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LATE CENOZOIC VOLCANISM OF THE UDA RIVER AREA (EASTERN SAYAN, SIBERIA): THE FIRST GEOCHEMICAL AND ISOTOPIC DATA

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Volcanic eruptions within the Baikal rift of predominantly basaltic composition belong to numerous small-volume eruptions, which took place in Cenozoic in Central Asia. The great majority of these eruptions occurred within the mobile belts in the southern framing of the Siberian craton. Only few of such eruptions have happened within the cratonic margin and these are of particular interest, because volcanic rock composition may provide insights on the composition of the cratonic lithosphere. Until recently, the Uda river area with the size of ~2000 km^2 located within the Biryusa block of the Siberian craton (Fig. 1) was a white spot in terms of precise geochemical and isotopic data for basalts. Here we provide such data for the first time.

Methods. The studied outcrops of volcanic rocks are scattered at upper tributaries of the Uda river, such as Khadama and Khunga rivers and their tributaries (Fig. 1). The lava outcrops vary in thickness from first meters up to 250 m. K-Ar dating allowed to distinguish lava of the two ages – about 8 Ma and 4 Ma [*Ivanov et al., 2015*].

The collected rock samples were analyzed for major and trace elements and for Sr-Nd isotopes. Trace elements were measured using equipment of the Centre of Ultramicroanalysis at the Limnological Institute of the Siberian Branch of the Russian Academy of Sciences, whereas all other analyses were conducted using equipment of the Centre of Geodynamics and

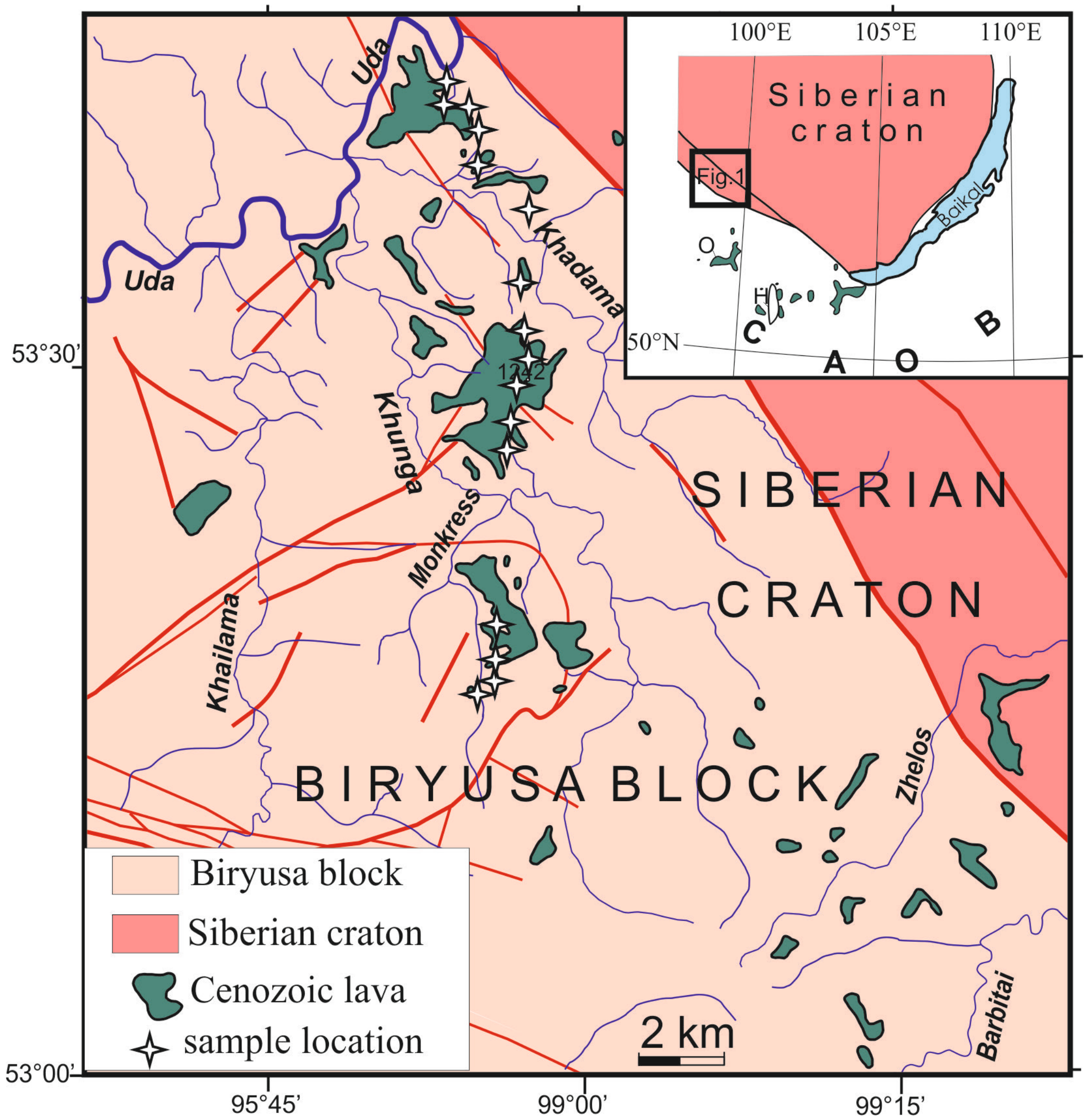

Fig. 1. Map of sample localities at the Uda river volcanic province (Eastern Sayan). O and H at the insert states for the Oka and Hovsgol volcanic areas. CAOB – Central Asian Orogenic Belt.

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Results. At the TAS diagram, the rocks fell into the fields of trachybasalts and basaltic trachyandesites. Using normative mineralogy, the rocks can be classified as hawaiites and olivine tholeiites. By the co-variations of Mg#, TiO_2, CaO, Al_2O_3 with SiO_2, the rocks of 4 and 8 Ma age groups form different trends. For example, while the rocks of 4 Ma group show the reverse correlation between decreasing Mg# (from 63 to 51 %) and increasing CaO/Al_2O_3 (from 0.35 to 0.53) and SiO_2 (from 47 to 53 wt. %), which is a characteristic of olivine, clinopyroxene and Ti-magnetite crystallization, the rocks of 8 Ma group show no correlations between these indexes with Mg#, CaO/Al_2O_3 and SiO_2 in the ranges of 56–67 %, 0.44–0.55 and 50.3 до 52 wt. %, respectively.

At the primitive mantle normalized diagrams, all studied rocks show trace element patterns similar to ocean island basalts. The rocks of the 4 Ma group are characterized by higher La/Yb (20–33) compared to the rocks of the 8 Ma group, where La/Yb are in the range of 15–18. This suggests higher amount of garnet in the source of melting and lower degrees of partial melting at 4 Ma.

There are differences between the rocks of the two age groups by Sr-Nd isotopes too (Fig. 2). The rocks with the age of 8 Ma have εNd values in the narrow range (from −0.3 to −0.5) at elevated εSr (from 5 to 6). Such isotope compositions are rare among basalts of the Baikal rift and were only reported for few samples collected at the Oka volcanic field [*Harris, 1998*], Hovsgol [*Yarmolyuk et al., 2003*] and Central Mongolia [*Savatenkov et al., 2010; Yarmolyuk et al., 2015*]. Sr-Nd isotopic compositions of the rock of 4 Ma group are in

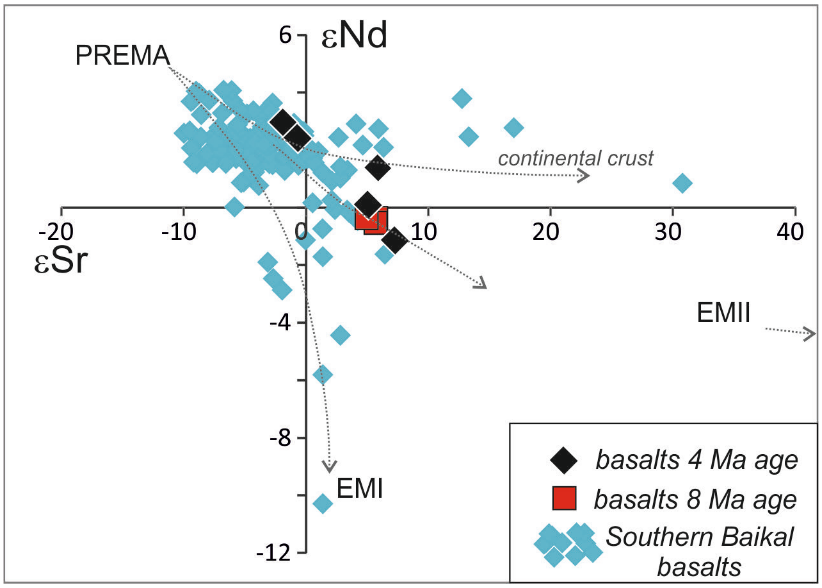

Fig. 2. εNd versus εSr for Cenozoic alkaline basalts in southwestern Baikal rift after [*Harris, 1998; Yarmolyuk et al., 2003; Rasskazov et al., 2002; Tsypukova et al., 2014*] including authors original data for the Iya-Uda river area. PREMA – prevalent mantle, EM – enriched mantle of I and II types.

the wider range (εNd from 2.9 to –1.2 and εSr from –1.8 to 5.9). There is no correlation between Sr isotope ratios and 1/Sr, suggesting absence of crustal contamination.

Discussion. Considering Cenozoic basalts of the Baikal rift and adjacent non-rifted regions in Mongolia, all researches acknowledge involvement in the melting few mantle components such as PREMA, EM I and EM II (sometimes giving them different names) and probable crustal contaminants (Fig. 2). However, geodynamic interpretation of the trace element and isotopic variations is more complex, that is reflected in a number of different models. For example, *Rasskazov et al.* [*2002*] suggest that the dominant melting occurs within the asthenosphere with PREMA features and such melts are mixed with lithospheric melts with EM I and EM II features. *Yarmolyuk et al.* [*2015*] involves a lower mantle plume for PREMA, EM I and EM II components irrespective of their origin. *Perepelov et al.* [*2017*] accept the lower mantle plume, though specify the EM I component as being derived from recycled oceanic lithosphere in form of eclogite. There is more agreement on the melting depth – the melting occurs at the garnet stability field in the range of ~60–80 km depth.

In the case of the Uda river area we see that magma of different age shows different trace element and isotopic compositions. Melting starts at 8 Ma at higher degrees of partial melting with involvement of PREMA and EM II components and after a time gap it reoccurs with dominant involvement of EM II component at lower degrees of partial melting and increasing amount of garnet in the source of melting (Fig. 2). We interpret such change as the melting starts within asthenospheric mantle and then vanish with time in the lithosphere, which contains some frozen eclogite lenses. Lithospheric melts are cooler and the lower temperature leads to fractional crystallization, which supports for the remaining melts to propagate to the state of eruption at the surface because of fractional crystallization driven decrees of melt density [*Ivanov, 2012*].

Conclusion. Volcanism at the Uda river area occurred within two episodes at 8 and 4 Ma. Erupted melts are typical in general for within plate tectonic settings, though there are some differences between the two episodes in terms of trace elements and Sr-Nd isotopes. Melting initiated 8 Ma at high degrees of partial melting, which is reflected in low La/Yb of 15–18 in basalts. The isotopic components involved at this episode were PREMA and EM II, which we interpret as asthenospheric and lithospheric components, respectively. At 4 Ma, the melting focused within lithosphere, which probably contained eclogitic lenses.

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