Voloshina Z.M., Karzhavin V.K. Modeling of heterogeneous equilibria at metamorphism of basic rocks from the Pechenga structural zone.

The Institute of Geology of Cola Scientific Center RAS 184200 Murmansk district, Apatity, ul. Fersmana 14
karzhavin@geoksc.apatity.ru

The Pechenga volcanic-sedimentary formations occur in the northwest part of the Cola peninsula. The rocks of this geological structure are regionally metamorphosed in prehnite-pumpellyite up to lower stages of amphibolite facies [1]. The prehnite-pumpellyite facies zone is mapped by the upper limit of pumpellyite paragenesis stability in metavolcanics [2] and occupies the central part of the Matert-pilgu-yarvinskaya series. The pumpellyite bearing volcanic and subvolcanic rocks are characterized by well preserved magmatic structures and textures. Magmatic clinopyroxene and also prehnite, pumpellyite, stilpnomelane, chlorite, albite, leucoxene, epidote are typical.

Mathematic modeling of heterogeneous equilibria in natural systems was realized on the basis of the studied sample from the low temperature zone of metamorphism with the following initial chemical composition (wt.%): SiO_2 – 48.64; TiO_2 – 1.76; Al_2O_3 – 13.33; Fe_2O_3 – 2.48; FeO – 9.79; MgO – 5.58; CaO – 11.94; Na_2O – 2.50, K_2O – 0.15; H_2O – 3.80; C – 0.05. The geochemical model of the system based on macro and microelement distribution was created. The thermodynamic conditions of the studied environment are as follows: 200-650^oC temperature range and pressure is up to 10 kbar. The multisystem that was initial for numeric processing consisted of 11 independent components (Si-Ti-Al-Fe-Mg-Ca-Na-K-C-H-O). The thermodynamic values for a number of minerals and chemical compounds of the modeled multisystem were taken from the earlier published literature and reference books [3-6]. The two calculation variant were considered: the multisystems with variable contents of water and those with variable contents of carbon dioxide.

<u>A model with variable water content (at constant initial carbon dioxide content).</u> The thermodynamic calculations showed that a relatively unsubstantial change in concentration of albite, microcline and a titanium-bearing mineral - sphen up to 500^oC, ilmenite at higher temperatures – was fixed for the initial composition of the multisystem within the interval of indicated T and P with changing water content from 1.9 to 7.6 wt.%. The anorthite concentration is stable in the system without water or at insignificant water content. Increasing water content leads to transformation of its content – the snorthite stability field and its concentration expands, the anorthite field border being shifted to higher temperature field. Under the same given conditions like those for anorthite the diopside stability field substantially changes. It should be noted that quartz stability of the studied system also depends on water concentration. Concerning the hydroxyl-bearing minerals of the given modeled system their behavior is not obvious though the border of their stability in PT-diagram is practically stable in the 300-500^oC interval. Prenite and pumpellyite formation is strictly determined by water content in the system (at 2 % and higher). The epidote field stability is shifted to the field of low temperatures and its concentration abruptly decreases at dehydration of the system. The chlorite and ferroactinolite contents are also well correlated with water content in the system. The hornblende behavior is absolutely opposite; the role of hornblende is increased with decreasing water concentration especially in the field of high pressures. A quite strict correlation of increasing concentration of hydrogen and carbon dioxide with water in the field of high pressures and low temperatures can be observed.

<u>A model with variable carbon dioxide concentration (at constant water content)</u>. The carbon dioxide inflow contributes to decreasing concentration of anorthite in the field of low temperatures, and the pressure decrease in the system causes its stability border to shift (expanding its stability field) from 350 to 550^oC. Diopside is stable in the field of high pressures and a temperature higher than 550^oC. The carbon dioxide affect on stability of hydroxyl-bearing minerals is ambiguous. The ferroactinolite and hornblende stability field expands from 350 to 500^oC with pressure increasing. The temperature increase causes decreasing ferroactinolite concentration unlike hornblende, the content of which would increase with pressure increasing in the system. The stability conditions for prehnite and pumpellyite are close, their temperature limit is 350^oC. A typical stability of pumpellyite should be noted, its content is always predominant over prehnite.

References:

1. Petrov V.P., Voloshina Z.M. Regional metamorphism of Pechenga structure // Magmatism, sedimentorygenesis and geodynamics. Apatity, KNTs, 1995, pp.164-182.
2. Voloshina Z.M., Petrov V.P., Rezhenova S.A. et al. Pumpellyite paragenesises of metabasites from Pechenga // The new data on mineralogy of magmatic and metamorphic complexes: Kola Peninsula. Apatity KNTs SSSR, 1986, pp.16-24.
3. Harumi Yokokawa. Tables of thermodynamic properties of inorganic compounds // J. Nat. Chem. Lab. Ind. (Spes. Iss). 1988. V.83.pp-.27-121.
4. Berman R.G. Internally-consistent thermodynamic data for minerals in the system Na_2O- K_2O-CaO-MgO-FeO-Fe_2O_3-Al_2O_3-SiO_2-TiO_2-H_2O-CO_2 // J. Petrol. 1988. V.29. N.2. pp. 445-522. Holland T.J.B., Powell R. An enlarged and update internally consistent thermodynamic dataset with un certainties and correlations: Na_2O-K_2O-CaO-MgO-FeO-Fe_2O_3-Al_2O_3-SiO_2-TiO_2-H_2O-CO_2-O_2 // J. Metamorph. Geol. 1990. V.8. N.1. pp.89-124.
5. Karzhavin V.K. Amphibolites. Thermodynamic properties. // Geochemistry. 1991. N.12. pp.1724-1732.
6. Nitsch K.H. Stabilitstbeziehungen von Prenit- und Pumpellyit-haltegen Paragenesen // Contrib. Miner. Petrol. 1970. V. 30. N. 3. pp. 240-260.
7. Vinkler G. Genesis of metamorphic rocks. // M., Nedra, 1979. 327 p.
8. Lio J.G., Maruyama S., Cho M. Phase equilibria and mineral parageneses of metabasites in low-grade metamorphism // Miner. Mag. 1985. V.49. Part 3. pp. 321-333.