

The mineralogy of Comet Wild-2 nucleus samples – What we think we know and what we do not know

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The sample return capsule of the Stardust spacecraft was successfully recovered in northern Utah on January 15, 2006, and its cargo of coma grains from Comet Wild-2 captured in aerogel tiles has now been the subject of intense investigation by approximately 200 scientists scattered across five continents. We have now performed mineralogical and petrographic analyses of particles derived directly from the Jupiter-family Comet Wild-2.

Numerous particles were collected by impact into low density aerogel. Dozens to thousands of fragments of the impacting particles are distributed along 100 m-1cm-length tracks. So far 52 of these tracks have been harvested, and samples of 26 tracks have been studied in enough detail to give first order views of their mineralogy [1]. The recovered Wild-2 samples are mixtures of crystalline and amorphous materials. However, it is unclear how much of the amorphous material was produced from the aerogel during the particle capture. Crystalline materials are abundant in Comet Wild-2 and many are “coarse-grained” (1-10 μm) relative to the submicrometer scales characteristic of anhydrous IDPs and interstellar dust. Of the best studied 26 tracks, eight are dominated by olivine, seven by low-Ca pyroxene, three by similar amounts of olivine and pyroxene, and the remaining eight are dominated by other minerals, mainly Fe-Ni sulfides. Our emerging model is that many of the impacting particles were very fine-grained, loosely-bound aggregates with a bulk chondritic composition. Most also contain large individual crystals (most commonly) of olivine, pyroxene and Fe-Ni sulfides, similar to chondritic IDPs. Olivine and Low-Ca Pyroxene is present in most Wild-2 particles, with grain sizes ranging from sub- μm to over 10 μm . Wild-2 olivine has an extremely wide compositional range, from Fo₄₋₁₀₀, with a pronounced peak at Fo₉₉. The wide Mg-Fe compositional range of Wild-2 olivine is similar to both anhydrous chondritic IDPs, and also to matrix minerals of the chondrites Murchison (CM2), and Orgueil (CI1), which have experienced significant-to-pervasive aqueous alteration. Both low- and high-Ca pyroxenes are present among the Wild-2 grains, with the former being dominant. The compositional range displayed by the low-calcium Ca pyroxene is also very extensive, from En₅₂₋₁₀₀, with a significant frequency peak centered at En₉₅.

Reference

- [1] Zolensky M. *et al.* (2006) Mineralogy and Petrology of Comet Wild 2 Nucleus Samples. *Science* **314**, 1735-1740

Rb-Sr single bed isochron dating with evidence of isotope equilibrium

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Introduction

Sedimentary rocks consist of various components, isotope ratios of which are considered to indicate different ages. If isotopic age determinations of the sedimentary rocks can be carried out, the isotopes had to equilibrate, after sources of them had deposited. It is difficult to verify the isotope equilibrium. Shibata and Mizutani (1982) reported Rb-Sr isochron age of 211 ± 4.7 Ma with initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.71325 ± 20 for the Triassic chert, which is younger than the fossil age. They regarded the Rb-Sr age as a diagenesis age. They collected the samples ranging 10 m in thickness. The strata of this thickness is hard to regard to be formed by a single sedimentary event. They didn't discuss equilibrium of Sr isotopes.

In this study, we used a single layer of the Triassic bedded chert in the Mino belt, central Japan to determine a Rb-Sr isochron age. Conodont fossils, one of the components of the chert, were also separated in order to measure the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio.

Analytical method

The sample was cut parallel to the bedding plain into twelve slices, each of which was used as a whole rock sample. Concentration of Rb and Sr of the slices were determined by a thermal ionization quadrupole mass spectrometer, Finnigan MAT Thermoquad THQ. Sr isotope ratio was measured with a VG Sector 54-30 thermal ionization mass spectrometer at Nagoya University. In case of conodonts, a Ta emitter solution (Brick, 1986) was used to load Sr onto single Re filament with $2\text{M-H}_3\text{PO}_4$.

Result and Discussion

Rb-Sr isochron age of the chert was 219 ± 22 Ma with the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.7125 ± 9 . The Rb-Sr age is indistinguishable from the depositional age (Norian: Sugiyama, 1997) indicated by the radiolarian fossils

Conodonts in the chert consist mainly of apatite. Apatite contains extremely low content of Rb but rich in Sr. This indicates that the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of conodonts would not have evolved since the conodonts were deposited. Since conodonts are part of marine organisms, the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio must be same as that of seawater at the time of deposition. The $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of the Triassic conodonts, however, is 0.712211 ± 22 ($^{87}\text{Rb}/^{86}\text{Sr}=0.10$) and higher than that of Triassic seawater ($=0.708$), while it is indistinguishable from the initial Sr ratio ($=0.7125 \pm 9$) of the chert. This indicates that the chert layer including conodont fossils are equilibrated in term of Sr isotopes after its deposition. Because the Rb-Sr age is consistent with the radiolarian age, the Sr isotopes were equilibrated just after the sources of chert had deposited.