THE EFFECT OF IMPACT SHOCK ON WATER AND H ISOTOPES IN AMPHIBOLE. M.E. Minitti[1], L.A. Leshin[1,2], Y. Guan[1], S. Luo[3] and T.J. Ahrens[3], [1]Dept. of Geological Sciences and [2]Center for Meteorite Studies, Arizona State University, Tempe, AZ 85287-1404, [3]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125 (minitti@asu.edu).

Introduction: The amount of water in and distribution of water between the various martian water reservoirs (atmospheric, hydrospheric, interior) are outstanding questions in martian science. Kaersutitic (Ti-rich) amphibole and apatite, the few water-bearing minerals present in the martian meteorites, have been studied to gain insight into all three martian water reservoirs. The igneous nature of the kaersutites and apatites connects the phases to the interior, or magmatic, water reservoir. Their residence time in the crust provides opportunity for the phases to interact with the atmospheric and hydrospheric reservoirs. The combined influence of the reservoirs is imprinted in the low water contents and high, variable H isotopic compositions of the kaersutites and apatites. Variations of up to δD = 900‰ exist within individual and between different grains [1]. Water content and H isotope measurements of one of the Martain apatites were made in an attempt to separate the signatures of the magmatic and atmospheric/hydrospheric (assumed to be in communication) reservoirs [2]. Results of the study led to a constraint on the H isotopic composition of the magmatic water reservoir and to the important conclusion that the hydrospheric reservoir is 2-3 times larger than previously determined [2]. Such a study illustrates the power and importance of understanding the water contents and H isotopic signatures of martian water-bearing minerals.

The water content and H isotopic composition of geologic materials, however, can be influenced via shock experienced in the impact process, the process which liberated the martian meteorites. Impact-induced loss of water and enrichment of H isotopic composition at shock pressures comparable to those experienced by the kaersutite-bearing martian meteorites (20-35 GPa) was demonstrated by [3]. If water contents and H isotopic compositions of martian water-bearing minerals were influenced by shock, such an effect could influence conclusions about the amounts of water present in and interactions between martian water reservoirs. In order to investigate the ability of shock to influence water, and in turn the validity of arguments based on martian kaersutite water contents and H isotopic compositions, we have conducted a series of shock experiments on terrestrial amphibole samples.

Experimental: Three samples of kaersutitic megacryst amphiboles with initial water contents of 0.48-1.32 wt.% H_2O were selected as the starting materials [D. Dyar, pers. comm.]. Cores of each kaersutite were drilled and doubly-polished discs with parallel faces were created. Each kaersutite was then encased in a vented stainless steel sample chamber, which allows escape of gases evolved during the shock experiment. Each sample chamber was evacuated to a vacuum of 40 microns prior to the experiment.

A Ta flyer plate attached to a lexan sabot fired at 1.18 km/s in the 20 mm powder gun in the Shock Wave Laboratory at California Institute of Technology imparted shock into the sample chamber. The peak pressure achieved in the samples via multiple reverberations was ~32 GPa, consistent with the degree of shock experienced by the kaersutite-bearing martian meteorites. The shocked kaersutites were recovered from the sample chambers via machining and prepared for analysis.

Analytical: H isotopic compositions of both unshocked and shocked samples of each kaersutite were measured with the Cameca IMS 6f ion microprobe at Arizona State University. Measurements of kaersutite water contents have also been attempted on the ion microprobe, but lack of appropriate standards is currently complicating interpretation of the measurements. A primary beam of Cs^+ was focused to a diameter of 40 µm and a field aperture was placed in the secondary beam path to limit collection of H^- and D^- ions from the innermost 10 µm of the primary beam spot. A primary beam current of 0.03-0.08 nA was utilized and analyses were conducted at a mass resolution of 900-1000 in order to effectively eliminate contribution of the H_2^- signal to the D^- signal. Multiple H isotope amphibole standards and an olivine from the Stillwater meteorite were analyzed concurrently with the kaersutite samples. Multiple amphibole standards were analyzed in order to employ the correction scheme of [4], which accounts for the influence of composition on instrument fractionation factor (α). Standards and samples were kept at high vacuum (<4 x 10^{-9} torr) prior to and during analysis in order to minimize the background signal of H. The background H signal was monitored using the Stillwater olivine and was removed from the H data of the standards and kaersutite samples.

During H isotope analysis, some difficulty was encountered due to differences between the heights of standards and kaersutite samples in the sample mounts.

Differences in sample heights lead to changes in the position at which the ion beam strikes a sample. The result of the standard and sample height discrepancies appears to be difficulty in determining absolute values of the kaersutite samples using measurements from the standards. This issue will be addressed in future work.

Fortunately, however, the paris of unshocked and shocked kaersutites were at comparable heights during each analysis session. Thus, little influence on the measured H isotopic compositions of the kaersutite samples from sample height differences is expected. Because no major-element composition difference between unshocked and shocked versions of the same kaersutite exists to influence α, measurements of the unshocked and shocked kaersutite pairs can be compared to assess the effect of impact shock.

Results: To make comparisons that are the least complicated by sample issues, we considered analyses from unshocked and shocked sample pairs at the same sample height. An example of data collected from one of the kaersutite samples is pictured in Fig. 1. The x-axis values, beam position, are not quantitatively important and are only used to determine which sample pairs are impinged by the ion beam in the same manner. Two unshocked-shocked sample pairs were measured at the same height, at beam positions 921 and 927. In both cases, the shocked kaersutite has a more enriched (D-rich) composition than its unshocked equivalent. The largest enrichment observed is on the order of $\delta D = +50‰$. The positively sloping trend of both the unshocked and shocked kaersutite data sets implies that if unshocked data were collected at smaller beam position values, the unshocked sample data would continue to fall at lighter δD's than the shocked sample data.

These preliminary results indicate that impact shock at shock pressures equivalent to those experienced by the kaersutite-bearing martian meteorites is capable of enriching the H isotopic compositions of amphibole. The largest measured enrichment of $\Delta D \approx +50‰$, however, is considerably smaller than the smallest H isotopic variation measured within individual or between different martian kaersutite grains (~1000‰) [1]. Thus, while impact shock likely played a role in establishing the H isotopic composition of the martian meteorite kaersutites (and perhaps the apatites), it does not appear that the effect is significant enough to alter conclusions made about Martian water reservoirs using martian meteorite H isotopic compositions.

References: [1] Watson L.L. et al. (1994) *Science, 265,* 86-90. [2] Leshin L.A. (2000) *GRL, 27, 14,* 2017-2020. [3] Tyburczy J. A. et al. (1990) *EPSL, 98*, 245-260. [4] Deloule E. et al. (1991) *GSA Spec. Pub., 3*, 53-62.

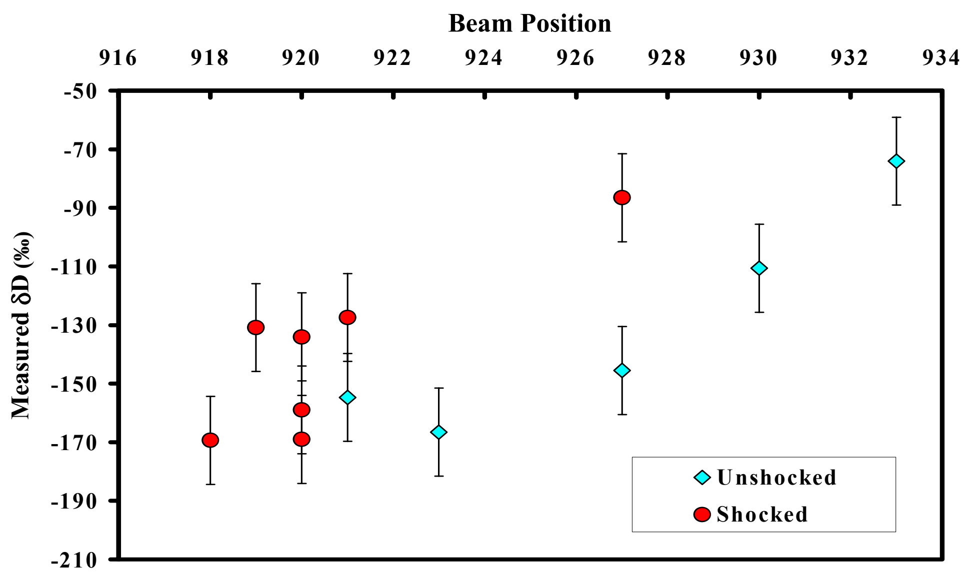

Figure 1: Plot demonstrating the variation of measured H isotopic compositions of unshocked and shocked kaersutites with position of the ion beam during ion microprobe analyses. The beam position shifted due to sample prepration and mounting issues, and will be minimized in future work. The H isotopic compositions are not corrected for instrumental fractionation; error bars are $\pm 2\sigma$. Unshocked-shocked kaersutite sample pairs measured at the same beam position reveal that the shocked kaersutite is isotopically heavier (more D-rich) than its unshocked counterpart. This result suggests that impact shock is capable of enriching H isotopic compositions in kaersutite.