NANODIAMOND OF METEORITES: CORRECTION RESULTS OF ISOTOPIC COMPOSITIONS OF XENON COMPONENTS. A.V. Fisenko, L.F. Semjonova, T.A. Pavlova T.A. Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Kosygin Street 19, Moscow, Russia (anat@chgnet.ru)

Introduction: The increased concentrations of heavy xenon isotopes in the isotopically-anomalous Xe-HL and Xe-P6e components, identified in [1], could be the result of implantation of xenon isotopes formed during a short time (about 2 hours) of the decay of their radioactive precursors [2]. The source of the latters is the classical *r*-process of nucleosynthesis, for example, in a type *II* supernova explosion. However, the short decay time does not correspond to the ratio of the excess content of $^{132}Xe/^{136}Xe$. To increase the degree of this accordance, we were corrected the isotopic compositions of the XeP3 and Xe-P6e components identified in [1]. In this work we present the results of such a correction and the calculated contents of the obtained potentially primary xenon components in the enriched in nanodiamond fractions (ENF) of such meteorites as Orgueil (CI), Allende (CV3), and Indarch (EH3,4).

Correction of the isotopic compositions of the xenon components: The correction was carried out under the assumption of the following:

1. Nanodiamond grains and their diamond-like surface border contain an almost isotopically-normal xenon component of different composition. The borders contain the Xe-P3 component. The difference between this component from the component released during the graphitization of nanodiamond grains and designated by us below as Xe-P3C is that Xe-P3 is enriched in the Xe-S component relative to Xe-P3C. This enrichment is assumed by us to be about 3% from the relative content of ^{130}Xe.
2. The isotopically anomalous component Xe-P6$_e$, identified using the high-temperature data for xenon during the pyrolysis of ENF in [1], is also enriched in Xe-S in an amount of 3%. The Xe-P6e component without this enrichment is designated below as Xe-P6$_e$C. The calculated excess abundances of xenon isotopes in the Xe-HL and Xe-P6eC components normalized to ^{130}Xe components relative to the Xe-P3C component amounted to new isotopic compositions of the isotopically anomalous components, designated below as Xe-pr1C and Xe-pr2C, respectively (Table 1). According to the Ott hypothesis, we calculated the durations of the radioactive precursor decay of the xenon isotopes of the Xe-pr1C and Xe-pr2C components from the moment of a type II supernova explosion to be 2.58 and 2.27 h, respectively. The values of the $^{132}Xe/^{136}Xe$ ratios in the Xe-pr1C and Xe-pr2C components are 0.0228 and 0.0243, respectively. These values are significantly less than the value 0.074 when using the Xe-HL and Xe-P3 components without corrections [2]. The values of the ratios obtained by us are still higher than the value (about 0.011), which corresponds to decay time of about 2.2 h. in according to the Ott hypothesis.

The isotopic compositions of the Xe-pr1C and Xe-pr2C components differ significantly from each other in the $^{129}Xe/^{132}Xe$ ratio (Table 1). This discrepancy is probably due to the difference between the carrier phases of the Xe-pr1C and Xe-pr2C components that we assume: for the Xe-pr1C component, this phase there are nanodiamond grains, while for the Xe-pr2C component there are nanograins, both diamond and SiC-X [3] (see below). That is, we assume that the ENF of meteorites contains two types of SiC grains. One of them there are SiC-X grains, which genesis is associated with type *II* supernova, while the other there are SiC grains formed, for example, in AGB stars. Probably, implantation of ^{129}I occurred in both types of SiC grains, however, at what stage of their evolution is an open question at the moment of the study. Therefore, in the calculations below, the Xe-pr2C component is used as a potentially-primary isotopically-anomalous component of xenon. We emphasize that grains of the SiC-X type associated with a type II supernova were found in the ARR of the Murchison meteorite (CM2) [4].

Content calculations of xenon components: The content calculations of the Xe-P3, Xe-P3C, Xe-pr1C, Xe-pr2C, and Xe-S components in the NEF of such meteorites as Orgueil (CI), Allende (CV3), and Indarch (EH3,4) were carried out upon the data for xenon in [1], as well as in the DN, DM and DK fractions of the Allende meteorite (CV3) upon the data in [5]. The calculations were held as a result of solving the following system of equations:

$X + Z + Y + V = [132Xe]_m$; (1)

$(^{130}Xe/^{132}Xe)_{P3}\times X + (^{130}Xe/^{132}Xe)_S\times V = (^{130}Xe/^{132}Xe)_m\times[^{132}Xe]_m$; (2)

$(^{134}Xe/^{132}Xe)_{P3}\times X + (^{134}Xe/^{132}Xe)_{pr2}\times Z + (^{134}Xe/^{132}Xe)_{pr1}\times Y + (^{134}Xe/^{132}Xe)_S\times V = (^{134}Xe/^{132}Xe)_m\times[^{132}Xe]_m$;(3)

$(^{136}Xe/^{132}Xe)_{P3}\times X + (^{136}Xe/^{132}Xe)_{pr2}\times Z + (^{136}Xe/^{132}Xe)_{pr1}\times Y + (^{136}Xe/^{132}Xe)_S\times V = (^{136}Xe/^{132}Xe)_m\times[^{132}Xe]_m$, (4)

where the variables X, Z, Y, V are the ^{132}Xe contents of the Xe-P3 or Xe-P3C, Xe-pr2C, Xe-pr1C and Xe-S components, respectively. The subscripts (P3, P3C), pr2C, S, and pr1C refer to the isotopic composition of xenon components (Table 1), while the index m refers to the measured ^{132}Xe abundances and xenon isotope ratios during the pyrolysis of meteorite fractions in [1] and [5].

Note the following: a) For the least thermally metamorphosed meteorite Orgueil (CI), the contents of xenon components released during the pyrolysis up to 865°C were calculated using the Xe-P3 component. For the higher pyrolysis temperatures of the NEF of this meteorite and also for all pyrolysis steps of NEF of the Indarch (EH3,4) and the Allende (CV3) meteorites that undergone high-temperature metamorphism, the composition of the Xe-P3C component was used. b) DM fraction, which is intermediate between the fine-grained and coarse-grained DN and DK fractions, respectively, contains about 80% of the total ENF of the Allende meteorite (CV3) [5].

Results and discussion: Comparison of the calculated contents of xenon components in the ENF of Orgueil (C1), Allende (CV3), Indarch (EH 3,4) meteorites (Table 2) showed the following.

1. The normalized Xe-pr2C content ratios in the Allende, All$_{av}$ and Indarch meteorites relatively to that for Orgueil - (1.67(52); 1,51(56) and 3.10(36)), differ significantly from the normalized Xe-pr1C content ratios for these meteorites (1.47 (14); 1,43(16) and 1.41 (10), respectively). It can be seen that the normalized content of Xe-pr2C for the Indarch (EH3,4) meteorite is much higher than for the Allende (CV3) meteorite. This factor, as well as the different kinetics of Xe-

pr1C and Xe-pr2C component release, confirm the above assumption that the Xe-pr1C and Xe-pr2C components are contained in different carrier-phases. Note that during metamorphism under oxidizing conditions, SiC grains are less stable than nanodiamond grains. In this case, it is confirmed by the fact that the Xe-pr2C/Xe-pr1C ratio for the Orgueil (C1) and Allende (CV3) meteorites, which suffered thermal metamorphism under oxidizing conditions, is significantly lower than for the Indarch meteorite (EH3,4), that suffered this metamorphism under reducing conditions - (0.33(12), 0.37(12), 0.347(24), versus 0.73(10), respectively).

Table 2.Contents of xenon components (10^{-8} cm^3/g) in ENF of meteorites

$^{132}Xe^{*}$	Xe-P3C	Xe-pr1C	Xe-pr2C	Xe-S
Orgueil (C1), 100^0 C**				
49.8	49.548(41)	0.100 (10)	0.033 (12)	0.134 (27)
Allende (CV3), 600^0 C**				
25.11	24.813(40)	0.147 (14)	0.055 (17)	0.095 (20)
All_{av}, 600^0 C**				
23.89	23.595(12)	0.1432(69)	0.0498(27)	0.1044(80)
Indarch (EH 3,4), 630^0C**				
30.91	30.354(35)	0.141 (10)	0.102 (12)	0.316 (21)

** Measured total content of ^{132}Xe [5]. **Temperature of metamorphism [6].*

2. The Xe-pr2C/Xe-S ratio values lie in the following row: 0.25(10); 0.324(44); 0.477(43); 0.58(22) for Orgueil (C1), Indarch (EH3,4), All_{av}, Allende (CV3) meteorites, respectively. The increased ratio for the Allende (CV3) meteorite is consistent with the following conclusion: SiC-X nanograins are less destroyed during high-temperature metamorphism under oxidizing conditions than larger SiC grains formed, for example, in AGB stars [3]. We emphasize that both types of SiC grains are contained in ENF released from the colloid-like solutions of meteorites. The noted difference in the Xe-pr2C/Xe-S ratios could arise if, for example, SiC nanograins were more effectively shielded by the primary matrix material from the effects of oxidative "reagents" during metamorphism.

Based on the calculated deviations of the $^{128,\ 129}Xe/^{132}Xe$ ratios from the measured ones in [1], it follows that, only at the initial stages of pyrolysis (≤1000^0 C) for each ENF of meteorites, the negative deviations of the calculated $^{129}Xe/^{132}Xe$ ratio from the measured one (-18.3(2.9)‰; -50.2(10.2)‰ and –78.1(2.4)‰ for Orgueil (C1), Indarch (EH3,4) and Allende (CV3), DM fraction, respectively) are observed. These deviations show that in our calculations we did not take into account the additional content of the ^{129}Xe isotope due to some factor(s). One of these factors can be, for example, the implantation of low-energy ions of the radioactive isotope ^{129}I into diamond nanograins and into SiC at the last stages of molecular cloud evolution. It is noteworthy that for the ENF of the Indarch (EH3,4) and Allende (CV3) (DM fraction) meteorites, which practically do not contain low-temperature (i.e., from the borders) Xe-P3, the $^{129}Xe/^{132}Xe$ deviation is also accompanied by a negative deviation of the calculated $^{128}Xe/^{132}Xe$ ratio from the measured one in [1]. Whether this is due to the conversion of a certain fraction of ^{127}I into ^{128}Xe as a result of irradiation with thermal neutrons is currently an open question.

Conclusion: The Xe-P3 and Xe-P6e components identified in [1] were corrected for agree of the short duration (about 2 hours) of the formation of excess heavy xenon isotopes as a result of the decay of their radioactive precursors according to the Ott hypothesis [1] with an excess ratio of $^{132}Xe/^{136}Xe$. As a result of the corrections made, new compositions of isotopically anomalous components were obtained, designated as Xe-pr1C and Xe-pr2C. In these components, which consist mainly of 134Xe and 136Xe isotopes, the value of the 132Xe/136Xe ratio is close to its value at a short duration of xenon formation of these components (2.58 and 2.27), respectively.

In the comparison of the calculated contents of the Xe-pr1C, Xe-pr2C, and also Xe-S components and the almost isotopically normal Xe-P3C component in the ENF of the Orgueil (C1), Allende (CV3) and Indarch (EH3,4) meteorites, the following is assumed:

a) The carrier phase for the Xe-pr1C component is diamond nanograins, while for the Xe-pr2C components are both nanodiamond grains and SiC-X grains. Consequently, the ENF of meteorites contains two types of SiC grains whose genesis is linked with a type *II* supernova and, for example, with the AGB stars. The Xe-pr1C and Xe-pr2C components differing in carrier phases and compositions were probably formed in different turbulent zones of mixing of fragments of the outer and inner shells during a type *II* supernova explosion. In this case, the necessary duration of the decay of the radioactive precursors of xenon isotopes to form the Xe-pr1C and Xe-pr2C components, (equal to 2.58 and 2.27 hours, respectively) to limits the "life" duration of their turbulent zones.

b) The content of the Xe-P3C, Xe-pr1C, and Xe-pr2C components in the ENF of various meteorites can be successfully calculated based on the measured xenon isotopic compositions. This allows these components to be considered as potentially primary components of xenon at the present moment in the study of meteorite matter.

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Table 1. Isotopic composition of xenon components (^{132}Xe ≡ 100).

Component	^{124}Xe	^{126}Xe	^{128}Xe	^{129}Xe	^{130}Xe	^{131}Xe	^{134}Xe	^{136}Xe
Xe-S	0	0.033(19)	21.59(14)	11.8 (1.1)	48.26(42)	18.6 (1.2)	2.22(53)	0.34
Xe-P3	0.451(6)	0.404 (4)	5.06 (2)	104.2(4)	15.91 (2)	82.32(10)	37.70(10)	31.0
Xe-P3C	0.4551	0.4073	7.9384	105.031	15.5788	82.8931	38.0191	31.2757
Xe-pr1C	43.9038	18.5601	132.7634	168.9506	0	254.3679	2911.543	4379.495
Xe-pr2C	40.6306	20.3649	162.1032	741.0886	0	308.9383	2440.655	4112.8