PAST SOLAR WIND FLUXES AT THE LOCATIONS OF GAS-RICH METEORITE PARENT BODIES BASED ON NOBLE GAS STUDIES: IMPLICATIONS TO THE PAST HELIOCENTRIC DISTANCES.

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Introduction: To understand the evolutions of asteroid orbits, past heliocentric distances (HDs) of asteroids are critical information, which can be provided by solar wind (SW) fluxes recorded on old regolith in the asteroids, as the SW flux is inversely related to the square of the HD. Several studies attempted to obtain the past HDs of meteorite parent bodies by comparing SW noble gas concentrations in gas-rich meteorites with those in the lunar samples [e.g. 1-4] but with a problem that the different properties between the lunar and asteroid regolith such as maturities, gardening processes and effect of the Earth's magnetosphere are not considered. Regolith breccias have experienced exposures to SW and galactic cosmic rays on the surface of the parent bodies [5] and acquired SW noble gases and cosmogenic ones. The past SW flux on the meteorite parent body can be calculated from a correlation between these noble gas abundances in the regolith breccia. Here we describe a new method to estimate past SW fluxes at the locations of meteorite parent bodies and calculate and recalculate the HDs of the parent bodies of several meteorites. For the calculations, the problem shown above is avoided by directly comparing the estimated SW fluxes with the 1 AU SW flux obtained by the Genesis mission without obstruction by the Earth's magnetosphere [6].

Methods: Gas-rich meteorites listed in Table 1 were analyzed for noble gases in previous studies. More than 18 samples from gas-rich portions show positive correlations of concentrations between SW-^{36}Ar ($^{36}Ar_S$) and cosmogenic-^{21}Ne ($^{21}Ne_C$) for the respective meteorites. Assuming that the surface regolith on a meteorite parent body is continuously well-mixed due to a repeated impact gardening, the concentrations of $^{36}Ar_S$ and $^{21}Ne_C$ in the regolith increase in a ratio of the $^{36}Ar_S$ flux to the production rate of $^{21}Ne_C$ (P_{21}) per unit area. Then, the slope of the correlation line corresponds to the ratio of the $^{36}Ar_S$ flux to the P_{21} per unit area. The past $^{36}Ar_S$ flux (F_{36}) at the HD of the parent body is obtained by the following equation; $F_{36} = \pi a P_{21}$, where a is the slope of the correlation line and π is a correction factor to take into account the rotation of the parent body. The P_{21} is calculated from a physical model [7].

Results & Discussion: The past $^{36}Ar_S$ flux at the location of the parent body of the howardite Kapoeta is 53 ± 9 atoms cm^{-2} s^{-1}. Assuming that the Kapoeta's parent body is asteroid 4 Vesta and its HD (2.4 AU) has never changed significantly, the past $^{36}Ar_S$ flux at 1 AU is calculated as 310 ± 50 atoms cm^{-2} s^{-1}, which is similar to the current $^{36}Ar_S$ flux obtained by the Genesis mission ([6]; Table 1). Assuming the past SW flux is similar to the current one, the past HDs of the meteorite parent bodies are given by comparing the estimated SW flux at the locations of the parent bodies (Table 1) with the SW flux at 1AU obtained by the Genesis mission. In Table 1 we summarized the calculated and recalculated HDs of the meteorite parent bodies with their classifications. The past HDs of the parent bodies of enstatite and rumuruti chondrites are close to the Sun compared to those of H chondrite parent bodies. Recent astrophysical model predicts the formation regions of enstatite, H and rumuruti chondrites as 1.9 - 2.1 AU, 2.43 AU, and 2.6 AU, respectively [8]. This is roughly in agreement with our estimations except for PRE 95410 (R3). The high SW flux on the PRE 95410 parent body may suggest inner migration from the formation region or several times higher SW flux than the current SW flux when the regolith was exposed to the SW. Dating the antiquities of the exposures are highly desirable for further constraints on the past HDs and the SW flux evolution in the history of the solar system.

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	PRE 95410	**ALH 85119**	**MAC 88136**	**Fayette-ville**	**Tsukuba**	**Acfer 111**	**Kapoeta**	**Genesis data [6]**
$^{36}Ar_S$ flux	221±64	<210	<138	86±21	46±17	41±6	53±9	371±5
Past heliocentric distance	1.3±0.2	>1.3	>1.6	2.1±0.3	2.8±0.5	3.0±0.2	2.6±0.2	-
Classification	R3	EL3	EL3	H4	H5-6	H3-6	Howardite	-
Noble gas data	[1]	[2]	[2]	[3]	[4]	[9]	[10]	-

Table 1. The past solar wind ^{36}Ar flux (atoms cm^{-2} s^{-1}) at the heliocentric distances of meteorite parent bodies with the current solar wind ^{36}Ar flux at 1 AU obtained by the Genesis mission [6] and the calculated and recalculated past heliocentric distances (AU) of the meteorite parent bodies.