THE I-Xe RECORD: EARLY ONSET OF AQUEOUS ALTERATION IN MAGNETITES SEPARATED FROM CM AND CV CARBONACEOUS CHONDRITES. O. Pravdivtseva, A. Meshik, C. M. Hohenberg. McDonnell Center for the Space Sciences and Department of Physics, CB 1105, One Brookings Drive, Washington University, St. Louis MO 63130, USA (olga@physics.wustl.edu).

Introduction: Magnetite is one of the first alteration products formed in carbonaceous chondrites during aqueous alteration. Thus it could provide a timeline for the metamorphic changes on various carbonaceous chondrite parent bodies. In preparation for the broader study of magnetites, we first analyzed by the I-Xe method two sets of Orgueil magnetite samples neutron irradiated at different times. Highly magnetic fractions were separated with hand magnet from crushed Orgueil, and later we analyzed another set of samples which consisted of highly magnetic fractions and 2 samples of pure magnetites from Orgueil, one chemically separated prior to the irradiation and another after, both separated following the procedure developed by Lewis and Anders [1]. All samples yielded well-defined isochrons and consistent I-Xe ages, with both of the pure magnetites indicating I-Xe closure in CI Orgueil 2.1 ± 0.2 Ma after formation of CAIs [2, 3, 4] contrary to the early report of Lewis and Anders [1]. However, the major thrust of this study is comparison of formation times of magnetites from different objects.

To study onset of the alteration and its chronology, we collected and prepared 25 magnetite-rich samples from carbonaceous chondrites of different types and metamorphic grades (Table). 6 samples of Orgueil magnetic separates included 5 provided by R. Lewis and prepared in an attempt to study magnetite grains of different morphologies. It was shown that they can potentially preserve individual I-Xe age records, reflecting complex alteration in Orgueil [5]. In CO3 chondrites the I-Xe ages of magnetites seem to reflect their petrologic type [6, 7]. And ungrouped C2 and C3 carbonaceous chondrites both indicated two distinct closure ages for the I-Xe system [8].

Results: Here we present new I-Xe data for 5 magnetite rich samples from CM Murchison and CV3 Bali, Kaba, Mokoia, Vigarano. Murchison separate was provided by R. Lewis. All meteorites was treated following same separation procedure [1], finely ground and stirred with a saturated LiCl solution for 8 days at 60 °C to remove possible silicate-magnetite intergrowth. After further separation in NaOH and washing [9] samples were dried and weighted, small amounts of resulting samples were saved for the later study of the magnetites morphologies. Grosnaja CV3 was part of the study, but did not yield any magnetic material. All CV samples had masses less than 1 gram before the chemical separation, 0.629 g for Grosnaja. Thus, if magnetites were distributed heterogeneously in the matrices, it would be difficult to obtain representative magnetite abundances.

The samples were sealed under vacuum in separate fused quartz ampoules and irradiated with thermal neutrons at the Missouri University Research Reactor along with reference standard and irradiation monitor Shallowater. All 25 magnetite separates which were part of this study were irradiated together in the package designated SLC-16 (Table).

Table. The SLC-16 magnetite separates.

CI 1	Orgueil (6 samples)	
CM 2	Murchison	
CV 3	Bali	
	Kaba	
	Mokoia	
	Vigarano	
CO 3.0	Y-81020,101	no ^{129*}Xe
3.0	Colony	
3.2	Kainsaz	
3.2	Y-82050,115	no ^{129*}Xe
3.3	Y-791717,103	no ^{129*}Xe
3.3	Felix	
3.4	Ornans	
3.5	Y-790992,80	no ^{129*}Xe
3.5	Lance	
3.5	Y-82094,110	
3.6	ALHA77003,117	no ^{129*}Xe
3.7	Warrenton	disturbed
C2-ung	MAC87300,64	
C3-ung	MAC88107,51	

All 4 CV chondrites as well as CM Murchison yielded well defined isochrons. I-Xe age of Murchison magnetite is 2.4 ± 0.1 Ma after formation of CAIs [2]. I-Xe ages of CV3 magnetites range from 1.7 ± 0.4 Ma to 3.9 ± 0.6 Ma after formation of CAIs, Vigarano yielding the oldest age that is in agreement with I-Xe closure in high temperature releases from Orgueil magnetites separated by size [5]. The size separation in Orgueil produced two samples which were enriched in magnetites with the stack of platelets morphology, and one sample that mostly consisted of small magnetite

framboids. Older I-Xe ages of magnetites in Orgueil most probably reflect the closure of the I-Xe system in the stack of platelets grains, and the small framboidal gains are about 1~4 Ma younger. The distinct morphologies of Orgueil magnetites and different I-Xe ages associated with them suggest at least two stages of aqueous alteration.

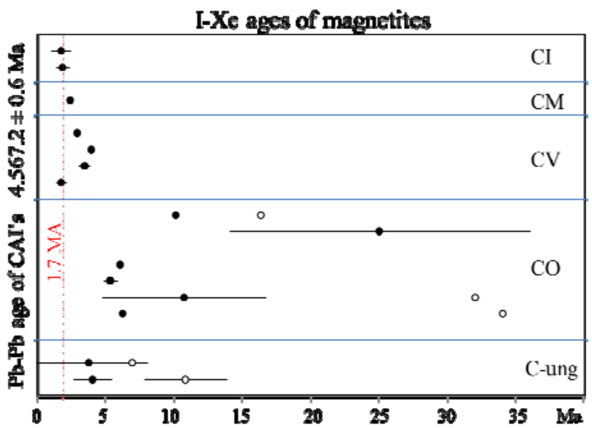

Fig. 1. Iodine-xenon ages of magnetites, separated from carbonaceous chondrites, representing different chondritic groups and metamorphic grades. Open symbols correspond to I-Xe ages derived from the low-temperature step-wise extraction steps.

Discussion: Mineralogical, petrographic and isotopic observations indicate that most groups of chondritic meteorites experienced asteroidal alteration to various degrees, resulting in formation of secondary minerals, including magnetite. The alteration occurred in the presence of aqueous solutions under variable conditions and in many cases was multistage [10]. It was proposed, based on Al-Mg, Mn-Cr and I-Xe ages of secondary minerals that the chondrite parent bodies must have accreted within the first 1-2 Ma after collapse of the protosolar molecular cloud and that alteration lasted up to 15 Ma [10]. I-Xe ages of CM Murchison magnetite and four CV magnetites reported here as well as previously reported ages of magnetites from Orgueil, and two ungrouped C2 and C3 chondrites, all point to the early onset of aqueous alteration (Fig. 1).

The CO chondrites experienced alteration similar to that observed in CV chondrites. A degree of alteration correlates with petrologic types of the host meteorites, suggesting that it occurred in an asteroidal setting [11]. Concentration of radiogenic ^{129*}Xe in 11 CO magnetites studied so far also correlate with their metamorphic grade, supporting asteroidal setting alteration. Three CO magnetites yielded two I-Xe ages, with younger data associated with lower temperature xenon releases. Unrelated to the origin of the low-temperature iodine carrier phase, magnetite or some other secondary mineral impurity in magnetite separate, these younger I-Xe ages indicate that aqueous alteration in CO lasted for about 30 Ma.

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