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NOBLE GAS CHRONOLOGY OF EH3 CHONDRITE ALHA77295 BY CLOSED SYSTEM STEPPED ETCHING. A. J. King[1,3], P. L. Clay[1], S. A. Crowther[1], M. Nottingham[1], J. D. Gilmour[1], R. Wieler[2] and H. Busemann[1], [1]School of Earth, Atmospheric and Environmental Sciences, The University of Manchester, Manchester M13 9PL, UK, [2]Institut für Geochemie und Petrologie, ETH Zürich, Clausiusstrasse 25, 8092, Zürich, Switzerland, [3]Department of Earth Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK (a.king@nhm.ac.uk).

Introduction: Enstatite chondrites contain distinctive silicates, sulphides and metals consistent with formation under highly reducing conditions close to the Sun [1, 2]. Establishing a precise chronology of processes and events on the enstatite parent body(ies) is crucial to understanding the evolution of the inner solar system.

To constrain the time of formation, thermal and shock history of enstatite chondrites and their components, we have been undertaking Closed System Stepped Etching (CSSE) experiments [3] combined with noble gas mass spectrometry. Previous analysis of unirradiated St. Mark's (EH5) meteorite (~250 mg) by CSSE showed early correlated releases of radiogenic $^{40}Ar^*$ and $^{129}Xe^*$, and low $^{21}Ne/^{22}Ne$ [4]. The host phase was tentatively identified as the K-bearing sulphide djerfisherite ($(K,Na)_6(Cu,Fe,Ni)_{25}S_{26}Cl)$) and may offer an opportunity to link the long-lived Ar-Ar and short-lived I-Xe chronometers.

We recently reported results from a new etch of irradiated St. Mark's (~50 mg) [5]. Although Ar-Ar and I-Xe ages were successfully obtained from at least two distinct phases in the meteorite (likely enstatite and feldspar minerals), neither could be reliably attributed to djerfisherite. This may be explained by the scarcity of djerfisherite in the highly altered St. Mark's meteorite (< 0.1%) [6] and relatively small sample mass analyzed compared to the study of [4]. Here we present first results from a CSSE experiment on ALHA77295 (EH3), an unequilibrated enstatite chondrite with a pristine mineral assemblage reflecting formation and accretion of its parent body.

Experimental: Approximately 30 mg of bulk ALHA77295 was neutron-irradiated (NRG Petten, ~2 × 10^{18} n/cm^2) and then analyzed for all noble gases (He – Xe) using the online CSSE gold line at ETH Zürich. The sample was etched over 29 steps in ~6 weeks using ~1 ml HF at temperatures between 20°C (acid vapor) to 75°C (distilled acid).

Gases released from the sample were gettered to remove H_2, HF, H_2O, CH_4 etc. before analysis using the noncommercial "*Albatros*" mass spectrometer. Procedural blanks, measurements without including the sample volume, were made both before and during the etch run. Mass discrimination and spectrometer sensitivities over the duration of the run were obtained regularly by measuring known amounts of pure calibration noble gases.

To support the bulk analysis, a thin section of ALHA77295 (A77) was studied by optical and electron microscopy. Twenty-three djerfisherite grains were identified according to their petrography, textures and mineral chemistry [7]. Several of the grains were extracted from the section using UV laser ablation and manual treatment and then neutron-irradiated (different irradiation but under the same conditions). Two djerfisherite grains, A77_H (~150 μm diameter) and A77_C (~50 μm), were laser-step heated and analyzed for Xe isotopes using the RELAX mass spectrometer [8]. During the grain analyses instrument blanks and air calibrations to monitor sensitivity were measured at regular intervals.

Results: *Bulk Etch.* Figures 1 and 2 show preliminary Ar and Xe isotopic data from the bulk etch experiment on irradiated ALHA77295. For Ar the largest releases were steps 14 (~20% of total release) and 15 (~13%). Most of the early steps (~1 – 14) contained a mixture of trapped solar wind (SW) and a radiogenic component. This is consistent with the observation of SW in some fragments of ALHA77295 [9] and the incorporation of SW in the parent body regolith into the uppermost micrometers of each grain. Most of the later steps (~15 – 29) contained a mixture of air and radiogenic Ar with a constant $^{40}Ar^*/^{39}Ar$ ratio ($^{40}Ar^*$ from the decay of ^{40}K) resulting in an isochron from which an age will be obtained. The largest releases of Xe came in steps 13 (~14%) and 14 (~13%). The Xe data show a good correlation between radiogenic $^{129}Xe^*$ (from the decay of ^{129}I) and ^{128}Xe (converted from ^{127}I) over all of the etch steps. Initial measurements of monitors for this irradiation suggest an age of ~24 Ma after the closure of Shallowater (Shallowater age 4562.3 Ma [10]), but a final I-Xe age for ALHA77295, plus an Ar-Ar age, will be presented at the meeting.

Djerfisherite Grains. Grain A77_H released Xe (~7 million total atoms of ^{132}Xe) over 40 heating steps. Releases from steps 20 – 40 displayed an excellent correlation between $^{129}Xe^*$ and ^{128}Xe (Fig. 3). The isochron defined by these steps gives an I-Xe age for grain A77_H of 1.9 ± 1.1 Ma before the closure of Shallowater. Grain A77_C released Xe over 28 heating steps, with $^{129}Xe^*$ and ^{128}Xe well correlated over steps 15 – 28. From the defined isochron A77_C has an age of 2.4 ± 2.5 Ma before Shallowater.

Discussion: Previous CSSE of the altered St. Mark's meteorite produced multiple Ar-Ar and I-Xe isochrons owing to its complex history [5]. In contrast ALHA77295 yielded only single Ar-Ar and I-Xe isochrons, likely due to its more primitive nature. Correlated $^{40}Ar^*$ and ^{39}Ar was clearly observed only in the later steps of the experiment, possibly due to it coming from a distinct phase not initially etched by the acid. Djerfisherite is the main K-bearing mineral in ALHA77295 although other candidates may include K-feldspar or roedderite ($(K,Na)_2Mg_5Si_{12}O_{30}$)). The host phase for Xe could be enstatite, although analysis of individual djerfisherite grains from ALHA77295 show that it is also a carrier of significant Xe.

Ar-Ar and Rb-Sr ages for djerfisherite in the EH3 meteorites Qingzhen and Y-691 range from ~2 – 4.4 Ga [11, 12]. The youngest ages are attributed to a late metamorphic event on the parent body that caused the breakdown of djerfisherite to troilite ("Qingzhen reaction") [13]. However, the I-Xe chronometer may be decoupled from Ar-Ar and Rb-Sr [14], and absolute I-Xe ages for the djerfisherite grains A77_H (4564.2 (±1.1) Ma) and A77_C (4564.7 (±2.5) Ma) are instead more comparable to the oldest chondrule ages (4564 – 4561.4 Ma) in the Qingzhen and Kota-Kota (EH3) meteorites [15]. As djerfisherite in ALHA77295 is very old and often pristine, lacking the breakdown structures typical of the "Qingzhen reaction", we suggest that it originated as a nebula condensate rather than forming on the parent body.

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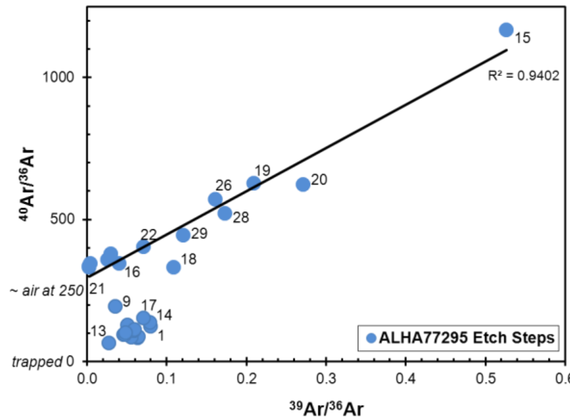

Figure 1. *Preliminary Ar isotope data from 29 etching steps (labeled) of bulk ALHA77295 (EH3). Later releases had correlated radiogenic $^{40}Ar^*$ and ^{39}Ar, possibly from a newly etched phase.*

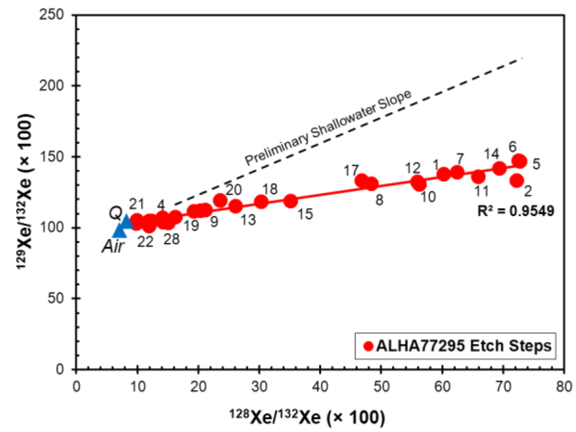

Figure 2. *Preliminary Xe isotope data from 29 etching steps (labeled) of bulk ALHA77295 (EH3). Radiogenic $^{129}Xe^*$ and ^{128}Xe were correlated over all of the etch steps and define an isochron from which an I-Xe age can be obtained.*

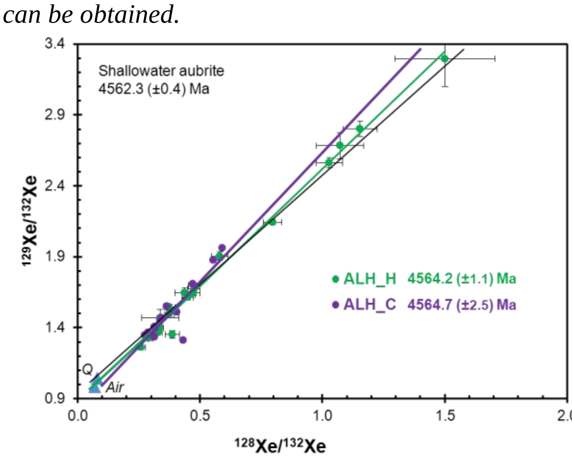

Figure 3. *Xe isotopic compositions for djerfisherite grains A77_H and A77_C. Isochrons give ages of 1.9 ± 1.1 Ma (A77_H, green) and 2.4 ± 2.5 Ma (A77_C, purple) before the closure of Shallowater (black).*