DETAILED STATISTICAL ANALYSIS OF FE-MG SYSTEMATICS OF AMOEBOID OLIVINE INCLUSIONS. L. J. Chizmadia[1] and H. Bravo-Ruiz[2], [1]Department of Geology, University of Puerto Rico at Mayagüez, PO Box 9000 Mayagüez, PR 00681-9000, Email: lysa.chizmadia@upr.edu, [2]Department of Geology and Geography, West Virigina University, Morgantown, WV 26506-6300.

Introduction:

The CO3 carbonaceous chondrites form a metamorphic sequence [1], not dissimiliar to that of the unequilibrated ordinary chondrites [2]. The similar styles of alteration was recently documented by [3], who found that the distribution of Cr2O3 in Fe-rich chondrule olivine varies systematically, in addition to the numerous other diagnostic features which show systematic changes with increasing levels of alteration, e.g. thermoluminescence temperatures [4], %Fa distribution in amoeboid olivine inclusions [5], Na metasomatism of chondrule glass [6], and the complexity of organic compounds [7]. They also found that under close scrutinity, the Cr2O3 concentrations and distribution show evidence for intermediate subtypes, e.g. 3.05, for both the ordinary and CO3 chondrites [3]. Unfortunately, this technique is limited to the lowest subyptes ($\leq$3.2) because the Cr2O3 levels homogenize and no longer show any changes [3]. This is a similar problem shown by the organic material [7].

The high surface area to volume ratios of the individual grains in AOIs has proven to be very sensitive to the effects of hydrothermal alteration [5]. The olivine grains in AOIs are initially very Mg-rich ($<Fa_1$) and become progressively more Fe-rich with increasing levels of alteration, until by subtype 3.8 no Mg-rich olivine remains. In addition, AOIs show continuous changes from the lowest subtypes to the highest – this is one of the few chemical signatures to span the whole range of subtypes [5]. Therefore, we tested the hypothesis that AOIs could show a similar level of sensitivity as seen by the Cr2O3 distribution in Fe-rich olivine phenocrysts [3] and additionally, they could be used to further define the subtypes of CO2 that have experienced more alteration than 3.3.

Methods:

Images of 21 CO3 chondrites were captured by using the LEO 1430VP scanning electron microscope (SEM) at UCLA [5] and the and the JEOL JSM5900 LV SEM at the Hawaii Institute for Geophysics and Planetology at the University of Hawaii, Manoa [8-9]. These images were used to estimate the percentages of Mg-rich olivine, Fe-rich olivine, anorthite-diopside-spinel (An-Di-Sp) assemblages, and Fe-Ni metal within each of the AOIs. To estimate the abundance of these minerals, a random grid in JMicroVision© point counting software was used. The sample size of each image consisted of 500 points, which were qualitatively selected. Points in the matrix or within voids in the AOIs were excluded. Also, the size of the AOIs and thicknesses of their veins were measured. The compositions of the 12 samples without subtypes were compared to those of the 9 CO3 chondrites previously studied by [5].

Results:

On the basis of a detailed statistical treatment of the Fe-Mg systematics in amoeboid olivine inclusions, we find that as a whole the resultant subtypes are consistent with those assigned by other workers (see Figure 1). The refinements proposed here include: Colony = 3.05 (see below for Discussion), Y-82050 & ALH 82101 = 3.25, ALHA77003 = 3.55, Isna & ALH3108 = 3.75, while MET00694, MET00711 & MET00737 = 3.8. Y-82050 (x=13.4 σ=13.58) and ALH82101 (x=14.73 σ=13.1) have means (x) and standard deviations (σ) of the Fe-Mg content that falls neatly between those for Kansaz (x=4.42 σ=4.93) and 3.2 Rainbow (x=5.309 σ=6.019) and 3.3 Felix (x=17.81 σ=16.05). The mean and standard deviation for ALHA77003 (x=26.25 σ=11.23) fall nearly exactly half-way in between those for 3.5 Y-790092 (x=24.44 σ=12.97) and 3.6 Y-791717 (x=29.23 σ=16.41).

Finally, the three MET chondrites have olivine compositions which have very little range, much like those of 3.75 Isna (x=37.536 σ=0.597) and ALH83108 (x=38.503 σ=.449). However the %Fa means for MET00694 (x=34.506), MET00711 (x=34.049) and MET00737 (x= 34.354) are slightly lower than those for Isna and ALH83108. Upon close examination, the maximum Fa contents are observed in Y-791717 (max=45.93) and EET92126 (max=45.14). The lower maximum %Fa values in the three MET chondrites likely reflect the early stages of equilibrium with type I porphyritic chondrules which have lower Fa contents ($\sim Fa_{39}$) [11].

Discussion:

The CO3 chondrite, Colony, is a difficult one for which to establish a petrologic subypte, mostly because of the high degree of terrestrial alteration. Colony is riddled with small veins of Fe-rich terrestrial materials which mix intimately with the pre-terrestrial materials. Therefore, it is extremely difficult to measure olivine in AOIs with no terrestrial component unambiguously [10]. Since the mean olivine value is

higher than those of Y-81020 (3.0) and ALHA77307 (3.0) (which are so lightly altered as to be considered two of the most primitive meteorites currently in our collections), and yet lower than A-881632 (3.1), Colony is assigned 3.05. However, it is important to note that this may very well be an artefact of the unintentional analysis of sub-micron veinlets of Fe-rich terrestrial material.

Conclusions:

Statistical analysis of the Mg-Fe composition and distribution of olivine in AOIs cooborates the presence of intermediate subtypes, proposed by [3]. This method offers an additional procedure to assign petrologic subtypes to CO3 chondrites, and shows that indeed several chemical components of the CO3 chondrites vary systematically due to hydrothermal alteration.

References:

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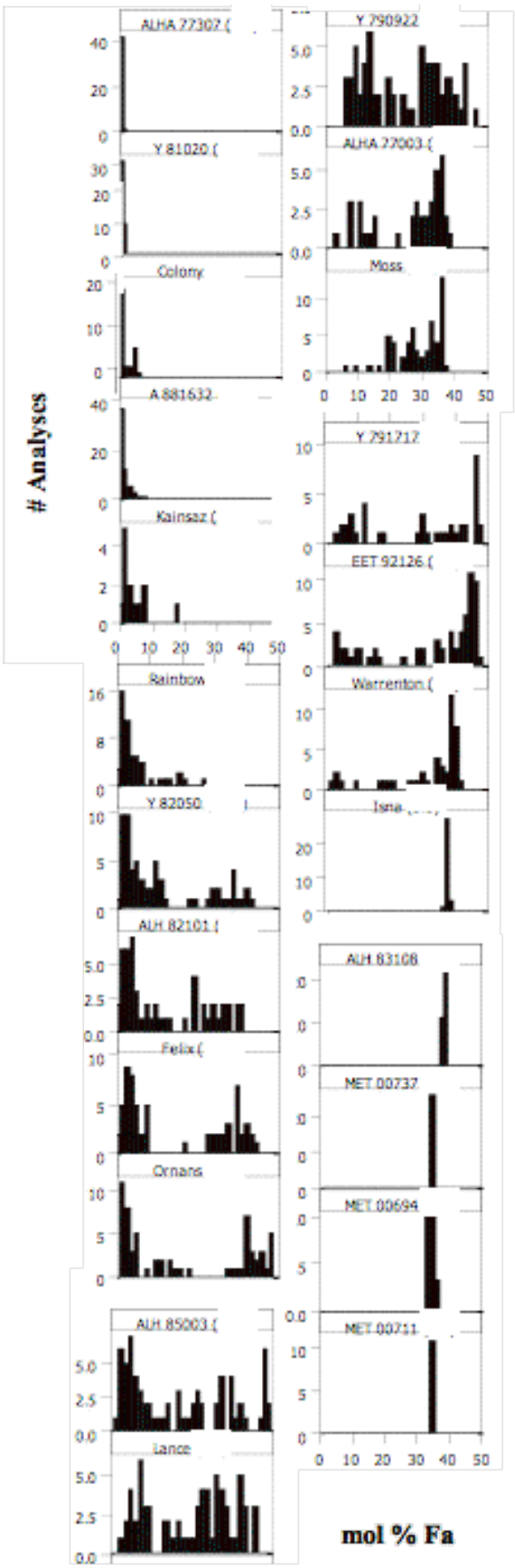

Figure 1. Histograms showing the distribution of mol% Fa in the olivine grains of amoeboid olivine inclusions in 21 CO3 carbonaceous chondrites, spanning the range of petrologic subtypes from 3.0 to 3.8. The number of analyses is represented by the y-axis, while the x-axis show the mol% Fa of each analysis.