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GEOLOGY

Geochronology of Mesozoic Granitoids and Associated Molybdenum Mineralization in the Western Part of the Dzhugdzhur–Stanovoi Superterrane

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The Dzhugdzhur superterrane [1] located at the southeastern margin of the Siberian Craton is one of the key structures of the eastern margin of Asia. It is made up of the traditionally distinguished Early and Late Precambrian complexes and numerous Early–Late Mesozoic intrusive and volcanoplutonic associations [2 and others]. The functioning of magmatic and ore systems of different ages and types in various geodynamic settings in the course of complex and multistage evolution of tectonic structures produced no less intricate metallogenic specifics of the region.

Results of the $^{40}Ar/^{39}Ar$ dating of magmatic and hydrothermal–metasomatic minerals in the Vykhodnoi ore occurrence

Rock	Sample no.	Mineral	Step ages, Ma	Plateau		Isochron		
				Age, Ma	Extracted ^{39}Ar (%)	Age, Ma	MSWD	$(^{40}Ar/^{36}Ar)_0$
Granite porphyry	S-325-a	Metasomatic biotite	122.7 ± 1.2	123.6 ± 1.2	93.9	121.4 ± 1.2	4.42	357.7 ± 12
Granite porphyry	S-325-a	Magmatic biotite	124.6 ± 1.9	124.1 ± 1.9	98.5	124.1 ± 1.6	2.36	275.3 ± 35
Biotitized diorites of phase I at the outer contact of the granite porphyry	S-326-a	Metasomatic biotite	120.1 ± 2.0	122.6 ± 1.9	89.5	122.4 ± 3.5	0.59	303.8 ± 80
Granodiorite of phase II	E-1720-1	Magmatic biotite	126.8 ± 2.9	126.6 ± 1.2	96.2	–	–	–

Note: $^{40}Ar/^{39}Ar$ determinations were made by step heating. Samples were stacked in a Cd-shielded cylinder and irradiated using a VVR-K scientific reactor at the Research Institute of Nuclear Physics in Tomsk. The neutron flux gradient was no more than 0.5%. Step heating experiments were carried out in the quartz reactor with an external furnace. ^{40}Ar blank (10 min at 1200°C) was no more than $5 \cdot 10^{-10}$ ncm^3. Ar was purified using Ti- and ZrAl SAES getters. The Ar isotopic composition was analyzed on a 5400 Noble Gas Micromass mass spectrometer (England). Measurement errors correspond to an interval of ±1σ. Interfering Ar isotopes from Ca, Cl, and K were corrected using the following coefficients: $(^{39}Ar/^{37}Ar)_{Ca} = 0.00073 \pm 0.000026$, $(^{36}Ar/^{37}Ar)_{Ca} = 0.00032 \pm 0.000021$, $(^{40}Ar/^{39}Ar)_K = 0.0641 \pm 0.0001$. The average $^{40}Ar/^{36}Ar$ ratios during measurements were 296.5 ± 0.5. Age plateaus were distinguished using criteria proposed in [13, 14]. Dashes denote that the calculations are absent.

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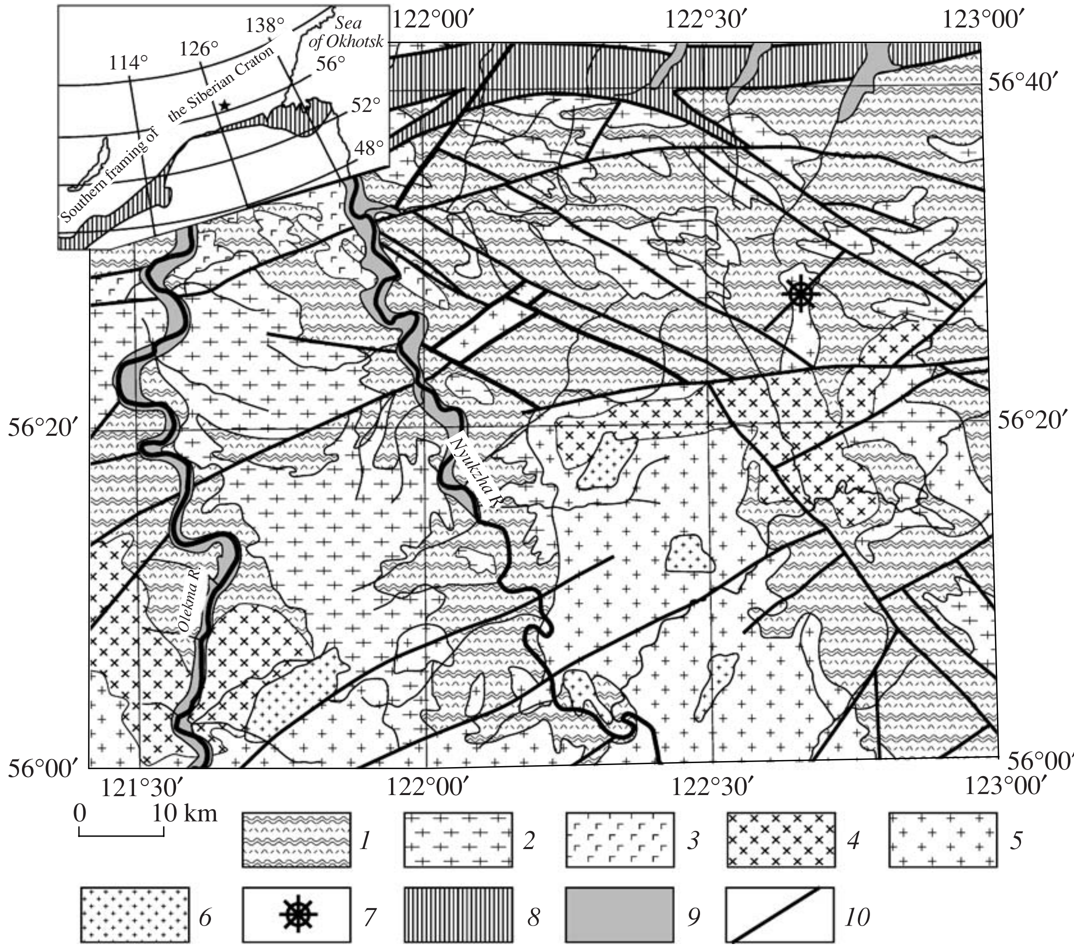

Fig. 1. Geological map of the western flank of the Selenga–Stanovoi terrane, the southern framing of the Siberian Craton (modified after [9]). (*1*) Supposedly Early Precambrian stratified metamorphic complexes of the Selenga–Stanovoi terrane; (*2*) supposedly Early Precambrian gneissic granites of the Subgan Complex; (*3*) supposedly Early Precambrian metagabbro; (*4–6*) Mesozoic intrusions of the Tynda–Bakaran (Uda–Zeya) Complex: (*4*) diorites, gabbrodiorites, and monzodiorites of phase I, (*5*) amphibole–biotite granites, granodiorites, and monzonites of phase II, (*6*) biotitic, aplitic, and porphyritic granites of phase III; (*7*) granite porphyry stock hosting the Vykhodnoi ore occurrence (beyond the scale); (*8*) diaphthoresis zone; (*9*) Cenozoic loose deposits; (*10*) faults. The asterisk in the inset shows the position of the Vykhodnoi granite porphyry stock. The shaded area is the Mongol–Okhotsk foldbelt.

The geology of this area, including the age position of magmatic and metamorphic complexes, was considered in detail in [3–6 and others]. However, insufficient study of the isotope geochronology of the majority of ore deposits in this region complicates correlation of tectonic, magmatic, and ore-forming processes. In particular, most ore objects are considered late Mesozoic [7, 8, and others]. This concept is mainly based on relations observed between mineralization and certain magmatic complexes. The exception is the Bam gold deposit with Rb–Sr and K–Ar ages of hydrothermal minerals estimated at 129 ± 3.6 and 114 Ma, respectively (see review in [8]).

The present work reports results of the $^{40}Ar/^{39}Ar$ study of the country and hydrothermally altered rocks that host the Vykhodnoi molybdenum occurrence.

This ore occurrence is located in the western part of the Dzhugdzhur–Stanovoi superterrane at the southern framing of the Siberian Craton (Fig. 1). It is confined to the eponymous ellipsoidal stock (800 × 600 m in size), which crosscuts the supposedly Precambrian metamorphic rocks and Mesozoic granitoids ascribed either to the Tynda–Bakaran [10, 11, and others] or Uda–Zeya [9] complexes. The granitoids form a huge (>3000 km^2) Chil'chin Massif in the Nyukzha and Olekma river basins (Fig. 1). This massif consists of three intrusive phases: (1) diorites, gabbrodiorites, and monzodiorites; (2) amphibole–biotite granites, granodiorites, and monzonites; and (3) biotitic, aplitic, and porphyritic granites [9]. Until recently, the age of this complex (in particular, the massif) was ambiguous. Available K–Ar geochronological data show a considerable scatter [11, 12]. Only granites of the main phase of the Chil'chin massif were recently dated by the U–Pb zircon method at 127 ± 1 Ma [4].

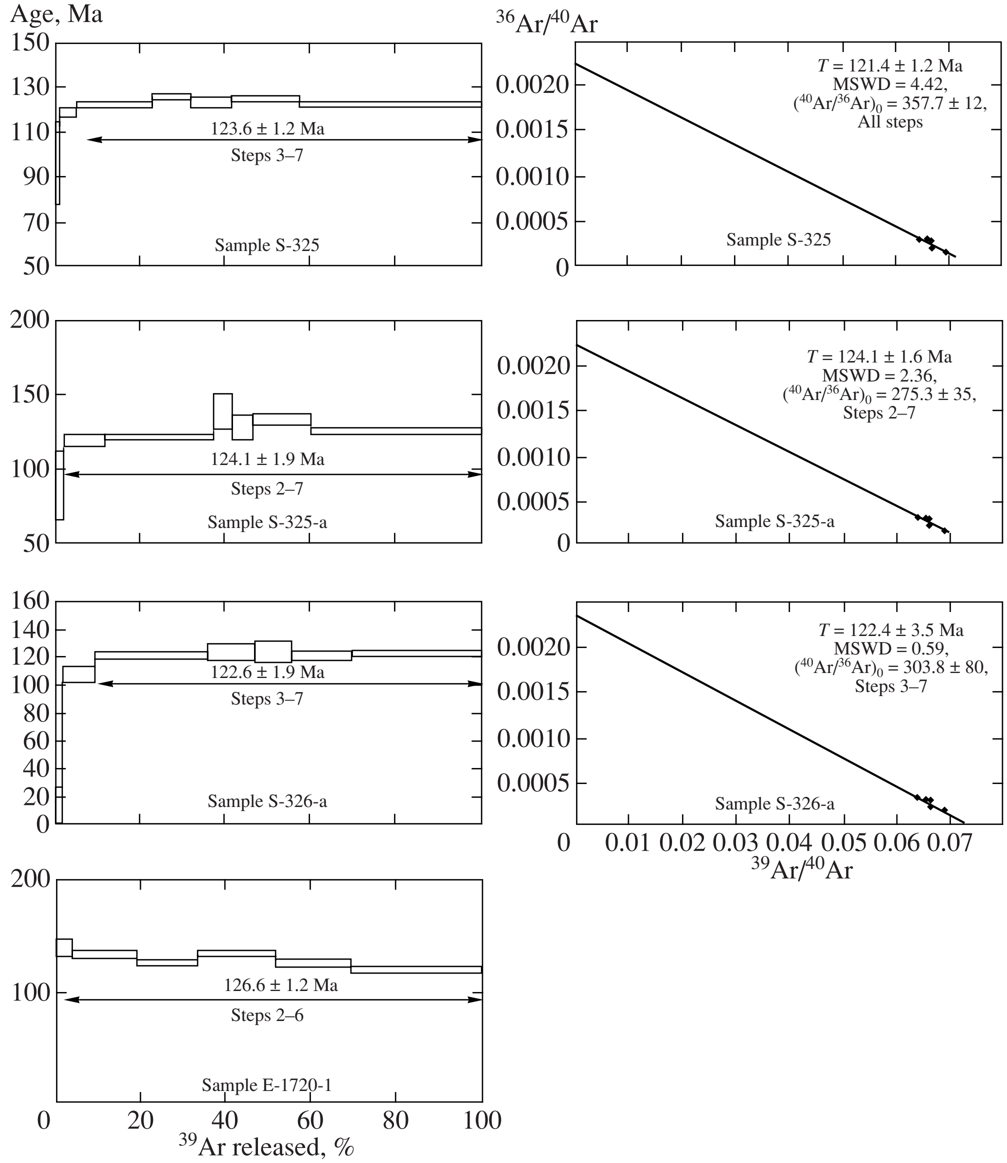

Fig. 2. Ar–Ar age spectra and isochron correlation for magmatic and hydrothermal–metasomatic minerals from the Vykhodnoi ore occurrence.

The Vykhodnoi granite porphyry stock is restricted to the NE-trending fault zone. Different levels of the stock were exposed due to its fragmentation into several blocks by later tectonic movements. The inner contact zone is composed of fine-grained rocks. The host granites and granodiorites in the outer contact zone are feldspathized and penetrated by numerous aplitic veins. Within the western part of the Dzhugdzhur–Stanovoi superterrane, similar complexes were ascribed to the independent Early–Late Cretaceous complex [9] or second activation stage [11].

Granite porphyries of the Vykhodnoi stock were pervasively replaced by feldspar and biotite, while host rocks remained almost unaltered. Later sericitization is widespread up to the point of the formation of quartz–sericite metasomatites (often, with pyrite). The degree of alteration increases toward the eastern flank of the ore occurrence. The main stockwork mineralization consists of a dense network of quartz–molybdenite stringers confined to the central and northern parts of the granite porphyry stock. The mineralization is most intense along the northeastern and sublatitudinal faults.

The ^{40}Ar/^{39}Ar dating was performed for rock samples from the Chil'chin Massif and Mo-bearing granite porphyries. It should be noted that all analyzed samples were subjected to different degrees of hydrothermal alteration. According to the existing concepts, the oldest rocks among the studied samples are the granodiorites of phase II (sample E-1720-1). The age spectrum of this sample (Fig. 2) shows that the age difference between the age plateaus is no more than 2σ. Therefore, despite the gentle decrease of step ages with increase in the heating temperature, the age was estimated at 126 ± 1.2 Ma based on the standard procedure [13]. This value practically coincides with the integral biotite age of 126.8 ± 2.9 Ma (table, Fig. 2), which is close to the U–Pb zircon age [4]. The step-heating age of metasomatic biotite from diorite I of the Chil'chin Massif (sample S-326-a) yields a definite plateau corresponding to 122.6 ± 1.9 Ma, which characterizes the age of superimposed metasomatism rather than that of magmatism (table, Fig. 2). Within the error limits, this age is quite consistent with the age of magmatic biotite from granite porphyry (sample S-325-a, 124.1 ± 1.9 Ma) and hydrothermal biotite from the Mo-bearing granite porphyry (sample S-325, 123.6 ± 1.2 Ma) (table, Fig. 2). It should be emphasized that similar ages were also obtained from isochron calculations.

Thus, we can draw the following conclusions:

(1) The age of granodiorite II of the Chil'chin Massif is about 126.8 ± 2.9 Ma. Within the limits of error, this value corresponds to the U–Pb zircon age obtained for granitoids [4].

(2) The ore-bearing granite porphyry stock has an age of 124.1 ± 1.9 Ma. Hence, granite porphyry bodies, previously considered an independent complex [9, 11], belong to the Tynda–Bakaran Complex.

(3) The age of hydrothermal mineralization (125–122 Ma) accompanying the ore mineralization indicates a relation between granite porphyries and molybdenum mineralization.

The results obtained are the first geochronological data on the molybdenum mineralization of the Dzhugdzhur superterrane. They indicate that the Vykhodnoi ore occurrence belongs to the youngest stage of the formation of the molybdenum and copper–molybdenum deposits in southern Siberia [15].

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