

a sound reference base for soils



the "référentiel pédologique"

(text in english)



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Translation by
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D. BLANCARD
1998, 376 p.

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FOREWORD

After eight years of elaboration and thanks to the collective effort of more than a hundred scientists from various countries, we are pleased to publish the first edition in English of the *Référentiel Pédologique 1995* (R.P.).

This book comprises :

- the basic principles of the *Référentiel Pédologique*, presented in the introduction entitled “Why this Référentiel Pédologique”¹;
- the definitions of 73 **Reference horizons**;
- the description of 102 **References**, in 30 chapters of varying length;
- a glossary of 235 **Qualifiers**;
- 6 appendices dealing with “humus forms”, hydromorphic processes, recommended methods of analysis, correspondances between the FAO-UNESCO Legend and the R.P. (as far as horizons, diagnostic properties and phases are concerned), etc.;
- an index.

The *Référentiel Pédologique 1995* is a soil reference system. It takes stock of all that is known today about soils in the world (except those of the arid and intertropical regions). It is based on revised and updated concepts and offers a clear and well-defined **language**. It is not only a means of organizing present knowledge but above all an efficient **tool for transferring information** in as much detail as possible, enabling **correlations** to be established between diverse regions. It is thus far more and much better than a mere soil classification system.

Nevertheless, this edition is still not exhaustive and definitive. Further chapters are still to be elaborated in the next few years. A great amount of work remains to be carried out on soils from arid and intertropical regions. In order to supplement the “*Référentiel Pédologique 1995*” successfully, we need the help of pedologists who have studied soils under these climates. That is why we are calling on all our colleagues, from all countries, to join us

1. This introduction has also been translated into German, Arabic, Spanish, Italian, Dutch, Portuguese and Russian. These translations are available, on request.

and help us in defining and naming the soils of these areas, according to the basic principles which have now been well-established.

The reader will find on the following page the translation options we have taken in order to go from the original French text to the present English version.

Denis BAIZE
Association Française
pour l'Étude du Sol²

WARNING TO READERS

TRANSLATION OPTIONS TAKEN IN THIS BOOK

Translation of the names of Reference horizons

We did not want to translate or anglicize the names of Reference horizons for two reasons. Firstly, by keeping their name in French, the reader sees immediately that it is a designation according to the “Référentiel Pédologique”.

Secondly, in certain cases, it avoids confusions with other classification systems. For example, the term “*horizon calcarique*” (*Km horizon*) does not have the same definition as the “*calcaric horizon*” of the FAO-UNESCO Legend. The same applies to “*horizons S calciques*” which is completely different from how “*calcic horizon*” is defined in the FAO-UNESCO Legend.

In this book, the reader will therefore find the Reference horizons designated by their letter code:

horizons calcariques Km	<i>Km horizons</i>
horizons S calciques Sci	<i>Sci horizons</i>

in the same way:

horizons éluviques E	<i>E horizons</i>
horizons podzoliques BP	<i>BP horizons</i>
horizons pétroferriques FEm	<i>FEm horizons</i>
etc.	

Names of References

The names of References are not translated and keep their exact French spelling. For example:

ARÉNOSOLS	→ <i>ARÉNOSOLS</i>
BRUNISOLS MÉSOSATURÉS	→ <i>BRUNISOLS MÉSOSATURÉS</i>
LUVISOLS DÉGRADÉS	→ <i>LUVISOLS DÉGRADÉS</i>
PEYROSOLS PIERRIQUES	→ <i>PEYROSOLS PIERRIQUES</i>
etc.	

We remind readers that the names of References (one or two words) must be written in capital letters to distinguish them from Qualifiers which are always written in lower-case letters.

Notion of attribution (of a solum, a mapping area or a mapping unit) to one or more Reference(s).

le rattachement (mental process)	→ <i>attribution (to)</i>
rattacher	→ <i>to attribute to</i>

rattaché	→ <i>attributed to</i>
être rattaché	→ <i>to be attributed to</i>

Terms specific to the *Référentiel Pédologique*

couverture pédologique	→ <i>soil mantle</i>
horizon (pédologique)	→ <i>horizon (= soil horizon)</i>
solum, solums	→ <i>solum, sola</i>
solum diagnostique	→ <i>diagnostic solum, or diagnostic horizon sequence</i>
Qualificatif	→ <i>Qualifier</i>
formes d'humus	→ <i>humus forms</i>
type fonctionnel d'humus	→ <i>behavioural type of humus</i>
ensemble Cognat	→ <i>Cognate set</i>
grand ensemble de Références (GER)	→ <i>major group of References (MGR)</i>
pédopaysage	→ <i>soil landscape</i>

Translations of neologisms

When writing the *Référentiel Pédologique*, we preferred creating new words for new concepts rather than giving new definitions to existing words which are already overloaded with various meanings and connotations.

The neologisms have been kept but put in an anglicized form. Examples:

holorganique	→ <i>holorganic</i>	anacarbonaté	→ <i>anacarbonated</i>
brunifié	→ <i>brunified</i>	palusmectique	→ <i>palusmectic</i>
penévolué	→ <i>penevolved</i>	pélosolique	→ <i>pelosolic</i>
anthropisé	→ <i>anthropized</i>	rédoxique	→ <i>redoxic</i>
gigalotique	→ <i>gigaliotic</i>	réductique	→ <i>reductic</i>
irragrique	→ <i>irragric</i>	etc.	
ondulique	→ <i>undulic</i>		

The word “carbonate” and its family

Several words from the “carbonate” family are difficult to put into English. Here are the translation options retained.

in French	in English
carbonate(s)	<i>carbonate(s)</i>
carbonaté (solum, horizon)	<i>carbonate-rich</i> (NB: here, “rich” means “which may contain varying amounts of” and not “which contains a lot of”).
décarbonatation	<i>decarbonatation</i> (soil process defined as a complete calcium carbonate removal)
décarbonaté	<i>carbonate-leached or completely leached of carbonates</i>
non carbonaté	<i>carbonate-free</i>
recarbonaté	<i>carbonate-enriched</i>
bathycarbonaté	<i>bathycarbonated</i> (neologism - Qualifier)
anacarbonaté	<i>anacarbonated</i> (neologism - Qualifier)
bicarbonaté	<i>bicarbonated</i> (Qualifier)

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WHY THIS *RÉFÉRENTIEL PÉDOLOGIQUE* ?

D. Baize, M.C. Girard, J. Boulaine,
Cl. Cheverry and A. Ruellan

Introduction

Since 1986 the *Association Française pour l'Étude du Sol* has undertaken a project to replace the earlier soil classification, introduced in 1967 by the *Commission de Pédologie et de Cartographie des Sols* (CPCS).

The new system presented here retains the classical morphogenetic approach, but two major innovations have been introduced :

- the objects of study are **soil mantles** which may be subdivided into horizons according to vertical or horizontal sequences ;
- the system being elaborated is not a hierarchic classification, but a soil reference system.

Soil Mantles

The word "soil" is commonly used to refer to the continuous three-dimensional and natural object forming the upper layers of the land surface. In the present soil reference system we prefer to use the term **soil mantle** which is similarly defined.

Soil mantles are composed of mineral and organic materials, in solid, liquid or gaseous forms. These constituents are so organized to form 'structures' characteristic of the soil material. Soil mantles change continuously and thus have a further dimension : time. This is why their study needs to be based on three kinds of data :

- those referring to their constitution (texture, stoniness, chemical and mineralogical composition),
- structural (organizational) data;
- data associated with dynamics, behaviour, development.

Soil mantles are usually continuous, but they may be very thin or even absent. Moreover, they are frequently modified by human activity to varied depths and to a more or less obvious degree.

They are heterogeneous continua; but the variations observed from place to place do not occur at random, because soil mantles are structured systems.

Several organizational levels may be distinguished within a soil mantle. At the lowest level various methods are used to identify soil structures ranging from the electron microscope to direct visual observation. At higher levels one may distinguish :

- **soil horizons = horizons** : these are homogeneous volumes (see below) into which soil mantles are divided.

- **pedological systems** : in these several horizons are associated and grouped in a three-dimensional space pattern. The common lateral dimension of pedological systems is the order of a hectometre, a kilometre or more; they cannot thus be observed at a single site, and further observations are required taking into account large areas (e.g. aerial photographs and satellite images).

To study soil mantles, it is necessary to auger and to dig trenches or pits for subsequent description, sampling and analytical investigation. The sites for description and sampling must be carefully chosen, using the results of a preliminary landscape analysis (geomorphology, hydrography, vegetation, etc.) and in the light of information obtained as the study progresses.

Soil mantles are affected over time by pseudo-cyclic, reversible or irreversible changes. The soil organization and some soil properties undergo periodic modification (i.e daily, seasonally, annually). Dates of observation and sampling must therefore be recorded.

Horizons

In Soil Science as in other sciences, we deal with continua by dividing them into smaller units : horizons and mapping units in a spatial context, soil types in a typological one.

The horizons are recognized by the subdivision of soil mantles into volumes considered to be appropriately homogeneous. It is clear that such homogeneity is relative and corresponds to a particular scale of investigation. The recognition of horizons clearly involves the detailed study of heterogeneity : the presence of distinct peds, the nature of the varied constituents forming the groundmass and also, of course, pedofeatures.

Because of their size (a thickness measured in centimetres or decimetres), horizons can be observed by eye in the field and samples easily taken by hand. Thus horizons are the most appropriate basic unit for describing and sampling soil mantles. The *Référentiel Pédologique* (abbreviated as R.P.) uses horizons as basic units to identify, characterize and depict soil mantles.

Each horizon has a finite volume. We need to define its **content**, by describing its constituents, its organizations, properties and analytical characteristics. We must also describe its **“container”** (its extent and the nature and form of

its boundaries). The vertical size of a horizon can be as little as a centimetre but often horizons are some decimetres thick or even a metre in places. Laterally, they have at least a decimetre wide but often can extend to a hectometre or several kilometres. A horizon is not infinite : it either fades laterally or passes gradually into another horizon. Its spatial extension is measurable.

The upper and lower limits of a horizon are often approximately parallel to the land surface. A horizon may however also occur as lenses or tongues, and it may even be completely surrounded by another horizon. Transitions between horizons may be clear or more or less progressive. Each horizon is almost always associated closely with other horizons and is tied to them by key relations, i.e. pedogenetic (gradual slow) evolution and functional relations (daily or seasonal changes). These latter aspects are of major practical importance.

The position of a horizon in relation to the interface zone of the soil mantle and the atmosphere is an essential feature. It governs in effect the accumulation of organic material, the thermal or water fluxes that affect or pass through the horizon, the mass of overlying layers which press down on it, the penetration of roots and animals, etc. In fact it influences almost all the circumstances that determine its development and behaviour.

Two other concepts are used in the *Référentiel Pédologique* (with definitions that vary from those given in other countries or in earlier works) : the Solum and the Profile.

The **Solum** is the vertical section of the soil mantle, that can be observed within a pit or a trench. If possible, the solum includes enough of the underlying rock to enable its characterization. The horizontal dimensions of the solum are of the order of a decimetre wide and a centimetre thick. The vertical dimension varies from a few cm (in LITHOSOLS) to several meters (old soil mantles developed under conditions of strong weathering).

The **Profile** is the sequence of information related to a solum ordered from the land surface downwards. This information includes visual properties (the structural profile) or one single variable (the calcium carbonate profile, the moisture profile, the texture profile, etc.), or even to more complex aspects such as the weathering profile.

Solum and Profile, thus defined, differ distinctly from the concept of the Pedon which is not used in the R.P.

Soil mantles are actual natural volumes. They are exploited by Man; they are studied *in situ* by scientists and mapped by soil surveyors, etc. Although the dimensions of a solum are arbitrarily limited, it can be nevertheless considered to be a real volume.

World-wide, soil scientists daily use conceptual horizons. These are the result of the interpretation of certain specific morphological properties of a horizon, associated to pedogenetic processes, but this interpretation takes also into account other horizons and various elements of the soil landscape¹.

1. Soil landscape: the whole of soil horizons and landform elements (vegetation, effects of human activities, geomorphology, hydrology, parent rocks or substrata) the spatial organization of which permits to define as a whole part or the total of a soil mantle.

Those conceptual horizons are classified by morphogenetic schemes and are given arbitrary notation with specific symbols : H, O, A, E, S, BT, BP... In the R.P. they are called **Reference horizons**.

Once interpreted, the solum may be described schematically in the form of superimposed reference horizons in a defined order : this corresponds to the **Conceptual solum**. Such conceptual solums are thus abstract perceptions in the collective minds of a group of soil scientists arising as a result of the generalization of repeated observations. This conceptualization, being the result of scientific progress and individual experience, associates a specific morphology, a specific behaviour, a range of properties and a process of evolution to define categories of various kinds : morphological, pedogenetic or other.

Objectives and basic principles of the *Référentiel Pédologique*

The *Référentiel Pédologique* is not a traditional classification system. Its authors have aimed to establish a typological framework which is scientific yet pragmatic, precise yet flexible, and which contains only two categories :

- References and
- Types, which are subdivisions of References and are named by the addition of one or more Qualifiers (adjectives, periphrases, prefixes used to describe selected properties).

The R.P. is conceived as a typological space with N dimensions, in which the References are located without consideration of hierarchy. When it is necessary to make regional, national or international correlations, the soil scientist identifies a solum-concept, a cartographic delineation or a mapping-unit, in relation to the References. The number of References in the R.P. will most probably increase in future. Indeed, as soon as sola sufficiently different from ones already established are recognized, a new concept can be defined and a new Reference specified. Thus the R.P. is an "open" system.

This typological framework takes into consideration, as far as possible :

- the morphology of the solum,
- soil behaviour and properties, and
- pedogenetic processes.

The morphology of the solum (in the broad sense including analytical and mineralogical data also), forms the main basis by which a solum is attributed to one or more References. Major emphasis is however placed on those properties that have a dominant effect on the behaviour and properties of soils (texture, depth, structural differentiation, etc.).

The behavioural properties (agronomic, sylvicultural, geotechnical) and function of soils (regime, hydrology or structural aspects...) are given emphasis when distinguishing and defining the References. This is why PÉLOSOLS, ARÉNOSOLS, VERTISOLS, PLANOSOLS, and RÉDUCTISOLS are essential elements in the system.

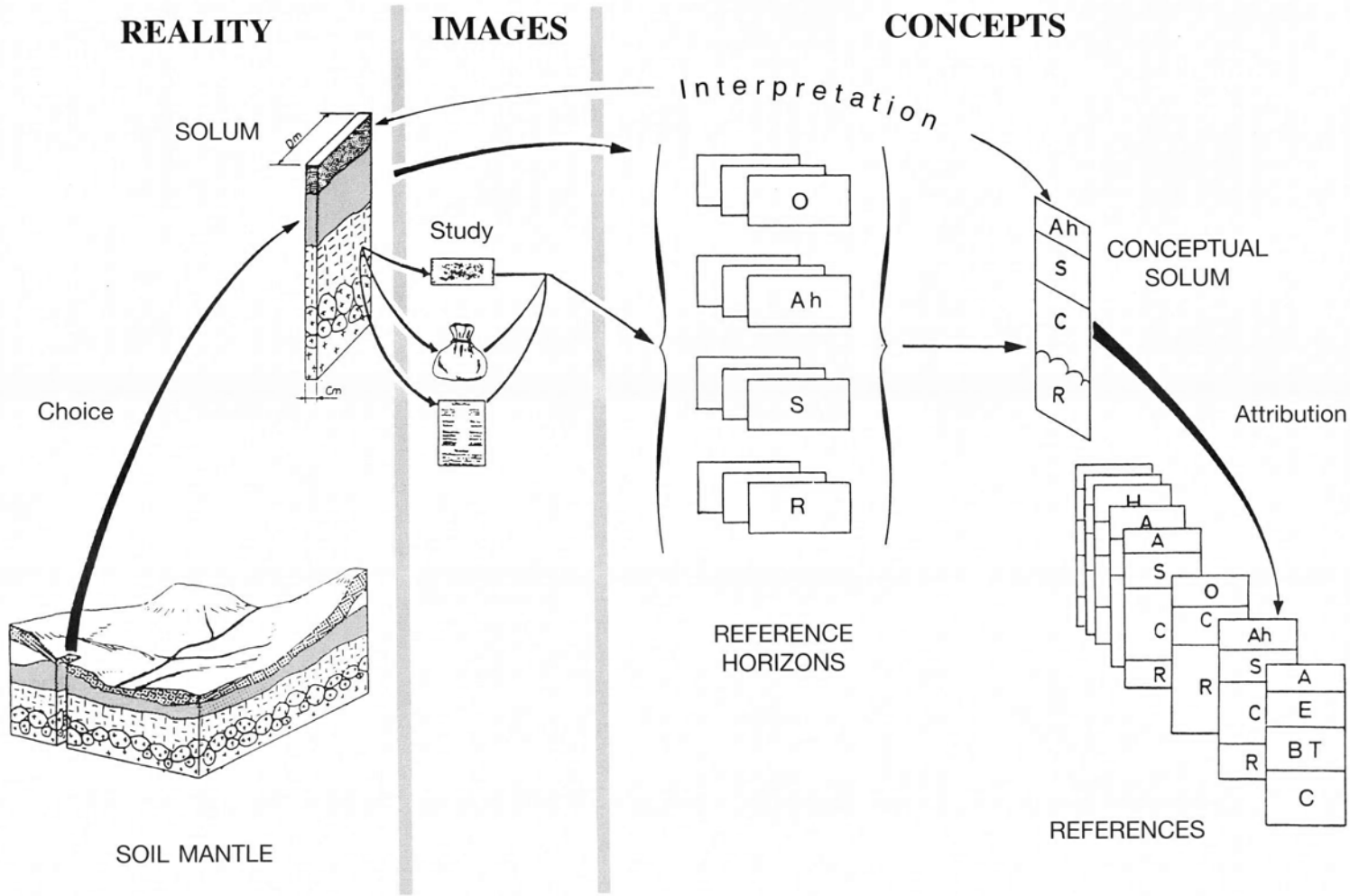


Figure 1. - Attribution of one solum to the *Référentiel Pédologique* (simple attribution).

Pedogenetic processes are used if they are sufficiently well understood. They form an ideal basis for the overall interpretation of sola and soil landscapes. In fact, in certain cases, the morphology and other soil properties depend largely on them. In other circumstances however, pedogenetic evolution is too weak and the solum mainly reflects the parent rock properties. Where it is known that several pedogenetic cycles have occurred, emphasis is given to the most recent cycle.

The R.P. constitutes also a synthetic **language** (synthetic in the classical sense). It includes a vocabulary developed over more than 20 years, nationally and internationally. Various terms originating from other systems (PLANOSOLS, PÉLOSOLS, ARÉNOSOLS) are used. As the result of new knowledge acquired since 1967, we have modified the definition of certain older terms and created new terms to express new concepts (ALOCRISOLS, PEYROSOLS, *horizon réductique*, etc.).

Organization of the *Référentiel Pédologique*

Reference horizons

Reference horizons form the basis of the system as they serve to define the References. The R.P. defines seventy three Reference horizons, each of them defined and described using various of the elements listed below :

- morphological characteristics (components, pedofeatures, structure, colour, physical or hydrological properties);
- analytical data (pH, base saturation, CEC, bulk density, etc.)
- pedogenetic significance;
- main possible variations of these characteristics;
- usual position within the soil mantles.

A Reference horizon is in general not diagnostic when considered on its own. Particular successions of Reference horizons however, identified together as “diagnostic sola”, are used to associate the sola with their appropriate Reference.

References

Usually a Reference is defined by its **diagnostic solum**. But some References are otherwise defined :

- by their position in the soil landscape and the nature of their parent rock (for example: FLUVIOSOLS and COLLUVIOSOLS);
- by macro-features of the solum, such as pedofeatures or properties that affect several horizons. Thus cracks within VERTISOLS or a strong textural differentiation and “abrupt textural change” in PLANOSOLS are macro-features used at the highest level to characterize these particular References.

The References are currently defined by vertical horizon sequences which have been replaced in their soil landscape. It is hoped that soon it will be possible to define “pedological systems” using the lateral organization of several sola.

In the R.P. each Reference is described in terms of the following:

- definition and pedogenetic significance;
- diagnostic solum and specific macro-features;
- associated Qualifiers (see below);
- situation in the landscape;
- examples of Types;
- agronomic, silvicultural, geotechnical properties;
- behaviour;
- intergrades and limits beyond which a solum can no more be attributed to this Reference (no longer qualifies for this Reference).

The differences between References are based on observable and/or measurable properties. The present version of R.P. describes 102 References. The number may reach 150 in a future edition to deal with the soils of the whole world. The names of the References consist of one or two words which by convention are written in capital letters.

Types and Qualifiers

The References can be subdivided into Types by prefixing one or several Qualifiers. For example, a fluvic, vertic, clayey CALCOSOL is a Type belonging within the CALCOSOL category.

It is very useful to add as many Qualifiers as possible to specify the main properties of a solum. As examples:

- pedomorphic, albic, dystic PLANOSOL TYPIQUE, with a moder, from a sandy clay ;
- colluvial, pachic, silty BRUNISOL MÉSOSATURÉ, with a mull, from a gneiss ;
- drained, resaturated LUVISOL DÉGRADÉ, with a fragipan, from an old loess.

An initial list of Qualifiers (adjectives, periphrases, prefixes) has been established. Each describes a property of the solum, and is defined so it has a precise meaning. The Qualifiers are always written in low case letters.

Only examples of known Types are presented in R.P.; many more however must exist. The list of the Qualifiers is open-ended, and the number of combinations is unlimited, so the number of Types is by its very nature without limit.

Globally, the References may suffice for the exchange of information, or to convey the major geographic distribution of soil qualities. At national, regional or local level however, more details are needed to complete the information and make it easy to use.

Using the Types, it is possible to establish links between the *Référentiel Pédologique* and other classification systems. At this level it is also possible

to extrapolate knowledge acquired at one site (the relation between the nature of soil mantle and its utilization) to other sites comparable in pedological terms. Thus, the results of an agronomic experiment on a drained, resaturated, redoxic LUVISOL DÉGRADÉ, with fragipan, developed from loam, in the Faux-Perche region, will probably be applicable to all soils of the same Type in the Paris Basin.

Major groups of References (MGR)

These refer to broad groups with well defined central concept recognized in several world classification systems (PODZOSOLS, ANDOSOLS, VERTISOLS, etc.), but which have rather ill-defined limits in relation to adjoining major groups.

MGRs have been adopted mainly to avoid unnecessary repetition in the presentation of References. They group several References which have many common characteristics, having, for example, the same Reference horizons. It has been necessary editorially to present these common properties and horizons in a single chapter.

The other more didactic advantage, is to regroup various References with the central concepts traditionally recognized as being associated. Thus seven References characterized by a podzolization process, are gathered in the PODZOSOLS MGR. In this book, several MGR are offered, but groups could be assembled in other ways.

The MGRs are not a category of the *Référentiel Pédologique*. Their role is only secondary and they have no hierarchical significance.

The process of attribution - How to attribute sola to References

The *Référentiel Pédologique* enables us to attribute any solum, any mapping area or any mapping unit to one or more References. The process of attribution includes three steps :

- characterization,
- interpretation, and
- attribution in the strict sense.

Characterization

Ideally characterization of the soil mantle at each site requires :

- description and analytical characterization of each horizon, including the underlying rock;
- description of the transitions between horizons;
- brief description of the surrounding environment;
- when possible, follow-up observations at regular intervals, to improve understanding of the soil regime and soil behaviour.