Field Handbook for the Soils of Western Canada

Section 4: Horizon Identification

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This field guide is one section of a Field Guide for the Soils of Western Canada, which is currently under development by the three authors. Our intent for the field guide is two-fold: 1) to simplify the use of the Canadian System of Soil Classification in the field and 2) to allow field testing of a new soil order for Anthroposolic soils, which has been proposed for inclusion in the Canadian System of Soil Classification. Other than the inclusion of the provisional Anthroposolic order there is no other (intentional) revision to the 3rd Edition of the Canadian System of Soil Classification.

This section draws very heavily on material from the following:

Soil Classification Working Group. 1998. The Canadian System of Soil Classification. 3rd Ed. Research Branch, Agriculture and Agri-Food Canada. Publication 1646. NRC Research Press, Ottawa, Ontario.

This is available on-line at http://sis.agr.gc.ca/cansis/taxa/cssc3/index.html.

Our section is designed to be used in conjunction with a field guide for describing soil morphology such as Section 3 of this Field Handbook, Soils Illustrated by Kent Watson, The Field Guide for Describing Soils in Ontario, or the CanSIS Manual for Describing Soils in the Field (available on-line at http://sis.agr.gc.ca/cansis/publications/manuals/1982-forms/index.html).

The material on Anthroposolic soils is drawn from:

Naeth, A., Archibald, H.A., Nemirsky, C.L., Leskiw, L.A., Brierley, A. J., Bock, M.D., VandenBygaart, A.J. and Chanasyk, D.S., 2012. Proposed classification for human modified soils in Canada: Anthroposolic order. Canadian Journal of Soil Science 92, 7-18.

The correct citation for this section is:

Pennock, D.J., K. Watson, and P. Sanborn. 2015. Section 4. Horizon Identification. From: D. Pennock, K. Watson, and P. Sanborn. Field Handbook for the Soils of Western Canada. Canadian Society of Soil Science.

CONTENTS

How Deep Should My Soil Pit Be?

The Control Section

The control section is the vertical exposure of soil that we describe in the field and on which classification is based. The properties of the material beneath the control section are important for many interpretive purposes and should be examined and described whenever possible.

Control Section for Mineral soils

1) If the upper boundary of the C or IIC is less than 75 cm from the mineral surface, the control section extends to a depth of 1 m.
2) If the upper boundary of the C or IIC is 75 cm or greater from the mineral surface, the control section extends from the mineral surface either to 25 cm below the upper boundary of the underlying C (or the permafrost table), or to a depth of 2 m, whichever is less.
3) If bedrock occurs at a depth of 10 cm or more but less than 1 m, the control section extends from the surface to the bedrock contact.
4) If permafrost occurs at a depth of less than 1 m and the soil does not show evidence of cryoturbation, the control section extends to a depth of 1 m.

Control Section for Organic soils

A. Soils of the Organic Order

The control section for Fibrisols, Mesisols, and Humisols extends from the surface either to a depth of 1.6 m or to a bedrock contact. It is divided into tiers, which are used in classification.

The control section for Folisols (organic soils found in forests and composed of thick LFH horizons or folic materials) is the same as that used for mineral soils. These soils must have more than 40 cm of folic materials if they overlie mineral soils or peat materials, or at least 10 cm if they overlie coherent or fragmented bedrock.

Organic layers less than 40 cm in thickness that overlie a mineral soil are recognized as a phase in the Canadian System of Soil Classification. For example, a Humic Luvic Gleysol with a 30-cm organic surface layer would be classified as a Humic Luvic Gleysol, peaty phase.

B. Soils of Organic Cryosol Great Group

The control section for Organic Cryosols extends to a depth of 1 m or to a bedrock contact. No tiers are defined.

Control Section for Anthroposolic soils

The diagnostic disturbed D layer of an Anthroposol great group is the one encompassing the greatest cumulative proportion of the disturbed profile, to a maximum of 120 cm. The cumulative proportion refers to layers of similar material composition, regardless of the position in the profile, added together to determine the proportion of the profile they occupy.

When layers of different material composition are found in equal proportions, the uppermost layer will be used for classification. When a modified profile is < 120 cm, a natural soil horizon will exist without modification within the 120 cm control section. The great group description will then apply to the material composition layer that occupies at least 50% of the depth of the modified profile or the greatest cumulative proportion thereof. For example, if the depth of modification is 40 cm, the layer upon which the great group level of classification applies would be ≥ 20 cm in thickness or the greatest cumulative proportion.

How Do I Assign Horizon Labels To My Layers?

Steps:

1) Complete your full profile description.
2) If you are unfamiliar with the master horizons used in the Canadian System of Soil Classification review the material in the following section.
3) Otherwise begin to work through the Visual Horizon Keys.

Overview of Master Horizons

Mineral horizons and layers

Mineral horizons contain 17% or less organic C (about 30% organic matter) by weight.

A Horizons

This mineral horizon forms at or near the surface. It forms from two distinct processes: leaching or eluviation of materials in solution or suspension (Ae), or maximum *in situ* accumulation of organic matter (Ah) or both (Ahe). The accumulated organic matter is usually expressed morphologically by a darkening of the surface soil and hence low colour values (Ah). The removal of organic matter and iron and/or enhanced weathering of minerals that occur close to the soil surface are usually expressed by a lightening of the soil color and hence higher colour values (Ae). The removal of clay from the upper part of the solum (Ae) is expressed by a coarser soil texture relative to the underlying subsoil layers.

B Horizons

The B horizon has one or more of the following: enrichment in organic matter, iron and aluminum, or clay; by the development of soil structure; or by a change of color by chemical weathering processes such as hydrolysis, reduction, or oxidation.

Clay accumulation is indicated by finer soil textures than the Ae horizon and by clay coatings on peds and lining pores (Bt). Soil structure developed in B horizons includes prismatic or columnar units with coatings or stainings and significant amounts of exchangeable sodium (Bn) and other changes of structure (Bm) from that of the parent material. Color changes include relatively uniform reddening or browning due to oxidation of iron (Bm), and mottling and gleying of structurally altered material associated with periodic reduction (Bg) due to water saturation. Podzolic soils may have horizons with translocated organic matter (Bh) that has darker colors relative to the overlying A and underlying C horizon.

C Horizons

This mineral horizon is comparatively unaffected by soil-forming processes operating in A and B horizons, except the process of gleying (Cg), the accumulation of calcium and magnesium carbonates (Cca) and more soluble salts (Csa), and turbation due to shrinking and swelling of clays (Css) or ice (Cz).

Transitional and Mixed horizons: It is common to find layers that have attributes of both the overlying and the underlying horizons (e.g. AB, BC, A and B etc.).

R Horizon
A consolidated bedrock layer that is too hard to break with the hands (>3 on Mohs' scale) or to dig with a spade when moist. It does not meet the requirements of a C horizon. The boundary between the R layer and any overlying unconsolidated material is called a lithic contact.

W Horizon
This layer of water may occur in Gleysolic, Organic, or Cryosolic soils. Hydric layers in Organic soils are a kind of W layer as is segregated ice formation in Cryosolic soils.

ORGANIC HORIZONS

Organic horizons are found in soils of the Organic order and are also common at the surface of mineral soils. They may occur at any depth beneath the surface in buried soils or overlying geologic deposits. They contain more than 17% organic C (about 30% or more organic matter) by weight. Two groups of these horizons are recognized, the O horizons (peat materials found in wetlands) and the L, F, and H horizons (organic materials derived from leaves and forest floor vegetation).

O HORIZONS

O-This organic horizon is developed mainly from mosses, rushes, and woody materials. It is common in wetlands in all regions of western Canada except the Prairies. Two field tests can be used to classify organic materials: the von Post decomposition scale and the rubbed fiber test. Two related tests that can be field-based if the correct equipment is available are the sieve test and the pyrophosphate test (see Watson 2007 for more information on these latter two tests).

Organic horizons are divided into tiers for classification purposes.

Surface tier: The surface tier is 40 cm thick excluding loose litter, crowns of sedges and reeds, or living mosses. Mineral soil on the surface of the profile is part of the surface tier. Shallow organic soils over bedrock may have only a surface tier.

Middle tier: The middle tier is 80 cm thick. It establishes the great group classification if no mineral soil, bedrock, or water substratum is present.

Bottom tier: The bottom tier is 40 cm thick. The material in this tier assists in the subgroup classification.

L, F, AND H HORIZONS

L, F, and H-These organic horizons develop in forests, primarily from the accumulation of leaves, twigs, and woody materials with or without a minor component of mosses. They are normally associated with upland forested soils with imperfect drainage or drier. They commonly occur in

forested mineral soils but in some cool, moist, and humid soils (such as those found on the West Coast of Canada) they are classified into the Folisol Great Group of the Organic Order.

L-This organic horizon is characterized by an accumulation of organic matter in which the original structures are easily discernible (litter).

F-This organic horizon is characterized by an accumulation of partly decomposed organic matter (folic). The material may be partly altered by soil fauna (moder), or it may be a partly decomposed mat permeated by fungal hyphae (mor).

H-This organic horizon is characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible. This horizon differs from the F by having greater humification due chiefly to the action of organisms. It is frequently intermixed with mineral grains, especially near the junction with a mineral horizon.

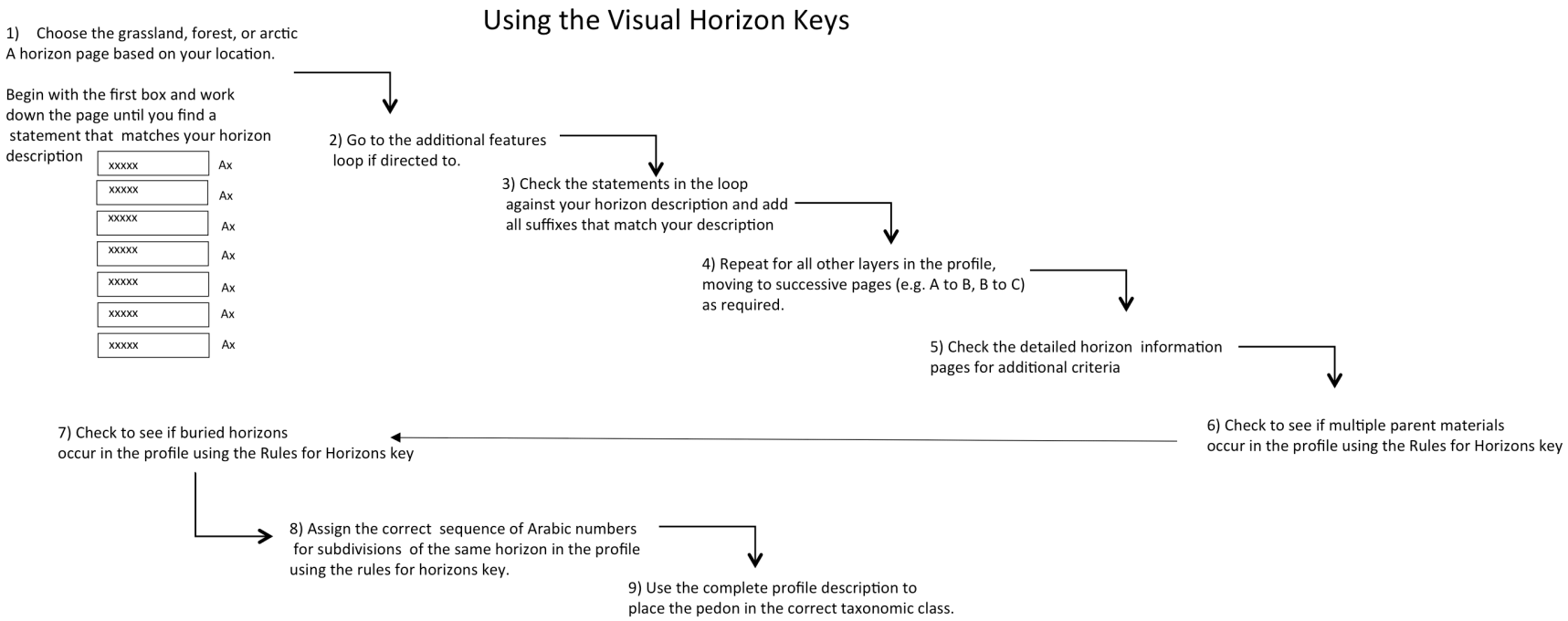
Note: In forest soils where burrowing faunal (primarily earthworms) activity is high, the F horizon does not form and instead a mull horizon (Ah) is found. This form of zoogenous, forest humus consists of an intimate mixture of well-humified organic matter and mineral soil with crumb or granular structure that makes a gradual transition to the horizon underneath.

ANTHROPIC (HUMAN-MADE) HORIZONS

D HORIZONS

These layers are anthropic (i.e., human-made) and have been significantly modified physically and/or chemically by human activities. The soil modification or disturbance must be visibly evident. The soil can be modified *in situ*, physically translocated, or added on top of existing natural soil or subsoil materials. *In situ* modification can include physical manipulation of structure or addition and incorporation of natural or human made materials. Anthroposolic D layers may be of amendment material such as peat or phosphogypsum, alone or mixed with mineral soil. The D layer may comprise severely admixed horizons, and no longer recognizable as the original undisturbed soil horizons. The D layer may be a removed or scalped layer that has not been replaced; thus, its absence makes the soil an Anthroposol.

USING THE VISUAL HORIZON KEY



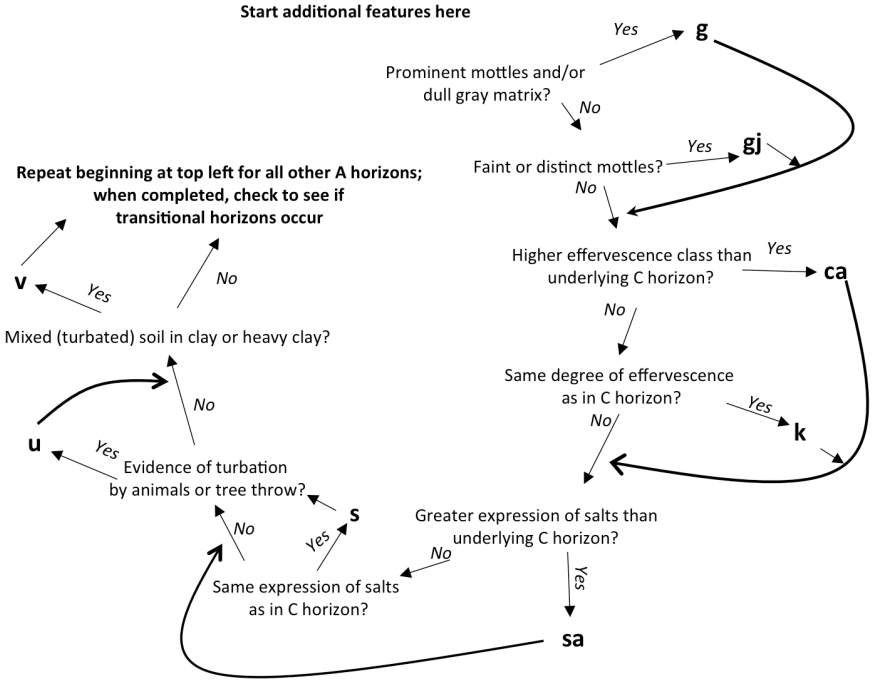
A HORIZONS FOR GRASSLAND AND GRASSLAND/FOREST TRANSITION SITES

Higher organic matter (darker colour values) than lower horizons AND salt-and-pepper effect when dry aggregates are crushed	Ahe*	Go to additional features
Higher organic matter (darker colour values) than lower horizons in layer mixed by humans in agricultural or forestry operations	Ap	Go to additional features
Higher organic matter (darker colour values) than lower horizons in undisturbed soil	Ah	Go to additional features
Grayish layer AND/OR less clay than underlying B horizon	Ae*	Go to additional features

* Weakly expressed examples of e, g, and v horizons may be assigned a j suffix (e.g. Aej, Aejgj)

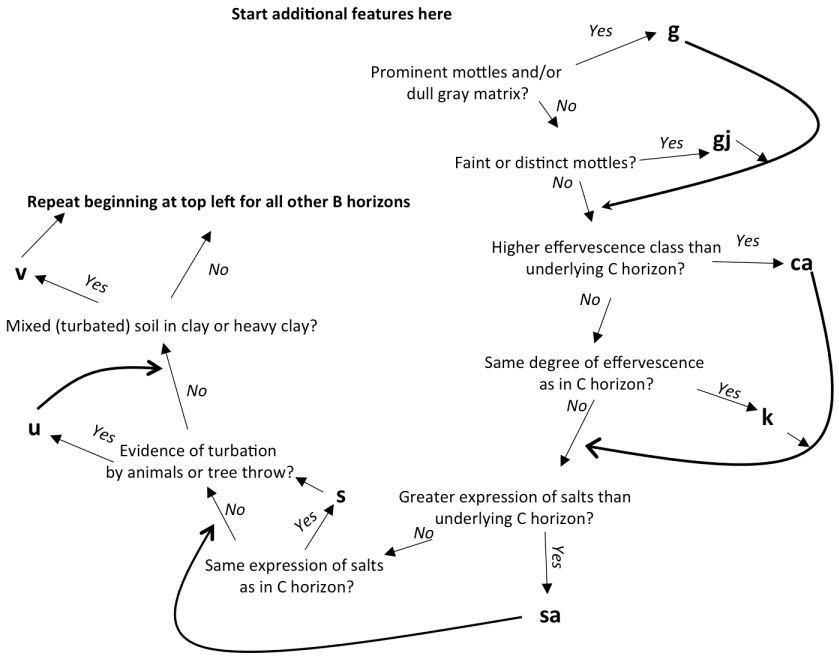
Gradual transition between lowermost A and B horizon	AB or BA*	Go to additional features
Horizons are interfingered or discrete inclusions from two horizons occur	A and B or B and A*	Go to additional features and/or use other A horizon (h, e) and B horizon (m, t, etc.) suffixes

*For transitional or mixed layers put the dominant horizon first



B HORIZONS FOR GRASSLAND AND GRASSLAND/FOREST TRANSITION SITES

Prismatic or columnar structures AND dark coatings on aggregate surfaces AND hard to very hard consistence when dry AND an increase in clay relative to A horizon	Bnt*	Go to additional features
Prismatic or columnar structures AND dark coatings on aggregate surfaces AND hard to very hard consistence when dry	Bn*	Go to additional features
Clay or heavy clay texture with polished or shiny surfaces	Bss	Go to additional features
Mixed (turbated) horizon in clay or heavy clay soils	Bv*	Go to additional features but skip v
An increase in clay relative to A horizon	Bt*	Go to additional features
Dull gray matrix colours AND/OR prominent mottles	Bg*	Go to additional features but skip g and gj
Higher effervescence class than underlying C horizon	Bca	Go to additional features but skip ca and k
Greater expression of salts than underlying C horizon	Bsa	Go to additional features but skip sa and s
Higher chromas and/or redder hues than underlying horizons OR complete or partial removal of carbonates OR change in structure from the underlying parent material	Bm	Go to additional features



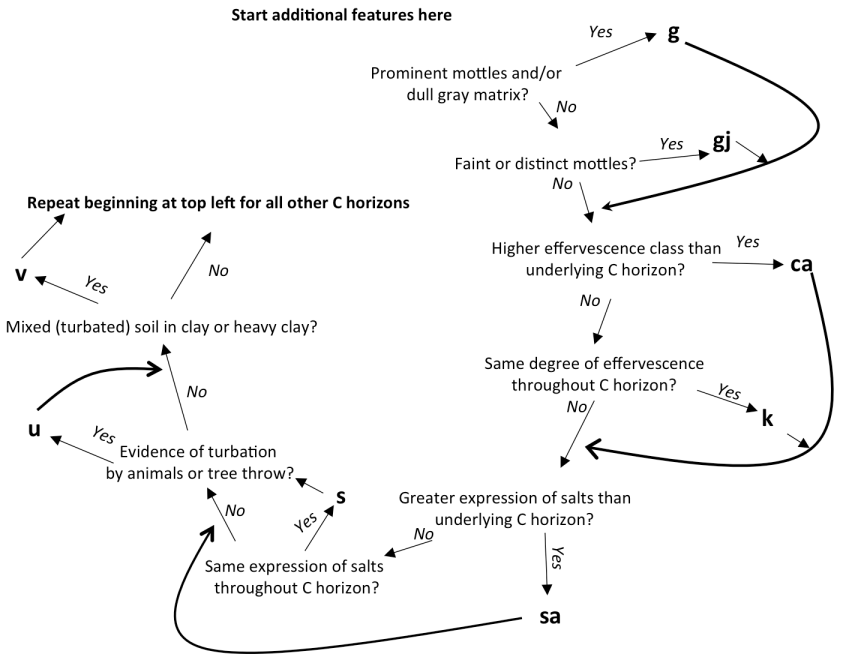
* Weakly expressed examples of n, t, g, and v horizons may be assigned a j suffix (e.g. Btj, Bnjtj, Bgj)

C HORIZONS FOR GRASSLAND AND GRASSLAND/FOREST TRANSITION SITES

Gradual transition between lowermost B and C horizon	BC or CB*	Go to additional features
Horizons are interfingered or discrete inclusion of two horizons occur	B and C or C and B*	Go to additional features

*For transitional or mixed layers put the dominant horizon first

Clay or heavy clay texture with polished or shiny surfaces	Css	Go to additional features
Dull gray matrix colours AND/OR prominent mottles	Cg*	Go to additional features but skip g
Higher effervescence class than underlying C horizon	Cca	Go to additional features but skip ca and k
Greater expression of salts than underlying C horizon	Csa	Go to additional features but skip sa and s
None of the above	C	Go to additional features but skip g, ca, and sa



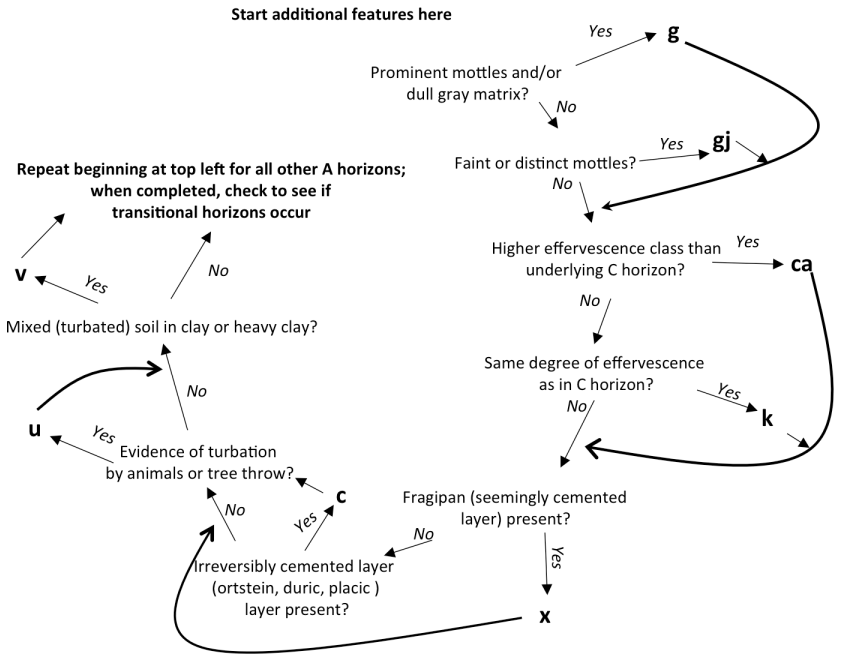
LFH AND A HORIZONS FOR FORESTED SITES

Surface organic layer where original leaf and woody material structures are readily apparent	L	
Surface organic layer where leaf and woody material are partially decomposed	F	
Surface organic layer where leaves and other organic matter are fully decomposed	H	
Higher organic matter (darker colour values) than lower horizons AND salt-and-pepper effect when dry aggregates are crushed	Ahe*	Go to additional features
Higher organic matter (darker colour values) than lower horizons in layer mixed by humans in agricultural or forestry operations	Ap	Go to additional features
Higher organic matter (darker colour values) than lower horizons in undisturbed soil	Ah	Go to additional features
Grayish layer AND/OR less clay than underlying B horizon	Ae*	Go to additional features

* Weakly expressed examples of e, g, and v horizons may be assigned a j suffix (e.g. Aej, Aejgj)

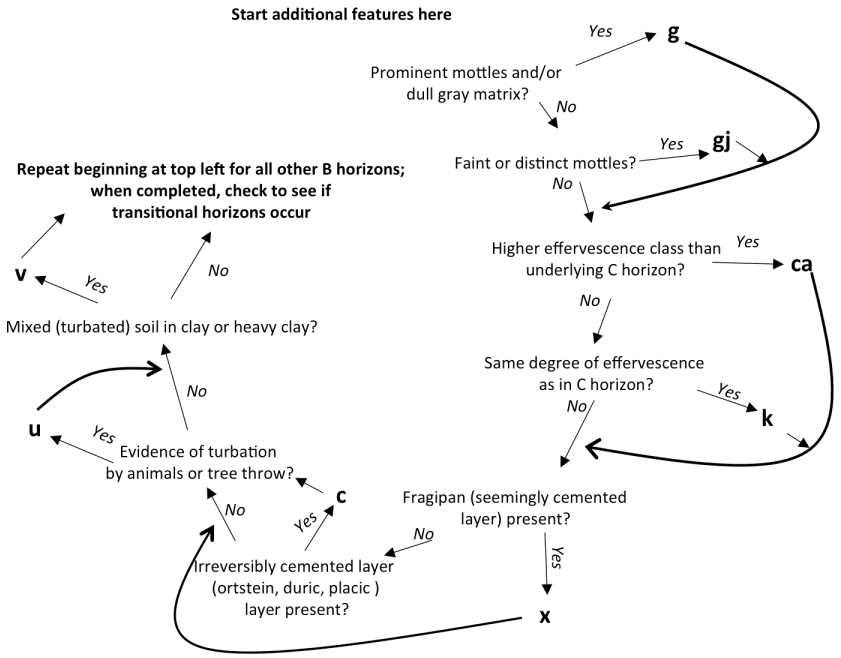
Gradual transition between lowermost A and B horizon	AB or BA*	Go to additional features
Horizons are interfingered or discrete inclusions from two horizons occur	A and B or B and A*	Go to additional features and/or use other A horizon (h, e) and B horizon (m, t, etc.) suffixes

*For transitional or mixed layers put the dominant horizon first



B HORIZONS FOR FORESTED SITES

Enrichment of translocated organic matter (colour value and chroma < 3) AND enrichment of iron and aluminum (red colour masked by high OM)	Bhf*	Go to additional features
Enrichment of translocated organic matter (colour value and chroma < 3) AND at least 10 cm thick	Bh	Go to additional features
Enrichment of iron and aluminum: hues of 7.5 Y/R or redder AND chroma > 3 OR 10YR near upper boundary and yellower with depth AND chroma > 3	Bf*,**	Go to additional features
An increase in clay relative to A horizon	Bt*	Go to additional features
Dull gray matrix colours AND/OR prominent mottles	Bg*	Go to additional features but skip g and gj
Higher chromas and/or redder hues than underlying horizons OR complete or partial removal of carbonates OR change in structure from the underlying parent material	Bm	Go to additional features



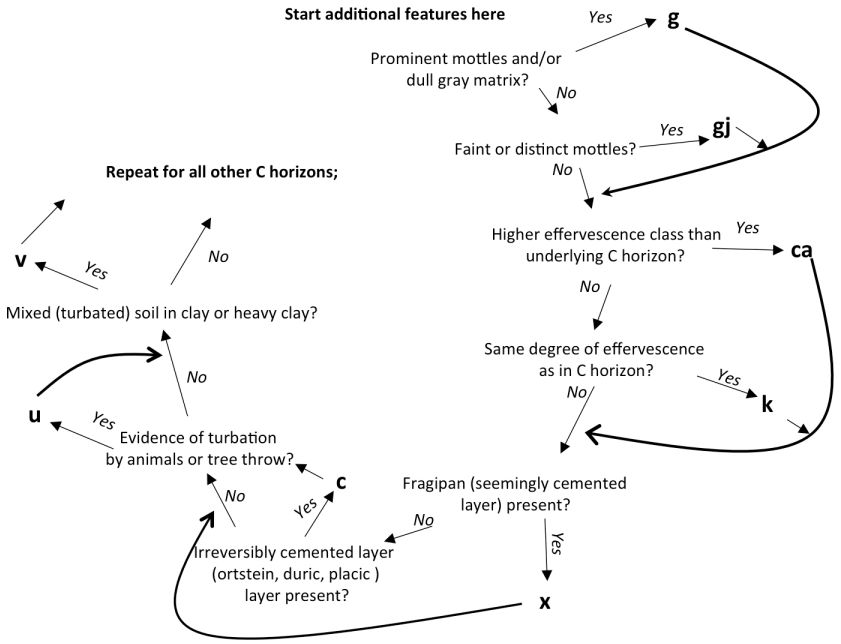
* Weakly expressed examples of f, t, and g, horizons may be assigned a j suffix (e.g. Btj, Bfj, Bgj)
** A Bgf horizon is a special case of a B horizon with f + g suffixes; see detailed horizon notes

C HORIZONS FOR FORESTED SITES

Gradual transition between lowermost B and C horizon	BC or CB*	Go to additional features
Horizons are interfingered or discrete inclusion of two horizons occur	B and C or C and B*	Go to additional features

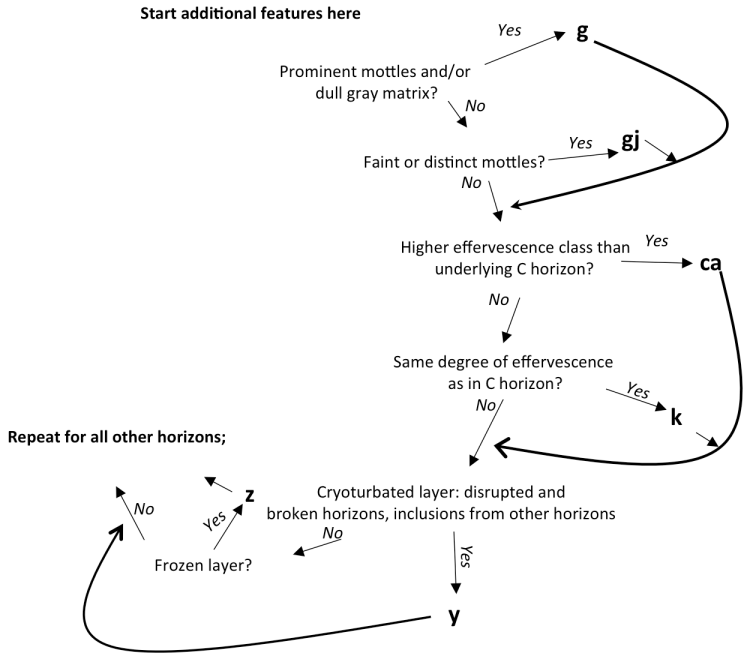
*For transitional or mixed layers put the dominant horizon first

Dull gray matrix colours AND/OR prominent mottles	Cg*	Go to additional features but skip g and gj
Higher effervescence class than underlying C horizon	Cca	Go to additional features but skip ca and k
Greater expression of salts than underlying C horizon	Csa	Go to additional features but skip sa and s
None of the above	C	Go to additional features but skip g, and ca



HORIZONS FOR PEATLANDS

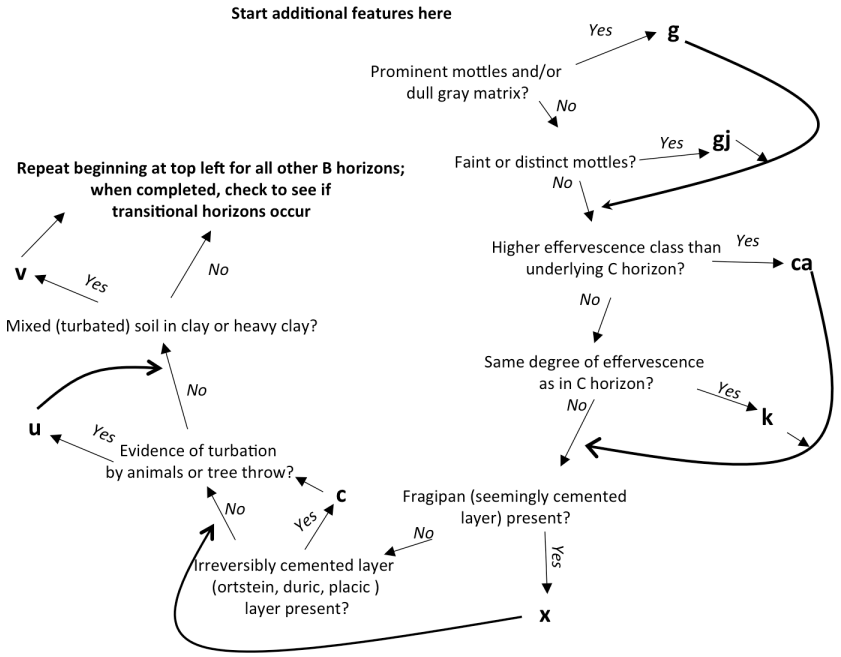
Organic	Fibric materials that are readily identifiable as to botanical origin; van Post score between 1 and 4	Of	Go to additional features but skip g, gj, ca, k
	Organic material is partially altered both physically and biochemically; van Post score 5 or 6	Om	Go to additional features but skip g, gj, ca, k
	Organic material is advanced state of decomposition; botanical origin undiscernible; van Post score 7 or higher	Oh	Go to additional features but skip g, gj, ca, k
	Forest litter overlying mineral soil (see forest charts for further information)	LFH	
Mineral	Higher organic matter (darker colour values) than lower horizons in undisturbed soil	Ah	Go to additional features
	Grayish layer AND/OR less clay than underlying B horizon	Ae	Go to additional features
	An increase in clay relative to A horizon	Bt	Go to additional features
	Higher chromas and/or redder hues than underlying horizons OR complete or partial removal of carbonates OR change in structure from the underlying parent material	Bm	Go to additional features
	Gradual transition between lowermost B and C horizon	BC	Go to additional features
	Largely unaltered parent material	C	Go to additional features
	Bedrock occurring within 10 to 160 cm of the surface	R	Go to additional features



HORIZONS FOR PERMAFROST SITES

Organic	Fibric materials that are readily identifiable as to botanical origin; van Post score between 1 and 4	Of
	Organic material is partially altered both physically and biochemically; van Post score 5 or 6	Om
	Organic material is advanced state of decomposition; botanical origin undiscernible; van Post score 7 or higher	Oh
	Layer deposited in water of plant material altered and excreted by aquatic organisms	Oco
Mineral	Marl: Layer of calcareous shells of aquatic animals and precipitated CaCO3; effervesces with dilute HCl	Ck
	Diatomaceous earth: mainly composed of Siliceous shells of diatoms; Matrix colour value of 4±1 when moist, dries to light gray or white.	C
	Largely unaltered parent material	C
	Bedrock occurring within 10 to 160 cm of the surface	R
Water	Water layer that extends from a depth of Not less than 40 cm to a depth of 1.6 m or more	W

Go to additional features



ANTHROPIC (HUMAN-MADE) HORIZONS

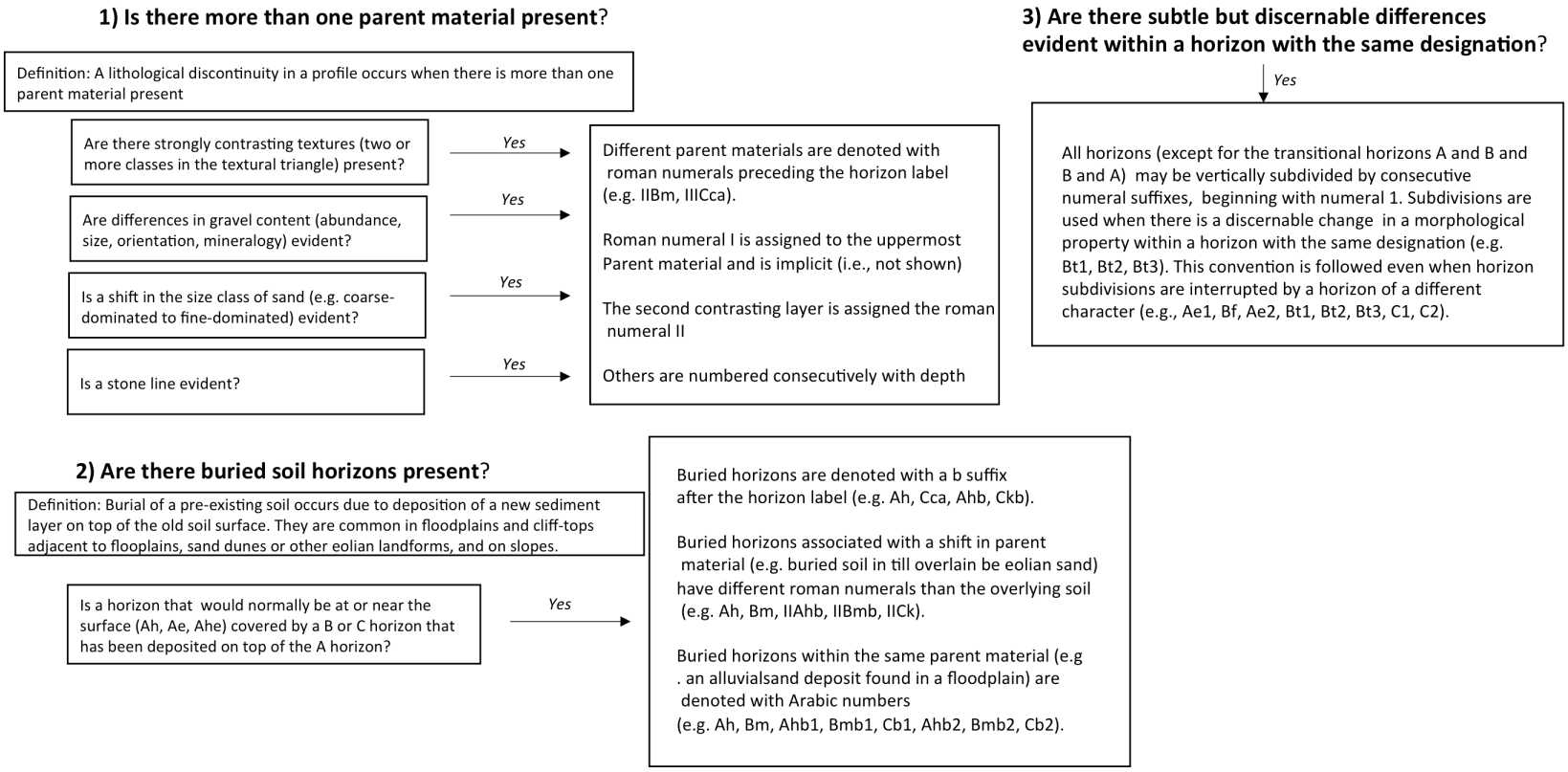
Horizon visibly disturbed by human activity AND organic material (>17% organic carbon) present	Do	Go to additional features
Horizon visibly disturbed by human activity AND hydrocarbons and/or other contaminants (e.g. industrial chemicals, Pesticides etc.) present	Dq	Go to additional features
Horizon visibly disturbed by human activity that contains artifacts of human origin (e.g. brick, pottery, glass, plastic etc.)	Dw	Go to additional features
Horizon visibly disturbed by human activity	D*	Go to additional features

* The D can be used with any appropriate suffix from the mineral horizon charts (e.g. Dh, Dm, Dg etc.)

Note: Additional properties for anthropic horizons are identified to allow the assignment of phases in the Anthroposolic order. The cumulative thickness of each layer and its position in the profile must be noted.

Effervescence (e.g. alkaline earth carbonates) present	Calcareous
Mineral soil with pH < 5.5 ($CaCl_2$) or 6 (water) present	Dystric
Hydrocarbons present	Hydrocarbic
Other contaminants (e.g. industrial chemicals, Pesticides, wood preservatives) present	Contaminic
EC > 4 dS m-1 AND/OR sodium adsorption ratio >13 present	Saltic
Layer with > 40% clay present	Clayic
Mineral soil showing evidence of root restriction due to compaction	Compatic
Mineral soil with a layer of sand or loamy sand present	Sablic
Surface layer greater than 40 thick	Thick
Refuse from human activity (e.g. glass, Plastic, concrete) present	Garbic
Materials deposited as a slurry layer present	Slurric

RULES FOR HORIZONS: MULTIPLE PARENT MATERIALS, BURIED HORIZONS, AND HORIZON SUBDIVISIONS



DETAILED NOTES FOR LOWERCASE SUFFIXES OF MINERAL HORIZONS

Note: This section focuses on field criteria for these horizons. In cases where additional chemical criteria are required check with the Canadian System of Soil Classification 3rd Ed. for details

b – A buried soil horizon. The soil horizon is designated using normal criteria and then the b suffix added (e.g. Ahb, Bntb, Ckb).

c - A cemented (irreversible) pedogenic horizon. Ortstein, placic and duric horizons are specific examples of cemented horizon that are primarily associated with Podzolic soils. Layers cemented by $CaCO_3$ are another example of a cemented horizon. Fragipan horizons (x suffix) may appear to be cemented, but break apart readily in water (slake).

Orstein: This strongly cemented, reddish brown to dark reddish brown horizon (2.5 YR and 5YR Hue pages) (Bhc, Bhfc, or Bfc) must be at least 3 cm thick and occur in more than one-third of the exposed face of the pedon.

Placic horizon - This is a thin layer (commonly 5 mm or less in thickness) or a series of thin layers that are irregular or involuted (i.e., curled or curved inward) hard, impervious, often glassy (vitrous), and dark reddish brown to black. Placic horizons may be cemented by Fe, Al-organic complexes (Bhfc or Bfc), hydrated Fe oxides (Bgfc), or a mixture of Fe and Mn oxides.

Duric horizon - This strongly cemented horizon usually has an abrupt upper boundary to an overlying podzolic B or to a Bm horizon and a diffuse lower boundary. Cementation is usually strongest near the upper boundary, which occurs commonly at a depth of 40 to 80 cm from the mineral surface. The color of the duric horizon usually differs little from that of the moderately coarse textured to coarse textured parent material, and the structure is usually massive or very coarse platy.Unlike fragipans, air-dry clods of duric horizons do not break apart in water (slake); moist clods at least 3 cm thick usually cannot be broken in the hands.

ca - A horizon of secondary carbonate enrichment in which the concentration of calcium carbonate (lime) exceeds that in the unenriched parent material. It is used with C (Cca) in soils were carbonate has been weathered from the upper horizons and re-crystallized in the C. It is used with A and B horizons (e.g. Ahca, Bca) where discharge of groundwater high in calcium and bicarbonate ions has lead to re-crystallization. Ahca horizons also occur where tillage, wind, or water erosion has truncated the profile and mixing of the Cca into the Ap horizon is occurring. The ca horizon must exhibit increased effervescence (ie., the release of CO_2 following the addition of 10% HCl) relative to the IC (parent material). In the field the effervescence class of the ca horizon should be at least one class higher than the IC. If no IC is present, this horizon

contains more than 5% by volume of secondary carbonates in concretions or in soft, powdery forms. There are additional chemical criteria for ca horizons.

cc - Cemented (irreversible) pedogenic concretions. Concretions are cemented units that are composed of visible concentric layers of material around a point line or plane. Concretions of Fe and Mn are common in wetland soils, and charcoal-cored concretions occur in forest soils.

e - A horizon characterized by the eluviation of clay, Fe, Al, or organic matter alone or in combination. When dry, it is usually higher in color value by one or more units than an underlying B horizon. It is only used with the A master horizon.

f - A horizon enriched with Fe and Al combined with organic matter. Most commonly found in sandy, acidic, forest soils. It is used with B alone (Bf), with B and h (Bhf), with B and g (Bfg), and with other suffixes. These criteria do not apply to Bgf horizons. There are also specific chemical criteria that these horizons must meet.

> Bf: Hues of 7.5YR or redder, or its hue must be 10YR near the upper boundary and become yellower with depth. When moist the chroma is higher than 3 or the value is 3 or less. It has 0.5-5% organic C.
>
> Bhf - more than 5% organic C. The black color of the organic matter can mask the red colour of the f horizon.
>
> Bgf See below under g suffix

g - A gleyed horizon characterized by dull (low chroma) gray colors, or prominent mottling, or both, indicating intense reduction due to permanent or periodic water saturation. It is the diagnostic horizon of the Gleysolic order.

In some reddish parent materials, matrix colors of reddish hues and high chromas may persist despite long periods of reduction. In these soils, horizons are designated as g if there is gray mottling or marked bleaching on ped faces or along cracks.

The contrast of mottles with the matrix (i.e., faint, distinct, prominent) is a key element in the description of these horizons. See section on contrast of mottles in Section 3 of this handbook for the specific criteria used. Horizons with faint or distinct mottles (rather than prominent mottles) are typically designated as gj horizons.

Colour criteria for g horizons: a g horizon must meet one of the following colour criteria:

1. Chromas of 1 without mottles on ped surfaces or in the matrix if peds are lacking; **OR**
2. Chromas of 2 or less in hues of 10YR or redder, on ped surfaces or in the matrix if peds are lacking **AND** more prominent mottles than those in the C horizon; **OR**
3. Chromas of 3 or less, in hues yellower than 10YR, on ped surfaces or in the matrix if peds are lacking **AND** prominent mottles. **OR**

4. Hues bluer than 10Y (see Gley 1 and Gley 2 charts in Munsell Colour book) with or without mottles on ped surfaces or in the matrix if peds are lacking.

Horizon-specific criteria for g horizons:

Aeg - This horizon must meet the definitions of A, e, and g. Ae horizons are normally gray, and prominent mottles must be present for the g suffix to be assigned. If only faint or distinct mottles are present the horizon is designated as an Aegj horizon.

Bg – A Bg horizon must have a change in structure from the C horizon AND meet one of the colour criteria presented above.

Bfg, Bhfg, Btg, Bgca and others - When used in any of these combinations, the limits set for f, hf, t, ca and others must be met as well as the colour criteria for the g horizon.

Bgf – This horizon occurs in Fera Gleysols and Fera Humic Gleysols and possibly below the Bfg of gleyed Podzols. It is distinguished from the Bfg of gleyed Podzols on the basis of the extractability of the Fe and Al (which requires a laboratory test). The Fe in the Bgf horizon is thought to have accumulated as a result of the oxidation of ferrous iron. The iron oxide formed is not associated intimately with organic matter or with Al and is sometimes crystalline. Bgf horizons are usually prominently mottled; more than half of the soil material occurs as mottles of high chroma (ie., chroma of 3 or higher).

Cg, Ckg, Ccag, Csg, Csag - When g is used with C alone, the horizon must meet only the colour criteria specified for the g horizon above to be assigned a g suffix. With C and one of the lowercase suffixes k, ca, s, or sa, the horizon must meet the definition for the g suffix and for the additional suffix.

h - A mineral horizon enriched with organic matter. It is used with A alone (Ah), or with A and e (Ahe), or with B alone (Bh), or with B and f (Bhf). Ah horizons occur in grasslands and in forest soils where mixing of forest litter and the mineral soil surface occurs. Ahe horizons are associated with forest-grassland transition areas. Bh and Bhf horizons occur in sandy, acid forest soils and are associated with the Podzolic soil order.

j - A modifier of suffixes e, f, g, n, t, and v (i.e., those horizons that are defined by quantitative criteria). It is used to denote an expression of, but failure to meet, the specified limits of the suffix it modifies. It must be placed to the right and adjacent to the suffix it modifies. For example, Bfgj means a Bf horizon with a weak expression of gleying; Bfjgj means a B horizon with weak expression of both f and g features. It is not used with an m suffix.

Aej - It denotes an eluvial horizon that is discontinuous, or slightly discernible (i.e., when dry, it is not higher in color value by one or more units than an underlying B horizon or the difference in clay with the Btj is minor).

Btj - It is a horizon with some illuviation of clay but not enough to meet the limits of Bt.

Bgj, Btgj, Bmgj, etc. - These horizons are mottled or have dull chromas but do not meet the criteria of g (see above). Typically they have faint or distinct mottles or they have prominent mottles but the chromas are too bright for a true g horizon.

Bfj - It is a horizon with some accumulation amorphous Al+Fe but not enough to meet the limits of Bf. In addition, the color of this horizon may not meet the color criteria set for Bf.

Btnj or Bnj - In these horizons the development of solonetzic B properties is evident but insufficient to meet the limits for Bn or Bnt. In the field this may be indicated by weakly developed prismatic or columnar structure, soft or slightly hard dry consistence of peds, or no or weakly developed dark coatings on peds.

Bvj - In this horizon mixing by shrinking and swelling of clays (argillipedoturbation) is evident but the disruption of other diagnostic horizons is insufficient to severely alter them.

k - Denotes the presence of primary or lithogenic carbonate inherited from the parent material. Typically primary carbonates are detected by visible effervescence when dilute HCI is added to the soil matrix (i.e., to the interior of peds). Concentrations of $CaCO_3$ (i.e., splotches, streaks) are evidence of secondary or pedogenic carbonates and are denoted with a ca suffix. The k suffix is used mostly with B and m (Bmk), n (Bntk, Bnk) or C (Ck) and occasionally with Ah or Ap (Ahk, Apk), or organic layers (Ofk, Omk). Apk horizons are common where erosion has truncated the original A and B horizons and mixing of the Ck and A horizon occurs.

m - A horizon slightly altered by chemical weathering (I.e., hydrolysis, oxidation, or solution, or all three) to give a change in color or structure, or both. This suffix can be used as Bm, Bmk, and Bms. Bmj is not used (the j suffix is redundant). An m horizon has the following properties:

1. Evidence of alteration in one or more of the following forms:
    a. Higher chromas and/or redder hues than the underlying horizons.
    b. Removal of carbonates either partially (Bmk) or completely (Bm).
    c. A change in structure from that of the parent material (i.e., the IC horizon).
    d. Illuviation, if evident, too slight to meet the requirements of a Bt or a podzolic B.
    e. No cementation or induration and lacks a brittle consistence when moist.

n – Soils high in sodium (Na) that are found on saline parent materials. It is used with B as Bn or Bnt. These horizons would usually overlay a saline (e.g. Csk, Cskg) horizon. The n horizon must also have all of the following distinctive morphological characteristics:

1. prismatic or columnar structure AND
2. dark coatings on ped surfaces AND
3. hard to very hard dry consistence.

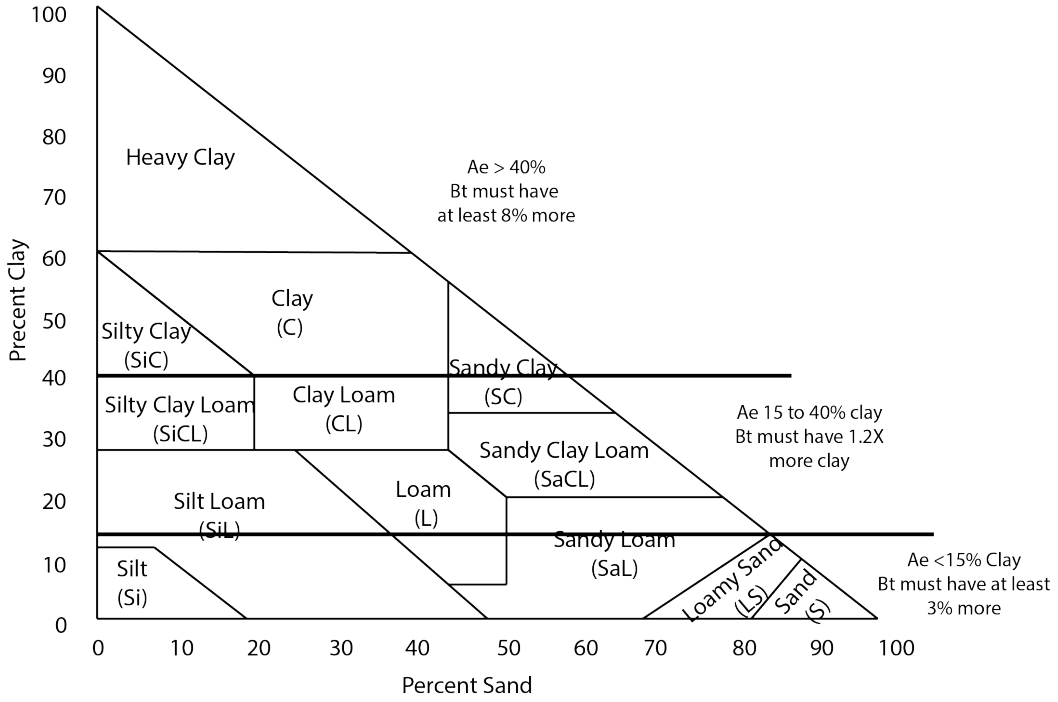
As well as these field criteria, the horizon must also meet additional chemical criteria.

p - A horizon disturbed by human activities such as cultivation, logging, and habitation. It is used with A and O. Specific information on the nature of the disturbance should be added as a comment in the description.

t - An illuvial horizon enriched with silicate clay. It is used with B alone (Bt), with B and g (Btg), with B and n (Bnt), etc.

Bt - A Bt horizon is one that contains illuvial layer lattice clays. It forms below an eluvial horizon (Ae, Ahe) but may occur at the surface of a soil that has been partially truncated by erosion. It usually has a higher ratio of fine clay to total clay than the IC (which requires a laboratory analysis for confirmation). It has the following properties:

a) A Bt horizon must be at least 5 cm thick. If less than 5 cm it is designated as a Btj horizon.
b) In sandy soils where clay accumulation occurs in the lamellae, the total thickness of the lamellae should be more than 10 cm in the upper 1.5 m of the profile.
c) If any part of an eluvial horizon remains and there is only one parent material present (i.e., no lithological discontinuity) between it and the Bt horizon, the Bt horizon contains more total clay than the Ae horizon as shown in the following figure:



d) If peds are present, a Bt horizon has clay skins on some of the vertical and horizontal ped surfaces and in the fine pores OR has illuvial oriented clays in 1% or more of the cross section as viewed in thin section under the microscope. Clay skins can be assessed in the field with a hand lens whereas thin section analysis is performed in the laboratory.
e) In massive soils the Bt horizon should have oriented clay in some pores and also as bridges between the sand grains.
f) If a soil has a lithological discontinuity between the eluvial horizon and the Bt horizon, or if only a plow layer overlies the Bt horizon, the Bt horizon need show only clay skins in some part, either in some fine pores or on some vertical and

horizontal ped surfaces. Thin sections should show that the horizon has about 1% or more of oriented clay bodies under the microscope.

Btj and Btg - Defined under j and g.

s - A horizon with salts more soluble than Ca and Mg carbonates, including gypsum, which may be detected as crystals or veins, as surface crusts of salt crystals, by depressed crop growth, or by the presence of salt-tolerant plants. The concentration of salts does not exceed that of the parent material (i.e., the IC horizon).

sa - A horizon with secondary enrichment of salts more soluble than Ca and Mg carbonates (including gypsum); the concentration of salts exceeds that of the unenriched parent material. The salts may be detected as crystals or veins, as surface crusts of salt crystals, by depressed crop growth, or by the presence of salt-tolerant plants. The conductivity of the saturation extract must be at least 4 mS/cm and exceed that of the C horizon by at least one-third.

ss – A horizon with the presence of several (more than two) slickensides. Slickensides occur in clay and heavy clay soils. Slickensides are shear surfaces, with an aerial extent of at least 4 cm^2, that form when one soil mass moves over another. They appear as polished or shiny surfaces. They commonly display unidirectional grooves parallel to the direction of movement and often occur at an angle of 20-60 degrees from the horizontal. Slickensides often intersect, resulting in the formation of wedge shaped aggregates that commonly occur in these soils. It is used with A, B, and C horizons.

u - A horizon that is visibly disrupted by physical or faunal processes other than a) turbation by ice, b) turbation by shrinking and swelling of clays or c) human activity. Evidence of marked disruption such as the inclusion of material from other horizons or the absence of the horizon must be evident in at least half of the cross section of the pedon. Such turbation can result from blowdown of trees, mass movement of soil on slopes, and burrowing animals. The u can be used with any horizon or subhorizon with the exception of A or B alone; e.g., Aheu, Bfu, Bcu. The cause of turbation should be noted as a comment.

v - A horizon affected by shrinking and swelling of clays (argillipedoturbation), as manifested by disruption and mixing caused by shrinking and swelling of the soil mass in clay and heavy clay soils. The disruption within this horizon is strong enough to prevent the development of horizons diagnostic of other orders, or if these horizons are present they are disrupted to the extent that they are no longer continuous and their orientation has been severely changed. It is used with B or BC horizons alone or in combination with other suffixes. It is characterized by the presence of the following: Irregular shaped, randomly oriented, intrusions of displaced materials within the solum and vertical cracks, often containing sloughed-in surface materials.

x - A fragipan is a loamy B or C horizon of high bulk density and very low organic matter content. When dry, it has a hard consistence and seems to be cemented. When moist, it has moderate to weak brittleness. It frequently has bleached fracture planes and is overlain by a friable B horizon. Air-dry clods of fragic horizons slake in water.

y - A horizon affected by cryoturbation as shown by disrupted and broken horizons, incorporation of materials from other horizons, and mechanical sorting in at least half of the cross section of the pedon. It is used with A, B. and C alone or in combination with other subscripts.

z - A frozen layer. It may be used with any horizon or layer.

Detailed Notes for Lowercase Suffixes of Organic Horizons

von Post Scale of Decomposition

The most common field test for organic horizons is the van Post scale of decomposition:

Squeeze a sample of organic material within your fist and observe the colour of the solution that emerges, the nature of the fibers, and what proportion of the original material remains in your fist.

1: Unaltered plant structure; only clear, light yellow-brown water emerges.

2: Plant structure distinct but very slight decomposition evident; only clear, light yellow-brown water emerges.

3: Plant structure distinct but slightly decomposed; residue not mushy; distinctly turbid brown water but no peat material emerges.

4: Plant structure distinct but slightly decomposed; residue partially mushy, partially firm; strongly turbid brown water but no peat material emerges.

5: Plant structure partially indistinct; residue very mushy; strongly turbid brown water and some peat material emerges.

6: Plant structure partially indistinct but clearer in squeezed residue than in undisturbed peat; residue very mushy; about 1/3 of peat escapes between fingers.

7: Plant structure partially indistinct but clearer in squeezed residue than in undisturbed peat; residue very mushy; about 1/2 of peat escapes between fingers.

8: Plant structure very indistinct; residue almost entirely resistant root fibers and wood; about 2/3 of peat escapes between fingers.

9: Plant structure almost unrecognizable; residue almost entirely resistant root fibers and wood; nearly all peat escapes between fingers.

10: Completely decomposed; all peat escapes between fingers.

ORGANIC HORIZONS

f- This O horizon consists largely of fibric materials that are readily identifiable as to botanical origin. Fiber is defined as the organic material retained on an l00-mesh sieve (0.15 mm), except for wood fragments that cannot be crushed in the hand and are larger than 2 cm in the smallest dimension.

A fibric horizon has one or more of the following:

1. A van Post scale of decomposition score between 1 and 4.
2. 40 to 75% or more of rubbed fiber by volume. Rubbed fiber is the fiber that remains after rubbing a sample of the layer about 10 times between the thumb and forefinger.

Three kinds of fibric horizons are named.

1. Fennic horizons are derived from rushes, reeds, and sedges.
2. Silvic horizons are derived from wood, moss with less than 75% of the volume being Sphagnum spp., and other herbaceous plants.
3. Sphagnic horizons are derived from sphagnum mosses.

m-This O horizon consists of mesic material, which is at a stage of decomposition intermediate between fibric and humic materials. The material is partly altered both physically and biochemically. A mesic horizon has one or more of the following:

1. A van Post scale of decomposition score of class 5 or 6.
2. A rubbed fiber content ranging from 10% to less than 40%,

h-This O horizon consists of humic material, which is at an advanced stage of decomposition. The horizon has the lowest amount of fiber, the highest bulk density, and the lowest saturated water-holding capacity of the O horizons. It is very stable and changes little physically or chemically with time unless it is drained. A humic horizon has one or more of the following properties:

1. A van Post scale of decomposition score of class 7 or higher.
2. Rubbed fiber content less than 10% by volume

co- This is a limnic layer composed of a minimum of 5 cm of coprogenous earth. Coprogenous earth is composed of aquatic plant debris modified by aquatic animals. It makes slightly viscous water suspensions and is slightly plastic but not sticky. The material shrinks upon drying to form clods that are difficult to rewet and commonly crack along horizontal planes. It has very few or no plant fragments recognizable to the naked eye, a pyrophosphate index of 5 or more, and a dry color value of less than 5.

NAMED ORGANIC LAYERS

The classification of Organic soils commonly involves named layers that are derived from the profile description. These named layers found in Organic soils are:

Cumulic layer-This is a layer or layers of mineral material that occur within the organic material in an Organic soils. Either the combined thickness of the mineral layers is more than 5 cm or a

single mineral layer 5-30 cm thick occurs. Each layer is denoted as a C horizon in the profile description.

Terric layer-This is either an unconsolidated mineral substratum underlying the organic horizons, or one continuous unconsolidated mineral layer (with 17% or less organic C) more than 30 cm thick in the middle or bottom tiers underlain by organic matter; both must occur within a depth of 1.6 m from the surface. It is denoted as a C horizon and any appropriate suffixes (e.g. Cg, Cgk) are also added.

Lithic layer- Bedrock occurring within 10 to 160 cm of the surface of Organic soils. It is denoted with an R.

Hydric layer-This is a layer of water that extends from a depth of not less than 40 cm from the organic surface to a depth of more than 1.6 m. It is denoted with a W.

Two inorganic limnic layers are named if they are ≥ 5 cm in thickness:

Diatomaceous earth is composed mainly of the siliceous shells of diatoms. It has a matrix color value of 4±1, if not previously dried, that changes on drying to the permanent, light gray or whitish color of diatoms. The diatom shells can be identified by microscopic (440 x) examination. Diatomaceous earth has a pyrophosphate index of 5 or more. It is frequently more nearly mineral than organic in composition. It is designated C in horizon descriptions.

Marl is composed of the shells of aquatic animals and $CaCO_3$ precipitated in water. It has a moist color value of 6±1 and effervesces with dilute HCI. The color of the matrix usually does not change on drying. Marl contains too little organic matter to coat the carbonate particles. It occurs primarily in wetlands located in terrain underlain by limestone. It is designated Ck in horizon descriptions.

Detailed Notes for Lowercase Suffixes of Anthropic Horizons

o- A horizon visibly disturbed by human activity that contains > 17% organic carbon. It is only used with the D master horizon.

q- A horizon visibly disturbed by human activity that has hydrocarbons present. It is only used with the D master horizon.

w- A horizon with artifacts of human origin (waste). The artefacts can include brick, pottery, glass, plastic, iron, slag and coal. It is only used with the D master horizon.