Atom-Probe Tomography of Cosmochemical Samples

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Atom-probe tomography (APT) is a powerful analytical technique that has been extensively used in materials science and is now also being applied in cosmochemistry. With a spatial resolution at the atomic level and single-atom sensitivity, APT is a unique tool to study the local elemental and isotopic compositions of extraterrestrial materials, inclusions, and nanoparticles. We developed sample preparation methods and optimized analytical parameters to analyze individual 2–3 nm-sized meteoritic nanodiamonds (ND) from the Allende meteorite. Bulk analyses by noble gas mass spectrometry revealed that ND carry a high anomalous Xe component which is due to neutron-capture nucleosynthesis in supernovae (Xe-HL; Lewis R et al. 1987 Nature 326, 160). In contrast, carbon and nitrogen isotopes in bulk ND samples analyzed by gas mass spectrometry advocate a Solar System origin (Russell SS et al. MAPS 31, 343). Single grain analyses with APT of the $^{12}C/^{13}C$ isotopic abundance ratios will determine if there are different populations of ND with different stellar origins or with an origin in the solar system – a question that has not been resolved since the discovery of the meteoritic ND 27 years ago. In the limited number of Allende ND that we have analyzed by APT, we have not found a significant difference from terrestrial carbon in the uncorrected $^{12}C/^{13}C$ ratios. In a larger sample set we would expect that some ND from supernovae would have highly anomalous $^{12}C/^{13}C$ ratios, similar to what is observed with other types of carbonaceous presolar grains. We discovered an instrumental bias with APT that affects the accuracy of carbon isotope ratio measurements. Efforts are underway to correct for this bias. Besides ND, we have analyzed presolar silicon carbide with APT and started to extend our effort to other types of samples.