PROGRESSIVE AQUEOUS ALTERATION OF CR CHONDRITES

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Although CR chondrites have experienced little or no thermal metamorphism, they have undergone varying degrees of parent-body aqueous alteration. O-isotopic measurements of CR chondrites show increasing $\delta^{17}O$ and $\delta^{18}O$ in more aqueously altered meteorites. However, these measurements have limitations because of terrestrial weathering and sample heterogeneity. What is needed is a petrologic scale for aqueous alteration in CR chondrites analogous to the one constructed for CM chondrites [1]. We examined 20 CR chondrites and used petrographic and compositional parameters to draft a preliminary CR alteration index.

The scale ranges from 2.0 (most altered, equivalent to petrologic type 1) to 3.0 (negligibly altered, roughly equivalent to that of LL3.0 Semarkona). With increasing CR-chondrite alteration, metallic Fe-Ni grains develop rinds of magnetite, S-bearing oxides and hydroxides, and other OH-bearing phases. Chondrule mesostases have been altered to phyllosilicate in some CR chondrites. Mafic silicate phenocrysts in chondrules in Renazzo, Al Rais, and A-881595 show incipient alteration.

QUE 99177 and MET 00426 were classified as type 3.0 by [2]; most of the CR chondrites we studied appear to have similar degrees of aqueous alteration to these meteorites, clustering around type 2.9-3.0. These samples can be distinguished from one another by the presence in some chondrules of transparent isotropic glass (QUE 99177, MET 00426, EET 92062, LAP 02342, Gao-Guenie (b), GRV 021710 [2]) and by TEM studies [2] indicating the extent of matrix hydration.

Renazzo and A-881595 contain ≥50-µm-size metal grains that have been partially converted to magnetite; small metal grains have been largely to completely converted to magnetite. Chondrule phenocrysts show incipient alteration along grain surfaces.

In CR-an Al Rais most metal grains not embedded deep within chondrules have substantial alteration rinds of magnetite and a S-bearing oxide. Many of the chondrules contain polysynthetically twinned low-Ca pyroxene grains displaying alteration along twin boundaries. Al Rais is more altered than Renazzo or A-881595.

GRO 95577 is similar to CM2.0 chondrites. All of the metal is nearly or completely oxidized; mafic-silicate phenocrysts have all been converted to phyllosilicate [3]. We found that some of the former metal grains consist of at least nine distinct nested layers of phyllosilicate. Because similarly sized metal grains in CR LAP 02342 are compositionally uniform, this suggests that the layering in GRO 95577 represents episodic alteration of an initially homogeneous substrate.

We used thermogravimetric analysis to examine the differences in bulk indigenous water among relatively unaltered CR chondrites. Preliminary results indicate that some less-altered samples contain about 1 wt% less water than Renazzo (5.67 wt%, [4]). Correction for volatiles in weathering products is required.

Further development and application of this index will enhance our understanding of parent-body aqueous alteration process on the CR parent body and offer a guide to sample selection in future studies of CR chondrites.

References: [1] Rubin A. E. et al. 2007. *GCA* 71:2361–2382. [2] Abreu N. M and Brearley A. J. 2010. *GCA* 74:1146-1171. [3] Weisberg M. K. and Huber H. 2007. *MPS* 42:1495-1503. [4] Wiik H. B. 1956. *GCA* 9:279-289.