BENCH CRATER METEORITE: HYDRATED ASTEROIDAL MATERIAL DELIVERED TO THE MOON.

K. H. Joy[1,2], S. Messenger[3], M. E. Zolensky[3], D. R. Frank[3], and D. A. Kring[1,2]. [1]SEAES, University of Manchester, Manchester M13 9PL, UK. Katherine.Joy@manchester.ac.uk. [2]CLSE, LPI-USRA, Houston, Texas 77058, USA. [3]ARES, NASA Johnson Space Center, Houston, TX 77058, USA.

Background: Projectiles striking the Moon have delivered volatiles to its surface and created the impact craters and basin that have modified its crust. Direct geochemical evidence of impactor origin is recorded by several meteorites that survived collision, helping to unlock the sources and causes of bombardment through time (see [1] and refs. therein). Here we report preliminary light element isotope data for Bench Crater meteorite [2-6], which is a small (3×1.75 mm) CM chondrite collected in regolith fines from Bench Crater at the Apollo 12 landing site.

Methods: We analysed Bench Crater in grain mount 12037,188 using the NASA JSC JEOL 7600f Field Emission Gun (FEG) SEM. Microtomed sections were analysed using the JSC JEOL 2200FS FEG TEM coupled to an Oxford EDX system. Two 15×15 μm areas of fragments pressed into gold foil were spatially mapped using the JSC NanoSIMS 50L ion microprobe for ^{1}H, ^{2}H, ^{12}C, ^{13}C, $^{12}C^{14}N$, $^{12}C^{15}N$, ^{16}O, and ^{28}Si isotopes. Terrestrial kerogen, NIST biotite, and 1-hydroxybenzotraizole hydrate were used for quantification. Data were also collected from the matrix of Murchison for cross comparison.

Results: Bench Crater is composed of aggregates of ferromagnesian minerals within a fine grained matrix. Many of the ferromagnesian phases have been replaced by hydrated mineral phases (i.e., saponite [6]) that retain structural water even after delivery to the lunar surface. The meteorite has a patchy thin (<100 μm) vesicular agglutinitic crust, coating about 10 % of its exterior suggesting interaction with the lunar regolith either during or after the impact event.

The H, C, and N isotopic compositions were found to be in the range of terrestrial materials. The two analysis areas yielded bulk δD of -36 and +200‰ (±20‰ 1σ), $\delta^{13}C$ = -2 and -23‰ (±10‰), and $\delta^{15}N$ = -27 and -52‰ (±10‰). No H-, C- or N- isotopically anomalous regions were identified. By comparison, the Murchison sample had a bulk matrix δD of -79‰ with μm-sized D-rich hotspots (δD>1,300‰), consistent with chondrite matrix organic globules seen previously [7].

Summary: D/H measurements from the lunar regolith agglutinates [8] indicate mixing between a low D/H solar implanted component and additional higher D/H sources (e.g., meteoritic/cometary/volcanic gases). We have determined the range and average D/H ratio of Bench Crater meteorite, which is the first direct D/H analysis of meteoritic material delivered to the lunar surface. This result provides an important ground truth for future investigations of lunar water resources by missions to the Moon.

References: [1] Joy K.H. et al. 2012. *Science* 336:1426-1429. [2] Wood J.A. et al. 1971. *Smithsonian Astrophys. Obs. Spec. Rep.* 333. p 177. [3] McSween H. Y. Jr. 1976. *Earth Planet. Sci. Lett.* 31:193–199. [4] Fitzgerald M.J. and Jones J.B. 1977 *Meteoritics & Planetary Science* 12:443–458.. [5] Zolensky M.E. et al. 1996. *Meteoritics & Planetary Science* Vol. 31:518–537. [6] Zolensky M.E. 1997. *Meteoritics & Planetary Science* 32:15–18. [7] Nakamura-Messenger K. et al. 2006. *Science* 314:1439-1442 [8] Liu Y. et al. 2012. *Nature Geoscience.* 5:779-782.