RELATIONSHIP BETWEEN POTENTIAL DIAMONDIFEROUS ABILITY AND OXYGEN-REDUCTION CONDITIONS FOR THE UPPER MANTLE

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Modern petrology studies of diamond genesis have been mostly concerned with its temperature and pressure environments of growth in the subcontinental lithosphere. Comparatively little attention has been paid to the role of oxygen fugacity, which determines whether either carbon exists as elemental carbon or as a carbon gas species. By Ryabchikov's (1980) and Saxena's (1989) models growth and preservation of diamonds depend upon the oxidation-reduction conditions of the mantle fluid and optimum conditions correspond to water-rich fluid. That is why the knowledge of oxygen-reduction conditions under which peridotitic and eclogitic parageneses in diamonds, diamond-bearing and diamond-free xenoliths is required to solve the problem of their origin and potential ability for diamondiferous.

The oxidation state of the mantle has been a source of recent controversy. Thermodynamic calculations of oxygen fugacity based on olivine-orthopyroxene-spinel equilibria (O'Neill and Wall, 1987) support a relatively oxidized mantle, characterized by values of oxygen fugacity between FMQ buffer and WM buffer. In contrast, other data, especially from studies of intrinsic oxygen fugacity are interpreted as indicating that portions of the mantle are more reduced with values of fo_2 near IW buffer (Arculus, 1985). It has been suggested (Haggerty and Tompkins, 1983) that the upper mantle is zoned with depleted lithosphere being more reduced than deeper, fertile portions of the asthenosphere.

The oxidation state of the mantle peridotite and eclogite assemblages can be estimated by reactions between oxygen and iron-bearing garnets (Simakov, 1993; 1994). Most suitable association for estimation of P and T for peridotites is garnet + orthopyroxene. For calculations we used geothermometer of Harley (1984) and geobarometer of Nickel and Green (1985) as most accuracy pair (Taylor and Green, 1991). P-T conditions of eclogite parageneses were estimated on the base of garnet-clinopyroxene geothermobarometers (Nikitina and Simakov 1993; Simakov, 1995). P-T-fo_2 conditions and equilibrium compositions of fluids for C-H-O system of South African, Yakutian and Australian peridotite and eclogite parageneses were estimated.

For peridotites practically all diamond inclusions and diamond-bearing xenoliths correspond to region of diamond stability by P and T, meanwhile main part of diamond-free xenoliths corresponds to region of graphite stability. In South Africa 75% of diamond inclusions and 50% of diamond-bearing xenoliths correspond to more reduced mantle (fo_2<WM). In Yakutiya - 38% of diamond-bearing xenoliths correspond to this field. Meanwhile diamond-free xenoliths mainly (Yakutiya - on 80%, Namibia - on 75% and Lesotho - on 60%) correspond to more oxidized mantle (fo_2>WM). Most inclusions in diamonds plot in the field of the methane-rich fluid (n.2, Fig.1), most diamond-bearing peridotites plot in the field of the water-rich fluid (n.1,3 Fig.1), whereas most diamond-free peridotites plot in the field of the CO_2-rich fluid (n.4-6, Fig.1'

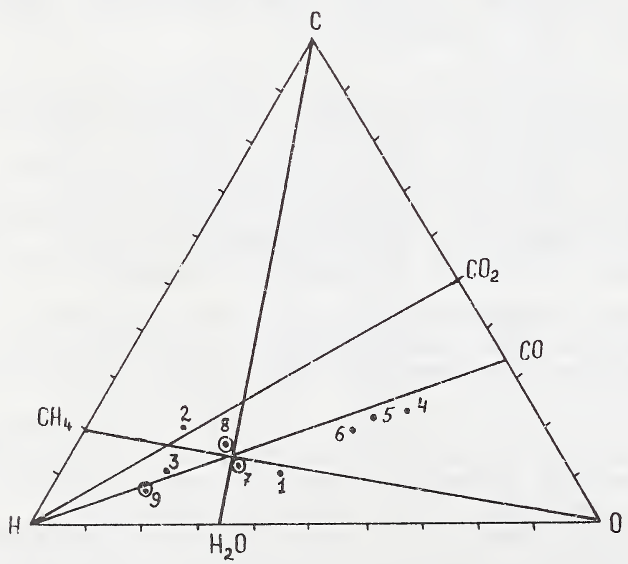

Fig.1. Average compositions of the calculated fluids and of those extracted from diamonds in the O-H-C system. 1 - Yakutian diamond-bearing xenoliths, 2- South African inclusions in diamonds, 3 - South African diamond-bearing xenoliths, 4 - Yakutian diamond-free xenoliths, 5 - Namibian diamond-free xenoliths, 6 - Lesotho diamond-free xenoliths, 7 - fluid extracted from South African, Brazilian and USA diamonds (Giardini and Melton, 1975), 8,9 - average fluid extracted from Yakutiyan diamonds and fluid extracted from pipe Mir diamonds correspondingly (Bartoshinskii et al., 1987).

For eclogites main part of diamond inclusions and diamond-bearing xenoliths corresponds to region of diamond stability by P and T, meanwhile main part of diamond-free xenoliths corresponds to region of graphite stability. In South Africa 70% of diamond inclusions and 65% of diamond-bearing xenoliths correspond to more reduced mantle (fo_2<WM). In Yakutiya 87% of diamond inclusions and - 65% of diamond-bearing xenoliths correspond to this field. The diamond inclusions from lamproite

pipe Argail for which estimated pressures correspond to somewhat more deeper levels (up to 90 kbar), lye in the field of more reduced conditions (near and low IW buffer). In Yakutiyan diamond-free xenoliths 65% of analyses correspond to more reduced mantle and in South African ones 80% of analyses correspond to this field. South African diamond inclusions and diamond-bearing xenoliths plot in the field of the water-rich fluid, Yakutiyan diamond inclusions - in the field of water-methane-rich fluid, and Australian ones - in the field of methane-rich fluid. Yakutiyan diamond-bearing and -free and South African diamond-free xenoliths plot in the field of the methane-water -rich fluid.

These calculations allow us to come to the conclusion that upper mantle is zoned. It consists of relatively oxidized and reduced zones. The main tendency is increasing degree of reduction with increasing the depth. It's correspond to the model suggested by Haggerty and Tompkins (1983). Eclogites correspond to somewhat more reduced conditions than peridotites. The average fluid compositions of inclusions in diamonds and diamond-bearing xenoliths mainly water-rich.

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