Effects of terrestrial contamination on bulk water contents in meteorites

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Meteorites are typically collected from hot or cold deserts, where they lay buried in ice or exposed to meteoric precipitation for hundreds to tens of thousands of years. More recently, prompted by radar observations, meteorites have been expeditiously recovered and stored in laboratory conditions. It has been shown that minor and trace elements, e.g. rare earth elements, Sr, Ba, and U, in bulk Antarctic meteorites can be redistributed due to terrestrial contamination [1]. Here we measured the water contents and D/H ratios of orthopyroxenes from recent ordinary chondrite falls and Antarctic finds to evaluate the effects of terrestrial contamination on volatiles in nominally anhydrous minerals (NAMs).

The water contents and D/H ratios of orthopyroxenes from two ordinary chondrite (OC) falls, i.e., LL5 Chelyabinsk and L6 Benenitra, and three Antarctic OC finds, namely, LL4 GRA06179, LL5 LAR 12241, and L6 DOM10035, were obtained using NanoSIMS 50L at Arizona State University [2, 3]. The minerals in the OC falls have water contents ranging between 210 and 900 parts per million weight (ppmw), and their D/H ratios normalized to Standard Mean Ocean Water (δD_{SMOW}) vary from -400‰ to -64‰. In contrast, the pyroxenes from the OC finds are characterized by higher water contents (458–1807 ppmw) and deuterated hydrogen isotopic signatures (δD_{SMOW} = -215‰ – 0‰).

We argue that the deuterated hydrogen isotopic signatures observed in minerals from OC finds are likely a mix of water intrinsic to the grains and variable amounts of terrestrial water that diffused into the meteorite stones. Although the true compositions of the minerals cannot be ascertained, the size of the recovered meteorite stones and long exposure time [4] in Antarctica dictate the rates of volatile equilibration. The masses of Antarctic stones in this study vary from 46 g to 523 g, and assuming a density of ordinary chondrites between 3-3.7 g/cm3, the diameters of these stones are <8 cm. On the other hand, Benenitra and Chelyabinsk were large (20-100 kg) and were collected immediately after they landed. Therefore, water contents and hydrogen isotopic systematics in small Antarctic meteorites must be interpreted carefully.

[1] Crozaz et al. (2003). GCA 67: 4727–4741. [2] Jin and Bose (2019) Sci. Adv. 5 eaav8106. [3] Jin and Bose (2020), LPSC #1470. [4] Wadhwa et al. (2020) Annu. Rev. Earth Planet. Sc. 48.