STUDIES ON ISOTOPIC RATIOS OF OSMIUM AND IRIDIUM IN COSMIC SPHERULES USING INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

Kazuo Yamakoshi[1] & Ken'ichi Nogami[2]

[1] Institute for Cosmic Ray Research Univ. Tokyo,
Tanashi Tokyo 188
Japan,

[2] Phys.Lab. Dokkyo Univ.School Medicine,
Mibu Shimotsugagun Tochigi 321-2
Japan.

ABSTRACT Studies on isotopic anomalies in cosmic meteoroids are expected to reveal the features of nuclear synthesis in various phases of star-evolution. The respective isotopes of noble metals had been produced through various reaction processes as well as in various regions of star-eruptions. However, isotopic anomalies of Os in extremely refractory inclusions of primordial carbonaceous chondrites have not been found up to now. In this work, isotopic ratios of the elements having high condensation temperatures, such as Os and Ir, in the cosmic spherules are examined using instrumental neutron activation analysis(INAA).

1. Introduction

The major parts of the magnetic, iron and chondritic spherules collected from deep sea sediments are confirmed to be of extraterrestrial origin (Yamakoshi et al 1981). In previous papers (Nogami et al 1978,Yamakoshi 1982), the isotopic ratios of Os and Ir in the iron spherules from deep sea sediments were measured in non-destructive form. However, no remarkable isotopic anomalies were found. During the entry into Earth's atmosphere, the cosmic meteoroids are suffered the thermal degeneration, lost some volume and changed into rounded bodies. Volatile elemental fractions were evaporated , however, refractory components,

A.C. Levasseur-Regourd and H. Hasegawa (eds.), Origin and Evolution of Interplanetary Dust, 109–112.

such as Os and Ir, are enriched in iron spherules. In some iron spherules Os and Ir are enriched so remarkably, that isotopes of Os and Ir can be well measured using INAA.

2.Sample Description

Large sized, iron spherules were picked out from the magnetic fractions gathered in deep sea sediments obtained off Hawaii Islands by a researching vessel "Hakurei-Maru", which belongs to the Metal Mining Agency of Japan.

The chemical compositions of the used spherules are shown in Table 1. The sample preparing process for INAA is described in detail elsewhere (Yamakoshi et al 1978).

Table 1. Chemical compositions of the used, iron spherules(Yamakoshi et al 1978). [$\pm\sigma$= error]※

SAMPLE CODE	SIZE [μm]	WEIGHT [μg]	Fe [%]	Ni [%]	Co [%]	Au [ppm]	Ir※※ [ppm]	Os※※※ [ppm]
23	530	293	70.1	10.8±0.6	0.062	0.022±0.011	5.7	23.9±0.5
24	500	303	67.1	5.6±0.2	0.26	0.083±0.018	3.0	9.4±0.2
28	500	255	82.9	1.6±0.1	0.13	< 0.003,	7.0	20.4±0.2
29	540	401	83.7	0.5±0.1	0.11	< 0.01	7.0	20.7±0.1
30	440	250	75.8	2.7±0.2	0.47	0.03±0.01	3.1	9.7±0.4

※In the cases of Fe,Co and Ir, the statistical errors could be neglected.

※※compared with Ir-192 of the reference, ※※※ with Os-191 of the reference.

3.Nuclear Data

The stable isotopes of Os are 184(0.018%), 186(1.59%), 187(1.64%), 188(13.3%), 189(16.1%), 190(26.4%) and 192(41.0%). The neutron induced radioisotopes used for INAA are 185(93.6 days), 191(15.4 d) and 193(30.0 hours).

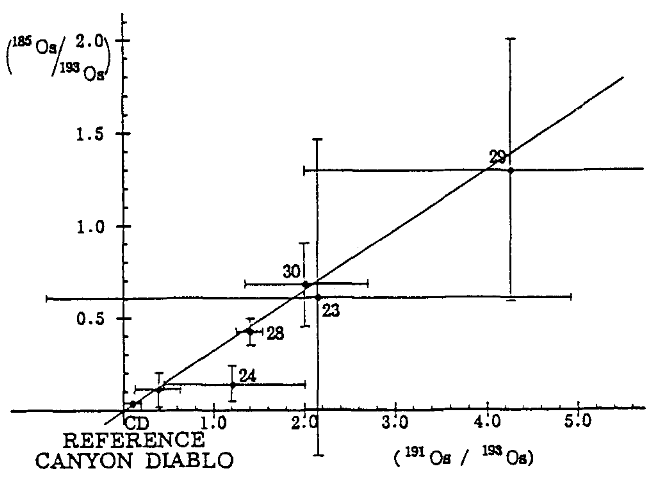
Ir isotopes are 191(37.4%) and 193(62.6%). Thus, the radioactive ones are 192 (74.02 days) and 194(19.15 hours). Unfortunately since the thermal neutron cross section values for such isotopes are not so precisely determined, it is difficult to calculate the atom numbers of the stable (target) isotopes from the radioactivities of the induced radionuclides.

In Os isotopes, Os-184 is produced through p-process only and Os-192 is induced through rapid-process only at super-novae explosions. The other nuclides are produced through both rapid- and slow-processes. The ratio of the fractions of Os-190 produced through r- and s-processes is given as 7(Seeger et al 1965). In the case of Os, Os-184, -190 and 192 can be determined using INAA, thus we can take a three-isotope plot for Os. Ir-190 and -192 are also produced through both r- and s-processes. The ratio of the contributions of r- and s-processes are 14 and 22.8, respectively. Ir has only two isotopes, so we can not make the three-isotope plot, thus we can not cancell out the chemical fractionation effects due to the thermal degenerations.

4. Experimental Results and Discussions

In this work short-lived nuclides were determined not so precisely, because we had received the irradiated samples delayed for two days from the reactor.
The following corrections were performed here; saturation factors during the neutron induced reactions, decays, counting efficiencies of detectors, branching ratios of the measured gamma rays and also side reactions, such as Ir-193(n,p) and Pt-196(n,alpha).
In this preliminary work, the isotopes of Os in a few iron spherules are measured by INAA, which are shown in Fig.1.

Fig.1. The three isotope plot for Os in iron spherules (Canyon Diablo is used for the reference.)



The life-time of Ir-194 is so short, that (Ir-192/Ir-194) ratios in iron meteorites, metal phases in chondrites and iron spherules were not so well determined.

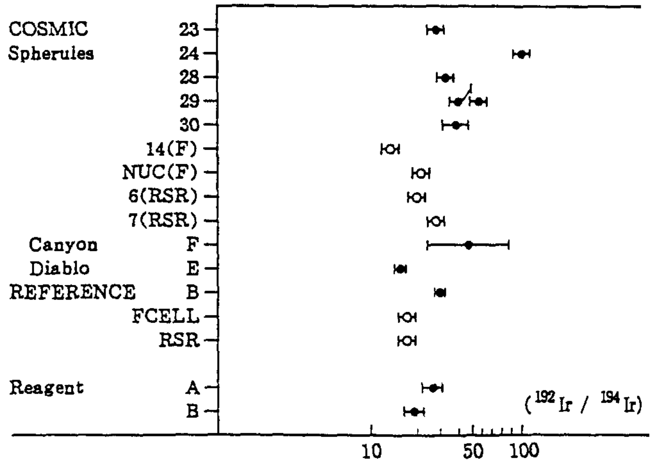


Fig.2. The ratios of (Ir-191/Ir-193) in various cosmic meteoroids obtained with INAA. Iron spherules are considered as melted droplets of iron meteoroids by friction heating in the upper atmosphere.

If so, during the melting, evaporating, and solidifying of the meteoroids, the original compositions of chemical and isotopic components will be changed , so to say, systematically.

In Fig.1 and Fig.2, preliminary results are shown. No remarkable anomalies were found. However, if enormous anomalies are found in both elements, further investigation will be fruitful! In future an ICP mass spectrometry is the most effective tool for extremely refractory metal studies, however, INAA mass spectrometry is also useful in frontier researches.

References

Nogami K, Shimamura T and Yamakoshi K 1973 Bull.General Educ.School Medicine 34 1

Seeger P A, Fowler W A and Clayton D D 1965 Astrophys.J.Suppl.Series 11 121

Yamakoshi K, Nogami K and Shimamura T 1981 J.Geophys.Res.86 B4 3129

Yamakoshi K 1982 Proc.15th ISAS Lunar and Planet.Symposium 326

https://doi.org/10.1017/S0252921100066598 Published online by Cambridge University Press