ACCRETION TEXTURES, IRON EVAPORATION AND RE-CONDENSATION IN RENAZZO CHONDRULES B. Zanda[1,2], M. Bourot-Denise[1], R. H. Hewins[2], B. A. Cohen[2], J. S. Delaney[2], M. Humayun[3] and A. J. Campbell[3]. [1]CNRS/Minéralogie MNHN, 61, rue Buffon, 75005-Paris, FRANCE, [2]Geological Sci., Rutgers University, Piscataway, NJ08855, [3]Geophysical Sci., The University of Chicago, Chicago, IL 60637.

Introduction: The Renazzo chondrite is unequilibrated, highly reduced and contains abundant metal (7.3 vol%) mostly associated with chondrules [1,2]. It thus provides a unique opportunity to understand the genetic relationship between chondritic silicates and metal. Metal in CR chondrites has often been believed to be of condensate origin for two reasons: (i) its P and Cr content [3]; (ii) its Co and Ni following a condensation trend i.e. having the cosmic ratio of 0.046 [3,2]. A tendency for Ni (and Co) to be higher in the grains in chondrule interiors compared to grains sitting on chondrule margins was thus interpreted as evidence that the core metal grains had condensed at higher temperatures, suggesting accretionary growth of chondrules at progressively lower temperatures [2], but [4] attributed this to late Fe addition to the grains sitting on the chondrule margins due to FeO reduction from the adjoining silicates. Zanda et al. [5] however showed that Ni and Co in the metal grains of the least melted chondrules (based on the silicate grain sizes and the chondrule outline) did not follow a condensation trend and that the Ni-Co correlation was gradually established during chondrule melting due to Fe oxidation or reduction. In addition, Zanda et al. [6] showed that the presence of Cr and Si in the metal could be explained by a reaction with the surrounding silicates at the time of chondrule formation.

Recently, the debate on the origin of chondritic metal was stirred again by the finding of zoned metal grains in CH-chondrites attributed to condensation [e.g. 7], whereas [8] analyzed PGE distribution in CR chondrites and argued that metal inside chondrules originated during melting via reduction from the silicate melt whereas rim metal was the product of recondensation from a vapor depleted in refractory siderophiles. The present work is a follow up on [6] in which we tried to correlate metal and silicate textures together with their compositions.

Textures of silicates and metal: Chondrules in Renazzo are often not spherical. They have convoluted outlines that suggest melted particles in the process of coalescing. (Fig. 1a). The least melted objects have fine-grained silicates and fine-grained metal dispersed throughout. As the melting progresses, the outline of the objects becomes smoother and the internal metal can be seen to coalesce while a metallic rim starts to develop (Fig. 1b). More extensively melted objects are almost spherical. They have very little remaining metal dispersed within the silicates, but exhibit a well developed metallic rim and sometimes can be seen to contain one or 2 large spherical metal grains (Fig. 1c).

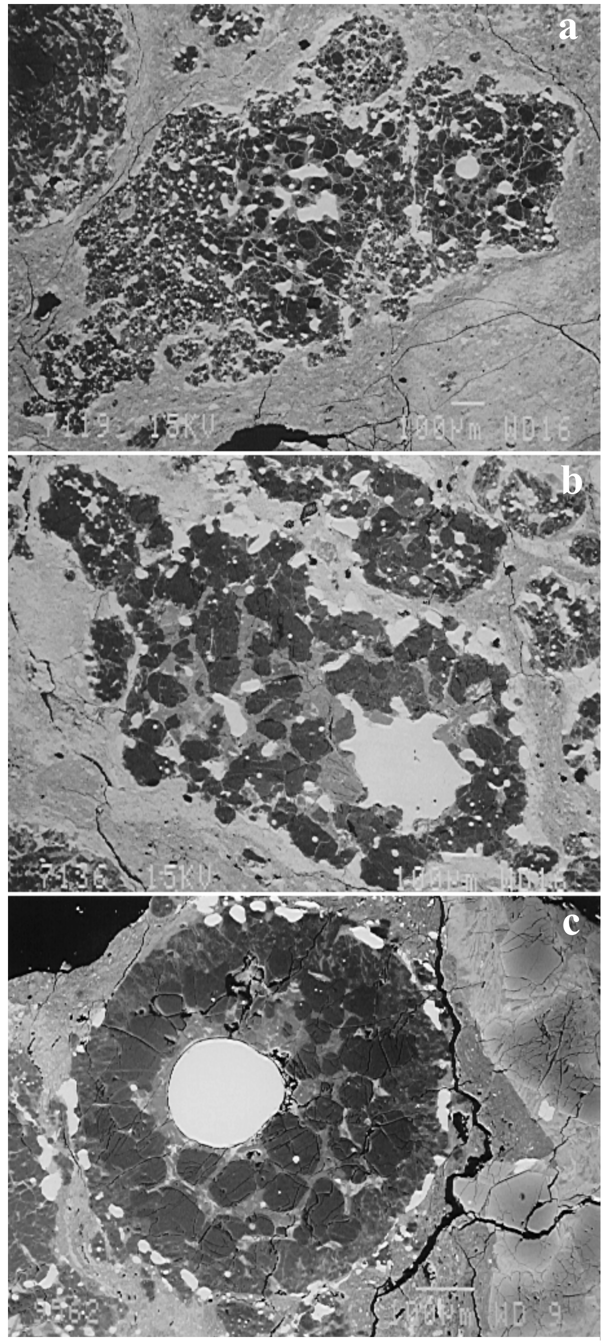

Figure 1: Three chondrules in Renazzo ranked from less melted (a) to more melted (c).

To allow a comparison between chondrules with various degrees of melting, we measured a convolution index (CVI) for each chondrule, defined as the ratio of the perimeter of the chondrule to that of a circle with the same area as that chondrule.

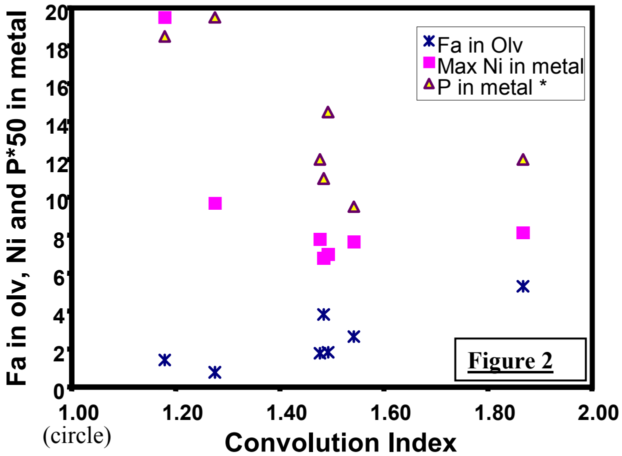

Figure 2 shows the Fa content of the olivine and the P and Ni content (wt%) of the metal, as a function of the convolution index. There is a correlation between these three variables and CVI: the closer the chondrule is to being a sphere, the lower the Fa content of its olivine, and the higher the Ni and P content of its internal metal.

Composition gradients: If enough metal remains within some of the most melted (circular) chondrules, a gradient can be seen in the composition of the metal. The grains shielded by the olivine (especially the small blebs enclosed within an olivine crystal) have the most Ni and P, whereas the grains close to the edge have less.

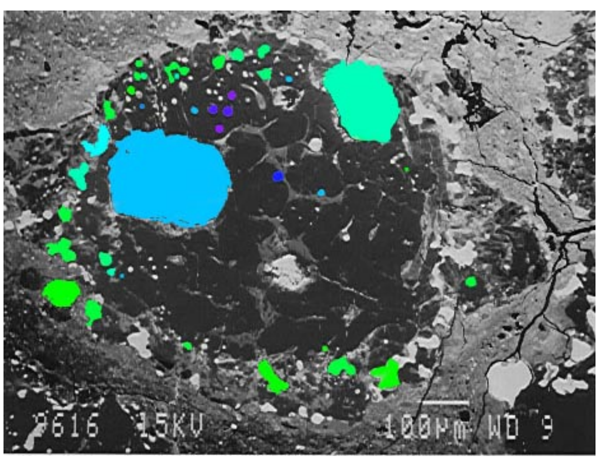

Figure 3 shows a chondrule (Fa = 0.7) in which Ni varies from 5.0 to 10.1 wt% and P from 0.2 to 1.8 wt%. Metal grains were color coded as a function of their Ni content ranging from yellowish green (low) to blue and purple (high).

Discussion: The simultaneous increase in Ni and P contents of the metal and decrease of Fa from the olivine as the chondrules get more extensively melted and spherical suggest evaporation of Fe during chondrule formation. This hypothesis is consistent with experimental observations [9] and with PGE data that show an enrichment of the refractory elements in the core grains of the most reduced chondrules [8,10]. As P in metal is more volatile than Fe, these results suggest that this process is controlled by oxidation and that exchange between metal and the surrounding silicate melt and crystals played a major role, presumably because of the need to transport to the surface the elements lost from the metal. As the composition of the metal thus seems to be controlled by Fe-loss, it is unclear that the metal can be a product of silicate reduction as advocated by [8]. The latter hypothesis also does not account for the presence of Ni, P and other siderophiles in the metal. Metal was perhaps present in the chondrule precursors, but our results are also consistent with formation of the metal by desulfidation of P-, Co-, Ni- and other siderophile-bearing condensate sulfides, as proposed by [11] for ordinary chondrite chondrules.

The observed composition gradients suggest that Fe re-condensed into the chondrule metal (and presumably into the glass), but that metal shielded by the olivine gained less Fe than the metal sitting around the edge of the chondrule. This hypothesis is consistent with the observation that volatile elements are enriched in the grains sitting on the chondrule margins [8, 10].

Conclusions: Chondrules in Renazzo show evidence for formation by aggregation of numerous droplets in a dust–rich environment. Extensive loss of Fe and other volatiles took place during the melting event and these elements subsequently re-condensed onto the chondrule surface and diffused inwards.

References: [1] Mason B. and Wiik H. B. (1962) *Amer. Mus. Novitates, 2106*. [2] Weisberg M. K. et al. (1993), *GCA 57*, 1567-1586. [3] Grossman L. and Olsen E. (1974), *GCA 38*, 173-187. [4] Lee M. S. et al. (1992), *GCA 56*, 2521-2533. [5] Zanda B. et al. (1993), *Meteoritics 28*, 466-467. [6] Zanda B. et al. (1994), Science 265, 1846-1849. [7] Meibom A. et al. (1999), *JGR-Planets 104*, 22053-22059. [8] Connolly H. C. Jr. et al. (2001), *GCA*, in press. [9] Cohen B. A. et al. (2000), *Nature 406*, 600-602. [10] Humayun M. et al. (2002), this conference. [11] Zanda B. et al. (1997), *LPI Tech. Rept #97-02, part 1*, 68-70.