

NOBLE GASES IN SHOCK-PRODUCED DIAMOND

Haruaki YAJIMA and Jun-ichi MATSUDA

Department of Earth Sciences, Faculty of Science, Kobe University, Nada, Kobe 657, Japan

It has been reported that shock-produced diamonds contained noble gases as large as those in vapor-growth diamonds from gaseous mixture of CH₄ and H₂ including Ar (1). We measured the noble gases in the shock-produced diamonds in more detail, in order to examine the mechanisms of trapping noble gases into diamonds during shock processes and to get the diffusion coefficients of noble gases in diamond.

Du Pont diamonds were used for the measurements as shock-produced diamond. According to the explanatory notes, natural graphite was transformed into diamond of about 0.01 μ m size under the pressure of 14-48 GPa by detonating an explosive. A cluster of micro-crystals forms poly-crystal diamond. These diamonds are separated by sizes and used for rubbing powder. We used three size fractions; DPF3(2-4 μ m), DPF9(6-12 μ m) and DPF30(22-36 μ m) for our purpose. Noble gases were analyzed by mass spectrometer using stepwise heating technique.

Fig. 1 shows the elemental abundance pattern normalized by ³⁶Ar relative to air. Except for ⁴He and ¹³²Xe, they seem to lie on a linear fractionation line. The amount of ⁴He was not well determined because of large blank correction. The fractionation of ¹³²Xe seems to be larger than the value extrapolated from the fractionation line from Ne to Kr. The fractionation from Ne to Kr is very small compared to that expected from physical adsorption. During shock processes, emplacement of noble gases into diamond is not accompanied with significant mass fractionation. It is estimated that noble gases within void in graphite and/or those adsorbed on the graphite surface were driven or dissolved in diamond. The high fractionation of Xe may suggest the possibility of the second component.

Small amounts of noble gases were degassed at low temperature below 1700°C, while major degassing occurred at 1700-1900°C at which temperature diamonds were graphitized. The low temperature components were caused by diffusion process in diamond. In general, natural diamond contains very small amounts of noble gases, and is very difficult to get the diffusion data in it. Because shock-produced diamonds contain large amounts of noble gases, the diffusion coefficients (D) (or D/a², where a is the effective radius) at low temperature can be determined for heavy noble gases of Ar, Kr and Xe. As the difference of D/a² was not discernible, the effective radius (a) seemed to have a common value for these three samples. The obtained values of D at 1300°C range from 1x10⁻¹³ to 1x10⁻²⁰ (cm²/sec), assuming that the value of a is 0.005-1.5 μ m. Although the effective radius (a) is still uncertain, the calculated range of D is compatible with that reported by other authors for ⁴He. (2, 3, 4, 5).

The Arrhenius diagram of the diffusion coefficients (D/a²) have two components. One represents the graphitization of diamond (high temp.), and another is the diffusion process (low temp.). The activation energies for diffusion were estimated; 90-

130 KJ/mol for ^{20}Ne , 70-100 KJ/mol for ^{36}Ar and 60-100 KJ/mol for ^{84}Kr , respectively. These values are smaller than the data of Ozima and Zashu by an order of magnitude (2). This is because they derived the activation energies at 1700-1900°C, at which temperature the reaction might be graphitization process and not diffusion process.

References (1) J. Matsuda and K. Nagao (1988) submitted to *Geochim. Cosmochim. Acta.* (2) M. Ozima and S. Zashu (1988) *J. Geophys. Res.* (in press) (3) M. Honda, J. H. Reynolds, E. Roedder and S. Epstein (1987) *J. Geophys. Res.* 92, 12507-12521. (4) M. D. Kurz, J. J. Gurney, W. J. Jenkins and D. E. Lott III (1987) *Earth Planet. Sci. Lett.* 86, 57-68. (5) D. Lal, J. F. Waker, R. Poreda and H. Craig (1987) *Meteoritics* 22, 437-438.

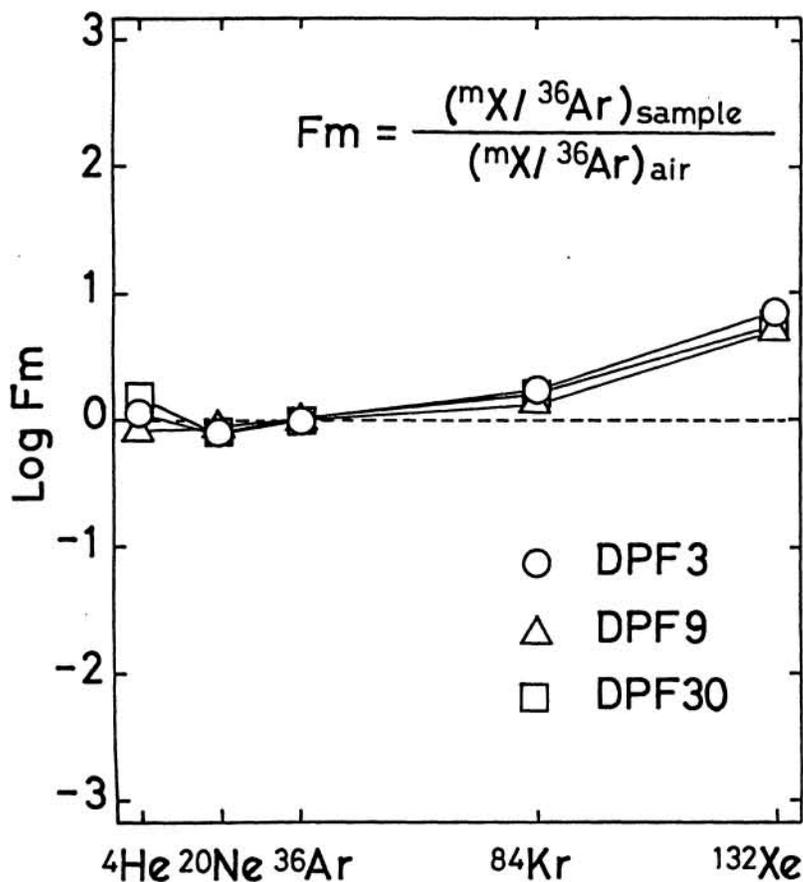


Fig. 1 Elemental abundance pattern of noble gases in shock-produced diamonds, displayed as a fractionation factor $F(m) = \frac{(mX/^{36}\text{Ar})_{\text{sample}}}{(mX/^{36}\text{Ar})_{\text{air}}}$ where mX represents a noble gas isotope of mass "m".