INTRODUCTION
The intrusive metamorphic complex of the Tavan Har area (TH) is located in the eastern Gobi desert of Mongolia. The TH complex formed within an accretionary tectonic environment (Johnson et al., 2001). This complex has not been studied in any detail (Bibikova et al., 1992). While working with the Keck Geology Consortium (summer 2003) in the eastern Gobi of Mongolia, I collected samples from an intrusive/metamorphic (I/M) complex and created a basic geologic map based upon valley and ridge transects. This paper addresses basic geologic history, intrusive, and metamorphic field relationships determined by field observation, petrography and microprobe investigation. This fundamental information will aid future comparisons with neighboring terranes and identification of terrane boundaries.

Geologic Setting
The southern margin of Mongolia coincides with an orogenic fold belt called the South Gobi Hercynides (Misar, 1997). This orogenic belt consists of a metamorphosed (probably Proterozoic in age) lower unit, with overlying Caledonian strata of Late Silurian age.

Orogenies of the Late Silurian ended with uplift of the region in the Devonian, when volcanic activity occurred within the belt. During the Late Carboniferous the belt was a continental margin, with deposits of synorogenic molasse. By the Permian the region was no longer in direct contact with the continental margin effects (Misar, 1997. Stratigraphic column in Carson et.al., this Volume). The TH complex was mapped as a Lower Proterozoic unit in the South Gobi Hercynides orogenic fold belt (Misar, 1997). The South Gobi Hercynides area is further separated into two terranes. The exact boundary of the terrane margin has not been determined in the TH area. The TH complex was mapped as part of a northern terrane called Ulaan-Uul (MUST, 2001). This terrane is identified by a sequence of metamorphic and intrusive units followed by the deposition of Cretaceous sediments. The southern terrane (Hovsgol-Ulaanbadrah) consists of a lower unit of Ordovician sediments (possibly Carboniferous, see Berney-Roberts et.al., this Volume) with records of deposition through the Mesozoic, interrupted by multiple intrusive events that continued through the Late Jurassic (MUST, 2001).

The TH I/M complex is currently interpreted to be a middle Proterozoic metamorphic suite intruded by upper Proterozoic dikes and plutons. The age of the complex is only constrained by an overlying limestone unit with Carboniferous fossil assemblages (Berney-Roberst et. al., this Volume). Additionally, metamorphic and intrusive events occurred in the Devonian and after or during the Cretaceous (Johnson et al., 2001).

METHODS
Mapping of the study area was done in river valleys that cut perpendicular to the
northeast/southwest trending range and regional strike of metamorphic fabrics. The valleys provide continuous exposures of geologic units. Large scale topographic maps and aerial photographs were not available in the field. Continual observations of the rock type were made in a pace/compass format. Once a unit was identified, a “standard” sample was collected and a GPS location was recorded. Whenever a contact, change in unit, fault, intrusive or foliation was found, the location was recorded with either a GPS or an approximation of distance from the last GPS waypoint. The river valley was followed to the level high ground on the range’s drainage divide. This process was used for ten river valleys along the complex, with the assistance of Kevin Pogue (Whitman College).

Results

Based on field and petrographic analysis, seven basic units are recognized by their mineral assemblages, structures/foliations, and metamorphic grade (Table 1): metagabbro, biotite schist, dioritic gneiss, granitic gneiss, granite with mafic xenoliths, foliated granitic intrusives, unfoliated granite intrusives. Field observations led to the creation of a stratigraphic column of the complex (Figure 1), and geologic map of the region (Figure 2).

All but unit contacts are intrusive in nature. The metagabbro is separated from the biotite schist unit by a fault. The metagabbro is cut by a serpentinized ultramafic intrusive. The metagabbro is characterized by mafic minerals such as olivine, amphibole and serpentine.

Foliation defined by chlorite are locally present within the metagabbro.

The garnet-bearing biotite schist was mapped as two units, but they do not differ substantially in thin section. The garnets range from 0.5-2.0 mm in size. Garnets display strain shadows plus “snowball” and concentric inclusion patterns.

The northwestern portion of the complex is well foliated, but grades to unfoliated biotite schist to the southeast.

The biotite schist is intruded by the dioritic gneiss. The diorite contains foliations defined mainly by chlorite and is locally mylonitic. Matrix minerals are retrogressed to epidote. Diorite is seen in contact with only the unfoliated variety of biotite schist. The diorite is intruded by the granitic gneiss which has a locally variable foliation defined by chlorite.

Amphibole has partially converted to biotite. Epidote is prominent in the unit.

The diorite was intruded by the granite containing mafic xenoliths (granite w/mx).
Sporadic ovoid 5-10 cm mafic xenoliths were observed in all outcrops.

All the above units were cross cut by two dike systems. The earlier dikes are composed of strongly foliated granite. Foliation is defined by biotite which reacted to epidote. This intrusive contains mafic minerals such as amphibole and olivine. The dikes are commonly large, 0.5-2.0 m in width, and several km in length. The foliated granite dikes are cross cut by unfoliated granitic dikes in the gabbro unit. The “unfoliated” intrusive actually displays a biotite foliation in thin section. This unit becomes pegmatitic in some outcrops. These intrusions are generally small: 5-20 cm in width and extending laterally for 15-20 m. The strike of every measured foliation, dike, and fault was to the northeast, around ~ N60°E.

CONCLUSIONS

The metagabbro has a metasedimentary bulk composition suggesting a mafic protolith. The biotite schist is lacking in highly mafic minerals suggesting it has a more pelitic protolith. The garnets display concentric compositional zoning and “snowball” patterned inclusions suggesting syntectonic growth. Mineral assemblages in the biotite schist are consistent with upper greenschist to lower amphibolite facies conditions. Granitic bodies intruded the metagabbro and biotite schist units. With further metamorphism all units became foliated (possible overprinting of garnets). Another granitic dike system intruded all units and was subsequently metamorphosed. The most recent intrusive event occurred, cross cutting all units. Units showed some evidence of epidotization (chloritized intrusive contacts). Foliations throughout the TH complex strike NE. This suggest that either all metamorphic events
were in one orientation, or the most recent metamorphic event overprinted the entire complex. Finally uplift and erosion occurred and brought these rocks to the surface.

**FUTURE RESEARCH**

Future work will attempt to date the metamorphisim of these rocks. The youngest unit in the TH complex is the “unfoliated” intrusive granite. This unit contains enough biotite for an $^{40}\text{Ar}/^{39}\text{Ar}$ age to be attained. Although the closure temperature of biotite is quite low, the age should indicate a minimum age of the most recent metamorphic event suffered by the complex. This would be the first absolute date for the intrusive/metamorphic complex.

**REFERENCES CITED**


Mongolian University of Science and Technology (MUST), Staff and Students, 2001, unpublished maps and stratigraphic columns.

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