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Hayabusa2 - mission and science results up to now

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Abstract

Hayabusa2 arrived at a C-type near Earth asteroid, (162173) Ryugu on 27 June 2018. We have carried out remote sensing observations, several descent operations, and releases of two small rovers and one lander within the year of 2018. Then in the year of 2019, the first touchdown operation was executed successfully in February, and the impactor experiment was done in April. We were able to observe the ejecta curtain and we have confirmed a crater created by the impactor. We have a lot of scientific data about Ryugu by the operations up to now and the natures of Ryugu have been revealed one after another.

1. Introduction

Hayabusa2 is the second sample return mission from asteroids in the world. The target asteroid is (162173) Ryugu, which is a C-type near Earth asteroid. The main objective of science is to study the organic matters and the water at the beginning of the solar system. In addition to this, demonstrations of some new technologies for small body explorations are also important purpose of Hayabua2.

Hayabusa2 was launched on 3 December 2014, and after the three and a half year journey in the space, it arrived at its destination, Ryugu on 27 June 2018. Then we observed Ryugu by the remote sensing instruments on board, released two small rovers (MINERVA-II-1) and one lander (MASCOT), and carried out descent operations several times. The touchdown operations to get the surface material was done on 22 February 2019 and the impactor operation to create a small crater on the surface of Ryugu was done on 5 April 2019. All the important operations at Ryugu were summarized in Table 1. The spacecraft will leave Ryugu at the end of 2019 and return to the Earth at the end of 2020.

Table 1: Hayabusa2 operation schedule at Ryugu

Year	Month/Date	Event	Minimum altitude
2018	6/27	Arrival at Ryugu (BOX-A)	20km
	7/17 - 25	BOX-C	6km
	7/31 - 8/2	Medium altitude obs.	5km
	8/5 - 10	Gravity measurement	851m
	8/18 - 9/7	BOX-B (South pole & dusk)	20km
	9/10 - 12	Rehearsal 1 for TD1	600m
	9/19 - 21	MINERVA-II-1	55m
	9/30 - 10/4	MASCOT	51m
	10/14 - 16	Rehearsal 1A for TD1	22.3m
	10/23 - 25	Rehearsal 3 for TD1	12m
	10/27 - 11/5	BOX-C	2.2km
	11/23-12/29	Solar conjunction	----
2019	1/6 - 13	BOX-B (Sub-solar point)	20km
	1/19 - 31	BOX-B (North pole)	20km
	2/20 - 22	Touchdown 1 (TD1)	0m
	2/23 - 3/1	BOX-C	5km
	3/6 - 8	Descent observation	22m
	3/20 - 22	Crater search (before SCI)	1.7km
	4/3 - 5	SCI (Crater generation)	500m
	4/23 - 25	Crater search (after SCI)	1.7km
	After May	Touchdown 2	
	After July	MINERVA-II-2	
	Aug. - Nov.	Stay near the asteroid	
	Nov. - Dec.	Departure from Ryugu	

(BOX-A, B, C are the names of areas in which the spacecraft is operated.)

2. Mission highlights

Remote sensing observations: The most prominent feature of Ryugu is that its shape is a spinning top, which was totally unexpected. Another important feature is that the surface of Ryugu is covered by numerous boulders. We could not find large areas without boulders. This makes the planning of the touchdown very difficult. These features are shown by images taken by optical navigation cameras (Figure 1 a,b). Hayabusa2 has four science instruments: Optical

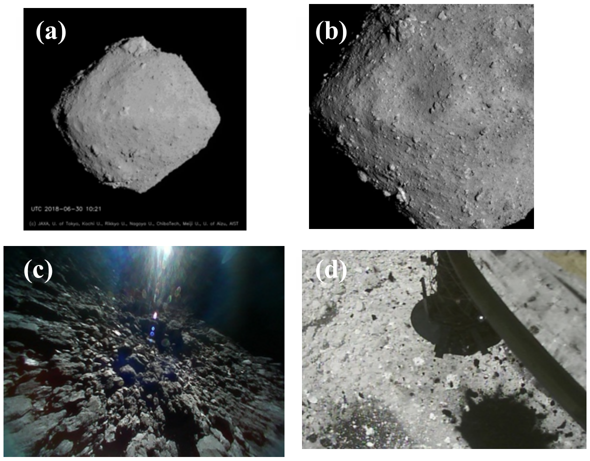

Figure 1: (a, b) Ryugu observed by ONC. (c) The surface of Ryugu observed by MINERVA-II-1. (d) Just after the touchdown.

Navigation Camera (ONC: wide and telescopic), Laser Altimeter (LIDAR), Near Infrared Spectrometer (NIRS3), and Thermal Infrared Imager (TIR). Using these instruments, we were able to get visual spectrum data, near infrared spectrum data, thermal data, very precise distance measurement data, etc.

Rover and Lander operations: Hayabusa2 has three small rovers, MINERVA-II and one lander, MASCOT. Two of MINERVA-II rovers were released in September and MASCOT, which were made by DLR and CNES, was released October in 2018. All of these were successfully landed on Ryugu and they took data on its surface. We were able to see the surface of Ryugu in very close distance. The surface was covered by rocks and we could not see fine gains (Figure 1c).

Touchdown operation: In original plan, the first touchdown was scheduled in late October in 2018. However, as mentioned above, there are no wide flat areas on the surface of Ryugu, so we decided to postpone the touchdown and considered how to execute touchdown safely. Finally, we found small area of 6m in diameter, and tried to touch down there on 22 February 2019. As a result, we were able to control the spacecraft in accuracy of 1m, and the touchdown was successful. Surprisingly, a lot of fragments of the surface material were blown up high into the sky (Figure 1d) when the spacecraft lifted off. We are confident that surface materials were collected in the capsule.

Impactor experiment: The most challenging operation of Hayabusa2 is the impactor operation.

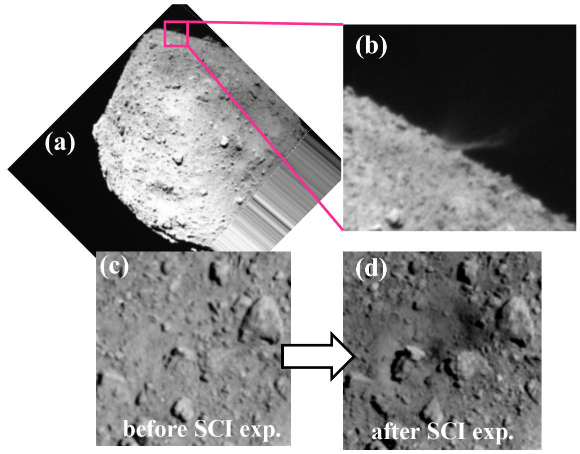

Figure 2: Results of SCI experiment. (a, b) the ejecta curtain just after SCI impact. (c, d) The change of the surface where impactor hit.

Hayabusa2 has a small carry-on impactor (SCI), and we tried to make a small crater on the surface of Ryugu. The experiment was carried out on 5 April 2019. SCI shot 2kg cupper in the speed of 2km/s. This is rather small impact, so we thought that just a small crater, a few meters in diameter at the most, would be created or that the crater would be too small to find. On the contrary, we saw a clear ejecta curtain and the size of created crater was about 15m in diameter (Figure 2).

3. Science results

Now we have a lot of data about Ryugu, so scientific studies are ongoing now. The first results are published in Science Journal [1], [2], [3]. In these papers, we discussed the shape of Ryugu, the surface properties, compositions, evolution, etc. We have a lot of new data in the operations of the touchdown and the impactor as well as the data taken by the remote sensing instruments. Our science work continues.

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