

U–Pb (SHRIMP) Zircon Age of Granitoid Pebbles from the Kukkarauk Conglomerates of the Vendian Asha Group (Alatau Anticlinorium, Southern Urals)

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Abstract—The lack of reliable geochronological data for the Vendian deposits of the Urals and other regions is one reason why there is still uncertainty in the age estimates of the Vendian lower boundary. According to the resolution of the Interdepartmental Stratigraphic Committee, it is distinguished at the level of 600 ± 10 Ma. Based on zircons from granitoid pebbles from deposits of the Kukkarauk Formation in the Vendian reference sections of the Alatau anticlinorium, the concordant U–Pb SHRIMP age of 713.6 ± 6.1 Ma was obtained. In fact, this is the only reliable age at present that can be used as a reference for rocks of the provenance area of the Vendian water basin in the Southern Urals. Moreover, this is evidence that this provenance area in the Vendian included granitoids, similar to granites of the Mazara and Barangulovo massifs, located in the northern part of the Uraltau Zone of the Southern Urals, to the east of the area of the Vendian sedimentation.

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The Vendian Asha Group in the reference sections of the Alatau anticlinorium (Southern Urals) is subdivided into the Bakeevo, Uryuk, Basa, Kukkarauk, and

Zigan formations (Fig. 1). The lower part of this Group (Bakeevo and Uryuk formations) is composed of sandstones, gravelites, and arkosic (quartz, at

Table 1. The U–Pb age of zircons from granite pebbles of polymictic conglomerates of the Kukkarauk Formation of the Asha Group (Vendian) (sample K 2270)

Analy- sis/ crater	²⁰⁶ Pb _c , %	Content, ppm			²³² Th/ ²³⁸ U	Age, Ma (1)	Isotope ratios (1)						Rho
		U	Th	²⁰⁶ Pb*			²⁰⁶ Pb/ ²³⁸ U	²⁰⁷ Pb*/ ²⁰⁶ Pb*, ± %	²⁰⁷ Pb*/ ²³⁵ U, ± %	²⁰⁶ Pb*/ ²³⁸ U, ± %			
1.1	0.50	114	63	11.9	0.57	736 ± 13	0.0598	3.9	0.996	4.3	0.1209	1.9	0.437
1.2	0.14	518	247	51.7	0.49	707 ± 10	0.06179	1.5	0.988	2.1	0.116	1.6	0.731
2.1	0.30	197	123	19.8	0.65	713 ± 11	0.061	2.7	0.984	3.2	0.1169	1.7	0.525
2.2	0.17	342	189	35.2	0.57	727 ± 11	0.0612	1.9	1.008	2.5	0.1194	1.6	0.644
3.1	0.16	131	89	12.9	0.70	696 ± 12	0.061	2.7	0.959	3.2	0.1141	1.8	0.543
4.1	0.18	204	161	20.5	0.82	712 ± 12	0.0616	3	0.992	3.4	0.1169	1.7	0.504
4.2	0.14	310	204	31.5	0.68	720 ± 11	0.0617	1.8	1.005	2.4	0.1181	1.6	0.670
5.1	0.24	124	90	12.2	0.75	695 ± 12	0.0622	2.9	0.975	3.4	0.1138	1.8	0.515
5.2	0.33	107	57	11	0.55	722 ± 12	0.0606	3.3	0.99	3.8	0.1185	1.8	0.485
6.1	0.31	79	46	7.89	0.60	709 ± 13	0.0614	3.9	0.984	4.4	0.1162	1.9	0.440
6.2	0.06	546	310	54.5	0.59	708 ± 10	0.06305	1.2	1.009	2	0.116	1.5	0.786
7.1	0.09	717	471	71.9	0.68	711 ± 10	0.062	1.1	0.996	1.9	0.1166	1.5	0.812
8.1	0.09	378	234	37.8	0.64	709 ± 11	0.06196	1.5	0.994	2.2	0.1163	1.6	0.723

Pb_c and Pb* are common and radiogenic lead. (1) ²⁰⁴Pb-corrected. Rho is the correlation coefficient. The error of calibration of standards is 0.60%.

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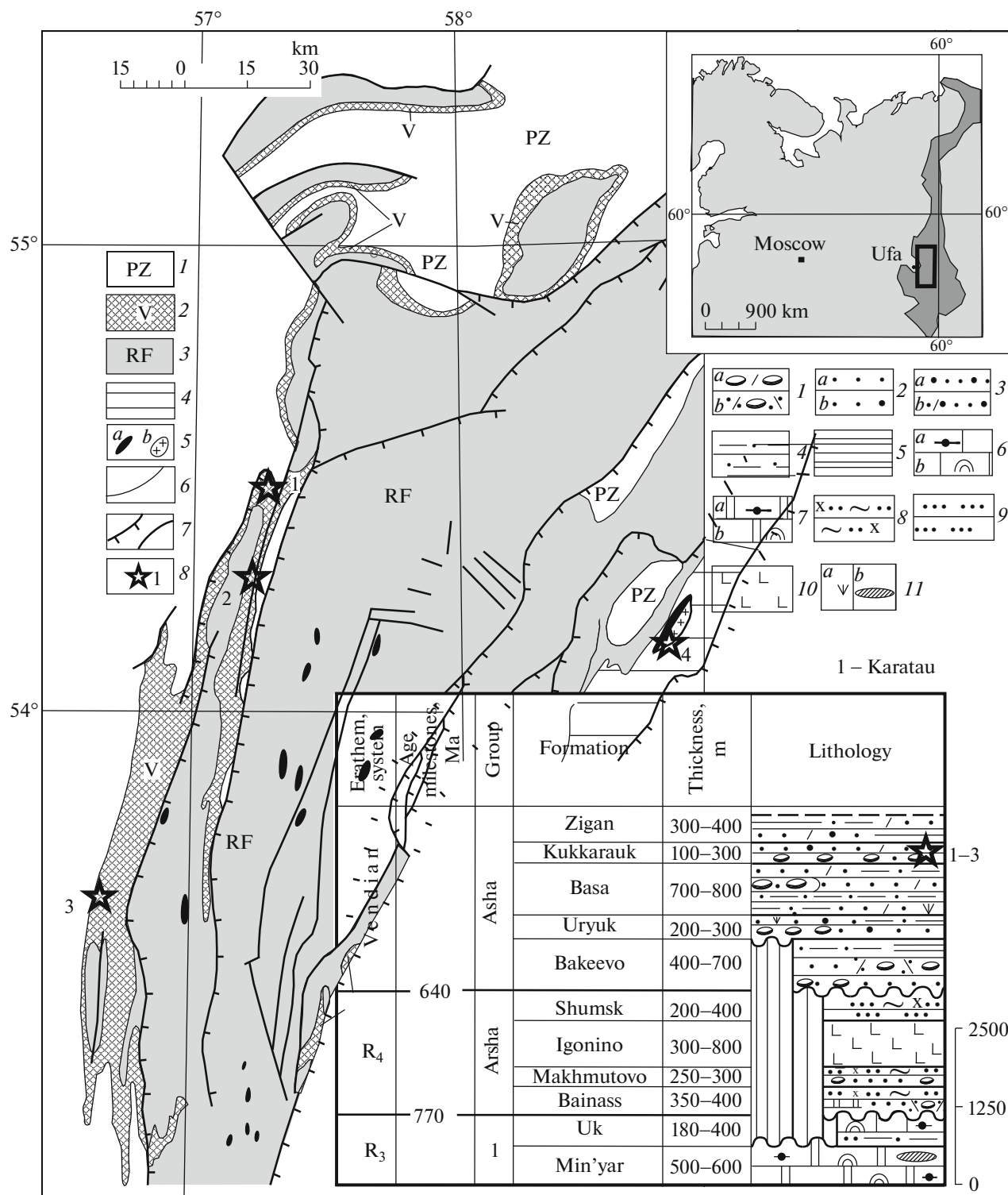


Fig. 1. Schematic geological map of the Bashkir Meganticlinorium (Southern Urals) and the generalized lithological–stratigraphic section of the Vendian Asha Group after [Geologicheskaya..., 2002] with amendments. Explanatory note to the geological map. 1–3, Unstratified deposits: 1, Paleozoic (PZ), 2, Vendian (V), 3, Riphean (RF); 4, metamorphic formations of the Uraltau anticlinorium; 5, igneous rocks: (a) gabbro–dolerites, (b) granites; 6, geological boundaries; 7, main fault zones; 8, sections and their numbers (1–3, Kukkarauk Formation of the Alatau anticlinorium: 1, along Agardy Creek, a right tributary of the Inzer River, 2 km north of the village of Gabdyuk; 2, along the Ufa–Inzer road, 5 km west of the Zuyachka River; 3, along Kukkarauk Creek); 4, granites of the Mazarinskii massif and Barangulovo gabbro–granite complex. Explanatory note to the lithological–stratigraphic section. 1, conglomerates (a), tillites (b); 2–3, sandstones: 2, quartz (a) and feldspar–quartz (b), 3, (a) arkose and (b) polymictic; 4, siltstones; 5, argillites; 6, limestones with (a) microphytolites and (b) stromatolites; 7, dolomites with (a) microphytolites and (b) stromatolites; 8, sericite–chlorite–quartz schists; 9, quartzites; 10, metabasalts; 11, description of rock: (a) glauconite, (b) cherts.

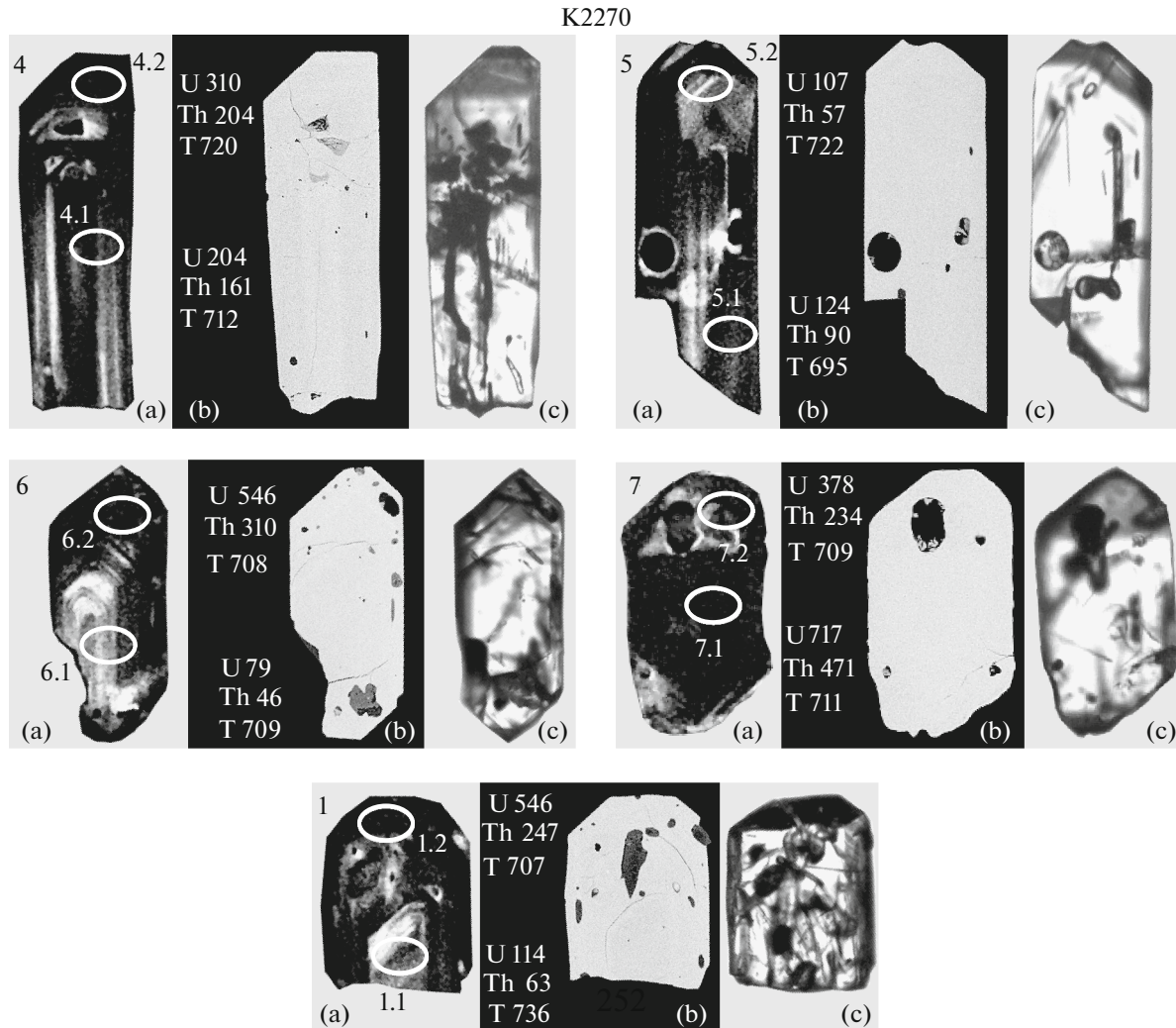


Fig. 2. Mineralogical and geochemical and geochronological features of zircons (sample K2270) from granitoid pebbles of the Kukkarauk conglomerates of the Asha Group (Vendian). Figures are the numbers of crystals, U and Th contents (ppm), T, age, Ma ($^{206}\text{Pb}/^{238}\text{U}$) (Table 1); (a, b, c) CL, BSE, and optical (transmitted light) images.

places) conglomerates; the upper part, including deposits of the Basa, Kukkarauk, and Zigan formations, has a polymictic composition and contains rock fragments varying in size, which is typical of the molasse formations. The Vendian deposits of the Asha Group rest erosively on different Upper Riphean horizons and are overlain by sandstones of the Takata Formation of the Emsian Stage (Lower Devonian). The lack of the reliable geochronological data on the Vendian deposits is a reason why the age of the Vendian lower boundary is still not officially determined. In the General Stratigraphic Scale of the Precambrian of Russia, according to the ISC resolution [1], it is at the age level of 600 ± 10 Ma. However, the Al–glauconite–based Rb–Sr age obtained recently for deposits of the Bakeevo Formation (the lower boundary of the Asha Group) is 638 ± 13 Ma [2, 3]. This age is in accordance with dates obtained for the Vendian lower

horizons in other regions and, according to M. Semikhatov [4], enables one to estimate the lower boundary of the Vendian (640 ± 5 Ma). However, there is no official resolution on this issue. Moreover, we cannot answer with confidence the questions about the location of the main provenance area and the age of eroded rocks in the Asha time. The results of the age dating of detrital zircons used for this purpose [5] do not solve these problems due to the wide range of ages varying for different reasons. We assume that the most reliable dates of rocks of the provenance area can be obtained by the age dating of zircons from pebbles of igneous rocks from conglomerates that are referenced to particular intervals. For this purpose, granitoid pebbles were sampled from conglomerates of the Kukkarauk Formation of the Asha Group (Vendian) in the periclinal closure of the Alatau anticlinorium, from the section exposed on the right side of the Agardy stream,

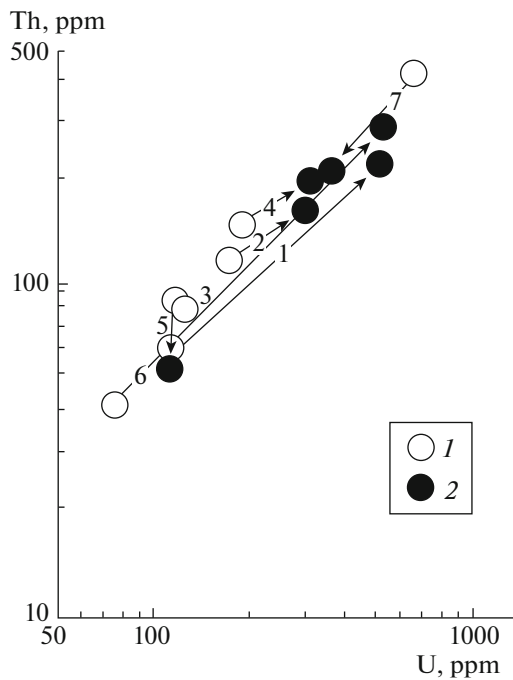


Fig. 3. The direct U–Th correlation ratio in granitoid pebbles from the Kukkarauk conglomerates. (1) Early zircon generation and (2) late zircon generation, connected by arrows.

a right tributary of the Inzer River (Sample K2270; 54°27.949' N and 057°18.298' E; Fig. 1, point 1). The thickness of the Kukkarauk Formation is estimated as 70 m at a maximum thickness of about 350 m in the stratotype section (Fig. 1, point 3) along Kukkarauk Creek [6].

The pebbles collected for geochronological studies are represented by plagiogranite and granite porphyry; the measurement points of these rocks on the TAS petrochemical diagram lie in the field of moderately alkaline granites and leucogranites.

The zircons extracted from granitoid pebbles of conglomerates (Sample K2270, Fig. 2) are characterized by a high degree of idiomorphism, predominantly prismatic habitus (elongation coefficient of 5–5.5), transparency, and colorlessness. There are abundant different inclusions varying from acicular minerals (apatite?) to complex aggregates of small rock fragments of various composition. In addition, there are heterogeneous, fluid–solid phase inclusions, sometimes rounded and large in size. The distinct zoning is represented by alternation of light and dark (CL image) wide bands, each of which combines a few thinner bands. Based on the set of all features, zircons are ascribed to the magmatic type. Crystals were deformed, which resulted in the development of differently oriented factors, often filled with the fluid phase.

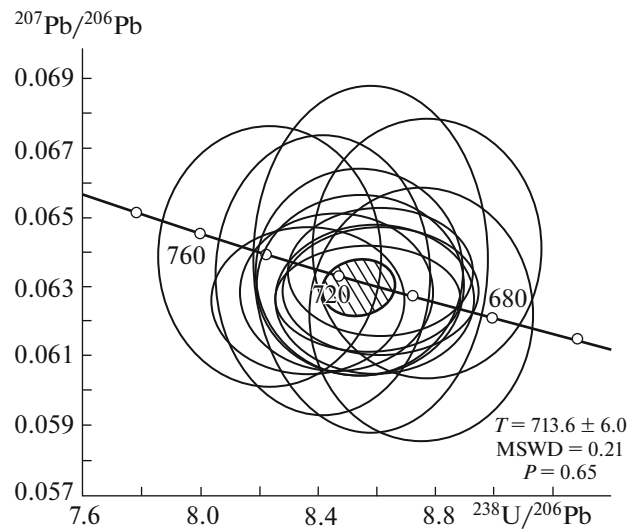


Fig. 4. U–Pb age of zircons (sample K2270) from granitoid pebbles of the Kukkarauk conglomerates of the Asha Group (Vendian).

The U and Th variations in zircons accentuate the unified geochemical community of crystals (Fig. 3, Table 1), the differences between them are only due to their belonging to different crystallization stages of the initial melt.

The mineralogical and geochemical similarity of zircon crystals are confirmed by their similar ages. All grains form a compact cluster with a concordant age of $T = 713.6 \pm 6.1$ Ma (Fig. 4, Table 1) that corresponds to the Middle Neoproterozoic (NP₂) [7]. The high reliability of this zircon age allows us to use it as a reference, which is still the only reliable age characterizing the rocks of the provenance area.

In addition, this is evidence that not only sedimentary and metamorphic formations were eroded in the Vendian, but also igneous (granitoid) formations, similar in age to granites of the Mazara massif (710–740 Ma [8]) and the Barangulovo gabbro–granite complex (725 ± 5 Ma [9]), located in the northern part of the Uraltau Zone in the Southern Urals (Fig. 1, point 4), to the east of the sampling site for geochronological studies (point 1, Fig. 1). Thus, both the sedimentation area and the provenance area are outlined. The latter was situated at the margin of the Timanide Orogen.

Similar ages should be considered as rare for the Urals, even unique. Due to this, they are of extreme importance for clarifying the geological evolution of the Urals in the Upper Precambrian, as they provide us information on the magmatism processes that occurred in the uppermost (terminal) Riphean (Arshinian) within the age interval of 640–770 Ma [4, 10]. The Ar–Ar microcline age of 530–550 Ma was previously obtained for granite pebbles from the Kukkarauk Formation conglomerates (Zuyachka River, along the

Ufa–Inzer road; Fig. 1, point 2) [11]. Taking into account the clear signs of secondary metasomatic transformations of feldspar (pelitization, chloritization, etc.), this age should be considered as “rejuvenated” and as the approximate age of the Kukkarauk Formation.

All studies admit the occurrence of an incised erosion depression in the Upper Riphean deposits, filled with Vendian deposits, recorded in the Alatau anticlinorium along the Zilim River (Tolparovo village area) [12] and a hiatus in sedimentation between the Riphean and the Vendian, but the duration of the hiatus is estimated in different way [6]. In our opinion, there was no prolonged hiatus in sedimentation at the Riphean–Vendian boundary in the western part of the Bashkir Meganticlinorium; that is, one can obtain the relevant geological information on the evolution of this part of the Southern Urals at the Riphean–Vendian boundary.

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