# MINERALS - INDICATORS OF TPX-PARAMETERS OF PETROGENESIS AND ACTUAL TASKS OF EXPERIMENTAL MINERALOGY

**Kotelnikov A.R., Suk N.I., Kovalsky A.M.** (IEM RAS)**, Kotelnikova Z.A.** (IGEM RAS)
*kotelnik@iem.ac.ru*; tel. (496-52) 25-857; fax (496-52) 44-425

Key words: *Mineral thermometers, thermodynamics, tasks of experimental mineralogy*

The investigation of TPX-parameters of geological processes, mineral and petrogenesis which determine minerals and rocks multiplicity is one of the main directions of recent petrology. Traditionally the mineral thermometry was used for estimation of P-T parameters of metamorphic complexes evolution mainly. Recently the necessity to study the complicate fluid-magmatic systems has been arisen. From one side it is connected with high ore ability of these systems, from another - with the development of ideas about trans-magmatic fluids, P-Q - type solutions, active fluids, liquid immiscibility, etc. The complicate evolution processes need the new methods of their investigation. They are thermodynamic calculations based on the mineral equilibria, sample-collecting devices which allows studying of compositions of mineral environment immediately and experimental modeling of mineral forming processes.

Estimation methods of mineral genesis TP-parameters (used mineral equilibria) include following points:

- equilibria of minerals with constant compositions;
- study of element distribution between nonequivalent positions in mineral crystal structure;
- the distribution of element admixtures between mineral phases;
- isotopic equilibria;
- study of phase T-X diagrams of mineral solid solutions;
- thermo- and barometry of fluid inclusions;
- equilibria mineral - fluid allowed calculating fluid composition.

Method of minerals - indicators for TPX-parameters estimation is worked-out best for the metamorphic complexes. The causes of this are following:

1. Long duration of metamorphic processes (~n*$10^6$ years) leaded to thermodynamic equilibrium mineral associations;

2. Sufficient high TP-parameters of mineral reactions that increase their velocity and lead to equilibrium state arrival;

3. Multicomponent systems postulate (according phase rule) presence of two (ore more) mineral phases - solid solutions which allow calculating TP-parameters according phase component distribution.

For the metamorphic processes according aforecited reasons it will be soon the possibility to pass completely on the theoretical calculation model method. Successful using of the program complex “Selector” for the estimation of evolution parameters of metamorphic complexes is an example of this thesis.

But there are a number of geological objects interesting in science and important in practice for which it is difficult to use the thermodynamic modeling according following reasons:

(1) absence of dependable thermodynamic data of individual phases, fractions in fluids and melts, solid solutions and others; (2) high velocities of crystallization processes make using of equilibrium thermodynamics apparatus difficult (in magmatic complexes); (3) relatively low mineral forming temperatures and specific paragenesis (diaphthorites) for which minerals the dependable thermodynamic data is practically absent.

Moreover, a number of objects (perhaps during fractional crystallization by increasing of volatile components concentration in residual melt and for existence of oversaturated volatile melts - immediately) demonstrate the properties of fluid-magmatic systems complicated by peculiarities of P-Q type systems. In these systems there are wide spread liquid immiscibility.

Zharikov V.A. (1976), Marakushev A.A. (1979), Kogarko L.N. (2002) indicated the existence of such systems in natural objects. Kogarko L.N. (2002) has pointed out that there are two characteristic processes of magmatic rocks forming: (1) with separation of volatile (and ore) components in distinct fluid phase; (2) without volatile separation - under certain physics-chemistry parameters during crystallization process of high alkaline (ultra agpaitic) magma the progressive transition from magmatic melt to hydrothermal solution (without separation of water into gas phase) may occur. In such a case ore minerals concentrate directly in massif body. Agpaitic alkaline complexes are just related to such

systems. For these natural systems it is very important to know TP-parameters evolution and volatile regime of mineral forming.

In this report the different mineral equilibrium are examined. These mineral equilibria are used for mineral thermo- and barometry (with minerals of constant composition, as well as with mineral solid solutions). The necessity of kinetic study of some mineral reactions for correctly application to estimation of TP- parameters of mineral genesis evolution is demonstrated.

We have worked out a number of minerals - indicators for the temperature and fluid compositions estimation during alkaline agpaitic massifs mineral genesis. Cooperative with colleagues of Vernadsky Institute RAS Ustinov V.I. and Grinenko V.A. (2006) we have experimentally studied the intrastructure distribution of oxygen isotopes in the sodalite (nozeane) structure depending on temperature and have created monomineralic thermometer which was used to estimate the temperatures of sodalite paragenesis forming in Lovozersky massif. The use of different mineral equilibria allow to estimate the TPX- parameters evolution trends during the development of complicate fluid-magmatic systems (such as ultra alkaline magmatic complexes of Kola Peninsula).

However it is necessary to work out special mineral thermometers for the dimension of temperature of alkaline rock mineral genesis based on the equilibria of triple solid solutions of alkaline clinopyroxenes and amphiboles.

The possibility of application of some mineral equilibrium (such as sodalite±nepheline - fluid; cancrinite - fluid; ussingite±albite - fluid; nepheline - aegirine - albite - magnetite - fluid) for estimation of the fugacity of fluid's components during evolution of petrogenesis is demonstrated.

So, it has been shown that experimental data of different phase equilibria is extensively used for the thermo- and barometry of natural geological complexes of different types of rocks. It has been made much. But it has to do much more.

We can chalk out some tasks of experimental mineralogy:

1. Study of phase diagrams and phase correspondence in fluid-magmatic systems with participation of P-Q type solutions. Liquid immiscibility is studied in fluid-magmatic and magmatic systems.

2. - Study of rheological properties of fluid-magmatic systems with participation of P-Q type solutions;

3. - Estimation of thermodynamic properties of dry and volatile saturated magmatic melts of different compositions;

4. - Investigation of transporting forms of main, minor and ore elements in fluid phase and especially in "high fluid" phase of fluid-magmatic P-Q type systems;

5. - Development of mineral thermometers for the estimation of TP-parameters of alkaline magmatic rock mineral forming (thermometers based on the associations CPx±Bi±Amf) and for the low stage metamorphism rocks (thermometers based on the paragenesis Cb±Chl±Gr);

6. - Experimental development of methods and materials for the technogenesis waste immobilization (especially - radioactive waste);

7. - Creation of new materials for the industry (nanomaterials, special ceramics and construction materials with predetermined properties).

*This work is supported of RFBR grant №06-05-64904*

**References**

*1. Kogarko L.N.* Problems of giant rare metal deposits of Kola Peninsula genesis. In: Russian Arctic: geological history, mineral genesis, geoecology // S-Petersburg. 2002. P. 773-787.

*2. Marakushev A.A.* Problems of layering intrusives genesis. In: Contact processes and mineralization in gabbro-peridotite intrusives // M.: Nauka. 1979.

*3. Ustinov V.I., Kotelnikov A.R., Grinenko V.A.* Temperature diapason of sodalite-bearing associations forming // Geokhimia. 2006. No 2. P. 230-232.

*4. Zharikov V.A.* Basis of physics-chemistry petrology // M.: Press MGU. 1976.

*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-20e.pdf*

*Published on July, 1, 2009*