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Introduction

Periglacial environments exist in areas where the effects of **freezing** and **thawing** drastically modify the ground surface. Types of modification include the displacement of soil materials, migration of groundwater, and the formation of unique landforms. More than a **third** of the Earth's terrestrial surface can be included in this definition.

Permafrost

Permafrost is a condition where a layer of soil, sediment, or rock below the ground surface remains frozen for a period greater than a year. Permafrost is not a necessary condition for creating periglacial landforms. However, many periglacial regions are underlain by permafrost and it influences geomorphic processes acting in this region of the world.

Permafrost is found in about 25 percent of the Earth's non-glaciated land surface (**Figures 10-1** and **10-2**). It occurs wherever the mean annual ground temperature is less than 32°F. In some areas, permafrost can be up to 1500 meters deep. Common depths of permafrost are several hundred meters. Most deposits of permafrost have an upper **active layer.** This active layer is subject to a cyclic thaw during the summer season.

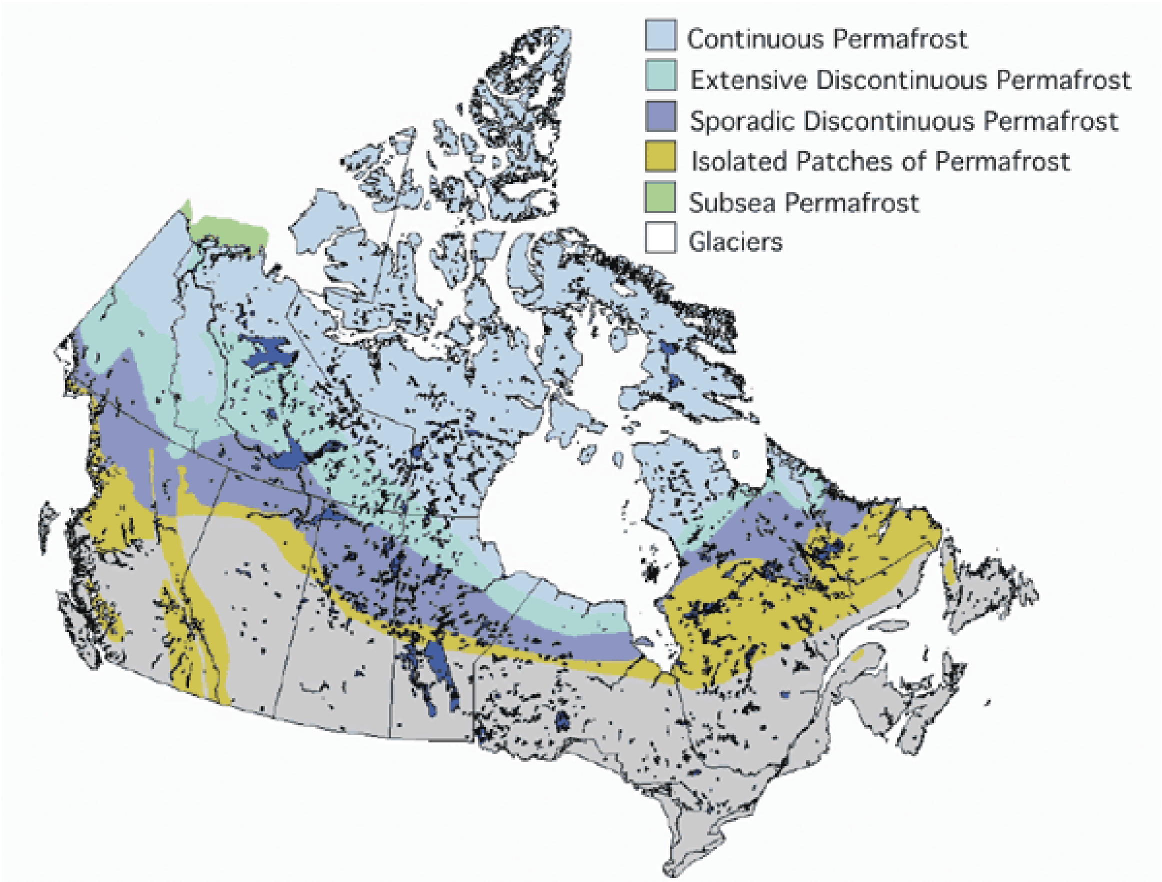


Figure 10-1: Distribution of the various types of permafrost in Canada. More than 50% of Canada is covered by some form of permafrost. This map does not identify areas of alpine permafrost (Source**:** Natural Resources Canada - Terrain Sciences Division - National Permafrost Database).

In some places, localized unfrozen layers or **taliks** are located on top, underneath, or within masses of permafrost (**Figure 10-2**). Often in continuous permafrost areas, taliks are found under lakes because of the ability of water to store and vertically transfer heat energy.

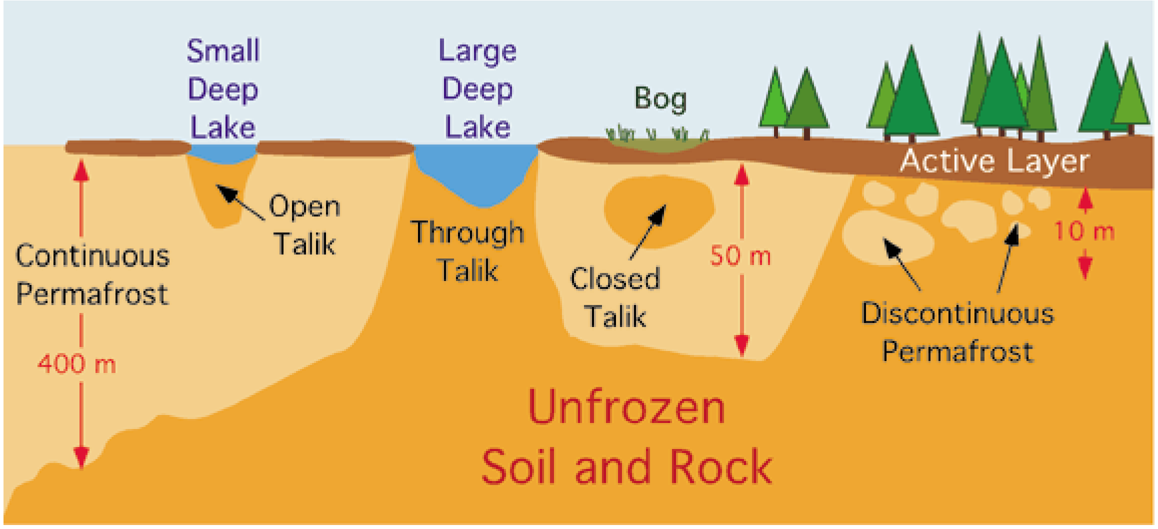


Figure 10-2: Vertical cross section of the transition zone between continuous and discontinuous permafrost and talik or unfrozen ground.

Periglacial Processes: Weathering

Locations that have a periglacial environment are characterized by the presence of large quantities of angular, fractured rock (**Figure 10-3**). The quantity of the deposits indicates that the frost weathering process operates over and over again in repeated cycles of **freeze-thaw**. In fact, repeated thawing allows further fracturing because the liquid water is able to fill newly developed cracks.

Figure 10-3: Frost-shattered granite bedrock, northern Manitoba. Extensive areas of blocks are called felsenmeer. (Source: Natural Resources Canada-Terrain Sciences Division-Canadian Landscapes).

Periglacial Processes: Ground Ice

Surface soils and sediments in periglacial environment are frequently influenced by a variety of different types of **ground ice**. Some of these masses of ground ice can be as much as 30 meters across. A common form of ground ice is **needle ice**. Needle ice consists of groups of narrow ice slivers that are up to several centimeters long. They normally form in moist soils when temperatures drop below freezing overnight. Needle ice plays an active role in loosening soil for erosion and tends to move small rocks upward to the soil surface. On sloped surfaces, needle ice can also enhance soil creep by moving soil particles at right angles to the grade. Needle ice occurs as far south as northern Alabama and Mississippi.

Ice wedges are downward narrowing masses of ice that are between 2 to 3 meters wide at the base and extend below the ground surface up to 10 meters. It is believed that they form when a seasonal crack in the ground forms in the winter. During this season, extreme cold temperatures can cause soil contraction. Soil and ice, like other solid materials, contracts as temperatures drop way below 0° Celsius. At first, the crack is several millimeters wide and about a meter deep. When temperatures warm up in the summer, liquid water from the active layer fills the crack. This water then refreezes because the fracture extends into the sub-zero permafrost. The freezing of the water results in a volumetric expansion of about 9%. This expansion then increases the width and depth of the fracture. At the same time, the soil layers adjacent to the developing ice wedge are pushed outward and upward creating a slight hill at the surface. The processes just described cause the ice wedge to increase in size with each passing year. Each winter new cracks form in the ice wedge because of contraction. In the summer, more liquid water seeps in to the cracks to become frozen and the summer warming results in the surface mound getting bigger (**Figure 10-4**).

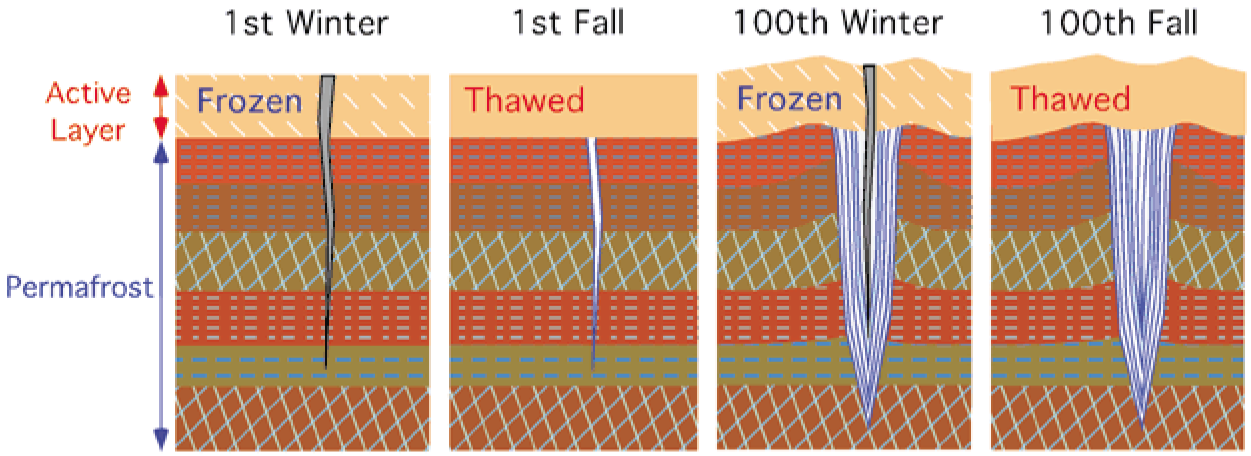
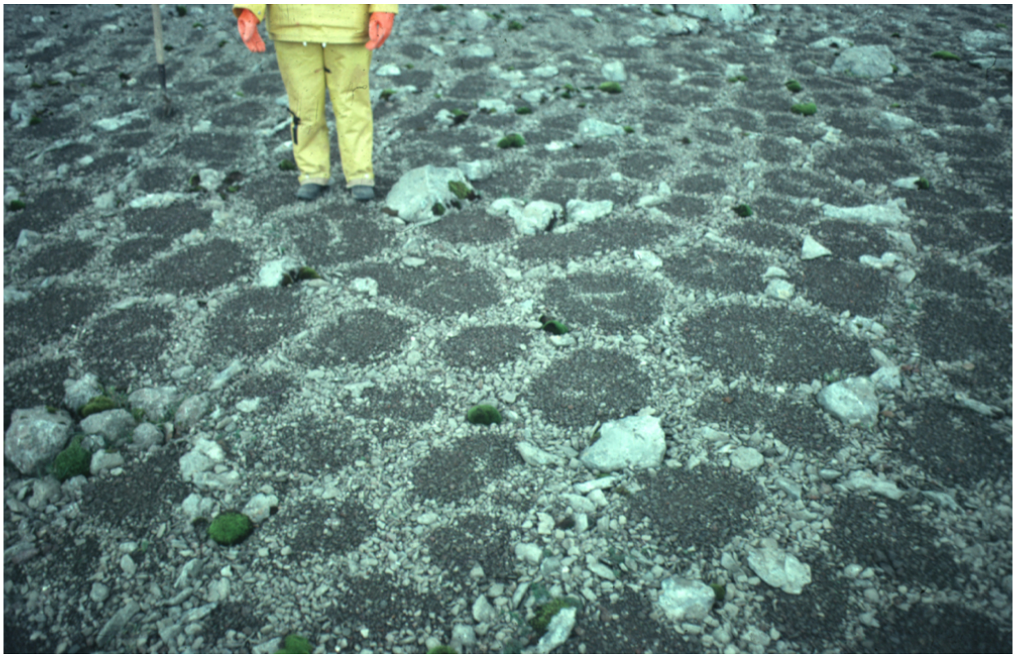


Figure 10-4: The following series of graphics showing the evolution of ice wedges. The cycle just described repeats itself year after year with new cracks forming in the developing ice wedge. The two graphics on the right show a well developed ice wedge after many cycles of development.

Periglacial Landforms

The surface of periglacial areas is often characterized by the presence of ground materials arranged in a variety of symmetrical, geometric shapes (**Figures 10-6** and **10-7**). These features are collectively known as **patterned ground**. Shapes of patterned ground can include stripes, steps, circles, polygons, and nets. Sometimes one pattern can morph into another shape. Researchers have discovered that a single process cannot explain the various forms observed. Many of these features appear to be caused by freeze-thaw action selectively moving coarse particles to the edge of the shape or to its surface.

Figure 10-6: Stone circles on Melville Island, Northwest Territories, Canada. Countless freeze-thaw cycles sorted the surface debris, continually heaving the finer matter to the surface, and leaving the coarser fragments around the edges. (Source**:** Natural Resources Canada - Terrain Sciences Division - Canadian Landscapes).



Palsas are low permafrost mounds with cores of layered segregated ice and peat (**Figure 10-8**). They are normally 1 to 7 meters high, 10 to 30 meters wide, and 15 to 150 meters long. Palsas are believed to form when areas of reduced snow cover allow frost to penetrate more deeply into an unfrozen peat bog. This frost freezes the water in the peat forming an initial ice layer.

Figure 10-8: Emerging palsa in a bog near Churchill, Manitoba. This palsa is in the initial stages of development and is growing by absorbing some of the water in the surrounding wetland. As ice builds up inside this feature, the water-loving vegetation growing on the peat is pushed up above the water table. This action causes the vegetation to die off, resulting in the bare brown peat surface on top of the mound. (Source: Natural Resources Canada-Terrain Sciences Division-Canadian Landscapes).

Pingos are ice-cored hills with a height between 3 to 70 meters and a diameter between 30 to 1000 meters (**Figure 10-9**). Most pingos are circular in shape. Large ones usually have exposed ice at their top and the melting of this ice often forms a crater.

Figure 10-9: Pingos on Prince Patrick Island, Northwest Territories, Canada. These features are up to 100 meters across. Eventually the ice core will grow to such a size that it will rupture the sediment cover and become exposed. (Source: Natural Resources Canada - Terrain Sciences Division - Canadian Landscapes).

Some pingos are still actively growing. The maximum rates of vertical growth of young pingos can be as high as 1.5 meters per year. The dating of pingos has reveled that these features are generally less than 10,000 years old. Many small ones in the Arctic have ages that are less than a few hundred years old.