TYPES OF ECLOGITE PALEOGEOTERMS IN THE UPPER MANTLE

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The knowledge of the equilibration conditions, temperature and pressure of eclogite garnet-clinopyroxene rocks, is required to solve the fundamental problems of their origin and dynamics in the upper mantle. The lack of reliable barometers for the bimineralic garnet-clinopyroxene rocks makes estimation of pressure difficult. Early Newton (1986) proposed a geobarometer for group B and group C eclogites (Coleman et al., 1965), that requires the presence of a third phase, quartz. Mantle eclogites (group A by Colleman et al., 1965) are most bimineralic and characterized by high Na and Al contents in clinopyroxenes.

Model of garnet-clinopyroxene barometer for deep mantle eclogites were developed on the base of the reaction (Simakov, 1995):

$$\underset{\text{Gross}}{Ca_3Al_2Si_3O_{12}} + \underset{\text{Pyr}}{2Mg_3Al_2Si_3O_{12}} + 4XSiO_2 + XNa_2O \rightarrow \underset{\text{Jad}}{2XNaAlSi_2O_6} +$$
$$\underset{\text{Diop}}{0.5(1+X)CaMgSi_2O_6} + \underset{\text{CEnst}}{0.5(11-X)MgSiO_3} + \underset{\text{CaTs}}{(3-X)CaAl_2SiO_6}$$

Thermochemical data for this reaction are taken from database of Berman (1988). Pyrope and grossular activities in garnet are calculated in accordance with Moecher et al. (1988) model (because in this model α_{Gr} is independent of pressure). Pyroxene activities are taken from the models of Navrotsky (1987) and Holland (1990). Activities of Na_2O and SiO_2 are assumed as 1. Molar volumes for pyrope and grossular components in garnet and for chermakite, diopside and clinoenstatite components in pyroxene are taken from the models of Aranovich (1991) and Mukhopadhyay (1991). Jadeite molar volume is calculated from assumption of Jad-Diop ideal solution. The model of geothermobarometer was calibrated on the base of experimental data of Akella (1976), Green and Adam (1991) and Kato (1989), which cover interval in temperatures from 1150 up to 1700 °C and in pressures from 30 up to 100 kbar. As a result, equation which connected values of "X" in the reaction and X_{Na} in garnets was obtained:

$$X = 1.965 - 188.485X_{Na}^{Gr} + 8535.3(X_{Na}^{Gr})^2 - 167420.813(X_{Na}^{Gr})^3 + 940886.813(X_{Na}^{Gr})^4$$

Model of well-known Ellis and Green garnet-clinopyroxene thermometer improved by Nikitina and Ivanov (1993) and our barometer is the most accuracy pair for the experimental data (Table. 1).

N^o	P(kb)	$T^o(C)$	X^{Gr}_{Na}	X^{Cpx}_{Jd}	P_1(kb)	$T^o_1(C)$
1315	30	1150	0.0043	0.15	30.5	1270
10	44	1300	0.011	0.11	41.8	1150
8006	55	1550	0.025	0.26	54.4	1513
3544	75	1600	0.049	0.27	76.8	1675
3536	100	1700	0.0989	0.31	99.1	1665

Table 1. Experimental data of Akella (1976) (N^o- 10), Green and Adam (1991) (N^o- 1315) and Kato (1989) (N^o- 8006, 3544 and 3536). P and T - experimental parameters; P_1 and T_1 - calculated parameters on the base of our barometer and thermometer of Nikitina and Ivanov (1993).

The new garnet-clinopyroxene thermobarometer for deep mantle eclogites was used to determine formation conditions of eclogite inclusions in diamonds and eclogite xenoliths from kimberlite and lamproite pipes of South Africa, Yakutiya and Australia. Eclogite crystallization in the mantle occurs at several levels of the depth from 50 to 300 km by these calculations. Eclogites of the upper level were discovered mainly in kimberlite pipes from marginal portions of these structures. Eclogites of the low and middle levels were founded only in the kimberlite pipes from the central parts of the cratons. Obtained thermodynamic gradients (TG=dT/dP), are different for them (13-19^o C/kbar for first one and 30-40^o C/kbar for the second one) (n.1 and 2, Fig.1). TG=0 for Argail eclogite inclusions in diamonds (n.3, Fig.1), which were formed mainly on the depths nearly 200-300 km. These types of paleogeotherms correspond to the numerical paleogeotherm, which was theoretically obtained on the base of assumption of the upper mantle convection (Christensen, 1983; Davies and Richards, 1992) (Fig.2). These differences in the paleogeotherm types are connected with the processes of the mantle dynamics under the cratons and may be explained by mantle plume, which occurred under the central parts of the cratons on 200-300 km.

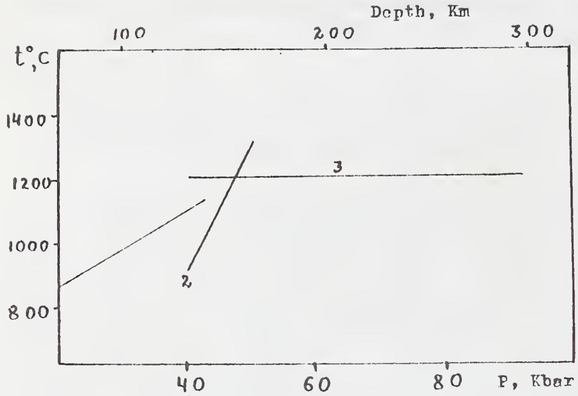

Fig.1. Types of paleogeotherms obtained for eclogites.

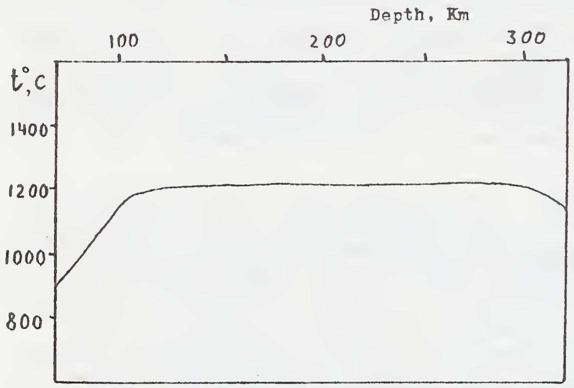

Fig.2. Variation of temperature with depth in accordance with models of Christensen, U. (1983) and Davies and Richards (1992).

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