Scientists shed light on powerful currents that create massive underwater canyons

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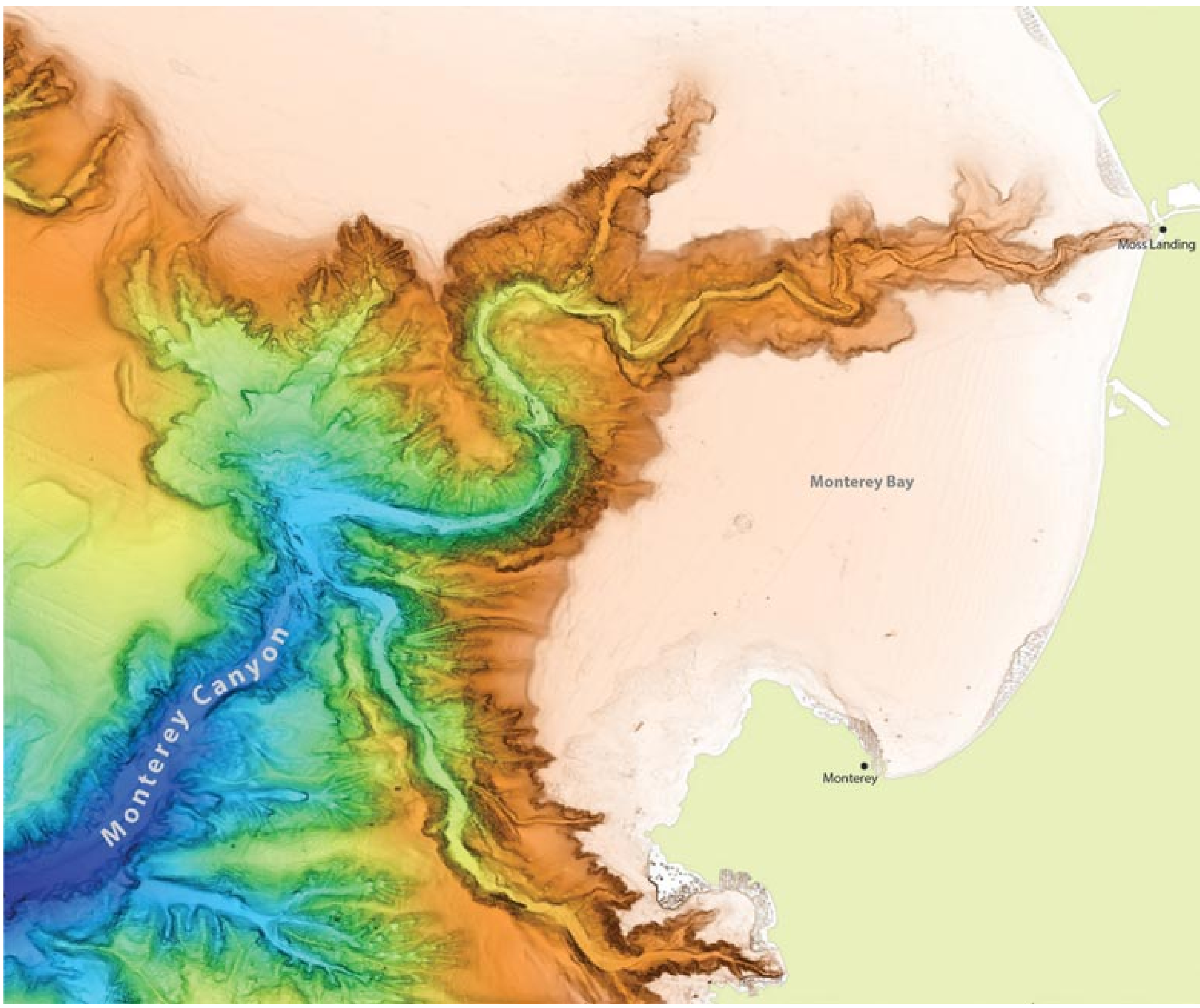

Recent research by Stanford scientists sheds light on the powerful ocean currents that carved the Monterey Canyon and other deep channels that extend hundreds of miles offshore. Credit: Monterey Bay Aquarium Research Institute

Through the use of mathematical models, Stanford researchers have better defined the powerful processes that carved some of the largest canyons on Earth, deep under the oceans.

Hidden off the central California coast is a gorge carved into the seafloor that rivals the Grand Canyon, its steep walls measuring nearly one mile from top to bottom. The Monterey Canyon is one of thousands of giant submarine canyons that crisscross the ocean floor.

Since the discovery of these features at the turn of the 19th century, scientists have hypothesized that turbidity currents – avalanche-like flows of rock, sand and silt suspended in water that can traverse hundreds of miles – eroded away the canyons and cut sinuous channels along the ocean floor. Supporting this hypothesis with direct measurement, however, has proven exceedingly difficult. Even the most robust monitoring equipment can't survive currents strong enough to sculpt canyons in the seafloor.

A computer modeling effort from Stanford researchers, published in the *Journal of Geophysical Research*, could fill in the gaps in describing these powerful currents that, when they're not creating some of the largest canyons on the planet, pose a significant risk to undersea telecommunications structures and oil rigs.

"There's still an air of mystery about deep-ocean processes. We have better images of the surface of Mars than we do of our own seafloor," said Miles Traer, the study's lead author who conducted the work as a graduate student in Stanford's School of Earth, Energy & Environmental Sciences. "How is it possible to have water flow through other water for such long distances while creating these huge features? Without direct measurements, that question has proven surprisingly difficult to answer, and it was one of the driving questions of our research."

Unlike a river, turbidity currents don't flow continuously; they seem to start suddenly, last for minutes to hours, and then stop. As they move, they mix with the surrounding sediment-free water along the upper boundary of the current. This mixing is one of the fundamental differences between turbidity currents and their on-land counterparts.

"Understanding this mixing is crucial when trying to predict where a turbidity current will go, how energetic it will be, how potentially damaging it will be, or where it will deposit large sandy reservoirs," said George Hilley, co-author on the study and associate professor at Stanford's School of Earth, Energy & Environmental Sciences. "To my knowledge, no one has ever measured the mixing process in the field, and yet it seems to control much of the flow physics."

In the study, Traer and his colleagues found that the standard mathematical model for turbidity currents, which is commonly employed in risk assessments and petroleum exploration, may have improperly captured this important mixing process, called entrainment. Clear-water entrainment along the upper boundary of the flow effectively acts as a brake, slowing the turbidity current down while simultaneously thickening it.

Using the standard model, the researchers found that the simulated turbidity currents were either too thick, or too fast. This indicated that the simulated flows would either be too dilute to carve out the canyons, or too energetic and carve them out much faster than the geological evidence suggests.

"The entrainment process is incredibly difficult to capture in the lab because the scales are so different," Traer said. "Our results suggest that the model used to describe the mixing process that was derived in the lab might be just one of many possible rules that apply depending on the scale of the flow."

The discovery has many implications for the formation and duration of the turbidity currents that not only carved out the large canyons but also constructed meandering channels along the seafloor.

"The research suggests that there is a delicate balance that turbidity currents must maintain between erosion and entrainment," Hilley said. "And our methods provide the groundwork to better capture the entrainment process and, in turn, better predict the patterns of erosion and deposition that create these massive features on the seafloor."

More information: M. M. Traer et al. Simulating depth-averaged, one-dimensional turbidity current dynamics using natural topographies, *Journal of Geophysical Research: Earth Surface* (2015). DOI: 10.1002/2015JF003638

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