INAA OF LARGE INTERPLANETARY DUST PARTICLES FROM COLLECTOR L2005: David J. Lindstrom and Michael E. Zolensky, Code SN2 NASA/Johnson Space Center, Houston, TX 77058, and Rene R. Martinez, Lockheed Engineering and Sciences Co., Houston, TX 77058.

Introduction. Instrumental Neutron Activation Analysis (INAA) of individual IDPs (Interplanetary Dust Particles) weighing 1-100 ng is now done routinely. The compositions of these particles are quite primitive, resembling carbonaceous chondrites in most cases. As such, they are not particularly well-suited for analysis by INAA, and only upper limits to concentrations are obtained for many elements. Nonetheless, geochemically useful abundance estimates can be obtained for about 10-12 elements in very small samples (1-2 ng), or 15 or more elements in larger samples (10s of ng).

Analytical. Procedures have been described previously [1-4]. Briefly, the samples and glass standards are placed in diamond-drilled depressions in pure quartz glass plates, irradiated for a week in a high-flux reactor (integrated dose about 2 x 10^{20} neutrons/cm^2), and transferred to plastic planchets for gamma-ray assay using large Ge detectors in a low-level counting facility. Chips of standard glasses weighing 10-20 ug allow absolute amounts of elements to be measured; concentrations require normalization to measured or assumed values for Fe. The technique is nondestructive. Alteration of hydrous silicates (smectites and serpentines) by heating during irradiation has not been found in TEM studies of these particles [5]. After INAA, the particles are mounted in epoxy and microtomed, the slices being studied with transmission electron microscopy and the remaining surface analyzed by electron microprobe techniques for major elements.

Results. Analyses of 11 different IDPs have been obtained in this work. Of these, four were anhydrous (C32 and K10 olivine type; C31 and K8 pyroxene type) and the rest were saponite type hydrated particles [5]. All 12 putative IDPs were observed to have near-chondritic compositions (e.g., Fig 1), but important compositional differences remain. Occasional particles with peculiar abundances might lead one to believe either that the trace elements are concentrated in widely separated grains, or that contamination is involved. Particle L2005 K9 broke during handling, and the two resulting pieces were analyzed separately. They had very similar compositions (Fig. 1), including high Na and very high K, similar near-chondritic transition elements (with 9b having slightly enriched Co and Ni), and nearly identical As, Sb, Ir, Zn, and Br. The only clear difference is in Au, and its wide variation in abundance between the two particles suggests either dispersed metal grains (not supported by Ir data) or contamination. Nonetheless, these two analyses of parts of the same particle look very similar, which is encouraging for interpretive efforts of individual particle analyses.

Br is enriched 3-10x relative to CI chondrites in most of the hydrated particles (open symbols in Fig. 2a), but not in hydrous particle L2 or in the anhydrous particles. These Br values are not as high as some previous results which range up to 40x CI [6]. This result, coupled with the fact that these larger particles have lower surface area to mass ratios suggests that the Br is a stratospheric contaminant. (For an excellent discussion of this hypothesis, see [6]). As and Sb are also enriched, by up to 15x and 100x, respectively. Early INAA results on As and Sb were discarded due to contamination from our original impute silica tubes [1], but our new containers should eliminate this source. The results for these elements on the two pieces of K9 discussed above also argue against contamination, since contamination of two halves of a particle to the same degree is quite unlikely. As and Sb are expected to reside mainly in sulfides, which are important phases in these particles, and they are moderately mobile elements, so their abundance variations may prove useful.

Other elements show more subtle variations, for example Co (Fig. 2b). Here the analytical precision is high, yet several particles fall well away from the dashed line connecting CI values with the origin. The difference between the Co contents of the two subsamples of K9 suggests that part of the variation is due to sampling, perhaps of pentlandite. It is tempting to postulate a horizontal line linking the anhydrous particles, though its existence is uncertain and its meaning obscure.

These trace element analyses clearly distinguish between geochemically primitive IDPs and the other particles obtained from the IDP collection flags. For example, easily and precisely determined Co/Sc ratios are typically about 90 in CI chondrites and IDPs, but unity or less in terrestrial volcanic rocks. Answers to more complex questions about the origins of IDPs will most likely require analyses of many more particles because

sampling problems can be severe, even for these typically fine-grained particles. For example, a section through L2007-15 revealed about 1/4 of the area to be a single sulfide grain, and a similar section through L2007-10 showed a single olivine grain making up more than half of the section. These observations illustrate the value of nondestructive elemental analysis techniques such as INAA and synchrotron XRF [6].

References: [1] Lindstrom et al. (1989) LPSC XX, 574-575. [2] Zolensky et al. (1989) LPSC XX, 1255-1256. [3] Lindstrom et al. (1990) LPSC XXI, 700-701. [4] Lindstrom (1990) Nucl. Instr. Meth., in press. [5] Zolensky and Lindstrom, this volume. [6] Flynn & Sutton (1990), Proc. 20th LPSC, 335-342. [7] Anders & Grevesse (1989), GCA 53, 197-214.

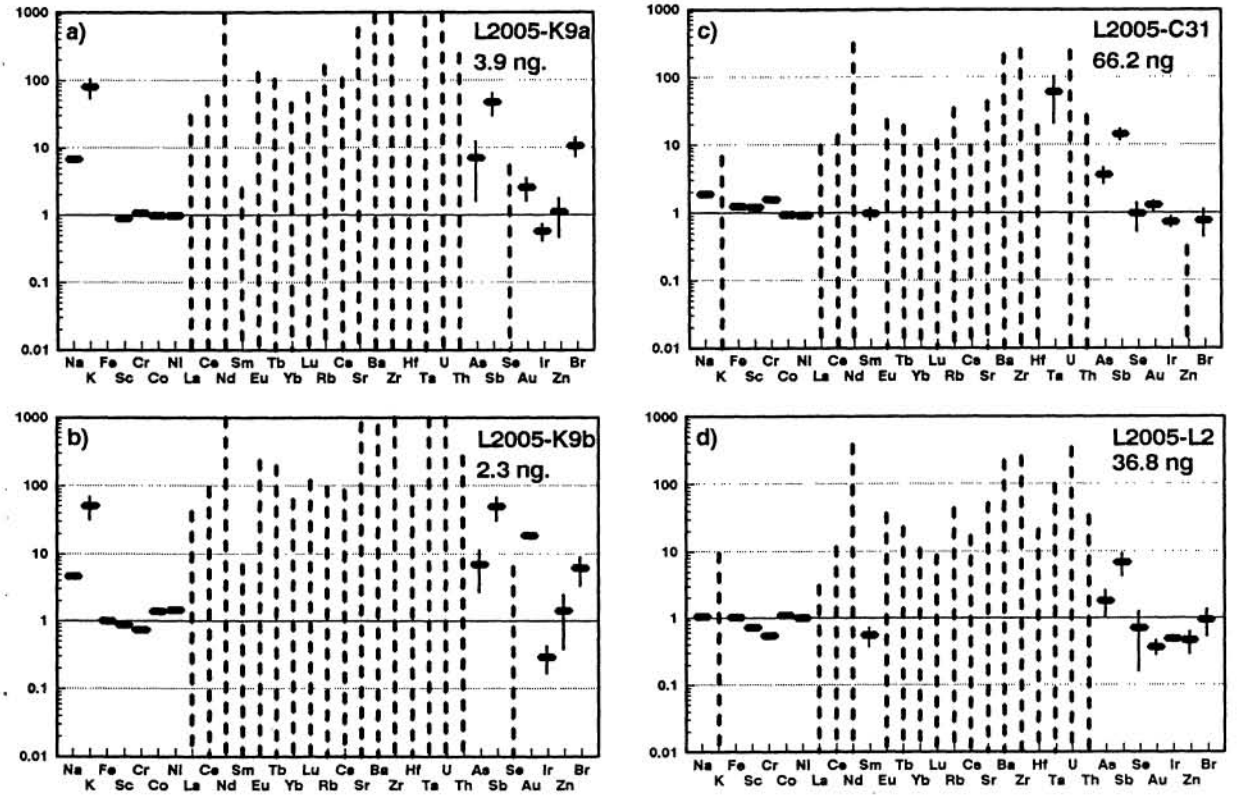

Figure 1. Abundances in IDPs normalized to CI chondrite values [7]. Error bars on points are two sigma uncertainties, mainly from counting statistics, and the tops of heavy dashed lines represent two sigma upper limits.

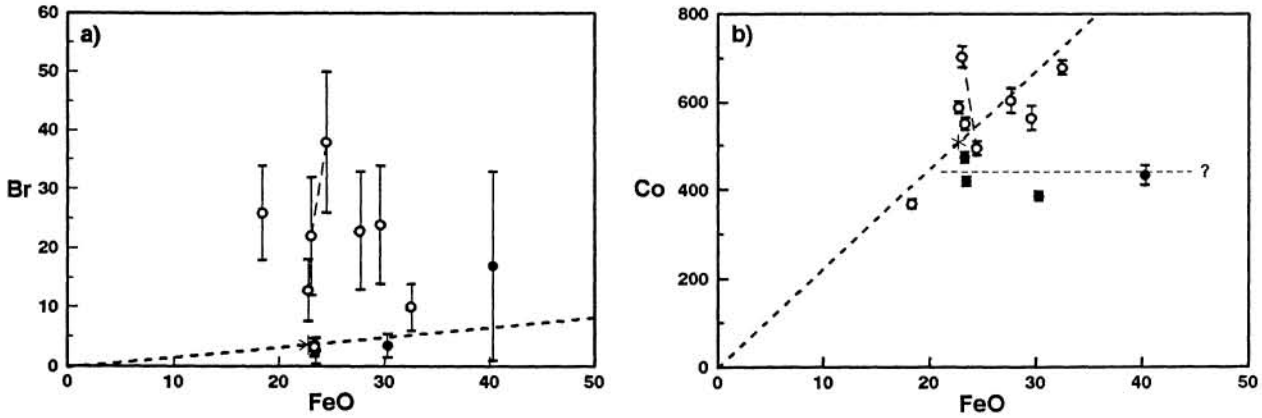

Figure 2. Abundances of elements in the 12 samples analyzed in this work. Solid symbols are anhydrous particles and open symbols are saponite type hydrated particles. Two sigma error bars are shown , except where they are smaller than the points. Asterisks represent CI compositions, and the dashed lines through the origin depict CI ratios. Even if weights of dust particles are wrong, the points should fall near this line. Dashed lines connect the two subsamples of L2005-K9.