Key Outcomes of the Canadian Permafrost Electrical Resistivity Survey (CPERS) Database Project

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Electrical resistivity tomography (ERT)
Motivation for a database
Created and populated a database

- 209 profiles
- 280 surveys
- 15 profiles with time-lapse data
- Data collected between 2008 - 2022
- 16 landform types

Standardized metadata describing the landform, substrate, vegetation, organic layer, disturbance, etc. for each profile
Built an interactive web map
Archived the data
Developed open-source data processing tools
Established best practices for using ERT to study permafrost

Best practices for using electrical resistivity tomography to investigate permafrost

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Abstract
Electrical resistivity tomography (ERT) is a minimally invasive geophysical method that produces a model of subsurface resistivity from a large number of electrical resistance measurements. Strong resistivity contrasts usually exist between frozen and unfrozen earth materials, making ERT an effective and increasingly utilized tool in permafrost research. In this paper, we review more than 200 scientific publications dating from 2000 to 2022 to identify the capabilities and limitations of ERT for permafrost applications. The annual publication rate has increased by a factor of 5 over this period, but several unique challenges remain, and best practices for acquiring, processing, and interpreting ERT data in permafrost environments have not been clearly established. In this paper, we make recommendations for ERT surveys of permafrost and highlight recent advances in the field, with the objective of maximizing the utility of existing and future surveys.

Keywords
electrical resistivity tomography, geophysics, permafrost

1 | INTRODUCTION
Electrical resistivity tomography (ERT) is a geophysical technique that estimates subsurface electrical resistivity, and is used to reproduce experimental voltage and current measurements; most commonly resulting in a two-dimensional resistivity cross-section. ERT can be used to identify frozen and unfrozen regions of the subsurface because the resistivity of earth materials generally increases substantially (up to several orders of magnitude) at subzero temperatures as pure water freezes. ERT can also be used to distinguish variations in ice content. In relation to permafrost investigations, the spatial coverage of ERT complements point location data, such as borehole temperatures and core stratigraphy. Depending on the acquisition parameters, ERT can produce high-resolution imagery of the top 1-2 m or image much deeper features, such as the base of permafrost, to depths of 100 m or more.

In the past two decades ERT has become increasingly employed to infer permafrost extent and characteristics, and to assess change over time. The annual number of publications that use ERT in the study of permafrost has increased by an order of magnitude, from two or three to more than 30 (Figure 1), with research sites located in all countries with significant occurrences of permafrost (Figure 2). Diverse applications include assessment of geohazards, examining interactions between permafrost and infrastructure, characterizing permafrost thaw due to climate change, and validating temperature models, and developing hydrogeologic models.
# Compiled literature sources

302 publications using ERT to study permafrost between 2000-2022

For a complete review of these papers, see "Best practices for using electrical resistivity tomography to investigate permafrost" by Herring et al. [Submitted to Permafrost and Periglacial Processes February 2023]

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Year</th>
<th>URL</th>
<th>Country code</th>
<th>Dimension</th>
<th>Time lapse?</th>
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<tr>
<td>Thermokarst lake to lagoon transitions in Eastern Siberia. Do submersed taliks refreeze?</td>
<td>Angelopoulos et al.</td>
<td>2020</td>
<td>link</td>
<td>RUS</td>
<td>2D</td>
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<td>Heat and salt flow in subsea permafrost modeled with CryoGRID2</td>
<td>Angelopoulos et al.</td>
<td>2019</td>
<td>link</td>
<td>RUS</td>
<td>2D</td>
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<td>Exploring the capabilities of electrical resistivity tomography to study subsea permafrost</td>
<td>Arboleda-Zapata et al.</td>
<td>2022</td>
<td>link</td>
<td>USA, RUS</td>
<td>2D</td>
<td>No</td>
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<tr>
<td>Shallow permafrost at the Crystal site of Peaceful Underground Nuclear Explosion (Yakutia, Russia): Evidence from electrical resistivity tomography</td>
<td>Artamonova et al.</td>
<td>2022</td>
<td>link</td>
<td>RUS</td>
<td>2D</td>
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<td>Geophysical investigations on Por-Bajin island, Tuva (Russia)</td>
<td>Azhantseva et al.</td>
<td>2009</td>
<td>link</td>
<td>RUS</td>
<td>2D</td>
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</table>
Started making large-scale interpretations

\[ \rho_{avg} = 10^{-0.15 \times MAAT} + 2.55 \]

\[ R^2 = 0.35 \]

\[ n = 231 \]
Started making large-scale interpretations

Modified from Herring et al. [Submitted to ICOP 2024]
Aspirations

• Add new data
• Better large-scale interpretations (machine learning?)
• Improve how data is shared and used in the permafrost community
With field and project support from Alejandro Alvarez, Brielle Andersen, Olivier Bellehumeur-Génier, Alexandre Bevington, Philip Bonniventure, Maxime Duguay, Bernd Etzelmüller, Michael Gooseff, Sarah Godsey, Christina Miceli, Sharon Smith, Casey Buchanan, Alain Cuerrier, Frédéric Dwyer-Samuel, Benoit Faucher, Luise Hermanutz, Zoé Kuntz, Caitlin Lapalme, and Allison Rubin.