# Relationships between pluton emplacement, mineralization and deformation at the Gander/Avalon boundary, Newfoundland from a geochronological and thermochronological perspective


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Geological Survey of Canada with Provincial and Territorial Collaboration


TGI 4 Ore Systems

## Introduction

Devonian plutonic suites in the Canadian Appalachians (Figs. 1, 2) are locally associated with Sn, W, Mo and In mineralization. In central Newfoundland, some of the most mineralogically-prospective plutons, for example the Ackley granite, are spatially associated with the Gander/Avalon terrane boundary. This relationship suggests that there may be tectonic and/or structural controls on pluton emplacement and localization of mineralization.

The Geological Survey of Canada Targeted Geoscience Initiatives IV Intrusion-Related Mineralization Project is focused on the tectonic controls on porphyry-style mineral systems to determine their potential as a vector towards zones of high mineral prospectivity. Identifying such relationships is especially significant in regions like the Canadian Appalachians where extensive glacial cover often masks direct observations of mineralization. Herein, we present preliminary results from our SHRIMP U-Pb and $^{40}Ar/^{39}Ar$ single crystal and in situ geochronological and thermochronological study. These data are used to constrain the timing of deformation along the Dover Fault, which marks the Gander-Avalon terrane boundary, and the regional emplacement/cooling history of spatially-associated plutonic suites. The role of shear zones as pathways for magmas and ore and implications for tectonics and mineral potential of the region are under consideration.

Questions under investigation:

- -Is displacement along the Gander-Avalon boundary temporally associated with emplacement of mineralized plutons?
- -What is the most favourable slip vector?
- -Does the Dover Fault spatially control mineralization? If so, where is it localized south of the Ackley granite?
- -What is the relationship between the Dover Fault and the Hermitage Bay Fault?
- -What are the implications for tectonic controls on intrusion-related mineralization in the Appalachians and other orogens?
- -What are the implications for intrusion-related mineral exploration in poorly exposed regions?

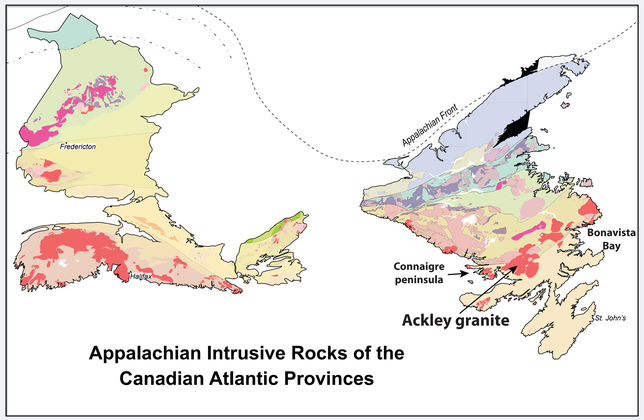



Figure 1: Geology of the Appalachian orogen in Atlantic Canada, highlighting location of Devonian plutonic suites.

Figure 2: Left, Pass Island granite, Connaigre Bay, south coast Newfoundland (Fig. 1,3). Centre - Deadman's Bay granite, northwest of Bonavista Bay (Fig. 1,3). Right - Terra Nova granite (Fig. 3).

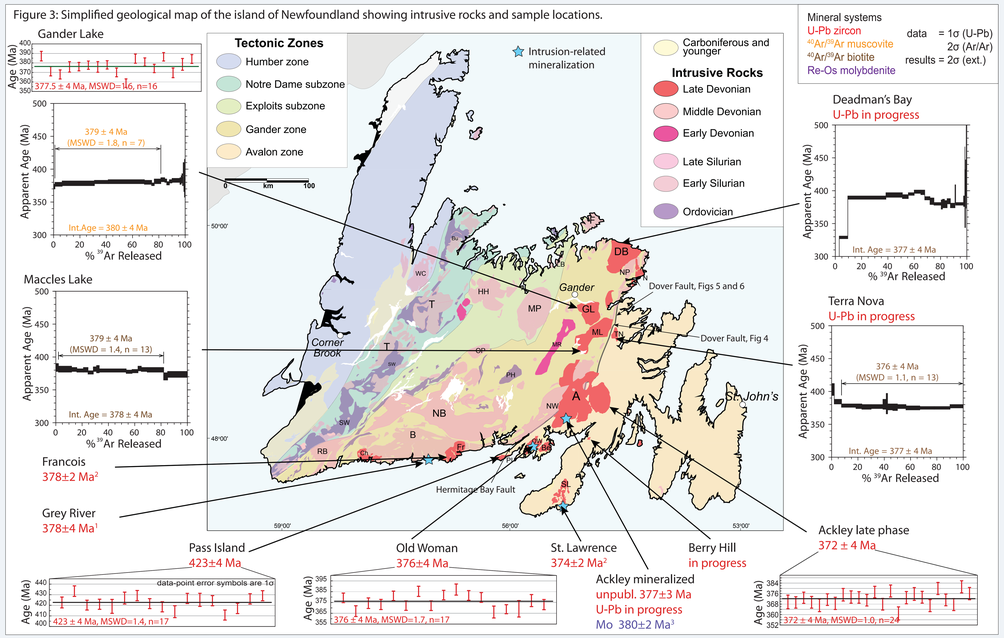
## Local geology and sampling strategy

The Dover fault is a broad (kms wide) mylonite zone that deforms Gander Zone gneiss and Avalon Zone volcanic rocks (Fig. 3). It is thought to have initially sinistrally juxtaposed the Avalon Zone against the Gander Zone during Silurian coeval with emplacement of granites, and then reactivated with a dextral shear sense (e.g. Holdsworth, 1994). Key pre-tectonic (Silurian) and syn-tectonic granites showing both sinistral and dextral shear-sense within the Dover fault were selected to contrain the timing of fault motion (Figs. 4-6).

Devonian megacrystic granites both straddle and stitch the length of the Gander/Avalon tectonic boundary in Newfoundland (Fig. 3). They are most typically K-feldspar megacrystic (Fig. 2), and contain biotite ± hornblende, muscovite, as well as abundant accessory zircon. The granites are undeformed (though local magmatic flow fabric is preserved), and are locally ore-bearing (W, Cu-Mo - Grey River; Mo - Ackley, Old Woman, Fl - St. Lawrence).

A suite of samples was collected from the field, and complemented by samples donated by the Geological Survey of Newfoundland and Labrador, to span the north-south and east-west extent of the granitic suite. These granites intrude and cross-cut both Silurian granites and host Gander Zone gneiss as well as Avalon Zone volcanic rocks. The granites also clearly cross-cut the Dover Fault, indicating their emplacement late syn- or post-ductile the final major phase of ductile deformation. Previously the southern extension of the Dover Fault has been related to the Hermitage Bay Fault that bounds the western margin of Connaigre Peninsula (Fig. 1,3).

Figure 3: Simplified geological map of the island of Newfoundland showing intrusive rocks and sample locations.




**Late Devonian**
A - Ackley Granite
Be - Belleoram Granite
DB - Deadmans Bay Granite
Ch - Chetwynd Granite
Fr - Francois Granite
GL - Gander Lake Granite
ML - Maccles Lake Granite
N - Newport Granite
OW - Old Woman stock
TN - Terra Nova Granite
SL - St. Lawrence Granite

**Early Devonian**
LB - Loon Bay batholith
MR - Middle Ridge Granite

**Late Silurian**
F - Fogo batholith
G - Gaultois Granite
HH - Hodges Hill Intrusive Suite
MP - Mount Peyton Intrusive Suite
NB - North Bay Granite Suite
NP - North Pond Granite
NW - North West Brook Complex
OP - Overflow Pond Granite
PI - Pass Island Granite
RB - Rose Blanche Granite

**Early Silurian**
B - Burgeo Intrusive Suite
Bu - Burlington granodiorite
T - Topsails Igneous Suite
WC - Wild Cove Pond Intrusive Suite

**Ordovician**
PH - Partridgeberry Hills Granite
SW - Southwest Brook complex

[1]Kerr and McNicoll, 2012
[2]Kerr et al., 1993
[3]Lynch et al., 2009

## Preliminary results, Devonian plutonic suite

Zircon U-Pb crystallization ages obtained thus far indicate that the suite of Devonian plutons was emplaced between ca. 378-372 Ma, with mineralized stocks (Grey River, Old Woman, Ackley, St. Lawrence) spanning the emplacement period. The Pass Island pluton, thought to be part of the Devonian suite, is in fact Silurian. Further data may shed light on a possible eastward younging trend: all dated plutons west of the Dover fault are ca. 378 Ma (e.g. Grey River, Francois, Gander Lake, Ackley mineralized) while the younger Ackley late phase and St. Lawrence plutons are entirely east of the Dover fault.

Ar/Ar data range from well-defined plateaux (typically muscovite, some biotite and hornblende; e.g. Gander Lake muscovite) to hump-shaped spectra (particularly biotite; e.g. Deadman's Bay granite). In general, muscovite and biotite integrated ages (and plateau ages where available) correspond or closely follow the range of known U-Pb zircon crystallization ages for the plutonic suite.

## Preliminary results, Dover fault


Figure 4. S-C fabric indicating sinistral shear sense in mylonitized granite of hypothesized Silurian crystallization age, deformed in Dover fault.

Ar/Ar step heat spectra for biotite are disturbed. Multiple aliquots yielded similar E-to M-Devonian integrated ages. Zircon U-Pb crystallization ages are pending.

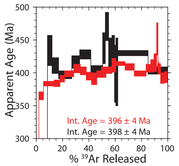




Figure 5. S-C fabric indicating dextral shear sense in mylonitized Hare Bay gneiss (Gander) in road cut. Deformed granite shallowly cross-cutting gneisses was sampled.

Ar/Ar step heat spectra for muscovite yield a poorly-defined plateau at ca. 377 Ma, yet many heating steps and another aliquot indicate an older, ca. 390 Ma component.

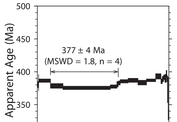
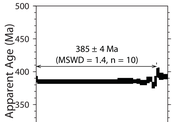



Figure 6. Late, syn-tectonic pegmatite at same road cut, cross-cuts gneiss at high angle and is weakly deformed.

Here Ar/Ar step heat spectra for muscovite yield a well-defined plateau at ca. 385 Ma. However, biotite grains yielded highly disturbed spectra and significantly younger (ca. 306 Ma) integrated ages of dubious geological significance. Zircon U-Pb ages are pending.




## Current interpretations, future directions

1. Temporo-spatial trend in pluton emplacement and relationship to mineralization.
2. Post-emplacement cooling appears to have been rapid on a regional scale (muscovite and biotite Ar/Ar ages similar to/coincide with zircon U-Pb crystallization ages).
3. Identification of a Silurian granite (Pass Island) in supposed Avalon Zone = major implications for location of the Gander-Avalon boundary and extension of the Dover fault, as well as tectonic affinity of the Connaigre Peninsula (currently focus of a TGI IV-funded PhD study at MUN).
4. Ar/Ar data from fault rocks correspond well with cross-cutting relationships, predating and/or co-inciding with Devonian pluton emplacement. This suggests that they may record recrystallization during or cooling after deformation. These possibilities will be investigated with petrography and further in situ Ar/Ar analysis.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