Permafrost in the Yukon Territory
by C. Burn

INTRODUCTION

Permafrost is "ground (soil or rock) that remains at or below 0°C for two or more years" (ACGR 1988); permafrost terrain comprises a seasonally-thawed active layer, underlain by perennially-frozen ground. Permafrost occurs in all of Yukon, but its thickness, and the proportion of ground it underlies, increases northwards (Fig. 1). All terrain, except rivers and lakes, is underlain by perennially-frozen ground in north Yukon, but the scattered permafrost of southern Yukon is found under less than 25% of the ground surface.

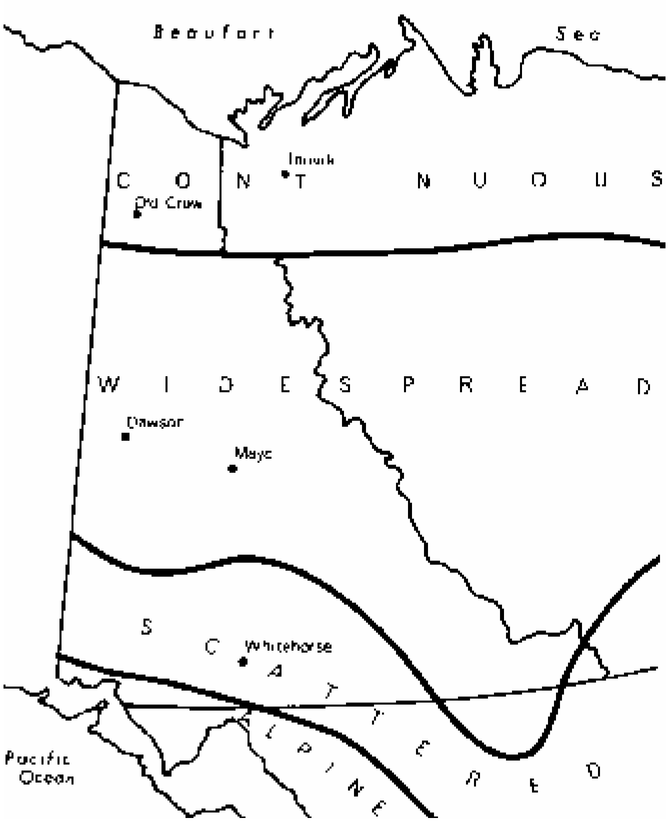

Figure 1. *Permafrost distribution in the Yukon Territory (after Brown, 1978).*

Thickness

Permafrost may be well over 300 m thick in the more westerly, unglaciated portions of the Yukon Coastal Plain (Rampton 1982), but it thins rapidly to the south, and is usually absent beneath glacial ice and lakes. At Old Crow it is only 63 m thick (EBA 1982). In areas underlain by coarse glacial deposits, convective heat from groundwater circulation may also locally raise the base of permafrost. Thicknesses between 20 and 60 m have been reported from valley-bottom sites in the Klondike Plateau near Dawson, and between 25 and 40 m near Mayo (Burn 1991). Drilling in the Takhini valley near Whitehorse, has revealed 16 m of frozen sediments, while municipal excavations near Teslin encountered 2 m.

Very thin permafrost may degrade or be established in years or decades, while the time scale for thicknesses of over 15 m is on the order of centuries (Burn 1993a). Permafrost in Yukon Coastal Plain has formed over millennia. The permafrost zones are therefore temporal, as well as spatial units.

Distribution

Mean annual near-surface ground temperatures below 0°C lead to permafrost growth. At macroscale, these are a function of air temperature, modified by the insulation of snow. In Yukon, physiographic factors are responsible for the presence of permafrost, particularly blocking of maritime air by St. Elias Mountains, and topographic enhancement of winter inversions within the dissected Yukon Plateaus (Harris 1983; Burn 1994). Permafrost in uplands of central and southern Yukon is a result of short, cool summers, for in winter, the ground is protected by a thick snow cover. In valleys, summer is commonly hot, but the winter cold may be extreme (Burn 1993b). Within the boreal forest, interception of snow by the canopy and reduced wind speeds mean that there is little snow drifting, and a uniform snowpack, but above or north of treeline, snow effects may be considerable, even leading to absence of permafrost (e.g. Smith 1975).

Within discontinuous permafrost, the specific location of frozen ground depends mainly on the thickness of the organic horizon, whose low thermal diffusivity restricts penetration of the summer temperature wave (Harris 1987; Riseborough and Burn 1988), and on the moisture content of the active layer which maintains evapotranspiration to reduce ground surface temperatures (Brown and Williams 1972).

The combinations of factors at various scales that lead to permafrost imply that its response to climate change is complex (Smith and Riseborough 1983). Changes in surface conditions, such as wrought by forest fire, often alter the ground thermal regime more rapidly than fluctuations in climate, and are currently causing permafrost degradation in Takhini valley (Burn 1993a; Rouse 1976). However, climate changes over decades, particularly if they involve changes in snow accumulation, may also warm permafrost (Burn 1992; Burn and Smith 1990).

Ground Ice

The practical significance of permafrost largely derives from the growth and decay of ground ice. There is commonly an ice-rich zone at the base of the active layer, which forms by ice segregation during downward migration of water into permafrost at the end of summer (Mackay 1983; Burn 1988; Burn and Michel 1988; Harris et al. 1992). Water may be injected into near-surface permafrost in autumn (Pollard and French 1984), and the growth of ice wedges by snowmelt infiltrating winter thermal contraction cracks, also contributes to high ice contents in the uppermost 10 m of the ground (Pollard and French 1980). Ice-wedge polygons are most easily seen in lowlands of northern Yukon, but individual wedges have been reported further south (Burn 1990; Yukon Territorial Government, Transportation Engineering Branch 1993).

Accumulation of ground ice leads to heaving of the ground surface. Thick, laterally extensive bodies of massive, near-surface ice, probably formed by ice segregation during permafrost growth, are found in Yukon Coastal Plain (Harry et al. 1988; Pollard and Dallimore 1988) and also in the Klondike District (French and Pollard 1986). Glaciolacustrine sediments in central and southern Yukon commonly contain beds of segregated ice (Burn et al. 1986), which may comprise over 80% ice by volume in the upper 10 m of the ground. Over 400 open-system pingos have been identified in central Yukon, mostly in unglaciated valleys, where coarse materials do not impede groundwater movement downslope (Hughes 1969). Numerous palsas, peat mounds with a core of segregated ice, have been identified in wet lands (Kershaw and Gill 1979; Harris 1993). Buried glacier ice is abundant near the termini of glaciers throughout southern Yukon, and rock glaciers are also widespread in the alpine zone (Johnson 1978).

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