UC SANTA BARBARA

THE Current

July 21, 2025
Sonia Fernandez

Dead Sea’s salt giants offer rare glimpse into Earth’s geological past

The Dead Sea is a confluence of extraordinary conditions: the lowest point on the earth’s surface, with one of the world’s highest salinities. The high concentration of salt gives it a correspondingly high density, and the water body’s status as the deepest hypersaline lake gives rise to interesting and often temperature-related phenomena below the water’s surface that researchers are still uncovering.

One of the most intriguing features of the Dead Sea continues to be revealed: salt giants, large-scale salt deposits.

“These large deposits in the earth’s crust can be many, many kilometers horizontally, and they can be more than a kilometer thick in the vertical direction,” said UC Santa Barbara mechanical engineering professor Eckart Meiburg, lead author of a paper published in the Annual Review of Fluid Mechanics. “How were they generated? The Dead Sea is really the only place in the world where we can study the mechanism of these things today.”

Indeed, while there are other bodies of water in the world with massive salt formations, such as the Mediterranean and Red seas, only in the Dead Sea can one find them in the making, which allows researchers to tackle the physical processes behind their evolution, and in particular, the spatial and temporal variations in their thickness.

Evaporation, precipitation, saturation

In their paper, Meiburg and fellow author Nadav Lensky of the Geological Survey of Israel cover the fluid dynamical and associated sediment transport processes currently governing the Dead Sea. These processes are influenced by several factors, including the Dead Sea's status as a saltwater terminal lake — a lake with no outflow — leaving evaporation as the primary way water leaves the lake, which has been shrinking for millennia and leaving salt deposits as it does so. More recently, damming of the Jordan River, which feeds into the lake, has accelerated lake level decline, estimated at roughly 1 meter (3 feet) per year.

Temperatures along the water column also play a role in the dynamics behind salt giants and other formations such as salt domes and chimneys. A once "meromictic" (stably stratified) lake — the Dead Sea was layered such that less dense warmer water at the surface overlaid a more saline, cooler layer at depth throughout the entire year.

"It used to be such that even in the winter when things cooled off, the top layer was still less dense than the bottom layer," Meiburg explained. "And so as a result, there was a stratification in the salt."

That changed in the early 1980s thanks to the partial diversion of the Jordan River, which resulted in evaporation outpacing the rate of freshwater inflow. At that time, the surface salinity reached the levels found at depth, enabling mixing between the two layers and transitioning the lake from meromictic to holomictic (a lake that experiences annual overturns in the water column). The Dead Sea continues to stratify, but only for eight of the warmer months of the year.

In 2019, Meiburg et al identified a rather unique process occurring in the lake during the summer: halite crystal precipitation or "snow" that was more typical in the cooler season. Halite ("rock salt") precipitates when the concentration of salt exceeds the amount that the water can dissolve, hence the deeper, colder, denser conditions of the bottom layer are where it is most likely to happen, and in the cooler months. However, they observed that during the summer, while evaporation was increasing the salinity of the upper layer, salts were nonetheless continuing to dissolve in that layer due to its warmer temperature.

This leads to a condition called “double diffusion” at the interface between the two layers, in which sections of the saltier warmer water of the top layer cool down and sink, while portions of the lower, cooler, relatively less dense water warm up and rise. As the upper, denser layer cools down, salts precipitate out, creating the “salt snow” effect.

The combination of evaporation, temperature fluctuations and density changes throughout the water column, in addition to other factors including internal currents and surface waves, conspire to create salt deposits of various shapes and sizes, assert the authors. In contrast to shallower hypersaline bodies in which precipitation and deposition occur during the dry season, in the Dead Sea, these processes were found to be most intense during the winter months. This year-round “snow” season at depth explains the emergence of the salt giants, found in other saline bodies such as the Mediterranean Sea, which once dried up during the Messinian Salinity Crisis, about 5.96 to 5.33 million years ago.

“There was always some inflow from the North Atlantic into the Mediterranean through the Strait of Gibraltar,” Meiburg said. “But when tectonic motion closed off the Strait of Gibraltar, there couldn’t be any water inflow from the North Atlantic.” The sea level dropped 3-5 km (2-3 miles) due to evaporation, creating the same conditions currently found in the Dead Sea and leaving behind the thickest of this salt crust that can still be found buried below the deep sections of the Mediterranean, he explained. “But then a few million years later the Strait of Gibraltar opened up again, and so you had inflow coming in from the North Atlantic and the Mediterranean filled up again.”

Meanwhile, salinity fluxes and the presence of springs on the sea floor contribute to the formation of other interesting salt structures, such as salt domes and salt chimneys, according to the researchers.

In addition to gaining a fundamental understanding of some of the idiosyncratic processes that can occur in evaporating, hypersaline lakes, research into the associated sediment transport processes occurring on the emerging beaches may also yield insight on the stability and erosion of arid coastlines under sea level change, as well as the potential for resource extraction, the authors state.

Tags
Ocean and Beaches

Media Contact
Sonia Fernandez
Senior Science Writer
(805) 893-4765
sonia.fernandez@ucsb.edu

About UC Santa Barbara