

# Geophysical signature of Precambrian basement structure and overlying sedimentary sequences in Alberta: insights from new airborne magnetic and gravity surveys

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## Summary

In 2021-2024, the Alberta Geological Survey (AGS) acquired high-quality airborne magnetic and gravity data over large regions of Alberta (Alberta Geological Survey, 2024). In 2023, the AGS contracted Ronacher McKenzie Geoscience to interpret these geophysical data. The objectives were to improve the understanding of the Precambrian crystalline basement of Alberta and overlying structure in the Western Canada Sedimentary Basin and Athabasca Basin. The new products facilitated modifications to previously established domain boundaries, identification of new features, and enhanced the understanding of the 3D basement architecture. These advancements may have implications for resource potential. This presentation details the results of the geological interpretation of the new geophysical data over Alberta.

## Introduction

The current definition of Alberta's lithotectonic domains was largely conducted between the late 1980s and early 2000s using potential-field data publicly available at that time (e.g., Hoffman, 1988; Villeneuve et al., 1993; Ross et al., 1994; Pilkington et al., 2000). The domain separation had been integrated with U-Pb geochronology, petrology and Sm-Nd isotope geochemistry conducted on basement drill core samples (Burwash et al., 1994; Ross et al., 1991, 1994), and with LITHOPROBE seismic studies (Hope et al. 1999; Ross and Eaton, 2002).

These studies also included or were followed by the interpretation of basement faults that may have propagated into the overlying sedimentary sequence and may have played a role in the emplacement of energy and mineral resources (e.g., Eaton et al., 1995; Pana, 2003; Lyatsky et al., 2005).

In 2021, the Government of Alberta released "Renewing Alberta's Mineral Future", a mineral strategy and action plan. One of the six key pillars of the strategy is to enhance the public geoscience knowledge base for emerging resources in Alberta. As part of this program, between 2021 and 2024 the AGS acquired modern high-quality airborne magnetic and gravity data over large regions of Alberta where this information was outdated, missing, or incomplete.

In 2023, the AGS contracted Ronacher McKenzie Geoscience to provide a geological interpretation of the new geophysical data, which is still ongoing. The objectives of the geological interpretation were to improve the understanding of the architecture of the Precambrian crystalline basement of Alberta, and overlying Athabasca Basin and Western Canada Sedimentary Basin.

## Methodology

The geological interpretation of geophysical data follows the methodology developed by Isles and Rankin (2013), where the process of interpretation of aeromagnetic and other potential-field data is broken down in three main stages: observations, integration, and interpretation. For interpretation, this methodology is applied to the measured data as well as filtered products.

The geological interpretation used a combination of manual and automatic methods applied to derivative and filtered products specifically created for this work. Manual interpretation focused on interpreting faults and magnetic domain boundaries. Automatic detection algorithms, conducted by Fathom Geophysics, were used for structure detection, radial symmetry detection (round features that could be interpreted as intrusions), fabric orientation mapping, and depth to basement products. The manual and automatically detected features were integrated with and calibrated against existing results from legacy geophysical studies, geological information, and regional structural interpretations.

Detailed description on the methodology can be found in already publicly available reports (Lopez et al., 2024; Brem et al., 2024).

## Results

The magnetic and gravity filter products and the automatic detection products derived from the new airborne magnetic and gravity surveys provide insights and add complexity to the basement of Alberta and its overlying sedimentary rocks. The geological interpretation involved a high-level integration with tectonic elements documented in government and academic publications.

Most relevant results of this work include:

- Delineation of basement anomalies potentially caused by intrusions
- Identification and delineation of known and new ductile and brittle structures
- Reinterpretation of basement arches (e.g. Peace River Arch)
- Correlation of kimberlite fields with basement features
- Modifications to previously defined basement lithotectonic domain boundaries and definition of new subdomains (Figure 1) that impact previous interpretations of the Precambrian tectonic history of Alberta (e.g., rifting and spreading zone features in northeastern Alberta).
- Creation of an improved structural framework
- Implications for resource potential

Reports and geophysical products derived from this work are available to the public through the AGS mineral mapping program webpage ([Alberta Geological Survey, 2025](#)).



into the Western Canada Sedimentary Basin may have also acted as pathways for mineralizing fluids.

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