ГРАНИТЫ И ЭВОЛЮЦИЯ ЗЕМЛИ:
мантия и кора в гранитообразовании

GRANITES AND THE EARTH'S EVOLUTION:
the Mantle and the Crust in Granite Origin

28–31
August
Ekaterinburg
Russia
2017

Материалы III международной геологической конференции
Proceedings of the 3rd International Geological Conference

РОССИЙСКАЯ АКАДЕМИЯ НАУК
УРАЛЬСКОЕ ОТДЕЛЕНИЕ
ИНСТИТУТ ГЕОЛОГИИ И ГЕОХИМИИ им. академика А.Н. ЗАВАРИЦКОГО
ФАНО РОССИИ
РОССИЙСКИЙ ФОНД ФУНДАМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ
УРАЛЬСКИЙ РЕГИОНАЛЬНЫЙ ПЕТРОГРАФИЧЕСКИЙ СОВЕТ МЕЖВЕДОМСТВЕННОГО ПЕТРОГРАФИЧЕСКОГО КОМИТЕТА ОНЗ РАН

ГРАНИТЫ И ЭВОЛЮЦИЯ ЗЕМЛИ: мантия и кора в гранитообразовании

Материалы III международной геологической конференции

28–31 августа 2017 г.
Екатеринбург, Россия

GRANITES AND THE EARTH'S EVOLUTION: the Mantle and the Crust in Granite Origin

Proceedings of the 3nd International Geological Conference

28-31 August 2017
Ekaterinburg, Russia

ЕКАТЕРИНБУРГ
2017

УДК 552.31+553.521+550.31

Граниты и эволюция Земли: мантия и кора в гранитообразовании. Материалы III международной геологической конференции, 28–31 августа 2017 г., Екатеринбург, Россия. – Екатеринбург: ИГГ УрО РАН, 2017. – 384 с.

ISBN 978-5-7691-2482-2

В сборнике представлены материалы исследований ведущих российских и зарубежных специалистов по гранитной петрологии. Рассмотрен широкий круг актуальных вопросов эволюции гранитоидного магматизма в геологической истории Земли, физико-химических и геотектонических условий формирования кислых расплавов, механизмов мантийно-корового взаимодействия, вещественных особенностей гранитных пород, связанных с разными источниками, их рудоносности.

Для широкого круга специалистов, аспирантов, студентов.

Утверждено к печати Ученым советом Института геологии и геохимии
им. академика А.Н. Заварицкого УрО РАН

Материалы публикуются в авторской редакции

Granites and the Earth's Evolution: the Mantle and the Crust in Granite Origin. Proceedings of the 3[nd] International Geological Conference, 28–31 August 2017, Ekaterinburg, Russia. – Ekaterinburg: IGG UB RAS, 2017. – 384 p.

Abstract volume includes the leading Russian and abroad scientists presentations focusing on different aspects of granite petrology: granitoid magmatism evolution in the Earth history, physico-chemical and tectonic conditions of granitic melt generation, mantle-crust interaction mechanisms, chemical features of granites generated from different sources, metallogeny of granitic rocks.

The materials of the volume are of a broad interest for geologists, earth scientists and students.

Approved for publishing by the Academic Board, A.N. Zavaritsky Institute of Geology and Geochemistry
of Ural Branch Russian Academy Sciences

Submitted materials are published in author's edition

ISBN 978-5-7691-2482-2

Диапазон $^{206}Pb/^{238}U$ возрастов цирконов по 9 отдельным зернам составляет от 187 до 147 млн лет. Рассчитанный средневзвешенный возраст для когерентной группы из 6 определений – 152.7 ± 3.9 млн лет (2σ, СКВО = = 2.73). Схожий состав элементов-примесей свидетельствует о том, что цирконы кристаллизовались из одной магмы. Модельная температура кристаллизации варьирует в интервале 840–640 °C. Положительные значения изотопного состава гафния цирконов этой пробы указывают на мантийный источник ($\varepsilon_{Hf}(t)$ от +4.6 до +9.2), модельный возраст T_{DM2} 0.79–0.53 млрд лет.

Таким образом, установлено, что гранитоиды формировались в позднеюрское время из гетерогенного по возрасту и составу субстрата. Биотитовые граниты Курунзулайского массива (шахтаминский комплекс) сформировались 160 млн лет назад при плавлении корового-мантийного (($\varepsilon_{Hf}(t)$ +0.82…+3.40) протолита с возрастом 1.10–0.87 млрд лет, амазонитовые граниты Тургинского массива (кукульбейский комплекс) формировались 152 млн лет назад, протолит амазонитовых гранитов более молодой (T_{DM2} 0.79–0.53 млрд лет) и мантийный ($\varepsilon_{Hf}(t)$ +4.6…+9.2).

Исследования проводятся в рамках проекта РФФИ № 17-05-00275.

ЛИТЕРАТУРА

Абушкевич В.С., Сырицо Л.Ф. Изотопно-геохимическая модель формирования Li-F гранитов Хангилайского рудного узла в Восточном Забайкалье. СПб.: Наука. 2007. 148 с.

Зарайский Г.П. Условия образования редкометалльных месторождений, связанных с гранитоидным магматизмом // Смирновский сборник-2004. М.: Фонд им. ак. В.И. Смирнова, 2004. С. 105-192.

Козлов В.Д. Особенности редкоэлементного состава и генезиса гранитоидов шахтаминского и кукульбейского редкометалльных комплексов Агинской зоны Забайкалья / Геология и геофизика, 2011, т. 52, № 5, С. 676-689.

Костицын Ю.А., Зарайский Г.П., Аксюк А.М., Чевычелов В.Ю. Геохимические и изотопные свидетельства генетической общности биотитовых и Li-F гранитов на примере месторождений Спокойнинское, Орловка, Этыка (Восточное Забайкалье) / Изотопное датирование геологических процессов, новые методы и результаты. Тез. докл. I Рос. конф. по изотопной геохронологии. М. ГЕОС, 2000. С. 185-188.

Watson E.B., Wark D.A., Thomas J.B. Crystallization thermometers for zircon and rutile // Contrib Mineral Petrol. 2006. V. 151. P. 413-433.

ISOTOPE GEOCHEMICAL CHARACTERISTICS OF GRANITOIDS OF SHAKHTAMINSKY AND KUKULBEYSKY COMPLEXES (EASTERN TRANSBAIKALIA): NEW DATA

Udoratina O.V., Varlamov D.A.**, Tsygankov A.A.***, Coble M.A.****, Geng J.Z.******

*Institute of Geology of the Komi SC UB RAS, Syktyvkar, Russia, udoratina@geo.komisc.ru
**Institute of Experimental Mineralogy RAS, Chernogolovka, Russia, dima@iem.ac.ru
***Geological Institute SB RAS, Ulan-Ude, Russia, tsygan@gin.bscnet.ru
****Stanford University, Stanford, USA, coblem@stanford.edu
*****Institute of Geology and Mineral Resources, Tianjin, China, mumu1270@163.com

Rare metal granites of the Eastern Transbaikalia have long attracted the attention of researchers due to their high ore concentrations of rare metals (Ta, Nb, Be, W, Sn, etc.). Within the Eastern Transbaikalia is a wide band of NE striking intrusive formations represented by granitoids of two complexes – Shakhtaminsky and Kukulbeysky.

There are various interpretations of the genetic relationship of the characteristics of the granitoid complexes and their ore load. The large volume of petrological-geochemical, geochronological (Rb-Sr, U-Pb) and isotope-geochemical (Sr, Nd) data accumulated to the present on some of the granitoid massifs suggest that their formation occurred due to different crustal versus mantle sources [Kozlov, 2011; Kostitsyn et al, 2000; Abushkevich, Syritso, 2007; Zaraisky et al., 2004].

A feature of the rare-metal granitoids of the Eastern Transbaikalia is the multistage and multiphase nature of magmatism, the absence of rocks that are more basic than biotite granites (rarely granodiorites), and enrichment in F, Rb, Cs, Li and rare metals. The final differentiates of the complexes are leucogranites and alaskites, which are associated with W, Mo, Sn, Be, Bi greisen mineralization and lithium-fluorine albite-amazonite granites with Ta-Nb mineralization in albitites. Industrial concentrations are characteristic only for final derivatives of granite-leucogranite magma, which is explained by the consecutive accumulation of incompatible trace elements in the residual melt during their differentiation and cooling in the upper parts of the earth's crust [Zaraiskii et al., 2004].

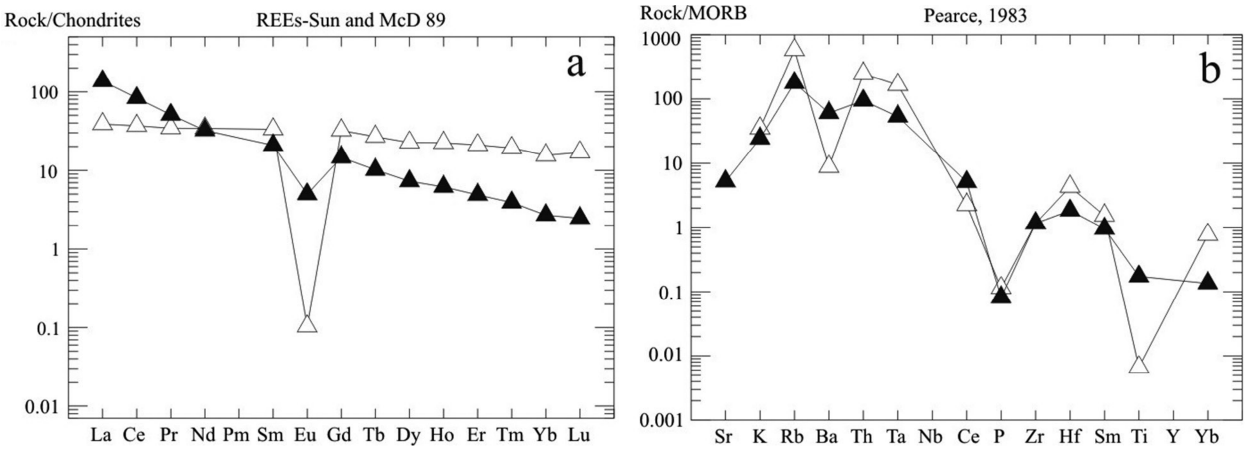

Fig. 1. Spectra of REE distribution of elements in rocks (a), multielement diagram (b).

The painted triangle – dated granites of Kurunzulaysky massif, unpainted – Turginsky.

This study, conducted in collaboration with G.P. Zaraysky between 2002 and 2008, investigates numerous occurrences of granitoids of the massifs. Below we present new data to better constrain the geological position, mineralogical and petrographical-petrochemical and geochemical features of Kurunzulaysky (Shakhtaminsky complex) and Turginsky (Kukulbeysky complex) massifs. To determine the age and rock crystallization conditions, we performed U-Pb isotope (SIMS) measurements, Ti-in-zircon thermometry, the REE in zircon compositions, and the isotopic composition of hafnium (ICP-MS) in zircons.

Shakhtaminsky complex. The granitoids of Kurunzulaysky massif are typical representatives of rocks related to Shakhtaminsky complex. Large or medium-grained, massive gray rocks are large-porphyritic biotite granites. Phenocrysts are represented by oligoclase, the matrix is composed of feldspar-plagioclase aggregate, and dark-colored minerals (up to 10 vol. %) are represented by siderophyllite (Li siderophyllite) and Li-Fe muscovite. Accessory minerals include zircon, apatite, titanite, monazite (Th-monazite), and allanite. Ore minerals are rutile (often enriched with Nb, Ta and W) and ilmenite.

Petrogeochemically the biotite granites of Kurunzulaysky massif are sub-alkaline moderately potassium (wt %), SiO_2 – 72, (Na_2O + K_2O) – 8, ASI – 0.87, metaaluminum. The content of REE is low, light rare earth elements predominate heavy ones, and a clearly manifested europium minimum is observed (Fig. 1, a). The multielement diagrams (Fig. 1, b) show the predominance of large ionic elements over the high-charged ones with sharp minima (Ti, P).

Kukulbeysky complex. The studied granitoids of Turginsky massif are referred to as the Kukulbeysky complex (Kamenistaya Mountain, "Gidokansky outlet") and were are selected from the dyke body. Fine-grained, massive grayish-white rocks

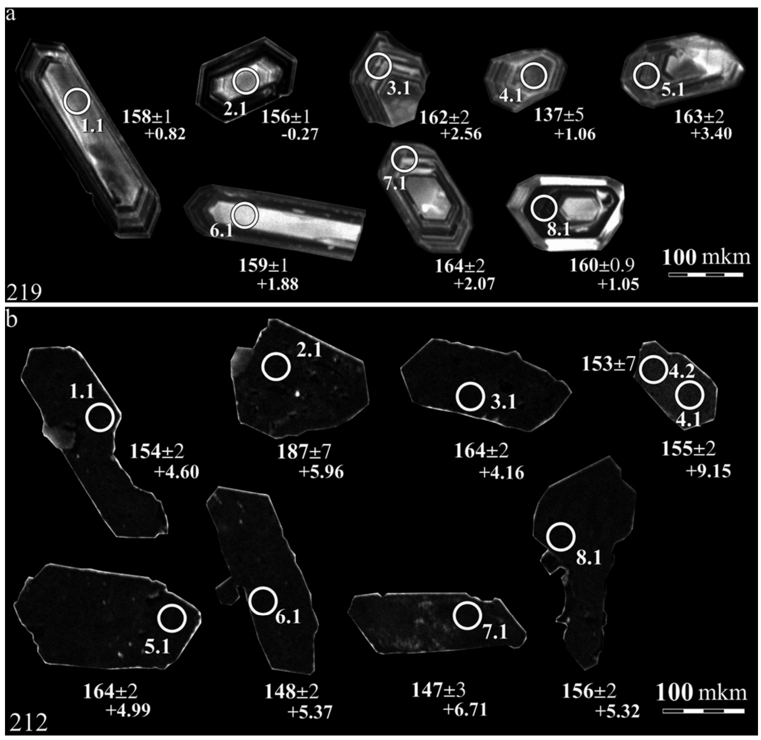

Fig. 2. Cathodoluminescence images of zircons with numbers of dated grains, analytical craters, age and data on the isotopic composition of hafnium.

a – zircons from biotite granites of the Kurunzulaysky massifs, Shakhtymsky complex, b – from amazonite granites of Turginsky massif of Kukulbeysky complex.

are amazonite granites. In thin section, granite microstructures and the development of albitization (lamellar and chess albite) are observed. Dark-colored minerals (1–5 vol. %) are represented by micas, including Li-Fe muscovite, zinnwaldite and Fe-polylithionite. Accessory minerals include zircon, xenotime, thorite, thorium phosphates. Ore minerals include columbite (Mn-and Fe-varieties), fergusonite, uraninite, galena.

Petrogeochemically the amazonite granites are alkaline high-potassium rocks (wt %) SiO_2 – 73, (Na_2O + K_2O) – 10, ASI – 1.01, low-titanium (0.01), low-magnesian (0.1). The REE content is low, with a flat europium minimum (Fig. 1, a). The multielement diagrams (Fig. 1, b) also show the predominance of large ionic elements over the high-charged ones, with sharp minima (Ti, P).

We also studied the zirconfor geochronological studies. The zircons of biotite granites from Kurunzulaysky massif (up to 200 mkm) are straw color, transparent, with a long-prismatic habit, Ku = 1:1, 1:2 with fine black nodules. In the cathodoluminescent, the magmatic oscillatory zoning is manifested with well-visible central zones (Fig. 2, a). The contents of U and Th in zircons vary very widely between 157–1422 and 69–1529 ppm, respectively.

The age of the zircons by $^{206}Pb/^{238}U$ is determined in eight points. The age range is 164–137 Ma. Weighted average age is 160.2 ± 2.1 Ma (MSWD = 2.52). Two points were (2.1 and 4.1) were removed, which we suspect were younger due to Pb-loss. The trace element concentrations are similar, indicating the zircons are likely from the same magmatic generation. The calculated Ti-in-zircon crystallization temperatures range from 800 to 670 °C. The positive values of the isotope composition of the hafnium of zircons of this sample indicate the mantle source ($\varepsilon_{Hf}(t)$ from +0.82 to +3.40), the model age of the protolith T_{DM2} is 1.10–0.87 Ga.

The zircons of amazonite granites of Turginsky massif (up to 200–300 mkm) are opaque and translucent dark yellow with a reddish tint, with a prismatic habit Ku = 1:2. In the cathodoluminescent are black (Fig. 2, b). The contents of U and Th in zircons are extremely high and vary widely – 6334–11919 and 686–18166 ppm, respectively.

The $^{206}Pb/^{238}U$ range of zircon ages for 9 individual grains ranges from 187 to 147 Ma. The calculated average age for a coherent group of 6 determinations is 152.7 ± 3.9 Ma (2σ, MSWD = 2.73). The trace element concentrations are similar, indicating that the zircons were crystallized from the same magma. The model Ti-in-zircon crystallization temperatures estimated by Ti content in zircon [Watson et al., 2006] range from 840 to 640 °C (at a_{SiO_2} = 1 and a_{TiO_2} = = 0.7). The positive values of the isotopic composition of the hafnium of zircons of this sample indicate a mantle source ($\varepsilon_{Hf}(t)$ from +4.6 to +9.2), model age T_{DM2} 0.79–0.53 Ga.

Thus we determined that the studied granitoids were formed in the Late Jurassic time from a substrate, which was heterogeneous in age and composition. The biotite granites of Kurunzulaysky massif (Shakhtaminsky complex) formed ~160 Ma during melting of the crust-mantle ($\varepsilon_{Hf}(t)$ +0.82…+3.40) protolith with the age of 1.10–0.87 Ga, and amazonite granites of Turginsky massif (Kukulbeysky complex) formed ~152 million years ago, the protolith of the amazonite granites is younger (T_{DM2} 0.79–0.53 Ga) and has mantle origin ($\varepsilon_{Hf}(t)$ +4.6…+9.2).

The researches are conducted within RFBR project No. 17-05-00275.

REFERENCES

Abushkevich V.S., Syritso L.F. Isotope-geochemical model of the formation of Li-F granites of the Khangilaysky ore cluster in the Eastern Transbaikalia. St. Petersburg: Nauka, 2007. 148 pp. (In Russian)

Zaraysky G.P. Conditions of formation of rare metal deposits associated with granitoid magmatism // Smirnovsky Sbornik-2004. Moscow: Fund named after Ac. V.I. Smirnov, 2004. P.105-192. (In Russian)

Kozlov V.D. Features of rare element composition and genesis of granitoids of Shakhtaminsky and Kukulbeysky rare metal complexes of Aginskaya zone of Transbaikalia // Geology and Geophysics, 2011, v. 52, No. 5. P. 676-689. (In Russian)

Kostitsyn Yu.A., Zaraisky G.P., Aksyuk A.M., Chevychelov V.Yu. Geochemical and isotopic evidence of the genetic community of biotite and Li-F granites by the example of the Spokoininskoye, Orlovka, and Etyka (Eastern Transbaikalia) deposits / Isotope dating of geological processes, new methods and results. Abstracts of the First Russian Conference on Isotope Geochronology. Moscow. GEOS, 2000. P. 185-188. (In Russian)

Watson E.B., Wark D.A., Thomas J.B. Crystallization thermometers for zircon and rutile // Contrib Mineral Petrol. 2006. V. 151. P. 413-433.