KECK GEOLOGY CONSORTIUM

PROCEEDINGS OF THE TWENTY-SECOND ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

April 2009
Franklin & Marshall College, Lancaster PA.

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THE BLACK LAKE SHEAR ZONE: A POSSIBLE TERRANE BOUNDARY IN THE ADIRONDACK LOWLANDS (GRENVILLE PROVINCE, NEW YORK)
Faculty: *WILLIAM H. PECK*, *BRUCE W. SELLECK* and *MARTIN S. WONG*: Colgate University
Students: *JOE CATALANO*: Union College; *ISIS FUKAI*: Oberlin College; *STEVEN HOCHMAN*: Pomona College; *JOSHUA T. MAURER*: Mt Union College; *ROBERT NOWAK*: The College of Wooster; *SEAN REGAN*: St. Lawrence University; *ASHLEY RUSSELL*: University of North Dakota; *ANDREW G. STOCKER*: Claremont McKenna College; *CELINA N. WILL*: Mount Holyoke College

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THE BLACK LAKE SHEAR ZONE: A POSSIBLE TERRANE BOUNDARY IN THE ADIRONDACK LOWLANDS (GRENVILLE PROVINCE, NEW YORK)
Project Faculty: ***WILLIAM H. PECK; BRUCE W. SELLECK; MARTIN S. WONG*** - Colgate University

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CALCITE-GRAPHITE ISOTOPE THERMOMETRY NEAR THE BLACK LAKE SHEAR ZONE, ADIRONDACK LOWLANDS, NY
CELINA N. WILL**:** Mount Holyoke College
Research Advisor: Steven R. Dunn

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WILLIAM H. PECK: Colgate University
BRUCE W. SELLECK: Colgate University
MARTIN S. WONG: Colgate University

INTRODUCTION

The Grenville Province extends from Labrador to New York, and exposes high-grade rocks that represent a variety of tectonic environments along the Mesoproterozoic margin of Laurentia. The Grenville has traditionally been subdivided into terranes bounded by ductile shear zones, based on differences in tectonic histories and rock assemblages (Davidson, 1995). These terranes may represent exotic crustal blocks accreted to North America, or different tectonic elements (e.g. continental arcs and basins) formed on Laurentia's margin (Hanmer et al., 2000). Identifying terrane boundaries and understanding their significance is especially difficult in the Grenville Province of New York and adjacent parts of Ontario and Quebec because of the overprinting effects of granulite and amphibolite-facies metamorphism, lack of coherent structural markers across shear zones, and the large number of shear zones to choose from. Recent recognition of orogen-scale collapse structures in the Grenville (e.g. Selleck et al., 2005) also raises the question as to which 'terrane boundaries' are true boundaries between different tectonic environments, and which are detachment/exhumation boundaries that juxtapose different levels of the same crustal blocks.

GEOLOGY OF THE ADIRONDACK LOWLANDS

The amphibolite-facies Adirondack Lowlands of New York (Fig. l) is made up of a package of supracrustal rocks intruded by magmatic suites that span ca. 1200-1150 Ma. The Adirondack Lowlands are bounded on the southeast by the Carthage-Colton shear zone, and transition into the Frontenac terrane of Ontario, with which it is often grouped in tectonic reconstructions, near the St. Lawrence River. For the past 20 years it has been generally accepted that the Carthage Colton Shear zone (CCSZ in Fig. 1) in the Adirondack Lowlands is the terrane boundary between granulite-facies metaigneous rocks of the Adirondack Highlands and the amphibolite-facies supracrustal package of the Adirondack Lowlands (e.g. Streepey et al., 2004).

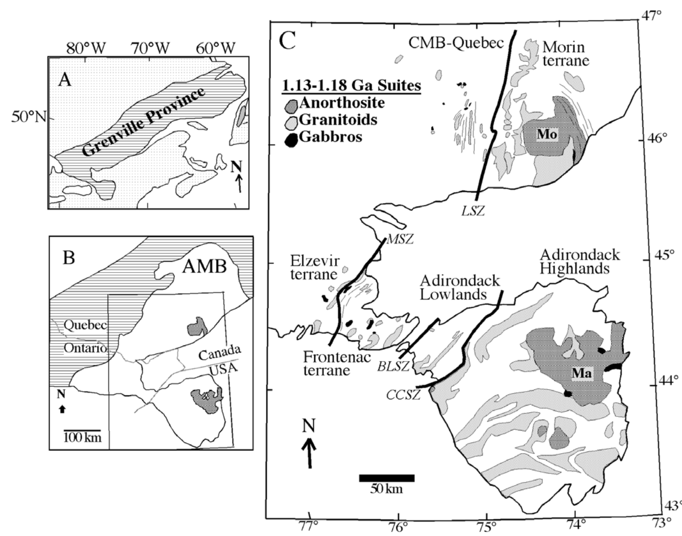

Figure 1. General map of the southwest Grenville Province, showing ca. 1.1-1.18 Ga anorthosites and granitoids and major shear zones. (A) Location of the study area within the Grenville Province. (B) Location map and subdivisions of the Allochthonous Monocyclic Belt (AMB) of the Grenville Province. (C) Detail of B. BLSZ—Black Lake shear zone; CCSZ— Carthage-Colton shear zone; CMBQuébec—Central Metasedimentary Belt of Québec; LDZ—Labelle deformation zone; MSZ—Maberly shear zone; Ma—Marcy anorthosite massif; Mo—Morin anorthosite massif.

Recent work has shown that the CCSZ was active as a high-temperature extensional ductile shear zone during the intrusion of Lyon Mountain suite (1050-

1035 Ma) granites into the lower plate (the Adirondack Highlands), and syn-extension hydrothermal mineralization is localized along this boundary and within the adjacent Adirondack Lowlands, which acted as the upper plate of the CCSZ (Selleck et al., 2005). This recognition forms a context for understanding observed discontinuities in age of metamorphism, metamorphic grade, and rock-types across the CCSZ, but leaves the relationship between the Adirondacks and the Grenville Province of Ontario poorly constrained. If the Adirondack Highlands and Lowlands represent different levels of the same crustal block, then a tectonic boundary may exist between the 'Adirondack terrane' and the rocks of the Frontenac terrane in Ontario. It has been proposed, mainly based on the occurrence and geochemistry of magmatic suites in the Adirondack Lowlands, that this terrane boundary is the Black Lake shear zone (BLSZ) near the St. Lawrence River (Davidson, 1995; Peck et al., 2004) (Fig. 2).

STRUCTURAL GEOLOGY OF THE BLACK LAKE SHEAR ZONE

The structural geology of the high-temperature Black Lake shear zone has received little attention since the original quadrangle mapping in the area (Cushing et al., 1910; Buddington, 1934; Guzowski, 1978; Baird and Shrady, 2008). Three student projects examined the structural geology, petrology, and geochronology of rocks in the shear zone.

The best exposures of the Black Lake shear zone crop out along a ~2 km long extent of I-81 near the southern limit of exposure and on Route 12 along the St. Lawrence. Along the I-81 outcrops, the rocks are dominated by calc-silicate lithologies which are variably deformed. Joshua Mauer examined both the structure and petrology of these calc-silicate rocks. Josh found that foliations in these rocks are typically steeply SE dipping, but switch to steeply NW dipping, possibly indicating significant folding of the sequence. Throughout much of the outcrop, the rocks lack a lineation, although several sections contain strong sub-horizontal mineral lineations defined by elongate clinopyroxene grains, indicating high temperature deformation. Some of these pyroxene grains formed sigma porphyroclasts, although there was no consistent sense of shear throughout the outcrop. Josh's petrologic and geochemical work suggests a sedimentary protolith for these rocks using major and trace element geochemistry.

Granitic dikes also intrude these calc-silicate rocks and other lithologies along the I-81 outcrops and elsewhere throughout the study area. Steven Hochman examined the deformation and geochemistry of these felsic dikes. Steve's work showed that the granitic dikes in the study area are variably deformed. Most are NW trending with a variety of dips and there appears to be no correlation between the orientation of the dike and its degree of deformation. In addition, there are no clear correlations between the bulk chemistry of the dike and its degree of deformation, suggesting the lithology did not play a role in controlling which dikes were deformed. These results may suggest that the dikes are all of similar age (possibly ca. 1170 Ma) and have undergone varying amounts of deformation, largely as a function of the location of high strain zones within the region. If these dikes are of the same age, the location of such strained dikes may indicate where significant deformation has been accommodated.

As part of his project, Joseph Catalano used anisotropy of magnetic susceptibility (AMS) as a tool to examine deformation in ca. 1170 Ma granites that sit on either side the Black Lake shear zone. AMS is largely controlled by mineralogy as well as the shape preferred orientation of grains. Therefore, in many circumstances it can be used as a direct proxy for strain in a sample. His results help to constrain the location and other structural aspects of the shear zone. Joe found several clear strain gradients that delineate the location of a high strain zone or zones that likely correlate with the Black Lake shear zone. His work also reveals that a sub-horizontal AMS lineation is common within the plutonic rocks, even though this was not readily visible in the field. This work, combined with Josh Mauer's field data, suggests that deformation in this zone may have been dominated by horizontal flow, although it is unclear what the kinematics of this shear zone might have been. Given the variance in the kinematic indicators, movement may have been either dominated by NW-directed shortening resulting in pure shear, by several phases of strike-slip reactivation, or some combination.

MAGMATIC SUITES ASTRIDE THE BLACK LAKE SHEAR ZONE

The Black Lake shear zone appears to form a boundary separating the distribution of several magmatic suites within the Adirondack Lowlands and Frontenac terrane (Fig. 2). The ca. 1200 Ma calc-alkaline Antwerp-Rossie suite is only recognized directly on the eastern side of the shear zone (Wasteneys et al., 1999). Ca. 1170 Ma granitic rocks intrude both sides of the shear zone, but are represented by the massive, sheet-like Rockport granite intrusions on the western side and dome-like bodies of the Hyde School gneiss on the eastern side (Wasteneys et al., 1999). Rocks contemporaneous with the ca. 1150 Ma anorthosite-mangerite-charnockite-granite suite in the Adirondack Highlands are present in the Frontenac terrane, but are only represented in the Adirondack Lowlands by the Edwardsville syenite; an intrusive body that abuts the Black Lake shear zone. The Kingston dike swarm, olivine diabase members of this suite, occur only within the Frontenac terrane (Davidson, 1995). Four students focused on the petrology and geochemistry of these magmatic suites to try to better constrain their spatial distribution, compositions, and implications for tectonic assembly of their source regions.

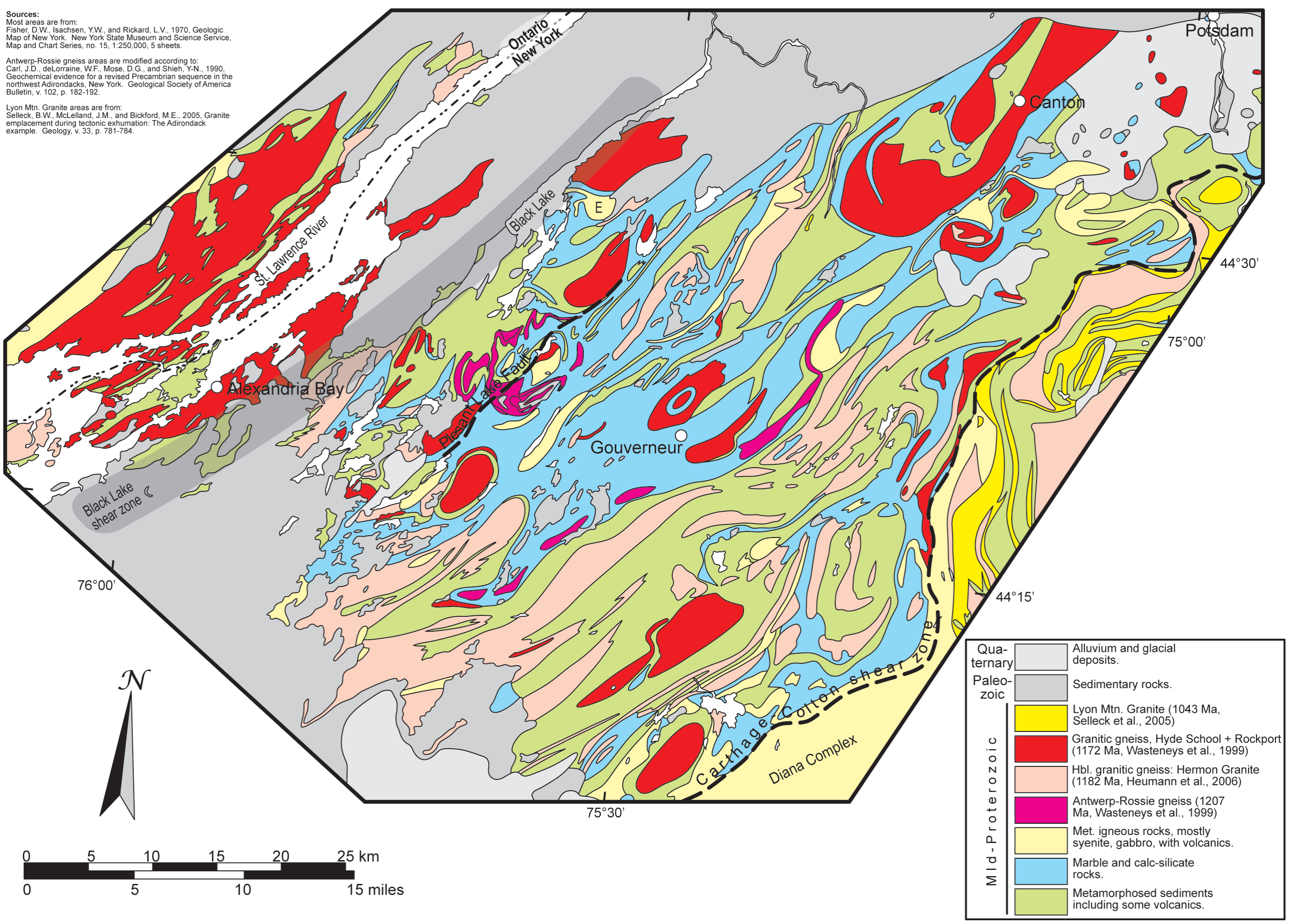

Figure 2. Geology of the Adirondack Lowlands, compiled by Joseph Catalano and Kurt Hollocher. Note that the distribution of the Antwerp-Rossie suite, Rockport granite, and Hyde School gneiss bodies appear to be controlled by the Black Lake shear zone. E= Edwardsville Syenite.

Sean Regan focused on the Antwerp-Rossie suite. He used major and trace element geochemistry and neodymium isotopes to constrain the origin of this suite, concluding that these calc-alkaline rocks are most likely related to subduction and melting of an enriched mantle source at ca. 1200 Ma.

Joseph Catalano examined the major element and trace element geochemistry of the 1170 Ma Rockport granite and several Hyde School gneiss bodies. His data demonstrate geochemical similarities between the Rockport and Hyde School gneiss and point to similar source region for these suites. This source is discrete from that of that of the Antwerp-Rossie suite.

The Hyde School gneiss bodies are surrounded by enigmatic garnet-bearing rocks that were studied by Robert Nowak. The origin of these aluminum and iron-rich rocks is controversial, and have been attributed by different workers to weathering, hydrothermal alteration, and melt extraction. Robert's petrologic, major element, trace element, and carbon isotope data link these rocks to magmatic rocks of the Hyde School gneiss and help constrain the role of contamination by wallrocks in these bodies.

Andrew Stocker made the first comprehensive petrologic study of the Edwardsville syenite, a possible member of 1150 Ma anorthosite-suite magmatism in the Adirondack Lowlands. Andrew's project uses field observations and major and trace element data to geochemically link a number of different mapped lithologies in the area of the Edwardsville syenite, and helps to confirm affinities to anorthosite-suite granitic rocks in the Frontenac terrane.

METAMORPHIC PETROLOGY IN THE NORTHWESTERN ADIRONDACK LOWLANDS

The area around the Black Lake shear zone has not been the focus of recent studies of metamorphism, in contrast to other areas in the Adirondack Lowlands. This is largely due to the prevalence of rock-types that are generally unsuitable for geothermobarometry. Understanding differences of pressures and temperatures around the shear zone is important because it helps constrain the crustal level exposed by faulting and may serve to expose discontinuities across the boundary. Conventional cation geothermobarometric data is scarce in the area of the shear zone (e.g. Streepey, 1997), and generally agrees with calcite-graphite carbon isotope thermometry that averages 670±25°C (Kitchen and Valley, 1995).

Celina Will collected graphite-bearing marbles for carbon isotope thermometry in the area of the Black Lake shear zone to expand on the results of Kitchen and Valley (1995) and better constrain metamorphic temperatures. Celina's sampling confirms earlier data and expands estimates of metamorphic temperatures to the area south of Black Lake, where calcite-graphite data show ca. 720°C temperatures.

Ashley Russell examined the petrology of pelitic schists and gneisses in the Adirondack Lowlands and in the Ontario Frontenac terrane, including distinctive 'eye-schists' described by Buddington (1934). She documents amphibolite facies assemblages in the Adirondack Lowlands, including rocks on either side of the shear zone, and orthopyroxene-bearing granulite facies in the Frontenac terrane of Ontario.

Isis Fukai examined the petrology of amphibolites on either side of the Black Lake shear zone and into the central Adirondack Lowlands. Her project was to evaluate the possibility of using amphibolites for thermobarometry, and the applicability of a newly-developed thermometer which uses the assemblage hornblende-plagioclase-clinopyroxene-quartz in amphibolites (Liogys and Jenkins, 2000). Amphibolites collected in the Adirondack Lowlands do not contain quartz, making them unsuitable for use of this thermometer. Pseudosections constructed for these rocks illustrate their high-variance assemblages and their unsuitability for precisely constraining metamorphic conditions.

CONCLUSIONS

This project has focused on the structural and petrologic characteristics of the Black Lake shear zone, a heretofore poorly described zone of high strain in the northwestern Adirondack Lowlands. Future work will focus on interpreting the plate-tectonic setting of the Antwerp-Rossie suite, the geochronology of variably deformed stitching pluton and dike suites, and determination of metamorphic temperatures in the Frontenac terrane to further understand discontinuities across the shear zone.

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REFERENCES

Baird, GB, and Shrady, CH, 2008, Nature of Ottawan Deformation in the Adirondack Lowlands, Geological Society of America Abstracts with Programs, v. 40(6), p. 236.

Buddington, AF, 1934, Geology and mineral resources of the Hammond, Antwerp, and Lowville quadrangles: New York State Museum Bulletin 296.

Carl, JD, and deLorraine, WF, 1997, Geochemical and field characteristics of metamorphosed granitic rocks, NW Adirondack Lowlands, New York: Northeastern Geology and Environmental Science, v. 19, p. 276–301.

Cushing, HP, Fairchild, HL, Ruedemann, R. and Smyth, CH, 1910, Geology of the Thousand Islands region, Alexandria Bay, Cape Vincent, Clayton, Grindstone, and Theresa quadrangles, New York: New York State Museum Bulletin 145.

Davidson, A., 1995, A review of the Grenville orogen in its North American type area: AGSO Journal of Australian Geology & Geophysics, v. 16, p. 3–24.

Guzowski, RV, 1978. Stratigraphy, structure and petrology of the Precambrian rocks in the Black Lake region, northwest Adirondacks, New York, Unpublished PhD thesis, Syracuse University, Syracuse, NY, 184 pp.

Hanmer, S, Corrigan, D, Pehrsson, S, and Nadeau, L., 2000, SW Grenville Province, Canada: the case against post-1.4 Ga accretionary tectonics, Tectonophysics, v. 319, p. 33-51.

Kitchen, NE and Valley, JW, 1995. Carbon isotope thermometry in marbles of the Adirondack Mountains, New York, Journal of Metamorphic Geology, v. 13, p. 577-594.

Liogys, VA and Jenkins, DM, 2000. Hornblende geothermometry of amphibolite layers of the Popple Hill gneiss, north-west Adirondack Lowlands, New York, USA, Journal of Metamorphic Geology, v. 18, p. 513-530.

Peck, WH, Valley, JW, Corriveau, L, Davidson, A, McLelland, J, and Farber, DA, 2004, Oxygen-isotope constraints on terrane boundaries and origin of 1.18–1.13 Ga granitoids in the southern Grenville Province, in Tollo, RP, Corriveau, L, McLelland, J, and Bartholomew, MJ, eds., Proterozoic tectonic evolution of the Grenville orogen in North America: Boulder, Colorado, Geological Society of America Memoir 197, p. 163-182.

Selleck, B, McLelland, JM, and Bickford, ME, 2005, Granite emplacement during tectonic exhumation: The Adirondack example: Geology, v. 33, p. 781-784.

Streepey, MM, Essene, EJ, van der Pluijm, BA, 1997, A compilation of thermobarometric data from the metasedimentary belt of the Grenville Province, Ontario and New York State, Canadian Mineralogist, v. 35, p. 1237-1247.

Streepey, MM, Lithgow-Bertelloni, C, van der Pluijm, BA, Essene, EJ, and Magloughlin, JF, 2004, Exhumation of a collisional orogen: a perspective from the North American Grenville Province, in Tollo, RP, Corriveau, L, McLelland, J, and Bartholomew, MJ, eds., Proterozoic tectonic evolution of the Grenville orogen in North America: Boulder, Colorado, Geological Society of America Memoir 197, p. 391- 410.

Wasteneys, H, Mclelland, JM, and Lumbers, S, 1999, Precise Zircon Geochronology in the Adirondack Lowlands and Implications for Revising Plate-Tectonic Models of the Central Metasedimentary Belt and Adirondack Mountains, Grenville Province, Ontario and New York, Canadian Journal of Earth Sciences, v. 36, p. 967-984.