Section of Earth Sciences
Department of Mineralogy

MCs. Thesis in Geology; option: Petrology, Geochemistry and Ore deposits

# Mineralogy, Geochemistry and Geochronology of Pegmatites and Associated Alkaline Granite Rocks of the Khan Bogd Complex, South Mongolia

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**September 2007**

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# Abstract

The Permian Khan Bogd Complex, located in the Gobi desert, southern Mongolia, consists of two circular granitic bodies. The larger, western body is a shallow depth laccolith crosscut by a ring dyke complex and hosts at its cupola abundant pegmatite lenses. The Khan Bogd Complex was emplaced in the Gobi-Tien Shan rift zone at the border of the Zuunbayan Basin, within medium alkaline basaltic to rhyolitic rocks of the Tsokiot Formation belonging to the Gurvansayhan Island arc terrane.

In this study we describe the field relationships and mineralogy, provide and discuss geochemical data, Sr and Pb isotopes and U-Pb ages of the Khan Bogd Complex rocks. This study focuses mainly on the western body, which is the one that contains the pegmatites. The pegmatites belong to the NYF-type and appear as zoned lenses or layered rocks in alternation with ekerites and aplites, in the cupola of the huge western alkaline granite body. Two types of pegmatites occur: (a) non-zoned, non-mineralized pegmatites appearing as quartz lenses, and (b) zoned elpidite-armstrongite mineralized pegmatites. The ekerite occurs as ring dykes, and the aplitic rocks, containing mainly quartz, albite, aegirine and arfvedsonite, are spotted or layered and strictly associated with the pegmatites. Field observations indicate that the aplite-pegmatite emplacement occurred during repeated transitions from the ductile to the brittle regime, which resulted in sudden pressure drops, undercooling and consequent formation of line rocks or unidirectional solidification textures. The mineralogy of the Khan Bogd rocks consists mainly of quartz, K-feldspar, aegirine and arfvedsonite, and accessory elpidite, armstrongite, gittinsite, titanite and small amounts of Fe-oxides.

The geochemistry of the Khan Bogd rocks indicates that they are the products of fractional crystallization of an alkaline granitic magma, that can be classified as A2 type according to the classification of Eby (1992), i.e., derived from melting of continental or underplated crust that has been formed through a cycle of continent-continent collision or/and island arc magmatism. The ekerites, aplites and pegmatites were formed from the most evolved granitic melt. The composition of the arfvedsonite points out that the parental magma was enriched in F and water, thus allowing the formation of F-complexes, which are able to keep in solution and transport HFSE such as Zr, Y, Nb and REE until the late stages of crystallisation. The enrichment of rare metals in the Khan Bogd Complex is a primary magmatic process, but it is possible that a late metasomatism partially and locally redistributed and concentrated these metals as indicated by the replacement of primary elpidite with secondary Ca-zirconosilicates (armstrongite and gittinsite).

Lead isotopes indicate a common origin for the pegmatites and granites, i.e., from the mantle without any sign of crustal contamination. This is also compatible with the 0.7025 and +6.9-8.0 values of $^{87}Sr/^{86}Sr_i$ and $\varepsilon_{Nd}$ (T) respectively measured in the Khan Bogd granite (Amaramgalan et al., unpublished data). Radiometric U-Pb dating on zircons and titanites allowed us to establish the following relationships among the different magmatic phases of the Khan Bogd Complex (in agreement with previous observations, Kovalenko et al., 2006); the MIP porphyritic alkali granite of Khan Bogd Complex considered to be an early magmatic stage was emplaced 292±0.51 My ago and shortly preceded the emplacement of the major MIP alkali granite which has been dated at 290±1 Ma by Kovalenko et al. (2006). The laccolith

intrusion of the MIP alkali granite hosts pegmatites (290.00±0.45 Ma, 290.94±0.31 Ma) and aplites (290.72±0.90 Ma). A porphyry biotite granite crosscutting the MIP alkali granite has been dated at 272.5 ± 1.2 Ma, and indicates protracted magmatic activity in the area.

Trace element signatures of the Khan Bogd Complex rocks show the presence of Nb and Ta negative anomalies indicating a subduction-related fingerprint. Additionally, their Sr and Nd isotopic compositions are identical to those of the subduction related volcanic rocks of the Tsokiot formation, erupted in an island arc context (Gurvansayhan terrane) during the Late Lower Carboniferous (around 330 Ma). This makes it likely that the granitic rocks of the Khan Bogd Complex are derived from the partial melting of lower crust equivalents of the Tsokiot subduction-related volcanic rocks (forming the island arc terrane of Gurvansayhan which hosts the Khan Bogd Complex), and is in agreement with the classification of the Khan Bogd granite as an A2-type alkaline granite, i.e., derived by the melting of crust that has been through a cycle of continent-continent collision or island arc magmatism (Eby, 1992).

Such a melting could have been related to a mantle plume (Kovalenko et al., 2006) or to an upwelling of astenospheric mantle after post-collisional lower crust delamination. The latter process would have put in contact the decompression-derived astenospheric melt with crustal lithologies of the Gurvansayhan terrane and caused their partial melting. Extensive plagioclase fractionation at shallower levels depleted the evolving magma in Ca, Sr and Al. The evolved granitic magma intruded the upper crust up to the layered beds of the Tsokiot formation.