COSMIC SPHERULES FROM TRIASSIC DEEP-SEA SEDIMENTS IN JAPAN.

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Introduction: Cosmic spherules are subspherical to spherical particles of <1 mm diameter which are produced by melting of interplanetary dust and large objects during atmospheric entry. Although cosmic spherules are known principally from the ice sheets of polar regions and Cenozoic deep-sea sediments [1-3], a few spherules older than Mesozoic were recovered from the sedimentary rocks of pelagic limestone, radiolarian chert, and halite [4, 5]. Here we report newly-discovered spherules from the Triassic radiolarian chert of southwest Japan, which is considered to have accumulated in a mid-oceanic basin of the ancient Pacific Ocean (Panthalassa). Spherules from the Triassic chert are of great significance for understanding the composition of earth-crossing materials as well as their flux rate during Triassic time.

Samples and methods: Spherules were discovered from the Triassic radiolarian chert succession of the Chichibu terrane, defined as a Jurassic subduction-generated accretionary complex in Japan. Radiolarian chert of the Chichibu terrane is considered to be long-lived Panthalassic remnants that represent a far-traveled proto-Pacific plate assemblage [6]. Our study section of the Chichibu terrane is located on Ajiro Island (GPS coordinates:33˚4.12N/131˚55.11E) in eastern Kyushu, southwest Japan. Radiolarian biostratigraphic investigation reveals that the chert succession (19 m thick) on Ajiro Island is correlated with the Anisian (ca. 245-237 Ma) to lower Ladinian. The average sedimentation rate of the chert, estimated from measured thickness and the time interval, is approximately 2 mm/kyr.

Spherules were extracted from samples of thin siliceous shale partings intercalated within 2-6 cm thick chert beds. Samples were mechanically crushed and their fragments were passed through a 250-µm mesh sieve. A grain size of less than 250 µm were selected until the total value of them became greater than 3 g. After sieving, the magnetic components were separated using the method for liquid-suspended particles [7]. Spherules were handpicked from the magnetic components under a binocular microscope and analyzed for detailed textural features using scanning electron microscope (SEM). The surface texture of the spherules was observe first, and then the spherules were sectioned and polished to acquire their internal texture. For the qualitative elemental characterization of the spherules, energy dispersive spectra (EDS) was used. The principles for identification of cosmic spherules are based on those described from Antarctic micrometeorites (AMMs) [8].

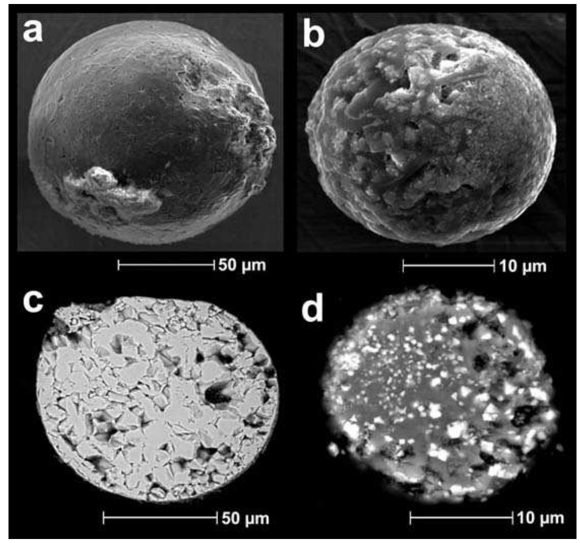

Fig. 1. Secondary (a, b) and backscatter (c, d) electron micrographs of cosmic spherules from Middle Triassic (Anisian) radiolarian chert. a, c) I-type spherule; b, d) porphyritic S-type spherule.

Results and discussion: 172 grams of the 36 shale samples from the Triassic chert succession yield 107 spherules. The Triassic spherules range in size from 5 to 128 μm, and the largest population is observed at size range from 20 to 50 μm. Most of the spherules are perfectly spherical whereas some were oval shape. Based chiefly upon the textures and chemical compositions, two major spherule types were discriminated: iron-type (I-type) and silicate-type (S-type) spherules (Fig. 1). In addition to these major types, glass with dendritic magnetite (G-type) spherules were found in the chert succession.

I-type spherules comprise about 84% of collected spherules. Various types of the textures are present in I-type spherules: polygonal, dendritic, smooth surface, and interlocking textures. A single spherical void is often recognized in a polished section of I-type spherules, and this void is possibly a mold of a Fe-Ni metallic core described in deep-sea spherules (DSS) [1]. Exterior surfaces of I-type spherules are rich in Fe with subordinate amount of Al, Si and K (Fig. 2). The concentration of Al, Si and K, however, are quiet low in internal parts. Internal parts of I-type spherules are dominated by Fe oxide with minor amounts of Fe-Ni oxide. Semi-quantitative SEM-EDS analysis shows that Fe-Ni spherules contain 2.8 to 21.5 wt% NiO. S-type spherules are about 13% of total number of spherules. Spherical voids are often present on the surfaces and internal parts of S-type spherules. Although their mineral composition remains uncertain, S-type spherules is characterized by cryptocrystalline and porphyritic textures similar to those reported in DSS. S-type spherules consist mostly of Mg, Si, and Fe with varying amounts of Al, K, Ca, and Ni (Fig. 3). Some S-type spherules show characteristic energy spectra known from collections of AMMs [8]: large peaks at Mg, Si and Fe, and small peaks at Al, Ca and Ni. However, most of S-type spherules from the Triassic chert are rich in Al and Si, and poor in Ca and Mg, as compared with AMMs. G-type spherules are characterized by dendritic magnetites in the silicate glass. Dendritic magnetites have a wide range of thickness and growth patterns.

The textures and major element compositions of the Triassic spherules are similar to those of DSS and AMMs. However, the Triassic spherules have a wide range in chemical composition, depending on degree of alteration. SEM-EDS analysis suggests that I-type spherules from the Triassic chert have been altered as indicated by the presence of Al, Si and K on the surface of the spherules (Fig. 2). S-type spherules in the Triassic chert are generally enriched in Al and Si, and depleted in Mg and Ca relative to DSS and AMMs (Fig. 3). Relatively large amounts of Al and Si in S-type spherules are most likely derived from the radiolarian chert which has high SiO_2 and Al_2O_3 contents [9]. Our results suggest that the original composition of most of the Triassic spherules is obscured by intense alteration during diagenetic processes.

Summary: Middle Triassic spherules are first described from the ancient deep-sea sediments in the accretionary complex of Japan. Although most of the Triassic spherules are degraded by chemical alteration, discovery of the spherules provide a valuable information for understanding the flux and compositions of extraterrestrial particles into the Earth during the Triassic. The radiolarian chert of the Chichibu terrane in Japan records a Lower Triassic to Middle Jurassic pelagic sedimentation, and its time span is about 90 million years. Systematic studies of the spherules from the Chichibu chert also provide long-term changes in spherule types throughout the Triassic and Jurassic periods.

References: [1] Blanchard M. B. et al. (1980) *Earth & Planet. Sci. Lett., 46,* 178-190. [2] Yada T. et al. (1996) *Proc. NIPR Symp. Antarct. Meteorites, 9*, 218-236. [3] Taylor S. et al. (2000) *Meteoritics & Planet. Sci., 55,* 651-666. [4] Taylor S. and Brownlee D. E. (1991) *Meteoritics, 26,* 203–211. [5] Davidson M. J. (2007) *LPS XXXVIII,* Abstract #1545. [6] Matsuoka A. (1992) *Palaeogeogr. Palaeoecol. Palaeoclimat., 90,* 1151–1154. [7] Mutch T. A. and Garrison R. E. (1967) *J. Sed. Petrol., 37,* 1139-1146. [8] Nakamura T. et al. (1999) *Antarct. Meteorite Res., 12,* 183–198. [9] Kunimaru T. et al. (1998) *Sediment. Geol., 119,* 195-217.

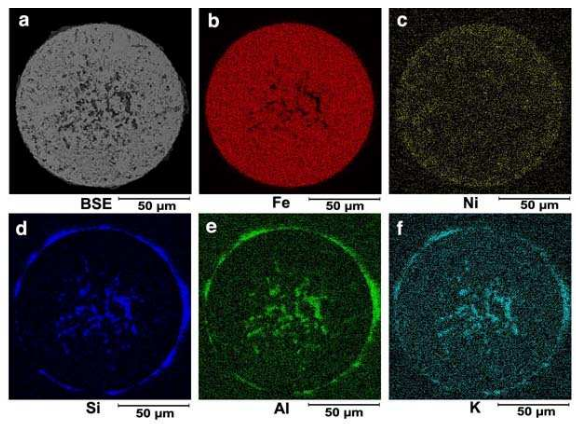

Fig. 2. Backscattered-electron image (a) and chemical compositional maps (b-f) of I-type spherule from Anisian radiolarian chert.

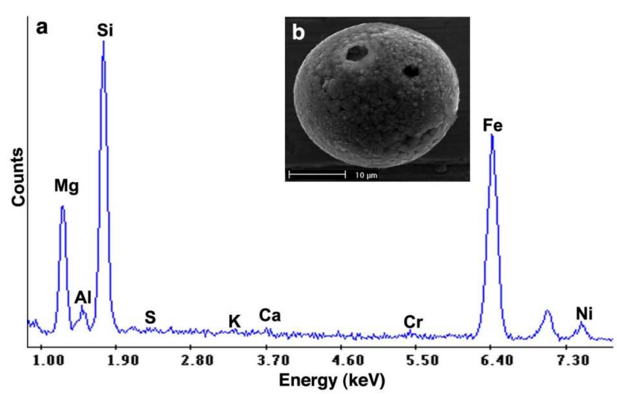

Fig. 3. X-ray energy spectrum (a) and SEM image (b) of S-type spherule from Anisian radiolarian chert.