Eos

SCIENCE NEWS BY AGU

VOL. 103 | NO. 5
MAY 2022

Rare Earth Elements in a Flash

MeerKAT Spies Milky Way's Heart

Earthquakes in the Ionosphere

INNOVATIONS IN Volcanology

CREATIVE APPROACHES TO STUDYING THE WORLD'S MOST FASCINATING HOTSPOTS

AGU
ADVANCING EARTH AND SPACE SCIENCE

Lipids from Europa's Ocean Could Be Detectable on the Surface

Astrobiologists Gordon Osinski of the University of Western Ontario and Mark Fox-Powell of the Open University in the United Kingdom explore Lost Hammer spring on Axel Heiberg Island in the Canadian Arctic. Credit: Mark Fox-Powell

Jupiter's moon Europa is often lauded as one of the most promising destinations in the search for life outside Earth. Its global subsurface ocean, filled with mineral-rich salts and shielded from harmful irradiation by an icy shell, means that microbial life could flourish in its watery depths. Europa will be visited by two upcoming missions, Europa Clipper from NASA and Jupiter Icy Moons Explorer (JUICE) from the European Space Agency, both of which seek to pinpoint areas where future landers might search for life.

"We can so far say that sulfate salts might be a good target to look for organics."

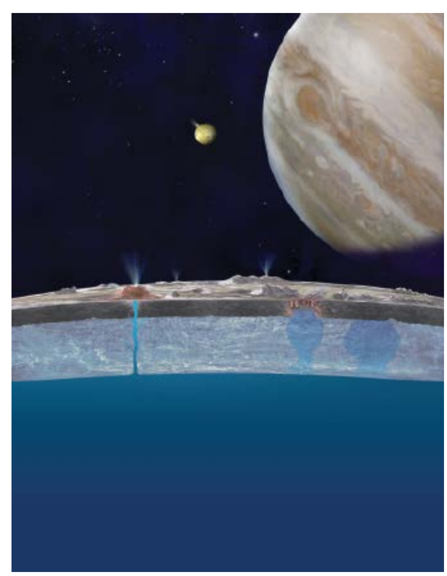
But any hypothesized life would be hidden within the ice-capped ocean and shielded from view. So how, then, could these spacecraft possibly find signs of life? New research found that if a geyser or other cryovolcanic feature brings ocean water up to the surface, any microbes within that water could be preserved as the water freezes on the surface. The organics could then precipitate out with the salts and minerals and be detectable by passing spacecraft.

From the Arctic to Europa

Planetary scientists still actively debate whether cryovolcanism—a process in which cold liquids underground migrate to the surface of a planetary body and freeze—exists on Europa. Strangely smooth patches of the moon's surface in some images from the Galileo spacecraft in the 1990s suggest freshly deposited material, and Hubble Space Telescope images from a few years ago hint at geyser-like plumes (although nothing as dramatic as those on Enceladus). Scientists also speculated that cracks in Europa's icy shell could let some ocean water escape to the surface through fissures, like mid-ocean ridges on Earth.

Any salty ocean water that reaches Europa's surface would freeze almost instantly. What would that do to biosignatures of microbial life? Past experiments have shown that when silica-rich hydrothermal fluids freeze, the minerals that the freezing process creates can trap microorganisms within them. Salts, too, can capture organics within their lattice. Those organics then precipitate out of the frozen liquid, after which scientists can detect them. But could this process work with the types of salts that are common on Europa?

Researchers went to the Canadian Arctic to find out. In 2017, they collected samples from the hypersaline Lost Hammer spring on Axel Heiberg Island. "The Lost Hammer spring is very unique, as it is anoxic, has below-zero temperatures, and [has] extremely high concentrations of sulfate and chloride—supersalty and extreme conditions," said lead researcher Arola Moreras-Marti, an astrobiologist at the University of St Andrews in the United Kingdom. The spring's salt deposits are made of "hydrated sodium sulfate and chloride, and



This illustration shows what cryovolcanism on Europa might look like. It could manifest as an effusive geyser or as a more understated fissure in the ground that connects the ice-capped ocean with the surface. Credit: NASA/JPL-Caltech, Public Domain they showed similar composition and also absorption features as Europa's nonicy materials measured by the Galileo spacecraft."

That makes Lost Hammer a great place to test what would happen to microbial life caught in a cryovolcanic eruption on Europa. The researchers tested 18 salt deposit samples from the spring by heating them and using a mass spectrometer to study the resulting gas—similar to what could be done by a lander. They also analyzed lipid biomarkers, measuring how much and which types of organic lipids they could detect within the salt deposits.

"The organic biomarker results…indicate the organics are mainly of microbial origin," Moreras-Marti said. Further analysis showed "that these organics are trapped inside the sulfate salts. This is particularly interesting, as the salts could protect the organics from oxidation, allowing for a better preservation [on Europa]." Moreras-Marti presented these preliminary results at the 2022 Lunar and Planetary Science Conference (bit.ly/Moreras-Marti).

What's in a Map

"I certainly find the idea intriguing," said Michael Brown, a planetary scientist at the California Institute of Technology in Pasadena. "Europa has several (at least) major different regions of surface composition, and trying to tease out which of these would be the best for preserving organic signatures is going to be quite important for understanding where to, eventually, land on Europa. I think their overall hypothesis—that crystallizing salts can capture and perhaps preserve organics—could be an important insight worth pursuing further." Brown was not involved with this research.

"These results from Lost Hammer will inform both future missions Europa Clipper and JUICE about how organic biomarkers are preserved in nonicy materials that have similar mineralogy to Europa's surface," Moreras-Marti said. Both missions seek to map the composition of Europa's surface, and results like these will help scientists interpret the maps and pinpoint areas more likely to contain evidence of life. Future Europa lander missions could then explore those areas. "We can so far say that sulfate salts might be a good target to look for organics."

By **Kimberly M. S. Cartier** (@AstroKimCartier), Staff Writer

Searching for Earthquakes in the Ionosphere

A magnitude 7.2 earthquake damaged roads across northwestern Mexico and Southern California, like this one in Calexico, when it struck on 4 April 2010. Credit: Adam DuBrowa/FEMA

In 2010, at 40 minutes past 3:00 in the afternoon on 4 April—Easter Sunday—northwestern Mexico started to shake. A magnitude 7.2 earthquake was rattling the Baja California region, ultimately causing three deaths and more than 100 injuries. The quake caused widespread damage in the border cities of Mexicali, Mexico, and Calexico. and made skyscrapers sway in San Diego, more than 160 kilometers west.

The earthquake sent waves through the ground around it, but high in the atmosphere, a very different sort of perturbation might have offered a forewarning of the earthquake's impending arrival, had anyone been able to see it. Subtle fluctuations in Earth's ionosphere, a region of charged particles high above the surface, preceded the Baja earthquake, said the authors of a new paper published in *Advances in Space Research.* Somehow, the fault that caused the earthquake may have been telegraphing its impending rupture, sending out a rush of electrically charged particles that resonated in the ionosphere (bit.ly/ionosphere-Baja).

The ionosphere, which begins about 48 kilometers above Earth's surface and stretches to around 965 kilometers in altitude, is where incoming energy from the Sun

The electron spike was located over the earthquake's epicenter, and it didn't look like anything else they'd seen in the data.

ionizes molecules in the atmosphere, knocking off electrons. The abundance of charged particles means the ionosphere reacts to electric and magnetic fields, something other regions of the atmosphere generally do not do.