

The banner features a diagram of the IceCube detector, which consists of a central vertical column surrounded by a hexagonal grid of smaller vertical tubes. To the right of the diagram, the ICECUBE logo is displayed, followed by the text "IceCube Polar Science Workshop". Below this, the event details are listed: "STARTS: 19 JAN 2021, 15:00 CET" and "ENDS: 20 JAN 2021, 20:30 CET". At the bottom, the URL "EVENTS.ICECUBE.WISC.EDU/EVENT/128/" is provided.

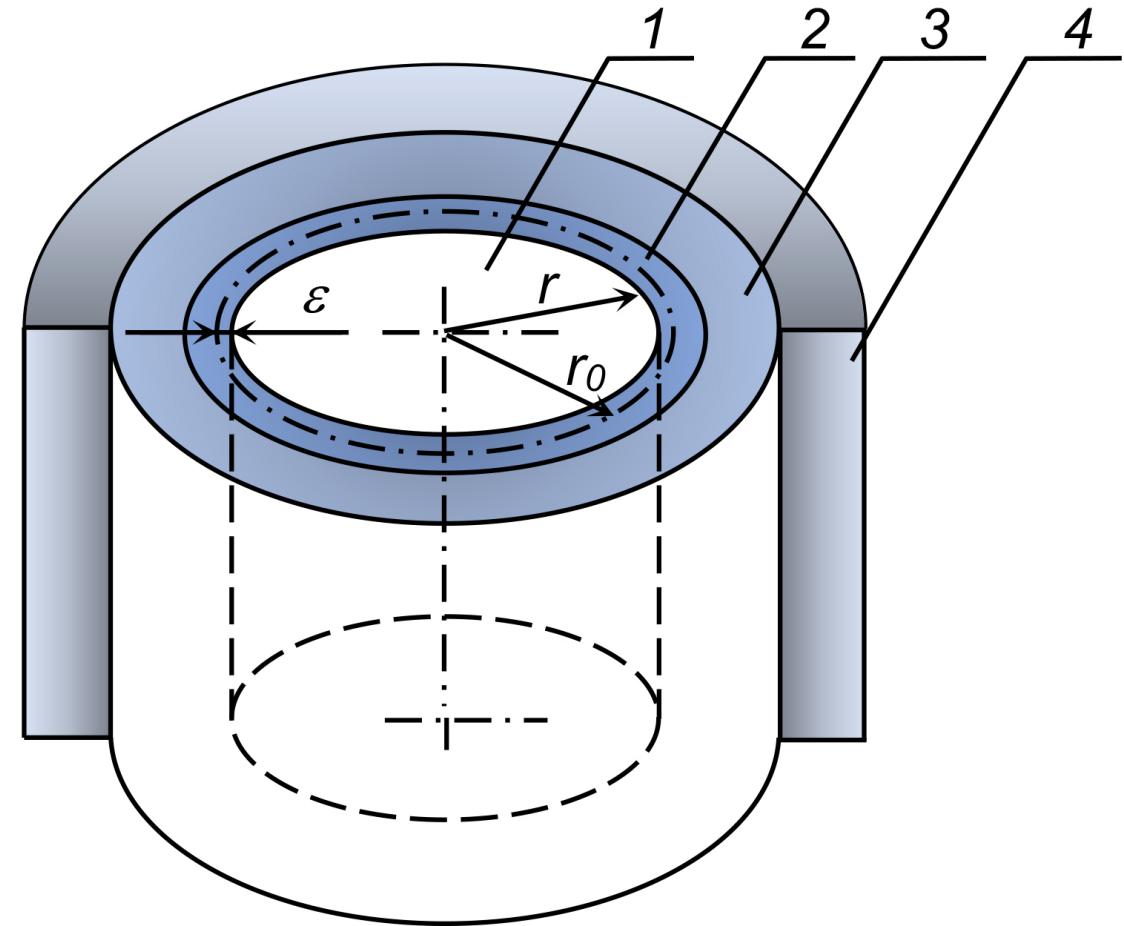
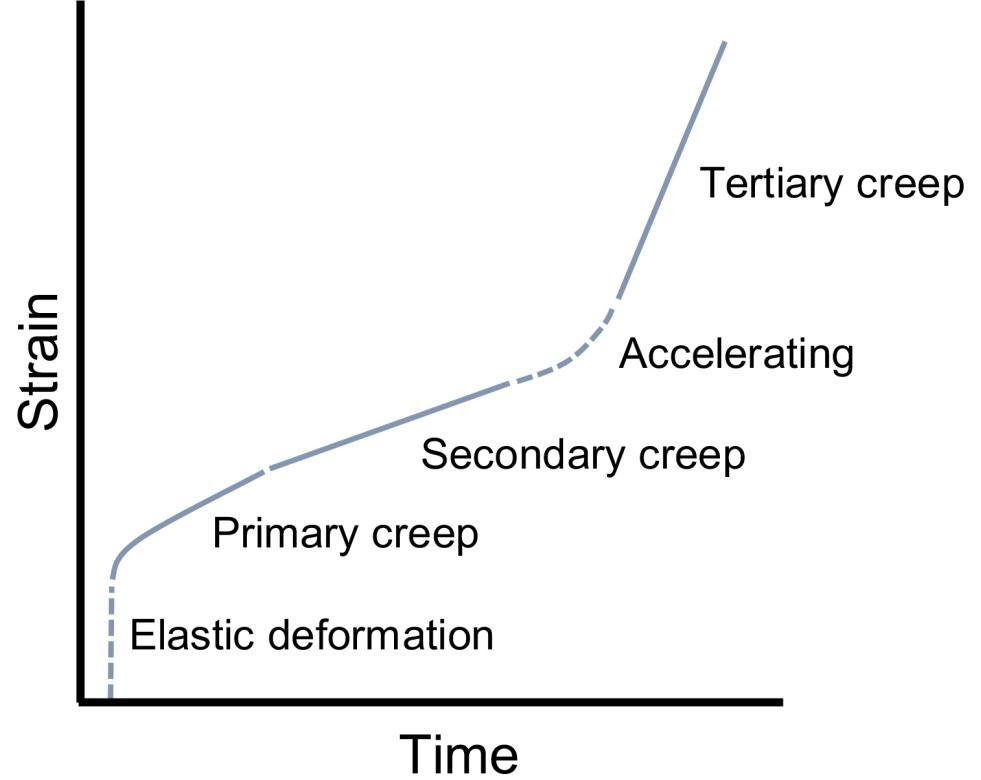
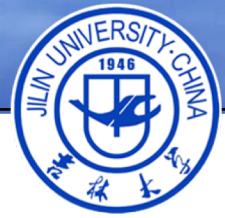
LONG-TERM STABILITY OF DEEP BOREHOLES IN ICE FILLED WITH ESTISOL™-140 DRILLING FLUID

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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

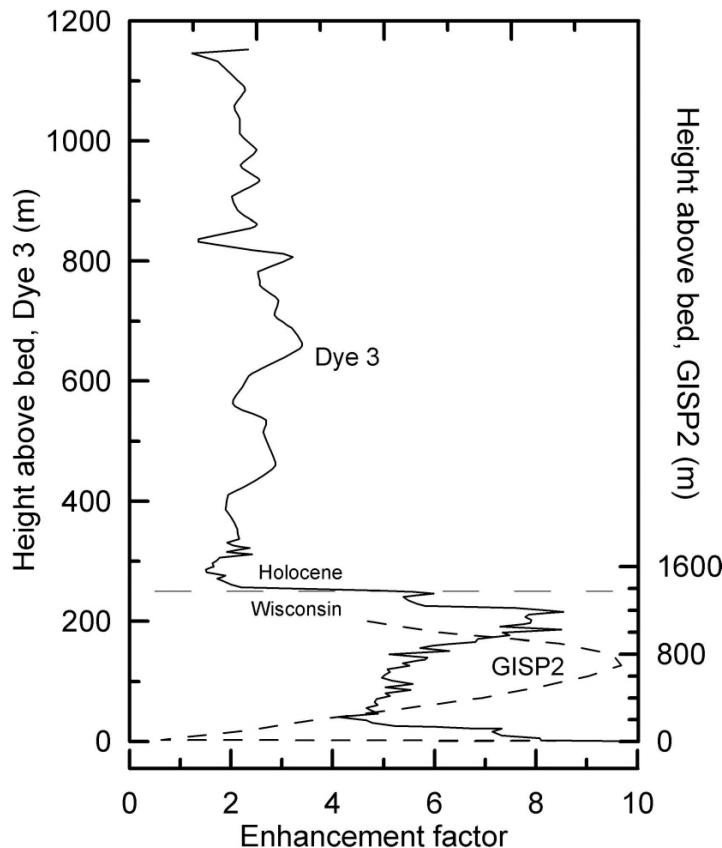
Cold Regions Science and Technology 98 (2014) 47–54

Deformation of ice boreholes



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

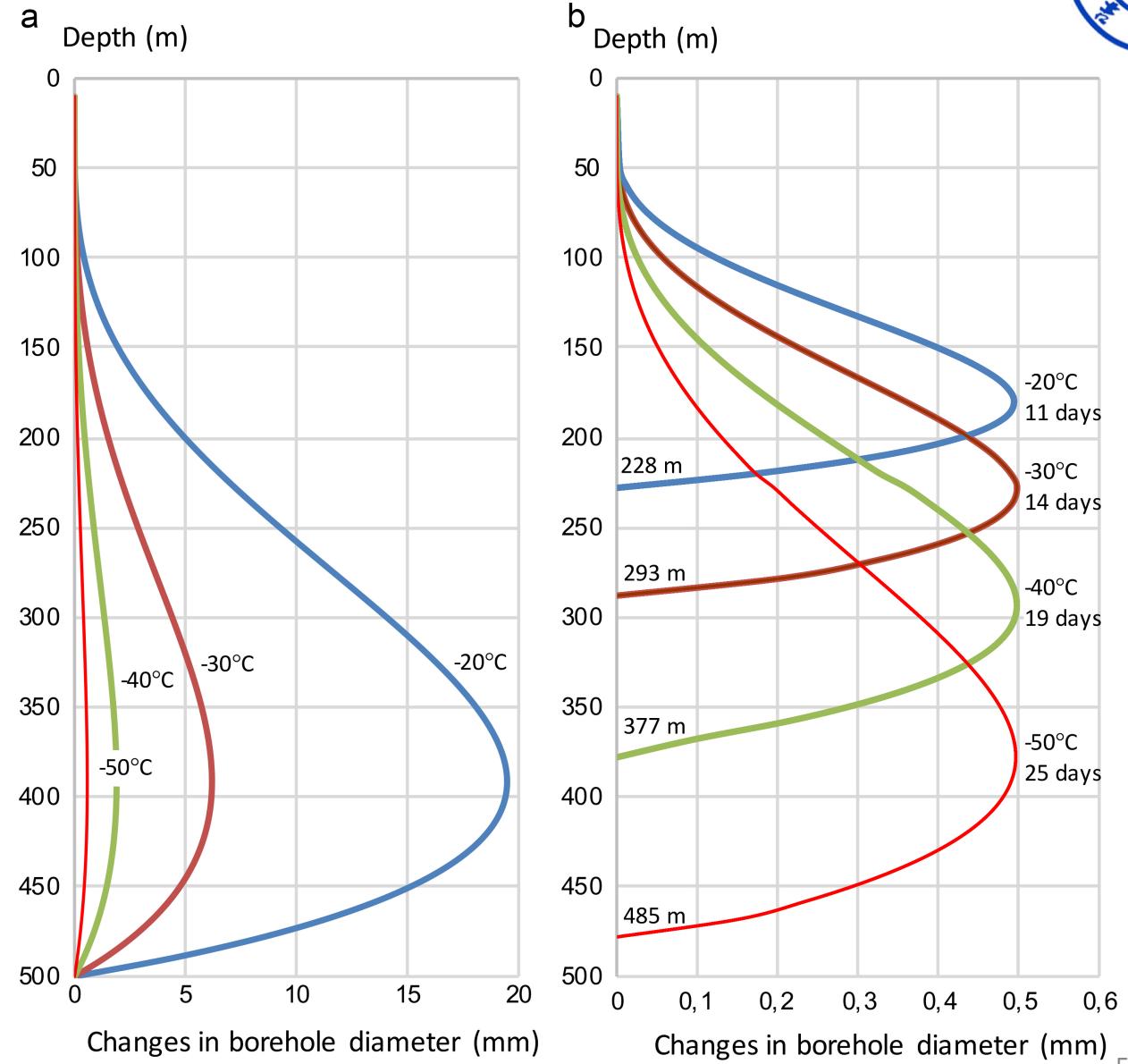
where r, r_0, D and D_0 in [m]; t in $^{\circ}\text{C}$; $\Delta P(z)$ in [Pa]; ΔT in [years].



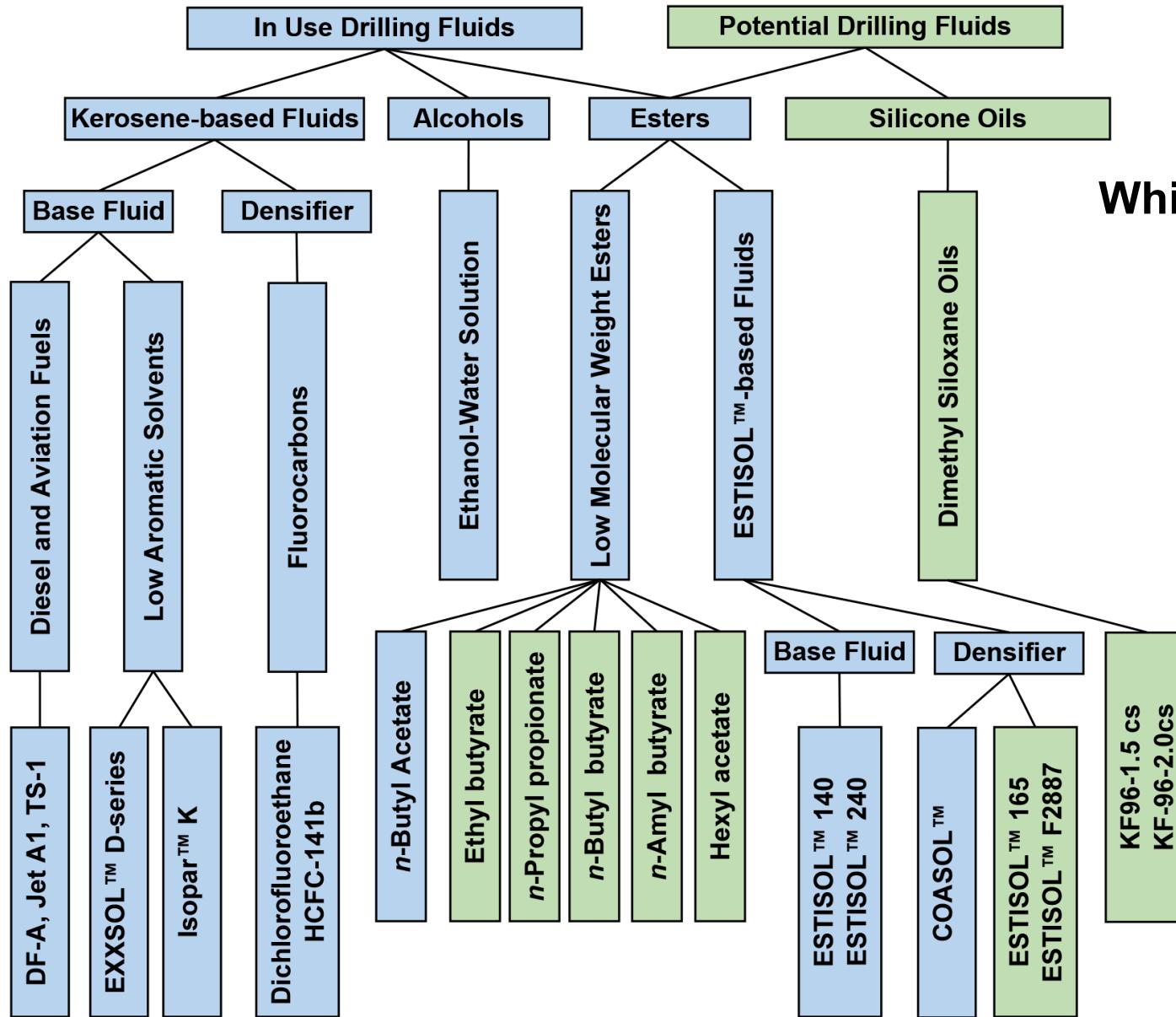
Deformation of “dry” ice boreholes



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



Drilling fluids

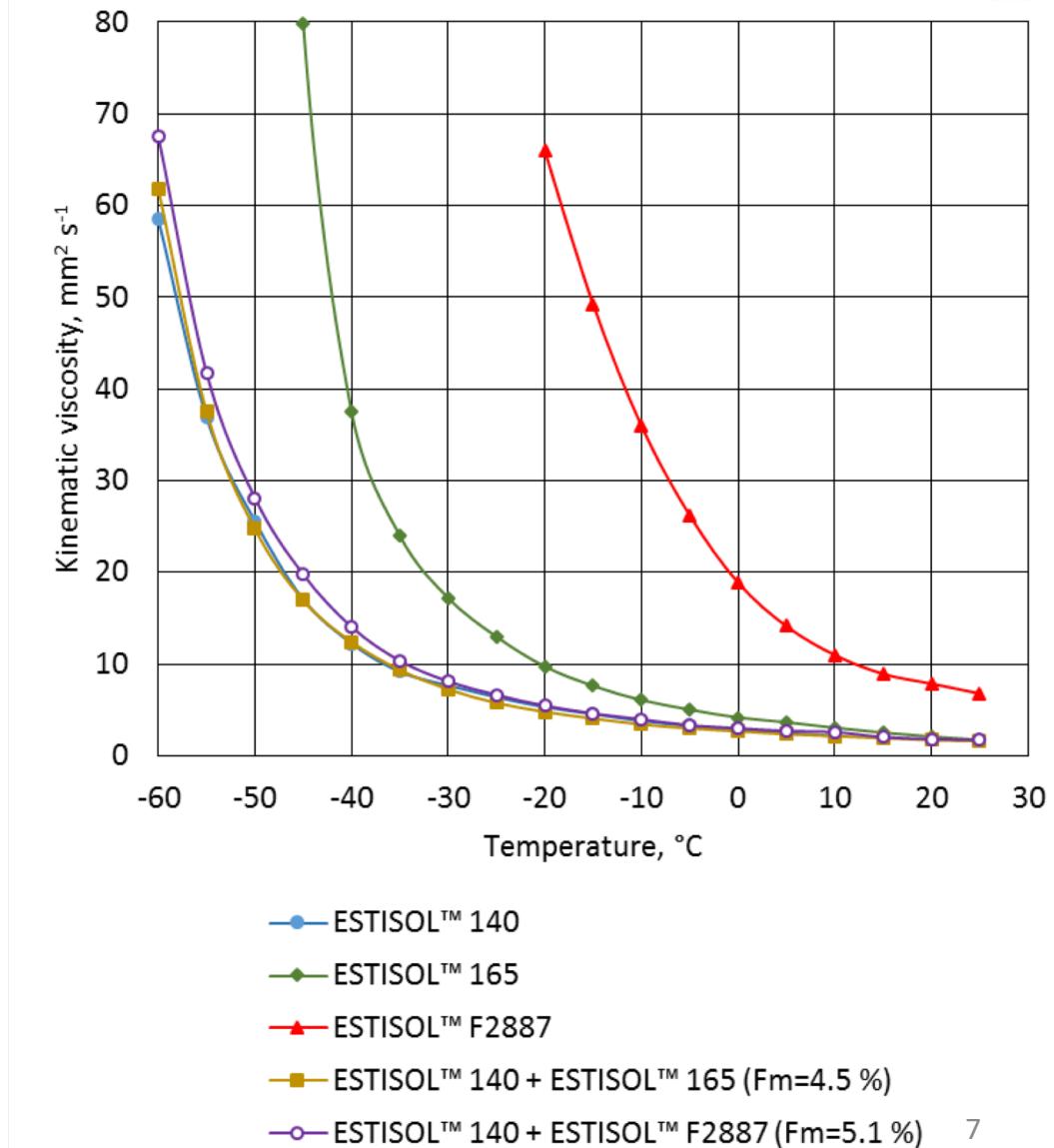
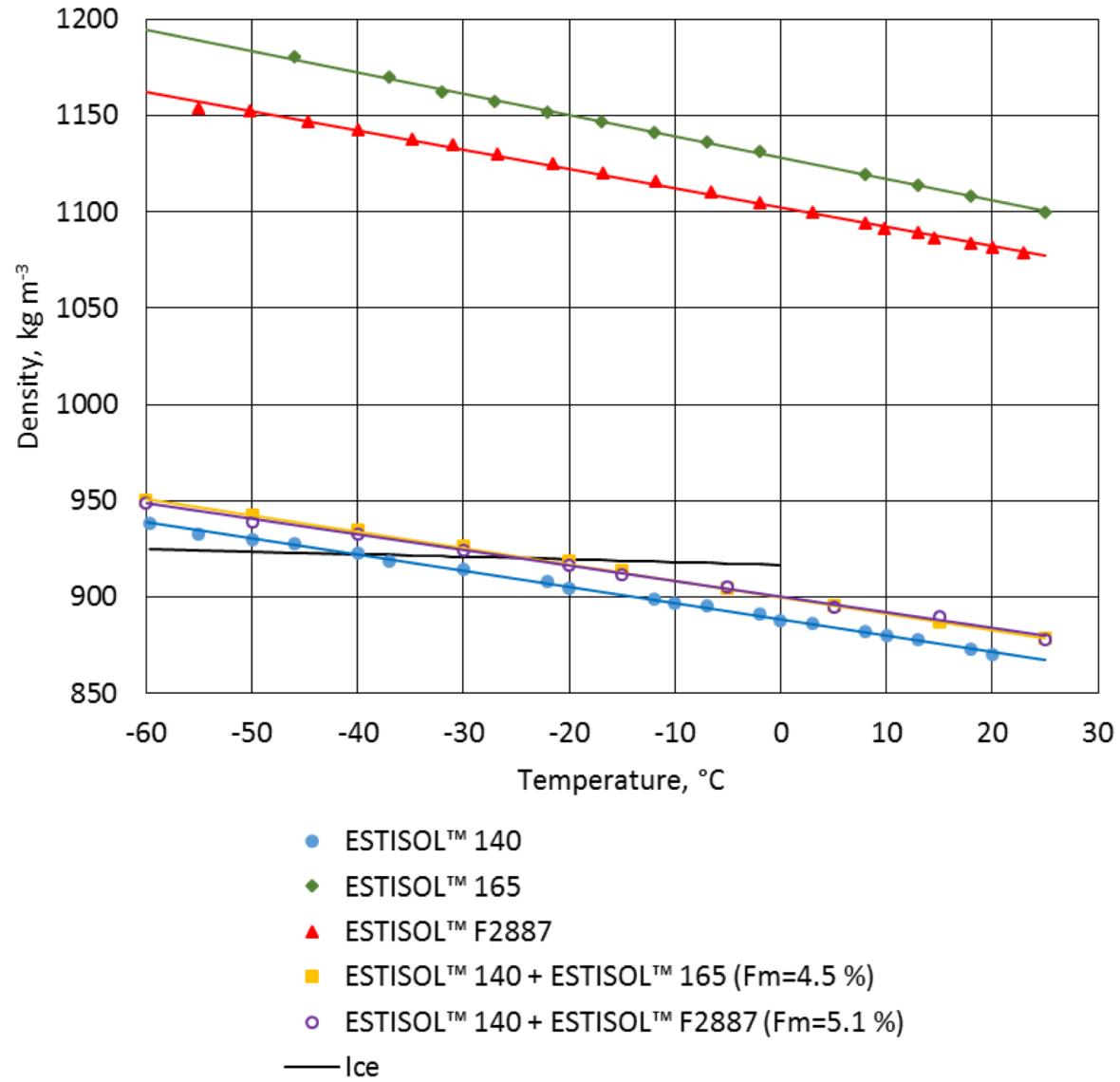


While ESTISOL™ 140 involves some issues

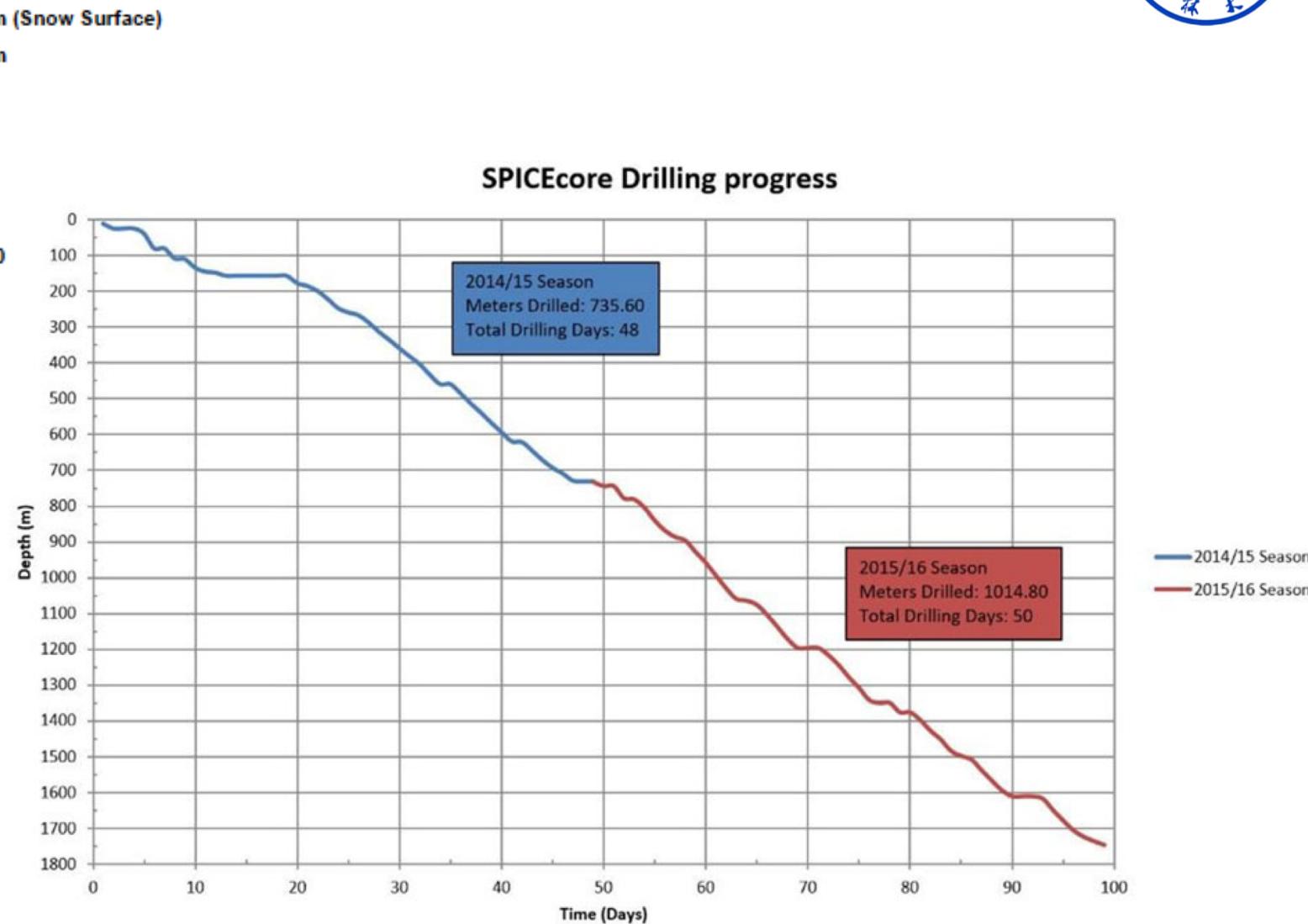
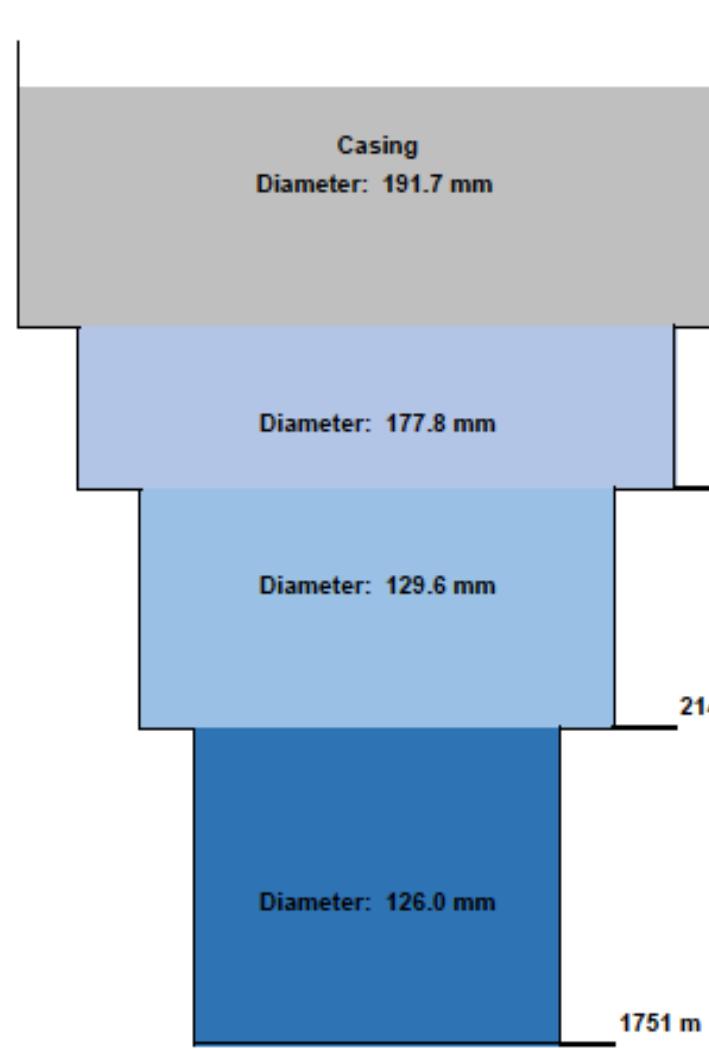
- **high viscosity,**
- **strong odor,**
- **health hazards,**
- **negative effects on many elastomers and plastic materials,**
- **convective problems with temperature logging**

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

ESTISOL™-140 properties



SPICEcore borehole



Credit: J. Johnson



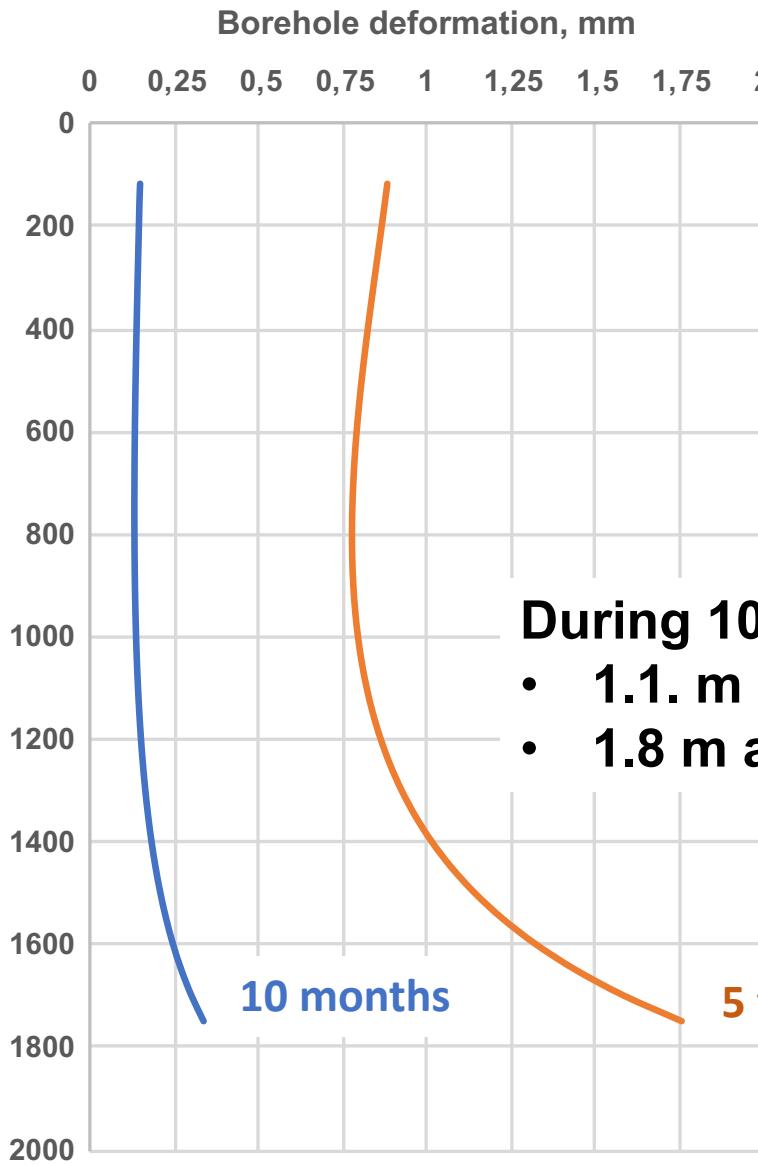
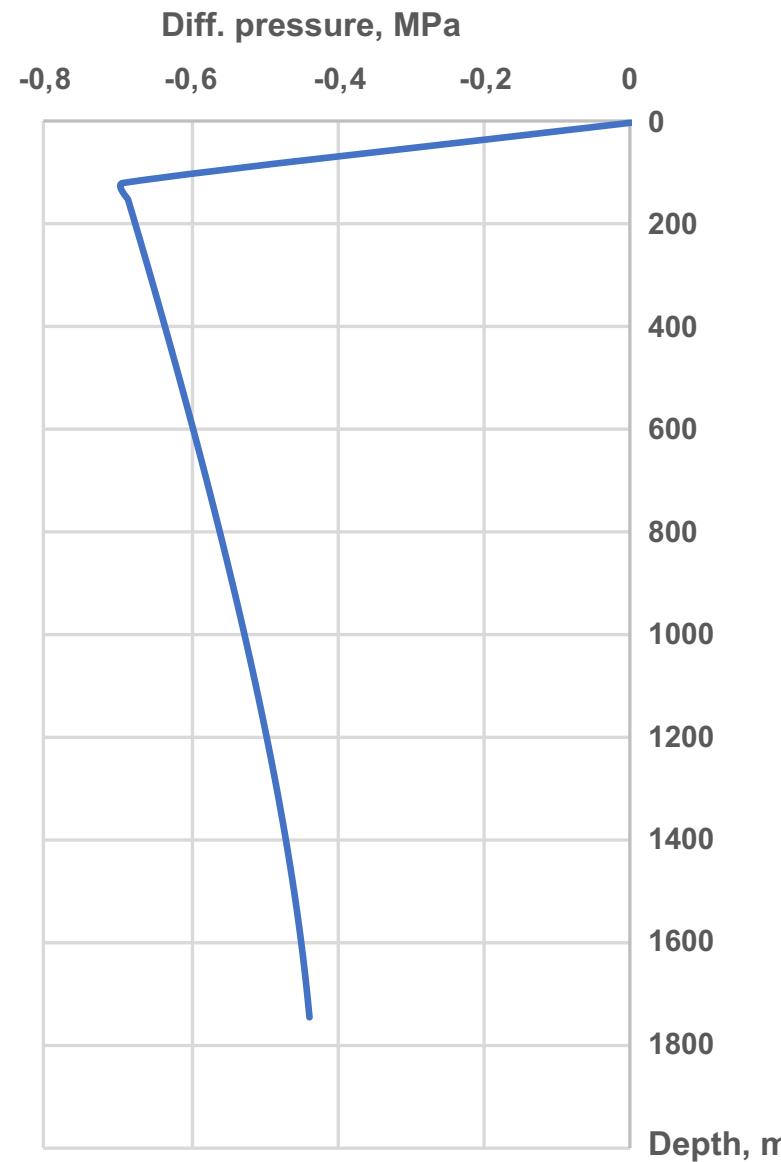
- Temperature distribution from AMANDA and IceCube measurements

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

$$R^2 = 0.997.$$

- $k = 1$
- 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



Diff. pressure, MPa

-0,80 -0,60 -0,40 -0,20 0,00



0 500 1000 1500 2000 2500 3000

Depth, m

Borehole deformation, mm

0 5 10 15 20 25 30 35 40



- Initial borehole diameter 88.9 mm

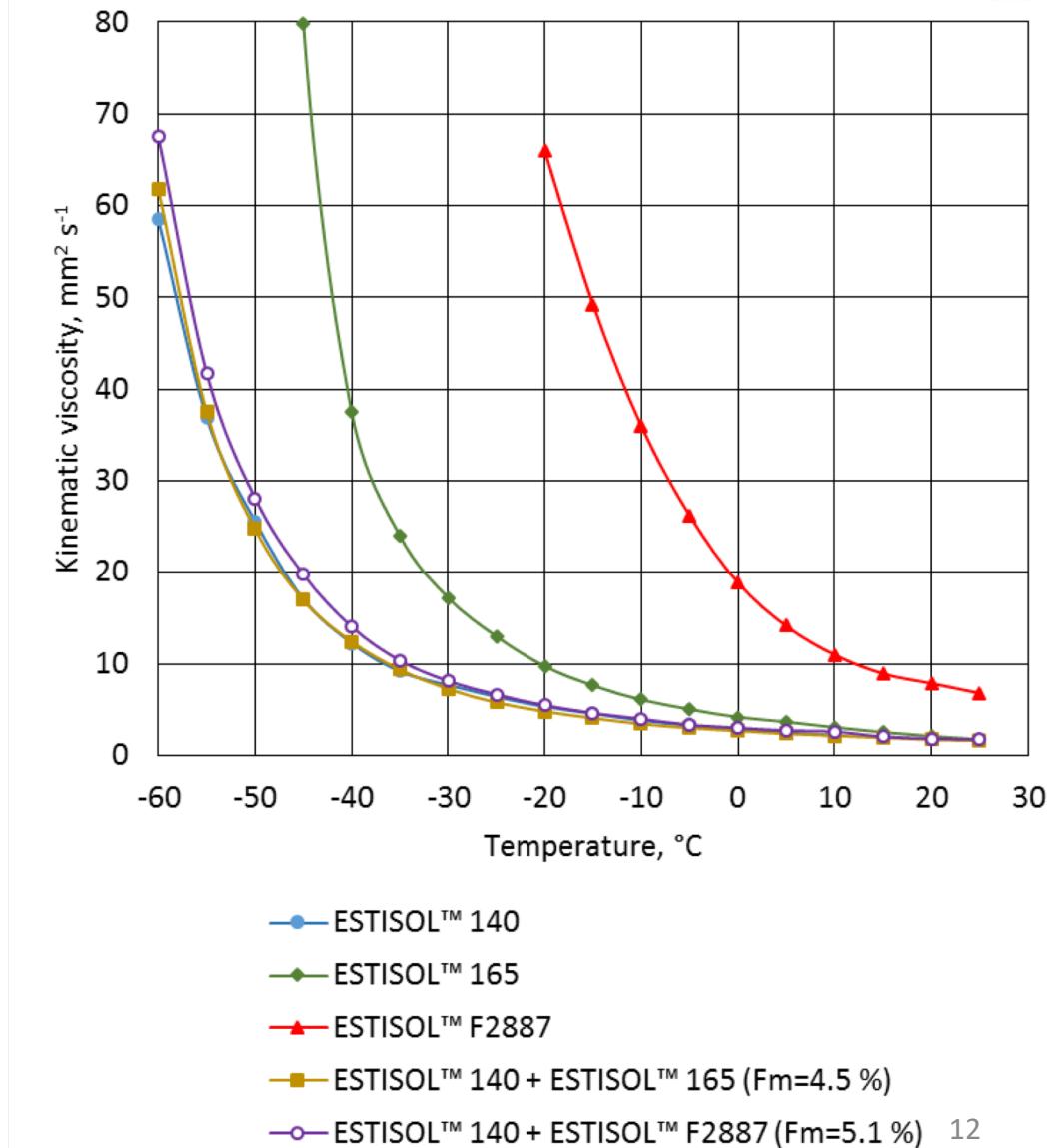
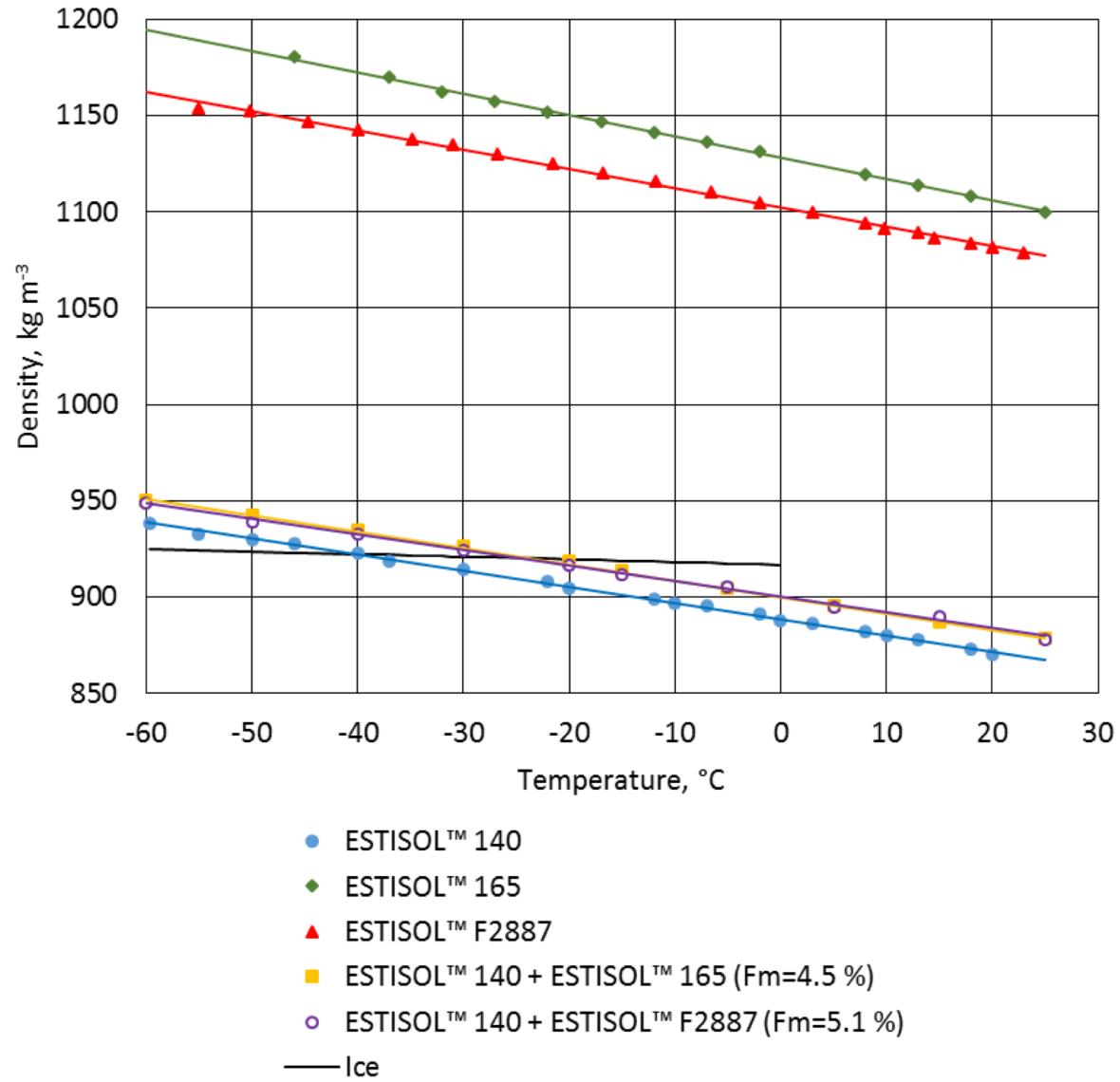
- ESTISOL™-140 density is not enough for long-term stability of deep ice boreholes

1 month

1 year

2 years

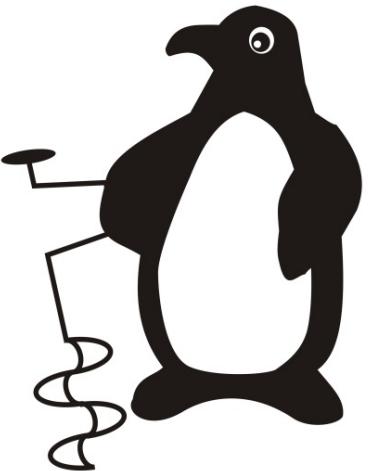
ESTISOL™-140 + Densifiers



Thanks for your attention



Polar Research Center
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吉林大学