

I-Xe SYSTEM IN CHEMICALLY SEPARATED ORGUEIL MAGNETITES. O. Pravdivtseva, R. S. Lewis, A. Meshik, and C. M. Hohenberg, McDonnell Center for the Space Sciences, Washington University, One Brookings Drive, Saint Louis, MO 63130, USA (olga@physics.wustl.edu).

Magnetites are considered to be one of the first alteration products formed in carbonaceous chondrites and thus provide insight for the onset and duration of aqueous alteration.

First I-Xe studies of Orgueil magnetite were published in 1973 [1] and 1975 [2], starting long-lived controversy (now resolved) of "anomalously old" I-Xe ages, predating formation of CAIs. Since then we analyzed two sets of Orgueil samples irradiated at different times. Highly magnetic fractions were separated with hand magnet from crushed Orgueil, and later we analyzed another set of samples, consisted of highly magnetic fractions and 2 pure magnetites, one chemically separated prior to the irradiation, and another after, from the irradiated Orgueil, both following the procedure developed by Lewis and Anders [2]. It became clear that the "anomalously old" I-Xe ages were due to the extreme differences in the iodine concentrations found in meteorites and in typical iodine-bearing compounds used as conversion monitors in earlier studies. This led to neutron self-shielding effects in the monitors of the earlier studies and thus erroneous I-Xe ages.

In all of our studies Orgueil separates yielded well-defined isochrons and consistent I-Xe ages, with pure magnetites indicating the onset of aqueous alteration in CI Orgueil 2.1 ± 0.2 Ma after formation of CAIs [3, 4]. The I-Xe ages of the highly magnetic fractions, separated with a hand magnet, vary more and tend to be about 4 Ma younger than the chemically separated magnetites [3, 5]. The radiogenic ^{129}Xe and ^{128}Xe in the highly magnetic samples are released at lower temperatures than in magnetites, suggesting at least two mineral phases in Orgueil preserve I-Xe age records. Moreover, there seems to be a heterogeneity in the pure Orgueil magnetite itself, characterized by two distinct morphologies, small octahedron grains (0.2–1 μm) and barrel-shaped stacks of platelets up to 40 μm in size. This observation places Orgueil magnetite apart from other magnetites chemically separated for I-Xe studies from CV3, CO3 and ungrouped C2 and C3 meteorites. Step-wise heating analyses with 50 $^{\circ}\text{C}$ temperature steps reveal fine structures of the radiogenic ^{129}Xe and ^{128}Xe release profiles, suggesting more than one iodine carrier in Orgueil magnetite. X-ray diffraction analyses confirm that the chemical separation performed yields Orgueil magnetite that is at least 90% pure [2]. Thus, the observed heterogeneity in the release profiles could be attributed either to the

remaining 10% impurities, or to different diffusion properties of magnetites of different morphologies. If so, grains of different magnetite morphologies can potentially preserve individual I-Xe age records.

To investigate this possibility we attempted to separate magnetite grains of these different morphologies by size/density methods. 35 mg of chemically separated Orgueil magnetite was ultrasonically dispersed in 2000 ml of deionized water. The magnetites were then separated into 3 fractions: (a) consisted of the sample settled out during the first hour, (b) magnetites that settled out between 1 and 24 hours. When the third, finest fraction, did not settle after few days, the solution was filtered and remaining magnetite (c) was collected from the filter paper. Small aliquots of these three magnetite separates have been saved for future, more detailed, morphological studies. The samples were irradiated with thermal neutrons in the Missouri University Research Reactor along with bulk Orgueil magnetite and Shallowater irradiation standard ($4,563.2 \pm 0.6$ Ma [6]). Xenon isotopic compositions, released in step-wise heating extractions, were measured in each fraction (a), (b), and (c).

Release profile of the trapped xenon component (OC) for all three samples is the same and does not correlate with release of the radiogenic component (Fig.1). The concentration of ^{132}Xe does not change from sample-to-sample, but the amount of the radiogenic component does (Table 1). Since the radiogenic ^{129}Xe concentration is twice as large in (b) and (c), compared with (a), approximately half of the fraction (a) did not contain radiogenic ^{129}Xe and iodine at all. However, (a) still contained the same concentration of the trapped component, suggesting significant differences in these separates.

Table. 1

	weight , mg	^{132}Xe $\times 10^{-10} \text{ cm}^3$ STP/g	^{129}Xe $\times 10^{-10} \text{ cm}^3$ STP/g	^{128}Xe $\times 10^{-10} \text{ cm}^3$ STP/g
a	22.30	8.53	19.75	29.21
b	11.13	7.61	42.18	74.67
c	<1.33	7.14	39.19	75.10

The release profiles for radiogenic ^{128}Xe , ^{129}Xe and OC, the Ordinary Chondrites component ^{132}Xe , are shown on Figure 1. Apparently, the separation procedure enriched the finest fraction (c) in a lower temperature radiogenic xenon carrier. The release profiles

for sample (b) indicate the presence of a higher temperature iodine carrier. When considered separately, different peaks in the release profiles of these three samples yield three different closure times for the I-Xe system in these samples (Table 2). Lower temperature I-Xe ages are consistent with the previously reported values for the highly magnetic fractions [5]. The I-Xe ages for extraction steps higher than 1300 °C are in good agreement with previously reported ages of chemically separated magnetites [3].

Figure 1.

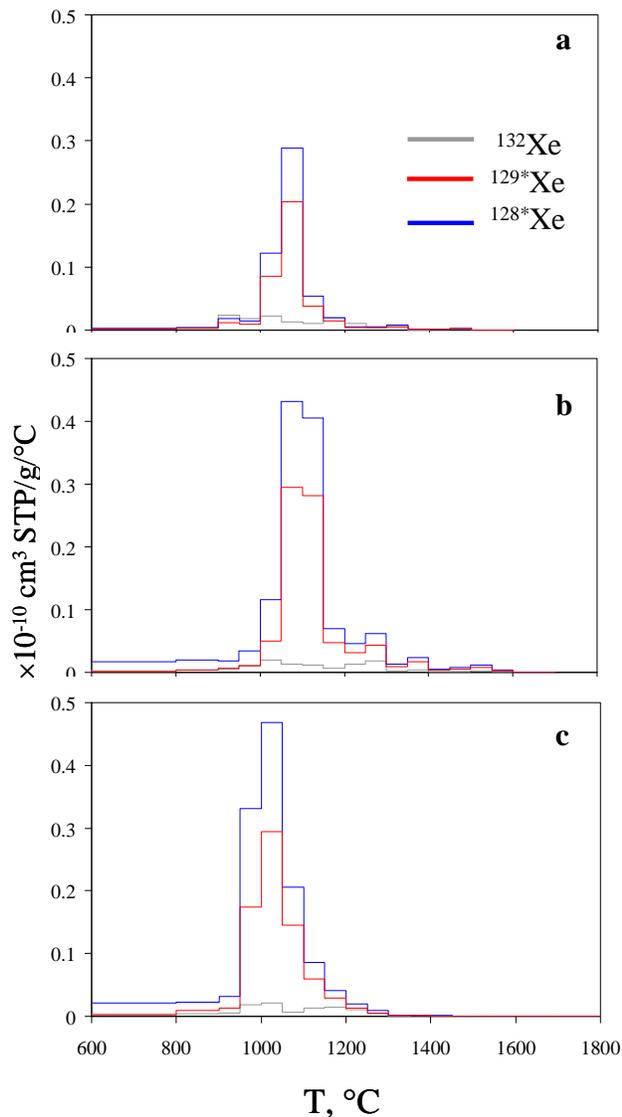


Table 2. The I-Xe ages relative to the Shallowater standard ($4,563.2 \pm 0.6$ Ma [6]). Negative values are younger than Shallowater.

sample	I-Xe ages, Ma		
	900–1050, °C	1000–1250, °C	1300–1700, °C
(a)	–	1.2 ± 0.2	2.3 ± 0.7
(b)	<i>-4.8 ± 0.3</i>	<i>0.6 ± 0.3</i>	2.2 ± 0.5
(c)	-3.5 ± 0.4	1.1 ± 0.3	–

Our results confirm the early onset of aqueous alteration in CI Orgueil at 1.8 ± 0.5 Ma after formation of CAIs, in agreement with the previously reported value 2.1 ± 0.2 Ma [3]. Release profiles of radiogenic $^{128*}\text{Xe}$ and $^{129*}\text{Xe}$ suggest presence of an iodine-rich carrier phase where I-Xe system closed about 1 Ma later. In sample (b), the 900–1050 and 1000–1250 peaks are not completely resolved, so the corresponding I-Xe ages (shown in italic blue in Table 2) are most probably artifacts of this superposition.

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References: [1] Herzog G. F et al. 1973. *Science* 180:489–491. [2] Lewis R. S. and Anders E. 1975. *Proceedings of National Academy of Science* 72:268–273. [3] Pravdivtseva O. et al. 2003. Abstract #1863. 24th Lunar & Planetary Science Conference. [4] Amelin Yu. et al. 2002. *Science* 297:1678–1683. [5] Hohenberg C. M. et al. 2000. *Geochimica et Cosmochimica Acta* 64:4257–4262. [6] Gilmour J. D. et al. 2006. *Meteoritics & Planetary Science* 41:19–31.