PRIMORDIAL NOBLE GASES IN "PHASE Q" FROM THE CV3 CHONDRITE VIGARANO STUDIED BY CLOSED-SYSTEM STEP ETCHING (CSSE).

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Introduction: Primitive chondrites contain primordial noble gas components that were incorporated in the early solar system or presolar environments. Most of these gases reside in carrier phases found in a carbonaceous residue that remains after dissolution of the bulk meteorite using HF and HCl [1]. Oxidation of the residue releases a major noble gas component that is contained in a small fraction called "phase Q" [1]. Phase Q hosts most Ar, Kr, and Xe and minor amounts of He and Ne with characteristic isotopic signatures ("Q-gases") [1,2]. Oxidation of presolar grains present in the residue often contributes other primordial (e.g., Ne-HL [3], Ne-E [2]) and cosmogenic components.

The closed-system step etching (CSSE) technique developed at ETH Zürich [4,5] allows to measure all Q-gases including the minor He-Q and Ne-Q with sufficient precision and separate them from other noble gas components. Residues from several meteorite classes have been analyzed by CSSE [2,5,6] including the oxidized CV chondrites Allende and Grosnaja. Here we present the first results for a residue from the reduced CV3 chondrite subgroup.

Material: Vigarano has a cosmic-ray exposure age of 5.2 to 5.9 Ma [7,8]. With a mass of ~15 kg Vigarano represents the only fall of a reduced CV3 chondrite. A carbonaceous HF/HCl-resistant residue containing large amounts of phase Q was separated from the bulk meteorite [2] following the "Chicago method" [e.g., 9,10]. Relict accessory phases are presolar grains as well as minor amounts of resistant minerals including, e.g., chromite, spinel, corundum, metal sulfides, and macromolecular organic carbon (kerogen) [e. g., 1,10,11].

Method: The CSSE experiment was carried out on 7 mg residue, etched online using concentrated HNO_3. Seventeen etch steps of increasingly harsher etching conditions were carried out. Etch durations ranged from 15 min to 288 h and temperatures from 20 to 100 °C. Noble gases from each etch step were admitted directly to the gas separation line. Measurements were carried out in static vacuum on a non-commercial single-collector magnetic-sector noble gas mass spectrometer equipped with a Baur-Signer ion source [3].

Results and discussion: Phase Q released the noble gases in largely constant relative proportions over the whole run. Q-gas release ceased after 14 etch steps. Elemental and, with the exception of $^{3}He/^{4}He$, isotopic ratios of the Q-gases agree with earlier Q-gas measurements [e.g., 2]. One intermediate step shows some evidence for Ne-E and might indicate marginal opening of minor presolar graphite, which is weakly susceptible to attack by nitric acid [2,6]. Excesses in ^{129}Xe indicate trapping of radiogenic ^{129}Xe from ^{129}I decay. During the last three steps 15 to 17, each lasting for ~150 h at 100 °C, large amounts of a compositionally distinct component dominated by He and Ne were released (20 % of total ^{3}He and ^{21}Ne, respectively). The He and Ne isotopic ratios indicate opening of a cosmogenic carrier phase that contains some radiogenic ^{4}He as well. Since cosmogenic production of ^{21}Ne from C is impossible, opening of another phase, possibly presolar grains or chromite, is indicated.

Elemental ratios of the total light noble gases He-Ar released from Vigarano phase Q follow the positive correlation of $(^{4}He/^{36}Ar)_Q$ and $(^{20}Ne/^{36}Ar)_Q$ observed for CM, oxidized CV, CO, and ordinary chondrites as analyzed by CSSE so far; the least thermally altered CM chondrites show the highest ratios [2,12]. Vigarano (CV3red) clusters with Grosnaja and Allende (both CV3ox) at lower ratios than the CM chondrites. Thermal processing is also reflected by the elemental ratios of single etch steps of Vigarano that only show low $^{4}He/^{36}Ar$ but lack the high ratios found in the early steps, e.g., of Cold Bokkeveld (CM2) [2].

Elemental ratios of the total heavy noble gases Kr-Xe released from Vigarano also follow the correlation of $(^{36}Ar/^{132}Xe)_Q$ and $(^{84}Kr/^{132}Xe)_Q$, which reflects the degree of aqueous alteration on the parent body for several CM, oxidized CV, CO, and ordinary chondrites [2]. The reduced CV3 chondrite Vigarano shows lower elemental ratios when compared to the oxidized CV3 chondrites Grosnaja and Allende in accordance with the higher degree of hydrous alteration experienced for reduced CV3 chondrites [2,13].

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