Ar-Ar Age of the L Chondrite Northwest Africa 091: More Evidence that Multiple Isochrons Reveal a Link to Fossil Meteorites. J. R. Weirich[1], C. E. Isachsen[2], and T. D. Swindle[1,2]. [1]University of Arizona, Department of Planetary Sciences, 1629 E. University Blvd., Tucson AZ, 85721, [2]University of Arizona, Department of Geosciences, 1040 E. 4th St., Tucson AZ, 85721.

Introduction: ^{40}Ar-^{39}Ar (hereafter referred to as Ar-Ar) dating of many L chondrites has revealed a large impact on the L chondrite parent body ~500 Ma, though many give slightly older ages [1]. Fossil meteorites (meteorites that have had most of their minerals replaced, but retain their texture) with cosmic ray exposure ages of 0.1-1 Ma have been found in a Swedish quarry dated to 467 ± 1.5 Ma [2]. Korochantseva et al. (2007) [3] used multiple isochrons to mathematically remove the trapped Ar componenent from their samples, and dated a suite of L chondrites to 470 ± 6 Ma, identical with the age of the quarry. Surprisingly, most meteorites had two trapped components, neither of which gave a ^{40}Ar/^{36}Ar ratio of terrestrial air (295.5 ± 0.5) or primordial Ar (<1), but instead ranged from ~126 to ~312. Here we report the Ar-Ar age of NWA 091, which gives a similar story.

Procedure: Three splits of Northwest Africa (NWA) 091 were wrapped in Al foil and irradiated at the Cd-lined in-core irradiation tube (CLICIT) reactor at Oregon State University for 35 hours (which converts ^{39}K to ^{39}Ar), and analyzed on a VG5400 at the University of Arizona via step heating experiments in a resistance furnace. The measured ^{38}Ar/^{36}Ar ratio was assumed to be a two-component mixture of trapped Ar (0.1869 ± 0.0004) and spallation (1.54 ± 0.02). After removing the spallation component, a reverse isochron plot was used to identify the trapped component.

Results:

Did we activate Cl? By irradiating our samples with Cd-shielding, we should have limited Cl-produced ^{38}Ar. However, a small contribution could still be present. By plotting ^{38}Ar/^{36}Ar vs. ^{37}Ar/^{36}Ar, steps that consist only of trapped Ar and Ca-spallation-produced Ar will form a straight line (see [4] for more explanation). This is shown in Fig. 1 for split B4. All steps have a ^{38}Ar/^{36}Ar below 1.54, and the vast majority of steps do indeed fall on a line (blue diamonds are included in the fit, red squares are not). Hence, it appears Cl-produced ^{38}Ar will not affect our results, though this is not always the case for meteorites irradiated at CLICIT [4].

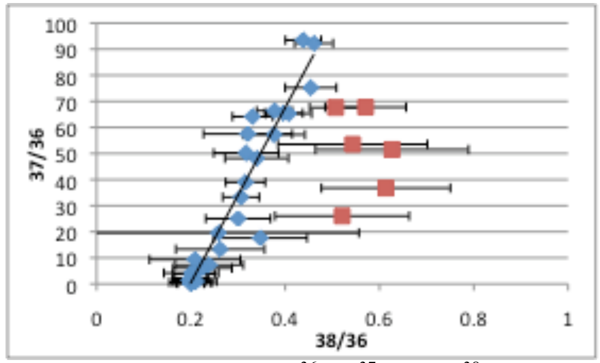

Figure 1. 3-isotope plot of ^{36}Ar, ^{37}Ar, and ^{38}Ar.

Isochron: A reverse isochron (after spallation removal) of sample B4 is shown in Fig. 2. Steps extracted below ~1200 °C are shown as blue diamonds (closed or open), those above are shown as red squares. Errors are often smaller than the symbol. The green line is a weighted fit of the closed diamonds, and the purple line is a weighted fit of the squares. The other two samples have the same behavior for points below 1200-1300 °C, though no obvious linear trend occurs at higher temperatures due to fewer steps at those temperatures. Results for the trapped components of all samples are listed in Table 1.

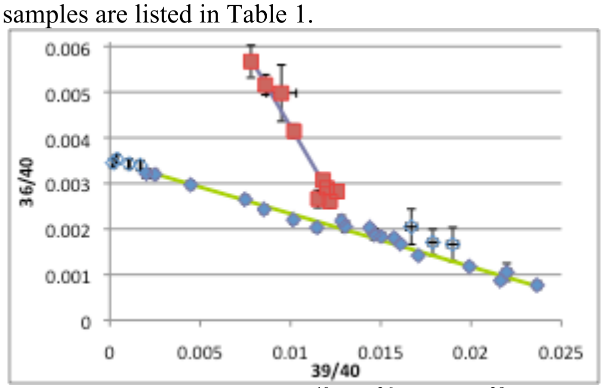

Figure 2. 3-isotope pot of ^{40}Ar, ^{36}Ar, and ^{39}Ar, corrected for spallation.

Plateau Plot: If the trapped Ar component is not "removed" from the plateau plot, the youngest apparent age of all extractions is ~575 Ma, and a distinct saddle shaped spectra is observed, indicating the prescence of excess Ar. Fig. 3 shows the plateau plot for all three samples (which are very well behaved) after "removing" the identified trapped component. The only discrepancy is above ~90% ^{39}Ar released, where splits B2 and B3 have low apparent ages due to assuming a single trapped component, when there are probably two. Large errors below ~5% ^{39}Ar released are due to a large trapped correction. Results are summarized in Table 1. In all three splits, there are a few steps between ~32 and 42 %^{39}Ar released (depending on the split) that give apparent ages less then the plateau age. From the release plot (not shown), these steps correspond to a transition from one release to another. These steps probably indicating weathering or partial resetting, and are not included in the plateau age. The plateau ages for each split are calculated by summing together the ^{39}Ar and ^{40}Ar from all steps in the plateau. A weighted average of the three low temperature plateaus give 472.2 ± 5.9 Ma.

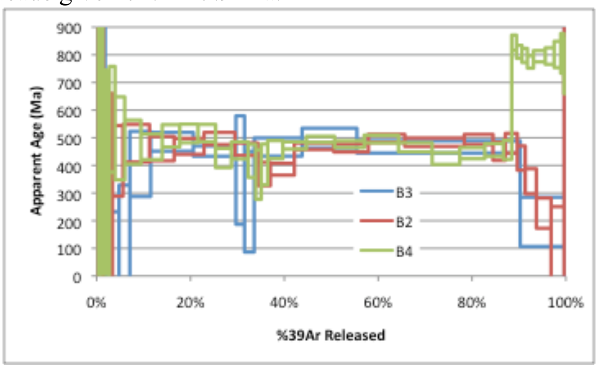

Figure 3. Plateau Plot of all 3 samples of NWA 091.

Table 1. Summary of Plateaus

	40/36 trap	#	%39	Age (Ma)
B3	289.5 ± 9.1	6	79.3	468.5 ± 14.5
B2	283.1 ± 4.8	13	78.5	476.0 ± 9.3
B4 plat 1	285.6 ± 3.9	19	81.6	474.2 ± 9.1
B4 plat 2	90.9 ± 5.5	9	11.6	799.1 ± 70.7

Conclusions: The younger plateau age is identical with the value determined by [3], further confirming a link between L chondrites and fossil meteorites. The older plateau found in split B4 is consistent with the Ar-Ar age of Cat Mountain and Y 74445 [4,5], hinting at another large impact on the L chondrite parent body ~800 Ma.

Two plateaus in the same split can be understood by two thermal events influencing different domains with different Ar retentivities. A large event at ~800 Ma that caused complete resetting in all domains, could have been followed by a smaller event at ~470 Ma which completely reset less retentive domains, but left the more retentive domains unaffected. By acquiring high resolution Arrhenius plots for two splits of NWA 091, [6] showed that the gas below ~35-40% ^{39}Ar released (<~900 °C) is from shocked feldspar, the gas from ~40-88% (~900 to ~1100 or ~1200 °C) is due to feldspar enclosed in pyroxene (seen in thin section and confirmed by diffusion parameters), with the remainder from feldspar enclosed in either large pyroxene grains or another high temperature mineral such as olivine (seen in thin section, hard to determine from diffusion data). This Ar retentivity pattern is fully consistent with the observed plateaus.

All three splits give a ^{40}Ar/^{36}Ar trapped component close to, but different from, terrestrial air (295.5 ± 0.5). A common source of the terrestrial trapped component in meteorites is adsorbed air and/or alteration products, and it may be possible to slightly fractionate these components. While this may explain the trapped gas in the first few extractions, we find it very hard to believe a trapped terrestrial component could be present at temperatures up to 1300 °C,which would indicate altered pyroxene. [3]'s preferred explanation for the non-terrestrial yet non-primordial trapped component is a mixture of primordial Ar and shock-mobilized radiogenic ^{40}Ar, though at this time it is undetermined why radiogenic ^{40}Ar would be homogenized with primordial Ar instead of simply lost via diffusion. Regardless of the source of trapped Ar, it is curious that the shocked feldspar and feldspar enclosed by pyroxene have the same trapped component, but the third source of K (feldspar enclosed by olivine?) has a different trapped component.

References: [1] Bogard D. D. (1995) *Meteoritics, 30,* 244-268. [2] Schmit B. et al. (2001) *EPSL, 194,* 1-15. [3] Korochantseva E. V. et al. (2007) *MAPS, 42,* 113-130. [4] Swindle. T. D. et al. (2011) *LPS XLII,* submitted. [5] Kring D. A. et al. (1996) *JGR, 101,* 29353-29371. [6] Weirich et al. (2011) *LPS XLII,* submitted.