NOBLE GAS STUDY ON 19 ORDINARY CHONDRITES OF THE KOREAMET ANTARCTIC METEORITE COLLECTION. S. Matsuda[1], R. Okazaki[2], K. Nagao[1], J. I. Lee[3], M. J. Lee[3], and I. S. Ahn[3], [1]Geochemical Research Center, Graduate School of Science, University of Tokyo, Hongo 7-3-1, Tokyo 113-0033, Japan (matsuda@eqchem.s.u-tokyo.ac.jp), [2]Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, Hakozaki, Fukuoka 812-8581, Japan, [3]Korea Polar Research Institute, KORDI, Songdo Techno Park 7-50, Songdo-dong, Yeonsu-gu, Incheon 406-840, Korea.

Introduction: The Korea Polar Research Institute (KOPRI) had collected 29 meteorites during the 2006, 2007, and 2008 field expeditions in Antarctica. As the fundamental information of the meteorites, noble gas isotopic compositions of bulk materials are helpful for other scientific research works. Noble gas data present 1) history of each meteorite such as cosmic-ray exposure age and gas retention age, 2) types and concentrations of trapped noble gas components contained in meteorites, and 3) paring(s) of meteorites in the meteorite collection. We measured noble gas concentrations and isotopic ratios for 19 ordinary chondrites from the 29 meteorites. Noble gases in the meteorites were extracted by totally melt the samples at 1800 ºC on the VG5400 noble gas mass spectrometer at Kyushu University. Weights of the measured samples in this work are 31.7–67.9 mg. The name, type, cosmic-ray exposure ages, and gas retention ages are summarized in Table 1.

Results and Discussion: Helium and Ne isotopic ratios of 17 meteorites are explained by cosmogenic component and radiogenic ^{4}He. Measured ^{20}Ne/^{22}Ne and ^{21}Ne/^{22}Ne ratios for these meteorites are in the ranges 0.805-0.913 and 0.772-0.944, respectively (Fig. 1). Two meteorites, TIL 06005 (H4) and TIL 07015 (H6), show higher ^{20}Ne/^{22}Ne of 6.5 and 5.4 and low ^{21}Ne/^{22}Ne of 0.46 and 0.51, respectively (Fig. 1), which indicate a contribution of noble gas of solar origin. The Ar is composed of cosmogenic and trapped components, in addition to radiogenic ^{40}Ar from ^{40}K. The isotopic ratios of Kr and Xe can be assumed as trapped gases and terrestrial atmospheric contamination.

Trapped noble gases Two meteorites, TIL 06005 and TIL 07015, have trapped Ne of solar origin (Fig. 1). Concentrations of solar ^{20}Ne corrected for cosmogenic component are 740 and 200 × 10^{-9} cm^{3}STP/g, respectively. In the same way, concentrations of ^{4}He corrected for cosmogenic one for these meteorites are 1770 and 51100 × 10^{-9} cm^{3}STP/g, respectively, which must be a mixture between radiogenic and solar ^{4}He. Upper limits to the solar ^{4}He/^{20}Ne ratio are calculated to 2.4 and 259, respectively. The former value is too low compared with the ratio of ca. 500 for solar wind [1], which indicates almost complete loss of solar He from TIL 06005.

Isotopic ratios of Kr and Xe indicate that ^{84}Kr and ^{132}Xe are assumed as mostly trapped component. In a graph of ^{36}Ar$_{trap}$/^{132}Xe ratio versus ^{84}Kr/^{132}Xe ratio (Fig. 2), about half of the meteorites are plotted in the range for chondrites (Q-gas). On the other hand, other data points show a contribution of fractionated terrestrial atmosphere to these meteorites. Some meteorites have been affected by terrestrial heavy noble gases during the residence in Antarctic ice.

Cosmic-ray exposure ages Cosmic-ray exposure ages (T_3, T_{21}, and T_{38}) were calculated from the concentrations of cosmogenic ^{3}He, ^{21}Ne, and ^{38}Ar, from which trapped component was subtracted [3]. The short exposure ages T_3 compared to the T_{21} ages may have resulted from diffusion loss of ^{3}He. On the other hand, the short T_{38} ages may have resulted from chemical heterogeneity of these meteorites or ^{38}Ar loss through weathering as pointed out for Antarctic E-chondrites [4]. Hence, we adopt the T_{21} as exposure ages of the meteorites in the following discussion. Five H-chondrites belong to a group with short exposure age around 8 Ma, three samples in intermediate ages, and remaining two TIL 08002 and TIL 08006 show very long exposure ages, 54 and 36 Ma, respectively (see histogram in [3]). Six L-chondrites have relatively short exposure ages ranging 6−11 Ma, one in intermediate (23 Ma), and two show long ages of ca. 40 Ma.

U,Th-H and K-Ar gas retention ages The U,Th-He and K-Ar gas retention ages presented in Table 1 were calculated adopting literature value of U, Th, and K for H and L chondrites; U = 13 and 15 ppb [4], Th/U = 3.53 ± 0.10 [5] and K = 780 and 920 ppm [4] , respectively. The calculated U,Th-He and K-Ar ages are in the ranges 0.1-2.9 Ga and 0.8-4.5 Ga, respectively. The U,Th-He ages are younger than K-Ar ages, which may be a result of selective diffusion loss of He from the meteorites.

To investigate timing and mechanism of He loss from the meteorite, the T_4/T_{40} and T_3/T_{21} ratios (Table 1) were considered. If a meteorite lost radiogenic ^{4}He while it was in the parent asteroid and if it retained cosmogenic ^{3}He and ^{21}Ne during cosmic-ray irradiation, it would give $T_3/T_{21} = 1$ and $T_4/T_{40} < 1$. The data obtained for the samples did not show such trends, but indicate that about half or more of both cosmogenic ^{3}He and radiogenic ^{4}He have been partially lost from the meteorites. This might be resulted by the He loss during the period of cosmic-ray irradiation, probably due to solar radiation.

Possible pairings Based on the concentrations and isotopic ratios of noble gases, concentrations of cosmogenic and radiogenic isotopes, cosmic-ray exposure ages (T_{21}), gas retention ages (T_4 and T_{40}), and neutron produced ^{80,82}Kr, we propose three pairings among the 19 H and L chondrites; Pair-1 (TIL 06001 and 07005), Pair-2 (TIL 06004, 07002, 07006, 070010, and 07013), and Pair-3 (TIL 08001 and 08003). Other ten meteorites may not be paired among them and seem to be individual falls.

References: [1] Fegley B. and Swindle T. D. (1993) *Resource of Near-Earth Space,* 367-426. [2] Herzog G. F. (2005) *Meteoritics, Comets, and Planets,* Treaties on Geochemistry Vol. 1. [3] Okazaki R. et al. (2000) *Antarct. Meteorite Res.,* 13, 153-169. [4] The Planetary Scientist's Companion (1998). [5] Goreva J. and Burnett D. (2001) *Meteorit. Planet. Sci.* 36, 63-74.

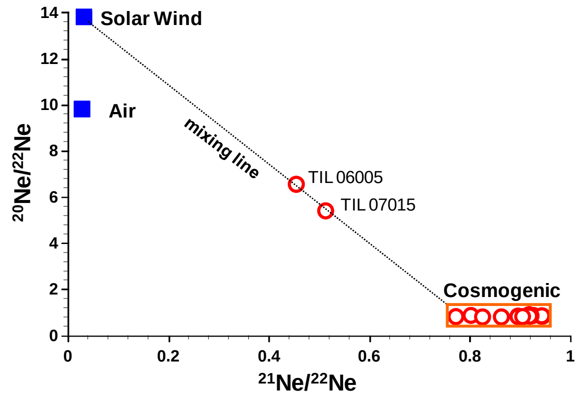

Fig.1. Three isotope plots of Ne. Solar Ne presents in two meteorites TIL 06005 and 07015, suggesting brecciation on their parent bodies. Ne in other meteorites is totally cosmogenic.

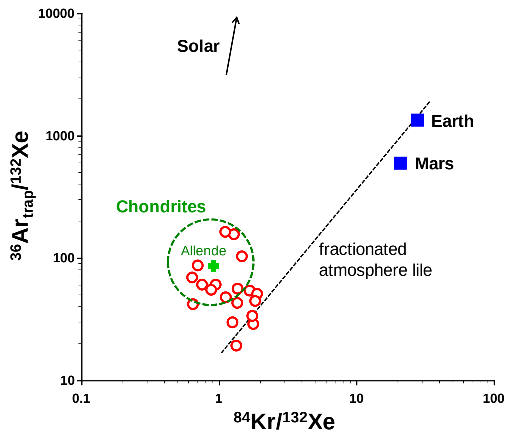

Fig. 2. Trapped ^{36}Ar/^{132}Xe versus ^{84}Kr/^{132}Xe ratios. About half of the samples are plotted in the area for typical chondrites. Others are plotted between the chondritic and elementary fractionated terrestrial atmospheric compositions. The latter may be affected by atmospheric contamination.

Table 1. Cosmic-ray exposure ages (T_3, T_{21}, and T_{38}) and U/Th-He (T_4) and K-Ar (T_{40}) ages.

Name	Type	T_3	T_{21}	T_{38}	U/Th-He			K-Ar			T_4/T_{40}	T_3/T_{21}
			Ma			Ga			Ga			
TIL 06001	H6	3.1	6.3	3.1	2.91	±	0.44	3.38	±	0.22	0.86	0.49
TIL 06002	L6	4.4	10.6	7.6	0.39	±	0.09	1.75	±	0.16	0.22	0.42
TIL 06003	L6	16.4	22.9	18.2	0.25	±	0.10	0.81	±	0.09	0.31	0.72
TIL 06004	L5	3.4	6.4	1.9	0.32	±	0.07	1.05	±	0.11	0.30	0.53
TIL 06005	H4	1.2	16.8	10.1	0.59	±	0.13	1.32	±	0.13	0.45	0.07
TIL 07002	L5	2.9	6.7	2.6	0.29	±	0.07	1.29	±	0.13	0.22	0.44
TIL 07004	H6	1.3	14.6	9.2	0.10	±	0.03	1.07	±	0.11	0.09	0.09
TIL 07005	H6	3.4	6.3	5.1	2.65	±	0.42	4.28	±	0.23	0.62	0.54
TIL 07006	L5	3.5	7.1	4.9	0.32	±	0.08	1.15	±	0.12	0.28	0.49
TIL 07010	L5	3.1	6.8	2.7	0.30	±	0.07	1.23	±	0.13	0.24	0.46
TIL 07011	H6	4.6	8.7	7.7	1.00	±	0.21	3.75	±	0.22	0.27	0.53
TIL 07013	L5	2.8	5.7	0.5	0.32	±	0.07	1.18	±	0.12	0.27	0.50
TIL 07015	H6	4.7	6.4	5.0	#			4.12	±	0.23	1.49	0.74
TIL 08001	L6	22.6	42.3	33.3	0.93	±	0.24	3.36	±	0.22	0.28	0.54
TIL 08002	H5	31.5	54.3	44.5	2.59	±	0.48	3.51	±	0.22	0.74	0.58
TIL 08003	L6	22.4	39.6	27.0	1.06	±	0.26	3.46	±	0.22	0.31	0.57
TIL 08005	H5	5.5	11.5	7.4	2.83	±	0.44	4.47	±	0.24	0.63	0.48
TIL 08006	H5	13.5	35.6	30.5	0.88	±	0.22	3.04	±	0.21	0.29	0.38
TIL 08008	H6	4.9	9.6	7.8	2.56	±	0.42	4.51	±	0.24	0.57	0.52

Production rates P_3, P_{21}, and P_{38} were calculated following Herzog (2005).
In the calculation of U,Th-He and K-Ar ages, concentrations of K and U of 780 ppm and 13 ppb (H-chonrites), and 920 ppm and 15 ppb (L-chondrites) were used (in The Planetary Scientis's Companion).
#: not be calculate because of high concentration of solar ^{4}He.