

KINETICS OF Xe-P3, Xe-HL, AND Xe-P6 RELEASE DURING STEPPED OXIDATION OF THE METEORITIC NANODIAMONDS. A. V. Fisenko and L. F. Semjonova, Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Kosygin Street 19, Moscow, Russia (anat@chgnnet.ru)

Abstract: The abundances and release kinetics of the Xe-P3, Xe-P6, and Xe-HL has been determined from published data for released xenon during stepwise oxidation of the Murchison nanodiamonds. From the obtained data it is follows that (a) the noble-gas components are contained in individual populations of diamond grains with different thermal-oxidative resistance, and (b) the P3 and P6 components may be contained in the same population diamond grains, but in different their parts: the P3 component is mainly in outer zone, while the P6 component is mainly in the inner one. In this case, the outer zone of the diamond grains must have a more defective crystal lattice than the inner zone.

Introduction: At present, a detailed analysis of the contents and release kinetics of the P3, HL, and P6 components for nanodiamonds of various chemical classes and petrologic types meteorites were carried out using only the stepped pyrolysis method [1, 2]. Here we present the results of a similar analysis using published in [3] the precision data for released xenon during the stepwise oxidation of the bulk LD1 nanodiamonds of the Murchison CM2 meteorite.

The ^{132}Xe abundances of noble-gas components in the Murchison LD1 nanodiamonds: The Xe-P3, Xe-P6, Xe-HL, and Xe-S abundances in LD1 nanodiamonds were calculated using the following set of equations.

$$\begin{aligned}x + z + y + s &= b \\A \times x + B \times z + C \times y + E \times s &= a \times b \\F \times x + H \times z + K \times y + L \times s &= d \times b \\M \times x + N \times z + P \times y + T \times s &= t \times b\end{aligned}$$

Here the variables are x , z , y , and s – the ^{132}Xe abundances of the P3, P6, HL components, and also of Xe-S in LD1 diamonds, respectively. The rest of parameters of the equations designate the following. Parameters b and a , t , d are equal to the measured in LD1 diamonds of both the ^{132}Xe abundance and the $^{130}\text{Xe}/^{132}\text{Xe}$, $^{134}\text{Xe}/^{132}\text{Xe}$, $^{136}\text{Xe}/^{132}\text{Xe}$ ratios, respectively; A , F , M , and E , L , T parameters are equal to the $^{130}\text{Xe}/^{132}\text{Xe}$, $^{134}\text{Xe}/^{132}\text{Xe}$, $^{136}\text{Xe}/^{132}\text{Xe}$ ratios of the Xe-P3 and

Xe-S, respectively; B , H , N , and C , K , P parameters are equal to the $^{130}\text{Xe}/^{132}\text{Xe}$, $^{134}\text{Xe}/^{132}\text{Xe}$, $^{136}\text{Xe}/^{132}\text{Xe}$ ratios for Xe-P6 and Xe-HL, respectively. The isotopic compositions of Xe-P3, Xe-P6, Xe-HL, and Xe-S are taken from [1].

Results and discussion: The calculated ^{132}Xe abundances of the noble-gas components in the Murchison LD1 diamonds are given in Table 1.

Table 1. ^{132}Xe abundances (in 10^{-8} ccSTP/g) of components in the Murchison LD1 and Orgueil diamonds.

T, °C	^{132}Xe	P3	HL	P6	Xe-S
Murchison LD1 diamonds ^a					
250	0.8574	0.796	0.047	0.012	0.002
298	2.5415	2.325	0.150	0.060	0.007
350	6.2169	5.720	0.417	0.068	0.012
400	13.2754	11.565	1.572	0.143	0
450	22.4071	15.304	6.807	0.336	0
475	13.242	1.781	9.212	2.270	0
500	0.5012	0	0.294	0.204	0.006
550	0.0299	0	0.015	0.015	0
600	0.0185	0.003	0.008	0.006	0
700	0.0177	0.003	0.006	.007	0.003
800	0.0227	0	0.008	0.011	0.003
900	0.0088	0.003	0.003	0	0.002
Total	59.1391	37.501	18.541	3.132	0.034
Orgueil diamonds ^b					
Total		33.49	14.11	2.16	0.041
Total	49.79	34.42	14.00	1.31	0.052
		± 0.67	± 0.32	± 0.07	± 0.14

^{a, b} Italic font – the data from [3] and [1], respectively.

The Table 1 also shows the content of noble-gas components in the Orgueil diamonds, calculated by us using Xe data from [1] and obtained also by Huss and Lewis in [1]. As can be seen, the component contents in the Murchison diamonds relative to those in Orgueil increases in the direction from P3 to P6 component. Probably, the repurification of the Murchison LD1 diamonds in [3] has led to varying degrees of preservation of the noble-gas components.

The release kinetics of Xe- P3, Xe-HL, and Xe-P6 during oxidation of the LD1 diamonds corresponds to log-normal dependences in the range of 250-500 °C (Figure 1).

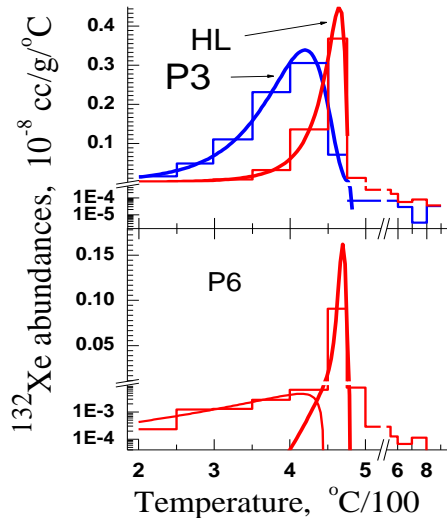


Figure 1. Xenon release kinetics. The curved lines are log-normal dependences. Histograms – on the data of Table 1.

The temperature of Xe-P3 release maximum is lower than Xe-HL, which indicates a lower thermal-oxidative resistance of diamond with a P3 component relative to a diamond with an HL component. In the 250-500 °C range, the share of released xenon of the each component is at least 98% from its content in the components. Release of the rest xenon of components is due to oxidation probably of the residues of coarse-grained diamond or of high-temperature submicron carbonaceous grains, e.g., SiC.

The integral Xe-P3, Xe-P6, and Xe-HL yields during the stepwise oxidation of LD1 diamonds, obtained on the basis of the log-normal dependences, are shown in Figure 2.

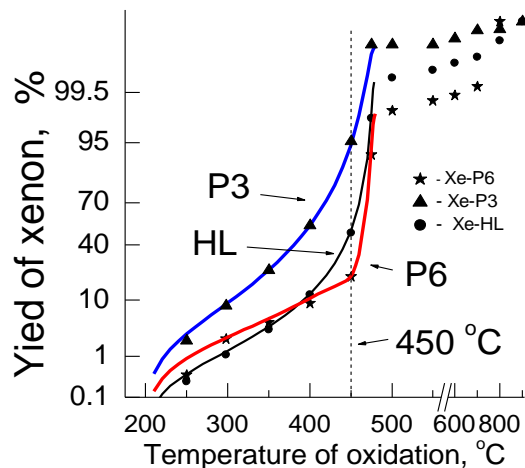


Figure 2. The integral Xe-P3, Xe-P6, Xe-HL yields. Lines – on the basis of log-normal dependences; symbols – on the data of Table 1.

The main features of these yields are as follows.

(1) The release of major amounts of Xe-P3 and Xe-P6 (95.2% and 79.5%, respectively) has occurred before and after the release of about 50% of Xe-HL, respectively. A sharp difference of the xenon yields of the P3 and P6 components relative to the HL component is the basis for concluding that noble-gas components are found in different populations of the diamond grains.

(2) The release of Xe-P6 occurs abruptly: ~20% of Xe-P6 is released in the oxidation temperature range 250-450 °C, whereas almost 80% of this xenon is released in the subsequent step 450-475 °C. Taking into account that (a) almost the whole of Xe-P3 is released in the range 250-450 °C, and (b) according to our calculations the during pyrolysis of the Murchison diamonds pH-fractions the amount of released Xe-P3 does not exceed 10% at 450 °C, and the amount of released Xe-P6 is not more than 5% at 500 °C, the following can be assumed. The noble-gas of P3 and P6 components are in diamond grains of the same population and these grains are non-uniform in content of noble-gas components: the main share of P3 component is in the outer part of the grains, while the main share of P6 component is in the inner one. In this case, the outer layer of diamond grains must have a more defective crystal lattice than the internal one. This assumption follows from the lower thermal stability of the noble gas P3 component than P6 component, both during the pyrolysis of nanodiamonds and in the thermal metamorphism of the meteorites parent bodies.

Conclusion: The kinetics of Xe-P3, Xe-HL, and Xe-P6 release during stepwise oxidation of the Murchison LD1 nanodiamonds corresponds to the contents of the P3, HL and P6 noble-gas components in individual populations of diamond grains with different thermal-oxidative resistance. It is possible that the main quantities of noble gases of the P3 and P6 components are contained in diamond grains of the same population, but in different their parts: the noble gases of P3 component are in the outer zone, while gases of the P6 component are in the inner one.

References: [1] Huss G. R. and Lewis R. S. (1994) *Meteoritics*, 29, 791-810. [2] Huss G. R. and Lewis R. S. (1994) *Meteoritics*, 29, 811-829. [3] Lewis R. S. (1994) *LPS XXV*, 793-794.