WOSSAC: 41961 Ian Baillie

RESEARCH BRANCH

DEPARTMENT OF AGRICULTURE

SARAWAK

Technical Paper No. 3

A DRAFT RECLASSIFICATION OF SOILS IN CENTRAL AND NORTH SARAWAK

(Second Edition) Sabah Malaysia.

by

I.M. Scott

Soil Surveyor

KUCHING

November, 1973

Technical Paper No. 3

A DRAFT RECLASSIFICATION OF SOILS IN CENTRAL AND NORTH SARAWAK

I.M. SCOTT
Soil Surveyor

Second Edition
November, 1973

The following attempt at reclassification of the main soils encountered in central and North Sarawak owes much to consultations with Mr. Lim Chin Pang, Soil Surveyor responsible for north Sarawak, and Messrs. I. L. A. Ysselmuiden and R. D. Law, Consultant Soil Surveyors presently working in north Sarawak. I am greatly indebted to them for their numerous comments. I am also indebted to Messrs. J. P. Andriesse and J. R. D. Wall, colleagues previously working in Sarawak, who contributed greatly to the establishment of the earlier classification of Sarawak soils in use since 1966. Despite its many acknowledged inadequacies, the 1966 classification established most of the basic guidelines for the present system and, without that previous work, attempted improvements to the ordering of Sarawak soils would be much more difficult.

The classification is confined to soils in the central and northern sectors of the State and is distributed in a very tentative form. It is assumed that many, if not most, of the definitions adopted will be further refined and more basic alterations in approach may also prove necessary. Such amendments can best be made, however, following the practical application of the system in the field, and the classification is tendered in its present form with that in view.

I. M. Scott
May, 1973

In the second edition of the draft, which is receiving a wider distribution than the first, a number of revisions and additions have been made and some confusing sections have been rewritten. The system has now been applied to survey projects by Consultants in North Sarawak and is reported there to be quite workable.

Two sections have been added, dealing with the classification and correlation at higher levels (and this is very provisional) and noting the changes between the present system and that adopted in 1966. The latter is included as an appendix.

The colour plates for a forthcoming memoir on soils in the central Sarawak lowlands have now been received and part of the over-run has been used to illustrate this edition.

I. M. Scott
November, 1973

A DRAFT RECLASSIFICATION OF SOILS IN CENTRAL AND NORTH SARAWAK

Background

A first formal classification of Sarawak soils was attempted in 1966. A reclassification is desirable at the present time for the following reasons:

use of the 1966 classification over the last six years has shown up many inconsistencies and inadequacies and some basic assumptions, such as the existence of argillic horizons, now appear to have been in error;

the 1966 classification was prepared in advance of the 1967 supplement to the USDA 7th Approximation, which offers many useful parameters for family-level groupings;

two permanent documents on Sarawak soils are at present in preparation (a Departmental memoir on the soils of the central Sarawak lowlands and a Consultants' report on soils in the Miri-Bintulu area.) It is advantageous that any revisions presently anticipated in the classification be made in advance of these texts being finalised.

The present reclassification is based on study of profiles in central Sarawak and discussions with Soil Surveyor (North Sarawak) and the consultant soils specialists presently engaged in Fourth Division. It is hoped that the classification thus adequately reflects our present knowledge of soils in central and north Sarawak. It does not incorporate soils which are confined to west Sarawak. These have been characterised in a memoir at present in printing, the text of which clearly indicates that they are classified in an inadequate system (the 1966 system) and that subsequent reclassification is to be expected. Much more study of west Sarawak soils is necessary, however, before the present classification can be extended to cover soils of that area as the soils specialists at present working in the State have little experience of west Sarawak soils.

The present classification has the following main aims:

(1) Criteria adopted for family-level definitions should be such that family identification can be reliably made on field evidence in most cases. Thus type of parent material has been discarded as a diagnostic feature at this level for many soils. It has had to be retained for some, however, where no alternative parameters have yet been chosen. Potential acid-sulphate soils and other saline soils have also to be characterised on analystical data, as have soils over calcareous shale.

(2) The 'working units' of the classification are the families and series. emphasis is placed on Great Soil Groups than in the 1966 system. It is, however, useful in many contexts to have a broad ordering of the families at a higher level and a provisional scheme is given in Table 1.

(3) At series level, if not family level, it is convenient for later correlatio that the defined units should correlate fairly closely with subgroups of the USDA system and with subunits of the World Soil Map legend; with this in mind many parameters from the USDA system have been employed. In a number of cases, however, this aim has not been met, either through lack of data or because series units resulting from adhering completely to this rule would lack relevance within the Sarawak soil spectrum.

(4) The classification should be couched in terms of precise definitions, whether or not these have to be arbitrary, and at both family and series level intergrades are employed where convenient, these being equally precisely bound by the same parameters as the labelled soils.

(5) Family and series labels, and the central concept of the soils to which they are attached, should deviate as little as possible from the 1966 system. Some major changes are essential, and have been made, but the 1966 system in quite well-known to readers of local soils publications. An entirely new classification and nomemclature would confuse rather than help.

The system, as drafted at present, is incomplete and will require bot expansion and revision as knowledge is gained on soils not presently covered and ideas on those soils now included are further crystallised. The developme of the system has, however, reached a stage where the main soils are moderatel well-characterised and the classification, at least at family level, can be conside reasonably stable and suitable for routine use.

Definitions

Many parameters are defined where they first appear in the classificat or in notes following the sections. Some are of general application and are defi here.

Unless otherwise stated, the profile is classified on features of the co section. The control section extends downwards to the top of any lithic or para-lithic horizon, or at any other C horizon showing residual rock structure, or to t top of any continuous stonelines more than 10cm thick, or to a depth of 1m, whic ever is the shallower. The upper limit of the control section is the base of the A1 horizon or a depth of 10cm from the surface, whichever is the deeper. For the purposes of locating the control section limits, the following definitions are adopted:

Paralithic material is considered material in which more than half the horizon comprises soft weathering rock or rock patches sufficiently soft to be broken by an Edelman auger. The material is not necessarily in situ and can be colluvial to some degree, provided there is no major contrast in type between the rock fragments or patches and the material of any underlying lithic horizon. It does not, however, include horizons dominated by hard discrete rock fragments such as sandstone corestones, which are presumed to be colluvial accumulations and are included in the control section. This definition departs from the USDA definition due to the difficulty of consistently recognising a USDA paralithic horizon in auger-sampling.

A lithic horizon is rock sufficiently hard that it cannot be penetrated by an Edelman auger. Confusion may arise where hard corestones are encountered and, where these are suspected, a number of augerings may be necessary at one site for the classification to be established. I can see no way of avoiding this without pitting.

A stoneline includes any subsurface residual accumulation of quartz gravel, iron-enriched rock brash, iron 'pipe-rock' fragments, or true concretions. Pebble or cobble bands in stratified alluvium are not considered as stonelines for the purpose of defining the control section unless they directly overlie lithic or paralithic material.

An A1 horizon is a surface horizon with relatively high carbon, relatively dark colours and maximum biological activity. Some arbitrary judgements are necessary in bounding it. Humus staining continues to some depth in many sandy soils and the lower part of the relatively darker surface zone in such soils I would exclude from A1 horizon. As this horizon varies in character depending on the soil which it caps, it is easier to recognise than define.

Texture is defined by two methods: the texture groups of the USDA system and the texture classes of the USDA soil survey manual. The texture groups are broad groupings which cut across the USDA manual classes as they consider the very fine sand of the latter as a silt for most purposes. The groups are defined in detail in the USDA Supplement (1970 : 38-41). For practical use the following definitions are approximately correct (the texture groups are underlined and their equivalents in terms of USDA soil survey manual classes follow):

Sands

sands; loamy sand coarser than loamy very fine sand

Coarse loams

(where the sand fraction is mainly fine or coarser) sandy loam; light loam; light silt loam; silt

Fine loams

(where the sand is mainly fine or coarser) sandy clay loam; heavy loam; heavy silt loam; light clay loam; light silty clay loam

Coarse silts

loamy very fine sand and (where the sand fraction is mainly very fine sand)
sandy clay loam; heavy loam; heavy silt loam; light clay loam; light silty clay loam

Fine silts

(where the sand is mainly very fine sand)
sandy clay loam; heavy loam; heavy silt loam; light clay loam; light silty clay loam

Clays

sandy clay; heavy clay loam; heavy silty clay loam; silty clay; clay

The subdivisions into 'heavy' and 'light' made in certain texture classes above are bounded by 18 or 35 per cent clay levels, whichever is relevant. Reference should be made to the texture triangle and the full definitions given in the USDA Supplement. Apart from some generalisation of the limits (and in classifying profiles on the basis of mechanical data the original USDA limits should be used) the above list deviates from the USDA scheme in two respects. Fragmental and skeletal texture groups are ignored. If such soils prove important these texture groups can be included in the system The fine and very fine divisions in the clays are also not used. The dividing limit is 60 per cent clay and all profiles of very heavy soils so far studied have clay percentages on or straddling this limit. While, therefore, a separation of very fine clays may usefully be made in a later version of the classification, a lower limit than 60 per cent would be required for local convenience.

In addition to the average texture of the control section the textural trend of the profile is classified, and this trend is considered a diagnostic feature at some points in the system. Five texture profiles are recognised and are defined as follows:

Uniform texture: clay percentage increases with depth or changes erratically between horizons but the variation is less than 5 per cent of the average clay percentage over the control section.

Erratic texture: clay percentage varies erratically between horizons and the variation exceeds 5 per cent of the average clay percentage over the control section in some horizon.

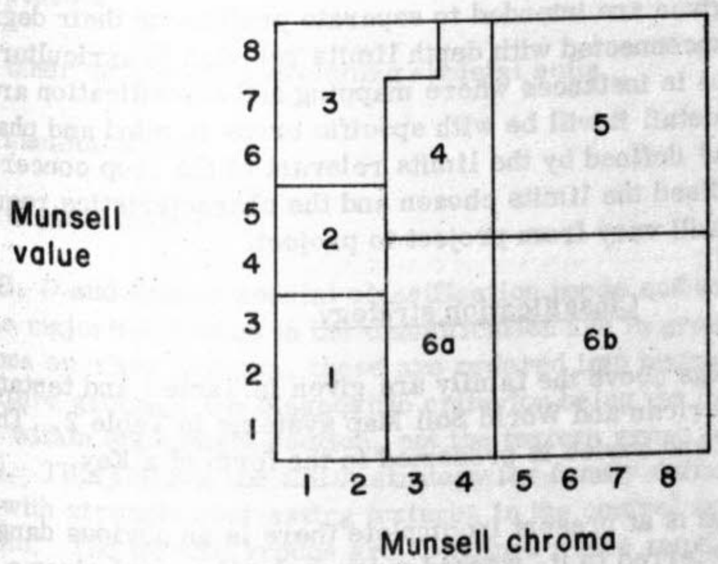
Gradational texture: clay percentage increases with depth but if the increase within the control section is more than 25 per cent clay (absolute) this increase takes place over a greater vertical distance than 12.5cm.

Contrasting texture: clay percentage increases with depth and an absolute increase of 25 per cent clay occurs within a vertical distance of 12.5cm or less.

Decreasing texture: clay percentage decreases with depth; the variation may or may not be greater than 5 per cent of the average clay percentage over the control section.

Peat is defined following the USDA terminology, being organic soil material which is either saturated with water for prolonged periods, or artificially drained, with 30 per cent or more organic matter if the mineral fraction is 50 per cent or more clay, or 20 per cent or more organic matter if the mineral fraction has no clay, or proportional intermediate organic matter if the clay fraction is intermediate. Included in the term, however, is alluvial material derived from eroded peats and meeting the same definition apart from drainage. Such material may be drained in nature.

A value/chroma index is used to define some soils in the system. This is adopted from Northcote with some modification and is defined as follows:



Phases

Phases can be set up as required and rules regarding standardisation of them can be considered as the problems arise. Standardisation of depth phase limits is one necessity, however, and these are defined here. For upland mineral soils (where surface peat is absent or less than 25cm thick) they are as follows (measured from the soil surface to the base of the control section.

(less than 25cm)	- (a family division)
25 - 50cm	- shallow
50 - 75cm	- moderately shallow
75 - 100cm	- moderately deep
more than 100cm	- deep

For deep organic soils (where surface peat is thicker than 1m) other limits are needed (measured to underlying mineral layers):

1 - 2m	- moderately deep
2 - 3m	- deep
more than 3m	- very deep

No decision has been taken regarding depth phases in shallow peat soils (those with surface peat 25 - 100cm thick) although a division will probably be needed. The problem of interlayered organic and mineral material is also not discussed at this point and is dealt with in the classification itself.

The depth phases given are intended to separate profiles on their degree of development and are unconnected with depth limits relevant to agricultural use. It is anticipated that in instances where mapping and classification are required at this level of detail it will be with specific crops in mind and phases are best distinguished and defined by the limits relevant to the crop concerned. Provided this is standardised the limits chosen and the characteristics requiring emphasis at phase level will vary from project to project.

Classification strategy

Provisional groupings above the family are given in Table 1 and tentative correlations with the American and World Soil Map systems in Table 2. The classification of families and series is presented in the form of a Key.

As the classification is at present incomplete there is an obvious danger that 'new' soils will be referred to it, worked through the Key, and given a quite inappropriate family or series designation. This can be avoided by confining operation of the system in its present form to the soil surveyors, who are aware which soils have so far been considered and which have not. It is also controlled to some extent by reference to the higher level classification. Where the series label derived from the Key places the profile in a group to which it obviously does not belong, this clearly indicates a need for revision and extension of the classification structure.

Apparent inconsistencies found when referring a profile to Table 2 may be less important. Provisional correlations with the USDA system are given but these are derived solely from those profiles with adequate laboratory data to classify them in this system. It is advantageous for correlation purposes that one series does not straddle many USDA subgroups and ideal if they could each be confined within one. But in many cases the parameters required for such a correlation cannot be recognised in the field and would put a considerable burden on the laboratory facilities if required on a routine basis. The basic problem here appears to be that many important Sarawak soils are on the borderline between two USDA groups (or even Orders). The advantages of adopting parameters which facilitate correlation must be weighed in each case against the need for the classification to be practicable in a Sarawak context and, where necessary, the latter must take precedence.

The construction of the Key is independent of the groupings above the family level. The soils are first divided into five sets, these each comprising soils within which there may be some confusion, though there should be little difficulty in deciding which set is appopriate to the profile being considered. The sets are as follows:

A - bottomland and coastal alluvium, and other accreting and permanently saturated mineral soils.

B - podzols

C - other upland soils excluding skeletal soils

D - skeletal soils

E - organic soils.

Sets B, D and E have special classification needs and are dealt with as appropriate. The majority of soils in the classification are in groups A and C. Together with divisions on other criteria, these are ordered into texture groups (or groupings of these texture groups), the diagnositic criterion being the average <u>texture</u> group of horizons within the control section, not the texture group of a particular horizon or horizons. This follows the USDA strategy for family definition and the separation of profiles with strongly contrasting textures in the control section also follows the USDA system. The texture groups are combined where required to give three possible schemes of texture division in the classification:

1	2	3
Sands	Sands	Sands
Loams and Silts	Loams	Coarse loams
		Fine loams
	Silts	Coarse silts
		Fine silts
Clays	Clays	Clays

At the family level at least the first division is invariably employed, i.e. sands, loams and clays are separated at this level throughout the system. The subsidiary divisions of the loams and silts in the second and third schemes shown above are also used as family distinctions where this is considered justified. Groupings outside these schemes are not permitted, i.e. silts and clays cannot be combined and if a fine silt family is established (adopting the third scheme) then provision for the three other texture families between the sands and clays must also be made. The significance of texture at the family level is considered to differ depending on the soils under consideration. Where soils are typically varied in texture, as in the alluvial soils, scheme 1 is used, the loams and silts grouped in one family, and further texture distinctions made at series level. In the upland soils on the other hand, texture commonly reflects the parent rock and is related to other soil characteristics. More emphasis is put on texture and the third scheme is used in family separation of these soils.

Within each family, series division is made and, throughout the system, no series may overlap two of the texture groups of scheme 3. In, therefore families bounded by texture parameters of the broader groups of scheme 1 or 2, a primary series split is made into narrower texture groups.

In summary, family texture groups are confined to the three-way division of scheme 1 and are subdivided further in the case of the broad loam group where this seems justified. Series texture groups are confined to the six-way split of scheme 3, and the series are defined as such where a broader texture group defines the family concerned. Where the family itself is defined in terms of the schemes 3 texture groups, any series division within the family is made on other characteristic

It will be noted that this application of texture in the classification means that, even at the series level, soils are characterised in terms of their average texture within the control section and that, particularly in the medium-textured soils, the actual texture class of any horizon may vary widely, and a rather broad range of texture profiles may all qualify for one series name. With this in mind, the soil is further characterised by combining with the series name the texture <u>class</u> dominant in the upper subsoil. The portion of the control section considered for this purpose varies depending on the texture profile of the soil concerned and is provisionally defined as follows:

(a) the texture class of the upper 25cm of the control section where texture is uniform within that depth;

(b) the texture of the highest horizon with uniform texture and at least 10cm thickness found within 25cm of the top of the control section where texture varies within that depth;

(c) the average texture of the upper 25cm of the control section where no horizon at least 10cm thick with uniform texture occurs within that depth;

(d) the texture of the surface 25cm in skeletal soils.

This definition does not cover all possibilities and will need further refinement. The main emphasis is that the texture class suffix to the series name is based on the texture of the 'A2' horizon if such exists, but where clay content is increasing rapidly with depth it is not necessarily the highest and coarsest textured horizon which is used unless that is significantly thick.

While this approach has some precedent in the USDA system in ordering the finer texture distinctions at family level it is not generally used at the series level and its use here requires justification. The approach appears useful in a Sarawak context because of the great variability of texture in otherwise like soils, particularly on upland sites underlain by sedimentary rocks. By common useage the establishment of a series requires the establishment of a series name for it. If a defined series were to be confined to a single texture class an extremely large number of series names would be required, many of which would probably serve little practical purpose and merely serve to confuse the user of the system. The combination of series name (signifying, among other features, a limited but still moderately broad texture range) and the texture of the upper subsoil (which, as the average texture of the control section must qualify for the series as defined regardless of the texture of individual horizons, automatically implies the texture of the middle and lower subsoil within fairly narrow limits) avoids this difficulty. If a particular soil ('Kerait silt loam series' for example) is found to be of wide extent and of especial importance, it might prove convenient to create a further series name for that combination of features, although difficulties can be foreseen in doing this. At present, however, this does not appear necessary and it is unlikely to be worth consideration until the agricultural significance of these finer texture distinctions is proved agronomically. It must, at the same time, be admitted, however, that the treatment of texture in this classification is such that the term 'series' is applied to groups of soils which might well be classed as 'subfamilies' in other systems.

Independant of division at family and series level on texture, distinctions are made on other grounds. The characteristics chosen to be diagnostic, and the level at which they are introduced into the classification, are varied however, depending on the type of soil under consideration and the importance attached to the features concerned. Only a few general points may be noted here. Criteria which cannot always be established in the field (origin of the parent material, for example) and criteria which can only be assessed in the laboratory, are reserved, as far as possible, for series definitions and are only introduced at the family level where they are felt to be particularly important. The intention here is that, as far as practicable, reliable family identification be possible in the field, even in situations where the series identification is uncertain. Secondly, it has been borne in mind that correlation with other classifications (especially the USDA system) is facilitated where the diagnostic limits used are common to those systems and, particularly in considering such features as colour, where the actual limits chosen must be somewhat arbitrary, the limits of the USDA system have been incorporated in the classification, at either family or series level. Where, however, adopting USDA divisions would lead to inconvenient groupings of local soils, the USDA system has been ignored. A prime requirement of the classification is that it be useful in a Sarawak context and correlation outside Sarawak is a secondary consideration.

Intergrade situations have been included at many points in the system at both family and series level. No set rule has been adopted for this but, in general where profiles occur the main feature of which is that they are transitional in character between two well-defined profile forms, then an intergrade nomenclature is thought preferable to a division into three series. In other cases the main criteria on which the classification rests are themselves variable (such as pH and conductivity) or are difficult to measure accurately and consistently (such as colour in some poorly-drained soils). Here also the use of intergrades and the resultant narrowing of the limits of variability within the named series which bound them appear to be advantageous.

It is not anticipated that intergrades between two series in the same family require names but where the intergrade position is between two families or higher groupings - and a number of intergrade forms are possible - series names are thought to be useful. In such cases, however, precise definition is required in addition to features suggested by the family or series names which indicate their position in the system. Only one such unit has so far been named. This is Lalis series, which is a Merit-Kapit or Jakar-Kapit Series intergrade (and thus a Merit-Kapit Family intergrade). A number of other such intergrade named series can be forseen as useful additions to the system.

Higher Groupings and Correlation

Primary Grouping	Secondary Grouping	Families
1. Very shallow soils overlying weathered rock	(a) lithic material at a shallow depth	Meluan?
	(b) soil depth limited by paralithic material; lithic horizons only at depth	Sedong Kapit Gaya
2. Non-accreting soils with strongly expressed lateritic features	(At present described only from west Sarawak. Not yet considered in the system.)	Bukit Mersing
3. Residual or non-accreting alluvial soils, other than sands, with weakly expressed podzolic or lateritic features	(a) dominantly red or yellow; calcareous	Kabuloh
	(b) dominantly red or yellow; noncalcareous	Merit Bekenu Nyalau (Piring) (~~Layang~~)(Changgan) (Arip) (Nyaroh)
	(c) dominantly grey, white or mottled; noncalcareous	Kerait Bandang Saratok Lubai Triboh
4. Podzols	(a) humus podzols	Miri Silantek
	(b) Iron podzols	(not yet considered)
5. Residual or non-accreting alluvial sandy soils, other than podzols		Peninjau Tika
6. Well-drained accreting alluvial soils		Seduau Bemang Kayan

Table 1 : Higher-level Groupings of Families for local use.

Primary Grouping	Secondary Grouping	Families
7. Poorly-drained	(a) Potential acid sulphate soils	Belat Nonok Rajang
	(b) Saline soils, other than above	Paloh Sirik Pendam
	(c) Nonsaline soils with no acid sulphate characteristics	Tatau Pakan Bijat
8. Poorly-drained non-accreting upland soils	(Not yet considered in the classification)	
9. Organic soils	(a) Residual peat soils on bottomlands	Igan Mukah Anderson
	(b) Alluvial peat soils	(Luk)
	(c) Upland peats	(Not yet considered)

Table 1 (cont.) : Higher-level Grouping of Families for local use.

Notes on Table 1

1. The primary and secondary groupings shown are intended to be broadly equivalent to Great Soil Groups and Subgroups.

2. With the exception of podzols, no formal labels are given above the family level. This has been avoided for two reasons. Firstly, many of the established terms which would appear appropriate have connotations which are at best doubtfully correct when applied to Sarawak soils, and many of those used in the past are definitely misleading. Secondly, the Group labels employed in the 1966 system have been constantly misused by other specialists, such as in printed statements that an agronomic experiment was on 'the Red-Yellow Podzolic soil' without further elaboration.

3. Precise definition of the groupings is not attempted in the Table. This will be necessary but cannot be done until the classification is more complete. The provisional definitions used at present can be inferred from the families which they cover and by reference to the Key, where the parameters defining these families are given.

4. There is particular difficulty in primary groups 2 and 3, which are equivalent to the 'Lateritic' and 'Podzolic' groups in the previous system. It is at present anticipated that it will prove best to isolate well-developed oxisols (such as Tarat Family in west Sarawak) in a separate group, and either consider both their weakly developed associates over basic rocks and similar soils over acid igneous rocks together with these soils which have weakly developed features possibly ascribable to a podzolic process (which is done at present) or - more logically perhaps - consider these soils a separate primary group.. The problem is left until the west Sarawak soils are considered.

5. Soils within primary group 8 will include those previously classed as Semadoh Family. Difficulties are expected in establishing suitable parameters to distinguish these soils from many now classed under group 3(c) in the Table.

6. The separation of calcareous upland soils (3(a)) as a 'subgroup' is very provisional. Few analytical data are available for them yet

Notes on Table 2

1. All correlations given in the Table are very tentative There is some uncertainty regarding the identification of a cambic horizon and this is critical for many of the soils considered There is also doubt regarding the existence of argillic horizons In the Table it is assumed that they do not occur, based on the following evidence: (a) clay skins are generally confined to minor channel cavities; a number of profiles have been sectioned but few illuvial clay skins have been found on structural surfaces: (b) clay incrreases may or may not be sufficient to qualify for the argillic definition; they commonly qualify in the pallid soils of grouping 3(c) of Table 1, but generally do not in the associated red and yellow soils of grouping 3(a); (c) there is commonly no clay bulge: the clay increase continues with depth below the solum. On the other hand, sectioning has shown considerable disturbance by worms in upland soils which may be considered to cancel the clay skin requirement, and many subsoils have swelling properties beyond that expected from the clay mineral data. Workers more experienced with the USDA system might therefore consider that argillic horizons exist in some profiles. Some correlations with Dystropepts/Ochric Cambisols may therefore be Paleudults/Helvic Acrisols If this is the case, however, it is likely to apply only to specific profiles and not to others with closely similar properties The distinction is thus not likely to be a very useful one

2. The correlations tiven apply only to profiles examined and do not cover the total range of profiles within each series, particularly in the case of USDA subgroups. Drainage phases within each well-drained series, for example, will extend the correlation in most cases to include aquic subgroups.

3. Where no entry is given no available profile has sufficient laboratory data to be tested in these systems.

Family	Series	USDA System	World Soil Map Legend
Meluan		Lithic Troporthent	Lithosol
Sedong			
Kapit		Typic Troporthent	Dystric Rhegosol
Gaya			
Merit-Kapit	Lalis		
Kabuloh	Kabuloh	Typic Eutropept Lithic Eutropept	Eutric Cambisol
	Karabungan	Typic Dystropept	
Merit	Merit	Oxic Dystropept Typic Dystropept	Ochric Cambisol
	Jakar	Oxic Dystropept Typic Dystropept	
	Lupar		
Bekenu	Bekenu	Oxic Dystropept Aquic Oxic Dystropept	Ochric Cambisol
	Sarikei	Tropeptic Haplorthox	Helvic Ferralsol
	Tukau		
Nyalau	Nyalau	Oxic Dystropept Typic Dystropept Typic Haplorthox Tropeptic Haplorthox	Ochric Cambisol Ochric Ferralsol Helvic Ferralsol
	Sabangang		
-	~~Layang~~ Changgan	Oxic Dystropept Typic Troporthent	Ochric Cambisol Dystric Rhegosol
-	Arip	Typic Dystropept	Ochric Cambisol
-	Piring	Tropeptic Haplorthox	Helvic Ferralsol
-	Nyaroh		
Kerait Bandang Saratok Lubai Triboh		Uncertain	Uncertain

Table 2 : Correlation of families and series with the USDA classification and the World Soil Map Legend

Family	Series	USDA System	World Soil Map Legend
Miri	Miri	Typic Tropaquod Typic Trophohumod	Gleyic Podzol Humic Podzol
	Bako		
Silantek	Silantek Tunggal	Typic Tropaquod Typic Tropohumod	Gleyic Podzol Humic Podzol
	(Others)		
Peninjau Tika	(all)	Typic Quartzipsamment	Eutric Rhegosol Dystric Rhegosol
Kayan Bemang Seduau	(all)	Typic Tropofluvent Aquic Tropofluvent	Dystric Fluvisol
Belat		Typic Tropaquent	Thionic Gleysol
Nonok Rajang	Rajang	Typic Tropaquent Hydraquent	
Paloh Sirik Pendam	Pendam	Typic Tropaquent	Salic Gleysol
Tatau	Jol Luis Matu	Histic Tropaquent	Histic Gleysol
	Tatau Plan	Typic Tropaquent	Fluvic Gleysol
Pakan	Pakan		
Bijat	Bijat Daro		
	Sebandi	Histic Tropaquent	Histic Gleysol
Igan Mukah		Histic Tropaquent Typic Tropohemist Typic Tropofibrist	Histic Gleysol Dystric Histosol
Anderson	Anderson	Typic Tropohemist Typic Tropofibrist	Dystric Histosol
	Luk	Histosol	Histosol

Table 2 (cont.) : Correlation of families and series with the USDA classification and the World Soil Map legend

4. The pallid soils (Saratok .. Bandang) are difficult to place in the USDA system due to the colour parameters. It would appear logical to consider them with the Dystropepts (or Paleodults) as are their associated red and yellow soils.

5. The family, and higher-level, groupings in the local system fit the groupings for the World Soil Map legend more easily that those of the USDA classification. This is to be expected considering the local approach to grouping. In considering cases where a profile is, within the terms of the classification, placeable in a particular series but correlation in Table 2 places it in a different subgroup/subunit from profiles of that series previously examined, then consideration must be given to expanding the classification and creating a new series. In weighing the advantages of this it is suggested that more weight be given to discrepancies with the World Soil Map subunits than to those with the USDA subgroups.

Key to the Classification

A. Accreting mineral soils and other permanently saturated bottomland soils with:

(1) no lithic or paralithic contact within 25cm of the surface

(2) no surface peat as much as 25cm in thickness

(3) no podzol morphology as defined under B

[The primary division is between well-drained and poorly-drained soils - AA and AB. Well-drained alluvial soils are split into families on texture and a medium-textured family is introduced. Analyses show that such soils are more extensive than previously expected. Series distinction is then made on colour. A CEC parameter is included as a provisional means of separating the soils derived from sedimentary parent materials, which are considered in the system, from alluvium derived from igneous rocks, which are not as yet. The latter are known to be extensive in west Sarawak. It is not certain that this is the most appropriate parameter to use and, should field differentiation of these soils from sedimentary-drived profiles prove consistently possible, consideration made also be given to separation of these soils at a family, rathen than series, level. Both these points are left unsettled at present.]

AA. no mottles with chromas of 2 or less within the surface 50cm; no matrix colour with chroma less than 1 or hue bluer than 10Y within 1m of the surface; accretion due partly or wholly to alluvial processes;

AAa. sands; all texture profiles except contrasting - KAYAN FAMILY

AAa.1. CEC/clay 30 or less.

AAa.11. riverine parent material.

AAa.111. Hue 10YR or yellower throughout surface 50cm - Kayan

AAa.112. ....

AAa.12. marine parent material.

AAa.121. Hue 10YR or yellower throughout surface 50cm - Kabong

AAa.122. Hue redder than 10YR in some horizon above 50cm - Belawa

AAa.2. CEC/clay more than 30

(unclassified. Ramun and Sematan Families in west Sarawak to be considered here).

AAb. loams and silts; all texture profiles except contrasting - BEMANG FAMILY

AAb.1. CEC/clay 30 or less

AAb.11. Riverine parent material

AAb.111. Hue 10YR or yellower throughout the surface 50cm: fine silt - Bemang

AAb.112. Hue 10YR or yellower throughout the surface 50cm; coarse loam; - Semilajau

AAb.113. ....

AAb.12. marine parent material - ....

AAb.2. CEC/clay more than 30 - ....

AAc. clays; CEC/clay less than 30; all texture profiles except contrasting - SEDUAU FAMILY

AAc.1. Hue 10YR or yellower throughout the surface 50cm; riverine parent material - Seduau

AAc.2. Hue redder than 10YR in some horizon above 50cm; riverine parent material; - Malang

AAd. clays; CEC/clay more than 30; all texture profiles except contrasting. (Unclassified Terbat Family to be considered here).

AAe. contrasting texture profiles.

AAe.1. texture contrast point deeper than 75cm

- classify into families and series under AAa - AAd but consider texture profile only above the contrast point.

AAe.2. texture contrast point at depth of 50 - 75cm

- classify into families under AAa - AAd on texture above the contrast point; separate series on texture below contrast point.

AAe.3. texture contrast point shallower than 50cm

- classify as family intergrade under AAa - AAd on basis of dominant texture above and below contrast point; if required, separate series on texture above contrast point or on other parameters as needed.

AB. Gleyed throughout the control section, with one of the following texture and matrix colour combinations; (see also Note A5):

(1) any colour <u>if</u> colour due to uncoated sand grains <u>and</u> texture loamy fine sand or coarser
(2) texture loamy very fine sand or finer <u>and</u> mottles rare or absent <u>and either</u> values less than 4 and chromas less than 1 <u>or</u> values 4 or more and chromas 1 or less
(3) texture loamy very fine sand or finer <u>and</u> mottles few or more <u>and</u> chromas 2 or less
(4) texture loamy fine sand or coarser <u>and</u> mottles rare or absent <u>and either</u> hues 10YR or redder and values less than 4 and chromas less than 1 <u>or</u> hues 10YR or redder and values 4 or more and chromas 1 or less <u>or</u> hues between 10YR and 10Y and chromas 1 or less <u>or</u> hues bluer than 10Y
(5) texture loamy fine sand or coarser and mottles few or more <u>and either</u> hues 10YR or redder and chromas 2 or less <u>or</u> hues between 10YR and 10Y and chromas 3 <u>or</u> hues bluer than 10Y
(6) any texture if permanently saturated <u>and</u> hues bluer than 10Y <u>and</u> colour changes on exposure to air.

<u>ABa</u>. accretion due wholly or in part to alluvial processes; all texture profile except contrasting.

<u>ABa.1</u>. sands; conductivity more than 500 micromhos throughout the control section; pH KCl less than 3.5 in some horizon within 1m of the surface - <u>BELAT FAMILY</u>

<u>ABa.2</u>. sands; conductivity more than 500 micromhos in at least some part of the control section; pH KCl 3.5 or more in all horizons within 1m of the surface - <u>NONOK FAMILY</u>

<u>ABa.3</u>. sands; conductivity less than 100 micromhos throughout the control section; pH KCl 3.5 or more in all horizons within 1m of the surface (see Note A6). - <u>TATAU FAMILY</u>

<u>ABa.31</u>. Hue not GY or bluer in any horizon within 75cm of the surface.

<u>ABa.311</u>. riverine parent material; no surface peat - <u>Plan</u>

<u>ABa.312</u>. riverine parent material; surface peat present - <u>Luis</u>

<u>ABa.313</u>. marine parent material; no surface peat - <u>Tatau</u>

<u>ABa.314</u>. marine parent material; surface peat present - <u>Matu</u>

<u>ABa.32</u>. Hue GY or bluer throughout the control section

- series separation required as under ABa.31.

COLOUR PLATES 1 - 4

1. **Lalis Series** (p. 35)

A typical form in the Durin-Kelupu area of central Sarawak, associated with Kapit, Jakar and Merit Series. Other common forms are deeper with rock fragments common but not dominant at such a shallow depth.

2. **Jakar Series** (p. 33)

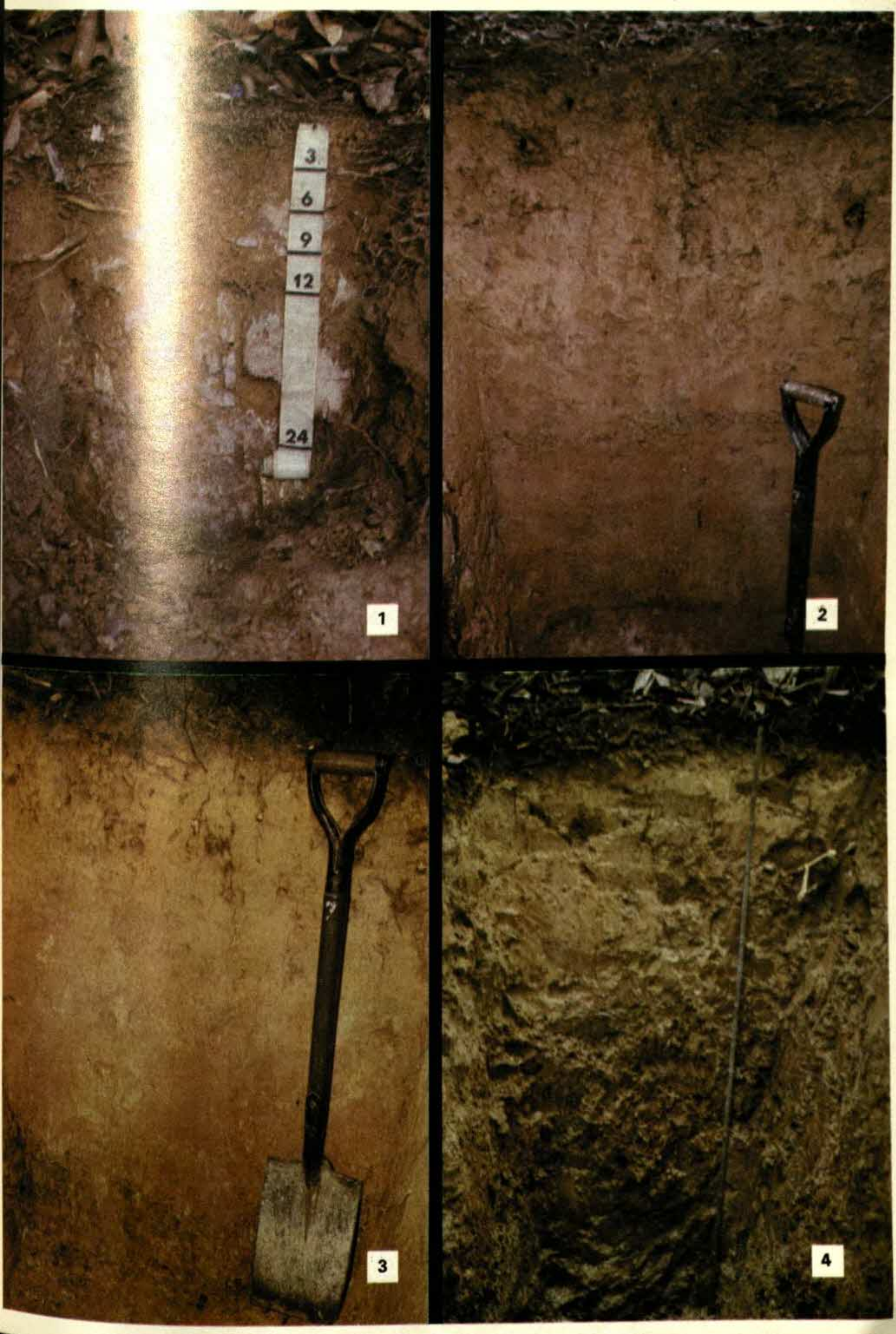
A profile from the Penipah-Bedengan area of Mukah District. In the Jakar area shallower profiles are more common.

3. **Merit Series** (p. 33)

This illustrates one of a number of Merit profile forms. The 'colour B' may be highly irregular, as shown, or occur at a moderately uniform depth. In many profiles the colour contrast with the upper subsoil is more pronounced, as is the stoneline at the base of the profile.

4. **Bekenu Series** (p. 33)

A weak 'colour B' occurs but coincides with the pronounced stoneline overlying the weathered shale. On the appearance in the plate this profile also conforms to Merit Series, there being equally little structural development in heavier-textured profiles.


3
6
9
12
24
1
2
3
4

[Intergrades between BELAT, NONOK and TATAU Families occur based on conductivity; within TATAU Family series intergrades may occur between ABa. 31 and ABa. 32 based on depth to strongly gleyed horizons.]

ABa.4. loams and silts; conductivity more than 500 micromhos throughout the control section; pH KCl less than 3.5 in some horizon within lm of the surface - PALOH FAMILY

ABa.41. marine parent material; fine silt; no surface peat - Paloh

ABa.42. ...

ABa.5. loams and silts; conductivity more than 500 micromhos in at least some part of the control section; pH KCl 3.5 or more in all horizons within lm of the surface - SIRIK FAMILY

ABa.51. marine parent material; fine silt; no surface peat - Sirik

ABa.6. loams and silts; conductivity less than 100 micromhos throughout the control section; pH KCl 3.5 or more in all horizons within lm of the surface (see Note A6.) - PAKAN FAMILY

ABa.61. riverine parent material; fine silt; no surface peat - Pakan

ABa.7. clays; conductivity less than 100 micromhos throughout the surface 75cm or to a lithic contact if shallower - BIJAT FAMILY

ABa.71. hues not GY or bluer in any horizon within 75cm of the surface.

ABa.711. riverine parent material; no surface peat - Bijat

ABa.712. riverine parent material; surface peat present - Sebandi

ABa.713. marine parent material; no surface peat - Daro

ABa.714. marine parent material; surface peat present - ...

ABa.72. hues GY or bluer throughout the control section

- (series separation as for ABa.61).

ABa.8. clays; conductivity between 100 and 500 micromhos in some horizon within 75cm of the surface but not higher than 500 micromhos in any horizon within this depth; pH KCl more than 3.5 throughout control section

- Bijat-Pendam intergrades at family level; Daro-Pendam intergrades, etc., at series level.

ABa. 9a. clays; conductivity more than 500 micromhos in some horizon above 75cm; pH KCl more than 3.5 throughout the control section - PENDAM FAMILY

ABa. 9a. 1. no surface peat - Pendam

ABa. 9a. 2. surface peat present - Jol

ABa. 9b. clays; pH KCl less than 3.5 in some horizon within 1m of the surface - RAJANG FAMILY

ABa. 9b. 1. conductivity more than 500 micromhos at some level within 75cm of the surface - Rajang

ABa. 9b. 2. ...

[No further series separation made at present but drained acid sulphate soils will probably require distinction. Conductivity and presence of jarosite colours at depth may be suitable parameters.]

ABb. as ABa but with contrasting texture profile

ABb. 1. texture contrast point deeper than 75cm

- classify into families and series under ABa. 1-9 considering the texture profile only above the contrast point.

ABb. 2. texture contrast point at depth of 50-75cm

- classify into families on criteria given above for ABb. 1; separate series may be required on character of material below contrast point

ABb. 3. texture contrast point shallower than 50cm

- strategy uncertain. Possibly classify as family intergrades on texture extremes in the control section, ignoring horizons thinner than 10cm where these would affect the placing, then separate in series on the average texture of the upper 50cm of the control section, or on other textural parameters as required.

ABc. as ABa but subsurface organic layers present within 1m of the surface

ABc. 1. including any surface organic horizon, both more than half the surface 80cm and half the surface 50cm is mineral material (by thickness)

- classify as if all organic layers within 50cm were at the surface (into Bijat Sebandi Series, etc.) (See Note A7)

ABc.2. including any surface organic horizon, more than half the surface 80cm is mineral material by thickness, but more than half the surface 50cm is organic.

- classify following strategy for ABc.11 and ABc.12 into series defined under A or E (Mukah, Igan etc) as necessary. (See Note A7)

ABc.3. more than half the upper 80cm is organic material

ABc.31. material underlying the 0-80cm profile is dominantly mineral

ABc.311. more than half the surface 50cm is mineral

- consider all organic layers within 50cm as being at the surface, then consider all organic layers within 80cm as being at the surface; classify as intergrades on these two bases. (See Note A7).

ABc.312. more than half the surface 50cm is organic

- classify assuming that all organic layers within 80cm are at the surface. (See Note A7)

ABc.32. material underlying the 0-80cm profile is either dominantly organic or is alternating mineral and organic layers

- classify assuming all organic layers in the surface 1.25m are at the surface into series defined under A or E. (See Note A7)

ABd. accretion due entirely to colluvial processes

- family separation required

AC. as AA but accretion due entirely to colluvial processes

- family separation required if these prove to be important.

AD. colours indicating drainage intermediate between AA and AB

- family and series intergrades.

* * * * * *

NOTES

A1. Accreting soils. This covers soils which are on bottomlands and are definitely flooded occasionally, plus some low terrace soils if they are subject to some flooding. In most cases these are classified on site. Where doubtful, carbon figures are used. Accreting soils are then defined as soils on a site where accretion is a possibility and in which carbon either decreases irregularly with depth, or decreases regularly bu remains above a level of 0.2 per cent at a depth of 1.25m. (This follows USDA fluventic subgroups; as analysis implies samples from a pit, there seems no disadvantage in using the USDA depth limit rather than 1m used for control sections).

A2. Drainage. Note that 'gley soils' now means soils gleyed throughout the control section. Many previous Bijats would now be Seduau-Bijat intergrades.

A3. pH KCl. Determined following single air-drying. A stricter measure could be used but this probably separates most potential acid-sulphate soils and, if necessary, can be carried out in the field.

A4. Conductivity parameters. The intention is to separate those soils definitely subject to brackish water influence from those where there is no such effect and the soils are entirely of riverine, rather than estuarine origin. As conductivity varies with tides, rainfall, etc. there is inevitably a zone of doubt in mapping these soils even where conductivity measurements have been made. Intergrade families have therefore been set up and the doubtful soils combined with those transitional profiles on the edge of the zone influenced by brackish water and having permanently intermediate conductivity levels. A further complication arises with certain interior floodplain soils which may have conductivities higher than 100 micromhos due to natural salts in the soil solution. Where it is certain that no brackish water influence exists these should be classified as non-saline soils regardless of their conductivity levels. The problem is more theoretical than real as it is unlikely that conductivity readings would be taken for such soils in normal circumstances.

A5. Colour of poorly-drained soils. The presence of thin surface peat is taken to qualify the profile for classification under AB even though some sands underlying peat have strong brownish staining and do not qualify under the colour definitions given.

A6. Some soils in coastal situations have conductivities higher than 100 micromhos in the surface horizons but low conductivities bel ow these layers. It is presumed that these are affected by wind-blown salts and the conductivity levels at the surface are ignored forclassification. The feature may be quite variable and the present family divisions have brackish groundwater in mind.

A7. Where alternating layers of mineral and organic material occur or where a mineral alluvial mantle overlies an older organic accumulation, the classification strategy adopted under ABc may place profiles under a series with which they have obviously conflicting features, prior to drainage or cultivation. Thus a profile with 15m of surface clay may be placed in Sebandi Series (which characteristically has a surface peat layer) on the character of layers at a lower depth. Included in Bijat Series on

B. Non-accreting mineral soils with (1) no lithic or paralithic contact within 25cm of the surface, (2) no surface peat as thick as 25cm, and (3) either (a) a sand or coarse loam upper subsoil horizon with a value/chroma index of 2 or 3 overlying a sand or coarse loam middle or lower subsoil horizon with a value/chroma index of 1, 2 or 6a and the Munsell value decreases between these horizons by at least 2 units or (b) a spodic horizon, where not included in the foregoing, meeting the following requirements:

if overlain by a strongly bleached continuous or intermittent eluvial horizon more than 18cm thick then (a) there is enough amorphous material that per cent elemental pyrophosphate-dithionite-extractable (C + Fe + A1) divided by per cent clay = 0.15 or more; (b) the horizon is at least 1cm thick either as a continuous horizon or as a sum of lamellae within 1m; (c) either per cent extractable (C + Fe + A1) = 1.0 or more, or hues are 7.5YR or redder and values 3 or less in some continuous part of the horizon or in any subhorizon that is at least 1cm thick and hues are as red or redder than the underlying horizon; (d) there are no clay skins on ped faces or in the pores; if the A horizon rests on the spodic horizon, then the spodic horizon meets the requirements of (a), (b), (c) and (d) above and, in addition, has (e) a 15-bar water content of less than 20 per cent or, if it is higher, a pH (H20) less than 5.0 but at least 0.5 higher than pH (KC1); (f) enough depth that the horizon is not obliterated by ploughing to a depth of 18cm or enough degree of expression that after mixing to 18cm: (i) carbon is more than 1.7 per cent, (ii) per cent extractable (C + Fe + A1) divided by per cent clay = 0.2 or more, (iii) fragments of amorphous coatings or pellets can be clearly identified, and (iv) either hues are redder than 10YR and values less than 3 or hues are 10YR or redder and chromas are 3 or more.

/The intention here is to separate Podzols as defined by the World Soil Map definition. This is not at present possible due to lack of data on pyrophosphate-extractable C, Fe and A1, or on 15-bar water content. It is meanwhile assumed that all well-developed humus podzols included in the alternative definition by colour given above would also meet the chemical requirements. Other profiles are left unclassified until laboratory data are available./

BA. The spodic horizon or dark subsoil horizon defined by colour above is sufficiently cemented that an Edelman auger cannot penetrate through it to the underlying material - MIRI FAMILY

BAa. the upper subsoil horizon has a value/chroma index of 3 and the middle or lower subsoil horizon a value/chroma index of 1.

BAa.1. alluvial parent material - Miri

BAa.2. sedimentary parent material - Bako

COLOUR PLATES 5 - 8

5. <u>Nyalau Series</u> (p. 33)

The deep uniform profile is typical of this series although a weak 'colour B' may also occur.

6. <u>Kerait Series</u> (p. 30)

Deep humus staining in the medium-textured upper subsoil horizons are common in this series. The lower subsoil is typically dense.

7. <u>Saratok Series</u> (p. 30)

A common profile form: uniform, poorly-structured and underlain by a stoneline of quartz gravel.

8. <u>Timang Series</u> (p. 30)

The profile has been cultivated and has a thick, weakly humic surface horizon. Gleying is pronounced throughout the subsoil.

5

6

7

8

BAb. ... /It is at present uncertain whether other colours than those given under BAa occur; in podzols with cemented humus pans, experience suggests that the pan is invariably very dark and the overlying material very pale in colour./

BB. The spodic horizon or darker subsoil horizon defined by colour above can be penetrated and sampled by an Edelman auger through to the underlying material; parts of the horizon may be sufficiently cemented that they cannot be crushed in the hand but, where this is the case, other parts of the horizon are friable or loose - SILANTEK FAMILY

BBa. The upper subsoil horizon has a value/chroma index of 3 and the middle or lower subsoil horizon a value/chroma index of 1 or 6a.

BBa.1. sedimentary parent material; no surface peat; spodic horizon overlies non-lithic material - Silantek

BBa.2. sedimentary parent material; no surface peat; spodic horizon overlies lithic material within control section - Tunggal

BBa.3. alluvial parent material; no surface peat; spodic horizon overlies unconsolidated alluvium - Buso

BBa.4. alluvial parent material; no surface peat; spodic horizon overlies residual sedimentary material showing rock structure - Banyut

BBa.5. alluvial parent material; surface peat present - Grang

BBa.6. ...

BBb. The upper subsoil horizon has a value/chroma index of 2 and the middle or lower subsoil horizon a value/chroma index of 1 or 6a.

BBb.1. sedimentary parent material; no surface peat; spodic horizon overlies non-lithic material - Bakau

BBb.2. alluvial parent material; spodic horizon overlies unconsolidated alluvium; no surface peat present - Metading

BBb.3. ...

BBc. The upper subsoil horizon has a value/chroma index of 3 and the middle or lower subsoil horizon a value/chroma index of 2 (including profiles where the colour contrast is well-defined but the 'Bh' so weakly developed that it is doubtful if it qualifies as a spodic horizon).

BBc.1. sedimentary or colluvial parent material; no surface peat present; the darker middle or lower subsoil horizon does not overlie lithic material - Daup

BBc.2. ...

* * * * * *

NOTES

B1. The main differences from the 1966 system are the deletion of parent material as a criterion at family level and the cancellation of Jerijeh Family meanwhile. Jerijeh profiles from the type area show little suggestion of an albic and are separated as Kabong Family, Belawai Series.

B2. There is a complete lack of analytical data regarding spodic horizons and further development of the system cannot be done without it. When such data become available this section of the classification will require considerable expansion and revision.

<u>C.</u> Other non-accreting mineral soils with:

(1) no lithic or paralithic contact within 25cm of the surface
(2) no surface peat as thick as 25cm
(3) no spodic horizon or colour Bh horizon as defined under B above

<u>CA</u>. the control section is at least 25cm in thickness if an A1 horizon is present; if there is no A1 horizon the base of the control section is at a depth or more than 25cm from the surface.

[Where the control section is bounded at depth by a lithic or paralithic horizon and this occurs at 25cm depth, the profile is at the division point between a shallow phase of a 'C' soil and a skeletal soil considered under 'D'. No intergrade is required. Where the control section is limited at depth by the presence of a thick stoneline, residual rock structure, or scattered lithorelicts, and the depth does not qualify for CA, but at the same time the lithic or paralithic horizon is at too great a depth to qualify for D, then the profile is considered a 'C-D' intergrade and keyed out under CB. This may seem an unnecessary confusion. The intention here is to classify out shallow or eroded phases together with their deeper equivalents wherever possible, i.e. wherever there is a sufficient thickness of subsoil material for identification of the diagnostic characteristics needed for such classification. An arbitrary thickness of 25cm is taken and, with eroded profiles in mind (which may still show well-developed subsoil features which can be confidently related to those of deeper soils), this thickness is measured from the surface if there is no topsoil. There remain, however, profiles which do not meet these requirements but which are too deep (by the definition used) to be classified as skeletal soils under D. (The commonest situation is a profile developed over shale with scattered lithorelicts throughout the subsoil, the amount increasing with depth but not meeting the local paralithic definition within 25cm of the surface.) The 'C-D' intergrade definition is reserved for such soils.]

[The definition of CA is different from in the first draft circulated as that was found to be confusing. The earlier intention was to cope with the rare instances in which the profile is quite deep but the apparent topsoil is also thick and the subsoil available for classification is less than 25cm thick. As phrased at present the classification puts such profiles in an intergrade position to skeletal soils although the profile as a whole may be 60cm (for example) deep, which would be quite contrary to the intention of the classification. This problem now remains and must be dealt with later. It is a rather unusual situation, however, and appears to be largely limited to light-textured soils with strong organic staining through what is best considered upper subsoil material.]

<u>CAa.</u> the dominant matrix colours in the control section have a value/chroma index of 3 (i.e. pallid) <u>or</u> the control section is variegated with at least one major colour component having a value/chroma index of 3 <u>or</u> the control section has a combination of pallid and variegated horizons. (see Note C3 and C4.)

<u>CAa.1.</u> sand; all texture profiles except contrasting (See Note C5) - <u>TIKA FAMILY</u>

CAa.11. sedimentary parent material; pallid - Tika

CAa.12. alluvial parent material; pallid - Bintulu

CAa.13. ...

CAa.2. loams; all texture profiles except contrasting (See Note C5) - SARATOK FAMILY

CAa.21. sedimentary parent material; pallid; coarse loam - Saratok

CAa.22. sedimentary parent material; variegated; coarse loam - Penipah

CAa.23. sedimentary parent material; pallid; fine loam - Durin

CAa.24. ...

CAa.3. silts; all texture profiles except contrasting (See Note C5) - BANDANG FAMILY

CAa.31. sedimentary parent material; pallid; fine silt - Bandang

CAa.32. sedimentary parent material; variegated; fine silt - Timang

CAa.33. ...

CAa.4. clays; all texture profiles except contrasting (See Note C5) - KERAIT FAMILY

CAa.41. sedimentary parent material; pallid; - Kerait

CAa.41. sedimentary parent material; variegated - Ajoh

CAa.43. ...

[Any soils over igneous rocks but otherwise qualifying under the above definitions - such as Lingga in West Sarawak - require series separation under the families established above and further study may suggest family separation is justified.]

/A number of colour combinations exist. Where the upper subsoil is pallid and the lower subsoil is variegated, the profile is considered pallid; where the reverse is the case, the profile is considered a pallid-variegated intergrade at series level. Horizon thickness limits will have to be established and may follow the limits for texture suffixes with regard to the inclusion of thin upper subsoil horizons contrasting in colour with the remainder of the profile./

CAa.5. contrasting texture profile (see Note C4.)

CAa.51. texture contrast point within 75cm of the surface.

CAa.511. upper subsoil sand or loam - TRIBOH FAMILY

CAa.5111. upper subsoil coarse loam and derived from alluvium - Triboh

CAa.5112. upper subsoil coarse loam; all subsoil material residual or only locally reworked - Kemuyang

CAa.5113. ...

CAa.512. upper subsoil silt - LUBAI FAMILY

CAa.5121. upper subsoil fine silt and derived from alluvium - Lubai

CAa.5122. ...

CAa.52. texture contrast point deeper than 75cm from the surface

- classify under CAa.1-4 ignoring texture below the point of contrast.

CAb. the dominant matrix colours in the control section have a value/chroma index of 5; any variegated horizons with a major colour component having a value/chroma index of 3 are confined to depths below 50cm from the surface and any mottles with a value/chroma index of 3 above this depth are clearly identifiable as mottles rather than matrix; no pallid horizons with a matrix colour having a value/chroma index of 3 occur above a depth of 75cm. (see Note C4).

CAb.1. sand; all texture profiles except contrasting (see Note C5) - PENINJAU FAMILY

CAb.11. sedimentary parent material - Peninjau

CAb.12. alluvial parent material - Sebaya

COLOUR PLATES 9 - 12

9. Daup Series (p. 28)

The weak Bh horizon is apparent in the field but is barely reflected in analysis. The quartz stoneline is inclined through the profile and is not conformable with the Bh horizon.

10. Silantek Series (p. 27)

A well-developed profile. Sesquioxide coatings to cracks and structure lines in the underlying weathered sandstone are clearly shown.

11. Buso Series (p. 27)

A profile developed on an extensive terrace flat. The Bh horizon is developed in the fine sandy upper subsoil and overlies a white sandy clay.

12. Miri Series (p. 25)

A typical profile form, although the humus staining following root lines in the albic horizon is commonly not so pronounced.

9

10

11

12

CAb. 2. loams; all texture profiles except contrasting (see Note C5).

CAb. 21. sedimentary or alluvial parent material - NYALAU FAMILY

CAb. 211. sedimentary parent material; fine loam - Nyalau

CAb. 212. alluvial parent material; coarse loam - Sabangang

CAb. 213. ...

[Further distinction under CAb. 21 may be needed on subsoil colour.]

CAb. 3. silts; all texture profiles except contrasting (see Note C5).

CAb. 31. sedimentary or alluvial parent material - BEKENU FAMILY

CAb. 311. hue 10YR or yellower in some part of the control section above 50cm; CEC/clay 16 or less in some part of the control section; sedimentary parent material; fine silt - Bekenu

CAb. 312. As CAb. 311 but hue redder than 10YR throughout the control section - Sarikei

CAb. 313. As CAb. 311 but developed in alluvial parent material - Tukau

CAb. 314. ...

CAb. 4. clay; all texture profiles except contrasting (see Note C5).

CAb. 41. noncalcareous sedimentary or alluvial parent material; base saturation less than 35 per cent in some part of the control section; pH H20 less than 6.0 in all horizons below a depth of 75cm or immediately above a paralithic or lithic contact if shallower than 75cm. - MERIT FAMILY

CAb. 411. hue 10YR or yellower in some part of the control section above 50cm; sedimentary parent material - Merit

CAb. 412. as CAb. 411 but hue redder than 10YR throughout the control section - Jakar

[Profiles which qualify on present definitions for Jakar Series have been noted in Fourth Division in association with Kabuloh and Karabungan Series and have proved to be over calcareous shales, despite the low pH and calcium saturation in the control section. Whether such soils should be considered within Jakar Series or not is under discussion. They have been mapped as a provisional 'Tangap Series'.]

<u>CAb.413</u>. alluvial parent material; hue 10YR or yellower in some part of the control section above 50cm - <u>Lupar</u>

<u>CAb.414</u>. ...

<u>CAb.42</u>. calcareous sedimentary or alluvial parent material; base saturation 35 per cent or more throughout the control section; pH H20 6.0 or more in at least some horizon below a depth of 75cm or immediately above a paralithic or lithic contact if shallower than 75cm - <u>KABULOH FAMILY</u>

<u>CAb.421</u>. Hue 2.5Y or yellower throughout the control section; base saturation and per cent Ca saturation more than 80; CEC/clay less than 30 (normally overlying lithic material within 1m of the surface) - <u>Kabuloh</u>

<u>CAb.422</u>. hue 10YR or redder in upper part of control section, 2.5Y or yellower at base, with a 'colour B' horizon 7.5YR or redder in the middle subsoil (upper subsoil where truncated); base saturation and per cent Ca saturation below 50 in upper part of control section, increasing to above 50 at depth within control section; CEC/clay above 30 throughout the control section - <u>Karabungan</u>

[A number of intergrades between Kabuloh and Karabungan Series occur. Intergrades between Karabungan Series and series within the Merit Family are also possible and some such profiles have been mapped as a provisional 'Tangap Series', the parameters of which are still under consideration. See under CAb.413 above.]

[Soils developed over igneous rocks but otherwise qualifying under the definitions for CAb.1 - CAb.4 require separation at family level. Parameters required must be established after further study of west Sarawak soils. In central Sarawak, the following series have been separated, and their position at family level is meanwhile left open:-

Changgan
<u>Layang Series</u>: fine loam; gradational texture profile; hue redder than 10YR throughout control section; CEC/clay less than 16 throughout control section; base saturation 10-35 throughout control section; more than 15 per cent fine earth coarser than fine sand; developed over granite or granodiorite.

Arip Series: fine silt; gradational texture profile; hue redder than 10YR throughout control section; CEC/clay 20-40, decreasing with depth; base saturation less than 10 throughout control section; water-dispersable clay less than 3 per cent throughout control section; developed over rhyolite and other acid igneous rocks.

Piring Series: clay; uniform texture profile; approximately 60 per cent clay throughout control section; hue redder than 10YR throughout control section; CEC/clay less than 16, base saturation less than 10 and water-dispersable clay less than 3 throughout the control section; developed over quartz-biotite hornfels or related acid igneous or metamorphic material.

Nyaroh Series: clay; gradational texture profile; clay percentage rising to above 60 at depth; hue 10YR or yellower throughout control section; CEC/clay more than 16 and water-dispersable clay more than 3 per cent in some horizon above 50cm but decreasing below these levels in all horizons below this depth; parent material doubtful but probably related to that of Arip and Piring Series._7

CAb.43. base saturation less than 35 per cent in upper part of control section; other features consistent with an intergrade position between CAb.41 and CAb.42
- MERIT-KABULOH intergrades

/A possible series under this subhead has been named - Tangap Series - but few analyses are yet available to define its parameters precisely. It is similar to Kabuloh Series but has lower base saturation and variegated lower subsoils/

CAb.5. contrasting texture profiles (see Note C4)

- strategy as for CAa.5 and CAa.6. Families not yet established.

CAc. colours are intermediate between CAa and CAb

- New series required but no families. (see Note C4)

CB. the control section is shallower than CA (see first explanatory note following CA above)

- intergrades at family level between soils under CA and skeletal soils (Kapit, Sedong Families, etc.) New series required. Difficulties may arise with soils over igneous rocks. The emphasis should be on type of parent material where necessary.

Only one series has been established so far:-

CBa. soils with the characteristics of CAb.411 or CAb.412 except for depth; argillaceous sedimentary parent material - Lalis

/Lalis series is classed a MERIT-KAPIT intergrade/

* * * * * *

NOTES

<u>C1</u>. This is the main section of the system and is likely to be the one requiring most revision. More thought is needed regarding a number of soils developed over sedimentary rocks but only well-represented in west Sarawak (Matang, Semongok, for example) in addition to further work on the igneous soils.

<u>C2</u>. In some pallid coarse-textured profiles a wash of organic material stains the profile to some depth, although the lower part of the zone stained greyish brown or brownish grey cannot be considered part of the A1 horizon. In such cases these upper subsoil horizons are considered part of the control section but the colour parameters are ignored. The profile is classified (or not) under CAa on the basis of the matrix colour below this zone.

<u>C3</u>. For classification into CAa/CAb/CAc where the control section colour is in the value/chroma range 3 - 4 - 5 but is not within one index throughout, the following rules are provisionally set up: '3 over 4' profiles are considered under CAa provided the horizons with index 3 extend to at least 50cm depth; '4 over 5' profile are considered under CAb provided the horizons with index 4 do <u>not</u> extend to 50cm depth; '3 over 5' profiles, where the colour change is abrupt, are left undefined until further studied (Matang Family should be considered here); all other colour combinations are considered intergrades under CAc with the proviso that horizon colours above a depth of 25cm or below a depth of 75cm are ignored if by doing so placement under CAa or CAb is then possible. In all cases (apart from the '3 or 5' profiles referred to above) the profiles are classified under the established families but are separated on the atypical colour profile at series level.

<u>C4</u>. The contrasting profiles considered under CAa.5 are assumed to be developed due to strong lateral leaching in the upper subsoil, to fossil alluvial stratification, or to other features which are likely to be consistent over a significant area. <u>Not</u> included under these heads are the occassional profiles found in areas of varied sedimentary lithology in which a medium-textured subsoil (of Nyalau or Bekenu Series, for example) abruptly overlies coarse or fine material which is in situ residuum from from shale or sandstone respectively. Where such material occurs at a shallow depth recognition of it in the classification may be necessary but otherwise it is ignored and the soil classified on the overlying subsoil. The argument in making this decision is that one can confidently assume that the underlying lithology is varied from the texture contrast itself, the substrata exposed many represent an outcrop little wider than the profile exposure, and substrata at the other textural extreme probably occur nearby. To recognise these differences in classification and mapping would confuse rather than help.

<u>C5</u>. While the texture profiles permissable under CAa.1-4 and CAb.1-4 are broad, the soils intended for consideration under these subheads are typically gradational (uniform in some cases). Erratic or decreasing texture profiles are not envisaged. A decision on whether to separate such profiles at a family or other level is, however, left until the problem presents itself in practise.

D. Other mineral soils with a lithic or paralithic contact within 25cm of the surface.

DA. Lithic contact within 25cm of the surface - MELUAN FAMILY

[Series within Meluan Family should be separated on the texture of the material above the lithic contact and on broad grouping of parent material. Such soils occur derived from, and associated with, outcrops of basic and acid igneous rocks, limestone, chert, sandstone and, more rarely, shale. In the majority of cases it is likely that the soils are of insufficient interest for series names to be set up. Further division can wait until the need arises.]

DB. Paralithic contact within 25cm of the surface; lithic contact deeper than 50cm; well-drained to imperfectly drained.

DBa. Derived from basic igneous rocks - SEDONG FAMILY

series division on texture

DBb. Derived from acid igneous rocks - unnamed family

DBc. Derived from sedimentary rocks or comprising a thin veneer of alluvium over paralithic sedimentary material.

DBc.1. Derived from argillaceous sedimentary rocks; clay texture in fine earth - KAPIT FAMILY

DBc.11. comprising a thin veneer of alluvium over paralithic sedimentary material.

DBc.111. poorly or very poorly drained - Kelupu

DBc.112. well to imperfectly drained - Binatang

DBc.12. comprising residual material over paralithic material derived from sedimentary rocks.

DBc.121. derived from noncalcareous parent material; clay texture in fine earth - Kapit

DBc.122. ... (a series associated with calcareous shales may be necessary, among others).

DBc.2. comprising colluvial or alluvial accumulations of hard cobbles, sandstone corestones. etc. in a fine earth matrix - GAYA FAMILY

DBc.3. ...

COLOUR PLATES 13 - 16

13. Semilajau Series (p.18)

A very typical profile. Cultivated for fruit trees in this instance and the topsoil possibly slightly truncated.

14. Seduau Series (p.18)

Photographed after a few days exposure. The coarse structure is generally not well-expressed in a fresh pit. Pronounced gleying in the lower subsoil is partly masked by smearing of the surface colours.

15. Bijat Series (p.21)

The bottomland has previously been farmed for wet rice and the humic topsoil is quite deep as a result.

16. Luk Series (p.42)

Saline marine clay underlies the organic debris near the base of the auger. The upper 40cm of the profile is dry and shows a colour contrast with wetter organic layers below. The well-sorted finely graded organic material has a very different appearance from the raw woody debris of Anderson Series.

13

14

15

16

DC. Paralithic contact within 25cm of the surface; lithic contact deeper than 25cm but not deeper than 50cm from the surface

- family-level intergrade between Meluan Family and the appropriate family separated under DB. Separate series where found to be important.

* * * * * *

NOTES

D1. Apart from Kapit Family, no texture is assigned at the family level. This may be necessary, but will add to the number of families.

D2. For the purposes of classification lithic and paralithic are defined as comprising more than 50 per cent lithorelicts (excluding iron-enriched stoneline fragments) and are separated on penetrability with an Edelman auger (lithic horizons cannot be penetrated). This may cause trouble in Gaya Family where the auger meets fresh correstones although fine earth is present elsewhere in the profile.

E. Organic soils with surface peat horizons at least 25cm thick.

EA. soils of basin swamps, floodplains and coastal swales.

[Classification of these soils is incomplete. The initial separation is on texture and origin. Alluvial organic soils are normally confined to present coasts, have a storm beach microrelief, good sorting of the organic material, and good drainage in the upper layers of the profile. Profiles farther from the coast which are permanently waterlogged, nonsaline and without surface microrelief features as described above are best grouped with the residual soils regardless of the degree of sorting of organic layers. Series distinctions are then made on salinity and the pH of the mineral horizons within the control section together with a distinction of highly organic peats from partly mineral muck soils now included within the peat definition. Distinction of fibric and hemic organic material are also required but are at present not made because of lack of data.]

EAa. the thickness of the surface peat layer is 25cm - lm if it overlies continuous mineral layers to a depth of at least 1.25cm, or the cumulative thickness of surface and subsurface peat layers is 25cm - 1 m if organic and mineral horizons are interstratified within a depth of 1.25m.

EAa.1. underlying (or interstratified) mineral horizons within the depths stated are dominantly sands. - IGAN FAMILY

[No series division within Igan Family has yet been made but where required the main series criteria should be those used for divisions within the Mukah Family below and listed in the note following EA above.]

EAa.2. underlying (or interstratified) mineral horizons within the depths stated are dominantly clays - MUKAH FAMILY

EAa.21. the organic horizons above 50cm depth have more than 65 per cent loss on ignition

EAa.211. The organic horizons are residual.

EAa.2111. conductivity of all organic and mineral horizons less than 100 mocromhos (see Note A6 above); pH KCl of mineral horizons 3.5 or more within 1.25m of the surface - Mukah

EAa.2112. conductivity of all organic and mineral horizons more than 500 micromhos; pH KCl less than 3.5 in some mineral horizon within 1.25m of the surface - Patok

EAa.2113. ...

EAa.212. The organic horizons are alluvial.

EAa.2121. Conductivity of all organic and mineral horizons more than 500 micromhos; pH KCl less than 3.5 in some mineral horizon within 1.25m of the surface - Mahat

EAa.2122. ....

[As these are essentially littoral soils, all are likely to be saline throughout and to have underlying clay with potential acid sulphate characteristics. Further series separation may not be required.]

EAa.22. the organic horizons above 50cm depth have less than 65 per cent loss on ignition.

EAa.221. the organic horizons are residual

EAa.2211. conductivity of all organic and mineral horizons less than 100 micromhos (see Note A6 above); pH KCl of mineral horizons 3.5 or more throughout surface 1.25m - Epai

EAa.2212. conductivity of all organic and mineral horizons more than 500 micromhos; pH KCl of 3.5 or more throughout surface 1.25m - Merapok

EAa.2213. ...

[Series separation of strongly saline soils without acid-sulphate characteristics is also required here.]

EAa.222. ...

EAa.3. mineral horizons with loam textures dominant - Igan-Mukah Family intergrades

EAb. peat depth or, where interstratified with mineral horizons, cumulative peat thickness, deeper than EAa. - ANDERSON FAMILY

[It is meanwhile assumed that the majority of deep peat soils are highly organic and that no partly-mineral muck soils of this depth occur. Division on this basis is therefore not made.]

EAb.1. the organic horizons are residual

EAb.11. conductivity of all horizons within 1.25m of the surface less than 100 micromhos; pH KCl of any mineral horizons within this depth 3.5 or more - Anderson

<u>EAb.12</u>. conductivity of all horizons within 1.25m of the surface more than 500 micromhos; pH KCl of any mineral horizons within this depth 3.5 or more - <u>Limbang</u>

<u>EAb.13</u>. ...

<u>EAb.2.</u> the organic horizons are alluvial

<u>EAb.21</u>. conductivity of all horizons within 1.25m of the surface more than 500 micromhos; pH KCl of any mineral horizons within this depth less than 3.5 - <u>Luk</u>

<u>EAb.22</u>. ...

<u>EB</u>. soils of upland sites - unnamed families

[These will include Mulu. Upland peats may largely be excluded from E because of insufficient thickness. Where they qualify a distinction should be made at family level between those at relatively low altitude formed due to flat or gently sloping terrain and those at high altitude formed due to microclimate differences and associated with moss forest.]

* * * * * * * *

NOTES

<u>E1</u>. Should the partial drainage and agricultural development of the deeper basin peats prove possible, series distinction on macro and micro elements will probably be advantageous

<u>E2</u>. Podzols in which surface peat deeper than 25cm occurs are included here and should be separated at family level from Igan. These soils are ignored until profiles can be studied in more detail; they appear to be very rare and have only been noted west of Selalang in central Sarawak.

Appendix 1

Nomenclature

Each family is named and the name chosen is in all cases a single word. Normally, this is a local river, hill or town name. Double-barreled names are avoided (such as Paya Megok, Batu Enam, etc.)

One of the main series within each family is given the name of the family. A rule is required, therefore, to make it clear whether it is the series or the family which is referred to in each context.

A texture suffix is added to the name in the case of series in some instances. In practise the suffix is mainly required in report texts and in naming individual described profiles. Except on detailed surveys it is unlikely to be required in mapping legends, although this need may arise occasionally at broader levels of survey. The addition of a texture suffix to the family name is theoretically permissable but is only likely to be required in occasional profile descriptions where the series remains in doubt. In general the suffix should be reserved for use at the series level.

In order to standardise the references to the classification terminology in report texts, mapping legends and formal profile description the following rules should be adhered to:-

Report texts

1) The word 'Series' or 'Family' is always included following the classification name, unless the context makes in very obvious which is referred to. Terms which have no meaning within the classification, such as 'Bijat soils' and 'Merit soil type' are never used. Where the context allows the name to stand on its own it should be treated as a proper name and used in isolation ('The drainage of Bijat is ....', 'Merit and Bekenu are ...', etc.) but care should be taken that no confusion will arise regarding the classification level referred to.

2) Intergrades, at both family and series level, should be designated as 'Family intergrade', 'Series intergrade'. The names of the families concerned are given in the order in which they appear in the Key to the classification and the names are separated by a hyphen. Thus 'Bijat-Pendam Series intergrade' and so forth, not 'Pendam-Bijat'. It must be remembered that, at many points in the system, families are separated by a single parameter and no intergrade is employed. 'Nyalau-Bekenu Family intergrade' is an impossibility within the terms of the system.

3) Compound and complex associations are designated by two (or, where unavoidable, three) of the main families or series concerned. The names are separated by virgules and are given in order of importance, not in the order in which they are first referred to in the classification. Within one survey area, therefore, a Nyalau/Silantek and a Silantek/Nyalau Association may be usefully separated and the order of the names indicates which series or family is dominant.

4) Associations need not be designated as series or families in the association label; the classification level concerned can be brought out in the text. As far as possible, however, the compound names should be at the same level throughout.

Mapping legends

1) The general rule is that family names appear in upper case in the Key, series names in lower case. Where the key lists both series mapping units and family mapping units, the family name is given for each and the series name added as necessary. This is to avoid giving the visual impression that names in capitals refer to units which are more important than those in lower case lettering. Thus:-

TATAU

TATAU (Matu Series)

PENDAM

PENDAM/RAJANG

or a tabulated key giving separate columns for families and series.

2) The normal three-letter abbreviations are used for captions within the mapping units. These should all be in lower-case regardless of the level of classification. Situations where this might cause confusion can be dealt with as they arise.

Profile descriptions

1) The description headings are displayed so that a separate listing is used for the family and for the series. If the series is unknown, this is stated following that heading. If a phase classification is given, a separate heading is added for this, following that for the series. Otherwise, no phase heading is included.

2) Where a series name is entered this is always followed by the texture suffix appropriate to the profile.

Appendix II

Notes on the families and series

Series are listed in the order in which they appear in the Key to the Classification. The notes comprise an estimate of areal extent and importance, an indication of which series units are new introductions to the system and which derived from the 1966 classification and, in the case of the latter, a discussion of any changes in definition which the present system entails.

KAYAN FAMILY

Kayan Series

Rarely extensive but a widely represented soil on the banks of all but major rivers and, in areas with mainly sandy upland soils, locally dominant in interior valley bottomlands. A 1966 unit but now confined to coarse-textured soils.

Kabong Series

The dominant well-drained series immediately behind present sand beaches in coastal situations. A 1966 unit but now confined to coarse-textured soils, although in practice medium-textured soils are rarely encountered near coastal beaches (and such soils developed in marine parent material have at present been ignored in this classification).

Belawai Series

An important soil in the Belawai-Rajang area but apparently of little significance elsewhere. In 1966 these soils were referred to a Jerijeh Family, considered an iron podzol; an albic horizon was diagnostic. More recent work in the area has failed to find any profile with an albic upper subsoil. If such profiles exist they are likely to be confined to west Sarawak. Belawai Series is introduced to cover those profiles redder than, but otherwise similar to, Kabong Series.

BEMANG FAMILY

A new addition, this family covers those soils of medium texture which were grouped with either the 'light' or 'heavy' alluvial soils in 1966. It was then thought that such soils were not sufficiently extensive to warrant separation. More analysis suggests otherwise.

Bemang Series

Transitional in character between Kayan and Seduau Series, soils in this texture range have been noted in both Third and Fourth Division.

Semilajau Series

Previously considered a light-textured family in 1966, the name has been transferred to soils in this texture range on the basis of analysed profiles. A common river-bank soil, probably more widespread than Kayan Series. Like Malang Series, this soil was grouped in the Red-Yellow Podzolic soils in 1966.

SEDUAU FAMILY

A previously established family which, in 1966, included heavy loams. It is now confined to clays.

Seduau Series.

A widespread riverine bottomland soil. Apart from the restricted texture range, the series has much the same definition limits as the previous family of that name.

Malang Series

In 1966 a Malang Family was employed for 'yellow over red' profiles and was grouped in the 'Red-Yellow Podzolic Soils' of that system. Grouping with other accreting soils has more justification. A widespread riverine bottomland soil but possibly less extensive than Seduau Series.

BELAT FAMILY

Essentially unchanged in concept from 1966 but now defined more precisely. Only of local importance.

NONOK FAMILY

Also a previously-established family, generally of restricted extent. Some changes in definition have been made but, again, the central concept is unchanged.

TATAU FAMILY

Many soils related to Tatau Family were separated at family level in 1966 and are now considered series within this family. (This was anticipated to some extent in 1967 amendments to the 1966 system).

Plan Series

Equivalent, with a more restricted t3xture range, to the 1966 Plan Family. Generally not of great extent in any area although widely scattered occurences have been noted.

Luis Series

Equivalent, with a more restricted texture range, to the 1966 Luis Family. An unimportant series, so far mapped only in Third Division.

Tatau Series

The equivalent of the 1966 Tatau Family, now confined by definition to sands (as it was in practice previously). A widespread series in coastal localities, generally in association with Kabong and Matu Series.

Matu Series

Equivalent to the Matu Family of 1966. A common soil in coastal situations, although rarely of great areal extent in any locality.

PALOH, SIRIK and PAKAN FAMILIES

These families are introduced to cover the medium-textured poorly-drained alluvial soils which in 1966 were included with either their light-textured or heavy-textured associates. Recent mechanical analyses suggest that such soils are more extensive than was previously thought and a separate texture grouping appears justified. In the case of Pakan Family, its cretion is also necessary following the establishment of the well-drained equivalent, Bemang Family, to allow the straightforward classification of intergrades between them.

It is as yet uncertain how extensive these families are in the State as, in the past, fewmechanical analyses have been undertaken on poorly-drained alluvial soils. They are expected to prove common, however.

BIJAT FAMILY

A family established in 1966, now restricted to clays rather than including heavy loams, and covering some soils which were then classed as separate families.

Bijat Series

Equivalent in concept to the 1966 Bijat Family in general terms although limits have been redefined. Profiles which are poorly-drained in the lower subsoil but with better drainage in the surface 50cm were previously included in the Family. These are now considered Seduau-Bijat intergrades. The series is now confined to profiles which are gleyed throughout the subsoil. A widespread soil in many interior valleys and on major river floodplains.

Sebandi Series

Previously considered a separate family, now grouped in the Bijat Family. The definition is essentially unchanged. A widely occuring soil although rarely extensive in any one locality.

Daro Series

A series of minor importance, reduced from a family unit in the previous system.

PENDAM and RAJANG FAMILIES

These families were established in the 1966 classification and the central concepts of them are unchanged. There is an important change in definition, however. It was previously thought that the presence or absence of potential acid-sulphate conditions was related to salinity levels and the former could thus be broadly inferred from the natural vegetation. This is now known to be unreliable. The families have therefore been redefined strictly on dry pH and on conductivity and these measurements will have to be taken in all cases (other than the extreme case of a coastal situation under Avicennia or Rhizophora, where the presence of Rajang rather than Pendam can be assumed). By the present definition it is hoped that Rajang and Pendam classifications can be reliably equated respectively with saline soils with potential acid sulphate characteristics and saline soils without such dangers.

Both families are widespread but it appear likely that, on the present definitions, many areas previously considered Pendam will now be classed as Rajang.

MIRI FAMILY

Miri Series

Locally important although rarely widespread. The series is equivalent to the Miri Family of 1966 with only minor changes in definition.

Bako Series

Locally important although rarely widespread. The series is equivalent to the Bako Family of 1966 with minor changes in definition. It is combined with Miri Series in one family due to the difficulty in some situations of establishing the type of parent material. The present arrangement ensures that the soil can be classified at family level even in such cases.

SILANTEK FAMILY

Silantek Series

Essentially equivalent to the Silantek Family of 1966. Locally important although rarely widespread.

Tunggal Series

A new introduction to cover profiles occurring in Balingian Subdistrict. It is uncertain whether the series is important in other areas.

Buso Series

Equivalent to the Buso Family in the 1966 system. Now grouped in the Silantek Family for the same reasons as those given above under Bako Series.

Banyut Series

A new introduction with profiles near Selalang in mind. Distribution elsewhere uncertain although possibly not uncommon.

Grang Series

A new introduction. Such profiles have only been recorded in the Selalang area to date but probably occur locally elsewhere.

Bakau Series

A new introduction covering some profiles in Third Division. Probably not uncommon elsewhere.

Metading Series

A new introduction covering profiles transitional between Buso and Tatau Series, commonly occurring on the Mukah-Balingian coast and possibly in other areas.

Daup Series

A new introduction covering those very weakly-developed podzol profiles which, when analytical data are available, many prove not to qualify as Spodosols in the USDA system.

TIKA FAMILY

The family was introduced in 1970 to cover coarse-textured profiles with no significant clay increase but which are residual on sedimentary rocks or developed in old non-accreting alluvium. By the definitions adopted there was no place for such soils in the 1966 system.

Tika Series

Locally important in the Balingian area and occasionally recorded elsewhere. Equivalent to the Tika Family of 1970.

Bintulu Series

Introduced mainly to cover 'giant podzols' where the spodic horizon is beyond both auger depth and the control section limits. Classification is thus on the albic material alone. Not allowed for in the 1966 system. Included in the Tika Family in case difficulties arise in identifying the alluvial origin on the parent material. Only known to be important near Bintulu.

SARATOK FAMILY

Equivalent to the central concept of the 1966 Saratok Family but now restricted to a much narrower texture range. The clay increase parameters are also waived.

Saratok Series

Equivalent to the 'type' Saratok Family in the previous system. A common series but normally in complex with other series.

Penipah Series

A new introduction covering profiles previously equated with Semadoh Family (not considered in this classification as yet). Noted near Sarikei. Importance elsewhere unknown.

Durin Series

A new introduction required by the texture-grouping rules established for the system. Few analysed profiles meet this definition but it is probably sporadically present in many localities.

BANDANG FAMILY

A new introduction covering soils which were defined within Saratok Family in 1966 but commonly classified with Kerait or Semadoh Families in subsequent practise.

Bandang Series

Noted near Selalang but probably not a common soil.

Timang Series

Like Bandang, very restricted in extent on present records.

KERAIT FAMILY

Established in the 1966 system and adopted here with similar limits. The clay increase limits have, however, been waived.

Kerait Series

A common soil, the series covers those profiles previously central to the concept of the Kerait Family.

Ajoh Series

A new introduction, covering soils locally important in the Sibu area and probably present in many other areas. In some cases these have been previously related to the Semadoh Family.

TRIBOH and LUBAI FAMILIES

These families were established in 1966 but with rather different definitions. The texture emphasis is now placed on the upper subsoil rather than on the material below the contrast point, as this seems more logical. These soils are mainly extensive in west Sarawak although their relative importance when reclassified by the present definitions have not been studied. Kenuyang Series is a new introduction covering certain profiles in the Sibu area.

PENINJAU FAMILY

Like Tika Family, these coarse-textured soils were not adequately accommodated in the 1966 system and were, in practise, included within the Nyalau Family. The Peninjau Family is therefore a new addition.

Peninjau Series

Provisionally established in Fourth Division in 1965 and locally present near Binatang in Third Division. Importance elsewhere uncertain.

NYALAU FAMILY

Equivalent to the 1966 Nyalau Family (with the inclusion of Sabangang Family. Although the texture limits are defined on very different basis from that used in 1966, the agreement in practise is very close. Clay increase parameters previously used have been waived. This is in accordance with the 1966 system as it has been applied in practise, although contrary to the definition given in that system.

Nyalau Series

Equivalent to the 1966 Nyalau Family. A widespread and important soil.

Sabangang Series

Equivalent to the 1966 Sabangang Family. Locally important near major rivers but rarely extensive.

BEKENU FAMILY

Equivalent to the 1966 Bekenu Family (but would now include fine silty soils developed in old alluvial material, if such are recorded). As with Nyalau Family, the texture range in the present classification is closely similar to that previously used.

Bekenu Series

Covers the yellower end of the colour range permitted within the family. Widespread and important.

Sarikei Series

A new addition, covering the redder profiles. Common in the Sarikei, Jakar and Pakan areas, and can be considered a medium-textured equivalent of Jakar Series, with which it is associated. Distribution elsewhere uncertain.

Tukau

A new addition. Yellow fine silty soils developed in old alluvial material have so far only been recorded in the Semilajau area of the Fourth Division.

MERIT FAMILY

Established in the 1966 system and, like Nyalau and Bekenu Families, essentially covering the same range of characteristics at family level in the present classification but now includes Lupar Family.

Merit Series

A widespread and important series; the clayey equivalent of Bekenu Series.

Jakar Series

A new addition equivalent to a clayey Sarikei Series. Common in the Sarikei and Jakar areas, in the Mukah-Balingian area and in parts of Fourth Division. In west Sarawak this series may be related to soils previously separated as Begunan Series.

Lupar Series

Separated as a Lupar Family in 1966. Equivalent to Merit Series but developed in old alluvial material. Only locally important.

KABULOH FAMILY

Considered in a separate Great Soil Group in the 1966 classification. Present appropriate status at higher levels uncertain. For the purposes of indentification discussed in relation to Merit Family, as all possible transitional types between soils over calcareous shales and those developed over noncalcareous shales occur. Parameters adopted for classification very tentative. Locally widespread in Fourth Division but so far not encountered elsewhere.

Kabuloh

The series has been redefined. It shows the most extreme features of soils associated with calcareous shale. Common in the Lambir-Subis area.

Karabungan

A new introduction, this series shows greater leaching and profile differentiation than Kabuloh Series, with which it is commonly in complex assiciation.

FAMILIES UNCLASSIFIED

Four series were distinguished in the Piring-Arip area of Third Division in association with acid igneous or metamorphic rocks. Series names have been given but family placement must await consideration of related soils in west Sarawak. Layang Changgan and Arip Series have characteristics linking them with the Abok Family of the 1966 system; Piring and Nyaroh Series may also be related to that family or to the Tarat Family. As soil variability over the rocks in the Arip-Piring area is quite great, other profile forms than those described under the four named series also occur and further series separation may be considered. No parameters are put to these series at present, therefore. They are described in the Key by what appear to be their typical characteristics on present information and full definition of them is left until more information on these and related soils is gathered.

MERIT-KAPIT Intergrades

Lalis Series

A new introduction, as is the general concept of named intergrades, which was not used in the 1966 system. A widespread series in dissected shale landscapes, associated with Kapit Series and/or shallow phases of Merit or Jakar Series.

MELUAN FAMILY

Defined as in the 1966 system. Not of great areal importance except on steep slopes overlying massive sandstones, or conglomerates. Much less widespread than Kapit Series.

SEDONG FAMILY

Included for completeness but, as so far studied, essentially a west Sarawak soil. Not present in those parts of central and north Sarawak so far surveyed although expected to occur where appropriate rock types are present. Defined as in the 1966 system.

KAPIT FAMILY

Established in the 1966 system and essentially follows the definition used at that time, but now includes Binatang and Kelupu Families.

Kelupu and Binatang Series

Considered as separate families in 1966; now demoted to series. The definitions are essentially unchanged. Recorded near Binatang but of very limited extent.

Kapit Series

A widespread series in dissected shale landscapes in all Divisions. Essentially equivalent to the Kapit Family of the 1966 system.

GAYA FAMILY

Established in the 1966 system and now defined more closely. Of limited extent wherever recorded.

IGAN FAMILY

Established in 1966. A 1m limit replaces the 40ins limit in the earlier system, but otherwise the definition is unchanged. A widespread family, particularly in coastal swamp situations.

MUKAH FAMILY

Established in 1966. Definition modified as for Igan Family above. A widespread family in the coastal zone and near major rivers farther inland. Division into series has not previously been made.

Mukah Series

The equivalent of the 1966 Mukah Family. It is suspected that many areas previously mapped as Mukah Family in coastal situations will, however, prove to be Patok Series on investigation of pH and conductivity.

Patok Series

Introduced to cover some profiles encountered in Third Division but expected to prove more widespread when detailed investigations are undertaken.

Mahat Series

Introduced to cover soils equivalent to Luk Series where the peat mantle is too thin to qualify for placement in the Anderson Family. Noted in the Rajang delta coastal area.

Epai Series

The 'clayey-muck' equivalent of Mukah Series, introduced to cover profiles examined in Fifth Division but expected to be sporadically common elsewhere, particularly in cultivated land.

Merapok Series

Introduced to cover soils equivalent to Limbang Series where the peat mantle is too thin to qualify for placement in the Anderson Family. Noted in Fifth Division.

ANDERSON FAMILY

With the exception of the depth limit change from 40ins to 1m this family remains as defined in 1966 but now includes soils previously classed as Limbang Family. An important family, occupying some 13 per cent of the State. Series divisions within the family were not previously made and are introduced here.

Anderson Series

The equivalent of the 1966 Anderson Family. Extremely widespread in the State.

Limbang Series

The equivalent of the 1966 Limbang Family, with more closely defined parameters. Noted in Fifth Division. Occurrence elsewhere uncertain.

Luk Series

A new introduction covering soils noted on the Rajang delta coast and sporadically occurring elsewhere.