OXYGEN ISOTOPIC COMPOSITIONS OF
SOME YAMATO METEORITES

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Abstract: Oxygen isotopic compositions are reported for eight Yamato meteorites, selected because of unusual compositions or textures. Y-791197 is confirmed to be of lunar origin; Y-74357, Y-75274, and Y-791493 are unusual achondrites possibly related to Lodran; Y-790981 is a slightly weathered ureilite; Y-790112 is a member of the Renazzo-class (CR) of the carbonaceous chondrites; Y-75097 is an L6 chondrite containing an achondritic inclusion with H-chondrite isotopic composition; Y-790269 is a badly weathered H-chondrite.

1. Introduction

Oxygen isotopes are useful for classification of meteorites and for recognition of genetic relationships between different types of meteoritic material (CLAYTON *et al.*, 1976). They may be especially useful in understanding the connection between unusual meteorites and the more common groups. The vast number of meteorites found in the Antarctic greatly increases the chances of discovery of rare classes and thus of finding new interrelationships of genetic significance. In the present study, oxygen isotopic compositions were determined for several specimens which were chosen on the basis of unusual composition or texture.

There is one potential drawback in an oxygen isotope study of Antarctic meteorites. It is the possibility of contamination of the sample by oxygen derived from the polar ice. Due to the efficient isotopic fractionation processes in the meteoric water cycle, the polar ice is very strongly depleted in the heavier isotopes of hydrogen and oxygen. For example, the ice in the Allan Hills region has $\delta^{18}O$ of about $-40‰$, relative to SMOW (FIREMAN and NORRIS, 1982). Thus a 2% contamination, such as by rusting of metallic iron, leads to a 1‰ displacement of the isotopic composition of the meteorite toward lower $\delta^{18}O$ values. An apparent example of an effect of such contamination was reported by TAYLOR *et al.* (1984).

2. Results and Discussion

Oxygen isotope analyses were carried out by procedures described by CLAYTON and MAYEDA (1983). Results are listed in Table 1; data for ureilites, lodranites, and a type 2 carbonaceous chondrite are compared in Fig. 1 with previous analyses of meteorites from the same class.

Y-791197 has chemical, mineralogical, and textural features that are characteristic of lunar breccias (YANAI and KOJIMA, 1984). The only other known meteorite with these characteristics is ALHA81005, for which a lunar origin is clearly indicated by many lines of evidence. (The September 1983 issue of Geophysical Research Letters

Table 1. Oxygen isotopic compositions of Yamato meteorites.

Sample	Type	$\delta^{18}O$ (SMOW) ‰	$\delta^{17}O$ (SMOW) ‰
Y-791197	Lunar (fresh)	6.08	3.33
	(weathered)	4.80	2.49
Y-74357,93	Achondrite	1.52	−0.42
Y-75274,91	Achondrite	2.45	0.08
Y-791493,93	Achondrite	1.19	−0.28
Y-790981,97	Ureilite	5.41	2.41
Y-790112,93	CR chondrite	2.39	−0.32
Y-75097,93	L6 chondrite	4.53	3.56
	inclusion	4.54	3.05
Y-790269,91	H4 chondrite	−0.08	0.50
		1.43	1.24

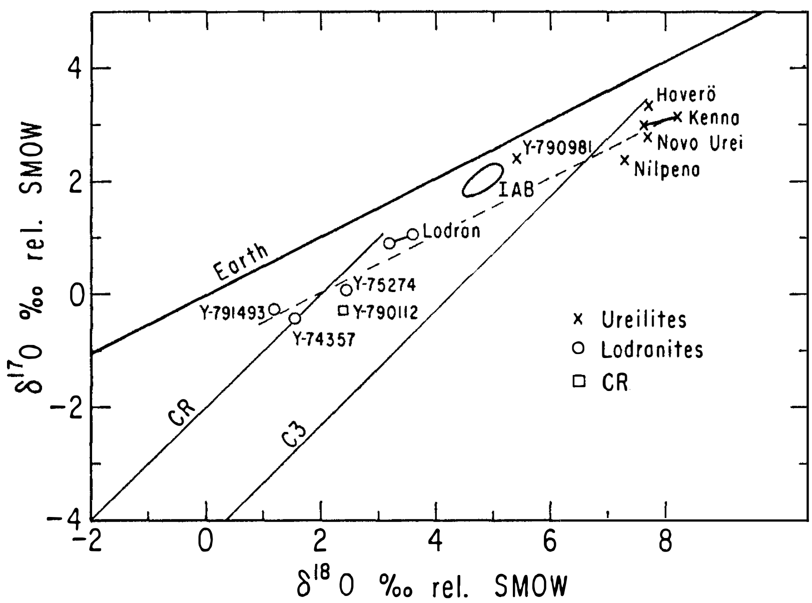

Fig. 1. Three-isotope graph of oxygen isotopic compositions. Reference lines shown are (1) the terrestrial mass-dependent-fractionation line (Earth), (2) the trend of separated anhydrous minerals from Renazzo and Al Rais (CR), (3) the trend of refractory inclusions from C3 chondrites (C3). The dashed line indicates a possible fractionation relationship between ureilites and lodranites. Y-790981 appears to depart from the ureilite group due to terrestrial weathering effects. The achondrites Y-74357, Y-75274, Y-791493 do not belong to the same oxygen isotope group as winonaites and silicates in IAB-IIICD irons (indicated by field labeled IAB). Y-790112 has a composition consistent with a CR classification.

contains 18 papers with independent observations identifying ALHA81005 as a lunar rock.) The oxygen isotopic composition of a fragment of Y-791197 without visible weathering effects is identical with that of ALHA81005 (MAYEDA *et al.*, 1983). The whole-rock composition of Y-791197 shows an apparent weathering effect resulting in lower $\delta^{18}O$ and $\delta^{17}O$. The oxygen isotope data support the conclusion that Y-791197 came from the Moon.

Y-74357, Y-75274, and Y-791493 have been described as "primitive achondrites" (YANAI *et al.*, 1984). In this category are included the winonaites, silicates in IAB and IIICD irons, Lodran, and Brachina. The oxygen isotope data are not consistent with derivation of all of these meteorites from a single reservoir. The data in Table 2 show that the IAB-IIICD silicates and the winonaites are tightly clustered and overlapping. The parameter (δ^{17}–0.52δ^{18}), which measures the vertical displacement of a data point from the terrestrial fractionation line, is identical, within the analytical uncertainty, for all members of these two groups (CLAYTON *et al.*, 1983), as is required

Table 2. Oxygen isotopic compositions of "primitive achondrites".

	δ^{18}	δ^{17}	δ^{17}–0.52δ^{18}
IAB-IIICD irons (mean of ten)	4.74±0.37	2.01±0.22	−0.46±0.10
Winonaites (mean of four)	5.07±0.59	2.19±0.35	−0.45±0.06
Brachina	3.48	1.61	−0.20
Lodran ol	3.20	0.92	−0.74
Lodran px	3.60	1.05	−0.82
Y-74357	1.52	−0.42	−1.21
Y-75274	2.45	0.08	−1.19
Y-791493	1.19	−0.28	−0.90

if the meteorites were derived from the same oxygen reservoir. However, none of the other members of the "primitive achondrite" group can have been derived from the same reservoir. Note that this conclusion is not affected by the possible presence of Antarctic weathering products. The effect of addition of very light Antarctic oxygen is to displace the composition parallel to the terrestrial fractionation line, without changing the value of (δ^{17}–0.52δ^{18}) by any significant amount. In any case, inspection in thin section shows that Y-791493 has the least amount of visible iron oxide staining of the three Yamato achondrites in this group, while it has the lowest δ^{18}O value. Hence much of the isotopic variation among these meteorites is probably not due to weathering. Further study of these interesting meteorites, through isotopic analysis of separated minerals, may reveal more about their relationships to one another and to other achondrites.

Y-790981 is a ureilite with highly shocked coarse-grained olivine and pyroxene. Rusty coatings are visible on grain surfaces and in interior cracks. The whole-rock isotopic composition plotted in Fig. 1 shows an ^{18}O displacement of about 2‰ from previously analyzed ureilites, which corresponds to about 4% contamination by oxygen in weathering products.

Y-790112 is a carbonaceous chondrite which was classified as a CR type (like Renazzo and Al Rais) primarily on the basis of the presence of a metal phase (NATIONAL INSTITUTE OF POLAR RESEARCH, 1982). This classification was supported by the nitrogen isotope data of GRADY *et al.* (1983). Renazzo and Al Rais are very heterogeneous in oxygen isotopic composition (CLAYTON and MAYEDA, 1977). The line labeled CR in Fig. 1 is the locus of data points for chondrules and separated olivine and pyroxene from these two meteorites. The phyllosilicate matrix falls near the terrestrial fractionation line off the diagram to the upper right (δ^{18}O of +10 to +14‰). Thus the isotopic composition of Y-790112 is what would be expected for a mixture of the anhydrous and hydrous components similar to those in Renazzo and Al Rais. This composition is quite different from that of any other C2 or C3 meteorite (CLAYTON and MAYEDA, 1984) and supports the CR classification.

Y-75097 is an L6 chondrite which contains a 2-cm diameter white dunitic inclusion. The isotopic composition of the host chondrite is typical of equilibrated L-group chondrites (CLAYTON and MAYEDA, 1982). The composition of the inclusion is distinctly different, and is close to the field of H-group chondrites. Although many examples of inclusions of carbonaceous chondrites in ordinary chondrites are known (WILKENING, 1977), inclusions of one iron-group of ordinary chondrites in another are rare. RUBIN *et al.* (1983) described inclusions of H, LL, and C material in the brecciated H-chondrite Dimmitt, and PELLAS (1973) and DODD (1974) described H-chondrite inclusions in the LL chondrite St. Mesmin. In fact, an H-chondrite inclusion in St. Mesmin has exactly the same oxygen isotopic composition as the inclusion in Y-75097. We are not aware of any previous report of H-chondrite material in an L-chondrite host. It should be noted, however, that the texture of the inclusion in Y-75097 is in no way chondritic, as the entire inclusion consists of tabular olivine cytstals with interstitial glass, and lacks opaque minerals. The oxygen isotopic composition does not match that of any know achondrites (CLAYTON and MAYEDA, 1983).

Y-790269 is an H4 chondrite selected for study of the isotopic composition of individual chondrules. However, two analyses of the bulk chondrite show extreme effects of Antarctic weathering. The sample with $\delta^{18}O=-0.08‰$ has been shifted by 4‰ relative to an unaltered H4 composition, which corresponds to a 9% contamination of the sample by weathering products. This meteorite was classified in weathering category C (severe) (NATIONAL INSTITUTE OF POLAR RESEARCH, 1982).

3. Conclusions

Oxygen isotopic compositions support the earlier classification of Y-791197 as a lunar rock and of Y-790112 as a CR chondrite. Compositions of achondrites Y-74357, Y-75274, and Y-791493 do not permit them to be derived from the same oxygen reservoir as the winonaites and silicates in the IAB-IIICD irons. Their possible genetic relationship to Lodran may be revealed by further analyses of separated minerals. Ureilite Y-790981 has been slightly altered by Antarctic weathering, and H-chondrite Y-790269 has been heavily altered. Y-75097 is an L6 chondrite containing a large dunitic inclusion with an oxygen isotopic composition typical of H-chondrite material.

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