Incremental Emplacement of Nelson Batholith, British Columbia?

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Summary

The Middle Jurassic Nelson Batholith in Southern British Columbia is a composite pluton ranging from diorite to granite. Understanding the formation of such large plutonic bodies like the Nelson batholith is a fundamental requirement to understanding the magma emplacement processes and their rates.

New zircon U-Pb SHRIMP geochronology study was initiated on six rock samples of the Nelson batholith and neighboring Middle Jurassic plutons. The results indicate a significant gap in time of ~15 my between the youngest and oldest samples collected. These ages of 153.2±2.3 Ma and 168.2±2.9 Ma were found in samples collected from the northwest and northeast margins of the Nelson Batholith, respectively. Other samples collected from the middle and southern parts of the Nelson batholith and of the neighboring Bonnington and Trail plutons range between 163.5±3.3 Ma and 168.9±2.0 Ma.

The new data is indicative of incremental assembly of Nelson Batholith and is consistent with such a model for large plutonic complexes.

Introduction

The Middle Jurassic Nelson Batholith of southern British Columbia is one of the best exposed and accessible plutonic rock bodies in the Canadian Cordillera and therefore suitable for studying processes of heat and mass transfer by magmas in active continental margins. The Nelson Batholith (NB) is part of the Quesnallia arc terrane of the Omineca Belt in the Canadian Cordillera in southern British Columbia. The Middle Jurassic intrusive rocks that formed the NB also includes three other plutons just southwest of the NB which include the Bonnington, Mackie, and Trail plutons (collectively, the BMT suite) which were suggested to be co-genetic with the NB based on spatial proximity, compositional similarity, and similar ages (LeClair, 1988). Carr and Simony (2006) hypothesized based on this data that the BMT suite was linked at depth by former magma conduits and based largely on field-mapping and structural analysis, they surmise that the deep portions of the NB and BMT suite was sheared and thrusted during the Cretaceous–Paleocene emplacement of the terrane, during which the plutons were cut-off from their source.

The processes involved in the formation of such large batholithic bodies such as the NB and BMT suite start with the tectonic events related to the formation of new magma in the mantle or crust. The magma composition can then change as a result of processes such as magma mixing and assimilation of country rocks as well as magma differentiation and fractional crystallization. Ascending of large portions of melt in the continental crust and the amalgamation of those melt pulses into the plutons we see today is yet another important aspect. The rate and specific mechanism of emplacement of such large batholithic bodies was questioned in the past few years [e.g., Glazner *et al*., 2004] and formation by incremental emplacement rather than a single voluminous diapiric event has been proposed.

Methods and results

The six samples chosen for analysis are scattered all around the main body of the Nelson batholith and in the Bonnington and Trail plutons (see Fig. 1). Petrographic study of the samples classified the compositions based on the QAP classification as Diorite (#29), Quartz monzonite (#10, 23, 30), Granodiorite (#21) and Granite (#34). Whole Rock XRF and ICP analyses were performed at the Geoanalytical labs of the Washington State University. The weight % SiO_2 of the samples are 52.74%, 60.82%, 60.45%, 61.31%, 66.17% and 71.07%, respectively. Most other elements show a linear distribution with weight % SiO_2 composition on Harker Plots (See Fig 2) with strongly coherent geochemical trends.

New geochronological ages of six rocks sampled from the Nelson, Bonnington and Trail plutons were determined on SHRIMP RG at the Australian National University labs. *In situ* Pb/U dating was conducted using standard techniques (Williams, 1998). Cathodoluminescence images of the zircons showed inherited cores and thus *in situ* analyses using the ion probe were carefully conducted on the magmatic rims of those grains to avoid any inheritance of older phases.

The mean, ^{207}Pb corrected ^{206}Pb/^{238}U ages for the six samples are as follows (all uncertainties are at 95% confidence and include the uncertainty on the standard): The diorite (#29) is 168.2±2.9 Ma (n=13), the Quartz monzonites (#10, 23, 30) are 164.3±1.9 Ma (n=24), 163.5±3.3 Ma (n=16), and 153.2±2.3 Ma (n=12) respectively, the Granodiorite (#21) is 168.9±2.0 Ma (n=15) and the Granite (#34) is 166.0±2.6 Ma (n=12).

Discussion

Five of the six new ages received for the Nelson, Bonnington and Trail yield similar ages (within error). These coeval samples range in SiO_2 content between 52.74 and 71.07 wt.% with linear correlation of other major and minor elements indicating a co-genetic connection through differentiation and fractional crystallization. The younger sample, #30, lies in the middle of the fractionation trend and thus implies that the younger pulse of magma which formed it resulted from a similar source which underwent similar differentiation and fractionation processes (Further work is planned in order to test this hypothesis).

The presence of at least two identified pulses of magma which formed chemically similar rocks previously mapped as one unit, and the gap in time between the pulses, represent a complex history for the formation of the NB and BMT suite. This evidence serves as a strong support for incremental emplacement for the Nelson batholith, similar to that suggested for comparable complexes in the Cordillera and other areas.

Future work planned includes LA-MC-ICP-MS *in situ* isotopic studies of Hf and O in the magmatic rims of zircon grains as well as in the inherited cores of those zircons, which will also be dated. Similar core ages can indicate on the same source for those samples and the isotopic ratios can indicate on the nature of it. These results are expected to contribute to the investigation of the co-genetic nature of the rocks of the NB and the BMT suite and identify connections and differences between samples from various locations in the plutons and thus the presence of pulses, their compositions and growth phases.

Conclusion

New geochronological data for six samples from the Nelson Batholith, Bonnington and Trail plutons indicate the presence of two magmatic pulses within the Nelson batholith itself and in the Middle Jurassic intrusive rock of the Nelson area in general. A gap in time of ~15 my between the northeast and northwest margins of the Nelson batholith indicate a complex assemblage history which includes multiple emplacement episodes, such as was suggested for similar large plutonic bodies worldwide.

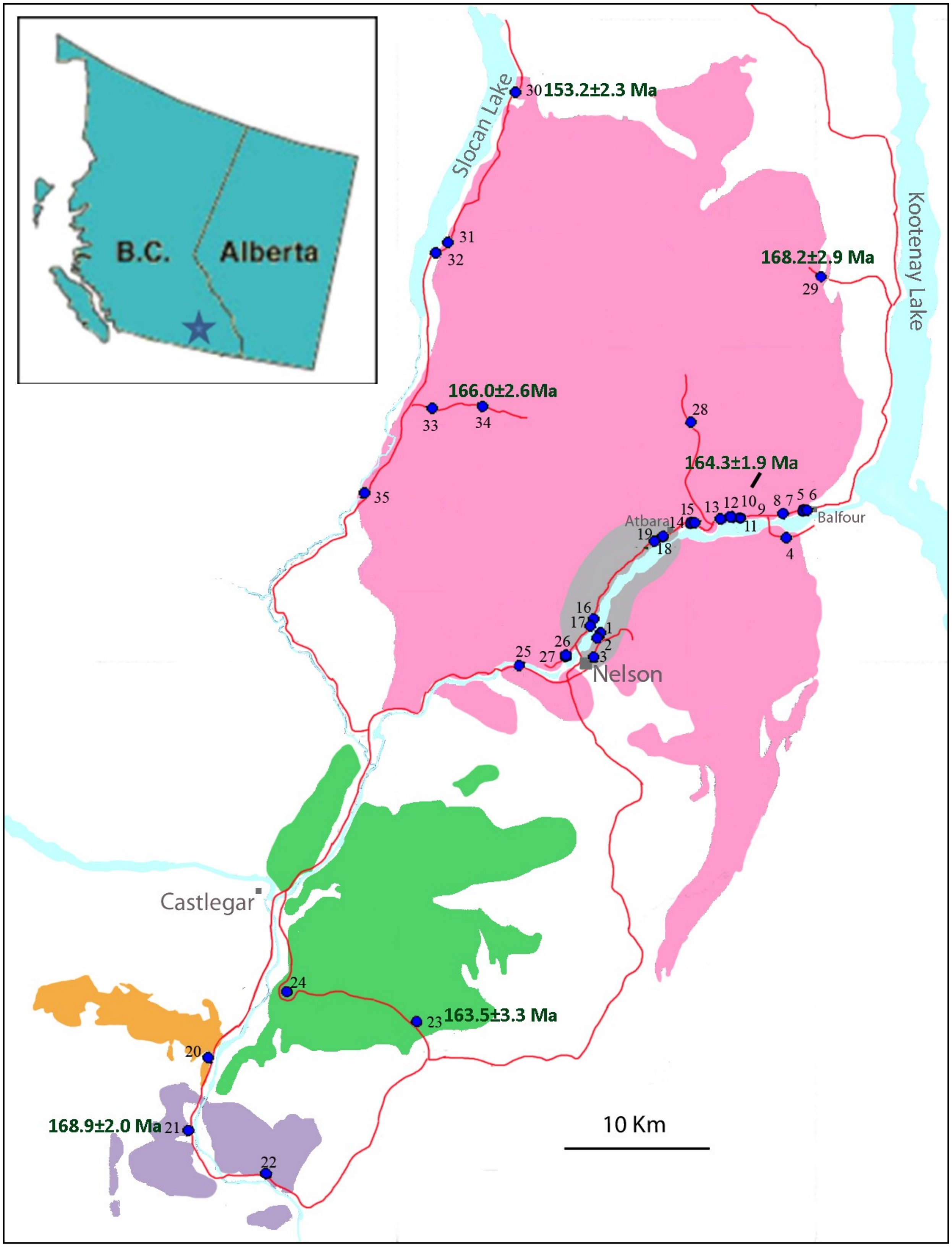

Fig 1 – Map of sample locations and their ages. The Nelson batholith (pink), Bonnington (green), Trail (purple) and Mackie (orange) plutons, Southern BC. In grey, early Paleocene intrusion (64±1 Ma, unpublished data of the author).

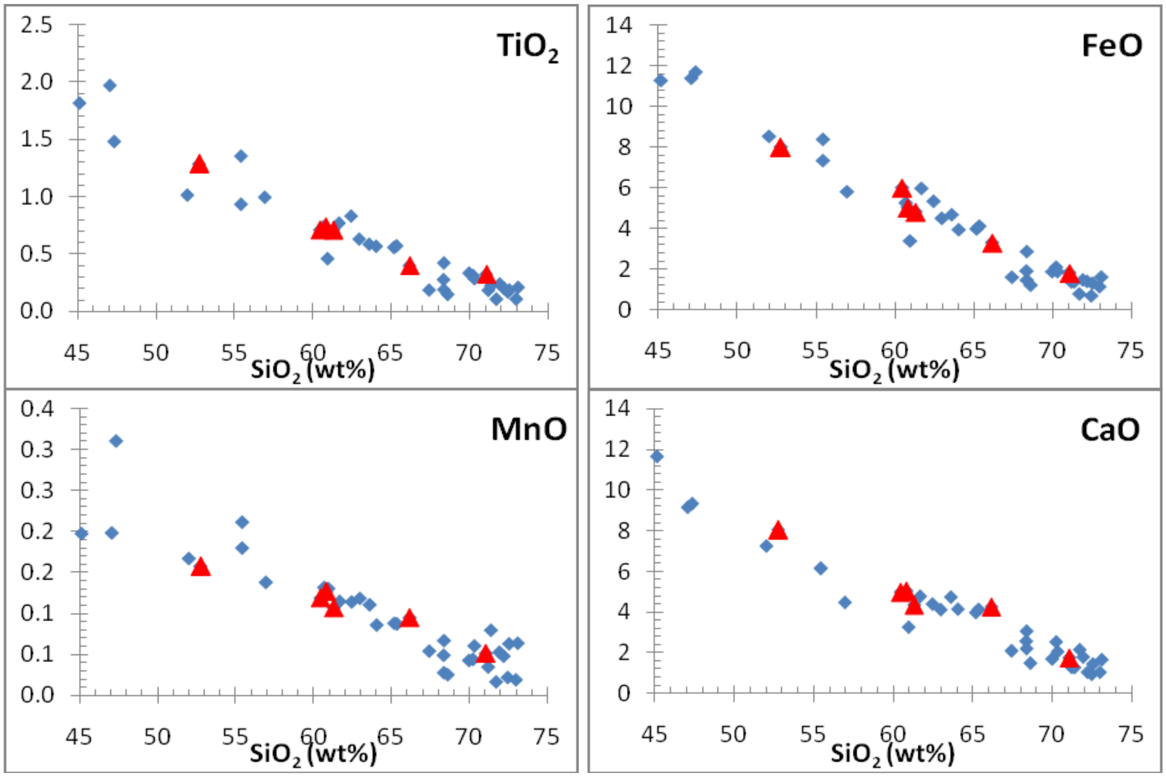

Fig 2 – Harker plots of Whole Rock XRF results for the six samples (in red triangles), compared with other samples collected for this study.

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