HELIUM AND NEON IN A STARDUST TRACK WALL.

R. O. Pepin[1], B. Marty[2], R. L. Palma[3,1], L. Zimmermann[2], D. J. Schlutter[1], P. G. Burnard[2], A. J. Westphal[4], C. J. Snead[4], Saša Bajt[5], R. H. Becker[1], J. E. Simones[3], [1]University of Minnesota, Minneapolis MN, USA, [2]Centre de Recherches Pétrographiques et Géochimiques, Vandoeuvre-lès-Nancy Cedex, France, [3]Minnesota State University, Mankato MN, USA, [4]Space Sciences Laboratory, University of California, Berkeley CA, USA, [5]Lawrence Livermore National Laboratory, Livermore CA, USA.

Introduction: We summarize data on light noble gas isotope ratios and concentrations, and on the identity of their likely carriers, recently obtained from a Wild 2 comet sample [1]. Materials analyzed in this study, mixtures of melted aerogel and small grains shed from the impacting particle, were extracted from the bulbous cavity wall of Track #41, Stardust aerogel cell C2044. Helium and Ne were measured independently by mass spectrometry at CRPG Nancy and Minnesota. Grain mineralogies and masses were determined using the synchrotron x-radiation source at Berkeley, and infrared analysis of a small section of track wall for organic matter was carried out at Lawrence Livermore.

Isotope Ratios: Gases were thermally released, from two samples (Thera-1 and Thera-2) at CRPG by single-step laser melting and from three (St1, St2, St3) at Minnesota by multi-step pyrolysis to ~1400°C. Neon compositions in the two samples with enough Ne for relatively precise measurement, one from each laboratory, lie within error (Fig. 1A) in the data field for Ne in "phase-Q", a minor macromolecular organic phase ubiquitous in chondritic and achondritic meteorites [2]. However He ratios (Fig. 2B) are about a factor 2 higher than He-Q [2], intermediate between He-Q – Jupiter [3] and an estimate for the early Sun following deuterium burning [4]. Both the Ne and He ratios are seen in Fig. 1 to be clearly distinct from those in the solar wind [5-7].

Gas Carriers: Helium and Ne were held very retentively in their host materials; temperatures above ~1250°C were required to release them in the Minnesota step-heating procedure. This points to gas siting in refractory carriers, consistent with X-ray absorption (Fe-XANES) identification of high-temperature FeNi metal, metal-sulphur, and metal-carbon minerals as the dominant components (~75% by mass) of the bulb-wall grains.

The Q-like Ne in Track #41 suggests the possibility that its host might be a refractory organic material

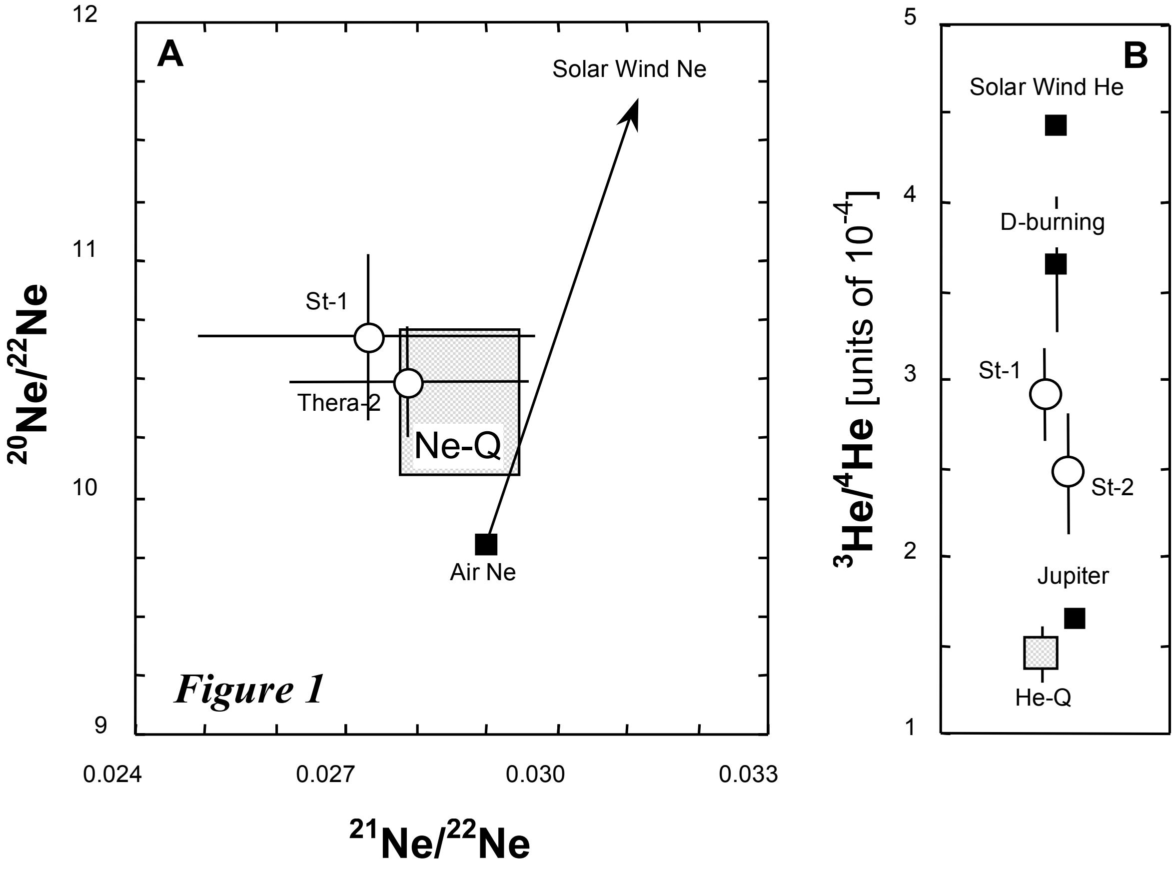

Figure 1

similar to the Ne-Q carrier in meteorites. Infrared spectroscopy (FTIR) measurements revealed no detectable organics above aerogel blank. However the IR search covered only a small fraction of the bulb wall and adjacent aerogel, and was not applied to the specific samples analyzed for noble gases, so the presence of heterogeneously distributed organics in the samples is not ruled out.

Gas Concentrations: The average measured gas abundances in the five samples were ~2 x 10^{-10} ccSTP for ^{4}He and ~3 x 10^{-11} ccSTP for ^{20}Ne. The average mass of track-wall grains in each sample, calculated from Fe masses measured by Fe fluorescence and the grain mineralogies determined by Fe-XANES, is ~ 0.25 ng assuming uniform grain distribution in the track wall —an assumption estimated to be uncertain by a factor 3 or so. It seems likely, although not proven, that these particles are the gas carriers. Resulting Ne concentrations in ccSTP/g are shown in Fig. 2. They are very high, comparable to those in IDPs [8] and lunar grains [9] loaded by solar wind ion irradiation, and far above estimates for solution [10,11] or adsorption [12] of gas-phase nebular Ne. Ne-Q concentrations in acid-resistant meteoritic residues are also much lower [2], although these are lower limits to the extent that the phase-Q carriers comprise only a fraction of the total residue masses.

Interpretations: The particle that carved Track #41 is a member of the large population of mineralogically igneous, refractory "rocklets" identified in the Stardust collection; their solar-like compositions point to origin in a high-temperature environment near the young Sun [13-16]. Results of the present study appear to characterize this environment in two additional respects. One is the observation of high concentrations of He and Ne that, of known gas acquisition mechanisms, only ion irradiation seems capable of explaining (Fig. 2). Another is the indication in Fig. 1 that, unlike the case for the IDPs and lunar grains, the source reservoir for the cometary He and Ne was not isotopically solar, contrary to what might have been expected for a gas reservoir so close to the early Sun. Collectively the evidence suggests that the Stardust grains and the carbonaceous carrier now found in meteorites sampled the same Q-like reservoir, the grains by ion implantation in an energetic environment near the young evolving Sun.

Although the possibility of a carbonaceous carrier for the noble gases remains open, the high concentrations found here are unlikely to be significantly lower, no matter what the carrier actually is. This issue will be addressed in a second suite of Track #41 samples now in preparation, in which an FTIR assay of organic abundances will be made directly.

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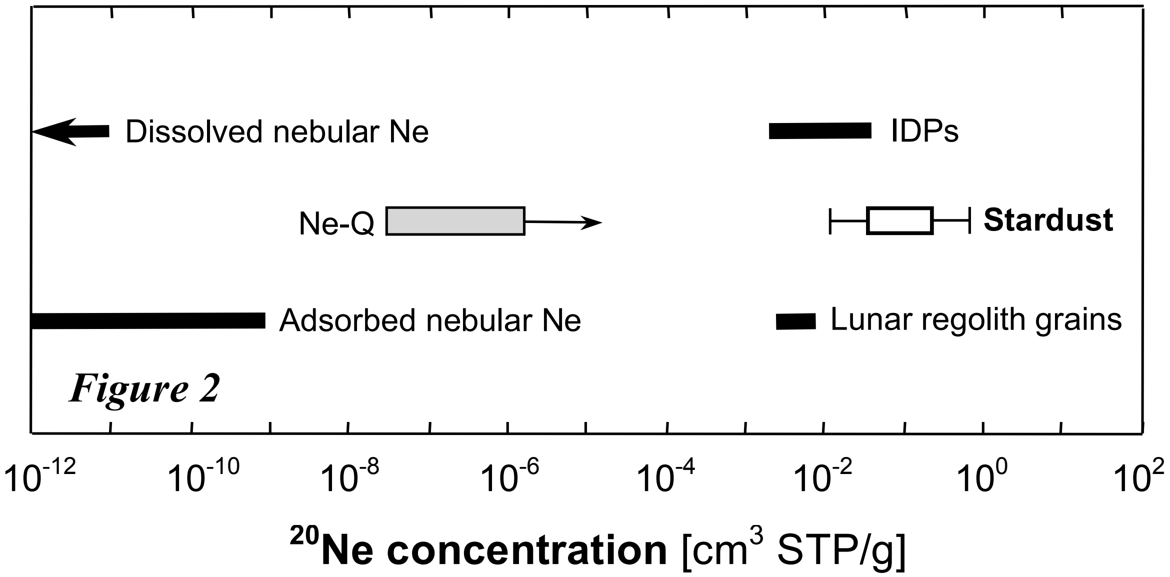

Figure 2