INTERNATIONAL PERMAFROST ASSOCIATION

MULTI-LANGUAGE GLOSSARY of PERMAFROST and RELATED GROUND-ICE TERMS

in

Chinese, English, French, German, Icelandic, Italian

Norwegian, Polish, Romanian, Russian, Spanish, and Swedish

ILLUSTRATIONS

Use BOOKMARKS to find individual Figures

Compiled and Edited by:

Robert O. van Everdingen
The Arctic Institute of North America
The University of Calgary
Calgary, Alberta, CANADA T2N 1N4

1998
(revised 2005)

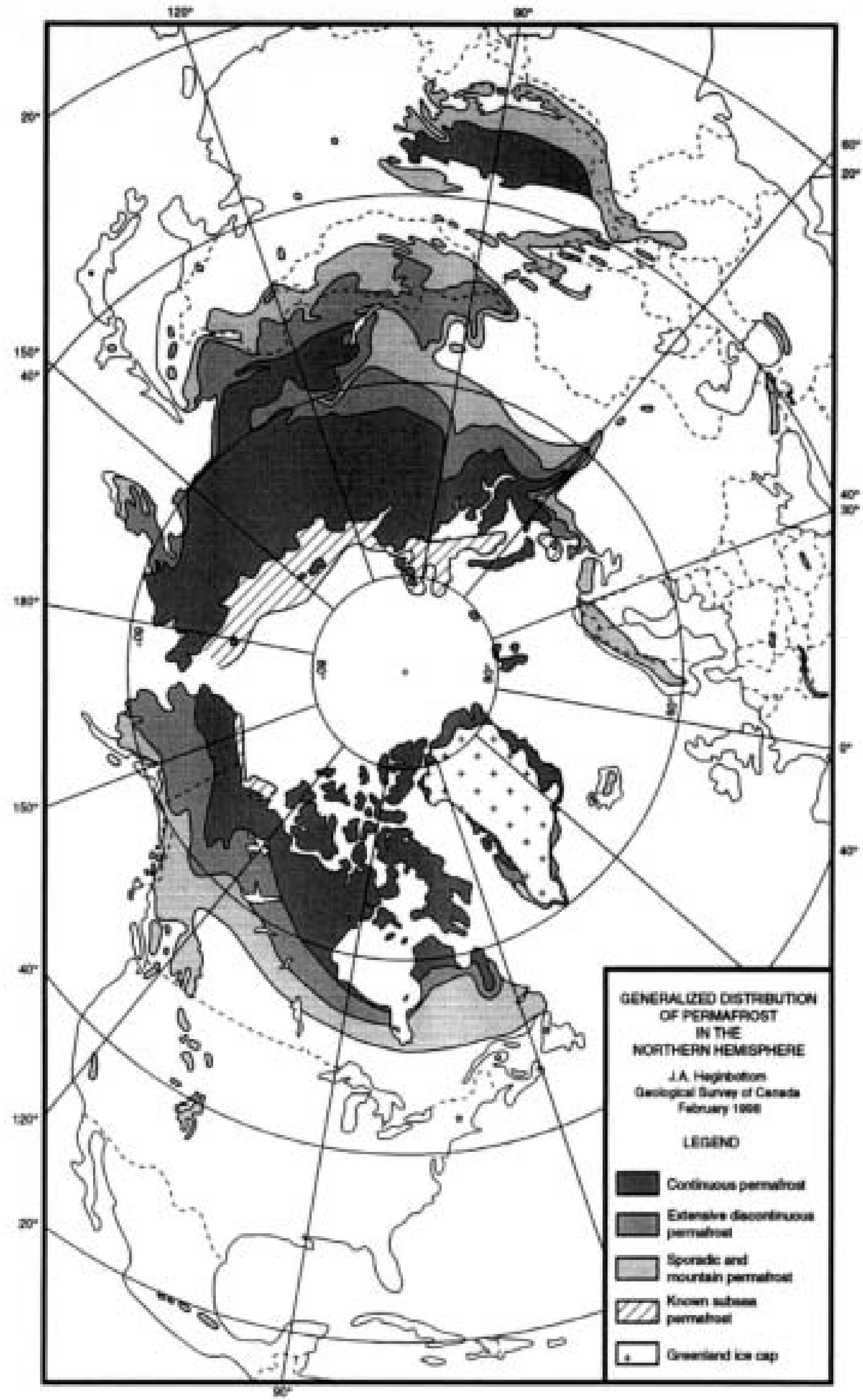

Figure 1. General distribution of permafrost in the Northern Hemisphere (by J. A. Heginbottom, February 1998).

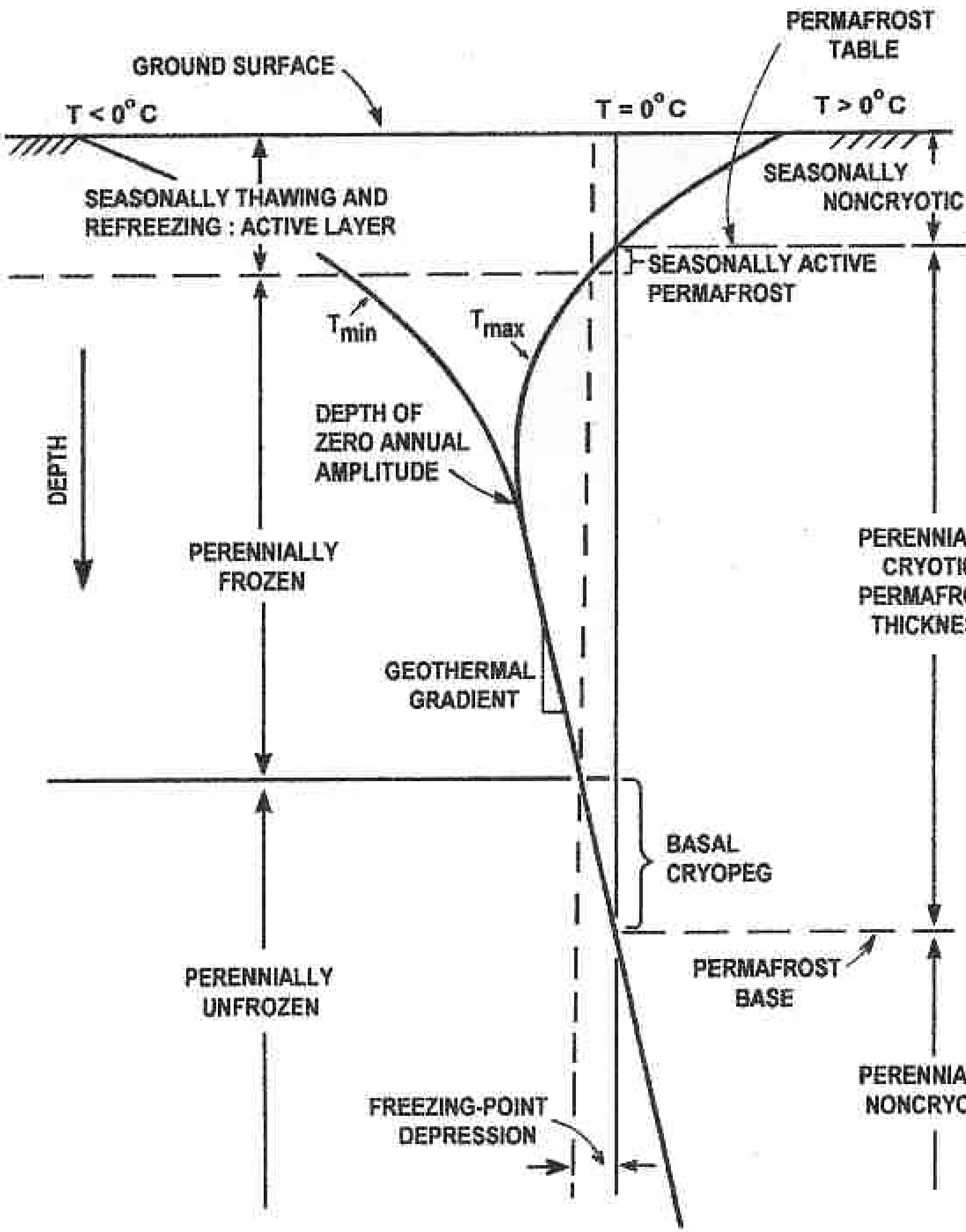

Figure 2. Terms used to describe the ground temperature relative to 0°C, and the state of the water versus depth, in a permafrost environment (modified from van Everdingen, 1985}

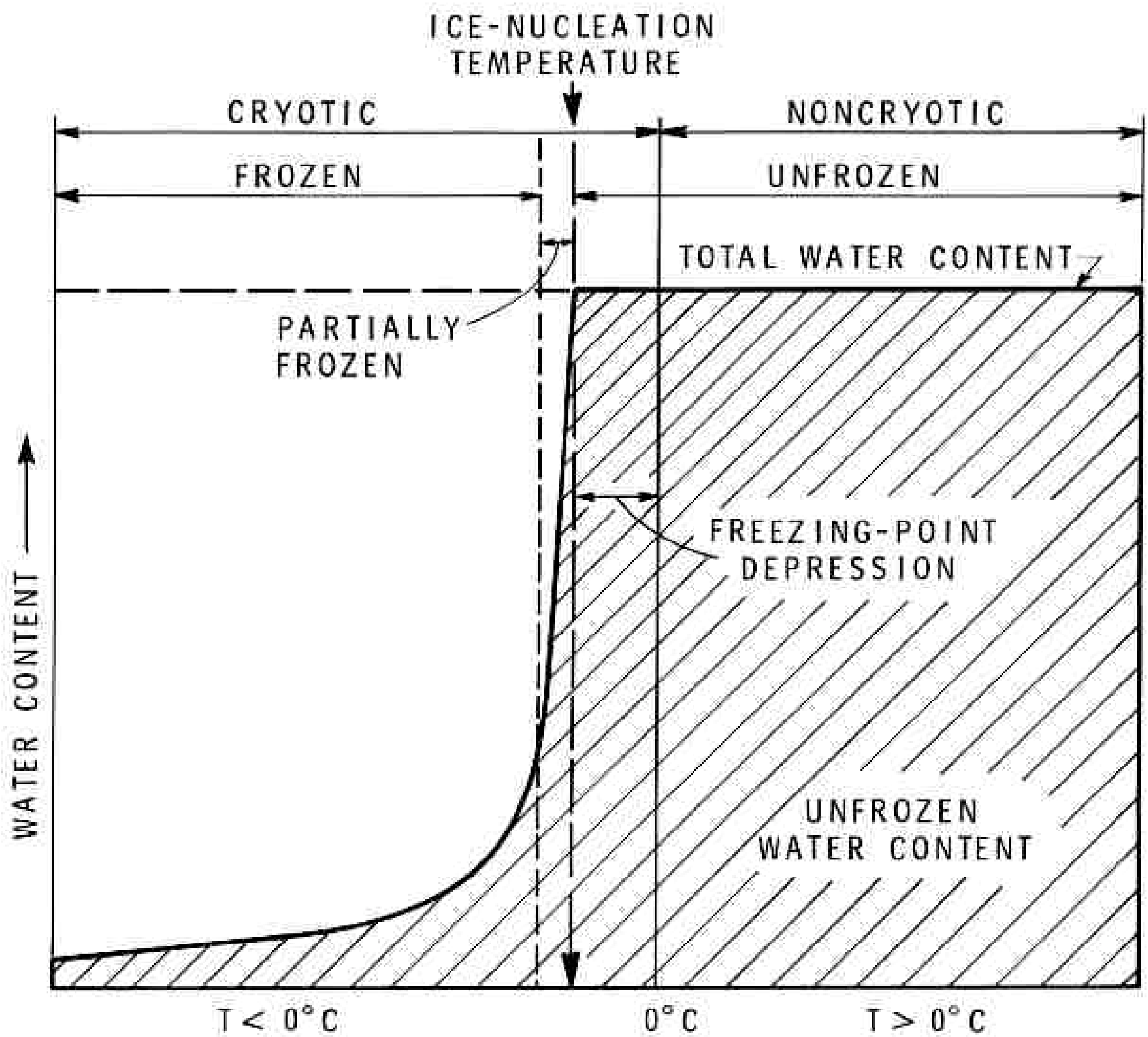

Figure 3. Terms used to describe the state of the water relative to ground temperature in soil materials subjected to freezing temperatures (modified from van Everdingen, 1985)

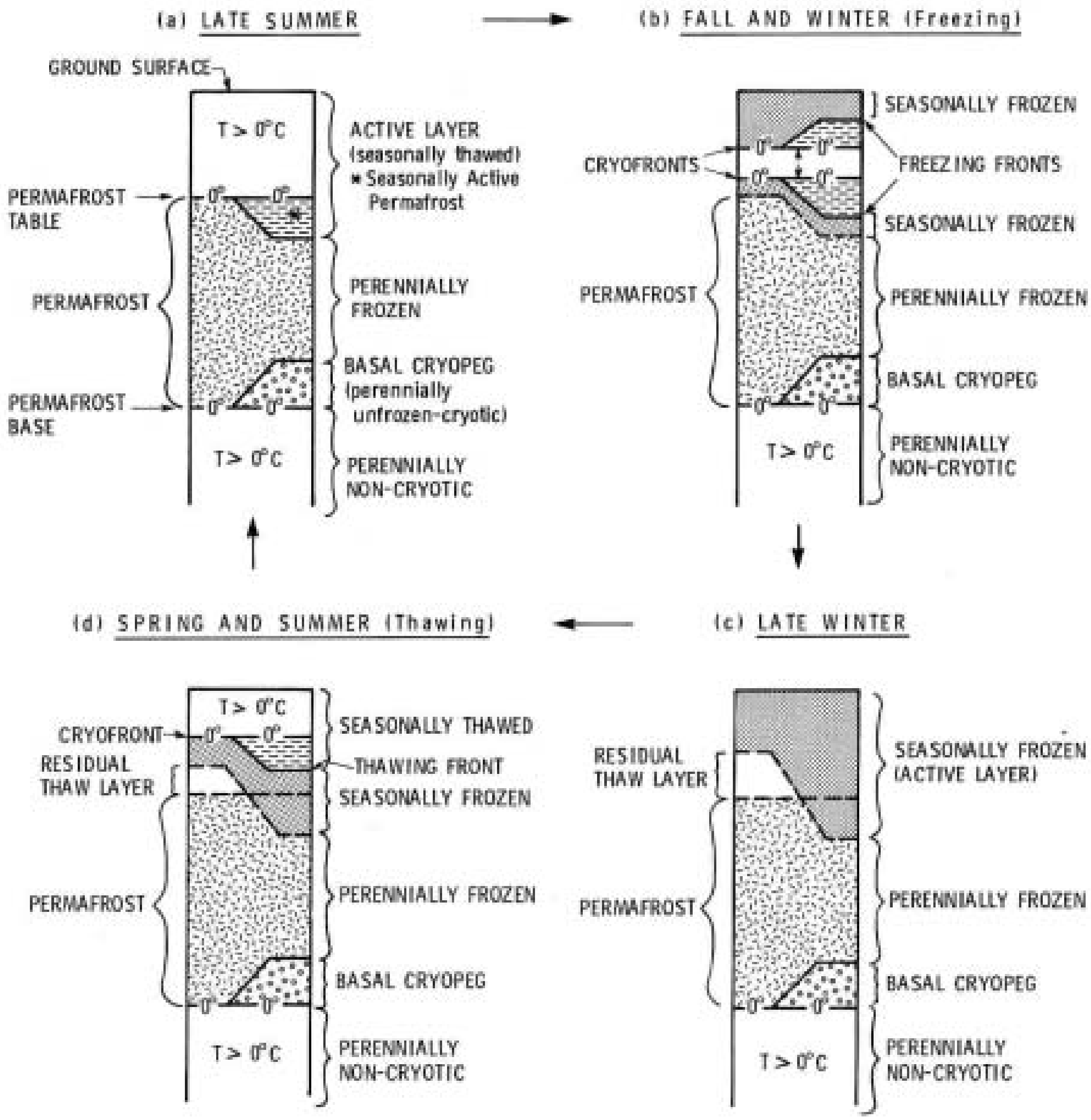

Figure 4. Terms used to describe seasonal changes in the ground temperature relative to 0°C, and in the state of the water versus depth, in a permafrost environment (modified from van Everdingen, 1985)

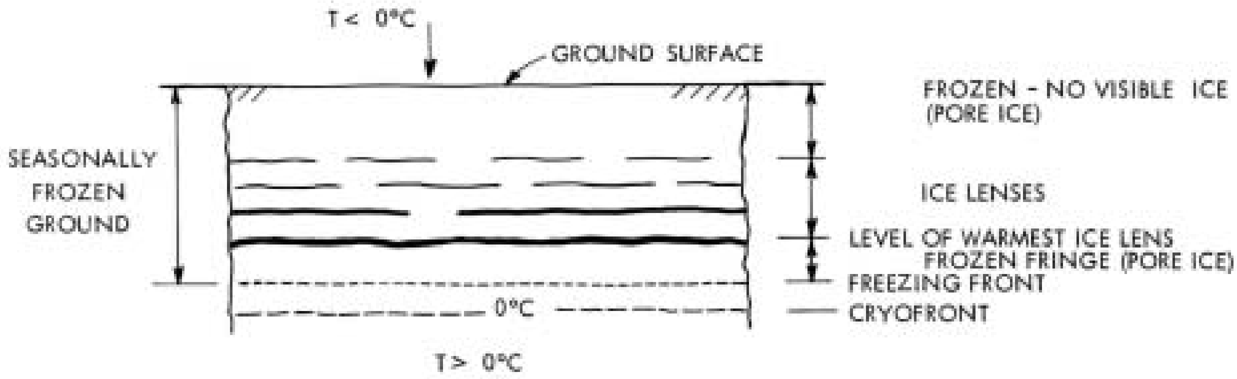

Figure 5. Diagram showing the relative positions of the *frozen fringe*, the *freezing front* and the *cryofront* during freezing of a fine-grained, *frost-susceptible soil*

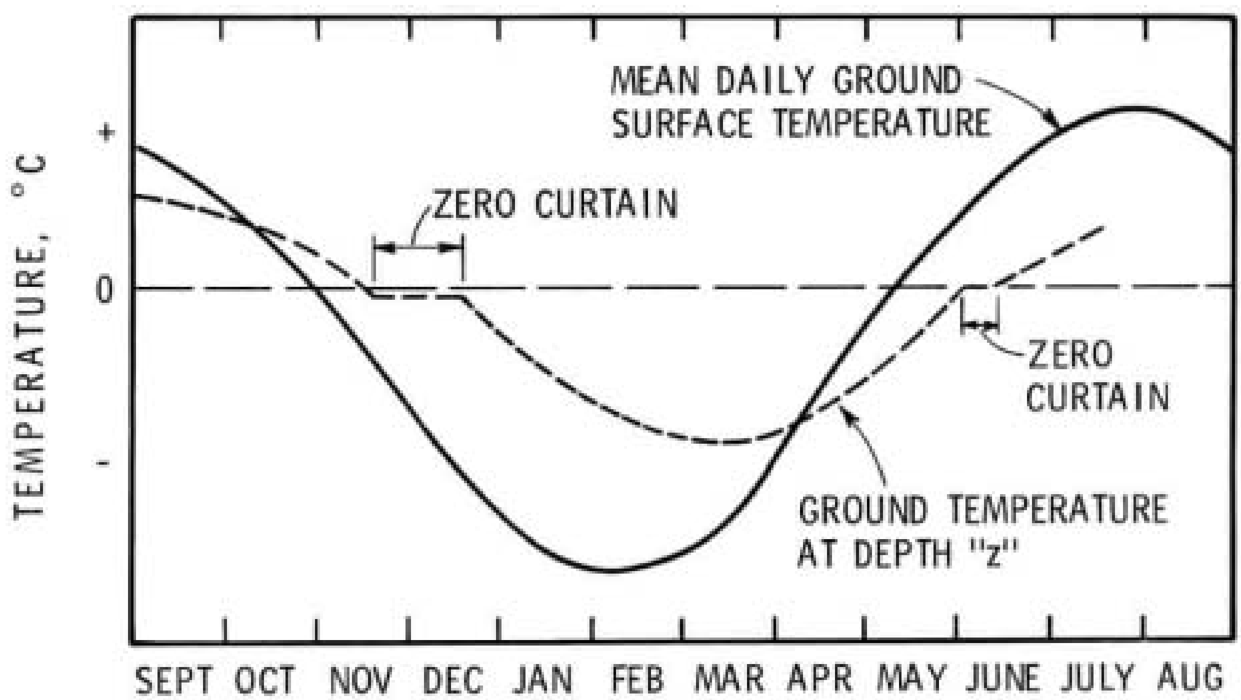

Figure 6. Diagram illustrating the zero curtain

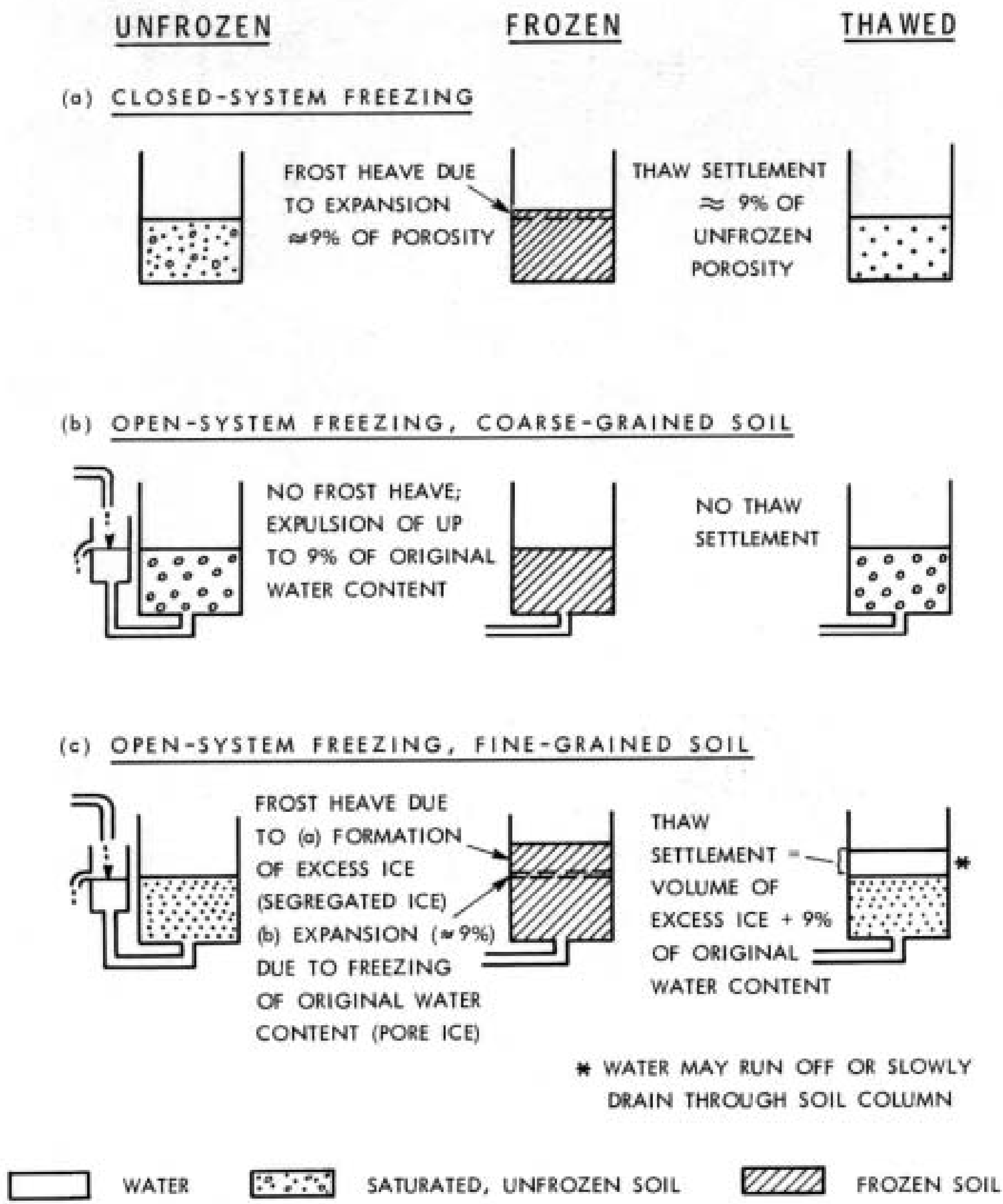

Figure 7. Diagrams illustrating frost heave and thaw settlement resulting from closed- and open-system freezing of soil materials and the formation of excess ice

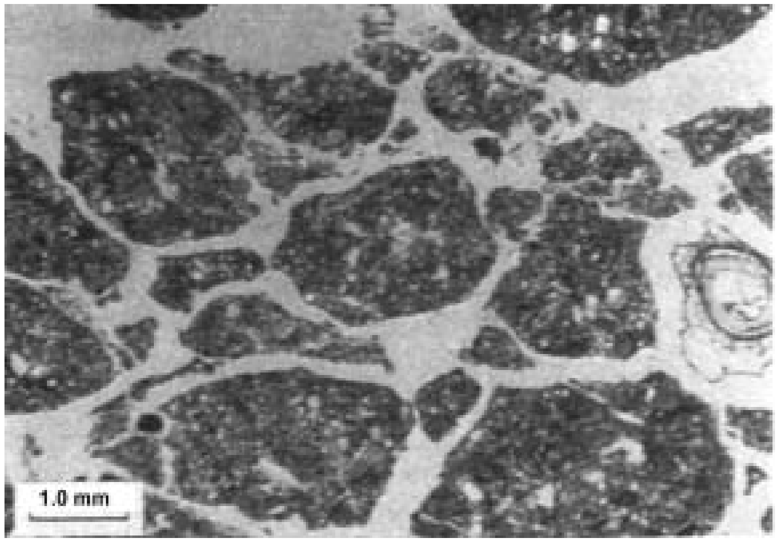

Figure 8a

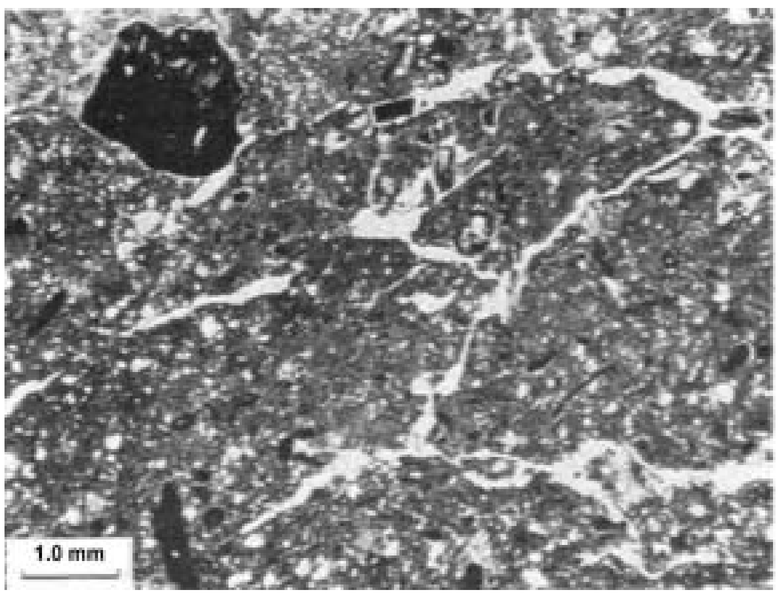

Figure 8b

Figure 8. *Cryogenic fabrics*, as seen in thin sections (Photos by C.A. Fox, Agriculture Canada, except for (c) by C. Tarnocai, Agriculture Canada).

(a) Discrete, rounded to subangular, units of soil material, granic fabric, at the 0 to 30 cm depth of a Brunisolic Turbic Cryosol developed in an *earth hummock* formed on an undulating morainal till deposit in the Mackenzie Plain, N.W.T. Plane-polarized light, vertical section.

(b) Planar voids resulting from the coalescence of discrete units at their contact points (fragmoidic fabric). Observed within permafrost at a depth of 25 to 38 cm in an Orthic Turbic Cryosol developed in an *earth hummock* formed on a rolling morainal till in the Mackenzie Plain near Carcajou River, N.W.T. Plane polarized light, vertical section.

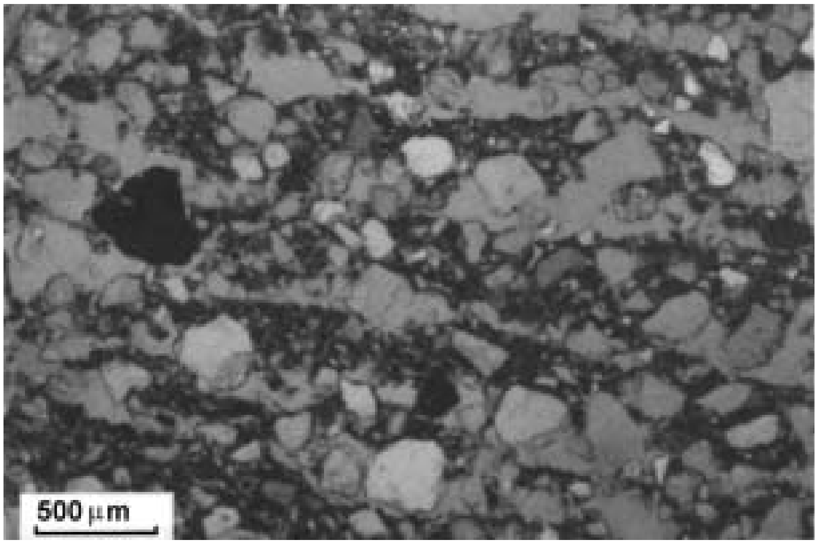

Figure 8c

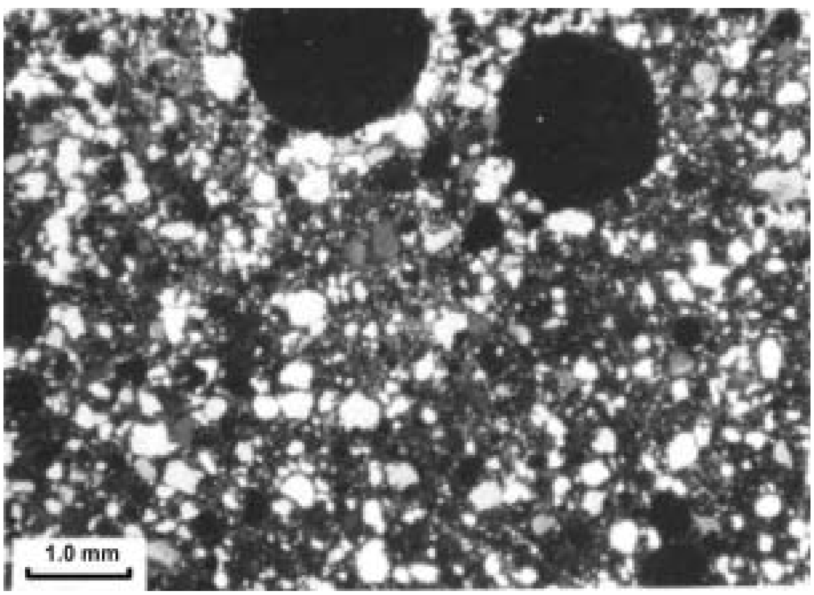

Figure 8d

Figure 8 (continued).

(c) Banded fabric showing a gradation of fine-to-coarse particle sizes within each layer. Observed within the *active layer* at approximately 30 cm in an Orthic Turbic Cryosol. This soil was developed in a small *polygon* formed on rolling terrain near Goodsir Inlet, Bathurst Island, N.W.T. Partially crossed nicols, vertical section.

(d) Coarse-sized particles form a circular to ellipsoidal pattern referred to as orbiculic fabric. The large circular black regions are pore space (vesicular pores). Observed at a depth of 0 to 20 cm in an Orthic Turbic Cryosol developed in a non-sorted circle on an unglaciated colluvial deposit of the Carcajou Range (Mackenzie Mountains) N.W.T. Crossed nicols, vertical section.

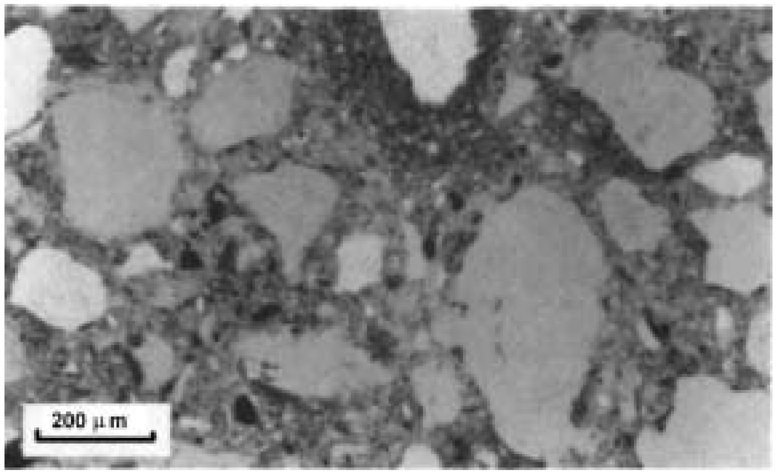

Figure 8e

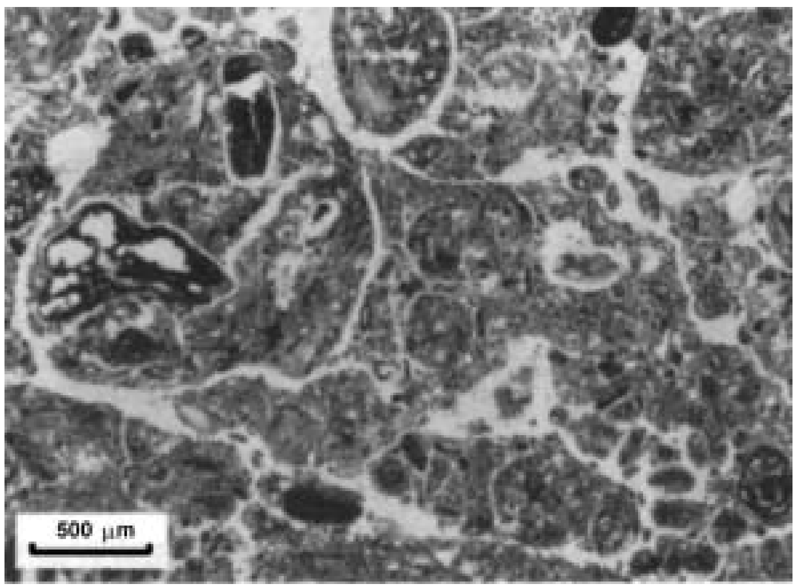

Figure 8f

Figure 8 (continued).

(e) Coarse-sized particles showing a tendency to be vertically or nearly vertically aligned (suscitic fabric). Some of the particles are also associated with surface accumulations of finer material. Observed at a depth of 0 to 20 cm in an Orthic Turbic Cryosol in a non-sorted circle on an unglaciated colluvial deposit of the Carcajou Range (Mackenzie Mountains) N.W.T. Partially crossed nicols, vertical section.

(f) Cryogenic processes have formed a complex morphology (conglomeric fabric) in which discrete fragments and rounded units are displaced, then enclosed by finer material and subjected to ice lens formation as evidenced by the associated planar voids. Observed within permafrost at a depth of 31 to 65 cm in a Gleysolic Turbic Cryosol developed in an *earth hummock* on a morainal till deposit in the Horn Plateau Region, N.W.T. Plane-polarized light, vertical section.

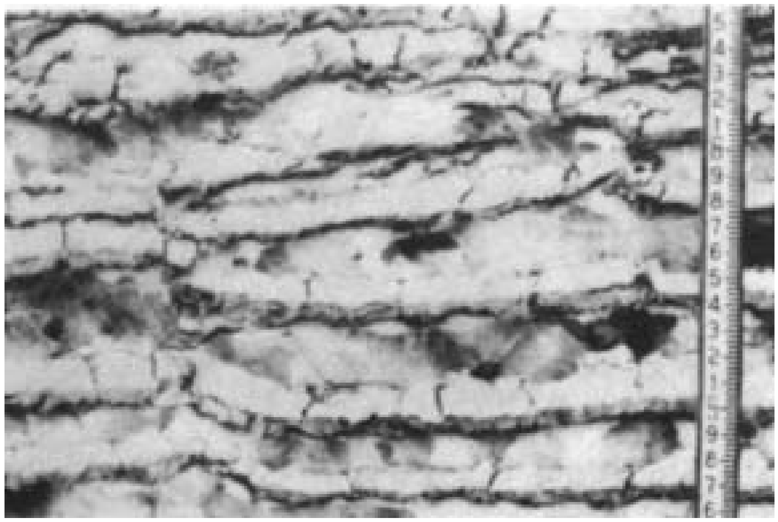

Figure 9a

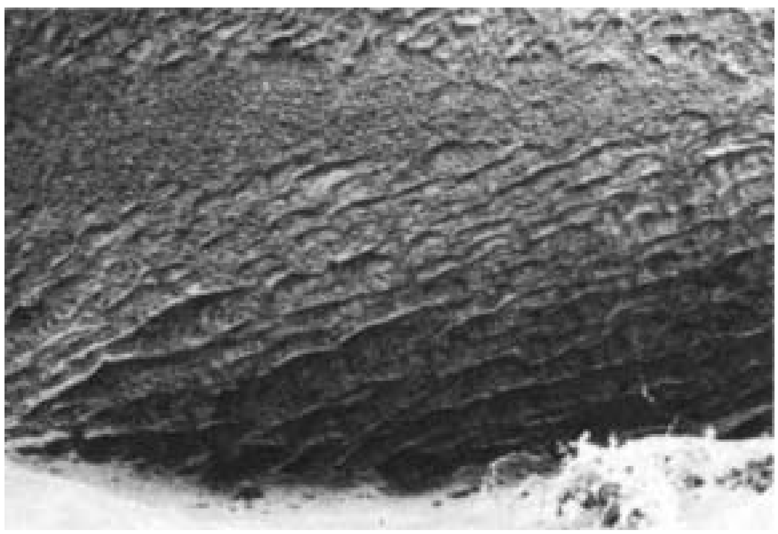

Figure 9b

Figure 9. Examples of *cryostructures* in frozen ground

(a) *Segregated ice* in varved glaciolacustrine silty clay, Thompson, Manitoba (Photo by G.H. Johnston, National Research Council of Canada)

(b) Inclined *ice lenses,* 30 to 80 cm long and 5 to 10 cm thick, formed by subaqueous syngenetic freezing of glaciolacustrine silty clay near Mayo, Yukon Territory (Photo by H.M. French, University of Ottawa)

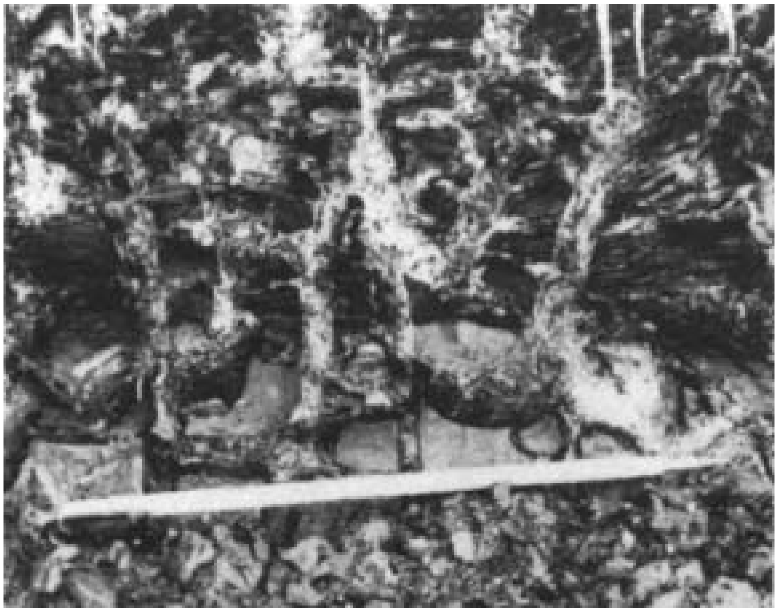

Figure 9c

Figure 9d

Figure 9 (continued).

(c) Coarse reticulate network of *ice veins* formed in glaciolacustrine clay, Sabine Point, Beaufort Sea coastal plain, Yukon Territory (Photo by D.G. Harry, Geological Survey of Canada)

(d) Fine reticulate network of *ice veins* formed in silty clay diamicton, Pelly Island, Mackenzie Delta, N.W.T. (Photo by H.M. French, University of Ottawa)

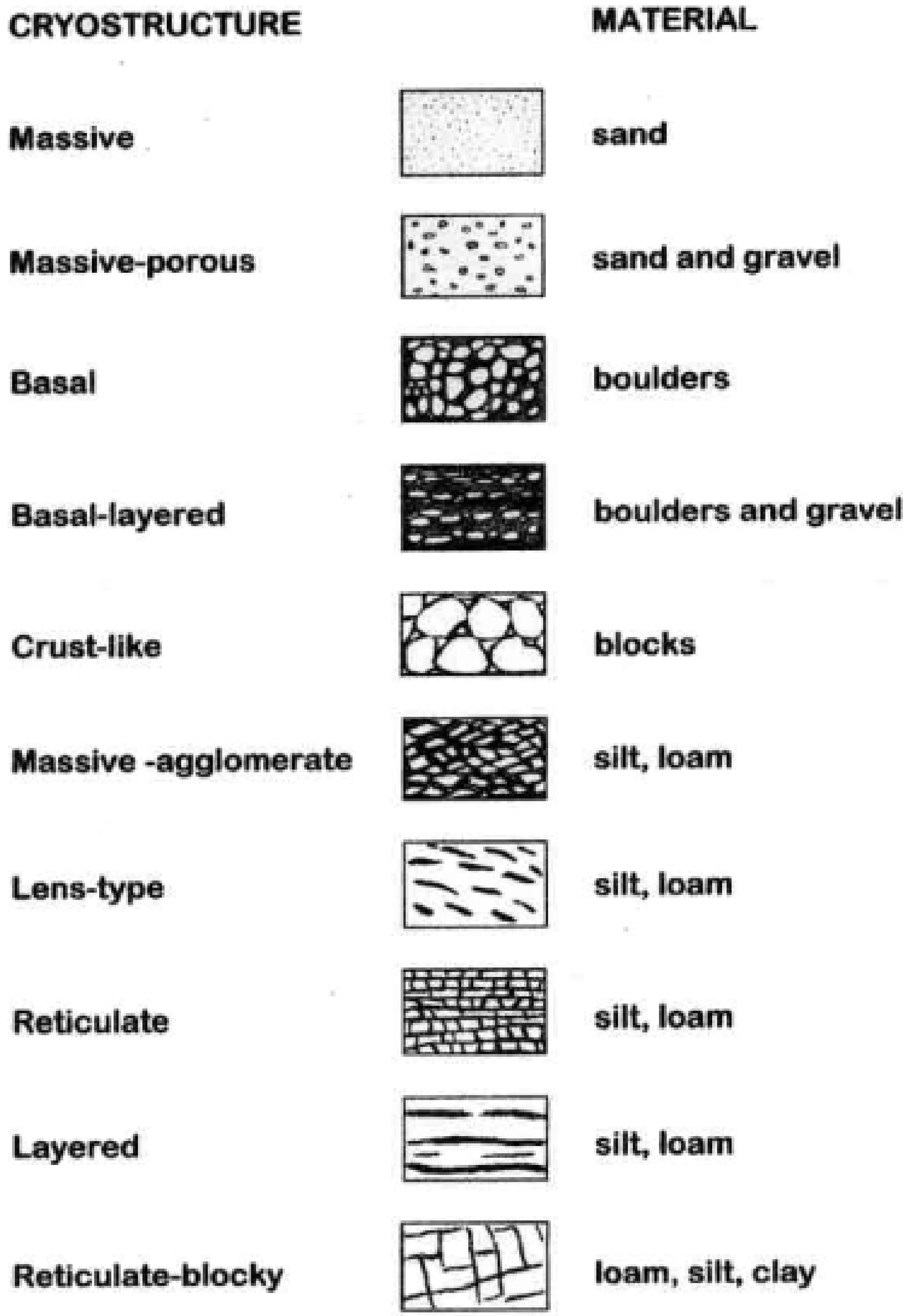

Figure 9e. Schematic drawings illustrating various cryostructure terms (after hand-drawn sketches by N. N. Romanovskii, 1995).

Figure 10a

Figure 10b

Figure 10. Examples of types *of ground ice*

(a) *Aggradational ice* at the top of permafrost and exposed at the 2 m depth in a pipeline trench, approximately 98 km south of Norman Wells, N.W.T. (Photo by D.G. Harry, Geological Survey of Canada)

(b) Ice *(dilation crack ice?)* between the ice core and heaved, silty, gravelly overburden of a collapsed *pingo*, Thomsen River, north central Banks Island, N.W.T. (Photo by H.M. French, University of Ottawa)

Figure 10c

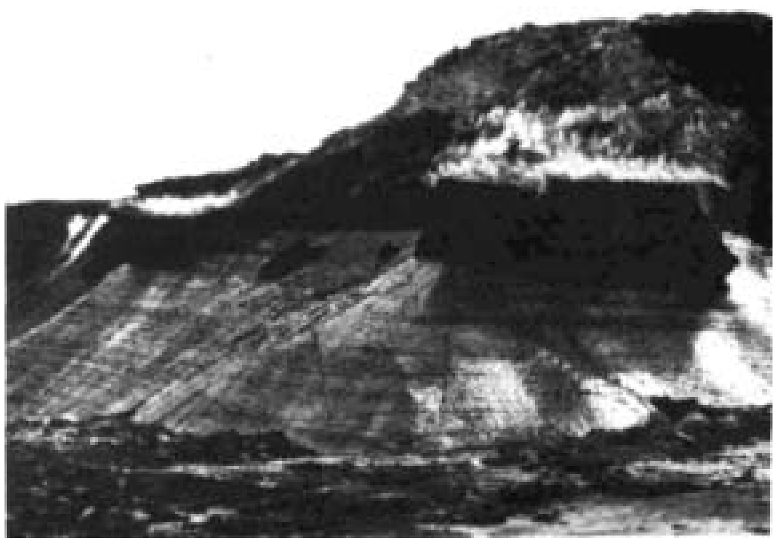

Figure l0d

Figure 10 (continued).

(c) Columnar ice crystals in a 10 to 20 cm thick layer of *intrusive ice* from within a seasonal *frost blister*, North Fork Pass, Ogilvie Mountains, Yukon Territory (Photo by W.H. Pollard, Memorial University)

(d) *Massive ice* exposed at Peninsula Point, 5 km southwest of Tuktoyaktuk, Mackenzie Delta, N.W.T. (Photo by H.M. French, University of Ottawa)

Figure 10e

Figure 10f

Figure 10 (continued).

(e) Glacially deformed *massive ice* exposed on north coast of Pelly Island, Mackenzie Delta, N.W.T. The exposure is approximately 7 to 10 m high. (Photo by D.G. Harry, Geological Survey of Canada)

(f) *Massive ice* body near Sabine Point, Beaufort Sea coastal plain, Yukon Territory. (Photo by H.M. French, University of Ottawa)

Figure 10g

Figure 10h

Figure 10 (continued).

(g) *Needle ice* exposed after removal of a stone, Boutillier Pass, Alaska Highway, Yukon Territory. (Photo by S.A. Harris, University of Calgary)

(h) Large body *of pingo ice* exposed near summit of a small growing *pingo*, 3 km west of Tuktoyaktuk, Mackenzie Delta, N.W.T. (Photo by H.M. French, University of Ottawa)

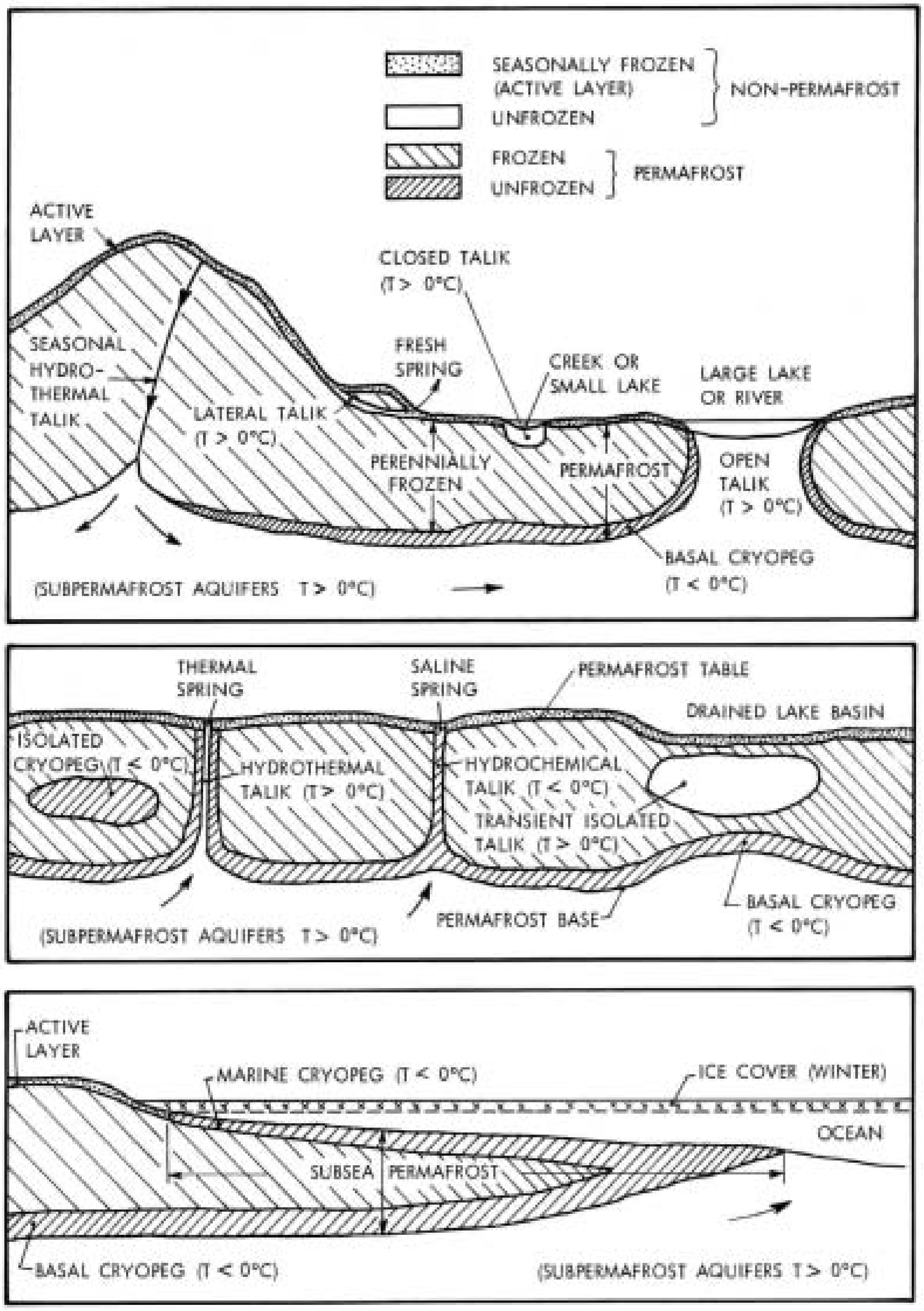

Figure 11. Cross sections illustrating terms used to describe unfrozen zones in a permafrost environment, and their relationships with surface water and groundwater flow (modified from van Everdingen, 1976)

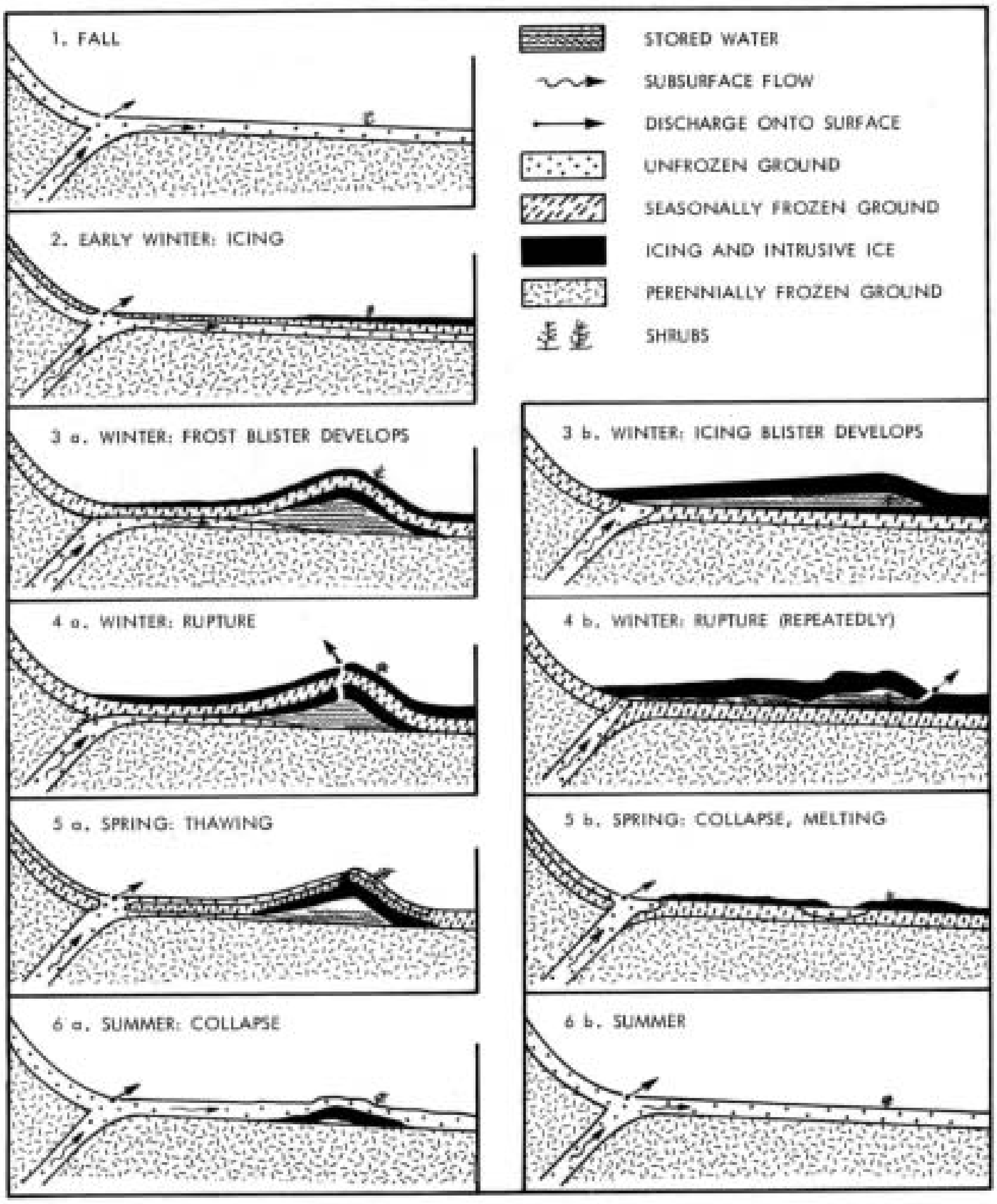

Figure 12. Sequence of events in the formation and decay of *frost blisters* and *icing blisters* (modified from van Everdingen, 1978)

Figure 13a

Figure 13b

Figure 13c

Figure 13. *Seasonal frost mounds* at Bear Rock, near Ft. Norman, N.W.T. (Photos by R.O. van Everdingen, Environment Canada)

(a) *Frost blister* in early July, after melting of snow and the surrounding *icing*

(b) The *same frost blister* in early September, after thawing of the seasonally frozen soil cover and partial collapse of the *intrusive ice* into the drained cavity

(c) Drained cavity (up to 40 cm high) exposed below cut-away *intrusive ice* in one of the *frost blisters* (cut at left is about 60 cm high)

Figure 13d

Figure 13e

Figure 13 (continued).

(d) Ruptured and partially collapsed *icing blister* in March (drained cavity was 90 cm high); note smaller *icing blister* in foreground

(e) Block of layered icing ice and massive *intrusive ice* from a ruptured *icing blister* (top is at left; tape shows centimetres)

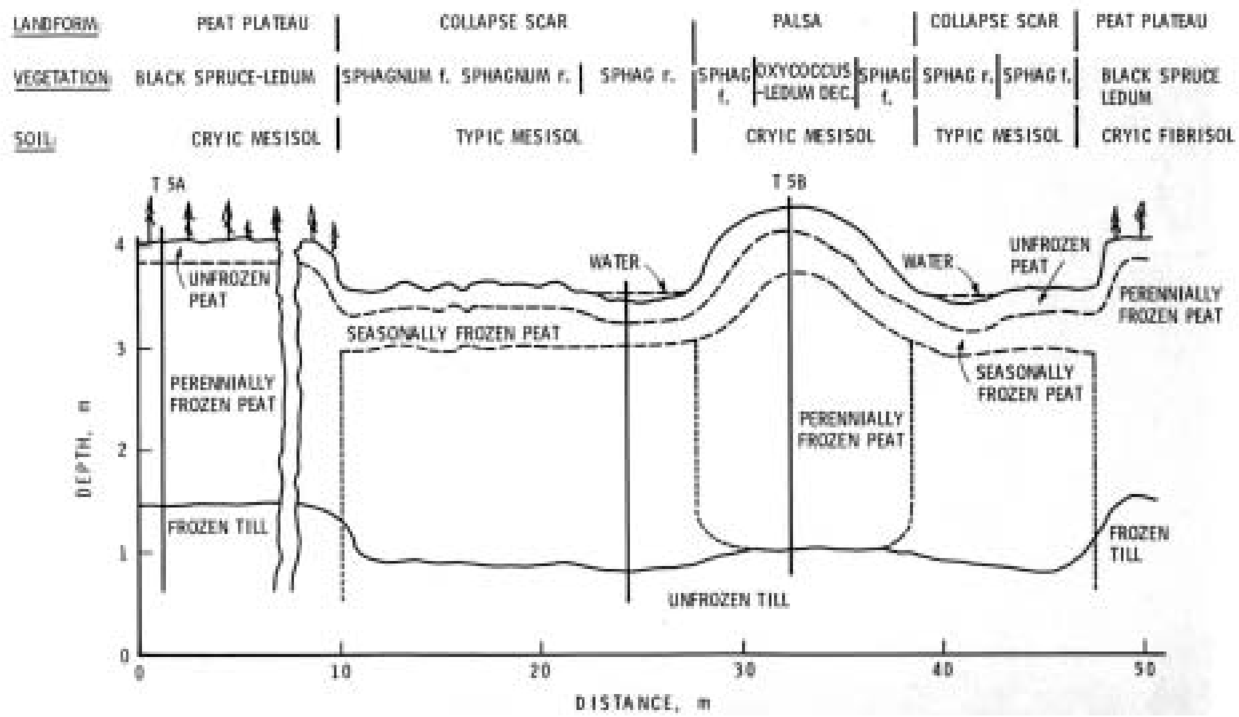

Figure 14. Cross section of a *peat plateau* - *collapse scar* area with a young *palsa* in the discontinuous permafrost zone (modified from Tarnocai, 1973)

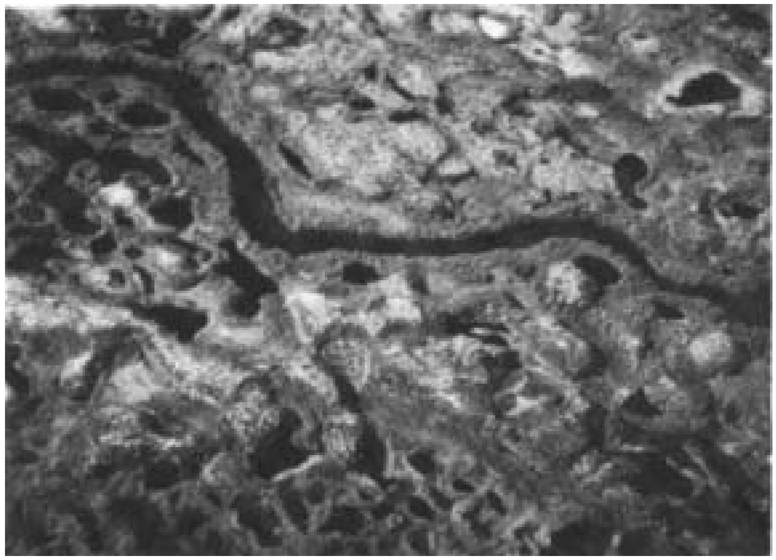

Figure 15a

Figure 15b

Figure 15. Examples of permafrost landforms developed in *peatlands*

(a) *Palsa* and *peat plateau* complex, Sheldrake Lake area, Quebec (Photo by M.K. Seguin, Universit~ Laval)

(b) *Peat plateaus* occurring as islands in an unfrozen *string fen*, Nelson River area, Manitoba (Photo by S.C. Zoltai, Environment Canada)

Figure 15c

Figure 15d

Figure 15 (continued).

(c) *Polygonal peat plateau* near the tree line, Richardson Mountains, N.W.T. (Photo by S.C. Zoltai, Environment Canada)

(d) A *string fen*, looking upstream, Lac La Ronge, Saskatchewan (Photo by S.C. Zoltai, Environment Canada)

Figure 15 (continued).

(e) *Collapse scars*, some with remnant *peat plateaus* marked by tall trees, near Wabowden, Manitoba (Photo by S.C. Zoltai, Environment Canada)

Figure 16. Examples of *patterned ground*

(a) Oblique aerial view of high-centre *polygons* on sediments of the Deer Bay Formation, northern Fosheim Peninsula, Ellesmere Island, N.W.T. (Photo by M.F. Nixon, Geological Survey of Canada)

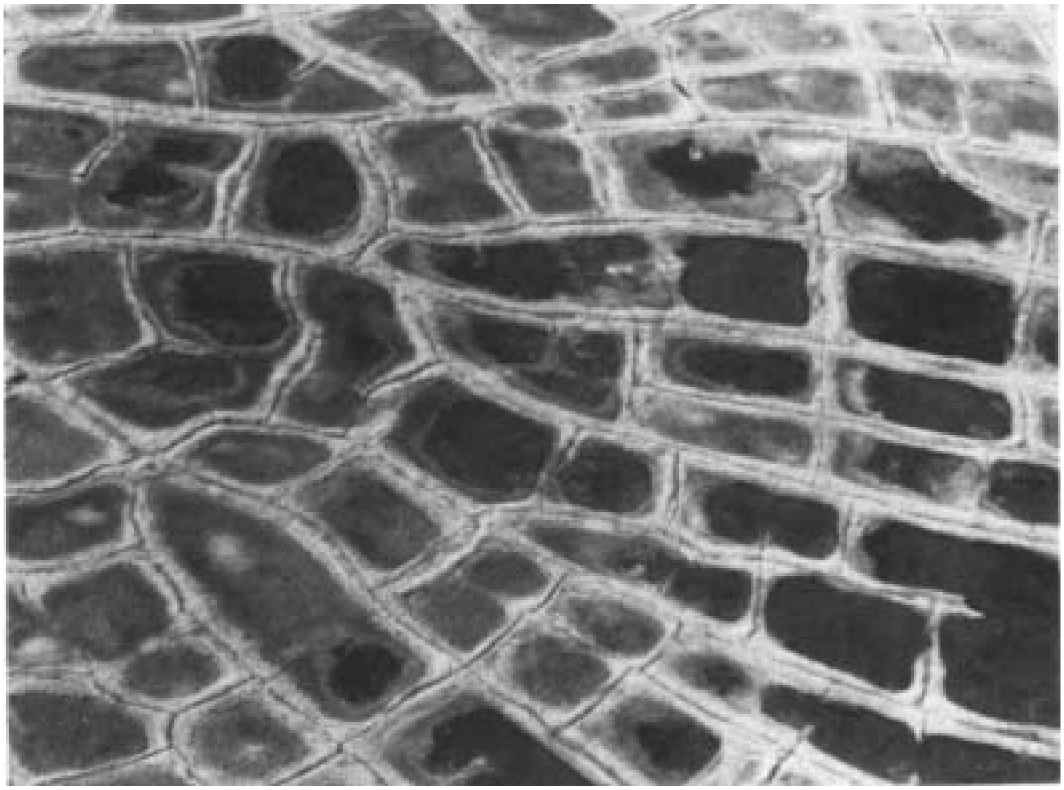

Figure 16 (continued).

(b) Oblique aerial view of low-centre *polygons* on a river terrace north of Raddi Lake, southwestern Banks Island, N.W.T. (Photo by J-S. Vincent, Geological Survey of Canada)

Figure l6 (continued).

(c) *Frost boils* on shallow lacustrine silts overlying till, on the west side of Irene Bay, central Ellesmere Island, N.W.T. (Photo by D.A. Hodgson, Geological Survey of Canada)

Figure 16 (continued).

(d) *Solifluction* of till across marine-limit raised beaches near Kaminak Lake, N.W.T. *Frost boils* can be seen on the till, thermal contraction crack *polygons* are seen on the raised beaches, and solifluction stripes are visible on the till in the middle-right of the field of view. The downslope edge of the solifluction sheet forms a turf-banked terrace. The white bar is the antenna of the helicopter. (Photo by W.W. Shilts, Geological Survey of Canada)

Figure 16 (continued).

(e) Non-sorted stripes in thin till overlying Cretaceous sandstones, eastern Banks Island, N.W.T. (Photo by H.M. French, University of Ottawa)

Figure 16 (continued).

(f) Sorted stripes on fissile sandstone of Jurassic age, near Mould Bay, Prince Patrick Island, N.W.T. (Photo by H.M. French, University of Ottawa)

Figure 17. *Ice, sand* and *soil wedges*

(a) *Ice wedge,* about 4 m wide at the top, in postglacial lake silts that overlie truncated glacially deformed. ice-rich Pleistocene sediments more than 40,000 years old. Garry Island, N.W.T. (Photo by J.R. Mackay, University of British Columbia)

Figure 17b

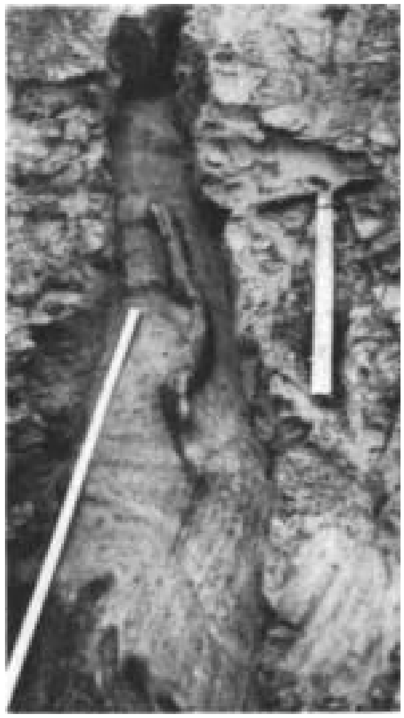

Figure 17c

Figure 17d

Figure 17 (continued).

(b) Inactive *ice wedge* formed in silty clay, Sachs River lowlands, Southern Banks Island, N.W.T. (Photo by D.G. Harry, Geological Survey of Canada)

(c) Small syngenetic *ice wedge* formed in silty sand of late-Quaternary age, Sachs River lowlands, southern Banks Island, N.W.T. (Photo by D.G. Harry, Geological Survey of Canada)

(d) Rejuvenated *ice wedge* showing primary and secondary wedge exposed in coastal bluff 3 km west of Sachs Harbour, southern Banks Island, N.W.T. (Photo by H.M. French, University of Ottawa)

Figure 17e

Figure 17f

Figure 17 (continued).

(e) Epigenetic *ice wedge* exposed in coastal bluff 3 km west of Sachs Harbour, southern Banks Island, N.W.T. (Photo by D.G. Harry, Geological Survey of Canada)

(f) *Ice-wedge ice* showing foliated nature, southern Banks Island, N.W.T. (Photo by H.M. French. University of Ottawa)

Figure 17g

Figure 17h

Figure 17 (continued).

(g) *Soil wedge* in "Wounded Moose" paleosol developed on pre-Reid till, Willow Hills, Yukon Territory (Photo by K. Valentine, Agriculture Canada)

(h) *Sand wedge* beneath polygonal trench in glaciofluvial deposits, Mary River area, northern Baffin Island, N.W.T. (Photo by G.H. Johnston, National Research Council of Canada)

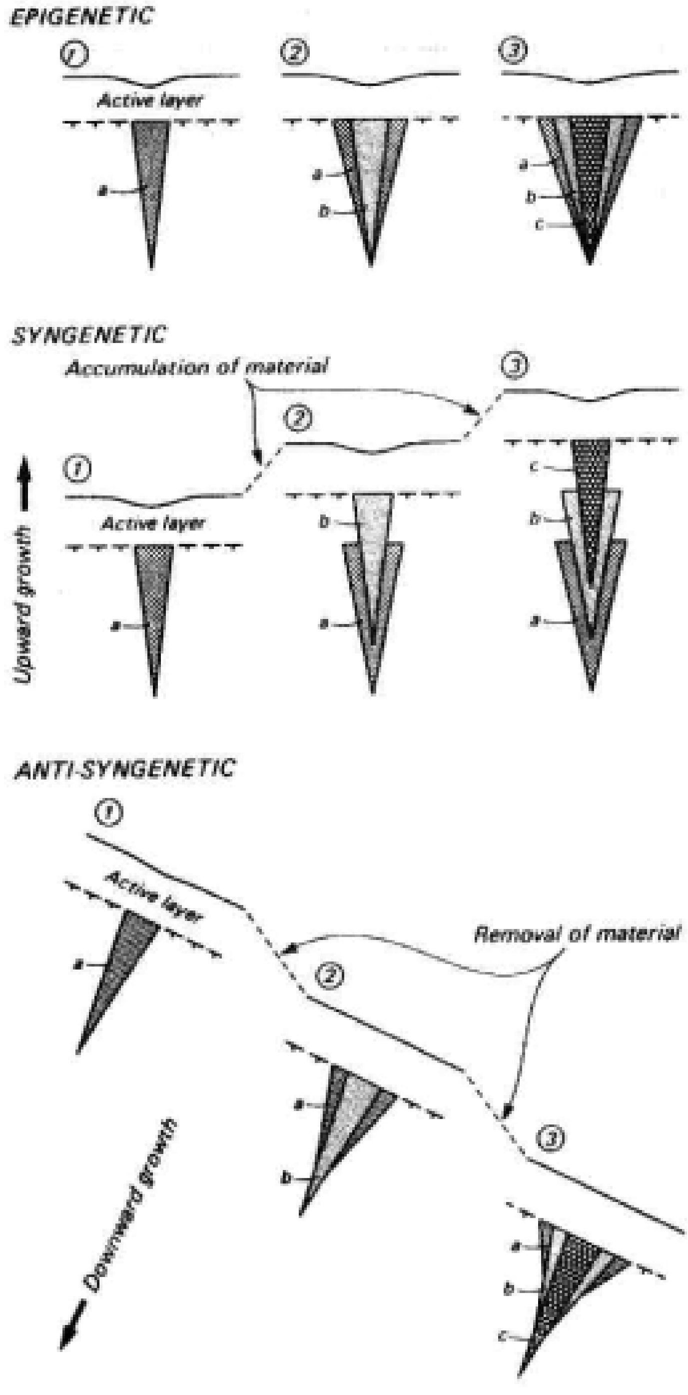

Figure 17 (continued).

(i) Schematic diagram showing three stages in the growth of epigenetic, syngenetic, and anti-syngenetic ice wedges: 1 - early, 2 - intermediate, and 3 - late (from Mackay, 1990, Fig.3). In an epigenetic ice wedge the ice on the sides is the oldest (a). In a syngenetic ice wedge the ice on the sides decreases in age from the bottom to the top. In an anti-syngenetic ice wedge the ice on the sides decreases in age from the top to the bottom.

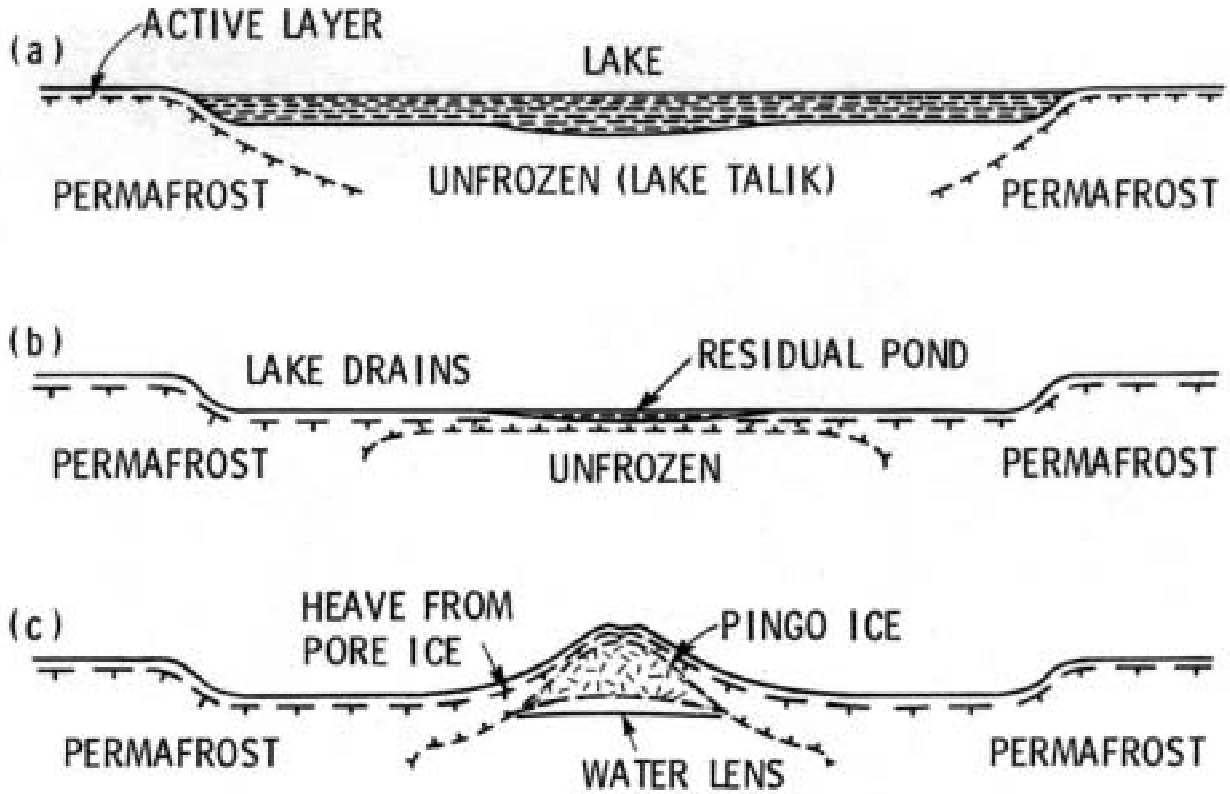

Figure 18. Illustration of the growth of a *closed-system pingo* (modified from Mackay, 1985)

Figure 19. *Pingos*

(a) *A closed-system pingo* (Ibyuk Pingo), 49 m high and 300 m in basal diameter, in the bottom of a drained lake near Tuktoyaktuk, N.W.T. The flats in the foreground are just above sea level and are flooded during storm surges. The pingo overburden is 15 m thick, the underlying sediments are sands and the pingo is still growing at the top at a rate of about 2 cm/year. (Photo by J.R. Mackay, University of British Columbia)

Figure 19b

Figure 19c

Figure 19 (continued).

(b) An *open-system pingo* on the alluvial fan in the Mala River Valley, Borden Peninsula, Baffin Island, N.W.T. (Photo by G.W. Scotter, Canadian Wildlife Service)

(c) A *pingo remnant* near Tuktoyaktuk, N.W.T. The basal diameter is about 300 m, which is almost identical with that of Ibyuk Pingo (see (a) above). The pond in the pingo is 5.4 m deep. The pingo probably grew at least several thousand years ago; the time of collapse is unknown. (Photo by J.R- Mackay, University of British Columbia)

Figure 20a

Figure 20b

Figure 20. Examples of *earth hummocks*

(a), (b) *Earth hummocks* near Inuvik, N.W.T., on a clay-silt colluvium, overlying outwash gravels. Individual hummocks are 1 to 2 m in diameter, and the troughs between the hummocks are 25 to 50 cm deep. Many hummocks have exposed mineral soil on the top; the troughs are commonly filled with moss and underlain by ice, year round. Figure 20(a) shows the natural terrain, with an open woodland of black spruce and alder. Figure 20(b) shows the same area following a forest fire in 1968. (Photos by H.M. French. University of Ottawa)

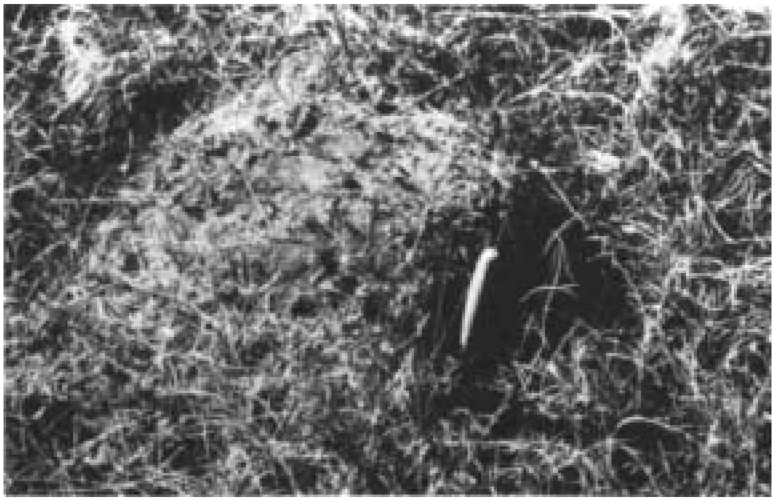

Figure 20c

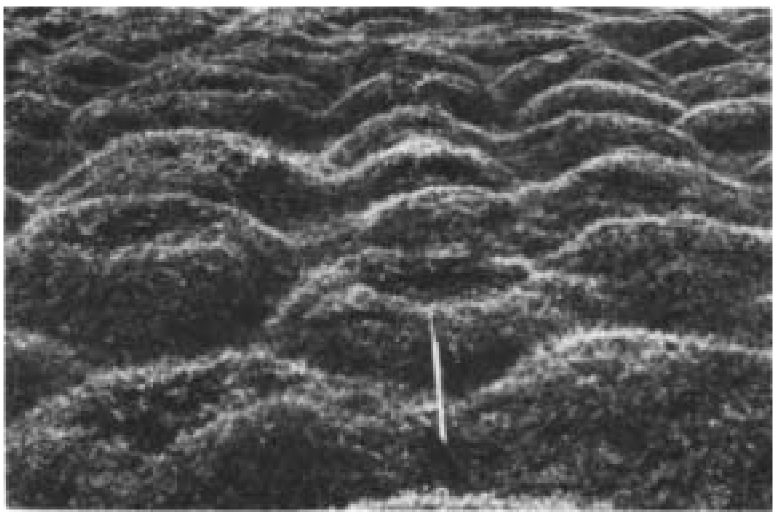

Figure 20d

Figure 20 (continued).

(c) *Turf hummock* consisting of living and dead *Sphagnum fuscum,* District of Keewatin, N.W.T. (Photo by S.C. Zoltai, Environment Canada)

(d) *Thufa* in volcanic ash soils, Sunshine Meadows, near Banff, Alberta. (Photo by S.C. Zoltai, Environment Canada)

Figure 21a

Figure 21b

Figure 21. Examples of *mass wasting* in permafrost areas

(a) Ac*tive-layer failure* in the upper Ramparts River area, Mackenzie Valley, N.W.T. (Photo by O.L. Hughes, Geological Survey of Canada)

(b) Active-layer detachment failure, Mackenzie Valley, N.W.T. (Photo by O.L. Hughes, Geological Survey of Canada)

Figure 21c

Figure 21d

Figure 21 (continued).

(c) *Retrogressive thaw slumping* in a borrow pit on the Dempster Highway near Ft. McPherson, N.W.T. (Photo by O.L. Hughes, Geological Survey of Canada)

(d) *Retrogressive thaw slumping* on the Yukon coastal plain near King Point, Yukon Territory. (Photo by J-S. Vincent, Geological Survey of Canada)

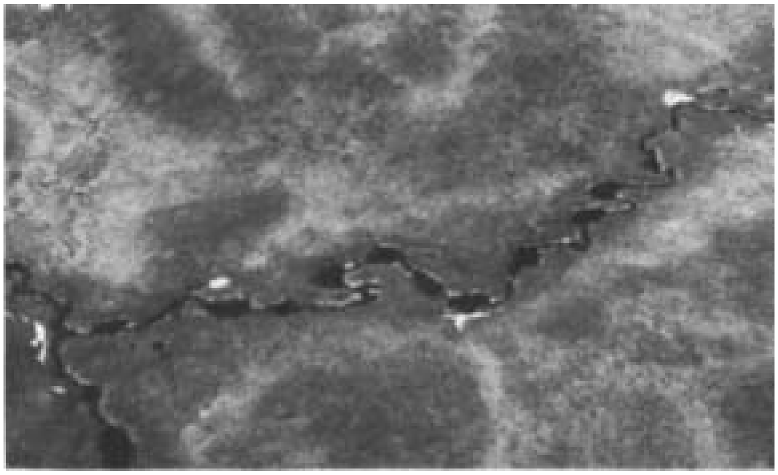

Figure 22a

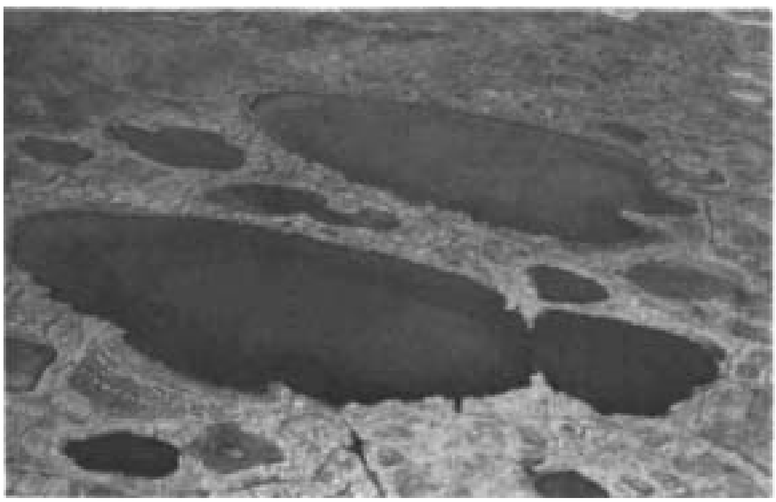

Figure 22b

Figure 22. Examples of thermokarst features in permafrost areas

(a) *Beaded stream*, Mackenzie Delta area, N.W.T. (Photo by H.M. French, University of Ottawa)

(b) *Oriented lakes,* Bathurst Peninsula, N.W.T. The large lake in the foreground is 250 m long. The long axes of the lakes are oriented normal to the strongest prevailing summer wind. (Photo by J.R. Mackay, University of British Columbia)

Figure 22c

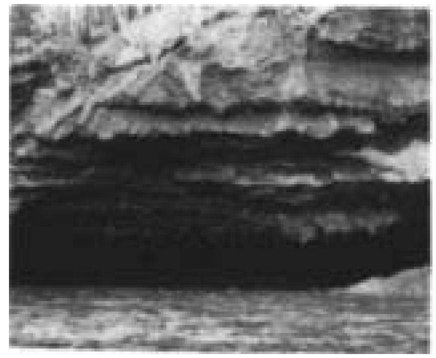

Figure 22d

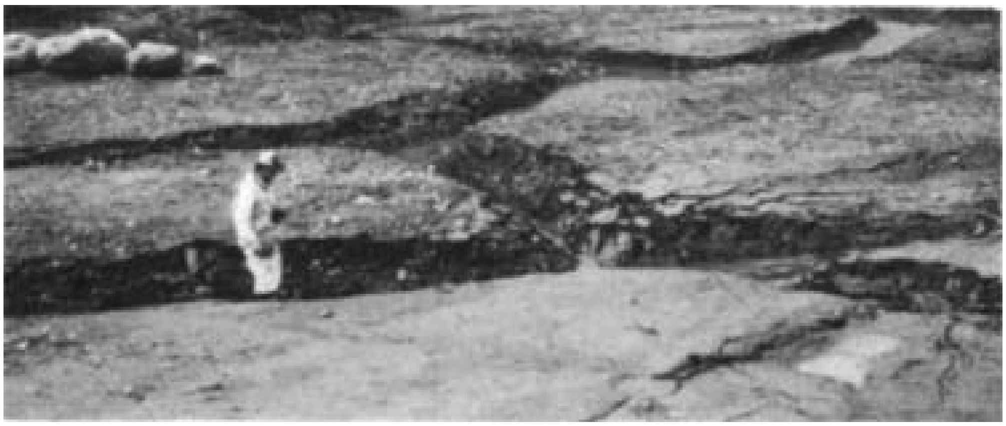

Figure 22e

Figure 22 (continued).

(c) *Thermokarst lake* showing shoreline erosion; shore of a typical expanding lake on overgrown pasture, west of Takhini River Crossing, Alaska Highway, Yukon Territory. (Photo by R.W. Klassen, Geological Survey of Canada)

(d) *Thermo-erosional niche* along the bank of the Rock River, Yukon Territory. (Photo by O.L. Hughes, Geological Survey of Canada)

(e) Fresh *thermokarst terrain* developing as a result of thawing of *ice wedges* in a borrow pit on the Dempster Highway near the crossing of the Blackstone River, Yukon Territory. (Photo by O.L. Hughes, Geological Survey of Canada)

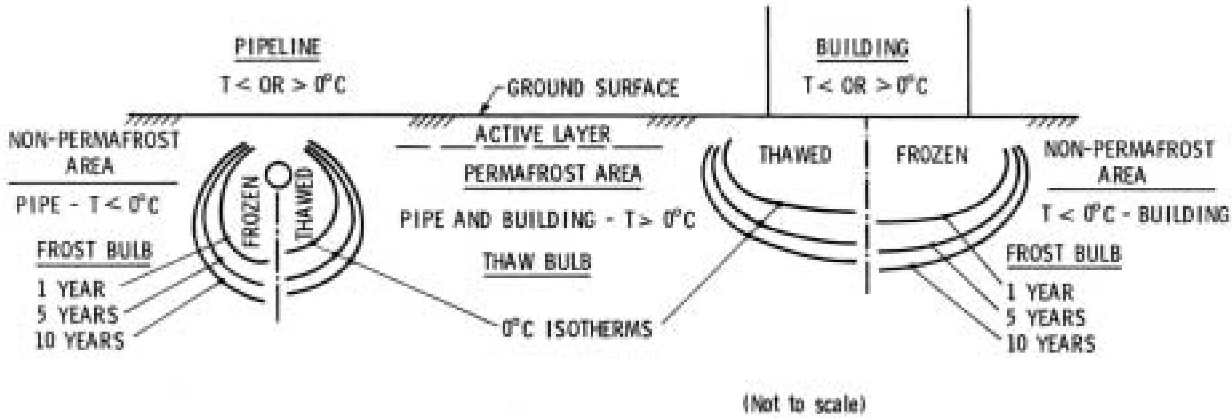

Figure 23. Illustration of the development *of frost* and *thaw bulbs* around buried pipelines and under buildings placed on the ground surface in permafrost and non-permafrost areas. For pipelines, the diagram illustrates a chilled pipeline in a non-permafrost area and a warm pipeline in a permafrost area. For buildings, the diagram illustrates a cold structure (e.g., an ice rink) in a non-permafrost area and a warm structure (e.g., a powerhouse) in a permafrost area. In all cases the pipelines and buildings are operated at temperatures either above or below 0°C, continuously for several years.

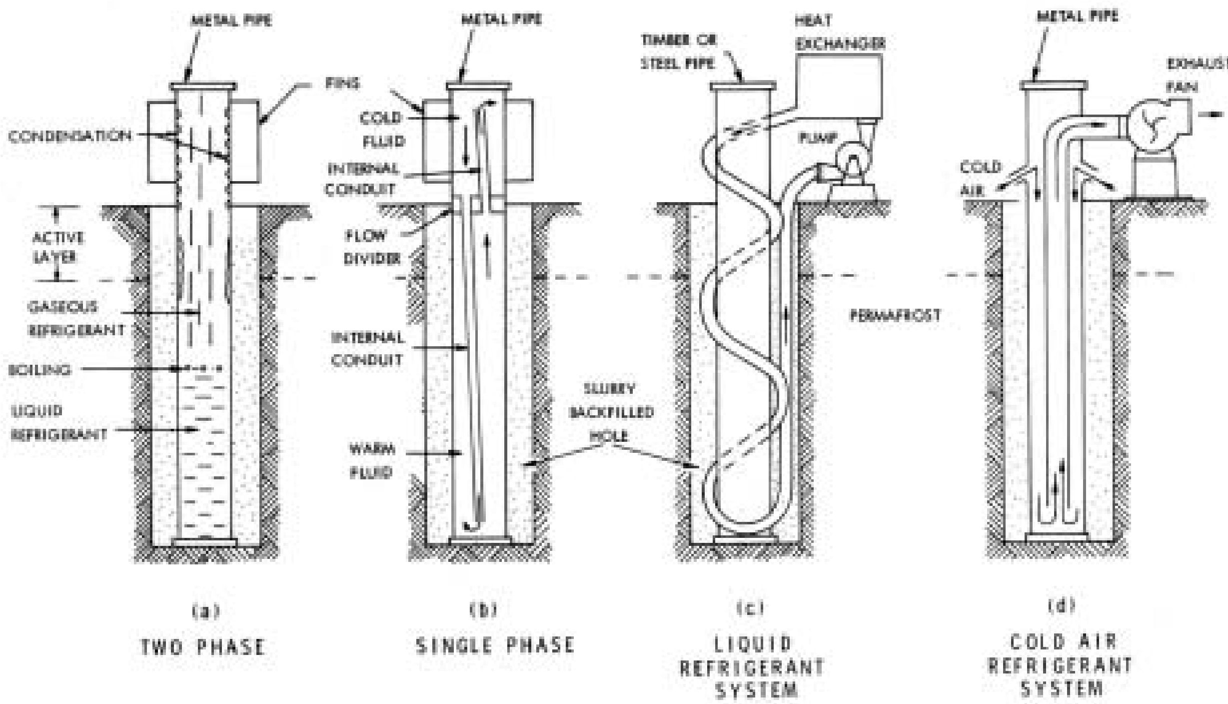

Figure 24. Representation of several *thermal pile* systems (after Johnston, 1981)