Spatial correlation of magnetic properties, deformation fabrics, and paragenesis: insights from the Athabasca granulite terrane, northern Saskatchewan

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Motivating questions

What can we learn through the integration of geophysical data and petrology to better understand metamorphic and structural processes at a variety of scales?

How can we use the knowledge of this petrophysical architecture to aid in understanding ancient and modern crustal processes?
Geological context of the Athabasca granulite terrane

Simplified map modified from Hanmer 1994
Magnetic patterning of the Athabasca granulite terrane

Raw data provided by the Geological Survey of Canada

<table>
<thead>
<tr>
<th>Aam</th>
<th>Axis mafic granulite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abm</td>
<td>Bohica mafic complex</td>
</tr>
<tr>
<td>Amg</td>
<td>Mary granite &amp; associated granitoids</td>
</tr>
<tr>
<td>Ac</td>
<td>Chipman batholith</td>
</tr>
<tr>
<td>Afg</td>
<td>Fehr granite</td>
</tr>
<tr>
<td>Apm</td>
<td>Pine Channel diatexite</td>
</tr>
</tbody>
</table>

Map extent: AB, SK, MB, NT, NU, ON

Lake Athabasca

Lake Black

Lake Reeve

Lake Chipman

Lake Bompas

Lake Selwyn

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Magnetic expression of the Chipman domain

CHIPMAN LAKE
CORA LAKE
EAST HAWKES LAKE
LEGS LAKE
LYTLE LAKE
MARY LAKE

4 (mafic granulite)
2 (tonalite)
1 (tonalite)
3 (tonalite)
5 km

300 0 300 600 900 1200 1500

5 km

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Chipman tonalite samples: 1, 2, & 3

Photo by: Sean P. Regan
Chipman tonalite samples: 1, 2, &3
Isothermal remanent magnetization

IRM acquisition curves
Chipman tonalite

Magnetizing field (T) vs. IRM (A/m) for Chipman tonalite samples 1, 2, & 3.

Magnetite saturation indicated by shaded area.

Magnetite saturation

IRM (A/m)

Magnetizing field (T)

1e−4

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SEM image: sample 1
(width \sim 0.075 \text{ mm})

Ilmenite
SEM image: sample 1
(width ~ 0.075 mm)

Iron sulfide
SEM image: sample 2
(width \sim 2 \text{ mm})

Magnetite

Ilmenite
Mafic granulite sample: 4

CHIPMAN LAKE
CORA LAKE
EAST HAWKES LAKE
LEGS LAKE
LYTLE LAKE
MARY LAKE

4 (mafic granulite)
2 (tonalite)
1 (tonalite)
3 (tonalite)
Mafic granulite sample: 4
Photo by: Sean P. Regan
Mafic granulite sample: 4
Heterogeneous magnetic susceptibility

A

B

Relative suscept.

A 7.32e-2
B 7.51e-3
C 7.41e-2

0.067
0.062
0.057
0.052
0.047
0.042
0.037
0.032
0.027
0.022
0.017
0.012
0.007
0.002
SEM image: A
(width $\sim 2 \text{ mm}$)
SEM image: B
(width $\sim 2$ mm)
SEM image: C
(width \sim 2 \text{ mm})
Mafic granulite sample: 4
Whole section compositional gradient in garnet

Fe / (Fe + Mg) in garnet
Field of view: 3.58 x 2.48 cm
Mafic granulite sample: 4
Garnet compositional mapping
Mafic granulite sample: 4
Garnet quantitative analyses
Iron rich garnet with magnetite tails
(width $\sim 2$ mm)
Implications for iron oxidation state

Volume of phases vs. $X_{\text{FeO}}$
1 GPa 830° C 0.75 $H_2O$

Percent volume
0.00 0.25 0.50 0.75 1.00

Anorthite
Diopside
Pargasite
Hematite
Quartz
Rutile
Magnetite
Orthopyroxene
Almandine
Ilmenite
Albite

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