Gartvich Ju. G.[1], Surkov N.V.[2], Drebushchak V.A.[3] **Clinopyroxene geobarometer for eclogites**

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Paleogeothermobarometric constructions for deep rocks and the stratification of mantle-derived xenoliths are getting rather customary procedures for theoretical reconstruction of the upper mantle structure and global tectonic constructions. The various methods of mineral geobarometry are developed for these purposes. The large variety of geothermobarometric relationships is based on the cations (calcium, magnesium, iron and so on) occupying different sites in the structure of a mineral or distributing among coexisting minerals. Most popular geothermobarometric relationship is the composition of clinopyroxen investigated in a section $CaMgSi_2O_6$ - $Mg_2Si_2O_6$ [1]. The geobarometric relationships are not large in numbers and most favorite among them are those connected with the distribution of aluminum cations between two sites, four-fold and six-fold coordination, investigated in the system MgO-Al_2O_3-SiO_2 [2].

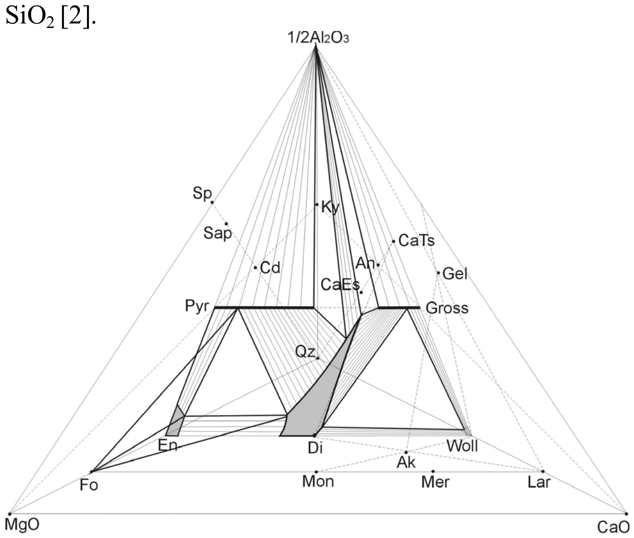

Fig. 1. Phase relations in the system CaO-MgO-Al_2O_3-SiO_2 at pressure 30 kbar and T =1200 °C

Most popular geobarometers are tested in the simplified synthetic systems. This makes it very important to choose the model system. Major components in the composition of deep paragenesis are the oxides of Ca, Mg, Al, Si, Fe, Na, Cr, Ti, K etc. The oxides of the first four components account 80-90 % of the bulk composition of deep rocks, the other components manifest themselves as isomorphic impurities in the phases of the system CaO-MgO-Al_2O_3-SiO_2. Besides, this system provides almost all the phases occurring in deep paragenesises (fig. 1) [3]. The comparison between the phase relations in the system CaO-MgO-Al_2O_3-SiO_2 and the mineral relations in deep paragenesises shows the similarity in their phase boundaries. This suggests that the system CaO-MgO-Al_2O_3-SiO_2 is a suitable object for the modeling of deep rocks.

The stepping stone in the phase diagram of the system CaO-MgO-Al_2O_3-SiO_2 is a nonvariant point (An,Fo,Sp,Cpx,Gr,Opx) [4] where the beams directed to the high-temperature part of the phase diagram and indicating monovariant reactions An+Fo=Cpx+Opx+Sp, Opx+An+Sp=Cpx+Gr and Sp+Opx+Cpx=Gr+Fo (fig. 2).

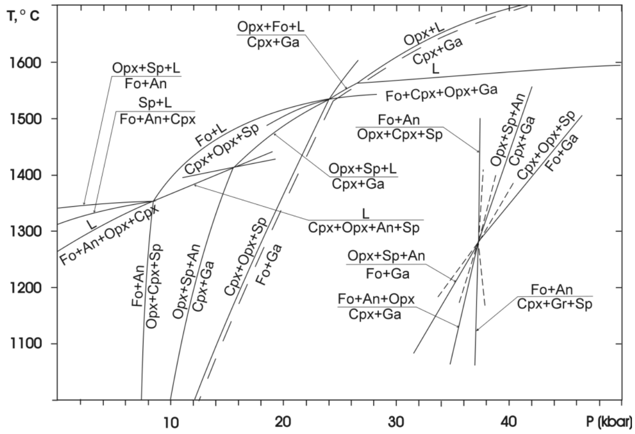

Fig. 2. Topology of monovariant reactions of the system CaO-MgO-Al_2O_3-SiO_2

The reaction Opx+An+Sp=Cpx+Gr has fundamental significance as the tie-line "garnet-clinopyroxen" is stable at higher pressures relative to the beam of the reaction. Subsequently, a number of associations referring to the paragenesises of eclogite-like rocks, purely eclogites, garnet pyroxenite and so on are stable too. The clinopyroxen-garnet association in the system CaO-MgO-Al_2O_3-SiO_2 is not divariant, and the composition of coexisting phases depends not only on temperature and pressure, but also on bulk composition of a system. Solution to a problem on the development of geobarometric relationship is possible because the clinopyroxens in this association are the multicomponent solid solutions and are characterized by two types of isomorphic substitution: 1) occupation of the position M2 with divalent cations and 2) occupation of the sites, normally occupied with cations Al^{+3}, with silicon atoms according to the tchermakite scheme $_{VI}R^{+2}{}_{IV}Si^{+4}{=}_{VI}Al^{+3}{}_{IV}Al^{+3}$. It means that the clinopyroxen composition depends on temperature and pressure. As a parameter taking into account the composition of a system, the calcium content of garnet can be considered [3]. The simplest geobarometer for eclogite paragenesis must consist of two equations. For the calculation of temperature and pressure these equations need three parameters: the enstatite component content of clinopyroxen, the calciumtschermakite component content of clinopyroxen, and the grossular component content of garnet.

For the development of eclogite geobarometer, the detailed experimental investigations of the composition of coexisting clinopyroxen and garnet in the magnesium part of Cpx+Gr association of the system CaO-MgO-Al_2O_3-SiO_2 were conducted in a temperature range from 1200 to 1585 °C and pressure 15 - 30 kbar. The experiments were performed using the high-pressure apparatus "piston - cylinder" according to a conventional technique [4]. The temperature was measured with thermocouple PtRh6-PtRh30. The starting materials for the synthesis were prepared by mixing the oxides, preliminary heated, of super high-purity mark and melting them into a transparent glass. The samples obtained were used to produce two-sided polished petrography plates, which were studied with usual petrographic methods using the polarizing microscope. The products were analyzed with X-ray diffraction methods, the composition of phases was determined with the electron microanalyser.

Table 1. Coefficients of polynomials fitting the relationship between composition of coexisting clinopyroxene and garnet as a function of temperature and pressure.

	Temperature	*Pressure*
f_1	1794.9028	97.372239
f_2	-805.4903	-64.51706
f_3	-1809.595	15.310452
f_4	-774.2796	-248.6717
f_5	3424.7345	157.20992
f_6	-2679.645	25.737019
f_7	-4839.156	242.51907
f_8	1827.7546	31.650826
f_9	5943.542	-403.9175
f_{10}	3367.0297	173.69664
N	39	39

The barometric relationship for the occupancy of crystallographic sites in four-fold coordination with aluminum cations was established. The occupancy of the crystallographic sites in the structures of clinopyroxen and garnet with magnesium and calcium cations turned out to depend on temperature. The enstatite and calciumtschermakite content of clinopyroxen increase with increasing pressure. The enstatite content increases with increasing temperature but no notable changes in the calciumtschermakite content were detected. The garnet becomes more magnesium with increasing pressure and temperature. Using the data on variations of composition of coexisting solid solutions with varying temperature and pressure, the coefficients of two polynomials $F=f_1+f_2x+f_3y+f_4z+f_5x^2+f_6y^2+f_7z^2+f_8xy+f_9xz+f_{10}yz)$ fitting the experimental composition of coexisting clinopyroxen and garnet as a function of temperature and pressure (table 1).

The note: x is the content of $Ca_3Al_2Si_3O_{12}$ in garnet (mol. %); y is the content of $Mg_2Si_2O_6$ in clinopyroxen (mol. %); z is the content of $CaAl_2SiO_6$ in clinopyroxen (mol. %); N is the number of points.

The relationship obtained can be used only under suggestion that aluminum cations occupying the sites with six-fold coordination in the structure of clinopyroxens do not affect essentially the aluminum and silicon cations occupying the sites with four-fold coordination. and the iron and sodium cations do not affect noticeably the distribution of magnesium and calcium cations between clinopyroxen and garnet.

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