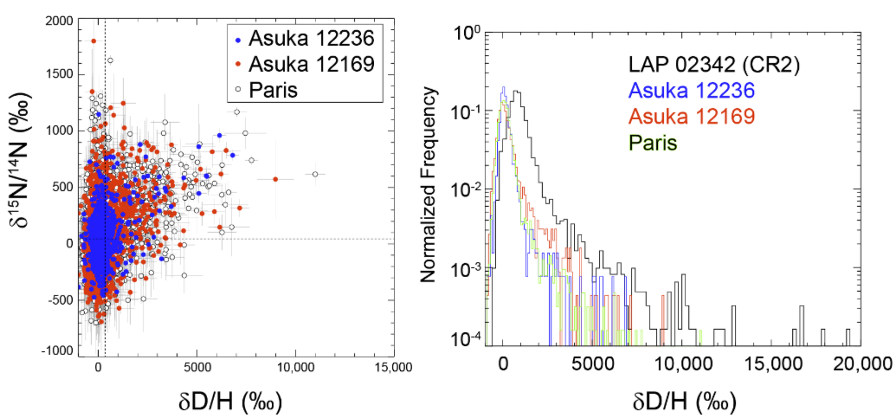
MICROSCALE H, C, AND N ISOTOPIC DISTRIBUTIONS IN THREE PRISTINE CM CHONDRITES.

L. R. Nittler[1*], C. M. O'D. Alexander[1], and M. J. Verdier-Paoletti[1,2], [1]Earth and Planets Laboratory, Carnegie Institution of Washington, 5241 Broad Branch Rd NW, Washington DC, 20015, USA (*lnittler@ciw.edu), [2] Muséum National d'Histoire Naturelle, Sorbonne University, UMR CNRS 7590, Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie, 75005, Paris, France.

Introduction: The major C carrier in primitive meteorites, insoluble organic matter (IOM), is known to be isotopically and chemically heterogeneous on sub-µm to whole-rock scales [1, 2]. The origin of IOM (i.e., whether it is a relic of the presolar molecular cloud or formed in the Solar System) is debated, a question that is complicated by the complex and poorly understood effects of parent-body alteration on its properties. The latter issue may be ameliorated by studying meteorites that show the least evidence for aqueous alteration and/or thermal metamorphism. The most primitive (e.g., the most D- and ^{15}N-rich) IOM is generally observed in the least-altered CR chondrites. Here, we report a NanoSIMS-based survey of the H, C, and N isotopic distributions measured in situ in three highly pristine CM chondrites: Paris, Asuka (A) 12236, and Asuka 12169. Recent work [3] has shown that the two Asuka meteorites are less altered than Paris, with abundant amino acids in A12236 [4] and very high presolar grain abundances in A12169 [5]. They thus allow a comparison with the least-altered members of other C chondrite groups.

Methods: We used a NanoSIMS 50L to analyze fine-grained matrix in polished sections of the three meteorites. Areas (15×15 µm or 20×20 µm) were first mapped for C and N isotopes (along with O, Si, and AlO signals) with a ~0.5-pA Cs^+ beam, followed by re-measurement for H, D, ^{12}C, and ^{12}CH, with a higher beam current (3-5 pA). Total integration time per image was ~1 hr for C-N, ~3 hr for H-D. Individual C-rich regions of interest (ROIs) were defined in the C-N images and, where possible, re-located and defined in the H-D images. However, due to stage shifts as well as sputtering /excavation effects, some ROIs were present in one set of images but not the other.

Results and Discussion: Total areas of 22,000, 3800, and 8800 µm^2 were mapped in Paris, A12236, and A12169, respectively. Some 18,000 C-rich ROIs were defined in total, with correlated H, C, and N isotopes for 12,500. Most are sub-µm, with many showing a nanoglobule appearance, but a few range up to 4 µm. The three meteorites show similar isotopic distributions (Fig A). Most ROIs have H and N isotopic compositions consistent within errors with average bulk values of δD~100-200‰, δ^{15}N~50-100 ‰ [6,7], but ~10% of them have resolvable ^{15}N and/or D enrichments or depletions ("hotspots/coldspots"), with δD up to 12,000‰ and δ^{15}N up to ~1800‰. A very small fraction of IOM ROIs (<2%) have anomalous C isotopes, typically 10-30% enrichments or depletions in ^{13}C; several presolar SiC grains and the first in-situ presolar Si_3N_4 grain were also identified. In general, the H, C, and N isotopes of hotspots and coldspots are not well-correlated (Fig. A). About ¼ are enriched in both D and ^{15}N with the rest being anomalous in one or the other isotope. ^{13}C-rich grains show a much wider range of N isotopes (δ^{15}N= -300 – +1700‰) than ^{13}C-poor grains (δ^{15}N= -400 – +500‰). One interesting grain has δ^{13}C~-400‰, δ^{15}N~-500‰, comparable to but more anomalous than a grain seen in CO3.0 DOM08006 [8]. Fig. B shows histograms of the C-rich ROI δD values for the three CMs as well as for CR2 LAP02342 [9]. Even in the most pristine, presolar grain-rich CM chondrite A12169, IOM is not as D- or ^{15}N-rich as seen in CRs. Either CMs accreted a distinct IOM from CRs or some very low level of thermal processing has altered the IOM isotopes without substantially affecting the presolar grain abundance or matrix mineralogy, as seen also in DOM08006 [8].



References: [1] Alexander C. M. O'D., et al. (2017) *Chemie der Erde, 77,* 227-256.[2] Busemann H., et al. (2006) *Science, 312,* 727–730. [3] Kimura M., et al. (2020) *Polar Science, 26,* 100565. [4] Glavin D. P., et al. (2020) *Meteoritics and Planetary Science, 55,* 1979–2006. [5] Nittler L. R., et al. (2020) *Meteoritics and Planetary Science, 56,* 260–276. [6] Nittler L. R., et al. (2020) *LPSC LI,* Abstract #2276. [7] Vacher L. G., et al. (2016) *The Astrophysical Journal, 827*. [8] Nittler L. R., et al. (2018) *Geochimica et Cosmochimica Acta, 226,* 107-131. [9] Nittler L. R., et al. (2019) *Nature Astronomy 3,* 659–666.