$^{40}Ar/^{39}Ar$ LASER STEP HEATING AGES OF SOME APOLLO 17 MELT ROCKS AND THE AGE OF THE SERENITATIS IMPACT: **G. Brent Dalrymple**, Oregon State University, Corvallis, OR 97331, and **Graham Ryder**, the Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston, TX 77058

We are attempting to refine the chronology of lunar basin formation in order to test the several hypotheses for the early bombardment history of the Moon by large impactors, which range from gradually declining early bombardment to late cataclysmic bombardment only [1,2,3]. Our approach is to use a laser system to obtain high-resolution $^{40}Ar/^{39}Ar$ ages on carefully characterized samples of impact melt rocks. The use of the laser system allows us to obtain high resolution age spectra on very small (sub-milligram) samples, thus avoiding or minimizing the effects of older clasts. Using these methods, we have determined an age of 3,893 ± 9 Ma for the Serenitatis impact, which is significantly older than our maximum age for the Imbrium impact of 3,867 Ma measured using the same methods [4].

We have obtained $^{40}Ar/^{39}Ar$ age spectra for six poikilitic impact melts whose chemical compositions are generally considered representative of the Serenitatis impact (Table). Sample **72395,96a** is a fragment of the fine-grained melt from Boulder 2, Station 2 (S. Massif). Sample **72535,7a** is a fragment of melt from a rake sample taken near Boulder 2, Station 2. Sample **76315,150** is a fragment of melt from a melt breccia sample chipped from Block 2 of the big boulder at Station 6 (N. Massif). These three samples gave similar $^{40}Ar/^{39}Ar$ age spectra (Figure) with anomalously high ages in the earliest (low T) increments, an intermediate T age plateau, and anomalously low ages over the high T increments. Such spectra are characteristic of ^{39}Ar recoil out of fine-grained, K-rich phases and its implantation into more retentive, K-poor phases [5]. Recoil generally does not affect the intermediate T increments, which still record the crystallization age of the sample. The mean age of the three intermediate-T age plateaus is 3,893 ± 9 Ma. Of these three samples, only 76315 had been dated previously and gave an $^{40}Ar/^{39}Ar$ plateau age of 3,920 ± 40 Ma [6], which is not significantly different from our new ages though less precise.

Sample **77135,178a**, a melt fragment from a vesicular breccia taken from a boulder at Station 7 (N. Massif), did not give a plateau but had low ages in the early (low T) increments rising to a maximum in the age spectrum at about 75% ^{39}Ar released indicating an age >3,743 Ma and thermal disturbance, perhaps caused by a younger impact. Previous workers obtained similar $^{40}Ar/^{39}Ar$ age spectra from samples of the matrix of this breccia [7,8], although Stettler et al [9] obtained age spectra on two aliquants of 77135,89 that showed Ar loss in the low T increments but increased to intermediate T plateaus indicating an age of 3,850 ± 30 Ma for this sample. The fragment we analyzed, as well as the one analyzed by Stettler et al., has an unusually high K/Ca (ca 10x, particularly in the early increments) making it distinctly different from the "typical" Serenitatis melt.

Table. Summary of $^{40}Ar/^{39}Ar$ incremental heating results.

Sample	Description	MgO (%)	Sm (ppm)	Weight (mg)	Spectrum description	Plateau ^{39}Ar (%[steps])	Age[a] (Ma)
72395,96a	poikilitic melt		17.1	0.529	good plateau	36[20 of 55]	3,893 ± 16
72535,7a	poikilitic melt	13.2	13.5	0.703	good plateau	31[18 of 48]	3,887 ± 16
73155,33a	gabbro clast		14.4	0.870	poor plateau	17[4 of 35]	3,865 ± 16
73155,33b	gabbro clast		14.2	0.322	good plateau	47[24 of 61]	3,900 ± 16
73155,33e	poikilitic melt			0.489	good plateau	34[10 of 42]	3,854 ± 16
73155,34a	poikilitic melt	10.5	14.4	0.474	good plateau	22[12 of 48]	3,937 ± 16
76315,150	poikilitic melt		15.4	0.620	good plateau	34[14 of 38]	3,900 ± 16
77135,178a	poikilitic melt		15.5	0.418	increasing		>3,743

[a] 2σ errors

$^{40}Ar/^{39}Ar$ Ages of Apollo 17Melt Rocks. Dalrymple G.B. & Ryder G.

Sample **73155** is a walnut-sized rock that was scooped from the landslide on the S. Massif. It consists of about 15% lithic clasts and 85% melt matrix whose composition is typical Serenitatis melt. There are no previous geochronologic analyses of this sample. 73155,33e and 34a were fragments intended to be pure melt. Both fragments give good age spectrum plateaus but the results are inconsistent, suggesting that one or both of the fragments may have been contaminated by clasts (Table). 77135,33a and 33b were fragments of gabbro clasts although we cannot be sure that they were entirely free of melt matrix; these, too, gave inconsistent plateau ages. It is clear that this sample has a complex history and it may have been strongly affected by or formed by a post-Serenitatis impact.

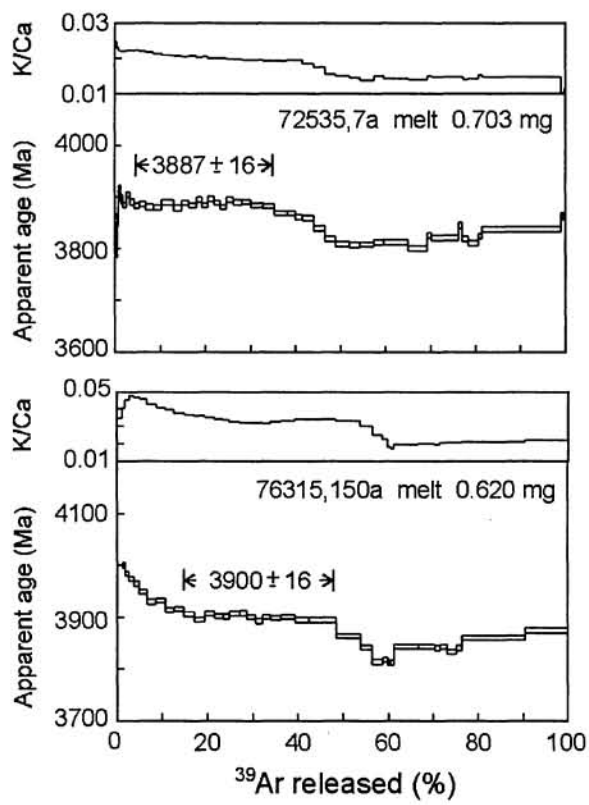

Figure 1. High resolution $^{40}Ar/^{39}Ar$ age spectra for two Apollo 17 melt rock fragments.

Our best estimate of the age of the Serenitatis impact is 3,893 ± 9 Ma, the mean of the three ages for Serenitatis melt samples **72395,96a, 72535,7a,** and **76315,150a**. In our previous study of Apollo 15 melt rocks [4] we found that six melt rocks, representing at least three and perhaps four distinct impact events, had very similar $^{40}Ar/^{39}Ar$ plateau ages with a mean of 3,867 ± 4 Ma. A seventh Apollo 15 melt gave a plateau age of 3,836 ± 11 Ma. From these data we concluded that the Imbrium impact was no older than 3,867 Ma and probably no older than 3,836 Ma. Our new age of 3,893 Ma for the Serenitatis impact indicates, therefore, that Serenitatis is significantly older than Imbrium even if Imbrium is as old as our maximum estimate of 3,867 Ma. This clear distinction in age is possible because of the substantially higher precision of our new melt rock data compared with previously published ages, which could not preclude the possibility that the Imbrium and Serenitatis were of similar age.

The significance of the age of the Serenitatis impact depends on its relative age with respect to other impact basins, for which the evidence is poor. If Serenitatis is one of the older nearside basins, as its degraded appearance and the density of large craters on its ejecta has led some workers to suggest [10, summary in 11], then much of the visible landscape formed between 3,893 Ma and 3,836 Ma. If Serenitatis is relatively young, as has also been argued [e.g., 12], then lunar basin formation might have extended over a much longer period of time. A careful reinvestigation of the stratigraphic evidence for the relative age of Serenitatis might help to answer this important question.

References:

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