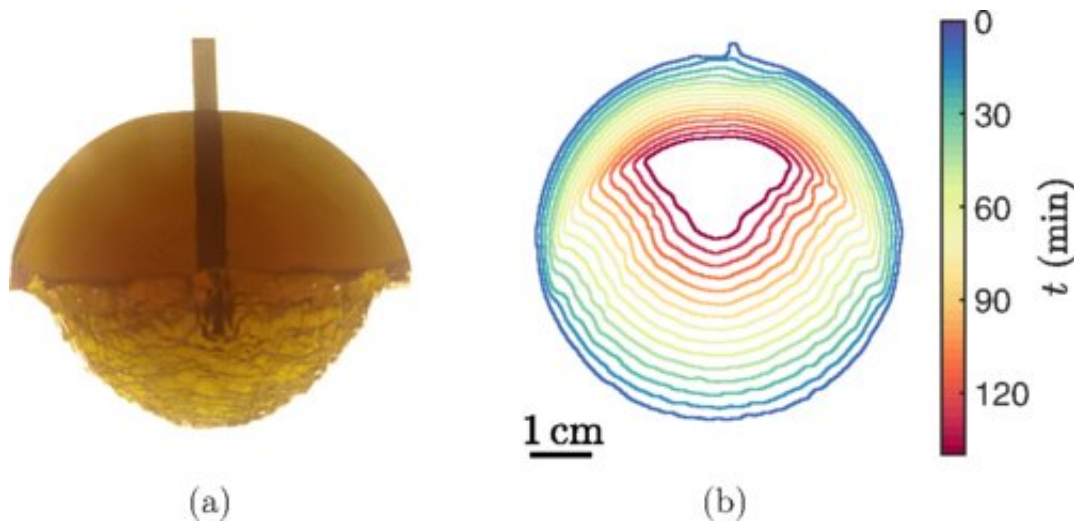


# How landscapes and landforms 'remember' or 'forget' their initial formations

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Shape evolution of a dissolving body. (a) Side-view photograph of candy body (initially a sphere) after dissolution in water for 70 min. (b) Measured profile shape displayed every 10 min. The upper surface remains smooth while the undersurface becomes pitted and dissolves several times faster. Credit: *Physical Review Fluids* (2018). DOI: 10.1103/PhysRevFluids.3.043801

Crescent dunes and meandering rivers can "forget" their initial shapes as they are carved and reshaped by wind and water while other landforms keep a memory of their past shape, suggests a new laboratory analysis by a team of mathematicians.

"Asking how these natural sculptures come to be is more than mere

curiosity because locked in their shapes are clues to the history of an environment," explains Leif Ristroph, an assistant professor at New York University's Courant Institute and the senior author of the paper, which appears in the journal *Physical Review Fluids*. "In our lab experiments, we found that some shapes keep a 'memory' of their starting conditions as they develop while others 'forget' the past entirely and take on new forms."

The paper's authors, who also included Megan Davies Wykes, a former postdoctoral researcher at the Courant Institute and currently postdoctoral researcher at the University of Cambridge, Jinzi Huang, a doctoral student of mathematics, and George Hajjar, an NYU undergraduate, note that this understanding is vital in geological dating and in understanding how landscapes form.

Shape "memory" and its "loss"—or the retention of or departure from earlier formations—are key issues in geomorphology, the field of study that tries to explain landforms and the developing face of the Earth and other celestial surfaces. The morphology, or [shape](#) of a landscape, is the first and most direct clue into its history and serves as a scientific window for a range of questions—such as inferring flowing [water](#) on Mars in the past as well as present-day erosion channels and river islands.

"The answer to the question 'What's in a shape?' hinges on this memory property," explains Ristroph, who directs NYU's Applied Math Lab, where the research was conducted.

To shed light on these phenomena, Ristroph and his colleagues replicated nature's dissolvable minerals—such as limestone—with a ready-made stand-in: pieces of hard candy. Specifically, they sought to understand how the candy dissolved to take different forms when placed in water.

To mimic different environmental conditions, they cast the candy into different initial shapes, which led to different flow conditions as the surface dissolved. Their results showed that when the candy dissolved most strongly from its lower surface, it tended to retain its overall shape—reflecting a near-perfect memory. By contrast, when dissolved from its upper surface, the candy tended to erase or "forget" any given initial shape and form an upward spike structure.

The key difference, the team found, is the type of water flow that "licks" and reshapes the candy. Turbulent flows on the underside tend to dissolve the [candy](#) at a uniform rate and thus preserve the shape. The smooth flow on an upper surface, however, carries the dissolved material from one location to the next, which changes the dissolving rate and leads to changes in shape.

"Candy in water may seem like a far cry from geology, but there are in fact whole landscapes carved from minerals dissolving in water, their shapes revealed later when the water table recedes," he adds. "Caves, sinkholes, stone pillars and other types of craggy terrain are born this way."

**More information:** Megan S. Davies Wykes et al. Self-sculpting of a dissolvable body due to gravitational convection, *Physical Review Fluids* (2018). [DOI: 10.1103/PhysRevFluids.3.043801](https://doi.org/10.1103/PhysRevFluids.3.043801)

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