

Granodiorites of the Grenville Phase in the Kokchetav Block, Northern Kazakhstan

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The Kokchetav Block is composed of Precambrian metamorphic rocks of the Zerenda and Sharyk groups. The Zerenda Group (amphibolite-facies rocks) is overlain with geological and metamorphic unconfor-

mities by greenschists of the Sharyk Group. Based on the U–Pb zircon dating, gneisses of the Zerenda Group in the central Kokchetav Block are estimated at 1300–1900 Ma [1].

Results of the U–Pb geochronological study of zircon from granodiorite (sample 1-Sh)

Sample no.	Fraction size (μm)	Weight, mg	Content, μg/g		Isotope ratios		
			Pb	U	²⁰⁶ Pb/ ²⁰⁴ Pb	²⁰⁷ Pb/ ²⁰⁶ Pb*	²⁰⁸ Pb/ ²⁰⁶ Pb*
1	60–85	0.72	39.6	297	560	0.0705 ± 5	0.1016 ± 1
2	100–130	0.35	63.3	446	747	0.0715 ± 3	0.0965 ± 1
3	100–130, IP, 3 h	–	8.1**	57.5**	2069	0.0737 ± 3	0.0966 ± 1
4	85–100, A 40%	0.48	106	636	1503	0.0750 ± 3	0.0941 ± 1
5	3 grains, CLC	–	0.95**	6.03**	489	0.0748 ± 3	0.0723 ± 1
6	3 grains, A 50%	–	0.29**	1.80**	1133	0.0751 ± 2	0.1065 ± 1
7	7 grains, A 80%	–	0.39**	2.26**	1646	0.0769 ± 2	0.0851 ± 1
8	4 grains, A 50%, CLC	–	0.47**	2.17**	239	0.0765 ± 3	0.0680 ± 1

Sample no.	Fraction size (μm)	Isotope ratios		<i>Rho</i>	Age, Ma		
		²⁰⁷ Pb/ ²³⁵ U	²⁰⁶ Pb/ ²³⁸ U		²⁰⁷ Pb/ ²³⁵ U	²⁰⁶ Pb/ ²³⁸ U	²⁰⁷ Pb/ ²⁰⁶ Pb
1	60–85	1.1628 ± 23	0.1196 ± 2	0.90	783 ± 1	729 ± 1	942 ± 1
2	100–130	1.2955 ± 26	0.1314 ± 3	0.82	844 ± 2	790 ± 1	972 ± 2
3	100–130, IP, 3 h	1.4118 ± 28	0.1389 ± 3	0.67	894 ± 2	838 ± 2	1034 ± 3
4	85–100, A 40%	1.6597 ± 33	0.1597 ± 3	0.73	993 ± 2	955 ± 2	1078 ± 3
5	3 grains, CLC	1.5381 ± 138	0.1492 ± 12	0.90	946 ± 8	896 ± 7	1062 ± 7
6	3 grains, A 50%	1.6154 ± 96	0.1561 ± 9	0.88	976 ± 6	935 ± 6	1071 ± 5
7	7 grains, A 80%	1.8479 ± 83	0.1744 ± 7	0.91	1063 ± 5	1036 ± 5	1118 ± 4
8	4 grains, A 50%, CLC	1.8532 ± 100	0.1757 ± 7	0.77	1065 ± 6	1043 ± 6	1108 ± 7

Note: (*) Isotope ratios corrected for procedure blank and common lead; (**) amounts of Pb and U in the experiment (ng). (IR) insoluble residue left after preliminary acid treatment; (A) residue after air abrasion (the amount of material removed during zircon air abrasion is shown in percents); (CLC) cathodoluminescent monitoring; (*Rho*) correlation coefficient of errors in the ²⁰⁷Pb/²³⁵U and ²⁰⁶Pb/²³⁸U ratios. Values of errors (2σ) correspond to the last decimal digits. (–) Weight was not determined.

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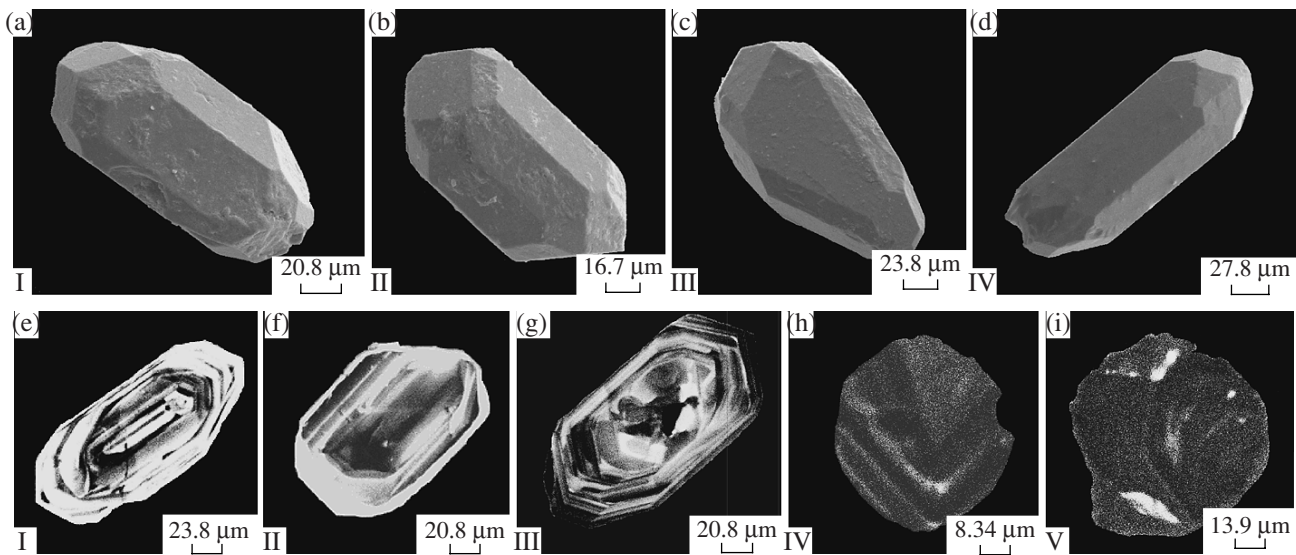


Fig. 1. Photomicrographs of zircon from the granodiorite sample 1-Sh (ANT 55 scanning electron microscope): (a) secondary electron image; (b) cathodoluminescence image.

The Kokchetav Block is characterized by anomalous Paleozoic granitoid magmatism, with individual massifs reaching several tens of kilometers in size [2]. To date, practically all large massifs have been dated by U–Pb zircon and Rb–Sr isochron methods [3, 4]. Their ages are no older than 480–490 Ma. Older granites have not been found in the block, although U–Pb zircon dating of the metavolcanic felsic rocks of the Kulet Formation yielded values corresponding to the Grenvillian magmatic phase [5].

We found small bodies of fine-grained granodiorites with cross-cutting relationships with host metamorphic

rocks in the Zerenda Group 4 km northeast of the Borovsk granite massif. We extracted zircon for U–Pb zircon dating from sample Sh-1 taken from one of these bodies (53°09'22.8"–70°28'36.9"). The results are discussed below.

As compared to the predominant Paleozoic biotite granites and the less common biotite–hornblende granites, the granodiorites have higher contents of CaO and MgO. They have the following composition (wt %): SiO₂ 63.61, TiO₂ 0.26, Al₂O₃ 14.50, Fe₂O₃ 1.31, FeO 1.24, MnO 0.07, MgO 1.35, CaO 7.66, Na₂O 3.93, K₂O 3.27, P₂O₅ 0.06, H₂O 0.16, CO₂ 1.49, L.O.I. 0.59, F 0.04, S 0.3, total 99.85 (analyst G.V. Bondareva, IZK). In addition, the plagiogranites contain 960 g/t Sr, 13 g/t Li, and 78 g/t Rb. Fine calcite veinlets, which partially replace plagioclase, are responsible for elevated contents of CaO and CO₂. In general, the rocks are weakly altered by postmagmatic processes and characterized by a medium-grained unequigranular texture. They have the following average composition (based on three measurements in thin sections): quartz 26, orthoclase 19.3, plagioclase (An_{35–40}) 46.5, biotite 4.2, hornblende 2, magnetite 1.5, and ilmenite 0.5%.

Accessory zircon was separated using the standard heavy liquid technique; hand-picked; and repeatedly treated in alcohol, acetone, and 1M HNO₃ to remove surface pollution. The zircon grain (or its fragment) was washed with water of specific purity after each stage. Zircon decomposition and separation of Pb and U were carried out following the Krogh technique [6]. All samples were spiked using mixed ²³⁵U–²⁰²Pb (nos. 5–8, table) and ²³⁵U–²⁰⁸Pb (Nos. 1–4, Table 1) tracers. The procedure blank did not exceed 10 pg for Pb. The Pb and U isotopic compositions were determined on a Finnigan MAT 251 mass spectrometer in a

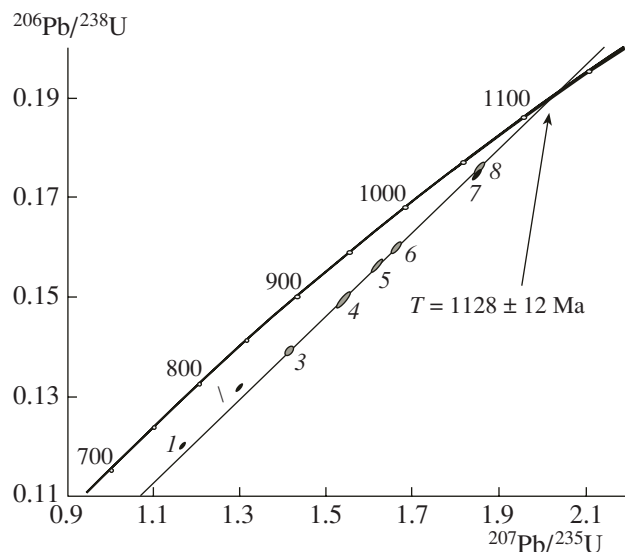


Fig. 2. Concordia diagram for zircons from the granodiorite (sample 1-Sh). Sample numbers correspond to the ordinal numbers in the table.

static regime or with an electron multiplier (discrimination coefficient for Pb was 0.32 ± 0.11 a.e.m.). The data obtained were processed with the PbDAT [7] and ISOPLLOT [8] programs. In calculating the age values, we used conventional decay constants [9]. Corrections for common Pb were introduced in compliance with the model values [10]. All errors are reported at the 2σ level.

The sample of accessory zircon separated from granodiorite (sample 1-Sh) usually consisted of opaque (rarely semitransparent) prismatic and long-prismatic crystals of brownish to pale yellow color ($K_{el} = 2-3$). The crystals have a complex shape defined by prisms {100} and {110} and dipyrramids {111}, {101}, and {211} (Fig. 1a). Zircon is characterized by lower luminescence, magmatic zoning, and the presence of recrystallized shells, which are characterized by high luminescence and partial disappearance of zoning (Fig. 1b, I, II). Some crystals contain inherited cores (Fig. 1b, III).

The U–Pb geochronological study was conducted with sufficiently large samples consisting of 20–100 grains (nos. 1–4, table) and small samples consisting of 3–7 grains (nos. 5–8, table). They were chosen using optical microscope and cathodoluminescence (CLC method [11]) methods. We analyzed not only untreated zircons, but also air-abraded and acid-treated varieties [12]. Only grains lacking recrystallization zones were used for isotopic studies (Fig. 1b, IV, V). In the concordia diagram, the data points of single zircon grains and zircon residues left after air abrasion and acid treatment form a discordia with the upper intercept at 1128 ± 12 Ma and the lower intercept at 336 ± 43 Ma (MSWD = 0.67) (Fig. 2). Data points of the untreated zircons are located left of the discordia, indicating the presence of the younger phase. The zircon morphology suggests a magmatic origin, and the obtained age of 1128 ± 12 Ma can be attributed to the timing of crystallization of the parental granodiorite melts.

Thus, results of the U–Pb geochronological study have revealed granodiorites of the Grenville phase of magmatism in the Kokchetav block. The obtained age of 1128 ± 12 Ma indicates that the Kokchetav Block contains fragments of the folded structures of early Grenvillian buildups usually assigned to the formation of the Rodinia supercontinent. Taking into consideration the available geochronological data on other regions of the Central Asian foldbelt [13–15], we can confidently suggest that these fragments belonged to a single system of the Grenville foldbelts, which are traced now as discrete chains over a great distance from

the Amalat Block in the east to the Kokchetav Block and Aktau–Dzhungar Massif in the west.

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REFERENCES

1. J. C. Claone Long, N. V. Sobolev, V. S. Shatsky, and A. V. Sobolev, *Geology* **19**, 710 (1991).
2. F. A. Letnikov, *Granitoids of Block Regions* (Nauka, Novosibirsk, 1975) [in Russian].
3. K. N. Shatagin, *Dokl. Akad. Nauk* **336**, 428 (1994).
4. F. A. Letnikov, A. B. Kotov, M. M. Shershakov, et al., in *Geodynamic Evolution of the Lithosphere of the Central Asian Foldbelt* (IZK SD RAS, Irkutsk, 2006), vol. 1, pp. 2006–2011 [in Russian].
5. A. I. Tugarinov, E. V. Bibikova, O. M. Rosen, and A. L. Polyakov, *Geokhimiya*, No. 1, 113 (1970).
6. T. E. Krogh, *Geochim. Cosmochim. Acta* **37**, 485 (1973).
7. K. R. Ludwig, *US Geol. Surv. Open File Rept.*, No. 88-542 (1991).
8. K. R. Ludwig, *Berkley Geochronol. Center Spec. Publ.*, No. 1a (1999).
9. R. H. Steiger and E. Jager, *Earth Planet. Sci. Lett.* **36**, 359 (1976).
10. J. S. Stacey and I. D. Kramers, *Earth Planet. Sci. Lett.* **26**, 207 (1975).
11. U. Poller, V. Leibertau, and W. Todt, *Chem. Geol.* **139**, 287 (1997).
12. J. M. Mattinson, *Contrib. Mineral. Petrol.* **116**, 117 (1994).
13. V. V. Yarmolyuk, V. I. Kovalenko, E. B. Sal’nikova, et al., *Dokl. Earth Sci.* **404**, 986 (2005) [*Dokl. Akad. Nauk* **404**, 84 (2005)].
14. K. E. Degtyarev, K. N. Shatagin, A. B. Kotov, et al., in *Geodynamic Evolution of the Lithosphere in the Central Asian Mobile Belt (from Ocean to Continent)* (IZK SD RAS, Irkutsk, 2006), Vol. 1, pp. 82–85 [in Russian].
15. G. E. Nekrasov, N. V. Rodionov, N. G. Berezhnaya, et al., *Dokl. Earth Sci.* **413**, 160 (2007) [*Dokl. Akad. Nauk* **412**, 661 (2007)].