K-Ar AGE OF YAMATO METEORITE, YAMATO-74190-01(L)

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Abstract: Preliminary measurements have been carried out on the isotopic compositions and contents of helium, neon and argon in Yamato-74190-01(L). K-Ar age and exposure ages on the meteorite have been calculated as follows: K-Ar age (~2.1 b.y.), exposure ages (24 and 22 m.y. in terms of ^{3}He and ^{21}Ne contents respectively). From the isotopic correlation diagram for neon and the isotopic ratio, ^{36}Ar/^{38}Ar, it has been suggested that this meteorite contains almost the same quantity of trapped rare gases as cosmogenic ones.

1. Introduction

Yamato-74190-01 (L), a hypersthene chondrite, is one of the meteorites which were collected on the glacier near the Yamato Mountains in Antarctica (70°S, 37°E) during a period from October 25, 1974 to January 17, 1975, by a four-man party of the 15th Japanese Antarctic Research Expedition (1973–1975). The situation of the search and collection of the meteorites was reported in detail by YANAI (1976).

Very few descriptions have been made hitherto on Yamato-74190-01 (L) except the report by KIMURA *et al.* (1977), so that this meteorite is grouped as type L6 according to the petrological classification by VAN SCHMUS and WOOD.

This paper forms part of a study on rare gases determinations and its related discussions as to the meteorite.

2. Experimental

One half of the sample weighing 1.3 g *in toto* was ground into powder using an agate mortar and stored in a desiccator over silica gel. About 100–200 mg of the sample was packed into a molybdenum crucible which was directly mounted on a tantalum heater. The extraction furnace above is connected in series with the ultra high vacuum mass spectrometer, which was reported previously (OKANO *et al.*, 1973). The whole system was heated for degassing in a pair of electric furnaces under vacuum at *ca.* 200°C, after which the gases were extracted by resistive heating at ~1,300°C (YI, YII-1) or at ~1,800°C (YII-2, YIII).

The extracted gases were purified initially by means of a cold trap cooled by liquid nitrogen to remove volatile components, and then they were exposed to a hot titanium filament and a getter made of Ti-Zr alloy operated at about 550°C. The gases thus purified were expanded to the inlet line of the mass spectrometer for immediate analysis of the argon and helium isotopic ratio.

Neon measurement was carried out after ^{40}Ar and CO_2 peaks were diminished by making all the gases exposed to a charcoal tube held at −195°C. Sample runs were interspersed with air aliquots of known volume which served as standards for each isotopic ratio, except for ^{3}He, ^{4}He and ^{21}Ne.

In addition, precisely known amounts of pure helium and neon were used to check the sensitivity of He and Ne for Ar. The absolute amount of each argon isotope was determined by isotope dilution analysis with a ^{38}Ar spike, while the amount of He and Ne by taking account of the sensitivity described above.

Every measurement was carried out so quickly that the errors, which were inherent to the permeation of mainly ^{4}He (through the quartz tube operated at 550°C) and the leakage of ^{40}Ar from air, were estimated to be less than a few percent.

3. Results and Discussion

The results of our analysis are shown in Table 1. Light rare gases (He, Ne, Ar) contained in a meteorite are considered to consist of three components (cosmogenic, radiogenic and trapped), in case air-contaminants are fully removed by degassing at ~200°C.

Table 1. Rare gases in Yamato-74190-01 (L).

	YI (~1300°C)	YII-1 (~1300°C)	YII-2 (1300~1800°C)	YII (totall)	YIII (~1800°C)
^{3}He	1.3×10^{-9}	6.27×10^{-7}	9.28×10^{-8}	7.20×10^{-7}	4.65×10^{-7}
^{4}He	3.5×10^{-8}	1.56×10^{-5}	7.52×10^{-6}	2.31×10^{-5}	1.27×10^{-5}
^{20}Ne	——	1.20×10^{-6}	6.75×10^{-7}	1.88×10^{-6}	7.98×10^{-7}
^{21}Ne	7.9×10^{-9}	1.07×10^{-7}	2.71×10^{-8}	1.34×10^{-7}	9.97×10^{-8}
^{22}Ne	——	2.02×10^{-7}	8.18×10^{-8}	2.84×10^{-7}	1.63×10^{-7}
^{36}Ar	3.3×10^{-8}	4.47×10^{-8}	3.09×10^{-8}	7.56×10^{-8}	5.53×10^{-8}
^{38}Ar	7.7×10^{-9}	3.69×10^{-8}	8.65×10^{-9}	4.56×10^{-8}	3.32×10^{-8}
^{40}Ar	3.7×10^{-6}	6.71×10^{-6}	7.96×10^{-6}	1.48×10^{-5}	1.30×10^{-5}
$^{3}He/^{4}He$	3.6×10^{-2}	4.04×10^{-2}	1.23×10^{-2}	3.34×10^{-2}	3.66×10^{-2}
$^{20}Ne/^{22}Ne$	——	5.92	8.26	6.62	4.92
$^{21}Ne/^{22}Ne$	——	5.28×10^{-1}	3.32×10^{-1}	4.72×10^{-1}	6.16×10^{-1}
$^{38}Ar/^{36}Ar$	2.3×10^{-1}	8.26×10^{-1}	2.81×10^{-1}	6.03×10^{-1}	5.92×10^{-1}
$^{40}Ar/^{38}Ar$	4.9×10^{2}	1.82×10^{2}	9.20×10^{2}	3.25×10^{2}	3.97×10^{2}
t_3(y)	5.2×10^{6}	——	——	2.91×10^{7}	1.88×10^{7}
t_{21}(y)	5.5×10^{6}	——	——	2.49×10^{7}	1.85×10^{7}
K-Ar age (y)	8.3×10^{8}	——	——	2.18×10^{9}	2.09×10^{9}

Concentrations in cm^3 STP/g.

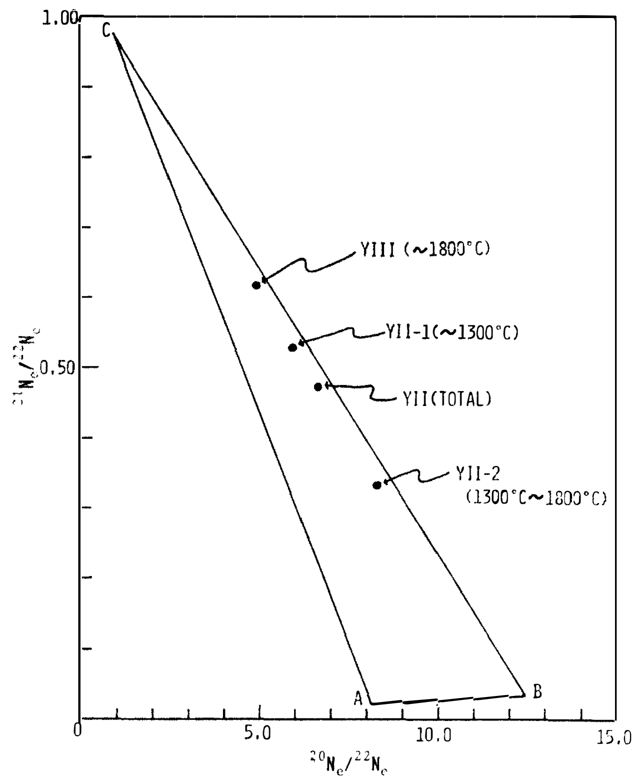

Fig. 1. Three-isotope correlation diagram for neon. Points A and B correspond to planetary-type Ne and solar-type Ne, respectively.

The table indicates that cosmogenic components are extracted mainly by the heating up to 1,300°C (YII-1), whereas trapped and radiogenic ones by the heating from 1,300°C to 1,800°C (YII-2). In spite of a small number of measurements, the content of each isotope and the isotopic ratios in YII are in good agreement with those of YIII, especially for argon.

The only discrepancy, however, is found for the value of $^{21}Ne/^{22}Ne$, which results in a significant shift of the position on the isotopic correlation diagram (Fig. 1) between YII and YIII. From this diagram and the $^{36}Ar/^{38}Ar$ ratio, it is considered that this meteorite consists of a mixture of cosmogenic component and trapped one in the ratio of about 1:1. From the observed abundances of ^{3}He and ^{21}Ne and the production rate (HERZOG *et al.*, 1971) calculated on the basis of the average chemical composition for L chondrite (MASON, 1971), the exposure age of this meteorite has been estimated separately for ^{3}He and ^{21}Ne. The agreement between the Ne- and He-exposure ages of each sample is reasonably good.

Thus the exposure ages are given as 24 and 22 m.y. respectively by the ^{3}He and ^{21}Ne-method. The gas-retention age of this meteorite has been estimated by the K-Ar method. The age for YII coincides well with that for YIII, and the ages determined being ~2.1 b.y. The result is consistent with the petrological identification by KIMURA *et al.* (1977) of this meteorite to type L6, which is considered to be rather thermally denatured.

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