OXYGEN ISOTOPIC COMPOSITION OF WATER IN MARTIAN METEORITE NORTHWEST AFRICA 7034 M. H. Nunn[1], C. B. Agee[2], and M. H. Thiemens[1], [1]Univ. California, San Diego, Dept. Chemistry and Biochemistry, La Jolla CA. (e-mail: mnunn@ucsd.edu), [2]Institute of Meteoritics and Dept. Earth and Planetary Sciences, Univ. New Mexico

Introduction: Northwest Africa (NWA) 7034 is a basaltic breccia, making it unique among Martian meteorites [Shergottites, Nakhlites, and Chassignites (SNCs)]. However, the composition of accessory phases in NWA 7034 is similar to those of SNCs [1-2]. Anlyses of Martian crustal rocks by the Gamma Ray Spectrometer (GRS) on the Mars Odyssey Orbiter and soils in Gusev Crater by the Alpha-Proton-X-ray Spectrometer (APXS) on the Mars Exploration Rover Spirit show much similarity to measurements of the major element composition of NWA 7034 [3-6].

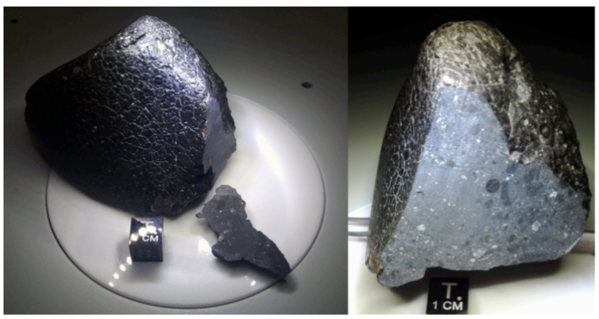

Figure 1. NWA 7034 hand specimen [7].

The source of the observed brecciation in NWA 7034 is unclear. Although the impact event that ejected NWA 7034 from the Martian surface likely caused some brecciation, the meteorite's petrography suggests a volcanic eruption may have also contributed. Measurements of the Fe-Mn composition of olivine and pyroxene indicates NWA 7034 is of Martian origin [8]. The age of NWA 7034 was determined to be 2.089 ± 0.081 Ga (2σ) by Rb-Sr analyses and 2.19 ± 1.4 Ga (2σ) by Sm-Nd measurements, making NWA 7034 the first known meteorite dating from the early Amazonian epoch [9].

Methods: A stainless steel mortar and pestle was used to crush whole rock samples of NWA 7034 to a powder of uniformly-sized grains. This sample was then loaded into a quartz reaction tube and pumped to vacuum until degassing had ceased. Subsequent stepwise heating to 50, 150, 320, 500 and 1000°C evolved water bound in different phases of the meteorite. Water was quantitatively converted to molecular oxygen (O_2) with the use of bromine pentafluoride (BrF_5). Each heat step was performed after obtaining a reproducible system blank of ≤ 0.1μmol of O_2 to minimize and correct for the contribution from the experimental system to measurements. A liquid nitrogen cold trap was used to collect evolved volatiles while holding the reaction tube containing the sample at each temperature step for at least one hour. The specificity of the BrF_5 reaction ensures all O_2 analyzed was produced from evolved water. Product O_2 was then collected on molecular sieve, and a Finnigan MAT 253 stable isotope ratio mass spectrometer was used to determine its oxygen isotopic ratios.

Oxygen Isotopic Composition of NWA 7034: Analyses of the bulk oxygen isotopic composition of NWA 7034 reveals a striking dissimilarity with SNC meteorites, as shown in Figure 2. Most notable in this plot are the significantly different $\Delta^{17}O$ values in bulk NWA 7034 and SNC meteorites (0.58 ± 0.05‰ and 0.15-0.45‰, respectively).

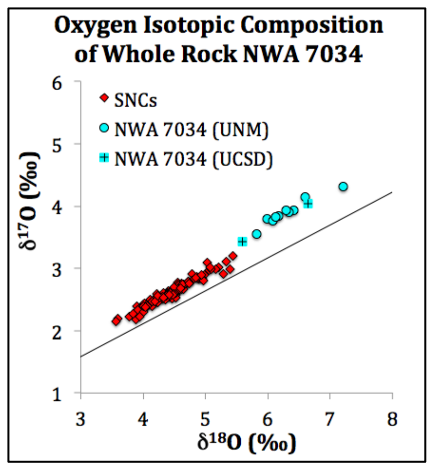

Figure 2. Oxygen isotopic composition of bulk rock NWA 7034. Data points in teal represent analyses made on samples of NWA 7034 that had been heated to 1000°C (UCSD), acid-washed (UNM), and non-acid washed (UNM). Literature whole rock values of SNCs are shown in red for comparison [10-13]. The terrestrial fractionation line [TFL, $\delta^{17}O$ (‰) = 0.528*$\delta^{18}O$ (‰)] is also included for comparison.

Results of analyses of the water contained in NWA 7034 and evolved during stepwise heating are presented in Figure 3. In terms of its oxygen isotopic composition, water in NWA 7034 ($\Delta^{17}O$ = 0.330 ± 0.03‰) predominantly falls within the range of literature bulk SNC values ($\Delta^{17}O$ = 0.15-0.45‰) than to its bulk (i.e., whole rock) composition ($\Delta^{17}O$ = 0.58 ± 0.05‰). This is particularly interesting in light of the fact that NWA

7034 possesses a bulk oxygen isotopic composition unlike any other achondrites or planetary samples. Measured $\Delta^{17}O$ values of water evolved at T = 50, 150, 320, and 500°C cluster around 0.33‰, but water evolved at 1000‰ approaches the terrestrial fractionation line ($\Delta^{17}O$ = 0‰). Differences in the oxygen isotopic compositions of SNCs and NWA 7034 suggest there exist multiple, distinct oxygen isotopic reservoirs on Mars.

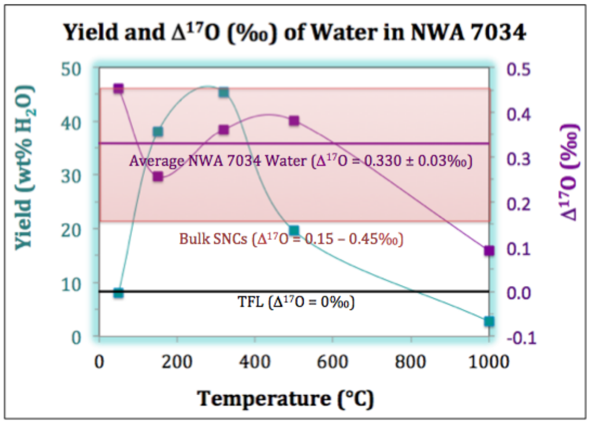

Figure 3. Yield and oxygen isotopic composition ($\Delta^{17}O = \delta^{17}O - 0.528*\delta^{18}O$) of water evolved during stepwise heating of NWA 7034. Average $\Delta^{17}O$ of NWA 7034 water ($\Delta^{17}O$ = 0.330 ± 0.03‰), the range in literature $\Delta^{17}O$ values of whole rock SNC meteorites ($\Delta^{17}O$ = 0.15-0.45‰), and the terrestrial fractionation line (TFL, $\Delta^{17}O$ = 0‰) are shown for comparison [10-13].

Backscatter electron (BSE) imaging and electron microprobe element mapping revealed the presence of carbonate veins produced during desert weathering. Although this carbonate is a minor phase, its terrestrial oxygen isotopic composition ($\Delta^{17}O$ = 0‰) means it could account for the low $\Delta^{17}O$ measured in water evolved at 1000°C. To determine the effect these carbonates have on measured values of oxygen isotopic composition of water, analogous measurements are being made on a slice of NWA 7034 cut from the center of the stone (where the carbonates are less abundant). These analyses are in progress and will also be presented.

Mechanisms that could explain the oxygen isotopic variability observed in Martian meteorites will also be presented and discussed.

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