NEW SNC METEORITE ALH84001: EVIDENCE FOR SNC METEORITE FROM NOBLE GASES;

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ALH84001 was originally classified as diogenite [1]. Small chips of this meteorite were allocated to us under the guise of a diogenite. However, ALH84001 was recently re-classified as a new type of SNC meteorite according to mineralogical and oxygen isotopic features [2]. We measured noble gases in ALH84001, which show some characteristic elemental and isotopic compositions similar to those of other SNC meteorites and of the Martian atmosphere.

Experiment and results: Noble gas analyses were performed twice using bulk samples weighting 0.513g (#1) and 0.448g (#2), respectively. Noble gases were extracted from the samples stepwisely, and isotopic and elemental compositions of He, Ne, Ar, Kr and Xe were determined. The extraction temperatures are 700°C and 1750°C for #1, and 700°C, 1000°C, 1300°C and 1750°C for #2, respectively. Apparatus and procedure of the measurements are about the same as those described in [3] except for some improvements, *e.g.*, installation of an ion counting system.

Isotopic compositions of Ne obtained by all extraction steps show that they are mostly cosmogenic components. We assumed 1)measured Kr is mostly trapped and 2)Ne and Kr are trapped with a ratio similar to a literature value of the Martian atmospheric Ne/Kr ratio [4]. Then, trapped ^{20}Ne concentration is only 5% in the measured total ^{20}Ne concentration. On the other hand, Ar consists of cosmogenic, radiogenic and trapped components. ^{40}Ar/^{36}Ar ratio extracted from 1000°C fraction of measurement #2 is about 8000, which is much higher than the Martian atmospheric value and also terrestrial atmospheric value. In this fraction, radiogenic ^{40}Ar originated from in situ decay of ^{40}K seems to be released. Although the measured bulk ^{40}Ar/^{36}Ar ratios are as low as 1940 and 2220, the ^{40}Ar/^{36}Ar corrected for cosmogenic contribution are 6200 and 6500. They are much higher than the Martian and terrestrial atmospheric ratios. The meteorite may contain radiogenic ^{40}Ar. The ^{129}Xe/^{132}Xe ratios except for the lowest temperature fractions of 700°C show constant ratio of 2.0-2.2, which is close to those obtained from a shergottite EETA79001 glass sample [5] and from the Viking lander [6]. It seems to contain a large amount of the Martian atmospheric Xe. This is one of the strong evidence that ALH84001 belongs to SNC meteorite group.

Cosmic-ray exposure ages: Concentrations of cosmogenic ^{3}He, ^{21}Ne and ^{38}Ar and the preliminary calculation of cosmic-ray exposure ages are summarized in Table 1. The concentrations of cosmogenic light noble gases are close to those in Chassigny. The cosmogenic ^{21}Ne/^{38}Ar ratios of these meteorites are about 10, which suggest their higher Mg/Fe ratios than those of L-chondrites and the other SNC meteorites. In fact, 100 Mg/(Mg+Fe^{2+}) of orthopyroxene in ALH84001 is as high as 19 [2]. In order to calculate the production rates for ALH84001, equations as a function of chemical compositions presented by [7] and the ordinary production rates for L-chondrite [8] were used. Since bulk chemical compositions of ALH84001 are unknown, the chemical compositions of orthopyroxene reported by [9] were adopted as bulk compositions here. The mean value of cosmic-ray exposure age of T_3, T_{21} and T_{38} is calculated to be 14+/-2 Ma. Although this exposure age is slightly longer than those of Chassigny and nakhlites, they are within error limits considering uncertainties in chemical compositions and shielding effect. The exposure age of ALH84001 belongs to one of the three clusters for SNC group.

Trapped noble gases: A High ^{129}Xe/^{132}Xe ratio of ALH84001 suggests that this meteorite contained abundant Martian atmospheric Xe and also other noble gases. In previous works on SNC meteorites, it has been suggested that there are at least two components for SNC's trapped noble gases, which are a)Martian mantle and b)Martian atmosphere in origin (e.g., [10]). Their compositions are characterized by a)low ^{84}Kr/^{132}Xe, low ^{129}Xe/^{132}Xe and low ^{40}Ar/^{36}Ar, and b)high ^{84}Kr/^{132}Xe, high ^{129}Xe/^{132}Xe and high ^{40}Ar/^{36}Ar, respectively. Fig. 1 shows ^{129}Xe/^{132}Xe versus ^{84}Kr/^{132}Xe ratios. The data of most shergottites lie on a mixing line between them [10]. However, ALH84001 are plotted far above the line. Those of Nakhlites are also plotted above the line. Drake *et al.* [11] proposed an explanation for the high ^{129}Xe/^{132}Xe ratio with

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relatively lower $^{84}Kr/^{132}Xe$ ratio for Nakhla that the meteorite interacted with an aqueous fluid after its crystallization, that is, atmospheric Xe was introduced into the meteorite as a sedimentary weathering product on the Mars. Our data for ALH84001 can be also explained by such a process, but there is now no other strong evidence for supporting it.

The plot for elemental ratios between $^{36}Ar/^{132}Xe$ and $^{84}Kr/^{132}Xe$ are presented in Fig. 2. The concentration of trapped ^{36}Ar is calculated assuming 0.188 and 1.55 as trapped and cosmogenic $^{38}Ar/^{36}Ar$ ratios, respectively, and those of trapped ^{84}Kr and ^{132}Xe are the measured concentrations. In this plot, elemental ratios of trapped Ar, Kr and Xe for ALH84001 do not fall on a trend between Chassigny and shergottites. The concentration of trapped Kr in ALH84001 is depleted compared with the trend of shergottite and Chassigny (Fig. 1), and that of trapped Ar is also depleted (Fig. 2). The fractionated elemental patterns can be attributed to the above process suggested by [11] or other physical processes such as shock implantation or adsorption.

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References: [1]*Antarctic Meteorite Newsletter* 8(2). [2]*Antarctic Meteorite Newsletter* 16(3). [3]Miura Y. *et al.* (1993) *GCA* 57, 1857. [4]Hunten D.M. *et al.* (1987) *Icarus* 69, 532. [5]Becker R.H. and Pepin R.O. (1984) *EPSL* 69, 225. [6]Owen T. *et al.* (1977) *JGR* 82, 4635. [7]Eugster O. and Michel Th. (1993) submitted to *GCA*. .[8]Marti K. and Graf T. (1992) *Annu. Rev. Earth Planet. Sci.* 20, 221. [9]Berkley J. and Boynton N.J. (1992) *Meteoritics* 27, 387. [10]Ott U. (1988) *GCA* 52, 1937. [11]Drake M.J. *et al.* (1993) *LPSC XXIV*, 431. [12]Ott U. and Lohr H.P. (1991) *Meteoritics* 27, 271. [13]compiled in Ozima M. and Podosek F.A. (1983) *Noble gas geochemistry*. [14]Bogard D.D. *et al.* (1984) *GCA* 48, 1723.

Table 1. Cosmogenic noble gases and cosmic-ray exposure ages

	^{3}He	^{21}Ne	^{38}Ar	T_3	T_{21}	T_{38}	T_{mean}
ALH84001 #1	24.9	4.02	0.428	15.0	11.6	14.2	13.6+/-1.8
ALH84001 #2	24.8	3.51	0.481	14.9	10.1	16.0	13.7+/-3.1

Concentrations are given in unit of $10^{-8}cm^3STP/g$, and ages in m.y.

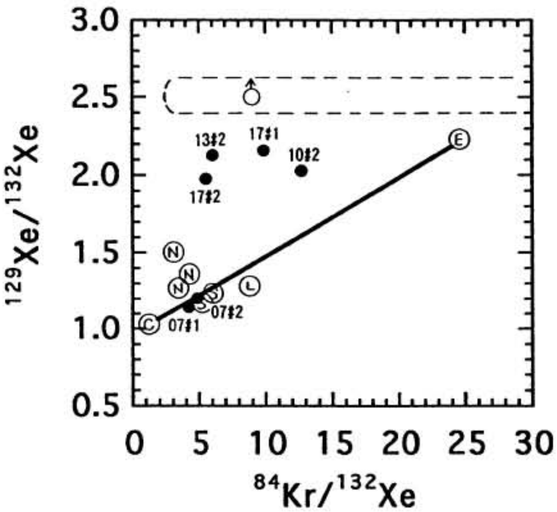

Fig 1. $^{129}Xe/^{132}Xe$ versus $^{84}Kr/^{132}Xe$.
●:This work (The numerical figures represent the extraction temperatures in 100°C) Ⓔ:EETA79001 glass[5], Ⓛ:LEW88516[12], Ⓢ:Shergotty[10], Ⓝ:Nakhla[10], Ⓒ:Chassigny[10], ♂:Mars's atmosphere (large uncertainty is included) [6],[13]

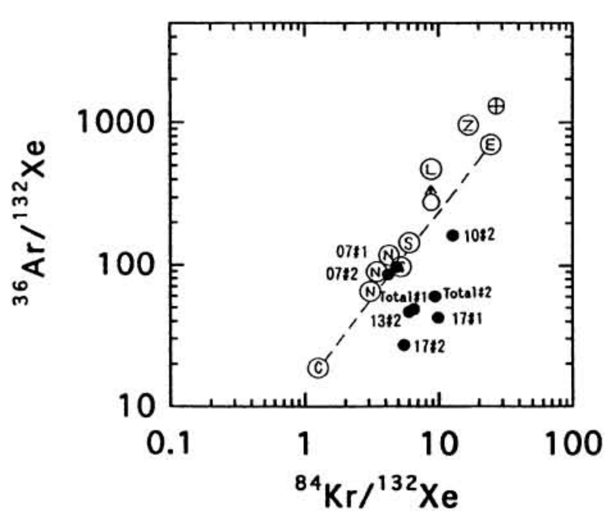

Fig 2. $^{36}Ar/^{132}Xe$ versus $^{84}Kr/^{132}Xe$.
⊕:Earth's atmosphere[13], the other symbols are the same as those in Fig. 1. Ⓩ:Datum given by [14] for Zagami , for which cosmigenic ^{36}Ar is removed using the same procedure noted in the text, are added.