EARLY I-Xe AGES OF CLASTS AND CHONDRULES FROM THE L6 CHONDRITE BARWELL. S. A. Crowther, M. J. Filtness and J. D. Gilmour, School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Manchester, M13 9PL, UK (sarah.crowther@manchester.ac.uk).

Introduction: The chondrite parent bodies are thought to have accreted at some point after CAIs and chondrules formed. It is reasonable to assume that they formed after ^{26}Al had decayed beyond the point that it could provide sufficient heat to completely melt an asteroid (>2 Ma after CAI formation). However this sequence of events does not explain the presence of ancient igneous clasts found within some chondrites.

Previous analyses of 2 individual clasts from the meteorite Barwell have shown the clasts to have very old formation ages: Hutchinson *et al*. [1] reported an I-Xe age of 4566.5(14) Ma for one individual clast, and Gilmour *et al*. [2] reported an age of 4566.40(72) Ma for another. These clasts are igneous in nature, rather than chondritic. One possible explanation for their unusually early ages is they are relics from a previous generation of melted, differentiated planetesimals. If this is the case, it would support data from magmatic iron meteorites that suggests that there was an earlier generation of planetesimals that pre-date the formation of the chondrite parent bodies [e.g. 3-5]. These "grandparent bodies" formed when ^{26}Al was still alive, which provided a source of heat causing them to melt and differentiate. Some of these early planetesimals could have been destroyed by collisions, and surviving fragments later incorporated into the next generation of planetesimals.

Barwell is classified as an L6 ordinary chondrite, and contains numerous chondrules and clasts. It shows signs of having experienced high temperature recrystallisation; the mineralogy suggests it experienced a maximum temperature $\leq 950\ ^{o}C$ [6]. The clasts in Barwell, which are unusually large, preserve evidence of early planetary, igneous differentiation. Their bulk compositions, however, are primarily chondritic, leading to some uncertainty regarding their origin [7]. The clasts tend to have broken surfaces and angular outlines, features indicative of them having belonged to larger objects. Chondrules in Barwell are typically 1-2 mm in diameter. The vast majority are microporphyritic olivine chondrules; other types of chondrules are rather scarce [6]. Although the chondrules are well defined, their borders and rims have sometimes fused with the surrounding matrix, a process which probably occurred during a period of metamorphism.

In addition to the I-Xe ages mentioned above, whole rock samples and clasts from Barwell have been dated using the Ar-Ar and Pb-Pb chronometers, with ages ranging between 4440 Ma and 4559 Ma [8-10]. This large range of ages suggests that Barwell may be composed from material which experience very different histories before the parent body accreted. Barwell may be a breccia, despite there being very little evidence of shock on the macroscopic scale [6].

In this study we have determined the I-Xe ages of several clasts and chondrules from Barwell to investigate whether other inclusions in the meteorite are as old as the previously reported clasts. Six clasts and five chondrules were extracted from Barwell for this study by J. Bridges (University of Leicester, UK) from samples provided by the NHM (London, UK). The clasts analysed in this work most closely match the criteria for impact-melt clasts [7], although their petrography was not examined in detail as obtaining I-Xe ages was the main goal of this study. In hand specimen the clasts have an igneous texture. SEM images reveal the clasts to be dominated by olivine phenocrysts surrounded by a pyroxene- and feldspar-rich glassy matrix [11].

Experimental: I-Xe dating relies on the β decay of ^{129}I to ^{129}Xe (half life 15.7 Ma). Prior to analysis samples are neutron irradiated to convert ^{127}I to ^{128}Xe. This allows simultaneous measurement of ^{129}Xe produced from decay of ^{129}I, and ^{127}I as ^{128}Xe. A correlation is sought between $^{128}Xe^*$ and $^{129}Xe^*$ (* denotes an excess over the trapped component) during a stepped heating experiment, from which the $^{129}Xe^*/^{128}Xe^*$ is determined. This is directly proportional to the initial $^{129}I/^{127}I$ ratio, and from this the relative age, in relation to other material, is determined. An absolute age is calculated by reference to a standard of known age. Samples analysed in this study were included in irradiation MN08-A at the Pelindaba reactor in South Africa (thermal fluence 7.53×10^{18} ncm^{-2}), along with aliquots of enstatite from the meteorite Shallowater as the irradiation standard.

Following irradiation samples were analysed using the RELAX (Refrigerator Enhanced Laser Analyser for Xenon) mass spectrometer [12,13] at the University of Manchester. Samples were step heated using a laser at sequentially increasing powers. The gas extracted in each individual heating step was analysed to determine the Xe isotopic ratios.

Results and Discussion: All the clasts and chondrules analysed in this study contained evidence of excess ^{129}Xe derived from ^{129}I. The chondrules tended to contain larger quantities of trapped Xe, and smaller quantities of I-derived Xe than the clasts. Only one chondrule, BCH4, failed to produce an isochron.

Two of the clasts have unusually old and well defined I-Xe ages: BCL3.7 is 2.52(47) Ma older than Shallowater and BCL3.5 is 3.14(34) Ma older (Fig. 1), which correspond to absolute ages of 4564.82(62) Ma and 4565.44(52) Ma respectively (assuming a Shallowater age of 4562.3±0.4 Ma [14]). These two clasts are ~1.0-1.7 Ma younger than the clasts analysed in previous studies [1,2]. These samples contained only very small quantities of trapped Xe, the Xe approaches pure I-derived Xe.

Two further clasts give somewhat younger ages: BCL4.2 is 2.27(49) Ma younger than Shallowater and BCL5.1 is 8.03(37) Ma younger, corresponding to absolute ages of 4560.04(64) Ma and 4554.27(54) Ma respectively. These two samples contained a larger contribution of trapped Xe than the two older samples, the composition of which is consistent with Xe-Q [15].

Only one chondrule, BCH3, gave a well defined age. It has a very old formation age, 4.31(98) Ma before Shallowater, corresponding to an absolute age of 4566.6(11) Ma. The age of this chondrule is somewhat older than the clasts analysed in this study; it is identical within uncertainty to the ages of the clasts analysed in previous studies [1,2].

Evidence from the U-Pb and Pb-Pb systems suggests that Barwell has not been disturbed, it remained unaltered [9]. Therefore it is unlikely that these I-Xe ages represent resetting events and probably do reflect their formation ages.

If the Barwell clasts originated from a previous generation of parent bodies, and have not been altered since, we would expect them to exhibit early I-Xe ages – this is exactly what is observed for BCL3.7, BCL3.5 and BCH3. BCH3 formed within ~1.6 Ma of CAIs (4568.2 Ma [16]); BCL3.7 and BCL3.5 within ~3-4 Ma of CAIs. The early ages are indicative of rapid cooling on the parent bodies where the clasts formed. However such rapid cooling in unlikely given that ^{26}Al and ^{60}Fe were still alive at that time. One possible explanation would be that the parent bodies of the clasts were destroyed by early collisions, exposing the core and hence causing a rapid decrease in temperature.

The Xe isotopic composition measured in two further clasts (BCL3.6 & BCL5.2) and three further chondrules (BCH1, BCH2 & BCH5) is not consistent with a Xe-Q trapped component that has evolved due to *in situ* decay of ^{129}I. Most of these samples exhibit low ^{129}Xe/^{132}Xe ratios relative to Xe-Q, but *in situ* decay of ^{129}I can only increase this ratio. Gilmour *et al.* [17] propose that rather than being the product of closed-system evolution, this may represent mixing of a pure I component with a component that contains both Xe and I. They suggest that this may be a result of shock incorporation of I: such a component is observed in

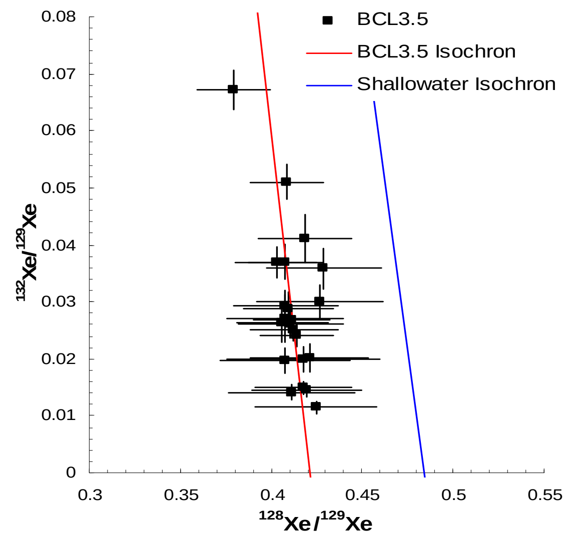

Fig. 1. High temperature heating steps for BCL3.5. Low temperature heating steps, which do not form part of the isochron, are excluded.

lightly shocked Nakhla, suggesting similar components may be widespread in other meteorites. Although Barwell shows little evidence of shock on the macroscopic scale, there are mineralogical and petrological indicators of low grade shock on the microscopic scale [6].

Conclusions: This study confirms the presence of ancient clasts in Barwell, whose formation requires the existence of a generation of early planetesimals. This adds to the emerging picture of a population of first generation planetesimals that formed within ~1 My of CAI formation. It is noteworthy that the I-Xe ages of these clasts have been preserved through metamorphism: Barwell is classified as a type 6 chondrite, and the petrology confirms a high degree of thermal alteration which might have been expected to have reset the I-Xe system.

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