New Constraints on Formation of Orthogneiss in Southern Adirondacks Using Integrated Petrology, Zircon U-Pb Geochronology, and Whole Rock Geochemistry

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Introduction

The Adirondack Mountains (ADK) are an outlier and the southern most part of the Grenville province in northeastern New York. The ADK are subdivided into two domains by the Carthage-Colton Mylonite Zone. The Lowlands are characterized by metasedimentary rocks, including marbles, evaporites, and volcanic units. The Highlands are formed by granulite facies meta igneous rocks and anorthosite-mangerite-charnokite-granite magmatic complex. Granulite-facies orthogneisses exposed in the Southern Highlands yield the oldest ages in ADK, however, those ages come from a limited number of outcrops. We present new petrological, geochemical, and geochronological data for several quartofeldspathic orthogneiss units to document the nature and origin of these rocks.

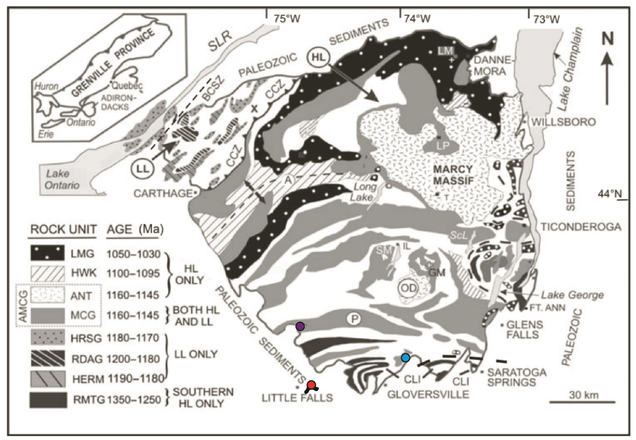

Figure 1: Locus Map indicating the location of collection for samples. Blue indicates SA-21-01. Red indicates SA-21-02. Purples indicate SA-21-03. Modified after (Mclelland et al., 2010)

Geochemistry

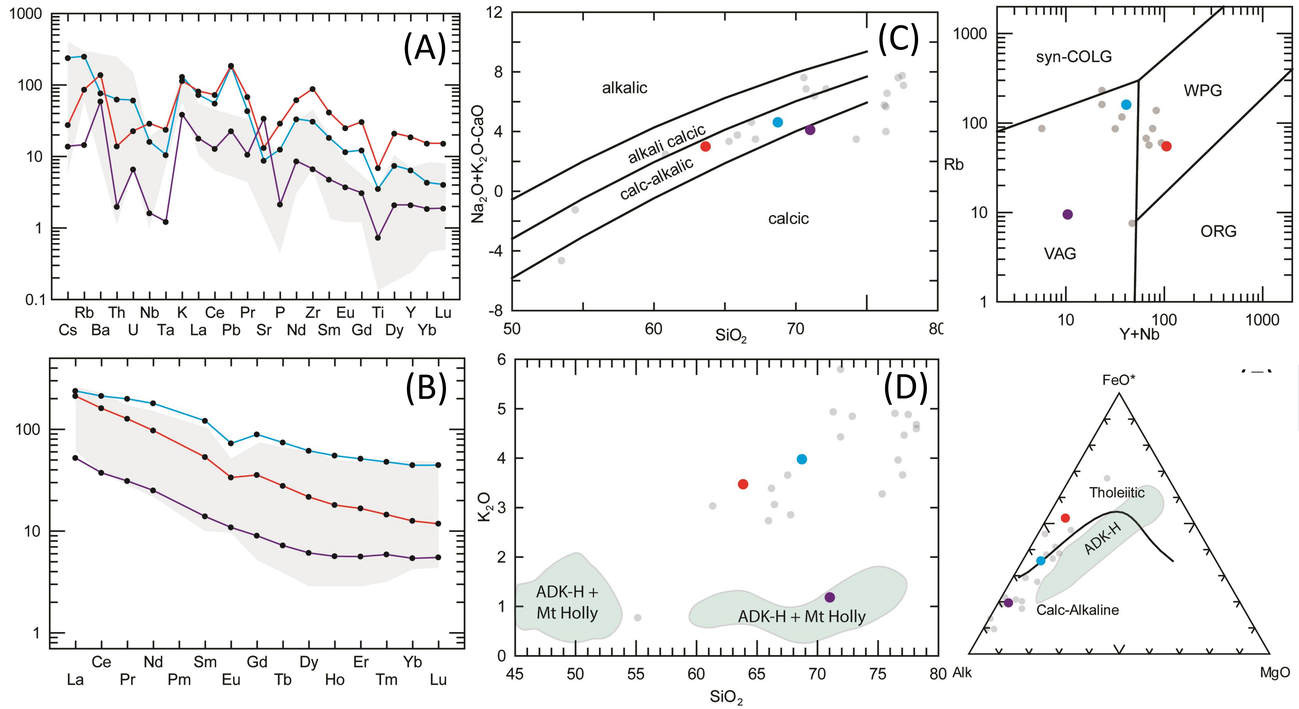

Figure 2: (A) Spider diagram normalized against primitive mantle (Sun and McDonough, 1989). (B) Rare earth element composition normalized against chondrite (Sun and McDonough, 1989). (C) MALI granite classification chart indicating nature of all samples. (Frost et al., 2001) (D) Comparison of K2O content against Geon 14 calk-alkaline rocks from the Adirondacks (ADK-H) and Mt. Holly complex in the Green Mountains (Ratcliffe et al., 1991) with additional data from Mont-Trembant gneiss, Grenville Province, Quebec (Peck, 2012). (E) Granitoid discrimination diagram (Frost, 2001) with additional data from (Peck, 2012) WPG (within plate granite); VAG (volcanic arc granite); syn-COLG (syn-collisional granite); ORG (orogenic granite). (F) AFM diagram with additional data and ADK-H (Peck, 2012).

Petrologic Analysis

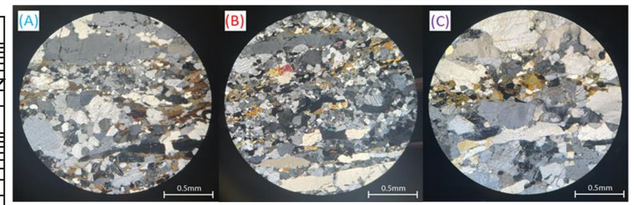

Figure 4: All samples have very high quartz and feldspar content. Variations in secondary and minor minerals are what show distinction. (A) SA-21-01 has large amounts of K-feldspar, plagioclase, and biotite. Biotite and elongate quartz ribbons form the laminae and foliation. Some opaque minor minerals are present. (B) SA-21-02 is majority composed of quartz and feldspar but also has a significant proportion of pyroxene. Biotite is present but not as significant. SA-21-02 also has high temperature metamorphic structures within the quartz and feldspar crystals. Flame perthites are common in feldspar throughout the thin section and quartz displays checkerboard extinction. (C) SA-21-03 has three majority minerals, feldspar, quartz and biotite. SA-21-03 is coarse grained and has ribbons of quartz that form foliation.

Results

- Petrologic analysis shows similar mineral compositions. SA-21-01 is 60% quartz, 30% feldspar and 10% biotite. Large K-feldspar grains common but are isolated. SA-21-02 is 70% quartz 20% feldspar 8% pyroxene and 2% biotite. SA-21-03 is 75% quartz 20% feldspar and 5% biotite.
- Major element geochemistry shows calc-alkalic affinities on MALI diagram and display a calc-alkaline trend in AFM diagram. Y+Nb vs. Rb tectonic discrimination diagram indicates WPG and VAG settings.
- REE geochemistry on the primitive mantle normalized spider diagram shows low Ti, Ta, Th, and P values. One sample has an opposite trend in Sr and a peak in U that is not found in the other two samples. Chondrite normalized spider diagram depicts two trends one showing Eu depletion and SA-21-03 displays a flat heavy REE.
- Geochronology presents two distinct age populations: c. 1150 Ma and c. 1350 Ma. Cathodoluminescence images show oscillatory growth patterns in cores and homogenous rim growths in majority of zircon grains.

Methods

- U-Pb geochronology using LA-ICP-MS (University of Arizona LaserChron Center)
- Petrologic analysis (Quality Thin Sections, AZ)
- Whole rock geochemistry (LA-ICP-MS) and (XRF) (Hamilton Analytical Lab, NY)

Geochronology

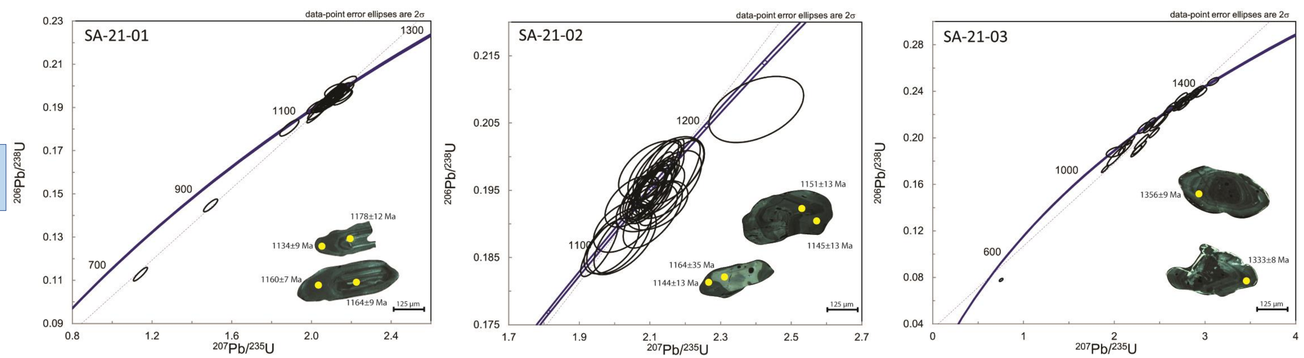

Figure 3: Concordia diagrams and cathodoluminescence images of selected zircon grains from all three samples. LA-ICP-MS zircon geochronology yields two distinct age populations of ca. 1150 Ma and ca. 1346 Ma. SA-21-01 has long prismatic dipyramid zircons with core and rim structures and yields a mean age of 1160±4 Ma (MSWD=1.06, n=25, U=463±201, U/Th=2.66±1.45). SA-21-02 zircons mostly reveal bright cores with deep embayment and darker rims and give a mean age of 1149±6 Ma (MSWD=1.2, n=28, U=101±73, U/Th=2.40±0.95). SA-21-03 zircons are mostly elongated, euhedral, and show oscillatory zoning. They show dark CL interiors, bright rims, and yield a mean age of 1346±14 Ma (MSWD=10.5, n=20, U=468±198, U/Th=6.75±3.06).

Conclusions

- U-Pb zircon geochronology results indicate two distinct age groups. The ca. 1350 Ma age aligns with the known early development of oceanic island arcs lithologies in the Adirondack Highlands (McLelland et al., 2010). The ca. 1150 Ma ages represent magmatism related to the Shawinigan Orogeny commonly found in the Highlands and southern Grenville Province in Canada (Peck et al., 2012).
- Major element geochemistry indicates subduction-related calc-alkaline magmatism. REE geochemistry presents a clear separation of two groups one having depleted Eu. Primitive mantle normalized spider diagram displays two groups with variations in Sr and U. Depleted Ti, Ta, Nb, and P values indicate subduction-related magmatism, similar to units exposed in the ADK Highlands and Grenville Province in Canada (Peck et al., 2012; McLelland et al., 2010)

Acknowledgements and References

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