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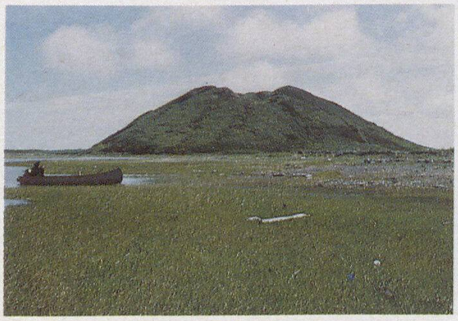

(NRCC-DBR)

Cover

Permafrost produces striking forms, such as this 40-m-high pingo near Tuktoyaktuk, but is an unreliable foundation for the works of man. (See story p. 8.)

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Microflaws and macrobreakdowns

Under sparkling lights, the hum of conversation swirls around the clinking of cocktail glasses like a stream around sharp rocks. Light from every window spills onto the lawn of one of the larger embassies in Rockcliffe Park. The evening is progressing well until darkness suddenly blots out the rooms. The main power cable that serves the Embassy and other local residences has short-circuited again.

If this particular scenario ever happens, it will be Dr. John Densley of NRC's Division of Electrical Engineering that is called in to examine the underground cable, as he has been called many times before. Will it need replacing? After all, it is only 4 years old, and high-voltage power cables used in transmission lines are designed to last from 30 to 40 years. Densley determines that the modified polyethylene that insulates the high-voltage conductor from ground is full of "water trees," a sign that it will fail again and again.

If current flow along a cable is considered the equivalent of water flow along a pipe, voltage is the equivalent of the pressure of that water. Transmission cables operate at high "pressures," and as such are under very high electrical stress. Densley's research, initiated in the late 1960's, has determined that tiny air bubbles (called microvoids) or contaminants in the insulation, probably a result of the extrusion process that forms the power cable, are the primary source of the insulation breakdown. If the electrical stress exceeds the breakdown strength of the gas in the microvoid, a spark will discharge across it. Contaminants, particularly metal slivers, raise the electrical stress in adjacent microvoids, increasing the chance of a spark. Because of the spark and the resultant high temperature, melting and deterioration of the polyethylene occur. The spark recurs at the same place, and pits start to develop at either end of the microvoid. Eventually, what Densley and others call an "electrical tree" develops. Once a tree exists, it is only a matter of a few hours to a few days before the cable short-circuits; this failure can be enough to sever a cable before the circuit breaker cuts off the current, thus destroying all evidence of what caused the fault.

When cables are laid in wet, underground conditions water trees become another source of breakdown. Water trees grow more slowly than electrical trees but at less than half the electrical stress. Although the exact mechanism is still unknown, water permeates the insulation, progressively filling the existing microvoids and creating others until the insulation is sufficiently weakened that failure occurs. Densley thinks that the voltage may even be "pulling" the water into the insulation. It is his opinion, one that he shared with the staff of the Embassy, that it may be necessary to hermetically seal underground cables to prevent the penetration of water.

In the laboratory, Dr. Densley is examining various methods of hermetically sealing cables. The main emphasis of the research, however, is on fundamental studies of the exact mechanism of breakdown. Exactly how the water trees cause cable failure is still unknown. Densley has developed techniques to accelerate the growth of both kinds of trees so that he can study their formation and perhaps determine a way to slow or prevent their growth.

Densley's research is aimed at answering the many questions still surrounding insulation breakdown in high-voltage power cables. If he gets the right answers, perhaps some day these power cables may last as long as they were designed to. The Embassy staff will be delighted — if not de-lighted. □

Margaret Shibley Simmons

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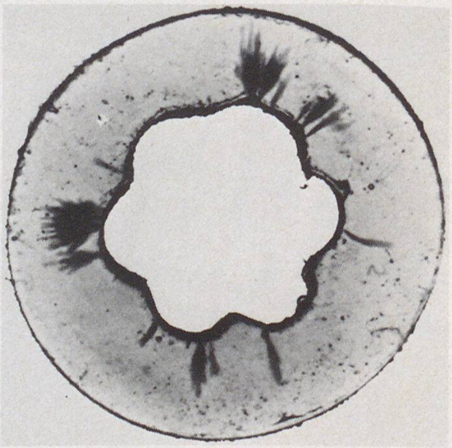

(John Densley)

These cross sections of high-voltage power cables (A is across the cable, B is along it) show the developing "trees" in the insulation that eventually cause the cable to short-circuit.