LONG-TERM STABILITY OF DEEP BOREHOLES IN ICE FILLED WITH ESTISOL™-140 DRILLING FLUID

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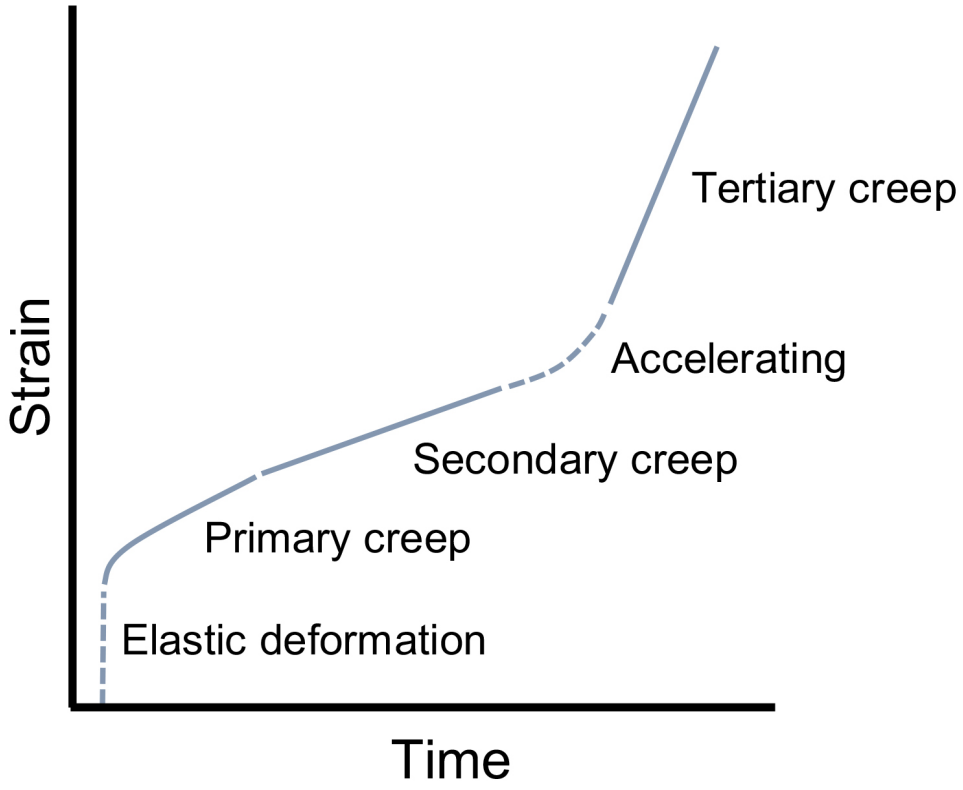
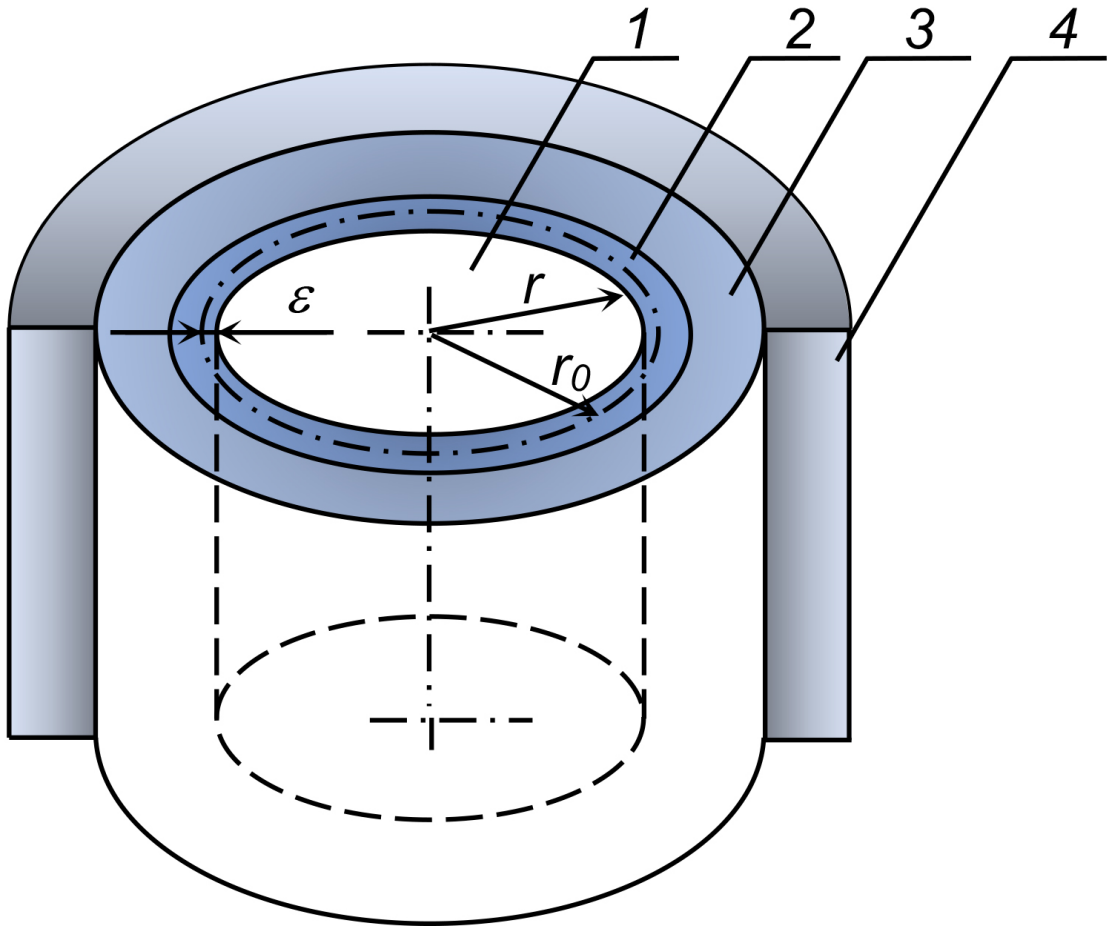
Ice creep





1 – borehole shaft; 2 – zone of plastic deformation; 3 – zone of elastic deformation; 4 – untouched ice

Deformation of ice boreholes

Annals of Glaciology 47 2007

Closure of deep boreholes in ice sheets: a discussion

P.G. TALALAY,[1] Roger LeB. HOOKE[2]

Drilling fluid technology in ice sheets: Hydrostatic pressure and borehole closure considerations

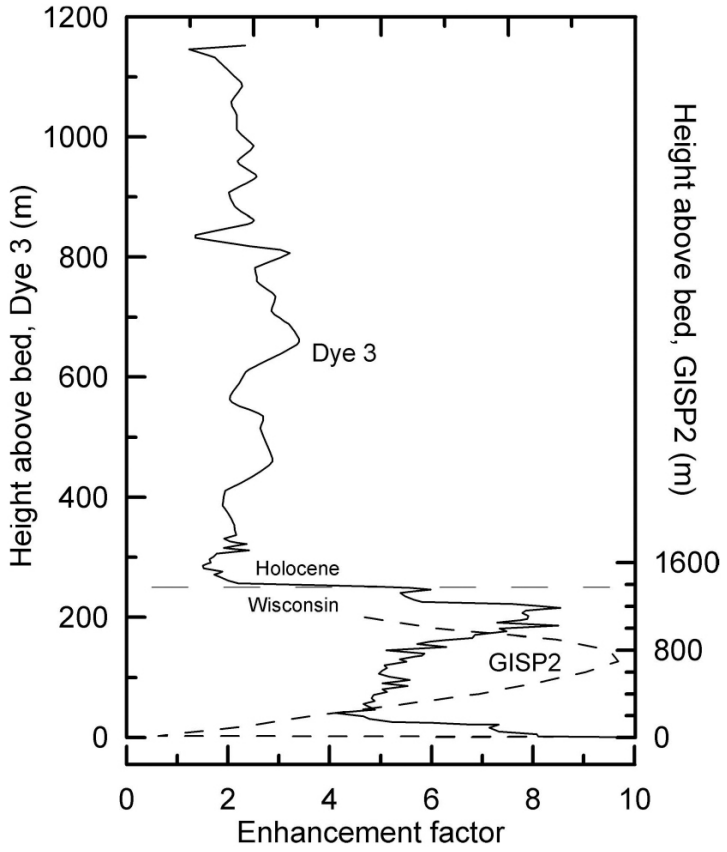
Pavel Talalay *, Xiaopeng Fan, Huiwen Xu, Dahui Yu, Lili Han, Junjie Han, Youhong Sun

Cold Regions Science and Technology 98 (2014) 47–54

Deformation of ice boreholes

$$D = D_0 \exp\left[2.2 \times 10^{-18} k e^{0.12t} \Delta P^3 \Delta T\right],$$

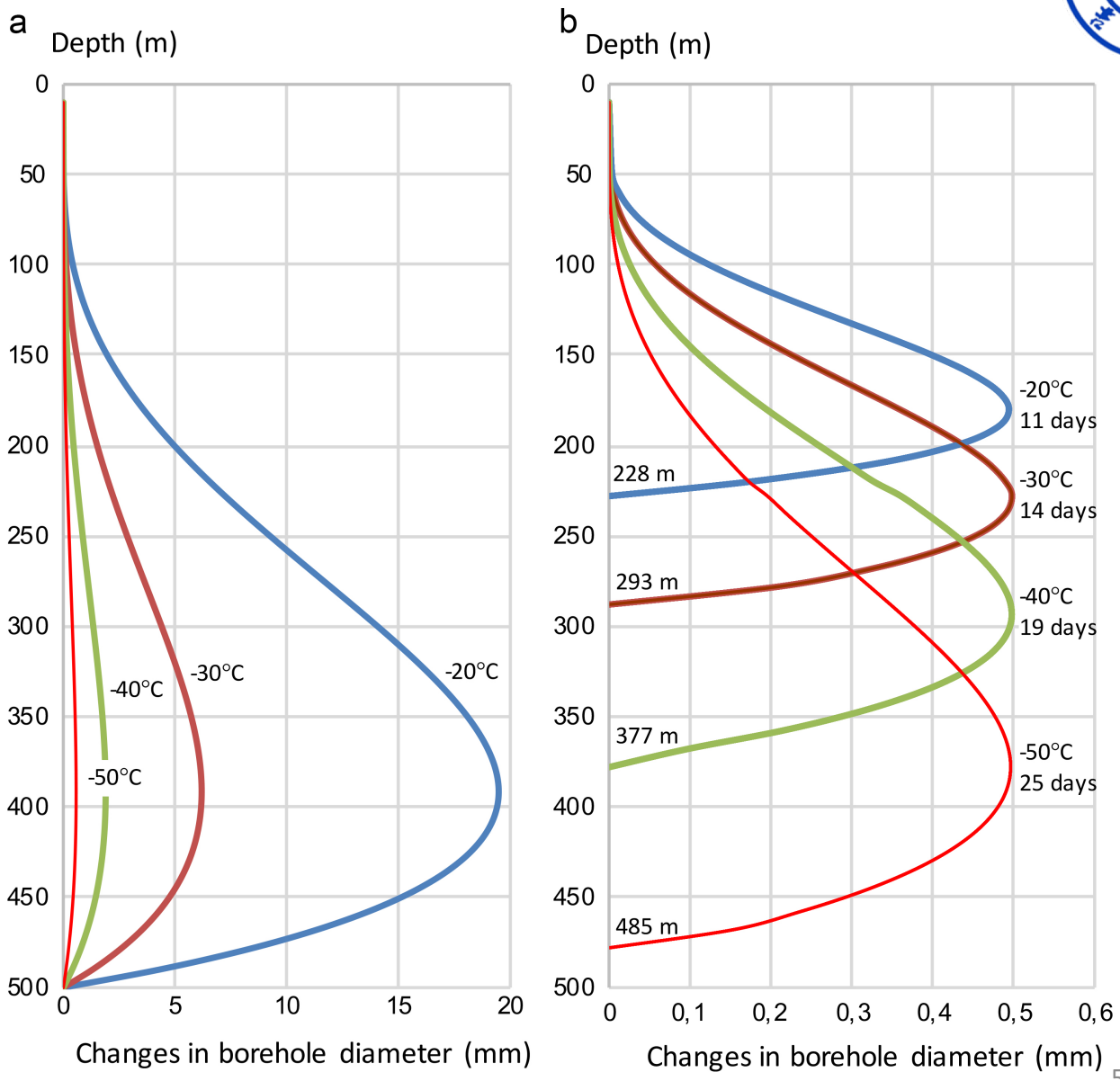
where r, r_0, D and D_0 in [m]; t in [°C]; $\Delta P(z)$ in [Pa]; ΔT in [years].



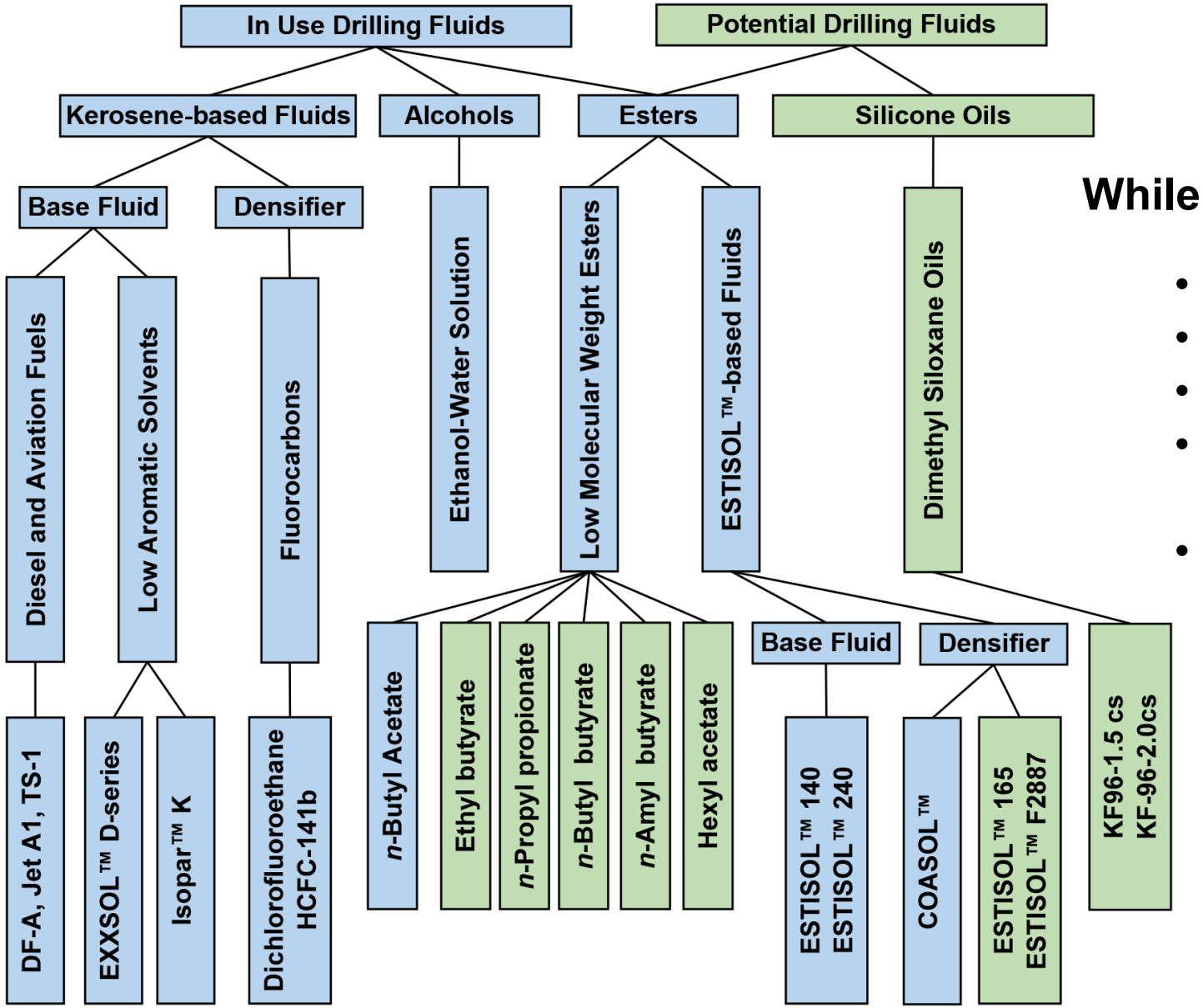
Deformation of “dry” ice boreholes

(a) final depth of 500-m

(b) maximal change in the borehole diameter of 0.5 mm



Drilling fluids

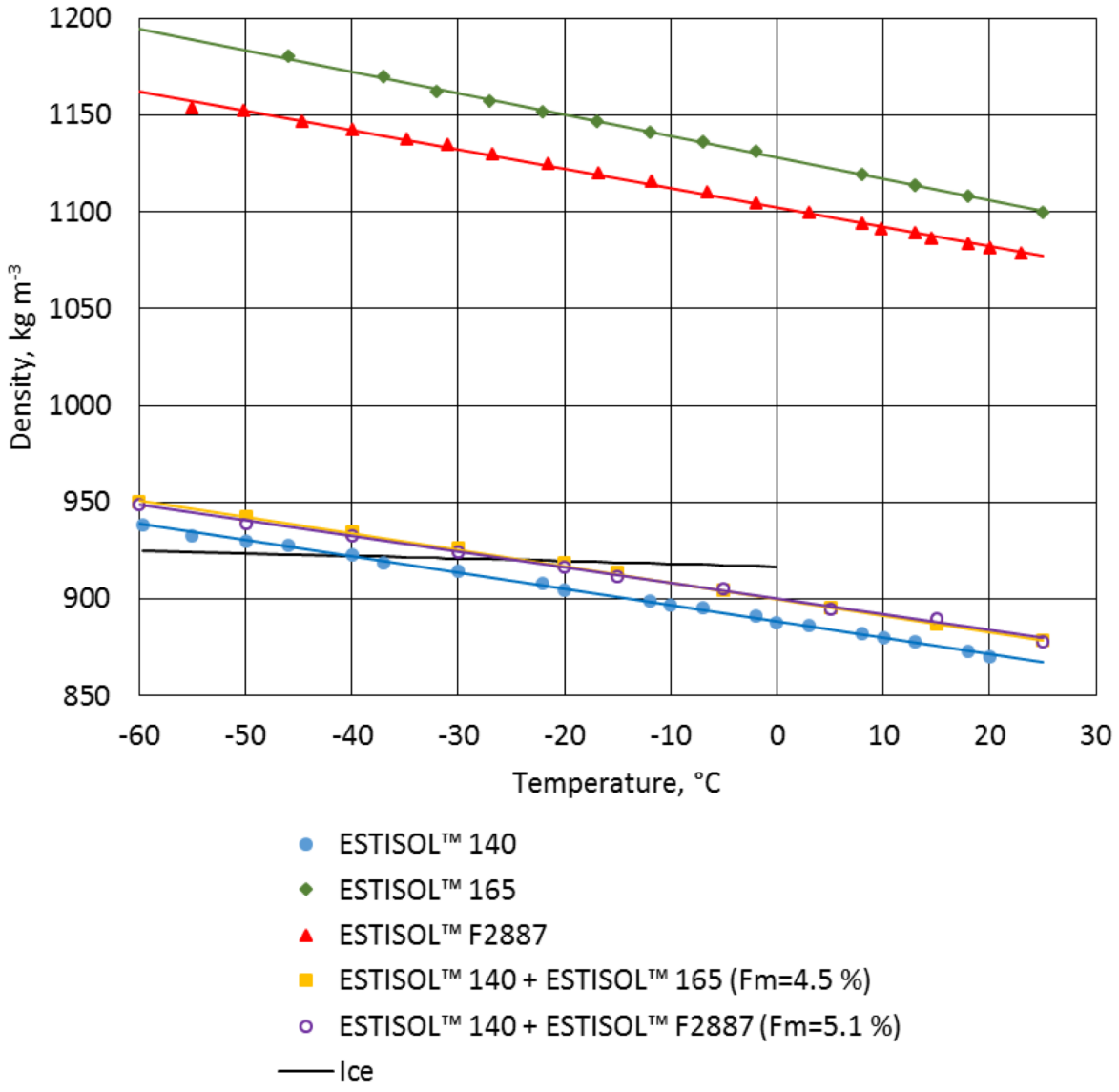


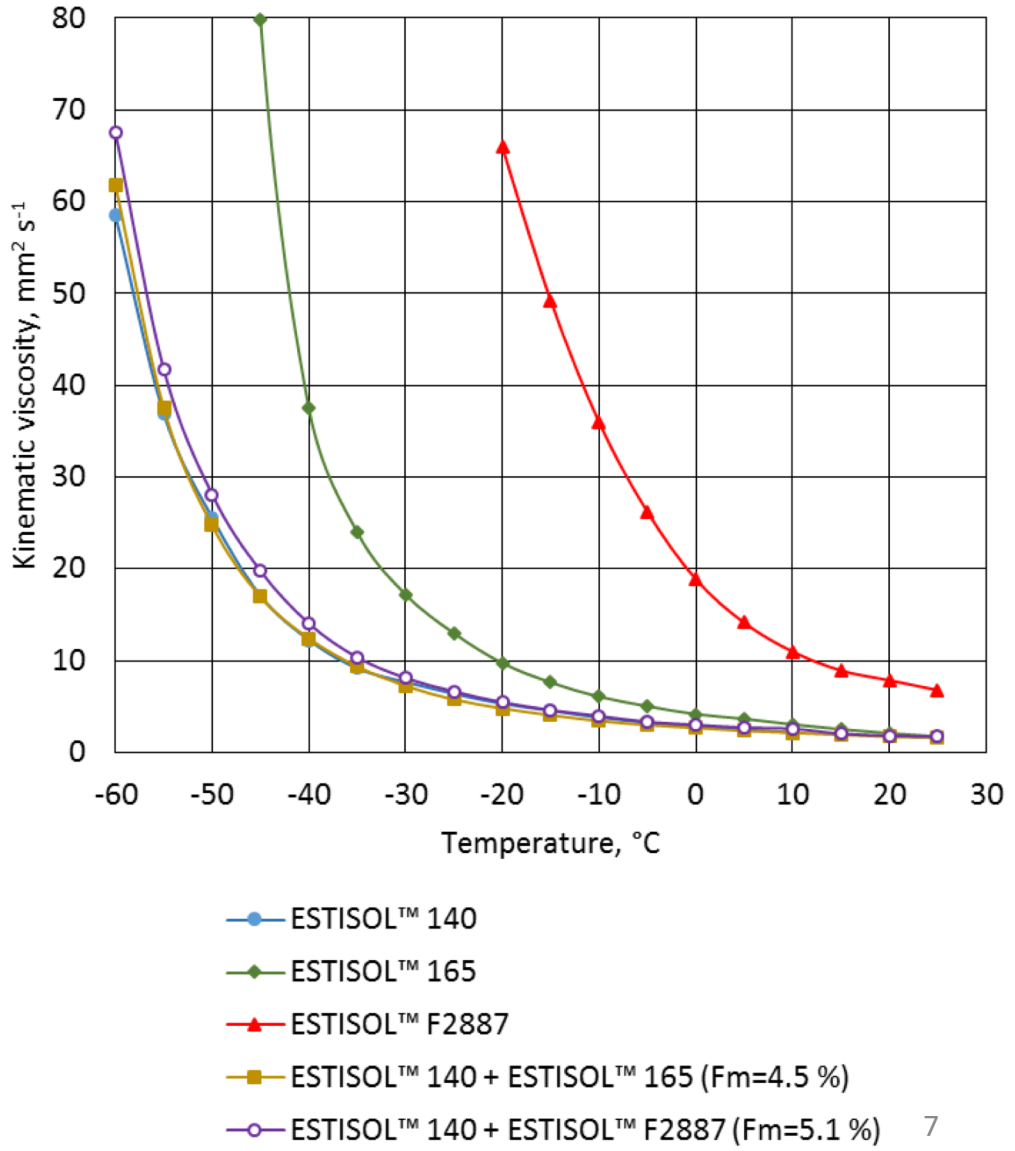
While ESTISOL™ 140 involves some issues

- high viscosity,
- strong odor,
- health hazards,
- negative effects on many elastomers and plastic materials,
- convective problems with temperature logging

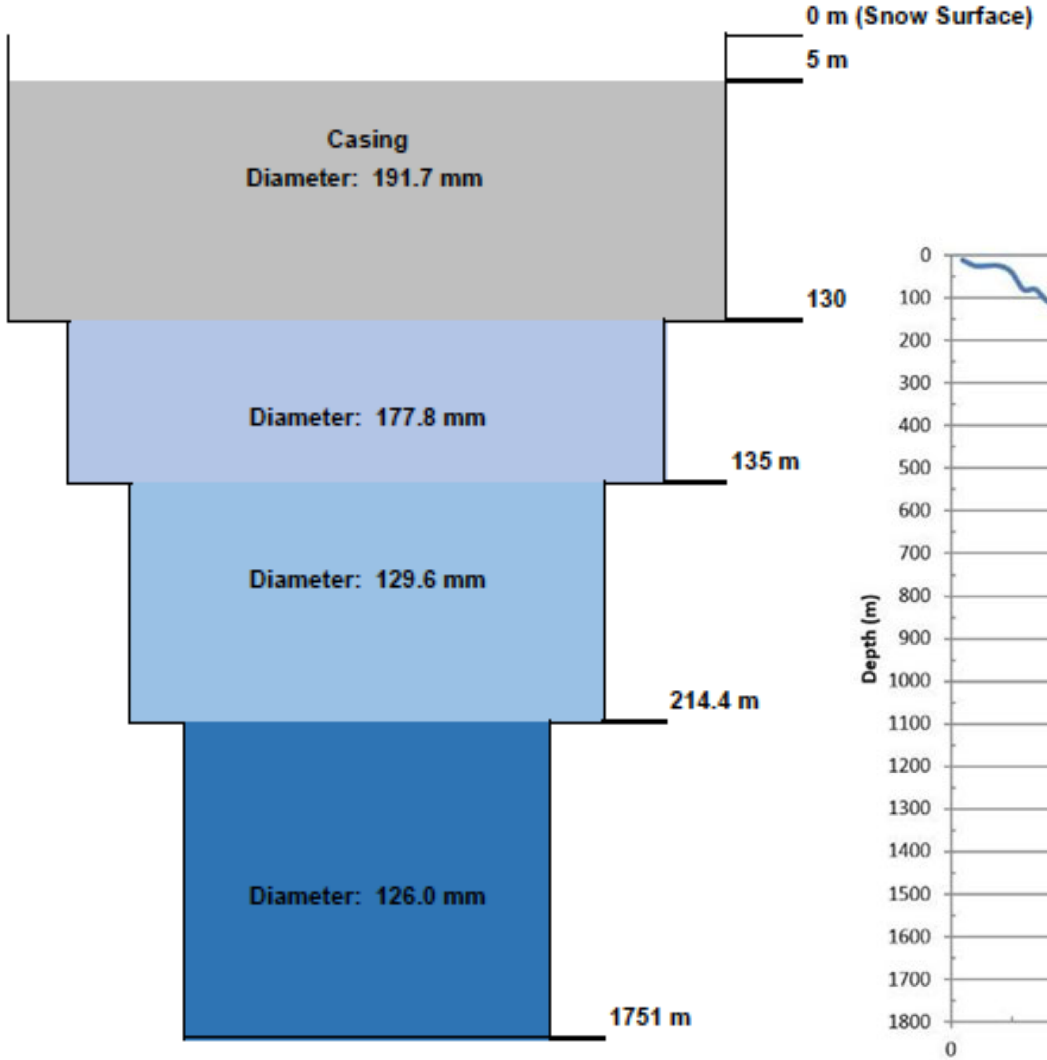
it will likely be used for future drilling projects until a better fluid is identified.

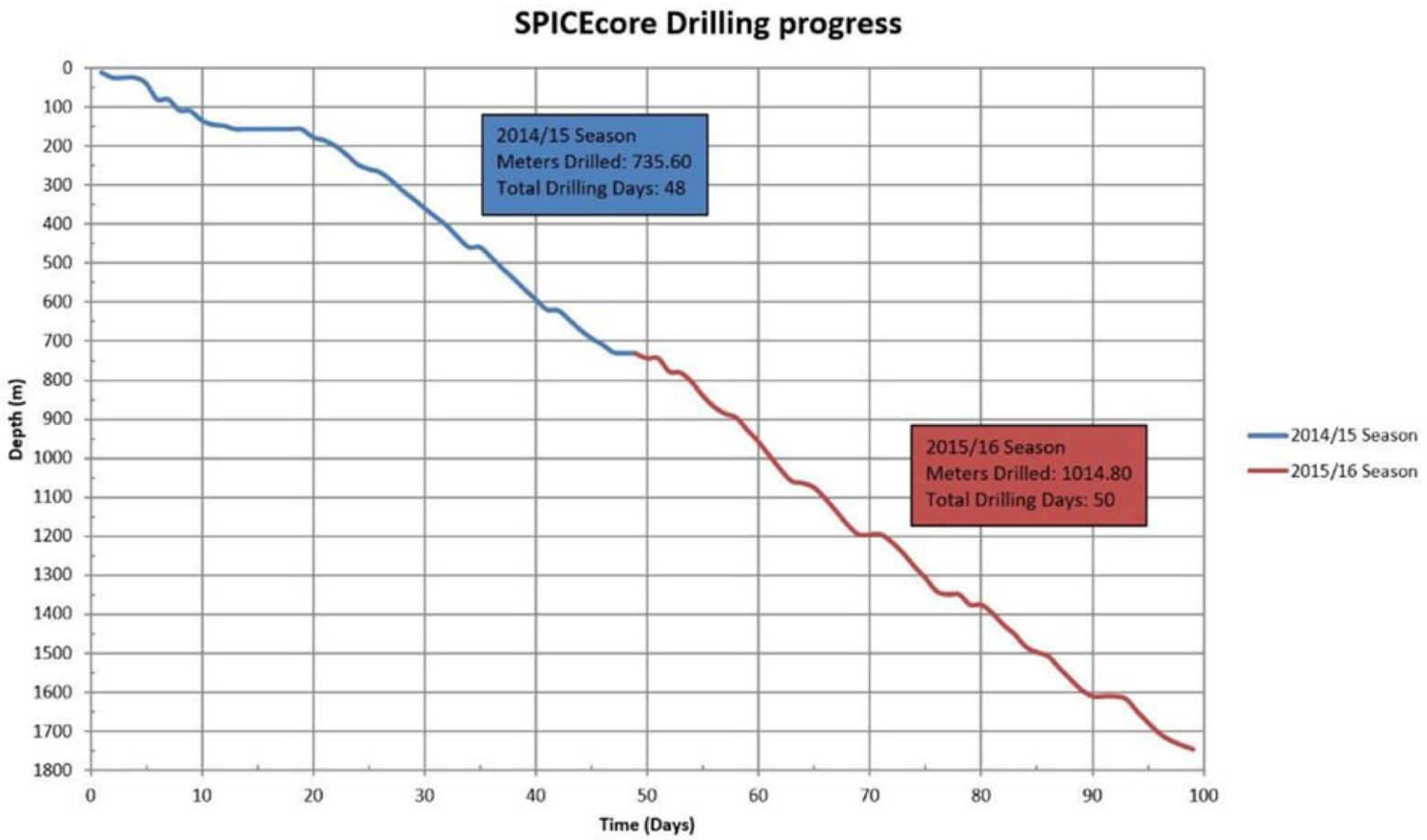
ESTISOL™-140 properties





SPICEcore borehole





Credit: J. Johnson

Initial parameters

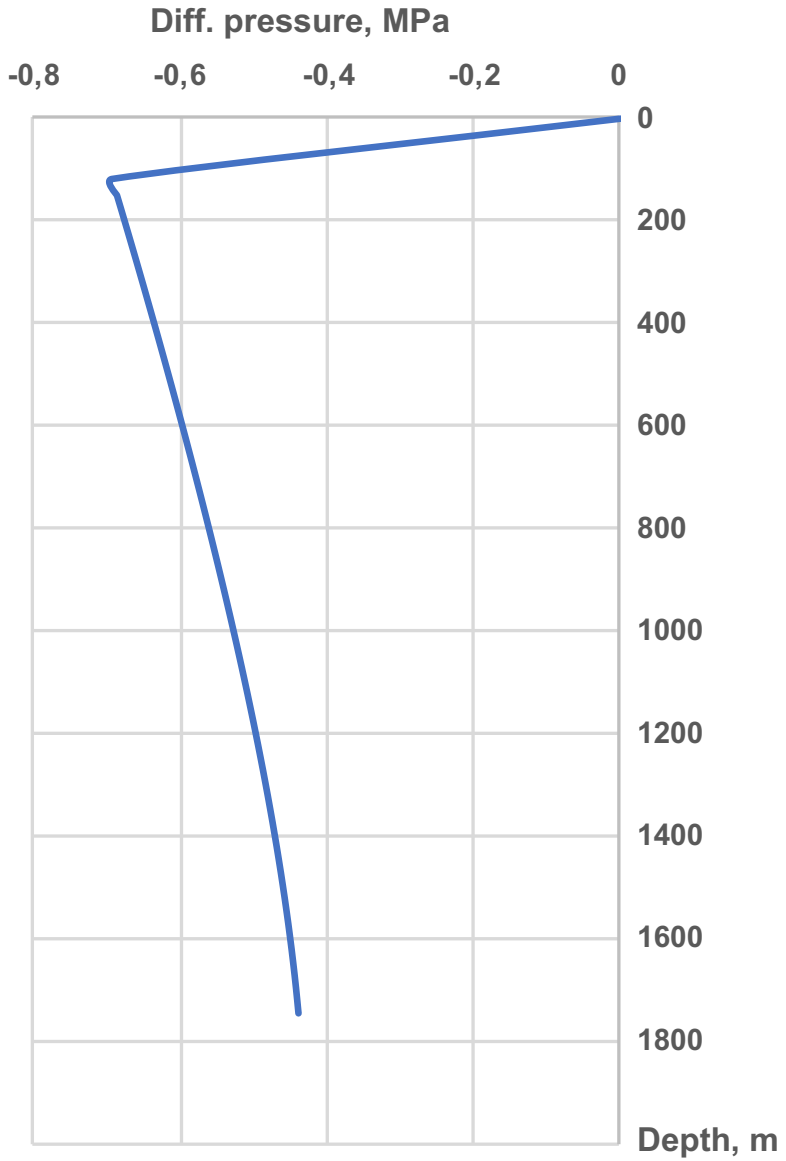
- **Temperature distribution from AMANDA and IceCube measurements**

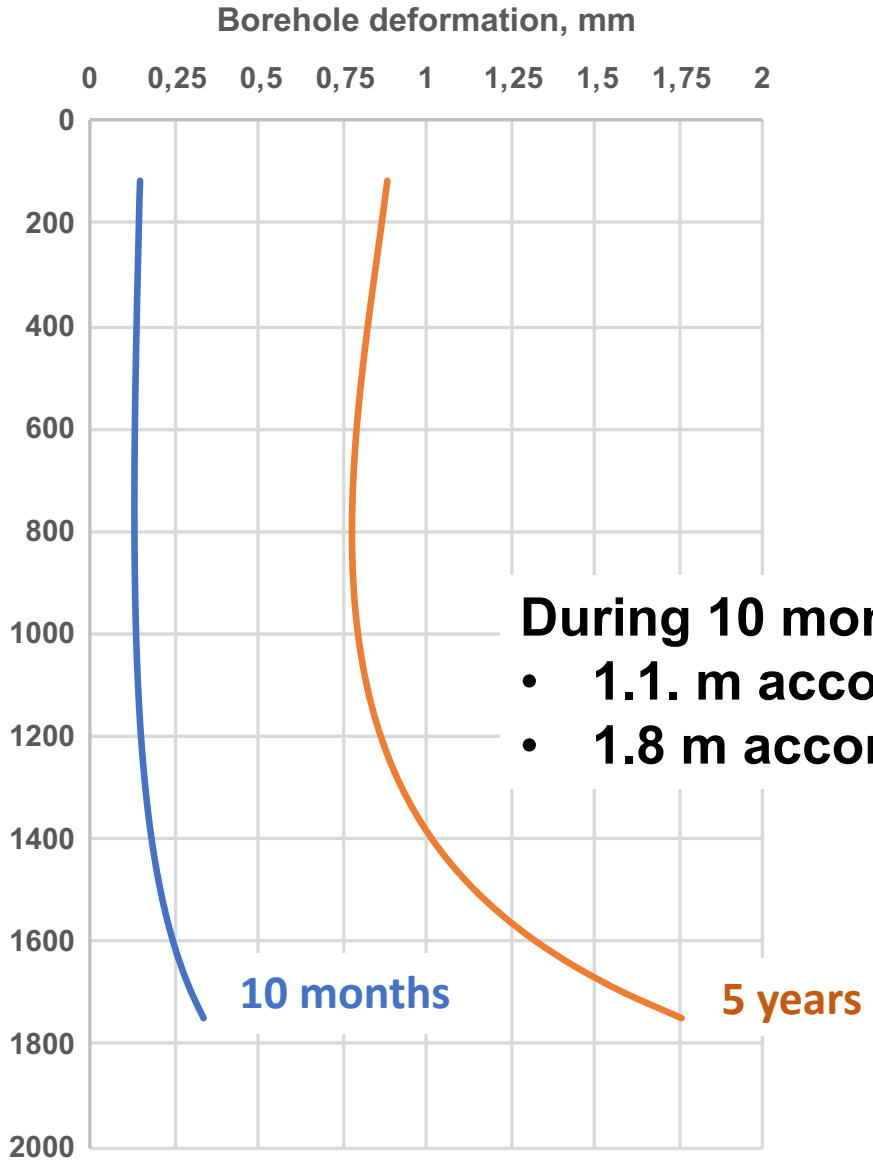
$$T = -52.885 + 6.049 \times 10^{-3} z - 1.841 \times 10^{-6} z^2 + 2.417 \times 10^{-9} z^3;$$

$$R^2 = 0.997.$$

- ***k*** **= 1**
- **Initial borehole diameter 126 mm**
- **LL = 118 m**
- **Firn correction 41 m**
- **Density of ice 920 kg m^{-3}**
- **Drilling fluid compressibility 1.01**

Estimation results

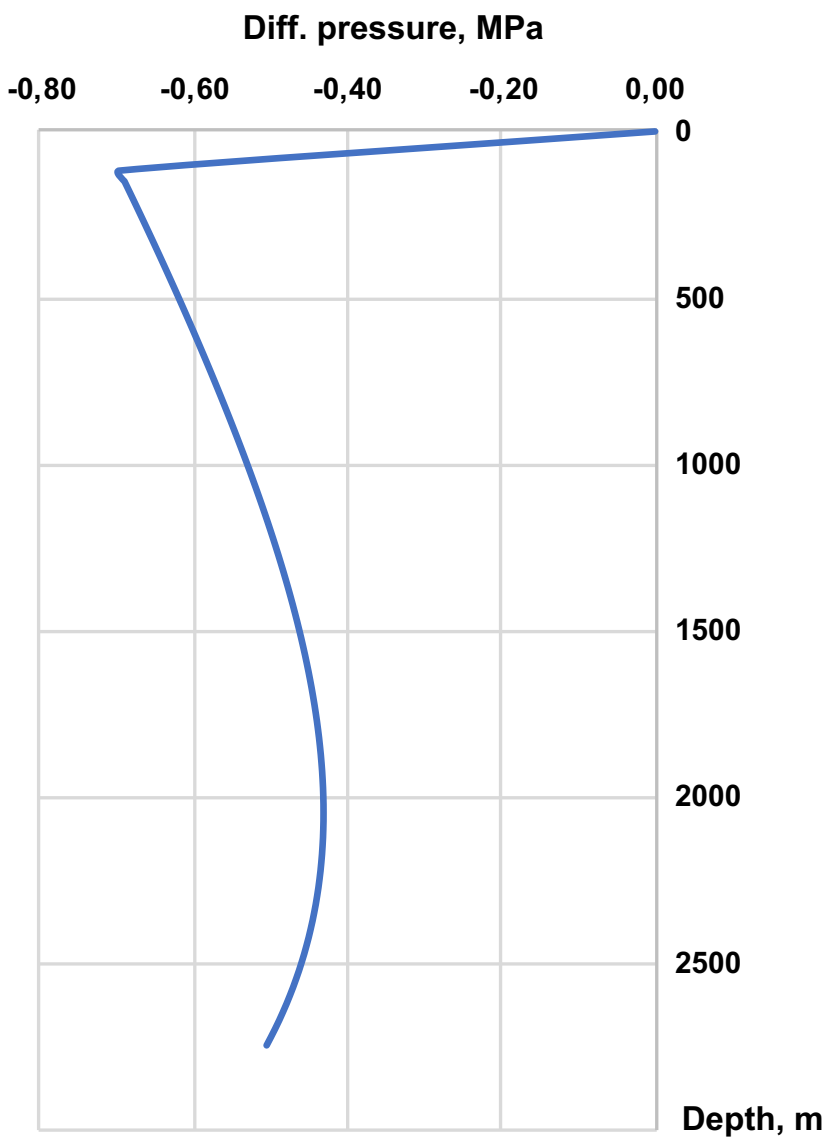


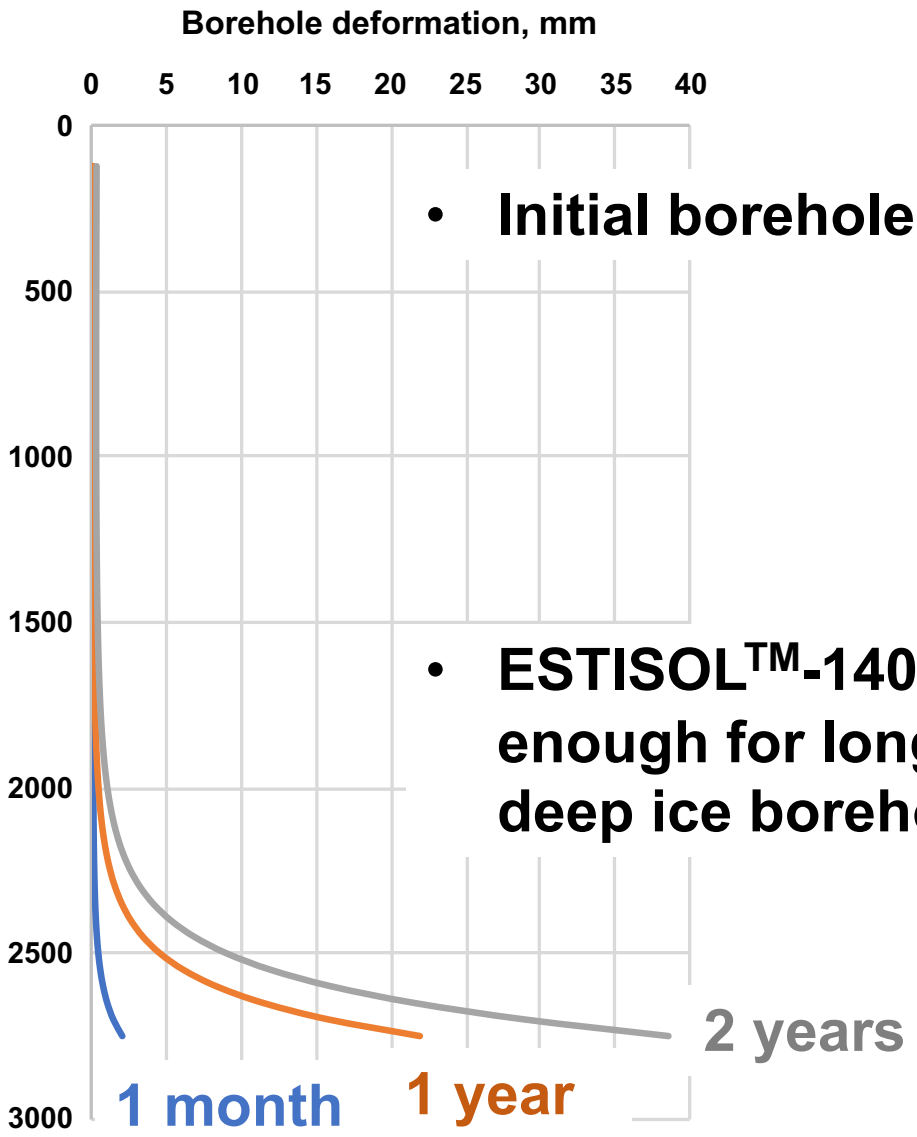


During 10 months LL raised on:

- **1.1. m according to measurements**
- **1.8 m according to estimations**

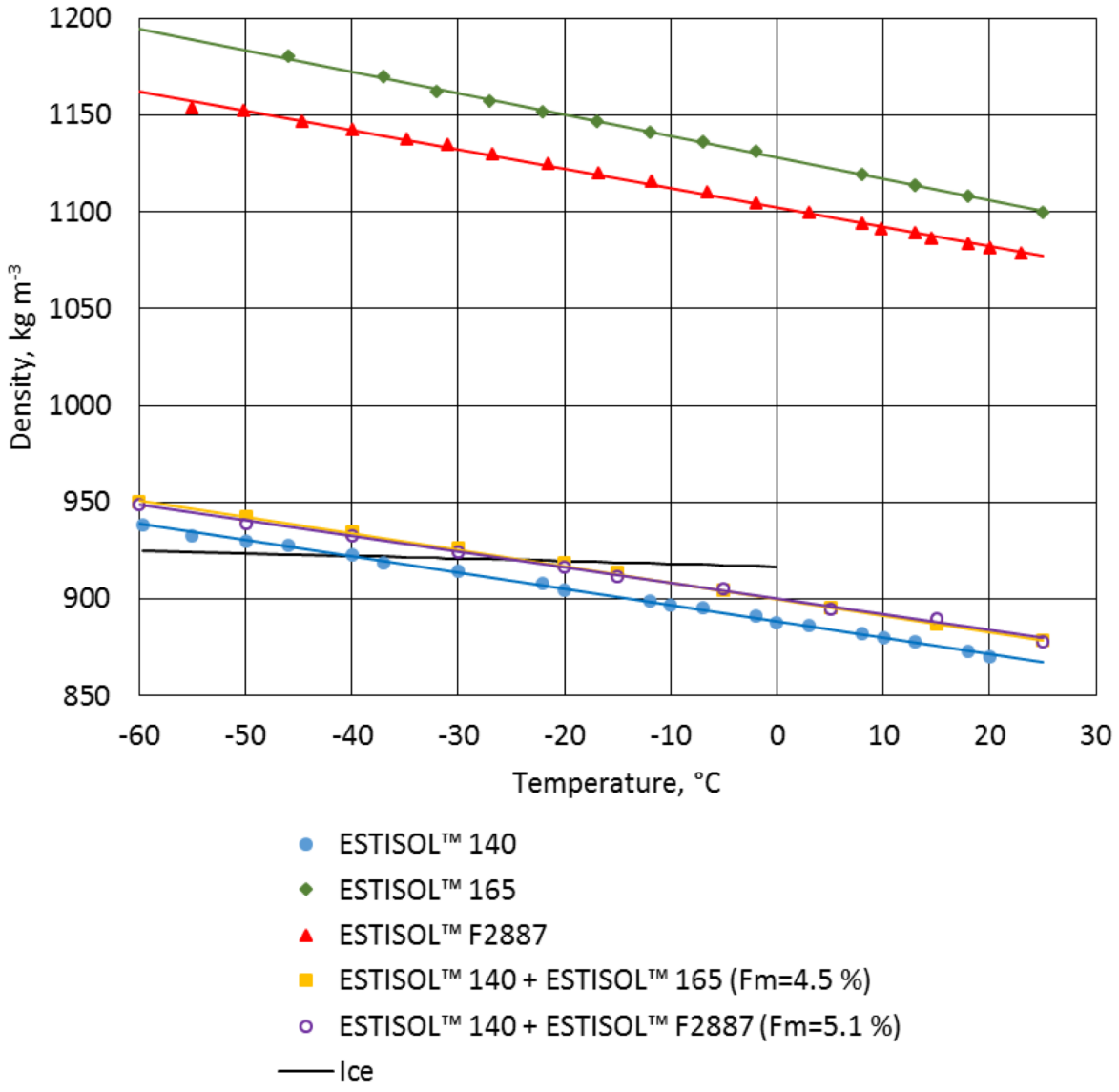
RAID borehole

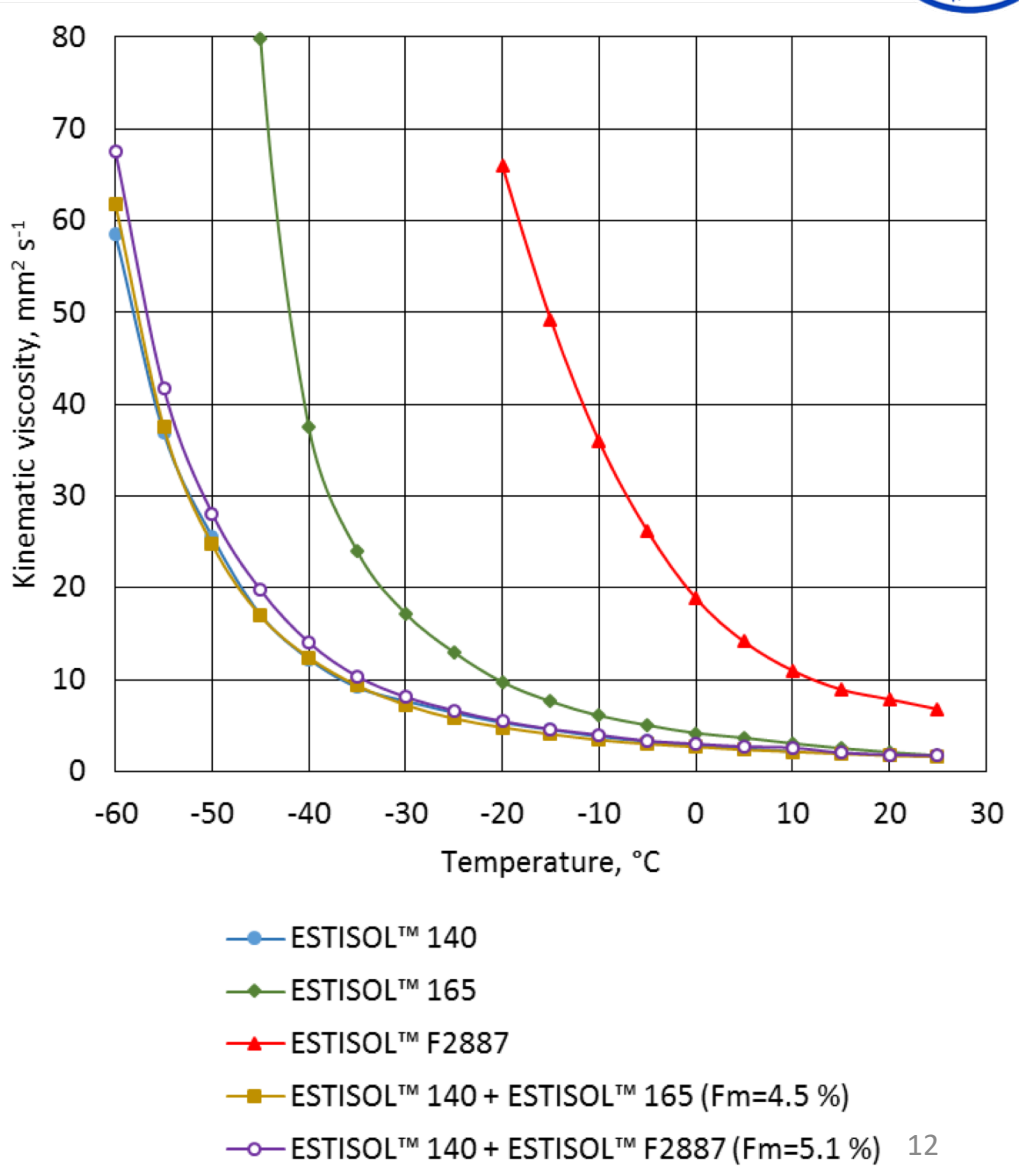




- Initial borehole diameter 88.9 mm
- ESTISOL^{TM}-140 density is not enough for long-term stability of deep ice boreholes

ESTISOL™-140 + Densifiers





Thanks for your attention

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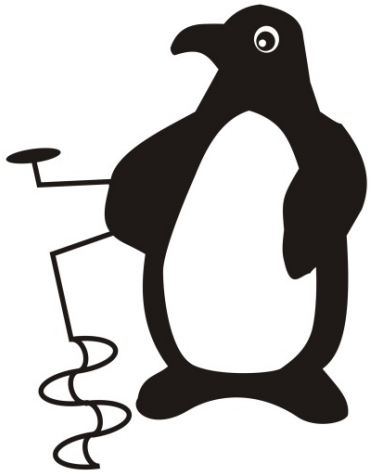

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