COSMIC SPHERULES IN BARE ICE NEAR THE ALLAN HILLS, VICTORIA LAND, ANTARCTICA (EXTENDED ABSTRACT)

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1. Introduction

Dust particles in the atmosphere are closely related to meteorological phenomena: nucleation agents of rain and snow, scatterers and/or absorbers of solar radiation, tracers for circulation of the atmosphere, etc. Most of the particles are of terrestrial origin whether they are natural or artificial, yet extraterrestrial particles may exist among them although probably only in small amount.

Polar regions are not only far from densely populated and/or arid areas but also almost entirely and semi-eternally covered with ice and snow. Therefore the extraterrestrial dust is relatively highly concentrated and unchangeably frozen in polar ice and snow.

NORDENSKIOLD was the first to discover nickel-iron particles referred to as Cryoconite (ice dust) on the Greenland ice cap in 1870, and suggested that the metalic dust might be of extraterrestrial origin (NORDENSKIOLD, 1874). Succeeding discovery of the spherical particles named Cosmic Spherules was made during the cruse of the R/V CHALLENGER VI 1872–1876 by MURRAY and RENARD (1883).

In the late 1950's, NISHIBORI and ISHIZAKI (1959) collected the first particulates from Antarctic snow, during the IGY. Since then there have been many works related to extraterrestrial dust and other particles in Antarctica (MARSHALL, 1962; SCHMIDT, 1964; THOMPSON *et al.*, 1975; FUJII, 1981).

Furthermore, since the middle of the 1970's, mass collections and investigations about two kinds of newly extraterrestrial matters have been carried out: the Antarctic meteorities from the Antarctic bare ice regions (YANAI, 1978; CASSIDY *et al.*, 1977) and chondritic microparticles named Brownlee particles from the stratosphere (BROWNLEE *et al.*, 1976, 1977).

This work was started in order to examine the following subjects: (1) whether positive proof of cosmic dust accretion onto the Earth's surface exists in Antarctic ice and snow or not, (2) whether the variations of dust concentration in the polar ice and snow are derived from those of the cosmic dust influx rate or not, (3) whether the influx rate and the chemical composition of the cosmic dust is correlated with those of Antarctic meteorites or not, etc. Some preliminary results about the Antarctic spherules are reported here.

2. Sample Preparations

Ice and snow samples collected by NISHIO and ANNEXSTAD (1979, 1980) from the bare ice region near the Allan Hills, Victoria Land, Antarctica were used for the laboratory study.

Dust particles were filtered from the frozen ice and snow samples and observed first for their appearances using an optical microscope. Next, spherical dust particles (spherules) more than 10 microns in diameter were picked up and set onto carbon stages for an electron microscope. For further study with X-ray diffraction photographs, the spherules were set again individually on the tips of toothpicks. These procedures were carried out on a clean bench with micro tweezers under view of a stereo zoom-microscope.

3. Experiments and Results

3.1. SEM and EDXMA studies

Two larger spherules in bare ice sample Station 9 (ALH-9-001 and -9-002)

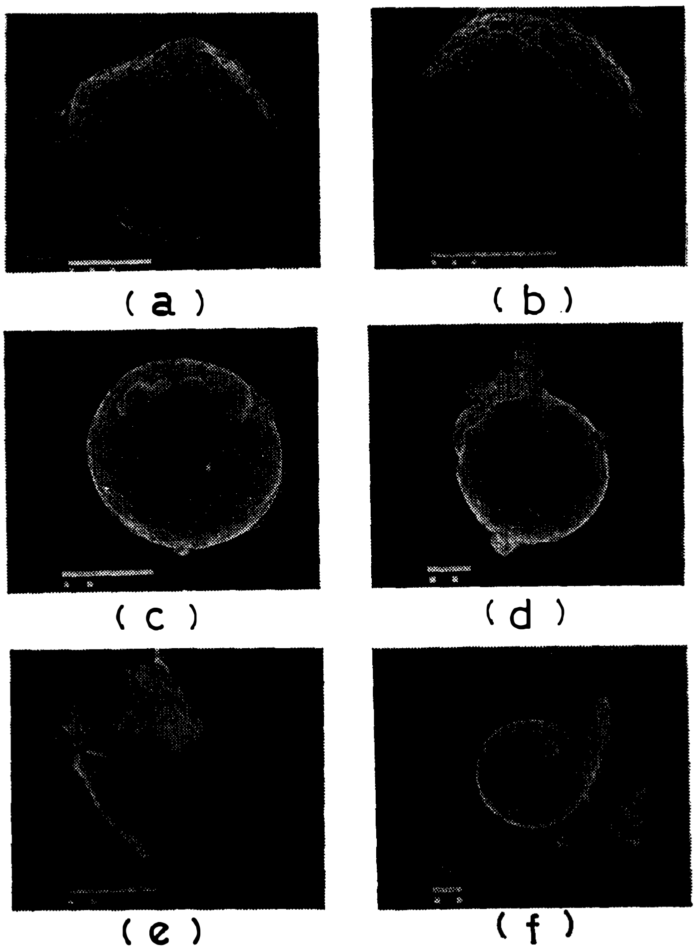

Fig. 1. Microphotographs of the analyzed spherules by means of a scanning electron microscope (SEM). (a) ALH-9-001, and (b) ALH-9-002, were collected from the bare ice sample at Station 9 near the Allan Hills. (c) (d), (e) and (f) are ALH-S-001, -S-002, -S-003 and -S-004, respectively, which were collected from the snow sample at a foot of the Allan Hills. Scale bars in (a) and (b) indicate 100 microns, and (c), (d), (e) and (f) in 10 microns.

and four tinny spherules in snow drifted near a foot of the Allan Hills (ALH-S-001, -S-002, -S-003 and -S-004), sizes of 250, 185, 21, 32, 17 and 35 microns in diameter, respectively, were studied for their morphological and chemical features by means of a scanning electron microscope (SEM) and energy dispersive X-ray microanalyses (EDXMA).

Morphologies of the spherules were quite similar to those of the cosmic spherules in deep-sea sediments, except that the ALH-S-002 had a milky white color with pearly luster never seen on the spherule in deep-sea sediments. The ALH-9-001, -9-002 and -S-001 were brownish black in color and somewhat lacked metallic luster, slightly resembling the fusion crusts of meteorites. The ALH-S-003 and -S-004 had black metallic luster. The spherules in the snow numbered with -S- had relatively smooth surfaces. On the other hand, the spherules at ice Station 9 had rougher surface structures, truncated and well-aligned step-like features with adhering hexagonal platelets (as shown in Fig. 1a) and were aggregated with cubic microcrystallites (as shown in Fig. 1b).

Microphotographs of the ALH-S- spherules are also shown in Figs. 1c-d.

Chemical compositions of the spherules obtained by EDXMA are shown in Fig. 2 with an X-ray pattern of a fragment of the Allende meteorite. The 9-001 and the 9-002 had closest resemblances to the Allende pattern and the typical pattern of chondritic Brownlee particles (BROWNLEE *et al.*, 1977); magnesium silicate with iron-nickel-sulphur. As one of the key elements indicating extraterrestrial origin is nickel in association with iron, the spherules in the snow (ALH-S-001, -002, -003 and -004) had little possibility of extraterrestrial origin, judged

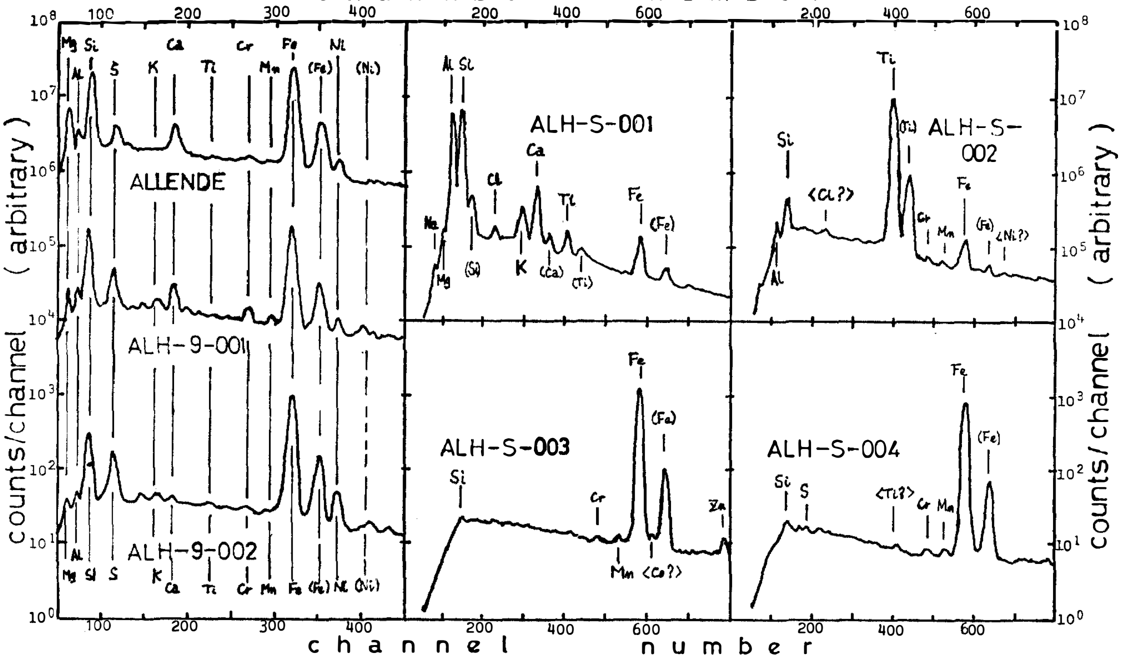

Fig. 2. X-ray patterns of the analyzed spherules compared with a fraction of "Allende" chondrite.

by their depletion of nickel.

3.2. XDP studies

In order to get the crystallographical and mineralogical information, X-ray diffraction photographs were carried out on the ALH-9-001 and -9-002 with K-X-rays of copper and molybdenum using the Debye-Scherrer method. The diffraction pattern of the ALH-9-001 was spotty and/or streaky; that of the ALH-9-002 was, on the other hand, smooth. These patterns were consistent with the morphologies mentioned above.

The lattice spacings of both of the spherules showed major lines of an iron depleted olivine and a few lines of a magnetite. Their chemical compositions (as shown in Fig. 2) suggested that iron-nickel alloys and/or iron-nickel-sulphides might exist; however, there were no more signs of metallic and/or sulphurous material anywhere in those diffraction patterns.

Metallic spherules in deep sea sediments often show the patterns of iron oxides; magnetite and wustite, and/or iron-nickel alloys; taenite and/or kamacite. Silicate spherules, on the other hand, often consist of iron depleted olivine, magnetite, chromite, quartz or glass, etc. (BLANCHARD *et al.*, 1979; TAZAWA, 1979; NOGAMI *et al.*, 1980). Results of this work suggested that the ALH-9-001 and the ALH-9-002 might be less altered than the spherules in deep sea sediments. Further investigations are being carried on.

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