A SEM AND NANOSIMS INVESTIGATION OF ORGANIC AGGREGATES IN THE CR CHONDRITES MILLER RANGE 07525 AND RENAZZO.

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Introduction: One of the unique characteristics of the Renazzo-type (CR) carbonaceous chondrites is the presence of a bulk nitrogen isotopic anomaly, with $\delta^{15}N$ ranging from 20 ‰ to 230 ‰, and up to a factor of three in hotspots [1–3]. Organic matter (OM) has been identified as the carrier of these ^{15}N-enrichments, but the origins of the anomalies are still a matter of debate. Proposed scenarios include low-temperature ion–molecule reactions in the cold interstellar medium or the outer protosolar nebula [e.g., 2], N_2 self-shielding [e.g., 4], or non-thermal nucleosynthesis induced by the young proto-Sun [5]. The OM in primitive Solar System materials may be surviving protosolar cloud material [6], or it might have been modified by by parent-body fluid reactions including ^{15}N-rich soluble molecules [7,8]. A previous study [9] reported two large (~8–10 µm) OM "veins" in the CRs Queen Alexandra Range (QUE) 99177 and Graves Nunataks (GRA) 95229 with unusually high ^{15}N-enrichments ($\delta^{15}N$ >500 ‰). Here, we report results on a search for similar aggregates in the CR2s Miller Range (MIL) 07525 and Renazzo.

Samples & Experimental: Secondary electron maps of polished thin sections of MIL 07525 and Renazzo were acquired with a LEO 1530 FE-SEM at the Max Planck Institute for Chemistry (MPIC). Organic aggregate candidates were identified by their dark contrast, and subsequently analyzed by EDS element mapping with an Oxford X-Max 80 SDD detector (acceleration voltage 10 kV). The C- and N-isotopic compositions of selected aggregates were measured by NanoSIMS at the MPIC by rastering a ~100 nm Cs^+ primary ion beam (~1 pA) over selected sample areas. Secondary ion images of $^{12,13}C^-$, $^{12}C^{14}N^-$, $^{12}C^{15}N^-$, and $^{28}Si^-$ were recorded in multi-collection mode.

Results & Discussion: *MIL 07525.* We identified 43 OM aggregates with complex morphologies and sizes of 2–20 µm. Element distribution maps showed that Ca is often associated with the organic material. Frequently, Ca-carbonates and/or -phosphates are present in the vicinity of or in direct contact with the aggregates. Similar observations were recently made for organic matter from the Zag meteorite [10]. In several other cases, Ca can also be detected *within* the OM, similar to the findings by [8] for organic grains from CR chondrites. Sometimes, Na or Cl are also present; this was also observed for OM in Renazzo, Murchison and Orgueil by [11]. The N-isotopic compositions of 28 OM aggregates were determined by NanoSIMS, with $\delta^{15}N$ ranging from ~20 to 900 ‰; 15 of these aggregates have ^{15}N-enrichments of 375–900 ‰. The $\delta^{15}N$ of OM in the vicinity of these aggregates ranges from ~10 to 260 ‰, in line with the compositions of bulk OM in CR chondrites [3].

Renazzo. We found 109 aggregates with various complex morphologies and sizes of 2–45 µm. Like in MIL 07525, Ca-carbonates and -phosphates are frequently associated with the OM aggregates, and Na or Cl are occasionally observed. Seven OM aggregates were measured by NanoSIMS. Three of the objects have irregular shapes, and display $\delta^{15}N$ from 215 to 410 ‰. A fourth aggregate consists of an assemblage of nanoglobular sub-units and has a $\delta^{15}N$ of ~700 ‰. Three aggregates show (multi-)globular morphologies, but contain several "layers" with heterogeneous N-distributions and differing ^{15}N-enrichments, partially separated by interstitial silicate material. Highly anomalous layers with $\delta^{15}N$ = 720–1,150 ‰ alternate with areas showing ^{15}N-enrichments of 80–265 ‰.

The presence of large organic assemblages with ^{15}N-enrichments higher than bulk CR N-anomalies emphasizes the heterogeneous nature of the organic material. Correlation of the organic aggregates with Ca-carbonates and -phosphates, as well as the presence of volatile elements like Na or Cl, strongly indicates fluid reactions that affected the OM. The layered (multi-)globular morphologies observed for three organic aggregates from Renazzo give strong support for OM formation/modification and the redistribution of ^{15}N-bearing molecules by (possibly episodic) fluid interactions on the respective meteorite parent bodies.

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