PETROLOGIC CONSTRAINTS ON THE SOURCES OF GRANITES FROM THE HANGAY MOUNTAINS, CENTRAL MONGOLIA

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INTRODUCTION

The core of the Hangay Mountains is underlain by the Hangay batholith, a granite batholith that intrudes into Devonian and Carboniferous metasedimentary rocks. This batholith is composed of two different granitoid units, the widespread Hangay unit and the smaller Egiin Davaa unit. The metasedimentary rocks of the study area are underlain by a Precambrian craton that forms the basement geology of the region (Badarch et al., 2002). The Hangay unit was intruded into the region during the late Permian to early Triassic, and the Egiin Davaa unit during the Triassic to Jurassic. A K-Ar age of 188 Ma exists for the Egiin Davaa unit (cited in Takahashi et al., 2000).

The Hangay batholith is temporally related to subduction that took place to the north of the study area as Mongolia began to collide with the overriding Siberian craton, possibly thickening the crust as far south as the Hangay region. Zorin (1999) argues that the Hangay granitoids formed as a direct result of this subduction event. However, Jahn et al. (2000) describe the formation of the batholith as a possible example of post-orogenic intraplate magmatism. They note that the timing and massive volume of magmatism indicate that granitoids like the Hangay batholith could not have been formed through subduction processes alone and propose that basaltic underplating of the Mongolian crust during a earlier Cambrian to Ordovician subduction event, followed by later crustal extension after collision was complete, as a mechanism of granitic magma formation. This study uses geochemical and petrologic characteristics to evaluate the potential sources of the granitoids.

PETROGRAPHY

Samples of igneous and metamorphic units present in the study area were collected to analyze their suitability for further study. (Fig. 1) Samples of both the main phase and a mafic igneous xenolith were collected from the Permian Hangay unit while samples of the main phase, several mafic igneous xenoliths, pegmatites, and an aplite were collected from the Triassic to Jurassic Egiin Davaa unit. Finally, metasedimentary rocks near the contact with the Egiin Davaa unit were collected to determine if mineral assemblages formed through contact metamorphism could provide information on pressure conditions at the time of emplacement. Thin sections of 26 samples were made for petrographic analysis, and four of the samples were studied further through use of the SEM/EDS.

The main phase of the Permian Hangay unit is a hornblende-biotite granite composed of approximately 30% plagioclase (An30), 25% quartz, 20% orthoclase and approximately 10% each of hornblende and biotite (Fe/Fe+Mg = 0.65), with the accessory minerals apatite, zircon, ilmenite, magnetite, titanite and epidote. The subhedral epidote appears to be magmatic in origin because it is associated with a range

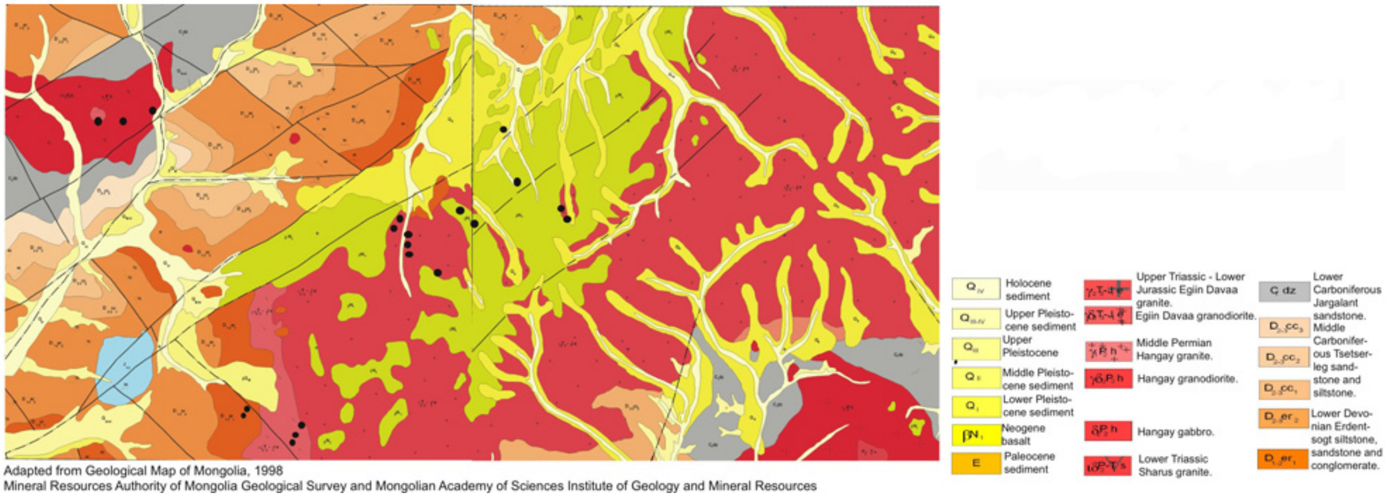

Figure 1. Geologic map of the study area. Black dots represent sample sites.

of surrounding minerals, from quartz to biotite, and suggests high pressures at emplacement. Orthoclase, plagioclase and hornblende grains were up to 2 cm in size and the plagioclase displayed concentric oscillatory zoning (Fig. 2a). The samples had massive and granitic textures.

The Triassic to Jurassic Egiin Davaa unit has a wider range of compositions than the Hangay unit. However, the overall assemblage was the same throughout the Egiin Davaa samples. The Egiin Davaa unit is a biotite granite containing 15-35% unzoned plagioclase (An30), 25-35% quartz, and 15-40% potassium feldspar, both microcline and orthoclase, 10-15% biotite (Fe/Fe+Mg = 0.78) and no hornblende. Accessory minerals were ilmenite, magnetite, apatite, zircon, and titanite (up to 5% modal). One sample was a biotite granodiorite. Grain size was generally slightly finer than that seen in the Hangay unit, with the largest grains of quartz and feldspar measuring at 1 cm. Substantial amounts of myrmekite (Fig. 2b) were present in samples at grain boundaries between quartz and potassium feldspar. While most of the Egiin Davaa unit was massive, some locations across the study area displayed a weak to moderate foliation defined by biotite. The foliation was present in the only sample collected at a visible contact between the granite and surrounding metasedimentary rocks.

Magmatic muscovite (Fig. 2c) is locally present in the Egiin Davaa unit, and also occurs in an aplite that contained both magmatic muscovite and garnet (Fig. 2d). The garnet (Xalm = 0.57, Xspess = 0.40) was euhedral, ranging up to 2 mm in size. Pegmatites from the unit also contained garnet.

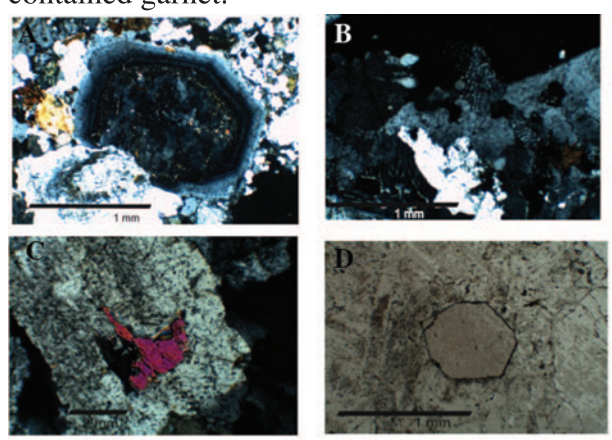

Figure 2. Photomicrographs from the Hangay and Egiin Davaa units. A) Concentric oscillatory zoning in plagioclase from the Hangay unit. B) Myrmekite at a grain boundary from the Egiin Davaa unit. C) Magmatic muscovite from the Egiin Davaa unit. D) Magmatic garnet from the Egiin Davaa unit.

The metasedimentary rocks found near the contact with the Egiin Davaa granites were analyzed to help to constrain the pressures at emplacement. Two of the samples were directly at the contact, while another two were collected farther away to allow comparison with samples that had only undergone regional metamorphism. Quartz grains in samples at the contact did show the equigranular polygonal texture characteristic of contact metamorphism. Unfortunately the mineral assemblage of 65-75% quartz, 25-30% biotite, 1-2% plagioclase, +/- muscovite and the accessory minerals zoisite and titanite does not place strong constraints on the depth of emplacement.

GEOCHEMISTRY

Samples were crushed, pulverized and pressed into disks. Major element concentrations were determined in the Amherst College electron-beam lab by energy dispersive analyses of ~0.5 mm regions on the disks. Minor and trace element concentrations were determined using XRF at the University of Massachusetts – Amherst. Both the Hangay and Egiin Davaa units vary in composition from 68-76 wt% SiO2. Na2O and K2O concentrations are also similar, ranging from 2.17-4.26 wt% Na2O and 3.22-4.84 wt% K2O. All samples from both units plot within the high-K calc-alkaline field and are peraluminous. The Egiin Davaa unit contains a higher average amount of Al2O3 (15.60-18.64 wt%) than the Hangay unit (15.81-16.77 wt%). It also contains a lower average amount of CaO (0.32-1.34 wt%) than the Hangay unit (1.24-3.13 wt%). The Hangay unit is enriched in MgO and FeO (2.00-2.33 wt% and 0.96-2.82 wt%) relative to the Egiin Davaa unit (0.23-1.86 wt% and 0.04-0.98 wt%).

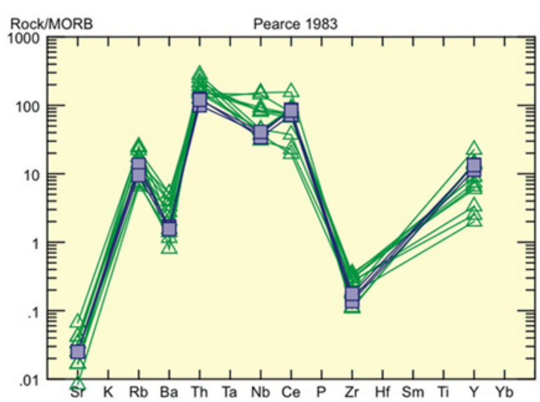

Figure 3. MORB-normalized spider diagram for the main phase lithologies of the Hangay unit (squares) and Egiin Davaa unit (triangles).

MORB-normalized spider diagrams of trace elements contained in the main phases of the Hangay and Egiin Davaa units show almost identical trace element signatures (Fig. 3), with substantial Ba, Zr and Sr troughs. Plotted against SiO2, the concentrations of these elements indicate the fractionation of potassium feldspar, zircon, and plagioclase in the magmas.

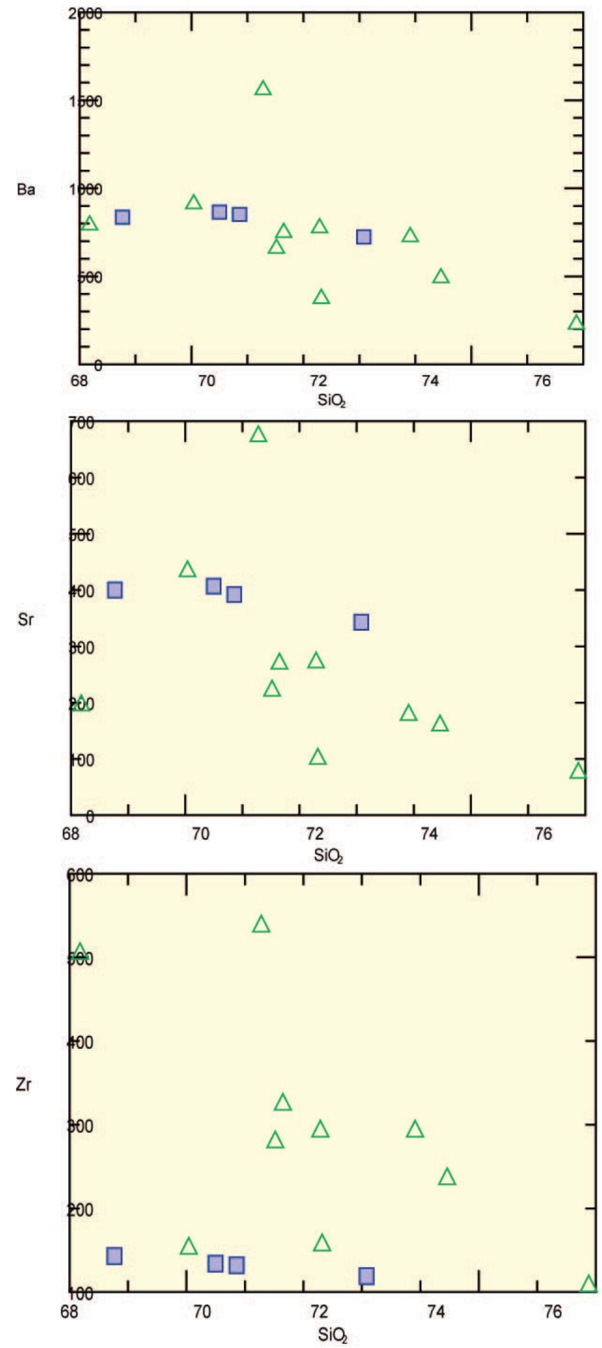

Figure 4. Concentrations of Ba, Sr, and Zr plotted against wt% SiO2 indicate fractionation of potassium feldspar, plagioclase, and zircon. Triangles represent the Egiin Davaa unit and squares represent the Hangay unit.

(Fig. 4) Igneous xenoliths from both units mirror the trace element signatures of the main phases as well, while the pegmatites and aplites from the Egiin Davaa unit do show variations. The wide ranges of compositional amounts and large Ba trough indicate an intraplate tectonic setting for both units. A Nb v. Y discrimination diagram also indicates an intraplate setting (Fig. 5). Almost every sample plots in the within plate granite field. As with the spider diagram, pegmatites and aplites from the Egiin Davaa unit are the only lithologies that show a significantly different composition.

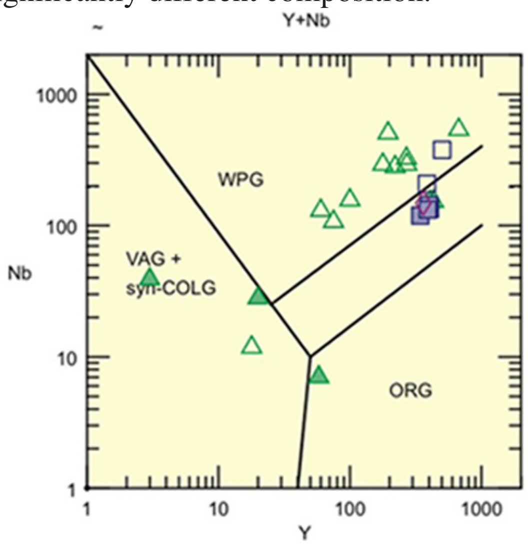

Figure 5. Nb v. Y discrimination diagram. Triangles represent the lithologies of the Egiin Davaa unit and squares represent the Hangay unit.

DISCUSSION

Age considerations, mineralogy, Al2O3 and CaO content at a given SiO2 content indicate that the two units did not form from the same initial magma. Yet the similarity of both the major and trace element compositions indicates that despite the difference in age both the Hangay and Egiin Davaa units were derived from similar sources and underwent similar fractionation processes. Nd isotopes (Jahn et al, 2004) suggest that the source of the Hangay unit is a combination of contributions from the mantle and the underlying Precambrian craton.

On the basis of trace element discrimination plots, it is suggested that both the Hangay and Egiin Davaa units formed in an intraplate setting, consistent with Jahn et al.'s (2004) interpretation of the Hangay batholith. They interpret a mechanism of post-orogenic magmatism resulting from basaltic underplating of the crust during subduction followed by crustal extension after subduction is complete.

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