FLUORINE SOLUBILITY IN MODEL GRANITIC AND NEPHELINE-SYENITIC MELTS (T=750-800C, 0,1GPA)

Zubkov E.S. Gramenitsky E.N. (geol. dep. MSU)
eszubkov@gmail.com; fax: (495) 932-38-39; phone: (495) 939-20-40

Key words: *phase relation, fluorine solubility, albite, cryolite*

Prerequisites for this investigation are facts of existence of natural fluorine-saturated quartz - and nepheline-normative melts (or magmas). The evidences of these facts are existence of cryolite, elpasolite, villiaumite and some other fluorides as an accessory minerals and crystalline inclusions in respective rocks, and dataset about fluorine concentration up to 8.9% wt in melt inclusion in the quartz and topaz from granite and granite pegmatite [1].

The fluorine solubility in aluminosilicate melt and phase relations in the system Si-Al-Na-O-F at 750 and 800^{o}C and water pressure equal to 0.1GP was investigated in our experiment. The most part of the experiments were preformed in cold-seal pressure vessel in the laboratory of Experimental Petrology of the MSU Geological Department, some part - at rapid-quench cold-seal pressure vessels in the IEM RAS (cooling to solidus temperature less than in 10 second). Duration of the experiments was about 7 days (160-170 hours). Precision of pressure measurement was ±50 bars, precision of temperature was ±5^{o}C. Starting mixes were produced from dry stoichiometric gels and were placed in ampoules prepared from seamless platinum tubing, and then ampoules were squeezed and welded. Water content was 7% wt. According to [2], [3], there are only evaluation data about water solubility in synthetic aluminousilicate melts with fluorine, from 4-6% wt in quartz-bearing area to 12.5% wt in strongly peraluminous melts. Taking in consideration that considerable parts of run products are water-free silicate phases and fluorides, and wet surface of the most part of our samples after extraction from the ampoules, it is possible to estimate that during the experiments. There were water-saturated conditions

Each sample was divided into 2 parts. First part of the sample was placed into epoxy block and analyzed by the electron microprobe CAMSCAN MV 2300 (IEM RAS) and by the device on basis of electron microscope «Jeol ISM-6480LV» and EPMA «INCA-Energy 350» at the MSU Petrology Chair. Second part of the sample was pulverized in agate mortar for the X-ray powder diffraction investigation by DRON device at the chair of Crystallography, MSU.

In cooperation with V.O. Yapaskurt (Laboratory of Electron Microprobe Analyses, chair of Petrology, MSU) we perform some methodical work for the optimization analyzable element's profiles. For the minimization of the statistical errors we applied the calibration with standard natural silicates and fluorides - chiolite ($Na_5Al_3Si_{14}$), cryolite (Na_3AlF_6), cryolithionite ($Na_3Al_2Li_3F_{12}$), MgF_2, feldspars. Absolute accuracy (analytical uncertainty) of measurement fluorine by this program ais adout ±1% rel, relative accuracy ±1.5% rel.

Obtained data are presented at the fig. 1. It is an isothermal section of our system at 750^{o}C in the coordinates Si/(Si+Al+Na) - lg(Na/Al). The main rule is increasing fluorine solubility from 1% wt in quartz-normative area to 30% wt in the equilibrium with fluorosodalite, under conditions decreasing of bulk SiO_2 in the system. Hence, fluorine and silica content have inverse correlation. The main rule is complicated by local maximum fluorine solubility in the area of albite composition (10% wt in the melt).

Comparison of our data with forerunners' data [4] shows the considerable decrease of the melt area with temperature decrease from 800 to 750^{o}C (fig. 2). Small expanding melt area 750^{o}C relatively to 800^{o}C at the equilibrium with quartz and fluorosodalite is the result of inaccurately draw of border owing to absence of experiments in these areas. Fluorine solubility increases with decreasing silica in melt at both temperatures, however, the regularity of distribution of local maxima is changing dramatically. There are 3 local maxima: in the area of quartz-albite, albite-nepheline eutectics, and the third, apparently, is a consequence of changing liquid phase (evidence of saturation of melt by fluorine) from cryolite to villiaumite and corresponding structural rebuilding of the melt. The latter maximum certainly present at T=750^{o}C. New experiments will confirm that idea.

The albite is unstable in the fluorine-bearing system It is confirmed by existence of fluorine-bearing (F=10% wt) melt, having albite composition, and by the absence of albite's peak at the X-ray diagrams. The series of experiments were realized that made it clear that albite is stable in the equilibrium with quartz and glass with fluorine content up to 2.5% wt (bulk 2% wt fluorine in the system). It

is remarkable that feldspar in K-bearing system is stable in the equilibrium with fluorine-saturated melt.

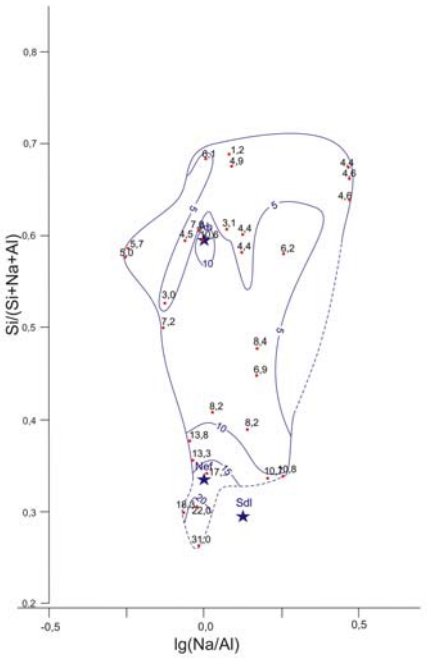

Fig.1. Border of stability of fluorine-bearing aluminousilicate melt at T=750°C. Numbers near points is fluorine solubility in aluminousilicate melt

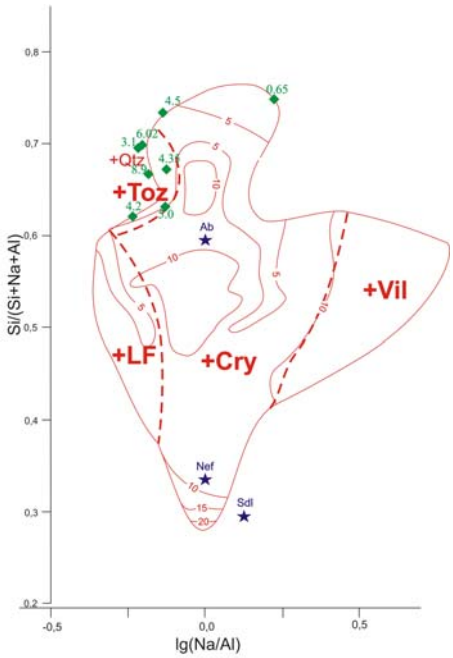

Fig.2. Border of stability fluorine-bearing aluminousilicate melt at T=800°C. Rhombuses - compositions of melt inclusions. Numbers near points is fluorine solubility in aluminousilicate melt

The obtained regularity disproves thermodynamic calculation [5] that suggests the increasing of fluorine solubility with the increasing of silica content in the system. There is a good accordance between experimental dataset and results of study of melt inclusions both in main petrologic components and in levels of fluorine solubility in melts (fig. 2). Composition areas of melt inclusions from quartz and topaz coincide with experimentally determined area of their crystallization. Fluorine concentration in the melt increases in general with joint crystallization of albite and quartz, but at 750°C this value don't reach saturation point. System saturation takes place at more low, near eutectic temperatures, when quartz, albite and cryolite are crystallize in general. That pattern can explain presence of accessory cryolite in granites. There are no data available about study of melt inclusions from nepheline, as well as data about evidence of existence of fluorine-saturated melts, except strongly peralkaline area of the system.

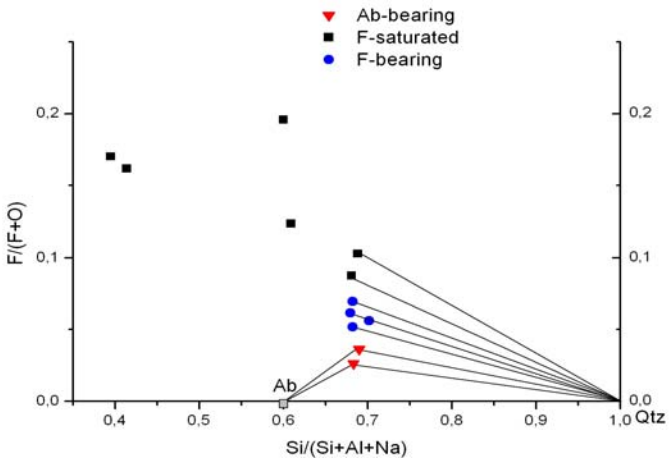

Fig.3. Albite stability with fluorine-unsaturated melt

References

1. Thomas R., Klemm W. Microthermometric Study of Silicate Melt Inclusions in Variscan Granites from SE Germany: Volatile Contents and Entrapment Conditions // Journal of Petrology. 1997. V. 38. No 12. P. 1753-1765.

2. Dolejs D., Baker Ron D. Liquidus Equilibria in the System K_2O-Na_2O-Al_2O_3-SiO_2-F_2O_{-1}-H_2O to 100 MPa: II. Differentiation Path of Fluorosilicic Magmas in Hydrous System // Journal of Petrology. 2007. V. 48. No 14. P. 807-828.

3. Johannes W., Holtz F. Petrogenesis and experimental petrology of granitic rocks // Berlin – Heidelberg: Springer-Verlag. 1996. 335p.

4. Gramenitsky E.N. Shchekina T.I. Devyatova V.N. Phase relations in fluorine-bearing granitic and nepheline-syenitic systems and elements distribution between phases // Moscow. GEOS. 2005. 186p.

5. Dolejs D, Baker Ron D. Thermodynamic analysis of the system Na_2O-K_2O-CaO-Al_2O_3-SiO_2-F_2O_{-1}-H_2O: Stability of fluorine-bearing minerals in felsic igneous suites // Contrib. Mineral. Petrol. 2004. V. 146. P. 762-778.

Electronic Scientific Information Journal "Vestnik Otdelenia nauk o Zemle RAN" № 1(27)'2009
ISSN 1819 – 6586
Informational Bulletin of the Annual Seminar of Experimental Mineralogy, Petrology and Geochemistry – 2009
URL: http://www.scgis.ru/russian/cp1251/h_dgggms/1-2009/informbul-1_2009/magm-14e.pdf

Published on July, 1, 2009