Pairing Relations of the CO3 chondrites recovered at the Dominion Range, Transantarctic Mountains.

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Introduction: Fourteen CO3 chondrites have been recovered in the Dominion Range (DOM) dense collection area of the Transantarctic Mtns by ANSMET teams during the 2008-09, 2010-11, and 2014-15 seasons [1-3]. DOM 08006, one of the largest masses, has been studied extensively and is recognized to be a very primitive unmetamorphosed sample of great value to planetary science [4]. Studies of pre-solar grains, organics, chondrules, inclusions, and matrix have revealed a rich scientific treasure helping to constrain the conditions in the early solar system (e.g., [4-8]). Many of the masses paired with this sample are significant, yet the pairing has been called into question due to the finding that DOM 08004 seems less primitive than DOM 08006 [5]. Because of the significant masses involved, and the great scientific value of DOM 08006, we have undertaken a detailed assessment of the pairing using field relations, macroscopic observations, petrography, and olivine compositions.

Samples and approach: We examined NASA-JSC library thin sections of DOM 08004, DOM 08006, DOM 08139, DOM 08351, DOM 10101, DOM 10104, DOM 10121, DOM 10299, DOM 10847, 10900, DOM 14019, DOM 14127, DOM 14305, and DOM 14359. Using the approach of [9] we measured the Cr content of olivine in type II FeO-rich chondrules. In addition to the olivine analyses, we also examined the field photos, labs photos for macroscopic appearance, and modal mineralogy in thin section.

Methods: Electron microprobe analyses were obtained using the Cameca SX100 electron microprobe at NASA Johnson Space Center. Standards employed were Marjalahti pallasite olivine, chromite, fayalite, diopside, oligoclase, and rhodonite. Analytical conditions include 15 kV accelerating voltage and 20 nA sample current. Because such chondrules are relatively rare in CO3 chondrites, we examined both full chondrules and individual olivine grains or fragments that are related to the FeO-rich chondrules, to increase the number of samples analyzed and thus the population statistics for the measurements. Standard deviation in Cr contents of as many olivine grains as possible were calculated and used to assess petrologic type (3.0, 3.1, 3.2, etc.) for each DOM sample [9].

Results: These samples all fall along the trend of Cr_2O_3 versus σ-Cr_2O_3 defined by previous studies of CO chondrites [9,10]. Many of the masses examined have primitive characteristics like DOM 08006 - DOM 08351, DOM 10104, DOM 10847, DOM 10900, and DOM 14359 all have high average Cr contents and relatively low σ-Cr_2O_3, and represent a total of 1.4 kg of material. On the other hand, DOM 08004, DOM 08139, DOM 10101, DOM 10121, DOM 10299, DOM14019, DOM 14127, and DOM 14305 all have higher σ-Cr_2O_3, and fall on the trend of more thermally altered, perhaps as 3.1 or 3.15. In addition, our measurements of magnetic susceptibility show that all of the least metamorphosed samples have $\log\chi$ values from 4.8 to 5.0, whereas the more metamorphosed samples have $\log\chi < 4.8$. Such trends have also been observed for other CO3 where metamorphic grade correlates with Raman parameters [11], $\log\chi$ [12], and thermal luminescence [13]; our data support these trends and suggest that unmetamorphosed CO3 have $\log\chi$ near 4.95.

Given the heterogeneity in olivine composition from this group, as well as suggestions from thermal luminescence that there is more than one pairing group [13], it seems likely that these samples might be part of at least two distinct groups. There could be two groups – one primitive (3.0 to 3.05) and one more thermally metamorphosed (3.1 to 3.2). Alternatively, the DOM CO3 chondrites could be from the same fall, perhaps similar in mass and size to the Sutter's Mill and Tagish Lake strewnfields [14,15] - 1.7 kg of material recovered over a length of ~6 km. In that case there would be an inherent heterogeneity and a range of metamorphic grades represented within the members of the group. Perhaps cosmic ray exposure and terrestrial age studies can help to resolve this issue.

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