AR AGES OF MARTIAN METEORITE NWA 7034. F. N. Lindsay⌧,[1,2]; J. S. Delaney[1,2], B. D. Turrin[2,3], G. F. Herzog[1,2], J. Park[1,2,4], and C. C. Swisher[2,3]. [1]Dept. of Chem. & Chem. Bio., (⌧flindsay@rci.rutgers.edu) [2]Rutgers University, New Brunswick, NJ, 08854; [3]Earth & Planet. Sci.; [4]Kingsborough Comm. Coll., Brooklyn, NY, 11235.

Introduction: NWA 7034 and the samples with which it is paired is a martian sedimentary rock. These stones contain several lithologies with different provenances. The ages of the bulk meteorites without lithologic constraint vary: a disturbed Rb-Sr age of 2.1 Ga [2]; Sm-Nd age of 4.4 Ga [3]; K-Ar ages between 0.9 and 1.6 Ga [4]; and a U-Th/He age of ~0.17 Ma [4].

[1,5] reported U-Pb zircon ages in both NWA 7034 and NWA 7533 of ~4.4 and 1.4 Ga. Further, [5] reported a later disturbance inferred from the U-Pb intercept at 1.7 Ga, which has been interpreted as heterogeneous resetting and/or a mixing between feldspar and whole rock 1.7 Ga ago [6]. A few zircons yield Pb-Pb ages of ~1.4 Ga [5]. Baddelyite grains have Pb-Pb ages ranging from 4.0 – 4.3 Ga and [6] reports a Pb-Pb phosphate age of 1.7 Ga. Ar-Ar ages for micro-samples of plagioclase separates and single alkali feldspar grains range from 0.80 – 2.12 Ga [7].

In summary, the age distributions of the breccias indicate that they mingle material from several sources including three with Ar/Ar ages of ~0.8, 1.4, and 2.0 Ga. To date, however, lithologic context for interpreting the ages has been limited.

Here we present Ar-Ar ages for the NWA 7034 stone, integrate them with our results from NWA 7533 [7], and examine the relationships between the Ar/Ar systematics for bulk samples with those of separated minerals from known lithic components.

Experimental Method: We received samples from: C.–Y Shih at NASA/JSC; and from C. Agee at UNM. The grains from NASA/JSC had been separated for other measurements [3]. We sorted them based on EDS derived semi-quantitative compositions of K_2O wt% as follows: Plag2: 0.1-0.45, Plag1: 0.5 – 4.0; Alk Fsp >10. These grains are identified by the superscript 1 in Table 1.

From UNM, we received chips that we polished and then mined from various lithic components. Although the grains were, for the most part, too small to measure individually (<1 µg), we were able to retain petrologic context during excavation by keeping grains from discrete clasts together. The UNM samples are identified by the superscript 2 in Table 1.

The samples were characterized using both Raman and energy dispersive spectroscopy. Ar isotopes were measured with a MAP 215 mass spectrometer at Rutgers Univ. [9] after an 78 hr. irradiation. Typical blanks (10^{-18} mol) were: ^{40}Ar, ≤110; ^{39}Ar, 3.8; ^{38}Ar, 1.1; ^{37}Ar, 23; ^{36}Ar, 3.8.

Results and Discussion: We present integrated and plateau ages, masses and a short description of each sample in Table 1.

Petrology: Our petrologic observations, which were made during microprobe work, agree with others' [2,4,8]. The stone is a sedimentary breccia with a variety of lithologic clasts and textures. Most feldspar grains (targets for Ar dating) were An_{60} to An_{10} in composition and < 100 µm in size; an unusual 1mm grain was riddled with calcite veining and inclusions. Lamellar exsolution was observed in both feldspar grains, as perthite and antiperthite, and pyroxenes, which have both cpx and opx hosts. Flow and quench textures are evident, with some clasts exhibiting shock mosaicism, radial plagioclase laths and impact sherules. Whereas some clasts are certainly magmatic, the matrix also contains larger grains that may be xenocrysts.

UNM sample descriptions: T(20) is part of a large (1.75mm × 0.75 mm) feldspar that was originally thought to be a single grain but fell apart during excavation from Chip5; Fsp8Grain consisted of 8 grains from the matrix of Chip2; bulkChip7 was a feldspar-enriched bulk sample from Chip7; HiKFsp was made up of 6 grains from within a discrete clast that disaggregated during excavation from Chip6.

Table 1. Descriptions and Ages of Samples from NWA 7034

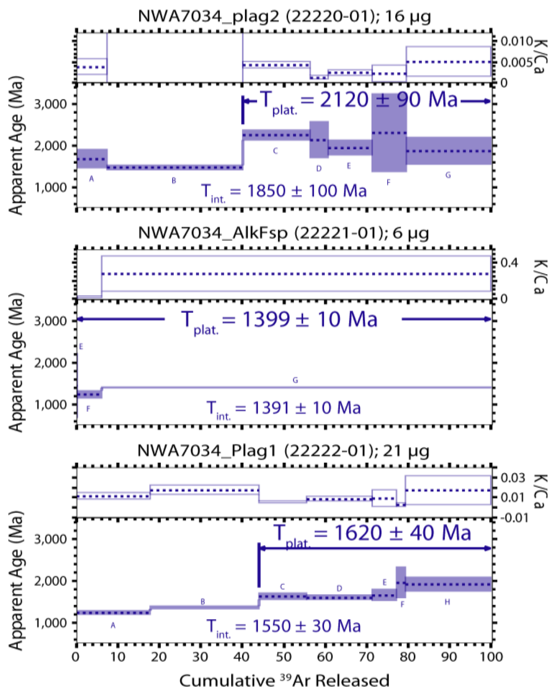
Sample	RU Id#	Mass (µg)	Description	Int. Age ± 1σ (Ma)	Plat. Age ±1σ (Ma) /% ^{39}Ar gas
Plag2[1]	22220	16	6 plag	1850±100	2120±90/59.8
AlkFsp[1]	22222	6	1 alk. fsp.	1391±10	1399±10/100
Plag1[1]	22221	21	12 plag	1550±30	1620±40/55.9
T(20)[2]	22344	37	1 alk. fsp.	1664±4	1765±8*/48.8
Fsp8Grain[2]	22345	20	8 plag	2040±40	2250±40/55.4 1690±50/44.6
bulkChip7[2]	22348	202	1 chip	1155±3	1285±4/51.6
HiK6Fsp[2]	22350	5.5	6 alk. fsp	1407±13	1436±9/85.0

1 From Shih at NASA/JSC
2 From Agee at UNM

Ages. Apparent plateau ages range between 1.4 and 2.3 Ga (Figures 1 & 2). We do not see a strong signal in NWA 7034 from the 800 Ma event noted in NWA 7533, although the HiKFsp sample shows low-temperature steps at ~ 850 Ma. Integrated ages range from 1.2 to 2.1 Ga and are generally concordant with the plateau ages for a given sample. An exception is the Fsp8Grain sample, which has 2 different plateau trends – the integrated age being an average of the two.

Three distinct Ar/Ar ages are represented in the results for NWA 7034 and NWA 7533 [6]. The ~2.1 Ga

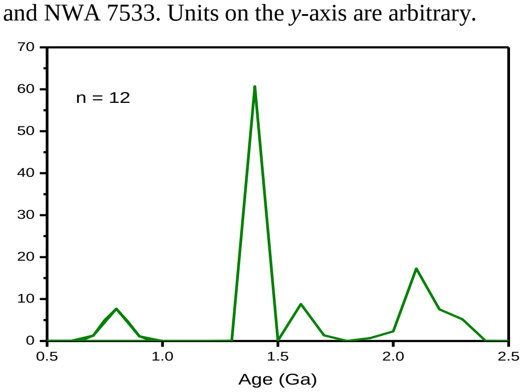
Figure 1. Ar release spectra of grains from NASA/JSC.



age dates the last significant disturbance of older grains incorporated into the sediments. The next age, which centers on 1.4 Ga, is the most common and may represent a magmatic event that produced many intrusive and extrusive igneous lithologies. The youngest age, ~0.8 Ga, is the upper limit on the time of assembly and/or lithification. These three ages are not surprising given the polymict character of the sediment.

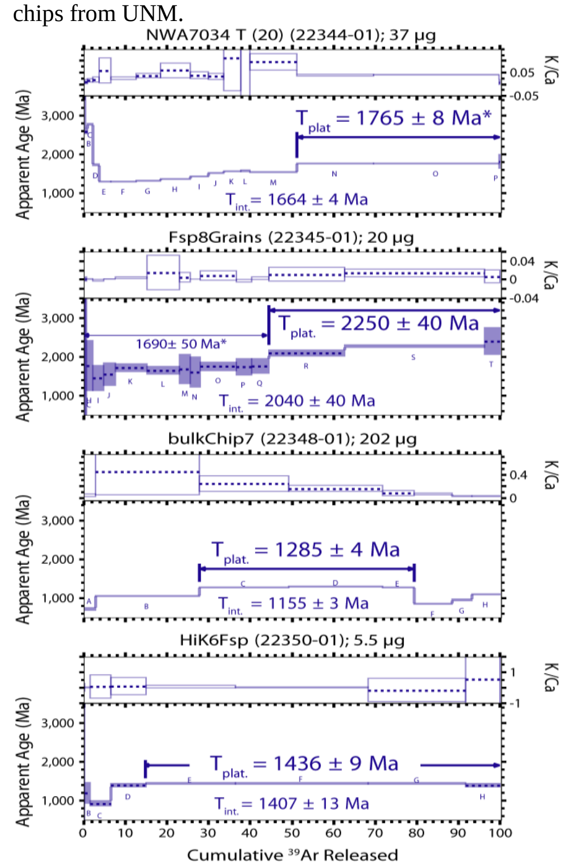
The youngest Ar plateau age (1285 Ma), for a bulk sample of 202 μg, reflects the modal age of the entire

Figure 3. Ar/Ar plateau age distribution of NWA 7034 and NWA 7533. Units on the *y*-axis are arbitrary.



sample suite (Figure 3). Also interesting is that, except for a 2-μg alkali feldspar from 7533[6], the age is

Figure 2. Ar release spectra of excavated samples of chips from UNM.



younger than that of any other sample. This is to be expected if the analyzed bulk sample is an aggregate of all three ages. The relatively low value suggests that while the 1.4 Ga 'magmatic' event dominates, the contribution from the 'lithification' age at 0.8 Ga is more significant than the one from the oldest xenocrystal age. While the 1.4-1.6 Ga event is seen in non-Ar age dates, the role of older ages and especially evidence of the younger 800 Ma age are difficult to extract from the bulk sample.

Conclusions: Three ages (Ga): (a)>2.0, (b)1.4-1.6 and (c)0.8 emerge from the ^{40}Ar-^{39}Ar dating of lithologically constrained samples from the NWA 7034 clan. We interpret them to represent (a) *xenocrystal material* added to (b) the *dominant igneous event* and (c) a later *overprint associated with assembly/lithification* of the sediment from which these meteorites formed.

References: [1] Yin, Q.-Z. et al. 2014. 45th *LPSC* #1320. [2] Agee, C.B. et al. 2013. *Science Express* doi: 10.1126/science.1228858. [3] Nyquist, L.E. et al. 2013. Meteoritical Society Abstract #5318. [4] Cartwright, J.A. et al. 2014. *EPSL* 400:77-87. [5] Humayun, M. et al. 2013. *Nature* **503**:513-517. [6] Bellucci et al., 45th LPSC, Abstract #1327. [7] Lindsay, F.N. et al., 2014. Meteoritical Society Abstract #5383. [8] Santos, A.R. et al., 2015. *Geochemica & Cosmochemica Acta* **157**:56-85. [9] Lindsay et al. 2014 *GCA* 129:96-110.