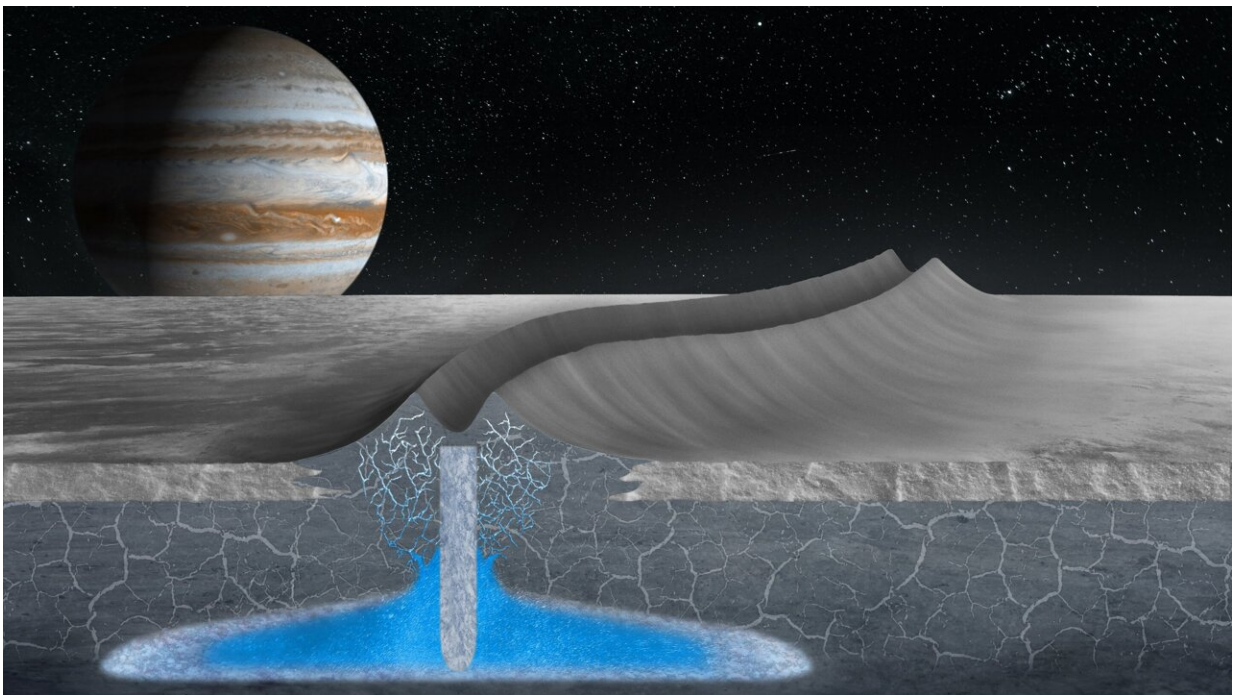


# Explanation for formation of abundant features on Europa bodes well for search for extraterrestrial life

April 19 2022, by Danielle Tucker

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This artist's conception shows how double ridges on the surface of Jupiter's moon Europa may form over shallow, refreezing water pockets within the ice shell. This mechanism is based on the study of an analogous double ridge feature found on Earth's Greenland Ice Sheet. Credit: Justice Blaine Wainwright

Europa is a prime candidate for life in our solar system, and its deep saltwater ocean has captivated scientists for decades. But it's enclosed by

an icy shell that could be miles to tens of miles thick, making sampling it a daunting prospect. Now, increasing evidence reveals the ice shell may be less of a barrier and more of a dynamic system—and site of potential habitability in its own right.

Ice-penetrating [radar observations](#) that captured the formation of a "double ridge" feature in Greenland suggest the ice shell of Europa may have an abundance of water pockets beneath similar features that are common on the surface. The findings, which appear in *Nature Communications* April 19, may be compelling for detecting potentially habitable environments within the exterior of the Jovian moon.

"Because it's closer to the surface, where you get interesting chemicals from space, other moons and the volcanoes of Io, there's a possibility that life has a shot if there are pockets of water in the shell," said study senior author Dustin Schroeder, an associate professor of geophysics at Stanford University's School of Earth, Energy & Environmental Sciences (Stanford Earth). "If the mechanism we see in Greenland is how these things happen on Europa, it suggests there's water everywhere."

## **A terrestrial analog**

On Earth, researchers analyze polar regions using airborne geophysical instruments to understand how the growth and retreat of ice sheets might impact [sea-level rise](#). Much of that study area occurs on land, where the flow of ice sheets is subject to complex hydrology—such as dynamic subglacial lakes, surface melt ponds and seasonal drainage conduits—that contributes to uncertainty in sea-level predictions.

Because a land-based subsurface is so different from Europa's subsurface ocean of liquid water, the study co-authors were surprised when, during a lab group presentation about Europa, they noticed that

formations that streak the icy moon looked extremely similar to a minor feature on the surface of the Greenland [ice sheet](#)—an ice sheet that the group has studied in detail.

"We were working on something totally different related to climate change and its impact on the surface of Greenland when we saw these tiny double ridges—and we were able to see the ridges go from 'not formed' to 'formed,' " Schroeder said.

Upon further examination, they found that the "M"-shaped crest in Greenland known as a double ridge could be a miniature version of the most prominent feature on Europa.

### **Prominent and prevalent**

Double ridges on Europa appear as dramatic gashes across the moon's icy surface, with crests reaching nearly 1000 feet, separated by valleys about a half-mile wide. Scientists have known about the features since the moon's surface was photographed by the Galileo spacecraft in the 1990s but have not been able to conceive a definitive explanation of how they were formed.

Through analyses of surface elevation data and ice-penetrating radar collected from 2015 to 2017 by NASA's Operation IceBridge, the researchers revealed how the double ridge on northwest Greenland was produced when the ice fractured around a pocket of pressurized liquid water that was refreezing inside of the ice sheet, causing two peaks to rise into the distinct shape.

"In Greenland, this double ridge formed in a place where water from surface lakes and streams frequently drains into the near-surface and refreezes," said lead study author Riley Culberg, a Ph.D. student in electrical engineering at Stanford. "One way that similar shallow water

pockets could form on Europa might be through water from the subsurface ocean being forced up into the ice shell through fractures—and that would suggest there could be a reasonable amount of exchange happening inside of the ice shell."

## **Snowballing complexity**

Rather than behaving like a block of inert ice, the shell of Europa seems to undergo a variety of geological and hydrological processes—an idea supported by this study and others, including [evidence of water plumes](#) that erupt to the surface. A dynamic ice shell supports habitability since it facilitates the exchange between the subsurface ocean and nutrients from neighboring celestial bodies accumulated on the [surface](#).

"People have been studying these double ridges for over 20 years now, but this is the first time we were actually able to watch something similar on Earth and see nature work out its magic," said study co-author Gregor Steinbrügge, a planetary scientist at NASA's Jet Propulsion Laboratory (JPL) who started working on the project as a postdoctoral researcher at Stanford. "We are making a much bigger step into the direction of understanding what processes actually dominate the physics and the dynamics of Europa's [ice shell](#)."

The co-authors said their explanation for how the double ridges form is so complex, they couldn't have conceived it without the analog on Earth.

"The mechanism we put forward in this paper would have been almost too audacious and complicated to propose without seeing it happen in Greenland," Schroeder said.

The findings equip researchers with a radar signature for quickly detecting this process of double ridge formation using ice-penetrating radar, which is among the instruments currently planned for exploring

Europa from space.

"We are another hypothesis on top of many—we just have the advantage that our hypothesis has some observations from the formation of a similar feature on Earth to back it up," Culberg said. "It's opening up all these new possibilities for a very exciting discovery."

**More information:** Riley Culberg, Double ridge formation over shallow water sills on Jupiter's moon Europa, *Nature Communications* (2022). [DOI: 10.1038/s41467-022-29458-3](https://doi.org/10.1038/s41467-022-29458-3).  
[www.nature.com/articles/s41467-022-29458-3](https://www.nature.com/articles/s41467-022-29458-3)

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