Q-LIKE NE HOSTED BY WATER-SUSCEPTIBLE PHASE IN PRIMITIVE CR CHONDRITE: A POSSIBLE LINK TO COMETARY MATERIALS.

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Introduction: Previous studies of noble gases in primitive meteorites have focused primarily on acid-resistant phases that contain most of the noble gases in the primitive meteorites. However, a recent study reported that H_2O treatment of the very primitive CR chondrite Miller Range (MIL) 090657 released surprisingly large amounts of He and Ne with isotopic composition of Q-Ne [1,2]. To identify the host phase of the Q-like Ne, we performed (1) stepwise heating noble gas analysis of MIL 090657 and (2) hydrothermal treatment of MIL 090657.

Methods: MIL 090657 was gently crushed into small grains (a few hundred μm in diameter) and separated into two fractions weighing 42 mg and 71 mg. The latter was hydrothermally treated for 20 days at 150 ℃ with 2 ml deionized water in a Teflon pressurized vessel (50 cm^3 in internal volume). The nanoscale petrographic and mineralogical characteristics of the treated and untreated MIL 090657 matrices were analyzed by transmission electron microscopy (TEM) at Tohoku University. The He, Ne, Ar, Kr, and Xe isotopic compositions of MIL 090657 and hydrothermally treated MIL 090657 were measured by the modified-VG5400/MS-III mass spectrometer at Korea Polar Research Institute. The noble gases were extracted by stepwise pyrolysis in the temperature range from 400 ℃ to 1800 ℃ with 200 ℃ intervals. The details of the TEM analysis and noble gas analysis are described in [3].

Results and discussion: We found amorphous silicate grains, a few hundred nm in diameter, containing sulfide nanograins in the MIL 090657 matrix. The texture resembles GEMS (glass with embedded glass and sulfides), which has been found in chondritic porous interplanetary dust particles [e.g., 4]. The presence of GEMS-like grains supports primitive characteristics of MIL 090657 since such GEMS-like grains are highly susceptible to aqueous alteration and have only been found in very primitive carbonaceous chondrites [e.g., 5,6]. The noble gas analysis revealed that large amounts of He and Ne in MIL 090657 were released at the 400 and 600 ℃ steps (3.0×10^{-5} and 1.5×10^{-5} cm^3STP/g for ^{4}He, 1.4×10^{-7} and 5.8×10^{-8} cm^3STP for ^{20}Ne, respectively), and the Ne isotopic composition of the 400 ℃ fraction ($^{20}Ne/^{22}Ne = 10.12$, $^{21}Ne/^{22}Ne = 0.047$) was close to the Q-Ne [7].

The GEMS-like amorphous silicates were not observed in the matrix of the hydrothermally treated MIL 090657, while phyllosilicates were commonly present, suggesting the alteration of the amorphous silicates during the treatment. The amounts of ^{4}He and ^{20}Ne released at the 400 ℃ and 600 ℃ steps for the treated MIL 090657 (1.4×10^{-6} and 3.0×10^{-6} cm^3STP/g for ^{4}He, 1.5×10^{-9} and 1.7×10^{-9} cm^3STP for ^{20}Ne, respectively) are much less than the untreated sample. The $^{20}Ne/^{132}Xe_{corr}$ ($^{132}Xe_{corr}$ is air-corrected ^{132}Xe) ratio of the treated MIL 090657 (44.6 ± 4.4) is smaller than the untreated sample (73.7 ± 6.2). These results indicate that the primitive CR chondrite contains a noble gas component with some unique properties of (1) Q-like Ne isotopic composition; (2) higher $^{20}Ne/^{132}Xe$ ratio than Q (3.2 ± 0.5; [7]); (3) low release temperature (<400―600 ℃); (4) water-susceptible host materials.

It has been reported that some cometary dust particles and cluster IDPs (interplanetary dust particles) contain highly concentrated Ne (10^{-1}―10^{-2} cm^3STP/g) with isotopic compositions of Q-Ne [e.g., 8,9]. In particular, a Ca- and Al-rich amorphous silicate IDP named "Manchanito" released isotopically Q-like Ne at 400―600 ℃. The properties of Manchanito Ne are consistent with the Q-like Ne in MIL 090657, suggesting that the Q-like Ne-rich noble gas component is hosted by Manchanito-like amorphous silicates. Since the Manchanito IDP probably originates in a comet [9], comets and CR chondrites may share similar materials hosting Q-like Ne. This idea is supported by the recent finding of an anomalous carbon-rich clast, probably a cometary material, in a CR chondrite [10]. The presence of the Q-like Ne-rich materials in the primitive CR chondrite may reflect the formation of the CR chondrites at a greater heliocentric distance (i.e., closer to the comet forming region) than the other chondrites [e.g., 11,12].

References: [1] Krietsch D. et al. (2019) *82nd Meteoritical Society Meeting*, Abstract #6296. [2] Krietsch D. (2020) Doctoral thesis, ETH Zurich. [3] Obase T. et al. (2021) *Geochimica et Cosmochimica Acta* 312:75–105. [4] Bradley J. P. (1994) *Science* 265:925–929. [5] Leroux H. et al. (2015) *Geochimica et Cosmochimica Acta* 170:471–494. [6] Matsumoto M. et al. (2019) *Science Advances* 5:eaax5078. [7] Busemann H. et al. (2000) *Meteoritics & Planetary Science* 35:949–973. [8] Marty B. (2008) *Science* 319:75–78. [9] Ogliore R. C. et al. (2020) *Geochimica et Cosmochimica Acta* 271:116–131. [10] Nittler L. R. (2019) Nature Astronomy 3:659–666. [11] Kooten et al. (2016) *Proceedings of the National Academy of Sciences* 113:2011–2016. [12] Budde G. et al. (2018) *Geochimica et Cosmochimica Acta* 222:284–304.