SELECTION OF A LOW TEMPERATURE FILLER FOR DEEP HOLES IN THE ANTARCTIC ICE SHEET

B.B. Kudryashov, V.K. Chistyakov and V.M. Pashkevich
The Leningrad Mining Institute, Leningrad, U.S.S.R.

and

V.N. Petrov
The Arctic and Antarctic Research Institute, Leningrad, U.S.S.R.

ABSTRACT

The development of a suitable low temperature liquid filler for the 2000 m deep hole at Vostok station, Antarctica, is described.

INTRODUCTION

In deep drilling through the East Antarctic Ice Sheet it is essential to maintain stability of the hole wall under increasing hydrostatic pressure and pressure. The amount of hole closure expected is primarily determined by the ice rheology and temperature as well as the duration and type of drilling.

The filler should meet certain requirements:

(1) The freezing temperature should not be higher than -60°C.

(2) It should not deteriorate when in contact with ice.

(3) It should be water immiscible.

(4) It should have low viscosity at low temperatures.

(5) It should be easy to handle, safe to work with, easily available and inexpensive.

Experimental studies of a number of hydrophyllic (alcohol-salt solutions) and hydrophobic liquids (immiscible with water) indicated the limited use of the former since they tend to interact with the ice if great care is not taken. Hydrophyllic liquids can be used conveniently when thermal drilling at temperatures down to about -30°C.

For deep drilling in the East Antarctic Ice Sheet at temperatures near -60°C a special low temperature filler, developed at the Leningrad Mining Institute, was used.

FILLER PROPERTIES

The filler is hydrocarbon based and its density may be varied from 0.880 Mg m^{-3} to 0.920 Mg m^{-3} by the addition of a loading material. Due to its low viscosity and high immiscibility with water, the filler kept the lower bore hole free of slush. The 2000 m deep hole at Vostok station was drilled in 1981-82 with the use of the LMI filler. No significant hole contractions were recorded.

USE OF THE FILLER

The filler level in the hole should not be less than about 100 m from the top of the hole, since the filler will permeate the firn. To be very economical this level may be set even lower, provided hole closure is not significant.

To calculate the filler density required to take account of the changing ice properties with depth and temperature, an analytical expression was developed. It is derived from an equation for the wall strain rate.

The final operational equation (Salamatin, *et al.*, 1981) is:

$$\rho_s = \rho_i - 10^3 n(gH)^{-1}(At)^{-1/n} \times (\ell n\, R_0/R)^{1/n} \quad (1)$$

where ρ_s and ρ_i are the densities of the drilling solution and the ice (Mg m^{-3}),

H is the depth of the hole (m),

R_0 and R are the initial and current hole radii (mm),

n is the dimensionless power index in the flow law,

A is the parameter in the flow law which is dependent on the physical properties of the ice (MPa^{-n} s^{-i}) and

t is the time elapsed (s).

Calculations made using this expression (1) for the Vostok station conditions are in good agreement with the field drilling results in the No. 3G hole in 1980 (Fig. 1).

Referring to Figure 1, the drilling down to 1415 m was made with incomplete balance of the ice pressure. The upper level of the filler (density 0.810 Mg m^{-3}) was maintained at fron 200 to 450 m below the surface. The hole diameter was measured periodically. Also, the drilling rates were watched carefully. These observations indicated that wall contraction did not exceed 0.5-1 mm.

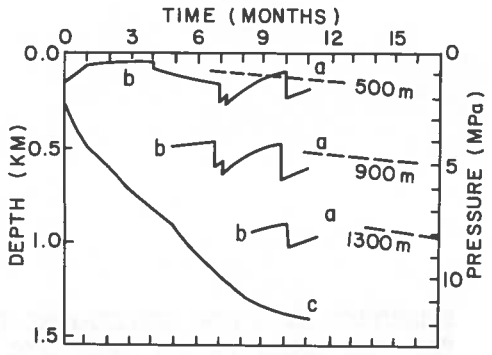

Figure 1. The calculated and observed liquid pressure in the No. 3G bore hole during the 1980 Vostok station operations. Curves (a)- the calculated and required pressures for depths of 500 m, 900 m and 1300 m. Curves (b)- the observed pressure values for depths of 500 m, 900 m and 1300 m. Curve (c) is the drilling progress plot.

REFERENCE

Salamatin, A.N., V.K.Chistyakov, D.N. Dmitriyev and V.M. Pashkevich (1981) Theoretical analysis and experimental studies of hole wall deformation, Antarctica. *Committee Reports*. vol. 20, Moscow.