The science behind the life and times of the Earth's salt flats

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Open water in the salt flats is critical habitat for many different kinds of animals. Credit: Sarah McKnight

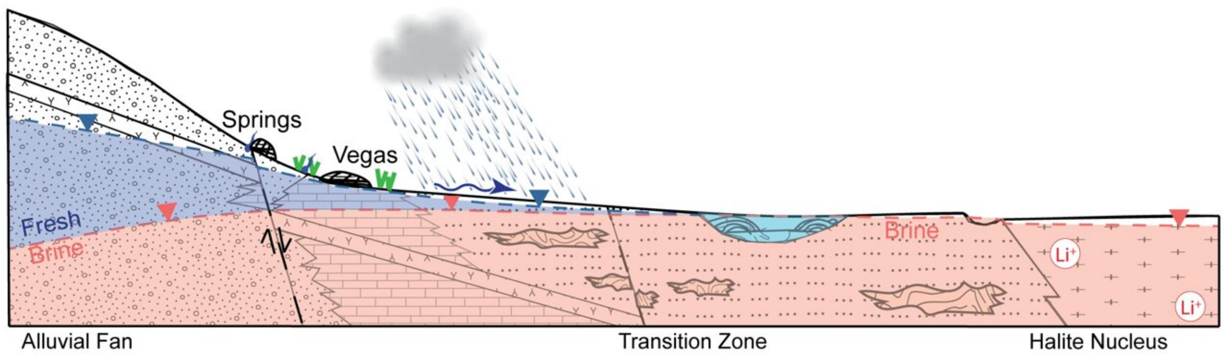
Researchers at the University of Massachusetts Amherst and the University of Alaska Anchorage are the first to characterize two different types of surface water in the hyperarid salars—or salt flats—that contain much of the world's lithium deposits. This new characterization represents a leap forward in understanding how water moves through such basins, and will be key to minimizing the environmental impact on such sensitive, critical habitats.

"You can't protect the salars if you don't first understand how they work," says Sarah McKnight, lead author of the research that appeared recently in *Water Resources Research*. She completed this work as part of her Ph.D in geosciences at UMass Amherst.

Think of a salar as a giant, shallow depression into which water is constantly flowing, both through surface runoff but also through the much slower flow of subsurface waters. In this depression, there's no outlet for the water, and because the bowl is in an extremely arid region, the rate of evaporation is such that enormous salt flats have developed over millennia.

There are different kinds of water in this depression; generally the nearer the lip of the bowl, the fresher the water. Down near the bottom of the depression, where the salt flats occur, the water is incredibly salty. However, the salt flats are occasionally pocketed with pools of brackish water. Many different kinds of valuable metals can be found in the salt flats—including lithium—while the pools of brackish water are critical habitat for animals like flamingoes and vicuñas.

One of the challenges of studying these systems is that many salars are relatively inaccessible. The one McKnight studies, the Salar de Atacama in Chile, is sandwiched between the Andes and the Atacama Desert. Furthermore, the hydrogeology is incredibly complex: water comes into the system from Andean runoff, as well as via the subsurface aquifer, but the process governing how exactly snow and groundwater eventually turn into salt flat is difficult to pin down.



Springs, runoff and release of groundwater storage result in the temporal variability of inflow to the salt flats. Credit: Sarah McKnight

Add to this the increased mining pressure in the area and the poorly understood effects it may have on water quality, as well as the mega-storms whose intensity and precipitation has increased markedly due to climate change, and you get a system whose workings are difficult to understand.

However, combining observations of surface and groundwater with data from the Sentinel-2 satellite and powerful computer modeling, McKnight and her colleagues were able to see something that has so far remained invisible to other researchers.

It turns out that not all water in the salar is the same. What McKnight and her colleagues call "terminal pools" are brackish ponds of water located in what is called the "transition zone," or the part of the salar where the water is increasingly briny but has not yet reached full concentration.

Then there are the "transitional pools," which are located right at the boundary between the briny waters and the salt flats. Water comes into each of these pools from different sources—some of them quite far away from the pools they feed—and exits the pools via different pathways.

"It's important to define these two different types of surface waters," says McKnight, "because they behave very differently. After a major storm event, the terminal pools flood quickly, and then quickly recede back to their pre-flood levels. But the transitional pools take a very long time—from a few months to almost a year—to recede back to their normal level after a major storm."

All of this has implications for how these particular ecosystems are managed. "We need to treat terminal and transitional pools differently," says McKnight, "which means paying more attention to where the water in the pools comes from and how long it takes to get there."

More information: S. V. McKnight et al, Distinct Hydrologic Pathways Regulate Perennial Surface Water Dynamics in a Hyperarid Basin, *Water Resources Research* (2023). DOI: 10.1029/2022WR034046

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