AR/AR SYSTEMATICS OF MARTIAN METEORITE NWA 2975. F.N. Lindsay[1], J. Osmond[2], J.S. Delaney[1], G.F. Herzog[1], B. Turrin[2], J. Park[1,3], and C.C. Swisher, III[2]. [1]Dept. Chem. & Biol. Chem., Rutgers University, New Brunswick, NJ 08854 (flindsay@rci.rutgers.edu); [2]Dept. Earth Planet. Sci., Rutgers University, New Brunswick, NJ 08854; [3]Lunar and Planetary Institute, Houston, TX 77058.

Introduction: Northwest Africa 2975 is a minimally weathered, highly shocked basaltic shergottite [1]. One of the more enriched basaltic shergottites [2], NWA 2975 is, by volume, ~53% pyroxene, ~38% plagioclase, ~3% opaques, ~2% phosphates and glass veins and pockets [3]. The maskelynitized groundmass plagioclase grains are compositionally homogenous and have lower K abundance than compositionally variable maskelynite found in regions of mesostasis [3]. We targeted single, homogenous maskelynite-grains for $^{40}Ar/^{39}Ar$ isotope geochronologic studies.

Analytical Procedures: The sample was gently crushed to ~300 µm sized grains. A total mass of 50 mg was separated under a microscope into 4 groups based on visual markers, such as color, cleavage and habit. Seven maskelynite grains were chosen for irradiation based on higher relative [K] wt%, as measured semi-quantitatively with energy dispersive spectroscopy (EDS) (Fig.1). The grains were irradiated (with Cd shielding) for 80 h at the USGS Triga reactor along with reference minerals FC-2 sanidine (28.2 Ma). Single grains were heated in 7 - 10 steps with a CO_2 laser (maximum T ≥ 1400 °C). The Ar isotopes were analyzed using a MAP 215-50 spectrometer operated in pulse-counting mode. A typical system blank (10^{-17} mol) is: ^{40}Ar= 8.21; ^{39}Ar= 0.37; ^{38}Ar= 0.03; ^{37}Ar= 1.35; ^{36}Ar= 0.13.

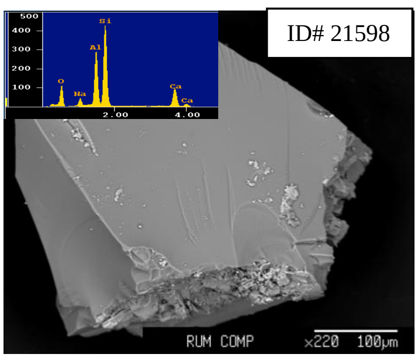


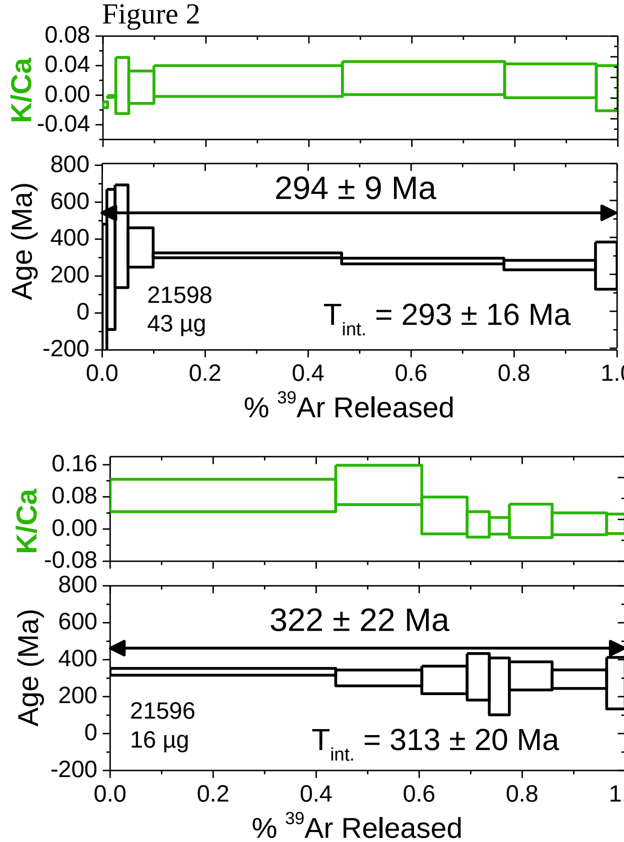
Figure1. Backscatter image of maskelynite 21598. Note the conchoidal fracture EDS spectrum shows plagioclase composition.

Results: Ranges for the total amounts of Ar isotopes (10^{-16} mol) in the samples are: ^{40}Ar=200-1300; ^{39}Ar= 0.3-2.7; ^{38}Ar= 0.01-0.06; ^{37}Ar= 1.0-10; ^{36}Ar= 0.03-0.08. J ranges from 0.01541-0.01549. Average heating increments yielded 11% of the total amount of gas; with a few yielding ~40%.

Elemental abundances (wt%) of [K] and [Ca] calculated from ^{39}Ar and ^{37}Ar are 0.05-0.22 and 1.3-27.19 wt%, respectively. With the exception of the maximum value for Ca of 27 wt%, these concentrations are in agreement with our semi-quantitative measurements and published values [4-6]. We think it likely that the grain yielding 27 wt% Ca had a sub-micron inclusion of a Ca-rich phase, most likely a phosphate or perhaps a melt inclusion. K/Ca ratios are typically flat across all temperature extractions of individual samples and average 0.02±0.02 for all seven grains, reflecting the calcic composition of the maskelynite. The maximum decrease in K/Ca for any one grain is a factor of 10.

Apparent plateau ages range from 294±9 Ma to 410±70 Ma and do not differ significantly from one another. The arithmetic mean is 341±45 (1σ) Ma; the weighted average is 314±7 Ma (1σ). Generally, the age spectrum for each grain is flat, although the uncertainties of the measurements are typically larger at low and/or high temperature extractions (Fig.2). The integrated ages agree with the apparent plateau ages within error.

Figure 2



An isochron plotted without corrections for cosmogenic ^{36}Ar indicates that any trapped component has a $^{40}Ar/^{36}Ar$ ratio indistinguishable from zero: the intercept is 3±6. The slope yields an age of 304±29 Ma in good agreement with the plateau ages (Fig 3a).

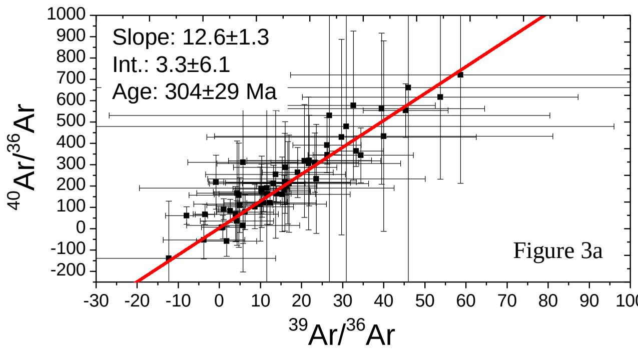


Figure 3a

We calculated the cosmogenic ^{36}Ar ($^{36}Ar_c$) from the minimum $^{36}Ar/^{37}Ar$ ratio for each grain [7] and plotted a combined isochron for all 7 grains using only the

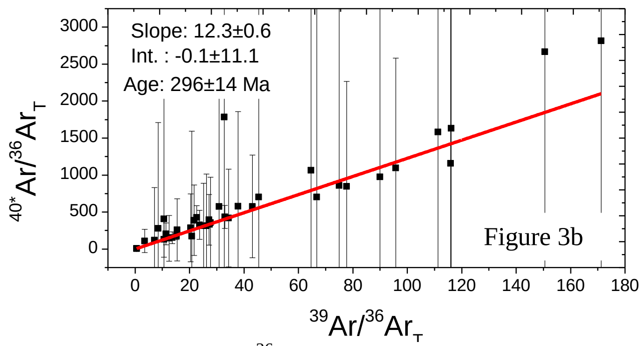


Figure 3b

trapped component of $^{36}Ar_{Tr}$. The fit yields an age of 296±14 Ma with an intercept of -0.1±11.1 (Fig.3b), results essentially indistinguishable from those quoted above. A fit to the data of [8 and J. Park, *pers. comm.*] gave an age of 356±29 Ma and an intercept of 163±34. We also calculated a total $^{36}Ar_c$ concentration of $3.2(10)^{-9}$, slightly higher than published values [8; $2.2(10)^{-9}$].

Discussion: NWA 2975, like other shergottites, has Ar-Ar apparent ages older than ages based on other radiometric techniques [7]. In particular they are older than the Sm/Nd age of 170 Ma [8]. The discrepancy of 120 Ma for NWA 2975 is larger than we observe in Zagami and ALH 77005, where it may reflect the presence of shock-implanted Ar from the Martian atmosphere or radiogenic ^{40}Ar inherited from magma or assimilated crustal country rock [8].

In the past, the trapped $^{40}Ar/^{36}Ar$ ratios of ~1800 have been taken as evidence for shock-implanted Ar. Although NWA 2975 is highly shocked with maskelynite clearly indicating shock metamorphism later than the primary magmatic event, we see no evidence from the isochrons of such a trapped component.

Assuming an emplacement event of 180 Ma, as proposed by [8], we can calculate an excess ^{40}Ar ($^{40}Ar_{xs}$) that is not attributable to *in-situ* radioactive decay of 4.36×10^{-7} cm^3 STP/g. This concentration is ~ 40% of all measured ^{40}Ar. Although ~ 3 times lower than the concentration found by [8] for NWA 2975, it is not significantly different from their average value of ~10^{-6} cm^3 STP/g $^{40}Ar_{xs}$, which was determined from results for a variety of Martian maskelynites and pyroxenes and found to be independent of [K] concentration. The difference could reflect minor contamination in the milligram maskelynite separate analyzed by [8] versus single grains used in this study.

The flatness of our release patterns, both for ages and K/Ca ratios, shows that any excess ^{40}Ar is uniformly distributed and released in concert with radiogenic ^{40}Ar that grew in place. Although unsettling, such behavior has been noted or suspected before [9].

A different interpretation is that our nominal age of 300 Ma is a lower bound on the time of an event or events that reset the Ar isotopes in an older protolith. The main and widely debated problem for this hypothesis is explaining how the Ar-Ar system in NWA 2975 could have escaped entirely the later effects of the event that reset the Sm/Nd systematics [10,11]. If water plays a role in the resetting of Sm-Nd [11], how might it affect Ar partitioning? Would burial depth (i.e. pressure changes) affect Ar solubility?

Conclusions: Our Ar-Ar data for NWA 2975 give an apparent age of 304±29 Ma but with no evidence for trapped ^{40}Ar that correlates with ^{36}Ar. This result appears to rule out the Martian (and the terrestrial) atmosphere as possible sources for any excess ^{40}Ar in NWA 2975. If a re-setting age of 300 Ma is impossible, then our result implies the presence of nearly pure, inherited radiogenic ^{40}Ar that was homogenized in maskelynite. The behavior of Ar in water during alteration processes on Mars needs to be investigated further.

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