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## Mesozoic A-Type Granites and Related Ore Mineralization, Eastern Mongolia

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### 1 Introduction

The Mesozoic North-Gobi rift forms one of a series of rifts superimposed on the Paleozoic Central Asian Orogenic Belt (CAOB) (Fig. 1). A large number of the Mesozoic alkaline (A-type) granitoids, which are emplaced in these rifts, are spatially and temporally associated with a bimodal basalt-comendite/rhyolite suite. Granitoids of the CAOB have been interpreted in terms of rifting (Yarmolyuk and Kovalenko, 1991), delamination of the CAOB root leading to upwelling of the asthenosphere (Wu et al., 2002), and a mantle plume (Yarmolyuk and Kuzmin, 2011). This mirrors the world-wide debate on the origin of A-type granitoids.

The A-type granites range in composition from syenogranites through peralkaline and alkali feldspar-rich granites to topaz granites (Eby, 1992). They are widespread, and many typically occur as volumetrically small intrusions with high concentrations of rare elements such as REE, niobium, thorium and uranium, which occasionally are economically significant. Although these alkali- and iron-rich granites are widely reported in geological literature, their origin, evolution and tectonic setting are still being debated. Eby (1992) subdivided A-type granites into two groups that differ in their tectonic significance. A1-type comprises anorogenic, mantle-derived granitoid rocks, whereas A2-type granites were emplaced in a variety of tectonic settings and were derived by melting of continental crust or underplated mafic crust.

We present new data on petrography, mineral chemistry, geochronology and geochemistry including major and trace elements and Nd and Sr isotopic ratios for the rocks of the Dashibalbar pluton (central Mongolia) and related units and discuss their petrogenetic significance as well as the tectonic setting.

### 2 Geology

One of the typical representative of Mesozoic granitoid magmatism, the Jurassic Dashibalbar granitoid pluton (~300 km<sup>2</sup>) crops out in the Triassic North-Gobi rift of central Mongolia, just south of the in 230-195 Ma Khentei batholith (Fig. 1 and 2). The granitoids are shallow-seated dominantly amphibole-bearing alkali feldspar granite and quartz-syenite that contain quartz-syenite/syenite enclaves. They are all composed of megacrystic mesoperthite, quartz, Ca-Na amphibole altered to biotite and rarely with pyroxene cores, magnetite and ilmenite. The enclaves were only partly crystallized when they were entrained by their granitic magma host. The pluton yielded a concordant U-Pb zircon age of  $186 \pm 1$  Ma, which is similar to published the  $189 \pm 3$  Ma <sup>40</sup>Ar/<sup>39</sup>Ar amphibole age, and indicates rapid cooling though ca. 550°C. This age is ca. 10 my younger than the  $196 \pm 4$  Ma age of the bimodal volcanic complex intruded by the pluton. The volcanic complex is composed of augite-phyric transitional basalt and rhyolite/comendite (Fig. 2).

### 3 Geochemistry

The granitoids are evolved alkaline, A-type granites and quartz-syenites that are enriched in light REE's, but with distinct depletion of Eu, Sr and Ba, indicative of feldspar fractionation. The data are consistent with derivation of the granites from the syenites by fractional crystallization accompanied by crustal contamination. The granitic rocks have  $\epsilon_{\text{Nd}}(t)$  values of ~+0.8 to +1.4, which are slightly lower than  $\epsilon_{\text{Nd}}$  values +1.4 to +1.6 in the syenites, although both have similar  $T_{\text{DM}}$  model ages (~800- 970 Ma). The basalts are evolved within-plate varieties with positive  $\epsilon_{\text{Nd}}(t)$  (~+ 2.7) values and light REE enrichment, whereas the felsic volcanic rocks have chemical characteristics of within-plate types with  $\epsilon_{\text{Nd}}(t)$  values similar to those of the basalts. The ~800 Ma model ages of the basalt and rhyolite/comendite are comparable to those of the intrusion and

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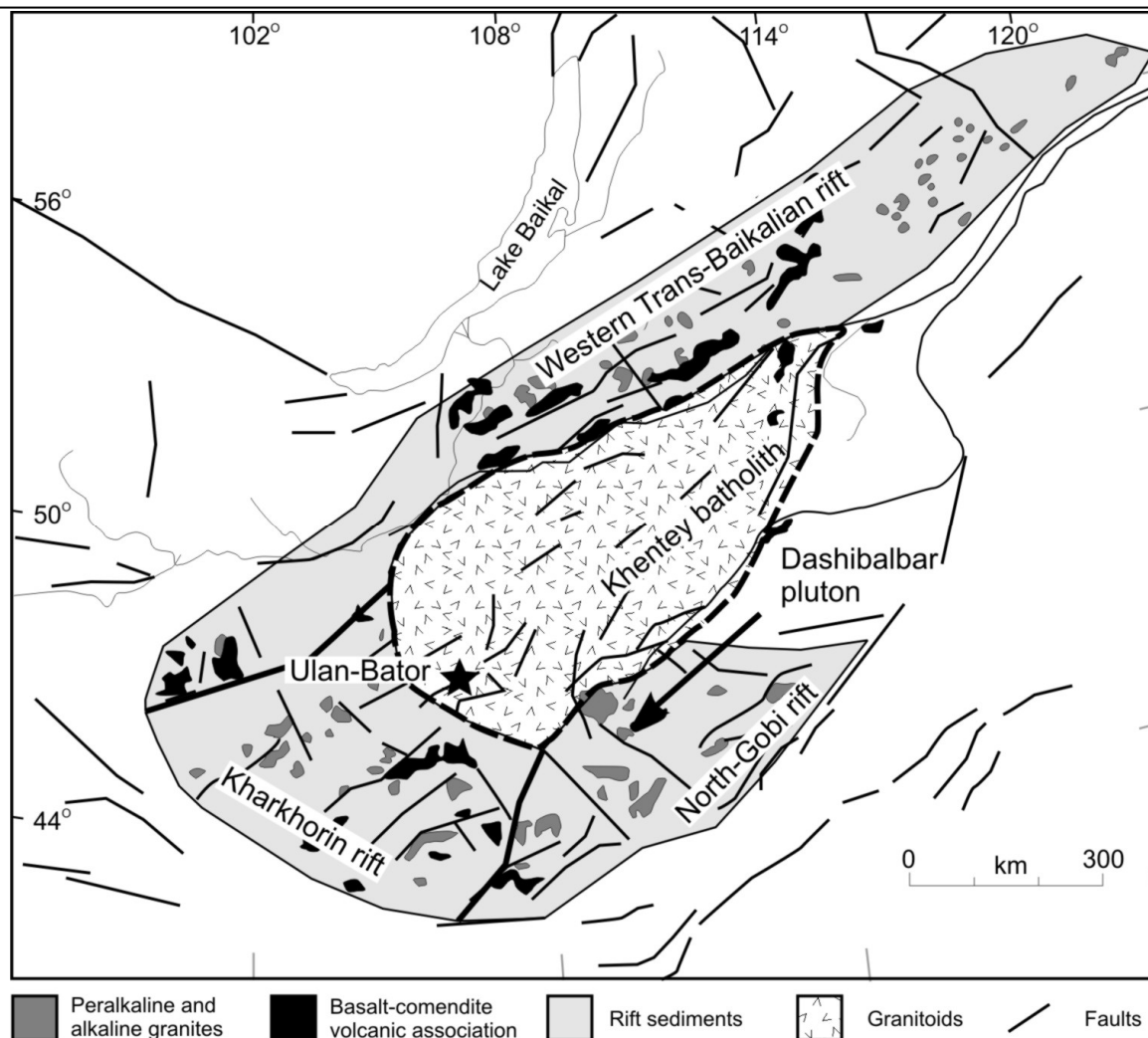


Fig. 1. Geological sketch map of central part of the Early Mesozoic Mongolian-Transbaikalian igneous province of the CAOB showing the Mesozoic North-Gobi and Western-Trans-Baikalian rifts and Khentey batholith (Dostal et al., 2014; modified after Yarmolyuk et al., 2002, and Yarmolyuk and Kuzmin, 2011).

enclaves. The composition of all these rocks including  $\epsilon_{\text{Nd}}$  and  $T_{\text{DM}}$ , are within the range of A-type granites and volcanic complexes of the Early Mesozoic Mongolian-Transbaikalian igneous province.

#### 4 Petrogenesis

The relatively Al-poor and Fe-rich Dashibalbar granites suggests an emplacement at relatively low, initial water pressure conditions. The Al and Fe abundances and the ferroan nature of the granites indicate that the rocks were generated at high temperature, emplaced at shallow depth and the magma was relatively anhydrous and reduced in nature. Such conditions are generally considered to be common in the extensional tectonic regime that is responsible for the generation of many A-type granitoids.

The major and trace element variations of the granitic rocks of the Dashibalbar pluton are interpreted to reflect predominantly fractional crystallization. The strong

depletion of Ba, Sr and Eu are likely result of fractional crystallization of feldspars during magma evolution.

The (quartz) syenitic rocks of the enclaves are spatially and probably temporally associated with granites and show many common geochemical and mineralogical characteristics. Significant differences in incompatible trace element ratios indicating that the granites were not derived from the syenite via continuous fractional crystallization. An alternative model to continuous fractional crystallization for the origin of the granites and their relation to the syenites is assimilation-fractional crystallization (AFC). The high Th/La ratios in granites (typically  $\sim 0.2-0.4$ ) suggest that the granites were contaminated by continental crust and the AFC process played a role during the evolution of the granites.

#### 5 Conclusion

The results suggest derivation of a parent magma of the

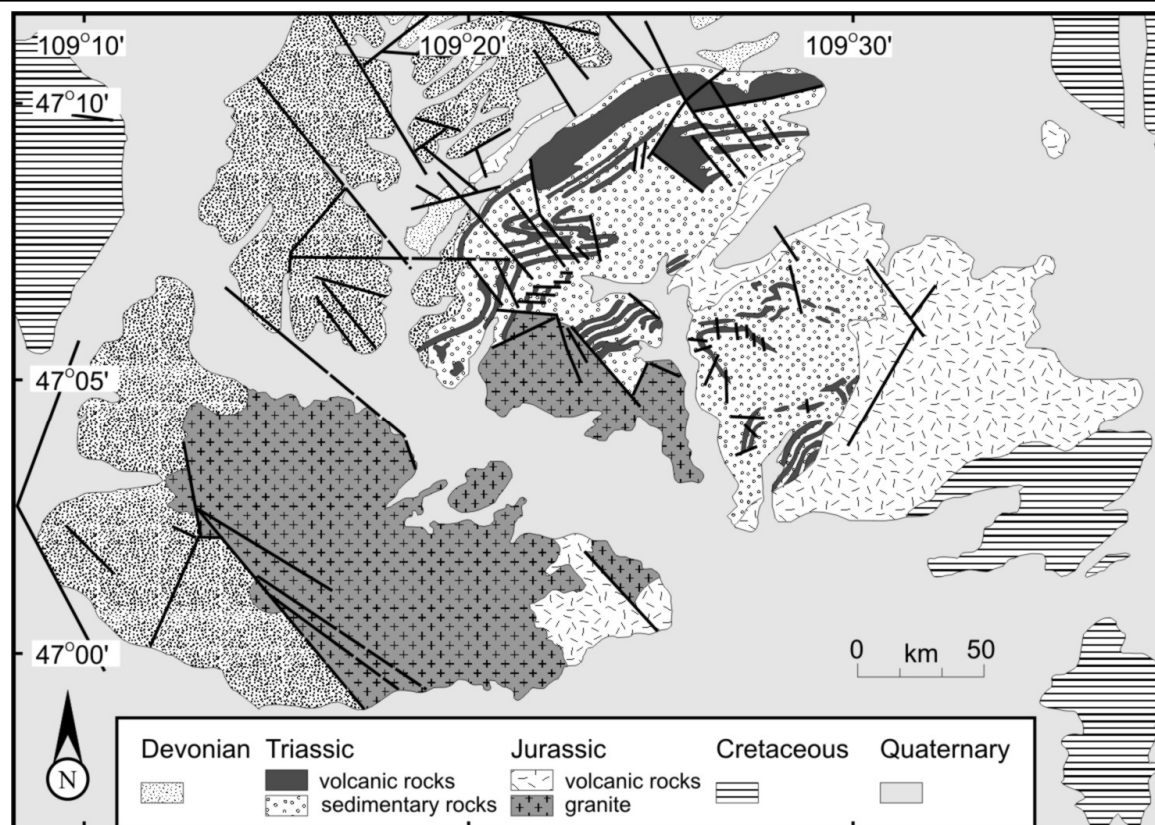


Fig. 2. Geological map of the Dashibalbar igneous complex (modified after Kalimulin, 1968; mapping report).

granitoids and felsic volcanic rocks from underplated, enriched, Neoproterozoic mantle-derived basaltic rocks in the lower crust, whereas the Dashibalbar basalts were derived from Neoproterozoic subcontinental lithospheric mantle; Neoproterozoic megablocks crop out in adjacent part of Central Asian Orogenic Belt. Melting of lower crust and subcontinental lithospheric mantle implies a rising heat source. Although such a heat source is consistent with both the rifting and passage over the Mongolian mantle plume, only the latter explains the west-to-east migration of the magmatism and rifting.

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