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GEOLOGY

Early Paleozoic Granitoids of the Aqtau–Dzungar Microcontinent (Central Kazakhstan)

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The Early Paleozoic is the most interesting and, probably, the least decipherable stage in the evolution of Paleozoides in Kazakhstan. Many Early Paleozoic lithostructural zones of this region are characterized by the wide development of diverse granitoid and other igneous rocks that formed in various geodynamic settings. However, Early Paleozoic magmatic complexes are still conditionally recognized (or attributed to older formations) for the Aqtau–Dzungar microcontinent located in the central part of the Paleozoides in Kazakhstan. Consequently, correlation of geological events in various lithostructural zones is hampered and interpretation of the Early Paleozoic evolution of the Aqtau–Dzungar microcontinent is ambiguous. Therefore, we attempted to solve this problem using U–Pb dating of zircon from granitoid massifs located in the best exposed northwestern part of the Aqtau–Dzungar microcontinent. The Early Paleozoic age of these massifs is assumed on the basis of geological data.

The Aqtau–Dzungar microcontinent is among the largest Precambrian sialic massifs in the Paleozoides of Kazakhstan (Fig. 1).

The Precambrian basement of this microcontinent is composed of Middle–Upper Riphean quartzite–schist and volcanic sequences intruded by large Late Riphean granite and gneiss–granite massifs [1, 5]. The unconformably overlying sequence includes Vendian–Upper Ordovician terrigenous–siliceous–carbonate rocks up to 1500 m thick [2, 3]. The microcontinent is surrounded by Lower Paleozoic and Silurian rocks with abundant fragments of siliceous and siliceous–basaltic rocks that make up large plates, outliers, and blocks in olistostromes [6]. The stratified Devonian–Carboniferous rocks of the study region are composed of thick continental and shallow-marine terrigenous, volcanic, and carbonate sequences.

The Aqtau–Dzungar microcontinent is characterized by an abundance of Precambrian and Paleozoic granitoid complexes. Within the framework of the existing correlation schemes, granitoids are subdivided into complexes based on geological and scanty geochronological data. The Precambrian granites were identified with consideration of the superimposed metamorphic transformations and the available U–Pb geochronological data [1]. The Middle–Late Paleozoic age of granites has been confirmed by K–Ar and Rb–Sr geochronological data, as well as by intrusive contacts with the stratified Devonian and Carboniferous rocks [5, 8]. The Early Paleozoic age was traditionally accepted only for quartz diorites, granodiorites, and granites of the Akzhal Complex, which intrude into the Precambrian rocks and, in turn, are unconformably overlain by Lower–Middle Devonian terrigenous sequences [4, 5, 7, 9]. In addition, Late Proterozoic (?) igneous rocks of the region accommodate unmetamorphosed quartz monzonites, syenites, and granosyenites of the Shumek Complex, which may also represent Early Paleozoic rocks. Thus, the available data are obviously insufficient to confirm the Early Paleozoic age of the Shumek and Akzhal granitoids.

The *Shumek Complex* includes quartz monzonites, syenites, and granosyenites of the eastern and northeastern parts of the Shumek massif. Its northwestern segment consists of Late Riphean granites of the Uzunzhal Complex (Fig. 1). The geochronological sample AM-023 (coordinates N 47°42.230′, E 73°19.651′) was taken from medium-grained massive hypidiomorphic-granular biotite–amphibole quartz monzonites with the following composition (%): plagioclase (30–35), K-feldspar (35–40), amphibole (15–20), quartz (~5), and

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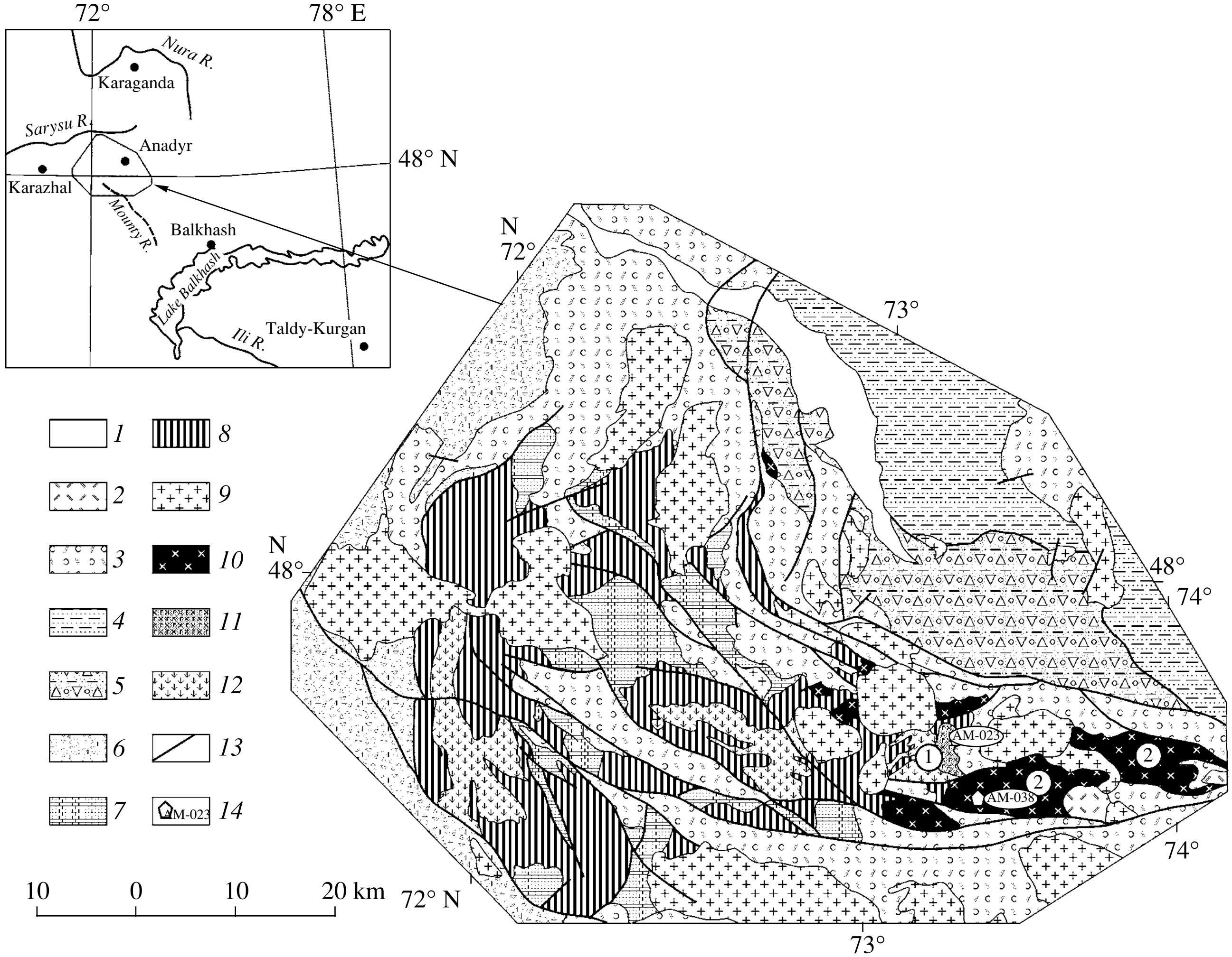

Fig. 1. Schematic geological setting of the northwestern Aqtau–Dzungar microcontinent (ADM). (*1*) Cenozoic sediments; (*2*) Carboniferous continental volcanic rocks; (*3*) Devonian–Carboniferous volcanic, terrigenous, and carbonate sequences; (*4*) Silurian flysch sequences; (*5, 6*) siliceous–basaltic and oligostromatic complexes of the ADM framing: (*5*) Lower Paleozoic, (*6*) Silurian; (*7, 8*) rock complexes of the ADM: (*7*) Vendian–Ordovician terrigenous–carbonate cover, (*8*) Riphean quartzite–schist and volcanic sequences; (*9–12*) granitoids: (*9*) Middle–Late Paleozoic, (*10*) Late Ordovician (Akzhal Complex), (*11*) Early Ordovician (Shumek Complex), (*12*) Late Riphean (Uzunzhal Complex); (*13*) faults; (*14*) sites sampled for the geochronological investigation. Massifs (numbers in circles): (1) Shumek, (2) Akzhal.

biotite (1–3). Accessory minerals are represented by the predominant apatite and the subordinate zircon, orthite, and ore mineral.

In sample AM-023, zircon occurs as rather large (>85 μm) yellow, subhedral and euhedral, translucent and transparent, short-prismatic and prismatic crystals. The internal structure of this mineral shows magmatic zonality partly distorted at the margin of crystals and a sectorial pattern in some places (Figs. 2a–2d).

The U–Pb geochronological investigation was carried out for three zircon samples of fraction –150 +100 μm (table, nos. 1–3). One sample (table, no. 2) was preliminarily subjected to air abrasion [11]. Figure 3 shows that the data point of the sample consisting of the 20 most transparent zircon grains (table, no. 3) lies on concordia with an age of 482 ± 2 Ma (MSWD = 0.2). Discordia calculated for the three zircon samples yield an upper intercept corresponding to 479 ± 5 Ma (MSWD = 1.5), while the lower intercept is close to zero. The morphological features of zircon grains from quartz monzonites of the Shumek massif are typical of magmatic origin. Hence, the concordant value (482 ± 2 Ma) obtained for the Shumek Complex can be accepted as its most precise dating corresponding to Early Ordovician.

The *Akzhal Complex*, which includes the large Akzhal and other smaller rock massifs (Fig. 1), consists of quartz diorites, granodiorites, and biotite–amphibole granites. The geochronological sample AM-038 (coordinates N 47°36.034′, E 73°25.543′) was taken from biotite–amphibole granodiorites in the southwestern sector of the Akzhal massif (Fig. 1). The hypidiomorphic (poikilitic in some places) massive rock has the follow-

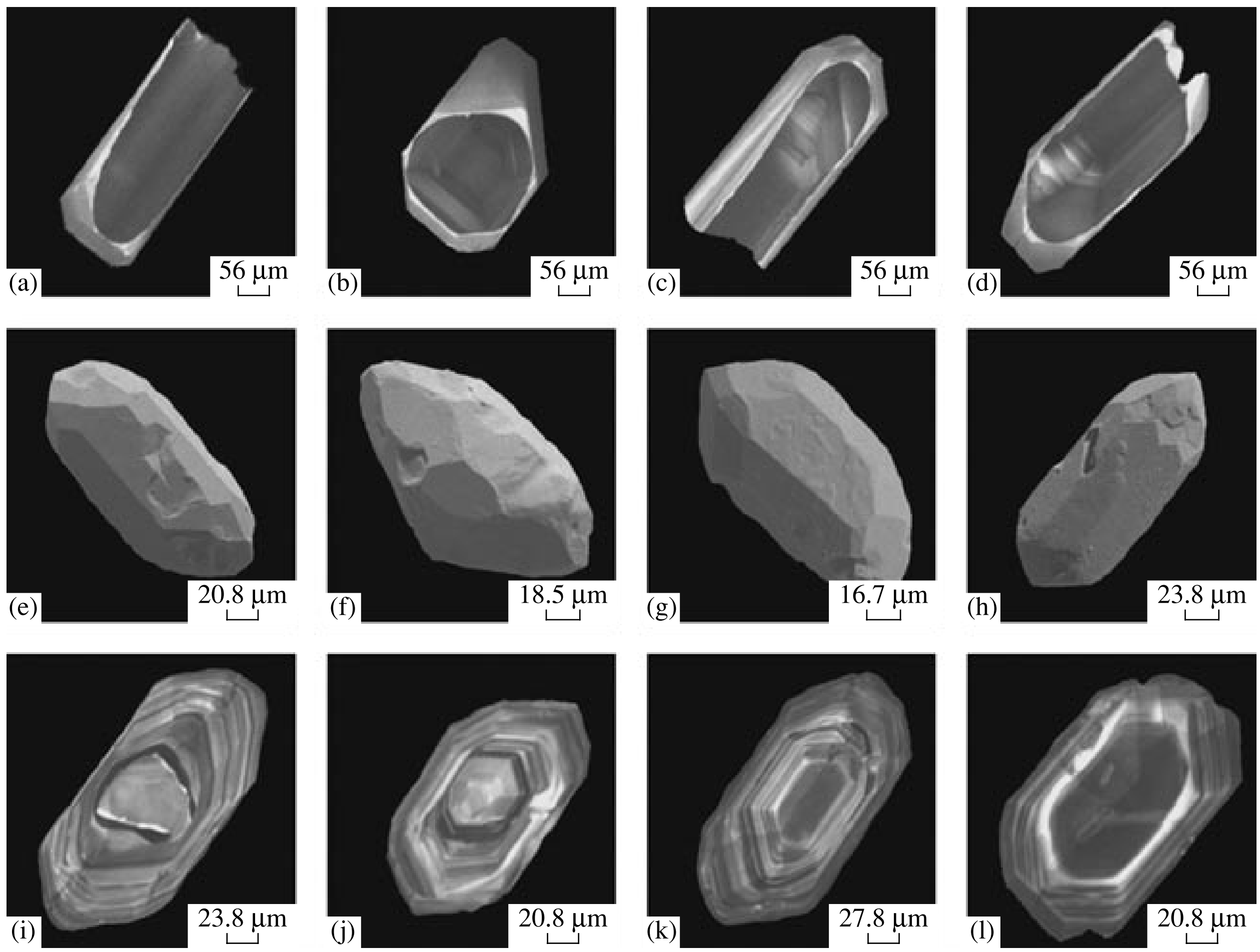

Fig. 2. Photomicrographs of zircon crystals. (e–h) ABT-55 SEM image (sample AM-038); ABT-55 SEM image taken with cathodoluminescence detector: (a–d) sample AM-023, (i–l) sample AM-038.

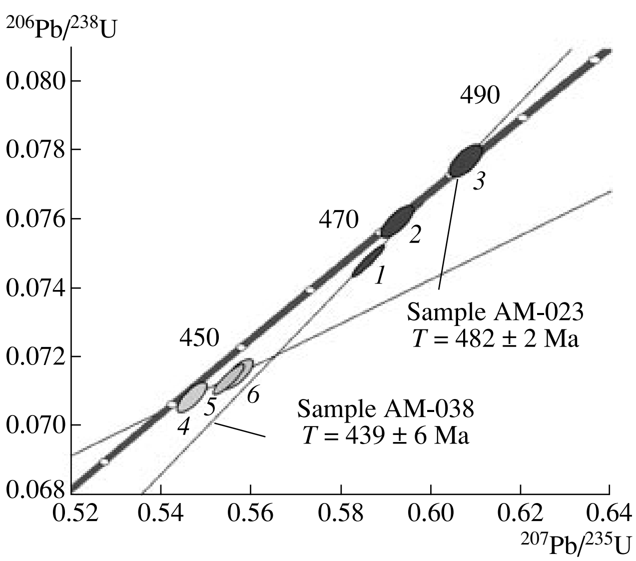

Fig. 3. Diagram with concordia for zircons from diorite–amphibole quartz monzonite of the Shumek massif (sample AM-023) and biotite–amphibole granodiorite of the Akzhal massif (sample AM-038). The number of points in the diagram corresponds to ordinal numbers in the table.

ing composition (%): plagioclase (60–70), amphibole and biotite (10–15), quartz (10–20), and K-feldspar (5–15). Accessory minerals are represented by the predominant large crystals of titanite and the subordinate apatite, zircon, orthite, and ore mineral.

In sample AM-038, the accessory zircon is represented by two morphological types ranging from 40 to 300 μm in size ($K_{el} = 2.0$). Zircon I occurs as pink euhedral, transparent and translucent, short-prismatic and prismatic crystals (Figs. 2e–2g). Their habitus is defined by the combination of prisms {100} and {110} with dipyramids {101}. Zircon I shows a zonal internal structure (Figs. 2i–2l). Some translucent crystals include nearly metamictic cores or their relicts (Fig. 2i).

Zircon II occurs as white subhedral translucent short-prismatic zonal crystals (Fig. 2g). Its zonal internal structure is characterized by the development of cores (up to 50 vol %) without distinct boundaries and a fine-grained shell with low birefringence.

The U–Pb geochronological investigation was carried out for three samples of very pure zircon I and II crystals extracted from the fraction >100 μm (table, Results of U–Pb zircon dating of zircons from granitoids of the Shumek and Akzhal complexes of the Aqtau–Dzungar microcontinent

Ord. no.	Fraction (μm) and its characteristic	Weight, mg	Content, μg/g		Isotopic ratio		
			Pb	U	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb^{(a)}$	$^{208}Pb/^{206}Pb^{(a)}$
Diorite–amphibole quartz monzonite of the Shumek massif (sample AM-023)							
1	–150+100	2.03	12.9	153	1849	0.0568 ± 1	0.2190 ± 1
2	–150+100, A 20%	1.10	9.95	118	3187	0.0566 ± 1	0.2267 ± 1
3	–150+100, 20 g	0.15	10.3	121	1042	0.0567 ± 2	0.2061 ± 1
Biotite–amphibole granodiorite of the Akzhal massif (sample AM-038)							
4	>100, I	0.30	19.7	273	3586	0.0560 ± 1	0.1214 ± 1
5	>100, I	0.35	24.4	311	5240	0.0564 ± 1	0.2151 ± 1
6	>100, II	0.09	30.9	403	940	0.0565 ± 1	0.1416 ± 1

Ord. no.	Fraction (μm) and its characteristic	Isotopic ratio		*Rho*	Age, Ma		
		$^{207}Pb/^{235}U$	$^{206}Pb/^{238}U$		$^{207}Pb/^{235}U$	$^{206}Pb/^{238}U$	$^{207}Pb/^{206}Pb$
Diorite–amphibole quartz monzonite of the Shumek massif (sample AM-023)							
1	–150+100	0.5859 ± 12	0.0748 ± 1	0.94	468 ± 1	465 ± 1	484 ± 2
2	–150+100, A 20%	0.5924 ± 12	0.0759 ± 1	0.75	472 ± 1	471 ± 1	477 ± 3
3	–150+100, 20 g	0.6076 ± 29	0.0777 ± 2	0.65	482 ± 2	482 ± 2	480 ± 8
Biotite–amphibole granodiorite of the Akzhal massif (sample AM-038)							
4	>100, I	0.5468 ± 11	0.0709 ± 1	0.77	443 ± 1	441 ± 1	451 ± 2
5	>100, I	0.5550 ± 17	0.0714 ± 2	0.89	448 ± 1	444 ± 1	468 ± 3
6	>100, II	0.5570 ± 21	0.0715 ± 2	0.75	450 ± 2	445 ± 1	471 ± 5

Note: (a) Isotopic ratios corrected for procedure blank and common lead; (A 20%) quantity of substance removed by the air abrasion of zircon; (20 g) number of analyzed zircon grains; (I, II) morphological type of zircon grains.
Error values correspond to the last significant digit. Accessory zircon was extracted in line with the standard technique using heavy liquids. Decomposition of zircons and chemical extraction of Pb and U were carried out using the modified Krogh's method [10]. The procedure blank during the investigation did not exceed 50 pg for Pb. Isotopic compositions of Pb and U were determined with a Finnigan MAT-261 mass spectrometer in the static regime or using the electron multiplier (coefficient discrimination for Pb was 0.32 ± 0.11 amu). Experimental data were processed using programs PbDAT and ISOPLOT [12, 13]. Standard values of uranium decay constant [15] were used for age calculations. Corrections for common lead were introduced in correspondence with model values [14]. All errors are quoted at the 2σ level.

nos. 4–6). In the concordia diagram (Fig. 3), their data points are approximated by the regression line near the lower intercept corresponding to 439 ± 6 Ma, whereas the upper intercept yields 1593 ± 960 Ma (MSWD = 0.03). The minor discordance of zircon is probably related to the absence of an inherited component of radiogenic lead. Taking into consideration the magmatic origin of zircon, we can accept the value of 439 ± 6 Ma as an estimate of its crystallization age. Thus, the data obtained unambiguously indicate the Late Ordovician age of the Akzhal Complex.

The results of the geochronological investigation of Early Paleozoic granitoid complexes of the Aqtau–Dzungar microcontinent make it possible to identify the Early Ordovician Shumek Complex of syenites, granosyenites, and monzodiorites. The development of the Shumek Complex could be simulated by rifting processes and the simultaneous formation of the terrigenous–siliceous–carbonate cover. We have proved the Late Ordovician age of the Akzhal Complex of quartz diorites, granodiorites, and granites. Therefore, this complex can be confidently correlated with its synchronous counterparts (Zerenda and Krykkuduk complexes) located in the western Kokchetav–North Tien Shan zone, for which the genetic link with suprasubduction environments has been proved reliably.

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