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GEOLOGY

First Results of Dating Detrital Zircons from the Late Precambrian Quartzite–Schist Sequences of the Chu Block (Southern Kazakhstan)

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Abstract—U–Pb geochronological studies of detrital zircons from quartzite–schist sequences of the Akbastau Formation of the Chu Block (northwestern part of the Chu–Kendyktas terrane, Southern Kazakhstan) have been provided. The concordant ages of detrital zircons are predominantly within the intervals of 1672–2115 Ma with peaks at 1697, 1780, 1857, and 2066 Ma. Individual zircon grains display ages of 2291–2332 Ma with peaks at 2303 and 2322 Ma. Neoarchean ages of 2608–2747 Ma with a peak at 2681 Ma characterize another significant zircon population. The lower limit of deposition for the Akbastau Formation of the Chu Block, corresponding to the youngest statistically significant zircon population, is estimated at 1.7 Ga.

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A characteristic feature of the western part of the Central Asian Fold Belt is widespread ancient sedimentary strata. They are mainly represented by quartzite and quartzite–schist sequences, confined to the upper horizons of the pre-Ediacarian basement of the sialic massifs of Kazakhstan and the Northern Tien Shan and are conventionally considered as a subplatform cover of a large continental block [2]. In the absence of the reliable data on the time of accumulation of these sequences, the age of their lower boundary was assumed similar to the age of the underlying volcanogenic–sedimentary and plutonic rocks, which varies in age from Paleo- to Neoproterozoic, depending on the particular massif [2].

In recent years, isotope geochronological U–Pb studies of detrital zircons from quartzite–schist sequences of the Kokchetav, Ishkeolmes, Erementau–Niyaz (Northern Kazakhstan), and Aktau–Mointy (Central Kazakhstan) massifs have been carried out. These studies have shown that the accumulation of the quartzite–schist sequences occurred due to the supply of clastic material from the same provenance areas composed of Precambrian rocks of a wide age range. The youngest zircon population is represented by detrital varieties of magmatic origin with an estimated age from 1 to 1.2 Ga [1, 8]. The Late Mesoproterozoic (~1130–1200 Ma) age of magmatic complexes underlying the quartzite–schist sequences within the sialic massifs of Northern Kazakhstan and Northern Tien Shan was also established [5]. The data obtained indicate that accumulation of the quartzite–schist sequences started in the Early Neoproterozoic, preceded by the stage of Late Mesoproterozoic magmatism, which completed the formation of the basement complexes of sialic massifs in these regions.

The ancient sedimentary sequences are also widespread in Southern Kazakhstan, where they occur within the Chu Block, located in the northwestern part of the Chu-Kendyktass Massif (Fig. 1). Here, large areas are occupied by intensely dislocated sequences composed of quartzites, quartzite–schists, and schists with interbeds of marbled limestones, which belong to the Borbass and Akbastau formations [3]. The structural and compositional features made it possible to consider them as analogues of quartzite–schist sialic massifs of Central and Northern Kazakhstan and to attribute them to the Proterozoic [2, 3]. Age estimates obtained for these formations were also supported by single isotope geochronological dates obtained for bulk zircon samples and by rare finds of microphytoliths [3]. A lower position within the section of the Chu Block basement was assumed to be taken by gneiss–amphibolites of the Aydaly series, which were considered as fragments of the Early Precambrian basement, whereon quartzite–schist strata were accumulated [2, 3]. Recently, however, the Neo-

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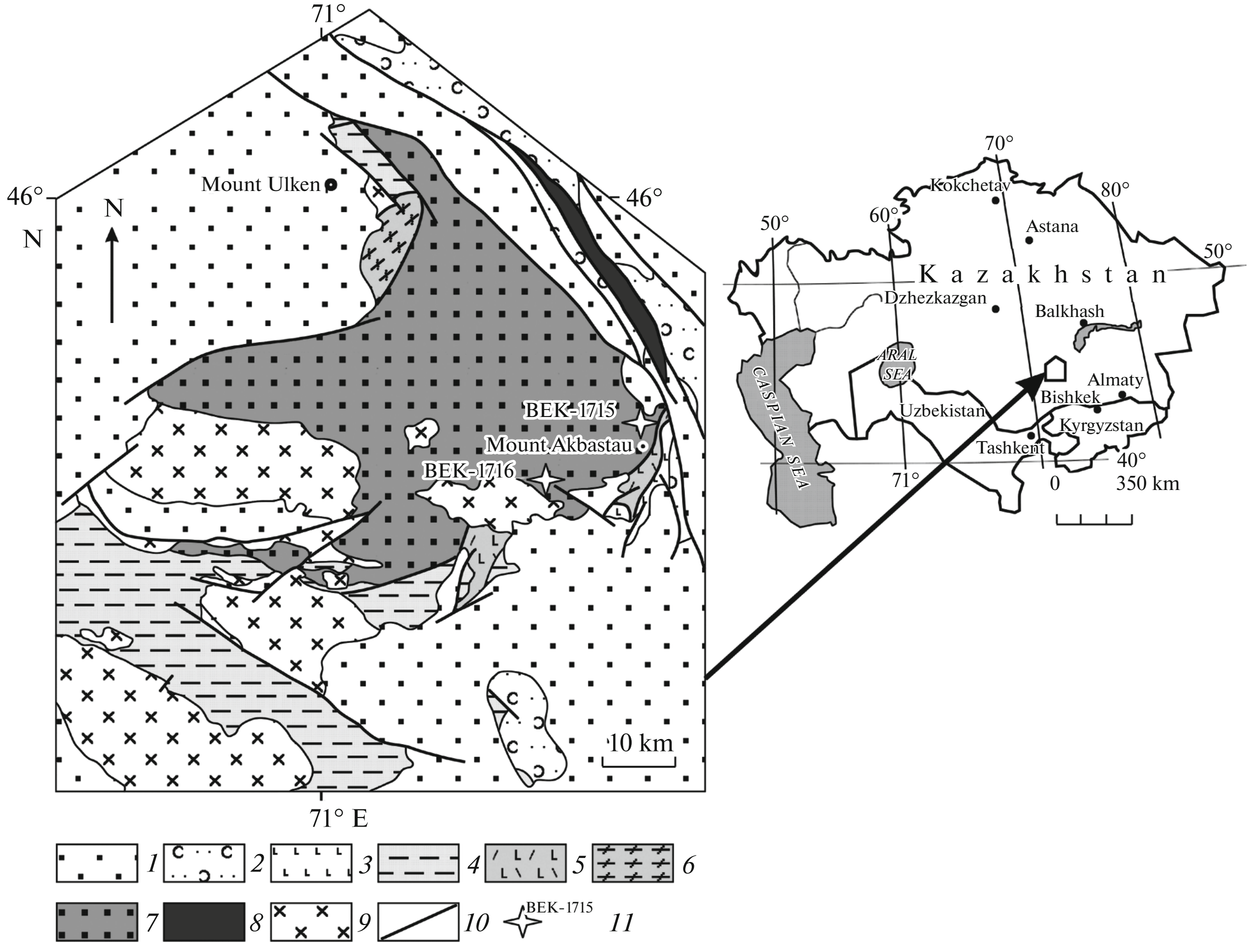

Fig. 1. Geological map of the Chu Block (northwestern part of the Chu–Kendyktass Massif). *1*, Devonian and Carboniferous volcanogenic–sedimentary rocks; *2*, Middle and Upper Ordovician sandstones, siltstones, tuffs of medium composition; *3*, Upper Cambrian basalts, jaspers, dolomites (Aschisu Formations); *4–7*, complexes of the Chu–Kendyktass Massif: *4*, Cambrian black schists, sandstones, siliceous rocks, basalts (Kiintas, Ogiztau, Zhoansk Formations); *5*, Neoproterozoic basalts, rhyolites, and tuffs (Yualy and Kshikrin Formations), granites, granulites, amphibolites (Aydaly Complex), *7*, Meso-Neoproterozoic quartzites, schists, marbles (Borbass and Akbastau Formations); *8*, serpentinite and serpentinite melange; *9*, Early Paleozoic granitoids; *10*, faults; *11*, sites of collecting Akbastau quartzite samples and their numbers.

proterozoic (~800 Ma) age of these metamorphic formations and their higher structural position relative to the sedimentary sequences have been discovered [3]. These data significantly change the interpretation of the subdivision of the Precambrian formations of the Chu–Kendyktass massif and make determining the lower age constraint and sources of quartzite–schist sequences highly relevant.

To solve this problem, we carried out U–Th–Pb LA–ICP–MS analyses of two samples of detrital zircons from quartzites of the Akbastau Formation of the Chu Block, which were collected on Mount Akbastau (45° 43′ 30.39″ N; 71° 34′ 54.34″ E), sample BEK-1715, and 8 km southwest of Mount Akbastau (45° 41′ 43.6″ N; 71° 29′ 5.0″ E), sample BEK-1716 (Fig. 1).

Zircons separated at the Geological Institute, Russian Academy of Sciences (Moscow), were mounted on epoxy resin and then studied in transmitted light in the modes of reflected electrons and cathodoluminescence using a Vega 3 scanning electron microscope at the Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences (St. Petersburg), which made it possible to reveal the inner structure of grains and select suitable spots for further studies. The U–Pb zircon dating by the LA–ICP–MS method was carried out at the Institute of Earth Sciences, Sinica Academy, Taipei, Taiwan, using an Agilent 7900 ICP mass-spectrometer, supplied with the Photon Machines Analyte G2 193 nm ArF excimer laser ablation system, according to the procedure in [4]. The analyses were carried out for the spots with a diameter of 35 μm for 60 s after 60 s of background measurements. Calibration was performed using the GJ-1 zircon standard, for which an accurate $^{207}Pb/^{206}Pb$ age estimate of 608.5 ± 0.4 Ma (2σ) was obtained using the method of isotope dilution–ther-

Table 1. Brief description of the samples used for geochronological LA–ICP–MS U–Th–Pb studies

No.	Sample ID	Number of zircon grains analyzed	Number of concordant age estimates	Ranges of concordant age estimates, Ma	Age maxima, Ma
1	BEK-1715	95	42	1743–1901; 2608–2747	1773, 1860, 2687
2	BEK-1716	92	64	1773–1935; 1937–2115; 2291–2332; 2630–2713	1854, 2066, 2303, 2322, 2670

mal ionization mass spectrometry (ID-TIMS) and one of 608.5 ± 1.5 Ma (2σ) was yielded by the upper discordia–concordia intersection [7]. Zircons 91 500 and PLS were used as secondary standards. $^{207}Pb/^{235}U$, $^{206}Pb/^{238}U$, $^{207}Pb/^{206}Pb$ ratios measured for the 91 500 standard resulted in the ages of 1066.0 ± 6, 1065.1 ± 7, 1068.5 ± 8 Ma, respectively. The weighted average age obtained for the PLS standard by $^{206}Pb/^{238}U$ was 337 ± 3 Ma (2σ, SD = 0.03, probability = 1.0). The data obtained were processed using the GLITTER software [11]; the concordant age was calculated for each grain using the Isoplot software package v. 4.15 [10]. Only values with a concordance exceeding 95% were used to construct histograms and curves of the age relative probability and calculate the age maxima.

We obtained 106 concordant age estimates (Table 1) out of 187 U–Th–Pb analyses of zircon grains. Processing the data with OVERLAP-SIMILARITY software indicated that the age distributions obtained for detrital zircons in the BEK-1715 and BEK-1716 samples are statistically indistinguishable (degrees of overlap and similarity are, 0.600 and 0.660, respectively). Such similarity and overlap may indicate similar sedimentation conditions and the same or similar sources of clastic material.

Concordant age estimates obtained for detrital zircons from the BEK-1715 and BEK-1716 samples are mainly within the range from 1672 to 2115 Ma, with maximums of 1697 (3 grains), 1780 (8 grains), 1857 (32 grains), and 2066 (14 grains) Ma. Some grains have age estimates in the range from 2291 to 2332 Ma, with weak maximums at 2303 (4 grains) and 2322 (4 grains) Ma. Another significant zircon population (16 grains) forms the Neoarchean interval of values from 2608 to 2747 with a maximum of 2681 Ma (Fig. 2).

The data obtained suggest that the accumulation of the quartzite–schist sequences of the Chu Block occurred due to erosion of complexes of the Paleoproterozoic and Neoarchean ages. Zircons with ages of ~1800 and ~2200–2300 Ma may have originated from igneous rocks, similar to those involved in the structure of the Middle Tien Shan [9] and Zheltava massifs (Southern Kazakhstan) [5]. Neoarchean complexes are not exposed on the modern erosion section in the western part of the Central Asian fold zone, so it can be assumed that they were either completely eroded or overlain by younger strata and form the buried foundation of the Chu–Kendyktass and other massifs of Southern Kazakhstan and Middle Tien Shan.

The lower age limit of the Akbastau Formation (Chu Block), corresponding to the youngest statistically significant zircon population, is estimated at 1.7 Ga. The data obtained indicate that within the Chu–Kendyktass Massif, quartzite–schist sequences are more ancient formations than the gneiss–amphibolite complex of the Aydaly series.

Thus, detrital zircon dates of the quartzite–schist sequences of the Chu–Kendyktas Massif suggest that their formation occurred on the continental basement

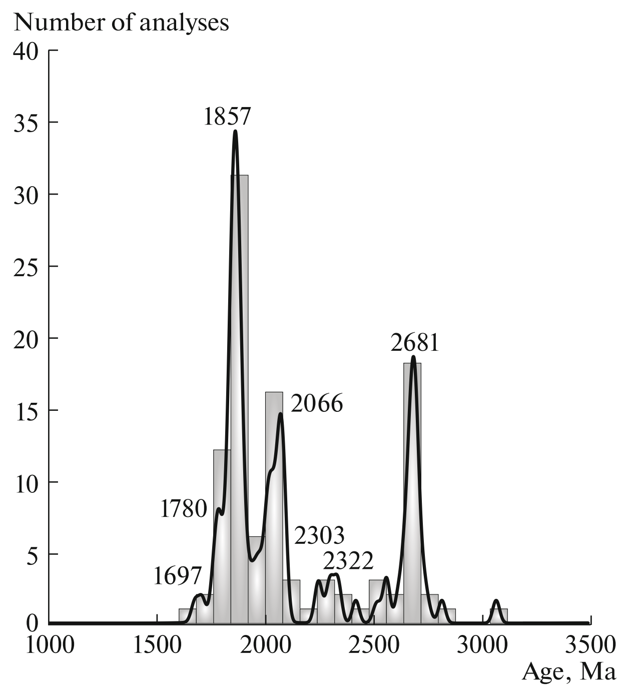

Fig. 2. Probability curve and age distribution histogram obtained for clastic zircons from quartzites of the Akbastau Formation of the Chu Block. Both are constructed using the Age Pick software [6].

of pre-Mesoproterozoic age. The accumulation of quartzite–schist sequences of the sialic massifs of Northern and Central Kazakhstan, on the other hand, occurred on the basement, composed mainly of Mesoproterozoic complexes, which were also the main sources of clastic material.

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