THE Pd-Ag SYSTEMATICS IN CHONDRITES AND MESOSIDERITES

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Excess ^{107}Ag (^{107}Ag*) has been found in several groups of meteorites [1-2] and is inferred to be due to *in situ* decay of ^{107}Pd ($t_{1/2}$ = 6.5 10^6y). The present work was carried out to search for ^{107}Ag* in chondrites and mesosiderites. A piece (4.79g) of Rose City, an olivine-bronzite chondrite (H5), was leached with dilute HBr, HCl and aqua regia to remove surface contamination. After leaching, the interior piece (4.53 g) was placed in 12M HCl for 8 days, then in hot aqua regia for 1 day. In this step, about 20% of the total sample was dissolved and the residue (3.64g) consisted mostly of silicates. The solution contained dissolved materials from Fe-Ni metal, sulfides and some silicate (olivine). Aliquots were taken for the determination of Ag isotopic composition and Pd, Ag concentrations. The results are shown in Table 1. The ^{107}Ag/^{109}Ag ratio in the metal-rich phases of Rose City is 1.080 $\pm$ 0.002 which is the same as in normal silver (1.0803 $\pm$ 0.0014). The ^{108}Pd/^{109}Ag ratio in Rose City is ~ 22. The Pd-Ag in another chondrite, Floyd (olivine-hypersthene chondrite, L4) were also determined using the same procedure as above. About 11% of the total sample was dissolved. The ^{107}Ag/^{109}Ag ratio in the metal-rich phase of Floyd is also the same as in normal silver. The ^{108}Pd/^{109}Ag ratio in Floyd is ~ 15. The ^{108}Pd/^{109}Ag ratios in Rose City and Floyd are comparable to those in group IA iron meteorites such as Canyon Diablo (i.e. ^{108}Pd/^{109}Ag ~ 40), but are much lower than those in other groups of iron meteorites (^{108}Pd/^{109}Ag ~ 10^2 to 10^5). The ^{108}Pd/^{109}Ag ratio for the average solar-system is ~ 1.6 [3].

In previous work [2], we found that the ^{108}Pd/^{109}Ag ratio in a mesosiderite, Morristown, was ~ 200 with a ^{107}Ag/^{109}Ag ratio (1.084) close to but slightly above normal (δ^{107}Ag = 2.6 $\pm$ 0.6). In the present study, we determined the Pd-Ag in a mesosiderite, Bencubbin, which is a polymict breccia containing metal clasts, silicate clasts, and chondritic xenoliths hrld together by a glass-metal matrix [4,5]. A piece of Bencubbin was analyzed using the same procedure as above for chondrites and about 55% of the total material was dissolved. However, after a few days of storage, small clusters of a black precipitate appeared in the metal-rich solution. The ^{108}Pd/^{109}Ag ratio determined in this solution is ~ 16 and the ^{107}Ag/^{109}Ag ratio is the same as in normal silver. The Pd content (0.31 μg/g) determined for this metal-rich phases of Bencubbin is from a factor of 5 to 20 lower than other groups of meteorites (Table 2). In order to verify this, we removed a single metal clast (0.15 g) from Bencubbin and dissolved it completely so that no precipitates were present. The Pd concentration in this metal clast is 3.0 μg/g. The discrepancy in Pd contents between the solution of the partially dissolved sample and the metal clast may indicate sample heterogeneity or more likely an artifact. Pd, Ag and other platinum group elements (PGE) may have been partially precipitated in the metal-rich solution. Palladium is one of the moderately volatile elements, with a condensation temperature ($\approx$ 1334°K) about the same as Fe and Ni [6]. The Ni contents in the metal clasts of Bencubbin vary from 5.3 to 7.5 wt% [5] which are similar to IA and IIAB irons. The Pd content (3.0 μg/g) in the metal clast of Bencubbin is within the range (3 to 5 μg/g) in IA irons. The fractionation of Pd relative to Ni is very limited in iron meteorites and other Fe-Ni phases in meteorites [7]. Therefore, the high abundance of Pd in the metal clast of Bencubbin seems more likely to be correct. A repeat experiment will be reported. Previous studies indicated that the compositions of the metal clasts of Bencubbin show elemental abundance patterns which are consistent with equilibrium condensation [5]. The matrix material in Bencubbin, characterized by an extensive fusion texture, is believed to be the result of shock induced melting. The shock event might only affect small particles surrounded by silicates, or metal adjacent to silicates and the duration of the heating event could be very short [5]. There is also no evidence of Ni mobility or recrystallization of chondritic fragments [5]. The ^{15}N/^{14}N ratios in the silicate phases of Bencubbin are enriched by as high as a factor of 2 [8]. The excess ^{15}N may be due either to a nucleosynthetic origin or to extreme isotopic fractionation [8]. This meteorite is obviously a peculiar aggregate. More work will be needed to better understand the geochemistry of Pd-Ag and the PGE in Bencubbin relative to other meteorite classes.

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In summary, the $^{107}Ag/^{109}Ag$ ratio in the metal phases of two chondrites and a mesosiderite are the same as in normal silver. This is consistent with the low $^{108}Pd/^{109}Ag$ ratios in these meteorites. The temporal connection between meteorites and chondrites using the ^{107}Pd chronometer is a most important one, however no metal phases with high Pd/Ag have so far been found in chondrites. The new results yield an upper limit of $^{107}Ag^*/^{108}Pd$ about 3×10^{-5} to 1.3×10^{-4} which is also consistent with $^{107}Ag^*/^{108}Pd$ determined for other meteorites including those where $^{107}Ag^*$ has been detected (Table 2).

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Table 1. Pd-Ag results[a]

Meteorite	Sample	Abundance (Atoms/g) ^{108}Pd (10^{15})	^{109}Ag (10^{14})	$^{107}Ag^b/^{109}Ag$	$^{108}Pd/^{109}Ag$
Chondrite					
Rose City (H5)	WR Leach	5.17 (2)	3.356 (6)	1.080 (2)	15.4 (1)
Floyd (L4)	WR Leach	2.55 (1)	1.182 (2)	1.079 (2)	21.6 (1)
Mesosiderite					
Bencubbin	WR Leach[c]	0.470 (2)	0.2896 (4)	1.081 (2)	16.3 (1)
	Metal Clast	4.54 (3)	0.2032 (4)	--	223 (2)

a. Numbers in parentheses represent 2σ errors of the last significant figures. b. Faraday cup data, $(^{107}Ag/^{109}Ag)_{normal} = 1.0803 \pm 0.0014$. c. Pd/Ag concentration may be too low, see text.

Table 2. Summary of Pd and Ag abundances in meteorites.

Group[a]	Pd(μg/g)	Ag(ng/g)	$\delta^{107}Ag$(‰)	$^{107}Ag^*/^{108}Pd$ $(\times 10^{-5})$
Chondrites (2)				
Rose City	3.5	125	- 0 -	< 11
Floyd	1.7	44	- 0 -	< 3
Pallasites (3)	4.5 - 5.9	6.14	0, 5.0	1
Mesosiderites (2)				
Bencubbin	0.31[c],3.0	11[c],7.6	- 0 -	< 13
Morristown	3.7	11	- 0 -	< 1.5
Irons				
IA (2)	3.6 - 4.5	28 - 47	- 0 -	< 2
IIB (1)	2.3	3.1	8.4	1.6
IIIA,B (3)	3.2 - 5.0	2.6 - 5.8	7 - 19	1.5
IVA (8)	2.9 - 6.4	0.03 - 0.20	300 - 7100	1.9 - 3.1
IVB (7)	6.4 - 12	0.06 - 16	26 - 1900	0.05 - 1.9
UN (5)	4.1 - 13	0.05 - 5.7	25 - 1600	0.3 - 1.7

a. Numbers in parentheses represent number of meteorites analyzed. b. From this work and [1,2]. c. See footnote c of Table 1.

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