CHEMICAL AND ISOTOPIC COMPOSITIONS OF REFRACTORY ELEMENTS IN DEEP SEA SPHERULES

Kazuo Yamakoshi and Koichi Honma
Institute for Cosmic Ray Research
University of Tokyo
Tanashi Tokyo 188
Japan

ABSTRACT. In order to study the inhomogeneity of the solar materials at the initial state, the enrichment factors and isotopic anomalies of refractory elements in deep sea spherules relative to the average solar abundance were examined using instrumental neutron activation analysis. Fairly high enrichment factors and isotopic anomalies of refractory elements were observed in several spherules, however, after the ablation process of the spherules during the atmospheric heatings they were not inconsistent with those of normal values in the solar system.

1. INTRODUCTION

During the developing time of the solar system, it is verified, the peak temperatures were inhomogeneous throughout the solar system and also the dynamical mixing of the condensed materials were imperfect. Especially the chemical and isotopic compositions of the elements, which have considerably high condensation temperatures, in the most primitive fractions in carbonaceous chondrites and also in the interplanetary dust are thought to be good indicators for the studies on the pre-history of the solar system.

2. ENRICHMENT FACTORS OF SIDEROPHILE ELEMENTS

In Fig.1, we compared the contents of refractory siderophile elements in deep sea spherules and metal grains from carbonaceous chondrites.
The data of stony spherules determined by Ganapathy et al. (1978) are also plotted. The enrichment factors are defined as the ratio of the elemental compositions to those of type 1 carbonaceous chondrites.

According to the condensation theory in equilibrium, the condensed materials in the solar nebula have the same chemical compositions with those of the solar abundance.

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Grossman and Ganapathy (1976) have given the mean enrichment factors as 18.6 for refractory siderophile and rare earth elements in metal grains from Allende meteorite. However, Palme and Wlotzka (1976) and Palme et al. (1982) gave extremely high enrichment factors of refractory elements in metal grains from carbonaceous chondrites. These very high enrichment factors could be hardly explained by the condensation theory in equilibrium, so they proposed a model of the alloy-condensation of the refractory elements in the solar nebula.

However, we have not yet found such high factors in deep sea spherules. These factors are coincided by chance with those given by Grossman and Ganapathy. However, these factors of the spherules can be explained sufficiently by melting and concentration processes of micrometeorites during the atmospheric heatings.

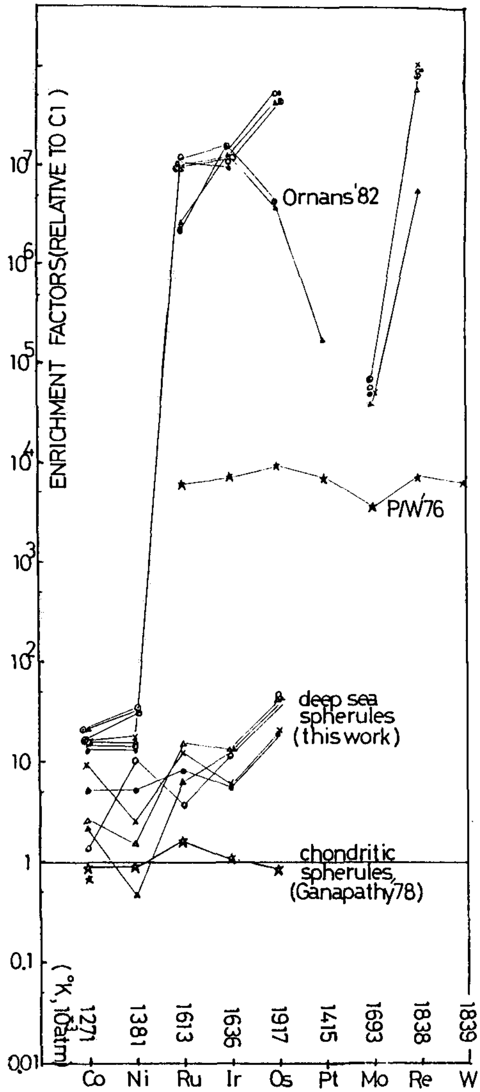

Figure 1. Enrichment factors of refractory elements in deep sea spherules and metal grains from carbonaceous chondrites.

3. (Ru/Os) vs. (Ir/Os) Plot.

In Fig.2, one trial was performed. The correlation between (Ru/Os) and (Ir/Os) is examined to obtain effective clues to understand some kinds of grouping of the data. The data of these metal grains in carbonaceous chondrites determined by Chicago group fall on the trajectory (a). And the end members are the bulk compositions of type 1 carbonaceous chondrites. However, the deep sea spherules fall on another curve (b), whose end members are ordinary iron meteorites, ex. Canyon Diablo. In addition, a strange family of the data from Ornans carbonaceous chondrite gathers on the line (c). This trial is indeed suggestive, however at the present time, no decisive conclusion can be drawn.

4. ISOTOPIC COMPOSITIONS OF OSMIUM AND IRIDIUM

Osmium and Iridium are very suitable elements for studies on the pre-solar and extra-solar materials. In this work, Os-184, Os-190 and Os-192 and also Ir-191 and Ir-193 were measured by instrumental neutron activation analysis.

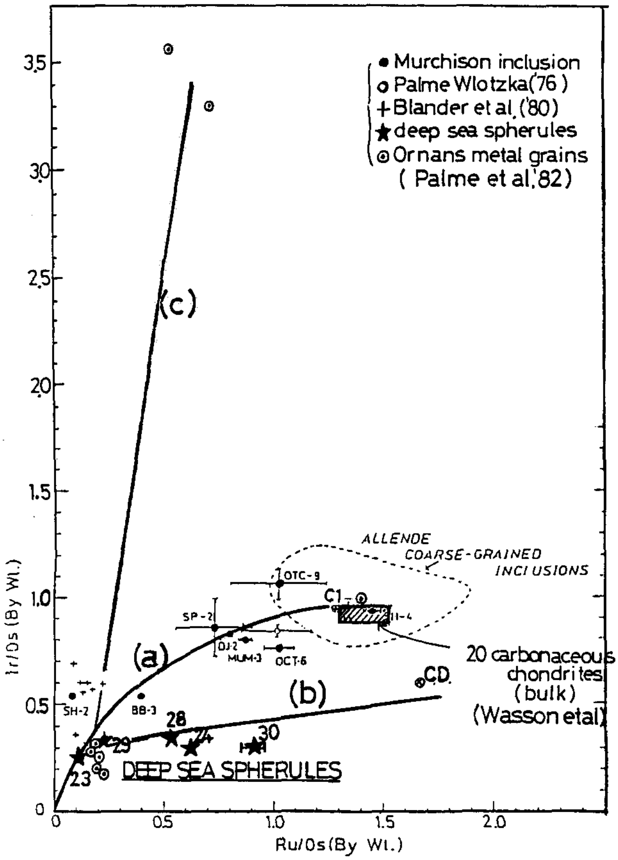

Figure 2. (Ru/Os) vs. (Ir/Os) plots of the deep sea spherules and also metal grains in many carbonaceous chondrites. (Details; see in the text.)

Os-184 is produced through p-process only and Os-192 is induced through r-process only in super-novae explosions. The other nuclides are produced both through r- and s-process.

According to Seeger et al. (1965), the ratio of the nuclides produced through r- and s-process is 7 for Os-190, 14 for Ir-191 and 22.8 for Ir-194, respectively. However, the half-lives of Os-193 (induced from Os-192) and Ir-194 (induced from Ir-193) are so short, that precise measurements of these nuclides could not yet succeeded. In Fig.3, the ratios of Os-185 and Os-191 activities in deep sea metallic spherules and also in Canyon Diablo are shown. And we measured Os reagent samples in many times and we have the reference values shown also in Fig.3.

Almost all spherules are not inconsistent with the reference values, if we take ±2 σ as the statistical errors, these data suggest not so strange results.

5. INTERIM CONCLUSION

Many experimental data obtained in metal grains from carbonaceous chondrites suggest the inhomogeneity of the condensed materials in the solar nebula, however, from the deep sea spherules we could obtain not so decisive evidence in chemical and isotopic compositions.

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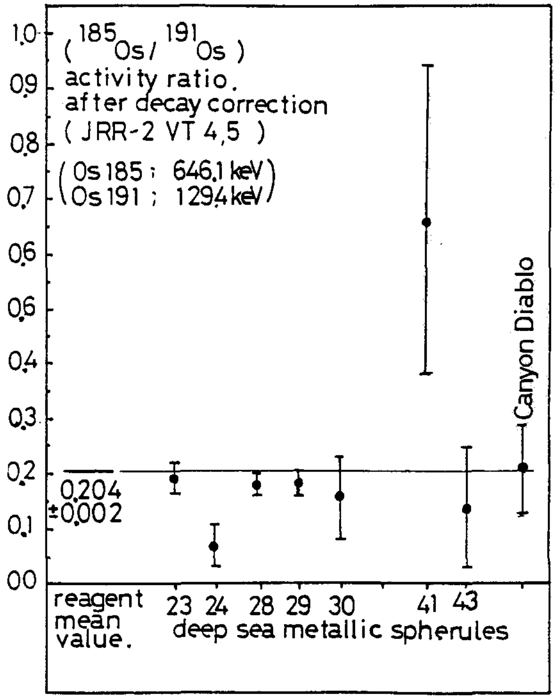

Figure 3. The activity ratio of (Os-185/Os-191) in deep sea spherules and Canyon Diablo. The reference value of the reagent is also shown.

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