



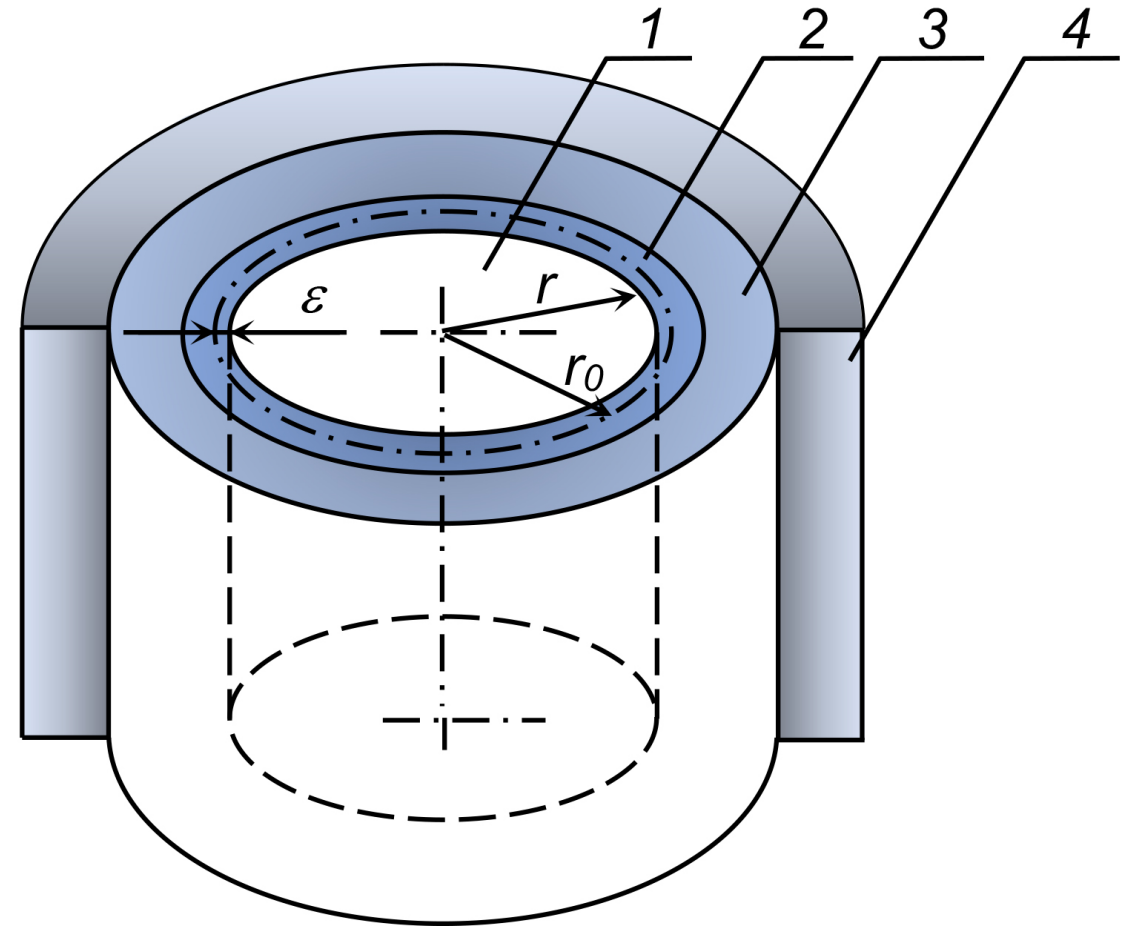
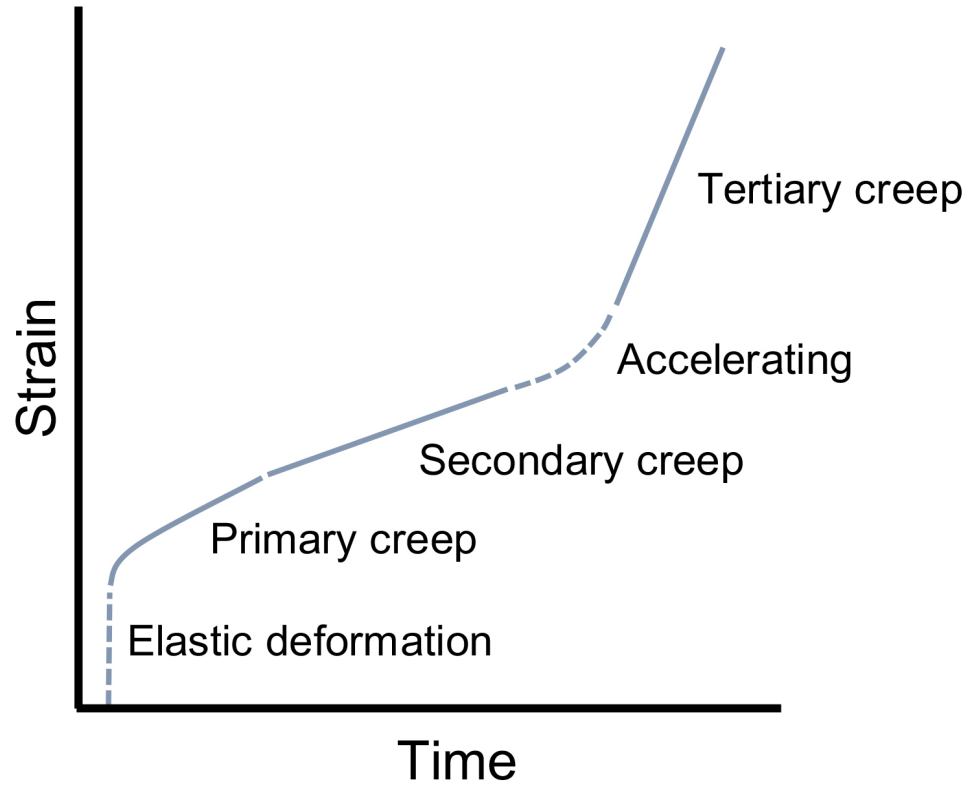
LONG-TERM STABILITY OF DEEP BOREHOLES IN ICE FILLED WITH ESTISOL™-140 DRILLING FLUID

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Ice creep



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

Annals of Glaciology 47 2007

Closure of deep boreholes in ice sheets: a discussion

P.G. TALALAY,¹ Roger LeB. HOOKE²

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

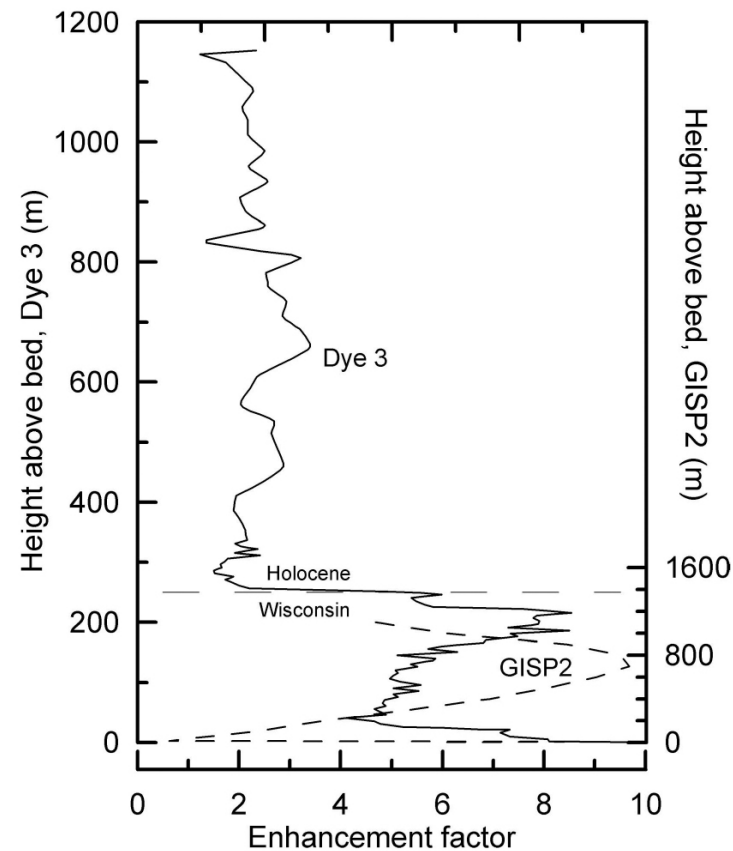
Cold Regions Science and Technology 98 (2014) 47–54

Deformation of ice boreholes



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

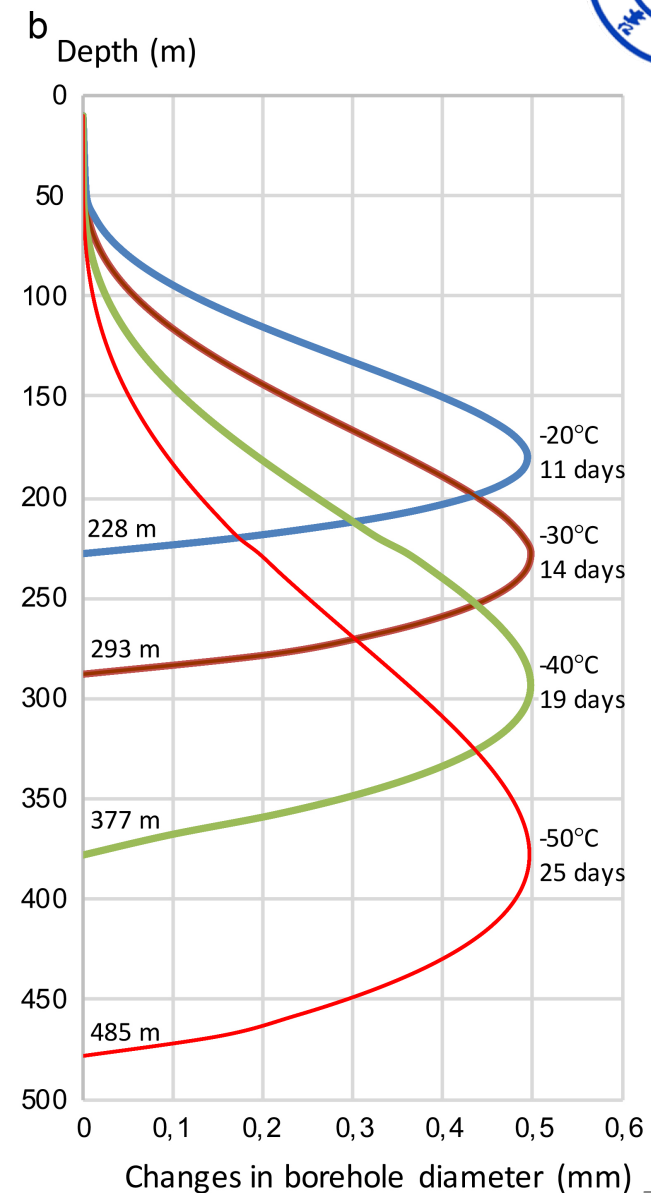
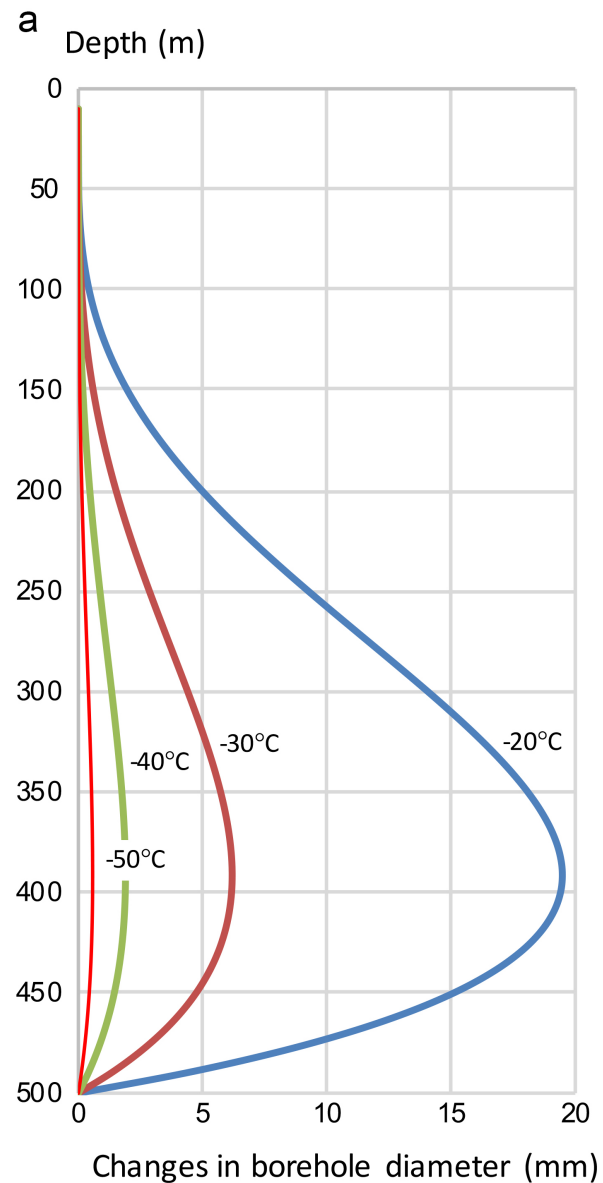
where r , r_0 , D and D_0 in [m]; t in [$^{\circ}\text{C}$]; $\Delta P(z)$ in [Pa]; ΔT in [years].



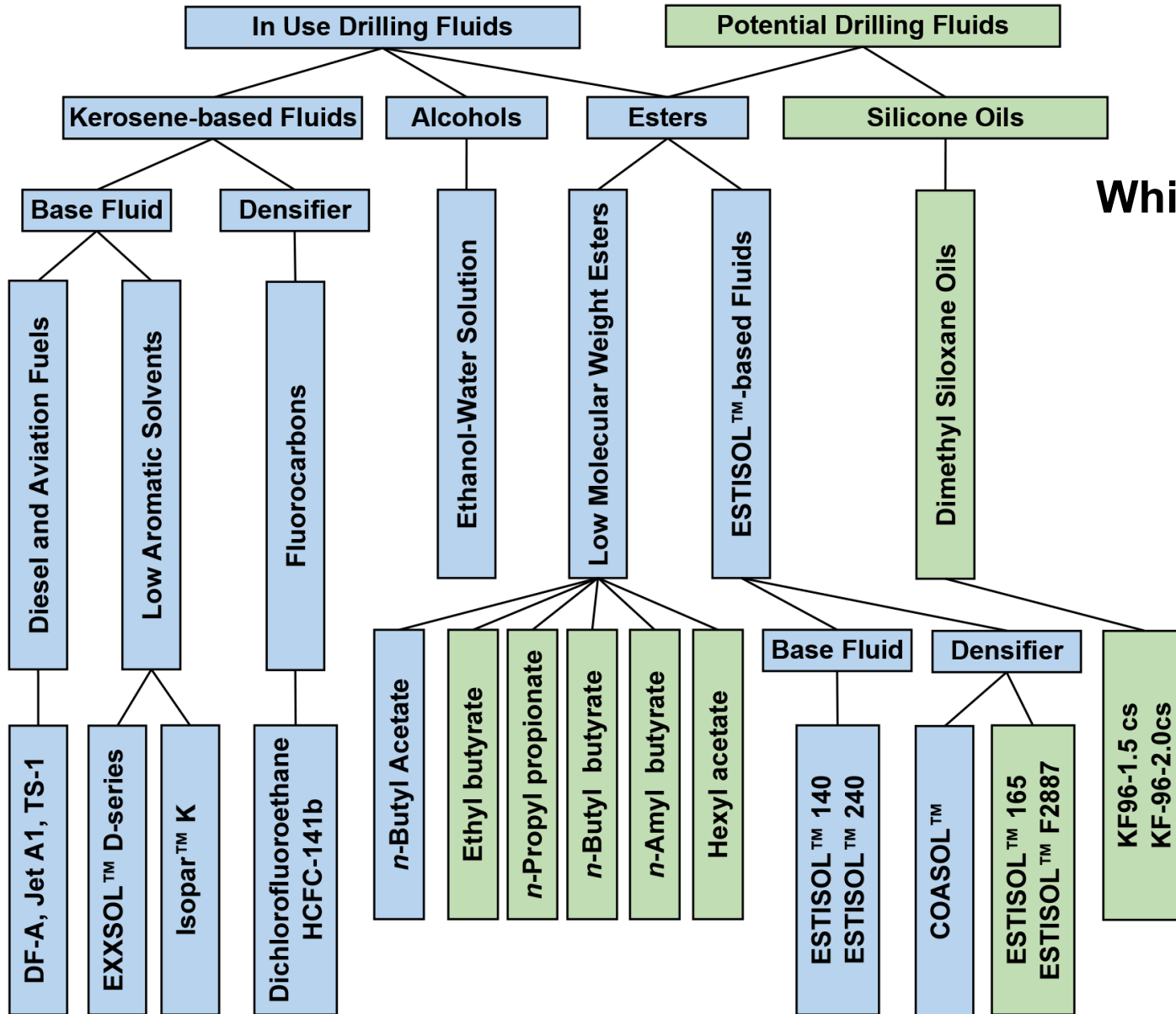
Deformation of "dry" ice boreholes



(a) final depth of 500-m
(b) maximal change in the borehole diameter of 0.5 mm



Drilling fluids

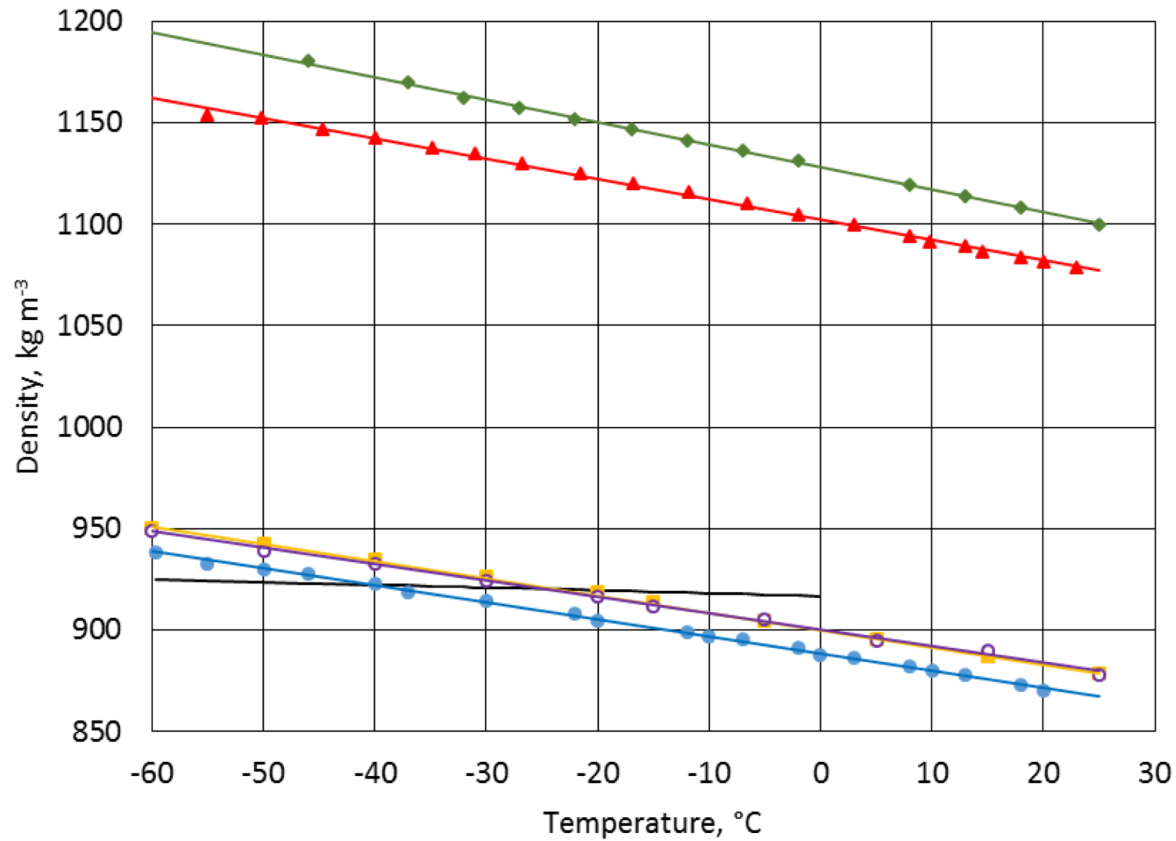


While ESTISOL™ 140 involves some issues

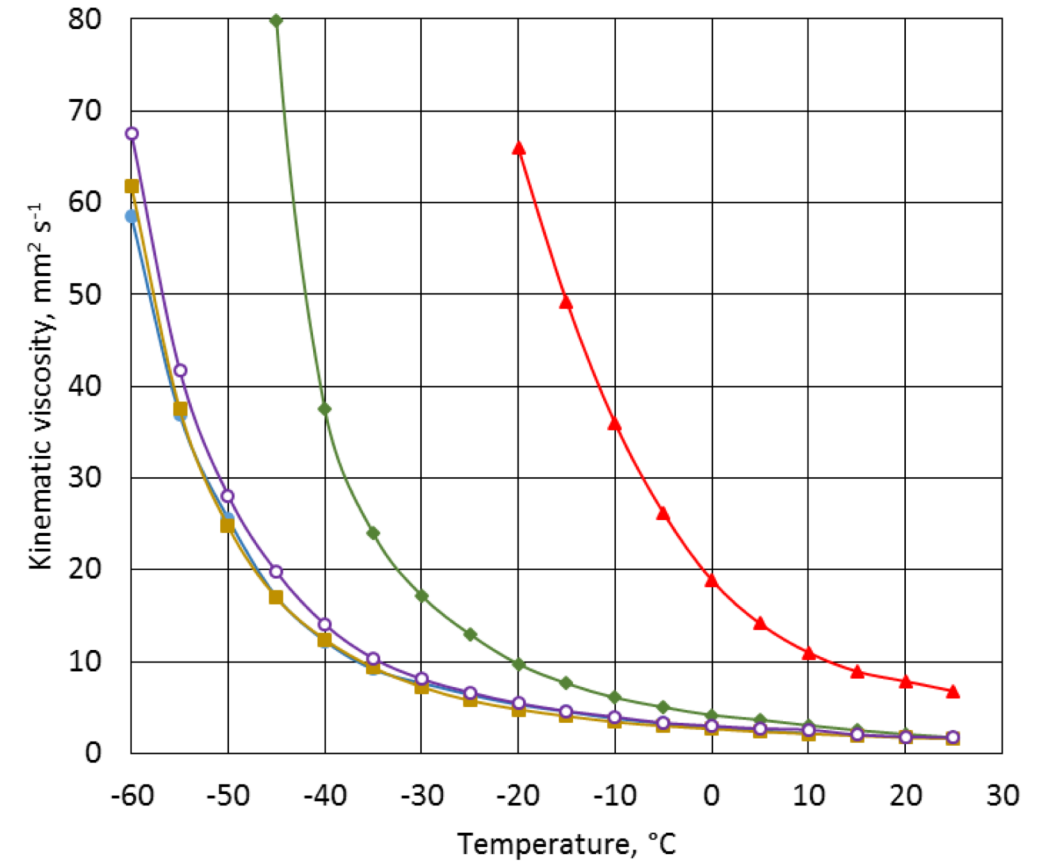
- high viscosity,
- strong odor,
- health hazards,
- negative effects on many elastomers and plastic materials,
- convective problems with temperature logging

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

ESTISOL™-140 properties

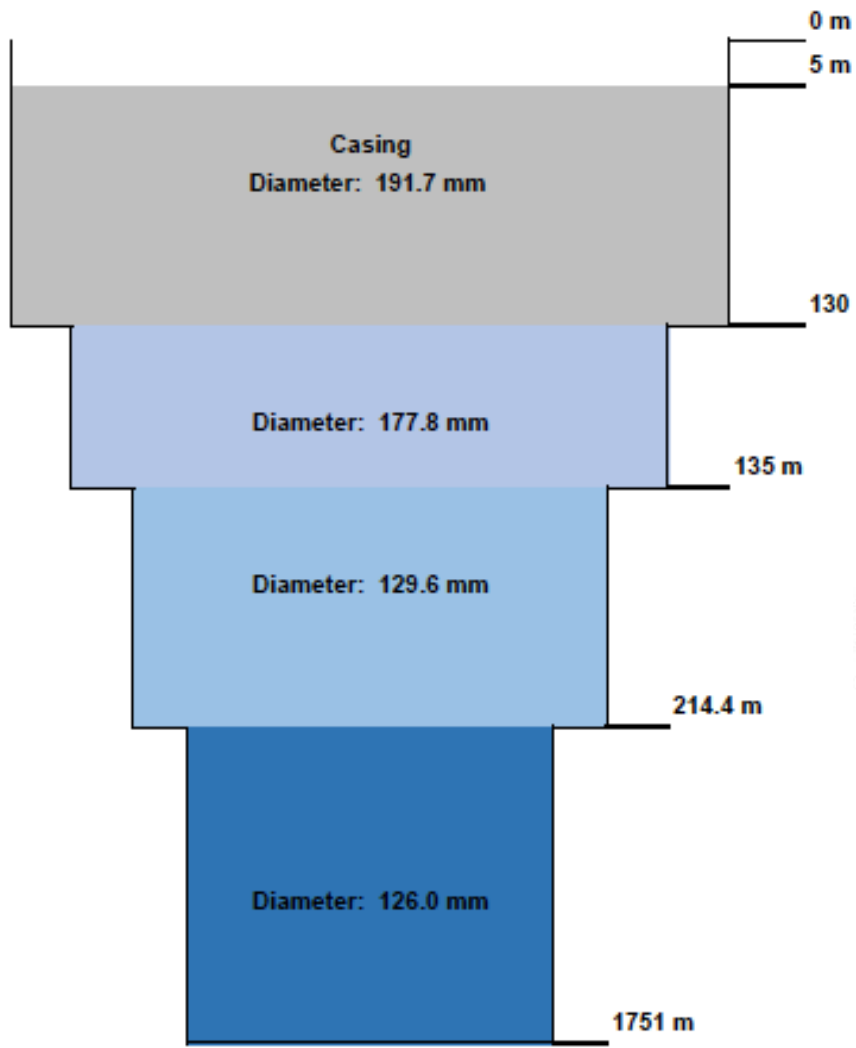


- ESTISOL™ 140
- ◆ ESTISOL™ 165
- ▲ ESTISOL™ F2887
- ESTISOL™ 140 + ESTISOL™ 165 (Fm=4.5%)
- ESTISOL™ 140 + ESTISOL™ F2887 (Fm=5.1%)
- Ice

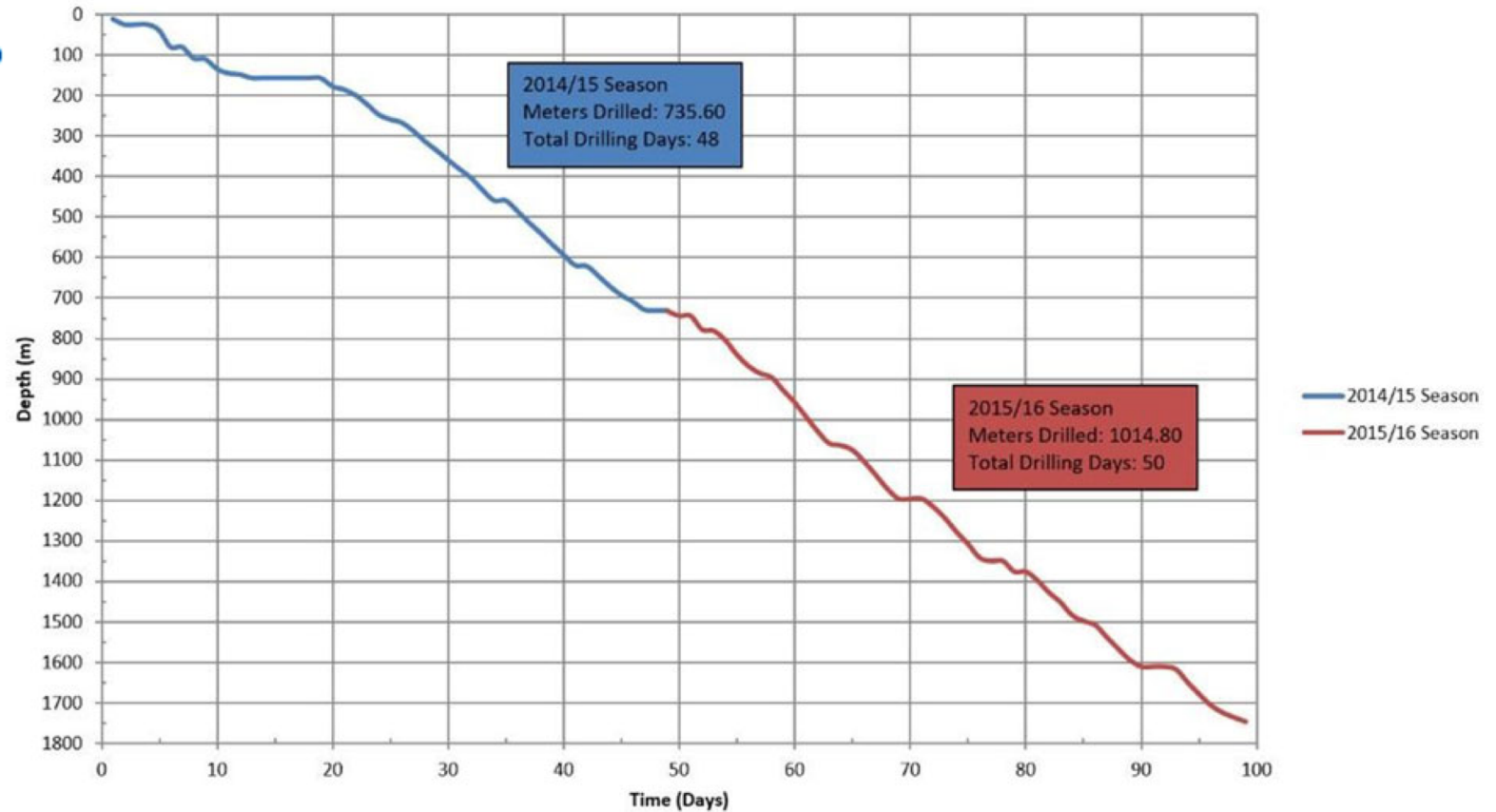


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SPICEcore borehole



SPICEcore Drilling progress



Credit: J. Johnson

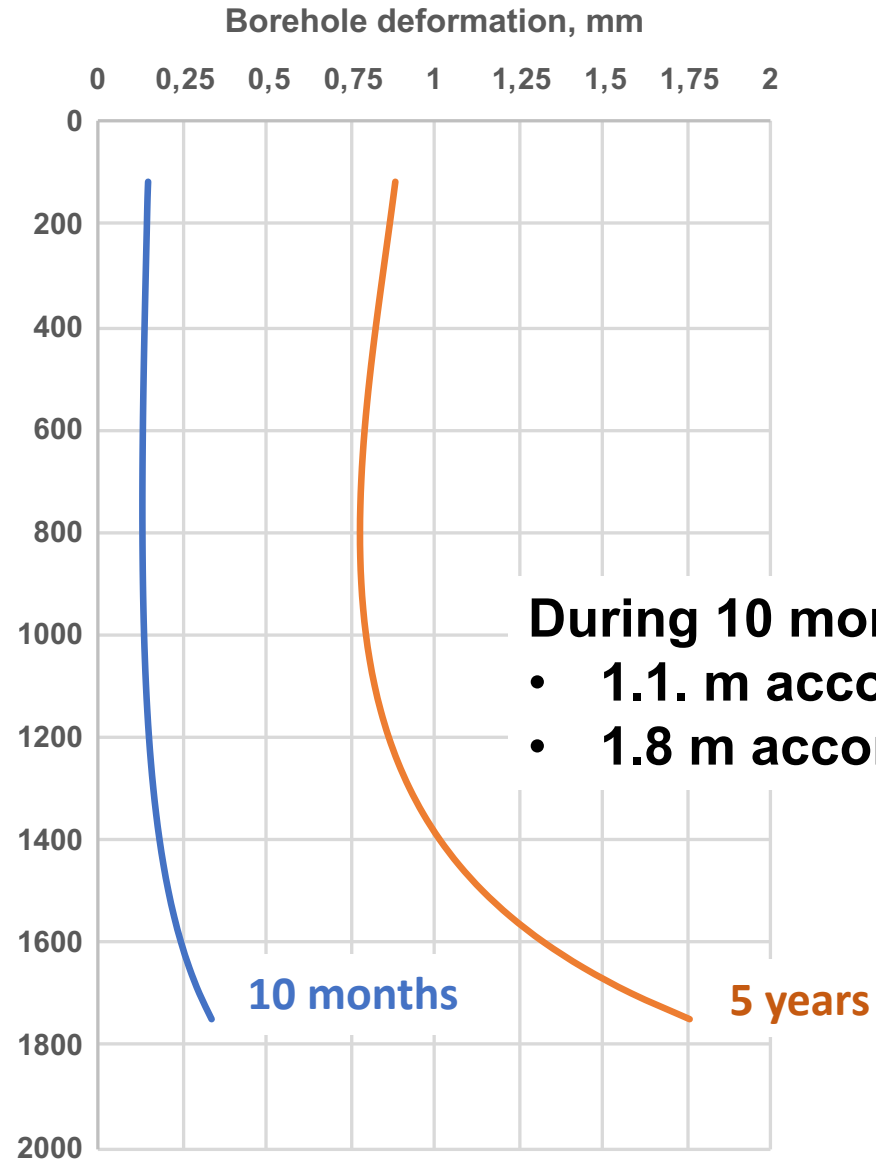
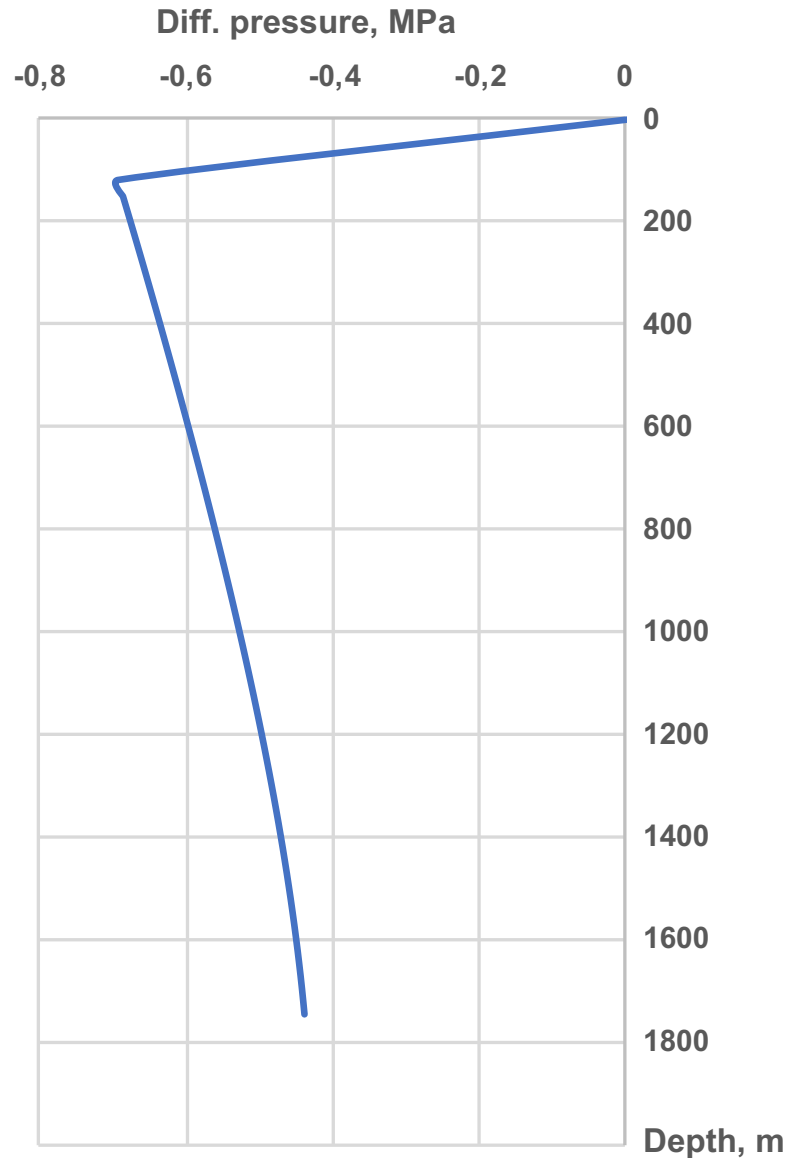
- **Temperature distribution from AMANDA and IceCube measurements**

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

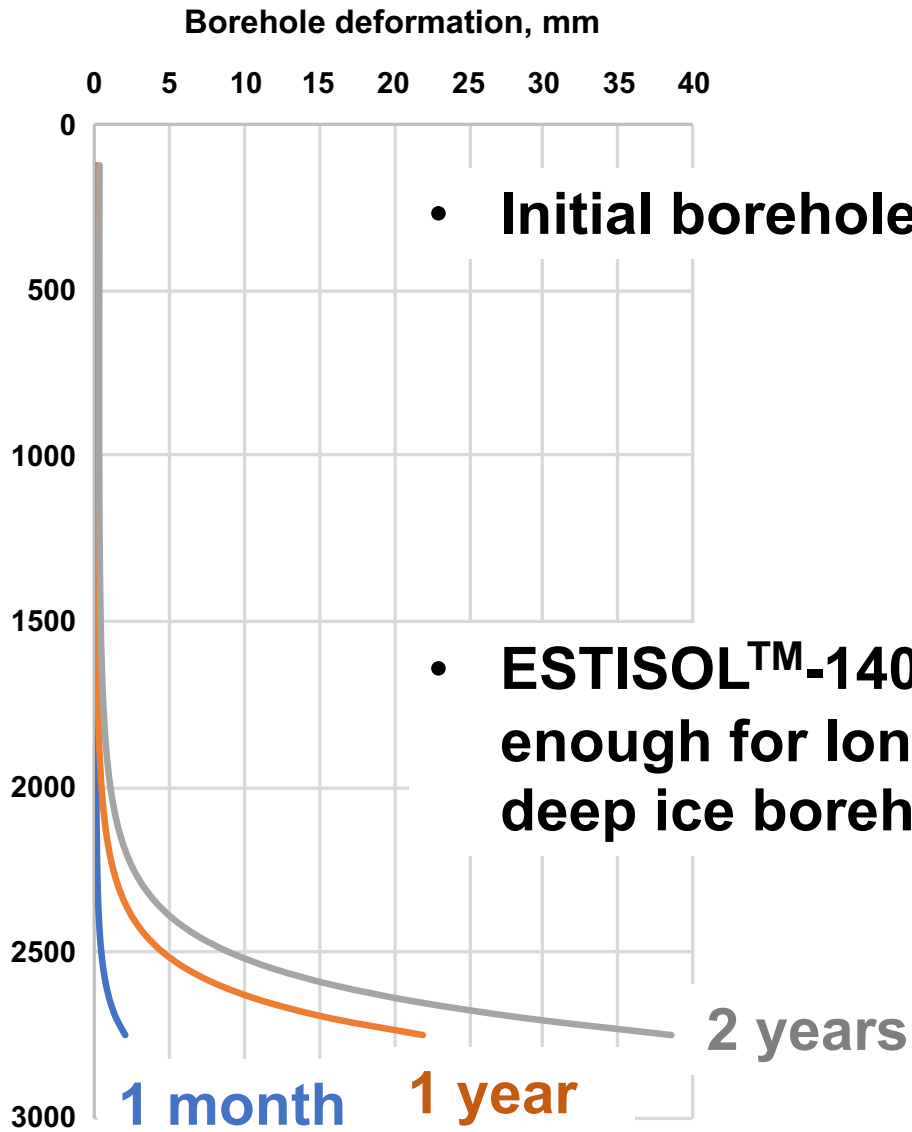
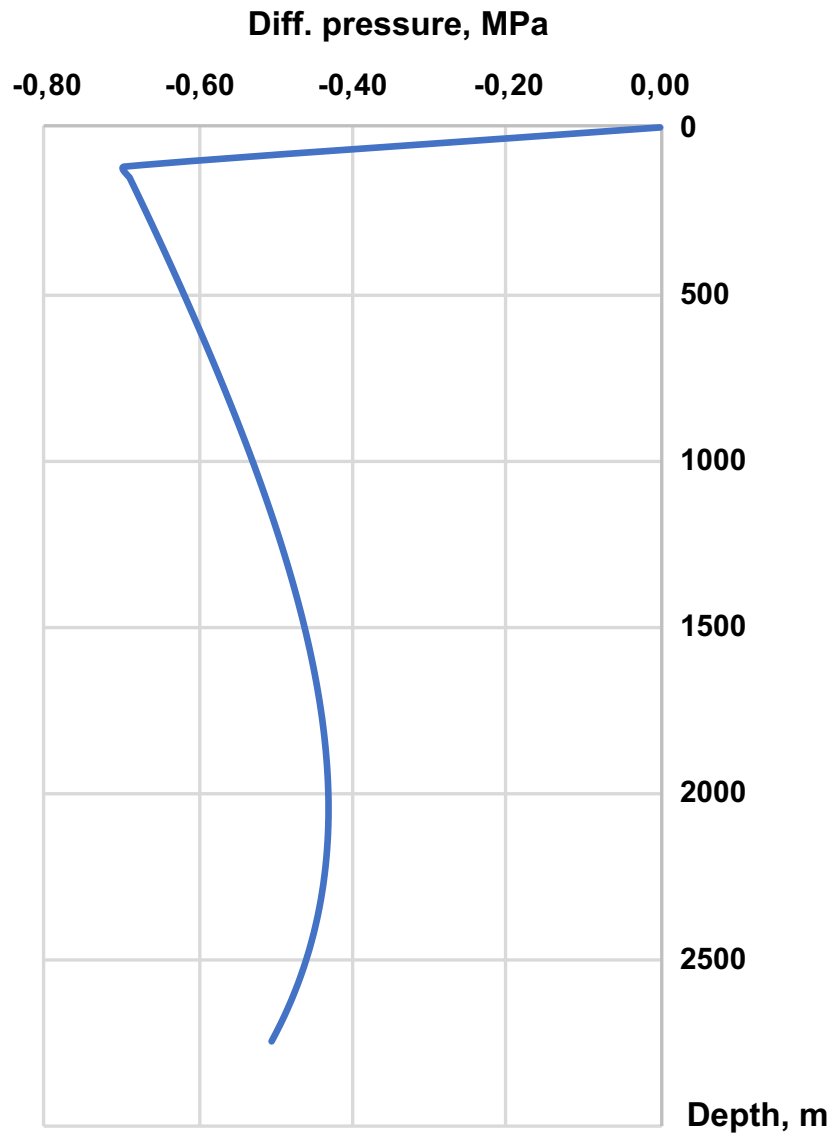
$$R^2 = 0.997.$$

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

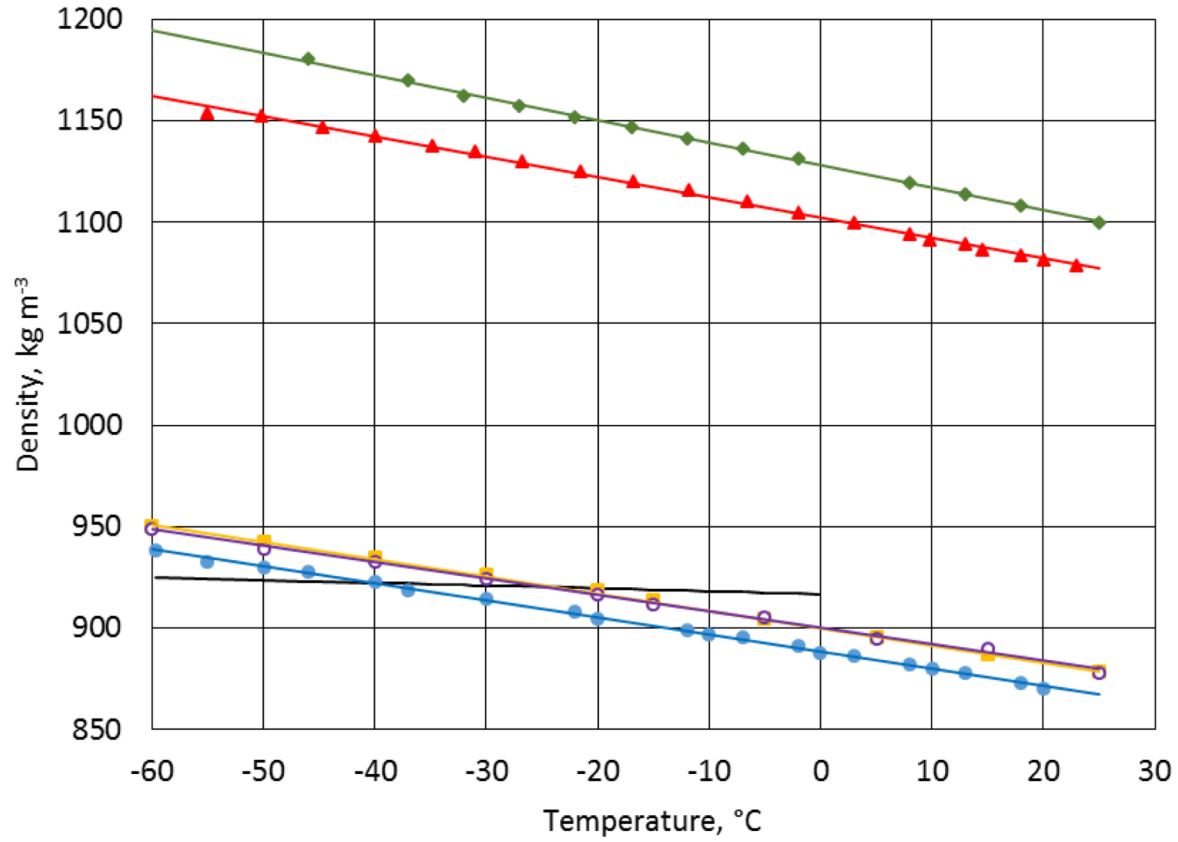
Estimation results



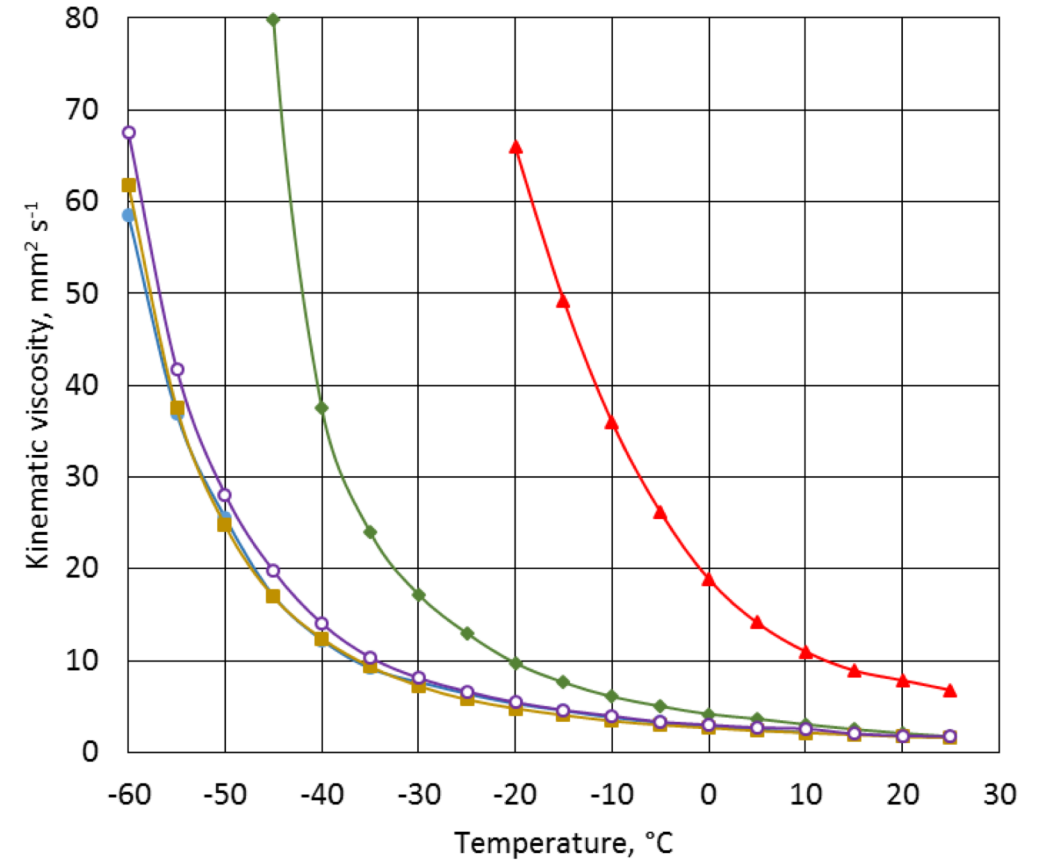
RAID borehole



ESTISOL™-140 + Densifiers



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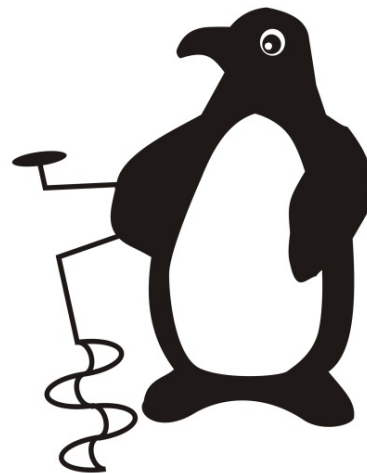


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Thanks for your attention



Polar Research
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吉林大学