

Age and mineralogical and geochemical parameters of rocks of the China alkaline massif (*western Transbaikalia*)

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Received 7 November 2016; accepted 4 January 2017

Abstract

Geochemical and U–Pb geochronological studies have shown that the alkali syenites of the China massif have an age of 311.4 ± 1.8 Ma and potassic specialization in contrast to most massifs of the Vitim alkaline-magmatism zone. The rocks are similar in geochemistry to the nepheline syenites of the Synnyr massif, dated at 289.5 ± 3.5 Ma. The alkali syenites of the China massif formed, most likely, from crustal protoliths.

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Keywords: alkali and nepheline syenites; high-K rocks; Late Paleozoic magmatism; sources; western Transbaikalia

Introduction

The Vitim alkaline-magmatism zone in western Transbaikalia includes more than twenty alkaline rock massifs localized in a NE striking band more than 450 km long and about 50 km wide (Fig. 1). These massifs were assigned to a Late Paleozoic alkali-gabbroid association (Saizhen complex) (Konev, 1982; Sharakshinov, 1984). Until recently, the age has been estimated based on geologic parameters or rock characteristics unstable toward the later changes in the Rb–Sr and K–Ar isotope systems. Because of the wide range of their age values (595–167 Ma), the rocks could not be related to a single geodynamic event proceeding in the particular period. Our geochronological studies of alkaline massifs (Doroshkevich et al., 2012a,b,c, 2014) showed at least two stages of their formation: Early Paleozoic (520–485 Ma) and Late Paleozoic (309–290 Ma). The rocks formed at both stages are of sodic or, more seldom, sodic–potassic specialization. The China massif, in contrast, is of potassic specialization and is similar to the ultrapotassic intrusions (Synnyr and South Sakun) in the Baikal–Stanovoi rift area. The earlier published materials (Konev, 1982; Sharakshinov, 1975, 1984; Sharak-

shinov et al., 1991) lack data on the age of the China massif and give incomplete information about the lithology and petrology of its rocks.

In this paper we present the geochronological, mineralogical, and geochemical characteristics of the China massif rocks, compare them with the parameters of alkaline rocks of the Vitim and Baikal–Stanovoi zones, and thus consider the sources of material for alkaline sodic and potassic magmas in western Transbaikalia.

Methods

Minerals were examined with an LEO-1430 electron scanning microscope equipped with an IncaEnergy-300 energy dispersive spectrometer at the Geological Institute, Ulan-Ude. Feldspar was analyzed by a defocused beam because the mineral is a fine-grained mesoperthitic aggregate of K-feldspar and albite. The chemical and trace-element compositions of rocks were determined at the Institute of Geology and Geochemistry, Yekaterinburg, and Geological Institute, Ulan-Ude, using conventional analytical methods and ICP MS.

The U–Pb (SHRIMP-II) zircon dating was made at the Center of Isotope Studies of the All-Russian Geological Research Institute, St. Petersburg. Zircon grains, together with

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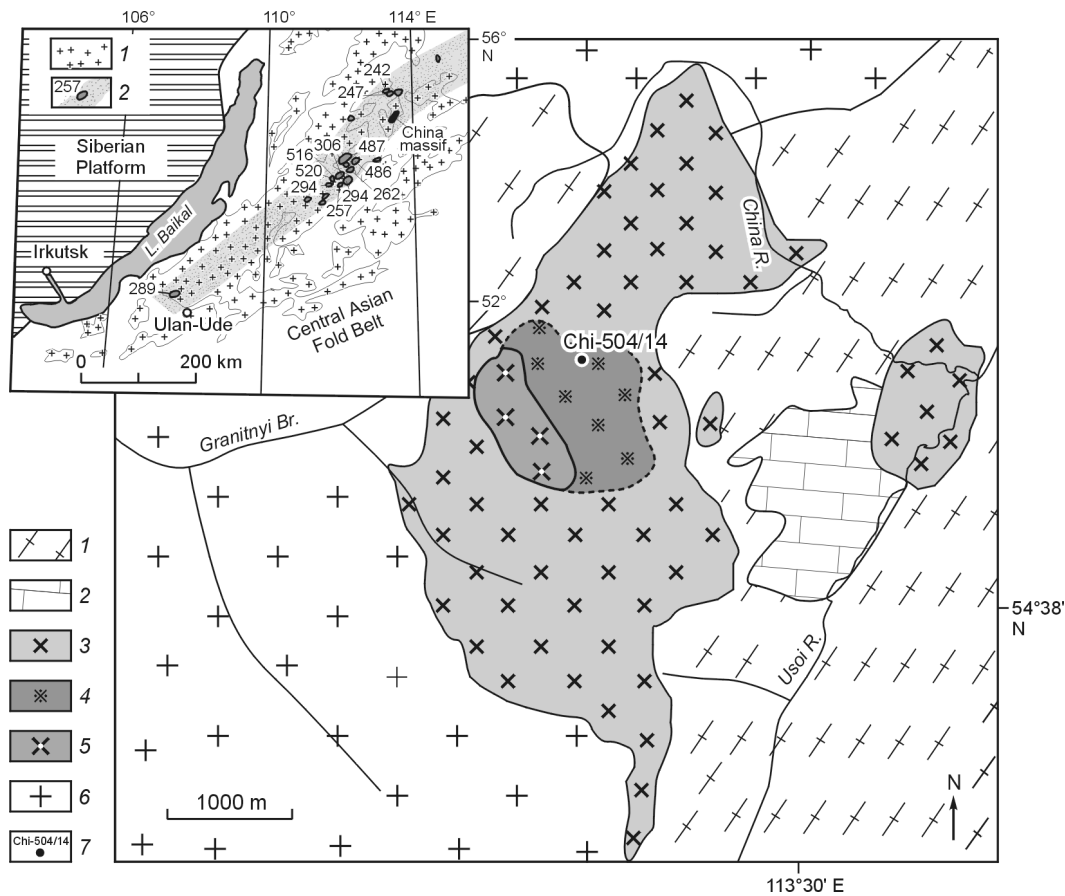


Fig. 1. Schematic geological map of the China massif (after S.V. Kostromin, simplified). 1, argillaceous shales and sericite schists; 2, limestones and dolomites; 3, fine-grained syenites of the peripheral zone; 4, syenites of the intermediate zone; 5, coarse- and giant-grained rocks of the central zone; 6, granites and granodiorites; 7, locality of sampling for geochronological studies. Inset shows the location of the China massif: 1, Angara–Vitim granite batholith; 2, alkaline massifs of the Vitim upland, with U–Pb and Ar–Ar dates (Ma).

the TEMORA geochronological standard zircon and Geostandarts zircon 91500, were injected into epoxy resin. Local U–Pb dating was made from the optical, BSE, and cathodoluminescent images of the grain surface reflecting the internal structure and zoning of zircon crystals. The U/Pb ratios were measured by the technique described by Williams (1998). The primary O_2 beam intensity was 4 nA, sampling crater diameter was 25 μm , and crater depth was up to 5 μm . The obtained data were processed by the SQUID software (Ludwig, 2000). The U/Pb ratios were normalized to the value of 0.0668 of the TEMORA standard zircon, corresponding to its age of 416.75 Ma (Black et al., 2003). The error of single analyses (U/Pb and age estimation) was at the 1σ level, and the error of the concordant age, at the 2σ level. Plots with a concordia were constructed using the ISOPLOT/EX software (Ludwig, 1999).

The U–Pb zircon dating by LA-SF-ICP-MS was performed on an Element XR (Thermo Fisher Scientific) high-resolution mass spectrometer with a UP-213 (New Wave Research) laser ablation sampler in the Laboratory of Physical Methods of the Geological Institute, Ulan-Ude (Khubanov et al., 2016). Dating was made for single zircon grains injected into epoxy resin together with TEMORA-II (Black et al., 2003) and Plešovice (Sláma et al., 2008) standard zircon grains. The

zircons were ground and polished to approximately half the thickness. Optical images and scanning electron microscopy (SEM) data were used to choose grain surface sites (points) for dating. Zircons were irradiated with a pulsed laser beam with a frequency of 10 Hz and a diameter of 25 μm for 30 s. The evaporated particles were carried away from the laser apparatus by a helium flow, which was mixed with an argon flow before the supply into the mass spectrometer. The analytical signals of isotopes ^{202}Hg , $^{204}(\text{Hg} + \text{Pb})$, ^{206}Pb , ^{207}Pb , ^{208}Pb , ^{232}Th , ^{235}U , and ^{238}U were measured with a magnetic-sector mass spectrometer with inductively coupled plasma. Correction of the isotope signal drift, recording of the background signals, and calculation of isotope ratios and their errors were made using the Glitter program (Griffin et al., 2008). The ages were estimated by constructing a $^{206}\text{Pb}/^{238}\text{U}$ – $^{207}\text{Pb}/^{235}\text{U}$ diagram with a concordia and calculating the weighted average values by the ISOPLOT-3 software (Ludwig, 2003).

The oxygen isotope composition of silicates, phosphates, and oxides was measured on a Finnigan MAT 253 mass spectrometer at the Geological Institute, Ulan-Ude, applying the laser fluorination method (Sharp, 1990). The samples were heated with CO_2 laser (100 W) in the BrF_5 atmosphere. As reference samples, the following International standard mate-

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