TRACE ELEMENT ANALYSIS BY INAA OF POSSIBLE MARTIAN WEATHERING PRODUCTS IN SHERGOTTITE EETA 79001: David J. Lindstrom, Code SN2 NASA/Johnson Space Center, Houston, TX 77058, and Rene R. Martinez, Lockheed Engineering and Sciences Co., Houston, TX 77058.

Introduction. The discovery of regions of carbonate+sulfate+phosphate salt deposits in interior samples of the glassy lithology C of Shergottite EETA 79001 [1] raises the interesting possibility that these are martian, not terrestrial, weathering products. Instrumental neutron activation analysis (INAA) procedures have been developed for analysis of individual IDPs (Interplanetary Dust Particles) weighing 1-100 ng [2-5]. These techniques were applied to a number of samples plucked from newly discovered "druse" surfaces of shergottite EETA 79001 [6]. Abundances significant at the two sigma level were obtained for up to 17 elements (Na, K, Ca, Fe, Sc, Cr, Co, Ni, Sr, La, Sm, Yb, As, Sb, Br, W, and Zn), depending on sample sizes and elemental abundances. Upper limits, some of which could be geochemically significant, were obtained for another 15 elements (Rb, Cs, Ba, Nd, Eu, Tb, Lu, Zr, Hf, Ta, U, Th, Se, Ir, and Au).

Samples. The layers of weathered material in the cracks of lithology C of this meteorite are very thin, so large, pure samples cannot be obtained. We tried to pluck single grains from the surfaces of samples EETA 79001,336 and ,327, including the cleanest samples we could get of the drusy material as well as samples of the major minerals for comparison. After INAA, the particles were mounted in epoxy and partially sliced with a diamond knife microtome. Slices are to be studied with transmission electron microscopy and the remaining surface has been analyzed by electron microprobe techniques for major elements.

Results. Some of the major mineral samples proved to be too radioactive to count, so they were split further after irradiation, providing a grand total of 45 samples. Of these, 13 were thought to consist primarily of salt deposits. The compositions of the major minerals were in general agreement with the results of [7] and a few elements in the major phases are shown in Fig.1; discussion of these results is beyond the scope of this abstract. Because the druse samples were too small to weigh accurately, nominal weights were chosen such that totals, assuming that the primary components were calcium carbonate and mafic silicates, did not exceed 100%. These weights ranged from 0.03 to 2.9 micrograms. Abundance data based on the chosen weights are shown on Fig. 1. The plan was to use data from microprobe analyses of the partially microtomed particles to estimate their masses from the known amounts of major (FeO, Na_2O, CaO) and minor (Cr, K) elements. Backscattered electron images and small-area microprobe analyses of the surfaces of the partially microtomed particles showed them to consist of a complex, extremely fine-grained assemblage dominated by carbonates, but also containing sulfates and phosphates, and occasional inclusions of relict minerals, mostly pyroxene. All analyses of the drusy material showed very low FeO contents <0.1 % by weight, clearly much lower than the values initially calculated for the particles. Thus the drusy samples analyzed were mixtures of salts and major minerals. On some diagrams, such as Fig. 1a, it makes little difference whether the mixing line extends from druse to matrix, pyroxene, or olivine, but others (Fig. 1b) clearly favor pyroxene as the dominant FeO-rich component.

Masses of druse particles were revised to fit on the mixing line between the CaO content of average druse material (about 50% CaO) and the FeO content of olivine (about 25% FeO). Pyroxene, the dominant mafic endmember, also lies near this mixing line (Fig. 2a), as do samples of the meteorite's fine-grained matrix. In two-element plots of this type, most elemental abundances fall on mixing lines that pass through the origin (cf. Fig 1b). That is, the druse material has effectively zero concentrations of most of the trace elements analyzed. Figures 2b-2d show the few elements that do not fall on mixing lines through the origin. Sodium (Fig. 2b) is clearly not associated with the pyroxene (or matrix) component, but varies considerably. Zinc (Fig. 2c) appears to have a concentration of about 70 ppm in pure drusy material. Higher values toward 100 ppm are observed as pyroxene is mixed in. The one aberrant point is also very high in Na and Br. Bromine (Fig. 2d) abundances scatter at about 5 +- 2 ppm.

Summary. Samples of druse-containing material weighing only 0.04-3.3 micrograms have been successfully analyzed for a variety of trace elements. Unfortunately, the samples are very low in trace element contents (except Zn and Br) and are contaminated with 8-90% of other material, mostly pyroxene.

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References:: [1] Gooding et al. (1988) Geochim. Cosmochim. Acta 53, 197-214. [2] Lindstrom et al. (1989) LPSC XX, 574-575. [3] Zolensky et al. (1989) LPSC XX, 1255-1256. [4] Lindstrom et al. (1990) LPSC XXI, 700-701. [5] Lindstrom (1990) Nucl. Instr. Meth., in press. [6] Gooding (1990) Antarctic Meteorite Newsletter 13, 4. [7] Smith et al. (1984) Proc. LPSC 14th,, JGR 89, B612-B630.

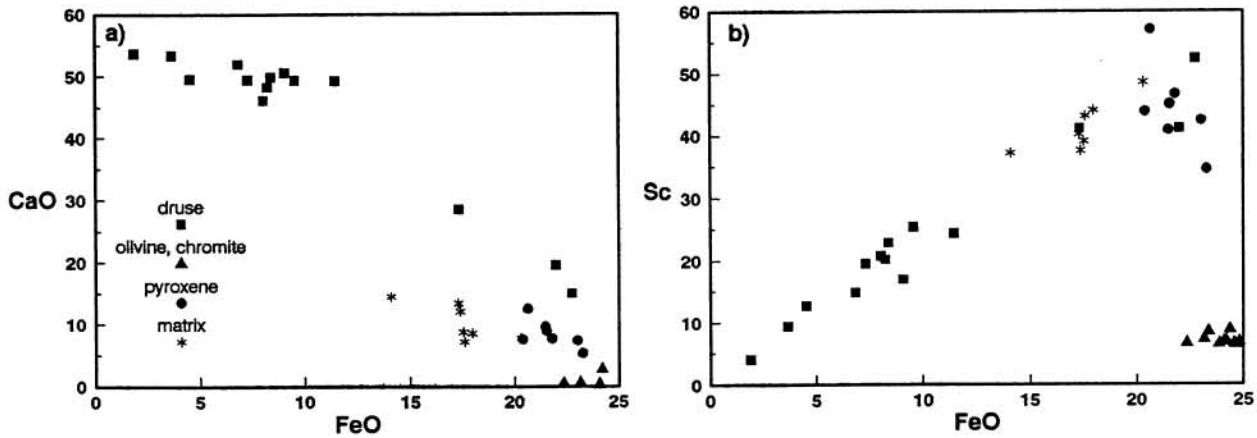

Figure 1. Analyses of subsamples of EETA 79001. Druse values are based on nominal weights; others are based on actual weights.

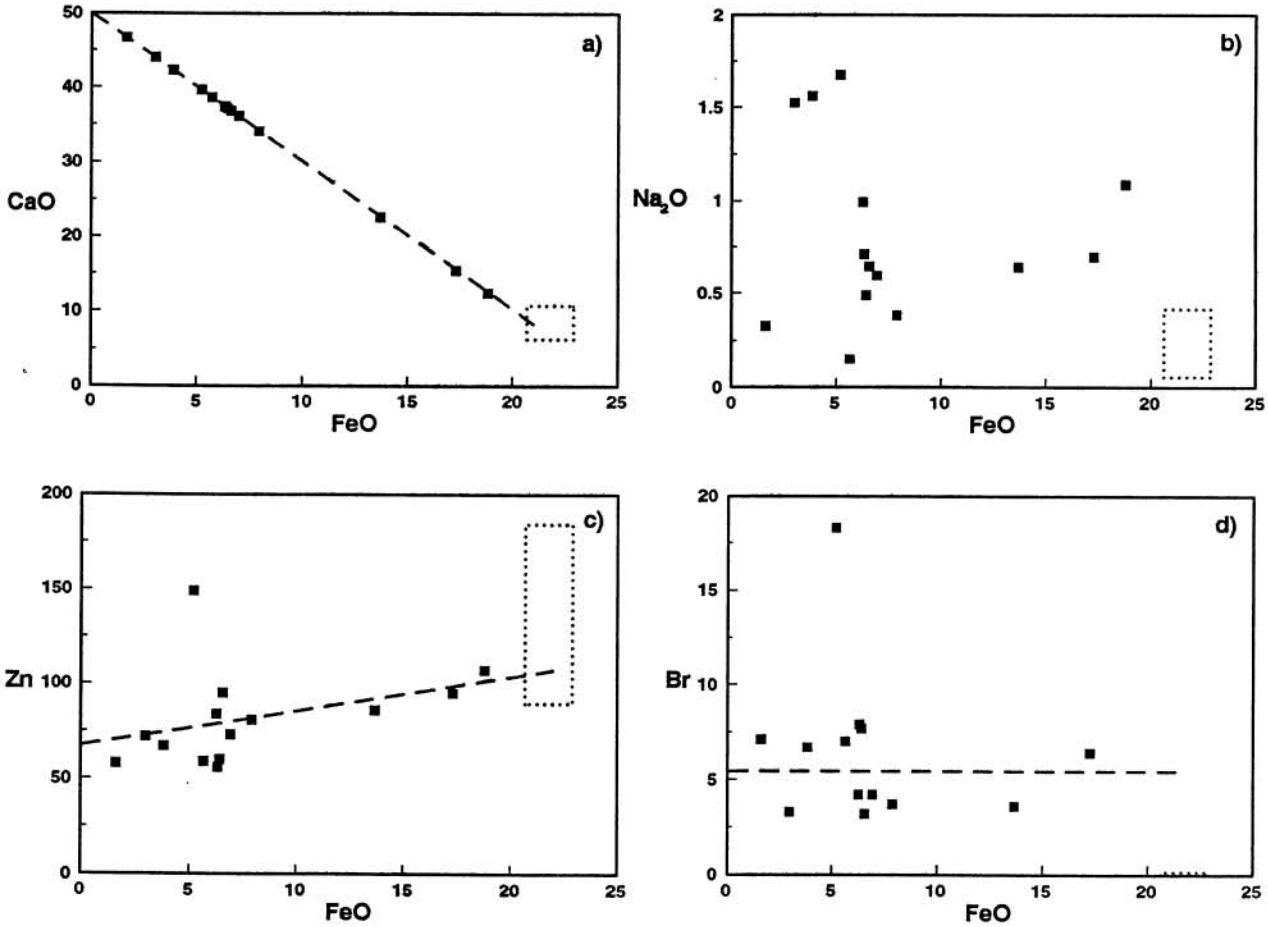

Figure 2. Analyses of druse particles based on weights calculated to fit the mixing line on Fig. 2a. Dotted boxes represent plus or minus one standard deviation on the mean composition of seven pyroxene particles. The heavy dashed line in c) is a least-squares fit to the druse data. The dashed line in d) is illustrative only.