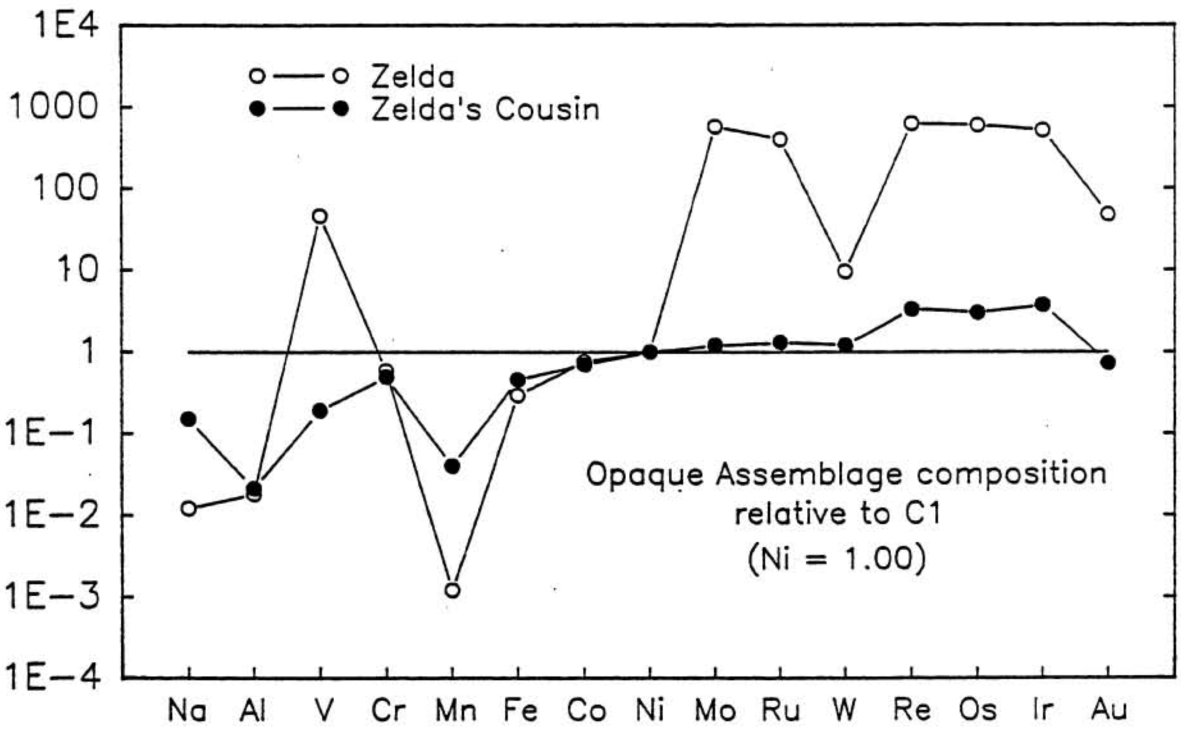
ZELDA'S COUSIN REVEALED A.J. Schilk[1,2], I.D. Hutcheon[5] and R.A. Schmitt[1-4]; [1]The Radiation Center and Departments of [2]Chemistry and [3]Geosciences and [4]College of Oceanography, Oregon State University, Corvallis, OR 97331; [5]The Lunatic Asylum of the Charles Arms Laboratory, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

A unique opaque assemblage (OA) has been found in the Mokoia chondrite (CV3, oxidized subgroup) whose overall mineralogy is somewhat reminiscent of that observed in Zelda, a mm-sized sulfide-rich spherule isolated from a fassaite crystal in the Allende CAI Egg6 [1,2 and references therein] and, as such, has been named "Zelda's Cousin" (ZC). This is the first published account of such an object in Mokoia, and it was obtained during an extensive collection/survey of chondrules from this meteorite. Due to the nature of collection and sample preparation, all evidence regarding the immediate neighborhood of ZC has been removed, although this type of object has been commonly found in CAIs, chondrules, and matrix material from most CV3 meteorites [3,4]. ZC resembles a flattened ovoid (roughly 1.4mm x 1.0mm x 0.7mm) with a mass of 1.76 mg and a density of approximately 3.4g/cc (as compared to the average 2.84 g/cc which was determined from nearly 100 silicate chondrules in Mokoia). Bulk chemical data was obtained by sequential instrumental NAA and is available from the primary author.

Mineralogically, ZC is compromised of a fine-grained intergrowth of magnetite (45% by area), pentlandite (43%) and a remarkable variety of phosphate minerals (11%). No NiFe metal or refractory metal nuggets (RMN) enriched in the Pt-group elements, particularly characteristic of OAs found in CV3 meteorites [e.g., 4], were observed in this preliminary investigation. Magnetite occurs as very fine grains (<0.1 to 1 μm) of nearly pure Fe_3O_4 with only 0 - 0.5% Al_2O_3 and 0.5 - 0.8% Cr_2O_3, although rare magnetites found near the periphery of ZC contain up to ~20% Cr_2O_3. This phase forms a homogenous, fine-grained matrix surrounding irregular and coarser pentlandite (1 - 10 μm) and phosphate crystals (0.5 - 5 μm; many euhedral crystals up to 20 μm were also observed). Pentlandite is relatively uniform in



composition [($\sim Fe_{5.8}Co_{0.1}Ni_{2.8}Cr_{0.1})S_8$] and more Ni-rich than pentlandite in Zelda [2], although it still falls within the range of compositions observed in Allende CAIs. The phosphates range from whitlockite (as in Allende) to Na- and Fe-rich, Ca-poor phases previously found only in iron meteorites [5]. All phosphates contain appreciable Na; Na_2O contents increase from ~3% in whitlockite to ~16% in panethite [$\sim Na_{1.7}Mg_{0.5}Fe_{1.5}(PO_4)_2$]. The larger phosphate crystals are rarely homogenous and as a group have the approximate composition $(Na,Ca)_{1.0}(Mg,Fe,Mn)_{2.5}(PO_4)_2$; phosphates with similar compositions are found in troilite nodules in IIIAB iron meteorites. Some silicate-rich material, possibly the remnant of a rim that once surrounded ZC (as for Zelda, [2]), is attached to the exterior. Olivine ($\sim Fo_{45}$) is the dominant phase in this discontinuous mantle, and it is cut by narrow (1 - 2 μm) laths of outwardly-radiating pentlandite. V- and Cr-rich magnetite, such as that commonly found associated with sulfide-rich Allende OAs, was not observed.

Chemically, ZC is distinguished from Zelda by the near paucity of many refractory (and volatile) siderophile element enrichments; in the former case, these elements are essentially equivalent to C1 (see figure; Zelda INAA data from [6]). This suggests that ZC originated in a different (spatial and/or temporal) environment in which siderophile element fractionation was not a major factor, thereby allowing ZC to retain its primitive, C1-like signature. In addition, ZC does not exhibit the strong V-enrichment or relative W-depletion as seen for Zelda. This seems to indicate that Zelda may have been exposed to a much higher temperature (metamorphic ?) and f_{O_2} than ZC such that W was oxidized, removed from the inclusion, and subsequently deposited within the host silicates [7]. An enhanced V-content in Zelda's magnetite might also be caused by such a phenomenon. Although both objects are somewhat depleted in Mn (with respect to the general trend), this behavior is less pronounced for ZC. This may imply that a larger fraction of Mn was present in the divalent state for ZC (due to the more reducing conditions) which would be conducive to a stronger retention of this element in its sulfide minerals. Compared to the Mokoia chondrule set, ZC has much higher siderophile (and chalcophile) element concentrations and Ni/Co, Ni/Se and Ni/Fe ratios are distinctly non-chondrule-like (i.e., they are considerable larger). Conversely, the Co/Se, Fe/Se and Fe/Co ratios from ZC are essentially equivalent to those observed for the total chondrule set. Based on the above observations, ZC may be similar to the oxide-sulfide assemblages found in olivine chondrules [3], and it is hoped that further investigations (specifically, EPMA of additional cross-sections of ZC) will serve to identify other phases and shed some light on this unique object.

REFERENCES: [1] Armstrong et al. (1985), LPS XVI, pp. 15-16; [2] Armstrong et al. (1987), GCA v. 51, pp. 3155-3173; [3] Haggerty and McMahon (1979), PLPSC 10, pp. 851-870; [4] Blum et al. (1989), GCA v. 53, pp. 543-556; [5] Buchwald (1984), Phosphate minerals, pp. 199-214; [6] Palme et al. (1989), LPS XX, pp. 814-815; [7] Palme et al. (1989), Meteoritics v. 24 p. 313.