

Fluids trapped within diamond: clues to mantle geochemistry

Johnson, L.H.¹, Burgess, R.¹, Turner, G.¹, and Milledge, H.J.²

¹ Dept. of Earth Sciences, University of Manchester, Oxford Rd., Manchester, UK

² Dept. of Geological Sciences, University College London, Gower St., London, UK

An extension of the ^{40}Ar - ^{39}Ar stepped heating method enables noble gas and halogen (Br, Cl and I) contents of H_2O - CO_2 - K_2O rich fluid inclusions (Navon *et al.*, 1988) within diamonds to be measured.

This study compares coated stones with fluid inclusion bearing 'clouds'. Coated stones show constant $^{40}\text{Ar}^*/\text{Cl}$ and Br/Cl values and limited variations in the I/Cl ratio (Burgess and Turner, 1995; Turner *et al.*, 1990; Ozima *et al.*, 1989). Initial results for clouds show variation in the Br/Cl and I/Cl ratios between high- and low-temperature releases for single stones. This may be a result of the more complicated growth history, as suggested by the nitrogen aggregation states of clouds.

Carbon isotope analyses of cloud diamonds record $\delta^{13}\text{C}$ values of between -3.4‰ to -8.2‰ in general agreement with the globally uniform coated stone established value (Boyd *et al.*, 1994).

Clouds from various kimberlite pipes have been studied; DeBeers Pool (3), Finsch (1), Koffiefontein (5), Venetia (3), and Premier (7); a total of 19. Average sample weight ranges from 5mg to 40mg. The system blanks are small enough to allow step heating of the diamonds, between 900°C and 2150°C.

All the clouds exhibit very different release patterns compared to coated stones (fig.1). The coat release pattern is characterised by two release peaks, one at low temperature (1600°C) and one associated with graphitisation (2050°C). Previous studies on coats (Turner *et al.*, 1990) suggest that the low temperature release is due to decrepitation of inclusions or radiation damage. Ozima *et al.*, (1989) note that the dominant release is at the graphitisation temperature. The release patterns for clouds are much broader, starting at 900°C. Often the bulk of the material (in some cases ~80%Ar, Br, Cl) is released before graphitisation (2050°C).

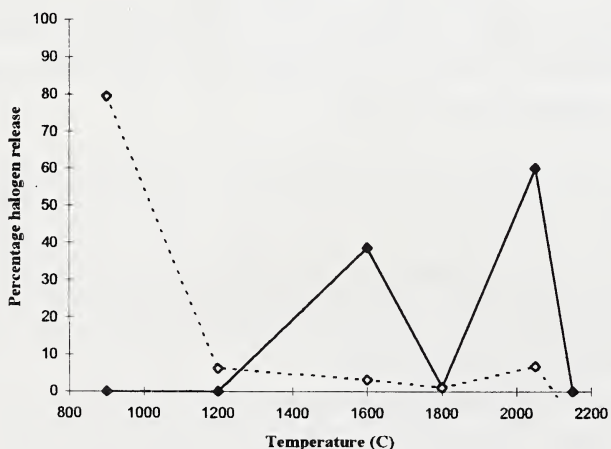


FIG 1. Typical pattern for halogen release (as percentage of the total halogens released) for a coat and a cloud. It is noted that the dominant release is often at low temperatures for clouds.

Unlike the coats, which exhibit compositional homogeneity across the temperature steps (Turner et al., 1990; Burgess and Turner, 1995), compositional variation is exhibited by clouds. Fig.2 shows the variation in Br/Cl ratio for a typical cloud. The bulk chemical data is presented in Table.1 for 8 clouds from 2 pipes, outlining the compositional differences that occur within a single pipe. These data show several fluid phases have been trapped within the diamond during multistage growth. This contrasts with the rapid growth of coats.

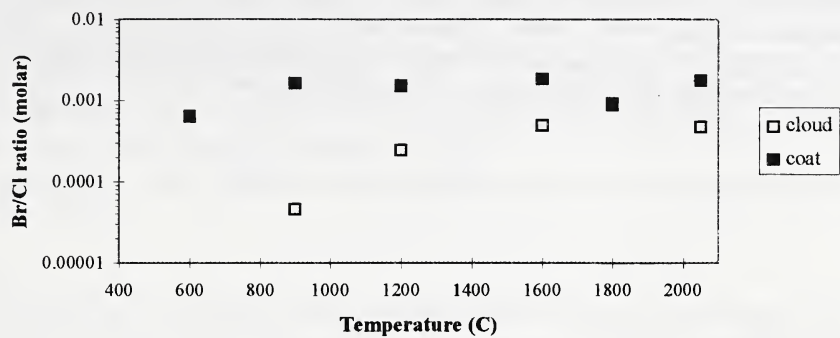


FIG 2. Compositional (Br/Cl) variations between temperature releases. The 2050°C releases are co-incident for both the coat (solid symbol) and the cloud (open symbol).

Infra-red spectroscopy studies suggest low mantle temperatures and short mantle residence times for coats (Boyd et al., 1987). Preliminary work on clouds (this study) show that increased aggregation states are common for cloud diamond, suggesting a longer mantle residence time and/or higher temperatures.

Separating the fluid component(s) trapped within the clouds will help to resolve questions of mantle heterogeneity and temporal geochemical variations.

sample	weight (mg)	Cl (ppm)	Br/Cl	K (ppm)	⁴⁰ Ar* cc/g (10 ⁻⁹ cm ³ g)	³⁶ Ar cc/g
K1	7.8	1.29	0.001	17.75	77	3.85
K2	9.4	0.96	0.01	13.82	7521	2.13
K3	10.4	28.1	0.002	133.22	4346	2.88
K4	10.5	1.0	0.02	5.61	105	1.90
P1	21.1	23.9	0.003	59.07	8673	4.27
P2	26.9	5.76	0.002	138.42	1346	1.12
P3	37.6	1.6	0.006	19.42	1136	29.26
P4	38.7	4.02	0.002	47.00	995	1.29
Zaire1	6.4	13.8		29.8	6990	0.30

TABLE 1. Bulk chemical data for ‘cloud’ samples from two pipes. Koffiefontein, K; Premier, P. Zaire stone (Turner et al., 1990) added for comparison.

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