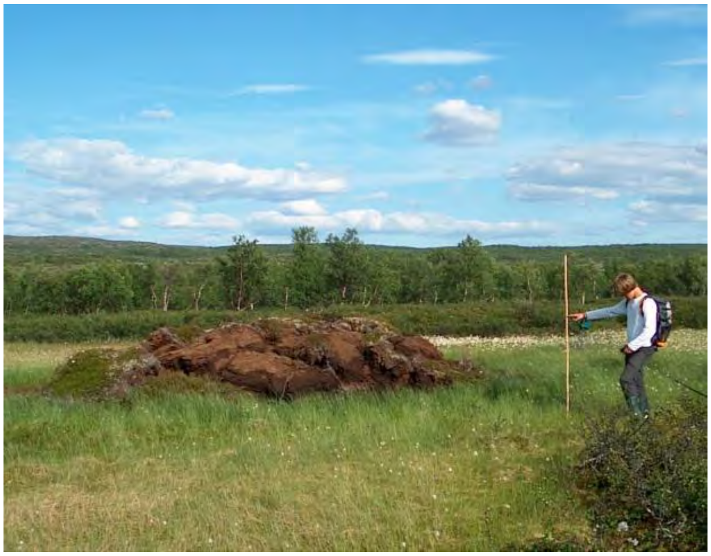
Provincials 2018 Envirothon; Northern Organic Soils

Organic Soil underlain with frozen layers

Soils of the Organic Order commonly called peatlands, are the dominant wetland soils found in forested regions of Canada, and in the Hudson Plains Lowlands Ecozone. Generally, organic soils (peatlands) are found in wetter areas. As plants die in these areas, they usually do not fully decompose, but slowly accumulate and build layers of partially decayed vegetation, due to lack of oxygen and in the north, cold temperatures. Peat is comprised mainly of moss, lichen, and leaves, with some animal matter such as remains of insects. In the Hudson Plains Lowlands, peat increases with distance from the coast. The thickest are found about 80 kms inland from Churchill, are about 4 meters thick, and are approximately 4000 yrs old. Peatlands in the north are a massive reservoir of stored carbon, with the Hudson Plains Lowlands being the largest area in North America.

Peat contains more air and water (90%) than plant material and is very spongy. During the summer, it acts as an insulator, preventing the complete melting of permafrost. Freezing and thawing produces small mounds or hummocks called Palsas, making the tundra uneven. This is also known as a Themokarsk landscape. Very large mounds, or hills called Pingos can also be formed due to large ice lenses.



Example of a Palsa

Active Layer: This is the depth of surface layer impacted by the freeze-thaw cycle; thawing during summer and freezing during winter. The Churchill area is underlain with permafrost with active layer depths ranging from 75-180 cm, becoming thicker as the distance to the coast increases.

Thermokarst is known as the forming of a landscape due to melting of permafrost ground. It can be caused by human activity or nature itself. Agriculture, deforestation or the construction of buildings as well as natural erosion most commonly lead to thermokarst, since the insulating layer of vegetation is being removed. The formation of the landscape is inevitably connected with the amount of ice beneath the surface.

Thermokarst activity is an indicator of a warming climate since rising temperatures cause the permafrost ground to thaw. Between 1954 and 2003 the annual average temperature in the arctic regions has risen about 1 °C. The recorded average temperature in the wintertime show an increase of about 2 to 4 °C. The warmer the temperatures get the deeper the soil thaws and the active layer thickens.

Along with rising temperatures comes an increase in melting of the mostly water organic soils. The melting water of the permafrost and the rainwater start pooling in small sinks or valleys. The presence of warmer water on the surface compared to the temperature of the underlying ground causes melting of the ice and the process of thermokarst changes to accelerate.

Organic soils/Peatland formations

There is a range of landscapes related to peat soils, and in conjunction with permafrost, they can have interesting forms.

Muskeg: General term which refers to the area of swamps and bogs, peatland soils which are water rich, spongy, and difficult to navigate unless frozen.

Fens are wetlands with the water table at or just above the ground surface. Peat is typically less than 40 cm. Fens are found only on moist saturated organic soils, and are **nutrient rich wetlands.** Permafrost missing or deeper than one meter.

Bogs are wetlands with the water table at or below the ground surface, and peat thickness greater than 40 cm. They are **nutrient poor**, and underlain by well-developed permafrost.

Polygonal peat plateau (ice wedge polygon) is caused by the formation of ice wedges, when peat expands and contracts deep inside the ground during periods of extreme cold temperature. Compression and expansion of peat in the summer causes narrow cracks to form in the peat, which causes further development of ice wedges in cold weather. Linear depressions (trenches) develop bordered by raised shoulders, some of which show up as a result of wind erosion as dark colored peat. This landscape is caused from the rapid intense cooling of the peatland surface. The active layer is less than 50 cm.

Peat plateaus without polygon formations exist, but are subject to thermokarst processes making their surface uneven.

Polygonal Pattern/ ice wedges

Ice wedges/ polygonal plateau with Pingo formation. [Pingos are very large mounds formed from growing ice lenses in the ground.]

Organic Soil Order and Great Groups (Fibrisol, Mesisol, and Humisol)

The degree of decomposition of the organic material in wetlands differs between sites and depends on the botanical origin of the wetland plant species, temperature, and the duration of water saturation and chemical composition of the water. **Fibric** material has undergone relatively little decomposition and most of the plant material can be readily identified as to its botanical origin. The other extreme is **humic** material, which is greatly decomposed and unrecognizable in origin. **Mesic** organic materials are intermediate between these two extremes.

The master horizon for the wetland Organic soils is the **O horizon**. The three decomposition stages are assigned **Of, Om, or Oh** designations depending on the degree of decomposition of the organic material. The organic horizons must achieve a minimum thickness to be classified into the Organic order. If the Organic horizons are less than these critical thicknesses, they are considered peaty phases of the Gleysolic order.

If permafrost occurs at a depth less than 1 m from the organic soil surface, the soils are classified into the Cryosolic Order.

[The upland versions of the Organic order are composed of leaf litter and other woody debris, which are termed folic materials. These organic horizons are assigned an L, F, or H designation, depending again on the degree of decomposition.]

Organic Great Groups: The placement of wetland organic soils into the three main great groups depends on depth relationships of the organic layers within the control section. For organic soils the **control section extends from the surface to a depth of 1.6 m or to a contact with mineral soil or bedrock if this occurs within 1.6 m of the surface.**

The control section for the three organic great groups for northern peatlands are: surface (0-40 cm); middle (40-120 cm); and bottom (120-160 cm). Classification at the great group level is based primarily on properties of the **middle tier (40-120 cm)**

Great groups: There are three great groups depending on the level of decomposition of the middle tier.

Fibrisol: **The middle tier is dominated by Of material. This O horizon consists largely of fibric materials that are readily identifiable as to botanical origin**. A fibric horizon (Of) has 40% or more of rubbed fiber by volume. Fiber is defined as the organic material retained on a 100-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

Mesisol: The middle tier is dominated by **Om** material. 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**. It does not meet the requirements of either a fibric or a humic horizon, has a rubbed fiber content ranging from 10% to less than 40%.

Humisol: The middle tier is dominated by **Oh** material. This O horizon consists of **humic** material, which is at an **advanced stage of decomposition**. **The horizon has the lowest amount of fiber and is very stable and changes little physically or chemically with time unless it is drained.**

Example of a Fibrisol

Example of a Mesisol

Growth of vegetation in northern peatlands is not a static process, but is impacted by climate and factors related to permafrost degradation. Overgrazing of animals, travel, and lightning induced fires can impact the surface and change the energy balance of the surface, impacting soil formation.

Peatlands become increasingly deep and varied in development with distance from the Hudson Bay coast. Horizontal and patterned fens have a sedge or sedge-brown moss vegetation with varying amounts of shrubs, with the amount of tamarack increasing to the south. Polygonal peat plateau bogs have generally moss and lichen vegetation with low shrubs. Peat plateau bogs have moss, lichen and shrub vegetation with increasing amounts of black spruce with distance from the coast, especially in the area south of Hudson Bay.

The northern Hudson Plain Lowlands is underlain by permafrost and covered by shallow to deep peat. This area is easily damaged by vehicle traffic, causing changes to surface albedo, the active layer, and compression of the underlying peat layers in summer.

FURTHER/ Key to Soil Order Cryosol

Soils that have permafrost within 1 m of the surface or within 2m if strongly cryoturbated… Cryosolic order

Example of the Cryosolic Order

Soil Order: Cryosolic soils are soils whose formation is affected by permafrost within the soil control section. (1-2 meters) This type of soil is generally referred to as Permafrost.

Permafrost is ground which remains frozen for at least two consecutive years.

Cryoturbation is the mixing of the soil layers in response to repeated freeze-thaw cycles. This can redistribute organic carbon from the surface into lower layers of the soil profile. The most common being mixing from frost heave. In areas of permafrost, freezing can occur from top and bottom of the soil layers. Cryoturbation is also known as frost churning.

Soils of the Cryosolic order occur throughout northern Canada and are the dominant soil type throughout most of the territories (northern Yukon, Northwest Territories, and Nunavut). Cryosols are also common in the regions around the Hudson Bay and Hudson Strait, particularly in northeastern Manitoba, northwestern Ontario, and the northernmost part of Quebec (the Ungava peninsula in Nunavik). These regions are characterized by long, cold winters and short, cool summers. As a consequence, the mean annual soil temperature is at or below 0°C, resulting in permafrost conditions, where the ground remains frozen for two or more consecutive years. The frequent freeze-thaw cycles associated with these cold environments contribute not only to the presence of permafrost near the soil surface but also to cryoturbation.

Figure: Example of frost churning or cryoturbation in soil

Although many of the same soil-forming processes that occur in other orders also take place in Cryosols (for example, the reduction-oxidation processes associated with Gleysols or the build-up of organic material associated with the Organic order), the near-surface permafrost contributes to a particular suite of soil properties that include, but are not limited to, horizons that have been affected by cryoturbation.

The diagnostic horizons associated with the Cryosolic order are represented by the suffixes ‘y’ (for horizons with evidence of cryoturbation) and ‘z’ (for frozen material, i.e., permafrost). These suffixes can be used alone with a major horizon (O, A, B, C) or together with another suffix to reflect a combination of soil-forming processes.