Sensors & Software

GPR & ARCTIC OIL EXPLORATION

IceMap surveys are typically conducted using a Noggin 500 MHz GPR

This case study follows the evolution of the IceMap system now widely used for ice thickness mapping.

Overview

Arctic oil exploration requires safe transportation of heavy equipment over ice-covered areas. Use of seismic vibrator sources demand that safe ice thickness be assured and quality of data can depend on finding grounded ice. This case study follows the evolution of the IceMap system now widely used for ice thickness mapping.

Most kimberlites are small vertical pipe-like rock features, The exploration challenges in diamond exploration are many but there are two critical steps.

Problem

Working on ice covered areas is always challenging since safety is always a concern. The load bearing capacity of ice is detemined by thickness as the well known Gold formula used by ice road managers demonstrates.

Seismic oil exploration faces an even more challenging requirement. Large vehicle mounted vibrator trucks are used to create sound waves for underground oil detection. These seismic sources require thicker ice and preferably grounded ice (ice covered areas where there is no water and the ice is bonded right to the bottom) to provide good coupling of signal into the ground.

GPR Contribution to Solution

Since the very early days, GPR has been demonstrated to be effective at determining ice thickness. While less common, GPR is also able to discern if ice is underlain by water or by soil or frozen ground.

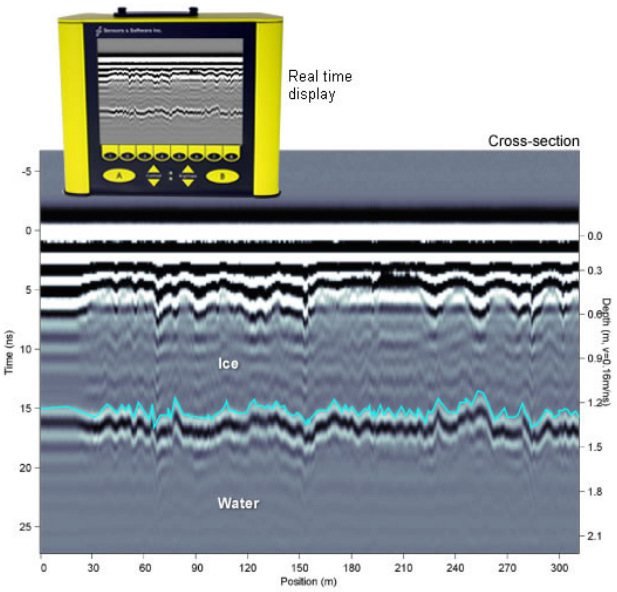
Originally, GPR required a specialist operator to carry out the survey measurements. In 2004, the IceMap team started by deploying a Noggin GPR system for ice thickness measurements. Excellent GPR data were acquired although analysis still required a skilled eye and operators needed training.

Working with the early adopters, the IceMap system took shape. First the user interface was simplified. Second, the ability to insert in-field coring data to calibrate thickness was added. Finally the ability to automate thickness computation in real-time and display on geo-referenced base maps and Google Earth in the field was developed.

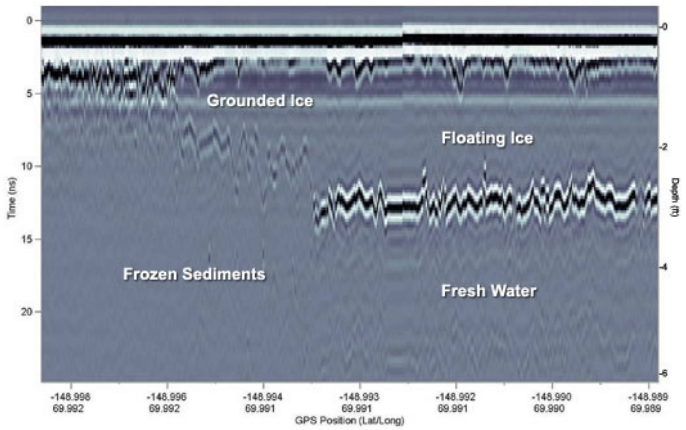
A by-product of extensive ice surveying was the realization that grounded ice was readily identifiable. The example below shows how grounded ice shows up in a GPR cross section. Since soil and frozen soil are poorer GPR reflectors than water, grounded ice zones standout.

A corollary use has recently appeared with the need to access liquid water in frigid winter conditions. In many small lakes and rivers, extraction of water becomes challenging when the water freezes to the bottom. Locating where to drill to access pockets of unfrozen water is a major advantage over time-consuming trial and error borings.

Rapid decision making is enhanced by interactive user displays such as the Google Earth image below. With ice thickness displayed in geo-referenced form, deciding on areas of concern is made easy.



Initial IceMap systems acquired data such as shown here with infield display shown above. IcePicker software was used post-survey to tabulate ice bottom reflector depth.



Example from a river in the Mackenzie Delta, where grounded ice is a major concern. Grounded ice and floating ice show a large change in GPR amplitude.

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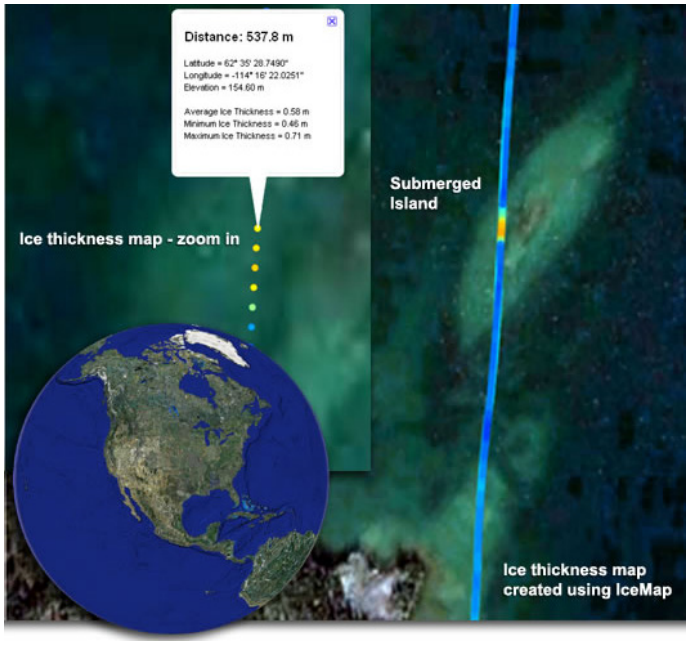

The IceMap survey line after the data are exported and plotted on Google Earth. Thin ice patches appear in yellow. A submerged island is visible in the Google Earth image corresponding exactly with the thin ice. Ice thicknesses in Google Earth are displayed as a series of colored dots. Zooming in and clicking on an individual dot shows the exact GPS position, elevation and the average, minimum and maximum ice thickness in that area.

Results & benefits

The evolution of IceMap demonstrates the value of GPR for arctic exploration. The same issue addressed by oil exploration is faced all across the arctic by exploration teams. Some key benefits of IceMap are:

- A simple, fast and easy-to-use solution
- Immediate feedback on ice conditions
- Capacity to locate both grounded ice and liquid water
- Users can be effective with only a few hours of training
- Ready correlation with exploration operations
- Effective users need minimal training

GPR responses vary greatly depending on the target being sought and the host material. GPR response variability can be challenging to new GPR users. When learning about GPR, the best practice is to review several similar case studies to develop an understanding of variability. Check for other insightful information on the resources tab to learn more. Use Contact Us or Ask-the-Expert to reach our Application Specialists who can help you tap into Sensors & Software's vast array of technical information.

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