COMPOSITIONAL VARIATIONS IN THE WHITE MICAS
OF THE BULL HILL AUGEN GNEISS,
THE CHESTER AND ATHENS DOMES, VERMONT

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The Chester and Athens Domes of southeastern Vermont were formed during the Devonian period as a result of the Acadian Orogeny. These structures represent a heating and an upwelling of the earth's crust that was locally characterized by high temperatures (520-570 C) and medium to low pressures (5-7 kb) (Thompson, 1976). Two separate orogenic events preceded the Acadian Orogeny in the northern Appalachians, the 1.6 b.y.a. Grenville Orogeny and the 450 m.y.a. Taconic Orogeny. It is difficult to establish specific pressure and temperature constraints for these two earlier metamorphic events because the later Acadian Orogeny has overprinted evidence of earlier deformations.

Rocks metamorphosed during the Grenville Orogeny reached the granulite grade of metamorphism and the Taconic Orogeny was characterized by medium to high pressures and medium temperatures. Westward directed thrust faulting is believed to have taken place during the Taconic Orogeny and may have been active during the Acadian Orogeny as well.

This poly-metamorphic history presents a problem to geologists. How does one distinguish between the textures and mineralogies produced by separate events? The chemical composition of the metamorphic mica phengite can be used as a geobarometer in the assemblage K-feldspar + quartz + biotite + muscovite (Velde, 1967). This study attempts to determine the chemical compositions of the white micas in the Bull Hill Augen Gneiss, a formation which outcrops along the periphery of the cores of the Chester and Athens Domes and is also exposed along the east side of the Green Mountain Massif.

The Bull Hill Augen Gneiss is a flaser to augen gneiss with microcline porphyroblasts measuring up to 6 cm in diameter. These augens are separated by thin mica-rich layers, which also contain quartz and epidote. This mineral assemblage makes the Bull Hill Augen Gneiss a good candidate for the study of naturally occurring phengites. Phengite is a metamorphic, dioctohedral mica which is colorless to pale green in thin section and is biaxially negative with a 2V between 28-35 degrees (Guidotti, 1984). It is associated with a variety of mineral assemblages but its composition is useful as a geobarometer in only one of them: K-feldspar + quartz + biotite + muscovite (Evans, 1987). The reason for this limitation is that the only phengite thermobarometer curves that have been established are based on studies of phengite formed in this assemblage (Velde, 1967).

Muscovite is known to deviate from its ideal composition $K_2Al_4(AL_2Si_6O_{20})(OH)_4$ by the Tschermak substitution (Guidotti, 1984). In this exchange Si^{4+} substitutes for Al^{3+} in the tetrahedral sites of the mineral, thus creating a charge imbalance. This imbalance is compensated for by the substitution of Mg^{2+} and Fe^{2+} for Al^{3+} in the mineral's octahedral sites. Fe^{3+} will also substitute for Al^{3+} in a separate substitution. As a result of these substitutions the overall Si:Al ratio in the mineral increases. The Si rich end-member celadonite has the composition $K(Mg^{2+},Fe^{2+})(Fe^{3+},Al)(Si_4O_{10})(OH)_2$. Phengites are intermediate members of the muscovite-celadonite solid solution series and first officially appear when the Si:Al ratio becomes 3:1.

As metamorphic pressures increase the Tschermak substitution is facilitated and phengite forms; the higher the pressures the higher the Si:Al ratios. High temperatures, however, decrease the Si:Al ratios. Phengites are frequently chemically zoned and several generations of phengite and muscovite may be present in one rock. Phengite can exist out of equilibrium with the minerals surrounding it; if phengite is present in the Bull Hill Augen Gneiss it is possible that it formed as a result of the Taconic Orogeny rather than the more recent high temperature, low pressure Acadian Orogeny.

Specimens were collected from the Bull Hill Augen Gneiss during August of 1988 [Figure 1]. Five of these specimens were chosen from different locations around the Chester and Athens Domes and modal analyses of their thin sections revealed that the mineral phengite could be present. Phengite is difficult to distinguish from muscovite in thin section, only a quantitative analysis of the chemical composition of the white micas can yield reliable information as to what their Si:AL ratios actually are. Polished thin sections were prepared for analysis with the Jeol 300 Scanning Electron Microscope, Tracor 5500 Energy Dispersive Spectrometer at Beloit College. The sections were carbon coated to reduce charging on the non-conducting specimens. A mount was designed to hold one thin section and a MINM 25-53 Mineral Mount with Faraday Cup. The Faraday Cup was used in conjunction with a beam current monitor to measure the beam current drift while acquiring spectral peaks. The mount also provided a mineral standard of known composition, biotite, for comparison with the spectral peaks acquired from the specimens.

Eighty-nine mineral spectra were acquired in five sittings. The EDS program MICROQ was then used to analyze these spectral peaks. Unfortunately biotite was a poor choice of standard; the Mg, Al, and Si element peaks interfere with one another in this mineral's spectrum as read by the EDS quantitative analysis program MICROQ, and none of the element peaks could be successfully subtracted from the biotite spectrum.

Attempting to use Beloit College's SEM/EDS unit as a microprobe was a valuable learning experience and the first such attempt at Beloit College. In the interest of time and workable results a trip to use the University of Chicago's microprobe is currently being arranged. This visit should yield the necessary data to successfully complete this study.

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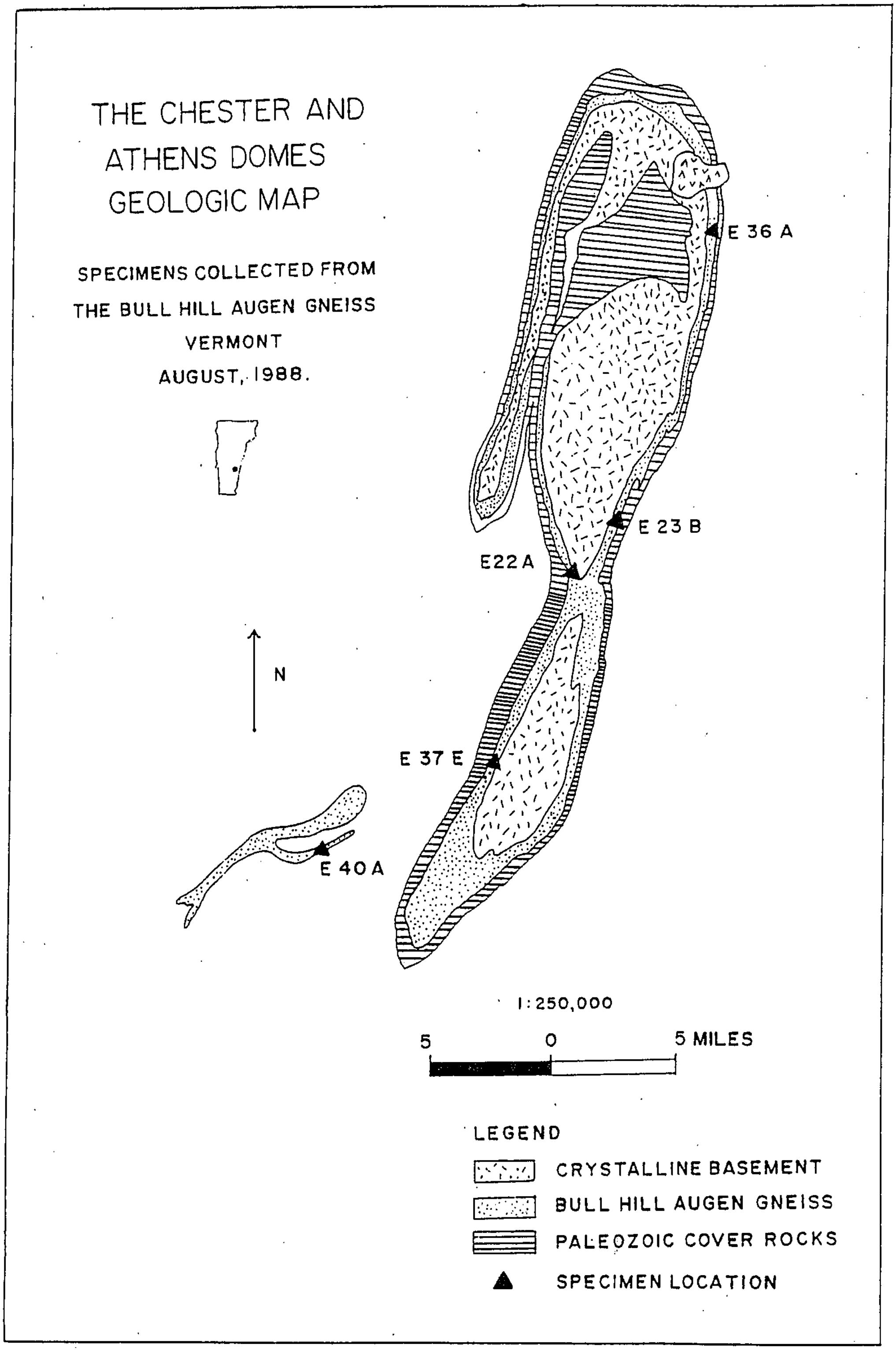

Figure 1. Geologic map of the Chester and Athens Domes showing specimen locations.