Elastic property of Ryugu samples collected at the second touch-down site

Keisuke Onodera[1], Yuta Ino[2,3], Satoshi Tanaka[3], Taichi Kawamura[4], Takuya Ishizaki[3], Ryota Fukai[3], Rei Kanemaru[3], Takahiro Iwata[3], Tomoki Nakamura[5], HAYABUSA2 initial sample analysis team

[1]*Earthquake Research Institute, The University of Tokyo*

[2]*Kwansei Gakuin University*

[3]*Institute of Space Astronautical Science, Japan Aerospace Exploration Agency*

[4]*Institut de Physique du Globe de Paris, Université Paris Cité*

[5]*Department of Earth Sciences, Tohoku University*

Introduction

Since the HAYABUSA2's successful return from the 6 years of space journey on December 5th 2020, many analyses of the collected samples have been conducted (e.g., [1]-[4]). Those studies help us better understand the ancient history of the solar system as well as the Ryugu's characteristics and its origin.

According to the initial analysis [1]-[3], it turned out that Ryugu showed high similarity to CI chondrites (e.g., Ivuna, Orgueil) from the petrological or mineralogical aspect. For example, Visible-Near infrared reflectance spectra of Ryugu samples show a sharp absorption at 2.72 μm – consistent with the remote sensing observation [5] – and weak absorptions at 3.4 and 3.95 μm as seen in CI chondrites. These observations provide us with chemical features, allowing us to interpret how these particles were formed under what kind of environment.

In addition to chemical aspects, physical properties such as density, porosity, and rigidity are also of great importance. Especially, rigidity is one of the paramount parameters to constrain the formation process from the catastrophic impact to re-accumulation to make a rubble pile body [4]. Also, the elastic behavior like seismic wave propagation is closely related to the asteroid's surface evolution (e.g., seismic shaking).

In this study, through the measurement of seismic wave velocity, we are trying to provide a detailed description on elastic properties such as seismic wave velocity, Young's modulus, and attenuation quality factor. Moreover, by comparing the derived parameters with those for other carbonaceous chondrites, we discuss which type is the most similar to Ryugu from the viewpoint of elastic property.

Samples used for measurements

For the measurements, C0002-No3 and No4 were allocated to us. Both particles are mm scale with a thickness of 0.5 – 1.0 mm, cut out of one of the largest samples collected at the second touch-down site. Figure 1 shows the micrographs of the respective particles. Note that the C0002-No4 was broken into two pieces over the course of the physical property measurements [4], and we measured their seismic waves individually.

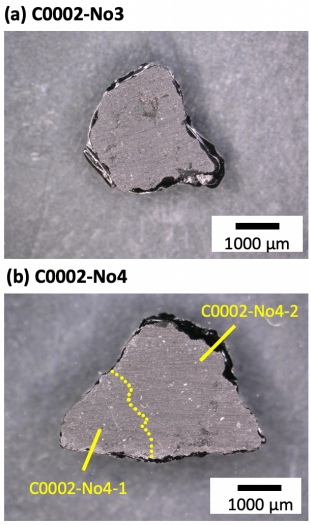

Figure 1. Micrographs of Ryugu sample (a: C0002-No3, b: C0002-No4). For the measurements, we used the divided pieces of C0004-No4 (1&2).

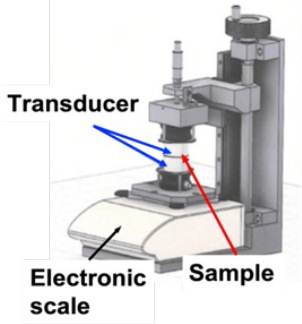

Figure 2. Schematic illustration of the experimental setting.

Seismic wave velocity measurement and estimation of Young's modulus

We adopted the pulse transmission method [6] to measure P and S wave velocities. The experimental setting is shown in Figure 2, where a sample is sandwiched with two transducers placed on an electronic scale. This kind of setting allows us to measure the wave velocity monitoring the loading simultaneously. The principle is to transmit a pulse from one side transducer to another side for two settings: (i) transducers without sample, (ii) transducers with a sample interposed. Then, we can obtain the time delay by comparing two signals (Figure 3). Since the thickness and density of each sample are known, the seismic wave velocity and Young's modulus can be obtained in the end. As a result, we obtained V_p=1.9 – 2.3 km/s, V_s=1.2 – 1.4 km/s, and 6.2 – 8.6 GPa for Young's

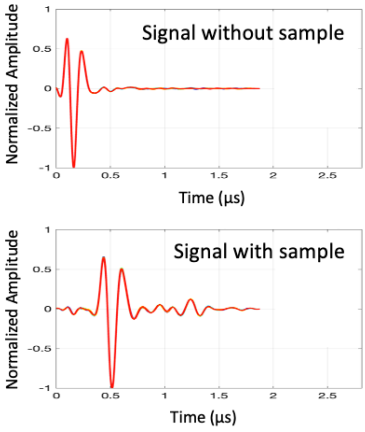

Figure 3. Transmitted signal without sample (top) and with sample (bottom). Time delay between them gives seismic wave velocity.

modulus under 1 MPa loading (Table 1). While Nakamura et al. [4] reported the average values of these samples, this presentation will show the individual results. Moreover, we discuss whether Ryugu is similar to CI chondrites also from elastic property through the comparison of our results with those for various carbonaceous chondrites.

Table 1. P- and S-wave velocities and Young's modulus for each sample

Sample name	V_p (km/s)	V_s (km/s)	Young's modulus (GPa)
C0002-No3	2.25±0.01	1.42±0.15	8.58±3.17
C0002-No4-1	1.94±0.01	1.20±0.01	6.24±2.80
C0002-No4-2	1.96±0.01	1.32±0.07	6.88±2.34

References

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