

## EXPERIMENTAL NOBLE GAS TRAPPING IN ORGANIC RESIDUES – ON THE WAY TO UNDERSTANDING “PHASE Q”?

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**Introduction:** Primitive chondrites commonly contain primordial noble gases that were trapped in the early solar system or presolar environments. Most of the gases reside in carrier phases in the carbonaceous residue that remains after dissolving a bulk meteorite in HF and HCl [1]. The residue is dominated by “phase Q”, which releases large amounts of Ar, Kr, and Xe (“Q-gases”) and minor He and Ne upon oxidation. High D/H ratios compared to solar system ratios found in the carbonaceous matter record a low-temperature formation with exposure to irradiation [2]. The widespread occurrence of phase Q in several groups of primitive and differentiated meteorites indicates that Q-gases were widely distributed in an extended, homogeneously-mixed reservoir [3] similar to presolar grains [4].

Deciphering the formation conditions of phase Q will add to our understanding of how the solar system formed, how volatiles and organic matter were mixed and incorporated into the first forming solids and, ultimately, delivered to Earth. Here we present first results of noble gas trapping experiments in organic residues that aim to reproduce the gas release characteristics and elemental and isotopic compositions of phase Q [e.g., 5].

**Preparation of the organic residues:** The organic residues were prepared at the Astrochemistry Laboratory of NASA Ames Research Center. Gas starting mixtures containing noble gases and other reactant molecules (Table 1) were mixed in a vacuum apparatus and admitted to the vacuum reaction chamber. A cold finger covered with aluminum foil was cooled to 15 K to freeze out gases and form ices. Irradiation by UV light for up to 48.5 hours induced the formation of reactive radicals. Upon subsequent warming to room temperature in static vacuum the radicals combine to more complex organics [6], the organic residues we finally analyze.

**Sample material:** Three samples of the organic residues have been analyzed for their noble gas content so far. The components for the starting gas mixtures were water, methanol, ammonia, krypton, and xenon (both noble gas reservoirs with terrestrial isotopic composition) and for two samples naphthalene (C<sub>10</sub>H<sub>8</sub>) was added (Table 1).

Table 1: Starting gas mixtures for the noble gas trapping experiments in the organic residues and duration of UV irradiation.

Sample	Starting gas mixture	Relative proportions of gas components	Duration of UV irradiation
1A, 1B	H <sub>2</sub> O:CH <sub>3</sub> OH:NH <sub>3</sub> :Kr:Xe	20:5:1:0.002:0.002	48 h, 44 h
2	H <sub>2</sub> O:CH <sub>3</sub> OH:NH <sub>3</sub> :C <sub>10</sub> H <sub>8</sub> :Kr:Xe	20:5:1:0.073:0.002:0.002	48.5 h
3A, 3B	H <sub>2</sub> O:CH <sub>3</sub> OH:NH <sub>3</sub> :C <sub>10</sub> H <sub>8</sub> :Kr:Xe	20:5:1:0.05:0.005:0.005	43.5 h

The organic residues exhibited compact, droplet-like morphology when prepared without naphthalene, and feathery, snow flake-like morphology when naphthalene was added. The Al foil with sample 3 was cut. One part was measured directly (3A), from another part (3B) the sample was removed using ethanol in order to weigh it and test for gas loss upon removal. The weight of sample 3B is 0.020±0.015 mg. Samples 1A to 2 were measured on the Al foil.

**Noble gas analyses:** The organic residues were wrapped in further Al foil and transferred into the UHV sample chamber of the oven. After degassing at 80 °C for several days, the noble gases were extracted by fusion in one heating step to ~1750 °C for 30 minutes. The released noble gases were admitted to the gas separation line and analyzed in three batches containing He-Ne, Ar, Kr-Xe [cf. 7]. Measurements were carried out in static vacuum with a non-commercial single-collector magnetic-sector noble gas mass spectrometer equipped with a Baur-Signer ion source.

**Results:** The measured gas amounts of Kr and Xe were comparably low due to the tiny sample amounts available. Nevertheless, the Kr and Xe contents in samples 1A, 1B, and 2 were clearly above blank level and trapping of both noble gases can be confirmed. Gas amounts of samples 3A and 3B were due to the very tiny split sample amounts not clearly resolvable from blank level. Gas loss due to sample removal by ethanol could hence not be observed.

The measured elemental ratios of <sup>84</sup>Kr/<sup>132</sup>Xe range from 0.3 to 1.9 and are thus distinct from the starting atmospheric <sup>84</sup>Kr/<sup>132</sup>Xe ratio. On average, the trapped <sup>84</sup>Kr/<sup>132</sup>Xe ratios of the analyzed organic residues fall in the range of phase Q around 0.8 [3]. The measured isotopic ratios of Kr and Xe are within error equal to the atmospheric noble gas composition but no isotopic fractionation by noble gas trapping can be observed in these small gas amounts.

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