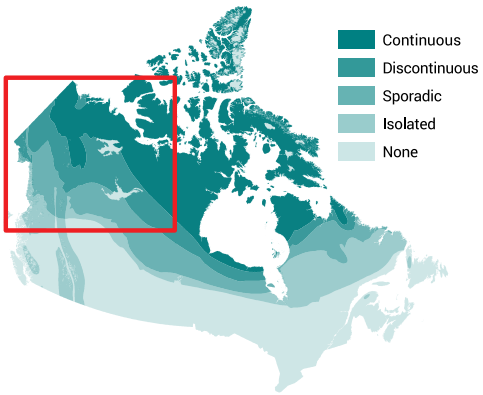
Non-destructive characterization of permafrost cores using industrial Computed Tomography and Multi-Sensor Core Logging



Study locations: Permafrost cores were from across Yukon and the Northwest Territories.

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Keywords: Ground ice, excess ice content, volumetric ice content, cryostructure, computed tomography, multi-sensor core logging.

Ground ice determines the potential for change in thawing permafrost landscapes. In this context, accurate measurement of ground characteristics is important for designing climate-resilient infrastructure and predicting the impacts of permafrost thaw. However, most methods for characterizing permafrost are destructive and have low resolution. Developing better and standardized methods for permafrost characterization will give us more robust information on permafrost and help understand future thaw trajectories of permafrost landscapes. This project assessed the characterization of permafrost cores using non-destructive methods: Computed Tomography (CT) and Multi-Sensor Core Logging system (MSCL). These methods enable us to image permafrost cores and measure their properties, including cryostructures, bulk density, magnetic susceptibility, and estimation of Excess Ice Content (EIC) and Volumetric Ice Content (VIC).

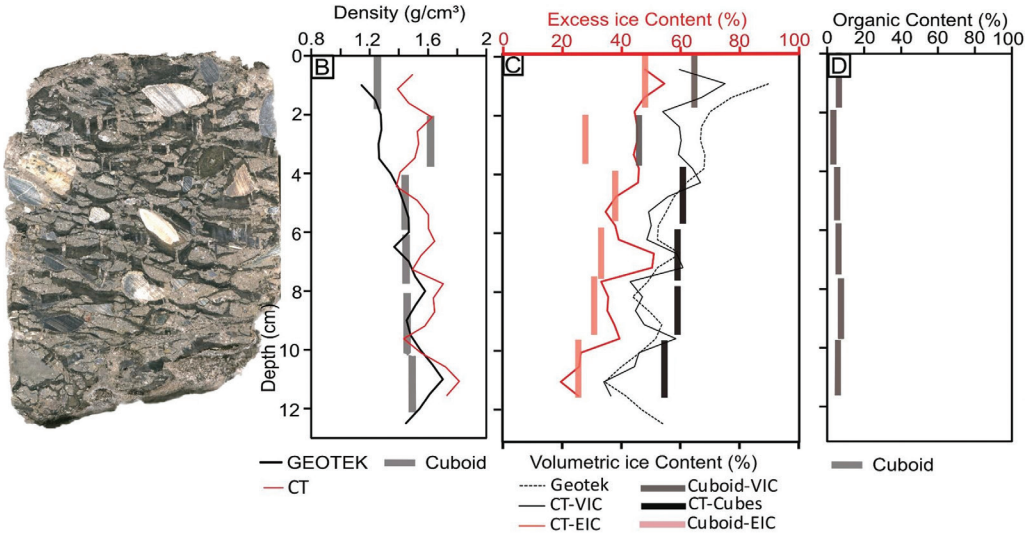

Figure 1. (A) MSCL image of the ice-poor silt core; (B) bulk density; (C) ice contents; (D) organic content distribution in core depth.

Research summary

Typically, permafrost samples are qualitatively described in the field based on visible or nonvisible ice content. These descriptions may include cryostructures of the ice and sediment, and a subset of these observations may be combined with destructive analyses to quantify volumetric ice content, excess ice, gravimetric moisture content, and soil organic matter. Considering the limitations of visual and experimental methods of ground ice classification and excess ice measurements, as well as different sample sizes and levels of resolution in these methods, there

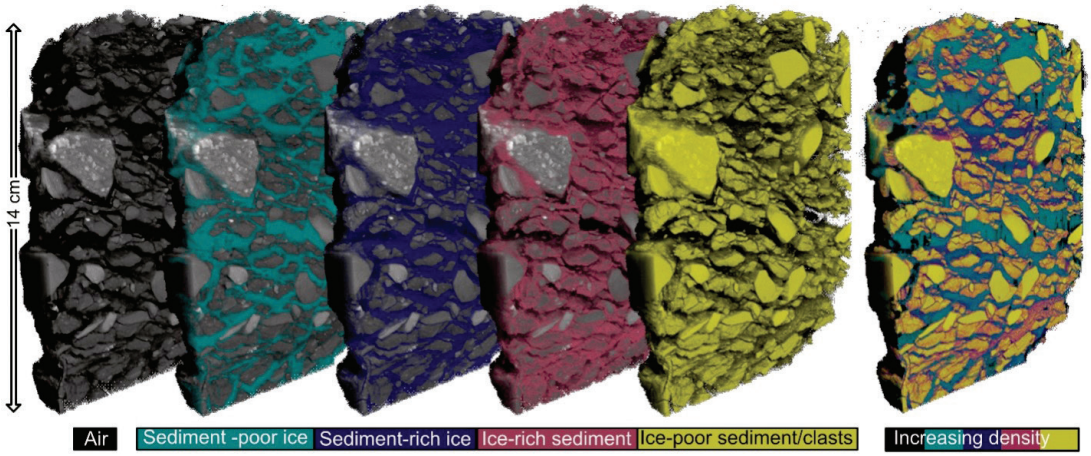

Figure 2. Three-dimensional reconstruction of the diamict core highlighting the main components identified during the image segmentation of the Computed Tomography data.

is a need to develop consistent and interoperable methods to classify and estimate ground ice that can be used on all types of sediments.

This study used CT imaging and MSCL as non-destructive methods to tackle the limitations of traditional permafrost characterization methods by measuring frozen bulk density and estimating EIC and VIC quantitatively from five permafrost samples at a high spatial resolution. The results agree with destructive analyses (cuboid method), demonstrating that these approaches can produce consistent results and provide the added benefit of enhanced digital archives of permafrost physical properties.

Taking action

These methods are becoming standard practices at the Permafrost ArChives Laboratory (PACS lab). This will ensure the continued development of a robust digital archive of permafrost physical properties. This digital record will aid in the development of regional-scale permafrost distribution products, which are critical to developing and maintaining northern infrastructure. Non-destructive approaches maintain the availability of the material for future investigations.

Connections to other projects

This project is part of Theme 1— *Characterisation of permafrost* and complements other projects in themes 1, 2, and 3. It is related to another theme 1 study of permafrost characteristics, *Permafrost Index Properties* by Omid Asghari.

Partners, team members and support

The project involved collaboration with researchers from the University of Alberta, PACS Lab, Northwest Territories Geological Survey, Sahtu Communities, and research assistants.

Acknowledgment, thanks and funding

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References

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