Two senior Navajo women (70–80 yr old) independently remember this crater as being much deeper during their childhood, and both suggest that the impact was witnessed three to four generations ago. Interestingly, many people in the Navajo community thought that this crater was of impact origin. Additional work is planned, including a broader aerial search for other possible impact sites.

COMPLEX ZONING IN HIBONITE IN SPINEL-HIBONITE SPHERULES FROM MURCHISON.

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Spinel-hibonite-rich (SH) spherules are a major type of refractory inclusion in the Murchison (CM2) carbonaceous chondrite. They typically consist of radially oriented, intersecting hibonite laths 5–10 µm wide and 10–30 µm long, partially enclosed in Mg-Al spinel ± perovskite (pv), and are thought to have been at least partially molten [e.g.,1]. Among a suite of ~20 SH spherule fragments recovered by freeze-thaw disaggregation of Murchison, we have discovered several in which the hibonite exhibits wider ranges in composition than previously observed within single inclusions and has complex zoning patterns not consistent with crystallization from a melt in a single-stage cooling event. For example, in H2-3, a spherule fragment with ~1% pv, most of which is enclosed in spinel, hibonite has 0.8–7.4 wt% TiO_2, and one crystal with ~2 wt% TiO_2 has thin, linear zones, mostly parallel to cleavage, with ~7 wt% TiO_2. In H2-18, a SH inclusion with a trace of pv, small, contiguous grains of hibonite with ~1.3 wt% TiO_2 are completely rimmed with relatively Ti-rich (~6.5 wt% TiO_2) hibonite, so that the latter appears to define angular, Ti-poor islands in backscattered electron images (BEI). This inclusion also contains a hibonite crystal that is nearly TiO_2 free (<0.3 wt%) in which Mg (up to 1 wt% MgO) is largely balanced by Si (up to 1.4 wt% SiO_2) instead of Ti. This grain has an ~1-µm-wide rim of Ti-bearing (~3 wt% TiO_2) hibonite, which is possibly related to the other Ti-rich overgrowths. We also found several SH spherule fragments in which the hibonite has patchy zoning with, for example, regions with ~7 and 0.7 wt% TiO_2 separated by diffuse and irregular contacts within a single crystal. Aureoles of Ti-rich hibonite around perovskite inclusions are not apparent in BEIs.

Virtually Ti-free hibonite is clearly not in equilibrium with overgrowths of Ti-rich hibonite, and in these inclusions the Ti-rich material is texturally late relative to the Ti-poor hibonite. This relationship is not expected from zoning trends observed in SH spherules such as H2-5 and B6 [2], which contain hibonite laths that appear to have nucleated in sprays or on the edges of the spherules. In these grains, TiO_2 contents decrease with increasing distance from the nucleation points, consistent with experiments on Al_2O_3-rich, SiO_2-bearing liquids [3], which give crystal/liquid distribution coefficients for Ti in hibonite >1. Unless early hibonite crystallized metastably and was followed by high degrees of spinel fractionation, SH melts should not yield the late, Ti-rich hibonite observed in the overgrowths described here, nor should early hibonite be Ti-poor relative to late hibonite. The Ti-poor hibonite found in the present samples probably represents an earlier generation of hibonite. In the Si-rich hibonite in H2-18, dominance of Si + Mg over Ti + Mg substitution, despite $D_{Si} \ll D_{Ti}$ [3], indicates that it formed in an environment in which very little Ti was available. Like the Ti-poor hibonite in the other inclusions considered here, it either had Ti-rich hibonite deposited on it or reacted with Ti-bearing liquid or vapor, or possibly with perovskite. Further investigation, such as determination of systematic variations of hibonite Ti content with distance from perovskite inclusions, or with inclusion bulk composition, may help distinguish between these possibilities.

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THE JAMES M. DUPONT COLLECTION OF METEORITES: 1950s to 1991.

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In the over 30 years that James M. DuPont collected meteorites, his collection grew from one of a modest collector into the world's largest private collection. At his death in July 1991, DuPont listed over 1000 meteorites in his collection. These included several that were somewhat controversial and unrecognized, along with a few others that represented new finds awaiting classification. This impressive collection had 1719 individual meteorites with a total mass over 500 kg. Over the past few years, this collection has been extensively researched, and a final inventory was prepared that took into consideration the controversial, the unclassified, and the various varieties of certain meteorites. These were separated from those that are officially recognized by the Meteoritical Society. The final count is 970 distinct meteorites with an additional 42 in research to determine their identity. Included in this group are several from Roosevelt County, New Mexico, a few stones from North Africa, two from Australia, and a mix of stones and irons from various states in the United States. Research is progressing well. In late 1994, the James M. DuPont Meteorite Collection was purchased by the Planetary Studies Foundation for the purpose of preserving the collection's identity, and to ensure its availability to the scientific community.

CROSS SECTIONS NEEDED FOR THE INTERPRETATION OF LONG-LIVED AND SHORT-LIVED COSMOGENIC NUCLIDE PRODUCTION IN EXTRATERRESTRIAL MATERIALS.

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Radionuclides produced by cosmic rays in extraterrestrial materials archive information that can be used to determine cosmic ray fluxes and study the history of the irradiated object. Long-lived radionuclides give information about the last ~5 m.y.; short-lived radionuclides give information about recent events. To calculate the solar cosmic ray (SCR) flux from measured depth profiles for cosmogenic radionuclides produced in lunar rocks, accurate and precise cross-section values for the production of these radionuclides from all relevant elements are needed.

About 98% of SCR and ~87% of galactic cosmic rays (GCR) falling on extraterrestrial materials are protons. Cross-section measurements were made using three proton accelerators to cover the energy range ~20–500 MeV. Thin-target techniques used in the irradiations minimized the number of protons scattered out of the stack and the neutron production within the stack. After irradiation, the short-lived radionuclides, e.g., ^{22}Na, ^{7}Be, ^{24}Na, ^{54}Mn, and ^{56}Co, were determined using γ ray spectroscopy. Carbon-14, ^{10}Be, and ^{26}Al were determined using accelerator mass spectrometry.

Our main objective is to measure the production cross sections of long-lived radionuclides. We have reported new cross-section values for making ^{10}Be from O and ^{14}C from O, Mg, Al, Si, Fe, and Ni [1,2]. Using these new results, better estimates for the solar proton flux over several time periods in the past were determined [3]. However, no single value for the SCR flux could explain the measured data from different time periods. Further cross-section measurements are being made to verify that the values used in these estimates were accurate.

Irradiations designed to give good cross-section measurements for long-lived radionuclides also give good cross-section measurements for short-lived radionuclides. Results will be presented for proton-production cross sections of ^{22}Na from Mg, Al, and Si, and ^{54}Mn and ^{56}Co from Fe and Ni; some values at low energies were reported previously [4]. These cross sections and other reported measurements [5,6] will be used to improve the estimates of the recent SCR fluxes from the depth profiles for ^{22}Na measured in lunar rocks [7,8], and to better understand the SCR cosmogenic