N AND C ISOTOPIC COMPOSITIONS OF AMPHIBOLE-BEARING R CHONDRITES: SPOOR OF INSOLUBLE ORGANIC MATTER (IOM)? A. H. Treiman,[1] A. B. Verchovsky[2], and M. M. Grady[2], [1]Lunar & Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058. <treiman-at-lpi.usra.edu>. [2]Planetary and Space Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK.

Introduction: The sources and characteristics of volatile constituents in the solar system are important for understanding its evolution and the emergence(s) of habitability [1-3]. A few R-chondrite meteorites are rich in water, LAP 04840 and MIL 11207 [4,5], and represent an unexpected possible reservoir of volatiles in the early solar system. Hydrogen in these meteorites is extremely heavy, δD ≈ +3660‰ and +2500‰ respectively [4,5], suggesting a source beyond those of planetary interiors and carbonaceous chondrite meteorites (CC) [1]. Potential sources for this D-rich R-chondrite water include comets [1,6], and IOM in ordinary chondrites (OC) [2,7]. The nitrogen isotope ratio provides a test of these possible sources of R-chondrite water: nearly all analyzed comets have very heavy N, $\delta^{15}N$ ≈ +1000‰ [3,6]; while IOM from OCs have $\delta^{15}N$ ≈ 0‰ [2,8].

To date, the literature contains nearly no data on H or on N in R chondrites [8]. The only H isotope analyses appear to be those of [4,5], and the sole analysis for N isotopes is in [9].

Methods: Fragments of LAP 04840 and MIL 11207, ~5 mg each, were selected from allocated samples, loaded into Pt foil, and analyzed by combustion for abundances and isotopic compositions of N and C in the FINESSE instrument at the OU [10]. Samples were heated in temperature steps of 100°C from 200°C to 1300 or 1400°C, and yields and isotopic compositions of N and C measured at each (Fig. 1). For LAP04840, results for C were compromised by a high abundance of sulfur; replicate runs on both samples are in the queue.

Results: Figure 1 shows the thermal release profiles (abundances and isotope ratios) for N and C from the amphibole-bearing R chondrites.

Nitrogen. The two R chondrites have significantly different release patterns for N. LAP04840 contains a total of ~17 ppm N, most of which is released between 200 and 600°C. The lowest-temperature release has $\delta^{15}N$ = -22‰, which goes up to a broad release (500-700°C) at $\delta^{15}N$ = +11‰; this range is consistent with decomposition of amphibole. At higher temperatures the $\delta^{15}N$ decreases to ~-45‰. MIL11207 contains a total of ~5 ppm N, most of which is released between 300-500°C. N released at 200°C is relatively heavy, +33‰; the bulk of N, released between 400-700°C, has $\delta^{15}N$ = +2‰; this range is consistent with decomposition of amphibole. At high temperatures $\delta^{15}N$ decreases to ~-20‰. These release patterns are quite different in detail (which could, in part, represent the abundances of N-bearing phases in the analyzed subsamples). However, $\delta^{15}N$ never exceeds +10‰ in release fractions above 200°C.

N isotopes have been analyzed for the amphibole-absent R chondrite PCA 91002 [9], which is rich in solar wind gases. Release steps above 600°C gave $\delta^{15}N$ ≈ -30‰, which is generally consistent with the light N released at high T from LAP 04840 and MIL 11207 (Fig. 1). Peroxide treatment removed most of the N, and the remainder had $\delta^{15}N$ ≈ -60‰. For comparison, solar wind has $\delta^{15}N$ = -407±7‰ [11].

Carbon. The two amphibole-bearing R chondrites have wildly different release patterns for carbon. MIL 11207 is rich in carbon, with a bulk abundance of 2600 ppm, and a range of $\delta^{13}C$ from -20 to -40‰. The strongest release is at 400-600°C, consistent with amphibole breakdown, at $\delta^{13}C$ ≈ -33‰. A second release peak, 800-900°C, gives $\delta^{13}C$ ≈ -30‰ which continues to the highest temperatures. Data for LAP04840 is

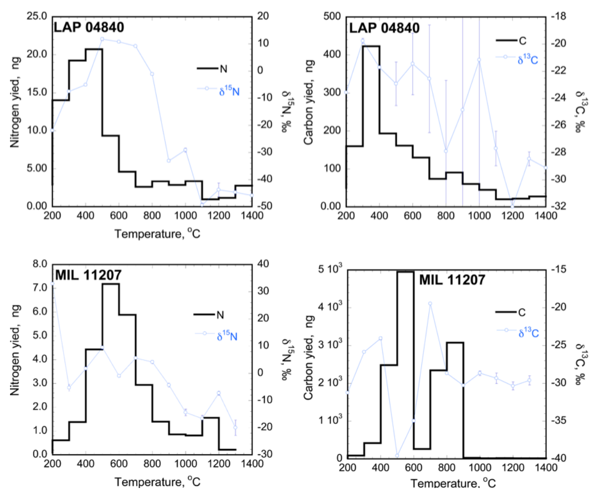

Fig. 1. Abundances and isotopic compositions of N and C in amphibole-bearing chondrites.

imprecise, because the sample contained significant sulfur. For it, $\delta^{13}C$ ranges between -20 and -30‰.

Interpretation: Although both amphibole-bearing R chondrites have very heavy hydrogen, they contain 'normal' nitrogen with bulk isotopic $\delta^{15}N$ = 0±20‰ (Fig. 2). Their N isotopic compositions (although the releases are complex in detail, Fig. 1), are fundamentally similar to those of most materials in the inner solar system (the Earth, Mars interior, and most chon-

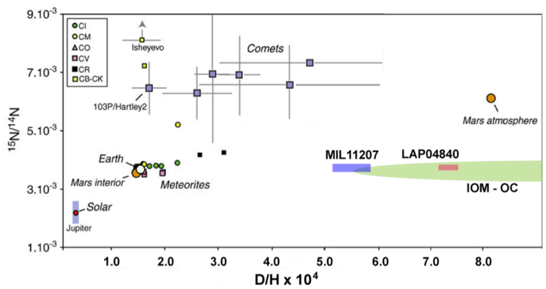

Figure 2. N and H isotope ratios in some solar system materials, after Figure 1 of [1]. Both amphibole-bearing R chondrites have N and H isotope ratios consistent with IOM in OC meteorites [7]. Their N is far lighter than that in most comets, and their H is far heavier than in the planets or in carbonaceous chondrites.

drite meteorites, except CR, CH, CB), Figure 2. This 'normal' N is unlike those of most comets, which have $\delta^{15}N \approx +1000‰$, Figure 2 [1]; the lowest measured comet value is from 73P/Schwassman-Wachman 3, which has $^{15}N/^{14}N \approx 4.5x10^{-3}$ ($\delta^{15}N \approx +230‰$) [6].

The $\delta^{13}C$ of carbon released from both amphibole-bearing R chondrites (at all temperature steps) is close to -2‰ – -30‰ (with complexities in detail). These values are consistent with terrestrial contamination, but are unlikely to represent only contamination because they extend to very high temperatures (Fig. 1). Carbon in the amphibole-bearing Rs is somewhat lighter than that of IOM in OC and heated CC (-5‰ – -25‰ [7]), but similar to that in low-grade CC (-15‰ – -30‰ [7]). There are no discernable contribution from heavy or very light carbon.

Implications: From an isotopic standpoint, the most likely source of water in the amphibole-bearing chondrites is oxidized IOM like that in OCs. However, the amount of IOM needed exceeds that in a typical OC, ~0.25% mass [7]. LAP04840 contains ~13% amphibole which has 2.0% H_2O [4], giving a bulk H abundance of 0.03% mass (ignoring H from phlogopite and apatite). OC IOM has H/C ≈ 0.3 atomic [7], for a H mass fraction of 0.025 or 2.5%. Thus, to form enough water to hydrate LAP04840 would require oxidation of at least 1 gram OC IOM per 100 gm meteorite. This is more IOM than in typical OCs [7], and likely to be more than in unmetamorphsed R chondrites, considering their high oxidation states [8,12], and the absence of reported graphite or other organic matter [8,13]. So, if the unmetamorphosed precursors of amphibole-bearing R chondrites contained IOM like the OCs, they must have accumulated H_2O from a larger volume of rock. In any case, derivation of the water from oxidation of IOM would have produced abundant CO_2, which must have been lost from the rock.

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