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GEOLOGY

Polychronous Origin of the Angara–Vitim Batholith

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In recent works devoted to the age and origin of magmatic complexes of the Transbaikal region, one can see a tendency to revise the timing of maximal tectonomagmatic activity in this region. The generally accepted concepts on the Late Precambrian age of the major orogenic pulse of magmatism are questioned, while ancient magmatic complexes are "rejuvenated." It is now evident that there was no global tectonic event in the western Transbaikal region. Instead, the region was involved in permanent epicratonic orogenesis that was manifested during the entire post-Riphean stage, the Phanerozoic included.

In this context, the recent methods of isotope dating have become a powerful means for solving problems of magmatism, tectonism, ore genesis, and evolution of the western Transbaikal region. The key object of the western Transbaikal region is the Uakit zone with polygenic Precambrian and Paleozoic rocks (Fig. 1). Recent studies have shown that the main tectonomagmatic event in this region occurred in the Upper Paleozoic. This view is supported by isotope–geochronological data on the Vitimkan Complex [1–3] and palynological findings [4]. At the same time, older magmatic rocks are also abundant in the region. In particular, varieties with a higher alkalinity can be distinguished as an autonomous West Olnya complex [5] among granitoids of the Vitimkan complex based on their physiographic features and compositions. They are developed in the Uakit–Muya watershed region and at the western Olnya–Uakit Muya watershed.

The West Olnya Complex mainly includes macroscopically indistinguishable "hybrid" rocks composed of subalkaline monzonites, syenites, monzodiorites, and less common alkali gabbrosyenites and plagiogranites. The gray or dark gray fine-grained rocks consist of variable proportions of K-feldspar, plagioclase, quartz, and hornblende with an admixture of biotite. The predominant biotite–hornblende syenites have the following composition (vol %): K-feldspar (45–73), plagioclase (up to 25), barkevikite–hastingsite hornblende (15–35) occasionally intergrown with biotite, and quartz (up to 5 vol %) in some places. Secondary minerals are chlorite and saussurite; accessory minerals are apatite, titanite, zircon, Ti-magnetite, and occasional fluorite, orthite, and anatase. The rocks are characterized by massive, schlieren, and less common heterogeneous structure. The texture is subhedral, xenomorphic and myrmekitic in some places. One can also see a coroniform texture (development of actinolite rim around fine-grained aggregates of K-feldspar (or albite) and hornblende forms). The rocks are saturated with alkali metals and can be classified as normative nepheline (Table 1).

These rocks are associated with the granitoids of the Vitimkan and Demin complexes. The gradual boundaries between the West Olnya and Vitimkan complexes seemingly attest to their nearly synchronous formation. The age data on the most closely spaced biotite granites of the Vitimkan Complex are as follows: (1) U–Pb dating of rocks from the upper reaches of the Nerunda–Mogoi River yielded 315 ± 19 Ma for zircon (protolith 1859 ± 124 Ma) and 303.1 ± 3.5 Ma for titanite (protolith 1349–1421 Ma) [2]; (2) Rb–Sr whole-rock isochron dating of rocks from the Vekov'insk Massif (sheet N-50-I) defined an age of 327 Ma [3]. The granites of the Demin Complex crosscut the Vitimkan and West Olnya complexes as dikes and veins. The Demin Complex is estimated at 279 Ma (Rb–Sr whole-rock isochron for granites of the Chuldym Massif, sheet N-50-I [3]).

Samples (5–6 kg) taken for dating subalkaline rocks of the West Olnya Complex were crushed manually in a mortar and sieved into 0.4–0.2 mm and <0.2 mm fractions. The sieved fractions were washed in the hot spring waters, treated with bromoform, and separated

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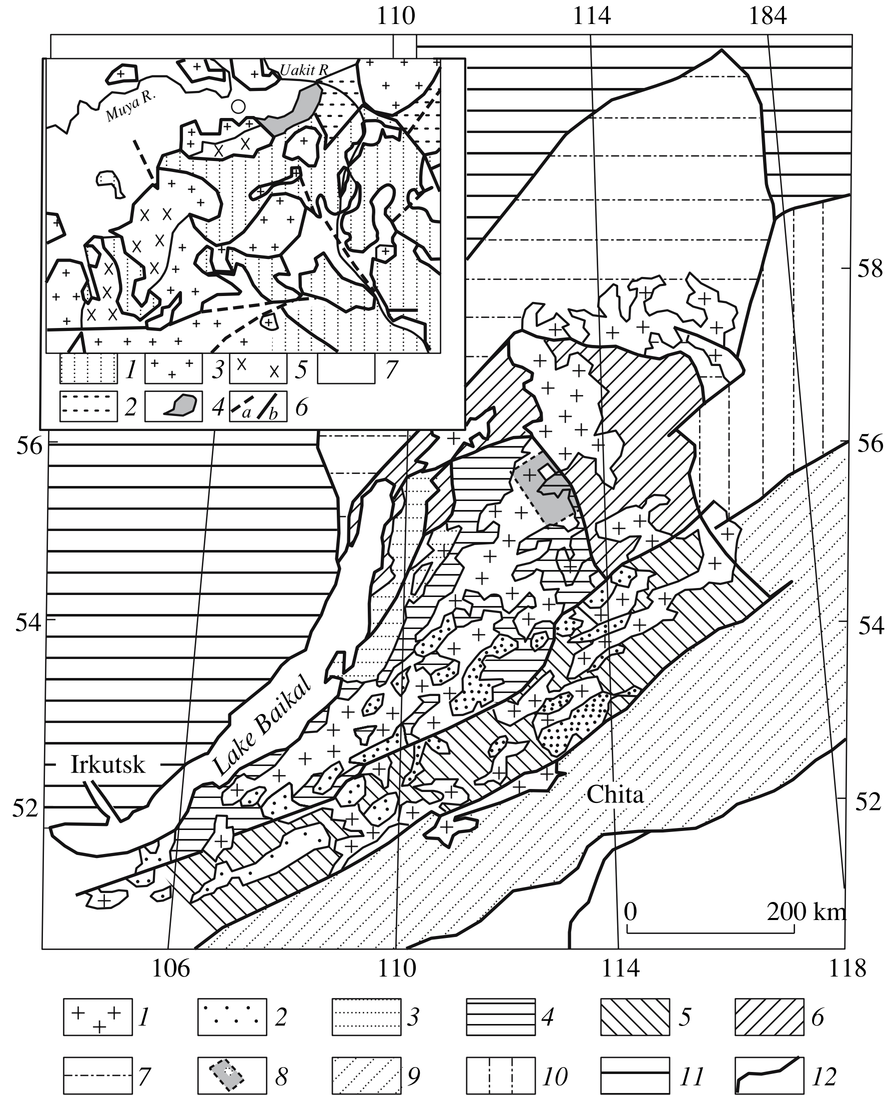

Fig. 1. Geological scheme of the Angara–Vitim Batholith (modified after V.V. Yarmolyuk et al., 1997). (*1–4*) Magmatic complexes and associations: (*1*) Barguzin and Vitimkan, (*2*) Zaza, (3) Chivyrkui, (*4–11*) lithostructural zones: (*4*) Baikal–Vitim, (*5*) Dzhida–Vitim, (*6*) Baikal–Muya, (*7*) Mamsk–Bodaibo, (*8*) Uakit, (*9*) Selenga–Stanovoi, (*10*) Chara–Udokan, (*11*) Siberian Craton; (*12*) boundaries of the lithostructural zones. Inset shows the tectonic scheme of the Uakit zone: (*1, 2*) stratified deposits: (*1*) Hercynian structural unit, (*2*) Riphean structural unit; (*3*) granitoids of the Vitimkan Complex; (*4*) granitoids of the Demin Complex; (*5*) subalkaline rocks of the West Olnya Complex; (*6*) faults: (*a*) proved, (*b*) inferred; (*7*) Neogene–Quaternary deposits.

using a Sochnev magnet. Zircons were hand-picked from the <0.2 mm fraction (0.2–0.4 mm fraction lacks zircons). The crystals of mainly hyacinth habit (0.015–0.065 mm in size) are predominant. The larger crystals show a distinct zoning. We analyzed relatively homogenous inclusion-free grains. Results of the radiological investigation are presented below.

U–Pb zircon dating was conducted on a SHRIMP II ion microprobe at the Center of Isotope Research, Karpinskii All-Russia Research Institute of Geology. The standard 1-inch microspecimen (plate) was sputtered by gold in a cathode–vacuum apparatus for 1 min at a current of 20 mA. The cathodoluminescence images were recorded on the scanning electron microscope (operation distance 25–28 mm, accelerating voltage 20 kV, and current of beam practically completely focused on the Faraday cylinder 4–6 nA). The beam current was varied to attain the most contrasting image and minimize corrosion of the plate surface owing to local heating.

Hand-picked zircons were mounted in epoxy resin together with standard zircons (TEMORA and 91500) and ground to approximately half-thickness. The dating points were chosen using optical (transmitted and reflected light) and cathodoluminescence images, which reflect the internal structure and zoning of zircons.

U–Pb ratios were measured on SHRIMP II according to the technique of [6]. The intensity of the primary beam of negatively charged oxygen ions was 4 nA. The

Table 1. Chemical and normative compositions of the rocks of the West Olnya Complex

Components	Subalkaline syenites							Alkaline gabbrosyenite	Plagiogranite
	sample 51-060	sample 51-170	sample 513	sample 514	sample 517	sample 518	sample 520-1	sample 51-080	sample 596-2
SiO_2	57.45	57.05	57.9	56.25	60.2	60.5	59.05	52.5	69.4
TiO_2	1.18	1.16	1.29	1.47	0.7	0.74	0.65	1.85	0.34
Al_2O_3	16.6	17.55	17.5	17.9	17	17	17.1	17.55	14.9
Fe_2O_3	1.16	1.66	0.7	1.67	0.96	1.27	1.84	2.3	0.77
FeO	6.06	5.49	5.9	6.02	6.39	6.24	6.14	6.36	1.87
MnO	0.16	0.14	0.1	0.15	0.19	0.17	0.19	0.16	0.03
MgO	1.39	1.48	1.67	1.84	0.29	0.29	0.33	2.59	1.21
CaO	3.24	3.2	3.6	3.85	2.26	2.13	2.42	4.19	2.5
Na_2O	5.2	5.2	4.65	5.29	4.83	5	5.04	4.93	3.9
K_2O	5.69	5.34	4.85	5	6	5.82	5.64	4.81	3.77
P_2O_5	0.414	0.429	0.605	0.587	0.107	0.13	0.084	0.97	0.14
L.O.I.	0.5	0.4	0.82	0.25	0.65	0.68	0.26	0.41	0.61
Total	99.91	99.1	99.59	100.28	99.58	99.97	98.87	98.77	99.44
Q	0	0	0.31	0	0.32	0.83	0	0	25.01
C	0	0	0	0	0	0	0	0	0.22
Or	34.12	31.97	29.02	29.54	35.84	34.64	33.84	28.94	23.34
Ab	36.94	38.72	39.84	35.85	41.31	42.61	43.22	29.92	32.24
An	5.21	8.87	12.69	10.31	7.04	6.78	7.52	11.74	11.73
Ne	4.17	3.17	0	4.82	0	0	0	6.8	0
Di	7.12	3.7	1.18	4.17	3.16	2.65	3.62	2.47	0
Hy	0	0	12.02	0	9.31	8.9	6.04	0	5.37
Ol	6.4	6.73	0	7.44	0	0	1.58	9.2	0
Mt	1.71	2.44	1.03	2.42	1.41	1.85	2.71	3.4	1.13
Il	2.27	2.23	2.48	2.79	1.34	1.42	1.25	3.58	0.65
Ap	0.92	0.95	1.34	1.28	0.24	0.29	0.19	2.16	0.31

Note: Major normative minerals: (Q) quartz, (C) corundum, (Or) K-feldspar, (Ab) albite, (An) anorthite, (Ne) nepheline, (Di) diopside, (Hy) hypersthene, (Ol) olivine, (Mt) magnetite, (Il) ilmenite, (Ap) apatite.

Table 2. Results of U–Pb study of zircons from the granitoids of the West Olnya Complex

Ordinal no.	Concordia age, Ma
595-5 (6 points)	440.9 ± 2.8
596 (7 points)	432.2 ± 4.9
596-1 (7 points)	435.9 ± 2.9
596-2 (6 points)	442.0 ± 2.6
597 (7 points)	436.3 ± 2.7
5 samples (31 points)	439 ± 1.7

spot (crater) diameter was 18 μm. Obtained data were processed with the SQUID program [7]. The U–Pb ratios were normalized to 0.0668 ascribed to the TEMORA standard, which corresponds to the zircon age of 416.75 Ma [8]. The errors of single analyses (ratios and ages) are given at the 1 σ level; the errors in calculated concordia and intercept ages, at the 2 σ level. The concordia diagrams were plotted with an ISOPLOT/EX program [9].

The age of the rocks of the West Olnya Complex determined on five samples varies within 432–442 Ma

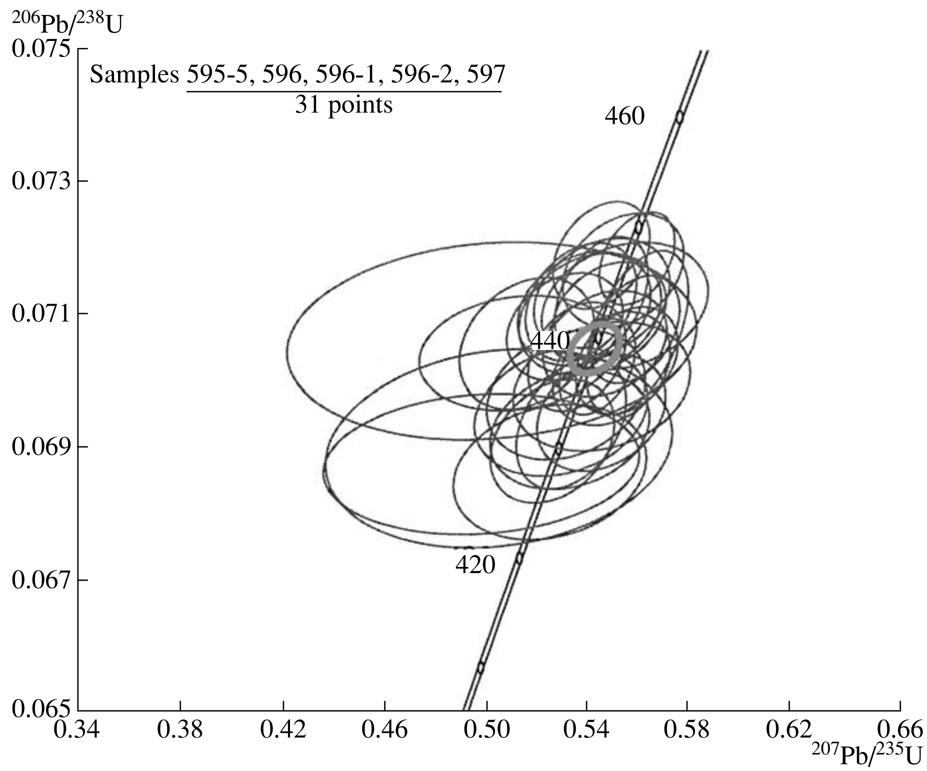

Fig. 2. Concordia diagram for zircons from the subalkaline rocks of the West Olnya Complex. Concordia age = 439 ± 1.6 Ma 95% confidence, decay-constant errors included), MSWD (of concordance) = 0.00016, probability (of concordance) = 0.99.

(Table 2). The total concordia corresponds to the age of 439 ± 1.6 Ma (Fig. 2).

Discussion and conclusions. It was suggested that the West Olnya Complex belongs to older rocks reworked by the granites of the Vitimkan Complex. The obtained radiological data confirm this assumption. The granitoids of the Late Hercynian Vitimkan Complex contains relicts of compositionally similar older rocks with vague geological boundaries. The domain of the Vitimkan Complex should be considered an area of polygenic and polychronous magmatism. Therefore, researchers should pay special attention to boundaries of granitoids. Geochronological dating by modern methods after the detailed geochemical study of rocks is the main tool for creating new maps in areas dominated by magmatic rocks. The experience of the application of the SHRIMP method for these purposes has demonstrated its efficiency for solving specified geological problems in the Uakit zone of the western Transbaikal region.

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