PRIMORDIAL 'PLANETARY' RARE GAS IN A MANTLE DERIVED AMPHIBOLE

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The abundances and the isotopic ratios of the five rare gases in a mantle derived amphibole (Kaersutite), from Kakanui, New Zeland, were measure (Table 1). The sample is a megacryst inclusion in an alkali basalt for which the geological age of lower Oligocene has been reported. The amphibole shows a low $^{87}Sr/^{86}Sr$ ratio of 0.7029. A K/Rb ratio of 1142 as well as the low $^{87}Sr/^{86}Sr$ ratio of the amphibole suggests that the source of the sample is similar to that of midoceanic ridge basalts.

The elemental abundances of the five rare gases are indistinguishable from 'planetary' rare gas as exemplified by some carbonaceous chondrites. The similarity is shown by plotting the data on a $^{84}Kr/^{130}Xe$ vs. $^{20}Ne/^{36}Ar$ diagram (Fig. 1), or by comparing the rare gas abundance with that in the carbonaceous chondrites (Fig. 2). In Fig. 2 the rare gas data of Mighei chondrite is plotted as a reference. In Fig. 3 the absolute abundances of rare gases is shown. The abundances of rare gases in the sample are high, especially Kr and Xe which show higher abundances than the earth's inventory (Atmospheric abundance/Mass of the earth). This high abundance may be either a result of concentration of rare gases in the mantle environment from which the amphibole crystallized or due to the efficient trapping of the rare gases in the partially empty 'A' site of kaersutite. In Fig. 3 the data of Mighei chondrite is also shown as a reference. Figure 3 shows a remarkable parallelism between the amphibole and the Mighei chondrite.

Table 1 shows the following salient aspects of the isotopic ratios of the gases in the amphibole.

He: $^{3}He/^{4}He$ ratio of 5×10^{-5} is obtained. This is one of the highest values ever found in terrestrial samples. The source of ^{3}He must be an originally trapped ^{3}He which still remains in the deep earth.

Ne: Excess ^{21}Ne was found. Although ^{21}Ne is produced by a ^{18}O (α, p) ^{21}Ne reaction, the ^{4}He abundance in the sample is too low to explain the ^{21}Ne anomaly by this reaction.

Ar: A $^{40}Ar/^{36}Ar$ ratio of 400 was measured. Almost complete exchange of the trapped Ar with the atmospheric argon can account for the $^{40}Ar/^{36}Ar$ of 400, but this explanation is incompatible with the He and Ne data. Making a correction of radiogenic ^{40}Ar accumulated after the solidification of the sample, the ratio becomes as low as 230.

Kr: ^{78}Kr and ^{80}Kr show anomalous abundance. Although the correction for the interference by $^{78}H_6C_6$ and $^{40}Ar_2^+$ were made, there still remains a little uncertainty in these corrections and ^{78}Kr and ^{80}Kr anomalies are doubtful. The other four isotopes of Kr show progressive enrichment in the heavier mass numbers as compared with the atmospheric abundance.

Xe: No significant difference from the atmospheric abundance was found.

Our data indicate that the earth has still retained its primordial rare gases and that the pattern of these gases is same as found in some 'planetary' type chondrites. However, the low $^{40}Ar/^{36}Ar$ ratio of 230 in the amphibole is difficult to explain by any degassing model.

TABLE 1. Abundance and isotopic composition of rare gases extracted from a 403.8 mg sample of handpicked, clear grains of amphibole from the Kakanui kaersutite megacryst.

Abundance

$^{4}He = (3.93 \pm 0.13) \times 10^{-6}$ cm STP/g

$^{20}Ne = (3.59 \pm 0.19) \times 10^{-9}$ cm STP/g

$^{36}Ar = (1.477 \pm 0.038) \times 10^{-8}$ cm STP/g

$^{84}Kr = (6.85 \pm 0.80) \times 10^{-10}$ cm STP/g

$^{132}Xe = (5.35 \pm 0.18) \times 10^{-10}$ cm STP/g

Isotopic Composition

^{4}He	^{3}He
≡1.000	$4.92 \pm 0.60 \times 10^{-5}$

^{20}Ne	^{21}Ne	^{22}Ne
≡1.000	$(6.66 \pm 0.51) \times 10^{-3}$	0.1006 ± 0.0085

^{36}Ar	^{38}Ar	^{40}Ar
≡1.000	0.1836 ± 0.0032	400.0 ± 4.8

^{78}Kr	^{80}Kr	^{82}Kr	^{83}Kr	^{84}Kr	^{86}Kr
0.006497 ±0.000065	0.04236 ±0.00042	0.2014 ±0.0006	0.2015 ±0.0004	≡1.000	0.3065 ±0.0006

^{124}Xe	^{126}Xe	^{128}Xe	^{129}Xe	^{130}Xe	^{131}Xe	^{132}Xe	^{134}Xe	^{136}Xe
0.00351 ±0.00011	0.00315 ±0.00011	0.07145 ±0.00071	0.9813 ±0.0037	0.1498 ±0.0015	0.7929 ±0.0003	≡1.000	0.3935 ±0.0029	0.3308 ±0.0025

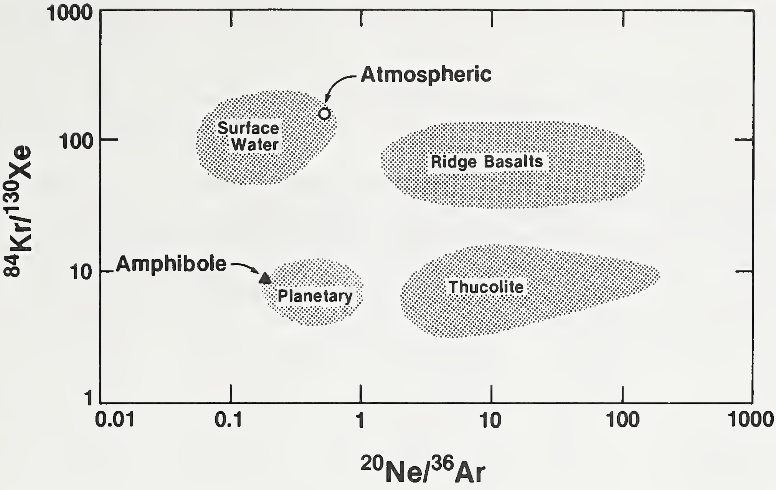

Fig. 1

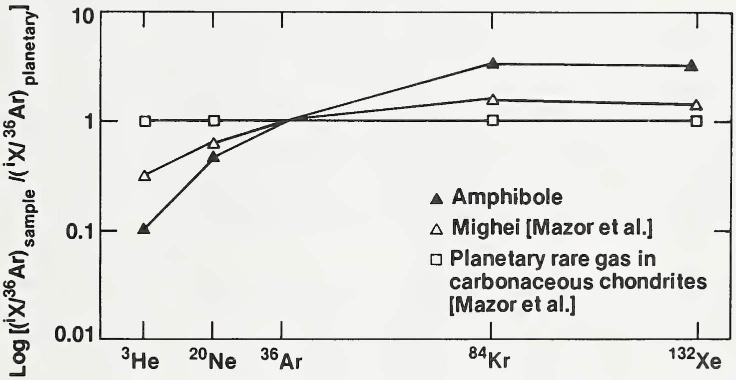

Fig. 2

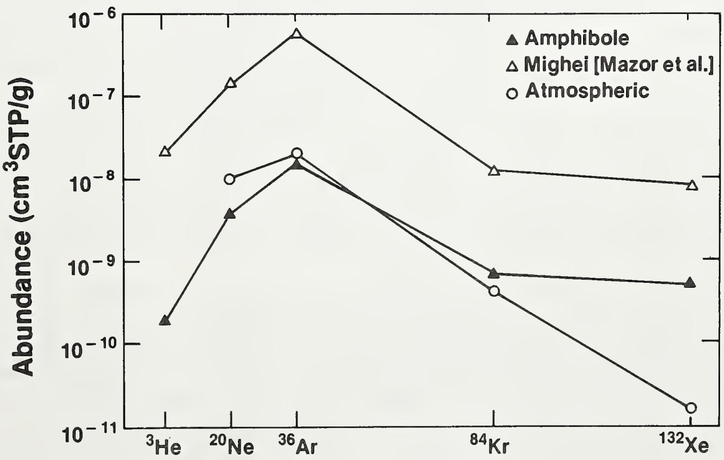

Fig. 3