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Anatomy of a Mesoarchean Batholith

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The North Caribou greenstone belt (NCGB) lies in the North Caribou Terrane (NCT) of the Superior Province at the northeastern boundary of the North Caribou Core and the Island Lake Domain (Stott et al. 2010). The NCGB hosts the Musselwhite gold mine, a banded-iron-formation-hosted orogenic load gold deposit, and structural controls on the deposit have been linked to intrusions along the margins of the NCGB (Stott and Biczok 2010). The most prominent of these intrusions is the North Caribou Batholith (NCB), which forms the southern and western boundaries of the west-central half of the NCGB. The contact of the NCB with the greenstone belt is marked by a crescent of low magnetic susceptibility relative to the centre of the NCB, and this has been interpreted by Stott and Biczok (2010) as a “crescent pluton,” like those found elsewhere in the Superior Province. These crescent plutons intrude along the contact of greenstone belts and older gneissic terranes and impose a strain aureole on the less-competent greenstone belts, causing them to form arcuate shapes. Since the margin of the NCB conforms to the structural and geometric constraints of crescent plutons, this area has been dubbed the North Caribou Pluton (NCP). This interpretation prompted an investigation of the NCP to determine if this pluton is a discrete, younger intrusion. New U-Pb ages from zircon and titanite, along with whole rock and zircon geochemistry, and amphibole and plagioclase thermobarometry illuminate the evolution and relationship between the NCP and the rest of the NCB.

Rocks in the NCB range from tonalites to granites and have a wide variety of textures and compositions. Textures throughout the NCB include enclaves of isotropic, equigranular, weakly-deformed granitoids, strongly foliated and lineated gneisses, and migmatites. Some of the migmatites are partially-melted amphibolites, which occur near the northern margin of the intrusive complex, but there are also granitoids with schlieren and other textures suggesting either partial melting, melt segregation, or magma mixing. Late K-feldspar-rich pegmatites occur around the margins of the NCB, in both the NCP and the central batholith.

U-Pb geochronology on zircon and titanite was conducted using LA-ICP-MS methods at the University of New Brunswick. Single zircon ages range from 3132-2693 Ma, with a majority of rock ages falling between 2870 Ma and 2830 Ma. These ages are consistent with those reported by previous workers in the NCB and elsewhere in the NCT (e.g. Biczok et al. 2012). Ages from titanite are similar to the younger zircon populations. In the central NCB, titanite ages from 2798-2791 Ma are found in rocks with zircon ages of 2834-2833 Ma. This 30 My difference could represent cooling through the different closure temperatures of titanite and zircon (500 and 900 °C, respectively). The titanite in the NCP, however, record ages between 2766 Ma and 2748 Ma, with a ~100 My difference between the zircon and titanite ages. As the titanites from these rocks are roughly aligned with the foliation, and the ages match zircon ages in younger intrusions surrounding the NCGB, these ages likely reflect later tectonism.

To further assess the relationship between the rocks in the NCP and those in the central NCB, depth and temperature of emplacement was estimated using the plagioclase-amphibole thermobarometer and the Ti-in-zircon thermometer. Titanium concentrations in zircon were

measured using LA-ICP-MS, and calculated temperatures range from 830-760 °C in the NCP and 790-750 °C in the central NCB. Plagioclase-amphibole temperatures and pressures were calculated following Holland and Blundy (1994) and Anderson and Smith (1995). Only five samples from the NCB have the appropriate mineralogy for the thermobarometer, only one of which was in the NCP. The temperature/ pressure conditions for the NCP sample are 600 ± 20 °C and 6.3 ± 0.2 kbar (~22 km). Since this sample also contained isotopically disturbed titanite, it is possible that the plagioclase and amphibole compositions record this later event, rather than the emplacement conditions. The PT conditions in the central part of the batholith range from 640-620 °C and 7.5-6.7 kbar (~26-23 km).

These data provide some evidence supporting the crescent pluton model of the NCP. The shape of the NCGB, the magnetic signature of the NCP, and the structural data from previous workers are similar to the observations of crescent plutons in other greenstone belts. The model requires an intrusive contact between the crescent plutons and the supracrustal rocks, and the partially-melted amphibolites in the NCP clearly demonstrate that this contact is intrusive. Major, minor, and trace element geochemistry from the NCP is less variable than that from the rest of the NCB, despite a wide range of SiO₂ concentrations, and REE patterns in zircon in the NCP have distinct, shallower slopes than those in the NCB. This suggests that the rocks in the NCP are more similar to each other than those in the rest of the NCB. U-Pb ages from titanite in the NCP are also younger than those in the central NCB.

There are, however, new data that do not support a late crescent pluton. Zircon U-Pb ages in the NCP range from 2870-2858 Ma, which is slightly older than the ages from the centre of the NCB, which are 2852-2833 Ma. There is also no difference between the textures in the pluton and the batholith, as both contain gneisses and isotropic granitoids. Temperatures and pressures are also indistinguishable across the contact between the NCP and the central NCB.

The older zircon ages in the NCP suggest either that the NCP represents a chill-margin on the NCB or a discrete earlier intrusion. Since the NCB has a map area of ~2800 km² and does not exhibit cumulate textures, it is unlikely the entire complex was emplaced as a single melt batch. It is more likely that the primary conduit for the magma was near the centre of the NCB, and that several, approximately concentric, intrusions emanating from this area were emplaced at roughly the same depth over ~40 My. This model predicts older granitoids on the margins of the intrusive complex, which have been forced away from the centre by continued magmatism. This is consistent with the aeromagnetic data and textures observed in the NCB, as well as the geochronology, geochemistry and thermobarometry. Since this study did not investigate fabrics and structures related to the intrusions, we cannot comment on whether the kinematics of this model are consistent with these data. Further studies of the NCB, including fabric analysis, could constrain the dynamics of the intrusions and improve the proposed model.

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