Redox state of the South Mountain Batholith, Nova Scotia, Canada: a reconnaissance study using zircon geochemistry

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The Late Devonian South Mountain Batholith (SMB) of southwestern Nova Scotia is the largest plutonic igneous body in the Appalachian orogen, with a current surface expression of 73 000 km^2. The batholith is composed of 13 distinct plutons that are broadly peraluminous in composition, ranging from tonalite to syenogranite. A parameter that has been particularly difficult to quantify for the SMB is the redox state, as measured by the oxygen fugacity (fO_2), which exerts a profound control on magmatic phase stability, element partitioning, and importantly, the potential for economic mineral deposits. We are attempting a redox state survey of mineralized and unmineralized phases of the SMB using the newly calibrated Ce-in-zircon oxygen barometer. This method combines bulk rock and zircon compositions to calculate apparent zircon/melt partition coefficients for Ce, a parameter which varies with the Ce^{4+}/Ce^{3+} in the melt, and hence oxygen fugacity. A total of 23 samples were collected; 13 of these were selected for zircon separation lithogeochemical analysis based on spatial distribution, mineralogy, and preliminary geochemical data acquired by portable XRF.

Zircons from the unmineralized Harrietsfield and Sandy Lake plutons, and mineralized New Ross pluton were imaged using CL to determine textural domains, which were a guide to subsequent analysis by electron microprobe and LA-ICPMS. Zircon cores, which were delineated based on CL response, display a large variation in shape (euhedral to anhedral) and pattern (zoned and unzoned), and are typically truncated by concentrically zoned rims. Data from LA-ICPMS analyses of cores and rims yielded two distinct patterns on chondrite-normalized REE diagrams. The first pattern depicts a continuous increase in REE concentration with increase in ionic radius (La to Lu), large positive Ce anomaly and negative Eu anomaly; these characteristics are typically associated with magmatic zircons. The second pattern also shows a negative Eu anomaly, but a subtler increase in REE concentration from La to Lu and a lack of Ce anomaly; these characteristics are typically associated with hydrothermal zircons. Most zircons in the mineralized SMB phase exhibit the hydrothermal pattern, whereas the unmineralized SMB phases display a combination of both patterns with a dominant magmatic component. Additionally, within the Sandy Lake monzogranite we observe a large range in inferred fO_2 values (based on calculated Ce^{4+}/Ce^{3+} in zircon) that is absent in other samples. The relationship between REE trends, other trace elements, fO_2, and textural characteristics of the analyzed zircons will also be discussed.

Atlantic Geology, 2019, Volume 55
Atlantic Geoscience Society Abstracts – 45th Colloquium & Annual General Meeting 2019
https://doi.org/10.4138/atlgeol.2019.005