Expedition to highest active volcano seeks to unearth clues about life on other worlds

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Solon and Steckel venture into a giant, frozen maze of icy, stalagmite-like spikes called penitentes. Credit: Amanda Steckel, University of Colorado at Boulder

A harsh sun shines down through a cloudless sky, across a vast and unforgiving landscape. It's covered in gray rock, giant ice sculptures and

expansive fields of spiky, yellow and orange bushes. In the distance, intimidating mountain peaks dominate the desolate scene, many miles from the nearest town. Yet alpacas roam freely and flamingos seek out scarce water, both unexpected sights in this wild world.

The extreme environment resembles something from a sci-fi film or another planet, but it's right here on Earth, on the flanks of the world's highest active volcano, 22,615-foot Ojos del Salado. Here, on the border of Argentina and Chile, a team of CU Boulder scientists seek to discover how tiny organisms persist at one of the driest and highest points on the planet.

This first-of-its-kind project may ultimately help inform the search for existing and extinct life on other planets.

"There's been almost no scientific studies on this volcano. So it's a new frontier in terms of geology, microbiology and the environment itself," said project lead Brian Hynek, professor of geological sciences and research associate at the Laboratory for Atmospheric and Space Physics (LASP).

For three weeks in December, Hynek was joined by Adam Solon, graduate student in ecology and evolutionary biology, and Amanda Steckel, graduate student in geological sciences and LASP, as the first researchers to ever explore and survey this high up on the Argentinian side of the mountain. Project co-leader Steve Schmidt, professor of ecology and evolutionary biology, and Nick Dragone, graduate student in ecology and evolutionary biology, are now hard at work analyzing the samples they brought back. And a second trip is in the works.

The team's previous research on neighboring volcanoes suggests this trip will provide valuable insights about the microbiology and flow of chemical elements through this habitat, which mimics those of the past

on neighboring planet Mars and possibly the present of Jupiter's smallest moon, Europa.

Training for great heights

While they didn't plan to spend much time at the summit, the team had to prepare for a base camp at 19,000 feet and to conduct research at 21,000 feet—the highest any of them have ever climbed.

That high up, oxygen is scarce. So in the months leading up to the trip, they often hiked and camped near Leadville, Colorado—the highest incorporated city in North America, at over 10,000 feet—to acclimate and break in their mountaineering boots.

Next, getting to Ojos del Salado was its own challenge, taking them two days and multiple flights to get to Northern Argentina, two days drive from the jungle to the high desert, and a day-and-a-half journey on a rough four-wheel-drive road to the base of the volcano at 19,000 feet. From there, the team climbed through the frigid night to over 21,000 feet, where they conducted their research.

From life on Ojos to life on Mars

Once settled in high above the Atacama Desert, the team set out to conduct research in an environment that closely mimics that of ancient Mars. Extremely dry conditions, high levels of ultraviolet radiation, large day-to-night temperature swings and limited water are all elements that make Ojos del Salado an ideal analog to the red planet.

"Going to places on Earth that mimic either the chemistry or the physics or volcanic conditions of early Mars can help us understand it better," said Hynek, a National Geographic explorer. "In the past, Mars probably

was a lot like Ojos, and not as extreme as it is now. So by studying this, we can get a good glimpse at habitability on past Mars."

Hynek, a planetary geologist, was eager to examine the hydrothermal systems, steam vents, fumaroles and hot springs on the volcano. These are places where water and fluids interact with rocks, create minerals and can support microbial life from the energy involved in these chemical reactions.

Today, Mars is riddled with remnant minerals from these interactions. By documenting under what temperatures, pressures and chemistries these minerals are created here in Earth's extremes, Hynek can apply that information to what remains on Mars today. So when a rover or an orbiter discovers particular minerals on Mars, he and fellow scientists can deduce what historical conditions in those places must have been like to produce them—and if they could have also supported life.

"The ultimate question is whether this is a good place where life could have come about," said Hynek. "Because life on Earth probably started in hydrothermal systems, it's probably where it would have started on Mars. These are key targets for looking for life on our neighbor."

Otherworldly ice fields

Solon and Steckel ventured into a giant, frozen maze of icy, stalagmite-like spikes called penitentes to conduct their research. Ranging from a few inches tall to 6 feet high, these snowy marvels exist not only in spite of, but as a result of the extreme conditions, providing a rare opportunity to understand how life can thrive there. They have only been sampled on two other volcanoes in the region, on expeditions lead by Schmidt.

Solon collected ice samples with tiny microbes living in them and the soil around them, and collaborators on the project are currently

sequencing their DNA back in a lab in Argentina.

"Even as extreme an environment as it is, it might be surprising how many different types of microbes are actually here. There can be a whole food web that is developed, even with these very limited resources," said Solon.

These persistent creatures may hold clues for the types of life which could exist on Jupiter's moon, Europa, as the conditions in these fields closely resemble those of the icy moon. The sixth-largest moon in the solar system, Europa's icy crust covering a global ocean make it a promising place to look for life.

Alongside Solon in the ice fields, Steckel used sensors to capture the light bouncing around and inside the cone shapes—part of what hollows them out into their unique designs. She nailed sensors into the ice at different heights to measure the intensity of the light at varying heights. Where Solon's samples assess the microbial diversity, Steckel's measurements will track radiation levels throughout the ice fields, illuminating what microbes have done to adapt to the intense UV conditions.

"I wanted to capture the uniqueness of this environment," said Steckel.

Steckel's measurements are also the first data collected at this altitude, providing valuable insights into real-life conditions under extreme UV.

Her preliminary numbers will also inform a more detailed study, when she or others from her team are able to return to the volcano. Hynek is already plotting the trip—potentially yet again this year—as they didn't make it to the summit and over to Chile, due to 70 mph winds.

"There will definitely be several studies that come out of the data, and

also further understanding of this region, which has had a limited amount of study," said Solon. "This would be a pretty good expedition to build off of."

Provided by University of Colorado at Boulder

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