HYDRATED CLUSTER PARTICLES: CHEMICAL AND MINERALOGICAL ANALYSES OF FRAGMENTS FROM TWO INTERPLANETARY DUST PARTICLES; K.L. Thomas1, L.P. Keller2, S.J. Clemett3, D.S. McKay4, S. Messenger5, and R.N. Zare6; 1Lockheed, C23, Nasa Rd. 1 Houston, TX 77058, 2Dept. of Chemistry, Stanford University, Stanford, CA 94305, 3MVA Inc., 5500/Suite 200, Oakbrook Pkwy., Norcross, GA 30093, 4NASA/JSC SN, Houston, TX 77058, 5McDonnel Center for Space Sciences, Physics Dept., Washington University, St.Louis, MO 63130

Chondritic interplanetary dust particles (IDPs) are among the most pristine solar system materials known, yet despite their small size they have been intensely studied. Our previous work on 53 fragments from one anhydrous cluster IDP (L2008 #5) showed that the individual fragments display strong chemical and mineralogical heterogeneity [1,2]. We are currently extending our studies of cluster particles to those consisting primarily of hydrated fragments in order to compare their chemical and mineralogical heterogeneity to anhydrous cluster particles, micrometeorites, and fine-grained chondrite matrix.

Five fragments for each of two cluster particles were analyzed in consortium mode as in our previous study [1,2]. All fragments from each cluster were distributed to several research groups and subjected to a variety of analyses including: SEM, TEM, ion microprobe, microprobe laser mass spectrometry, and reflectance spectroscopy. Laser mass spectrometry [3] and ion microprobe[4] measurements on some fragments are in progress.

Methods. We were allocated 5 fragments from 2 cluster particles, L2011#5 and L2005#31, for a total of 10 IDPs. All fragments were >5 micrometers in diameter. We determined the bulk composition for elements with Z > 5 of all 10 fragments. Our procedures and analytical checks for quantitative SEM EDX light element analysis are described in detail elsewhere [5]. Following the chemical analyses, all particles were analyzed using reflectance spectroscopy [technique described in 6]. Six IDPs, three from each cluster, were embedded in epoxy, thin sectioned using an ultramicrotome, and examined in the TEM. The 4 remaining fragments were analyzed for polycyclic aromatic hydrocarbon signatures and for D/H ratios using an ion microprobe.

Results. One related fragment from our first cluster, L2011#5, is documented in the JSC Cosmic Dust Catalog [7]. This fragment, L2011B1, has a chondritic spectra with a low bulk Ca content and a smooth surface morphology, two typical characteristics of hydrated IDPs [8]. In general, our five fragments from cluster L2011#5 have chondritic compositions for all major elements. The three fragments analyzed in the TEM are composed predominantly (>50% by volume) of serpentine (0.7 nm basal spacing). Only one fragment contains anhydrous silicates; olivines are Fo -99-100 and no pyroxenes are observed. Phyllosilicates are both coarse and fine-grained in all fragments. Fe-Ni sulfides are ubiquitous in the fine-grained serpentine; Ni contents range from ~0.5-42 wt.%. Reflectance spectra were obtained for each of the fragments over the range of 380-800 nm. Three fragments are indistinguishable and show typical flat C-type spectra.

Heating History of Our First Cluster. Distinct magnetite rims were located on the exterior surfaces of one fragment. In all three fragments, discrete regions of serpentine located at the outer edge had a vesicular texture. Magnetite rims result from atmospheric entry heating [9] and we believe that the vesicular serpentine on the particle surfaces also forms during atmospheric entry either through volatilization of solar wind implanted gases or through dehydroxylation of serpentine. One related fragment, L2011B5, was analyzed for noble gas content and He release temperature [10]. The 4He abundance was low in this IDP (2.3 cm³STP/gx10³). The 50% He release temperature was 550 °C which indicates that this fragment experienced only mild heating during atmospheric entry.
Several related fragments from our second cluster, L2005#31, are pictured in the JSC Cosmic Dust Catalog [11]. These fragments have chondritic EDX spectra and show either porous or smooth surface morphologies. Three fragments of this cluster have been analyzed previously by others; two of these are typical pyroxene-rich, porous, anhydrous IDPs, L2005F31 [Keller, pers. comm] and L2005F39 [Zolensky, 12 and pers. comm], while the third fragment (L2005F37) is a saponite-dominated particle [Klöck, pers. comm]. We obtained 5 additional fragments of L2005#31 in order to determine whether this cluster particle was only partly hydrated. Major element compositions are chondritic (within 2xCI) for all five fragments. From our group of three fragments analyzed in the TEM, two were anhydrous and were dominated by pyroxene. They contained carbonaceous material, Ni-poor sulfides, glass, Fe-Ni metal, chromite, and discontinuous magnetite rims. The third fragment contained no anhydrous silicates; it is composed of saponite, sulfides with Ni ranging from 3-21 wt.%, chromite, and rare Si-rich glass. Although cluster L2005#31 contains both anhydrous and hydrated IDPs, the fragments have several anhydrous phases in common which strongly indicates that the fragments are derived from the same parent cluster.

Reflectance spectra from the fragments show two major trends: three spectra are flat or gently rise into the red and two fall steeply into the red. The TEM data indicate that fragments in the first group are dominantly anhydrous while the latter group are hydrated fragments.

**Reflectance spectra**

**Heating History of Our Second Cluster** The presence of minor, discontinuous magnetite rims indicates that fragments from L2005#31 were heated little during atmospheric entry. Another related fragment, L2005F38, was analyzed by [13]; it had a 50% He release temperature of 530 °C which indicates that this fragment also experienced minor atmospheric heating.

**How do individual cluster differ from each other?** This and previous work show that cluster particles can be composed of anhydrous, hydrated, or a mixture of both anhydrous and hydrated fragments. Prior work on one anhydrous cluster, L2008#5, showed that the chemical compositions and mineralogy widely varied from fragment to fragment (i.e., some were dominated by Fe-Ni sulfides, olivine, or by carbon and pyroxene)[1,2]. In this study, our two cluster particles are chemically and mineralogically different from the anhydrous cluster previously studied. Fragments in cluster L2011#5 are composed mainly of serpentine and are remarkably similar in chemistry, mineralogy, and reflectance spectra; this homogeneity is a likely consequence of extensive aqueous alteration on its parent body. However, cluster L2005#31 contains both anhydrous and hydrated fragments which show a much greater degree of chemical and mineralogical heterogeneity. Dramatic differences in mineralogy and reflectance spectra between fragments from cluster L2008#5 and L2005#31 are most likely due to the nature of parent bodies of these clusters; the anhydrous and mixed clusters are essentially heterogeneous breccias made up of different materials having different histories which were physically combined either in the early nebula or in the regolith of a parent body.

**How do cluster particles differ from micrometeorites?** Cluster IDPs are within the same size range (~50-100 μm in diameter) as smaller-sized Antarctic micrometeorites (MMs). In general, more than 50% of these MMs have been highly heated during atmospheric entry [14]. Approximately 6% of MMs with unmelted-looking surfaces have abundant magnetite and depleted bulk S (relative to CI) which suggests that they have been extensively heated. However, fragments from our cluster particles contain chondritic S and minor amounts of magnetite; they most closely resemble the relatively unheated, small-sized IDPs.

**References:**