NOBLE GASES IN INSOLUBLE ORGANIC MATTER IN THE VERY PRIMITIVE METEORITES BELLS, EET 92042 AND GRO 95577. H. Busemann[1,2], C. M. O'D. Alexander[2], L. R. Nittler[2], R. Wieler[3], [1]Planetary & Space Science Research Institute, The Open University, Milton Keynes, MK7 6AA, UK, h.busemann@open.ac.uk, [2]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington DC, USA, [3]Isotope Geology, Department of Earth Sciences, ETH Zürich, Switzerland.

Introduction: Most of the primordially trapped heavy and some of the light noble gases in primitive meteorites reside in an elusive carrier named "phase Q" [1-3]. A few of its properties are known: Phase Q is carbonaceous, oxidizable with weak acid vapour and almost mass-less, possibly indicating an adsorption site, rather than physically separable matter. However, physical methods succeeded in enriching phase Q in low-density organic matter [4], suggesting a discrete carrier. Moreover, high release temperatures >1000°C may contradict adsorptive trapping. It has been found recently that ~60% of the trapped Xe in Orgueil insoluble organic matter (IOM) is released by treatment with the organic "swelling agent" pyridine C_5H_5N [5].

We aim to better characterize the Q-gas carrier, and examined chondritic IOM extracted from Bells, GRO 95577, and EET 92042. Stable isotope and Raman spectroscopic studies indicate that these meteorites contain among the most primitive IOM of all chondrites [6-8]. Here, we discuss the noble gases in untreated and pyridine-treated IOM.

Our results show that phase Q in the analyzed meteorites is not significantly attacked by pyridine. This is in contrast to the finding on Orgueil IOM [5]. Furthermore, the IOM in CR chondrites does not indicate high temperature alteration in the nebula, and is similar to IOM in other primitive meteorite classes [6-8].

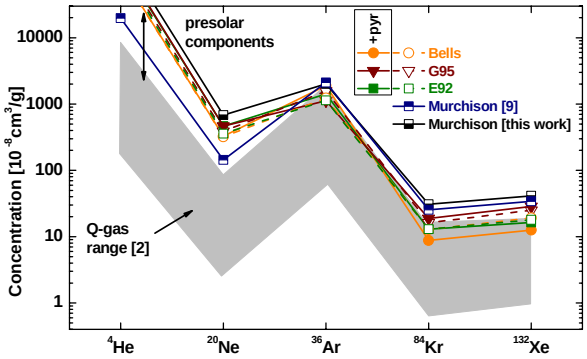

Fig. 1: Gas concentrations in E92, G95, Bells and Murchison IOM before and after pyridine treatment.

Experimental: Noble gases in ~1 mg aliquots of IOM prepared with Cs-HF [7] from Murchison (CM2), Bells (anomalous CM), EET 92042 ("E92", CR2) and GRO 95577 ("G95", CR1) were analyzed at ETH Zürich [2]. Further aliquots of Bells, E92, and G95 were placed prior to analysis for ~2h at room temperature into pyridine. Noble gases were extracted by pyrolysis at ~500°C and 1800°C. He/Ne, Ar, and Kr/Xe fractions were measured separately. Many 500°C steps, including most Ar-Xe fractions, could not be analyzed due to abundant reactive gases. Hence, most concentrations presented are lower limits. He/Ne concentrations will be too low by ~10%, Kr/Xe might be underestimated by a factor of two. These estimates are based on the completed analysis of G95, and literature data on Murchison residues [9]. Another Murchison IOM sample was analyzed with the online etch facility [2] to directly analyze the gas released with pyridine, but no noble gases were detected.

All data were corrected for blanks (<5 % for all isotopes, except for ^{40}Ar), incomplete noble gas separation, and instrumental mass fractionation.

Secondary ion mass spectrometry and Raman spectroscopy on IOM from the same meteorites, before and after pyridine treatment, will be discussed separately.

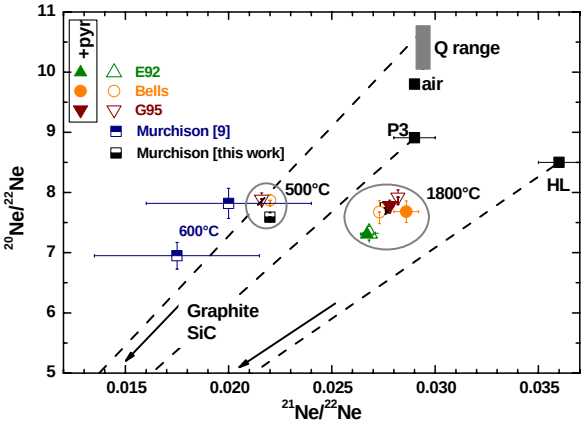

Fig. 2: The Ne isotopic compositions in IOM of E92, G95, Bells and Murchison are very similar, indicating a homogeneous mixture of presolar components.

Results: *Element concentrations.* All residues contain a mixture of noble gases from presolar grains (dominating the released He and Ne) and phase Q (the main fractions of Ar-Xe). Concentrations (Fig. 1) are compared with pure Q-gas concentrations released by CSSE (grey area [2]) and the average composition of Murchison residues produced with HF/HCl [9]. The concentrations are remarkably similar, although IOM can show significant heterogeneity [9], and the missing

concentrations in the 500°C steps may cause additional variation. He and Ne plot above the Q area, due to large contributions from presolar diamonds, but also above previous Murchison data, indicating more abundant presolar components in the present residues. Kr and Xe concentrations are comparable with the Q-gas range. In spite of the missing 500°C contributions, the concentrations plot at the upper end of the Q-gas range. Kr and Xe from presolar grains can be neglected here. The Xe isotopic compositions (see below) show that the released gas is mainly Q-gas.

Elemental ratios. Due to large differences in the demineralization yields, noble gas concentrations in residues alone cannot unambiguously be used to determine the degree of metamorphism experienced by IOM, although severe thermal alteration will certainly lower the gas concentrations [2]. Elemental ratios give additional clues. The Ar/Xe and Kr/Xe ratios in all residues (not shown here) plot very close to those found in CI, CM and the most primitive LL chondrites (see Fig. 8 in [2]), implying that the original IOM in all these classes was similar.

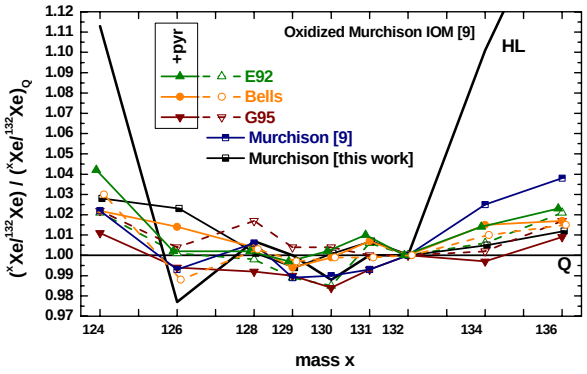

Fig. 3: Xe isotopic compositions in IOM normalized to Xe-Q [2]. Oxidized Murchison data are dominated by Xe-HL [9]. All samples, including the pyridine-treated ones, show a composition typical for residues, consisting of Xe-Q, Xe-HL and other presolar Xe.

Isotopes. The He isotopic compositions of all except for two steps are in the small range between $^3He/^4He$ = 1.30 and 1.37 × 10^{-4}, proving the presence of abundant He from presolar diamonds. The slightly higher values (1.47 and 1.77 × 10^{-4}) in the 500°C steps of Murchison and Bells indicate small additions of cosmogenic He. The Ne isotopes (Fig. 2) show the expected mixture of Ne from presolar SiC and graphite (essentially pure ^{22}Ne, see arrows), Ne from presolar diamonds ("HL", "P3" [3,10]), and –in this case– probably neglible Ne-Q [2]. All 500°C steps show almost identical Ne compositions. Murchison IOM in low temperature steps [9] shows the same trend. The Xe isotopic compositions in all steps (Fig. 3) indicate Q-Xe compositions plus variable but small amounts of presolar Xe-HL and further presolar components.

Pyridine. Noble gas abundances in samples with and without pyridine treatment are similar. Apart from variations that are most likely due to sample inhomogeneity and unknown portions in the 500°C steps, concentrations and isotopic ratios are essentially the same. Significant loss of Q-gas due to pyridine [5] would be visible in lower Ar-Xe concentrations (Fig. 1) and – perhaps more clearly– Xe isotopic compositions (Fig. 3) that would show typical Xe-HL dominated "w-shaped" patterns. The online "etch" experiment with Murchison IOM did not release any gas above the blank even after 15h of exposure to pyridine vapour.

Conclusions: (i) In contrast to Orgueil [5], pyridine appears to have no significant effect on the noble gas contents of IOM in the CRs E92 and G95 and the CMs Bells and Murchison. This may support the view of two noble gas carriers [2, 5, 11]. Both Q- and HL-gases from presolar diamonds were unaffected, although both components were suggested to be partially attacked [5].

(ii) Noble gases in Murchison IOM produced with Cs-HF [7] are essentially identical in isotopic and elemental compositions to those in IOM produced with the Chicago HF/HCl recipe [1,9].

(iii) Noble gases in E92, G95, Bells and Murchison are very similar. Ar, Kr and Xe isotopic and relative element abundances demonstrate the presence of phase Q and presolar grains in similar proportions. Variations due to heating in the nebula as suggested to explain low noble gas abundances in CR chondrites [12] are not visible. The "normal" noble gas content in CR chondritic IOM agrees with the finding of relatively high SiC abundances in the same class [13]. High-resolution stepwise heating and further online release experiments on the noble gases in CR chondrite IOM will be performed to finally clarify this issue.

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