

## Gramenitskii E.N., Shchekina T.I. Accumulation of ore components in the fluorine-bearing granite system

Lomonosov's Moscow State University

*key words: fluidized melts, re-distribution of elements, geochemical indicators*

In order to find out a regularities of relations between magmatism and ore formation, the phase concentrated the ore substance should be found. Such approach is elaborated experimentally in our studies [1-9]. In the melt-crystal and melt-aqueous fluid equilibria, metals are concentrated in melts [1]. On the latest stages of differentiation, a release of salt liquids (fluidized melts) from the residue liquid inevitably occurs. These liquids can bear different salts (chlorides, fluorides, carbonates, phosphates, sulfides). Such fluidized melts are able to selectively extract ore components.

The system (Na, K)-Al-Si-H-O-F has been experimentally studied. A wide immiscibility gap between aluminosilicate and alkali-alumino-fluoride melts is identified in this system [2, 3]. It is related to the limited (3-3.5 %) solubility of fluorine in the silicate melt. The immiscibility is resulted from the formation of complexes  $AlF_6^{3-}$  in the melt, which in connection with alkalis (Na, K, Li) form a liquid phase of composition  $Me_3AlF_6$ .

The forming melts [3, 6] are close in composition to common type of granites, from plagiogranites with the agpaite coefficient 0.7 to sub-alkaline and alkaline granites with the agpaite coefficient 1.2. as well as to Li-F granites, miaskites, and agpaite nepheline syenites. Composition of the silicate melts depends on initial composition of the system, i.e. Si/Al ratio and Na, K, Li content.

A participation of the fluidized fluoride melts in natural processes is proved by the presence of their inclusions in rock-forming minerals (quartz, feldspars, topaz), as well as by a formation of separate bodies in plutonic rocks, such as cryolite lenses in alkaline granites [8]. A participation of salt liquids in alkaline-halide metasomatism at post-magmatic stages of evolution of plutonic complexes, accompanied by ore accumulation, also has no doubt.

Data on partitioning of about 30 elements have been obtained. Three groups of elements are established by the character of partitioning. Elements of the first group, Al, F, Na, K, Li, Sc, Sr, are accumulated exclusively in the aluminofluoride melt with the partitioning coefficient (silicate melt/fluidized melt)  $K_p < 1$ . F, Al, Na, and K form major structural elements of the fluidized melt. Potassium shows an affinity to the silicate liquid, whereas sodium accumulates in the aluminofluoride liquid. Lithium is stronger by the order of magnitude accumulated in the fluoride fluidized melt [3, 4]. That explains a common geochemical relation of Li with F and Na. Therefore, a release of the fluidized melt from the granitic magma is an effective mechanism of Li accumulation in pegmatites on the magmatic stage and in

greisens in the post-magmatic processes. Elements of the second group, W, Mo, Pb, Ge, Ca, Ba, P, Y, REE, are accumulated in the fluidized melt only in some specific portions of the system [5, 6, 9]. Presence of Li assists to the accumulation of some of these elements. The third group is composed of Si, Rb, Ta, Nb, Zr, Hf, Zn, Th, U, which are accumulated only in the silicate melt with the partitioning coefficient  $K_p > 1$ . Addition of Li into the system results in an increase of concentration of some elements (e.g. Zr and Hf) in the fluidized melt, that corresponds to a decrease of  $K_p$ . An increase of  $K_p$  for Nb was observed at the addition of carbon dioxide in all quartz-normative melts and a decrease of this parameter was identified in nepheline-normative melts.

A study of the relative ability for extraction of rare elements into the fluidized fluorine melt from granite and nepheline syenite (plumasite and agpaite) melts showed that only Sc can be extracted from all three melts. La and Ce are extracted preferentially from the granitic melt, HREE and Th are extracted preferentially from the nepheline syenite melt. Eu and Gd tend to accumulate in the fluidized melts released by plumasite melts, whereas Dy, Ho, Lu show accumulation in the fluidized melts released by agpaite melts.

Thus, the factors influencing  $K_p$  of the above elements are established. They are variations of K/Na ratio, addition of Li and a degree of its substitution by K and Na, saturation by silica, agpaite character, and replacement of F for carbon dioxide.

Changes in  $K_p$  is different for close elements. That relates to changes of corresponding "geochemical indicators". As the fluoride melt is released from the granitic magma, the Nb/Ta and Zr/Hf ratios decrease. In miaskite nepheline syenite magmas, similar tendency is observed for the Nb/Ta ratio, but the ratio Zr/Hf does not change. Both ratios increase for nepheline-normative melts. Values of  $K_p$  decrease for HREE in the nepheline syenite portion of the system in comparison to the granitic. In contrast, these values increase for LREE. That results in the increase of the LREE/HREE ratio. Comparison of the data with the natural observations show, that the experimental data on partitioning of the above elements can explain the changes in the geochemical indicators. The data do not contradict to the empirical regularities on relation of ore deposits with specific magmas. The effects related to the release of fluidized melts are important for understanding of elemental geochemistry and ore formation. This mechanism operates on the final stages of differentiation, coupled with the common mechanisms.

The study is supported by the Russian Foundation for Basic Research (projects no. 01-05-64512).

### References:

1. Gramenitskii E.N. // Vestnik Moskovskogo Universiteta. Ser. 4. Geologiya. 1986. no. 2. P. 3-17.
2. Gramenitskii E.N., Shchekina T.I. // Doklady Rossiiskoy Akademii Nauk. 1989. V. 306. no. 6. P. 1446-1450.
3. Gramenitskii E.N., Shchekina T.I. // Geokhimiya. 1993. no. 6. P. 821-840.

4. Gramenitskii E.N., Shchekina T.I. // Doklady Rossiiskoy Akademii Nauk. 1993. V. 331. no. 1. P. 87-90.
5. Gramenitskii E.N., Shchekina T.I., Romanenko I.M. // Doklady Rossiiskoy Akademii Nauk. 1995. V. 340. no. 6. P. 801-804.
6. Gramenitskii E.N., Shchekina T.I. // Geokhimiya. 2001. no. 6. P. 621-635.
7. Marakushev A.A., Gramenitskii E.N., Korotaev M.Yu. // Geologiya rudnyh mestorozhdenii. 1983. no. 1. P. 3-21.
8. Shchekina T.I., Gramenitskii E.N. // Experiment in Geosciences. 1996. no. 1. P. 42-44.
9. Shchekina T.I., Gramenitskii E.N. // Abstract of EUG 9 Union Symposia. Strasburg: Terra Nova, 1997. V. 9. no. 1. P. 530.