DEUTERIUM ENRICHMENTS IN CLUSTER IDPS; S. Messenger, R. M. Walker, S. J Clemett, R. N. Zare. 1McDonnell Center for the Space Sciences and Physics Dept., Washington University, St. Louis MO, 63130, USA. 2Department of Chemistry, Stanford University, Stanford CA, 94305, USA.

Substantial enrichments in D/H, of up to +2,700‰, have been previously observed in roughly 1/3 of chondritic IDPs [1]. Often D-rich IDPs are marked by significant isotopic variations between different subfragments. The most extreme example of this isotopic heterogeneity is the IDP Butterfly, in which δD varies between -200 and +2700‰. Ion imaging of one fragment from Butterfly found the D highly concentrated relative to the H, with an inferred δD of at least +9,000‰. Recent measurements of an unusual 'cluster' IDP (Dragonfly) dramatically surpass these results, with δD ranging up to ~ +50,000‰ [2].

We have performed a H isotopic survey of cluster IDPs in order to determine if such large enrichments are common among these materials. We were allocated two fragments each from 17 clusters, originating from collectors L2008, L2009 and L2011. The ion microprobe measurement techniques are similar to those described in [3]. Complementary measurements of polycyclic aromatic hydrocarbons (PAHs) were performed on all particles to investigate their possible relationship to D enrichments. PAHs were measured using microprobe two-step laser mass spectrometry (μL²MS) as described in [4].

Preliminary results indicate that D enrichments in cluster IDPs are larger, more common, and have higher variability than previously measured IDPs. Of the 11 clusters analyzed so far, 10 have large D enrichments. Six clusters exhibit higher D enrichments than previously measured in IDPs (except the Dragonfly cluster), ranging from +2,900 to +12,000‰. Ion images in H, D, C, CN, O, Si and S were obtained in four of the D-rich fragments. Large local D concentrations were observed in two of these fragments (see fig.). The D/H is estimated to be a factor of three higher than the bulk measurements in both of these 'hotspots'. In all cases the H appeared to correlate well with the C distribution.

Previous work found that D enrichments were correlated with the C/O ratio among subfragments of a given IDP [1]. The D-rich phases are therefore inferred to be carbonaceous, although their detailed nature remains unknown. Substantial PAH signals were detected in five of the particles measured here. The PAH spectra are not dominated by odd mass peaks as previously observed in two IDPs [4]. Although it is not yet possible to directly determine the H isotopic composition of these molecules, it is interesting to note that of the 8 IDPs yielding strong PAH signals reported in this and previous work [4], so far all have had D enrichments, although the converse is not true.

Large D enrichments in IDPs and some primitive meteorites are likely due to the partial preservation of presolar molecules [5]. Although the number of particles studied is still small, it appears that cluster IDPs are by and large more isotopically primitive than either individual IDPs or primitive meteorites. It is not obvious why this should be so. There is a prejudice that ‘fluffy’, highly porous, fragile particles are the most primitive IDPs. While at some level cluster IDPs are fragile since they do not survive collection intact, most particles included in this study appear smooth and compact.

Cluster IDPs are larger than previously analyzed IDPs, suggesting that the difference is related to atmospheric entry heating. Large particles are expected to reach higher peak temperatures, resulting in greater volatile loss. While the preferential loss of a D-poor component
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would help explain these results, clusters apparently suffer little volatile loss [6]. The particles in this study were collected between the summer and fall of 1989, and thus may represent a unique event, such as an Earth crossing comet. Further measurements of individual and cluster IDPs from other collectors may help to answer this question. The possibility remains that cluster particles primarily sample D-rich parent bodies. While some individual IDPs must be derived from cluster parents, the proportion may be small compared to those from other sources.


Figure 1. Ion images of a fragment from L2009 cluster #13. The particle has a δD of +5,585‰.