MAKING HIDDEN PRISTINE SUBMICRON CARBONACEOUS HOLLOW GRAINS STAND OUT IN SITU IN INTERPLANETARY DUST

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Carbonaceous or organic hollow globules have been observed in interplanetary dust particles (IDPs) and Stardust Wild 2 particles as well as in primitive meteorites [1-7], but the number of the globules reported so far appears to be much lower in the former than in the latter. This may be due in part to the challenge of not altering sub-µm hollow globules in fragile ultra-fined IDPs and in comet Wild 2 particles by microtoming and the resulting difficulty of recognizing them from transmission electron microscopy (TEM) images of thin-sectioned samples. Anhydrous chondritic porous IDPs represent the most primitive extraterrestrial materials currently available for laboratory study [8]. Developing alternative approaches to locating and mapping hollow globules in situ in bulk IDPs is not only crucial for assessing their abundance in the most primitive extraterrestrial dust but also important for understanding how this population of grains came into being in the first instance. In addition, the fragile ultra-fined IDPs have more likely originated from comets because of their unusual structural and compositional properties. Hence, finding the most pristine hollow globules in bulk IDPs would also provide a valuable resource for understanding the mechanism and processes by which Wild 2's hollow grains were formed.

Yet there are obstacles to in situ visualizing pristine hollow globules in bulk IDPs because of their small size and low density. An answer to these has emerged from the success of in situ mapping indigenous pore structure and thermal alteration products in IDPs by phase contrast X-ray nanotomography (PCXNT) [9-11]. By turning distinct properties of such grains into an advantage, we have identified intact sub-µm sized carbonaceous hollow grains in a porous IDP, which frequently exhibit complex 3-D morphology but resemble such typical organic hollow globules in a 2-D projection as observed by TEM. The sub-µm hollow grains are cohesively blended with other grains in the porous aggregate particle, each containing a distinct "central" nanohole that tends to be morphologically hidden. PCXNT, with its extreme sensitivity and 3-D nanoscale resolution, allows hidden pristine hollow globules to become not only visible but conspicuous in situ in 3-D space, which opens up a new avenue to unravel mysteries of these intriguing ancient grains.

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