REPORT

on the

FIFTH MEETING OF THE NATIONAL SOIL SURVEY COMMITTEE OF CANADA

Held at

WINNIPEG, MANITOBA

MARCH 4 - 8, 1963

TABLE OF CONTENTS

Proceedings of the Fifth National Meeting of the
National Soil Survey Committee of Canada

Foreword - A. Leahey

The fifth national meeting of the National Soil Survey Committee of Canada was held during the week of March 4 to 8, 1963 in the Agricultural Building, University of Manitoba. The first day was devoted to subcommittee meetings, the second day to a joint meeting with the National Soil Fertility Committee on interpretive classifications and other matters of mutual interest, and the last three days to plenary sessions.

Since the proceedings of the joint session of the two committees is presented in the report of the National Soil Fertility Committee meeting, 1963, only the report of the joint subcommittee on interpretive classifications and the resolutions arising out of this report are included here. However, two other reports presented at the joint session are of direct interest to pedologists. They are "Extrapolation and interpretation of results of soil fertility studies on soil types" by P.O. Ripley and B.C. Matthews and "ARDA investigations toward a nation-wide land capability inventory" by L.E. Pratt.

The reports on the classification of mineral soils and soil horizon designations do not represent any marked departure from those appearing in the 1960 Proceedings of the N.S.S.C. except in the case of the Gleysolic order. However, there are enough additions, deletions and revisions to require the presentation of complete reports rather than just to note the changes from the 1960 reports. The major changes in the six orders of mineral soils are:

Chernozemic soils: addition of Carbonated and Grumic subgroups in all great groups and an Eluviated subgroup in the Dark Gray great group.

Solonetzic soils : deletion of the Alkali Solonetz great group.

Podzolic soils : addition of a Gray Forested great group with two subgroups. Addition of Ironpan Humic Podzol and Concretionary Podzol subgroups.

Brunisolic soils : addition of a Subalpine Brown great group with 3 subgroups and a Degraded Acid Brown Wooded subgroup.

Regosolic soils : no change.

Gleysolic soils : replacement of the Dark Gray Gleysolic and Meadow great groups by one great group named Humic Gleysol. Deletion of Degraded, Calcareous, and Ferralitic subgroups. Addition of Rego, Carbonated and Sub-Arctic subgroups.

Peaty subgroups : same criterion throughout the system; namely where the organic surface horizon is 6 to 12 inches of muck or consolidated peat.

In the reports on Soil Horizon Designations and the classification of mineral soils, more precise definitions than given in the 1960 reports are included wherever possible.

The N.S.S.C. taxonomic system for mineral soils as revised in 1963 continues to be the official system in Canada. In so far as organic soils are concerned, the committee has not accepted an official system but the proposals contained in the report "Classification of Organic Soils" were accepted for trial purposes.

Reports on a number of topics, apart from those on soil classification, are included in these proceedings. These reports for the most part are revisions of the reports on these topics included in the proceedings of the 3rd national meeting held at Saskatoon in 1955. The reports on Soil Moisture (formerly Drainage), Structure and Consistence, and Landscape Features were adopted for official use, while those on Physical and Chemical Analyses and Interpretive Classifications may be considered of an advisory nature.

The N.S.S.C. at its Winnipeg meeting passed a resolution which has resulted in a greatly increased work load by the soil survey organizations and by the committee. This resolution, together with a summary of events arising from it, is included under the heading of "Soil Capability Classification for Agriculture".

Dr. A.A. Klingebiel, Director, Soil Survey Interpretations, U.S.D.A., represented the U.S. Division of Soil Surveys at our meeting. Dr. Klingebiel made many valuable contributions to the discussions for which we owe him a debt of gratitude. We appreciate also, this concrete expression of the continuing interest of the U.S. Division of Soil Surveys in our work.

On behalf of the committee I would express our appreciation and thanks for the excellent arrangements made at the University for our meeting and for hospitality and courtesies extended to us by the President of the University, the Dean of Agriculture, members of the Department of Soils and the Manitoba Soil Survey.

REPORT ON SOIL HORIZON DESIGNATIONS

D.W. Hoffman

Chairman, Subcommittee on Soil Horizons

This is the fourth report of the Subcommittee on Soil Horizon Designations and, except for a few revisions in the definition of the B horizon and those of the lower case suffixes, is much the same as the report presented by the Subcommittee in 1960.

Although the Subcommittee attempted to evolve workable limits for the lower case suffixes such limits could not always be established because of the lack of chemical and physical data. Most difficulty arose over limits for the suffixes f and t. It was moved by Mr. Bowser and seconded by Dr. Stobbe that:

> Survey units and others concerned be instructed to prepare limits for suffixes f and t for presentation at the next N.S.S.C. meeting; and that additional submissions relating to chemical and physical limits for the suffix n be also considered at that time.

Motion carried.

It is suggested that the following limits for f and t be used as a guide in establishing a permanent definition.

f - A horizon enriched with free iron (fe). It has a chroma of 3 or more and is redder than the horizon below. It contains 0.5 per cent free iron more than the C horizon and is without well or moderately well developed blocky structure.

t - A horizon enriched with silicate clay (ton), and meeting the following requirements.

1. Where an eluviated A horizon remains and there is no lithologic discontinuity between the A and the t horizon it contains more clay as follows:

    (a) If the A has less than 15 per cent clay in the fine earth fraction the horizon must contain at least 2 per cent more clay than the A.

    (b) If the A has more than 5 per cent clay and less than 40 per cent in the fine earth fraction, the ratio of the clay in the t horizon to that in the A must be 1.2 or more.

    (c) If the A has more than 40 per cent clay in the fine earth fraction, the t horizon must contain at least 8 per cent more clay than the A.

2. The t horizon must be at least one-tenth the thickness of the sum of all overlying horizons, or more than 6 inches thick.

3. The t horizon does not necessarily have more clay than the C horizon but it should have more fine clay than the C when expressed as a per cent of total clay.

The above limits should act as a starting point in establishing workable limits for f and t. It should be noted that j is used with t or f when the enrichment of free iron or clay is insufficient to make the lower limits imposed by the definitions.

Following is a listing of the horizon designations and their definitions:

Organic Horizons

The O (organic) horizon designation is to be dropped and replaced with:

L - An organic layer characterized by the accumulation of organic matter in which the original structures are easily discernible.

F - An organic layer characterized by the accumulation of partly decomposed organic matter. The original structures are discernible with difficulty. Fungi mycelia often present.

H - An organic layer characterized by an accumulation of decomposed organic matter in which the original structures are undiscernible.

Note 1 - If it is not possible or advisable to subdivide the organic layer it may be referred to as L - H or other combinations.

Note 2 - It may be desirable to use lower case suffixes to differentiate kinds of organic material. However, none is suggested in this report.

Master Mineral Horizons

A - A mineral horizon or horizons formed at or near the surface in the zone of maximum removal of materials in solution and suspension and/or maximum in situ accumulation of organic matter. It includes:

(1) horizons in which organic matter has accumulated as a result of biological activity (Ah);

(2) horizons that have been eluviated of clay, iron, aluminum, and/or organic matter (Ae);

(3) horizons dominated by 1 and 2 above but transitional to underlying B or C (AB or A and B);

(4) horizons markedly disturbed by cultivation or pasture (Ap).

B - A mineral horizon or horizons characterized by one or more of the following:

(1) an enrichment (exclusive of dolomite or salts more soluble in water) in silicate clay, iron, aluminum, and/or illuvial organic matter (Bt, Bf, Bh, Bfh);

(2) a prismatic or columnar structure which exhibits pronounced coatings or stainings and characterized by the presence of significant amounts of exchangeable sodium and/or magnesium (Bn).

(3) an alteration by hydrolysis or oxidation to give a change in colour and/or structure and does not meet the requirements of (1) and (2) above (Bm).

C - A mineral horizon or horizons comparatively unaffected by the pedogenic processes operative in A and B, excepting (1) the process of gleying, and (2) the accumulation of dolomite and salts more soluble in water (Cca, Csa, Cg and C).

<u>Lower Case Suffixes</u>

c - A cemented (irreversible) pedogenic horizon.

ca - A horizon with secondary carbonate enrichment where the concentration of lime exceeds that present in the unenriched parent material.

cc - Cemented (irreversible) pedogenic concretions.

e - A horizon characterized by the removal of clay, iron, aluminum or organic matter. Lighter in colour by 1 unit of value or chroma when dry than the layer below (eluviated).

f - A horizon enriched with hydrated iron (fe). It has a chroma of 3 or more and is redder than the horizon above or below.

g - A horizon characterized by reduction and gray colours; often mottled (gley).

h - A horizon enriched with organic matter. When used with A it must show at least one Munsell unit of value darker than the layer immediately below (humus). When used as the only suffix to B(Bh) this horizon must contain 10 per cent or more of organic matter.

j - A horizon whose characteristics are weakly expressed. It must be used with some other suffix.

k - Presence of carbonate as indicated by visible effervescence with dilute HCl (kalk).

m - A horizon slightly altered by hydrolosis, oxidation and/or solution to give a change in colour and/or structure (mellowed). See note 9.

n - A horizon with distinctive morphological and physical characteristics as shown by black or dark colourations or coatings on the surface of the peds and characterized by prismatic or columnar structure, and hard to very hard consistency when dry. It contains more than 12 per cent exchangeable sodium or more than 50 per cent exchangeable sodium plus magnesium (natrium).

p - A layer disturbed by man's activities i.e. by cultivation and/or pasturing. To be used only with A.

sa - A horizon with secondary enrichment of salts more soluble than carbonates where the concentration of salts exceeds that present in the unenriched parent material.

s - A horizon with salts including gypsum which may be detected as crystals or veins, or as surface crusts of salt crystals, or by distressed crop growth, or presence of salt tolerant plants (salt).

t - A horizon enriched with silicate clay (ton).

z - A permanently frozen layer (zero).

Notes

1. Lithologic changes, to be indicated by Roman Numeral prefixes (I to be assumed). E.g. Ah, Ae, IIBt1, IIBt2, IIIC.

2. Transition horizons need capitals only, and

   (a) If transition gradual use e.g. AB.
   (b) If transition interfingered use e.g. A and B.
   (c) If desired, dominance can be shown by order e.g. AB and BA.

3. Horizon subdivisions to be shown with Arabic Numerals used as suffixes. E.g. Bt1, Bt2, Bt3.

4. Capitals used alone indicate that no further separations were made.

5. If more than one lower case suffix is required and if one only is a weak expression then the j is to be linked to that suffix with a bar. E.g. $Bf\overline{cj}$.
If two are weak cover both with a bar. E.g. $B\overline{fcj}$.

6. It is to be noted that position is required with respect to A but not B or C.

7. Note that some new lower case letters appear and some have been changed from our previous report. All, as used, have been suggested by some workers. In part, the changes are suggested to reduce all to one letter symbols to avoid confusion. Exceptions are cc, ca, and sa.

8. Note that g covers all gleying. When used with A or B it indicates that other pedogenic processes have been operative and should be indicated. When used with C it indicates that gleying is dominant and has virtually prevented the operation of any other process.

9. The suffix m should be used with B and then only alone or with the suffixes k, s, or g. Horizons formerly designated as Bmf or Bmt should now be shown Bfj or Btj.

10. Not all conditions are covered; it is still necessary to write profile descriptions.

THE NATIONAL TAXONOMIC CLASSIFICATION OF CANADIAN SOILS
(as of March 1963)

A. Leahey, Chairman, N.S.S.C.

Taxonomic groupings of soils have been used on a provincial basis for many years but it was not until 1955 that the National Soil Survey Committee first proposed a national system for trial. Then in 1960 the Committee presented a classification system which was adopted for official use by all the soil survey organizations in Canada. In March 1963 at a meeting of the N.S.S.C. a number of changes were made in the 1960 system. The classification system discussed in the following reports on soil classification includes these changes.

The Canadian taxonomic classification of soils has six categories: type, series, family, subgroup, great group and order. However, the reports on classification presented here deal only with the classes and nomenclature of the last three categories. These three categories, the subgroup, great group and order are for the classification of types of profiles. The differentiating characteristics of the classes in these three categories are presented in the various subcommittee reports on soil classification.

The fact that the three lower categories, type, series, family, are not described in the classification reports does not mean they are less important categories than the higher ones. The soil series, in particular, can be considered as the most important category in the system inasmuch as it is the basic unit of classification and it is also the basic unit for most soil mapping. Brief definitions of these lower categories and of phases are given below. More complete definitions may be found in many soil survey reports and in the U.S.D.A. Handbook No. 18 "Soil Survey Manual."

Soil family A group of soil series within a subgroup that are relatively homogeneous with respect to soil-air, soil-water and plant-root relationships. Hence families are differentiated primarily on the basis of properties important to the growth of plants. This category as yet has not been widely used in Canada.

Soil series A group of soils having soil horizons similar in differentiating characteristics and arrangement within the soil profile and developed from a particular kind of parent material. Hence all the soils in a series have the same type of profile at the subgroup level. However, two or more series on the same kind of parent material may be differentiated on the basis of significant differences in the thickness of a horizon or horizons.

Soil series are designated either by place or other geographical names or by a combination of such names and the subgroup name. The latter designations are used where the place name refers to the parent material in a particular soil climatic zone.

Soil types A subdivision of a series based on the texture of the surface soil. The type name is a combination of the series name and the textural class name of the surface soil.

Phase A subdivision of any class in the taxonomic system but not itself a category of the system. The basis of this subdivision may be any characteristic or combination of characteristics potentially significant to man's use or management of land apart from the properties used in the taxonomic classification. Common examples in Canada are topographic phases, stony phases and erosion phases.

The grouping of soils at progressively higher levels of abstraction above the series level in this system is based on selected features of the soil profile. In so far as the subgroup, great group and order are concerned the differentiating criteria are largely the morphological features which reflect the effects of climate, vegetation, local moisture relations and age on the parent material. In other words while this classification is based on soil profile properties, concepts of soil genesis affect the selection of criteria used for these higher groupings.

OUTLINE OF THE NATIONAL SYSTEM FOR CLASSIFYING CANADIAN SOILS (as of March 1963)

Note 1

Gleyed subgroups should only be used for imperfectly-drained soils. (See Report of Subcommittee on Soil Moisture - definition of imperfectly-drained soils.)

Note 2 - Conventions

(a) Subgroups shown by a dash and oblique stroke between the first two numerals and the last numeral are to be used with other subgroups in the same great group. Thus a Gleyed Orthic Brown Forest is to be numbered 4.11/8 and a Gleyed Degraded Brown Forest as 4.12/8.

(b) Horizon designations of profile types in the reports on classification make use of the following conventions:
Diagnostic horizons are underlined,
Non-diagnostic horizons that may be present are bracketed.
Diagnostic surface horizons apply only to undisturbed soils.

ORDER	GREAT GROUP	SUBGROUP	
1. Chernozemic	1.1 Brown	1.11	Orthic Brown
		1.12	Rego Brown
		1.13	Calcareous Brown
		1.14	Eluviated Brown
		1.1-/5	Saline Brown
		1.1-/6	Carbonated Brown
		1.1-/7	Grumic Brown
		1.1-/8	Gleyed Brown
	1.2 Dark Brown	Subgroups same as for Brown except for great group name - thus 1.21 Orthic Dark Brown	
	1.3 Black	Subgroups same as for Brown except for great group name - thus 1.31 Orthic Black	
	1.4 Dark Gray	Subgroups same as for Brown except for great group name - thus 1.41 Orthic Dark Gray	
2. Solonetzic	2.1 Solonetz	2.11	Brown Solonetz
		2.12	Dark Brown Solonetz
		2.13	Black Solonetz
		2.14	Dark Gray Solonetz
		2.1-/8	Gleyed Solonetz

ORDER	GREAT GROUP	SUBGROUP	
2. Solonetzic	2.2 Solodized Solonetz	2.21	Brown Solodized Solonetz
		2.22	Dark Brown Solodized Solonetz
		2.23	Black Solodized Solonetz
		2.24	Dark Gray Solodized Solonetz
		2.25	Gray Wooded Solodized Solonetz
		2.2-/8	Gleyed Solodized Solonetz
	2.3 Solod	2.31	Brown Solod
		2.32	Dark Brown Solod
		2.33	Black Solod
		2.34	Dark Gray Solod
		2.35	Gray Wooded Solod
		2.3-/8	Gleyed Solod
3. Podzolic	3.1 Gray Brown Podzolic	3.11	Orthic Gray Brown Podzolic
		3.12	Minimal Gray Brown Podzolic
		3.13	Brunisolic Gray Brown Podzolic
		3.14	Bisequa Gray Brown Podzolic
		3.1-/8	Gleyed Gray Brown Podzolic
		3.1-/9	Peaty Gray Brown Podzolic
	3.2 Gray Wooded	3.21	Orthic Gray Wooded
		3.22	Dark Gray Wooded
		3.23	Brunisolic Gray Wooded
		3.24	Bisequa Gray Wooded
		3.2-/8	Gleyed Gray Wooded
		3.2-/9	Peaty Gray Wooded
	3.3 Gray Forested	3.31	Orthic Gray Forested
		3.32	Dark Gray Forested
	3.4 Humic Podzol	3.41	Orthic Humic Podzol
		3.42	Humus Podzol
		3.4-/3	Ironpan Podzol
		3.4-/8	Gleyed Humic Podzol
		3.4-/9	Peaty Humic Podzol

ORDER	GREAT GROUP	SUBGROUP	
3. Podzolic	3.5 Podzol	3.51	Orthic Podzol
		3.52	Minimal Podzol
		3.53	Ortstein Podzol
		3.54	Concretionary Podzol
		3.55	Textural Podzol
		3.56	Bisequa Podzol
		3.5-/7	Sub-Arctic Podzol
		3.5-/8	Gleyed Podzol
		3.5-/9	Peaty Podzol
4. Brunisolic	4.1 Brown Forest	4.11	Orthic Brown Forest
		4.12	Degraded Brown Forest
		4.1-/8	Gleyed Brown Forest
	4.2 Brown Wooded	4.21	Orthic Brown Wooded
		4.22	Degraded Brown Wooded
		4.2-/7	Sub-Arctic Brown Wooded
		4.2-/8	Gleyed Brown Wooded
	4.3 Acid Brown Wooded (Brown Podzolic)	4.31	Orthic Acid Brown Wooded
		4.32	Degraded Acid Brown Wooded
		4.3-/7	Sub-Arctic Acid Brown Wooded
		4.3-/8	Gleyed Acid Brown Wooded
	4.4 Acid Brown Forest	4.41	Orthic Acid Brown Forest
		4.4-/8	Gleyed Acid Brown Forest
	4.5 Concretionary Brown	4.51	Orthic Concretionary Brown
		4.5-/8	Gleyed Concretionary Brown
	4.6 Subalpine Brown	4.61	Orthic Subalpine Brown
		4.6-/7	Sub-Arctic Subalpine Brown
		4.6-/8	Gleyed Subalpine Brown

ORDER	GREAT GROUP	SUBGROUP	
5. Regosolic	5.1 Regosol	5.11	Orthic Regosol
		5.12	Mull Regosol
		5.13	Mor Regosol
		5.14	Organo Regosol
		5.1-/5	Saline Regosol
		5.1-/7	Sub-Arctic Regosol
		5.1-/8	Gleyed Regosol
		5.1-/9	Peaty Regosol
6. Gleysolic	6.1 Humic Gleysol	6.11	Rego Humic Gleysol
		6.12	Orthic Humic Gleysol
		6.1-/5	Saline Humic Gleysol
		6.1-/6	Carbonated Humic Gleysol
		6.1-/7	Sub-Arctic Humic Gleysol
		6.1-/9	Peaty Humic Gleysol
	6.2 Gleysol	6.21	Rego Gleysol
		6.22	Orthic Gleysol
		6.2-/5	Saline Gleysol
		6.2-/6	Carbonated Gleysol
		6.2-/7	Sub-Arctic Gleysol
		6.2-/9	Peaty Gleysol
	6.3 Eluviated Gleysol	6.31	Humic Eluviated Gleysol
		6.32	Low Humic Eluviated Gleysol
		6.3-/9	Peaty Eluviated Gleysol

REPORT ON THE CLASSIFICATION OF CHERNOZEMIC SOILS

J. S. Clayton

Chairman, Subcommittee on Chernozemic Soils

Order 1

Well to imperfectly drained soils with Chernozemic A horizons as defined, and B or C horizons of high base saturation, with divalent cations, usually calcium, being dominant. Soils occurring under cool, semi-arid to sub-humid continental climates with the characteristics of the A horizons developed and maintained from the accumulation and decomposition of a cyclic growth of xero- or meso-phytic grasses and forbs*, representative of grassland communities, or of transitional grassland-forest communities with associated shrubs and trees.

Soils with dark coloured surface horizons developed under other vegetative communities, including those of the Arctic and Alpine regions are excluded. Soils having solonetzic Bn, or strongly gleyed subsoil horizons are excluded by definition from the Chernozemic Order and classified as Solonetzic or Gleysolic soils respectively.

At the Great Group level, Chernozemic soils are subdivided into Brown, Dark Brown, Black, and Dark Gray soils, on recognition of significant differences in darkness of colour and other associated characteristics of the A horizons as defined. These differences are closely related to changes in organic matter content reflecting shifts from xero- to meso-phytic vegetation, or from grass, to shrub and tree cover, and are indicative of changes in soil moisture efficiency and in humidity of the soil climate.

At the Subgroup level, Chernozemic soils are subdivided into Rego, Calcareous, Orthic and Eluviated soils on the recognition of distinctive Ae, B, or C horizons or by combinations of these as defined. These separations reflect the development of processes of leaching, decalcification, and progressive eluviation within the solum. Subgroup profiles with salinized, carbonated, gleyed, or grumic (self-mulching), characteristics are recognized as defined. While these are listed as subgroups they are not used alone but as modifications of the main subgroup profiles, e.g., 1.11/5, Saline Orthic Brown.

A key outline of the classification system for Chernozemic soils is presented in Table 1, and the horizon pattern of the key profiles in the subgroups are diagrammatically represented in Figure 1.

---

* The term "forb" is used for a non-grasslike herb, i.e. a non-graminoid herb.

Table 1 - Key to Classification and Horizon Nomenclature of Chernozemic Soils

Order 1 Chernozemic

Well to imperfectly drained soils with Chernozemic Ah, Ahe or Ap horizons, and B or C horizons as defined. Colour criteria of 6 inches of mixed surface horizons or Ap:

Values darker than 3.5 moist and darker than 5.5 dry.
Chroma less than 4, moist or dry.

Great Groups		Subgroups and their horizon designations	
1.1	Brown Colour criteria of 6" of mixed surface or Ap. Value 4.5 - 5.5 dry with chroma less than 4.	1.11	Orthic Brown Ah, Bm or Bt, C, (Cca), (Ck)
		1.12	Rego Brown Ah, C, (Cca), (Ck)
		1.13	Calcareous Brown Ah, Bmk, Cca or Ck
		1.14	Eluviated Brown Ah, Ae, (AB), Bt or Btj, C, (Cca), (Ck)
		1.1-/5	Saline Brown Saline A, B, and C horizons
		1.1-/6	Carbonated Brown A or B horizons of secondary carbonate enrichment.
		1.1-/7	Grumic Brown A and B transitional self-mulching horizons.
		1.1-/8	Gleyed Brown Gleyed B and C horizons.
1.2	Dark Brown Colour criteria 6" of mixed surface or Ap. Value 3.5 - 4.5 dry with chroma less than 2.5. Value 2.5 - 4.5 dry with chroma greater than 2.5.	1.21	Orthic Dark Brown Ah, Bm or Bt, C, (Cca), (Ck)
		1.22	Rego Dark Brown Ah, C, (Cca), (Ck)
		1.23	Calcareous Dark Brown Ah, Bmk, Cca or Ck
		1.24	Eluviated Dark Brown Ah, Ae, (AB), Bt or Btj, C (Cca), (Ck)
		1.2-/5	Saline Dark Brown Saline A, B, and C horizons.

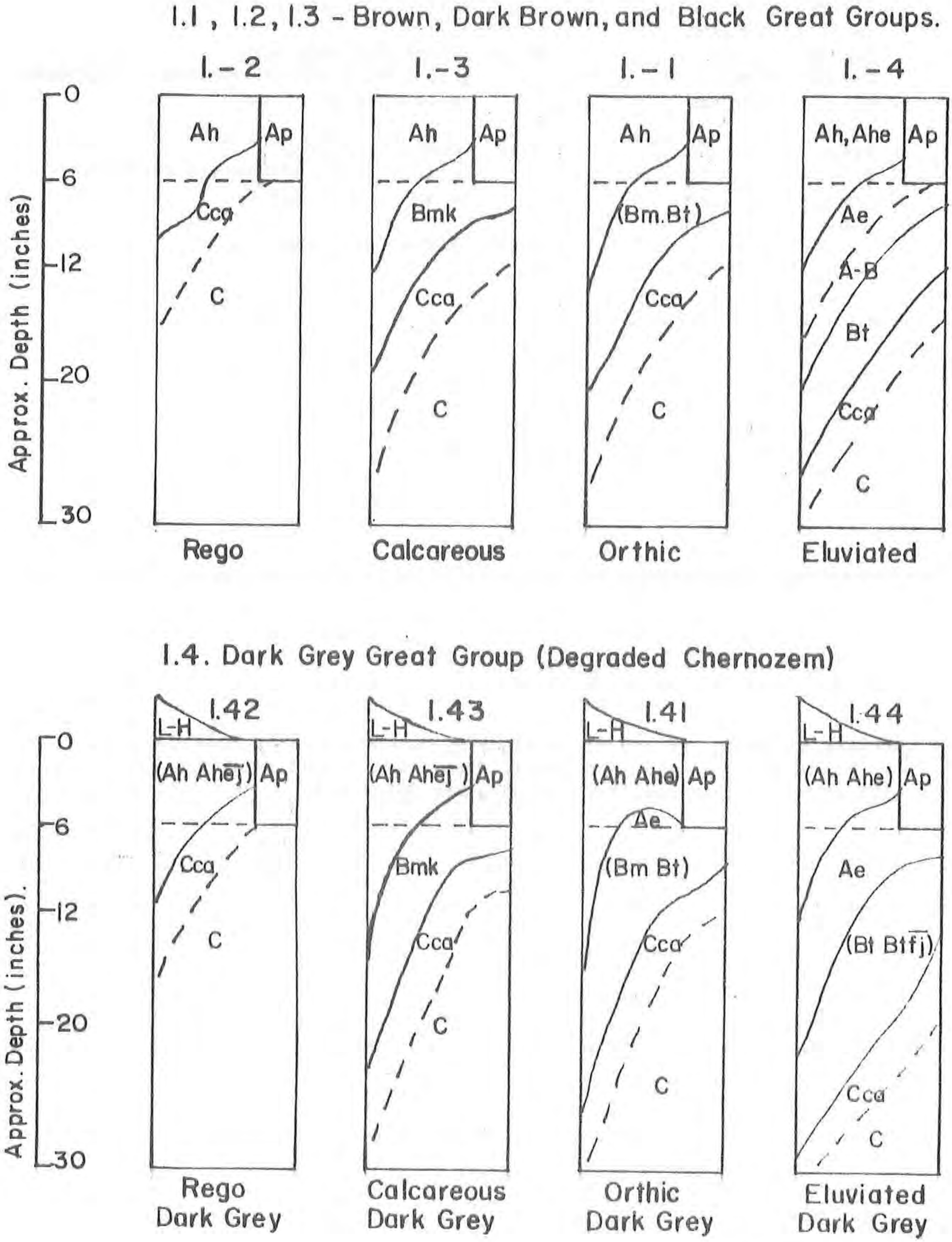
Great Groups	Subgroups and their horizon designations
1.2 Dark Brown (Continued) Colour criteria 6" of mixed surface or Ap. Value 3.5 - 4.5 dry with chroma less than 2.5. Value 2.5 - 4.5 dry with chroma greater than 2.5.	1.2-/6 Carbonated Dark Brown A or B horizons of secondary carbonate enrichment. 1.2-/7 Grumic Dark Brown A and B transitional self-mulching horizons. 1.2-/8 Gleyed Dark Brown Gleyed B and C horizons.
	* Subgroups and Diagnostic Horizons
1.3 Black Colour criteria 6" of mixed surface or Ap. Value darker than 3.5 dry and chroma less than 2.5.	1.31 Orthic Black Ah, Bm or Bt, C, (Cca), (Ck) 1.32 Rego Black Ah, C, (Cca), (Ck) 1.33 Calcareous Black Ah, Bmk, Cca or Ck 1.34 Eluviated Black Ah, Ae, (AB), Bt or Btj, C, (Cca), (Ck) 1.3-/5 Saline Black Saline A, B, and C horizons 1.3-/6 Carbonated Black A or B horizons of secondary carbonate enrichment. 1.3-/7 Grumic Black A and B transitional self-mulching horizons. 1.3-/8 Gleyed Black Gleyed B and C horizons.
1.4 Dark Gray (Degraded Chernozem) An (L-H) horizon may be present. Colour criteria 6" of mixed surface or Ap. Value 3.5 - 5.0 dry. Chroma less than 2.5.	1.41 Orthic Dark Gray (L-H), Ah (Ahe), Bm or Bt, C, (Cca), (Ck) 1.42 Rego Dark Gray (L-H), Ah, (Ahe), C, (Cca), (Ck) 1.43 Calcareous Dark Gray (L-H), Ah, (Ahe), Bmk, Cca or Ck 1.44 Eluviated Dark Gray (L-H), Ah (Ahe), Ae, (AB), Bt or Btj or Bfj, C (Cca) (Ck)

Great Groups	Subgroups and Diagnostic Horizons *
1.4 Dark Gray (Continued) (Degraded Chernozem) An (L-H) horizon may be present. Colour criteria 6" of mixed surface or Ap. Value 3.5 - 5.0 dry. Chroma less than 2.5.	1.4-/5 Saline Dark Grey Saline A, B and C horizons
	1.4-/6 Carbonated Dark Gray A or B horizons of secondary carbonate enrichment (k or ca)[1]
	1.4-/7 Grumic Dark Gray Exhibiting minor characteristics of self-mulching.
	1.4-/8 Gleyed Dark Gray.

---

* Horizon nomenclature and definitions by Subcommittee on Soil Horizon Designations. Saline, Carbonated, Grumic and Gleyed Subgroups are only to be used as modification of other Subgroups.

Fig. 1 Diagrammatic horizon pattern and designations of the key profiles of the Chernozemic order.



National Soil Survey
Committee of Canada. 1963

Definitions and Criteria to be used with Order 1

All colour comparisons, unless otherwise specified, are determined on moist and dry, crushed or rubbed soils, and are based on differences measurable by comparison to Munsell Colour Charts. The surface colours of clods or peds are frequently distinctive and may be recorded and used as supplemental criteria.

In order to relate virgin, and disturbed or cultivated soils, the colour criteria used for separations at the Order and Great Group levels are based on the colours obtained from 6 inches of mixed surface, or from an Ap horizon. Thin horizons which would be destroyed by the mixing of 6 inches of surface soil should be recorded but are not considered critical for evaluation.

Chemical and physical data, other than that measurable by simple field test are used as supplemental or supporting criteria.

Order Level. A Chernozemic A horizon should conform to the following characteristics. An Ah horizon when rubbed or crushed should have colour with chroma of 4.0 or less (moist and dry) and values darker than 3.5 moist and 5.5 when dry. The thickness and darkness of the Ah horizon must be sufficient to produce 6 inches of mixed surface or of Ap horizon with colour values darker than 3.5 when moist or 5.5 when dry. The colour of the Ah or Ap horizon, moist or dry, should be at least 1 Munsell unit darker in value than the C horizon and should be lower in chroma than the B horizon if present.

The Ah or Ap horizon should have an organic matter content usually in excess of 1.5% in 6 inches of mixed surface with a carbon-nitrogen ratio of 17 or less in virgin Ah horizons and usually not exceeding 13 in cultivated horizons. The A horizons should have well flocculated structures which do not become massive or very hard in consistence on wetting and drying.

Definitions and Criteria for Separations at the Great Group Level

Separation of the Great Group profiles under the Order are based on significant colour differences in characteristic of Ah or Ap horizons, all conforming to the criteria established at the Order level, but differing mainly in colour values and chroma. The colour values of the surface horizons are closely associated with organic matter content.

The thickness and darkness of Ah, or combined Ah,Ahe horizons must be sufficient to produce 6 inches of mixed surface or cultivated Ap horizon with the following specific ranges of moist and dry Munsell colour value and chroma.

1.1 Brown

A soil with an Ah horizon of value darker than 3.5 moist and 5.5 dry; of sufficient thickness to produce 6 inches of mixed surface or an Ap horizon with the following ranges of moist and dry colour.

Value darker than 3.5 moist and from 4.5 to 5.5 dry. Chroma usually more than 1.5 dry.

Brown soils are usually but not exclusively associated with, and developed from the decomposition of a cyclic growth of mixed xero- to meso-phytic grasses and forbs.

1.2 Dark Brown

A soil with an Ah horizon of value darker than 3.5 moist and 4.5 dry; of sufficient thickness to produce 6 inches of mixed surface, or an Ap horizon with the following ranges of moist and dry colour.

Values darker than 3.5 moist and between 3.5 and 4.5 dry if the chroma is less than 2.5, or with values from 2.5 to 4.5 dry if the chroma is greater than 2.5.

Dark Brown soils are usually associated with, and developed from the decomposition of a cyclic growth of meso-phytic grasses and forbs.

1.3 Black

A soil with an Ah horizon of value darker than 3.5 moist or dry, and chroma less than 2.5; of sufficient thickness to produce 6 inches of mixed surface, or an Ap horizon of the same range of moist and dry colour, i.e., values less than 3.5 and chroma less than 2.5.

Black soils are usually but not exclusively associated with and developed from the decomposition of a cyclic growth of meso-phytic grasses and forbs, but may also be associated with thin or discontinuous tree and shrub cover. Where this latter condition prevails the dominant ground cover is one of forbs and grasses, and leaf mats. L-H horizons are usually absent or of insignificant occurrence.

1.4 Dark Gray (Formerly termed Degraded Black)

A soil with a Chernozemic A horizon by Order definition, but with significant characteristics indicative of degradation or other modification resulting from the accumulation and decomposition of forest vegetation including leaf mats, (L-H) horizons. Such soils in their original or undisturbed state support a mixed vegetation of trees, shrubs, forbs and grasses, characteristic of transitional areas between grassland and forest, but if protected from fire tend to be dominated by tree and shrub cover.

Virgin Dark Gray soils frequently have leaf mats, (L-H) horizons overlying Ah or Ahe horizons. The peds of the A horizons may have relatively dark coloured surfaces but these will usually crush or rub out to grayer or browner colours of higher value or chroma. A "salt and pepper effect," i.e. lighter grayish spots or bands may be observable in Ahe horizons, and these exhibit a tendency to platy structures which crush easily to a fine granular condition. In Rego and Calcareous Dark Gray subgroups these evidences of degradation are frequently weakly expressed and may be designated as an Ahej horizon.

A Dark Gray Chernozemic A has the following criteria. An Ah horizon in Virgin Dark Gray soils has colour values darker than 3.5 moist and chroma of less than 2.5. The Ahe horizon has peds which crush to lighter colours than the Ah if present, with values between 3.5 and 5.0 dry and chroma less than 2.5. The Ah, Ahe or (Ah, Ahe) combination must be of sufficient thickness to produce 6 inches of mixed surface below a leaf mat, or an Ap horizon with values darker than 3.5 moist and 5.0 dry and with chroma less than 2.5. If these limits are not met such soils should be considered as Regosolic or Podzolic soils and classified within their respective orders.

Definitions for separation at the subgroup level

The surface Ah or Ap horizons of Chernozemic soils may be underlain by various combinations and sequences of master mineral A, B and C horizons, each of which may be differentiated into specific horizon types with criteria as established by the Soil Horizon Committee. The characteristics imparted to the soil profiles by significant differences in these horizon combinations are used as criteria for the separation of subgroup profiles below the Great Group level. Thin horizons which would be destroyed by the mixing of 6 inches of surface horizons or by the formation of an Ap horizon, should be recorded, but are not considered critical for subgroup evaluation.

The B and C horizons of Chernozemic soils should be of relatively high base status, dominated by bivalent cations, particularly calcium, and should have structures characterized by well aggregated peds and well flocculated colloidal material. Soils with Solonetzic Bn horizons as defined, and soils with master gley horizons g are excluded from the Order by definition.

The major horizon characteristics developed through progressive leaching and eluvial processes are used to establish the main sub-profile types with the following sequences of diagnostic horizons or horizon combinations below an Ah, (Ah,Ahe) or Ap: Rego (Cca,C), Calcareous (Bmk), (Cca,C), Orthic (Bm,Bt), (Cca,C), and Eluviated (Ae,AB), (Bt), (Cca,C). One or more of the horizons designated in brackets must occur to be diagnostic. Profiles with salinized, carbonated, gleyed, and grumic (self-mulching) modifications of these horizon sequences are also recognized as significant in minor subgroup separations. However, these are not used alone but in conjunction with the main sub-profile types.

Rego Chernozemic

	Profile Types	Horizon Sequences
1.12	Rego Brown	Ah, C, (Cca), (Ck)
1.22	Rego Dark Brown	Ah, C, (Cca), (Ck)
1.32	Rego Black	Ah, C, (Cca), (Ck)
1.42	Rego Dark Gray	Ah, (Ahe), C (Cca), (Ck)
1.-2/5	Saline Rego*	Saline Ah and C horizons
1.-2/6	Carbonated Rego*	Carbonated A and C horizons
1.-2/7	Grumic Rego*	Ah and C transitional horizons
1.-2/8	Gleyed Rego*	Gleyed upper C horizons

* Used only in conjunction with main subgroup profiles.

Soils with Ah or Ap horizons as defined in the Order and Great Groups, underlain by C horizons. Profiles in which no major leaching of indigenous alkaline earth carbonates has occurred below the A horizons. Transition AC horizons may occur. No significant development of colour Bm is permitted in Rego Chernozemic soils.

In profiles with well developed internal drainage, or in those occurring on sites with moderate to excessive surface drainage the virgin Ah horizons are commonly free from carbonates or salts and overlie a C or weakly expressed Ccaj horizon. When disturbed or under cultivation, the A horizon is usually calcareous.

In profiles with limited internal drainage, or in those occurring on sites of imperfect drainage and excessive moisture accumulation, the A horizons may be infused with secondary carbonates, or salts, due to precipitation from solution of lime or salt bearing waters. Carbonated rego profiles may usually be detected by visual observation of strings or beads of carbonate crystals occurring in the Ah horizon and confirmable by an effervescence test with acid, Ahk. Under cultivation such soils usually have a distinctly grayish surface cast or colour.

Salinized rego profiles may be detected by visual evidence of salt crystals or surface crust. No limit of salinity is imposed but it should be sufficient to be suspected by eye and confirmable by simple qualitative field test (As,Cs).

Grumic phases of rego profiles are mainly confined to fine textured soils, usually with over 50 per cent clay. The self-mulching properties of these soils, due to the repetition of swelling, shrinking and the sloughing of surface material into cracks, result in profiles with ill-defined A horizons which merge into a transitional AC horizon. A tendency to form a surface granular mulch is particularly characteristic of grumic phases.

Gleyed phases of rego profiles are characterized by weak development of mottling, and other characteristics of temporary wetness in the A and upper C horizons. Carbonated and saline profiles are frequently but not invariably associated with gleyed phases.

The use of ca with A or B horizons is restricted to significant accumulations of secondary carbonates greater than that present in the parent material.

Calcareous Chernozemic

	Profile Types	Horizon Sequences
1.13	Calcareous Brown	Ah, Bmk, Cca or Ck
1.23	Calcareous Dark Brown	Ah, Bmk, Cca, or Ck
1.33	Calcareous Black	Ah, Bmk, Cca, or Ck
1.43	Calcareous Dark Gray	Ah, (Ahe), Bmk, Cca or Ck
1.-3/5	Saline Calcareous*	Saline A, B and C horizons
1.-3/6	Carbonated Calcareous*	A or B horizons of secondary carbonate enrichment
1.-3/7	Grumic Calcareous*	A or B transitional self-mulching horizons
1.-3/8	Gleyed Calcareous*	Gleyed B and C horizons

* Used only in conjunction with main subgroup profiles.

Soils with Ah or Ap horizons as defined in the Order and Great Groups underlain by colour Bm horizons, from which indigenous alkaline earth carbonates are not completely removed, (Bmk).

The B is usually medium to fine prismatic in macro-structure, and slightly to moderately alkaline in reaction. Coarse prismatic structure is usually associated with coarse textured fabric. A lighter coloured Cca horizon of carbonate accumulation is usually present above the C.

In profiles occurring on sites with moderate to excessive surface drainage, the indigenous carbonates in the B horizon are present through insufficient leaching and represent a lack of full modal profile development.

In profiles occurring on sites of imperfect drainage and excessive moisture accumulation, the occurrence of carbonates above the C horizon may be indigenous due to retardation of leaching, Bmk, or an expression of upward moisture movement and precipitation of secondary carbonates. In this latter circumstance both carbonated and gleyed phases may be recognized if significant and the carbonates frequently extend into the surface A horizon.

Grumic phases of calcareous profiles with self-mulching characteristics may be found in profiles of fine texture (greater than 50 per cent clay). In these soils a tendency to form a surface granular mulch is common and the separations of A, B and C horizons tend to be diffuse and transitional. Tongues of A horizon frequently extend into the B and C horizons due to sloughing into cracks. Slickensides may be frequently observed in the C horizons.

Orthic Chernozemic

Profile Types		Horizon Sequences
1.11	Orthic Brown	Ah, Bm, or Bt, C (Cca), (Ck)
1.21	Orthic Dark Brown	Ah, Bm, or Bt, C (Cca), (Ck)
1.31	Orthic Black	Ah, Bm, or Bt, C (Cca), (Ck)
1.41	Orthic Dark Gray	Ah, (Ahe), Bm or Bt, C, (Cca) (Ck)
1.-1/5	Saline Orthic*	Saline A, B, and C horizons
1.-1/6	Carbonated Orthic*	A or B Horizons of secondary carbonate enrichment
1.-1/7	Grumic Orthic*	A and B transitional self-mulching horizons
1.-1/8	Gleyed Orthic*	Gleyed B and C horizons

* Used only in conjunction with main subgroup profiles.

Soils with Ah or Ap horizons as defined in the Order and Great Groups, underlain by a colour Bm, or a weak to moderately textural Btj, Bt horizon. The B horizons are free of indigenous carbonates, and range in reaction from slightly alkaline to slightly acidic.

The B horizon is normally medium to fine prismatic in macro-structure, breaking to medium and fine blocky or to coarse granular aggregates. Coarse prismatic structure is usually associated with coarse textured fabric. Decreasing size of macro-prismatic structure and an increasing tendency to break into finer blocky and granular aggregates is apparently associated with increasing clay content of the solum, and particularly with the occurrence of a textural Bt horizon. Thin discontinuous coatings on the surface of peds may occur in textural Bt horizons. Although these are not readily visible by eye, they may be observed with a hand lens or in thin section. The occurrence of textural B horizons in orthic chernozems may reflect simple gravitational movement and colloidal flow through pores and cleavages, or trends towards minimal development of solonetzic or podzolic characteristics.

A thin weakly developed colour B horizon or a transitional BC horizon is frequently present between the modal B and C horizons. A lighter coloured horizon of carbonate accumulation, Cca is usually present but is not an essential criterion. Profiles with weakly gleyed, saline, or carbonated A and B horizons may occur and can be subdivided if desired.

Orthic profiles with minimal grumic characteristics occur in soils of high clay content, and are characterized by granular to fine subangular blocky peds in the A horizon and massive to angular blocky structure in the B horizon. Frequently dark tongues of A horizon extend into the B and C due to sloughing into cracks. The boundaries between A, Bm and Ck horizons are usually sharper and less diffuse than in rego and calcareous chernozemic subtypes.

A minimum development of Ae horizon of less than 2 inches is allowable within the 6 inches of surface below the leaf mat of orthic Dark Gray profiles providing that the mixed combination of Ah,Ahe and Ae will meet the criteria for Chernozemic soil, and that no undisturbed Ae horizon is present below this depth.

Eluviated Chernozemic

	Profile Types	Horizon Sequences
1.14	Eluviated Brown)	Ah, Ae (AB), Bt or Btj, C, (Cca), (Ck)
1.24	Eluviated Dark Brown)	Ah, Ae (AB), Bt or Btj, C, (Cca), (Ck)
1.34	Eluviated Black)	Ah, Ae (AB), Bt or Btj, C, (Cca), (Ck)
1.44	Eluviated Dark Gray (Degraded)	(L-H) Ah (Ahe), Ae (AB), Bt or Btj or Bfj, C (Cca) (Ck)
1.-4/5	Saline Eluviated[*] (Uncommon)	Saline A, B and C horizons
1.-4/6	Carbonated Eluviated[*] (Uncommon)	A or B horizons of secondary carbonate enrichment (k or ca)
1.-4/7	Grumic Eluviated[*] (Occurrence doubtful)	Exhibiting minor characteristics of self-mulching
1.-4/8	Gleyed Eluviated[*]	Gleyed Dark Gray

[*] Used only in conjunction with main subgroups.

Soils with Ah or Ap horizons as defined in the Order and Great Groups, underlain by significant horizons of leaching or eluviation, beyond the concepts of the orthic chernozemic development.

This significance is manifested by the occurrence of combinations and sequences of eluvial Ahe, Ae, and transitional AB horizons, underlain by illuvial B horizons. The leached horizons are characterized by the development of slight to moderate acidity and a minor reduction in base saturation.

The genesis of eluviated Chernozemic soils is apparently complex and at present obscure. For these reasons no official separations within the subgroup category are at present authorized. Inferential explanations based on limited factual data suggest a minimum of three genetic types, each of which have modifying profile characteristics indicative of their particular development. These types include the following:

A. A profile type, in which eluviation has developed through in situ leaching. This type is characterized by relic macro-prismatic structure below the Ah or Ap, which breaks into coarse to medium platy peds, which often exhibit vesicular or tubular voids; suggesting the formation of Ae and AB horizons from a former prismatic B. The Bt horizon is somewhat finer textured than the Ae, with well developed macro-prismatic structure breaking to blocky peds of lower colour value and slightly higher chroma than for the Ae. The development of coatings on the surface of the peds if present are less strongly expressed than in solonetzic Bn horizons and the cationic ratio of calcium to other ions usually remains relatively high. They are, however, frequently indicative of a trend towards minimal solodic developments.

B. A "Cumulic" type, in which the cumulative effects of surficial deposition of transported soil material, merge and overlap the horizon differentiation due to leaching in situ. Such soils are characterized by thick horizons of partially leached accumulated materials, overlying transitional AB horizons. They are usually found in concave slope positions of depositional accumulation. The occurrence of a slight lithological differentiation within the solum from roughly sorted to unsorted material is frequently detectable in this profile type.

C. A "Degraded" type, in which pronounced leaching and eluviation has resulted due to the genetic influence of accumulation and decomposition of wooded vegetation, including leaf mats. Such soils are most commonly found within the Dark Gray Great Group in those soils intergrading towards the Gray Wooded soils of the Podzolic Order, and include soils which have been formerly designated as moderately degraded black. They are characterized by surface combinations of L-H, Ah, Ahe or Ap horizons conforming to the criteria established for the Dark Gray Great Group, but underlain by well-developed light coloured Ae horizons of medium to fine platy structure, which occur at depths greater than 6 inches beneath a leaf mat or beneath the surface of a cultivated Aa horizon. Virgin soils with less than 3 inches of Ah, Ahe beneath a leaf mat and with Ae horizon extending below 6 inches in depth will not usually meet the requirements of an Eluviated Dark Gray Chernozemic soil.

These Ae horizons are underlain by textural Bt horizons, usually subangular blocky to coarse granular in structure and frequently showing a weakly expressed enrichment of hydrated iron (Btfj). This iron enrichment may be visible in the form of thin bands of strong chroma. The reaction of the Bt is usually slightly acidic, but the lower B horizon above the Cca may be slightly calcareous.

Eluviated profiles with gleyed horizons are of frequent occurrence. Saline or carbonated horizons occur less frequently. Where significant these profiles may be subdivided as Gleyed, Saline, or Carbonated subgroups, but only in conjunction with the main types. Eluviated Chernozemic profiles with grumic characteristics have not been observed and their occurrence is doubtful. Finer textured phases are usually characterized by an increase in granular (shotty) and fine subangular rather than medium to coarse blocky structures in the Ahe, Ae and B horizons.

CLASSIFICATION OF THE SOLONETZIC ORDER OF SOILS

W. Earl Bowser

Chairman, Subcommittee on Solonetzic Soils

Order 2

Soils with solonetzic or disintegrating solonetzic B horizons which have an exchangeable base status in which 50% or more is sodium plus magnesium, or which have more than 12% exchangeable sodium, and usually with saline subsoils (EC greater than 4). Cca and Csa, horizons of lime and salt enrichment, may be present but are not diagnostic. Well- to imperfectly-drained soils developed under a vegetative cover of grasses or forbs. Solodized Solonetz and Solod soils may occur under trees; it is suggested that the trees did not become established until solodization was dominant.

Solonetz	-	Ah, Bnt, Csk, or C
Solodized Solonetz	-	Ah, Ae, (AB), Bnt, Csk, or C
Solod	-	Ah, Ae, AB, Bnt, Csk, or C

L-H horizons may occur in the Dark Gray and Gray Wooded subgroups. Ah horizons may be thin and in some cases absent.

The criteria for subgroup colors are similar to those for the Chernozemic and Gray Wooded soils. Strongly gleyed (g) horizons may occur in all profile types. The gleyed subgroups are not used alone but in conjunction with all other subgroup profiles.

e.g. 2.22/8 - Gleyed Dark Brown Solonetz.

2.1 Solonetz

Profile type: (Ah), Bnt, C, (Csk).

The solonetzic B horizon is strongly expressed, has a neutral to alkaline reaction and may contain free carbonates. The upper C is usually saline and calcareous (Csk).

2.11 Brown Solonetz

2.12 Dark Brown Solonetz

2.13 Black Solonetz

2.14 Dark Gray Solonetz (occurrence doubtful)

2.1-/8 Gleyed Solonetz

2.2 Solodized Solonetz

Profile type: (Ah), Ae, (AB), Bnt, C, (Csk)

The Ae is well developed and acidic in reaction and the Bnt horizon has a strongly expressed columnar structure which may vary from mildly acidic to alkaline in reaction;

2.21 Brown Solodized Solonetz

2.22 Dark Brown Solodized Solonetz

2.23 Black Solodized Solonetz

2.2 Solodized Solonetz (Continued)

the columns are hard to very hard and usually white capped. The upper C is usually saline and calcareous (Csk).

2.24 Dark Gray Solodized Solonetz

2.25 Gray Wooded Solodized Solonetz

2.2-/8 Gleyed Solodized Solonetz

2.3 Solod

Profile type: (Ah), Ae, AB, Bnt, C, (Csk).

The Ae is well developed and acidic in reaction; a pronounced transition AB horizon expressing disintegration of the upper part of the Solonetzic B is characteristic; the columnar Bnt breaks readily into blocky aggregates. The Bnt may be relatively thin. The C horizon is usually calcareous and saline (Csk).

2.31 Brown Solod

2.32 Dark Brown Solod

2.33 Black Solod

2.34 Dark Gray Solod

2.35 Gray Wooded Solod

2.3-/8 Gleyed Solod

Criteria and Definitions to be used with Order 2

Order 2 - Solonetzic

Definition

Soils with A horizons overlying solonetzic or disintegrating solonetzic B horizons usually with saline subhorizons or with subhorizons influenced by saline waters. The B horizons are characterized by a base status in which the magnesium plus sodium cations are 50% or more of the total exchangeable bases or in which the exchangeable sodium exceeds 12%.

Desalinization of these horizons results in an increase of alkali-peptised and deflocculated colloidal fractions which coat and partially infiltrate the peds in the B horizon with dispersed material. These horizons are characterized by coated columnar or prismatic macro-structures, and blocky meso-structures, with hard to very hard consistence when dry. This firm consistence of the coated peds of solonetzic B horizons tends to result in characteristic concentration of root development along the cleavage planes rather than in a uniform penetration of the peds.

Further leaching and removal of alkaline bases result in the formation of acidic Ae horizons with blocky to platy structures, and finally to the de-alkalinization and structural breakdown of the solonetzic B horizon. The major horizon features resulting from these processes are used as criteria for the separation of the Solonetzic soils into three great groups with the following horizon sequences: Ah or Ap, Bnt, Csk, C; Ah or Ap, Ae, (AB), Bnt, Csk, C; and Ah or Ap, Ae, AB, Bnt, Csk, C.

Definitions for separation at the Great Group Level

2.1 Solonetz Great Group

A soil with an A horizon as defined in the subgroup, but usually thin when compared to the B horizon. A very thin (less than ½ inch) to discontinuous Ae may occur. The Bnt horizon has strong coatings and very dark stainings, has a neutral to strongly alkaline reaction, and may contain free carbonates. The Bnt horizon has a very firm consistence when dry and may have a weak to moderate development of gray colored round tops to the columnar structure. The C horizon is usually dominantly saline and calcareous, Csk. Profiles with imperfectly drained or gleyed horizons may be separated if desired.

The occurrence of Dark Gray Solonetz profiles are considered doubtful, as it is unlikely that tree growth could be sustained on soils with such alkalinity and structure. A Gray Wooded subgroup is considered impossible.

2.2 Solodized Solonetz Great Group

A Solodized Solonetz profile usually has an Ah or Ap horizon as defined in the subgroups, although the Ah may be relatively thin in relation to the underlying lighter-colored Ae. In the latter case the Ap is generally lighter in color than in associated Solonetz and Chernozemic soils. Under cultivation an Ae or the white caps of the columnar B must be present to classify the soil as a Solodized Solonetz; if the Ap lies directly on the columnar Bnt the soil should be classed a Solonetz.

The Ae horizon is significantly lighter in color than the B horizon and has a strongly developed platy structure. The reaction of the Ae varies from acidic to neutral. The Bnt horizon is very hard, usually with white capped columnar macro-structure, the latter making an abrupt textural change between the friable Ae and the very hard Bnt horizons; however, a thin AB horizon may occur. During periods of excess moisture water may be held temporarily above the Bnt. This is generally indicated by some mottling in the Ae and/or upper Bnt. The meso-structure of the Bnt is blocky with a very hard consistence when dry. The surfaces of the aggregates are strongly coated and are usually darker in color than the inside of the peds. The reaction of the B horizon varies from slightly acidic to moderately alkaline. The lower B and C horizons are normally alkaline and frequently saline.

2.3 Solod Great Group

Soils with Ah horizons as defined in the subgroups. There is often an Ahe subhorizon. The Ae horizon is lighter in color and usually thicker than the Bnt. The Ae is usually prismatic in macro-structure and platy in micro-structure. The Ae may frequently be divided into Ae1 and Ae2 layers on variation in color and structure.

There is an AB transitional horizon between the Ae and Bnt horizons that indicate a breakdown of former Bnt. It is characterized by a weak or fragmental prismatic structure breaking easily to blocky aggregates of moderate consistence. The peds of this AB horizon are usually coated with light colored siliceous material, and are acidic in reaction. The Bnt is characterized by a macro-prismatic or columnar structure that breaks readily to hard blocky aggregates. These aggregates have dark surface coatings and stainings. There may be a BC horizon.

The C horizon is usually saline and calcareous, Csk. Occasionally the Cs is below the Ck.

Definitions for separation at the Subgroup Level

At the subgroup level the great soil groups may be divided on the basis of significant differences in the darkness and color of surface Ah or Ap horizons, similar to those defined for Chernozemic soils, but in addition including provision for a Gray Wooded subgroup with L-H, Ae; or Ap, Ae; types corresponding to those defined for Podzolic soils. It should be noted that while the general characteristics of the A horizons of the Solonetzic soils with respect to color, organic matter content, and base saturation are very similar to those recognized for the Chernozemic soils and may be subdivided in the same way, the structures developed in the Ap horizons usually become a little more massive and hard on wetting and drying than is found in the Chernozemic soils. It should be noted that in the Solodized Solonetz and Solod soils the mixed A (Ap) horizon may be lighter (higher value) than in associated Chernozemic soils. In some Solonetz soils the Ah is quite thin and in some Solodized Solonetz areas the A horizon has been eroded off. In both of these soils the subgroup is determined by the geographically associated soils.

Note

It is known that there are soils that are intergrades between Solonetz and Orthic Chernozemic and also ones that are a transition between Solods and Eluviated Chernozems. At present there is no satisfactory criteria by which to identify and classify them. When satisfactory criteria are developed these intergrades will be established in the classification system.

REPORT ON THE CLASSIFICATION OF PODZOLIC SOILS

P.C. Stobbe

Chairman, Subcommittee on Podzolic Soils

Order	Great Group		Subgroup
3. Podzolic	3.1 Gray Brown Podzolic	3.11	Orthic Gray Brown Podzolic
		3.12	Minimal Gray Brown Podzolic
		3.13	Brunisolic Gray Brown Podzolic
		3.14	Bisequa Gray Brown Podzolic
		3.1-/8	Gleyed Gray Brown Podzolic
		3.1-/9	Peaty Gray Brown Podzolic
	3.2 Gray Wooded	3.21	Orthic Gray Wooded
		3.22	Dark Gray Wooded
		3.23	Brunisolic Gray Wooded
		3.24	Bisequa Gray Wooded
		3.2-/8	Gleyed Gray Wooded
		3.2-/9	Peaty Gray Wooded
	3.3 Gray Forested	3.31	Orthic Gray Forested
		3.32	Dark Gray Forested
	3.4 Humic Podzol	3.41	Orthic Humic Podzol
		3.42	Humus Podzol
		3.4-/3	Ironpan Podzol
		3.4-/8	Gleyed Humic Podzol
		3.4-/9	Peaty Humic Podzol
	3.5 Podzol	3.51	Orthic Podzol
		3.52	Minimal Podzol
		3.53	Ortstein Podzol
		3.54	Concretionary Podzol
		3.55	Textural Podzol
		3.56	Bisequa Podzol
		3.5-/7	Sub-Arctic Podzol
		3.5-/8	Gleyed Podzol
		3.5-/9	Peaty Podzol

3. Podzolic Order

Well and imperfectly drained soils developed under forest or heath having light colored eluviated horizons (Ae) and illuvial (B) horizons with accumulations of sesquioxides, organic matter or clay; or any combinations of these. They may have organic (L-H) and mineral-organic (Ah) surface horizons.

3.1 Gray Brown Podzolic Great Group

Soils with dark colored mull-type surface horizons (Ah), more than 2 inches thick, with lighter colored eluviated horizons (Ae) and with illuvial horizons (Bt) in which clay is the main accumulation product. An increase of free sesquioxides is usually associated with the accumulation of clay. Developed on basic or calcareous parent materials. The solum generally has a medium to high degree of base saturation.

They have developed under deciduous or mixed forest vegetation and under moderate climatic conditions (M.A.T. above 40°F.). They have a high earthworm population; the organic surface layers (L-F) are quickly incorporated into the Ah horizon and seldom accumulate.

3.11 Orthic Gray Brown Podzolic

Soils with well-developed Ah, Ae and Bt horizons. Ae is light colored with chroma of less than 3; it lacks a definite, brown upper subhorizon; the difference in chroma between the upper and lower Ae is less than 1.

The solum of these soils is generally deep (more than 18").

Profile type: (L-H), Ah, Ae, (AB), Bt, C.

3.12 Minimal Gray Brown Podzolic

Soils with well-developed Ah but with weakly expressed Ae and Bt horizons relative to the development in the Orthic and Brunisolic subgroups on similar materials. The ratio of clay between the Bt and Ae is at or just above the lower limit for textural B horizons.

The solum of these soils is generally shallow (less than 18 inches). These soils represent intergrades between the Brown Forest and Gray Brown Podzolic groups but are more closely related to the latter than to the former group.

Profile type: (L-H), Ah, Ae, Bt, C.

3.13 Brunisolic Gray Brown Podzolic

Soils with well-developed Ah, Ae and Bt horizons. The upper Ae1 is brown (chroma of 3 or more) and grades to lighter colored lower Ae2. The difference in chroma between upper and lower Ae is 1 or more. The thickness of the upper Ae1 (or Bm) should be sufficient that it can be recognized under a cultivated (Ap) layer.

This subgroup represents early intergrade stages between the Orthic subgroup and the Acid Brown Wooded soils. The upper Ae may be considered as a Bm or Bfj horizon and the lower Ae as the C horizon of the upper sequum. The degree of base saturation of the upper solum is more typical of the Gray Brown Podzolic than of the Acid Brown Wooded soils.

Profile type: (L-H), Ah, Ae1, Ae2, (AB), Bt, C.

3.14 Bisequa Gray Brown Podzolic

Gray Brown Podzolic soils in which a Podzol sequence of horizons (Ae and Bfh) has developed in the Ae of the Gray Brown Podzolic soil and which is underlain by a continuous textural (Bt) horizon.

Under cultivated conditions these soils may be distinguished from the Brunisolic subgroups by the presence of the podzolic B (with high chroma) under the cultivated (Ap) layer. They differ from the Bisequa Gray Wooded soils in that they have a mull-type Ah; when the Ah does not meet the requirements of the Gray Brown Podzolic group the soil is classified with the Bisequa Gray Wooded soils.

Profile type: (L-H), Ah, Ae, Bfh or Bf, (Ae), Bt, C.

3.1-/8 Gleyed Gray Brown Podzolic

Soils with the same type of profile as any of the above subgroups but with mottling and commonly with duller colors in the Ae and Bt horizons than in the associated well-drained soils due to periodic wetness.

The Gleyed Gray Brown Podzolic soils generally have thicker and darker Ah horizons than the well-drained subgroups. The color and textural differences between the Ae and Bt are generally less marked in the gleyed than in the well-drained subgroups.

Specific profile types may be indicated as 3.11/8, 3.13/8, etc.

Profile types: (L-H), Ah, Aeg, Btg, C.

3.1-/9 Peaty Gray Brown Podzolic

Soils with the same type of profile as the gleyed subgroup, but with 6 to 12 inches of muck, compacted peat, or both, on the mineral soil surface. This subgroup is of rare occurrence.

3.2 Gray Wooded Great Group

Soils with organic surface horizons (L-H), with light colored eluvial horizons (Ae) and with illuvial horizons (Bt) in which clay is the main accumulation product. An increase of free sesquioxides is usually associated with the accumulation of clay. The solum generally has a medium to high degree of base saturation.

The best developed Gray Wooded soils are found under cool climatic conditions (M.A.T. 40°F. or less) and under boreal forest or under forest in the grassland-forest transition zone, although some Gray Wooded soils may also occur under somewhat warmer climates under mixed forest vegetation. They generally have developed on basic parent materials. They differ from the Gray Brown Podzolic soils mainly in that they lack or have a very thin mull-like Ah horizon. Earthworms are absent or very scarce. They lack a chernozemic Ah, although in some transition types, thin (less than 4 inches) chernozemic-like Ah and Ahe horizons may occur under virgin conditions. The color of the cultivated surface (Ap) has a value of 3.5, or higher, moist. They differ from the Podzol soils which may be found under similar climatic and vegetative conditions mainly in the nature of the B horizon.

3.21 Orthic Gray Wooded

Soils with organic surface horizons (L-H) with a light colored Ae and a Bt. They may have a thin (less than 2 inches) Ah, a slightly mottled lower Ae and generally have a marked AB horizon. The Ae has a color value of 6.0 or more (dry) and a chroma of less than 3, although higher chromas may occur on some parent materials. A cultivated surface horizon (Ap 6 inches thick) has a dry color value of 6 or more.

Profile type: L-H, (Ah) or (Ahe), Ae, (AB) Bt, C.

3.22 Dark Gray Wooded

Soils with organic surface horizons (L-H) and with chernozemic-like Ah or Ahe horizons 2 to 4 inches thick over light colored Ae underlain by Bt, or soils with thinner Ah but with prominent Aeh. The mixed plowed layer (Ap) of both of these subtypes is darker than that of the orthic subgroup (value 6.0 dry) but lighter than that of the associated chernozemic soils (value 3.5 moist or 5.0 dry).

This subgroup represents intergrades between the Orthic Gray Wooded and the eluviated chernozemic soils and therefore a range in relative thickness and color of Ah and Ae horizons can be expected. The following is suggested as a guide: Ah and Ahe horizons (having color values of less than 3.5 and chromas of less than 2.5) less than 4 inches thick over a lighter colored Ae of sufficient thickness and of color to produce an Ap horizon lighter than 3.5 moist or 5.0 dry, or without Ah horizon but with prominent Aeh horizon darker than color value 6.0 (dry) and of sufficient depth to produce an Ap horizon lighter than 3.5 moist, or any combination of color and thickness of A horizons that gives similar results.

Profile types: L-H, Ah or Ahe Ae, (AB), Bt, C.
L-H (Ah), (Ahe), Aeh (Ae) Bt, C.

3.23 Brunisolic Gray Wooded

Soils with organic surface (L-H) over brown upper Ae1, which generally grades to a lighter colored lower Ae2 over Bt horizon.

This subgroup represents early intergrade stages between Gray Wooded and Acid Brown Wooded soils. The entire profile may be considered as having a bisequa development. The upper sequum approaches that of a weakly developed Acid Brown Wooded soil. The degree of base saturation of the upper sequum is generally somewhat higher than that of comparable Acid Brown Wooded soils. The upper Ae1 may be considered as a Bfj and the lower Ae2 as a C horizon of the upper sequum. The color of the Bfj has a chroma of 3 or more and the difference in chroma between the Bfj and the lower Ae or C should be 1, or more. The thickness of the Bfj should be sufficient that it can be recognized under a cultivated (Ap) layer.

In some soils there is no appreciable difference in chroma between the upper and lower Ae. They represent either advanced stages of development in which the Bf (with higher chroma) has developed throughout the entire depth of the Ae to the Bt, or they represent normal Ae horizons (generally with chromas of 3) with chromas inherited from the parent material. The latter should be classed with the Orthic subgroup regardless of anything stated above. The Bt horizon is continuous. Where the Bt horizon is disintegrating and no longer continuous the soil should be classified in the Brunisolic order. No depth limits are suggested for the upper sequum. The depth to Bt rarely exceeds 48 inches and is generally considerably less.

Profile type : L-H, Ae, Bt, C.
L-H Ae1, Ae2, (AB) Bt, C.

3.24 Bisequa Gray Wooded

Gray Wooded soils in which a Podzol sequence of horizons (Ae and Bfh) has developed in the Ae of the Gray Wooded soil and which is underlain by a continuous textural (Bt) horizon.

The development of the Podzol sequence relative to the Bt may vary greatly in intensity and in depth, resulting in a range of profiles that approach the Orthic or Brunisolic Gray Wooded soil on the one hand and the Bisequa Podzol on the other. An arbitrary limit between the Bisequa Gray Wooded and Bisequa Podzol is suggested as a guide for the separation of the two subgroups. A depth of 36 inches, of a weakly to moderately developed podzol solum, to a well-developed Bt horizon, or a depth of 18 inches to the Bt horizon if the Podzol solum is strongly developed (Ae horizon exceeding 3 inches and substantial accumulations in Bfh).

Profile types: L-H, Ae, (Bfh) Bf, (Bfj) Ae Bt, C.
L-H, Ae, Bfh, (Bf) Ae Bt, C.

3.28 Gleyed Gray Wooded

Soils with the same type of profile as any of the above subgroups but with mottling and commonly with duller colors in the Ae and Bt horizons than the associated well-drained soils, due to periodic wetness.

The Gleyed Gray Wooded soils generally have thicker L-H horizons than the well-drained subgroups. They often have thicker Ae and stronger developed Bt horizons in depressions, on reasonably permeable materials, than the associated well-drained soils in the Gray Wooded and grassland transition zones. In more humid regions, on level land, particularly on less permeable materials, the gleyed members may have less-developed Ae and Bt horizons than the associated well-drained soils. They differ from the Eluviated Low Humic Gleysols in that the latter have developed under greater extremes of wetness and have lower chroma.

Profile type: L-H, Aeg, Btg, C.
Specific profiles may be designated as 3.21/8, 3.23/8, etc.

3.2-/9 Peaty Gray Wooded

Soils with the same type of profile as any of the above subgroups, but with 6 to 12 inches of muck, compacted peat or both, on the mineral soil surface. Specific profiles may be designated as 3.21/9, 3.23/8/9.

3.3 Gray Forest Group

Soils with thin organic surface horizons (L-H), with thick, light colored, eluvial (Ae) horizons and with illuvial horizons which have higher chroma or lower value than the adjacent eluvial horizons.

The illuvial horizon contains small concentrations of clay in isolated peds, tongues, or clay flows rather than in a continuous Bt horizon, or small accumulations of clay and/or iron in bands or lamellae. It is often interrupted by gray tongues of eluvial (Ae) material resulting in a horizon consisting of separate pockets of A and B materials. In extreme cases this horizon consists dominantly of light colored eluvial material and small peds of darker colored illuvial material, giving it a mottled appearance. The peds appear to be degrading; the interior resembles B material, while the exterior consists of gray coatings resembling Ae material.

The Ae horizons are thick (often several feet) and light colored (apparently due to a lack of free iron to form brown upper subhorizons). An Ah horizon may be present. The solum is weakly acidic but highly base saturated.

These soils have developed on coarse textured, slightly calcareous materials under similar climatic and vegetative conditions as adjacent Gray Wooded soils. They are regosolic in nature and they may be considered as intergrades between the Regosols and Gray Wooded soils. The B horizon does not contain enough clay to meet the requirements of the Bt horizon of Gray Wooded soils (probably due to very slight accumulation of clay in the first instance and possibly to subsequent deterioration) and they do not appear to have sufficient accumulation of sesquioxides (or increase in chroma) to meet the requirements of Podzols. The B horizon, therefore, might be recognized as a Btj horizon.

3.31 Orthic Gray Forest

Gray Forested soils without Ah horizons or with Ah horizon less than 2 inches thick, with thick light gray eluvial horizons and with evidence of clay accumulation in the lower part of the sola in the form of pockets, or clay flows.

Profiles - L-H, (Ah), Ae, AB and BA (BC), C.

3.32 Dark Gray Forest

Gray Forested soils with prominent Ah or Ahe horizons (more than 2 inches thick), with thick light gray eluvial horizons and with evidence of clay accumulation in the lower part of the sola in the form of pockets, or clay flows.

Profiles - L-H, Ah or Ahe, Ae, AB and BA (BC), C.

3.4 Humic Podzol Great Group

Soils with thick organic surface horizons (L, F, H), with light colored eluviated horizon (Ae) and with illuvial horizons (Bh) in which organic matter is the main accumulation product. The Bh is at least 2 inches thick, has a color of 5YR 3/3 or darker and contains 10 per cent or more of organic matter. It may be underlain by Bfh or Bf horizon. A thin (less than 1 inch), involute, impervious, hard, dark reddish brown hardpan may occur in the solum. Degree of base saturation of solum is very low and cation-exchange capacity of Bh is very high.

These soils have developed under heath or forest with heath and sphagnum undercover, consequently the L-H horizons are generally thick and peaty. The Humic Podzols are known to occur in cool, moist coastal regions, in cool, moist locations at higher altitudes inland, and in some peaty depressions in warmer and less moist regions.

The dark color (5YR 3/3) and high organic matter (10 per cent) content are not always complementary. The color and organic matter limits are given as a guide as they generally coincide with the climatic and vegetative conditions. Soils with colors of 5YR 3/3 (or darker) but with only 8 per cent of organic matter, and soils with 10 per cent (or more) of organic matter but with slightly lighter colors than 5YR 3/3 may also be included with this group. In cases where free iron is lacking in the dark colored B horizon it may contain somewhat less organic matter.

3.41 Orthic Humic Podzol

Soils with organic surface horizons (L, F, H) with light colored eluviated Ae and with dark colored (5YR 3/3) illuvial (Bh) horizon containing free iron, as well as about 10 per cent, or more, of organic matter. The Bh horizon is underlain by Bhf or Bf horizons containing less organic matter. They may be friable or cemented. A thin, involute, impervious, hard, dark reddish brown hardpan is lacking.

Profile type : L, F, H, Ae, Bh, Bhf or Bf, C.

3.42 Humus Podzol

Soils with organic surface horizons (L, F, H), with light colored eluviated Ae, and with dark colored (5YR 3/3) illuvial (Bh) horizon containing about 10 per cent, or more, of organic matter but lacking free iron oxide or so low in iron oxide that it does not turn red on ignition. The Bh horizon may be underlain by Bhf or Bf horizons. The B horizons may be friable or cemented. A thin (less than 1 inch), involute, impervious, hard, dark reddish brown hardpan is lacking.

These soils generally have formed on parent materials low in iron or the organic matter has accumulated to form the Bh in an Ae horizon which has already lost free iron. The Bh horizons are generally very dark, often black, but they may contain less than 10 per cent organic matter.

Profile type : L, F, H, Ae, Bh, (Bhf), (Bf), C.

3.4-/3 Ironpan Podzol

Soils with profiles like 3.31 and 3.32 but with thin "ironpan," generally less than $\frac{1}{2}$ inch thick. The pan is continuous, irregular or involute, impervious, hard and dark reddish brown in color. It may rest on any of the other horizons and it may extend into the parent material but it generally occurs below the Bh and above the C horizon. Due to its impermeability some gleying generally occurs immediately above the pan but the soil below the pan is well drained.

The "ironpans" that have been studied to date contained in the vicinity of 20 per cent of free iron oxide and approximately equal amounts of organic matter. The genesis of the pan is not clearly understood.

The profiles overlying the hardpan, particularly in the depressions or troughs of the pan, are often strongly gleyed humic or humus podzols and in extreme cases they may represent peaty Gleysols. The hardpan designation therefore should always be used with the appropriate subgroups, i.e. Humic(us), Gleyed Humic(us) Podzol with "ironpan". The ironpan Podzol may also be intergraded with the Gleysols.

Profile types: Same as other subgroups but with thin ironpan Bfc.

3.4-/8 Gleyed Humic(us) Podzol

Podzols with the same general types of profiles as either of the above subgroups but with indications of excessive wetness. The Gleyed Humic Podzol differs somewhat from the Gleyed Humus Podzol in genesis and morphology. In the Gleyed Humic Podzol mottling and iron staining is evident in the Ae and B horizons. In the dark colored Bh mottling and iron staining is often only visible along root channels but it is prominent in the underlying Bhf and Bf horizons. In the Gleyed Humus Podzol there is no evidence of mottling due to iron in the Ae and Bh horizons but mottling and iron staining may or may not occur in the underlying B horizons. The B horizons may be splotched, black and gray. The organic matter content of the iron-free B horizon may in some instances be less than in the orthic subgroups.

The free iron in the Gleyed Humus Podzol has been removed under extreme reducing conditions from the upper part of the solum, or from the entire solum. The thick organic surface horizons yield large quantities of humus which accumulates in the Bh horizon.

Profile types: L, F, H, Aeg, Bhg, Bfhg or Bfg, C
L, F, H, Aeg, Bhg, (Bfjg), C.

3.4-/9 Peaty Humic(us) Podzol

Soils with the same type of profile as any of the above subgroups, but with 6 to 12 inches of muck, compacted peat, or both, on the mineral soil surface. If the thickness of peat exceeds 12 inches, the soil should be considered as an organic soil that may be intergraded to the Humic Podzols.

Specific profiles may be designated as 3.41/9, 3.41/8/9.

3.5 Podzol Great Group

The undisturbed soils have organic surface horizons (L-H), a light colored eluviated horizon (Ae), and an illuvial B horizon, with higher chroma (Bfh or Bf), in which organic matter and sesquioxides are the main accumulation products. The main B horizon contains less than 10 per cent organic matter but a thin (less than 2 inches) Bh horizon containing ten per cent organic matter may be present immediately below the Ae. The solum is generally moderately to strongly acid. Under cultivated conditions the upper horizons may be mixed but remnants of Bhf or Bf horizons should be clearly visible and remnants of Ae may or may not be present.

The Podzol soils have developed under mixed or coniferous vegetation over a wide range of climatic conditions but they are dominant on the better-drained sites in moist, cool regions on noncalcareous materials or on materials from which free lime has been removed.

The major processes of development involve the accumulation of organic surface layers and the formation of organic-sesquioxide complexes which accumulate in the B horizon. Clay translocation and accumulation in the B is generally absent or not significant although some infiltration of dispersed clay may take place. The Podzols may or may not be underlain by fragipans.

3.51 Orthic Podzol

Soils with organic surface horizons (L-H), a light colored eluviated horizon (Ae), more than 1 inch thick, and a friable Bfh or Bf horizon of high chroma. If a Bh subhorizon containing more than 10 per cent organic matter is present it is less than 2 inches thick. Some mottling may be present in the lower B horizon particularly if the B horizon is underlain by a fragipan.

Profile types: L-H, Ae, (Bh) Bfh, Bf (Bfg), C.
L-H, Ae, Bf, BC, C.

3.52 Minimal Podzol

Soils with organic surface horizons (L-H) and weakly developed Ae and Bfh or Bf horizons. The development may be considered as weak when the difference in chroma or value between Ae and B horizons is less than 2 or when the Ae is thin (less than 1 inch) but the Bfh and Bh development is moderately strong and deep enough (8 inches or more) so that it can be recognized below the plow layer, when cultivated.

Soils in which Ae horizon is less than 1 inch thick and podzolic Bhf and Bf horizons are less than 8 inches thick (can not be clearly identified under cultivated conditions) should be classed with the Degraded Acid Brown Wooded soils.

Profile types: L-H, Aej, Bfj, C
L-H, Ae, Bfh, (Bf), C.

3.53 Ortstein Podzol

Soils with organic surface horizons (L-H), a light colored eluviated horizon (Ae) and with cemented Bfh or Bf horizons of high chroma. The cemented B horizons may be discontinuous or interrupted. They generally lie immediately below the Ae horizon but they may also occur at lower depth below a friable B horizon.

Profile type : L-H, Ae, Bfhc, or Bfc, (Bf), C.

3.54 Concretionary Podzol

Soils with organic surface horizons (L-H), a light colored eluviated horizon (Ae), more than 1 inch thick and an illuvial horizon with high chroma containing numerous hard magnetic, rounded concretions (Bcc) in addition to illuviated organic matter and sesquioxides. Degrading concretions with gray coatings may occur in the Ae; some mottling may occur in the lower B. The solum is generally moderately to strongly acid and unsaturated.

These soils occur in the west coast region in a climate characterized by mild wet winters and cool dry summers. They have developed under a coniferous vegetation of hemlock, red cedar and Douglas fir with a dense understory of ferns, bracken, salal and Oregon grape on moderately coarse to fine-textured materials.

Soils with an Ae less than 1 inch thick and with a weak B development (difference in chroma or value between Ae and B less than 2 or thickness of B less than 8 inches) are classed with the Concretionary Brown soils.

Profile type : L-H, Ae, Bfhcc or Bfcc, (Bccg), C.

3.55 Textural Podzol (Podzol - Gray Wooded Intergrade)

Soils with organic surface horizons (L-H), a light colored eluviated horizon and illuvial horizons containing accumulations of organic matter, sesquioxides and clay (Btf). The organic matter and free sesquioxide accumulation is greatest in the upper B (Bft) and drops rapidly with depth; the clay content increases significantly from Ae to the upper B and continues to increase slightly with depth to the lower Bt2 or Bt3. There is no appreciable decrease of total or fine clay in the C horizon. The solum is acid and generally unsaturated.

This subgroup may be considered as an intergrade between the Podzol and Gray Wooded Groups as the B horizon has some characteristics of both. It differs from the Bisequa Podzols in which the podzolic B horizon (BfH) overlies the textural (Bt) horizon and the two B horizons are generally separated by an Ae horizon.

These soils have formed on medium- to fine-textured acidic materials in which the clay disperses readily. Clay flows may extend into the parent material to a considerable depth.

Profile type : L-H, Ae, Bft, Bt, (BC), C.

3.56 Bisequa Podzol

Podzol sola, with organic surface horizons (L-H), Ae and Bhf or Bf horizons, that have developed in the Ae of Gray Wooded or Gray Brown Podzolic soils and are underlain by a textural (Bt) horizon. The Bf and Bt horizons are generally separated by a lighter colored horizon which represents the lower part of the original Ae and which may be considered as the C horizon of the upper Podzol profile.

An arbitrary limit between Bisequa Gray Wooded and Bisequa Podzol is given under 3.24. In the Bisequa Podzol the depth to the Bt horizon is more than 36 inches if podzol development is weak or more than 18 inches if podzol development is strong. If Bt is discontinuous or so weak that it does not influence the moisture regime, the Podzol profiles are classified with the other appropriate Podzol subgroups.

Profile type : L-H, Ae, Bfh or Bf, (Ae), Bt, C.

3.5-/7 Sub-Arctic Podzol (with permafrost)

Podzol soils underlain by permafrost within 4 feet of the mineral soil surface. This subgroup may form intergrades with any of the other subgroups, i.e. 3.51/7; 3.51/7/8; etc. The soils with permafrost may be gleyed in the lower part of the solum.

Profile types: L-H, Ae, Bf, Cz.
L-H, Ae, Bfg, Cz.

3.5-/8 Gleyed Podzols

Podzol soils with the general characteristics of any of the above subgroups but with mottling and duller colors due to periodic wetness in the Ae and B horizons. Specific profile types may be indicated as follows: 3.51/8, 3.53/8, etc.

Profile type : L-H, (Ah), Aeg, Bfg, Cg.

3.5-/9 Peaty Podzols

Soils with the same type of profile as any of the above subgroups but with 6 to 12 inches of muck, compacted peat, or both, on the mineral soil surface.

Specific profiles may be designated as 3.51/9, 3.51-/8/9

REPORT ON THE CLASSIFICATION OF BRUNISOLIC SOILS

Paul G. Lajoie

Chairman, Subcommittee on Brunisolic Soils

Order 4 : Brunisolic Soils

Well to imperfectly drained soils developed under forest, mixed forest and grass, or heath vegetation with brownish colored sola without marked eluvial or illuvial horizons. They may or may not have a distinct Ah horizon as defined below.

A distinct Ah is more than 2 inches thick with a Munsell color value of 3.5 or less when moist and should be lower in value by one unit or more or lower in chroma by 2 units or more than the next underlying horizon.

Great Groups	Subgroups and Their Horizon Designations
4.1 Brown Forest Soils with weakly acidic to mildly alkaline sola and with a distinct Ah horizon.	4.11 Orthic Brown Forest - (L-H), Ah, Bm, Ck, (Cca) 4.12 Degraded Brown Forest - (L-H), Ah, (Aej), AB, Btj, Ck, (Cca) 4.1-/8 Gleyed Brown Forest - with gleyed B and C horizons.
4.2 Brown Wooded Soils with weakly acidic to mildly alkaline sola and without a distinct Ah horizon.	4.21 Orthic Brown Wooded - L-H, (Ah), Bm or Bf, (BC), Ck, (Cca) 4.22 Degraded Brown Wooded - L-H, (Ah), Aej, AB, Btj, Ck, (Cca) 4.2-/7 Sub-Arctic Brown Wooded - with permafrost in C horizon 4.2-/8 Gleyed Brown Wooded - with gleyed B and C horizons.
4.3 Acid Brown Wooded Soils with moderately to strongly acidic sola and without a distinct Ah horizon.	4.31 Orthic Acid Brown Wooded - L-H, Bf or Bhf or Bm, C 4.32 Degraded Acid Brown Wooded - L-H, Aej, Bf, Bhf, or Bm, C 4.3-/7 Sub-Arctic Acid Brown Wooded - with permafrost in the C horizon 4.3-/8 Gleyed Acid Brown Wooded - with gleyed B and C horizons.
4.4 Acid Brown Forest Soils with moderately to strongly acidic sola and with a distinct Ah horizon.	4.41 Orthic Acid Brown Forest - (L-H), Ah, Bm, C 4.4-/8 Gleyed Acid Brown Forest - with gleyed B and C horizons.

Great Groups	Subgroups and Their Horizon Designations
4.5 Concretionary Brown Soils with thin organic and organic-mineral horizons, underlain by a reddish mineral horizon containing numerous small magnetic concretions and with acidic sola.	4.51 Orthic Concretionary Brown - L-H, (Ahe), Bfcc, (Bm), C 4.5-/8 Gleyed Concretionary Brown - with gleyed B and C horizons.
4.6 Subalpine Brown Soils with thin organic mats (L-H) and with dark colored, turfy (Ah) horizons, underlain by (B) horizons grading through various colors, from reddish-browns to yellowish-browns and gray-browns with depth, and varying from moderately to strongly acidic.	4.61 Orthic Subalpine Brown - L-H, Ah, B, C 4.6-/7 Sub-Arctic Subalpine Brown - with permafrost in the C horizon 4.6-/8 Gleyed Subalpine Brown - with gleyed B and C horizons.

Characteristics and environmental conditions of Brunisolic Great Groups and Subgroups

4.1 Brown Forest Great Group

Soils with weakly acidic to mildly alkaline sola and with a distinct Ah horizon. An L-H horizon may or may not be present. Usually it is destroyed through the actions of earthworms. The parent material is usually calcareous. The thickness of the solum is usually less than two feet.

The Brown Forest soils occur almost entirely in the Great Lakes — St. Lawrence Lowland physiographic region. Here they have developed under similar climatic and biotic conditions as the Gray-Brown Podzolics and they appear to represent a stage of soil development between a Regosol and a Gray-Brown Podzolic soil. Their lack of distinct eluvial or illuvial horizons may be due to their youthfulness, high lime parent material or a combination of both.

The subgroups recognized are the Orthic, the Degraded and the Gleyed Brown Forest soils.

4.11 Orthic Brown Forest soils are well drained, with no apparent eluviated or illuviated horizons.

4.12 Degraded Brown Forest soils are well drained, with weakly developed illuvial horizons as judged by some clay accumulation.

4.1-/8 Gleyed Brown Forest soils are imperfectly drained, with mottling and duller colors than the well-drained Brown Forest soils.

4.2 Brown Wooded Great Group

Soils with weakly acidic to mildly alkaline sola and without a distinct Ah horizon. An L-H horizon is usually present. The parent material is usually calcareous. The thickness of the solum is usually less than two feet.

The Brown Wooded soils occur in dry valleys in the Cordillera extending from the United States into the Yukon Territory. They are common on the intermediate and upper terraces of the rivers in the forested region on the Great Plains. They are of rare occurrence on the uplands in the Great Plains. In the Cordillera they appear to be the zonal soils of the dry forest areas while elsewhere they are developing under similar climatic and biotic conditions as the Gray Wooded soils. The Brown Wooded soils appear to represent a stage of soil development between a Regosol and a Gray Wooded soil. Their lack of distinct eluvial or illuvial horizons appears to be due to dry climate, youthfulness, high-lime parent material or a combination of all these factors.

The four subgroups recognized are the Orthic, the Degraded, the Gleyed Brown Wooded, and the Sub-Arctic Brown Wooded.

4.21 Orthic Brown Wooded soils are well drained, with no apparent eluviated or illuviated horizons. The upper part of the mineral solum may have a higher chroma than the lower part.

4.22 Degraded Brown Wooded soils are well drained, with weakly developed illuvial horizons as shown by some clay accumulation.

4.2-/7 Sub-Arctic Brown Wooded soils have permafrost within 4 feet of the mineral soil surface.

4.2-/8 Gleyed Brown Wooded soils are imperfectly drained, with mottling and duller colors than the well-drained Brown Wooded soils.

4.3 Acid Brown Wooded Great Group[1]

Soils with moderately to strongly acidic sola and without a distinct Ah horizon. An L-H horizon is usually present. The parent material is usually of low base saturation.

The Acid Brown Wooded soils occur in all provinces but their major distribution is in the western part of the Appalachian region in Quebec and in the southern parts of the Canadian Shield in Ontario and Quebec. In these areas they may be considered as zonal soils. The Acid Brown Wooded soils appear to represent a stage of soil development between the Regosol and Podzol. Their lack of distinct eluvial and illuvial horizons may in some instances be attributed to age or resistant mineral material. However, for the most part the reasons for their failure to develop into podzols are unknown.

---

[1] Formerly known as Brown Podzolic soils.

The four subgroups recognized to date are the Orthic, the Degraded, the Gleyed Acid Brown Wooded and the Sub-Arctic Acid Brown Wooded.

4.31 Orthic Acid Brown Wooded soils are well drained.

4.32 Degraded Acid Brown Wooded soils are well drained, with weak eluvial horizon (Ae less than 1" thick or Aej which may be several inches thick).

4.3-/7 Sub-Arctic Acid Brown Wooded soils have permafrost within 4 feet of the mineral soil surface.

4.3-/8 Gleyed Acid Brown Wooded soils are imperfectly drained, with mottling present throughout the solum.

4.4 Acid Brown Forest Great Group

Soils with moderately to strongly acidic sola and with a distinct Ah horizon.

Soils classified into this group at present have parent materials of both low and high base status. A thin organic horizon may be present.

The only place where soils have been classified into this group is on the southeastern coastal plain of Vancouver Island. The distinct Ah horizon may be a relic from a time when these soils were under grass or a grass and oak vegetation. At present some of the virgin sites are covered by coniferous trees.

The subgroups recognized to date are the Orthic and the Gleyed Acid Brown Forest soils.

4.41 Orthic Acid Brown Forest soils are well drained.

4.4-/8 Gleyed Acid Brown Forest soils are imperfectly drained with mottles and duller colors than the Orthic subgroup.

4.5 Concretionary Brown Great Group

Soils with thin organic and organic-mineral horizons, underlain by a reddish mineral horizon containing numerous small magnetic concretions and with acidic sola.

The Concretionary Brown soils usually exhibit some translocated clay in the lower part of the solum but not a distinct (Bt) clay accumulation. Thin Ahe horizons may occur. The parent materials are generally moderately acidic and of medium or fine texture. The differentiating field criterion of this great group is the presence of numerous magnetic concretions in the upper B horizon.

Iron and aluminum oxides are formed in the upper B horizon but are not translocated downward. The iron oxides bind the other soil constituents into hard magnetic concretions which range in size from silt to fine gravel and these oxides inactivate both organic and inorganic exchange sites. The present investigations suggest that the aluminum oxides result in the formation of dioctahedral aluminum chlorite from interstratified montmorillonite clay inherited from the parent material. The exchange cation content of the Bcc horizons is low but owing to the low cation exchange capacity the base saturation is moderately high.

The Concretionary Brown soils have been found in Canada only at the lower elevations on the west coast of British Columbia. The climate under which they have formed is characterized by mild winters and cool dry summers. The mean annual temperature is about 50°F. and the annual precipitation where these soils are found ranges from 35 to 70 inches of which only 1.5 to 3 inches fall in July and August. These soils are seldom affected by frost.

The natural vegetation found on these soils is Douglas fir, hemlock and red cedar with a dense understay of ferns, bracken, salal and Oregon grapes.

There are two subgroups of the Concretionary Brown: the Orthic and the Gleyed.

4.51 Orthic Concretionary Brown soils have indistinct or no mottling in the sola.

4.5-/8 Gleyed Concretionary Brown soils have distinct mottles in the lower part of the sola. They have somewhat thicker Ah horizons and brighter chroma in the Bcc horizons than the associated Orthic Concretionary Brown soils.

4.6 Subalpine Brown Great Group

Soils with thin, usually turfy, organic mats (L-H) and with distinct Ah horizons usually turfy in the upper part, and underlain by (B) horizons grading through various colors, from reddish browns to yellowish-browns and grayish-browns, with depth and varying from moderately to strongly acidic.

The parent materials of the Subalpine Brown soils are moderately acid and of medium to coarse texture. The cation exchange capacity is low and base saturation very low. There is no visual evidence of translocation of mineral elements noted in the profile but chemical techniques indicate a slight increase in base saturation with depth.

A very weak podzolic process is thought to be operating at a very slow rate. Apparently frost processes, down slope movement, and other physical soil disturbing processes are also active. In addition, the short growing season and low temperatures greatly reduce chemical and biological activities.

These soils have been recognized to date in south-central British Columbia in the forest-alpine transitional areas. The vegetation is generally park-like with the ground vegetation similar to the alpine type but with scattered trees. The climate is more moderate than in the true alpine, but cooler and more humid than in the adjacent forested areas at lower elevation.

4.61 Orthic Subalpine Brown soils are well drained.

4.6-/7 Sub-Arctic Subalpine Brown soils have permafrost within 4 feet of the mineral soil surface.

4.6-/8 Gleyed Subalpine Brown soils have faint mottles and higher chromas in the lower part of the sola than in the Orthic subgroup.

REPORT ON THE CLASSIFICATION OF REGOSOLIC SOILS

L. Farstad

Chairman, Subcommittee on Regosolic Soils

5. Regosolic Order

Well and imperfectly drained soils that lack discernible horizons or in which development is limited to an organic-mineral surface horizon (Ah) or to organic surface horizons (L-H) less than 12 inches thick.

Soils with dark colored mineral surface horizons developed under xero- or meso-phytic grasses and forbs representative of grassland communities, or under transitional grassland-forest communities, are excluded. (See definition of Chernozemic Order).

5.1 Regosol Great Soil Group

Only one great group has been recognized to date. Therefore the great group definition is the same as for the order.

5.11 Orthic Regosol

Soils lacking any horizon development, or with thin or weak Ah horizons, and without visible evidence of salts or gleying. (Weak Ah horizons are those that fail to produce Ap horizons 6 inches thick, one Munsell unit darker in value when dry than the C horizons). An L-H horizon up to 2 inches in thickness may be present.

(L-H), (Ah), C.

5.12 Mull Regosol

Soils with an Ah horizon, and without visible evidence of salts or gleying. An L-H horizon up to 2 inches in thickness may be present.

(L-H), Ah, C.

5.13 Mor Regosol

Soils with organic surface horizons (L-H) 2 to 6 inches thick and without visible evidence of salts or gleying.

(L-H), (Ah), C.

5.14 Organo Regosol

Soils containing a relatively high content of organic matter in the profile. The organic matter may occur as layers or pockets separated by mineral materials without visible evidence of salts or gleying.

(L-H), (Ah), C.

5.1-/5 Saline Regosol

Regosols containing soluble salts in the parent material.

(L-H), (Ah), Cs.

5.1-/7 Sub-Arctic Regosol

Regosols with permafrost within 4 feet of the mineral soil surface.

5.1-/8 Gleyed Regosol

Regosols with gleyed upper C horizons.

5.1-/9 Peaty Regosols

Regosols having 6 to 12 inches of muck, compacted peat, or both, on the surface. To be used only with Mor and Organo subgroups.

REPORT ON THE CLASSIFICATION OF GLEYSOLIC SOILS

W.A. Ehrlich

Chairman, Subcommittee on Gleysolic Soils

Order	Great Group	Subgroups and their Horizon Designations	
6.0 Gleysolic	6.1 Humic Gleysol	6.11	Rego Humic Gleysol (L-H), Ah, Cg, (Ckg), (Ccag)
		6.12	Orthic Humic Gleysol (L-H), Ah (Ahe), Bmg or Btjg, Cg, (Ckg), (Ccag)
		6.1-/5	Saline Humic Gleysol with saline C horizons; A or B horizons may be saline
		6.1-/6	Carbonated Humic Gleysol with calcareous Ah horizons
		6.1-/7	Sub-Arctic Humic Gleysol with permafrost in the C horizon
		6.1-/9	Peaty Humic Gleysol with 6 to 12 inches of muck, compacted peat, or both
	6.2 Gleysol	6.21	Rego Gleysol (L-H), (Ah), Cg, (Ckg), (Ccag)
		6.22	Orthic Gleysol (L-H), (Ah), (Aejg), Bmg or Btjg or Bfjg, Cg, (Ckg), (Ccag)
		6.2-/5	Saline Gleysol with saline C horizons, A or B horizons may be saline
		6.2-/6	Carbonated Gleysol with calcareous surface mineral horizon
		6.2-/7	Sub-Arctic Gleysol with permafrost in the C horizon
		6.2-/9	Peaty Gleysol with 6 to 12 inches of muck, compacted peat
	6.3 Eluviated Gleysol	6.31	Humic Eluviated Gleysol (L-H), Ah or Ahe, Aeg, Btg, Cg, (Ckg), (Ccag)
		6.32	Low Humic Eluviated Gleysol (L-H), (Ah), (Ahe), Aeg, Btg, Cg, (Ckg), (Ccag)
		6.3-9/	Peaty Eluviated Gleysol with 6 to 12 inches of muck, compacted peat, or both.

6.0 Gleysolic Order

The soils are saturated with water at one or more seasons, or are artificially drained. The soils developed under hydrophytic vegetation or they may be expected to produce hydrophytic vegetation if left undisturbed.

These soils may have an organic horizon of less than 12 inches in thickness (compacted or solid), an Ah horizon, or both, or without these horizons. If the soils are cultivated the suggested criteria for classifying surface horizons is presented in the definitions of 6.1 and 6.2. The B horizons,*

* The color criteria for B and C horizons are suggested as guides for classifying Gleysolic soils.

if present, may have one of the following combination of colors:

(a) Dominant chromas of 1 to 2 in hues of 10YR or redder on the ped surfaces, or in the matrix if peds are lacking, accompanied by mottles of stronger chroma, or

(b) Dominant chromas of 1 to 3 in hues of 2.5Y or yellower on the ped surfaces, or in the matrix if the peds are lacking, accompanied by mottles of stronger chroma and redder hue, or

(c) Dominant chromas of 1 or less on the surfaces of the peds or on the matrix if peds are lacking, and stronger chroma of mottles if present.

The C horizons have colors in one of the following:

(a) Hues as red as 10YR or redder, chromas of 2 or less if mottled, less than 1 if not mottled, or

(b) Hues between 10YR and 10Y (i.e. 2.5Y, 5Y, 7.5Y) chromas of 3 or less if mottled and 1 or less if not mottled, or

(c) Hues bluer than 10Y (i.e. hues in GY, G, BG, B and PB), or

(d) Any color that may be due to uncoated sand grains.

6.1 Humic Gleysol Great Group

Soils with an Ah horizon more than 3 inches thick under virgin conditions and when mixed to a depth of 6 inches (or cultivated Ap)[**] has more than 3 per cent organic matter and has a rubbed or crushed color darker than 3.5 when moist (or 5.0 when dry) and is at least 1.5 units of value (moist) darker than the next underlying horizon B or C. Examples of cultivated soil:

$$\frac{Ap}{B \text{ or } C} = \frac{3.5}{5.0 \text{ or higher}} = \frac{3.0}{4.5 \text{ or higher}}$$

May have organic horizons not exceeding 12 inches.

6.11 Rego Humic Subgroup

Soils with a noncalcareous (<2 per cent $CaCO_3$ equivalent)[***] Ah or Ap horizon which grades into dull colored, gleyed soil material. May have surface organic horizons up to 3 inches thick.

(This subgroup includes the Orthic Meadow and some Dark Gray Gleysolic soils described in the 1960 N.S.S.C. proceedings).

[**] Criteria for separation of Humic from Low Humic soils when cultivated is suggested for trial purposes.

[***] Application of HCl to soils with approximately 2 per cent $CaCO_3$ equivalent results in weak effervescence that can be detected only when treated sample is held near the ear.

6.12 Orthic Humic Gleysol Subgroup

Soils with a noncalcareous (<2 per cent $CaCO_3$ equivalent) Ah, Ahe or Ap horizon and a strongly gleyed B horizon underlain by strongly gleyed neutral colored soil material. May have up to 6 inches of peat on the surface. (This subgroup includes the Degraded Meadow and Degraded Dark Gray Gleysolic soils described in the 1960 N.S.S.C. proceedings).

6.1-/5 Saline Humic Gleysol

Soils with a saline (>4 mmhos/cm conductivity) horizon or layer within 2 feet of the surface or salinity exceeding a conductivity of 6 mmhos/cm between 2 to 4 feet if the soil above is nonsaline (i.e. 4 mmhos/cm). May have up to 6 inches of peat on the surface. The soils of this subgroup should be named either Saline Rego Humic Gleysol or Saline Orthic Humic Gleysol. (This subgroup includes Saline Dark Gray Gleysolic and Saline Meadow soils described in the 1960 N.S.S.C. proceedings).

6.1-/6 Carbonated Humic Gleysol

Soils with a carbonated (>2 per cent $CaCO_3$ equivalent) Ah or Ap horizon which grades into calcareous, nonsaline horizons or layers. May have up to 6 inches of peat on the surface. The soils of this subgroup should be named Carbonated Rego Humic Gleysol or Carbonated Orthic Humic Gleysol. (This subgroup includes the Calcareous Meadow listed in the 1960 N.S.S.C. proceedings).

6.1-/7 Sub-Arctic Humic Gleysol

Any Humic Gleysol soil having permafrost within 4 feet of the mineral soil surface.

6.1-/9 Peaty Humic Gleysol

Any Humic Gleysol with 6 to 12 inches of compacted muck, peat or both. The soils should be named Peaty Rego Humic Gleysol, Peaty Orthic Humic Gleysol, Peaty Saline (Rego or Orthic) Humic Gleysol and Peaty Carbonated (Rego or Orthic) Humic Gleysol. (This group includes the Peaty members of the Meadow and Dark Gray Gleysolic soils listed in the 1960 N.S.S.C. proceedings).

6.2 Gleysol Great Group

Soils that may have a dark colored surface horizon up to 3 inches thick under virgin conditions and when mixed to a depth of 6 inches (or cultivated Ap) has either less than 3 per cent organic matter or it differs from the next underlying horizon (Aej, B, or C) by 1.5 units or less of value when moist if the value of the underlying horizon is 4 or more; or one unit or less if the value of the underlying horizon is 3 or less.

Examples: $\frac{\text{Ap}}{\text{Aej, B or C}} = \frac{2.5}{4.0}$ or higher, $\frac{2.0}{3.0}$ or higher

May have organic horizons not exceeding 12 inches.

6.21 Rego Gleysol Subgroup

Soils with an Ah or Ap, Cg or Cg horizon sequence. The Ah, if present, is less than 3 inches thick under virgin conditions and the soil with or without this horizon when cultivated is identified by the description under 6.2. The surface horizon is noncalcareous (<2 per cent $CaCO_3$ equivalent).

May have surface organic horizons up to 6 inches thick. (This subgroup includes Orthic Gleysol and Rego Gleysol described in the 1960 N.S.S.C. proceedings).

6.22 Orthic Gleysol Subgroup

Soils with an A, B, C horizon sequence. The Ah, if present, is less than 3 inches thick under virgin conditions and the soil with or without this horizon when cultivated is identified by the description under 6.2. May have organic horizons on the surface up to 6 inches thick. (This subgroup includes Ferralitic Eluviated Gleysol described in the 1960 N.S.S.C. proceedings).

6.2-/5 Saline Gleysol

Soils with a saline (>4 mmhos/cm conductivity) horizon or layer within 2 feet of the surface or salinity exceeding a conductivity of 6 mmhos/cm between 2 to 4 feet if the soil above is nonsaline, (i.e. <4 mmhos/cm). May have organic horizons on the surface up to 3 inches thick. The soils of this subgroup should be named either Saline Rego Gleysol or Saline Orthic Gleysol. (This subgroup includes Saline Gleysol described in the 1960 N.S.S.C. proceedings).

6.2-/6 Carbonated Gleysol

Soils with a carbonated (>2 per cent $CaCO_3$ equivalent) surface horizon or layer which grades into calcareous, nonsaline horizons or layers. May have up to 6 inches of peat on the surface. The soils of this subgroup should be named Carbonated Rego Gleysol or Carbonated Orthic Gleysol. (This subgroup includes the Calcareous Gleysol soil described in the 1960 N.S.S.C. proceedings).

6.2-/7 Sub-Arctic Gleysol

Any Gleysol soil having permafrost within 4 feet of the mineral soil surface.

6.2-/9 Peaty Gleysol

Any Gleysol soil with 6 to 12 inches of compacted muck, peat, or both. The soils should be named Peaty Rego Gleysol, Peaty Orthic Gleysol, Peaty, Saline (Rego or Orthic) Gleysol and Peaty Carbonated (Rego or Orthic) Gleysol. (This group includes the Peaty members of the Gleysol soils described in the 1960 proceedings).

6.3 Eluviated Gleysol Great Group

Soils with or without an Ah horizon under virgin conditions and with Aeg and Btg horizons. If cultivated the surface horizon (Ap) is differentiated on the basis of the descriptions given under 6.1 and 6.2. May have up to 12 inches of peat on the surface.

6.31 Humic Eluviated Gleysol Subgroup

Soils with an Ah greater than 3 inches thick under virgin conditions or an Ap horizon as described under 6.1 and with Aeg, Btg and Cg horizons. May have organic horizons on the surface up to 6 inches thick. (Classification of this soil is the same as in the 1960 N.S.S.C. proceedings).

6.32 Low Humic Eluviated Gleysol Subgroup

Soils with an Ah less than 3 inches thick under virgin conditions or an Ap horizon as described under 6.2 and with Aeg, Btg and Cg horizons. May have organic horizons up to 6 inches thick. (Classification of this soil is the same as in the 1960 N.S.S.C. proceedings).

6.3-/9 Peaty Eluviated Gleysol

Any Eluviated Gleysol with 6 to 12 inches of compacted muck, peat, or both. (Classification of peaty is the same as in the 1960 N.S.S.C. proceedings).

CLASSIFICATION OF ORGANIC SOILS

R.E. Wicklund

Chairman, Subcommittee on Organic Soils

The objective of this committee was to review the proposals made in 1960 and to suggest further criteria that might be used by field personnel in the classification and mapping of organic soils. It was recognized that until data from field examinations can be assembled from a number of widely spaced points, that the development of a permanent system of classification will not be possible.

The following proposals are therefore tentative and are to be considered as a working model for the assembly of field information. The categories suggested are not intended to be a counterpart of those used in inorganic soils except in so far as they represent similar levels of generalization. The criteria used are mainly botanical and have been developed from a study of three different systems of classification of organic deposits.

The committee reviewed the published report on "Soviet Peat Resources" by Razakov, the classification by the "Norwegian Peat Bog Association" and publications on the classification of "Organic Terrain" by Dr. Norman Radforth. The divisions in the subgroup category are modifications of the decomposition stages of peat proposed by Lennant von Post.

Great Group Category

Two divisions are suggested in this category for trial study namely, low nutrient bogs vs. high nutrient bogs. This coincides with the first major division used by Kazakov with the exception that in that classification a transition type with medium nutrition is included. A suggestion was put forward to include such a division in the committee proposal, and may be inserted at a future date when its characteristics can be established.

Criteria that may be of importance in characterizing peats on the basis of nutritive status are (1) degree of decomposition, (2) ash content, (3) C/N ratio, (4) Vegetation species. The degree of decomposition can be estimated in a general way by visual examination. The degree is determined as a percentage of the whole mass, the figures being rounded off to the nearest 5 per cent. The procedure for examination involves a consideration of (a) quantity and preservation of plant remains (b) color and plasticity of the mass and (c) color and transparency of the water squeezed out of it. The ash content of the peat material should be expressed as per cent of weight of absolute dry peat (Constant weight at 105°C).

Bog vegetation may be broadly classified into plant species that have high nutritive requirements and others with low nutritive requirements. Grass bogs are considered to be the richest and Sphagnum bogs the poorest in plant nutrients with many transitional forms occurring between these two extremes. The difficulties of assessing surface cover on a species basis has been pointed out by Radforth, since differing species or admixtures of species may share similar environments. The relationship assumed to exist between the nutritive status of the bog and the kind of vegetation will need to be studied in detail.

A. Low nutrient bogs (Oligotrophic)

Soil reaction - strongly acid. Degree of decomposition is slight, probably less than 15 per cent. Ash content low, less than 5 per cent. C/N ratio - 30 to 65. Surface vegetation undetermined.

B. High nutrient bogs (Eutrophic)

Soil reaction - acid to alkaline. Degree of decomposition may vary from 20 to 55 per cent. Ash content may vary from 5 to 15 per cent. C/N ratio - 15 to 30. Surface vegetation undetermined.

Sub-group category

The criterion suggested for this category is the stage of decomposition of the peat material in the surface 12 inch depth. A modification of the lo-division scale (H_1 to H_{10}) of Lennan van Post is suggested in which 7.11 combines (H_1 - H_2), 7.12 combines (H_3 - H_5), 7.13 combines (H_6 - H_9) and 7.14 is equivalent to H_{10}. It is suggested that 7.11 represents the relatively raw or undecomposed peats; 7.12 represents the agriculturally arable peats; 7.13 represents the fuel peats and 7.14 represents the fluid sedimentary peats.

Series

The members of the committee are not attempting at this time to formulate criteria for series differentiation. Profile examinations of various peat bogs will eventually reveal characteristics that will serve for purposes of classification. It is recommended that the following features be examined.

1. Composition and arrangement of peat material below the 12 inch depth.

2. Kind of mineral substrate, and kind of genetic horizons developed in the mineral material.

Phase

The depth of peat is recommended as phase criteria. There is some evidence that shallow peat bogs are the most nutritious bogs and may therefore merit a higher categorical treatment. The relation between depth of peat and its physiographic position will also need to be evaluated.

Proposed Classification

Order

7. Organic soils - soils that contain 30 per cent or more of organic matter and have a depth of 12 inches or more of consolidated material.

Great Group

7.1 Low nutrient bogs, (Oligotrophic) strongly acid, slight decomposition, low ash content, C/N ratio 30 to 65.

7.2 High nutrient bogs (Eutrophic), acid to alkaline, moderate to well decomposed, high ash content, C/N ratio 15 to 30.

Sub-Group

7.11 Plant structures well defined and when pressed in the hand give off clear, colourless water.

7.12 Partly decomposed and disintegrated organic material, when pressed in the hand gives off marked muddy water, but without loss of peat substance.

7.13 Well decomposed organic material, when pressed in the hand gives off marked muddy water consisting of finely divided peat substance.

7.14 Organic ooze - The entire peat substance passes through the fingers.

Series

1. Composition and arrangement of peat material below 12 inch depth.

2. Kind of mineral substrate - coarse, medium, fine, marly, and genetic horizon development in the mineral substrate.

Phase

Depth to mineral layer.

1. Shallow, less than 24 inches.

2. Deep, 24 inches to 48 inches.

3. Very deep, 48 inches plus.

FIELD SHEET FOR ORGANIC SOIL

Location Co.............................Con. ....Lot ....

Size (acres)........................Physiographic position..................

Depth Max. ....Min. ....

Vegetation Native...

....

....

Soil Moisture ....

Mineral substrate Depth.............Texture..............Reaction..........

Genesis...............Geology........................

Frost Depth............................Date...........................

Associated mineral soil series ....

Profile Description

	Depth	Color	Texture	Structure	Decomposition	Group, Type & Character
1						
2						
3						
4						
5						
6						
7						
8						

Sample Analyses

	Number	Decomposition Pyrophosphate	Reaction	Ash Content	C/N ratio	
1						
2						
3						
4						

STRUCTURAL UNITS OF PEAT DEPOSITS

Groups of peat forming vegetation	Types of Peat	Character of peat layers	Color of layers	Texture of layers	Structure of layers
Aquatic	Macerated Colloidal	Pulpy (Sedimentary)	Olive green, brown-black	Coarse to very finely divided	Compact, stiff, loose, friable
Marsh	Reed Sedge Brown Moss	Fibrous	Gray, Red, Brown	Coarse to fine fibered	Dense, matted, felty, porous, spongy
Bog	Bog Moss Heath Shrub				
Swamp	Willow-Alder Deciduous Forest Coniferous Forest	Woody	Dark brown to Black-brown	Coarsely fragmental to granular	Compact, granular, loose.

Characteristics of Pulpy - Sedimentary nature. No visible bedding planes. Particles finely divided. High shrinkage property. Flows when wet. Weathers to dust when dry.

Characteristics of Fibrous - Matted, felt-like, interwoven network of plant remains. Layered because of differences in vegetation units that have succeeded one another.

Characteristics of Woody - Woody material either as dominant component or a prominent admixture in fibrous or pulpy material. Derived from Heath shrubs, willow, alder, deciduous and coniferous forests.

REPORT ON LANDSCAPE FEATURES

D.B. Cann

Chairman, Subcommittee on Landscape Features

The 1948 and 1955 reports on landscape features contain a large amount of valuable background material concerning the methods of dealing with landscape features in the various provinces. They contain also, proposed classifications of topography, landforms, erosion, stoniness, land use, and vegetative cover, some of which were suggested for trial and others were adopted for use.

The present subcommittee was asked to make a careful and critical review of this material and to endeavour to find acceptable solutions to some of the controversial matters arising out of these reports. The report of the subcommittee, which follows, is presented in three sections -- (1) Land Forms and Topographic Classes, (2) Erosion and Stoniness, and (3) Land Use and Vegetative Cover.

1. Land Forms and Topographic Classes

Land Forms: The subcommittee felt strongly that some means of indicating land form on the map in relation to soil type was important. It would be desirable to have a method of indicating land form in the mapping symbol, but there are many difficulties involved and no satisfactory scheme was proposed.

The subcommittee proposed that a list of land forms be compiled describing those secondary landforms that are encountered by the surveyor and which are not adequately described in standard texts. It was recommended that soil survey organizations in each province be asked to supply a list and description of the landforms recognized in their area and, if possible, to supply aerial photographs illustrating these landforms. Such photos would be used to compile a national collection of landform illustrations.

During the discussion by the plenary session, it was pointed out that several agencies were investigating landforms or had photos of landforms available.

It was moved that action be delayed until we have further information on the subject. Carried.

Topographic Classes: The topographic classes suggested for use in 1955 were given critical examination. It was felt that, in general, the classes should be retained, but the symbols could be simplified. It was felt also that additions to the slope classes over 30 per cent were necessary to cover slopes found in mountainous terrain. Considerable discussion centered around the 0 per cent slope class. It was thought that this could be included with the 0 - 0.5 per cent class without altering the effectiveness of the classes. The question of symbols received much discussion and decisions were reversed several times. There was a unanimous desire for a less cumbersome symbol to show slope class.

The following topographic classes and symbols were proposed by the subcommittee to the plenary session and were adopted for use.

Simple Topography Single slopes (regular surface)		Complex Topography Multiple slopes (irregular surface)	Slope %
A	depressional to level	a	0 - 0.5
B	very gently sloping	b	0.5 - 2
C	gently sloping	c	2 - 5
D	moderately sloping	d	6 - 9
E	strongly sloping	e	10 - 15
F	steeply sloping	f	16 - 30
G	very steeply sloping	g	30 - 60
H	extremely sloping	h	over 60

When descriptive terms such as undulating, rolling, etc., are used, they should be defined, either in a glossary or in connection with descriptions of the soil type.

2. Erosion and Stoniness

Water Erosion: The subcommittee recommended the adoption of water erosion classes as defined in the U.S.D.A. Soil Survey Manual, page 261 - 264. The four classes would be designated on the map as W1, W2, W3, and W4. Adopted.

Wind Erosion: The subcommittee recommended adoption of wind erosion classes as defined in the U.S.D.A. Soil Survey Manual page 267. The classes would be designated on the map as D1, D2, and D3. Adopted.

Gully Erosion: The subcommittee recommended the adoption of the gully erosion classes as defined on page 54 of the 1955 report, together with the symbols denoting accumulation of eroded materials and special symbols denoting blow-out pits, dune-like accumulations and hummocky areas on page 55 of the report. Adopted.

Stoniness and Rockiness: The subcommittee recommended the adoption of the classes of stoniness, rockiness and coarse fragments as expressed in the 1955 report on pages 55 and 56. These are similar to those defined in the U.S.D.A. Soil Survey Manual, except that the agricultural significance and the description of the classes of stoniness and rockiness should be determined by each regional organization. Note that Stones 0 should be added to the table on page 55. Adopted.

3. Land Use and Vegetative Cover

The subcommittee is in general agreement with the views expressed on pages 66 and 67 of the 1955 report. With the exception of some special maps, land use and vegetative cover are not shown on soil maps. Most survey organizations record some of these features on field sheets, aerial photographs or in notebooks and they are used as additional information in describing the soils in the soil survey report.

It was felt that it would not be feasible to set up a uniform system of classifying and recording data for all of Canada, but this might be done on a regional basis. The broad groupings into cultivated and noncultivated land suggested in the 1955 report are applicable everywhere, but subdivisions of these groups will depend on the object of the survey.

The subcommittee recommended that soil survey organizations continue to record land use and vegetative cover.

General Discussion on Report on Landscape Features

1. Land Forms and Topographic Classes

Stobbe	- very good to have a list of landforms, but our interpretation of landforms is changing and if we disagree with geomorphologists and others, it may not be too useful.
Pawluk	- Don Scott of Waterloo is trying to coordinate landscape mapping in Canada.
Hoffman	- photos of landforms have been prepared by Ontario Department of Lands and Forests and are available from them.
Day	- obtained a list of permafrost landforms from Dr. Mollard in Regina.
Stobbe	- surface geological sections have lists of photos.
Leahey	- if we could get a list from someone else it would save us a lot of work.
Clayton	- In Saskatchewan we use land pattern and the rest of the provinces are not ready to adopt this as yet; we would go along with this as such, but in our own way.
Ellis	- cannot do away with depressional topography.
Hodges	- has N.S.S.C. considered the possibility of a system of slopes as it affects erosion; steepness as affecting machinery, etc.? Can't see reason for mapping slope as such by itself.
Leahey	- need landform and characteristic pattern, but in association with slope limits.
Klingebiel	- U.S.D.A. assigned slope ranges to different soils on erodability. It is important to have slope classes based on gradient limits so that you can come back to them and re-interpret them. You always need something firm to come back to.
Leahey	- How do you handle complex slopes?
Klingebiel	- K, L, M with the broader slope classes.
Bowser	- We need a split between 0 and 0.5 per cent slope.
Ehrlich	- you cannot measure this in the field with an Abney level.
Leahey	- A major problem is finding satisfactory symbols for the slope classes, and the Cartographic Section may be of use to us in this.

2. Erosion and Stoniness

Stobbe	-	is the 1955 system working? (General agreement that it is usable.)
Hodges	-	stated that in talking to Simonson, the U.S.D.A. was dropping rockiness - should we do the same?
Stobbe and Lajoie	-	felt that such a class was necessary in Canada.

3. Land Use and Vegetative Cover

Stobbe	-	doesn't know of any maps having these features.
Ellis	-	thought there should be correlation of symbols within provinces.
Clayton	-	we have not followed the symbols of the 1955 report, but the Assessment Commission of Saskatchewan does have symbols and nomenclature.
Leahey	-	do we need to reprint 1955 information?
Cann	-	condense 1955 report.

REPORT ON SOIL MOISTURE

B.C. Matthews

Chairman, Subcommittee on Soil Moisture

The 1955 report of the Committee on Soil Drainage Terminology attempted to describe drainage classes on the basis of soil morphological features that were presumed to indicate the moisture status of the soil. On application of these criteria it became apparent that soils of similar morphological features did not necessarily have similar moisture regimes.

Accordingly, the present Committee on Soil Moisture has defined the soil moisture classes in terms of (1) actual moisture content in excess of field moisture capacity, and (2) the extent of the period during which such excess water is present in the plant-root zone.

It is recognized that permeability, level of ground-water and seepage are factors affecting moisture status. However, because these are not easily observed or measured in the field, they cannot be used generally as criteria of moisture status.

It is further recognized that soil profile morphology, e.g. mottling, normally but not always reflects soil moisture status. Hence, it is recommended that although soil morphology may be a valuable field indication of moisture status it should not be the overriding criterion. For example, a soil may exhibit the morphology of a poorly-drained soil but recent changes (either natural or artificial) may have established the moisture status as defined for imperfectly-drained soils. Such a soil should be classified as imperfectly drained regardless of its morphology. Some soils that we consider to be well drained are mottled within their sola during the early spring and unmottled throughout most of the year. Other well-drained soils are permanently mottled in their sola due to the nature and distribution of minerals within them. Soil moisture classes, thus, cannot be based solely upon presence or absence of mottling. Topographic position and vegetation as well as soil morphology are useful field criteria for assessing soil moisture status.

The recommended definitions of the soil moisture classes are underlined. As a guide to surveyors, additional comments under each class indicate some of the pertinent morphological features that commonly but not necessarily are found in soils having the particular moisture status. Note: the word "significant" as used in the definitions is to be considered in relation to plant growth.

1. Rapidly drained - Soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions.

   Soils are free of any evidence of gleying throughout the profile. Rapidly drained soils are commonly soils of coarse texture or soils on steep slopes.

2. Well drained - Soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year.

They are usually free of mottling in the upper three feet but may be mottled below depths of three feet. B horizons, if present, are reddish, brownish, or yellowish.

3. Moderately well-drained - Soil moisture in excess of field capacity remains for a small but significant period of the year.

The soils are commonly mottled in the lower B and C horizons or below a depth of two feet. The Ae horizon, if present, may be faintly mottled in fine-textured soils or in medium-textured soils that have a slowly permeable layer below the solum. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark.

4. Imperfectly drained - Soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year.

The B and C horizons commonly are mottled; the Ae horizon, if present, may or may not be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

5. Poorly drained - Soil moisture in excess of field capacity remains in all horizons for a large part of the year.

The soil profiles show evidence of strong gleying. Except in high chroma parent materials the B, if present, and upper C horizons have matrix colors of low chroma. Faint mottling may occur throughout.

6. Very poorly drained - Free water remains at or within 12 inches of the surface most of the year.

The soil profiles show evidence of very strong gleying. Subsurface horizons are of low chroma and yellowish to bluish hues. Mottling may be present but at depth in the profile. Very poorly-drained soils usually have a mucky or peaty surface horizon.

Note: In some instances it may be desirable to indicate whether the moisture status is a result of high ground-water level, low permeability, seepage, or telluric water. If so, appropriate notation can be made following the moisture class designation.

REPORT OF THE SUBCOMMITTEE ON SOIL STRUCTURE AND CONSISTENCE

Wm. Odynsky

Chairman, Subcommittee on Structure and Consistence

Introduction

The Subcommittee was instructed to review the reports of 1948 and 1955 which were presented by Dr. W.A. Ehrlich and to determine the need of any modifications in the classification of soil structure and soil consistence.

From the comments received in reply to a questionnaire forwarded to the membership and the added information supplied by Dr. R.W. Simonson concerning recent proposals submitted by the U.S.D.A. Subcommittee, the following suggestions were submitted for consideration by the National Soil Survey Committee:

1. That "structureless" be deleted from Grade and be included as a type of structure.

2. That the Miscellaneous Structures referred to in the 1960 report consisting of "crumb," "fragmental," and "shotty" be deleted from the classification of structure.

3. That with respect to structure classification the term "species" be substituted by the term "class."

4. That the classification of soil consistence be modified by the deletion of "very friable," "extremely firm," "slightly hard," and "extremely hard" to permit some degree of duplication in this classification.

5. That cementation may be classified as "weakly," "moderately," and "strongly" cemented through the deletion of "indurated."

6. That whereas the dry - moist standard of soil moisture is used in the evaluation of soil structure, consideration be given to the use of a similar soil moisture standard in the evaluation of consistence or durability with respect to the natural peds. Such usage will permit the inclusion of the designation of durability in the terms describing soil structure. Furthermore, it was suggested that such terms as "soft," "friable," "hard" may be adequate when used alone since by definition they denote small, recognizable differences in durability.

7. That the recognition of related features such as porosity, void spaces, clay films, silica flour and other relevant morphological features should receive further attention to provide for terminology and conventions in describing these features.

The changes agreed upon are incorporated in the following:

SOIL STRUCTURE

Soil structure refers to the aggregation of the primary soil particles into compound particles, or clusters of primary particles, which are separated from adjoining aggregates by surfaces of weakness. The exteriors of some aggregates have thin, often dark colored, surface films which may serve to keep the aggregates apart. Other aggregates have surfaces and interiors of like color, and the forces holding the aggregates together appear to be wholly internal.

An individual natural soil aggregate is called a ped and should not be confused with (1) a clod, formed as a result of some disturbance, such as plowing or digging, that moulds the soil to a transient mass that changes with alternating wetting and drying, (2) a fragment, formed by a rupture of a soil mass across natural surfaces of weakness, or (3) a concretion, formed by local concentrations of compounds that irreversibly cement the soil grains together.

The classification of structure involves consideration of (1) the shape and arrangement, (2) the size, and (3) the distinctness of the visible aggregates or peds. The terminology of structure consists of separate sets of terms designating each of these categories, which by combination form the names of the structure. Shape and arrangement of peds is designated as type of soil structure which in turn is subdivided into kinds on the basis of the character of the faces and edges of the aggregates. The size of the peds is of consideration under the class of soil structure, whereas the degree of distinctness is expressed in the grades.

The accompanying table indicates four principal types of structure. (1) Structureless in which there is no observable aggregation or no definite orderly arrangement of natural lines of weakness; (2) Block-like in which the soil particles are arranged around a point and bounded by flat or rounded surfaces; (3) Plate-like in which the soil particles are arranged around a horizontal plane and generally bounded by relatively flat horizontal surfaces; and (4) Prism-like in which the soil particles are arranged around a vertical axis and bounded by relatively flat vertical surfaces. Most of these types are subdivided into kinds or sub types. Thus, under structureless, the single grain kind consists of an incoherent mass of individual particles whereas massive consists of a coherent mass showing no evidence of any distinct arrangement along natural lines of weakness. The block-like type includes three kinds: the angular blocky, whose faces are rectangular and flattened, bounded by planes intersecting at relatively sharp angles; the subangular blocky, whose faces are subrectangular, or consist of mixed rounded and plane surfaces, with vertices mostly rounded, and the granular that are spheroidal, characterized by rounded vertices. Each type of structure includes peds that vary in shape, and detailed soil descriptions may require supplemental statements about the shape of the individual peds.

The classes recognized are indicated by their name and their size limits. The size limits vary with respect to the shape and arrangement. In this respect, the oblique dimension is inferred for the block-like type, the vertical dimension for the plate-like, and the horizontal dimension for the prism-like type.

Grade of structure is the degree of distinctness of aggregation. It expresses the differential between cohesion within the aggregates and adhesion between aggregates, and is determined mainly by noting the durability of the aggregates and the proportions between aggregated and unaggregated material when the aggregates are displaced or gently crushed. Grade of structure varies with the moistening of the soil and should be described at the most important soil moisture content of the soil horizon. The principal description of the structure of a soil horizon should refer to its normal moisture content, although attention should be called to any striking contrasts in structure under other moisture conditions to which the soil is subject. If grade is designated at an unstated moisture content, it is assumed that the soil is nearly dry or slightly moist, which is commonly that part of the range in soil moisture in which soil structure is most strongly expressed. Terms for grade of structure are as follows:

1. Weak peds - That grade of structure characterized by weakly formed peds that are barely observable in place.

2. Moderate - That grade of structure characterized by moderately well-formed peds that are moderately evident in place. Soil material of this grade, when disturbed, breaks down into a mixture of many distinct entire peds, some broken peds, and little unaggregated material.

3. Strong - That grade of structure characterized by strongly formed peds that are quite evident in undisplaced soil. They adhere to one another and withstand displacement and separation when the soil is disturbed. When displaced, soil material of this grade consists very largely of entire peds and includes few broken peds and little unaggregated material.

The sequence followed in combining the terms to characterize the structure is (1) Grade (distinctness), (2) Class (size), (3) Kind (shape). Thus the designation for the soil structure in which the peds are loosely packed and roundish, dominantly below 2 mm. in diameter, and quite distinct is strong fine granular. The designation of structure by grade, class, and kind can be modified with any other appropriate terms wherever necessary to describe other characteristics of the peds.

Many soil horizons have compound structure consisting of one or more sets of smaller peds held together as larger peds. Such compound structures may be described as follows: Compound moderate very coarse prismatic and moderate medium granular. Soil that has one structural form when in place may assume some other form when disturbed. When removed the larger peds may fall into smaller peds, such as large prisms into medium blocks.

SOIL CONSISTENCE

Soil consistence comprises the attributes of soil materials that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation and rupture. Every soil material has consistence irrespective of whether the mass be large or small, in a natural condition or greatly disturbed, aggregated or structureless, moist or dry. Although consistence and structure are interrelated, structure deals with the shape, size, and definition of natural aggregates that result from variations in the forces of attraction within a soil mass, whereas consistence deals with the strength and nature of such forces themselves.

The terminology for consistence includes separate terms for description at three standard moisture contents (dry, moist, and wet). If moisture conditions are not stated in using any consistence term, the moisture condition is that under which the particular term is defined. Thus friable used without a statement of the moisture content specifies friable when moist; likewise, hard used alone means hard when dry, and plastic means plastic when wet. If a term is used to describe consistence at some moisture content other than the standard condition under which the term is defined, a statement of the moisture condition is essential. Usually it is unnecessary to describe consistence at all three standard moisture conditions. The consistence when moist is commonly the most significant, and a soil description with this omitted can hardly be regarded as complete; the consistence when dry is generally useful but may be irrelevant in descriptions of soil materials that are never dry; and the consistence when wet is unessential in the description of many soils but extremely important in some.

Although evaluation of consistence involves some disturbance, unless otherwise stated, descriptions of consistence customarily refer to that of soil from undisturbed horizons. In addition, descriptions of consistence under moist or dry conditions carry an implication that disturbance causes little modification of consistence or that the original consistence can be almost restored by pressing the material together. Where such an implication is misleading, as in compacted layers, the consistence both before and after disturbance may require separate description. Then, too, compound consistences occur, as in a loose mass of hard granules. In a detailed description of soils having compound structure, the consistence of the mass as a whole and of its parts should be stated.

The terms used in soil descriptions for consistence follow:

I. Consistence When Wet

Consistence when wet is determined at moisture levels at or slightly above field capacity.

A. Stickiness - Stickiness is the quality of adhesion to other objects. For field evaluation of stickiness, soil material is pressed between thumb and finger and its adherence is noted. Degrees of stickiness are described as follows:

0. Non-sticky: After release of pressure, practically no soil material adheres to thumb and finger.

1. Slightly sticky: After pressure, soil material adheres to both thumb and finger but comes off one or the other rather cleanly. It is not appreciably stretched when the digits are separated.

2. Sticky: After pressure, soil material adheres to both thumb and finger and tends to stretch somewhat and pull apart rather than pulling free from either digit.

3. Very sticky: After pressure, soil material adheres strongly to both thumb and forefinger and is decidedly stretched when they are separated.

B. Plasticity - Plasticity is the ability to change shape continuously under the influence of an applied stress and to retain the impressed shape on removal of the stress. For field determination of plasticity, roll the soil material between thumb and finger and observe whether or not a wire or thin rod of soil can be formed. If helpful to the reader of particular descriptions, state the range of moisture content within which plasticity continues, as plastic when slightly moist or wetter, plastic when moderately moist or wetter, and plastic only when wet, or as plastic with a wide, medium, or narrow range of moisture content. Express degree of resistance to deformation at or slightly above field capacity as follows:

0. Non-plastic: No wire is formable.

1. Slightly plastic: Wire formable but soil mass easily deformable.

2. Plastic: Wire formable and moderate pressure required for deformation of the soil mass.

3. Very plastic: Wire formable and much pressure required for the deformation of the soil mass.

II. Consistence When Moist

Consistence when moist is determined at a moisture content approximately midway between air dry and field capacity. At this moisture content most soil materials exhibit a form of consistence characterized by (a) tendency to break into smaller masses rather than into powder, (b) some deformation prior to rupture, (c) absence of brittleness, and (d) ability of the material after disturbance to cohere again when pressed together. The resistance decreases with moisture content, and the accuracy of estimating moisture content. To evaluate this consistence, select and attempt to crush in the hand a mass that appears slightly moist.

0. Loose: Noncoherent.

1. Very friable: Soil material crushed under very gentle pressure but coheres when pressed together.

2. Friable: Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together.

3. Firm: Soil material crushes under moderate pressure between thumb and forefinger but resistance is distinctly noticeable.

4. Very firm: Soil material crushes under strong pressure, barely crushable between thumb and forefinger.

(The term <u>compact</u> denotes a combination of firm consistence and a close packing or arrangement of particles and should be used only in this sense. It can be given degrees by the use of "very" and "extremely".)

III. Consistence When Dry

The consistence of soil materials when dry is characterized by rigidity, brittleness, maximum resistance to pressure, more or less tendency to crush to a powder or to fragments with rather sharp edges, and inability of crushed material to cohere again when pressed together. To evaluate, select an air-dry mass and break in the hand.

0. <u>Loose</u>: Noncoherent.

1. <u>Soft</u>: Soil mass is weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.

2. <u>Slightly hard</u>: Weakly resistant to pressure; easily broken between the thumb and forefinger.

3. <u>Hard</u>: Moderately resistant to pressure; can be broken in the hands without difficulty but rarely breakable between thumb and forefinger.

4. <u>Very hard</u>: Very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger.

5. <u>Extremely hard</u>: Extremely resistant to pressure; cannot be broken in the hands.

IV. Cementation

Cementation of soil materials refers to a brittle hard consistence caused by some cementing substance other than clay minerals, such as calcium carbonate, silica, or oxides or salts of iron and aluminum. Typically, the cementation is altered little, if any, by moistening, the hardness and brittleness persist in the wet condition. Semi-reversible cements, which generally resist moistening but soften under prolonged wetting, occur in some soils and give rise to soil layers having a cementation that is pronounced when dry but very weak when wet. Some layers cemented with calcium carbonate soften somewhat with wetting. Unless stated to the contrary, descriptions of cementation imply that the condition is altered little, if any, by wetting. If the cementation is greatly altered by moistening, it should be so stated. Cementation may be either continuous or discontinuous within a given horizon.

1. <u>Weakly cemented</u>: Cemented mass is brittle and hard but can be broken in the hands.

2. <u>Strongly cemented</u>: Cemented mass is brittle and harder than can be broken in the hands but is easily broken with a hammer.

3. Indurated: Very strongly cemented, brittle, does not soften under prolonged wetting and is so extremely hard that for breakage, a sharp blow with a hammer is required; hammer generally rings as a result of the blow.

PARENT MATERIALS

In the parent material of soils, the material with structural shapes may be designated as pseudo-blocky, pseudo-platy, etc.

Reference to geological terms in the description of parent materials should apply to accepted terminology. Many of the terms used in stratigraphy have differing definitions. Generally the arrangement of sediments in layers is referred to as stratification. If these layers are not parallel to the dip of the formation they may be referred to as cross-stratified.

Stratum* - A layer characterized by certain unifying characteristics, properties, or attributes distinguishing it from adjacent layers. However, bedding and lamination connote a thickness of the strata, thus:

Bed* - A unit layer in a stratified sequence which is visually or physically more or less distinctly separable from other layers above and below and is one or more centimeter in thickness. A similar layer whose thickness is less than one centimeter is called a lamina.

When thickness is implied, reference to cross-stratification will involve consideration of cross-bedding or cross-lamination.

---

* International Sub-commission on Stratigraphic Terminology - International Geological Congress Proceedings, XXV, 1960.

Types and Classes of Soil Structure

Type	Kind	Class	mm
1. Structureless - no observable aggregation or no definite orderly arrangement around natural lines of weakness.	A. Single grain structure - loose, incoherent mass of individual particles as in sands.		
	B. Amorphorus (massive) structure - a coherent mass showing no evidence of any distinct arrangement of soil particles.		
2. Block-like - soil particles are arranged around a point and bounded by flat or rounded surfaces.	A. Blocky (angular blocky) - faces rectangular and flattened, vertices sharply angular.	Fine blocky	<10
		Medium blocky	10-20
		Coarse blocky	20-50
		Very coarse blocky	>50
	B. Subangular blocky - faces subrectangular, vertices mostly oblique, or subrounded.	Fine subangular blocky	<10
		Medium subangular blocky	10-20
		Coarse subangular blocky	20-50
		Very coarse subangular blocky	>50
	C. Granular - spheroidal - characterized by rounded vertices.	Fine granular	<2
		Medium granular	2-5
		Coarse granular	5-10
3. Plate-like - soil particles are arranged around a horizontal plane and generally bounded by relatively flat horizontal surfaces.	A. Platy structure - horizontal planes more or less developed.	Fine platy	<2
		Medium platy	2-5
		Coarse platy	5
4. Prism-like - soil particles are arranged around a vertical axis and bounded by relatively flat vertical surfaces.	A. Prismatic structure - vertical faces well defined, and edges are sharp.	Fine prismatic	<20
		Medium prismatic	20-50
		Coarse prismatic	50-100
		Very coarse prismatic	>100
	B. Columnar structure - vertical edges near top of columns are not sharp. (Columns may be flat-topped, round-topped, or irregular.)	Fine columnar	<20
		Medium columnar	20-50
		Coarse columnar	50-100
		Very coarse columnar	>100

REPORT OF THE SUBCOMMITTEE ON CHEMICAL AND PHYSICAL ANALYSES

A.F. MacKenzie

Chairman, Subcommittee on Chemical and Physical Analyses

The subcommittees on chemical and physical analyses were combined for the Winnipeg meetings. The committee was asked to review the reports of 1955 and 1948, to determine the chief problems of the survey organizations, prepare definite revisions and additions to the recommendations of 1955, and study the future needs for chemical and physical analyses of soils.

To begin, the subcommittee felt it was necessary to redefine the purposes of chemical and physical analyses. The following purposes were outlined.

(a) Pedogenetic Studies:

These studies include analyses to establish the properties of a taxonomic unit. This involves complete characterization of a soil for its definitive properties. These analyses are necessary to infer the genesis of soils as well as to determine present properties. However, an hypothesis of the genesis and probable properties of the soil is necessary if rational analyses are to be carried out. This is required of the individual and must be proposed to suit individual environments. Thus the subcommittee made no recommendations on the required analyses for this purpose. Because of wide interest in the results of such research, individual projects should be set up to render them suitable for publication in scientific journals or other suitable media.

(b) Classification and Mapping:

One purpose of chemical and physical analyses is to obtain data that will help to solve or simplify problems of classification not resolved by field observations. The subcommittee felt that it was desirable, if not essential, to eliminate the term "routine analyses" with reference to analyses for classification purposes. The problems of placement of soils are met only by using analyses pertinent to the particular soil in question. The subcommittee felt this was best arrived at by deciding the possible profiles and analysing for the pertinent diagnostic horizons. Thus it is necessary to start with the soil, not the analytical methods, and select only those analyses required.

Diagnostic Horizon	Analysis
h.	Carbon, nitrogen, C.E.C., color, pH.
f.	Free Iron
k.	Carbonates
n.	Exchangeable cations
s.	Soluble salts
t.	Particle size analysis
e.	Carbon, nitrogen, particle size analysis, free iron
g.	Color
m.	-

In order to use this approach the diagnostic horizons may have to be defined more precisely. Precise characterization of the diagnostic horizons is desirable, and may be stimulated by this approach. Also it is necessary that standard methods be used. The subcommittee felt that the collection and dissemination of information on standard methods was a continuing job, but that a start should be made by the subcommittee.

(c) Interpretive Studies:

Soil survey information can be used by people working in many disciplines. The two main groups are those working in soil mechanics and those in agronomy - horticulture - forestry. The kind of information the latter group requires from the map may vary from region to region. The analyses may best be done by soil survey personnel, but should be those requested by the appropriate group. Thus it is impossible to state what analyses should be carried out to make soil survey information more useful to other groups or disciplines. Such analyses should be carried out on the dominant soil types in the particular region concerned.

In conclusion, the committee made the following recommendations:

1. That analyses for classification purposes be carried out only on diagnostic horizons that are defined in chemical or physical terms.

2. That the committee undertake to tabulate methods of analyses and suggest appropriate methods with their probable errors.

3. That expression of analyses be as the oxide in silicate analyses, as the element for all other analyses.

4. That analytical methods be stated in survey reports.

5. That analyses for pedogenetic or characterization purposes be adapted to the particular profile, and that the results be published.

6. That interpretive studies be carried out only as requested by responsible groups, and only on a regional basis.

DISCUSSION

Stobbe - asked if analyses assist in classification and mapping of soils.

MacKenzie - stated that the analyses recommended by the subcommittee are to be used principally for classification, but will also be used to confirm mapping.

Wicklund - suggested that analyses of soils have a two-fold purpose --

(a) as a tool in mapping.
(b) as a check on soil genesis.

Clayton - stated that analyses could be used to determine the range of diagnostic horizons.

St. Arnaud - suggested that the analyses be used to determine the limits of diagnostic horizons and to discover if limits already used fit the definition of the diagnostic horizon.

Day - routine analyses in addition to those specified by the subcommittee are required for family classification.

MacKenzie - stated that any analyses in addition to those specified can be done as long as there is an objective.

Stobbe - stated that analyses should characterize the soil as a whole.

Pawluk - suggested that characterization of the soil is covered by pedogenetic studies. This is a specific request with a specific objective and the kind and number of analyses to be conducted is the decision of the individual doing the research. The subcommittee decided that it could not recommend all analyses on all soils.

Bowser - said that there are two categories of analyses:

1. Analyses to find the limits of diagnostic horizons.
2. Routine analyses to discover the kind of diagnostic horizon.

He also asked why the subcommittee had not recommended physical analyses in addition to particle size distribution. Physical analyses appear to be necessary for use in interpretive work. He suggested that hydraulic conductivity is required to determine a Bn horizon.

Clayton - said that the work of establishing soil characteristics will be done in pedogenetic studies. Such studies will include physical analyses. He also stated that the Munsell colour charts were not adequate in establishing colour and that research is required in this matter.

Stobbe - stated that there are now more colours and greater colour ranges.

Pratt - said that the subcommittee had not fulfilled its responsibilities because the analyses recommended are aimed at the upper categories. Analyses are most important at the series, type and phase levels for interpretive studies.

MacKenzie - said that analyses at the lower categories is the work of the regional groups and may vary from province to province.

Leahey - the approach of the subcommittee focuses attention on what is needed under conditions circumscribed by lack of facilities and manpower.

Stobbe - commented as follows:

1. Interpretive analyses should be done only on request.
2. The number of analyses to characterize soils depends on the time available.
3. pH is required for every soil.

Pratt - stated that the concept of doing analyses for a specific purpose is very dangerous. The purpose of making those analyses required only for soil classification will lead to lack of progress.

Ellis - stated that we are weak in physical analysis. We should do the analyses most urgently needed and leave the interpretive work to those who require it.

Ehrlich - stated that more fertility analyses are required, regardless of whether or not the fertility people desire to have such analyses conducted.

Bowser - suggested that the chemical and physical analyses done should be sufficient to characterize the soil series.

Leahey - suggested that a fourth major item might be added to the subcommittee report - characterization. He suggested that if bench mark soils are to be established, complete analyses should be done.

Cann - stated that soil reports are only vehicle available to show the chemical characterization of the soil.

Stobbe - suggested that information on Canadian soils should be drawn together in one publication.

The report of the Subcommittee on Chemical and Physical Analyses was accepted, with the general feeling that some characterization should be done even if it enters into some other purposes. Also, membership in the subcommittee should include two practising soil surveyors. It was decided to continue the subcommittee as a combined subcommittee for the present.

REPORT ON INTERPRETIVE CLASSIFICATION

J.A. Toogood

Chairman, Subcommittee on Interpretive Classification

Introduction by J.A. Toogood

An interpretive classification of soils means a grouping of soil types according to their suitability for a specific purpose. Kellogg defines it as the prediction of behaviour of soils in defined situations.

One might give the development of the concept in Canada in the following steps:

1. 1945-1955 Developing a draft of a Canadian Soil Classification System.

2. 1955 N.S.S.C. meeting at Saskatoon. Six categories suggested: Order, Great Group, Sub-Order, Family, Series, Type.

3. 1955-1960 (1) Field trial of system
   (2) Soil groupings for agronomic purposes
      (a) Peace River block; southern Saskatchewan
      (b) Manitoba
      (c) Soil ratings, soil zones, vegetation and climatic belts, etc.

4. 1960 N.S.S.C. meeting at Guelph. Adoption of a National System for classifying soils. Amendments being made in 1963.

5. 1955-1963 N.S.F.C. preparing inventory of fertility studies on soil types. Recognition of weakness of fertilizer recommendations on a soil zone basis; need for agronomic groupings.

6. Soil ratings, associated with soil survey reports to date, of general value but not specific enough. Increased use of soil survey information by foresters, assessors, engineers, city planners, economists, agronomists, conservationists, biologists, sociologists etc., each interested in land use for specific purposes. Soil survey data and maps require interpreting in a specific way for each of these groups.

7. ARDA - Interested in land use from national viewpoint. Developing an inventory of Canada's lands from a capability standpoint. Meeting held November, 1962.

8. Meetings of provincial advisory fertilizer committees discussed agronomic groupings of soils in Winnipeg and Edmonton last December.

The problems before us can be briefly stated as follows:

1. Who is to make the synthesis of all data available (soil survey information, research findings, practical experience) and produce the predictions required for each interpretive classification?

2. How are the objectives of a particular classification formulated?

3. What basic data on our soils should we be collecting so that we can meet the needs of all foreseeable interpretive classifications wanted by society? What research is needed?

4. What limitations on groupings result from the present methods used in soil survey?

5. How can an interpretive classification best be portrayed, by table or map?

Data available for different kinds of interpretative classifications, by L. Farstad

In the scientific survey of our soil resources the Natural System of classification has emerged as the system used almost exclusively in those countries where soil surveys are part of the technical service to agriculture. Classification is based on differences in characteristics caused by differences in the soil forming factors--parent material, climate, vegetation, relief and drainage, and time. The resultant effect of these factors of soil formation in various combinations is that different soils occur with unique morphology.

Soil Survey refers to the study, classification, mapping and description of the soil conditions of an area with the securing of related information on geology, climate, vegetation, land forms, drainage, settlement, transportation, agriculture, forestry, range and other types of land use. In addition, chemical and physical analyses are made of typical soil samples. Where possible the evaluations of soils are checked with the results of field experiments.

The result is a soil map and accompanying report showing and explaining the results of these investigations.

The smallest individual soil unit is referred to as a pedon. It is described and classified on the basis of its important internal characteristics which include kind, thickness and arrangement of soil horizons, color, texture, structure, consistence, organic matter content, lime, pore space, and chemical and mineralogical composition. The soil type allows a limited range of soil individuals or pedons that occur over a large area. The soil mapping unit, or series, is the soil type plus its external conditions such as slope, drainage, erosion, etc.

The Soil Family category, though it has a very high potential, has not been developed to the fullest in Canada. As outlined in our N.S.S. scheme, the family permits the grouping together of soil series that are assumed to be similar in moisture relationships, general fertility status, drainability, etc. Thus, families are reasonably homogeneous in regard to the soil characteristics that are significant to soil-plant relationships.

At higher levels of classification a distinction is made in Subgroups, Great Groups and Orders. Considering all the known soils in Canada 7 Orders have been established, the U.S. system, intended for world-wide use, has 10 Orders.

The number of individual soils that have been recognized in Canada now exceeds 1600. Since many of the named soils include several types and phases and the catenas or associations several series, the number of individual soils may be closer to three thousand.

The defined soil units mentioned require proper classification in order to systematize our knowledge. In this regard the main objective of the N.S.S.C. has been to develop a scheme of classification showing how and why the soils of each category differ in terms of their morphology and genesis. With the large number of different soils already mentioned it is not feasible to conduct all kinds of research on them all nor is it necessary.

For interpretative purposes, the next step must be to group the individual soils on the basis of their similarities to enable us to use the information accumulated on one soil type to make predictions for other similar soil types.

The soil taxonomic units mentioned are seldom identical with the soil mapping units because soil areas are rarely that homogeneous. One does not map a single profile but with the aid of external soil characteristics such as relief and other observable features of the landscape one can recognize and map soil units or combinations of units consistently.

The intricate pattern of soils occurring on the terrain frequently prevents their presentation on maps of a certain scale. Soil mapping units then have to be combined in a complex unit, called catena or association. A system of classifying soil mapping units has thus been developed analogous to the procedure followed in botany. The taxonomic unit is identical with plant systematics and the cartographic unit with plant geography.

According to the degree of intensity with which the surveys have been carried out various types of soil maps have been published. The type of soil map is indicated by the scale and grouped to three broad classes, broad reconnaissance or exploratory, reconnaissance, and detailed.

A wide variety of information is necessary in preparing interpretative classifications. In addition to soil surveys, climatic records, ecologically classified vegetation zones, water resource and geological investigations, topographic surveys, and aerial photographs are available. Local information is obtainable from farm operators, and technical specialists and actual field observations may be necessary to check the validity of information derived from the various sources.

Interpretative groupings as commonly used refer to use for some practical purpose, and it is by such means that the results of soil classification and soil survey become really useful for many kinds of human activity. The various factors which affect plant growth do not act independently. Indeed, no general relationship exists between any one soil characteristic and crop performance.

There is no set procedure for soil survey interpretation. However, if a body of recorded information is available for a variety of soil conditions, an important step is that of appropriately assembling this information by soil series, types and phases. Another step is the summarization of the major characteristics of different classes of soils which affect soil-plant relationships. In such a summarization, soil qualities such as natural drainage, permeability, general fertility status and other terms that already have interpretative meaning, are adduced from groups or combinations of characteristics. Soil drainage, for instance, is inferred from colors of the horizons of the soil profile, depth of water table at various times, relief, growing plants, etc. Permeability is inferred from soil consistence, texture and porosity, and the fertility and productivity evaluations from combinations of such factors as organic matter content, pH, texture, cation exchange capacity, base saturation, etc. together with observation of growing crops on different soil types.

Trees, like other plants, require water, nutrients and an aerated soil. The problem of relating growth or productivity to the inherent characteristics is more difficult. Here one expects the predominant factors to vary not only with the soil, but with the climate and age of the crop. In old stands, it appears that physical factors are more important than chemical ones. In some of our studies deep gravelly, permeable soils with low concentrations of nutrients are as productive (site index evaluations) as heavier textured soils with a moderate to high concentration of nutrients. This suggests that in interpretations for forestry purposes in our climate, one must distinguish between concentration of nutrients, amount of nutrients offered by the soil, and the continuity of supply.

The suitability of soils for various crops changes with economic circumstances and changes in technology. The soil surveyor cannot be held solely responsible for developing taxonomic classifications as well as interpretative classifications. Neither can he leave this work to others. He is the only man who understands the terminology of the soil map and the only one who can handle his soil units as natural units. In preparing interpretations he must cooperate with the economist, engineer, forester, range specialist and all research men who can and will collaborate and coordinate their work. The soil surveyor then will appreciate some of his units more and the quality of the maps will improve.

Limitations of interpretative grouping based on reconnaissance soil survey information, by B.C. Matthews

Interpretative groupings can be made only for specific objectives. The soil characteristics selected as criteria for interpretative classification will be dictated by the objective.

If the objective of the classification is narrow so that one particular soil characteristic suffices to differentiate soils then it is possible to make a relatively accurate map showing interpretative groups. This is true even with reconnaissance soil survey information.

However, even if only one soil characteristic is significant for the grouping the resultant interpretative map cannot be more accurate than the original soil map. In other words the limitations of the soil map because of scale, detail of field survey, etc. still exist in the interpretative map.

If the objective of the classification is broad, e.g. an agricultural land use capability, then no single soil characteristic will suffice as a criterion for classification. Indeed, many if not all of the differentiating characteristics of the soil type must be considered. In addition, several additional characteristics e.g. slope and stoniness, are also significant in an agricultural land use capability classification.

On reconnaissance soil maps, because of scale, detail of field survey, etc., areas labelled as a particular soil type are not completely homogeneous even though the range allowable within the soil type as a taxonomic unit may be considerable. Furthermore, on some soil maps the cartographic units are not soil types but rather associations of soils covering the whole range of natural drainage. Obviously, drainage is an important characteristic in an agronomic grouping. If drainage classes are not delineated on the soil map, then an interpretative map will have serious limitations.

The situation is often worse in regard to slope and stoniness. Few of the soil maps in Ontario carry slope and stoniness information in sufficient detail to allow one to delineate anything but the steepest and stoniest soils (land that would fall in Class 7 or 8). This is a deficiency resulting not from the scale of the map but from the fact that the information was not recorded at the time of the soil survey.

Interpretative classifications are further complicated by the fact that the significance of one characteristic varies depending on the other characteristics. This is the point at which the skill and experience of the interpreter become of great significance.

It is true, I believe, that interpretative groups can be described reasonably precisely. The limitations arise when one attempts to delineate them on maps. With our present reconnaissance soil maps, areas delineated as a given interpretative (use capability) class are of necessity very heterogeneous.

What are the objectives of various interpretive groupings, by R.A. Wallace

Interpretive groupings of soils to be most useful must be made for specific purposes and to satisfy specific objectives. Different purposes will usually require different groupings.

In Manitoba some of the interpretive groups that have been and are being made and their objectives are:

(1) Land use capability classification

This kind of grouping is done on large areas like soil survey map sheets and watershed areas, as well as on individual farms. The objective of land use capability mapping is to group soils on the basis of the different kind of soil management practices required if these soils are to remain permanently and economically productive.

(2) Productivity index rating

A productivity index for wheat, oats, barley and flax is being established for the cultivated land on each quarter section in Manitoba. The objective of this grouping is to provide some measure of yield prediction. Very specifically this is being done to provide a base for the crop insurance rates of the Manitoba Crop Insurance Corporation. This kind of grouping will have several other applications in economic land classification, land assessment, land inventories, and land use administration. The important aspect of this grouping is that it brings together all available information on crops and soils for administrative units.

(3) Soil groupings for fertilizer recommendations

The objective of this is to show on a map groupings of soils for which different general fertilizer recommendations can be made.

(4) Soil groupings for tillage recommendations

Interpretive groups of soil into five categories on the basis of texture and drainage have been made for which different tillage procedures can be recommended.

(5) Multiple land use classification

Three specific land use study projects are now under way in relation to the application of ARDA in Manitoba. In this study, classifications will be made of Arable Land, Grazing Land, Wildlife Land, Recreation Land and Forestry Land. The objective of this is to provide land administration maps of these areas from a multiple use point of view.

(6) Soil groupings for irrigation suitability

For the Morden-Winkler area, soils have been placed into five groups on the basis of their irrigation suitability. The objective is to provide the information needed for the irrigation study under way in the area and will indicate the location and extent of soil suitable for irrigation.

(7) Economic classification of land

This project is under way in Manitoba under the direction of the Economics Division of the Canada Department of Agriculture. The objective will be to group by townships the land having similar net returns potential.

(8) Agronomic grouping

In 1960, L.E. Pratt proposed eleven agronomic groups for Manitoba soils. The objective was to provide a base for making general fertilizer recommendations. In actual practice no direct use has been made of this, because soil morphology is not necessarily the major factor causing different fertilizer requirements.

In summary, then, interpretive groupings must be made for specific objectives. It is not possible to make one universal interpretive grouping to satisfy all requirements.

Are interpretive classifications necessary, by H.A. Steppler

The classification of soils by the pedologist is a fine exercise for the pedologist - it becomes useful to the agronomist only when an interpretation of the classification has been made. The answer to the question posed is a simple "yes" - the qualification of the answer is far from simple.

An interpretation would normally be made in response to a request. This request must clearly set down the proposed use of the interpretation, prescribe limits of proposed use, indicate whether this is a soil productivity interpretation or a response to management or both, etc. Many different interpretations could be made with the same pedological classification as the base, for example, in Quebec we might develop:-

(1) an interpretative classification for soils best suited to alfalfa

a - without special amendments,
b - with special amendments with those specified by the interpretation,

or

(2) a classification of the soils best suited to corn within the climatic region for corn.

The obvious questions then arise - who will make the interpretation and do we have the correct information upon which to base the interpretation.

It is my opinion that the soil specialist is the person best suited to make the interpretation but only if given a specific request. The soil specialist is in the best position to collate the information presented in the survey. The question of adequacy of data on which to base interpretations - in my opinion - cannot be answered without knowledge of the interpretation required. Suffice it to say that we probably do not have adequate data on which to base fertility recommendations - we are reasonably safe on prediction of lime requirements to adjust pH.

Methods of showing groupings - tables versus maps, by W.E. Johnson

The first comment that one might make regarding a discussion of tables versus maps in use groupings is that such a topic is in large degree irrelevant. Most maps, except for very simple types, are only as good as the legend which accompanies the map. We could say that tables (or legends) are essential whether one wants to use maps or not.

We could then ask whether maps are essential. The answer seems to me to be very simple. Firstly, our soil survey maps are basic to any further grouping that we may make for agricultural purposes. There may be some question as to the personnel who will eventually make and use the many groupings which may be of help in agricultural and land-use programs. It would seem to be useful to prepare a limited supply of uncolored soils maps for later groupings or program-planning maps.

We would suggest however, that most of the maps in which we are interested would be based very closely on the basic soil survey. The most important decision to be made regarding maps is that a map is not an end in itself. The number of types of maps on any major real basis may be rather limited. Beyond the basic soil survey and the broad general land capability classification, one might contend that the major use of maps is to facilitate local or regional planning. Maps are simpler to use in extension programs, discussion with administrative personnel and other similar approaches. Beyond the preparation of basic maps and maps for action programs, maps, because of relatively high cost and often, rather quick obsolescence, should be restricted in numbers. A great number of maps which follow no good cartographic principles would add very little.

Tables or charts are of considerable importance. As we have mentioned, a good legend is an important part of any map. We do need simple, easily understandable tables listing soil characteristics. Tables or charts may be of varying degrees of complexity. The simple tables used in Ontario soil survey reports are useful for a quick judgement on soils as to suitability for various crops. The professional agrologist would probably prefer a table listing not only the suitability for various crops but the limiting factors which may place soils in these suitability classes.

We could list many types of interpretive groupings of soils. As C.E. Kellogg has suggested, these groupings are or should be syntheses, utilizing the characteristics, qualities, and responses of soils to management. At any one time we may be interested in a single factor grouping or a grouping which attempts to rate the influence of all interactions on production of a certain crop. It would be neither practical nor economical to utilize maps for all of the interpretive groups one might make.

We could conclude that an interpretive grouping is not a prime essential. Given accurate basic soil survey maps, each soil can be rated by behaviour for any use, within the limits of data available for each soil. Mapping the groups is mainly an attempt to simplify and at the same time it must be recognized that we reduce the accuracy of information available.

It seems unlikely that any soil scientist would care to operate without maps, not only for basic soil survey but for the broad physiographic and use groupings. It is, however, just as unlikely that we would want a complex series of use maps, lacking in the quantitative information we need. Such maps should be prepared mainly for unique and specific regional purposes.

On the other hand, tabulation of all the pertinent data and the most dependable interpretation thereof are essential to adequate inventory and utilization of the information on soils now available and being continuously obtained.

Resolutions

Several resolutions were presented for the purpose of stimulating discussion, and the following were approved:

I. Whereas an increased load is being imposed on soil survey staffs for interpretive information,

And whereas the job in interpretation is closely allied to educational and extension activities,

And whereas the Soils Research group in each province, and in particular the soil survey units, consider these interpretations as a major part of their responsibilities,

Therefore this meeting recommends that in each province there should be more Soil Specialists attached to the Soil Survey group, the University Soil Science Department, or the Department of Agriculture, whose duty would be to make interpretive groupings of soils as required by governmental and other agencies.

II. Whereas there exists no taxonomic grouping of soils in Canada between the Subgroup and Series levels,

And whereas such a grouping would be useful as a base for further generalization and as a check on the validity of individual mapping units,

Therefore this meeting recommends to the N.S.S.C. that there is a need in Canada for a Family grouping of soils between the Subgroup and Series level and that to this end the N.S.S.C. should press for a definition for the term "Family" and retain this category for taxonomic use in classifying soils.

III. Whereas the number of soil types in Canada is too large to permit research work to be done on each,

And whereas personnel and budgets are necessarily limited in each province to the more important soil series,

And whereas work in the United States has demonstrated the value of extensive research on carefully selected soil types with subsequent interpolation for closely related types,

Therefore this meeting recommends to the N.S.F.C. and N.S.S.C., that as an aid to interpretive groupings of soils, the idea of benchmark soils be studied with a view to adoption in Canada on a formal basis.

IV. Whereas there is lack of data on the physical properties of soils and little investigation is being made into the effects of soil physical properties on soil productivity or crop yields,

Therefore this meeting recommends increased emphasis on the determination of soil physical properties as part of the analysis of soil survey samples, and that the National Soil Fertility Committee be asked to encourage investigations with the object of determining, as far as possible, the effects of soil physical properties on crop yields and soil productivity.

SOIL CAPABILITY CLASSIFICATION FOR AGRICULTURE

The following resolution was submitted for consideration by the N.S.S.C. at its business session on March 8, 1963.

WHEREAS the ARDA administration has the responsibility for developing a far-reaching program designed to improve the use of Canada's land resources

WHEREAS the Canadian Soil Survey organizations have collected a large volume of soil information on soil maps and in reports

WHEREAS this soils information requires additional interpretation to be most useful to administrators, specialists in other disciplines and the general public who will be involved in any program of renewable resource planning

WHEREAS such interpretation can be done effectively only by experienced soil survey personnel

WHEREAS for such purposes, additional personnel, equipment etc. may be made available on ARDA funds through the ARDA administration in each province to work under the direction of the experienced soil survey personnel currently employed in Canada.

THEREFORE be it resolved

That the National Soil Survey Committee, through its membership in each province and with the co-operation of the federal ARDA administration and the ARDA administration in each province, develop an agricultural soil capability classification for Canadian soils and establish an inventory of agricultural soil capability for the settled areas of Canada in which soil surveys have been completed, with as much precision as possible within the next two years.

MOVED BY: B.C. Matthews

SECONDED BY: W.L. Hutcheon

It is understood that:

(1) this inventory may be prepared most easily in tabular or graphic form showing acreages of each capability class and units or associations of soil capability classes and units by Counties, Sections, Townships, or natural regions.

(2) if sufficient additional personnel, equipment etc. are provided and if considered necessary, generalized maps showing area distribution of associations of soil capability classes may be prepared on a provincial or intra-provincial region basis.

After considerable discussion this resolution was passed by a unanimous vote for submission to the National Co-ordinating Committee on Agricultural Services. Our parent committee endorsed the resolution at its annual meeting on April 23.

Since there was considerable urgency to establish the principles of this kind of an interpretive classification before the start of the field season two work planning meetings, eastern and western, were held early in May under the auspices of the N.S.S.C. and ARDA. The eastern meeting was held on May 1 - 3 at Ottawa, and the western one at Regina on May 8 - 9. Unanimous agreement was reached at these work planning meetings on the principles and definitions of a national soil capability classification for agriculture.

During the field season of 1963 a good start was made by the federal-provincial soil survey organizations in implementing this interpretive classification. In general, the system developed by the work planning meetings in May has been reasonably satisfactory. However, as expected, the actual implementation of the classification has indicated the need for some modifications, more precise definitions and good guidelines. A national work planning meeting of the N.S.S.C. will be held in February 1964 to deal with these matters.

OTHER MATTERS OF BUSINESS

1. The question of whether or not the N.S.S.C. should recognize in the classification system intergrades between the Chernozemic and Solonetzic orders of soils received considerable attention. Since on the basis of existing data no satisfactory criteria could be established for the separation of such intergrades, the N.S.S.C. requested the Saskatchewan and Alberta Soil Surveys to carry out a joint field and laboratory study of soils which might be considered as true intergrades with the expectation that the results from such a study would enable the committee to resolve the question.

2. The chairman of the subcommittee on Regosolic soils presented a report on their classification which would drastically change the system in current use. While most members expressed some dissatisfaction with the present system of classification for Regosolic soils, they were opposed to adopting the new report on relatively short notice. Hence the N.S.S.C. members accepted a motion that the report on Regosolic soils be circulated for study purposes with the expectation a report based on this study will be submitted for consideration to the next meeting of the N.S.S.C. In the meantime we will follow the system adopted in 1960. It was also suggested that the other systems for the classification of these soils be studied in conjunction with the one proposed by the chairman of the subcommittee.

3. The N.S.S.C. decided that if possible its next meeting should be held in 1965 in Eastern Canada. Topics which should receive attention at the 1965 meeting would include phases, soil families, land forms, diagnostic horizons, chemical and physical analyses, Regosolic soils and Chernozemic-Solonetzic intergrades. A general desire was indicated for more collaboration with forest soils men in the discussions at the next meeting.

MEMBERSHIP OF SUBCOMMITTEES FOR THE WINNIPEG MEETING

Soil Classification:	Only the Chairmen were appointed as all members of the N.S.S.C. were considered as members.
Chemical and Physical Analyses:	MacKenzie (Chairman), Baril, Clarke, Hoffman, Pawluk, St. Arnaud.
Landscape Features:	Cann (Chairman), Acton, Chapman, Lajoie, Sprout.
Soil Drainage:	Matthews (Chairman), Langmaid, McKeague, Peters, Scott, Smith.
Soil Horizons:	Hoffman (Chairman), Baril, Bowser, Ellis, Hilchey.
Soil Structure and Consistence:	Odynsky (Chairman), Day, Ellis, Langmaid, Wicklund.
Interpretive Classifications:	Toogood (Chairman), Cann, Farstad, Johnson, Matthews, Pratt, Steppler, Wallace.

(A joint subcommittee of the N.S.S.C. and the N.S.F.C.)

ATTENDANCE AT PLENARY SESSIONS

British Columbia

H. Gardner	University of British Columbia	Vancouver
L. Farstad	Research Branch, C.D.A.	Vancouver
D. Lacate	Research Branch, C.D.F.	Victoria
N. Sprout	B.C. Soil Survey Branch	Kelowna

Alberta

W.E. Bowser	Research Branch, C.D.A.	Edmonton
D. Lindsay	Soil Survey, A.R.C.	Edmonton
W. Odynsky	Soil Survey, A.R.C.	Edmonton
S. Pawluck	University of Alberta	Edmonton
T.W. Peters	Research Branch, C.D.A.	Edmonton
G.C. Russell	Research Branch, C.D.A.	Lethbridge
J. Toogood	University of Alberta	Edmonton

Saskatchewan

D. Acton	Research Branch, C.D.A.	Saskatoon
J.S. Clayton	Research Branch, C.D.A.	Saskatoon
J. Ellis	University of Saskatchewan	Saskatoon
W.L. Hutcheon	University of Saskatchewan	Saskatoon
W.E. Johnson	Department of Agriculture	Regina
R. St. Arnaud	University of Saskatchewan	Saskatoon

Manitoba

W.A. Ehrlich	Research Branch, C.D.A.	Winnipeg
R.A. Hedlin	University of Manitoba	Winnipeg
R. Smith	Research Branch, C.D.A.	Winnipeg

Other members of the Department of Soils and the Manitoba Soil Survey and some members of the Extension Service of the Manitoba Department of Agriculture attended a number of the plenary sessions.

Ontario (outside of Ottawa)

D.W. Hoffman	Agricultural College	Guelph
B.C. Matthews	Agricultural College	Guelph
R.E. Wicklund	Research Branch, C.D.A.	Guelph

Quebec

G. Godbout	Quebec Soil Survey	La Pocatiere
P. Lajoie	Research Branch, C.D.A.	Macdonald College
A.F. MacKenzie	Faculty of Agriculture	Macdonald College
B. Rochefort	Research Branch, C.D.A.	La Pocatiere

New Brunswick

K.K. Langmaid	Research Branch, C.D.A.	Fredericton

Nova Scotia

D.B. Cann	Research Branch, C.D.A.	Truro
J. Hilchey	Agricultural College	Truro

Newfoundland

H.W.R. Chancey	Research Branch, C.D.A.	St. John's

Washington, D.C.

A.A. Klingebiel	Soil Conservation Service, U.S.D.A.	Washington, D.C.

Ottawa

J. Day	Research Branch, C.D.A.
R.C. Hodges	ARDA, C.D.A.
A. Leahey	Research Branch, C.D.A.
L.E. Pratt	ARDA, C.D.A.
P.O. Ripley	Research Branch, C.D.A.
J.S. Rowe	Research Branch, C.D.F.
P.C. Stobbe	Research Branch, C.D.A.