THE TYPOLOGICAL LANGUAGE*
A NEW METHODOLOGY FOR SOIL AND ENVIRONMENTAL STUDY

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The first part of a soil scientist's work is the understanding of soils and the processes responsible for their formation at different map scales both in space and time.

The second, and equally important part of his work, is undertaken after the information has been collected. It concerns the transmission of this information. Transmission can either be a horizontal communication between different scales of observation or a vertical communication between different scientific disciplines.

There are several ways of transmitting such information:

first by classification and second, through language and typology.

Classification and language can be based on the simple principle of diagnosis. Soil scientists are continually making diagnoses. Each elementary factor represents a diagnosis. These diagnoses can be classified very easily. These are the elementary morphological diagnoses (pedological observations) and elementary analytical diagnoses (laboratory results). This elementary level is usually insufficient,

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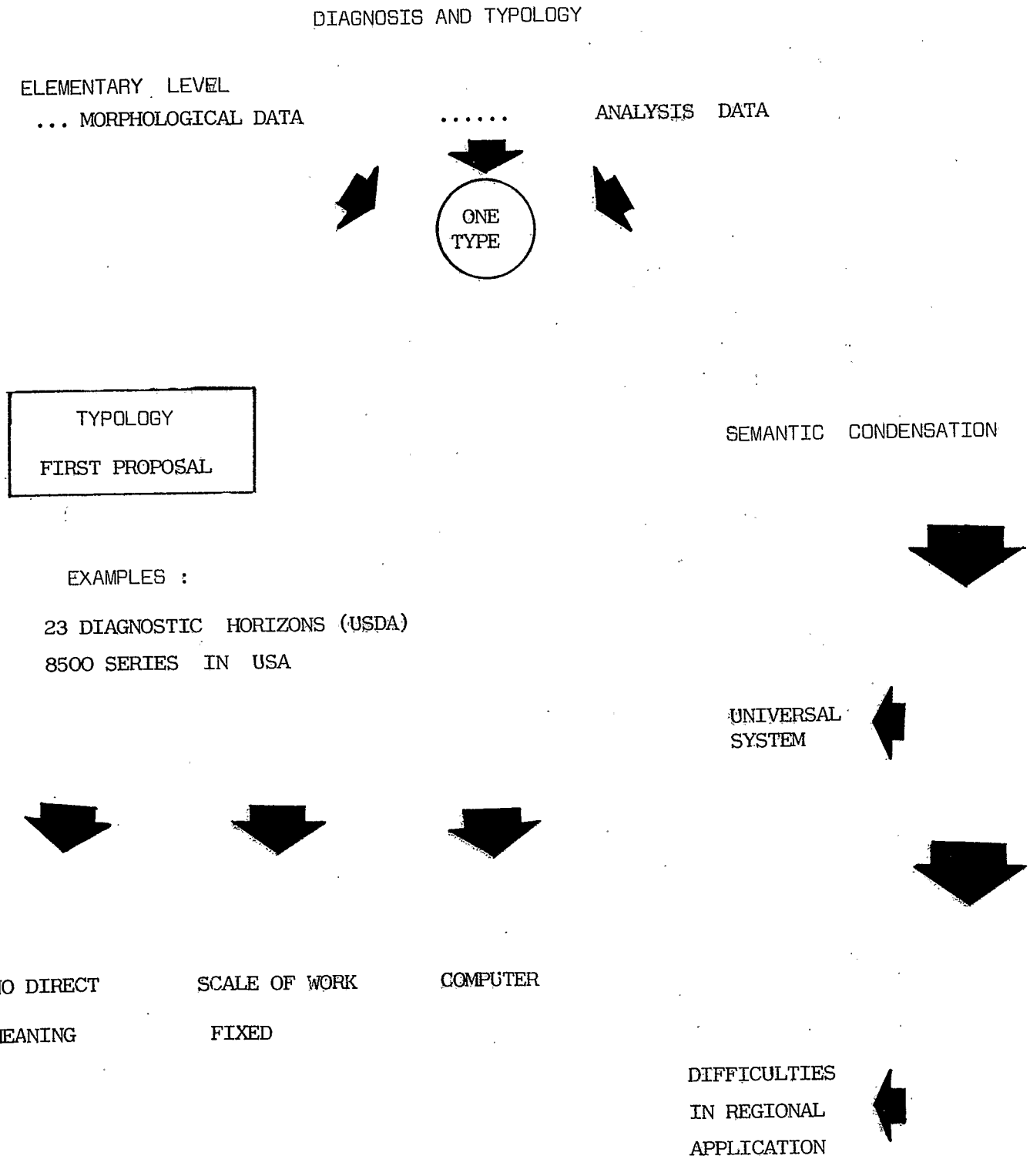
*Although this paper does not strictly relate to the main theme of the Forum, it was presented for discussion purposes and is therefore included in the Proceedings.

Figure 1


DIAGNOSIS AND TYPOLOGY
ELEMENTARY LEVEL
... MORPHOLOGICAL DATA
.....
ANALYSIS DATA
ONE TYPE
TYPOLOGY
FIRST PROPOSAL
SEMANTIC CONDENSATION
EXAMPLES :
23 DIAGNOSTIC HORIZONS (USDA)
8500 SERIES IN USA
UNIVERSAL SYSTEM
NO DIRECT MEANING
SCALE OF WORK FIXED
COMPUTER
DIFFICULTIES IN REGIONAL APPLICATION

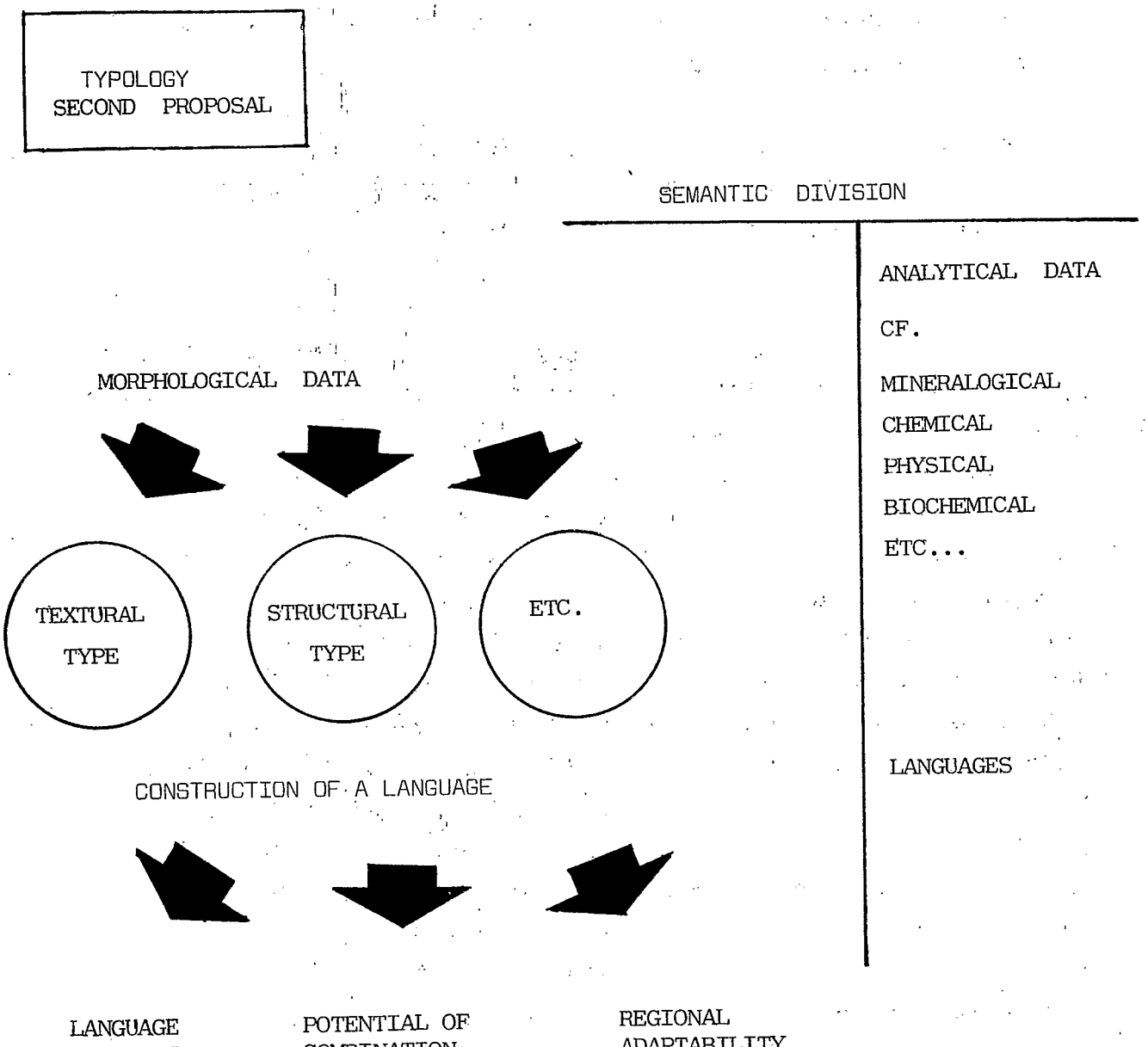
and scientists have to envisage a higher level of synthesis. In general a pedologist passes from an elementary diagnosis to one which is expressed by very general and abstract genetic concepts. This final synthesis involves a good deal of interpretation and leaves some parts uncertain. Therefore it is not strictly an objective way to treat information.

Between the elementary and the final genetic level there are other levels of synthesis which can be called compound diagnoses. These compound diagnoses constitute a typology. Two principles are used:

First, that of semantic condensation: (Fig. 1). Each type is defined by a large number of elementary data which are very different from each other (e.g., colour, texture, nature of clays, structure, percentage of organic matter etc.,.....). This process of semantic condensation has the special capacity of giving rise to classifications with a finite number of taxa. A classification must take into account the problems of memorizing it. An example is provided by Soil Taxonomy (Soil Survey Staff, 1975) in which a number of diagnostic horizons are included which are as easy to memorize by name and in their definitions. But the semantic condensation is much larger for the definitions are supposed to be applicable to all the world's soils. In any classification the number of great groups and subgroups is always relatively limited. If a classification includes a large number of taxa it cannot be memorized. Also, the citation by name of the classification's units falls short in accounting for all soil characteristics that should be considered, and especially so when the name is based on toponymy, for it loses much of the pedological information.

Second, that of semantic division: (Fig. 2). This process does not lead to a classification but to a language. In this system diverse factors concerning morphology, physics, chemistry and mineralogy are not brought together in highly synthesised taxonomic units. On the contrary, establishing a semantic division means that one gives a precise and limited meaning to a word. Thus, in such a system

Figure 2


TYPOLOGY
SECOND PROPOSAL
SEMANTIC DIVISION
ANALYTICAL DATA
CF.
MINERALOGICAL
CHEMICAL
PHYSICAL
BIOCHEMICAL
ETC...
MORPHOLOGICAL DATA
TEXTURAL TYPE
STRUCTURAL TYPE
ETC.
LANGUAGES
CONSTRUCTION OF A LANGUAGE
LANGUAGE WIDENING
POTENTIAL OF COMBINATION
QUANTIFICATION
DESCRIPTION OF INTERGRADES
REGIONAL ADAPTABILITY

several levels of diagnosis will exist. Each one of these concerns a precise subject. Let us take soil structures for example. The diagnosis concerning soil structures receives a name (amérode, pauciclode...) which has only one structural significance (it does not take into account mineralogy nor geochemistry nor colour, etc.). The term pauciclode for example is defined as follows: within a continuous horizon there are planes and angular edges. They practically never separate out into really well formed angular blocky aggregates. Natural faces and artefacts derived from breakage yield angular blocks of variable size.

Thus each time one wants to characterise a given soil several diagnoses and therefore several words must be used. As the diagnoses are semantically independent the language is infinitely open and it can assimilate new diagnoses translated by new words without being disturbed. This is contrary to what happens in classifications where the addition of new knowledge necessitates basic rearrangements.

However, the number of words is limited and has to stay limited so that it does not exceed the capacity of memorization. In fact it is by the multiplicity of possible combinations between the different terms that the language is able to describe various soils without needing a large vocabulary.

The Establishment of Several Levels of Diagnosis. (Fig. 3)

These different levels of diagnosis are not graded according to their greater or lesser genetic significance.

1. The first diagnostic level (major diagnosis) is based on directly observable morphological characters. These characters must fulfil two conditions: first, they must immediately serve to identify all components of a soil; and second, they must apply at all levels of observation (from a thin microscope section to a landscape).
   Thus, the first level must constitute a comprehensive structural canvas on which all the rest can be grafted. Let us take the term STRUCTICHRON: it concerns a soft, friable, porous, homo-

Figure 3

COMPOSED DIAGNOSIS	FIRST LEVEL OF DIAGNOSIS AND VARIATIONS	SECOND LEVEL OF DIAGNOSIS	THIRD LEVEL OF DIAGNOSIS
APEXOL	APPUMITE STRUCTICHRON	AMERO PAUCI ANGU ALIA PSAMMO → CLODE	COLOUR TEXTURE MINERALOGY BIOLOGICAL CHARACTERISTICS ETC.
INFRASOL	GRAVOLITE GRAVELON STERITE RETICHRON ALTERITE		

GROUPING IN: DEVELOPMENT : ORTHO - BRACHY - LEPTO

SITUATION : EPI - HYPO

DEFINITION : ORTHIC - PARORTHIC

Figure 4

TYPOLOGICAL QUANTIFICATION

X : 0% OF A	Two phases
X-STIGMEA : 0-5 % OF A	STRUCTICHRON
X-PHASE A : 5-15 % OF A	ALTERITIC STIGME STRUCTICHRON
X-A : 15-30 % OF A	ALTERITIC PHASE STRUCTICHRON
(A)-X : 30-45 % OF A	ALTERITIC STRUCTICHRON
X-A OR A-X : 45-55 % OF A	ALTE - STRUCTICHRON
	ALTERITE - STRUCTICHRON

genous, brightly coloured mineral horizon. It is homogenous in the sense that all the particles of clay or sand, ferruginous or not, are intimately bound up with each other. This definition uses only those criteria available from simple morphological observation and follows well the principle of semantic division.

2. The second diagnostic level (secondary diagnosis) concerns the structural organisation of the soil of which the terms amérode, anguclode, aliatode are examples (see appendix). Structural diagnosis such as is defined here goes further than the usual reference to geometric forms and so, in fact, corresponds to a more synthetic level of diagnosis than that of the elementary diagnosis. Let us take for an example the typological diagnosis anguclode. It is concerned with the planes of the separation faces, the presence of sharp edges, the presence of isolated aggregates and, equally, allows for the existence of a certain number of incompletely formed aggregates.

3. The third level of diagnosis (complementary diagnosis). It regroups the traditional diagnoses of pedology. It is concerned with colours, textures, chemical, biochemical and mineralogical parameters, etc. The diagnoses and terminologies have been in existence for a long time.

It needs to be understood that the first two of the diagnostic levels fill a gap in the standard descriptive system used in pedology. This gap prevents the establishment of a comprehensive structural framework of soils.

All these diagnoses can be very easily associated when they are properly designated. For example, one can speak of a structichron anguclode, red, clayey, kaolinitic gibbsitic, unsaturated,etc.

Altogether this constitutes a scientific terminology adapted to the study of world pedology. The language thus formed possesses a certain number of linguistic capacities allowing for a good adaptation to the objects treated. This language must be a real working tool,

that is to say it must be a means to treat information already acquired and, equally, be a means of discovering new information. For this it must give combinative characters. Then it is possible to identify, classify and compare varied soils having all sorts of associations and intergradings.

Let us now examine the different applications of this language:

- It is possible to create several descriptive categories:

o in definition: horizons and soils will be orthique when they correspond closely to their central concepts and parorthique when the resemblance is less;

o in location: the use of prefixes epi - or hypo - allows the horizon to be localised in a profile;

o in development: this concerns the upper part of the soil: the apexol. It is possible to distinguish lepto - (slightly thick), brachy - (medium thick) and ortho - (very thick) - apexols.

- In addition, like all languages this one is grammatical and its terms have a capacity of derivation which allows them to be associated together. For example we can present a structichron or a retichron (nouns), express a structichrome (adj.) phase, a process of retichromation (derived noun),etc. Equally we can describe a structi-retichron, a structichrome retichron,etc.

- The capacity of the language can be enlarged further by quantification (Fig. 4). The rules of writing have been established. They are flexible enough to adapt themselves to a variable number of classes determined according to environmental characters or to the detail and level of observation. The rules allow mixtures or juxtapositions of 2, 3, 4 or more elements to be described quantitatively. In practice quantification is most necessary,for pedological materials are never simple.

Figure 5.

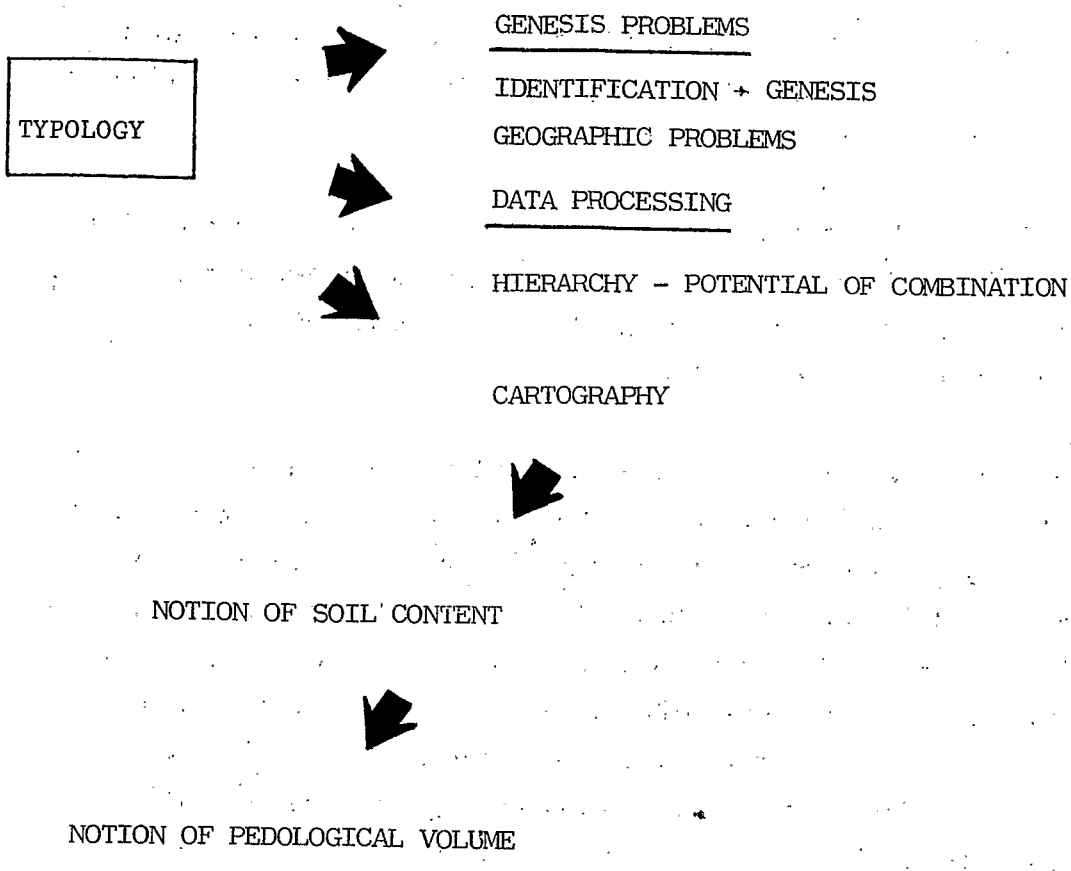
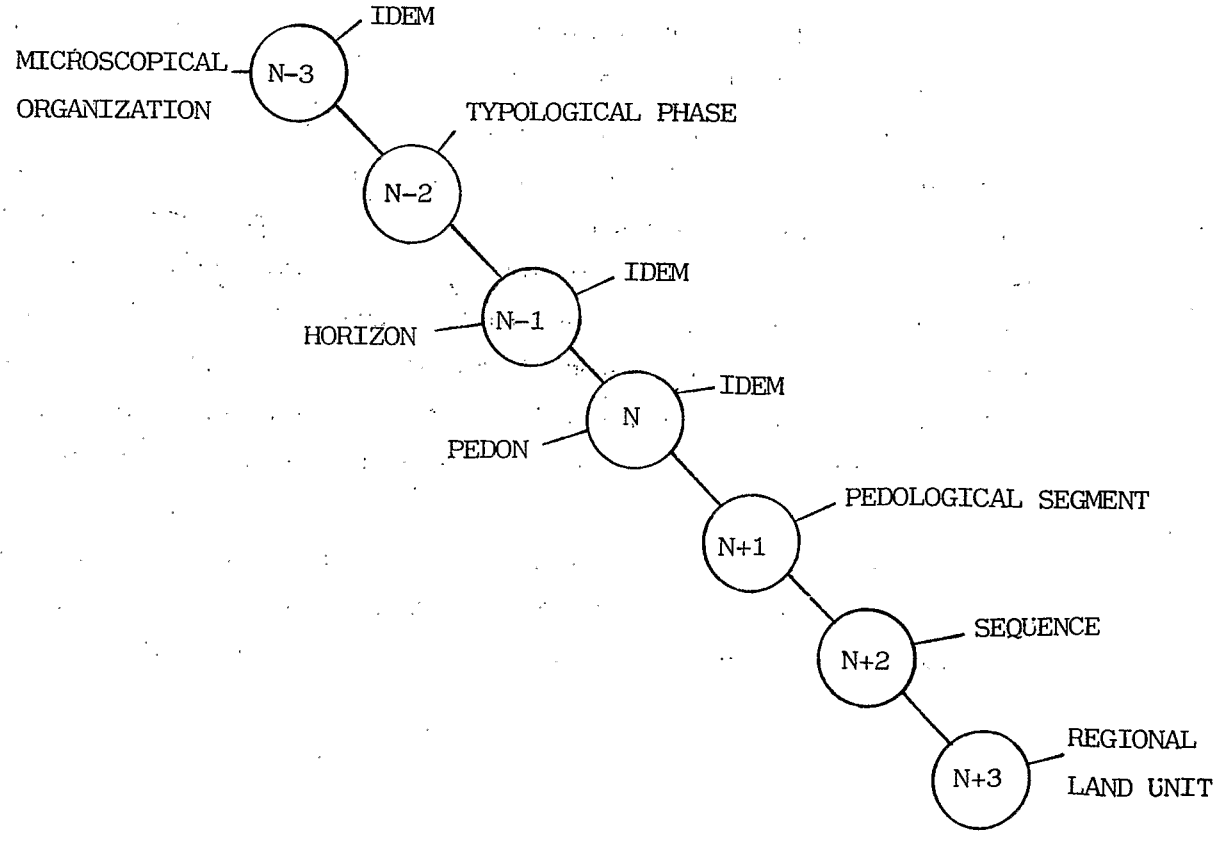


Figure 6. Pedological Volumes



Thus, the descriptive system which we have constructed copies, in a way, the multitude of natural combinations. It is a grammar for the treatment of scientific information (Fig. 5).

The whole system follows closely practical realities, especially at the level of soil survey. Soil maps using this system have been prepared for West Africa and Central Africa (Beaudou and Chatelin, 1977; Beaudou and Collinet, 1977).

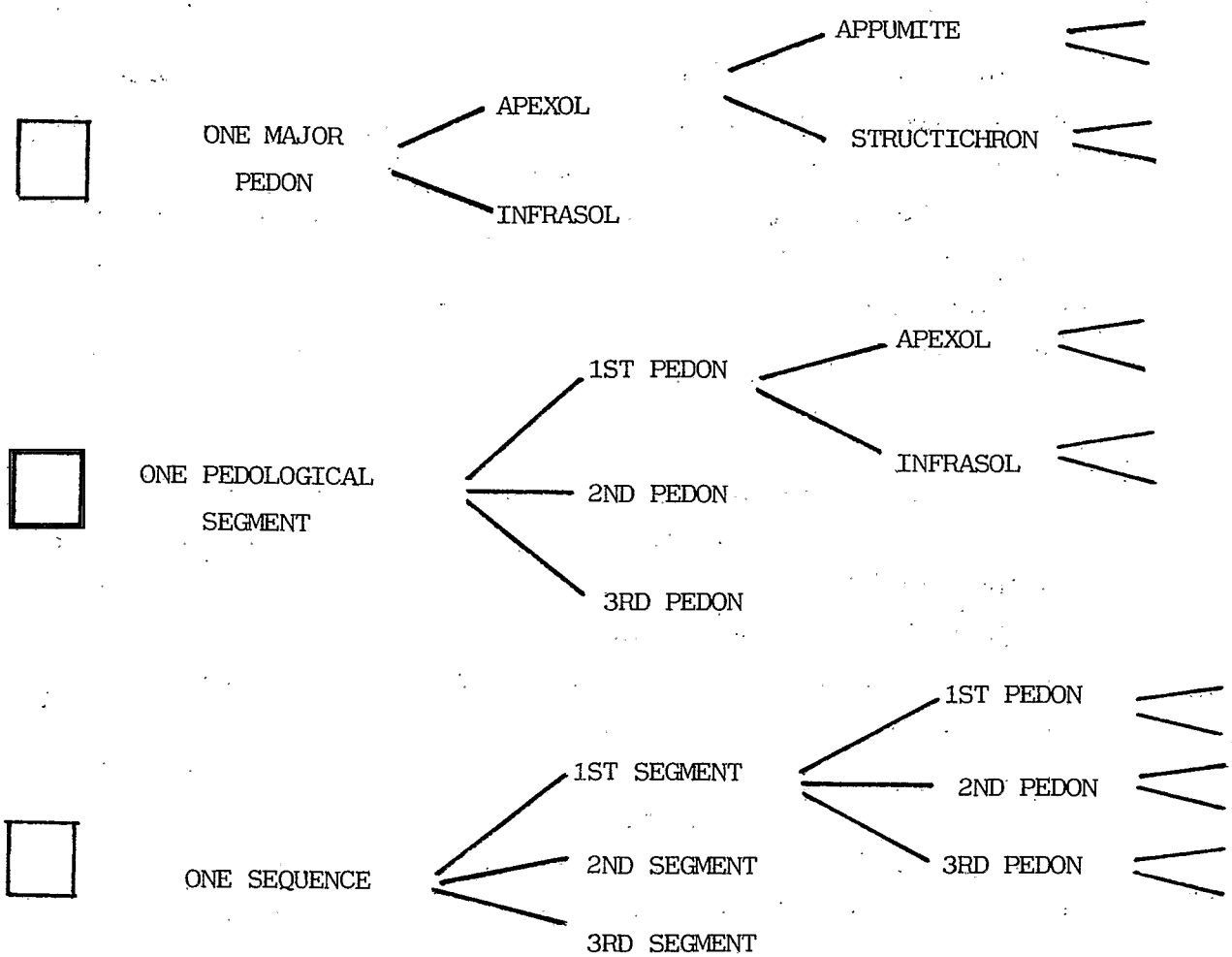
Typology allows all the observed characters found in a variety of spatial units (for example region, landscape, soil) to be expressed in a sufficiently concise and accurate way. In this way the variable development of soft horizons (apexols) is quickly translated by the use of lepto -, brachy -, ortho-apexols. In the same way a given apexol may top a heterogenous infrasol of sterite, steri-retichron, gravolite,etc. Typologic terminology thus takes account of multiple characteristics without however, masking the dominant morphogenetic characters. It is therefore a new way of developing the notion of the contained soil in a given spatial unit.

Typology has unified the means of description at the microscopic and field levels. Equally it allows for a greater or lesser complexity in the contained soils to be expressed. This said, we can now turn to the definition of some pedological spatial units. Several of them are already in current use (e.g.,horizon, pedon), others are new. From the smallest to the largest the following spatial units can be named: microscopic, typological phase, horizon, pedon, pedological segment, pedological landscape and region. These are encoded as the following expressions, starting with the smallest, and in order of size: n-3, n-2, n-1, n, n+1, n+2, n+3. These different spatial units are contained within one another (Fig. 6). Thus several pedons (n) constitute a segment (n+1), several segments a landscape (n+2),etc. Figure 7 shows the degree of organisation of pedological groups.

Finally, for natural mappable soils the contained soil must be distinguished from its physiographic cover. A complete interfluve corresponds to the physiographic cover of a landscape. When the

Figure 7

SURVEY UNITS



pedological mantle can be analysed into several segments, the contents, like the cover, correspond well to that which has been defined as size n+2. But there also exist cases where the pedological cover is little differentiated. The cover then corresponds to a landscape (n+2) but the contained soil can be at the level of a segment (n+1) or even a pedon (n).

Figure 8 is an example of the representation of a cartographic unity. It shows the association of three semantic fields:- that defining the forms of relief; that of the typology of the soils; and, finally that of pedogenetical concepts.

This system has been used on the Ivory Coast. Maps (5 degree squares) have been made and the contained soils have been represented with the aid of a typological system. From these initial soil maps (segments and landscapes) other interpretative maps have been made to show the potential for the north of the country. These new maps are in fact the maps of land suitability for agriculture and include features such as slopes, hollows, rock outcrops, iron crust development, etc.

To conclude this overview I will briefly re-state the salient points covered. I have tried to explain an approach which has led us from the idea of diagnosis to the construction of a typology, then through to the notion of contained soils, and lastly the idea of pedological spatial units. In other words, it is about the path from theoretical reflection to practical utilisation. This approach has been made possible by concentrating research at the level of means of expression and from this to the transmission of information from specialist to user. Information transmission is carried out with the aid of a structural language which allows all the information collected in the field to be utilized.

Through these concepts of diagnoses, type, language, semantic division, combination, quantification, contained soil, physiographic cover, a new systematic methodology for the study of soils has been presented.

Figure 8

EXAMPLE OF A SIMPLIFIED LEGEND
GIVEN TO A PEDOLOGICAL SEGMENT

MORPHOLOGY - LANDFORM	SOIL - CONTENT
CONVEXO-CONCAVE SUB-LEVELLED HILL-TOPS	- LEPTO-APEXOLS AND BRACHY-APESOLS WITH RED STRUCTICHRON, SANDY-CLAY, PAUCICLODE. - INFRASOLS WITH STRUCTI-ALTERITE AND ALTERITE.

PEDOGENETIC CONCEPTS

FERRALLITIZATION, REJUVENATION BY EROSION

PEDOPLASMATION

Some of the advantages of this methodology have been stressed. It is important to emphasise that the approach has an interdisciplinary base (an identical language exists for studying plant structures, the forms of relief, landscapes). One final point must be made: the soil classifications (FAO/UNESCO (1974), Soil Taxonomy) are presented as work tools to be used on a world scale. Certain principles are imposed with the objective of making the transfer of information easier between countries. The new methodology presented here is founded on a language which also has a universal value. Also, it allows a certain independence, thus facilitating work performed at a regional scale. The diagnoses used can be adapted to particular areas or to various subjects, without restrictions. Pedogenetic concepts from one school of thought are not rejected but can be easily added according to the principle of semantic division. Finally, this language allows for conceptual diversity.

APPENDIX

Typological Language: Some Definitions

1) The first diagnostic level

STRUCTICHRON: mineral material, soft, relatively homogenous, having the structural organisation of a true soil, dissimilar to the material of origin. Thus, it is characterized by its colour and structure. Two variants can be identified.

DYSCROPHE STRUCTICHRON: is characterized by addition of organic matter which gives it a dull colouration. The dyscrophe structichron will be homogenous if the colouration is evenly distributed or heterogenous if the organic matter occurs as mottles or stripes (value 3 to 5 - chroma 3 to 5 in 10YR and 7.5YR hues; the chroma varies 3 to 6 in 5YR and 2.5YR hues, the value staying unchanged).

STRICT STRUCTICHRON: is characterized by the absence of organic matter and by bright red or yellow colours (value 4 to 6 - chroma 5 to 8).

GRAVOLITE: indicates a large concentration of nodules of metallic sesquioxides (>45%). This diagnosis is always associated with another (structichron, retichron, etc). The form of the nodules is variable. Sometimes the nodules consist of pseudomorphosed minerals or rocky fragments, or of altered material, strongly impregnated by metallic sesquioxides.

STERITE: represents hard and continuous formations of metallic sesquioxides. Sterites are rarely homogenous and show a very great variation in colour and facies. Two variants have been distinguished according to their hardness:

PETRO-STERITE: is very hard and cannot be broken without use of a spade.

FRAGI-STERITE: is not hard and can be broken up more or less easily in the hand.

RETICHRON: designates a usually soft material, yellow or beige in colour, mottled or marbled with red and red-ochre. This colouration may be reversed so that mottles and marbling are yellow or beige on a red or red-ochre background. In general the mottles or marblings make an alveolar or reticulate design in which the mesh measures several centimeters. It is an evolved mineral combination having no macroscopic analogy with its parent rock. A variant has been defined:

DURI-RETICHRON: This variant is characterized by slight hardening of the coloured mottles.

2) The second diagnostic level

ANGUCLODE: The planes of the separation faces and sharp edges constitute a structure of well defined angular aggregates. The anguclode type can include the polyhedric, prismatic and cubic pure types or associations of these. The basic units are of variable size.

PAUCICLODE: is characterized by cracks and angular edges. They practically never separate out into really well formed angular blocky aggregates. Natural faces and artefacts derived from breakage yield angular blocks of variable size.

AMERODE: indicates massive and continuous structure but which can have rare fissures which are angular on splitting.

ALIATODE: indicates "floury", "powdery" or "degraded" structures. Elementary descriptive schemes are poorly adapted to accommodate these structures. The very fine elements (micro-aggregates) are distributed near continuously and without fissures. It is very porous and friable under pressure but it withstands erosion very well.

APEXOL: It is formed by assemblage of the humic and structichrome horizons. When the structichron is well developed only the upper part, directly allied to biological processes and fertility, belongs to the apexol. The transition to the lower part of the structichron where colouration is more pronounced and the pedo-climate is more regular, is very gradual. Thus, the limit between the upper structichron and the lower structichron is very difficult to define and has been fixed arbitrarily at 150 cms. This is also the lower limit of the apexol.

Several categories of apexols have been recognised according to their development:

LEPTO-APEXOL: It is comprised of one only humite, appumite, or melanumite.

BRACHY-APEXOL: It is formed of one humite, appumite or melanumite, and a structichron. Two degrees of development can be recognised.

- o BRACHY-APEXOLS PEU DEVELOPPES: They are composed of a humite, melanumite or appumite and a dyscrophe structichron.

o BRACHY-APEXOLS STRICT: They are composed of a humite or appumite with a dyscrophe structichron and a strict structichron. But the combination is always less than 150 cms thick.

ORTHO-APEXOL: It is composed of a humite or appumite, a dyscrophe structichron and a strict structichron. The combination is at least 150 cms thick.

INFRASOL: It is composed of gravelly, retichrome, steritic and alteritic, regolic, psammitic horizons. A structichron can also be found in the infrasol. It can be derived from the structichron of an ortho-apexol, where it will be a deep structichron. If it appears under a gravolite, sterite, or gravelon it will be a hypo-structichron.

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