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# ANNUAL REPORT 1986

**International Soil Reference and Information Centre**
**Wageningen - The Netherlands**

ISRIC was born out of an initiative of the International Society of Soil Science, and was adopted by Unesco as one of its activities in the field of earth sciences. It was formally founded on 1st January 1966 by the Government of The Netherlands, upon assignment by the General Conference of Unesco in 1964.

Most of the working founds are provided by the Dutch Ministry for Education and Sciences, and are accountable to the Directorate-General for International Cooperation (DGIS) of the Ministry of Foreign Affairs.

The constituent memebers of the Board of ISRIC are the International Institute for Aerospace Survey and Earth Sciences (ITC) in Enschede, the Wageningen Agricultural University (WAU) and the Directorate for Agricultural Research (DLO).

Advice on the programmes and activities of ISRIC is given by a Unesco-FAO appointed International Advisory Panel (IAP) and by a Netherlands Advisory Council (NAC)

The financial-administrative responsibility for the working funds and for the permanent staff of ISRIC rest formally with the Board of Governors of ITC.

Up to 31 December 1983 the name was International Soil Museum (ISM).

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ISRIC
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# 1 THE ORGANIZATION AND ITS DEVELOPMENTS

## 1.1 ORGANIZATION

The activities of ISRIC are organized in six complementing sections, two programmes, consulting and miscellaneous projects.

### SECTIONS

**Soil monolith collection**
This section deals with the building up to ISRIC's world collection of monoliths and encompasses all work from the selection and taking of the soil profile to the final monolith being placed in the exhibition room or reference store ("pedonarium"). Related is the National Soil Reference Collection Programme (NASREC) and the Collection of Reference Laterite Profiles (CORLAT).

**Laboratory**
Besides regular analytical work for the monolith collection, this section carries out a number of ad-hoc analyses, particularly for reference purposes. Related is the Laboratory Methods and Data Exchange Programme (LABEX).

**Micromorphology**
The work includes the preparation and description of the thin sections belonging to the soils of the collection. Like the laboratory, this section is involved in a number of other activities as well.

**Documentation**
This section deals with the development of ISRIC's Soil Information System (ISIS), the library, and the map collection.

**Soil classification correlation and mapping**
Activities in this section are mainly related to the development of a Revised Legend for the FAO/Unesco Soil Map of the World, to some International Committees for the improvement of the USDA Soil Taxonomy and to the establishment of a World Soils and Terrain Digital Database, at 1:1 million scale (SOTER project of ISSS).

**Transfer of knowledge**
This section deals with the Course on the Establishment and Use of National Soil Reference Collections, with receiving visitors, lecturing, and supplying written and oral information.

### PROGRAMMES

These are fixed term activities, for which extra funds have been secured.

**National Soil Reference Collection Programme (NASREC)**

This programme encompasses the building up of a number of national soil reference collections in Africa, South America and Asia.

**Laboratory Methods and Data Exchange Programme (LABEX)**

This is a soil sample exchange programme between about 100 laboratories.

Its aim is to improve the quality of soil analytical data by providing external references and standard procedures to the participants.

## CONSULTING

This embraces not only relatively short missions of ISRIC staff members, but also longer missions of specialized extra personnel.

## MISCELLANEOUS PROJECTS

These mostly concern ad-hoc activities.

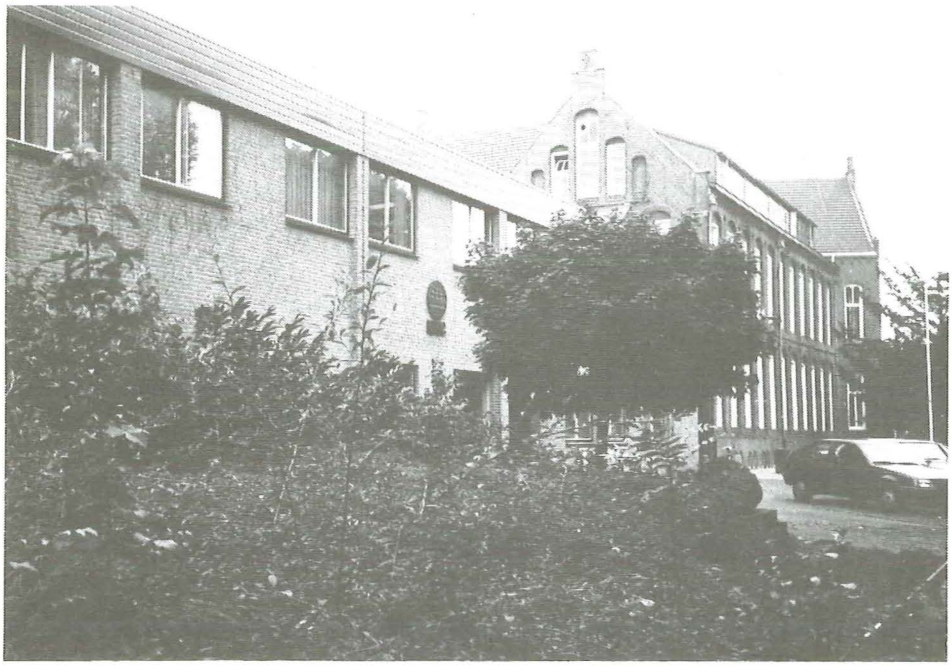
## 1.2 INSTITUTIONAL DEVELOPMENTS

ISRIC's collection of monoliths and sample material on the most important soils of the world, and of those of the tropics and subtropics in particular, is nearing the level at which it can be qualified as being comprehensive and representative. Much remains to be done on complete characterization of the specimen collection, and on improving the accessibility of the material for demonstration, educational and research purposes. The Centre's focus of attention is however gradually shifting to applications: comparison of whole groups of soils for improving classification criteria; developing international guidelines and standards for soil mapping, description and analysis; support for the establishment of national soil reference collections and soil information systems in developing countries, expansion of cartographic documentation and support for world soil geographic information systems using new computer facilities; assessment of the agricultural production potential of the world's soils and their ecological stability; climate-soil-vegetation interactions; etc.

This trend is already apparent from the increased attention to special-funding programmes such as LABEX, NASREC, and the ISSS-SOTER project initiated at the Centre. It has also resulted in a substantial increase in personnel: in addition to the formal core staff of 12 persons, there are now at the average 10 temporary staff members (project personnel, guest researchers, trainees, volonteers).

This is a very positive development, but together with the continuous increase in the amount of sample material, in apparatus and in documentation, it has resulted in a shortage of working space at the Centre's premises. Negotiations are therefore underway with the Wageningen Agricultural University to obtain additional space in an adjacent building.

Preparations to make ISRIC a separate Foundation with effective international representation on its Board of Management were nearing completion towards the end of the reporting year, and modalities of a formal management contract for financial and personnel administration with an appropriate major institution in the Netherlands are actively pursued.



ISRIC building

## REQUEST FOR MAPS AND REPORTS ON SOIL RESOURCES

Cartographic materials form an important part of ISRIC's documentation section. Geographic coverage of the collection is the whole world with emphasis on developing countries. The subject emphasis is on soils, but related geographic information on climate, ecology, vegetation, land use, land capability, geology, geomorphology, etc. is also of importance to the collection.

The acquisition policy is to obtain world coverage of maps at reconnaissance and smaller scale; examples of more detailed maps and index maps/lists of soil and related surveys carried out in a country. The selection criteria are relevance of the maps for soil science, agricultural development and environmental issues.

The major purpose of maintaining and enlarging the map collection at ISRIC is its use for the possible updating of the FAO-Unesco Soil Map of the World at scale 1:5 million and the compilation of a new, computerized world soil map at 1:1 million. The map collection serves also as a source of basic information for scientists and students using ISRIC's facilities for guest research or training.

**You are kindly requested to send maps and accompanying reports,**

of the types indicated above, either:
— directly to ISRIC, P.O.Box 353, 6700 AJ Wageningen, The Netherlands;
— through the Dutch Embassy or Consulate in your country;
— or through the Regional Offices of Unesco and FAO.

# 2 REVIEWS AND ARTICLES

## SOIL CLASSIFICATION AS USED IN BRAZILIAN SOIL SURVEYS

*M.N. Camargo, E. Klamt and J.H. Kauffman**

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### 1. INTRODUCTION

Brazilian soil science is in its infancy. In studies before 1947 soils were mainly classified in relation to parent material or geomorphological units. In 1947 a national soil science society and survey institution were founded. A programme of reconnaissance soil surveys of Brazil started with the survey of the state of Rio de Janeiro in 1954. At present the entire country has been mapped at the exploratory level, with about 20% at exploratory-reconnaissance level, plus 15% at reconnaissance level and a rather small percentage at more detailed levels.

The former USA soil classification system has been used for the soil map legend and the definition of soil classes (Baldwin et al., 1938; Thorp and Smith, 1949). The great group level was used to refer to the major soils of cartographic units, however, depending on soil variability and distribution patterns also higher or lower taxonomic classes were used.

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## 2. NATURE OF THE SYSTEM

From the inception of soil surveys in Brazil the concepts of soil classes, their distinction and definition, have been drawn up to serve primarily as units in soil-mapping legends. There has never been a formal soil classification system primarily developed for Brazil, but fragmentary outlines of soil classification elements encompassed in the description of mapping units have been published in various soil survey reports.

By and large, central concepts adopted from the former USA system (Baldwin et al., 1938; Thorp and Smith, 1949) constitute the basis of the soil classification in Brazil. Nevertheless, arising from the experience of soil surveys, changes in the original reference system have taken place. During the numerous soil surveys criteria have been modified, subdivisions created and intergrades recognized. Since the late 1950s, use has been made of principles from the approximations preceeding Soil Taxonomy (Soil Survey Staff, 1975).

The National Soil Survey and Conservation Service (SNLCS-EMBRAPA), successor of the original National Soils Commission, is at present coordinating the development of a new Brazilian system of soil classification. The existing scheme is undergoing thorough reformulation and a formally organized system is under development. Although a 2nd approximation of the system has been completed, it is unsuitable for publication, as it is only a working document. The system is designed to include all known soils of Brazil, but at the same time remaining an open system in which new classes may be incorporated. A multi-categorical and descending system is being developed, the basis of which is morphogenetic, since its organization is keyed to soil horizon characteristics which result from pedogenetic processes. For this purpose, morphological, physical, chemical and mineralogical properties are used.

At the present time an explicit arrangement is sought to serve as a provisional reference base. Such an interim classification is the scope of this paper.

## 3. DIAGNOSTIC HORIZONS AND DIAGNOSTIC PROPERTIES

Criteria currently applied to soil classification in Brazil by EMBRAPA-SNLCS largely conform with those commonly used by soil scientists in many other countries. They have been drawn from the 7th Approximation (Soil Survey Staff, 1960), from the legend of the Soil Map of the World (FAO-Unesco, 1974) and Soil Taxonomy (Soil Survey Staff, 1975).

Excerpts of the major features of the soil classification criteria contained in a monograph (Carvalho et al., 1986) are given in the following summary.

### 3.1 Diagnostic horizons

The relatively stable B-horizon was used as a distinctive criterion. An adherence to surface and subsurface diagnostic horizons occurred in the early 1960s, based on the 7th Approximation of the USA (Soil Survey Staff, 1960). However, some of the concepts used in the Brazilian scheme were modified and improved to suit local conditions. The diagnostic horizons currently used in Brazil are compared with the equivalent horizons of the FAO-Unesco Legend (1974) and Soil Taxonomy (Soil Survey Staff, 1975) in Table 1.

### 3.2 Diagnostic properties

Soil colour correlated with mineral components

In Latosols particularly, the colour of the B horizon was used as an important criterion to distinguish soil classes. At a regional scale colour is linked with other properties, such as iron oxides/hydroxides in the less than 2 mm fraction and the magnetic susceptibility of dry crushed material. It is also associated with behaviour pertaining to agricultural use, and related to soil climatic conditions. However, soil colour *per se* as a high level criterion has not been strongly favoured.

Table 1 - Comparison between diagnostic horizons of FAO, Soil Taxonomy and Brazilian system of soil classification and specific criteria used in Brazil-EMBRAPA-SNLCS

| Systems of classification | | | Specific or additional criteria used in Brazilian system - SNLCS |
|---|---|---|---|
| FAO | Soil Taxonomy | Brazilian-SNLCS | |
| - Surface Diagnostic Horizons - | | | |
| Mollic A | Mollic Epipedon | Chernozemic A | equivalent definitions |
| Umbric A | Umbric Epipedon | Prominent A | corresponds to a weakly developed umbric epipedon (thinner/and/or less organic carbon content) |
| --- | Anthropic Epipedon | Anthropic A | equivalent definitions |
| Ochric A (~weak ochric A) | Ochric Epipedon | Moderate A | corresponds to a well-developed ochric epipedon |
| Ochric A (~very weak ochric A) | --- | Weak A | surface horizon with <0.58% organic carbon, light colours with moist values >5 and without development of structure or weak structure; corresponds to a weakly developed ochric epipedon |
| --- | --- | Humic A | corresponds to a well developed umbric epipedon (thicker and/or higher organic carbon content) |
| - Subsurface diagnostic horizons - | | | |
| Argillic B | Argillic horizon | textural B | similar definitions, but textural gradient (ratio of average clay content of B horizon/ A horizon excluding BC) is: >1.5 if A horizon has >40% clay; >1.7 if A horizon has 15 to 40% clay; >1.8 if A horizon has <15% clay. When the B horizon has a blocky or prismatic structure with associated clay skins which exceed few and weak, the former textural gradient is not required |

Table 1 - (cont.)

| Systems of classification | | | Specific or additional criteria |
|---|---|---|---|
| FAO | Soil Taxonomy | Brazilian-SNLCS | used in Brazilian system - SNLCS |
| | - Surface Diagnostic Horizons - | | |
| Natric B | Natric horizon | Natric B | equivalent definitions |
| Spodic B | Spodic horizon | Spodic B | equivalent definitions |
| Cambic B | Cambic horizon | Incipient B | similar definitions, but a) to distinguish from latosolic B, it should meet one or more of the following requirements: the 0.05-2 mm fraction contains $\geq$4% weatherable minerals on basis of total fraction $<$2 mm; CEC of clay $\geq$13 meq/100 g after correction for organic carbon; or silt/clay ratio 0.7; Ki index ($SiO_2/Al_2O_3$ molar ratio) $\geq$2.2; or $\geq$5% by volume of rock fragments or saprolite; and b) excluding characteristics from reduction processes and from plinthitization, respectively referred to gley horizon and plinthic horizon |
| Oxic B | Oxic horizon | Latosolic B | similar definitions, but exclusive of A or AB horizons, and a) meeting all of the following requirements: thickness $\geq$50 cm; CEC after deduction of the contribution of organic carbon $<$13 meq/100 g of clay; Ki index $\leq$2.2; silt/clay ratio $<$0.7; if present in the 0.05-2 mm fraction, $<$4% weatherable minerals on basis of total fraction $<$2 mm; $<$5% by volume of rock fragments or saprolite; strong very fine granular to moderate subangular blocky structure; b) always with clay gradient in the solum insufficient for textural B; and c) additional exclusion of characteristics from reduction processes and from plinthitization, respectively referred to gley horizon and plinthic horizon |

Table 1 - (cont.)

| Systems of classification | | | Specific or additional criteria |
|---|---|---|---|
| FAO | Soil Taxonomy | Brazilian-SNLCS | used in Brazilian system - SNLCS |
| | | - Surface Diagnostic Horizons - | |
| --- | --- | Plinthic horizon | horizon at least 15 cm thick and containing ≥15% by volume of plinthite, as defined in Soil Taxonomy |
| Calcic horizon | Calcic horizon | Calcic horizon | equivalent definitions |
| --- | Petrocalcic horizon | Petrocalcic horizon | equivalent definitions |
| Sulfuric horizon | Sulfuric horizon | Sulfuric horizon | equivalent definitions |
| --- | Fragipan | Fragipan | equivalent definitions |
| --- | Duripan | Duripan | equivalent definitions |
| | | - Surface or Subsurface Diagnostic Horizons - | |
| Histic A | Histic epipedon | Turfose A | equivalent definitions |
| Albic E | Albic horizon | Albic E horizon | equivalent definitions |
| --- | --- | Gley horizon | hydromorphic properties pro parte as described in the FAO system: 1) dominant neutral (N) hues or bluer than 10Y; and/or 2) saturation of water at some period of the year, or artificially drained, with evidence of reduction processes, or of reduction and segregation of iron reflected by ≥20% of mottles of chromas of ≤2, otherwise if not mottled, the value being >4, the chroma is >1 and if the value is ≥4, chroma ≤1 |
| --- | Salic horizon | Salic horizon | equivalent definitions |

## Activity of Clay

This is expressed by the cation exchange capacity (CEC) as determined at pH 7.0, and referred to the fraction less than 0.002 mm and reported as meq per 100 g of clay. It is considered after subtraction of the contribution to the CEC by organic carbon. As a distinctive criterion it applies to the B horizon, or the C for AC soils, or the A horizon in the case of AR soils.

The following equation can be used:

$$\text{CEC (100 g clay)} = \left(\text{CEC (100 g soil)} - (4.5 \times \%\text{C})\right) \times 100 \; \% \text{ of clay}$$

For more precise procedure and especially for Latosols, the graphic method proposed by Bennema (1966) should be used. Two main classes of activity of clay are used:

High activity - soils with CEC $\geq$24 meq/100 g clay, and

Low activity - soils with CEC $<$24 meq/100 g clay.

Further subdivisions of importance, particularly concerning the Latosols, are indicated by CEC 13 meq, as a requisite for all Latosols, and CEC $\leq$6.5 to separate the mature typical Latosols. A comparison of parameters concerning the CEC used in Brazil with those of Soil Taxonomy (Soil Survey Staff, 1975) is presented in Table 2, according to the correlation developed by Olmos & Paolinelli (1982).

Table 2 - Relationship of CEC limits used in the Brazilian system with those of Soil Taxonomy

| Brazilian* | CEC values meq/100 g of clay | | | Soil Taxonomy** |
|---|---|---|---|---|
| | Brazilian° | | Soil Taxonomy°° | |
| | - Org. C | + Org. C | + Org. C | |
| High activity/low activity clay | 24 | 27 | 42 | -- |
| Upper limit latosolic B horizon | 13 | 16 | 24 | upper limit oxic subgroups |
| Upper limit latosolic B horizon of highly weathered kind | 6.5 | 10 | 16 | upper limit oxic horizon |

*Distinction intended by the Brazilian system
°CEC values determined according to SNLCS method (pH 7.0)
°°CEC values determined according to Soil Taxonomy method (pH 7.0)
**Distinction intended by the Soil Taxonomy system
- Org. C = Organic Carbon contribution is subtracted from CEC values
+ Org. C = CEC values are not corrected for organic carbon

Silica/Alumina Molar Ratio

The molar ratio $SiO_2/Al_2O_3$ of the clay fraction is used as an index expressing the degree of weathering. In the tables it is referred to as the Ki index.

High Al saturation (Allic)

The term "Allic" is used to define soil classes with Al saturation $\geq 50\%$ and a minimum of 0.3 meq of extractable Al[1] in the B horizon when present, in the C horizon for AC soils, or in the A horizon for AR soils.

The formula 100.Al/S+Al[1] is used to calculate it.

"Epiallic" designates the presence of allic character in the upper solum.

Base saturation (V)

The same definition is used as in Soil Taxonomy and for the FAO-Unesco Soil Map of the World. Eutrophic refers to a base saturation $\geq 50\%$, and dystrophic $<50\%$ according to CEC at pH 7.0 in the B horizon when present, in the C horizon for AC soils, or in the A horizon for AR soils.

Sodic

Same ESP[2] specifications are used as those required for Natric horizon in Soil Taxonomy and the FAO-Unesco Soil Map of the World.

Solodic

Refers to ESP $\geq 6$ and $<15\%$ in the B horizon when present, or in the C horizon for AC soils.

Saline

Refers to the presence of soluble salts, expressed by an ECs[3] 4mS, according to USDA Agricultural Handbook 60 (Richards, 1954).

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1) 1N KCl extractable acidity, in most soils corresponding virtually to A, being expressed as meq of Al/100 g of soil. Details about analytical methods used by the SNLCS are given in Appendix II
2) ESP = Exchangeable Sodium Percentage
3) ECs = electrical conductivity of the saturation extract

Carbonatic

Refers to presence of 15% or more $CaCO_3$, but without a Calcic horizon.

Abrupt textural change (Abruptic)

"Abruptic" denotes a marked increase in clay content from A or E to B horizon, as established in Soil Taxonomy and the FAO-Unesco Soil Map of the World.

Major textural class

This refers to the main denomination of texture in the B horizon or the C for AC soils, or the A for AR soils, as established in Soil Taxonomy viz. very fine clayey $\geq$60% clay; clayey 35-60; medium < 35% clay and >15% sand and exclusive of loamy sand and sand classes; silty <15% sand and < 35% clay; sandy comprising the classes loamy sand and sand. Outstanding textural changes from the upper solum to the B horizon stand as a binomial textural criterion.

Other diagnostic properties

Gilgai, slickensides, clay skins, (para)lithic contact, durinodes, plinthite, sulfidic materials and weatherable minerals, all as defined in Soil Taxonomy or the FAO-Unesco Soil Map of the World, are also used as diagnostic properties. In addition: petroplinthite; the silica/aluminium molecular ratio of the clay fraction; mottling or matrix of reduction colors, i.e. very low chromas or hues bluer than 10Y.

Intergrades

This term refers to the inherent gradation of soil character as between the classes in higher taxonomic categories. Recognized intergrades are: litholic - merging with Litholic soils; cambic - merging with Cambisols; latosolic - merging with Latosols; podzolic - merging with Red Yellow Podzolics; planosolic - merging with Planosols; vertic - with Vertisols; gleyic - with Gleysols; plinthic - with Plinthosols (primary kinds); petroplinthic - merging with concretionary kinds of Plinthosols.

Phases

Most soil surveys in Brazil are medium to small scale reconnaissance surveys or of an exploratory nature. In these circumstances, the appropriate taxonomic soil classes characterizing soil mapping units are rather above the series category, implying a higher abstraction level and a wider taxonomic grouping.

Despite the general nature of these surveys, phases of relief, substratum (for shallow semi-developed soils), primary natural vegetation, stoniness and rockiness have been used as criteria to distinguish mapping units. This has been done in order to provide additional information of interest to soil survey interpretations, especially for agricultual purposes. Criteria currently selected refer to soil and land conditions influencing land use, or which are indicative of pedo-climatic conditions.

Complementary information concerning vegetation phases are found in Appendix 1.

## 4. SOIL CLASSES AND THEIR DEFINITIONS

Although the system of classification for Brazilian soils has been applied to distinguish and define soil classes, as components of mapping units, thus being implied in the various soil survey reports, there is no special account which deals with the classification itself. Table 3 has been prepared to show in a simplified version the system as it is used by EMBRAPA-SNLCS.

The following publications given in the bibliography form the basis of Table 3: the legend of the 1:5.000.000 scale soil map of Brazil (EMBRAPA-SNLCS, 1981), Bennema & Camargo (1964), Bennema (1966), the proceedings of the 1st Reunião de Classificação de Solos (1979), and Olmos (1981). Other publications used are listed in the bibliography, viz. numbers 2, 5, 11, 12, 13, 14 and 25.

The diagnostic properties for further subdivision of classes at lower levels are given. The system is open ended, and at lower levels incomplete. No formal structure has been established, and no formulated lower class definitions are given.

Some examples are given of how these diagnostic properties are used at lower levels to distinguish soil classes and the phases which are added to characterize mapping units in soil surveys.

Example 1: A soil having a thick, dark organic carbon rich acid surface horizon, followed by a latosolic B horizon, low in iron content and orange colour, with ≥50% aluminium saturation in the subsurface diagnostic horizon, clayey texture, vegetation of tropical humid forest, and found on moderately sloping topography, would be classified as:
Humic-Red Yellow Latosol Allic, clayey; evergreen tropical forest, rolling relief phase.

Example 2: A soil with a not very distinct A horizon, followed by a textural B horizon, with or without an intervening E horizon, with grayish brown colours, ≥50% base saturation, cation exchange capacity after correction for organic carbon ≥24 meq per 100 g of clay, abrupt textural change, medium texture in the A and clayey in the B horizon, vegetation of partially deciduous subtropical forest and slightly sloping topography, would be classified as:
Gray-Brown Podzolic Eutrophic, high clay activity, abruptic moderate A horizon, medium/clayey; semideciduous subtropical forest, gently undulating relief phase.

Example 3: A soil having a thick dark organic carbon rich slight acid to neutral A horizon, friable, clayey texture overlaying soft caliche, and occurring under subxerophytic shrubs and low trees on slightly sloping topography is classified as:
Rendzina, clayey; hipoxerophilous thorn scrub, gently undulating relief phase.

In this particular case, since the type of surface diagnostic horizon (chernozemic A), the high base saturation and high activity of clay are properties implicit in the definition of the soil class, they are unsuited for further subdivisions of classes in lower categorical levels.

Example 4: A soil with a not very distinct A horizon, followed by a textural B of rather bright yellow colours, with <50% base satuation, and <50% Aluminium saturation, with only a moderate clay increase from the A to B horizon, with a low weatherable mineral content (but with a somewhat higher weatherable mineral content found in isolated rotten rock remains), cation exchange capacity after correction for organic carbon < 24 meq per 100 g of clay, loamy texture in the A and B horizons, vegetation of permanently humid subtropical forest on rather sloping topography, is classified as:
Red Yellow Podzolic Dystrophic Cambic, low clay activity, moderate A horizon, loamy; perudic subtropical forest, hilly relief phase.

Table 3 - Synopsis of high level soil classes established at present and diagnostic properties used for subdivision of classes in lower categorical levels

| | Soil classes of high level | Diagnostic properties for further subdivision of classes |
|---|---|---|
| 1. | Mineral soils, non hydromorphic, with latosolic B horizon following any diagnostic A horizon except turfose (histic). Subdivisions according to type of latosolic B: | - Humic A character for humic Latosol, or presence of high amounts of organic carbon with a light soil colour characteristic for cryptohumic Latosols |
| 1.1 | Dusky red to dark reddish brown colours related to very high content of $Fe_2O_3$ (≥36%)*, very strong magnetic attraction, Ki index (silica/alumina molar ratio) 0.06-0.9<br>LATOSSOLO FERRÍFERO<br>(Ferriferous Latosol) | - Base or Al saturation (eutrophic, dystrophic, allic)<br>- Presence of lateritic concretions, thin solum (concretionary, shallow) |
| 1.2 | Dusky red to dark reddish brown colours related to high content of $Fe_2O_3$ (18-40%)*, strong magnetic attraction, Ki index 0.20-2.0<br>LATOSSOLO ROXO<br>(Dusky Red Latosol) | - Intergradational properties (podzolic, cambic, plinthic), intergrade with Quartzose Sands and intergrades with other kinds of Latosols<br>- Types of A horizon (prominent, moderate ...)<br>- Textural class |
| 1.3 | Dark red to dark reddish brown colours related to medium content of $Fe_2O_3$ (8-18%)*, weak magnetic attraction, Ki index 0.20-2.2<br>LATOSSOLO VERMELHO-ESCURO<br>(Dark Red Latosol) | - Phases of vegetation and relief |
| 1.4 | Red, yellowish red to strong brown colours related to low content of $Fe_2O_3$ (7-11%)*, virtually no magnetic attraction, Ki index mostly <1.5<br>LATOSSOLO VERMELHO-AMARELO<br>(Red-Yellow Latosol) | |

* Applied to clay content ≥35% (clayey texture). For loamy soils, values of the $Al_2O_3/Fe_2O_3$ molar ratio is used as distinctive criterion, e.g. 3.14 is upper limit for Dark Red Latosols.

Table 3 - (cont.)

| Soil classes of high level | Diagnostic properties for further subdivision of classes |
|---|---|
| 1.5 Brown, strong brown, yellowish brown to olive brown colours related to very low content of $Fe_2O_3$ (<7%)*, no magnetic attraction, Ki index 1.5-2.2<br>LATOSSOLO AMARELO<br>(Yellow Latosol) | |
| 1.6 Dark brown to reddish brown colours related to medium to high content of $Fe_2O_3$ (>11%)*, virtually no magnetic attraction, Ki index 0.2-2.0<br>LATOSSOLO VARIAÇÃO UNA<br>(Latosol "Una" Variant) | |
| 1.7 Dark brown to dark yellowish brown colours reddening downward related to medium to high content of $Fe_2O_3$ (>11%)*, virtually no magnetic attraction, Ki index 0.2-2.2<br>LATOSSOLO BRUNO<br>(Brown Latosol) | |

* Applied to clay content ⩾35% (clayey texture). For loamy soils, values of the $Al_2O_3/Fe_2O_3$ molecular ratio is used as distinctive criterion, e.g. 3.14 is upper limit for Dark Red Latosols.

Table 3 - (cont.)

| Soil classes of high level | | Diagnostic properties for further subdivision of classes |
|---|---|---|
| 2. | Mineral soils, non hydromorphic, clayey, with textural B horizon following any diagnostic A horizon except turfose (histic), low activity clay, only small clay increase A to B horizon, which has moderate to strong blocky or composite prismatic structure, with associated clay skins that are at least common and moderately developed, red or brown colours related to medium to high content of $Fe_2O_3$. Subdivisions according to type of B horizon: | - Base or Al saturation<br>- Intergradational properties (latosolic, intergrade with Reddish Brunizem)<br>- Type of A horizon: moderate, prominent or humic<br>- Phases of vegetation and relief |
| 2.1 | Dark reddish brown, dusky red, reddish brown, dark red to red colours, rather high content of $Fe_2O_3$ ($\geq$15%) and $TiO_2 \geq 1.50$, weak to no magnetic attraction, Ki index 0.90-2.30<br>TERRA ROXA ESTRUTURADA<br>(Structured Dusky Red Earth) | |
| 2.2 | Brown, dark brown, strong brown, reddish brown to yellowish red colours, medium to high content of $Fe_2O_3$ (>10%), no magnetic attraction, Ki index 1.70-2.10<br>TERRA BRUNA ESTRUTURADA<br>(Structured Brown Earth) | |

Table 3 - (cont.)

| Soil classes of high level | Diagnostic properties for further subdivision of classes |
|---|---|
| 3. Mineral soils, non hydromorphic, with non plinthic textural B horizon following any diagnostic E or A horizon except Turfose (histic), with small to large clay increase from A to B horizon and lacking the distinctive features of Planosols. Subdivisions according to B horizon: | - High activity clay or low activity clay if applicable<br>- Base or Al saturation<br>- Presence of fragipan, abrupt textural change, thin solum (fragic, abruptic, shallow) |
| 3.1 Red to dark reddish brown colours coupled to content of $Fe_2O_3 \leq 15\%$ and $TiO_2 \leq 1.70$, often low activity clay<br>PODZÓLICO VERMELHO-ESCURO<br>(Dark Red Podzolic) | - Intergradational properties (latosolic, cambic, plinthic, intergrade with Reddish Brunizem) |
| 3.2 Red, yellowish red to strong brown colours, content of $Fe_2O_3 \leq 11\%$<br>PODZÓLICO VERMELHO-AMARELO<br>(Red-Yellow Podzolic) | - Type of A horizon, excluding the combinations: high base saturation ($\geq 50\%$) + high activity clay + either chernozemic or weak A horizon (cf. 5.2 and 7); high Al saturation + high activity clay + humic A horizon (cf. 6) |
| 3.3 Dark brown to dark yellowish brown upper B horizon often over a lower B horizon with yellowish brown or reddish brown mottling<br>PODZÓLICO BRUNO-ACINZENTADO<br>(Gray-Brown Podzolic) | - Textural class<br>- Phases of vegetation and relief |
| 3.4 Brown, strong brown, yellowish brown to olive brown colours related to very low content of $Fe_2O_3$ ($<7\%$), rather low activity clay (CEC $<13$ meq and Ki index, $\leq 2.2$), low base saturation<br>PODZÓLICO AMARELO<br>(Yellow Podzolic) | |

Table 3 - (cont.)

| Soil classes of high level | | Diagnostic properties for further subdivision of classes |
|---|---|---|
| 4. | Mineral soils with a spodic B horizon following any diagnostic E or A horizon | - Base or Al saturation<br>- Presence of fragipan, very thick A + E (albic) horizon, presence of ortstein (fragic, giant, with ortstein)<br>- Intergradational properties (intergrade with Quartzose Marine Sands)<br>- Type of A horizon<br>- Textural class<br>- Phase of vegetation and relief |
| 4.1 | Non hydromorphic<br>PODZOL | |
| 4.2 | Hydromorphic<br>PODZOL HIDROMÓRFICO<br>(Hydromorphic Podzol) | |
| 5. | Mineral soils, non hydromorphic, with incipient or textural B horizon, following a chernozemic A horizon, high activity clay, rather high base saturation, lacking the distinctive features of Planosols | - Presence of calcic, or k horizon in Brunizems, calcium carbonate remains in Reddish Brunizems and Brunizems, abrupt textural change, thin solum (calcic, carbonatic, abruptic, shallow)<br>- Intergradational properties (vertic, planosolic, litholic, intergrade Reddish Brunizem with Terra Roxa Estruturada)<br>- Textural class<br>- Phases of vegetation and relief |
| 5.1 | Presence of a neat distinct chernozemic A together with incipient B or dull colour textural B horizon<br>BRUNIZEM | |
| 5.2 | Modest chernozemic A together with moderate coloured, mostly reddish tinted, textural B horizon<br>BRUNIZEM AVERMELHADO<br>(Reddish Brunizem) | |
| 6. | Mineral soils, non hydromorphic, clayey, with a textural B horizon below a humic A, high activity clay, for the most part reddish colour, moderate to strong prismatic or blocky structure, extremely high Al saturation<br>RUBROZEM | - Intergradational properties (cambic, intergrade with Humic Gley)<br>- Textural class<br>- Phases of vegetation and relief |

Table 3 - (cont.)

| Soil classes of high level | | Diagnostic properties for further subdivision of classes |
|---|---|---|
| 7. | Mineral soils, non hydromorphic with a reddish coloured textural B horizon, strongly contrasting with a usually massive and hard weak and seldom moderate A horizon, high base saturation and relatively high activity clay<br>BRUNO NÃO CÁLCICO<br>(Non Calcic Brown) | - Presence of calcium carbonate remains, slight sodium saturation, abrupt textural change (carbonatic, solodic, abruptic)<br>- Intergradational properties (litholic, planosolic, vertic), intergrade with Reddish Brunizem, intergrade with Red-Yellow Podzolic<br>- Weak or moderate A horizon<br>- Textural class<br>- Phases of vegetation and relief |
| 8. | Mineral soils with a textural B horizon, abrupt textural change, and sharp horizon transition, eventually developing when dry a crack between the E or A and the underlying B, which is usually mottled with dull colours<br>PLANOSSOLO<br>(Planosol) | - Activity of clay<br>- Base or Al saturation<br>- Presence of fragipan, calcic or k horizon, calcium carbonate remains, slight sodium saturation (fragic, calcic, carbonatic, solodic)<br>- Intergradational properties (vertic, gleyic, plinthic, intergrade with Brunizem)<br>- Type of A horizon<br>- Textural class<br>- Phases of vegetation and relief |
| 9. | Mineral soils with a natric B horizon below any diagnostic E, or moderate or weak A horizon, well contrasting with the natric B usually with faded colours<br>SOLONETZ-SOLODIZADO<br>(Solodized Solonetz) | - Activity of clay<br>- Base saturation<br>- Presence of fragipan, duripan, abrupt textural change, calcium carbonate remains (fragic, duric, abruptic, carbonatic)<br>- Intergradational properties (vertic, plinthic, intergrade with Solonchak)<br>- Weak or moderate A horizon<br>- Textural class<br>- Phases of vegetation and relief |

Table 3 - (cont.)

| Soil classes of high level | Diagnostic properties for further subdivision of classes |
|---|---|
| 10. Mineral soils mostly hydromorphic either with a salic horizon, or saline C horizon (Cgz or Cz) following the A horizon | - High E.S.P. $\geq$15% (sodic)<br>- Weak, moderate A horizon<br>- Phases of vegetation and relief if applicable |
| 10.1 Developed on terrestrial or semiterrestrial landscapes<br>SOLONCHAK | |
| 10.2 Developed on semi-aquatic landscapes<br>SOLOS SALINOS COSTEIROS INDISCRIMINADOS<br>(Undifferentiated Coastal Saline Soils - usually mangrove land) | |
| 11. Mineral soils usually non hydromorphic, with an incipient B horizon, lacking expressive evidences of gleyzation, non plinthic, following any diagnostic A horizon except turfose (histic)<br>CAMBISSOLO<br>(Cambisol) | - Activity of clay<br>- Base or Al saturation<br>- Presence of calcium carbonate remains, thin solum, over-thick A (carbonatic, shallow, humic)<br>- Intergradational properties (latosolic, gleyic, podzolic, litholic, vertic, plinthic)<br>- Type of A horizon, excluding turfose (histic) and the combination: high base saturation ($\geq$50%) + high activity clay + chernozemic A horizon (cf. 5.1)<br>- Textural class<br>- Phases of vegetation, substratum and relief |
| 12. Mineral soils with a plinthic horizon, superimposed or not on a textural B, following any E or A diagnostic horizon except turfose (histic) | - Activity of clay<br>- Base or Al saturation |

Table 3 - (cont.)

| Soil classes of high level | Diagnostic properties for further subdivision of classes |
|---|---|
| 12.1 Lacking or with only rare concretions and nodules from hardening of plinthite (petroplinthite)<br>PLINTOSSOLO<br>(Plinthosol comprises Groundwater Laterite pro-parte and some related soils) | - Abrupt textural change, slight sodium saturation (abruptic, solodic), besides as yet unestablished subdivision according to presence of albic diagnostic horizon<br>- Drainage class<br>- Type of A horizon except turfose (histic) |
| 12.2 Presence of 15% or more by volume of petroplinthite<br>PLINTOSSOLO PÉTRICO<br>(Petroplinthosols) | - Textural class<br>- Phases of vegetation and relief |
| 13. Hydromorphic mineral soils with a gley horizon, superimposed or not on a textural B, in sequence to any A diagnostic horizon except weak, with or without an intervening E horizon | - Activity of clay<br>- Base or Al saturation |
| 13.1 Presence of a gleyic yet textural B horizon preceded or not by an E horizon but anyway lacking an abrupt textural change<br>HIDROMÓRFICO CINZENTO<br>(Gray Hydromorphic Soils) | - Presence of calcium carbonate remains, fragipan, slight sodium saturation (carbonatic, fragic, solodic)<br>- Intergradational properties (vertic, cambic) |
| 13.2 Presence of turfose (histic), humic or prominent diagnostic A horizon followed by a non textural B gley horizon and lacking sulfidic materials or a sulfuric horizon<br>GLEI HÚMICO<br>(Humic Gley) | - Type of A horizon if applicable<br>- Textural class<br>- Phases of vegetation and relief |
| 13.3 As above but with a moderate diagnostic A horizon<br>GLEI POUCO HÚMICO<br>(Low Humic Gley) | |
| 13.4 Presence of sulfidic materials or sulfuric horizon<br>GLEI TIOMÓRFICO<br>(Thiomorphic Gley) | |

Table 3 - (cont.)

| Soil classes of high level | | Diagnostic properties for further subdivision of classes |
|---|---|---|
| 14. | Mineral soils with 30% or more clay, ill-defined horizonation (AC profiles), relatively high activity clay, having marked changes in volume with moisture variation, as shown by cracks at some period in most years, by intersecting slickensides and eventually wedge-shaped structural aggregates, or gilgai microrelief<br>VERTISSOLO<br>(Vertisol) | - Base saturation<br>- Presence of calcic or Ck horizon, calcium carbonate remains, Cy horizon, thin soil, slight sodium saturation (calcic, carbonatic, gypsic, shallow, solodic)<br>- Intergradational properties (planosolic)<br>- Type of A horizon: weak, moderate, chernozemic<br>- Phases of vegetation and relief |
| 15. | Weakly developed mineral soils, exclusive of Vertisols, without subsurface diagnostic horizon. | |
| 15.1 | Non hydromorphic, having AC profile with chernozemic A horizon, formed on calcareous material<br>RENDZINA | - Textural class, phases of vegetation and relief |
| 15.2 | Non hydromorphic, shallow to hard bedrock (excluding petroplinthite), having AR profile with or without a thin intervening C horizon<br>SOLOS LITÓLICOS<br>(Litholic Soils) | - Activity of clay, base or Al saturation, type of A horizon, presence of calcic or Ck horizon and calcium carbonate remains (calcic, carbonatic), textural class, phases of vegetation, substratum and relief |
| 15.3 | Non hydromorphic, having AC profile, formed on saprolite, pedisediment or other reworked materials carrying weatherable minerals<br>REGOSSOLO<br>(Regosol) | - Base or Al saturation, presence of fragipan (fragic), intergradational properties (cambic), type of A horizon except turfose (histic), textural class and phases of vegetation and relief |

Table 3 - (cont.)

| Soil classes of high level | Diagnostic properties for further subdivision of classes |
| --- | --- |
| 15.4 Hydromorphic or not, having AC profile, formed on quartzose sands<br>AREIAS QUARTZOSAS<br>(Quartzose Sands) | - Base or Al saturation, presence of fragipan (fragic), intergradational properties (latosolic, podzolic, intergrade with Podzol) type of A horizon and phases of vegetation and relief |
| 15.5 Mostly non hydromorphic, having AC profile, formed on recent fluvial or lacustrine layered deposits<br>SOLOS ALUVIAIS<br>(Alluvial Soils) | - Activity of clay, evidences of hydromorphism (hydromorphic), base or Al saturation, remains of calcium carbonate, slight sodium saturation (carbonatic, solodic), intergradational properties (cambic, vertic, gleyic), type of A horizon except turfose (histic), textural class and phases of vegetation and relief |
| 16. Hydromorphic soils consisting of organic materials | |
| 16.1 Lacking sulfidic materials or sulfuric horizon<br>SOLOS ORGÂNICOS NÃO TIOMÓRFICOS<br>(Non-Thiomorphic Organic Soils) | - Base or Al saturation<br>- Slight sodium saturation (solodic) |
| 16.2 Presence of sulfidic materials or sulfuric horizon<br>SOLOS ORGÂNICOS TIOMÓRFICOS<br>(Thiomorphic Organic Soils) | - Phases of vegetation and relief |

## 5. CORRELATION BETWEEN SOIL CLASSES OF BRAZILIAN-SNLCS, FAO AND SOIL TAXONOMY SYSTEMS

A correlation between Brazilian, FAO and Soil Taxonomy soil classification systems has been made, based on about 470 soil profiles described and classified in Brazilian soil survey reports.

In Table 4A results are presented for the first taxonomic level. In Table 4B results are presented for the subclasses of Latosols, as specified in Table 3. The number of actual profiles referred to each FAO unit of second taxonomic level and to each great soil group of Soil Taxonomy varies from two to about twenty.

A reasonable comparison can only be attained for the first taxonomic level (Table 4A). For instance, most of the Latosols of the Brazilian system fit into the Ferralsol unit of FAO World Soil Map legend and into the Oxisol order of Soil Taxonomy.

Comparison on the second taxonomic level is already difficult and confusing (Table 4B). A wide scattering prevails when the Brazilian subclasses of Latosols were correlated to the second level of FAO and to suborder and great groups of Soil Taxonomy. A similar scattering prevails for other classes, including Red-Yellow Podzolic, Terra Roxa Estruturada, Reddish Brunizem and Litholic soils.

This scattering is inevitable as different criteria are used for subdivision on the second or lower levels. For example, colour coupled to iron oxide content is used in the Brazilian system for the Latosols, while presence of plinthite, an umbric A horizon, low CEC and colour are used for Ferralsols in the FAO system. On the other hand, for Oxisols in Soil Taxonomy the moisture regime at the second level and the presence of gibbsite or plinthite, umbric or ochric epipedon, sombric horizon, base saturation and CEC at the third level are used.

Table 4A - Tentative correlation between high level soil classes of the Brazilian system with FAO (FAO-Unesco, 1974) and with Soil Taxonomy (Soil Survey Staff, 1975)°

| Brazilian system-SNLCS | FAO World Soil Map legend | Soil Taxonomy |
|---|---|---|
| 1. Latossolos (Latosols) | Ferralsols pp°°, *Cambisols pp | Oxisols pp°°, *Inceptisols pp |
| 2. Solos Podzólicos (Podzolic Soils) | Acrisols pp, Luvisols pp, Nitosols pp, *Phaeozems pp, *Planosols pp | Ultisols pp, Alfisols pp, *Mollisols pp |
| 3. Terra Roxa Estruturada and Terra Bruna Estruturada (Structured Dusky Red and Brown Earths) | Nitosols pp, *Phaeozems pp | Alfisols pp, Ultisols pp, *Mollisols pp |
| 4. Podzols | Podzols | Spodosols, Entisols pp |
| 5. Brunizems | Phaeozems pp, Chernozems | Mollisols pp |
| 6. Rubrozems | Acrisols pp, Nitosols pp | Ultisols pp |
| 7. Solos Brunos Não Cálcicos (Non-Calcic Brown Soils) | Xerosols, *Planosols pp | Aridisols pp, Alfisols pp |
| 8. Planossolos (Planosols) | Planosols pp, Xerosols pp, *Phaeozems pp | Alfisols pp, Ultisols pp, *Mollisols pp, *Aridisols pp, *Vertisols pp |
| 9 Solonetz-Solodizado (Solodized Solonetz) | Solonetz, *Planosols pp | Alfisols pp, Aridisols pp |
| 10. Solos Salinos (Saline Soils) | Solonchaks, *Fluvisols pp | Aridisols pp, Entisols pp |
| 11. Cambissolos (Cambisol) | Cambisols pp, *Gleysols pp, *Ferralsols pp | Inceptisols pp, *Mollisols pp, *Oxisols pp |

°Correspondence should only be sought from the Brazilian to FAO or from the Brazilian to Soil Taxonomy systems. No specific correlation between FAO and S.T. systems and vice-versa is intended.
°°pp = pro-parte
*to a minor extent

Table 4A - (cont.)

| Brazilian system-SNLCS | FAO World Soil Map legend | Soil Taxonomy |
|---|---|---|
| 12. Plintossolos (Plinthosols) | Acrisols pp[°°], Arenosols pp, Ferralsols pp, Gleysols pp, Planosols pp, *Luvisols pp | Ultisols pp, Oxisols pp, Inceptisols pp, Entisols pp, *Alfisols pp |
| 13. Gleissolos (Gleysols) | Gleysols pp, *Fluvisols pp | Inceptisols pp, Ultisols pp, *Mollisols pp, *Alfisols pp, *Entisols pp |
| 14. Vertissolos (Vertisols) | Vertisols | Vertisols pp |
| 15.1 Rendzinas | Rendzinas | Mollisols pp |
| 15.2 Solos Litolicos (Litholic Soils) | Lithosols, Rankers, Cambisols pp, Regosols pp, Phaeozems pp, *Histosols pp | Entisols pp, Inceptisols pp, *Mollisols pp, *Histosols pp |
| 15.3 Regossolos (Regosols) | Regosols pp, Arenosols pp, *Planosols pp, *Phaeozems pp | Inceptisols pp, Entisols pp, Aridisols pp, *Mollisols pp |
| 15.4 Areias Quartzosas (Quartzose Sands) | Arenosols pp, *Gleysols pp | Entisols pp, Inceptisols pp |
| 15.5 Solos Aluviais (Alluvial Soils) | Fluvisols pp | Entisols pp |
| 16. Solos Orgânicos (Organic Soils) | Histosols pp | Histosols pp, Entisols pp |

°°pp = pro-parte
*to a minor extent

Table 4B - Tentative correlation between second taxonomic level subclasses of Brazilian Latossolos with second level FAO units (FAO-Unesco, 1974) and with great soil groups of Soil Taxonomy (Soil Survey Staff, 1975)

| Brazilian system-SNLCS | FAO World Soil Map legend | Soil Taxonomy |
|---|---|---|
| 1.1 Latossolos Ferríferos (Ferriferous Latosols) | pp Humic Acric-Rhodic Ferralsols | pp Acrohumox |
| 1.2 Latossolos Roxos (Dusky Red Latosols) | pp: Rhodic, Acric-Rhodic, Humic-Rhodic Ferralsols; *Chromic-Ferralic & Chromic-Humic Cambisols | pp: Acr, Hapl, Eutr Orthox & Ustox; *Umbriorthox; Acr & *Hapl Humox; *Dystropepts & rarely Dystrochrepts |
| 1.3 Latossolos Vermelho-Escuro (Dark Red Latosols) | as above | as above, plus rarely Ustropepts |
| 1.4 Latossolos Vermelho-Amarelos (Yellow-Red Latosols) | pp: Orthic, Acric, Humic & *Xanthic Ferralsols; *Ferralic & Humic Cambisols | pp: Acr, Hapl Orthox & Ustox; Umbr & Sombr Orthox; Acr, Sombr & *Hapl Humox; *Eutrustox & Torrox; * Dystr & Ust Tropepts |
| 1.5 Latossolos Amarelos (Yellow Latosols) | pp: Xanthic Ferralsols; *Humic-Xanthic Ferralsols; *Ferralic Cambisols | pp: Hapl, Acr Orthox & Ustox, *Hapl & Acr Humox; *Torrox; *Dystr & Ust Tropepts |
| 1.6 Latossolos Variação Una (Latosols "Una" Variant) | pp: Humic & Acric Ferralsols; rarely Ferralic Cambisols | pp: Acr, Sombr Orthox & *Ustox; *Sombrihumox; rarely Dystropepts |
| 1.7 Latossolos Brunos (Brown Latosols) | pp: Humic Ferralsols; *Humic & Ferralic Cambisols | pp: Acr, Hapl Humox; Sombri, Acr, Umbr Orthox; *Humi & Dystrochrepts |

pp = pro-parte
* = to a minor extent

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**Appendix 1**

PHASES OF ORIGINAL NATURAL VEGETATION

Since the early 1960s, the main types of primary vegetation have been introduced as phase criteria for general soil surveys executed in Brazil (Camargo et al., 1962). The reasoning behind this procedure has been further explained in a soil workshop sponsored by SNLCS-EMBRAPA (Reunião de Classificação, Correlação e Interpretação de Aptidão Agrícola de Solos, 1979) and lately reiterated by Carvalho et al. (1986).

The primary vegetation is determined by climatic and/or edaphic conditions. Areal comparison of climatic divisions with phytogeographic divisions (thermic and hydric indexes versus nature of primary vegetation) shows relationships. Natural soil fertility (oligotrophic or eutrophic status) also influences the character of the primary vegetation.

Field observations of soil climate and especially the soil moisture regime are rare. However, the distinction of phases of primary vegetation allow inferences on climatic conditions and the soil moisture regime to be made. Certainly, besides their pedological significance, the subdivisions carry broader ecological implications, giving further insight into relationships between soil classes, land units and their agricultural capabilities, thus enhancing the utilitarian value of soil surveys.

The main types of original natural vegetation recognized as phases and indicative of pedoclimatic conditions, or sometimes of soil fertility status (Carvalho et al., 1986), are presented in the following Table. Correlations with calculated soil moisture and temperature regimes (Van Wambeke, 1981), as used in Soil Taxonomy (Soil Survey Staff, 1975), are given by comparing the calculated regimes from about 250 meteorological stations with the primary vegetation type or co-existing types (e.g. forest and cerrado; grassland and forest) in the region near the station location. The number of locations referred to each primary vegetation type and corresponding calculated soil moisture and temperature regimes is given between brackets in the table.

Equivalences concerning main phases of primary vegetation* as applied in general soil surveys in Brazil by EMBRAPA-SNLCS versus calculated soil moisture and temperature regimes and classes of tentative subdivisions of moisture regimes

| Primary vegetation phases (EMBRAPA-SNLCS) | Calculated soil moisture and temperature regimes (Van Wambeke, 1981) | Tentative subdivisions of moisture regimes (Van Wambeke, 1981) |
|---|---|---|
| 1. Floresta equatorial (Tropical forest) | | |
| 1.1 Perúmida (7) (Perhumid evergreen rain forest) | Perudic Isohyperthermic (7) | Perudic (7) |
| 1.2 Perenifólia (12) (Evergreen rain forest) | Udic Isohyperthermic (9)<br>Ustic Isohyperthermic (3) | Typic Udic (6)<br>Udic Tropustic (3)<br>Dry Tropudic (3) |
| 1.3 Subperenifólia (9) (Semi-evergreen) | Ustic Isohyperthermic (7)<br>Udic Isohyperthermic (2) | Typic Tropustic (4)<br>Udic Tropustic (3)<br>Dry Tropudic (2) |
| 1.4 Subcaducifólia (4) (Semideciduous) | Ustic Isohyperthermic (4) | Udic Tropustic (4) |
| 1.5 Higrófila de várzea (Hygrophilous riverine) | Aquic, at least pro-parte | |
| 1.6 Hidrófila de varzea (Hydrophilous riverine) | Aquic | |
| 2. Floresta tropical (Tropical forest) | | |
| 2.1 Perúmida (5) (Perhumid evergreen rain forest) | Perudic Isohyperthermic (5) | Perudic (5) |
| 2.2 Perenifólia (31) (Evergreen rain forest) | Udic Isothermic (14)<br>Udic Isohyperthermic (8)<br>Perudic Isohyperthermic (4)<br>Perudic Hyperthermic (3)<br>Perudic Isothermic (1)<br>Udic Hyperthermic (1) | Typic Udic (23)<br>Perudic (8) |
| 2.3 Subperenifólia (55) (Semi-evergreen) | Udic Isohyperthermic (33)<br>Ustic Isohyperthermic (15)<br>Udic Isothermic (6)<br>Ustic Isothermic (1) | Typic Udic (26)<br>Dry Tropudic (13)<br>Udic Tropustic (11)<br>Typic Tropustic (5) |
| 2.4 Subcaducifólia (31) (Semideciduous) | Ustic Isohyperthermic (18)<br>Udic Isohyperthermic (12)<br>Ustic Isothermic (1) | Typic Tropustic (10)<br>Udic Tropustic (9)<br>Dry Tropudic (8)<br>Typic Udic (4) |
| 2.5 Caducifólia (19) (Deciduous) | Ustic Isohyperthermic (19) | Typic Tropustic (10)<br>Udic Tropustic (9) |
| 2.6 Higrófila de várzea (Hygrophilous riverine) | Aquic, at least pro-parte | Aquic |
| 2.7 Hidrófila de várzea (Hydrophilous riverine) | Aquic | |

* A few formation-types of minor extent are omitted in the Table given.

(cont.)

| Primary vegetation phases (EMBRAPA-SNLCS) | Calculated soil moisture and temperature regimes (Van Wambeke, 1981) | Tentative subdivisions of moisture regimes (Van Wambeke, 1981) |
|---|---|---|
| 3. Floresta subtropical (Warm temperate forest) | | |
| 3.1 Perúmida (2) (Perhumid evergreen rain forest) | Perudic Isothermic (2) | Perudic (2) |
| 3.2 Perenifólia (8) (Evergreen rain forest) | Perudic thermic (6)<br>Perudic Isothermic (1)<br>Udic Isothermic (1) | Perudic (7)<br>Typic Udic (1) |
| 3.3 Subperenifólia (3) (Semi-evergreen) | Udic Thermic (2)<br>Udic Isothermic (1) | Typic Udic (3) |
| 3.4 Subcaducifólia (2) (Semideciduous woodland) | Udic Thermic (2) | Typic Udic (2) |
| 3.5 Higrófila de várzea (Hygrophilous riverine woodland) | Aquic, at least pro-parte | |
| 3.6 Hidrófila de várzea (Hydrophilous riverine woodland) | Aquic | |
| 4. Vegetação de restinga (Sand bars and coastal sand plains psammophilous vegetation) | | |
| 4.1 Floresta mesófila (15) (Mesophyllous forest) | Udic Isohyperthermic (6)<br>Ustic Isohyperthermic (4)<br>Perudic Isohyperthermic (3)<br>Udic Thermic (2) | Typic Udic (6)<br>Perudic (3)<br>Dry Tropudic (2)<br>Udic Tropustic (2)<br>Typic Tropustic (2) |
| 4.2 Floresta hidrófila (Hydrophilous woodland) | Aquic | |
| 4.3 Formação herbácea-arbustiva (Shrub-grassland) | Same conditions as 4.1 | |
| 5. Cerrado <u>sensu lato</u> (variously savanna woodland, tree and/or shrub savannas, savanna grassland, all of oligotrophic and scleromorphous nature) | | |
| 5.1 Cerrado equatorial subperenifólio (4) (Tropical semi-evergreen tree and/or shrub savannas) | Ustic Isohyperthermic (4) | Dry Tropudic (2)<br>Udic Tropustic (2) |
| 5.2 Campo cerrado equatorial (2) (Tropical savanna grassland) | Udic Isohyperthermic (1)<br>Ustic Isohyperthermic (1) | Dry Tropudic (1)<br>Udic Tropustic (1) |

(cont.)

| Primary vegetation phases (EMBRAPA-SNLCS) | Calculated soil moisture and temperature regimes (Van Wambeke, 1981) | Tentative subdivisi of moisture regimes (Van Wambeke, 1981) |
|---|---|---|
| 5.3 Cerrado e cerradão tropical subperenifólio (16) (Tropical semi-evergreen savanna woodland & tree and/or shrub savannas) | Udic Isohyperthermic (7)<br>Udic Isothermic (7)<br>Ustic Isohyperthermic (2) | Typic Udic (14)<br>Udic Tropustic (2) |
| 5.4 Cerrado e cerradão tropical subcaducifólio (31) (ditto though semideciduous) | Ustic Isohyperthermic (18)<br>Udic Isohyperthermic (11)<br>Ustic Isothermic (1)<br>Udic Isothermic (1) | Udic Tropustic (14)<br>Dry Tropudic (12)<br>Typic Tropustic (5) |
| 5.5 Cerrado e cerradao tropical caducifólio (6) (ditto though deciduous) | Ustic Isohyperthermic (6) | Typic Tropustic (4)<br>Udic Tropustic (2) |
| 5.6 Campo cerrado tropical (3) (Tropical savanna grassland) | Udic Isohyperthermic (2)<br>Udic Isothermic (1) | Typic Udic (3) |
| 6. Caatinga (Thorn scrub) | | |
| 6.1 Hipoxerófila (9) (Hypoxerophilous) | Ustic Isohyperthermic (8)<br>Aridic Isohyperthermic (1) | Aridic Tropustic (<br>Typic Tropustic (3<br>Weak Aridic (1) |
| 6.2 Hiperxerófila (8) (Hyperxerophilous) | Ustic Isohyperthermic (5)<br>Aridic Isohyperthermic (3) | Aridic Tropustic (<br>Typic Aridic (2)<br>Weak Aridic (1) |
| 7. Vegetação Campestre (Grasslands) | | |
| 7.1 Campo tropical higrófilo de várzea (Tropical meadow) | Aquic | |
| 7.2 Campo tropical hidrófilo de várzea (Tropical swamp grassland) | Aquic | |
| 7.3 Campo subtropical perúmido - vegetação altimontana (2) (Subtropical montane grass-land - perhumid) | Perudic Isothermic (1)<br>Perudic Isomesic (1) | Perudic (2) |
| 7.4 Campo subtropical úmido (11) (Subtropical mesophyllous grassland) | Perudic Isothermic (5)<br>Perudic Thermic (4)<br>Udic Isothermic (2) | Perudic (9)<br>Typic Udic (2) |
| 7.5 Campo subtropical subúmido (4) (Subtropical subhumid grassland - pampas) | Udic Thermic (4) | Typic Udic (4) |
| 7.6 Campo subtropical higrófilo de várzea (Subtropical meadow) | Aquic | |
| 7.7 Campo subtropical hidrófilo de várzea (Subtropical swamp grassland) | Aquic | |

**Appendix 2**

ANALYTICAL METHODS USED BY THE BRAZILIAN SOIL SURVEY SERVICE - SNLCS

Brief descriptions of analytical methods are given here but full details are available in the "Manual de metodos de analise de solo" (Empresa Brasileira de Pesquisa Agropecuaria - SNLCS, 1979), as indicated by the reference numbers.

Fraction >2 mm (gravel and cobbles) and <2 mm (fine earth) - air-dried whole samples, wood rolling to break clods and sieving through rounded hole 2 mm sieve; volume percentage determined by volumetric measurement of fractions coarser and finer than 2 mm (Method 1,2,2); weight percentage by gravimetric determination (Method 1,2,1).

Particle size distribution - determined in the <2 mm fraction dispersed in water with NaOH or occasionally calgon, high speed stirring, sedimentation; clay measured in supernatant by modified hydrometer method, sands by sieving and silt by difference; no pretreatment to destroy organic matter (Method 1,16,2).

Water dispersible clay - same as above, except no dispersing agent used (Method 1,17,2).

Flocculated clay ratio - derived value based on percentage of clay fraction and percentage of water dispersible clay (Method 1,18).

Bulk density - measured in core samples by volumetric ring (Kopecky) method (Method 1,11,1) or paraffin-coated clods (Method 1,11,3), when applicable - reported on oven dry base.

Particle density - volumetric flask and ethyl alcohol (Method 1,12).

Porosity - derived value based on bulk density and particle density (Method 1,13).

Water content ~1/3 bar - determined in presaturated <2 mm fraction by centrifugation at 2,400 rpm during thirty minutes (Method 1,8).

pH H20 and 1N KCl - measured by glass electrode in a soil-water and soil-1N KCl 1:2.5 suspension contact for no less than thirty minutes, stirring immediately before reading (Methods 2,1,1 and 2,1,2).

Extractable bases - $Ca^{++}$ and $Mg^{++}$ extracted with 1N KCl and titrated with EDTA (Methods 2,9 and 2,10); $K^{+}$ and $Na^{+}$ extracted with 0.05N HCl + 0.025 N $H_2SO_4$ and determined by flame photometer (Method 2,12 and 2,13).

Sum of bases - calculated as sum of $Ca^{++}$, $Mg^{++}$, $K^{+}$ and $Na^{+}$ determined as above (Method 2,14).

Extractable acidity - $Al^{+++}$ extracted with 1N KCl, titration of acidity with 0.025N NaOH and bromothymol blue as indicator (Method 2,8); $H^{+}$ + $Al^{+++}$ extracted with 1N Ca $(OAC)_2$ pH 7.0, titration of acidity with 0.0606N NaOH and phenolphtalein as indicator (Method 2,15); $H^{+}$ calculated by difference from above determinations (Method 2,16).

CEC - sum of cations (at pH 7.0) - calculated by summing extractable bases and extractable acidity as above (Method 2,17).

Base saturation - derived valued based on extractable bases and CEC as above, reported as percentage of CEC (Method 2,18).

Aluminum "saturation" - derived value based on extractable $Al^{+++}$ and extractable bases reported as percentage of summation of these values (Method 2,19).

Extractable P - extracted with 0.05N HCl + 0.025N $H_2SO_4$ and determined colorimetrically (Method 2,6).

Total P - H2S04 1:1 attack - determined colorimetrically using ascorbic acid (Method 2,28).

Organic carbon - wet oxidation with 0.4N $K_2Cr_2O_7$ and titration with 0.1N $FeSO_4$ (Method 2,2).

Total nitrogen - Kjeldahl - digestion with acid mixture, diffusion and titration of $NH_3$ with 0.01N HCl (Method 2,4,1).

Attack by H2S04 1:1 and NaOH 0.8% - boiling solubilization of <2 mm size fraction to (1) extract in the filtrate: iron and aluminum - determined complexometrically by titration, reported as $Fe_2O_3$ and $Al_2O_3$ (Methods 2,24 and 2,25); titanium, manganese and phosphorus - determined colorimetrically, reported as $TiO_2$, MnO and $P_2O_5$ (Methods 2,26; 2,27; 2,28); (2) in the residue of the sulfuric attack, extraction of silicon with NaOH 0.8% and determined colorimetrically, reported as $SiO_2$ (Method 2,23,3).

Si02/Al203, Si02/R203, Al203/Fe203 ratios* - calculation on molecular basis, derived from above determinations (Methods 2,29 and 2,30).

CBD extractable iron - determined by atomic absorption spectrophotometry, reported as $Fe_2O_3$ (Method 2,31).

CaC03 equivalent - reaction with HCl 1:1 and gasometric determination of $CO_2$ evolved (Method 2,43,3).

Electric conductivity of the saturation extract - water extraction of a saturated paste (Method 2,32) and conductimetric determination (Method 2,33).

Total sulfur - Attack by HCl 1:1, precipitation with $BaCl_2$ and determined gravimetrically (Method 2,45).

Mineralogy of sands and fractions >2 mm - identification of mineral particles by optical methods using binocular microscope and polarizing microscope, with occasional complementary chemical microtests; qualitative and semiquantitative determinations of mineralogical species are made and results expressed in approximate percentage (Methods 4,3; 4,4,1; 4,5).

Clay mineralogy - X-ray diffraction and differential thermal analysis.

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* Indexes of overall composition of the secondary mineral constituents plus iron contained in ilmenite.

# SOIL DATA, A MATTER OF CONCERN

*P.M. Driessen**

## Introduction

Simulation techniques and quantified evaluation procedures become increasingly important attributes of modern soil science.

Mathematical modelling in particular is widely appreciated as a means to gain a better understanding of the role of soils (and their spatial and temporal variability) in the performance of land use systems.

In this context, it is perhaps good to stress that the quality and relevance of a model's output are ultimately limited by the quality of its input: information on land and land use, including data collected by soil scientists. A good model merely makes visible the consequences of the evaluator's basic data selection with a minimum of distortion added.

There is growing awareness among those engaged in developing and applying quantified (land) evaluation procedures that much routinely collected information on soils is redundant.

It is the purpose of this contribution to demonstrate a need for re-thinking of the quality requirements for soil data and data collection procedures.

## Soil data for (eco)system analysis

Soil data normally refer to individual characteristics of individual horizons in individual pedons. Such bits of information are collected in the field and in the laboratory. "Field data" and "laboratory data" complement each other; they have in common that (i) they pertain to a situation *at one point in time;* variations in parameter values over time are not expressed although land use systems are highly dynamic in many respects, and (ii) they pertain to a situation *at one point in space;* results of this point analysis are often projected onto a soil continuum although a single pedon is rarely representative of a soil mapping unit.

FIELD DATA refer to morphometric profile characteristics. Some field data are truly quantitative (e.g. horizon depths in cm) but most are semi-quantitative at best (texture class, porosity class, etc.). Field data are collected from the soil *in situ* and reflect the geometry/arrangement of the soil material in its natural state. This information, collected with simple techniques, cannot always be explicit but it comes directly from the source and is little distorted.

LABORATORY DATA are determined on soil samples that, even if "undisturb-

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ed", are removed from their physical context. Laboratory data concern mainly the composition and properties of soil material. Such data are often credited with being "hard", quantitative information but may not accurately reflect the properties of the natural soil if determined on material that was modified during pre-treatment of the sample (drying, grinding, sieving) or during the analysis procedure itself.

Particularly if the material is analyzed under conditions that deviate strongly from those in the field (analysis in buffered solutions, high electrolyte concentrations, etc.), the data produced may be inappropriate for use in simulation studies.

Critical examination of common soil parameter definitions and of the methods used to collect and present soil parameter values reveals a general carelessness on the part of both the producers and the users of soil data. This attitude exists already for so long that one must fear that (many of) the collected 'facts' and numbers were never used in quantified AND VERIFIED data evaluation procedures. With the advent of mathematical models, unconcern about the quality requirements for soil information becomes more clearly exposed than before. We are now definitely forced to (i) re-examine concepts and definitions, (ii) reconsider the methods of data collection (sampling and analysis procedures) and (iii) improve data formats. As this paper cannot be exhaustive, the need for action is perhaps best illustrated by briefly discussing some practical cases that seem to need our attention.

## Case number 1: concepts and definitions

The quantity of Total Available Soil Moisture (TASM, in cm) at any moment is defined as:

$$TASM = (SMFC\text{-}SMPWP) * RD$$

where:
SMFC is the soil moisture content at field capacity, in $cm^3\ cm^{-3}$
SMPWP is the soil moisture content at permanent wilting point, in $cm^3\ cm^{-3}$
RD is the momentary (equivalent) root zone depth, in cm.

In this concept, SMFC and SMPWP are "soil moisture constants". SMFC is the lowest moisture content that a wet soil will reach after a few days of drainage. Alternatively, it represents the highest moisture content that a freely draining dry soil can hold if water is added to it. Hysteresis effects between these two approaches may be considerable. The SMFC value applicable to a particular situation is thus partly determined by momentary (changes in) soil moisture status; it is not a true soil constant. The general practice to substitute for SMFC the moisture content measured after exposing a saturated soil sample to a suction of 1/3 bar, is in conflict with this notion.

SMPWP is the soil moisture content at which a vegetation or crop succumbs to moisture stress. The moisture content measured after exposing a dried, sieved and subsequently moistened soil sample to a suction of 16 bars (equivalent to pF 4.2), is commonly used as an approximation of SMPWP. We know, however, that sensitive crops wilt and die at much lower suction values than 16 bars while hardy, drought resistant crops survive values of, say, 25 bars. This variation in suction is obscured by expressing matric potentials on a logarithmic scale where a suction range of 10 to 25 bars corresponds with a seemingly narrow (= "acceptable") pF range of pF 4.0 to pF 4.4.

RD estimates add further uncertainties to the TASM concept but as these depend on crop characteristics rather than on soil properties they will not be discussed here.

The "available moisture content" is now found by subtracting a questionable SMPWP value from an equally questionable value for SMFC. The implicit assumption that amounts of water held in excess of field capacity are unavailable for plants is unrealistic, for plants must surely take upe some of this water (it takes a few days after prolonged heavy rain or irrigation to reach SMFC, the time taken for this excess moisture to drain away).

The TASM concept is used in a procedure to estimate the effect of soil moisture depletion on the consumptive water use of a crop or vegetation. The quantity of soil water available for unhindered uptake is approximate by multiplying TASM by a "soil water depletion fraction", estimated as a function of momentary crop properties and evaporative demand of the atmosphere. In other words, water stress becomes apparent once a certain fraction of TASM is depleted. Plant performance, however, seems not so much influenced by the quantity of soil moisture that is already taken up from the root zone as by the soil moisture potential that the plant must overcome in water uptake.

**Case number 2: data collection procedures**

The concentration of "available" elements in soil material is normally estimated by treating a soil sample with a "mild" extraction agent that is supposed to resemble the action of plant roots in taking up elements from the soil. As an example let us consider the element phosphorus. It is not unrealistic to anticipate a clear correlation between the quantity of phosphorus in the soil extract and the phosphorus concentration of plants grown on that same soil material, *if the analyzed plants are grown under constant (controlled) conditions,* e.g. in a climate chamber. No usable correlation may be expected if the extraction procedure is conditioned but P-uptake took place in the field, i.e. in an open system where uptake is influenced by a score of non-soil factors such as the weather during the growth cycle and the actions of man. Yet, this is common practice; poor correlation between the phosphorus concentrations of extracts and of plant tissue is rule rather than exception. Apparently, this is blamed on the choice of extractant and not on procedural error.

By now, we avail of P-water, P-citr.acid, P-Amm.Lact., P-Mehlich, P-Olsen, P-mod.Olsen, P-Bray 2 , and many more. Perhaps we should discontinue the search for that one extractant that can do the impossible. "Available element" figures have a limited predictive value. They reflect the likelihood of nutrient stress under field conditions, but since no one can guarantee that actual system parameters will be the same as during the experiment in which they correlation was established, they appear to promise more than they can deliver.

## Case number 3: soil data formats

The results of chemical soil analysis are commonly expressed on a weight per unit-weight basis: kg $kg^{-1}$, percent, p.p.m., etc. This practice may be understandable from the analyst's point of view but it frustrates data interpretation. The dry WEIGHT of a rooting medium is irrelevant for crop performance while the soil VOLUME to which plant roots have access matters. Where appropriate, soil data should be expressed as, or be convertible to, weights-per-volume. That means that bulk density values ought to be a standard part of any soil data set. If bulk density indications are left out of the set, serious misinterpretation of data is bound to happen. An example: the bulk density values of natural peat soils range from 0.05 to 0.4 kg $dm^{-3}$, so that a peat with 1 percent (by weight) of nitrogen in its top 10 cm tier contains anywhere between 500 and 4000 kg N $ha^{-1}$ $(10\ cm)^{-1}$. This 8-fold variation is not expressed in the analysis data but is of vital importance to user of the peat. The example may seem to overstate the case because the bulk densities of the more common mineral soils range "only" between 0.85 and 1.7 kg $dm^{-3}$. Even then, it would seem prudent not to use wt/wt criteria in soil classification without reference to the bulk density of the material in situ. (It must be remembered here that bulk densities are by no means stable values. Normal cultivation practices involve traffic which increases bulk density values and plowing which decreases them, and all that in the span of only one crop cycle.)

This paragraph has touched upon just a few out of the many questions that users of soil data are confronted with. It is the author's view that soil scientists could do much good by redefining differentiating soil criteria in such a way that class denotations not only reflect a soil's genetic past but also describe its present state in an unambiguous manner.

## The documentation of soil data

It was argued earlier in this paper that the analytical value of soil data is jeopardized if such data are removed from their natural, spatial and temporal context. The problem is aggravated if the data are incomplete and/or insufficiently documented. An example: the Total Pore Space fraction (TPS, in $cm^3\ cm^{-3}$) is often absent from standard soil data sets but is important in the reconstruction/simulation of a soil's water balance. Assuming equivalent specific weights of 2.65 kg $dm^{-3}$ for the mineral soil fraction and 1.43 kg $dm^{-3}$ for the organic soil fraction, one could reconstruct TPS values with:

$$TPS = 1 - BD^* (0.38 + 0.32^*OM)$$

were:

BD is the dry bulk density of the soil, in kg $dm^{-3}$
OM is the organic matter content of the soil, in kg $kg^{-1}$.

Let us assume that BD and OM values are in the available data set. The relevance of the approximate TPS values now depends on the correctness of the above relation but also on the correctness of the BD and OM values in the data set. The possibility erratic BD values was mentioned earlier; OM values may also be incorrect, e.g. if the analytical method used is not appropriate for the soil material at hand. An OM determination by dry combustion, for instance, will count $CO_2$ losses from carbonatic soils and $H_2O$ losses from clay minerals (5-14 wt% in smectites and 13-20 wt% in kandites) as organic matter. In other words, sampling and analysis specifications must be indicated on the data sheet to make the information explicit.

The interpretation of field data knows similar difficulties. It is possible, for instance, to supply missing information on groundwater fluctuations over the year by interpreting hydromorphic features in the profile description, but only if fossil mottling can be distinguished from current mottling. Statements such as "common fine rusty mottling observed" are not enough.

## Conclusions

There is clearly a need for a critical reappraisal of data concepts and data collection procedures, with attention paid to the quality requirements that the collected information must meet. Sampling techniques must be extended to take into account the temporal and spatial variability of soil properties and sample processing and analysis must aim at minimal distortion of the collected information. An ISSS initiative towards standardization of concepts/definitions and guidelines for data collection and presentation would be helpful.

## REQUEST FOR INFORMATION ON VISUAL TRAINING AIDS

During the last decade a large increase in the use of films, slides and videotapes and other training aids can be noticed at universities, agricultural highschools, training institutes, etc. This will also apply to soil science. Unfortunately, there is no central listing of the available material.

In cooperation with the Secretariat of the ISSS a register of such visual aids is now being made. It will, in due course, appear in the Bulletin of the ISSS.

We would be grateful if recipients of the Annual Report could send to the Secretary-General of the ISSS, P.O. Box 353, 6700 AJ Wageningen, the Netherlands a listing of available films, slides or slide sets, and videotapes on soil science *sensu largo.*

Please supply information on:

- title and main contents,
- level of audience,
- size and length of film,
- type of sound track,
- video system type,
- year of preparation,
- availability and price,
- ordering/contact address.

# 3 REGULAR ACTIVITIES BY THE SECTIONS

## 3.1 SOIL MONOLITH COLLECTION

During the reporting period the number of soil monoliths increased with 83 to 743 (see table below).

Monolith collection, December 1986
Within parentheses: aquisitions in 1986

| | | | |
|---|---|---|---|
| Australia | 39 (6) | Mozambique | 8 |
| Belgium | 4 | Nambia | 11 |
| Botswana | 7 | Netherlands | 24 |
| Brazil | 29 (15) | New Zealand | 5 |
| Cameroon | 1 | Nigeria | 14 |
| Canada | 21 | Norway | 3 |
| People's Rep. of China | 16 | Oman | 4 |
| Colombia | 19 | Pakistan | 6 (6) |
| Czechoslovakia | 8 | Peru | 1 |
| Denmark (Greenland) | 6 | Philippines | 6 |
| Finland | 5 | Romania | 11 |
| France | 12 | Rwanda | 10 (10) |
| Fed. Rep. of Germany | 17 | Rep. of South Africa | 20 |
| Ghana | 4 | Spain | 20 |
| Gabon | 6 | Sri Lanka | 4 |
| Greece | 15 | Sweden | 17 |
| Hungary | 20 | Switzerland | 1 |
| India | 30 | Syria | 4 |
| Indonesia | 25 | Thailand | 13 |
| Ireland | 11 | Turkey | 13 |
| Italy | 17 | United Kingdom | 11 |
| Ivory Coast | 7 | U.S.A. | 25 |
| Jamaica | 3 | U.S.S.R. | 62 |
| Japan | 4 | Uruguay | 10 (4) |
| Kenya | 65 (32) | West Samoa | 5 |
| Malaysia (East) | 11 | Yugoslavia | 3 |
| Malaysia (West) | 7 | Zaire | 2 |
| Mali | 10 (9) | Zambia | 11 (1) |
| | | Total | 743 (83) |

## Acquisitions in 1986

**Australia:** Guest researcher Prof. J.W. McGarity collected a sequence of 5 Vertisol profiles near Armidale, NSW. Together with another Vertisol profile, collected in the early 1960's, they form part of the basic material for his study on Vertisols, carried out at ISRIC during 1986.
**Brazil:** ISRIC's soil scientist J.H. Kauffman collected, in cooperation with soil scientists from EMBRAPA-SNLCS and EMBRAPA-CPAC, 15 profiles in the states of Alagoas, Paraiba, Pernambuco, Minas Gerais, Goias and the Federal District. The collection contains Acrisols, Arenosols, Ferralsols, Phaeozems, Planosols, and Solonetzes.
**Kenya** and **Rwanda:** Made possible with extra funds, Ir. J. Kuyper carried out collection work in these countries for the Department of Soil Science and Geology of the Wageningen Agricultural University and ISRIC. In close cooperation with the Kenya Soil Survey, the Wageningen Training Project in Pedology, and the Projet Carte Pédologique de Rwanda, he assembled a total of 100 soil profiles in Kenya, of which 32 meant for ISRIC, and 10 in Rwanda, all for ISRIC. The Kenyan profiles show several sequences, the most important one covers a 300 km long traverse from Mount Kenya to Garissa.
**Mali:** In the framework of the NASREC programme, ISRIC's soil scientist J.H. Kauffman collected nine profiles in cooperation with the Malian 'Projet de l'Inventaire des Ressources Terrestres' (PIRT). The profiles form a sequence through the main ecological zones: the Sahara, Sahel, and Sudan.
**Pakistan:** Mr. M.A. Tahir, Soil Survey of Pakistan, Lahore, who is a former course participant, collected six profiles.
**Uruguay:** Mr. A.I. Califra, Direccion de Suelos - M.A.P., Montevideo, who is a former course participant, and Ir. R.F. Breimer, then soil scientist with Unesco, collected four profiles in addition to the six already taken before. These complete the collection of major soils of the country.
**Zambia:** Dr. O.C. Spaargaren, Mt. Makulu Central Research Station, Chilanga, collected a Vertisol for Prof. McGarity's research programme.

## General

Arrangements for collecting soil profiles in the coming five years or so have been made with institutions and individuals in a number of countries. Some of these have plans for the establishment or enlargement of soil reference collections for their own purpose.

The countries with which ISRIC is in contact include: Brazil, Burundi, People's Republic of China, Ecuador, Ghana, Indonesia, Israel, Kenya, Mali, Mexico, Pakistan, Poland, Portugal, Rwanda, Spain (Canary Islands), Sri Lanka, Sudan, Tanzania, U.S.A., Venezuela, Vietnam and several countries in North Africa and the Near East.

In the coming two years a part of the profiles-to-be-collected will come from the countries participating in the National Soil Reference Collection programme (NASREC).

Except for the NASREC profiles most of the sampling will be carried out by non-ISRIC soil scientists, part of whom are participants of the annual training course.

### Preparation of monoliths

During the reporting period about 30 profiles have been impregnated and 25 monoliths have been re-impregnated/repaired. During the annual training course about 12 profiles have been taken and treated as exercise material.

## 3.2 LABORATORY

### Regular analytical work, related to the collection

Also this year much attention was given to analytical work for the studies by guest researchers (see Chapter 5). In 1985/6 some sixty Ferralsols/Oxisols and related soils were fully analysed; in 1986 about 20 Vertisols were completed.

For a new section of the exhibition at ISRIC a catena of six profiles in Ivory Coast and three catenas of twelve profiles in Indonesia were analysed as well.

### Other work

- For several departments of ITC analytical work was carried out relating to research and student field work.
- As a spin-off of the Ferralsols project over a hundred samples were analyzed for free iron oxides with different procedures aimed at better identification of these soils.
- A simplified method for the COLE determination of Vertisols was developed and tested in cooperation with guest researcher Prof. J.W. McGarity.

## 3.3 MICROMORPHOLOGY

### Technical work

The treatment of undisturbed soil samples and the subsequent preparation of thin sections is carried out by the technician of ISRIC at the laboratory of the Netherlands Soil Survey Institute (Stiboka) at Wageningen. There is a close cooperation with the technician of Stiboka and there are material contributions to the laboratory.

In 1986, 206 samples were received for treatment from the following countries: Australia, Indonesia, Kenya, the Netherlands, Pakistan, Peru, Spain, and Uruguay.

In the same year 175 thin sections were prepared. 149 thin sections were made for the regular soil collection of ISRIC. These concerned soils from Brazil, People's Republic of China, Ivory Coast, Kenya, Malaysia, and the Netherlands.

Thin sections for other studies totalled 26, including samples from Australia, to be investigated by guest researcher Prof. J.W. McGarity, and samples from study areas of ITC in Spain and Indonesia.

### Investigations

The regular descriptions of thin sections is carried out according to the system as proposed in the Handbook for Soil Thin Section Description, which was published in 1985 under the auspices of the ISSS. The wide range of soils available at ISRIC permits a critical testing and application of the definitions and terminology of the new system. It is the aim of ISRIC to support the system by making suggestions for improvement so that the Handbook can be strengthened with time.

In 1986 descriptions were made of thin sections of soils from the following countries: Colombia, France, Ireland, Fed. Rep. of Germany, Greece, Hungary, the Netherlands, Nigeria, South Africa, Sovjet Union, and Sweden. These form part of the documentation related to the monoliths in the exhibition.

Furthermore, thin sections from Mozambique and Ivory Coast were studied in view of a new section of the exhibition at ISRIC. Brazilian soils were studied in relation to the work of guest researcher Prof. E. Klamt, and Australian soils for guest researcher Prof. J.W. McGarity.

## 3.4 DOCUMENTATION

### ISRIC Soil Information System (ISIS)

The soil monolith documentation forms an essential part of the information which is available at ISRIC. Improving the access to this information was felt to be necessary. During the years 1985 and 1986 a (micro-)computer-based soil information system was made. ISIS will help to improve storage, retrieval and selection of the data of the collected soil monoliths. It is primarily developed to handle the documentation of ISRIC's soil reference collection. Consequently, the soil descriptions are extensive and the selection and output procedures are written to meet ISRIC's requirements. ISIS can however also be considered as a concept for the development of a soil information system at national level. Anyone familiar with the dBASE III application language can easily modify the procedures to make the system suitable for use in a non-ISRIC environment.

Towards the end of the year the data of about 100 soil monoliths were stored in ISIS. Before storing the information, it must be screened and updated. The system will be published in 1987 as a Technical Paper containing: technical manual, guidelines for coded soil description, and diskette with programme. The system requirements are:
Hardware: IBM-XT (or compatibles on which dBASE III runs without problems); at least 256 Kb RAM; Harddisk; Printer, which can print 132 characters/line.
Software: dBASE III/DOS 2.10 (or later).

From ISIS a selection of data from 40 Ferralsols/Oxisols was made available at the request of the USDA Soil Conservation Service for reviewing Soil Taxonomy classifications.

### Map collection and Library

Maps and publications form an important part of the Centre's documentation. The coverage is the whole world with emphasis on developing countries. The collection is dominated by soil and related geographic information on climate, vegetation, land use, land capability, geology and geomorphology. At present the map collection includes about 4000 sheets and some 600 photonegatives and transparencies.

The acquisition policy is to obtain world coverage of soil maps at reconnaissance and smaller scale, with examples of more detailed soil maps and index maps/lists of all soil surveys carried out in a country. Other thematic maps are collected mainly if they complement soil information. The selection criteria are the relevance of the maps for soil science, agricultural development and environmental issues.

One of the purposes of maintaining the map collection is its use for updating of the Soil Map of the World at scale 1:5 million and the compilation of a new, computerized world soil map at 1:1 million.

The library collection includes about 4500 publications, about 2500 of which are on a regional basis, mostly reports on soil and land surveys. The remainder is constituted mainly by textbooks on soil science and related subjects, bibliographies and atlases. There is an annual increase of two to three hundred publications. ISRIC has subscriptions to about 35 journals. The map and book collection increasingly serves as a source of basic information for use by scientists, students and consultants in soil correlation studies and in the preparation of missions. There is especially an increase in its use by students of Wageningen Agricultural University, participants of the M.Sc. Course in Soil Science and Water Management, and the International Course for development-oriented Research in Agriculture (ICRA).

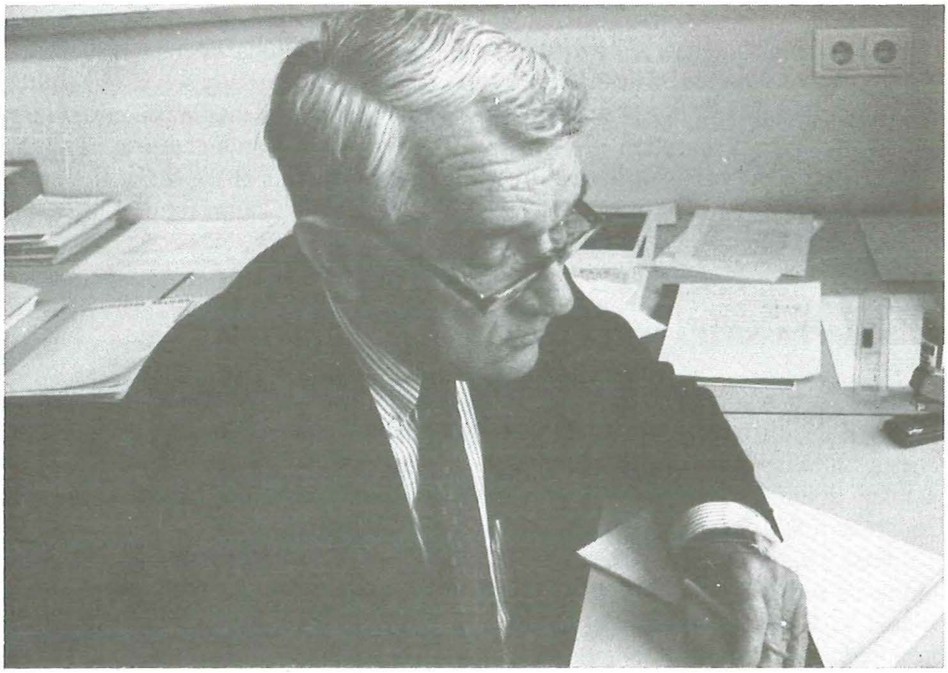
## 3.5 SOIL CLASSIFICATION, CORRELATION AND MAPPING

The draft report by a working group of FAO, Unesco and ISRIC (see Annual Report 1985) on a revision and elaboration of the Legend terminology of the FAO-Unesco Soil Map of the World was circulated to interested soil classification specialists in many countries and was also presented and discussed at the 13th International Congress of Soil Science in Hamburg, Fed. Rep. of Germany.

Based upon comments received the working group divised addition changes during its fourth meeting. In 1987, the Revised Legend will be finalized and then printed by FAO for worldwide distribution. Many of the changes accepted and/or proposed by the various International Committees for the improvement of the USDA Soil Taxonomy system of soil classification were incorporated, in one way or another, to ensure as much compatibility as feasible. The International Committee on the revision of the classification of Oxisols (ICOMOX) held a workshop in Brazil in May, in which Dr. W.G. Sombroek participated. During the workshop, many representative Brazilian Ferralsol/Oxisol profiles, most of them already sampled in the current joint ISRIC-EMBRAPA soil monolith collection programme (see Section 3.1), were minutely examined as regards field and laboratory characteristics.

Contacts were maintained with national soil investigation institutes that are elaborating an own national system of soil classification (Australia, Brazil, People's Rep. of China, Fed. Rep. of Germany, and New Zealand). The increasing number of national systems of classification necessitates the development of an international reference base. This was one of the reasons for the ISSS to set up a Working Group International Reference Base for soil classification (IRB). Unfortunately, this Working Group made slow progress, if only for the lack of working funds. This lack of progress was a main reason for ISRIC to accept the invitation of FAO to work together on the revision of the FAO-Unesco Legend. It is hoped that this new and more detailed legend will contribute significantly to the eventual establishment of an International Reference Base for soil classification (IRB) that can be accepted by the international community of scientists dealing with soils anywhere, as one of the means for exchange of information on the behavior of the great variety of soils existing in the world.

In January 1986 ISRIC was the host of an international workshop on the feasibility of a project to establish a World Soils and Terrain Digital Database (SOTER), at a scale



Guest researcher Prof. Baumgardner

of 1:1 million. The workshop was organized by an ad-hoc ISSS Working Group. The discussions resulted in a concrete proposal for a project, elaborated by ISRIC's guest researcher Prof. Dr. M.F. Baumgardner (Purdue University, U.S.A.) and staff member Dr. Ir. L.R. Oldeman.

The proceedings of the workshop and the project proposal were discussed and accepted during the International Congress of Soil Science. The Working Group was also formalized. The SOTER proposal was thereupon circulated to many national, regional and international institutions and funding agencies, and the concept was widely acclaimed as useful and timely.

The choice of pilot areas and the siting of a central processing unit and regional support/dissemination centres depends on the wishes of customer countries and funding agencies.

Close liaison is foreseen with existing data bases such as the GRID system of UNEP and the World Digital Database for Environmental Sciences (WDDES) of the International Council of Scientific Unions.

## 3.6 TRANSFER OF KNOWLEDGE

### Group visits

About 1300 persons visited ISRIC in groups, mainly from educational institutions, such as universities, agricultural and technical colleges, and from international training courses, congresses and meetings. The ISRIC collection has been incorporated in the courses on regional soil science of Wageningen Agricultural University and its M.Sc. course on Soil Science and Water Management, of the Tropical Section of the National

Visitors of the exhibition

Agricultural College, Deventer, and of other courses held in the Netherlands, e.g. at ITC, Enschede.

In addition, groups of students are regularly coming from Belgium, the Federal Republic of Germany and the United Kingdom. See also Appendix 1.

On the occasion of the XIII Congress of the ISSS held at Hamburg, ISRIC was visited by Pre-Congress excursion B and Post-Congress excursion H participants.

## Individual visits

The number of people coming individually or in small groups amounts to about 300. Most visitors are professional soil scientists, and two-thirds come from abroad. They usually visit ISRIC for discussions with staff members or for consulting the monolith collection, the library and the map collection.

## Course on the Establishment and Use of National Soil Reference Collections

The objective of this course is to train soil scientists, in particular from developing countries, in all aspects related to national soil reference collections (NASREC).

The 1986 course was held from 12 May to 20 June and was attended by six participants, four from Latin America, one from Asia and one from Africa. Three participants were sponsored by Unesco, two by the United Nations Environmental Program Clearing House Facility (NASREC), and one by the Netherlands Universities Foundation for International Cooperation (NUFFIC)

The participants were:

- Mr. Pedro G. Paredes Arce, from Iquitos, Peru (Unesco)
- Mr. Oumar Doumbia, from Bamako, Mali (NASREC)
- Mr. Eko Handayanto, from Malang, Indonesia (NUFFIC)
- Mrs. Mabel Suzana Pazos, from Balcare, Argentina (Unesco)
- Mr. Guillermo del Posso M., from Quito, Ecuador (NASREC)
- Mrs. Maria J. Mendez Rosales, from Maracay, Venezuela (Unesco).

The course curriculum consisted of six elements:

1. Field work: taking soil profiles and lacquer peels, profile description and sampling, photography of landscape and profile;
2. Workshop activities: conservation and preparation of soil profiles (= monoliths);
3. Lectures and exercises: soil classification, micromorphology, laboratory methods, land evaluation, use of national soil reference collections, agroclimatology, computerized soil data handling;
4. Excursions: soils and landscape, exhibition techniques, soil science and related institutes;
5. Final presentation: preparation and presentation of a small monolith exhibition (monoliths made during the course);
6. Follow-up discussions.

## Other training

A short course on impregnation techniques was given to a soil scientist from the People's Republic of China. Training was also given to a staff member of ITC, Enschede, in these techniques.
To a number of soil scientists ISRIC's Soil Information System (ISIS) was explained and training was given in its applicability and use.

## Extramural lectures

As in the previous years, staff members of ISRIC participated in the Standard course Soil Survey of ITC, Enschede, the Netherlands by giving lectures on special topics of soil genesis and classification, mineralogy and soil chemistry. Both the FAO-Unesco Soil Map of the World and the USDA Soil Taxonomy system were discussed. These lectures are illustrated with slides, hand-outs, lecture notes and other materials derived from the ISRIC collection.

ISRIC was invited by the Swedish University of Agricultural Sciences to give lectures on classification of soils in the tropics and on land evaluation at the Second Post-graduate Soil Conservation Course, in Uppsala, Sweden. These lectures were given by Mr. J.H.V. van Baren.

## Lectures by guests

In 1986 four guests have presented lectures on topics related to their research. The lectures were held at the premises of ISRIC, and staff members of various institutes were invited to attend.

- Dr. A.S.P. Murthy (Univ. of Agricultural Sciences, Dharwad, Karnataka, India): Characteristics and Management of Vertisols in Karnataka State, India.
- Dr. C. Mizota (Kyushu University, Fukuoka, Japan): Parent Material of Japanese Soils coming from China.
- Dr. J. Clark (Land Resources Research Centre, Ottawa, Canada): Physical Aspects of Soil Management.
- Dr. T. Boski (IFAQ, Free University, Brussels, Belgium): Geochemical Aspects of Weathering: a Mineralogical Comparison of two Laterite Profiles.

## Publications

*Soil Monolith Papers*

Only one SMP was published: Calcic Chernozem (Vermic Haplustoll), Romania, 85 p., with two maps, 1 colour photo and 8 slides, by N.M. Pons-Ghitulescu.

Two papers are nearing completion.

*Technical Papers*

The following Technical Papers were issued:

- TP 9: Procedures for soil analysis, edited by L.P. van Reeuwijk, 106 p.
- TP 12: Problem soils: their reclamation and management. K.J. Beek, W.A. Blokhuis, N. van Breemen, R. Brinkman and L.J. Pons. Taken from: Land reclamation and water management. Developments, Problems and Challenges. ILRI Publication 27, 1980, pp. 43-72).

A reprint of TP 4, Field Extract of Soil Taxonomy, was made.

In the series *'Consultancy/Mission Report',* was issued:
**(85/3)** Consultancy Report to Colombia (Choco Department), L.R. Oldeman.

In the series *'Working Paper and Preprint'* the following was issued:
**(86/1)** The Laboratory Methods and Data Exchange Programme - Interim Report on the Exchange Round 85-2, L.K. Pleijsier.
**(86/2)** Characterization of Main Experimental Sites and Sub-sites and Questions of Instrumentation, L.R. Oldeman. Presented at the Inter-Centre Workshop on Agro-ecological Characterization, Classification and Mapping, Rome, Italy, 14-18 April 1986. (restricted distribution).
**(86/3)** Class limits for Land and Soil Properties. A comparative literature study for use at the establishment of a World Soil and Terrain Digital Database (SOTER), A.W. Vogel. (Draft, for discussion and completion; restricted distribution).
**(86/4)** The Laboratory Methods and Data Exchange Programme - Interim Report on the Exchange Round 86-1, L.K. Pleijsier.
**(86/5)** Contribution of Organic Matter to Exchange Properties of Oxisols, E. Klamt and W.G. Sombroek. Joint Contribution ISRIC and Soil Science Dept. of UFRGS, Porto Alegre, Brazil, 8th International Soil Classification Workshop on Classification, Characterization and Utilization of Oxisols, Brazil, 12-23 May 1986.

Also published were:
Response of Rice to Weather Variables (Report of an IRRI/WMO Special Project), by L.R. Oldeman, D.V. Seshu, F.B. Cady, IRRI, Philippines, April 1986.
Proceedings of an International Workshop on the Structure of a Digital International Soil Resources Map annex Data base, edited by M.F. Baumgardner and L.R. Oldeman, ISRIC, Wageningen, August 1986.
Project Proposal: World Soils and Terrain Digital Database at a Scale of 1:1 M ("SOTER"), ISSS/ISRIC, October 1986.

Annual Report 1985 contains two articles, viz. Soil Survey and Landscape Ecological Survey, by A.P.A. Vink, and Enhancement of Tropical Soil Fertility; the Role of Biological Research, by M.J. Swift.

# 4 NON-REGULAR ACTIVITIES

## 4.1 PROGRAMMES

### The National Soil Reference Collection Programme (NASREC)

Especially during the last decade, ISRIC has been requested by soil institutes in many countries to support the establishment of National Soil Reference Collections (NASREC's). A few countries already received assistance through incidental project support. For several others initial steps have been taken through the short annual course on this subject given since 1981. The new NASREC programme, a three-year project financed by DGIS/UNEP, enables ISRIC to strengthen its capacity to support countries initiating such programmes.

In cooperation with national soil institutions basic collections will be established in at least six countries. These institutions will be responsible for their further development and functioning as a national soil reference collection. A few countries will receive assistance in all steps necessary to establish a NASREC, including field missions by an ISRIC staffmember for soil profile sampling, monolith preparation, soil analytical work, micromorphology, soil and environmental information handling, and exhibition techniques. For other countries, cooperation will be restricted to the dispatch of necessary materials/equipment and a short visit by a staffmember. Soil profiles which are of interest to ISRIC's world collection will also be taken.

The project involves also the six-week course to train scientists in the establishment and use of soil reference collections. It is assumed that the participating institutes will nominate at least one member of their staff for participation in the course.

In 1986 the activities of the programme embraced:

- evaluation of all formal requests for support to ISRIC in the past, by means of a questionnaire with background information for updating the requested aid;
- selection of countries to receive support through the NASREC programme. These countries include: Ecuador, Mali and probably Indonesia as major support countries; Brazil, Ghana, Sri Lanka, Venezuela and possibly Vietnam as minor support countries;
- ISRIC's international "Course on the Establishment and Use of National Soil Reference Collections", which was held in May and June (see Section 3.7);
- two field missions, one to Brazil (March/April) and one to Mali (October/ December). For details on these missions see Chapter 6.

### The Laboratory Methods and Data Exchange Programme (LABEX)

The LABEX programme is a soil sample exchange programme between a large number of laboratories with its secretariat at ISRIC. It is receiving special funding from DGIS, initially till mid 1987. The aim is to improve the quality of soil analytical data by providing external reference to the participants.

In 1986 the LABEX programme continued the work started in 1985. The results of the 1985-2 soil sample exchange round were compiled in Working Paper and Preprint 86/1. In February new soil samples were mailed. The requested analyses were: texture, pH, exchangeable cation and CEC. The analytical procedures were given by LABEX. In August the results were published in Working Paper and Preprint 86/4.

It appeared that the analytical variability is still very large. To discuss the results and to outline the future of the programme an international workshop as held in Wageningen from 25-29 August. It was attended by nearly 70 persons. At this workshop a number of papers was presented on new or revised soil analytical procedures.

Labex Workshop participants

The discussions resulted in a number of resolutions. The workshop recommended that LABEX be continued after July 1987, the expiration date of the present contract. It was expressed that participants value the programme mainly as a means of external quality control. The soil analyses will be expanded with parameters such as available P, soluble salts, carbonates, gypsum, acidity, iron, aluminium, manganese and others. A summary of the discussions and the presented papers will be published in the workshop proceedings.

The number of participating laboratories has further increased to nearly 90. They are listed in the Annex.

New bulk soil samples were received from Hungary and the Netherlands. Samples from the Philippines are underway. These will be used in one of the next sample exchanges.

- About a hundred samples were analyzed for LABEX participants on key parameters for local reference purposes (CEC, exchangeable bases, texture).
- As LABEX participant, the laboratory duly analyzed a set of reference samples on prescribed parameters.

## 4.2 CONSULTING

### Agroclimatology

With the appointment of Dr. Ir. L.R. Oldeman as an an agroclimatologist/soil scientist for a fixed term, activities in the field have been initiated in the course of 1985 and 1986.

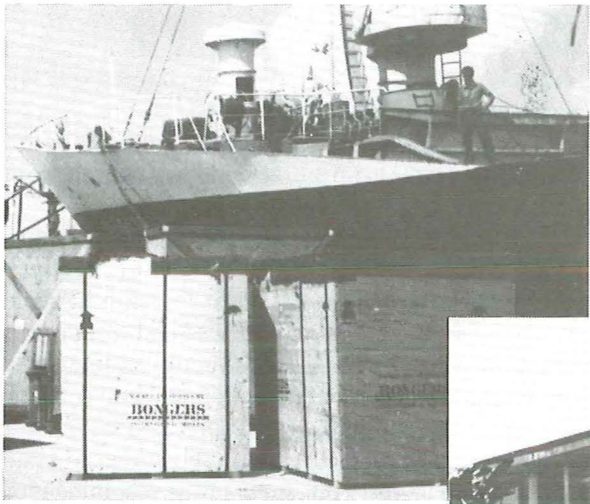
At the request of the Netherlands Directorate-General for International Cooperation (DGIS) various aspects of agricultural production and agricultural research activities within the framework of the DIAR project (Desarrollo Integral Agricola Rural), located in the Choco department of Colombia, were reviewed and recommendations made for research activities aimed at providing the farming community a package of technology that will lead to improved production within the limits of their capabilities to apply this new technology. The Consultancy/Mission Report 85/3 was submitted in January 1986. The review committee for DIAR has met 4 times in 1986 and an associate scientist has been appointed to carry out some of the recommended research activities.

For an agro-ecological characterization of Madagascar in the framework of the International Rice Research Institute (IRRI) - Madagascar Rice Research Project, a consultancy is being undertaken. It consists mainly of the establishment of an agro-climatic databank an d the preparation of a 1:1 million agro-climatic map of Madagascar; the establishment of agro-meteorological stations at six agricultural experiment sites throughout the country; and a training course in agro-climatology at the Centre National de la Recherche Appliquée au Développement Rural (FOFIFA).

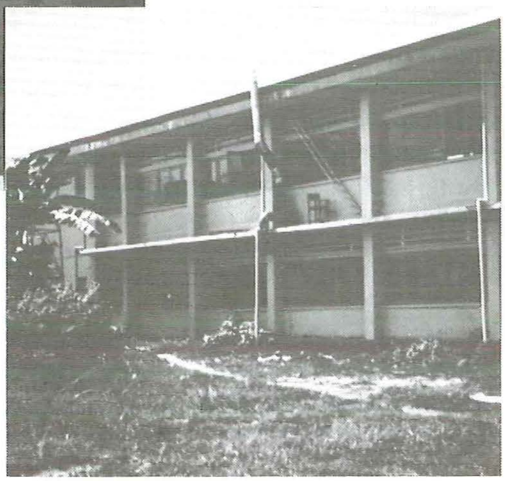
The consultancy is a combined desk study at ISRIC to inventorize and interpret environmental data on soils and climate of Madagascar, and a field study to be carried out in 1987. The consultancy is financed through IRRI by USAID. A two-week orientation visit to Madagascar was carried out in October 1986 as well as a 10-day visit to IRAT centre in Montpellier, the IRAT reference centre in Nogent-sur-Marne, and to the ORSTOM documentation centre in Paris. A total of 150 sites with long-term historic climatic records has been retrieved to form the agro-climatic databank of Madagascar.

Furthermore, an IRRI/WMO special report was finalized on "Responce of Rice to Weather Variables". It was prepared for and presented at a Workshop on "Impact of Weather parameters on the growth and yield of rice", held at IRRI, Philippines, in April 1986. An abbreviated version of the report was prepared for inclusion in the proceedings of this workshop, to be published in 1987.

An Inter-Center workshop entitled "Agro-ecological Characterization, Classification and Mapping" was organized by ICARDA, held at FAO, Rome. A Working Paper and Preprint 86/2 was prepared and presented: "Characterization of main experimental sites and sub-sites and questions of instrumentation". Proceedings of the workshop will be published in 1987.



Laboratory equipment on its way to Ambon



Soil laboratory Maluku Regional Development Project

**Installation of a soil laboratory in Indonesia**

Maluku Regional Development Project, University of Pattimura, Ambon, Indonesia.

This consultancy was carried out for ITC/DGIS by ISRIC's laboratory analists Messrs. J.R.M. Huting and A.J.M. van Oostrum in January-April 1986. The objective was to establish a soil and plant analysis laboratory and to give instruction and training to personnel in analytical methods and laboratory management. The consultancy included also the selection, purchase and shipment of all apparatus, chemicals and materials, and the putting into operation of the laboratory as a whole.

**Cooperation with the People's Republic of China**

Since 1980 a cooperative programme has been functioning between the Nanjing Institute of Soil Science of the Academia Sinica and ISRIC, for strengthening scientific relations and exchanges. This programme is jointly funded by the Academia Sinica (Chinese Academy of Sciences) and the Royal Netherlands Academy of Arts and Sciences (KNAW). The programme includes exchange visits by soil scientists.

From 25 October 1986 - 25 January 1987 Mr. Luo Guobao stayed at ISRIC for a literature study on soil classification systems; soil survey and land evaluation methods; study of some laboratory methods; introduction to computer storage of soil data, and techniques of preparation of soil monoliths.

## 4.3 MISCELLANEOUS PROJECTS

### International Collection of Reference Laterite Profiles (CORLAT)

As already outlined in Annual Report 1985, the programme of support to the extablishment of an interdisciplinary collection of reference laterite profiles continued. In spite of the lack of funds, special attention was paid to the promotion of the programme and, thanks to the volunteer Secretary Mr. M.L. Moura and Working Party some activities were developed:

- Dr. C.R.M. Butt (CSIRO, Australia) proceeded with the arrangements for sampling two bauxite-profiles in the Darling Ranges, Australia. The first samples (lump samples and drill cuttings) have arrived at ISRIC.
- Prof. G. Stoops (University of Ghent, Belgium), jointly with Dr. E. Zainol (Rubber Research Institute, Malaysia), organized the collection of a representative laterite profile near Malacca, Peninsular Malaysia.
- Thin sections of the first CORLAT profile (Trombetas, Brazil) were dispatched to Prof. Stoops for micromorphological studies.

Information on the programme was distributed to interested scientists during the Symposium of Geochemistry of the Earth Surface and Processes of Mineral Formation, Granada, Spain.

In 1987, the procurement of financial support will be discussed with interested parties.

### The application of lateritic materials in civil engineering

In Annual Report 1985 a description of this research project is given. Between January and July 1986 the following activities were carried out by guest researcher Mr. F.A.J. van den Steen van Ommeren.

- A progress report was prepared on the basis of a literature study. It includes some preliminary conclusions on classification and testing of laterites for road construction purposes. It was found that difficulties mainly concern a useful classification of the various types of laterite, and the identification of their possible uses as construction material. What is needed is a generally accepted "Laterite-Technology", by means of which laterite samples can be tested with simple methods and with which the specific characteristics, such as hardening on exposure, can be determined.
- An experimental plate bearing test was set up, and a first trial was conducted in the laboratory on a sand sample to assess its suitability in predicting the bearing capacity of base material. A report of the findings was made. Further research is needed for more definite conclusions on the method.
- A possible follow-up programme of activities was formulated. However, as no funds could be secured, the research project ended in July. Part of the work, expecially the testing of the lateritic materials, will be continued by the Department of Civil Engineering and Irrigation of Wageningen Agricultural University.

**'Soils of the World' wall chart**

This cooperation project of Elsevier Publishing Company and ISRIC, and supported by FAO and Unesco, embraces the production of a wall chart of about 110 × 160 cm. It shows 106 colour photographs of soils illustrating the units of the FAO-Unesco Soil Map of the World legend and enlists seven soil classification systems (from Australia (2 systems), Canada, England and Wales, France, Fed. Rep. of Germany, and the United States of America). All the soils will be correlated in these systems, as far as this is feasible. Mr. J.H.V. van Baren was responsible for the scientific content of the chart, in close cooperation with Prof. R. Dudal, Catholic University Leuven, Belgium. It will become available early 1987.

Logos of the Laboratory Methods and Data Exchange Programme LABEX, the Collection of Reference Laterite Profiles CORLAT, and the National Soil Reference Collection programme NASREC.

# 5 GUEST RESEARCH

## Ferralsols and similar soils. Characteristics, classification and limitations for land use

*Prof. Dr. E. Klamt,* Soil Science Department of UFRGS, Porto Alegre, Brazil.
Period: 25 January 1985 - 30 January 1986 and 21-28 August 1986.
Funding: Federal University of Rio Grande do Sul (UFRGS)/Conselho Nacional de Pesquisa (CNPq).

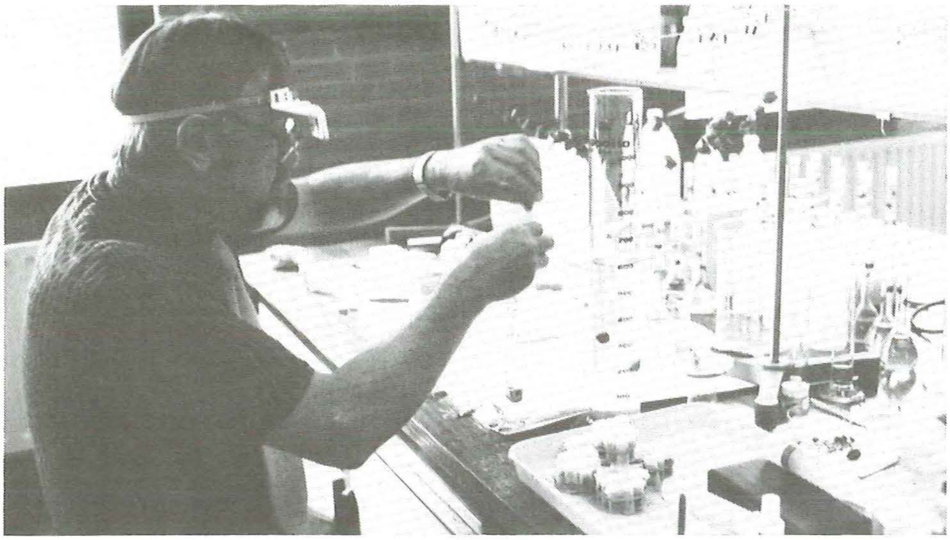
The broad aims of this research project are to evaluate the variability of properties of Ferralsols and similar soils, such as low-activity-clay Nitosols, Acrisols, Cambisols and Luvisols, to obtain criteria for taxonomic and capability classification and land evaluation for agricultural development.

Fifty-eight monoliths of the ISRIC collection, described and sampled in eighteen countries, were selected for this study. In addition to the morphological properties and environmental information described in the field, physical, chemical and mineralogical characteristics have been determined in the laboratory, using a uniform methodology. The data are analyzed statistically to assess their variability, correlation and clustering. The research is carried out in close cooperation with regular ISRIC staff.

The results will be published in 1988 as Soil Monograph 3.

## Studies on Vertisols

*Prof. Dr. J.W. McGarity,* University of Armidale, New South Wales, Australia.
Period: 1 August - 24 December 1986.



Guest researcher Prof. McGarity

Funding: Fellowship of the Netherlands' Ministry of Agriculture and Fisheries - International Agricultural Centre.

The aims of this research project are to study and evaluate the variability of properties of Vertisols and similar soils present at ISRIC's collection, including also data from research already carried out by Dr. McGarity in Australia. The work concentrated on bulk density determination, COLE values - for its determination a new method was developed -, dispersion index, and micromorphology. Furthermore, attention was given to morphological characteristics, especially the occurrence and form of cracks, slickensides and aggregates.

Due attention was given to the development of an improved horizon nomenclature and to various aspects of classification of Vertisols.

Two publications are foreseen to appear in 1988.

**The state of research of African soils in European countries.**

*Prof. Dr. K. Kyuma,* Kyoto University, Japan.
Period: 11 July - 16 September 1986.
Funding: Ministry of Education, Science and Culture, Japan.

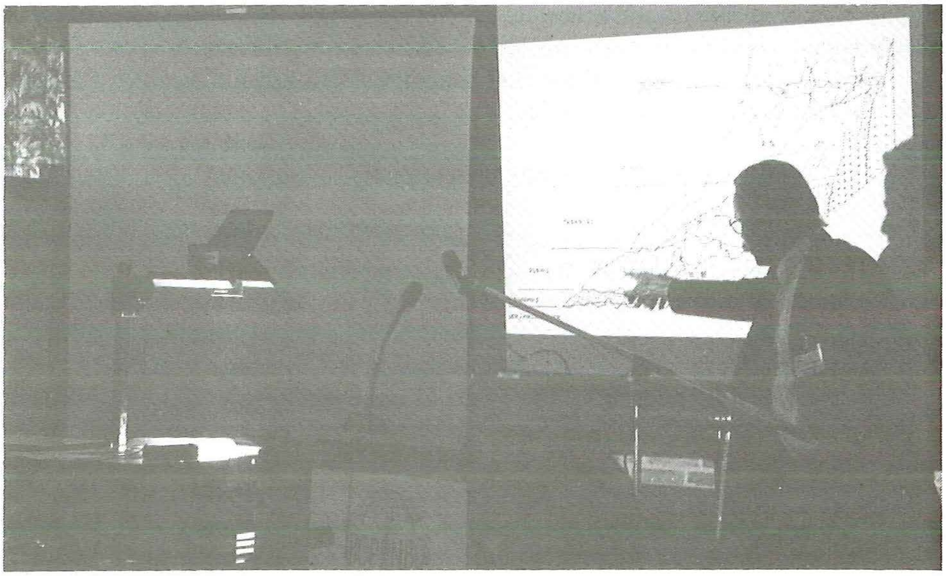
The purpose of Dr. Kyuma's stay at ISRIC was a search for literature and other information of African soils, as available in Belgium, France, the Netherlands and the United Kingdom, and to know about ongoing and newly planned activities. Japan wants to participate in soil research activities in Africa, and it was found imperative to learn from the experience of other scientists and institutions.

# 6 TRAVEL AND MISSIONS

**(86/1) Visit to Brazil,** February 1986. *Participant: W.G. Sombroek.*

Discussions with Government Institutions in Brasilia, especially the Brazilian Forest Development Institute (IBDP), on a joint forest-ecological research programme to be undertaken in the lower Tapajos or other areas of the Amazon region, on behalf of the Dutch-originated "Tropenbos" programme.

Discussions with the National Soil Survey organization (EMBRAPA-SNLCS) in Rio de Janeiro, on continuation of cooperation with ISRIC.



ISRIC director Dr. Sombroek contributes to a meeting on the research programme on tropical forests "Tropenbos".

**(86/2) Meeting Working Group on Rice-Weather Studies,** Ithaca, U.S.A., February 1986. *Participant: L.R. Oldeman.*

Finalization of a technical report on the 1982-1985 rice weather studies: a joint IRRI-WMO project, financed by UNDP. Oldeman participated earlier in this project as project manager, supported by the Netherlands Directorate-General for International Cooperation (DGIS), as erstwhile guest researcher of the Netherlands Soil Survey Institute (see also 86/4).

**(86/3) Meeting Geochemistry of the Earth Surface and Process of Mineral Formation,** Granada, Spain, March 1986. *Participant: M.L. Moura.*

To investigate possible cooperation in research on laterites (project proposal to EEC); exchange of information and cooperation in profile collection and sampling of laterite reference profiles; introduction on CORLAT research project and discussion on its further development possibilities (EUROLAT-meeting).

**(86/4) Workshop Impact of Weather Parameters on Growth and Yield of Rice,** Los Baños, Philippines, April 1986. *Participant: L.R. OLdeman.*

Presentation of the results of a technical report: "Response of Rice to Weather Variables", by L.R. Oldeman, D.V. Seshu, and F.B. Cady.

**(86/5) CGIAR Inter-Center Workshop on Agro-ecological Characterization, Classification, and Mapping,** FAO, Rome, Italy, April 1986. *Participants: L.R. Oldeman and W.G. Sombroek.*

Presentation of a paper on "Characterization of Main Experimental Sites and Sub-sites, and questions on Instrumentation", by L.R. Oldeman. The workshop drafted a series of recommendation to the institutes that are cooperating in the Consultative Group of International Agricultural Research (CGIAR), based on the urgent need to improve the various climatic and soil databases currently established or in progress and to facilitate exchange of the data in order to improve efforts to characterize, classify and map the agro-ecological environment.

**(86/6) Soil profile collection and study tour to Brazil,** March-May 1986. *Participant: J.H. Kauffman.*

During this second monolith sampling and training tour, fifteen sites in the states of Alagoas, Pernambuco, Goias, Federal District, Minas Gerais and Paraiba were visited. At each site three or four soil profiles were taken; one for ISRIC's world collection, and the others for the national and regional collections which will be housed at EMBRAPA-SNLCS in Rio de Janeiro and Recife, and EMBRAPA-CPAC in Planaltina.

During this work several staffmembers of these institutes were trained. Several aspects on preparation, display and use of soil reference collections were explained and discussed in several sessions.

**(86/7) Visits to Brazil, Costa Rica and Mexico,** May 1986. *Participant: W.G. Sombroek.*

- Participation in the eighth international soil classification workshop for improvement of the USDA "Soil Taxonomy" system of soil classification, concentrating on the Oxisol order (ICOMOX), organized by SMSS and EMBRAPA-SNLCS in Brazil.
- Discussions on regional interest for the preparation of a digitized World Soils and Terrain Map and Data Base at a scale of 1:1 million (SOTER) with national institutions and regional research and development centres (IICA and CATIE in Costa Rica).
- Factfinding on facilities and institutional support for the possible holding of the 14th International Congress of Soil Science in 1990 in Latin America (Brazil and Mexicio).

**(86/8) Fifth Workshop on Land Evaluation for European Community Countries,** Brussels, Belgium, June 1986. *Participant: L.R. Oldeman.*

A one-day workshop to develop a methodology for land evaluation for E.C. countries: more emphasis is needed on machine readable storage of collected information on soil and climatic data; assessment and adaptation of the FAO Agro-ecological Zones project for European conditions in the light of possible uses of the 1:1 million soil map of E.C. countries.

**(86/9) World Digital Database for Environmental Sciences (WDDES) Workshop,** Geneva, Switzerland, July 1986. *Participant: L.R. Oldeman.*

On behalf of ISSS, a summary of the draft proposal on the World Soils and Terrain Digital Database at a scale of 1:1 million (SOTER) was presented. Participants expressed desire for future cooperation between ISSS and WDDES.

**(86/10a) 13th International Congress of Soil Science,** Hamburg, Fed. Rep. of Germany, August 1986. *Participants: J.H.V. van Baren and D. Creutzberg.*

To represent ISRIC at a poster exhibition and discuss possibilities for cooperation with a number of countries; participation in plenary sessions and meetings.

**(86/10b) 13th International Congress of Soil Science,** Hamburg, Fed. Rep. of Germany, August 1986. *Participant: W.G. Sombroek.*

Presenting, as Secretary-General of ISSS, the Society's report over the past four years to the General Assembly. Preparation and reporting upon the four sessions of the ISSS Council. Chairing of a UNEP symposium on National Soil Policies and of an inaugural meeting of the ISSS Working Group on a digitized international soil and terrain map (WG/DM). Participation, as observer, in an IBSRAM Board meeting. Confirmation of mandate as ISSS Secretary-General for another four-year period.

**(86/11) Annual meeting of CASAFA,** Berlin, Fed. Rep. of Germany, August-September 1986. *Participant: W.G. Sombroek.*

Attending the annual meeting of standing Commission on the Application of Science to Agriculture, Forestry and Aquaculture (CASAFA), of the International Council of Scientific Unions (ICSU), hosted by the Deutsche Forschungs Gemeinschaft (DFG).

**(86/12) General Assembly of the International Council of Scientific Unions (ICSU),** Bern, Switzerland, September 1986. *Participant: W.G. Sombroek.*

Strengthening of relationships of ISSS with ICSU's Executive Board, its national members, scientific Union members and its standing committees. Participation in the discussions on ICSU's new multidisciplinary research programme on past and future Geosphere-Biosphere interactions and trends ("Global Change").

**(86/13) Visit to several institutions in Belgium,** September 1986. *Participant: W.G. Sombroek.*

- Attending the fourth meeting of the FAO-ISRIC working group on revision and elaboration of the FAO-Unesco Legend terminology for the Soil Map of the World (Leuven).
- Discussion with the EEC-related Office for Cooperation in Education in Brussels on a joint request by a number of Soil Departments of Universities in the EEC for financial support to strengthen the educational functions of ISRIC.
- Participation in discussions with representatives of several EEC-Directorates in

**(86/14) Golden Jubilee Meeting of the Soil Science Society of America,** New Orleans, November-December 1986 and visit to International Institutions in Washington.
*Participant: W.G. Sombroek.*

Formal representation of ISSS at the 1986 annual meeting of the Agronomy, Crop and Soil Science Societies of the USA.

Discussions of prospect for funding of SOTER project with officials of World Bank, World Resources Institute, Resources for the Future Inc., and the EEC-Worldbank SPAAR programme.

**(86/15) Soil profile collection and study tour to Mali,** October-November 1986.
*Participant: J.H. Kauffman.*

The first phase of this NASREC activity consisted mainly of a field programme, which was executed from 16 October to 30 November 1986.

From the three main ecological zones, Sahara, Sahel and Sudan zones two series of nine soil profiles were taken: one for ISRIC's world soil collection and the other for the National Reference Collection of Mali. For more details see Chapter 5.

**Note:** Reports 86/7, 86/11, 86/12, 86/14 concern partly or wholy travels by W.G. Sombroek in his capacity of Secretary-General of the International Society of Soil Science (ISSS).


Recording soil data for easy entering into the ISRIC Soil Information System (ISIS) is partly done in the field with this portable computer.

# 7 RELATIONS WITH OTHER INSTITUTIONS

## 7.1 INTERNATIONAL RELATIONS AND ACTIVITIES

Contacts and activities with international institutions included the following:

*Food and Agricultural Organization of the United Nations* (FAO, Rome)
- Further development of an improved legend for small-scale soil mapping, as a successor to the FAO-Unesco Soil Map of the World Legend.
- Collection of maps for the updating of the FAO-Unesco Soil Map of the World at scale 1:5 million, and for a digitized soil and terrain map at 1:1 million.
- Exchange of publications and documentation on soils and their management, agro-climatic zones, etc.
- Start of consultancy to apply the Revised Legend of the Soil Map of the World, and to assess the extent and quality of irrigable lands, both at scale 1:1 million, for several countries in north-eastern Africa.

*United Nations Educational, Scientific and Cultural Organization* (Unesco, Paris)
- Finalizing and co-distribution of a MAB Technical Note (no. 17) on Guidelines for Soil survey and Land evaluation in Ecological Research, on the basis of an earlier Unesco-ISRIC cooperative programme for soil studies in "Man and Biospher" reserves and research sites (see previous Annual Reports).
- Unesco's financial support and identification of candidates for ISRIC's International Course on the Establishment and Use of National Soil Reference Collections.

*United Nations Environment Programme* (UNEP, Nairobi)
- Advise on the promotion of UNEP's World Soils Policy.
- UNEP/DGIS financial support, through its "Clearing House Facility", for ISRIC's programme to assist in the establishment of national soil reference collections in a number of developing countries (NASREC programme).
- Discussions on a UNEP proposal to assess the global extent of soil degradation, and its quantification in several pilot areas.

*International Society of Soil Science* (ISSS)
- Administrative assistance to the Secretariat-General of ISSS, housed at ISRIC.
- Organizing and editing of the book-review section of the six-monthly Bulletin of the Society.
- Participation in the ISSS Working Group "International Reference Base for soil classification" (WG/RB), through formulation of proposals and assembling of documentation.
- Participation in the ISSS Working Group on the preparation of a digitized international soil and terrain map (WG/DM).
- Establishment of a reference collection of soil thin sections for the ISSS Subcommission of Soil Micromorphology.

- Registration of visual training aids on soil science.
- Repository of biographical material on outstanding soil scientists and on the early history of organized soil science for the ISSS Working Group on the History, Philosophy and Sociology of Soil Science (WG/HP).

*Other international contacts*

- Commission of the European Communities (Brussels); submission and screening of research proposals; contacts on support for educational function of ISRIC.
- International Service for National Agricultural Research (ISNAR, The Hague); exchange of programmes information.
- International Development Research Centre (IDRC, Ottawa); support for soil data centres.
- Institut français de recherche scientifique pour le développement en coopération (ORSTOM, Paris); exchange of information.
- Centre Technique de Coopération Agricole et Rurale of EEC/Lomé Convention countries (CTA, Wageningen/Ede); exchange of data.
- U.S. Agency for International Development (USAID) and several of its soil-related programmes (IBSNAT, SMSS); exchange of information; attendance of workshop; requests for financial support.
- Several of the International Agricultural Research Centres of the Consultative Group of International Agricultural Research (IITA, IRRI, CIAT, ICARDA); exchange of information.
- International Union of Biological Sciences (IUBS); cooperation on formulation of a proposal for network research on Tropical Soil Biology and Fertility (TSBF), and preparation of a manual for the project (site selection and characterization; methods for chemical analysis of soil and water samples).
- National Soil Survey and Soil Research Institutes in many countries.

## 7.2 NATIONAL RELATIONS AND ACTIVITIES

- Royal Netherlands Academy of Arts and Sciences (KNAW, Amsterdam); continuation of cooperation programme with Nanjing Institute of Soil Science of the Academia Sinica; participation in a Dutch national committee for CASAFA.
- International Institute for Aerospace Survey and Earth Sciences (ITC, Enschede); management servicing of ISRIC; lecturing at ITC Soils Course; analysis of soil and water samples; soil data base development.
- Department of Science Policy of the Dutch Ministry of Education and Sciences (MOW-WB, The Hague); cooperation on the elaboration of a multidisciplinary research programme on tropical forests (Tropenbos).
- Centre for World Food Studies (SOW, Wageningen/Amsterdam); exchange of information.
- Department of Soil Science and Geology of Wageningen Agricultural University; cooperation on clay mineralogy; exchange of information; representation at international meetings; lecturing.

- International Agricultural Centre (IAC, Wageningen); visitors accommodation; guest researcher's fellowships; advice on soil-related projects in developing countries.
- M.Sc. Course in Soil Science and Water Management of Wageningen Agricultural University; guidance of students at thesis work.
- Netherlands Soil Survey Institute (Stiboka, Wageningen); cooperation on micromorphology, including methodology of description; exchange of information; representation at international meetings.

Staff and some equipment of the laboratory of Maluku Regional Development Project, Ambon, Indonesia. ISRIC aided in the establishment of the laboratory and training of its personeel in 1985 and 1986.

# 8 PERSONNEL

## 8.1 BOARD OF MANAGEMENT

Members of the Board of Management on 31 December 1986 were:

- Prof. Dr. Ir. F.R. Moormann, Chairman Netherlands Advisory Council
- Prof. Dr. L. van der Plas, Wageningen Agricultural University
- Ir. P. van der Schans, International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede
- Dr. Ir. F. Sonneveld, Directorate for Agricultural Research, Ministry of Agriculture and Fisheries, Wageningen (Chairman)
- Prof. Dr. Ir. T. Wormer (personal member).

## 8.2 INTERNATIONAL ADVISORY PANEL

The International Advisory Panel (IAP) met in 1967, 1972, 1979 and 1983. The members of the last IAP were:

- Dr. F. Fournier, Division of Ecological Sciences, Unesco, Paris, France
- Dr. H. Ghanem, Institut Agronomique et Vétérinaire, Rabat, Morocco (for Northern Africa)
- Prof. E.G. Hallsworth, IFIAS Save-Our-Soils Project, Brighton, U.K. and past President ISSS (for Australia and ISSS)
- Mr. G.M. Higgins, Land and Water Development Division, FAO, Rome, Italy
- Dr. C.S. Holzhey, USDA Soil Conservation Service, Lincoln, Nebrasca, U.S.A. (for North America)
- Dr. M. Jamagne, Service d'Etude des Sols et de la Carte Pédologique de France, Olivet, France (for Western Europe)
- Mr. F.N. Muchena, Kenya Soil Survey, Nairobi, Kenya (for Africa South of the Sahara)
- Dr. A. Osman, Soil Science Division, Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD), Damascus, Syria (for the Middle East)
- Dr. C.R. Panabokke, Sri Lanka (for South and East Asia): could not attend
- Dr. C. Valverde, Programa Nacional de Suelos, Lima, Peru: at present International Service for National Agricultural Research (ISNAR), The Hague, the Netherlands (for Latin America and CGIAR institutes)
- Dr. G. Varallyay, Research Institute for Soil Science and Agricultural Chemistry, Budapest, Hungary (for Eastern Europe).

## 8.3 NETHERLANDS ADVISORY COUNCIL

Members of the NAC on 31 December 1986 were:

- Ir. J.G. van Alphen, International Institute for Land Reclamation and Improvement,

Wageningen
- Dr. J.P. Andriesse, Royal Tropical Institute, Amsterdam
- Dr. Ir. N. van Breemen, Soil Science Society of the Netherlands, Wageningen
- Prof. Dr. Ir. A. van Diest, Royal Netherlands Society of Agriculture, Wageningen
- Dr. Ir. P.M. Driessen, Centre for World Food Studies, Amsterdam-Wageningen
- Dr. Ir. J.C. Dijkerman, M.Sc. Course in Soil Science and Water Management, Wageningen Agricultural University
- Dr. Ir. G.W.W. Elbersen, International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede
- Ir. J. van der Heide, Institute for Soil Fertility, Haren
- Ir. W.B. Hoogmoed, Soil Tillage Laboratory, Wageningen Agricultural University
- Dr. F. Kadijk, Laboratory for Soil and Crop Testing, Oosterbeek
- Dr. Ir. T. de Meester, Department of Soil Science and Geology, Wageningen Agricultural University
- Prof. Dr. Ir. F.R. Moormann, State University Utrecht (Chairman)
- Dr. F.W.T. Penning de Vries, Centre for Agrobiological Research (CABO), Wageningen
- Dr. J.F.Th. Schoute, Free University, Amsterdam
- Dr. J. Sevink, University of Amsterdam
- Prof. Dr. A.W.L. Veen, State University Groningen
- Dr. Ir. P.K.J. van der Voorde, Euroconsult, Arnhem
- Ir. W. van Vuure, Directorate for Agricultural Research, Ministry of Agriculture and Fisheries, Wageningen
- Drs. R.F. van de Weg, Soil Survey Institute, Wageningen
- Ir. A.L.M. van Wijk, Institute for Land and Water Management Research (ICW), Wageningen

Mutations:
Ir. B. van Heuveln (State University Groningen) is succeeded by Prof. Dr. A.W.L. Veen; Dr. Ir. J. Bouma (Soil Science Society of the Netherlands) by Dr. Ir. N. van Breemen; and Ir. A.L.M. van Wijk (ICW) replaced Dr. Ir. G.P. Wind.

## 8.4 ISRIC STAFF

Staff members of ISRIC on 31 December 1986 were:

| | |
|---|---|
| Dr. Ir. W.G. Sombroek | : Director, soil classification and correlation, soil ecology |
| Drs. J.H.V. van Baren | : Curator, documentation and publications |
| Drs. D. Creutzberg | : Soil micromorphology, educational affairs |
| Ir. J.H. Kauffman | : Senior soil scientist |
| Dr. Ir. L.R. Oldeman | : Agricultural applications |
| Ir. L.K. Pleijsier | : Labex programme secretary |
| Dr. Ir. L.P. van Reeuwijk, M.Sc. | : Soil chemistry, mineralogy and physics |
| Ing. R.O. Bleyert | : Soil micromorphology, map documentation |

| | |
|---|---|
| W.C.W.A. Bomer | : Technician, photography and drawing |
| Ing. A.B. Bos | : Monolith preparation, technical services, soil documentation |
| J. Verhagen | : Monolith preparation |
| J. Brussen | : Internal administration* |
| J.R.M. Huting | : Laboratory analyst |
| B. van Lagen | : Laboratory analyst |
| A.J.M. van Oostrum | : Senior laboratory analyst |
| J.D. Scheiber | : Technician, thin-section preparation |
| R.A. Smaal | : Laboratory analyst |
| Ms. M.B. Clabaut<br>Ms. Y.G.L. Karpes-Liem | : Clerical services |
| Ms. J.C. Jonker-Verbiesen | : Library assistant |

* External administration by ITC, Enschede.

## 8.5 GUEST RESEARCHERS

Soil and other scientists working at ISRIC during (part of) 1986 as guest researchers were:

- Prof. M.F. Baumgardner, U.S.A.
- Ir. P. Kiepe, the Netherlands
- Prof. Dr. E. Klamt, Brazil
- Ir. J. Kuyper, the Netherlands
- Dr. K. Kyuma, Japan
- Mr. Luo Guo-bao, People's Republic of China
- Prof. J.W. McGarity, Australia
- Drs. M.L. Moura, the Netherlands
- Dr. N.M. Pons-Ghitulescu, the Netherlands
- Ir. F.A.J. van den Steen van Ommeren, the Netherlands
- Ir. R. Swart, the Netherlands

# APPENDIX 1 - GROUP VISITS IN 1986

## Professional

| Institutions | Approximate number of persons |
|---|---|
| *Belgium* | |
| University of Ghent | 16 |
| University of Leuven | 20 |
| *Fed. Rep. of Germany* | |
| University of Aachen | 25 |
| University of Bochum | 20 |
| University of Bonn | 15 |
| University of Hamburg | 2 visits of 45 |
| Fachhochschule Osnabrück | 2 visits of 25 |
| *Japan* | |
| Representatives of several Agricultural Institutes | 16 |
| *The Netherlands* | |
| Free University, Amsterdam | 12 |
| University of Amsterdam | 30 |
| International Institute of Hydrologic and Environmental Engineering, Delft | 46 |
| National Agricultural College, Deventer | 2 visits of 24 |
| Agricultural College, Dronten | 3 |
| International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede | 2 visits of 30 |
| Agricultural College, Groningen | 10 |
| University of Groningen | 5 |
| Institute for Soil Fertility, Haren | 30 |
| Agricultural School, Hoofddorp | 45 |
| IJsselmeer Development Authority, Lelystad | 6 |
| University of Utrecht | 45 |
| College for Forestry and Land and Water Management, Velp | 2 visits of 10 |
| International Agricultural Centre Fertilizing Course, Wageningen | 15 |
| International Course for Development Oriented Research in Agriculture (ICRA), Wageningen | 18 |
| International Institute for Land Reclamation and Improvement (ILRI), Wageningen | 30 |
| Netherlands Advisory Council ISRIC, Wageningen | 16 |
| Plant Protection Service, Wageningen | 14 |
| Wageningen Agricultural University | 16 visits of 26 |
| *People's Republic of China* | |
| Delegation of agronomists | 7 |
| *Poland* | |
| Deans and representatives of several Universities | 6 |
| *United Kingdom* | |
| School of Geography and Geology, Cheltenham | 25 |
| Portsmouth Polytechnic | 18 |
| *Various* | |
| Participants ISSS Pre-Congress tour | 22 |
| Participants ISSS Post-Congress tour | 18 |
| Participants Labex Workshop | 63 |

# APPENDIX 2 - LABORATORIES PARTICIPATING IN THE LABORATORY METHODS AND DATA EXCHANGE PROGRAMME (LABEX)

ARGENTINA
Secretaria de Agricultura
INTA
Departamento de Suelos
1712 Castelar F.C.S.

AUSTRALIA
CSIRO Davies Laboratory
Private Bag
Aitkenvale, QLD 4814

CSIRO Division of Soils
Private Bag no. 2
Glen Osmond, SA 5064

Dept. of Primary Industries
Meiers Road
Indooroopilly, QLD 4068

AUSTRIA
Institut für Bodenforschung
Gregor-Mendelstrasse 33
A-1180 Wien

BELGIUM
Geologisch Instituut
Krijgslaan 281 - S8
B-9000 Gent

BENIN
Centre Nat.
d'Agro-Pédologie
B.P. 988
Cotonou

BOLIVIA
CIAT, Bolivia
Casilla 247
Santa Cruz

BOTSWANA
Soil Mapping and Advisory Unit
P.O. Box 54
Gaborone

BRAZIL
SNLCS-EMBRAPA
Rua Jardim Botanico 1024,
Gavea
22460 Rio de Janeiro, RJ

Instituto Agronomico
C.P. 28
13020 Campinas, SP

BURKINA FASO
Bureau National des Sols
B.P. 7028
Ouagadougou

CAMEROON
IRA/CNS Ekona
PMB 25
Buea

CANADA
Canadian Forestry Service
5320, 122 Street
Edmonton, Alberta
T6H 3S5

Land Resource Research Inst.
Central Experimental Farm
Neatby Bldg.
Ottawa, Ontario
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'Agustin Codazzi'
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Bogota

CIAT
Apartado Aereo 6713
Cali

Colombian Agric. Institute
ICA
Apartado Aereo 2316
Barranquila

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CATIE
Turrialba

Universidad de Costa Rica
Ciudad Univ. 'Rodrigo Facio'
San Jose

CUBA
Instituto de Suelos
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Giza

Soil Science Department
El Minia University
El Minia

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Bundesanst. f. Geowissenschaften
Postfach 51 01 53
D-3000 Hannover 51

Universität Hamburg
Allende-Platz 2
D-2000 Hamburg 13

GHANA

Soil Research Insittute
Academy Post Office
Kwadaso, Kumasi

GREECE

Agricultural Research Service
Land Reclamation Institute
574 00 Sindos

HUNGARY

Plant Protec. and Agric. Station
Pf. 127
H-1502 Budapest

Research Inst. for Soil Science
Herman Otto u. 15
H-1022 Budapest

INDIA

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Regional Centre, Hebbal
Bangalore 560 024

Adv. Centre for Black Soil Res.
Dharwad Campus
Dharwad 580 005

INDONESIA

Centre for soil Research
Jalan Ir. H. Juanda 98
Bogor

Brawijaya Univ. Dept. Soil Sc.
Jalan Mayjen Haryono 163
Malang

IRAN

Soil Institute of Iran
Kargar Shomali Avenue
Teheran

IRELAND

National Soil Survey
Johnstown Castle
Wexford

JAMAICA

Jamaica Soil Survey Project
P.O. Box 390
Half Way Tree
Kingston 10

JAPAN

Hokkaido University
Faculty of Agriculture
Kita 9, Nishi 9, Kita ku
Sapporo 060

Laboratory of Soils
Kyoto University
Kitashirakawa, Sakyo ku
Kyoto 606

Tropical Agric. Research Centre
1-2 0-washi
Yatabe Tsukaba
Ibaraki 305

JORDAN

Soils Division JVA
P.O.B. 2769
Amman

KENYA

Kenya Soil Survey
P.O. Box 14733
Nairobi

MALAWI

Chitedze Research Station
P.O. Box 158
Lilongwe

MALAYSIA

Soil Management Branch
Jalan Mahameru
Kuala Lumpur 10-02

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Agricultural University
Dept. of Soil Science and Plant Nutrition
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6700 EC Wageningen

ISRIC
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6700 AJ Wageningen

Lab. for Soil and Crop Testing
P.O. Box 115
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## APPENDIX 3 - ACRONYMS USED IN ANNUAL REPORT 1986

| | |
|---|---|
| ACSAD | Arab Centre for the Studies of Arid Zones and Dry Lands, Syria |
| CABO | Centre for Agrobiological Research, the Netherlands |
| CASAFA | Commission on the Application of Science to Agriculture, Forestry and Aquaculture, ICSU |
| CATIE | Centro Agronomico Tropical de Investigacion y Ensenanza, Costa Rica |
| CGIAR | Consultative Group of International Agricultural Research |
| CIAT | Centro Internacional de Agricultural Tropical, Colombia |
| CNPq | Conselho Nacional de Pesquisa, Brazil |
| CORLAT | International Collection of Reference Laterite Profiles, ISRIC |
| CPAC | Centro de Pesquisa Agropecuaria dos Cerrados, Brazil |
| CSIRO | Council for Scientific and Industrial Research, Australia |
| CTA | Centre Technique de Cooperation Agricole et Rurale, the Netherlands |
| DFG | Deutsche Forschungs Gemeinschaft, Fed. Rep. of Germany |
| DGIS | Directorate-General for International Cooperation, Ministry of Foreign Affairs, the Netherlands |
| DIAR | Desarrollo Integral Agricola Rural, Colombia |
| DLO | Directorate for Agricultural Research, Ministry of Agriculture and Fisheries, the Netherlands |
| EEC/EC | European Economic Community |
| EMBRAPA | Empresa Brasileira de Pesquisa Agropecuaria, Brazil |
| FAO | Food and Agriculture Organization of the United Nations |
| FOFIFA | Centre national de la recherche appliquée au développement rural, Madagascar |
| IAC | International Agricultural Centre, the Netherlands |
| ISBNAT | International Benchmark Sites Network for Agrotechnology Transfer, U.S.A. |
| ICARDA | The International Centre for Agricultural Research in the Dry Areas, Syria |
| ICOMOX | International Commission on Oxisols, U.S.A. |
| ICRA | International Course for Development-oriented Research in Agriculture, the Netherlands |
| ICSU | International Council of Scientific Unions |
| ICW | Institute for Land and Water Management Research, the Netherlands |
| IDRC | International Development Research Centre, Canada |
| IICA | Instituto Interamericano de Ciencias Agricolas, Costa Rica |
| IITA | International Institute of Tropical Agriculture, Nigeria |
| IRAT | Institut de recherche agronomique tropical, France |
| IRB | International Reference Base for soil classification, ISSS |
| IRRI | International Rice Research Institute, The Philippines |
| ISIS | ISRIC Soil Information System |

| | |
|---|---|
| ISNAR | International Service for National Agricultural Research, the Netherlands |
| ISSS | International Society of Soil Science |
| ITC | International Institute for Aerospace Survey and Earth Sciences, the Netherlands |
| IUBS | International Union of Biological Sciences |
| KNAW | Royal Netherlands Academy of Arts and Sciences |
| LABEX | Laboratory Methods and Data Exchange Programme, ISRIC |
| MAB | Man and the Biosphere Programme, Unesco |
| NASREC | National Soil Reference Collections, ISRIC |
| NUFFIC | Netherlands Universities Foundation for International Cooperation |
| ORSTOM | Institut français de recherche scientifique pour le développement en coopération |
| SCS | Soil Conservation Service, USDA, U.S.A. |
| SMSS | Soil Management Support Services, SCS, U.S.A. |
| SNLCS | Serviço Nacional de Levantamento e Conservaçao de Solos, Brazil |
| SOTER | World Soils and Terrain Digital Database, ISSS |
| SOW | Centre for World Food Studies, the Netherlands |
| SPAAR | Special Program for African Agricultural Research |
| STIBOKA | Netherlands Soil Survey Institute |
| TSBF | Tropical Soil Biology and Fertility Programme, IUBS/Unesco |
| UFRGS | Universade Federal do Rio Grande do Sul, Brazil |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Education, Scientific and Cultural Organization |
| USAID | United States Agency for International Development |
| USDA | United States Department of Agriculture |
| WDDES | World Digital Database for Environmental Sciences |
| WG/DM | Working Group Digitized International Soil and Terrain Map, ISSS |
| WG/HP | Working Group History, Philosophy and Sociology of Soil Science, ISSS |
| WG/RB | Working Group International Reference Base for soil classification (IRB), ISSS |
| WMO | World Meteorological Organisation. |

## PUBLICATIONS

### Soil Monolith Papers

1. Thionic Fluvisol *(Sulfic Tropaquept)* Thailand, 1981
2. Orthic Ferralsol *(Typic Haplustox)* Zambia, in prep.
3. Placic Podzol *(Placaquod)* Ireland, in prep.
4. Humic Nitosol *(Oxic Paleustalf)* Kenya, in prep.
5. Humic Acrisol *(Orthoxic Palehumult)* Jamaica, 1982
6. Acri-Orthic Ferralsol *(Haplic Acrorthox)* Jamaica, 1982
7. Chernozem calcique *(Vermustoll Typique)* Romania, 1986
8. Ferric Luvisol *(Oxic Paleustalf)*, Nigeria, in prep.

### Technical Papers

1. Procedures for the collection and preservation of soil profiles, 1979
2. The photography of soils and associated landscapes, 1981
3. A new suction apparatus for mounting clay specimens on small-size porous plates for X-ray diffraction, 1979 (exhausted, superseded by TP 11)
4. Field extract of "Soil Taxonomy", 1980, 4th printing 1986
5. The flat wetlands of the world, 1982
6. Laboratory methods and data exchange program for soil characterization. A Report on the pilot round. Part I: CEC and Texture, 1982, 3rd printing 1984
7. Field extract of "classification des sols", 1984
8. Laboratory methods and data exchange program for soil characterization. A report on the pilot round. Part II: Exchangeable bases, base saturation and pH, 1984
9. Procedures for soil analysis, 1986; 2nd edition, 1987
10. Aspects of the exhibition of soil monoliths and relevant information (provisional edition, 1985)
11. A simplified new suction apparatus for the preparation of small-size porous plate clay specimens for X-ray diffraction, 1986
12. Problem soils: their reclamation and managment (copied form ILRI Publication 27, 1980, pp. 43-72), 1986
13. Proceedings of an International Workshop on the Laboratory Methods and Data Exchange Programme: 25-29 August 1986, Wageningen, The Netherlands, 1987
14. Guidelines for the Description and Coding of Soil Data, 1987 (provisional edition)
15. ISRIC Soil Information System - User and Technical Manuals, 1987
16. Comparative classification of some deep, well-drained red clay soils of Mozambique, 1987

**Monographs**

1. Podzols and podzolization in temperate regions, 1982
   with wall chart: Podzols and related soils, 1983
2. Clay mineralogy and chemistry of Andisols and related soils from diverse climatic regions, in prep.
3. Ferralsols and similar soils; characteristics, classification and limitations for land use, in prep.

**Wall charts**

- Podzols and related soils, 67 × 97 cm, 1983 (see Monograph 1)
- Soils of the World, 85 × 135 cm, 1987 (Elsevier, in cooperation with ISRIC, FAO and Unesco)

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