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Physico-chemical transition from peridotite assemblage to the eclogite one (experimental data at 7.0 GPa).

Valentina Butvina and Yurii Litvin
IEM RAS, Chernogolovka, Russian Federation (valkil@yandex.ru)

Peridotites and eclogites, including diamond-bearing ones, are the basic ultra-basic and basic rocks of the upper mantle (Ringwood, 1969, 1975; Sobolev, 1974; Marakushev, 1985; Taylor & Anand, 2004). These rocks are presented in the assemblage of mantle xenolyths in kimberlites, but the basic minerals of peridotite paragenesis, olivine, orthopyroxene, garnet and clinopyroxene as well as of an eclogite paragenesis, garnet and omphacite are wide-spread synthetic inclusions in diamonds. The cases of finding minerals and peridotite and eclogite parageneses in diamond are described. It implies that these parageneses can have a single mantle source. However, the formation of peridotite and eclogite mineral parageneses at differentiation of the primary ultrabasite melt during physico-chemical single process is possible only at overcoming the “eclogite” thermal barrier (O’Hara, 1968; Litvin, 1991).

Eclogite genesis is one of the most difficult and discussional problems of modern petrology. Among investigators there is an opinion about eclogite heterogeneity not only on conditions of formation (crust, mantle), but also by composition of the initial rocks (para-, orthoeclogites) as well as by the way of their formation (magmatic, metamorphic, metasomatic). In literature diamond-bearing eclogite nodules of kimberlite pipes are often considered as metamorphic, which are formed at subduction of the Archean or of the Proterozoic oceanic crust (MacGregor & Manton, 1986; McCandless & Gurney, 1986, 1997 et al.). Only the presence of Na_2O in garnet and K_2O in clinopyroxene is a criterion of their participation in mantle magmatic processes.

Together with the hypotheses considered on eclogite origin there exists a version suggested in papers (Kushiro, 1972; Kushiro & Yoder, 1974), according to which mantle eclogites could be formed due to peridotite substance in the processes of fractional crystallization of ultrabasite magmas. The present paper is devoted to the experimental study of this problem.

Physico-chemical transition from peridotite assemblage to the eclogite one can be only ensured by the processes of fractional crystallization of mantle magmatic melts. The primary melting and magmatic evolution of mantle garnet lerzolite (or the Ringwood pyrolite) is controlled by a five-phase peritectics “p” Ol+Opx+Cpx+Grt+L and four cotectic curves conjugated to it (Litvin, 1991). In melting and evolution of melts of both olivine eclogites and coesite and corundum eclogites the corresponding five-phase eutectics are of a dominant importance. A general ridge for all elementary tetrahedrons (simplexes) is a line of compositions diopside-pyrope (clinopyroxene-garnet) which bimineral eclogite assemblages belong to. The internal section En-Di-Cor of the general tetrahendric diagram (symplex complex) separates olivine-saturated and silica-saturated compositions. “Eclogite” thermal barrier is “thermal barrier” on (O’Hara, 1968), on the cotectic line Opx+Cpx+Grt+L, connecting “peridotite” peritectic and “eclogite” eutectic points.

Meanwhile, at equilibrium (and fractional) crystallization of peridotite system in the peritectic point “p” orthopyroxene vanishes as a result of the peritectic reaction “orthopyroxene + melt → clinopyroxene” (Davis, 1963; Litvin, 1991). With further temperature decrease the composition of the remnant melt is controlled by the nonorthopyroxene cotectics Ol+Cpx+Grt+L first, in the limits of the peridotite “simplex”, but then mechanism of fractional crystallization is also realized in the limits of the olivine-eclogite “simplex” up to the corresponding nonvariant eutectics.

The considered cotectics Ol+Cpx+Grt+L is of the greatest interest from the viewpoint of a possible change of compositions of remnant melts from olivine-normative to silica-normative ones. One can assume that under the conditions of fractional melt crystallization along the cotectic curve Ol+Cpx+Grt+L together with olivine jigging accumulation of incorehent elements, including Na, Fe etc. takes place. It leads to a gradual increase of jadeite component content in remnant melts what creates grounds for reactional interaction of jadeite and olivine components with olivine vanishing and garnet formation in accordance with the reaction found in (Litvin et al., 2004). A gradual decrease of olivine component content in remnant melts caused by that fact realizes a "turn" to the cotectic curve Ol+Cpx+Grt+L in the direction of the boundary section En – Di – Cor and, probably its exit to the line Di–Prp (clinopyroxene-garnet). Further under the conditions of fractional crystallization melt composition point can penetrate into the volumes of coesite-eclogite, kyanite-eclogite and corundum-eclogite "symplexes". Thus, an overcoming of "eclogite" thermal barrier between olivine-normative peridotite-pyroxene and SiO_2 – normative eclogite compositions occurs. So, one can speak about the "destruction" of liquidus peridotite-eclogite thermal barrier in the limits of the peridotite "simplex" as a result of realization of two reaction mechanisms: (1) vanishing of orthopyroxene as a result of its peritectic reaction with the melt with clinopyroxene formation and (2) olivine vanishing as a result of its reactional interaction of jadeite with garnet formation. If with respect to the first mechanism definite experimental evidence exists (Litvin, 1991; Davis, 1963) then for the second mechanism it is absent.

Due to this fact the main purpose of this paper is an experimental study of phase relationships in the model system forsterite-dioside-jadeite at pressure of 7 GPa and foundation of possible physico-chemical correct transitions between peridotite and eclogite parageneses with overcoming liquidus "eclogite" thermal barrier. To construct a diagram of a ternary system forsterite-diopside-jadeite it is necessary to study its boundary binary sections forsterite-jadeite and fosterite-diopside as well as a number of internal polythermic sections. The section jadeite-diopside at 7 GPa has been studied earlier (Bobrov, Litvin, Kojitani, Akaogi, 2006; 2008) and it is characterized by the unlimited miscibility of jadeite and diopside components in solid and liquid states.

The first experimental results obtained at the initial stage of the investigation of this problem can be characterized as follows.

For the experimental study polythermic sections of forsterite-(jadeite$_{50}$diopside$_{50}$) and forsterite-(jadeite$_{25}$diopside$_{75}$) have been chosen. The obtained data testify to the fact that olivine vanishing and garnet formation are realized in both sections. The problem of further investigations is to search minimum concentrations of jadeite in the composition of this system where a total olivine vanishing takes place.

Thus, the performed experimental investigations of the model system forsterite-diospside-jadeite at pressure 7 GPa testify to the fact that forsterite (olivine) is a stable phase in the boundary system forsterite-diopside (olivine-clinopyroxene). While introducing rather low contents of jadeite component into the composition of this system the reaction of jadeite component with forsterite takes place in the melt. As a result, garnet appears as liquidus phase.

With the increase of the jadeite component concentration in the system the field of liquidus garnet expands, but a physico-chemical control of crystallization differentiation of the remnant melts transforms from the monovariant cotectics Fo + Di_{SS} + L through the invariant peritectic point Fo + Di_{SS} + Grt + L to the monovariant cotectics Grt + Cpx + L, which is responsible for crystallization of bimineral garnet-omphazite eclogite parageneses. The obtained experimental results testify unambiguously to the fact that in the system Fo-Di-Jd a physico-chemical mechanism of overcoming liquidus peridotite-eclogite barrier at mantle magma differentiation is realized. Thus, a gradual transition from olivine-bearing assemblages to those close by their characteristics to bimineral eclogites is provided.

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