NOBLE METAL ENRICHMENTS IN COSMIC SPHERULES

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ABSTRACT. In this work, studies on relationships of chemical compositions between fusion crust and nucleus in iron spherules are reported. More than 10% of the iron spherules which were picked out from deep sea sediment, have cores and crusts. We were able to divide three of them into cores and crusts. Each cores and crusts were analyzed individually by INAA. The core mainly consists of iron and nickel. Other trace elements, especially noble metal Au and Ir were concentrated in the core. The mechanism of core formation in the iron spherules shows us the origin of them.

1. Introduction

After Murray and Renard's first discovery of cosmic spherules a century ago, many spherules found out from sea sediments were investigated in recent two decades by means of various new methods. The achievement of this area has been drawing scientist's attention more and more to it.

Spherules from deep sea sediment were classified into three main groups by Yamakoshi(1984): iron spherules, silicate spherules and glassy spherules. The iron spherules are of quite importance for its Ni, Ir and high noble metal contents, which have been determined as extraterrestrial matter. Some of the iron spherules have a metalic nucleus (Brownlee(1984), Robin(1987)), thereafter we call it only "core" , and in this paper we mainly examine those spherules. How did the iron spherules with the cores in them come to be? Many hypotheses have been discussed. A widely believed one is that the spherules are ablation products of larger bodies which have frictionized with the atmosphere. Another one is that the spherules exist already in interplanetary space as cosmic dusts or micrometeorites.

2. Experiment

In this work, we examined iron spherules from deep-sea sediments and their 3 cores and its crusts individually with the high sensitive instrumental neutron activation analysis (INAA). All of our spherules were picked from pelagic clay sediments. Most of them are of shiny metallic gray or shiny black colors, and

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small vesicular cavities were found in a few of them. In the iron spherules, small core were found occasionally. Some cracks were in the crusts of 3 iron sperules so we were able to separate the cores from their crusts easily.

Samples of the iron spherules were irradiated with a artificial standard and some powder of Allende chondrite as a reference material in TRIGA II reactor under flux of $0.7\text{-}4.0\times10^{12}$ n/cm^2/s for 15-24 hours. After the irradiation, each sample was measured for 60000 sec with high sensitive Ge(Li) detector. The obtained result of the Allende chondrite showed a good consistency with that given by the literature materials within ±5% deviation.

3. Results

The element concentrations and sample weights of the cores, crusts of 3 iron spherules are listed in Table 1. Fig.1 shows the ratio of the elemental concentration between core and crust. The data of average five typical ordinary iron spherules and an iron meteorite are listed here together for comparison. The analytical errors for the elements, Fe, Ni, Co, Au, Ir and Os are within ±10% under the confidence level of 90%. But the errors for the other elements for which only core/crust ratio are listed in the table are more than 50%.

The obtained results in Table.1 show that the compositions of 3 cores are simply Fe-Ni and trace of some refractory siderophile element. High contents of the Ni and Ir make them sure as extraterrestrial origin which have often been used as a reliable touchstone to identify the extraterres trial origin for their very low abundance in the earth crust and higher in extraterrestrial materials.

Gold is one of the elements which easily evaporates by ablation. So, the abundance of gold in each iron spherules can be used to know their thermal history, whether they were once melted or not. In addition, the differences between the element contents in cores and in their crusts are so large that it is doubtful whether the cores could formed completely during their passage through the atmosphere without gold depletion.

4. Conclusion

Some spherules from pelagic clay sediments were studied individually with INAA. From 3 of them we can separate their core and crust. Core formation mechanism will show us the history of those spherules. The bulk compositions of them are similar to that of the iron meteorite. Ni contents in the 3 cores are more than 33.6%. This is about the same content (Ni: 13 - 46%) in the taenite in iron meteorite. Almost all measured elements are more abundant in core than in crust. Ni has the highest ratio of elemental abundance between core and crust, (Ni:core/crust)=182 the average of three of them. If the parent body were to be the materials which have the same bulk elemental compositions as spherules with the core, these cores and the crust would have been made by melting somewhere.

The high gold contents, which is easily depleted by high temperature melting, suggests that they were heated by just a little over the melting point. And the dulation of melting shold enough for Ni to move toward the center of the spherules to create cores. And when the cores are created, Ni scavenge the

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trace shiderophile elements, noble metals and some rare earth elements to the core.

The condensation of noble metals in the core together with volatile gold, imply some special condition for growing the core in the iron spherules. The heating would occure more slowly than the heating by the friction with earth atmosphere when they are rushed into the earth. The artificial ablation experiments will reveals the formation mechanisms of core in the iron spherules or the nuggets in the silicate spherules.

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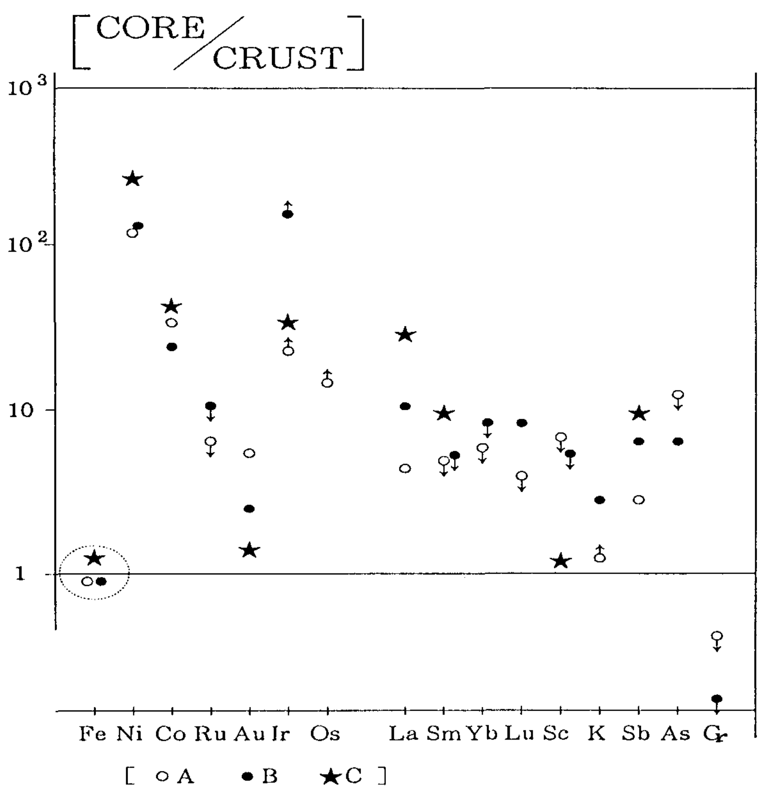

Fig.1 Ratio of the elemental concentration of core/crust.

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TABLE 1. Contens of the elements in the core and crust of three iron spherules.

	A			B			C			Iron Sphe.	C.D.
	CORE	CRUST	CORE/CRUST	CORE	CRUST	CORE/CRUST	CORE	CRUST	CORE/CRUST	(1)	(2)
WEIGHT(mg)	0.0128	0.0958		0.0407	0.1269		0.047	0.177			
Fe (%)	64	78.2	0.818	57	70.3	0.81	53.3	43.3	1.22	75.92	92.3
Ni (%)	33.6	0.27	124	44.2	0.33	134	46.0	0.16	288	4.24	7.25
Co (%)	1.6	0.05	32	2.86	0.12	24	1.70	0.044	39	0.206	0.49
Au (ppm)	20.5	3.6	5.7	2.2	1	2.2	7.33	5.5	1.33	0.045	2.1
Ir (ppm)	29.2	<1.3	-	27.2	<0.17	-	42.4	1.3	33	5.2	2.1
Os (ppm)	<20.3	<2.3	-	30.2	<2.0	-	28.3	-	-	17	3.6
Ru			<10.35			<6.8					
Cr			<0.057			<0.45					
K			>1.33			2.63					
La			11.3			4.23			26.0		
Sm			<4.96			<4.67			9.59		
Yb			<8.2			<5.54					
Lu			8.97			<4.05					
Sc			<5.73			<6.71			1.12		
Sb			7.81			2.76			9.93		
As			>12.5			2.76					

(1) Average five typical ordinary iron spherules.

(2) Iron meteorite (Canyon Diabro)

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