TUNDRA
Topography and Soil

MYTH: Tundra, especially of high latitudes, is flat and featureless.

FACT: Anyone who attempts to walk across tundra soon finds that flatness is an illusion. The land surface is gouged by ravines, gullies, troughs, and sinks and pockmarked by rises, hillocks, and mounds.

Section 2
TUNDRA INSIGHTS

Pingos, **thermokarsts**, **ice wedges**, **frost boils**, and **high and low center polygons** are all landscape features created by **permafrost;** they can grow or change over a span of years instead of over the centuries or a millennium required in other environments (*see following pages*).

In **high-latitude tundra**, permafrost – perennially frozen ground – lies a few inches to a few feet below the soil surface and can extend to depths of 2240 feet (683 meters).

In **alpine tundra**, where permafrost is absent or patchy, the shallow bedrock or layers of rock near the soil's surface block water drainage and create some of the same landscape features that permafrost does.

TUNDRA WETLANDS

Although precipitation in arctic tundra is similar to that of deserts (5 inches –12.7 centimeters – or less), the water has nowhere to go once it hits the permafrost. The soil above the permafrost or bedrock, called the **active layer**, becomes saturated like a wet sponge. The results are (1) **wetlands** typical of much wetter environments and (2) freeze-thaw landforms of tundra topography.

The tundra contains ponds, lakes, bogs, marshes, and river and stream corridor wetlands. (*For curriculum materials on Alaska's wetlands, see the* U.S. Fish & Wildlife *Service's* Wetlands and Wildlife.)

Mosaic of Wet and Moist Sites

Tundra is a mosaic of many landforms and plant communities. Elevation, which affects the degree of wetness of an area, is an important factor in determining where various plants can grow. Mere inches of elevation can separate different plant communities.

The wettest tundra areas typically have shallow, standing water throughout the summer. Sedges such as cottongrass thrive there. In somewhat drier patches (gravel bars, river banks, hummocks, and ridges of polygons), where surface water drains by late summer, grasses and dwarf willows can become established. The tiny flowers of mountain avens (D*ryas* species), saxifrages, and taller arctic poppies grow there.

Where conditions are dry enough for tussock-forming plants to grow, these plants create their own mini-uplands. Although initially only several inches higher than the surrounding wet tundra, the tussocks provide roothold for dwarf and shrub birches, Labrador tea, lichens, and berry-producing plants such as lingonberrry, cloudberry, and bearberry.

Migratory Bird Mecca

Some tundra wetland areas are extremely productive during the brief arctic summer. Millions of migratory shorebirds, waterfowl, and other birds are attracted to the rich food sources of tundra wetlands for nesting and raising their young. Deep and shallow tundra ponds, lakes, streams, and coastal wetlands are most heavily used (see INSIGHTS S*ection* 3 on migration as a tundra adaptation).

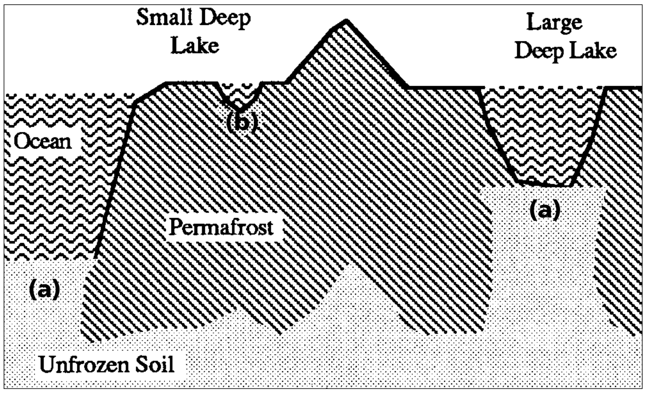
Fish Habitat and Predators

Fish and invertebrates move into flooded wetlands near stream courses, where they grow and reproduce. Sticklebacks swarm in wetland complexes, where they are preyed upon by loons and other fish-eating birds.

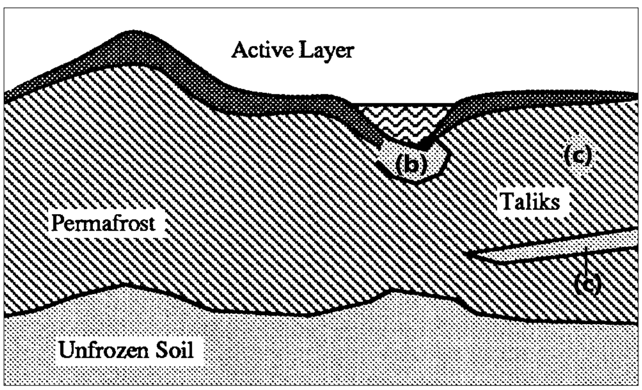
Caribou Calving and Wildlife of All Sizes

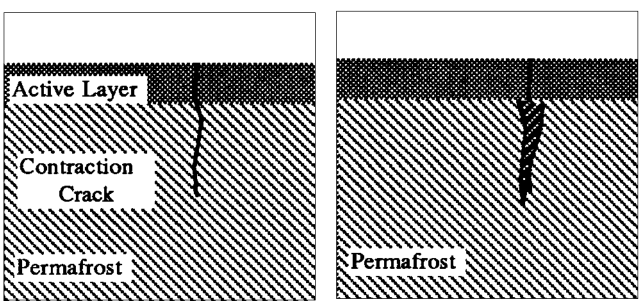
Caribou calve and find summer foods that will allow them to survive the long, lean winter. They seek insect relief on the snowfields that last late into summer. Lemmings graze green growth and stockpile "haystacks" for winter eating under the snow. Brown bears, arctic foxes, jaegers, and snowy owls roam the tundra searching for meals of small mammals or bird eggs and nestlings.

TUNDRA FACTS – PERMAFROST

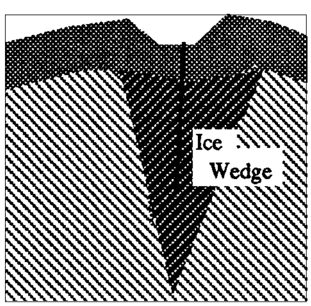


The occurrence and depth of permafrost is affected by the presence of deep lakes, hills, and the ocean. (a) Permafrost is absent beneath large, deep lakes and most ocean areas. (b) Small, deep lakes are underlain by a bulb of unfrozen soil.





Ice wedges are formed when water drains into a contraction crack in the soil, followed by winter freezing and expansion. The ice wedge grows larger each year, forcing surrounding soil out and upward.



Permafrost

Permafrost is perennially frozen ground or ground in which a temperature less than 32°F (0°C) has existed continuously for two or more years. Permafrost may contain chunks of ice or have little or no ice. The upper surface of permafrost is called the permafrost table. Almost no water can penetrate this table, thus it acts as a barrier to water movement (percolation) through the ground.

Continuous permafrost underlies the tundra of arctic and northwestern Alaska. In these regions, the ground is frozen everywhere except under those lakes and rivers that do not freeze solid in winter. Permafrost can extend to 2240 feet (683 meters) below the soil surface. Below this, heat from the earth's core keeps the ground thawed.

Discontinuous permafrost underlies the tundra and forests of interior and southwestern Alaska. In these regions, the ground is perennially frozen in some places, but is free of permafrost in others. Permafrost may not be present beneath south-facing slopes, at sites where vegetation has been disturbed, and under lakes and rivers.

Active Layer

The **active layer** is the surface layer of soil that thaws and refreezes every year. It usually is underlain by permafrost soil. The depth of the active layer varies from about 12 inches (30 centimeters) to 10 feet (3 meters) depending upon the local climate. Near Barrow, the active layer is about 12 inches (30 centimeters) deep.

Talik

Layers and pockets of unfrozen soil that occur within permafrost soil are called **taliks** – *(c) on the adjacent diagram*.

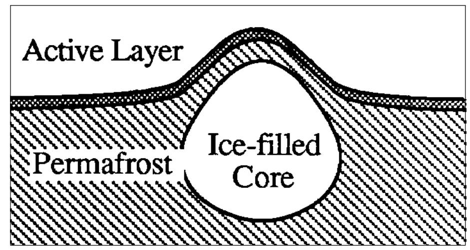
Ice Wedges

Soil contracts or shrinks during periods of intense winter cold. As the soil contracts, cracks form. Often, the cracking makes a loud sound. The winter that it first forms, a contraction crack is small – only 3/8 inch (9-10 millimeters) wide.

During spring snowmelt and summer rains, water flows into the crack and is trapped and frozen by surrounding permafrost. Freezing water expands and forces the surrounding soil upward and outward.

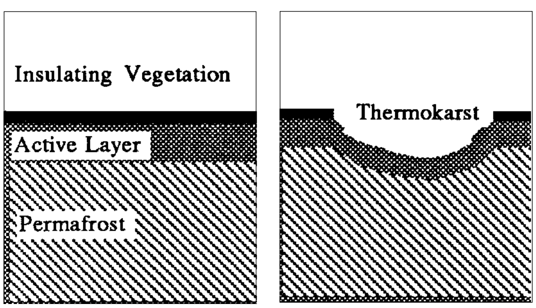
Over many years, the crack gradually enlarges through the freezing and expansion of trapped water and repeated winter cracking. Ice wedges grow to be as much as 33 feet (10 meters) across, and may extend 33 feet (10 meters) below the surface. Some large ice wedges may have taken 1000 years to form. Together, the cracks usually form a polygon (a many-sided geometric shape).

TUNDRA FACTS – PERMAFROST



Thermokarst Dynamics

Water expands as it freezes. Thus, when permafrost melts, the melted water in the soil takes up much less room than it did when frozen. The land slumps into the void, creating a surface depression or **thermokarst**. These thermokarsts may be pits, funnel-shaped sinkholes, valleys, ravines, or, in early stages of melting, caves. Permafrost melts when vegetation is removed (by fire or human activities), the area floods, or the climate warms (*see following article*: "Ups and Downs of Life on Frozen Ground").



Thermokarst develops when insulating vegetation is removed.

Pingos

The word "*pingo*" comes from an Inupiaq name for a cone-shaped hill or mound of soil with a core of ice. An average **pingo** is about 100 feet (30 meters) high and 1650 feet (50 meters) in diameter. Pingos occur in areas of both continuous and discontinuous permafrost.

Closed-system pingos are the most common type in tundra areas. They form after drainage or after sedimentation fills in a tundra lake.

The wet soil underlying a deep tundra lake remains unfrozen year-round because the overlying water retains heat and insulates the soil during winter. When a lake is drained, however, or when it fills partially with sediments so that the water is no longer deep, the surface layer of soil on the lake bottom slowly freezes.

This newly frozen surface and the surrounding permafrost trap water in the underlying, but still unfrozen, soil. As permafrost slowly advances around the trapped, unfrozen core, the water in the soil is forced inward by pressure through soil pores.

When the trapped water itself freezes, it expands in the only direction possible – upward. This creates a hill or mound. The size of the pingo depends on the amount of trapped water. Pingos form and grow by as much as 5 feet (1.5 meters) per year, and continue to grow slowly (1 to 1½ feet [0.3-0.5 meters] per year) for thousands of years.

If vegetation on top of a pingo is disturbed or if pressure from the expanding ice cracks the surface soil, the ice core is exposed to air and warm summer temperatures. When the exposed ice melts, the top of the pingo collapses, creating a crater. The crater may or may not contain a lake.

Polygons

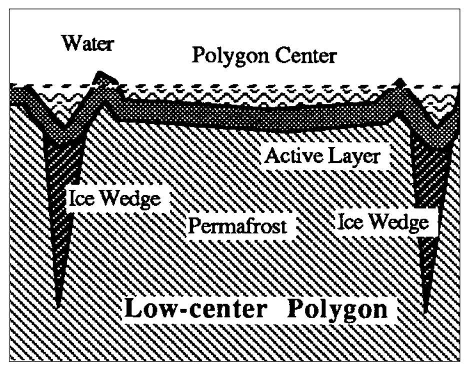
Polygons are a common topographic feature in areas with permafrost and seasonal frost. They are formed by contraction cracks enlarged by ice wedges.

The pressure created by an ice wedge forces the soil around the crack upward to form two small ridges as much as $1\frac{1}{2}$ feet (0.5 meters) tall. This creates a polygonal shape of raised edges, or a low-center polygon.

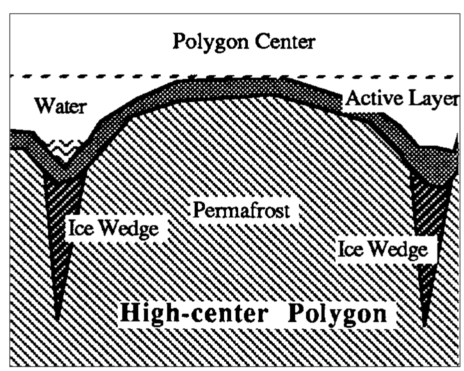
In poorly drained sites, water fills the center of the polygon and the center of the ice-wedge troughs. Collected water efficiently conducts heat from sunlight so it melts underlying permafrost, which causes additional slumping.

As the water-filled troughs and centers enlarge and deepen, they eventually meet to form a small lake. When the lake is drained, or filled in with organic material, a new low-center polygon forms. Over a period of hundreds of years, poorly drained sites gradually cycle between flooded low-center polygons and small lakes.

In well-drained soil, the troughs around a low-center polygon enlarge and sink, while the center remains in place. It appears that the center of the polygon has raised, when actually, the troughs have sunk. The center may be 5 feet (1.5 meters) above the bottom of the troughs. As the thermokarst slumping caused by the growing troughs continues, the mound may eventually collapse, too.



Original Soil Level



Original Soil Level

Solifluction or Geliflution

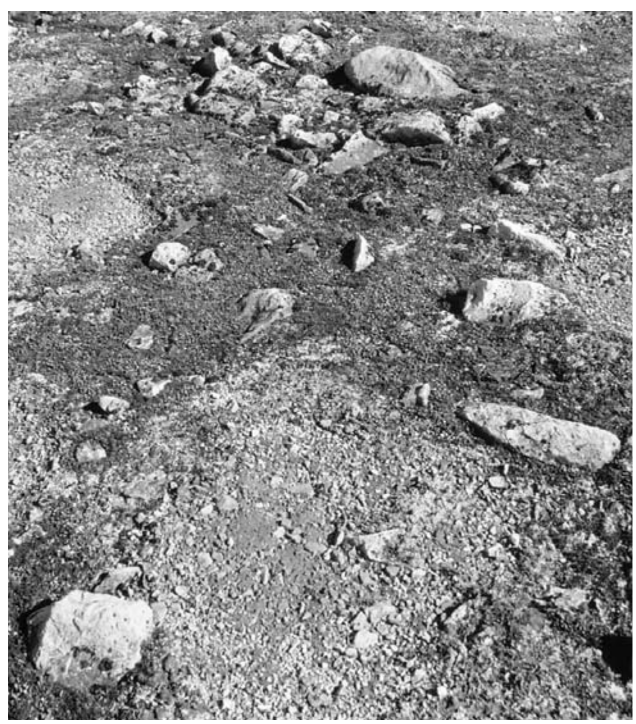
Little water can seep into permafrost soil. Thus, water from rain, melting snow, or melting ice in the surface soil is trapped in the active layer of soil.

On sloping land, the weight of the water-saturated soil causes the active layer to slide, or slump, downhill when thawed in summer. The rate of movement depends on the slope and amount of vegetative cover. Movement can vary from a fraction of an inch per year to an avalanche rush.

Sorted Rock Piles and Frost Boils

In soils containing rocks, the forces created by seasonal freezing and thawing move – and sometimes sort – soil particles. Although the exact processes that cause this are still debated, scientists agree that different rates of freezing and the forces of expansion, contraction, and gravity are involved.

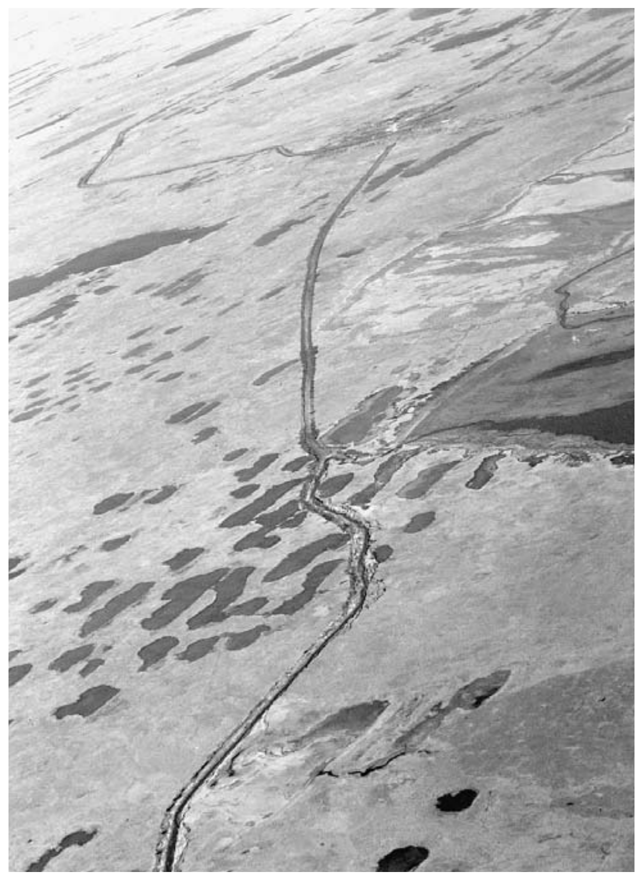
Similarly to the creation of pingos, frost action first pushes noncompressible objects – large particles or stones – to the soil surface. When these formations occur in soil with water-filled, fine-grained soil, the expansion and contraction of this soil tends to move surface stones laterally across the ground. The movements create sorted nets, circles, and polygons rimmed by large- and medium-sized stones with centers of fine silt or clay material.



Thermokarst Slumping in Vehicle Tracks

A tracked vehicle left a swath of newly disturbed vegetation and compacted soil as it crossed the tundra (*photograph at left*) at Storkersen Point, northwest of Prudhoe Bay in 1971.

Five years later, this photograph was taken at the same location at Storkersen Point. The tundra disturbed by the tracked vehicle formed thermokarst depressions. Water from surrounding areas now accumulates in the ruts. Note that few plants have colonized the tracks after five years.



This 1971 aerial photograph shows a summer view of a winter road across the tundra near Oliktok Point. Thermokarst formation in the winter road has affected the surrounding tundra by causing drainage of large and small lakes.