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Late Mesozoic–Cenozoic intraplate magmatism in Central Asia and its relation with mantle diapirism: Evidence from the South Khangai volcanic region, Mongolia

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ABSTRACT

The South Khangai volcanic region (SKVR) comprises fields of Late Mesozoic–Cenozoic volcanic rocks scattered over southern and central Mongolia. Evolution of the region from the Late Jurassic to the Late Cenozoic includes 13 successive igneous episodes that are more or less evenly distributed in time. Major patterns in the distribution of different-aged volcanic complexes were controlled by a systematic temporal migration of volcanic centers over the region. The total length of their trajectory exceeds 1600 km.

Principle characteristics of local magmatism are determined. The composition of igneous rocks varies from basanites to rhyolites (predominantly, high-K rocks), with geochemistry close to that of OIB. The rock composition, however, underwent transformations in the Mesozoic–Cenozoic. Rejuvenation of mafic rocks is accompanied by decrease in the contents of HREE and increase of Nb and Ta. According to isotope data, the SKVR magmatic melts were derived from three isotope sources that differed in the Sr, Nd, and Pb isotopic compositions and successively alternated in time. In the Early Cretaceous, the predominant source composition was controlled by interaction of the EMII- and PREMA-type mantle materials. The PREMA-type mantle material dominated quantitatively in the Late Cretaceous and initial Early Cenozoic. From the latest Early Cenozoic to Late Cenozoic, the magma source also contained the EMI-type material along with the PREMA-type.

The structural fabric, rock composition, major evolutionary pattern, and inner structure of SKVR generally comply with the criteria used to distinguish the mantle plume-related regions. Analogous features can be seen in other regions of recent volcanism in Central Asia (South Baikal, Udokan, Vitim, and Tok Stanovik). The structural autonomy of these regions suggests that distribution of the Late Mesozoic–Cenozoic volcanism in Central Asia was controlled by a group of relatively small hot finger-type mantle plumes associated with the common hot mantle field of Central Asia.

1. Introduction

In the Late Mesozoic and Cenozoic, the East Asian continent was involved in intraplate activity accompanied by the formation of graben systems and large volcanic fields. These processes were particularly prominent in the Late Cenozoic when rifting and volcanism encompassed the continental margin within 3000 km from the Pacific coast up to Tuva (Russia) and western Mongolia (Fig. 1). The intraplate activity produced a volcanic province 3000 × 2000 km in size. The autonomous position of the volcanic province (relative to plate boundaries) and the formation of rift (Baikal, Ordos, and Tan-Lu) zones within the province suggest that this region is one of the largest modern intracontinental provinces in the world. It comprises a number of different-sized volcanic fields (Yarmolyuk et al., 1996, 2011), which are usually isolated in space but marked by compositional similarity of volcanic rocks, succession of volcanic activity, and predominantly fissure-type eruptions. In accordance with this type of volcanic activity, eruption products in this province are mainly represented by lava plateaus (e.g., Dariganga) crowned with a chain of small cinder cones along the fissure conduits.

At the same time, some zones of this province are marked by significant differences in evolution. The Far East zone is dominated

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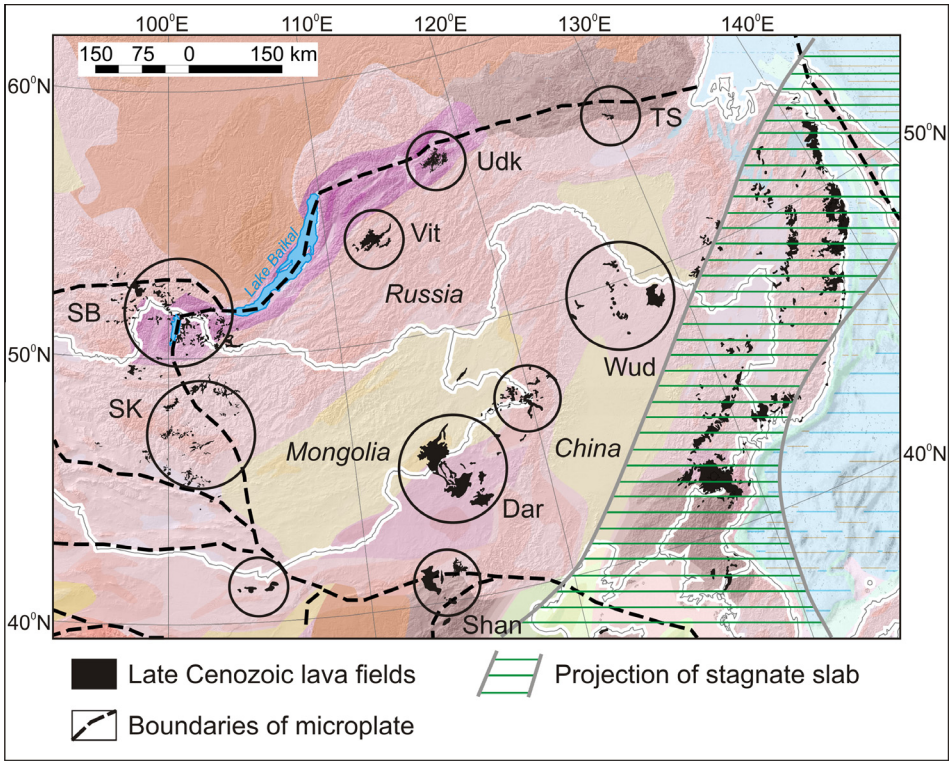

Fig. 1. Map of recent volcanism in the East Asian continent based on Kovalenko et al. (2009) showing location of volcanic regions: (SK) South Khangai, (SB) South Baikal, (Vit) Vitim, (Udk) Udokan, (TS) Tok Stanovik, (Wud) Wudalianchi, (Dar) Dariganga, (Shan) Shanxi, and others. Adopted from Neotectonic Map of the World (1984).

by Late Cenozoic volcanic fields (Yarmolyuk et al., 2011), whereas volcanic activity in the western (Central Asian) zone has a much longer evolution history that can be traced back to the Late Mesozoic.

The geodynamic setting of this province is debatable. According to our opinion (Yarmolyuk et al., 1996), its evolution was related to the activity of the Central Asian mantle hot field, whose existence was inferred from gravimetric data (Zorin et al., 1988). Seismic tomography data (Zhao, 2004, 2009) suggested an unusual structure of the convergence zone in the West Pacific. It was demonstrated that the subducted Pacific slab is stagnated in the upper mantle transitional zone, extended far westward, and traced beneath the eastern part of the volcanic province. In particular, such behavior of the subducted lithosphere is recorded beneath the Far East zone of the volcanic province. According to the model based on this observation (Wei et al., 2012; Zhao, 2004, 2009; Zhao et al., 2009, 2011; Zorin et al., 2006a, 2006b), intraplate volcanic activity in the East Asian province is governed by fluxes of fertilized mantle material from the upper part of the stagnant slab. In other words, this model relates intraplate activity in the inner part of the continent with subduction processes in the West Pacific.

It should be mentioned that the major part of the volcanic province lies outside the hypothetical influence zone of the stagnant slab (Fig. 1). This fact compels us to search for other models of the origination and evolution of the province. In the context of this problem, important information can be derived from certain volcanic regions in the Central Asian part of the province. Their geology complies with criteria of relations with mantle plumes (Campbell, 2005, 2007; Hawkesworth and Scherstén, 2007; Lustrino, 2005; Saunders et al., 2007; and others). These volcanic regions are characterized by the following properties: (i) long evolutionary history (more than dozens of million years); (ii) rock compositions corresponding to enriched mantle sources (Barry et al., 2003; Kudryashova et al., 2010; Savatenkov et al., 2010); (iii) systematic migration of volcanic centers over the area that can be associated with traces of hotspots in the overlying migrating lithosphere (Kovalenko, 2009, 2010; Kovalenko et al., 1997; Yarmolyuk et al., 1991, 1996, 2007b); and (iv) spatial restriction to recent domes (Barruol et al., 2008; Barry and Kent, 1998; Barry et al., 2007; Kudryashova et al., 2010; Tiberi et al., 2008; Windley and Allen, 1993; Yarmolyuk et al., 2008b; and others). According to its characteristics (spatial isolation, relatively small amounts of magmatic products, and dominance of alkaline rocks), volcanic regions of Central Asia can be compared with counterparts in the Central European volcanic province, the development of which is related to local mantle plumes or "hot fingers" (Granet et al., 1995; Montelli et al., 2006; Wilson and Downes, 2006; Wilson and Patterson, 2001; Zhao et al., 2013; and others).

The aim of the present work is to decipher the evolution trends of intraplate magmatism in Central Asia and evaluate the role of mantle plumes and/or other mantle processes in origination of the Late Mesozoic–Cenozoic volcanic fields in Asia. This work is based on the geological, geochronological, geochemical, and isotopic studies of volcanic rocks sampled in one of the largest volcanic fields of the province identified as the South Khangai volcanic region (SKVR).

2. Geological background

The South Khangai volcanic region comprises Late Mesozoic and Cenozoic volcanic fields in the central parts of central and southern Mongolia (Yarmolyuk et al., 1995b, 1996). It extends over an area of 500 × 1000 km in the Gobi Altai ranges, eastern termination of the Gobi Tien Shan ranges, Khangai Plateau, and surrounding areas (Fig. 2). The region is dominated by spatially and structurally autonomous Early Cretaceous and Late Cenozoic volcanic complexes, which were described in Barry and Kent (1998), Florensov and Solonenko (1963), Frikh-Khar and Luchitskaya (1978),