RARE EARTH ELEMENTS IN A COMPOUND GROUP II ALLENDE INCLUSION;

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A petrographic investigation of Allende inclusion TS63F1 suggested that it may be a compound inclusion. TS63F1 consists of a hibonite-, spinel-rich region (H-S, =1/3 of the section); a vermicular-textured, spinel-anorthite-diopside region (VSAD, =2/3) and a 500 μm wide spinel-, diopside-rich outer mantle surrounding both regions. Distinctive 10 μm layers of anorthite and wollastonite are found where the two regions contact [1]. INAA measurements of the bulk inclusion indicate that TS63F1 has a group II REE pattern. The Chicago ion microprobe has been used to measure REE in individual grains in the major regions of the inclusion for evidence that these regions may have had independent formation histories.

In the H-S region is a hibonite crystal greater than 500 μm across. This hibonite was measured for REE in several different spots at least 100 μm apart. All the patterns obtained from the hibonite were the same as shown in Fig. 1. The pattern is similar to group II, but differs in the following two respects. There is no Eu depletion, even though the REE are depleted in Yb, and the LREE are greatly enriched because of an additional fractionation dependent on differences in ion radii of the REE.

Ideally one would prefer to compare REE measurements of the same mineral in each region but the VSAD region contains very little hibonite. However the region does contain perovskite. Four types of perovskite were measured for REE in the VSAD region: (1) aggregates of small grains in spinel, (2) individual grains randomly distributed in the region, (3) grains which are located at the contact boundary of the H-S and VSAD regions and (4) grains which form chains and are located at the boundary between the VSAD region and the outer mantle. All the type 1 and 2 perovskite measured for REE were well inside the VSAD region and gave the same group II pattern as shown in Fig. 2. Fig. 3 and 4 are measurements of type 3 and 4 perovskite respectively. All the perovskite grains have group II patterns but they differ significantly in their LREE patterns. Those perovskite in the center of the VSAD region (type 1 and 2) have uniform LREE enrichments but those near the edge of the region either at the boundary with the H-S region or the mantle (type 3 and 4) have apparent enrichments of Ce and Sm. Group II patterns are formed by condensation from a gas which has already had an ultrarefractory component removed. At very high removal temperatures a negligible fraction of the LREE are included in this ultrarefractory component and condensates from the remaining gas have unfractionated LREE patterns. Sometimes the ultrarefractory component is removed at a low enough temperature that it includes appreciable amounts of La, Nd and Pr. Condensates from the remaining gas have a saw-toothed LREE pattern with an apparent enrichment of Ce and Sm. Thus the type 1 and 2 perovskite must have condensed from a different gas reservoir than the type 3 and 4.

The REE data collected from individual grains of perovskite and hibonite suggest the following formation history for TS63F1. The H-S and VSAD regions formed as independent condensates. Both condensed from gases which had previously lost their most refractory REE component but at a high enough temperature that the resulting LREE patterns in each condensate were not fractionated due to differences in volatility (H-S=Fig. 1, VSAD= Fig. 2). At some later time the VSAD condensate was in a nebular site where additional material condensed on the outside. Among the new condensates were the perovskite grains with REE patterns like Fig. 3. The gas from which this new material condensed was distinctly different from that from which either the H-S or VSAD regions condensed. This gas had previously lost a refractory REE component at a low enough temperature that the LREE were fractionated by differences in their volatilities. Since the perovskite grains are not in equilibrium (Fig. 3 *vs*. Fig. 2) the VSAD condensate was not melted during this event or at any time later. The H-S and VSAD condensates collided and were intimately joined, probably in the same event which formed the outer mantle. The two regions are still separated by a zone containing perovskite with volatility-fractionated

LREE patterns unlike the LREE patterns found in the cores of both regions. The depletion of the most volatile REE, Eu and Yb, in the perovskite grains closest to the edge (Fig. 4) may mean the whole inclusion was strongly heated again. TS63F1 is a very complex inclusion.

REFERENCE: 1. S. M. Kuehner and L. Grossman (1987) *Meteoritics* **22**, in press.