NEW INSIGHTS ON MARTIAN ATMOSPHERIC NEON FROM MARTIAN METEORITE, DHOFAR 378. J. PARK[1*] and K. NAGAO[1], [1]Laboratory for Earthquake Chemistry, Graduate School of Science, University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. *Current address: ARES, Code KR, NASA Johnson Space Center, 2101 NASA Parkway, Houston, Texas 77058, USA. Jisun.park1@jsc.nasa.gov

Introduction: Martian space probe, Viking landers could not measure Ne isotopic ratios, but only had the concentration of Ne as 2.5 ppm (error +3.5, -1.5) in Martian atmosphere [1]. After that, there have been many efforts to determine Ne isotopic composition of Martian atmosphere, by examining the Martian atmospheric gases trapped in impact glasses of the EET 79001 and other shergottites [2-6]. The suggested $^{20}Ne/^{22}Ne$ ratios of Martian atmosphere are various from ~7.0 to 10.6, assuming the trapped $^{21}Ne/^{22}Ne$ ratio of 0.028 - 0.03. For example, Pepin [5] suggested the Martian atmospheric $^{20}Ne/^{22}Ne$ ratio of 10.1±0.7, compromising two different values 10.6±0.6 [4] and 9.6±0.6 [3]. Afterward, Garrison and Bogard [6] inferred Ne composition of Martian atmosphere as a value of ~7.0 for $^{20}Ne/^{22}Ne$ ratio, with $^{21}Ne/^{22}Ne$ ratio of 0.029 from the extrapolation of Y-793605, while other data for shergottites seemed to be scattered between 7~10 in $^{20}Ne/^{22}Ne$ ratios. Even though Martian atmospheric Ar, Kr, and Xe have been fairly constrained, the composition of atmospheric Ne is poorly determined, because of predominant cosmogenic and terrestrial Ne components in Martian meteorites.

Accurate determination of $^{20}Ne/^{22}Ne$ and $^{21}Ne/^{22}Ne$ ratios of Martian atmosphere is essential to clarify the Martian atmospheric history of volatile element degassing and subsequent evolution, because the ratios will constrain the origin of Ne, degree of degassing from interior, degree of atmospheric loss to space, and contribution of spallogenic Ne to atmosphere.

Here we present a new data on $^{20}Ne/^{22}Ne$ ratio of Martian atmosphere inferred from the noble gas data obtained from Dhofar 378 shergottite (hereafter DHO 378). The full data set of noble gas concentrations and isotopic ratios of DHO 378 had been reported by Park [7].

Experimental Method: The DHO 378 shergottite is a single stone, which has no pairing meteorite. It has transparent plagioclase glass (47 vol. %) and black-colored clinopyroxenes (49 vol. %) with minor accessory minerals [8, 9]. The plagioclase glassy part has been recrystallized, indicating that DHO 378 must have experienced very strong shock on Mars, followed by slow cooling to allow recrystallization of plagioclase [10].

Grains taken from the DHO 378 were washed in diluted-HNO_3-solution with an ultrasonic bath to avoid terrestrial materials and weathering products adhering on the sample surfaces. After the treatment, microscopic observation shows clean glassy surface and numerous cavities inside the samples, suggesting volatile rich bubbles of Martian origin. Noble gases were analyzed using a mass spectrometer (modified-VG5400/MS-II) at the Laboratory for Earthquake Chemistry, University of Tokyo. In the series of noble analyses of DHO 378, stepwise heating on pyroxene-rich separates (0.1070g) showed high concentrations and low $^{20}Ne/^{22}Ne$ ratios of trapped Ne, which seems to be closely related to the Martian atmospheric Ne. It is noteworthy that trapped Ne was highly enriched in DHO 378 compared to those of other shergottites. The trapped ^{20}Ne is not enriched in the plagioclase glass phase but in pyroxene-rich phase of this meteorite.

Results and Discussion: Here we present a new data on $^{20}Ne/^{22}Ne$ ratio of Martian atmosphere inferred from the noble gas data obtained from DHO 378. Three data points of pyroxene-part in DHO 378 (Fig. 1) for the temperature fractions of 600, 800 and 1000°C, which have the Ne-enrichments, show a perfect linear correlation. This means a mixing of two Ne components of different origins; one is cosmic-ray produced Ne and another trapped (Martian atmospheric) Ne. Other three points especially for the lowest (400°C) and the highest (1750°C) temperature fractions are plotted above the linear array, which would be caused by additional component(s) probably from terrestrial Ne contamination. Extrapolation of the line fitted to the 600, 800 and 1000°C data points to $^{21}Ne/^{22}Ne$ ratio of ~0.03 (typical cosmogenic-free solar system Ne) gives the trapped $^{20}Ne/^{22}Ne$ ratio of 7.3 ± 0.1. Almost the same value of ~7.0 has been proposed as the Martian atmospheric Ne based on the Ne data for Y 793605 and EET 79001 glasses by Garrison and Bogard [6]. The Ne isotopic ratios for Y 793605 glass by them are also plotted in Fig. 1, where the data point for 350°C is also plotted on the line within experimental errors. The good agreement supports the $^{20}Ne/^{22}Ne$ ratio of 7.3 ± 0.1 for the Martian atmosphere. The value, however, does not agree with the higher values around 10 by Swindle *et al.* [4] and Wiens *et al.* [3].

Origin of noble gases in Earth's atmosphere has been discussed in Ozima & Podosek [11, 12] and Ozima *et al.* [13]. They showed a linear trend for the abundance ratios among ^{20}Ne, ^{36}Ar, ^{84}Kr and ^{130}Xe in the plot of $log(r_{jk}/R_{jk})$ versus $\sqrt{m_i / m_j}$ - $\sqrt{m_i / m_k}$, deduced from mass-dependent Rayleigh fractionation

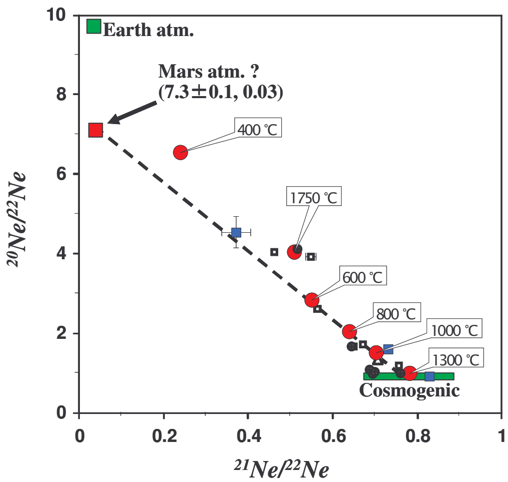

Fig. 1. Neon three-isotope plot for DHO 378 from stepwise heating methods. The red filled circles are for pyroxene-rich separates, and other black symbols for bulk and plagioclase-maskelynite separates. Low temperature fraction (350°C) of Y793605 [6] (blue square symbol) is plotted on the line within experimental uncertainties, which supports the value of 7.3 estimated for the Martian atmospheric Ne from DHO 378.

in a multicomponent system, where r_{jk} and R_{jk} stand for ratios for any pair of noble gas isotopes with masses of m_j and m_k in Earth's atmosphere and in solar gas reservoir. The linear trend passing an origin in the plot after correction for "missing Xe" strongly suggests that the noble gas compositions of Earth's atmosphere have been established principally by mass-dependent Rayleigh distillation process from solar composition. Similar trend is shown for noble gases of Martian atmosphere in Fig. 2, where noble gas elemental compositions in Martian atmosphere [5] were used for calculation. "Missing Xe" is also corrected by multiplying a factor of 6 to the Xe concentration in Martian atmosphere. The linear array passing through the origin strongly suggests that the noble gas abundance pattern of Martian atmosphere relative to solar composition have also been established by mass-dependent Rayleigh distillation as demonstrated by Ozima and Podosek [11, 12] for Earth's atmospheric noble gases.

The depletion factors for ^{22}Ne and ^{38}Ar are calculated using the formula, $(r_{ji}/R_{ji}) = \{F_i\}^{\sqrt{m_i/m_j}-1}$, given in Ozima and Podosek [12], where $\{F_i\}$ is the depletion factor for isotope *"i"*. Almost identical depletions of 2.2×10^{-6} and 2.0×10^{-6} for ^{22}Ne and ^{38}Ar, respectively, are obtained assuming the fractionation from solar isotopic ratios (^{20}Ne/^{22}Ne=13.8 and ^{36}Ar/^{38}Ar=5.59) to the present-day Martian atmospheric values (^{20}Ne/^{22}Ne=7.3: this work, and ^{36}Ar/^{38}Ar=3.9 [14]). Because the isotopic fractionation for Ar in the Martian atmosphere has been fairly established [6, 14], the almost same degree of depletion for Ne and Ar supports the heavy fractionation occurred on Ne isotopic composition in Martian atmosphere. However, if we consider the mass-dependent Rayleigh process as indicated in Fig. 2, the depletion of Ne should be 2 orders of magnitude heavier than that for Ar. Depletion of 10^{-8} deduced from the depletion factor of 2×10^{-6} obtained for Ar would have reduced the ^{20}Ne/^{22}Ne ratio to 5.6 from the solar Ne value of 13.8. Hence, the slightly higher ^{20}Ne/^{22}Ne ratio of 7.3±0.1 in the Martian atmosphere might be maintained by some source of Ne with higher ^{20}Ne/^{22}Ne ratio.

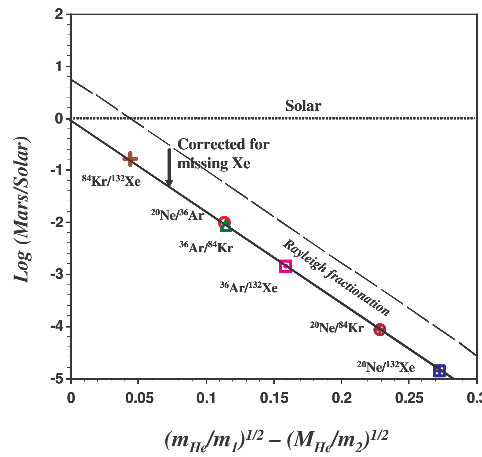

Fig. 2. Noble gas elemental ratios compared to those of solar gas are plotted against $\sqrt{m_i/m_j}$ - $\sqrt{m_i/m_k}$ values. Ratios ^{20}Ne/^{132}Xe, ^{36}Ar/^{132}Xe and ^{84}Kr/^{132}Xe are corrected for "missing Xe" [11] by multiplying a factor of 6 to the Xe concentration in Martian atmosphere. All the points plotted on a linear line passing through the origin, which can be produced by mass-dependent Rayleigh distillation from solar composition.

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