KECK GEOLOGY CONSORTIUM

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

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Keck Geology Consortium: Projects 2011-2012
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GARNET-BIOTITE GEOTHERMOBAROMETRY OF THE CENTRAL METASEDIMENTARY BELT BOUDARY THRUST ZONE OF THE GRENVILLE PROVINCE, ONTARIO, CANADA

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INTRODUCTION

The processes related to the plate tectonic assembly of continents is reflected in the metamorphic rocks that were formed during such times. One aspect of the plate tectonic history recorded in these rocks is the pressure-temperature (P-T) conditions that the rocks experienced. Geothermobarometry, a technique used to calculate the equilibrium temperatures and pressures from the measured distribution of elements between coexisting phases, (typically of garnet-bearing ortho and paragneiss) allow metamorphic conditions to be assessed in the Central Metasedimentary Belt boundary thrust zone (CMBbtz) of the southern Grenville Province (Figure 1, Peck et al., this volume). Garnet-rich gneisses and schists were acquired from several locations in the CMBbtz, which will allow the comparison with the adjacent Central Gneiss Belt, the Composite Arc Belt, and shed light on tectonic reconstructions of this area. We have identified Garnet-Biotite, Garnet-Aluminosilicate-Silica-Plagioclase (GASP), and Amphibole-rich assemblages in these rocks, and are in the process of analyzing them for their compositions to estimate P-T conditions using Garnet-Biotite thermometry and GASP barometry (e.g. Patiño-Douce et al., 1993). The electron microprobe will be used to conduct geothermobarometry on the available rock samples. The microprobe data will be augmented by phase relationships observed in thin section, which provides rough constraints on the P-T conditions.

GEOLOGIC BACKGROUND

The CMBbtz is the southeast-dipping ductile shear zone that marks the western boundary of a region known as the Composite Arc Belt and the eastern boundary of the Central Gneiss Belt (Peck and Valley, 2000). The Composite Arc Belt consists dominantly of <1300 Ma volcanic, plutonic, volcaniclastic, carbonate, and siliciclastic rocks from arcs, rifted arcs, and marginal basins (Carr et al., 2000). An interpretation for the formation of the Composite Arc Belt is given by Carr et al. (2000) who suggests a progression in age from early primitive arcs to the development of more mature arcs, and finally rifted arcs. Subsequently, volcanic and sedimentary sequences were invaded by gabbroic and granitic rocks. The timing of the tectonic assembly of the Composite Arc Belt is uncertain (Carr et al., 2000). The Central Gneiss Belt is dominated by 1.7-1.4 Ga upper-amphibolite- and granulite-facies orthogneiss with minor paragneiss (Easton, 1992), and has been subdivided on the basis of rock types, metamorphism, and structural style (e.g., Davidson, 1984). Many of the rocks examined here are interpreted to be metamorphic equivalents of hydrothermally altered volcanic rocks similar to those in the adjacent Composite Arc Belt (Peck and Smith, 2005), others represent metamorphosed aluminous sediments.

METHODS

For the first two weeks of July 2011, rock samples were collected from the CMBbtz. Rock samples were selected based on assemblages suitable for geothermobarometry, such as garnet, biotite, quartz, plagioclase, sillimanite and amphibole. A total of twenty-four samples were acquired. Upon completion of sample collecting, two weeks were spent at Colgate University selecting and preparing samples for analysis, from which fifteen samples were prepared. The preparation process consisted of identifying the rocks' lineation and foliation and cutting it perpendicular to foliation and parallel to lineation. Using a kerosene saw larger rock samples were cut into 1 in thick slabs, soaked in water with soap to wash the kerosene off, dried and rewashed if needed. The smaller samples and the cut slabs were then cut with a water saw into small billets of approximately 1 ½ in x 1 in x ¼ in.

These billets were then labeled and shipped off to be made into polished thin sections. In the mean time, using spare billets, five thin sections were prepared in the laboratory at Colgate University to get an initial view of the petrography. Upon arrival to the University of Texas at El Paso reconnaissance petrography of the samples was performed to identify assemblages that constrain pressure and temperature and will enable us to make geothermobarometry calculations. Garnet-Biotite, Garnet-Sillimanite-Quartz-Plagioclase, and Amphibole-rich assemblages were identified and used to make Pressure-Temperature diagrams and for geothermobarometric analysis on to determine conditions of metamorphism of these rocks.

HAND SAMPLE DESCRIPTIONS

Rock samples chosen for this project were selected based on composition. Of the fifteen samples originally selected for geothermobarometry, four are being prepared for analysis by electron microprobe (Figure 2).

11AM1 Northeast of Fishtail Lake, Ontario, Canada

This sample is a garnet-rich gneiss. Basic petrography of this rock was done and the identified minerals in it are garnet, biotite, quartz, plagioclase, cordierite, and some opaque minerals. Some of the garnets in this sample have inclusions of biotite, quartz and possibly plagioclase.

11AM17 West Guilford Rd. just Northwest of West Guilford, Ontario, Canada

This sample is a two-amphibole schist. In hand sample this rock is a dark, almost black rock, but in thin section, it is mostly green. This color is due to the minerals that compose it. Minerals that were identified in this sample are biotite altering to chlorite, small zircon inclusions, quartz, and two amphiboles, one being gedrite, cordierite, and some plagioclase.

11AM20 Line Road 30 Haliburton County, Ontario, Canada

This sample is a garnet-bearing schist with very small garnets. Minerals in this sample include quartz, biotite, garnet, plagioclase, muscovite, and possibly amphibole and K-feldspar.

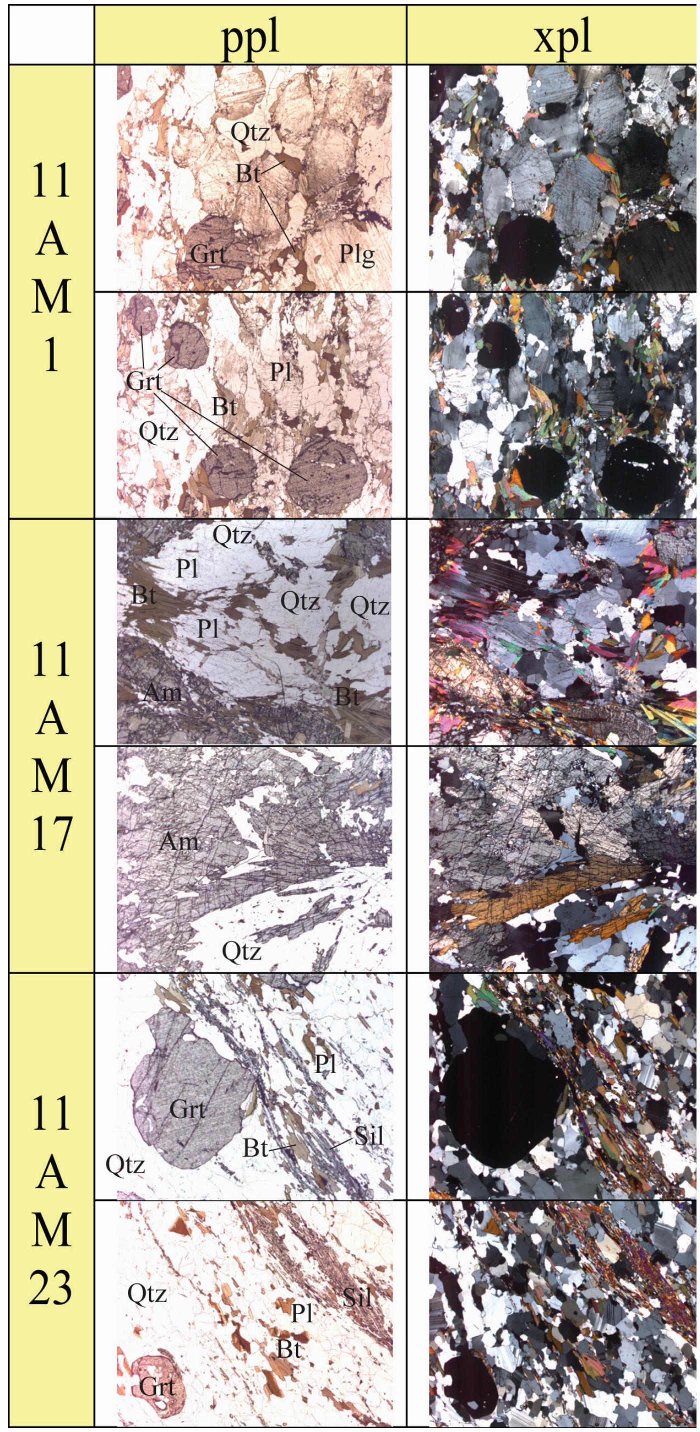

Figure 2 Primary minerals being analyzed for this study. Abbreviations for these are as follows: Gr = garnet, Qtz = quartz, Bt = biotite, Pl = plagioclase, Sil = sillimanite, Am = amphibole, ppl = plain polarized light, xpl = cross polarized light. Field of view is 2mm.

11AM23 Ontario Rt. 118, Ontario, Canada

This rock sample is a garnet-rich gneiss. The main minerals in this sample are garnet, sillimanite, quartz, plagioclase, biotite, and some opaque minerals. There are biotite inclusions in some of the garnets and some of them have little to no inclusions.

RESULTS AND DISCUSSION

Suitable mineral assemblages have been confirmed among the field samples, namely: Garnet-Biotite, Garnet-Sillimanite-Plagioclase, and Amphibole-rich assemblages. Using P-T diagrams for samples in the NaKFMSH system from Spear et al. (1999) and Spear (1995), we can limit the P-T conditions to the sillimanite field, due to the presence of sillimanite in them. These factors allow us to assume that there are at least two reactions that can be used to limit the P-T conditions. Figure 3 is a P-T diagram taken from Spear et al. (1999) used to plot a set range for the conditions of the selected rock samples. Based on the assemblage of sample 11AM1, we can constrain the conditions to ~650-850 ˚C and ~1.75-8 kbar. Due to the assemblage present in sample 11AM20, conditions are restricted to the Ms+Ab=As+Kfs+L reaction line because of the presence of muscovite + quartz in the rock. This sample has an approximate range of ~650-700 ˚C and ~3.75-8 kbar. Sample 11AM23 falls within the middle to upper pressure limit of this diagram because of the presence of sillimanite. Large ranges for temperature-pressure conditions for this sample are ~650-850 ˚C and ~2-10.5 kbar respectively. Further analysis is yet to be done on sample 11AM17, which will use amphiboles present to further restrict conditions.

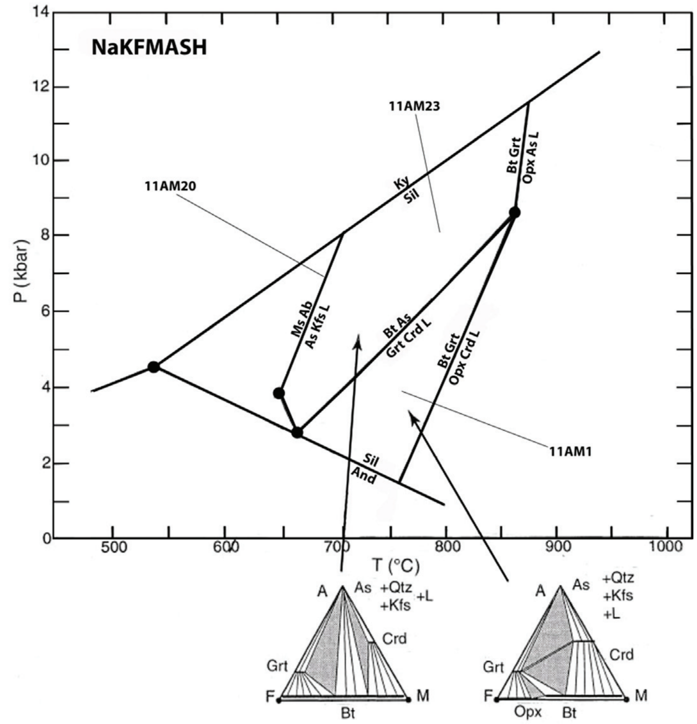

Figure 3. NaKFMASH P-T diagram from Spear et al. (1999) showing P-T ranges of selected samples, with the exception of 11AM17. Each line is a compositional dependant reaction line. Abbreviations are, As= aluminosilicate, Kfs= K-feldspar, Ab=albite, Bt= biotite, Grt= garnet, Sil= sillimanite, And= andalusite, Ky= kyanite, Crd= cordierite, Opx= orthopyroxene, L= liquid. AFM diagrams showing stable mineral assemblages are shown at the bottom.

CONCLUSIONS

Garnet-Biotite, Garnet-Sillimanite-Plagioclase, and Amphibole-rich assemblages have permitted us to suggest a preliminary P-T range of ~2-10 kbar and ~650-850 ˚C respectively. Further analysis will be carried out to further constrain these ranges to a more accurate P-T condition for each sample.

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