Rationale for use of Estisol™ 140 as drilling fluid for the South Pole Ice Core

The National Science Foundation has funded a project to collect a 1500-meter ice core from the vicinity of the South Pole Station in Antarctica. The U.S. scientific community will study this core for a variety of gases, chemistry, isotopes and physical properties. It is imperative that the highest quality ice core be collected from the ice sheet. Drilling ice cores below ~200-meters requires the use of a drilling fluid in order to compensate for the removal of the ice core from the borehole to keep pressure equilibrium in the bore hole. The drill fluid also lubricates the cutting teeth-ice interface reducing chattering in the cutting process.

In the past a wide variety of drill fluids have been used for ice core projects (Talalay, 2011) but many of these have been identified as undesirable due to health and/or environmental impacts. A specific site condition at the South Pole for selection of a drill fluid is the density of the fluid at ice temperature (-50C). Other factors that influence the selection of a drill fluid include: viscosity; freezing point; aggressiveness to ice, drill and cable; flammability; explosiveness; toxicity; environmental impacts; and price.

When the South Pole project was proposed in June 2011, Isopar-K™ was identified as the most likely drill fluid. This fluid was used as part of the drill fluid for the WAIS Divide Ice core. Isopar-K™ meets all the desirable factors of a drill fluid mentioned above with the exception of the density. In order to achieve pressure equilibrium and preserve the WAIS Divide borehole a denser compound, HCFC 141b, was required. This more dense liquid is now no longer produced in the U.S. and remaining stocks are extremely expensive precluding its use on the South Pole project. For the South Pole project, the pressure equilibrium by only using Isopar-K™ as the drilling fluid is not expected to affect core quality from the ice core. However, the lower density of the Isopar-K™ compared to the surrounding ice will not preserve the South Pole borehole for future scientific observations.

Since submission of the South Pole ice core proposal, research teams from Denmark and China conducted parallel studies on drill fluids, specifically for cold ice conditions (<-50C). A new fluid, Estisol™-140, was identified which has a density at -50C very close to ice. This fluid is a synthetic ester manufactured by a Danish company, EstiChem. Testing of the drill fluid began in the Danish and Chinese laboratories in 2011, and the Danish team at the Greenland NEEM site performed a field test during the summer of 2012. Results from both the laboratory and field tests were very positive. The Australian led multi-national Aurora Basin 400-meter ice core project plans to use Estisol-140 during the 2013-2014 austral field season.

The laboratory and field results of this new fluid make it a highly desirable drill fluid for the South Pole ice core and will preserve the 1500-meter borehole for future scientific observations. The only downside expressed about the fluid is the fruit-like smell; “the smell Estisol-140 isn't unpleasant though it is noticeable” (Simon Sheldon, CIC, 2013, per com).

We highly recommend the use of Estisol-140 for the South Pole ice core project.

PIs on the: Collaborative Research: A 1500-meter ice core from the South Pole project

Talalay, Pavel G., 2011, Drilling Fluids for Deep Coring In Central Antarctica, Technical Report PRC 12-01 (available at http://icedrill.org/documents/view.shtml?id=791)