SHOCK-INDUCED DEVOLATILIZATION AND ISOTOPIC FRACTIONATION OF H FROM MURCHISON METEORITE, POSSIBLE IMPLICATION FOR ATMOSPHERIC ACCRETION;

James A. Tyburczy* , Thomas J. Ahrens, Xiaomei Xu, and Samuel Epstein,
Division of Geological Sciences, California Institute of Technology, Pasadena, CA 91125
*permanent address: Department of Geology, Arizona State University, Tempe, AZ 85287

We have conducted the first shock recovery experiments on a primitive carbonaceous chondrite (Murchison) in which ~76% of the H was driven -off by controlled shock up to 14 GPa. The new results imply that previous proto-planet thresholds (mass=~$7x10^{25}$ g) for inducing proto-planetary atmospheres were too large as these were based on experiments on crystal and porous serpentine [1, 2]. Based on the new Murchison data, infall velocities of ~1 km/s, corresponding to ~10^3km diameter ($2x10^{25}$g), now appear to be required to remove chemically bound water from materials similar in mineralogy and structure to Murchison and hence begin to form a proto-atmosphere upon infall accretion.

The similarity of the relative abundances and isotopic ratios of the rock-forming elements in the sun and primitive meteorites, has long suggested that the terrestrial planets and the cores of the major planets accreted from a common reservoir of planetesimals which formed from an accretion disc around the early sun. Moreover, the gross similarity in noble gas and their relative abundances in primitive meteorites and planetary atmospheres also suggest an impact accretion origin from planetesimals. The volatile-bearing planetesimals are often assumed to have composition and microstructure similar to the primitive carbonaceous chondrites, such as Murchison.

We conducted a series of shock-recovery experiments using 24 g of Murchison samples sawn from the interior of a 100 g sample and untouched by personnel and placed in a series of highly polished, super-clean stainless steel containers which were preheated to 60 ± 10° C for 6 hours under 40 μm (Hg) vacuum.

Sample assemblies were impacted with a series of 304 stainless steel impactors at speeds of 1.38 to 1.68 km/sec providing initial shock pressures of 10.5 to 13.8 GPa in the samples.

After shock recovery, total carbon and hydrogen was extracted from aliquots of the sample by combustion @ 900°C in a gas source mass spectrometer. Although Murchison is a very complex mixture of phases, many of which are poorly characterized, the results (Table 1) are qualitatively similar to previous results in which the gas generated upon impact was analyzed, rather than in the present experiments in which the residual shocked material's gas content is analyzed. As can be seen in Table 1, up to 0.76 of the initial H content of the sample was devolatilized in the most heavily shocked (13.8 GPa) sample. Moreover, some 35% of the C was also lost in shot#40-939. The δD data indicate the residual sample gas became slightly heavier (more D) indicating the shock compression and release induced relatively more devolatilization of H than D. In contrast, the $\delta^{13}C$ data indicated that the shocked Murchison lost more ^{12}C relative to ^{13}C. These data are qualitatively consistent with previous experiments on minerals and our general ideas about atmospheric accretion [3]. Detailed chemical and isotopic modeling of these initial results is in progress.

Table 1. Results of H and C analysis of shocked Murchison Meteorite

Sample	Impact Vel. km/sec	Shock Press. (GPa)	Amt. (mg)	CO_2 (µmole)	CO_2 (µm) /mg	H_2 (µmole)	H_2 (µm)/mg	Mass Frac. H lost	H_2/C	δD (SMOW)	$\delta^{13}C$ (PDB)
Shot #40-938	1.38	10.2	6.2	8.2	1.3	16.9	2.7	0.43	2.1	-63.0	-7.42
Shot #40-891	1.54	12.0	6.0	7.4	1.2	19.8	3.3	0.30	2.7	-66.7	-7.81
Shot #40-939	1.68	13.8	5.0	5.4	1.1	5.4	1.1	0.76	1.0	-80.0	-11.37
Murchi-son (Chicago)	0	0	5.0	8.5	1.7	23.7	4.7	1.00	2.8	-98.5	-4.71

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