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Peralkaline granitoid magmatism in the Mongolian–Transbaikalian Belt: Evolution, petrogenesis and tectonic significance

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ABSTRACT

The Central Asian Orogenic Belt (CAOB) is well-known for its massive generation of juvenile crust in the Phanerozoic. In eastern CAOB, voluminous peralkaline and alkaline (alkali-feldspar) granitoids and genetically related bimodal volcanics were emplaced in three stages from Early Permian to late Mesozoic: 295–270 Ma, 230–190 Ma and 150–120 Ma. They occur as huge granitoid belts in extensional tectonic settings and form a complex network of about 12 million km^2 in area. Among them the 2500 km-long Mongolian–Transbaikalian Belt (MTB) is the most spectacular and it comprises more than 350 granite–syenite plutons and stocks, with numerous co-genetic volcanic fields. The three stages of granitoids have similar chemical compositions but show temporal variation in Nd isotopic composition. Initial εNd(T) values range from −1 to −5 for the Early Permian, 0 to +4 for the early Mesozoic, and −2 to −3.5 for the late Mesozoic granitoids. The negative εNd(T) values observed in the MTB are not typical of the CAOB granitoids, which are generally characterized by positive values. However, several pieces of evidence suggest that the MTB peralkaline and alkali feldspar granitoids were produced from enriched mantle-derived sources. The evidence includes: (1) Felsic and mafic rocks formed in the same stage have similar initial Nd–Sr isotopic ratios and Sm–Nd model ages (T_{DM}). (2) The granitoid belts extend over thousands of kilometers and intersect distinct crustal provinces, but no correlation is found in chemical compositions between the granitoids and country rocks. (3) The abundant syenites are considered to be cogenetic or, in some cases, parental to the granites. Experimental and isotope data argue for the derivation of syenites from an enriched mantle source, thus the granites (and comendites) are regarded as mantle-derived. (4) A study of melt inclusions in quartz phenocrysts of comendite indicates a high liquidus temperature of 1000–1100 °C for the magma generation. This suggests that the silicic magma was generated in an unusually high temperature condition which is likely produced by basaltic magma that underplated the lower crust. The generation of voluminous peralkaline and alkaline (alkali-feldspar) granitoids and genetically related bimodal volcanic rocks represents an important addition of juvenile crustal mass to the Earth's continental crust during a time span of about 150 Ma from Late Paleozoic to Late Mesozoic.

1. Introduction

Since “A-type granite” was first recognized about 30 years ago (Loiselle and Wones, 1979; Collins et al., 1982), a spectrum of alkali-rich granitic rocks has been included in this type, and their compositions range from syenogranite through peralkaline granite, syenite, rapakivi granite, charnockite, and finally to fluorine-rich topaz granite (e.g., Collins et al., 1982; Whalen et al., 1987; Eby, 1992; Patiño Douce, 1997; Wu et al., 2002; Bonin, 2007). Such a wide range of composition leads to constant debate about the origin of A-type granites (e.g., Whalen et al., 1987; Bonin, 2004; Whalen, 2005; Bonin, 2007). Clearly, a unified model for the generation of A-type granitoids is unrealistic.

In this paper, we study the origin of peralkaline and alkaline (particularly, alkali-feldspar) granites and their extrusive equivalents from Transbaikalia of eastern Siberia (Russia). The term ‘peralkaline granitoids’ is used for granite and syenite with agpaitic index NK/A>1, containing Na-rich amphibole and pyroxene. The ‘alkali-feldspar granitoids’ include granite and syenite with NK/A ranging from 0.9 to 1, and alumina saturation index A/CNK = 1 ± 0.15; they consist mainly of perthitic alkali feldspar, quartz, Fe-rich biotite, Ca–Na amphibole (the latter mostly in syenite). In the paper we use abbreviations PA and AFS for peralkaline and alkali-feldspar granitoids,

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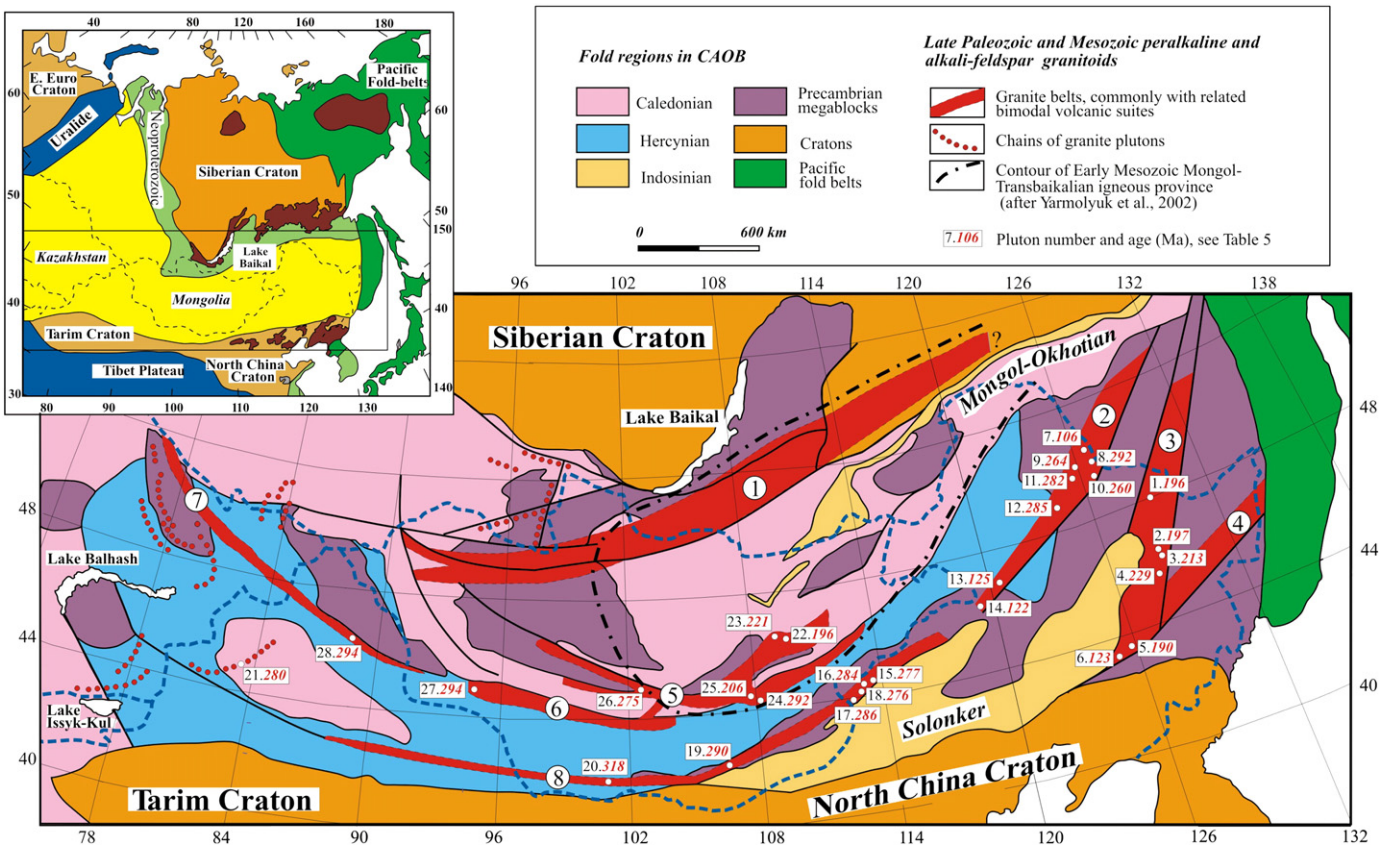

Fig. 1. Distribution of the Late Paleozoic and Mesozoic granitoid belts in the Central Asian Orogenic Belt. The map area corresponds to the rectangle of the inset map. The numbers of plutons correspond to that in Table 5; ages (Ma, in red) beside numbers are also taken from this table. Granite belts: 1 = Mongolian–Transbaikalian, 2 = Great Xing'an, 3 = Zhangguangcai, 4 = Jiamusi, 5 = Gobi–Altai, 6 = Main Mongolian Lineament, 7 = Eastern Kazakhstan, 8 = Gobi–Tien Shan. Data sources: Leontiev et al., 1981; Yarmolyuk, 1983; Zanvilevich et al., 1985; Geological map of Mongolia (1: 1,500,000), 1989. The map of magmatic rocks of Transbaikalia, Eastern Sayan and the adjacent areas in Mongolia (1: 1,500,000) was produced using the following literature data: Han et al. (1997), Wang S. et al. (1995), Hong D.W. et al. (1994, 1996), Yarmolyuk et al. (2001, 2002, 2005), Wu et al. (2002), Jahn (2004), Kovalenko et al. (2004), and Yanshin (1980).

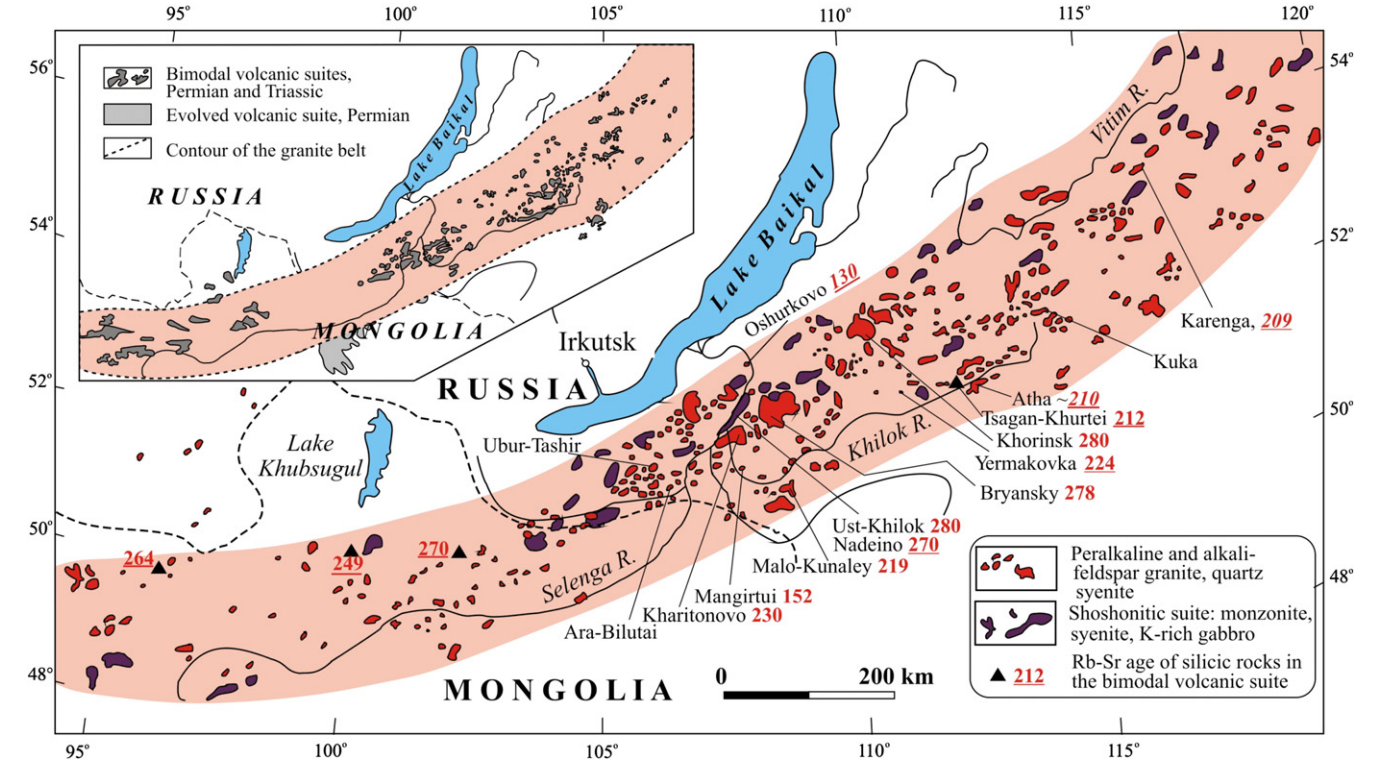

Fig. 2. Distribution of the Late Paleozoic and Mesozoic PA and AFS granitoids in the Mongolian–Transbaikalian Belt. The numbers by the pluton names designate the U–Pb (zircon) and Rb–Sr (WR, underlined) isotopic ages (in Ma). In the western part of the belt, Rb–Sr ages of trachyrhyolite and pantellerite from the bimodal volcanic suites in three localities are shown (after Yarmolyuk et al., 2005; see Table 1). In the inset, the main bimodal volcanic fields are also shown (the smaller fields are shown off scale).