HOLE LIQUIDS

by

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In deep drilling, the hole must be filled with a liquid in order to prevent hole closure from the surrounding ice. The maximum depth received in a dry hole is 906 m at Dome C using a thermal drill in ice with a temperature of -50°C (Ritz and others, 1982). In Greenland, a thermal auger reached 404 m in -30°C ice (Clausen and others, 1988). Mechanical drills have a more limited depth capability in a dry hole than a thermal drill due to the lack of clearance at the drill head. Nevertheless, it was possible to core 360 m at South Pole (-55°C) and 325 m at Renland in East Greenland (-18°C). In deeper drillings, the hole has to be filled with a liquid.

The ideal hole liquid has a density of 920 kg/m^3, does not react with the ice hole wall, is completely miscible with Jet A1 (Kerosene) that serve as the main hole filler, is cheap, has a low viscosity and not toxic. In practice, severe compromise has to be made as the following indicates :

At Camp Century (1966) and Byrd Station (1968) the main filler was DFA (Hansen, 1976). The chips produced while drilling were dissolved by a glycol/water mixture and the major part of this mixture brought to the surface in a bailer in the drill. The density was increased from the 825 kg/m^3 of pure DFA to 920 kg/m^3 by adding trichlorethylene. This four-component liquid (DFA/-trichlor/glycol/water) worked fine as evidenced by the recent logging of the Byrd hole (Hansen and others, in prep.). 20 years after completion of the drilling, the hole is open. The mixing ratio of glycol and water is critical in order to prevent slush to be formed : Slush formed due to the use of excessive amounts of glycol used to compensate lack of trichlorethylene lead to the loss of the drill in 1969. The main drawback was the use of trichlor, that is quite poisonous. While drilling, the operators has to inhale the fumes on sustain spray of liquid.

In the russian drillings in Antarctica, alcohol/water has been used, both to dissolve ice and as hole liquid. The mixture is clean, has relatively low viscosity and is not toxic. It has served well in spite the absence of a stable alcohol/water ratio. The last means, that the hole will be destroyed with time. The mixture has mainly been used at places with an ice temperature of -50°C, and at these temperatures the hole wall dissolves so slowly, that the hole has been usable for several years. Morev and Yakovlev (1984) has provided graphs on mixing ratio, density and viscosity versus temperature. In other drillings, pure hydrocarbon (DFA?) has been used although little information is available (Kudryashov and others, 1984). Again, due to the low temperatures, the hole has been usable for several years in spite of the hole liquid density of around 860 kg/m^3.

In the US/Danish/Swiss drilling at Dye 3, South Greenland, the main filler was Jet AI with perchlorethylene as densifier (Gundestrup and others, 1984). Again, perchlor is unsafe to work with.

The Australian deep drilling at Law Dome, Antarctica, will use Jet AI as main filler and has considered Freon 11 (CCl_3F, Trichlorofluoromethane) as densifier (Vin Morgan, private communication). Freon 11 is completely miscible with Jet AI, non-flammable, low viscosity, chemical inactive and not as toxic as perchlor or trichlor. Density is 1579 kg/m^3 at -20°C. It seems as an ideal densifier except for its possible role in the creation of the ozone hole. Until Freon 11 is found not to participate in the destruction of the ozone layer, this may preclude its wider acceptance as densifier. Freon 113, having a higher boiling point and sligthly less harmfull effects on the ozone layer may be a better. choice than Freon 11.

DENSITY REQUIREMENT

As it is difficult to find an ideal hole liquid, the allowable range of liquid densities should be considered. Johnsen and others (1980) has calculated the hole closure rate at different temperatures and pressure differential. Based on this figure, we obtain the following table of closure rates in mm/yr of a 100 mm hole :

Table 1 - Closure rate in mm/yr

pressure differential	0	-10	-20	-30	-40
5 bars	11	2.6	.6	.15	.026
10 bars	75	18	4.5	0.9	0.15
20 bars		170	37	7.3	1.4

The table shows the significant changes in deformation rate with temperature and pressure. At ice temperatures belows -40°C, a pressure differential of 10 bars causes insignificant deformation ratio. In deep drilling however, the bottom temperature approaches 0°C, and thus the pressure should be correct within a few bars : In a 3000 m deep hole, the bottom pressure is 270 bars. If we want the pressure to be correct within 3 bars, the maximum density error is ± 9 kg/m^3.

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