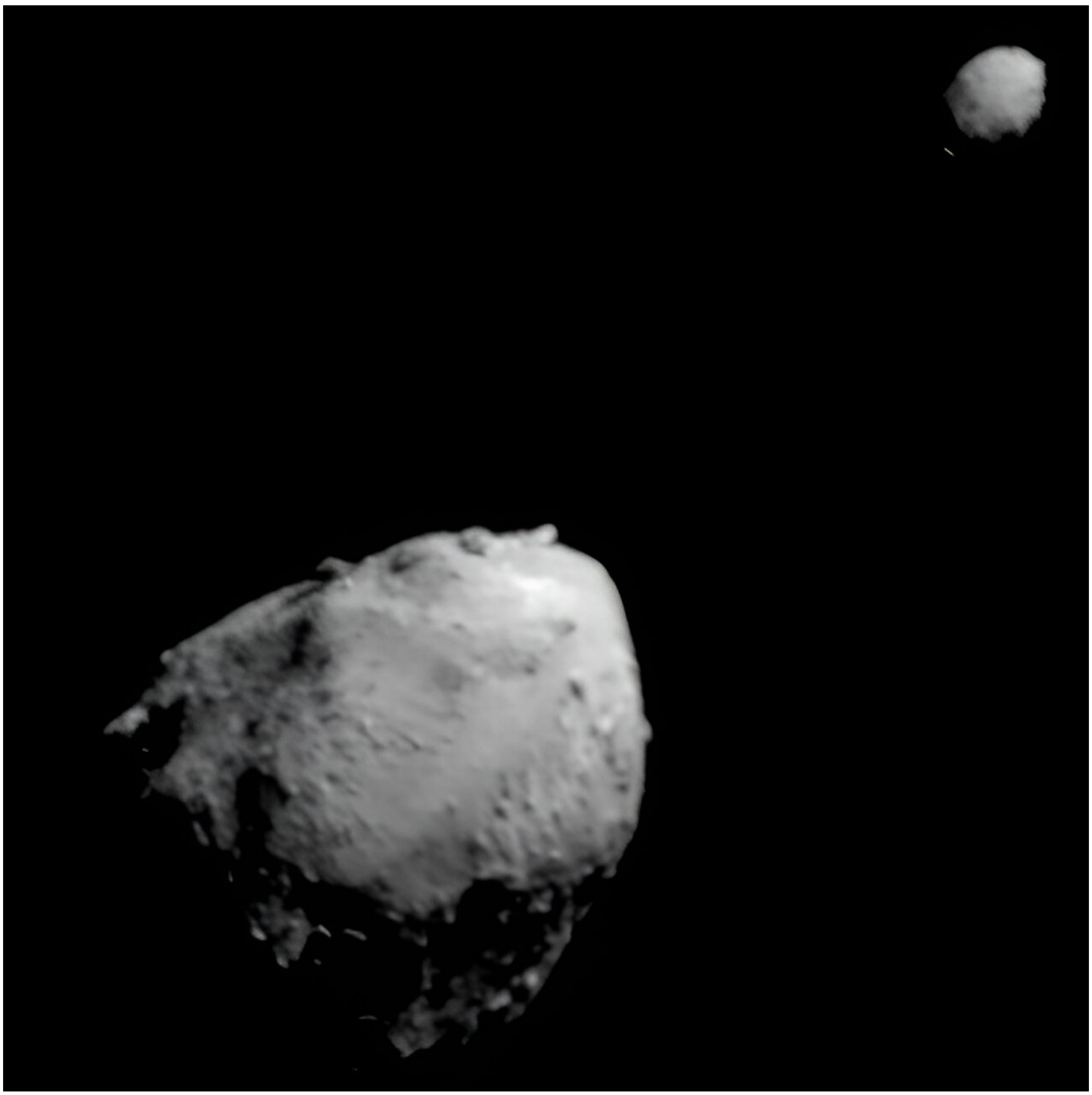
After DART smashed into Dimorphous, what happened to the larger asteroid Didymos?

October 26 2023, by Nancy Atkinson



Asteroid Didymos (bottom left) and its moonlet, Dimorphos, about 2.5 minutes before the impact of NASA's DART spacecraft. Credit: NASA/Johns Hopkins APL

NASA's DART mission (Double Asteroid Redirection Test) slammed into asteroid Dimorphos in September 2022, changing its orbital period. Ground and space-based telescopes turned to watch the event unfold, not only to study what happened to the asteroid, but also to help inform planetary defense efforts that might one day be needed to mitigate potential collisions with our planet.

Astronomers have continued to observe and study Dimorphos, well past the impact event. However, Dimorphos is the smaller asteroid in this binary system, and is just a small moon orbiting the larger asteroid Didymos.

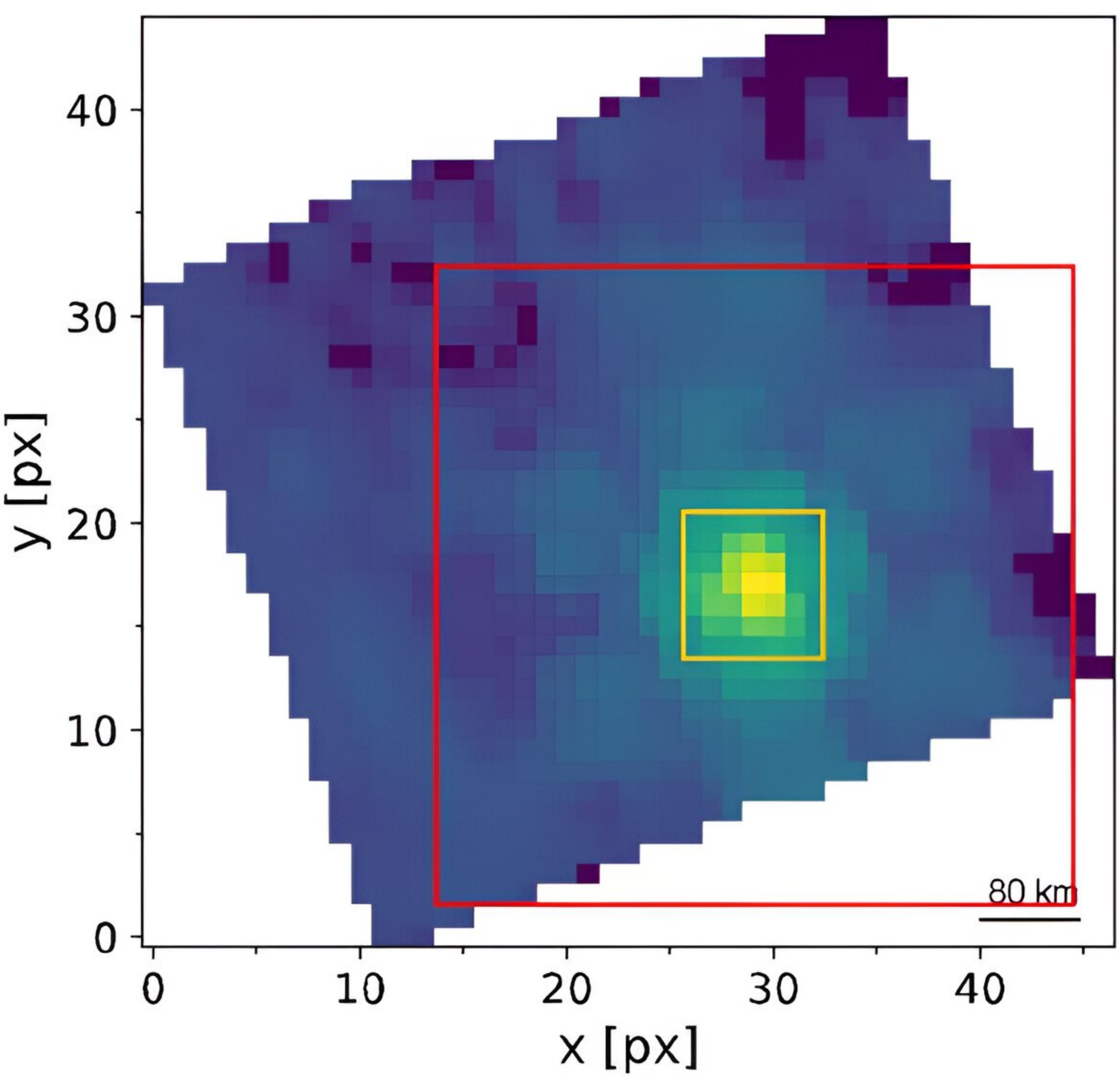
The James Webb Space Telescope (JWST) is the only telescope capable of visually distinguishing between the two closely orbiting asteroids. Now, astronomers have made follow-on observations on the system with JWST to see what happened to Didymos after the dust cleared.

In a new preprint paper posted to the *arXiv* server, a team of scientists, led by Andrew Rivkin, the Investigation Lead for DART, explain how they used two instruments on JWST to measure spectra of Didymos about two months after the DART impact. One of their biggest takeaways is that Didymos and Dimorphos appear to be of the same composition, which is that of an ordinary chondrite. That's the class of stony meteorites which account for over 80% of total meteorite falls on Earth. This means DART's test was an extremely good proxy for the type of asteroids that might pose a threat one day.

"One of the benefits of using the Didymos system was definitely that we thought it was representative of most of what's out there in its properties," Rivkin told Universe Today via email. "People working on planetary defense often note that the 'asteroid picks us rather than the other way around,' but showing that what we did at Dimorphos is broadly applicable is very important."

For the new observations, the scientists used NIRSpec—the near infrared spectrometer—and MIRI, the mid-infrared instrument, on November 28, 2022.

At the time of the observations, the centers of Didymos and Dimorphos were never separated by more than 0.1" from each other, from JWST's vantage point. But the team did take advantage of Dimorphos being occulted by Didymos during the MIRI observations.

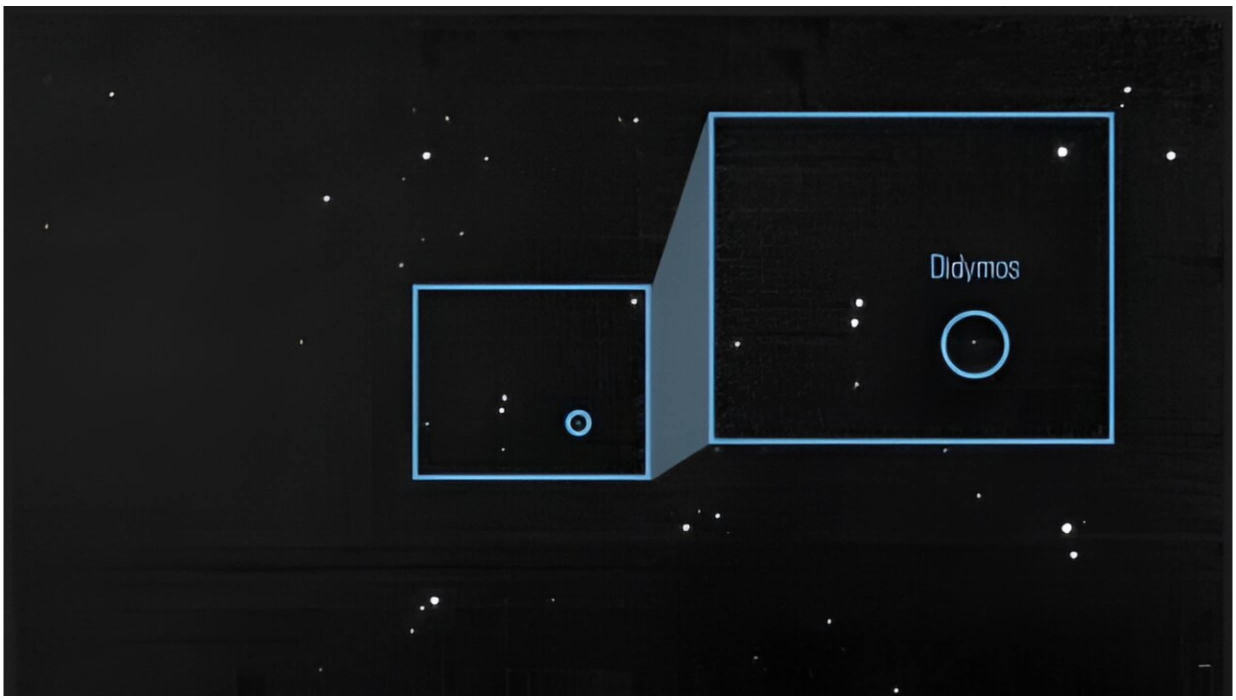


Median averaged slice through the MIRI MRS IFU showing Didymos. Note that Dimorphos was being occulted by Didymos during the entire period of MIRI observations. Credit: Rivkin et al, 2023

"Didymos is roughly five times larger in diameter than Dimorphos and therefore it has roughly 25 times the cross-sectional area as Dimorphos," the researchers wrote. "This size difference between the components means that roughly 96% of flux from the system typically comes from

Didymos."

The researchers said several lines of evidence suggest that the asteroid and its moon have similar compositions and the team concludes they "can reasonably estimate the composition of Dimorphos specifically from measurements of the Didymos-dominated flux."



This image from the DART spacecraft of the light from asteroid Didymos and its orbiting moonlet Dimorphos. Credit: NASA/JPL-Caltech/DART Navigation Team

Given how hard it is to distinguish between Didymos and Dimorphos in long-range observations, I asked Rivkin if they were able to see any noticeable changes in the observations of Didymos after the impact to Dimorphos, given all the dust and debris from the impact. The results seem to indicate Didymos escaped mostly unscathed from DART's impact of the asteroid's moon.

"We have a lot of new results from observations of the Didymos system that are getting published (including this pre-print paper led by Theodore Kareta) talking about the tail development and evolution. It shows that after 25 days or so there was no extra brightness from debris within the Didymos system, and so by November 2022, observations of the system (including the JWST ones!) are pretty much all Didymos again."

Rivkin added that they've made some puzzling observations using polarized light that suggest perhaps the average particle size or the average reflectivity might have slightly changed on Didymos, but they are waiting for spring 2024 to get more observations.

Rivulets of melted rock line the fusion crust of melted rock on this small Chelyabinsk meteorite. Credit: Bob King

An interesting (and fun!) comparison that Rivkin and his team made is how similar in composition Didymos is to the Chelyabinsk meteor, the famous meteor that created a huge airburst event over Russia in February 2013. The Chelyabinsk meteor is thought to be the biggest natural space object to enter Earth's atmosphere since the 1908 Tunguska event. So, it too serves as a very representative near-Earth asteroid.

"Yes, that comparison seemed particularly apt!" Rivkin said. "What Didymos and Dimorphos are composed of are very common among near-Earth asteroids, so even a randomly chosen meteorite would have a good chance of matching!"

Other asteroids that have been studied even more closely—such as Eros and Itokawa—also have similar compositions, Rivkin said, even though they likely don't come from the same original object. But all the asteroids mentioned here are from the same class, S-type asteroids—siliceous or stony.

Eros was the first asteroid to be orbited by a spacecraft (NEAR in 2000), and the first asteroid to have a spacecraft land on it. It was also the first near-Earth asteroid (NEA) to be discovered, in 1898. Itokawa was visited by the JAXA Hayabusa mission, and was the first asteroid from which samples were captured and brought to Earth for analysis.

Even though remote observations of distant objects like Didymos and

Dimorphos are incredibly difficult—especially for precisely determining asteroid composition—Rivkin said he's heartened by the success they've had.

"We've spent over 50 years trying to sort out some very detailed questions and how to approach them," he said. "Studies like the JWST observations and all of the other great work done to observe Didymos over the years and the fact they agree on the big-picture story gives us a chance to step back and realize how far we've come in being able to remotely tell what something is made of."

But the observations of Dimorphos and Didymos will continue, and astronomers are looking forward to learning even more soon. ESA's Hera mission is scheduled to arrive at the Didymos system in late 2026, and the researchers said they'll be able to follow up or extend several of the results they found with JWST.

Hera specifically will be able to image Didymos' surface at higher spatial resolution than was possible from DART (as well as from LICIACube—the Light Italian CubeSat for Imaging of Asteroids, a cubesat that was part of the DART mission, which sent back images of the impact.) Hera will be able to perform a test of the regolith particle size inferences derived from mid-infrared spectroscopy and a do check on the measured thermal inertia.

"We look forward to Hera and future JWST measurements of additional S-complex asteroids to help us continue efforts to understand the population of potential asteroid impactors, for the science return and to help inform planetary defense efforts to mitigate potential collisions," the researchers said.

More information: Andrew S. Rivkin et al, Near to Mid-Infrared Spectroscopy of (65803) Didymos as observed by JWST:

Characterization Observations Supporting the Double Asteroid Redirection Test, *arXiv* (2023). DOI: 10.48550/arxiv.2310.11168

Provided by Universe Today