^{40}AR/^{39}AR AGES OF PLAGIOCLASE-BEARING SHERGOTTITE NORTHWEST AFRICA 4480. B. D. Turrin[1], J. B. Setera[1], J. Park[2], J. S. Delaney[1], C. C. Swisher, III[1], G. F. Herzog[3], and A. J. Irving[4]. [1]Dept. Earth & Planet. Sci., Rutgers U., Piscataway, NJ, 08854, bturrin@rci.rutgers.edu, [2]Kingsborough Comm. Coll., Brooklyn, NY 11235, USA, [3]Dept. Chem. & Chem. Biol., [5]Rutgers Univ., Piscataway, NJ 08854. [4]Dept. Earth & Space Sciences, U. Washington, Seattle, WA 98195, USA.

Introduction: Northwest Africa (NWA) 4480 is a small (13 gram) and very unusual shergottite stone found in 2007. Petrologic, elemental, and isotopic studies [1-3] demonstrate that it is unique among known Martian meteorites in several ways. It was derived from a part of the Martian mantle with a unique radiogenic isotope signature, between those for the intermediate and depleted shergottite clusters. It has one of the longest noble gas cosmic ray exposure ages. Third, while almost all the 94 unpaired shergottites experienced shock pressures greater than 27 GPa [4] which converted plagioclase to maskelynite, NWA 4480 shows evidence for mild shock at most (J. Gross, Pers. Comm.). As plagioclase hosts much of the potassium-40 (the radioactive parent of ^{40}Ar), this stone presents a so-far singular opportunity to examine ^{40}Ar/^{39}Ar systematics and ages of a shergottite that is unperturbed by strong shock and that may derive from a previously unsampled location on Mars.

The small recovered mass of NWA 4480 makes the application of microscale techniques desirable. We set out, therefore, to measure the ^{40}Ar/^{39}Ar ages and thermal diffusion properties of small plagioclase samples. Our purposes were to learn more about major thermal events in the history of this meteorite and to see how that history compares to those of related meteorites.

Figure 1. Twinned, birefringent, plagioclase (cross polars) indicates low shock.

Experimental methods: The hand-picked plagioclase material analyzed in this work was obtained in the course of mineral separations conducted at the University of Houston for Lu-Hf and Sm-Nd isochron studies [5]. From it we took 4 portions of ~4-6 grains each; typical grain dimensions [μm] were 100×50×50; estimated masses were from 0.3 to 5 μg.

Samples along with the reference standards Fish Canyon (FC) sanidine (28.201 Ma [6]) and Hb3Gr hornblende (1080 Ma; [7]) were irradiated at the US Geological Survey TRIGA reactor for 77 hours without Cd-shielding. The known, controlled positions of the samples and standards during irradiation allowed for the determination of and correction for any significant gradients in the reactor's neutron-flux. *J*-values were 0.019714 ± 0.000073 and 0.019452 ± 0.00001 for the 22920-xx and 22877 samples, respectively.

After irradiation, samples were transferred to small Ta-platforms and placed in a vacuum extraction system. There the samples were heated indirectly for 300 s by aiming a laser at the the tantalum substrate; temperatures were monitored by two-color optical pyrometry [8]. The reactive gases released with each heating step were removed by exposure to SAES ST 101 getter material. Argon isotopes were measured using an upgraded Mass Analyzer Products (MAP) 215–50 noble gas mass spectrometer. For a ten minute extraction (including 300 s of heating), typical static system blanks were (10^{-18} mol): ^{40}Ar = 714 ± 30; ^{39}Ar = 13.3 ± 1.0; ^{38}Ar=1.1±0.5; ^{37}Ar=24±0.2; and ^{36}Ar=3.6±0.14. We have determined that the blanks are independent of temperature. Most of the Ar temperature fractions analyzed were 2× to 5× the blanks. All errors are quoted at the 1-sigma level of uncertainty.

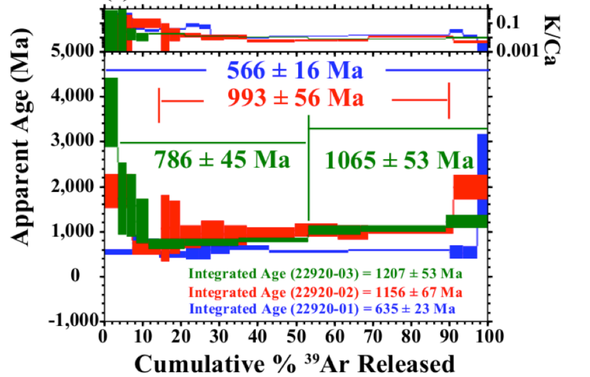
Results: Figure 2 shows the the age release profiles and Table 1 summarizes the ^{40}Ar/^{39}Ar measurements. The data for sample 920-03 are open to different interpretations. After corrections for cosmogenic ^{36}Ar, the isochron has an adjusted R^2 of 0.988 and the release diagram of Figure 2 can be read as a steadily increasing pattern, rather than one comprising two steps. These results are consistent with release from a single population of grains with uniform properties. On the other hand, noticeable self-sorting of the results for 920-03 by temperature, K/Ca ratio, and diffusion pa-

Table 1.

ID	920-01	920-02	920-03
Fusion age	635±23	1156±67	1207±53
Plateau age(s) (%^{39}Ar)	566±16(100)	993±56(75)	*786±45(55), 1065±53(45)*
K/Ca on plateau(s)	0.011	0.011	0.007, 0.011
Isochron age	519±67[1]	800±140[2]	740±170[2]
Intercept	14±17[1]	60±70[2]	262±84[2]
Inverse isochron age	526±70[1]	--	700±400[2]
Intercept	13±5[1]	--	300±110[2]

1) No corrections for cosmogenic ^{36}Ar. [2]Corrected for cosmogenic ^{36}Ar with $(^{36}Ar/^{38}Ar)_{Trapped}$=5.35 and $(^{36}Ar/^{38}Ar)_{Cosmogenic}$=0.65. Ages ±1σ.

Figure 2. Stepwise release patterns.for apparent $^{40}Ar/^{39}Ar$ ages and K/Ca (atom/atom) ratios.



rameters for $^{37,39}Ar$, if not for ^{40}Ar, (see below) suggests the degassing of two different K sources.

We see no evidence for Martian atmospheric argon in the samples. The average, unweighted, $^{40}Ar^{39}Ar$-isochron age for 920-01, 02, and 03 (Table 1) is 700±140 Ma. The isochron ages differ by about 2-σ; the possibility that this difference is significant needs confirmation.

Figure 3 shows Arrhenius plots for ^{39}Ar [see 9]. The calculated activation energies, E_a, and diffusivities, D_0/a^2, are presented in Table 2. For ^{37}Ar, the results are similar to values published for terrestrial feldspars [10]. Lower values for $^{39,40}Ar$ within each sample suggest uneven enrichments of K, probably in twin lamellae (Fig 1 and [11]). Higher activation energies for ^{37}Ar and ^{39}Ar may indicate compositional heterogeneity of the feldspars.

Table 2.

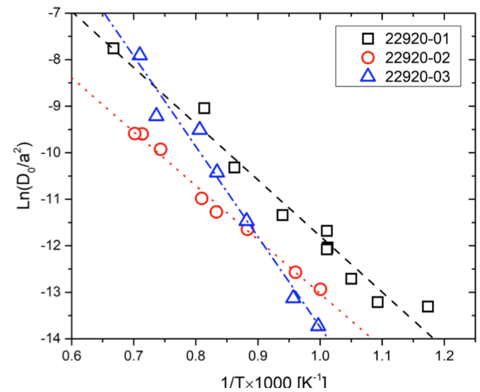
	E_a kJ/mol	$Ln(D_0/a^2)$
	^{37}Ar	
920-01	179±17	7±8
920-02	195±6	7±6
920-03	268±24	15±16
	^{39}Ar	
920-01	100±7	0.28±0.01
920-02	96±4	-1.4±2.4
920-03	161±9	5.7±5.6
	^{40}Ar	
920-01	95±5	-0.6±0.2
920-02	78±5	-3.4±4.2
920-03[1]	89±11	-1.1±0.9

[1]No trapped correction.

Discussion: NWA 4480 is one of three Martian meteorites classified as fine-grained with intermediate trace element concentrations. It is reassuring that in a stone where shock effects can be discounted, the chronometers so far available agree [4].

The apparent $^{40}Ar/^{39}Ar$ ages of EET 79001, lithology B, another fine-grained (but heavily shocked) intermediate basalt, are all larger than 1 Ga and probably

Figure 3. Arrhenius plots for ^{39}Ar



compromised by Martian atmospheric argon [12]. On the other hand, the Rb/Sr and Sm/Nd ages for Lithology B agree at about 180 Ma [13], and are clearly smaller than the average $^{40}Ar/^{39}Ar$ age, 700±140 Ma, of our NWA 4480 samples, which, as noted above appear not to contain Martian atmospheric argon.

Several other shergottites have radiochronometric ages between 500 and 1000 Ga [see 14]. One, Dho 019, also has an unusually old cosmic-ray-exposure age, ~ 20 Ma [15], which is comparable to that of NWA 4480 [2], but the two stones are clearly unrelated.

Conclusions: Ages, petrographic data, and geochemical data for NWA 4480 all set it apart from other shergottites. The expectation that a shergottite with low shock should have an $^{40}Ar/^{39}Ar$ age concordant with other ages from less labile radiochronometers appears to be borne out, at least so far. The $^{40}Ar/^{39}Ar$ release systematics hint at a non-uniform spatial distribution of K in at least one sample.

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