potentially acid (incubated pH less than 4) within 100 cm;
  - Saline, EC_e more than 4 mS cm^{-1} within 100 cm;
  - Unripe; n-value greater than 0.7 in the upper 20 cm.
- *Raw saline acid sulphate clay*: These are very young acid sulphate soils in the initial phase of severe acidity, with reserves of pyrite remaining in the upper part of the profile. Plates 4.4 and 4.5 show examples of this kind of soil.

  Their characteristics are:
  - pH is less than 4 within 60 cm;
  - Jarosite mottles or more than 0.05 per cent soluble sulphate are present within 60 cm;
  - The pH of some layer within 100 cm will fall below 4 and by at least 0.2 during incubation;

- Typically, they are saline; EC_e greater than 4 mS cm^{-1} within 100 cm;
- Typically, they are unripe, with n-value greater than 0.7 within 20 cm.

– *Ripe acid sulphate clay with raw subsoil*: These are young acid sulphate soils with a ripe, severely acid topsoil and with reserves of pyrite in the subsoil. The topsoil may be leached of excess soluble salts. Plate 4.6 shows an example of a ripe acid sulphate clay with a raw subsoil.
  Their characteristics are:
  - pH is less than 4 within 60 cm;
  - Jarosite mottles or more than 0.05 per cent soluble sulphate present within 60 cm;
  - n-value less than 0.7 in the upper 20 cm, and greater than 0.7 within 60 cm or greater than 1.0 within 100 cm;
  - The pH of the subsoil will fall to less than 4 and by at least 0.2 during incubation.

– *Ripe acid sulphate clay*: These are old acid sulphate soils that no longer have any reserves of pyrite within the crop rooting zone. Compared with young acid sulphate soils, their present acidity is typically less severe, but pH is still less than 4 within 60 cm. They are physically ripe, and may be completely leached of excess soluble salts. Sulphidic material may be present below 100 cm. Plate 4.7 shows an example of a ripe acid sulphate clay.
  Their characteristics are:
  - pH is less than 4 within 60 cm;
  - Jarosite mottles are present within 60 cm;
  - n-value less than 0.7 in the upper 60 cm and less than 1.0 in the 60 to 100 cm layer;
  - The pH of the subsoil between 60 cm and 100 cm does not fall to less than 4 and by 0.2 during incubation.

– *Ripe acid aluminium clay*: These are not acid sulphate soils, although they may have developed from acid sulphate soils through a long period of weathering. They are severely acid, with pH less than 4 within 60 cm, but do not have jarosite or sulphidic material within 100 cm.
  Their characteristics are:
  - pH is less than 4 within 60 cm;
  - No jarosite within 100 cm;
  - n-value less than 0.7 in the upper 60 cm and less than 1 in the 60 to 100 cm layer;
  - The pH of the subsoil between 60 and 100 cm does not fall to less than 4 and by 0.2 during incubation

  The important characteristic of these soils is that the exchange complex is dominated by aluminium. At pH less than 4, soluble aluminium hampers crop growth, and aluminium can always be displaced from the exchange complex, for example by increasing salinity. So far as amelioration is concerned, the cation exchange capacity is crucial. If it is low, then relatively small amounts of lime will be required; if high, then amelioration may be too expensive.

Examples of the classification of acid clays are shown in Figure 5.2. The groups have been distinguished according to the nature of limitations to reclamation and crop growth. Within each group, more acid, less acid, or saline soils can be distinguished, according to local needs.

The soil groups distinguished above do not include all the possible combinations

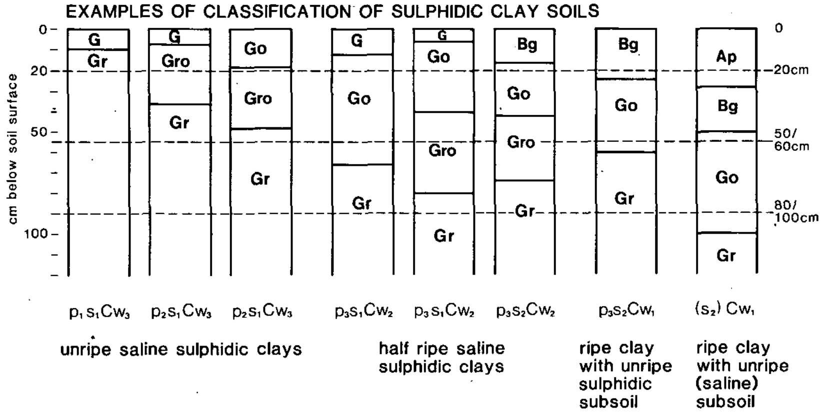

Figure 5.2 Classification of profile forms of acid clays

of composition, acidity, salinity, and ripeness. If other groups are found to be useful and widespread, they can be included easily in this scheme. However, because of the nature of sedimentation and also the rapid evolution of acid sulphate soils following drainage, intergrades will always bridge any arbitrary grouping, and extragrades will occur between acid sulphate soils and other soils with which they are associated in the landscape.

5.5 International classification of acid sulphate soils

5.5.1 Soil Taxonomy

In Soil Taxonomy (Soil Survey Staff 1975), *potential acid sulphate soils* are recognised by the presence of sulfidic materials – 'waterlogged mineral or organic soil materials that contain 0.75 per cent or more sulfur (dry weight) mostly in the form of sulfides and that have less than three times as much carbonate ($CaCO_3$ equivalent) as sulfur'.

Sulfihemists are potential acid sulphate soils that are dominantly organic. They have sulfidic materials within 100 cm of the surface.
Sulfaquents are mineral soils with sulfidic material within 50 cm of the mineral soil surface.
Sulfic Fluvaquents are ripe mineral soils with an irregular distribution of organic matter down the profile and with sulfidic material between 50 and 100 cm depth.
Sulfic Haplaquents are ripe mineral soils in which organic matter decreases regularly with depth below a depth of 25 cm and with sulfidic matter between 50 and 100 cm depth.
Sulfic Hydraquents are unripe or half ripe mineral soils with sulfidic material between 50 and 100 cm depth.

Acid sulphate soils are recognised by the presence of a sulfuric horizon, which is defined as 'mineral or organic material that has both a pH less than 3.5 (1:1 in water) and jarosite mottles (hue 2.5Y or yellower and chroma of 6 or more)'. The term 'per-

Table 5.3 Approximate correlation between Soil Taxonomy and ILRI classification of acid sulphate soils

Soil Taxonomy	Profile Form				ILRI nomenclature	Principal soil groups
Sulfihemists	$p_1 p_2 p_3$	O		$w_2 w_3$	unripe sulphidic peat	Potential acid sulphate soils
		O/C C/O O/S S/O			unripe sulphidic muck	
Sulfaquents	$p_1 p_2$	S	$s_1 s_2$		saline sulphidic sand	
		C	$s_1 s_2$	$w_2 w_3$	unripe saline sulphidic clay	
Sulfic Hydraquents	p_3					
Sulfic Fluvaquents and Sulfic Haplaquents	p_3	S	s_2		sand with saline sulphidic subsoil	
		C	s_2	w_1	ripe clay with saline sulphidic subsoil	
Sulfohemists	$a_1 a_2$	O	$s_1 s_2$	$w_2 w_3$	raw saline acid sulphate peat	Raw acid sulphate soils
			s_2	w_1	peat with raw subsoil	
		O/C C/O O/S S/O	$s_1 s_2$	$w_2 w_3$	raw saline acid sulphate muck	
			s_2	w_1	muck with raw subsoil	
		O			acid sulphate peat	
		O/C C/O O/S S/O			acid sulphate muck	
Sulfaquepts	$a_1 a_2$	S	$s_1 s_2$		raw saline acid sulphate sand	
		C	$s_1 s_2$	$w_2 w_3$	raw saline acid sulphate clay	
			s_2	w_1	acid sulphate clay with raw subsoil	
					ripe acid sulphate clay	Ripe acid sulphate soils
Sulfic Haplaquepts and Sulfic Tropaquepts	a_3	S			sand with acid sulphate subsoil	
		C	s_2	w_1	ripe clay with raw acid sulphate subsoil	
					ripe clay with acid sulphate subsoil	
					ripe acid aluminium clay	Acid aluminium soils

* Definitions of profile form are given in Table 5.1. Soil Taxonomy definitions of sulfidic material and sulfuric horizons are more rigorous than the definition of potentially acid and severely acid material used in the profile form.

Table 5.4 Summary of the ORSTOM classification of acid sulphate soils (from Segalen et al. 1982)

Grande sous-classe	-sous-classe	Grands groupes	Groupes	Sous-groupes
Thiosols	Halique saline ($EC_s > 8$ mS cm^{-1}) within 60 cm Gypsique gypsum and secondary carbonate > 15 per cent within 60 cm Carboxique secondary carbonate > 15 per cent within 60 cm	Dystrique mineral, pH < 5.5 Eutrique mineral, pH > 5.5 Sombrique organic, peat and muck Pallidique low-organic	Amérisé thion at surface Orthique subsurface thion Graveleux ou Caillouteux gravelly or stoney Argilanique ou Bulgique with clay skins Halique Gypsique Carboxique	Gravelleux Caillouteux Arénique sandy Vertique clays with shrin-swell properties Prismatique prismatic structure Colonnaire columnar structure Hypohalique moderate salinity (EC_e 4-8 mS cm^{-1}) Hypogypsique moderate gypsum carbonate Hypocarboxique moderate secondary carbonate
Sulfosols	Halique Gypsique Carboxique	Dystrique Orthique Eutrique Sombrique Pallidique	Amérisé sulfon at surface Sulfuré subsurface sulfon Thionique subsurface thion Other groups as for Thiosols	subsurface thion, Other sub-groups as for Thiosols

dysic horizon' has been used in the Mekong Delta to describe soils with sulphate acidity but without jarosite mottles (Pons, personal communication).

Sulfohemists are acid sulphate soils that are dominantly organic and have a sulfuric horizon within 50 cm of the surface.

Sulfaquepts are mineral soils with a sulfuric horizon within 50 cm of the surface.

Sulfic Haplaquepts are ripe mineral soils with jarosite mottles and pH between 3.5 and 4 within 50 cm of the surface, or jarosite mottles and pH (1:1 water, air dried slowly in shade) less than 4 in some part between 50 and 150 cm depth).

Sulfic Tropaquepts are ripe mineral soils with a mean annual soil temperature of 8° C or higher; jarosite mottles and a pH between 3.5 and 4 within 50 cm of the surface or jarosite mottles and a pH (1:1 water, air dried slowly in the shade) less than 4 in some part between 50 and 150 cm depth.

Table 5.3 shows the approximate correlation between Soil Taxonomy and the ILRI classification. Soil Taxonomy defines potentially acid materials by their sulphur and carbonate contents, as opposed to their incubated pH value; and defines acid sulphate horizons by a pH (1:1 in water) of less than 3.5, as opposed to a field pH of less than 4.

Separations introduced in the ILRI system that are not made in Soil Taxonomy include:
- Distinction of peat and muck within organic soils;
- Distinction of sandy and clayey groups within the mineral soils;
- Distinction of raw acid sulphate soils, ripe acid sulphate soils, and acid aluminium soils according to the reserves of pyrite and sulphate acidity;
- Separation according to salinity;
- The problem of separation according to climate has been tackled by adopting different diagnostic depth limits according to the potential soil water deficit.

5.5.2 ORSTOM

The ORSTOM classification (Segalen et al. 1979; 1982) distinguishes acid sulphate soils within the class of saline soils.

Two sub-classes are distinguished:
- *Thiosols*-soils with a reduced 'thion' within 60 cm of the surface. A thion has more than 0.75 per cent oxidisable sulphur and becomes acid upon oxidation.
- *Sulfosols*-soils with an oxidised 'sulfon' within 60 cm of the surface. A sulfon has jarosite mottles, free sulphuric acid, more than 0.75 per cent sulphur, and a pH less than 3.5.

These correspond to potential acid sulphate soils and actual acid sulphate soils. The definitions are based on Soil Taxonomy and suffer the same difficulties. In addition, soils with diagnostic horizons deeper than 60 cm are not considered, which is unsatisfactory for land reclamation and management purposes.

Within each subclass, there is provision for four further hierachical subdivisions. These are summarised in Table 5.4. Most of the categories provided do not exist. A more serious drawback of this classification is that many groupings and separations that are made have no practical significance, although they may be of pedological interest.

5.5.3 FAO/Unesco

The FAO/Unesco Soil Map of the World legend (FAO/Unesco 1974) groups both potential acid sulphate soils and actual acid sulphate soils together as:

- *Thionic Fluvisols* – soils that contain sufficient sulphides to produce a pH less than 3.5 within 100 cm of the surface.

No subdivision of this group is required for the soil map at a scale of 1:5 million.