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THE ORIGINS AND INTERNATIONAL IMPLICATIONS OF SOIL HORIZON NOMENCLATURE

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Introduction

The subject of soil horizons and their nomenclature may be divided conveniently into two parts. On the one hand there is the concept, definition and description of the morphological features which pedologists identify as horizons, and on the other there are the labels or designations which are given to horizons for the purposes of discussion, communication, classification and interpretation.

The Concept of Soil Horizons

The basis of soil study by pedologists in virtually all countries of the World is a soil volume, represented by a soil profile with its constituent horizons and layers. Ideally, the soil volume should be of sufficient size to encompass the nature of the horizons and any variablilty present. Such a soil volume has been called a pedounit (FitzPatrick, 1967), soil area, Muir (1969) or pedon (Soil Survey Staff, 1975). Although it at first appears to be an easy task, definition of such an entity is difficult. The upper boundary with the atmosphere is clear, but boundaries with other soils are frequently zones of transition, and the lower boundary between soil and 'not soil' is left somewhat vague. It would be possible to argue about the detail of a definition of soil horizons ad infinitum, but at least everyone present at this meeting knows what a soil horizon is and what it looks like. With some helpful suggestions from colleagues, the following definition has been prepared and is reproduced from ISRIC Technical Paper No.19, Soil Horizon Designations (Bridges, 1989).

> Soil horizon: A layer of soil, revealed in a soil profile, lying approximately parallel to the earth's surface having pedological characteristics. A soil horizon is the vertical expression of a volume of soil which can be distinguished from other horizons by morphology, physical makeup, chemical properties and composition and biological characteristics. The vertical and horizontal limits of soil horizons occur where these attributes undergo significant change in appearance or amount.

The concept of soils being composed of layers approximately parallel to the ground surface is very old. Since Roman times it has been known that surface soil, subsoil and weathered material rest upon consolidated rock. It has been suggested (Soil Survey Staff, 1951) that 'surface soil' is used for the uppermost soil layer whereas 'topsoil' implies the fertile, organic-rich surface soil of gardens or ploughlands and often used as a surface layer for amenity soils

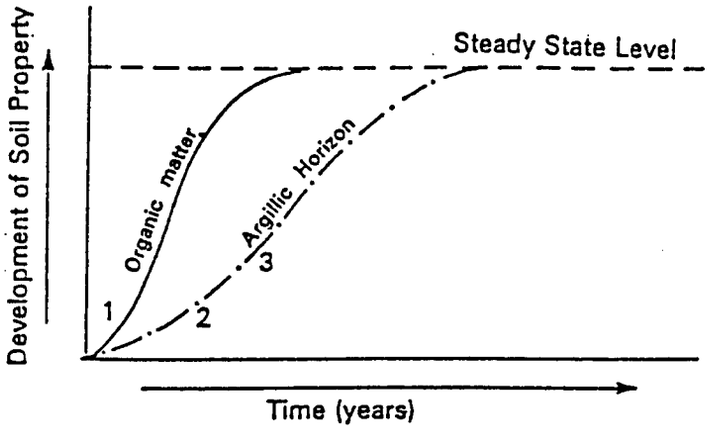
Before going any further, it must be made clear that this contribution is not about diagnostic horizons or reference horizons; these are special cases where horizons are used for classification purposes. One of the major differences between horizons in general and diagnostic or reference horizons is that the latter must additionally conform to specifications of thickness and degree of development.

Often a horizon may be clearly developed in a soil profile but does not meet the criteria for a diagnostic horizon. This may be illustrated graphically where the vertical axis represents development of horizon properties and the horizontal axis represents the passage of time. In the case of organic matter accumulation, the first crumb of organic matter deposited on a parent material represents the beginning of soil formation. This may be very clear almost from the beginning of soil formation, position 1 on Figure 1, whereas development of an argillic or podzolic B horizon may be evident at position 2 on the graph but only significant for classification purposes at 3. Any interruption of the soil forming processes will only delay the process of soil maturation and the time when the soil and its constituent features reaches a steady state situation.

The concept of soil horizons, conceived by Dokuchaev, was slow to be adopted outside Russia. Taking Britain as an example, throughout history, soils have been recognised by their texture and geological substrates. Sir A.D. Hall, who wrote our first modern text 'The Soil' is an example of this tradition which prevailed throughout the first two decades of this century. By 1937, Professor G.W. Robinson had adopted the concept of soil horizons in 'Mother Earth: Letters on Soil' and profiles are described in his textbook, 'Soils, Their Origin, Constitution and Classification' published in the same year, in terms of the horizons present.

Fig. 1.

ASYMPTOTIC NATURE OF SOIL HORIZON DEVELOPMENT



Soil horizon designations

This paper takes a positive view of the use and applications of soil horizon designations. Other contributions may take a more critical view of their place in the study of soils, but as soil horizon designations have served pedology well in the past, it is felt desirable to try to place on record a fair and balanced account of their origins and development and secondly to attempt to summarise something of the international implications of their use. I am happy to declare my own support for their continued use in the right context, but in some circumstances a blind adherence to their use can be counter-productive and even misleading. A definition of a soil horizon designation is as follows:

> An interpretative symbol, based on horizon morphology and implied genesis that is used to identify and label a soil horizon.

Origins

The identification of soil horizons and their designation by letters of the alphabet may be traced back to studies carried out by Dokuchaev and Sibirtzev on chernozem soils in the Ukraine towards the end of the nineteenth century. It may never be known for certain how it happened, but reference to Dokuchaev's writings shows that he was a systematic worker, carefully listing sections of both geology and soils. Reading these foundation contributions to soil science of the last century, it is possible to see how Dokuchaev's systematic labelling of geological sections with A, B, C, or with 1, 2, 3, was carried over to his soil profile descriptions. In the collection of Dokuchaev's works entitled Russian Chernozem (translated N. Kramer, 1967) the use of ABC occurs in descriptions of soils in the Chern and Novosil districts: at the village of Kazarino he describes

A homogeneous chernozem
B transitional horizon
C subsoil yellowish-brown loess

However, in the same part of the account he uses the letters A, B and C to label alluvial accumulations in the banks of the Kachnya river near the village of Milyukovo, but on the following page he uses the ABC nomenclature for the soil horizons again.

Thus the first use of soil horizon designations appears to have been a use of letters and/or numbers as simple ciphers. However, what appeared to begin as a simple, ordered labelling of the horizons present in a soil profile, had by the turn of the century acquired a strong genetic connotation. Other people followed Dokuchaev's lead, but problems arose when the ABC labels (with their connotations of genesis) were applied subsequently to soil types other than chernozems.

In the first two decades of this century, some Russian pedologists continued to use a nomenclature which Zakharov had introduced in 1906 (and still advocated in 1932) where the following letters were used to symbolise soil horizons:

A Upper humus horizon
B Transitional or podzol-eluvial horizon
C Illuvial (ortstein) horizon
D Parent material

The general principle of illuviation was put forward by Vysotsky in 1899 but several years were to pass before a clear picture of eluvial and illuvial horizons was established (Muir, 1961), but by 1930, the symbolisation proposed by Glinka was adopted:

A Eluvial horizon
B Illuvial horizon
C Parent material

Subsequently, with the addition of numerical subscripts for horizon subdivisions, this became the standard procedure for the identification of soil horizons (Muir, 1961). In this way also the idea of the primary division of the soil profile into master horizons became established. Although it was to be several years before the Russian ideas were to reach western European countries and the United States, Ramann (1911) was already describing in detail the meaning of the ABC designations:

A horizon (comprising topsoil) with humus mixed throughout, usually dark-coloured soil layer. The upper part contains humus which still retains evidence of plant structure and

is equal to moder. The lower parts of this horizon are characterised by dark staining. This is the horizon of eluviation, dominated by leaching.

B horizon (comprising subsoil) the weathering layer of soils. It is possible to distinguish: 1. leaching through the action of humus is strongly expressed; 2. by a process of mechanical addition the layer of ortstein is formed.

C horizon The raw soil (substrate) from which the A and B horizons have been formed by weathering. No chemical action of weathering can be distinguished by the naked eye, but physical disruption can be seen.

Ramann (1917; trans Whittles, 1928) remarked that the Russians use the symbols ABC in a different sense from that of topsoil, subsoil and parent material. The symbol A was used to denote an eluvial horizon from which substances were removed by leaching and B represented an illuvial horizon which has been enriched by substances from the horizon above. Ramann supported the idea of the designation by the letters ABC but makes the point that the names eluvial and illuvial, developed from the investigation of podzol soils, can only be applied to soil where there is a downwards movement of material; they are inappropriate in arid areas where the B horizon may be enriched from below, or in many other cases where the B horizon does not receive any additions at all.

The use of ABC system of horizon designation during the second decade of the twentieth century is documented in the Handbüch der Bodenlehre (Ruger, 1930). The system is demonstrated in several typical profile descriptions, but from the text it is apparent that the A horizon was regarded as topsoil the B horizon as subsoil and the parent material as the C horizon.

Soil profile description using the ABC system of horizon designation was included in Die Typen der Bodenbildung (Glinka, 1914), but it was not until 1927 that an English version, translated by Marbut as The Great Soil Groups of the World and their Development, was published in the United States. This seemed to pave the way for the eventual adoption of the ABC

system of horizon designation in the US Soil Survey Manual (Soil Survey Staff, 1951).

The concept of different forms of organic materials had developed before the turn of the century. Muller (1879, 1884, 1887) is usually accorded the honour of first naming the organic layers mull and mor and the letter designations L, F and H were introduced by Hesselman (1926).

Thus, by the 1930s the use of soil horizons and the foundations of soil horizon designations had been established. After a period of consolidation and the Second World War, a large step forward was made with the publication of the US Soil Survey Manual in 1951. This book alone was responsible for bringing a uniform approach to soil profile description. It utilised the ABC designations with numerical subdivisions but a few letter designations were introduced to indicate specific characters of the horizons present. These included the use of the letter g for gleying, t for clay accumulation, ca for accumulation of calcium carbonate and cs for accumulation of calcium sulphate foreshadowing things to come.

As many countries modelled their soil survey handbooks on the pattern of the 1951 US Soil Survey Manual, its influence became widespread, and for many it became the ultimate word for all aspects of field pedology. The useage of the ABC designations was confirmed in the 1962 supplement to the Handbook which re-inforced the concept of master horizons and further extended it by the inclusion of an O horizon, and even the C became a master horizon, referred to as 'a mineral horizon or layer'. The use of letter subscripts remained the same as in the manual, and this continued into the 7th Approximation, but the symbols used in the 1962 supplement were reproduced in Soil Taxonomy.

At this point it is instructive to compare the definitions provided by the 1951 Soil Survey Manual and the 1957 Pochvy Syemka:

> **A_2 horizon.** This surface or subsurface horizon, usually lighter in colour than the underlying horizon, has lost clay minerals, iron, or aluminium, or all three, with the resultant concentration of the more resistant minerals. It is a horizon of eluviation - of leaching of material out in solution or suspension. Much of the dissolved and dispersed material, including clay, moves completely out of the whole

soil, not simply into the B horizon. The A_2 is the principal gray or light-colored leached layer in podzols (bleicherde), solodized-Solonetz, Planosols, and podzolic soils generally.

The A2 horizonis the horizon underlying the A1 horizon, with light colours (Light grey or whitish), a loose consistency, a low amount of clay minerals and low humus content, and a relative enrichment in silica. It is mostly not structured or with a lamellae structure. The A2 horizon is characteristic for podzolized and solodized soils.

At this stage it is clear that the concept of horizons and their designation in the USA and the USSR were relatively close. However, in the following decade divergence occurred.

The morphologial phase.

In order to pick up the threads of this phase, it is necessary to return to the 1930's. In his study of German arable and forest soils, Laatsch (1938) introduced the symbol (B) for those subsurface horizons which were not formed by illuviation. Pallmann and Haffter (1933) from studies of Swiss soils found the need to distinguish different forms of podzolic B horizon and so introduced the use of subscripts s and h for sesquioxide- and humus-enriched B horizons. Kubiena (1953) clearly found these letter symbols useful and more informative than the earlier numerical subscripts and in 'The Soils of Europe' he provides profile diagrams which indicate both systems (Fig. 2).

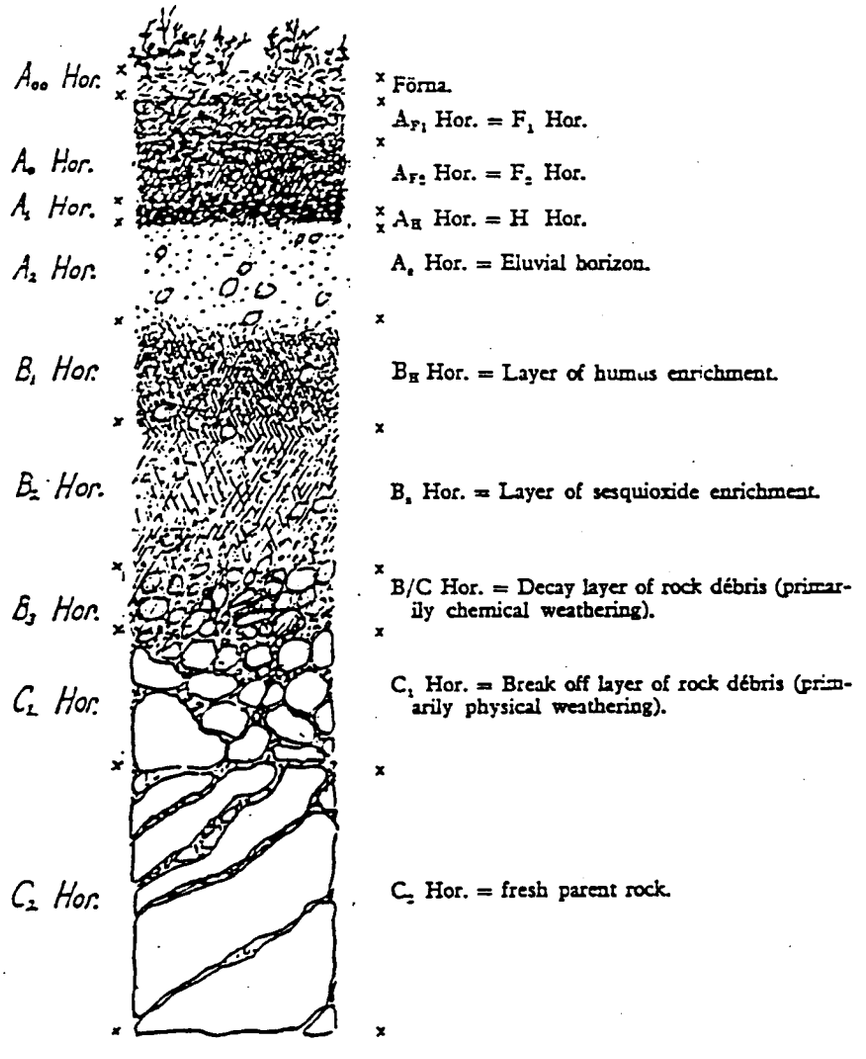
Another significant introduction, first appearing in Kubiena's book is the use of the letter e to signify an eluvial horizon (formerly referred to as an A_2 horizon). He also brings in the letters L F and H as subscripts for the layers of the organic materials on the soil surface. The subscript e continues in use in the Canadian system of horizon designations as a sub-division of the A horizon, but elsewhere it has become a master horizon.

Until the 1950s, the development of soil horizons was associated with processes of soil formation and these were subjectively taken into account in determining the nature of the horizons present in a profile. Looking back with the benefit of hindsight, it is now obvious that during this phase of development in our discipline, the emphasis gradually moved from an

Fig. 2.

HORIZON DESIGNATIONS FOR A PODZOL SOIL

(KUBIENA, 1953)



interpretative (subjective) approach to a morphological (objective) approach as greater reliance was placed upon the presence of specific morphological features in the identification of horizons.

In 1959, Eugene Whiteside proposed a new system of symbols for soil horizon designations, but in his own words, these were 'based on interpretations of the predominant process or processes that have differentiated them from primary materials'. By this time the more objective morphological approach had taken hold and although Whiteside's proposals were discussed, they were not adopted. I suspect that they helped to give impetus for discussions which subsequently took place under the auspices of the International Society. A proposal was eventually published in the Bulletin in 1967, and was discussed at the 9th Congress in Australia in 1968.

The ISSS committee agreed on a system which had the O, A, E, B, C, master horizons with additional letters R, G, plus the letter K suggested by Gile et al, (1965), for carbonate-rich horizons. Master horizons were described as:

dominant kinds of departure from the assumed parent material

and the suffix letters were added to indicate properties of the master horizon. Thus, the emphasis was specifically on the morphology of the horizons present and not on their supposed genesis. Throughout the 1960s compilations were being made for the FAO-Unesco Soil Map of the World and when the Legend was published in 1974, it included a section on soil horizon designations which was similar to the ISSS committee recommendations but simplified to only have one letter per feature e.g. n = accumulation of sodium rather than the subscript na.

Pressure for uniformity in commercial soil surveys led to the production of the FAO (1977) 'Guidelines for soil Profile Description' which has helped provide some international uniformity. These guidelines included the list of soil horizon designations used by the Soil Map of the World Legend.

A review of the master horizons used by different organisations and surveys shows considerable agreement, Table 1. Unfortunately there is less

Table 1.

MASTER HORIZONS RECOGNISED BY DIFFERENT SCHEMES

Source	Organic horizons free	sat.	subaq.	Mineral horizons	Additional
Soil Survey Staff USA (1951)	(Ao)			A	R
Tiurin *et al.* USSR (1959)	(Ao)	(AT)		A B C D	R
Whiteside (1959)	O			V E I P U	G X S R Z
Soil Survey Staff USA (1962)	O			A B C	R
Taylor & Pohlen (1962)	O			A B C	
ISSS Committee (1967)	O			A E B C	R G K
FAO-Unesco (1974)	O	H		A E B C	R
FAO Guidelines (1977)	O	H		A E B C	R
Soil Survey Staff USA (1975)	O			A B C	R
Canada (1978)	LFH	O		A B C	R W
Maignien France (1980)	O	H		A E B C	R G K S
Avery (SSEW) (1980)	LFH	O		A E B C	R G
Soil Survey Staff USA (1981)	O			A E B C	R
Fridland USSR (1982)	O	T		A EL B C	MD G GO IPMR KSL AO
McDonald (Aust) (1984)	LFH	O		A B C D	R
Germany (1985)	LO	H	F	A B C P	G T S Ml
SMSS (1986)	O			A E B C	R
New Zealand (1986)	O			A E B C	R

international agreement about the use of letter subscripts. The most widely accepted are those of the FAO-Unesco Soil Map of the World legend and the 1981 US Soil Survey Manual (draft) and Cornell University Department of Agronomy's (1986) Designations for Master Horizons and Layers in Soils (Table 2). One problem with these systems is that so many letters have been used to designate morphological features of B horizons that few are left for other features.

The systems of soil horizon designation mentioned so far have been those of the early pioneers or the systems adopted by institutions associated with soil survey - the establishment view. Throughout the period since Dokucheav's foundation contributions were made, some soil scientists have found it difficult to accept the use of the ABC system of soil horizon designations. In 1927, Vilensky attempted to develop an alternative system based on the letters A (for accumulation of organic matter), E (for eluvial horizon) and I (for illuvial horizons). Sokolovsky (1932) followed a similar line of reasoning and proposed the designations H (for humus), E (for eluvial), I (for illuvial) and P for parent material. He went on the suggest the use of these designations in a formula with the thickness of the horizon as subscripts to the horizon symbols: $HE_5E_{16}EI_{30}I_{19}P$

These early morphogenetic proposals appear to have been overlooked until recent times when following the great increase in information available after the Second World War, it became increasingly evident that there were difficulties in the blanket application of the genetic ABC designations to soils in differing parts of the world. Nye (1954) found it preferable in Ghana to indicate two primary horizons: a creep (Cr)horizon and a sedentary (S) horizon. Using a morphogenetic approach he identified horizons developed from worm-cast material (CrW), from termite activity (CrT) and horizons formed from ironstone gravel material (CrG). These horizons rested on the sedentary horizons which were distinguished S_1 to S_3 according to their content of weathered rock material. In Zimbabwe, Watson (1964) encountered similar difficulties in a study of a catena on granite parent materials. He used the symbols S (for coarse stony material, mainly quartz), F (for material composed of ironstone gravel), F/S (where ferricrete predominates), M (for finer-grained material), W (for weathered rock) and G for horizons with gley features. These authors indicated that although the 'classical' ABC nomenclature could be applied in some cases, in general it was difficult to use in the soils of tropical regions.

Table 2.

SUBORDINATE LETTER SUFFIXES USED IN THE FAO-Unesco SOIL MAP OF THE WORLD (FAO-Unesco, 1974)

b Buried or bisequal soil horizon (for example, Btb).

c Accumulation in concretionary form; this suffix is commonly used in combination with another which indicates the nature of the concretionary material (for example, Bck, Ccs).

g Mottling reflecting variations in oxidation and reduction (for example, Bg, Btg, Cg).

h Accumulation of organic matter in mineral horizons (for example, Ah, Bh); for the A horizon, the h suffix is applied only where there has been no disturbance or mixing from ploughing, pasturing or other activities of man (h and p suffixes are thus mutually exlusive).

k Accumulation of calcium carbonate.

m Strongly cemented, consolidated, indurated; this suffix is commonly used in combination with another indicating the cementing material (for example, Cmk marking a petrocalcic horizon within a C horizon, Bms marking an iron pan within a B horizon).

n Accumulation of sodium (for example, Btn).

p Disturbed by ploughing or other tillage practices (for example, Ap).

q Accumulation of silica (Cmq, marking a silcrete layer in a C horizon).

r Strong reduction as a result of groundwater influence (for example, Cr).

s Accumulation of sesquioxides (for example, Bs).

t Illuvial accumulation of clay (for example, Bt).

u Unspecified; this suffix is used in connection with A and B horizons which are not qualified by another suffix but have to be subdivided vertically by figure suffixes (for example, Au1, Au2, Bu1, Bu2). The addition of u to the capital letter is provided to avoid confusion with the fomer notations A1, A2, A3, B1, B2, B3 in which the figures had a genetic connotation. If no subdivision using figure suffixes is needed, the symbols A and B can be used without u.

w Alteration in situ as reflected by clay content, colour, structure (for example, Bw).

x Occurrence of a fragipan (for example, Btx).

y Accumulation of gypsum (for example, Cy).

z Accumulation of salts more soluble than gypsum (for example, Az or Ahz).

When needed, i, e and a suffixes can be used to qualify H horizons composed of fibric, hemic or sapric organic material respectively.

Since the 1960s, FitzPatrick (1967, 1980, 1988) has developed his own independant approach to the identification and designation of soil horizons and their use in soil classification. By the identification and use of reference, intergrade, compound and composite horizons it is possible to identify 83 reference segments which have 'an unique dominating property or a unique combination of dominating properties formed principally by a single set of processes'. Such an approach offers a viable alternative to a continuation of the ABC system and its modern derivatives.

So we come through to the present day when we find that our soil horizon designation is made up of:

1. Capital letters to designate the master horizons.
2. Lower case letters to indicate specific character of the horizon.
3. Arabic numerals to indicate subdivisions of horizons.
4. Punctuation marks, the prime ' or double prime " is used for repeated or in some systems, buried horizons.

The most recent trend which is apparent in the development of soil horizon designations was exemplified by the approach which Avery (1980) adopted in the Soil Survey of England and Wales, and which has been followed elsewhere in Commonwealth Countries such as Canada, Australia and New Zealand. The work which has been accomplished here in Rennes and the publication by AFES (1987, 1988) of the two editions of the Référential Pédologique Français appear to be following a trend to prescribe in considerable detail the nature of the horizon to be designated by a particular formula made up of the combination of capital letters, lower case letters and numbers. The example chosen is from Avery's Soil Classification for England and Wales, and from the written submissions, you will see that Avery urges the meeting to agree on a system of horizon designations precisely defined in quantitative terms:

Bg B horizon with dominant colours, on ped faces or throughout, attributable to reduction and segregation of iron caused by periodic saturation with water in the presence of organic matter. Ferruginous segregations occur mainly as mottles within peds rather than as coats on skeletal grains or bordering voids or as tubules associated with root channels. A Bg horizon lacks fragipan characteristics; has blocky or prismatic peds, more clay and/or less $CaCo_3$ than the underlying horizon, or both

and meets one of the following colour requirements:

1. Moist chroma 1 or less dominanton ped faces, or in the matrix if peds are absent, with or without mottles. etc.

In summary it appears that in our identification of our soil horizons we have evolved from 1. origins, through 2. a numerical (genetic) phase, and 3. a morphological phase to 4. a prescribed phase.

In conclusion, the international implications of our perception of soil horizons and their designation are:

1. Recognition of soil horizons is fundamental to pedology and soil studies throughout the World. It is essential that this should be placed on as uniform basis as is humanly possible, otherwise the aim of knowledge transfer will be thwarted.

2. Experience has demonstrated the need for labeling soil horizons for use in discussion and communication.

3. Although soil horizon designations are not part of contemporary soil classification procedures, they are helpful in interpretation of the soil profile.

4. There is need for agreement so that misunderstanding should not occur when information is being exchanged and transferred between individuals and organisations from different countries.

5. There is a need for any revised or new system to be compatable with data handling systems

6. We need to demonstrate to the world outside soil science - and even to our colleagues in other branches or our subject - that we can present a progressive but united front on how to identify, describe and label the most fundamental features of soils.

7. Our credibility with other scientists and particularly with those who might employ us on resource surveys is not enhanced by what appears from the outside to be a jargon-ridden muddle with everyone going their own idiosyncratic ways.

8. That acceptable proposals be complied and forwarded to the ISSS. The International Soil Reference and Information Centre would be willing to act as a vehicle for such proposals. Five strategies for the future are included in the documentation provided for the Soil Horizon meeting. It is

to be hoped that these would form a basis for discussion on the future use of soil horizon designations.

9. That proposals are placed before the International Society of Soil Science at its meeting in Japan in 1990 for the agreement and adoption of members.

The initial interpretation of the soil profile - where horizon boundaries are drawn - is unavoidably a subjective process and it is the responsibility of pedologists to try to minimise the variation in interpretation at this point. The aim should be to provide an accurate account of the profile with sufficient horizons described to provide a clear picture, but not with so many horizons as to be confusing. The description of each horizon should be an objective factual record of the soil profile as it appears in the soil pit or exposure.

It is not necessary to label each horizon to make a description, and this is stressed in many field handbooks but some numbering or labeling system is necessary for sampling. It is contended that some form of horizon designation is much more helpful than a mere numberical cipher. Perhaps I have been overduly influenced by the 1951 US Soil Survey Handbook which states: 'one connot usefully compare arbitrary defined 12-24 inch layers of soil but B horizons can be usefully compared'. To me the attachment of a horizon designation is clear and simple in operation; it allows discussion and communication of ideas.

The surveyor describing the profile, who sits in the pit with the horizons of the profile in front of him, is the only person who can really assess where the horizons are and the relationship of the various horizons of a profile. In the past this assessment was essentially based on supposed genesis deduced from the morphology of the soil profile. The art of interpretation has not disappeared, but the present-day approach is based much more soundly on the morphology of the horizon and the profile as a whole. This is an objective proceedure upon which subsequent techniques of classification may be soundly based.

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