

IS XE-HL A REAL COMPONENT? *A.V. Fisenko¹, A.B. Verchovsky², L.F. Semjonova¹, I. P. Wright² and C.T. Pillinger²; ¹Vernadsky Institute of Geochemistry and Analytical chemistry, RAS, Russia; ²Planetary and Space Sciences Research Institute, The Open University, Milton Keynes, UK.*

Introduction. It is known that Xe-HL represents a mixture of (i) *r*- and *p*-process isotopes generated in a supernova with (ii) isotopically normal Xe identified by the presence of *s*-process ¹³⁰Xe. The question of whether the ultimate mixture of these components has occurred before implantation into presolar diamonds, or whether the components have been implanted separately remains unanswered. Based on the experimental implantation of noble gases into synthetic nanodiamonds it has been concluded that the actual mixture has occurred in the diamonds and that the isotopically normal component is Xe-P3 [1]. This also means that the isotopically anomalous component may not contain ¹³⁰Xe at all. On the other hand, analyses of grain size fractions of diamonds separated from the Efremovka CV3 meteorite [2] indicate that Xe-P3 and Xe-HL are effectively separated from each other in the different size fractions because they were implanted at different energies. Since no further separation of Xe-HL into subcomponents is observed in the finest grain size fractions of diamonds it is clear that the Xe-HL was mixed with a component containing *s*-isotopes (which is not Xe-P3), and then both were implanted simultaneously with similar energies. This would explain why the ¹³⁶Xe/¹³²Xe ratio in levels off at a value of about 0.71 with decreasing of size of diamond grains.

In the present study we have analysed this problem using a set of diamond grain-size fractions separated from the Boriskino CM2 meteorite which contain significantly more low temperature Xe-P3 than the Efremovka diamonds.

Results and Discussion. The procedures of isolating diamonds from the meteorite, their separation into grain-size fractions and the results of noble gas analyses during pyrolysis up to 700°C with subsequent combustion from 300 to 900°C are given in [3].

If the HL gases are a mixture of isotopically anomalous (A) and P3 components released in combustion steps then the (¹³⁶Xe/¹³²Xe)_A can be found from the following mixing equations:

$$(^{136}\text{Xe}/^{132}\text{Xe})_{\text{M}} = [(^{136}\text{Xe}/^{132}\text{Xe})_{\text{A}} + (^{136}\text{Xe}/^{132}\text{Xe})_{\text{P3}} \times \text{R}] / (1+\text{R}),$$

$$(^{36}\text{Ar}/^{132}\text{Xe})_{\text{M}} = [(^{36}\text{Ar}/^{132}\text{Xe})_{\text{A}} + (^{36}\text{Ar}/^{132}\text{Xe})_{\text{P3}} \times \text{R}] / (1+\text{R}),$$

where the subscript M corresponds to the measured compositions and $\text{R} = (^{132}\text{Xe-P3}) / (^{132}\text{Xe-A})$. Eliminating R we have:

$$(^{136}\text{Xe}/^{132}\text{Xe})_{\text{A}} = \{ (^{136}\text{Xe}/^{132}\text{Xe})_{\text{M}} \times (^{36}\text{Ar}/^{132}\text{Xe})_{\text{P3}} - (^{36}\text{Ar}/^{132}\text{Xe})_{\text{A}} \} / \{ [(^{136}\text{Xe}/^{132}\text{Xe})_{\text{M}} - (^{136}\text{Xe}/^{132}\text{Xe})_{\text{P3}}] - (^{136}\text{Xe}/^{132}\text{Xe})_{\text{P3}} \times [(^{36}\text{Ar}/^{132}\text{Xe})_{\text{M}}] / [(^{36}\text{Ar}/^{132}\text{Xe})_{\text{P3}} - (^{36}\text{Ar}/^{132}\text{Xe})_{\text{M}}] \}.$$

Since the value of (³⁶Ar/¹³²Xe)_A × [(¹³⁶Xe/¹³²Xe)_M - (¹³⁶Xe/¹³²Xe)_{P3}] cannot be negative, the upper limit for the (¹³⁶Xe/¹³²Xe)_A can be determined from the following equation:

$$(^{136}\text{Xe}/^{132}\text{Xe})_{\text{A}} \leq [(^{136}\text{Xe}/^{132}\text{Xe})_{\text{M}} \times (^{36}\text{Ar}/^{132}\text{Xe})_{\text{P3}} - (^{36}\text{Ar}/^{132}\text{Xe})_{\text{P3}} \times (^{36}\text{Ar}/^{132}\text{Xe})_{\text{M}}] / [(^{36}\text{Ar}/^{132}\text{Xe})_{\text{P3}} - (^{36}\text{Ar}/^{132}\text{Xe})_{\text{M}}].$$

The value for the ratio (³⁶Ar/¹³²Xe)_{P3} is considered to be that measured in the 700°C pyrolysis step since the elemental compositions of noble gases of the same component in low- and high-temperature defects must be identical.

The results of calculations made for three grain-size fractions (BD-4, 5 and 6) and the bulk diamond fraction (BD-1) indicate that (¹³⁶Xe/¹³²Xe)_A cannot be higher than 0.71±0.04, 0.73±0.04, 0.99±0.21 and 0.9±0.33 respectively. The same calculations

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made for Orgueil diamonds [4] gives the value of 0.85 ± 0.07 which is, within error, similar to those in the coarse-grained fractions for Boriskino (BD-6 and 1). It appears that there is a systematic increase in the calculated upper limits for $(^{136}\text{Xe}/^{132}\text{Xe})_A$ with grain size, that can be explained by preferential losses of ^{36}Ar from the coarsest fractions (which turned out to have higher concentrations of defects than the fine ones [3]). Thus, the value of 0.71 ± 0.04 found for the fine fraction BD-4 gives the best estimation for the $(^{136}\text{Xe}/^{132}\text{Xe})_A$ ratio. This value is not significantly different from that accepted in [4] on the basis of the $^{136}\text{Xe}/^{132}\text{Xe}$ - $^{134}\text{Xe}/^{132}\text{Xe}$ correlation and

from that found in the finest grain size fraction of the Efremovka diamonds [2].

Conclusion. The calculations made for the grain size fractions of the Boriskino nanodiamonds indicate that Xe-HL is a real component formed as a mixture of *r*- and *p*-process products of nucleosynthesis with an isotopically normal component that is not equal to that of P3. The $^{136}\text{Xe}/^{132}\text{Xe}$ ratio of Xe-HL is ≤ 0.71 .

References. [1]. Koscheev A.P. et al. // Nature. 2001. **412**. P. 615-617. [2]. Verchovsky A.B. et al. // Science. 1998. **281**. P. 1165-1168. [3]. Fisenko A.V. et al. // Geochimia (in Russian), 2003 (in press). [4]. Huss G.R. and Lewis R.S. // Meteoritics. 1994. **29**. P. 791-810.

Table. Some noble gas data for the grain-size fractions of Boriskino CM2 diamond.

Sample	Average grain size, nm	$^{136}\text{Xe}/^{132}\text{Xe}$		$^{36}\text{Ar}/^{132}\text{Xe}$	
		Pyrolysis (up to 700°C)	Combustion (300-900°C)	Pyrolysis (up to 700°C)	Combustion (300-900°C)
BD-1	$\cong 2.6$	0.304 ± 0.005	0.528 ± 0.007	571 ± 58	359 ± 36
BD-4	~ 2.7	0.317 ± 0.005	0.580 ± 0.008	1069 ± 32	339 ± 11
BD-5	~ 2.7	0.320 ± 0.005	0.577 ± 0.007	934 ± 21	339 ± 9
BD-6	~ 5.3	0.308 ± 0.003	0.498 ± 0.008	449 ± 18	372 ± 14