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GEOCHEMISTRY

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## New Data on the Age of Lamproite–Lamprophyre Magmatism in the Urals

S. V. Pribavkin<sup>a</sup>, Yu. L. Ronkin<sup>a</sup>, A. V. Travin<sup>b</sup>, and V. A. Ponomarchuk<sup>b</sup>

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Several occurrences of lamproites on the eastern slope of the Urals are objects of our investigation (Fig. 1). The lamproite occurrence situated in the central and eastern part of the Paleozoic Magnitogorsk island-arc system at a few tens of kilometers northeast from Magnitogorsk was described in [4, 9]. These lamproites make up a petrogenetic series with lamprophyres (monchiquite, camptonite, minette, and kersantite) identified as the Kalymbai Complex [9]. The second lamproite occurrence (Pervomaiskii area) is located in the eastern part of the East Ural Uplift 40 km south of Chelyabinsk near Pervomaiskii Settlement [3, 7]. This area includes a number of pipe-shaped magnetic anomalies, as well as diatremes and dikes that crosscut the Devonian rocks. In addition, we previously studied the lamproite occurrence near Skalistyi Settlement 25 km west of the town of Troitsk in the Transural region [6], where lamproite dikes crosscut adamellites of the Lower Sanarka pluton.

Based on Rb–Sr and K–Ar datings, the ages of the lamproites mentioned above vary from 198 to 295 Ma [1–4]. Lamproites of this age are related to the postcollision extension of the Earth's crust [9], tectonomagmatic reactivation of the young platform along latitudinal transverse faults [4], or manifestation of an epicontinental hot spot [11].

Lamprophyres have been investigated in the Urals to a lesser extent than lamproites, although they occur in many places and vary in age. The best studied and most easily accessible lamprophyre related to the alkaline–ultrabasic potassic magmatism is represented by a dike in the Shartash granitic pluton on the outskirts of Yekaterinburg [5]. This occurrence is situated at the conti-

ental margin west of the Murzinka–Adui Block of the East Ural Uplift. The K–Ar age of the Shartash dike, which is appreciably altered at the contact with granite, ranges from 261 Ma (reaction amphibole at the contact) to 274 Ma (phlogopite) [5].

In this communication, we present the first results of <sup>40</sup>Ar/<sup>39</sup>Ar dating of lamproites of the Kalymbai Complex, Pervomaiskii area, Shartash ultramafic lamprophyre occurrence, and Lower Sanarka pluton of unknown age.

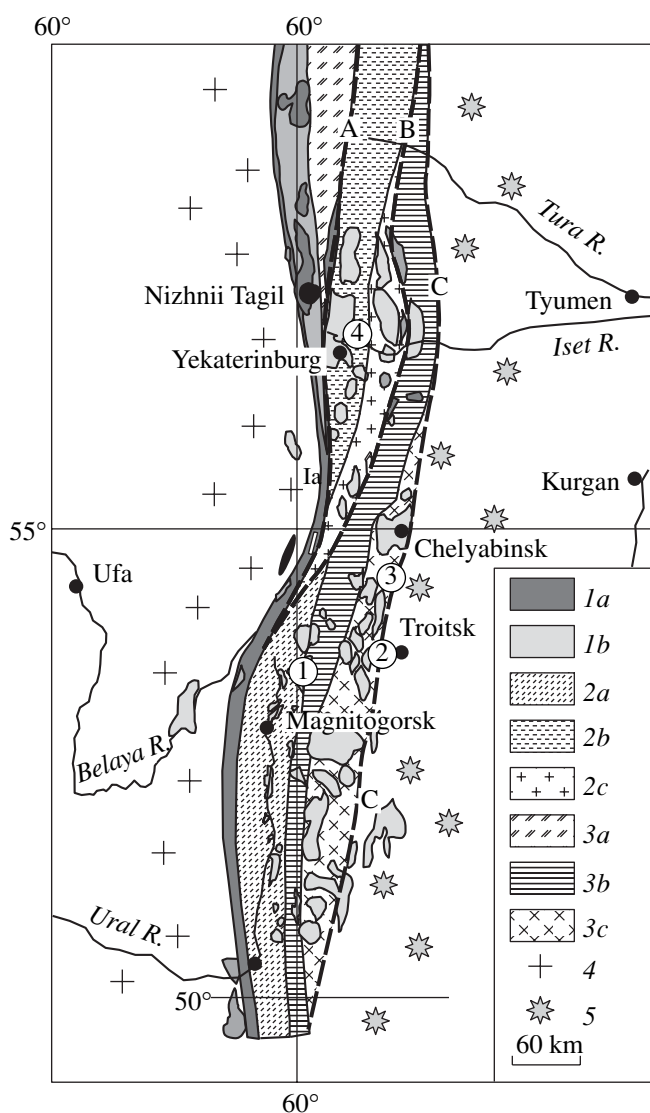
The least altered samples of dikes with fresh phlogopite phenocrysts 1–5 mm in size were chosen for dating. The samples with phlogopite severely deformed and partially replaced by chlorite were rejected. In the process of sample preparation, including crushing, sieving, and subsequent examination under a binocular microscope, fractions consisting of phlogopite phenocrysts larger than 1 mm were not picked out, because such large phenocrysts should be more conservative with respect to probable argon loss. The phlogopite flakes were wrapped in aluminum foil and, after air exhaust, welded in a quartz ampoule together with charges of biotites MCA-11 and LP-6 as monitors. The samples were irradiated in a cadmium-plated channel of a VVR-K research reactor similar to that installed at the Research Institute of Nuclear Physics in Tomsk. The gradient of the neutron current did not exceed 0.5% on the sample size. After preliminary degassing of samples in vacuum at 300°C, the experiments on stepwise heating from 550 to 1200°C were carried out in a quartz reactor with a furnace of outer heating and precision ( $\pm 1^\circ\text{C}$ ) temperature control with a thermocouple. The procedure blank (10 min at 1200°C) was not higher than  $n \cdot 10^{-10}$  ncm<sup>3</sup> for <sup>40</sup>Ar. The released argon was refined with Ti and SAES getters. The Ar isotopic composition was measured on a Micromass 5400 mass spectrometer (England).

The results of dating are shown in Fig. 2. Lamproite from the Lower Sanarka pluton (sample ps-314) has an age of  $308.4 \pm 3.8$  Ma; lamproite from the Pervomaiskii area (sample ps-316 from the Sheinskii open pit),

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<sup>a</sup> Institute of Geology and Geochemistry,  
Ural Division, Russian Academy of Sciences,  
Pochtovyi per. 7, Yekaterinburg, 620151 Russia;  
e-mail: pribavkin@igg.uran.ru

<sup>b</sup> Institute of Geology and Mineralogy, Siberian Division,  
Russian Academy of Sciences, pr. akademika Koptyuga 3,  
Novosibirsk, 630090 Russia



**Fig. 1.** Tectonomagmatic units of the central and southern Urals, after Fershtater (1992) and location of the studied lamproites and lamprophyres. Megablocks (1–3): (1) General Ural Suture: (a) Main Ural Fault Zone, (b) Platinum Belt; (2, 3) northwestern and southeastern island-arc–continental blocks, respectively: (a) island-arc zones, (b) continental-margin zones, and (c) continental zones; (4) paleo-continental sector, passive margin; (5) Transural region, the zone transitional to Kazakhstanides. The dashed lines are tectonic sutures: (A) Serov–Mauk, (B) Alapaevsk, (C) Chelyabinsk. Occurrences of lamproites and lamprophyres (numerals in circles): (1) Kalymbai Complex, (2) Lower Sanarka pluton, (3) Pervomaiskii area, (4) Shartash pluton.

$303.7 \pm 3.8$  Ma; and lamproite of the Kalymbai Complex (sample ps-304 from the Malyy Kuibas open pit),  $304.8 \pm 3.8$  Ma. The dike in the Shartash pluton (sample ps-339 taken from the open pit of the Berezovskii Building Works) was dated at  $284.4 \pm 3.6$  Ma. All analyzed samples are characterized by a distinct plateau (more than 90% of the released  $^{39}\text{Ar}$ ), indicating good preservation of the samples. The coincidence (within

the limits of uncertainty) of three datings of lamproite samples from different sites is a strong argument in favor of the reliability of the above results.

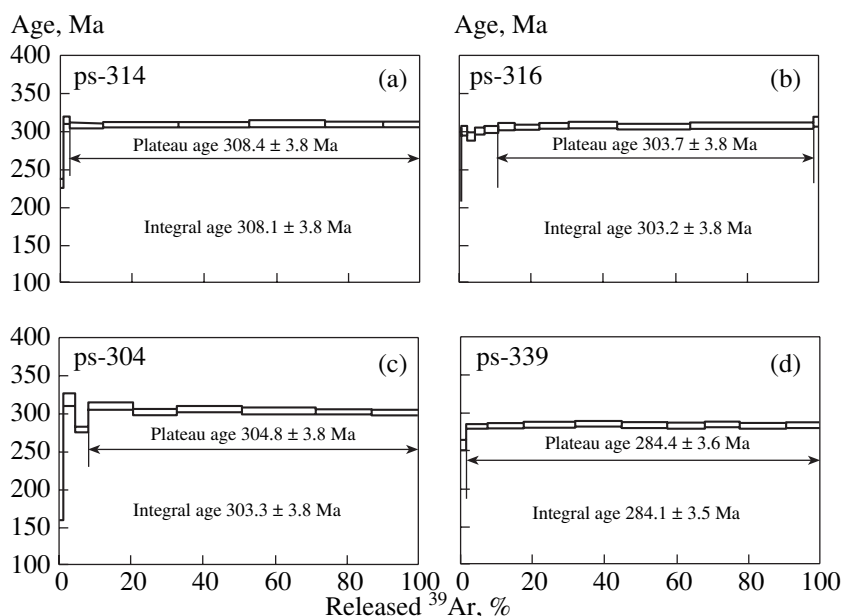
The Late Carboniferous  $^{39}\text{Ar}/^{40}\text{Ar}$  age of lamproites (308–304 Ma) markedly differs from the results obtained with other methods. Correlation of the previously published geochronological data with geological events is doubtful because the samples used for dating were affected by significant metasomatic alterations that could disturb the primary isotopic systems.

The first data on the Rb–Sr age of lamproite of the Kalymbai Complex ( $197 \pm 5$  Ma) was published by Luk'yanova [4]. Since the initial analytical data and age calculation method were not reported, the significance of this date can hardly be estimated. Gorozhanin [1] reported two intersecting isochrons with ages of  $198 \pm 4.5$  and  $221 \pm 31$  Ma for the same (partially altered) rocks. The discordant ages of 240 and 295 Ma obtained with the K–Ar whole-rock dating of lamproite samples pertaining to the Kalymbai Complex [2] probably reflect partial losses of potassium and radiogenic argon in the course of metasomatic alteration.

The K–Ar age of rocks of the Pervomaiskii area ( $230 \pm 10$  Ma [3]) characterizes lamproite from a tuff-site diatreme. However, this is an altered rock composed of chlorite, muscovite, pyrophyllite, carbonate, hematite, and quartz. The reliability of the lamproite age obtained for this rock is doubtful. The K–Ar dating of two phlogopite fractions picked out from altered lamproites in the Pervomaiskiy area yielded a more reliable result ( $278 \pm 10$  Ma). These determinations were performed at the Laboratory of Radiogeology, Institute of Geology and Geochemistry, Yekaterinburg, under the supervision of A.A. Krasnobaev.

Petrographic examination showed that the phlogopite phenocrysts studied in our work are resistant to aumetasomatic alteration. Therefore, we believe that the age interval of 310–300 Ma obtained in this work is more correct and related to a real geologic event, i.e., the formation of lamproite–lamprophyre series on the eastern slope of the Urals. In terms of geodynamics, this interval characterizes an amagmatic setting characterized by transition from the suprasubduction regime to collision magmatism [10].

According to the new data, the ultramafic lamprophyre in the Shartash pluton was formed 284 Ma ago. This estimate is close to the previously obtained K–Ar age of phlogopite. Thus, the traditional K–Ar method may be applied to lamproites and lamprophyres if unaltered primary minerals are used for analysis. The refined age of the Shartash lamprophyre corresponds to the timing of monzodiorite–granite ring intrusions of the Stepnoe Complex presumably related to extension zones [8, 10, 11].



**Fig. 2.** Spectra of  $^{39}\text{Ar}/^{40}\text{Ar}$  ages of phlogopite phenocrysts from (a–c) lamproite and (d) lamprophyre dikes in the Urals. (a) Skalistyi Settlement, Lower Sanarka Pluton; (b) Sheinskii limestone open pit, the Pervomaiskii area; (c) open pit of the Malyi Kuibas iron deposit; (d) Shartash pluton, open pit of the Berezovskii Building Works.

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