I-Xe AGE OF A NON-PORPHYRITIC MAGNESIAN CHONDRULE FROM THE HAMMADAH AL HAMRA 237 CB CARBONACEOUS CHONDRITE: VALIDATION OF ABSOLUTE I-Xe AGES. O. Pravdivtseva[1], A. Meshik[1], C. M. Hohenberg[1], A. N. Krot[2] and Yu. Amelin[3], [1]Physics Department, Washington University in St. Louis, St. Louis MO 63130, USA (olga@physics.wustl.edu), [2]University of Hawai'i at Manoa, Honolulu, HI 96822, USA, [3]Research School of Earth Sciences, Australian National University, Canberra ACT 0200 Australia.

Introduction: The CB (Bencubbin-like) carbonaceous chondrites differ from other chondrite groups by high metal content (up to 80 vol%), significant depletion in volatile elements, and nearly a complete lack of interchondrule matrix material. Chondrules in CB chondrites have exclusively magnesium-rich compositions and non-porphyritic textures (skeletal and cryptocrystalline); relict grains or coarse-grained igneous rims, indicative of multiple chondrule melting events, are absent. Based on these observations and young Pb-Pb age of CB chondrules, it was proposed that the CB chondrules formed during a single-stage highly-energetic event in a late-stage protoplanetary disk, most likely in an impact-generated plume [1]. According to this model, skeletal chondrules, rich in Ca and Al, represent melt fraction of the plume, whereas cryptocrystalline chondrules, highly depleted in Ca and Al, represent gas-liquid condensates. Such an event, followed by rapid cooling, is capable of resetting different chronometers, thus CB chondrules may be good candidates for anchoring short-lived relative chronometers (e.g., ^{26}Al-^{26}Mg, ^{53}Mn-^{53}Cr, and ^{129}I-^{129}Xe) to absolute (U-corrected Pb-Pb) chronology. Recently, Bollard et al. [2] reported U-corrected Pb-Pb ages of the magnesian skeletal chondrules in Gujba (CB_a): 4562.52±0.44 Ma. High-precision Mg-isotope measurements of skeletal chondrules from Hammadah al Hamra 237 (HH237, CB_b) showed no resolvable ^{26}Mg excess [(^{26}Al/^{27}Al) = (4.5±8.3)×10^{-7}], consistent with their late-stage origin, but not very useful for testing heterogeneity of ^{26}Al distribution in the disk [3].

Previous I-Xe studies of chondrules from Gujba and HH237 by Gilmour et al [4] seemed to yield a closure time 1.87±0.4 Ma before the Shallowater aubrite, which corresponds to an absolute age of 4564.2±0.6 Ma. This age is older than that reported by [2]. However, only 1 of the 7 chondrules measured by [4] yielded an I-Xe isochron. This may be due to intense shock metamorphism experienced by Gujba, which could have disturbed I-Xe systematics in chondrules to various degrees. Here we present I-Xe data for 4 Gujba and 2 HH237 chondrules.

Results and Discussion: The Gujba and HH237 chondrules studied have non-porphyritic skeletal olivine-pyroxene textures and magnesium-rich compositions. Each chondrule was split into fragments to allow combined I-Xe (this study) and Pb-Pb (work in progress) isotope measurements.

The samples were irradiated at the University of Missouri Research Reactor, receiving 2×10^{19} thermal neutrons/cm^3. Xenon was extracted by step-wise pyrolysis in a low blank, W-coil heating element and its isotopic composition was measured by ion-counting mass-spectrometry.

Concentrations of radiogenic ^{129*}Xe and ^{128*}Xe, trapped ^{132}Xe, and U-fission ^{132}Xe are given in Table 1. Concentrations for ^{128*}Xe shown for all extraction steps, minus the first one (800°C), to minimize contributions from ^{128*}Xe associated with the superficial iodine contamination. All concentrations listed should be considered upper limits since iodine- and uranium-bearing phases most probably constitute for only a part of the each chondrule fragment studied.

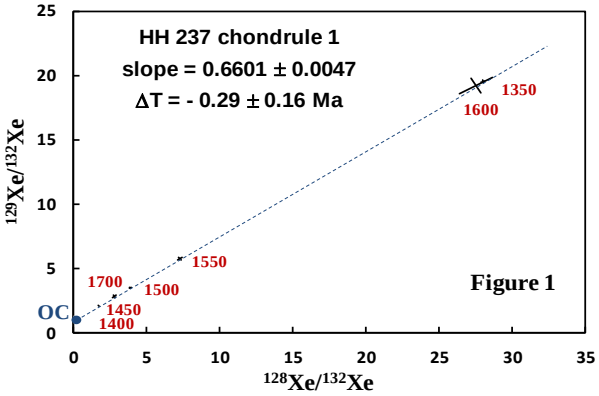
Table 1.

	Ch#	^{129*}Xe	^{128*}Xe	^{132}Xe trapped	^{132}Xe fission
		×10^{-10} cm^{3}STP/g			
Gujba	1	< 0.001	0.2	7.8	0.2
	2	< 0.001	0.6	0.09	0.02
	4	< 0.002	0.06	0.008	0.09
	5	< 0.001	0.8	0.9	0.1
HH237	1	31.1	57.4	9.8	0.1
	3	0.013	2.6	0.7	0.1

All chondrules, with an exception of the Gujba chondrule #2, contain comparable concentrations of U-fission xenon. In all Gujba and HH237 chondrules, U-derived ^{132}Xe shows similar high temperature release patterns in the 1300–1700°C interval (Fig. 2b).

None of the Gujba chondrules studied have detectable ^{129*}Xe, and their concentrations of ^{128*}Xe are at least one order of magnitude lower than those in HH237, similar to what was observed by [4]. The HH237 chondrule #1 yielded a high precision isochron defined by 7 experimental points in the temperature interval from 1300°C up to the melting temperature of platinum (~1770°C). The data obtained for this chondrule are illustrated on a three-isotope diagram, where ^{128}Xe/^{132}Xe plotted versus ^{129}Xe/^{132}Xe after correction for fission Xe (Fig. 1). Fission corrections are generally of negligible impact on I-Xe ages. To verify this we routinely apply the alternative normalization to ^{130}Xe

and compare the resulting ages. In all cases, the slopes of the isochrons using both normalizations agree, well within the uncertainties. In the HH237 chondrule #1, they correspond to a closure of the I-Xe system 0.29±0.16 Ma after Shallowater. This I-Xe age corresponds to an absolute age of 4562.0±0.4 Ma, which is about 2 Ma younger that previously reported I-Xe age for the Gujba chondrule [4].

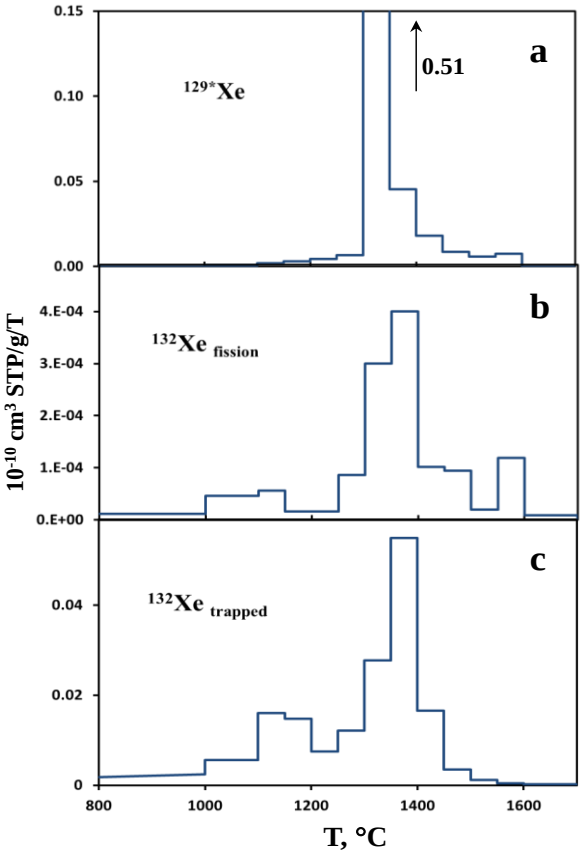


The absolute I-Xe age of the HH237 chondrule #1 of 4562.0±0.4 Ma is in a good agreement with the U-corrected Pb-Pb age of the Gujba chondrules, 4562.52±0.44 Ma [2] and HH237 silicates, 4561.9±0.9 Ma [1]. The release profiles of iodine-derived ^{129*}Xe and U-fission ^{132}Xe seems to correlate at two higher temperatures peaks 1300–1400°C and 1550–1600°C, suggesting a common host and that the I-Xe and Pb-Pb systems in skeletal olivine-pyroxene CB chondrules may indeed have closed at the same time. This independently verifies, within the very small uncertainties, the latest refined absolute closure time of Shallowater aubrite [4], the anchor of absolute I-Xe ages. Given the impact-plume model for the formation of CB chondrules [1] and the inferred simultaneous closure of the I-Xe and Pb-Pb systems [this study], an even more refined intercalibration of I-Xe and Pb-Pb might be possible by a direct comparison of common host Pb-Pb and I-Xe ages of additional CB chondrules.

HH237 appears to be more suitable for the I-Xe studies than Gujba. One in four HH237 chondrules yielded a high precision I-Xe age compared with one in nine for Gujba ([4] + this study). Although Xe in the earlier Gujba work, and reported here for HH237, follows a similar release pattern, in the case of HH237 the experimental points corresponding to both release peaks fall on the same isochron. In addition, the HH237 chondrule has higher concentrations of radiogenic ^{129*}Xe and ^{128*}Xe than the Gujba chondrule [4].

Model calculations for an impact between the core of tidally disrupted body with the composition of CR metal and an H chondrite body assumed to produce a plume with the same metal/silicate ratio as CB chondrites [5]. However the bulk compositions of most CB chondrules do not lay along equilibrium condensation trends indicating that chondrules may have formed by melting of silicate mixtures [5].

Figure 2.



The earlier reported I-Xe age of the Gujba chondrule 4564.2±0.6 Ma [4] is consistent with the absolute I-Xe ages of the oldest chondrules from ordinary chondrites 4564.5±1.8 Ma [6]. We suggest that the I-Xe age of this Gujba chondrule corresponds to the iodine-carrier phase that survived a catastrophic impact between planetary CR- and H-chondrite embryos. The I-Xe age of the HH237 chondrule of 4562.0±0.4 Ma, reported here, may reflect closure after the impact and following rapid cooling at the chondrule formation time, and it appears to reflect a simultaneous reset of the I-Xe and Pb-Pb systems.

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