A 114 000-year-old convection current accounts for the growth of aragonite needles in the Esparros cave

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The Esparros cave, renowned for its gorgeous clusters of aragonite needles, was discovered in 1938 by Norbert Casteret (1897-1987). Aragonite growth on both walls and speleothems, is arranged below a well-defined boundary that can be traced using 3D laser scanning for several hundred meters along the gallery. Previous interpretations considered this upper limit of aragonite crystallization as the imprint of a fossil flow, air or water. The recent growth of additional aragonite needles along pathways built to accommodate tourist visits, suggests instead an active system.

The combined installation of autonomous temperature sensors and Piche evaporimeters reveal the presence of two air masses permanently superimposed in the gallery: the lower air mass is undersaturated and slightly cooler than the upper saturated air mass. The boundary between the two air masses follows the upper limit of aragonite growth. A fog machine was used in combination with two particle counters placed in both air masses at different locations to confirm the presence of a very slow air circulation that dries out the bottom part of the gallery, thus allowing the formation of aragonite concretions. At the end of the gallery, the moist air flows back at the gallery roof, and condenses as it encounters cooler regions of the cavity. Drip rate measurements show a very regular pattern completely independent of those measured on active speleothems. Unlike the bottom part of the gallery coated with aragonite needles, the upper part is strongly corroded with the presence of a significant microbial life. Continuous measurements of ^{222}Rn indicate a permanent ventilation of the gallery even when the outside temperature is higher than the cavity temperature. Evidence of air circulation was also directly acquired using a flag sensor made from a mylar sheet and a position sensor that detects air velocities less than 1 cm/s. U-Th dating of aragonite needles suggests that the climatic system has been established for at least 114 000 years. Those observations relate a unique example of coupled processes competing in a natural site with a remarkable application of out-of-equilibrium thermodynamics for the preservation of precious underground heritage in the context of climate change and anthropogenic disturbances.