More than just skin deep: What waits for us beneath Charon's cracked surface

June 30 2014, by Sheyna Gifford, Astrobio.net

An artist's concept of Pluto as viewed from the surface of one its moons. Pluto is the large disk at the center of the image. Charon is the smaller disk to the right. Credit: NASA, ESA and G. Bacon (STScI)

Is there evidence of an ocean-past or present-waiting to surprise us on Charon? It isn't impossible. In fact, it might be likely.

What used to be the smallest planet in our solar system has, comparatively, the biggest moon. Pluto, now classified as a dwarf planet, has a moon, Charon, almost 1/8th its own mass and almost half its physical volume. Our Moon, by comparison, has about 1% of the Earth's mass and only 2% of its volume. Charon is so large compared to Pluto that some astronomer's consider the two to be a sort of binary dwarf-planet system, as opposed to a moon-and-planet system.

Both Charon and our Moon are believed to have formed in the same way: when they were knocked off their parent planets. Enormous collisions liquified parts of the Earth and Pluto. The debris was thrown into orbit where it later cooled. In the process of cooling into solid bodies around the Earth and Pluto, the Moon and Charon became locked to their parent planets' orbits. That locking of the planets to moons results in tides: here on Earth, on the Moon, and, we believe, on Pluto and Charon.

An analysis by scientists at Goddard suggests that tides on Pluto and Charon could have been especially high as Charon cooled. This is because the part of Pluto knocked into orbit didn't get very far. Charon formed incredibly close to Pluto: only 19,000 km (12,000 miles) away. By comparison, our Moon is currently 384,000 km (238,855 mi) from Earth. Initially, the orbit might not have been very circular, either: it might have been more eccentric or elliptical-shaped. Eccentrically-moving, close-by Charon would have pulled on Pluto, and Pluto would have pulled back, resulting in heating of both planets and—maybe—an ocean under Charon's ice shell.

"Depending on exactly how Charon's orbit evolved, particularly if it went through a high-eccentricity phase, there may have been enough heat from tidal deformation to maintain liquid water beneath the surface of Charon for some time," said Alyssa Rhoden of NASA's Goddard Space Flight Center in Greenbelt, Maryland. "Using plausible interior structure models that include an ocean, we found it wouldn't have taken much eccentricity (less than 0.01) to generate surface fractures like we are seeing on Europa."

Artist impression of the New Horizons spacecraft as it approached Jupiter en route to Pluto. Credit: NASA

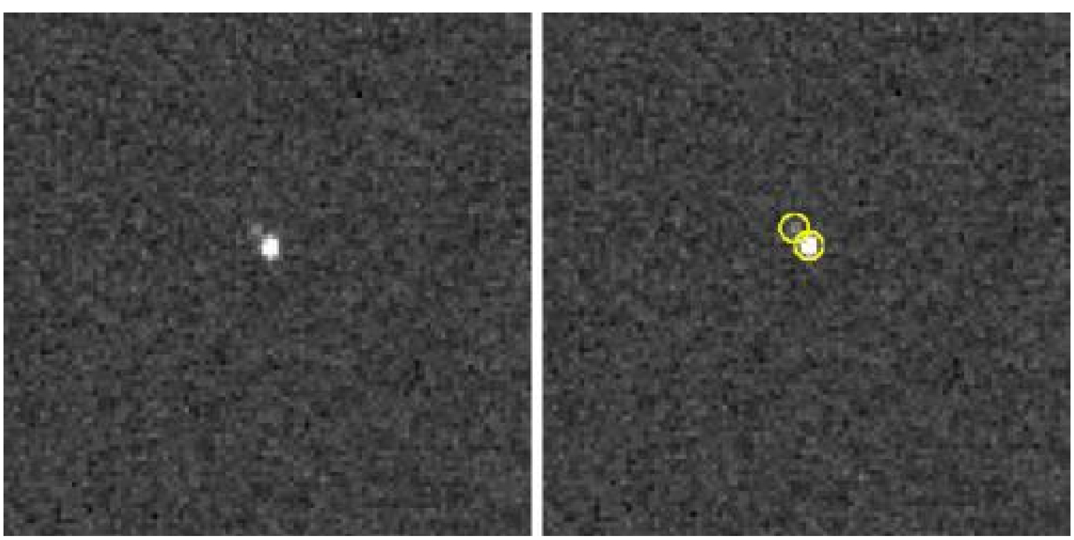
On icy moons like Europa and Enceladus, tidal forces exerted by their parent planets cause massive surface cracks to form. Those cracks are easily appreciated by passing spacecraft. According to Rhoden and colleagues' model, Charon's surface should be similarly cracked. We expect to see evidence of this fractured surface geology as the New Horizons spacecraft approaches Pluto. New Horizons will pass directly over Pluto and Charon, briefly, on July 15th 2015.

Charon was discovered thirty-five years ago, in 1978, but well-photographed for the first time by New Horizons in 2013. With the 2015 close-up just around the corner, scientists are working swiftly to make best use of surface photographs returned by the spacecraft. New Horizons will give us the ability to resolve objects as small as a football field on part of the surface of Pluto and Charon. With pictures of that detail and models such as this one, we may be able to look backwards in time to determine details about both bodies, such as how thick their ice shells were when they formed.

Studying patterns of fractures in Charon's surface is critical to building accurate models of the ice shell and layers beneath.

"Our model predicts different fracture patterns on the surface of Charon depending on the thickness of its surface ice, the structure of the moon's interior and how easily it deforms, and how its orbit evolved," said Rhoden. "By comparing the actual New Horizons observations of Charon to the various predictions, we can see what fits best and discover if Charon could have had a subsurface ocean in its past, driven by high eccentricity."

The oceans of certain icy moons with surface fractures are considered to be places where extraterrestrial life might be found. Like Charon, Europa and Enceladus are very cold and very distant from the sun. In all three cases, the formation and maintenance of life would depend upon a reliable energy source as well as elements that can participate in the chemistry of life, such as carbon, nitrogen, and phosphorus.



New Horizons Long Range Reconnaissance Imager (LORRI) composite image showing the detection of Pluto's largest moon, Charon. When these images were taken on July 1 and July 3, 2013, the New Horizons spacecraft was still about 550 million miles (880 million kilometers) from Pluto. On July 14, 2015, the spacecraft is scheduled to pass just 7,750 miles (12,500 kilometers) above Pluto's surface, where LORRI will be able to spot features about the size of a football field. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute

It is unknown if a potential ocean on Charon may have harbored these ingredients or if the ocean there existed for long enough for life to form. The same questions apply to any ancient ocean on any moon in our Solar System or any other. The first step on Charon is to find the fractures, and then go looking for the warmth that liquified water.

"Since it's so easy to get fractures, if we get to Charon and there are none, it puts a very strong constraint on how high the eccentricity could have been and how warm the interior ever could have been," said Rhoden. "This research gives us a head start on the New Horizons arrival – what should we look for and what can we learn from it. We're going to Pluto and Pluto is fascinating, but Charon is also going to be fascinating."

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https://phys.org/news/2014-06-skin-deep-beneath-charon-surface.html