SAINT PETERSBURG STATE UNIVERSITY (SPBSU)

VERNADSKY INSTITUTE OF GEOCHEMISTRY AND ANALYTICAL CHEMISTRY OF RUSSIAN ACADEMY OF SCIENCES (GEOKHI RAS)

Magmatism of the Earth and related strategic metal deposits

Proceedings of XXXVI International Conference

23-26 May 2019, Saint Petersburg

Supported by Saint Petersburg State University, OPTEC (ZEISS Group) and LIMS (Raw Materials Research Laboratory)

“Magmatism of the Earth and related strategic metal deposits”. Proceedings of International Conference. Saint Petersburg State University, 23-23 May 2019**.** M.: GEOKHI RAS, 2019. 378 p. ISSN - 2618-835X.

The mineral deposits of strategic metals are vulnerable to political and economic changes, and their availability is essential for high-technology, green energy, and other applications. The most of they are related to the deep-seated alkaline magmas. This book offers a collection of papers presented at the 36th International Conference on “Magmatism of the Earth and Related Strategic Metal Deposits” held from May 23th to 26th 2019 in Saint Petersburg State University, Saint Petersburg, Russia. The conference articles are focused on the understanding of the geological processes that produce high concentrations of critical metals in geological systems such as the metal transport in the mantle and crust and enrichment processes, hydrothermal and metasomatic processes leading to the formation of such significant deposits. Papers in this book give a representative overview including mineralogy, geochemistry and origin of strategic metals deposits.

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ISSN-2618-835X

The cover pictures – View down the Neva to the river between the Winter house of its Imperial Majesty and Academy of Sciences. G.A. Kachalov's engraving according to M.I. Makhayev's drawing (approx. 1750-1752).

RARE METALS AND RARE EARTH ELEMENTS IN MINERALS FROM DEVONIAN ULTRABASIC ALKALINE ROCKS, DEEP CRUSTAL STRUCTURES (BELARUS)

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Upper Devonian igneous rocks of the Pripyat Paleorift are the most interesting object which is promising for identifying carbonatites and (or) primary sources of diamonds (kimberlite-like rocks, lamproites, etc.). The Pripyat Paleorift consists of the Pripyat Paleograben and Braginsky and Loevsky Saddle, the North Pripyat Shoulder and Zhlobin Saddle.

The detailed analysis of Devonian igneous and volcanogenic clastic rocks of the Pripyat Paleograben was carried out mainly in the 60-70s of the last century when there were absent modern instrumental capabilities for the analysis of minerals. So it did not allow characterizing mineral phases and assemblages fully. At the same time mineralogical criteria are very important while determining mineragenic type of rocks and making overall assessment of metallogeny of specific alkaline provinces because average petrochemical indicators may not be sufficient for the formation differentiation of ultrabasic alkali rocks due to their extreme convergence. The consistent patterns of the distribution of minerals of rare metals (Nb, Sr, Ba, etc.) and rare earth elements (REE) which are a direct reflection of the results of geochemical processes are very essential (Хомяков, 1990).

The work on identifying the structure and typomorphism of accessory minerals for the Devonian igneous complex of Belarus was carried out for the first time. The structures of the minerals were studied on a Tescan VEGA-II XMU electron scanning microscope with an INCA Energy 450 energy dispersive spectrometer of the Institute of Experimental Mineralogy (Chernogolovka, Russia). Ti-magnetite, copper sulphides, sphene, apatite as well as barite are the most common accessory minerals in ultrabasic alkaline rocks. The microprobe analysis showed that apatite and barite have a significant strontium admixture which indicates the alkaline nature of magmatism. As a result of the detailed microprobe studies of nephelinite from Yastrebovskaya 3 drill-hole core (depth 958–977 m), alkaline picrite from Vasiliyevskaya 1 drill-hole core (1785–1788 m depth) and nephelinite from Tsentrolit 2 drill-hole core (420 m) we managed to reveal minerals of rare and rare-earth elements: fluorcaphite (Ignatkevich, Varlamov, 2014), monazite, thorite and chabazite-Sr which were previously unknown for Devonian magmatic formation of Belarus. We also obtained information about their relationship with the rock-forming components and identified the characteristics of their chemical structure.

The results of the study of the characteristics of the morphology and chemical structure (Table 1) of the monazite which was first discovered in the rocks of the Devonian igneous complex of Belarus were given in this work. Monazite is an important rare-earth indicator of mineralization and rock-forming conditions (Ковальчук, 2011). This mineral together with neodymium-ceric area of specialization forms small (about 5 microns) grains in chlorite-phlogopite glass in alkaline picrite from Vasiliyevskaya 1 drill-hole core. It is often formed in the immediate vicinity of apatite (Figure). It should be noted that the obtained analyzes are not suitable for carrying out calculations due to the small size of the detected grains and they are given in the work to diagnose the mineral species.

As it is known (Пеков, 2001), monazite is a product of late hydrothermal activity in strongly alkaline (agpaite) complexes in contrast to less alkaline complexes where this mineral is a part of the high-temperature early coexisting. According to the structural relationship with accessory apatite (Figure) monazite was formed in situ due to the phosphorus released by dissolving this phosphate.

Thorite is a typomorphic mineral of ultra-alkaline igneous complexes. It forms small (4-5 microns) crystals in the rutile congeries in nephelinite from Yastrebovskaya 3 drill-hole core. Thorite is isomorphic with zircon and rutile. The device sensitivity didn't allow separating the phases. The content of thorium dioxide is up to 28.1 % wt. and 32.5 % wt., of zirconium – 22.7 % wt. and 29.6 % wt. and titanium – 0.1 % wt. and 10.1 % wt. which correspond to a solid solution of thorite with zircon as well as to a solid solution of a mixed structure (zircon-thorite-rutile). As a rule similar compounds are formed due to intergrowth inside and / or at the primary accessory phase outer circle. Their formation is determined by the modification of previous minerals due to the effect of fluids (Пеков, 2001).

Table 1. Composition of monazite.

Crystal	1	2
P_2O_5	30,9	30,1
CaO	24,2	20,3
Ce_2O_3	9,2	11,8
La_2O_3	5,1	6,5
Pr_2O_3	0,8	0,7
Nd_2O_3	2,5	3,3
ThO_2	*0,3*	0,6
SmO	*0,2*	*0,2*
Gd_2O_3	0,6	0,6
EuO	*0,0*	*0,3*
Ga_2O_3	*0,0*	*0,2*
V_2O_5	*0,0*	*0,2*
MgO	6,4	6,0
Fe_2O_3	1,6	1,4
TiO_2	0,5	0,5
Al_2O_3	2,7	2,3
SiO_2	6,0	6,2
Total	84,9	85,1

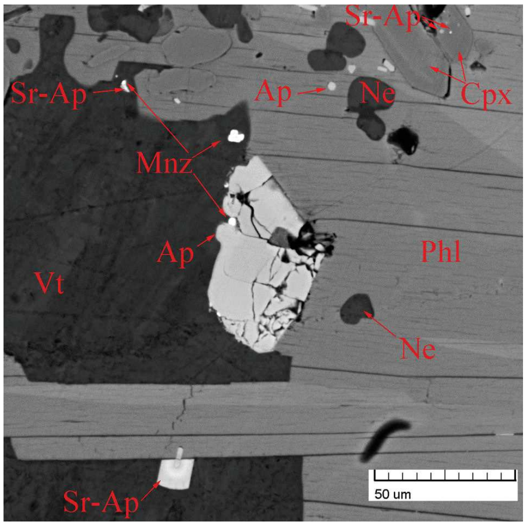

Figure. Minerals from alkaline picrite from Vasilyevskaya 1 drill-hole core.

Chabazite-Sr is the mineral found exclusively in hydrothermalites of ultragpaitic rocks (Пеков, 2001). Such Sr-zeolites are widely developed in the late differentials of the Khibino-Lovozero alkaline complex on the Kola Peninsula. The representatives of chabazite, thomsonite and heulandite series are the main concentrators of strontium in hydrothermalites of many types. Strontium is dispersed in asperolite, aspidelite and other minerals at the igneous stage of development of alkali complexes. Strontium is bound to calcium at hydrothermal stages, compounds with zeolite cavities in the structure become its haven. It has been experimentally proven that strontium enters chabazite in appreciable amounts only in solution, where its concentration is up to 7%. The content of strontium oxide in chabazite does not exceed 0.9 % wt. at strontium lower concentrations in the washing solutions (Ловская, 2005).

We found strontium zeolite in the nephelinite from Tsentrolit 2 drill-hole core. Seeing that the crystals (microns) are of the small size and their percentage in the rock (single grains) is small, only a preliminary diagnosis of the mineral species has been carried out by studying the chemical composition of the mineral by electron microsounding. Mineral was preliminary classified to chabazite-Sr. It was established SrO % wt. was 22.9 in chabazite-Sr (?) which implies the replacement of calcium with strontium in the structure of chabazite and probably it is associated with exposure to high-strontium solutions with a concentration of at least 7%. Besides strontium zeiolites there were revealed fluorite and celestine in the same nephelinite sample by microprobe studies. Their presence may be an indicator of hydrothermal exposure.

Thus, the minerals fluorcaphite, monazite, thorite, chabazite-Sr (?) previously unknown for Upper Devonian igneous complex were found in the ultrabasic alkaline rocks of Pripyat Paleograben and Braginsky and Loevsky Saddle. The presence of such rare and rare-earth minerals in the rocks of this complex indicates the highly alkaline conditions of their crystallization, magma differentiation, possible association with rare metal carbonatites and, as a consequence, the potential prospects of Pripyat Paleograben and conjugate structures for industrially valuable phosphorus ores, rare and rare earth metals.

This research was carried out with financial support from the Belarusian Republican Foundation of Fundamental Investigations (grant № X14M-088).

References

Ковальчук Н.С., Шумилова Т.Г., Козырева И.В. Морфология и особенности химического состава монацита в карбонатитах Косьюкского массива (Средний Тиман) // Известия Коми научного центра УрО РАН. 2011. Вып.1(5). С. 48-52.

Ловская, Е.В. Катионный обмен как важнейший фактор, влияющий на химический состав шабазита в щелочных массивах // Геохимия магматических пород: труды Всероссийского семинара с участием стран СНГ, Москва, 2005, с. 41-42.

Пеков И.В. Ловозерский массив: история исследования, пегматиты, минералы. Москва, 2001, 432 с.

Хомяков А.П. Минералогия ультраагпаитовых щелочных пород. Москва, 1990, 196 с.

Ignatkevich, E.S., Varlamov D.A. Typochemism of the apatite supergroup minerals from Devonian ultrabasic alkaline rocks found in the Braginsky and Loevsky saddle (Belarus) // Ore potential of alkaline, kimberlite and carbonatite magmatism: abstracts of XXX International conference, Antalya, 2014, p. 77–78.