ECLOGITES IN THE MANTLE: T, P AND F_{O_2}, EQUILIBRIUM CONDITIONS AND DEPTHS OF FORMATION.

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Knowledge of the temperature, pressure and oxygen fugacity equilibrium conditions, under which eclogites are formed in the mantle is required to solve the problem of their origin. The semi-empirical garnet-clinopyroxene thermobarometer (Nikitina & Simakov, 1994) were used to determine P-T formation conditions of eclogitic inclusions in diamonds and eclogite xenoliths from kimberlite and lamproite pipes. This thermobarometer allows to evaluate P-T equilibrium conditions of garnet-clinopyroxene assemblages, including those with high Na and Al content in clinopyroxenes over a wide range: $25 \le P \le 70$kbar and $650 \le T \le 1700^{o}$C. The presence of Fe^{+3} in eclogite garnets permit using the garnet-clinopyroxene assemblage to calculate oxygen fugacity at fixed T and P by garnet-clinopyroxene oxygen barometer (Simakov, 1993).

The data available on mineral compositions of eclogitic inclusions in diamonds and eclogite xenoliths from kimberlite and lamproite pipes of Africa, Australia and East Siberia, published by B. Harte, C. Hatton, W. Griffin, J. Gurney, A. Jaques, M. Lappin, J. Mac Gregor, H. Meyer, R. Moore, M. O'Hara, M. Otter, M. Prinz, R. Rickard, S. Shee, H. Tsai, N Sobolev and their coauthors also in "Physics and Chemistry of the Earth", vol. 9 (1975), Proceedings of the Second (1979) and the Fourth (1989) International Kimberlite Conferences and articles (Sobolev, 1977; Sobolev et al., 1989; 1991; Shee et al., 1982; Hills & Haggerty, 1989; Ukhanov et al.,1989; Specius et al., 1992.) were analyzed.

P, T and oxygen fugacity estimations obtained (Fig.1-4) permit to draw some important conclusions concerning conditions and depths of eclogite formation in the mantle. Eclogite crystallization in the mantle occurs from 50-60 to 220-230km. Eclogite observed as inclusions in diamonds correspond to the deepest level (over 150-160km). They were crystallized at the highest pressures (over 40-45kbar) and temperatures (over 1200^{o}C). Eclogitic inclusions in diamonds from Australian lamproites were formed under pressures exceeding 40-45 kbar, but at slightly lower temperatures (below 1200^{o}C), than eclogitic inclusions in diamonds from kimberlites. Diamond-bearing eclogites and most of diamond-free eclogites from diamondiferous pipes refer to the middle level. These eclogites were formed at pressures from 35-40 to 55-60kbar and temperatures $800-1000^{o}$C. Diamond-free eclogites were crystallized predominantly at depth from 50-60 to 130-140 km (upper level), at pressures from 15-20 to 30-35 kbar and temperatures from 650-700 to $900-950^{o}$C.

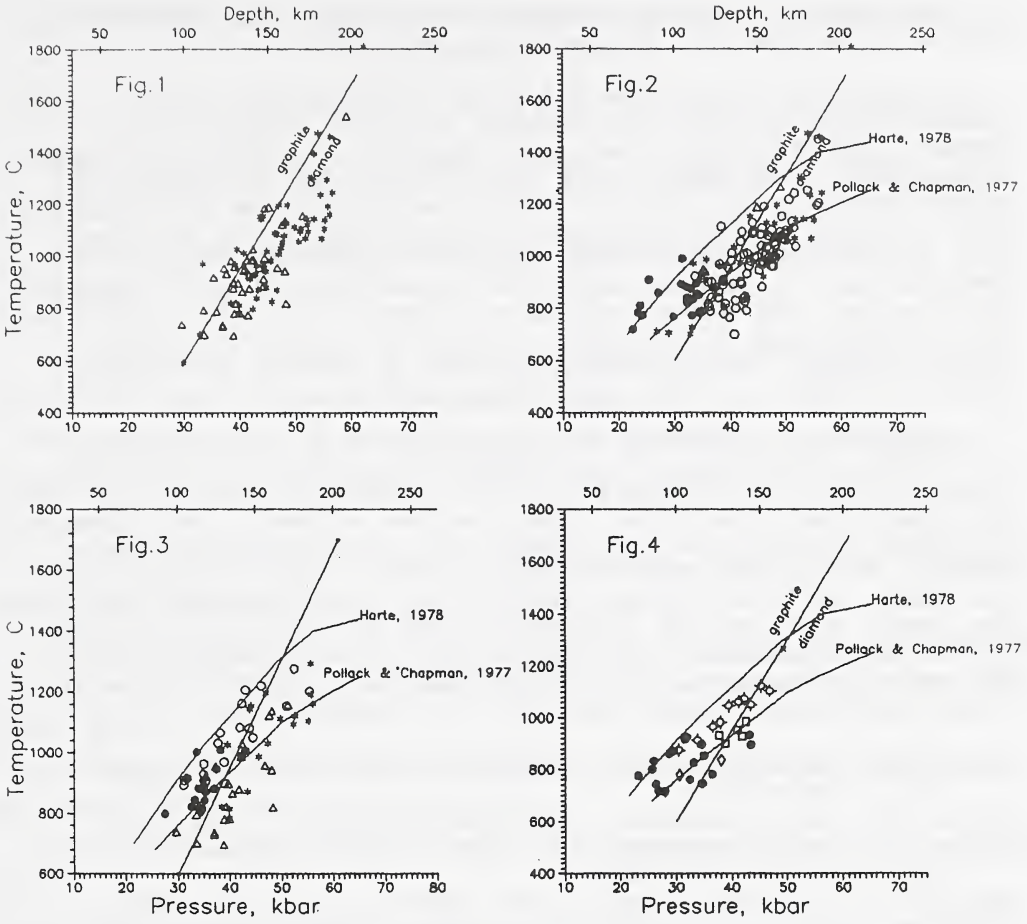

Fig.1. Pressure-temperature plot for eclogitic inclusions in diamonds (*), and eclogite xenoliths with diamond (Δ) from kimberlite pipes. The diamond-graphite transition after Bundy et al. (1961).

Fig.2. Pressure-temperature plot for eclogitic inclusion in diamonds (*, the kimberlite pipes Monastery, Premier, Koffiefontain), diamond-bearing (Δ) and diamond-free (o) eclogite xenoliths (the pipes Roberts Victor, Jagersfontain, Bobbijaan, Wesselton, and Orapa) and diamond-free eclogite xenoliths from Lesotho pipes (●). Pollack & Chapman 1977 -continental geotherm for conductive heat transfer with surface heat flows of 40mW/m^2; Harte 1978 - convection-related sheld geotherm.

Fig.3 Pressure-temperature plot for eclogites from the East Siberian kimberlite pipes: diamond-free eclogites from the pipe Obnazhennaya (●). eclogitic inclusions in diamonds (*), diamond- bearing (Δ) and diamond-free (o) eclogite xenoliths from the Udachnaya and Mir pipes.

Fig.4. Pressure-temperature plot for eclogite xenoliths from the Koidu kimberlite complex, Sierra Leone. Eclogites:

low-MgO (●),high-MgO (⌖), low-MgO eclogites with diamond (▫), diamond+graphite (x), and graphite only (◊).

Eclogites of the low and middle levels were found in the kimberlite pipes from the central parts of the ancient cratons (the Kaapvaal craton and the East Siberian platform). Eclogites of the upper level were discovered in kimberlite pipes from marginal portions of these structures and in pipes from the Koidu kimberlite complex, located in the marginal part of the Man Shield, West African Craton, as well. Fluid compositions of diamond eclogite inclusions, diamond- bearing and diamond-free eclogites are different. Average composition of the first and second ones lie on the water line of the C-O-H diagram, whereas the third one is shifted to the more reduction area, and his main component is CH_4.

Depths of formation for the majority of the eclogitic inclusions in diamonds from kimberlite pipes coincide with formation depths of sheared garnet lherzolite xenoliths from the same pipes (Nikitina, 1994). We can suggest, that these eclogites are derived from upper part of the asthenosphere beneath the ancient cratons (Boyd, 1973). Then middle level eclogites, diamondiferous predominantly, correspond likely to the lowest part of the lithosphere and the uppermost portion of the asthenosphere. This assignment is in agreement with the model of Basu et.al., (1986) about an origin of Roberts Victor eclogites, which fall into the middle level.

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