Continents loss to oceans boosts staying power

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New research in the *Proceedings of the National Academy of Science* finds that the geological staying power of continents comes partly from their losing battle with the Earth's oceans over magnesium. Continents lose more than 20 percent of their initial mass to chemical weathering, but they ultimately gain because the lighter, silicon-rich rock that's left behind is more buoyant and less prone to being subducted and returned to the mantle.

New research suggests that the geological staying power of continents comes partly from their losing battle with the Earth's oceans over magnesium. The research finds continents lose more than 20 percent of their initial mass via chemical reactions involving the Earth's crust, water and atmosphere. Because much of the lost mass is dominated by magnesium and calcium, continents ultimately gain because the lighter, silicon-rich rock that's left behind is buoyed up by denser rock beneath the Earth's crust.

The Earth's continents seem like fixtures, having changed little throughout recorded human history. But geologists know that continents have come and gone during the Earth's 4.5 billion years. However, there are more theories than hard data about some of the key processes that govern continents' lives.

"Continents are built by new rock that wells up from volcanoes in island arcs like Japan," said lead author Cin-Ty Lee, assistant professor of Earth science at Rice University. "In addition to chemical weathering at the Earth’s surface, we know that some magnesium is also lost due to destabilizing convective forces beneath these arcs."

Lee's research, which appeared in the March 24 issue of the *Proceedings of the National Academy of Science*, marks the first attempt to precisely nail down how much magnesium is lost through two markedly different routes -- destabilizing convective forces deep inside the Earth and chemical weathering reactions on its surface. Lee said the project might not have happened at all if it weren't for some laboratory serendipity.

"I'd acquired some tourmaline samples in San Diego with my childhood mentor, Doug Morton," Lee said. "We were adding to our rock collections, like kids, but when I got back to the lab, I was curious where the lithium, a major element in tourmaline, needed to make the tourmalines came from. I decided to measure the lithium content in the granitic rocks from the same area, and that's where this started."

In examining the lithium content in a variety of rocks, Lee realized that lithium tended to behave like the magnesium that was missing from continents. In fact, the correlation was so close, he realized that lithium could be used as a proxy to find out how much magnesium continents had lost due to chemical weathering.

Continents ride higher than oceans, partly because the Earth's crust is thicker beneath continents than it is beneath the oceans. In addition, the rock beneath continents is made primarily of silicon-rich minerals like granite and quartz, which are less dense than the magnesium-rich basalt beneath the oceans.

Lee said he always assumed that processes deep in the Earth, beneath the volcanoes that feed continents, accounted for far more magnesium loss than weathering. In particular, a process called "delamination" occurs in subduction zones, places where one piece of the Earth's crust slides beneath another and gets recycled into the Earth's magma. As magma wells up beneath continent-feeding volcanoes, it often leaves behind a dense, magnesium-rich layer that ultimately founders back into the Earth's interior.

In previous research, Lee found that about 40 percent of the magnesium in basaltic magma was lost to delamination. He said he was thus surprised to find that chemical weathering alone accounted for another 20 percent.

"Weathering occurs in just the top few meters or so of the Earth's crust, and it's driven by the hydrosphere, the water that moves between the air, land and oceans," Lee said. "It appears that our planet has continents because we have an active hydrosphere, so if we want to find a hydrosphere on distant planets, perhaps we should look for continents."

Source: Rice University

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