CHARACTERISTIC ZONING AND COMPOSITIONS OF C3 FORSTERITES: Ian M. Steele, Dept. of the Geophysical Sciences, University of Chicago, 5734 S. Ellis Ave., Chicago, IL, 60637.

INTRODUCTION: Unusual compositions for isolated forsterites in carbonaceous and unequilibrated ordinary chondrites have been recognized (1) and zoning profiles for forsterites in Ornans presented (2). Data are given below comparing forsterite compositions and zoning for 3 C3 meteorites emphasizing two compositional ranges: 1) a core characterized by low FeO and only slight zoning, and 2) a rim characterized by rapidly increasing FeO and MnO and a complex zoning pattern for Cr2O3. The boundary between the core and rim is sharp and easily recognized in most grains. Below are described the typical zoning profiles as well as chemical features of the two compositional regions. The meteorites described include Allende (C3V), Ornans (C3O) and ALHA 84028,11 (C3V), and for each about 8 forsterite grains have been documented.

CHARACTERISTIC ZONING: Figure 1 shows a typical profile for 6 elements from an Allende forsterite grain. The features to be noted can also be found in many Ornans forsterites (2) and in forsterites from ALHA 84028,11 suggesting that these are indeed general features at least of C3 forsterites. Features include: 1) an core and rim sequence with the transition best seen by a sharp change in slope of Fe concentration as indicated on Fig. 1. Less dramatic, but sharp changes occur for Mn and Cr profiles with the position of the slope change identical to that of Fe as seen on Fig. 1; 2) In all cases the Fe zoning is normal (increasing concentration toward rim) and smooth; 3) Within the core Mn is at the detection limit (40ppmw) and no increase can be detected within the core while Cr shows normal zoning like Fe. In the rim the FeO/MnO ratio increases linearly from about 30 at the core-rim boundary to 115 at the grain edge but within the core this ratio is >100 depending on the actual value of Mn; 4) within the core, Al and Ti (and also V) are highly correlated and show sharp discontinuities and in the extreme, oscillatory zoning (3). These discontinuities are not reflected in Mn, Fe, Cr or Ca profiles. This Al-Ti correlation also occurs in the rim of the grains but sharp changes are not present in this region. The levels and changes in these two elements are directly reflected in the cathodoluminescence intensity provided FeO is below ~0.75 wt%. The Al2O3/TiO2 ratio changes from a constant value of 3.5 in the core to 1.5 at the grain edge without a sharp change at the core-rim boundary; 5) the Cr profile usually shows a hump in the rim region with the Cr level at the extreme edge similar to that of the core but with a maximum about 2x the core concentration; Ca shows a smooth profile with no obvious change at the core rim boundary but with rim concentrations less that those of the core.

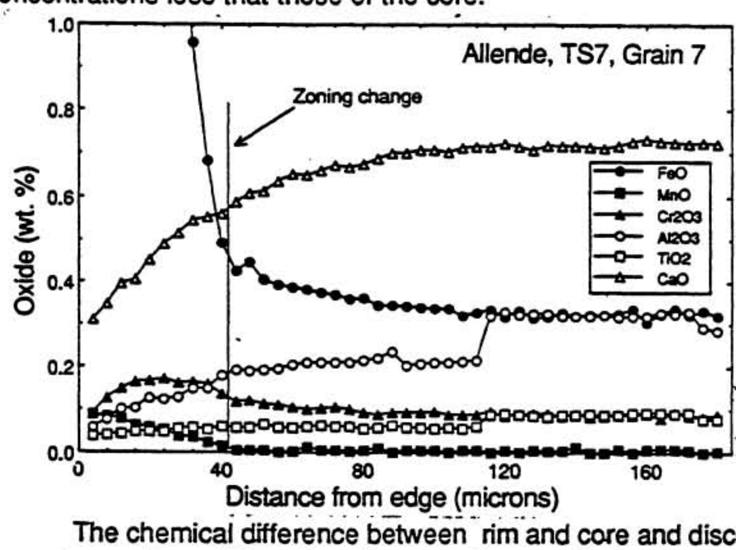

Fig. 1. Zoning profile from grain edge to core of Allende forsterite. A boundary labeled 'Zoning change' is indicated which separates the core and rim of this grain. The position of this boundary is most easily seen in the FeO profile but can also be recognized in the MnO and Cr2O3 profiles.

The chemical difference between rim and core and discontinuities at their boundary indicate that these two regions did not form by a continuous single process but rather reflect different processes or subsequent modification to form the rim. The chemical features of the two regions should be treated independently and below data for forsterite cores from 3 C3 meteorites are selected based on the Fe profile. These core data are thought to represent a primary growth feature while the rim data may reflect a change in growth condition or diffusion exchange or more realistically, both processes.

CHEMICAL FEATURES OF CORE: Data representing core compositions were selected based on the change in slope of the FeO concentration profile for 23 grains in 3 C3 meteorites. Grains were selected based on cathodoluminescence which is an indicator of FeO levels below 0.75 wt.%. Figs. 2 and 3 show plots for element pairs Ca-Al and Ti-Al with each meteorite plotted with a different symbol. Several significant features are: 1) by visual estimation, the ranges of data for the three meteorites represented on these two graphs are identical with a few notable exceptions; 2) the Al/Ti atomic ratio is constant at ~6.1 for most grains from the 3 meteorites and the range of CaO is near constant at 0.65 wt.%; 3) Several forsterite grains show very different levels of these 3 elements relative to the main group of data.

The clustering of compositions for different grains and for different meteorites strongly suggests that most grains were formed under similar if not identical conditions; however, the occurrence of 3 forsterite grains with very different levels of minor elements shows that there are several types of forsterites probably due to different environments of formation. Particularly interesting would be the oxygen isotope signature of these forsterites to compare with the known excess of ^{16}O in the few analyzed grains of forsterite (4). These three grains do not appear otherwise unusual and one has clear oscillatory zoning in its cathodoluminescence similar to some grains in the main group.

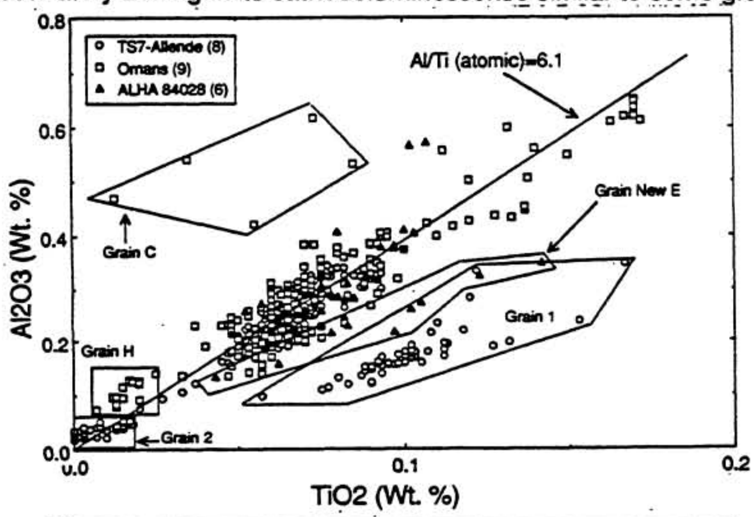

Fig.2. Variation of TiO2 vs Al2O3 for forsterite cores in 23 grains from 3 C3 meteorites. The line is a visual fit to the main group of data. Anomalous grains are indicated. In general, most grains have indistinguishable levels of these two elements.

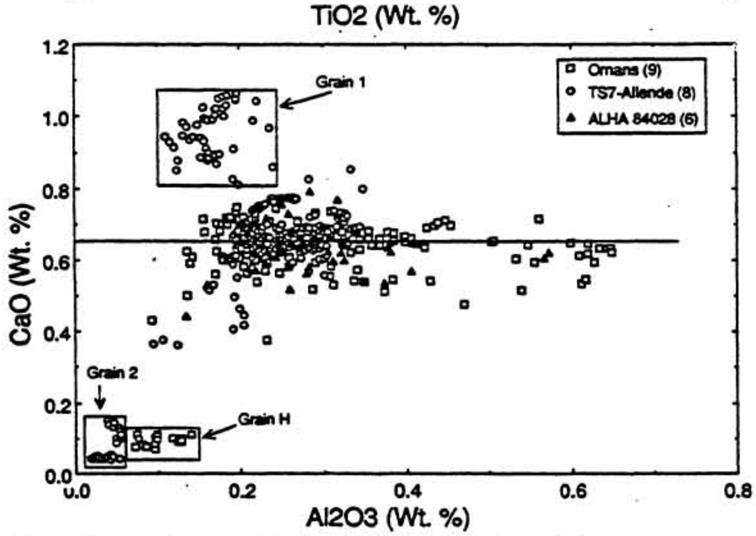

Fig. 3. Variation of CaO vs Al2O3 for forsterite cores in 23 grains from three C3 meteorites. The average CaO of the main group of data is near 0.65 wt% and the forsterites from the 3 meteorites show nearly identical ranges of concentrations. The same grains that were anomalous on Fig. 2 also show unusual CaO values relative to the main group of data.

REFERENCES: (1) Steele, I.M. (1986) Geochim. Cosmochim. Acta 50, 1379-1395; (2) Steele, I.M. (1989) Geochim. Cosmochim. Acta 53, 2069-2079; (3) Steele, I.M. (1990) LPSC XXI, 1196-1197; (4) Weinbruch, S., Zinner, E.K., Steele, I.M., El Goresy, A., and Palme, H. (1989) Proc. 52nd Meteoritical Society, 262.

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