Researchers propose a novel mechanism to explain High Plains elevation

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Wyoming High Plains.Credit: Bri Weldon, Flickr

No one really knows how the High Plains got so high. About 70 million years ago, eastern Colorado, southeastern Wyoming, western Kansas and western Nebraska were near sea level. Since then, the region has risen about two kilometers, leading to some head scratching at geology conferences.

Now researchers at the Cooperative Institute for Research in Environmental Sciences (CIRES) and the Department of Geological Sciences at the University of Colorado Boulder have proposed a new way to explain the uplift: Water trapped deep below Earth's crust may have flooded the lower crust, creating buoyancy and lift. The research appears online this week in the journal *Geology* and could represent a new mechanism for elevating broad regions of continental crust.

"The High Plains are perplexing because there is no deformation—such as major faults or volcanic activity—in the area to explain how this big, vast area got elevated," said lead author Craig Jones, a CIRES fellow and associate professor of geology at CU-Boulder. "What we suggest is that by hydrating the lower crust, it became more buoyant, and the whole thing came up."

"It's like flooding Colorado from below," Jones said.

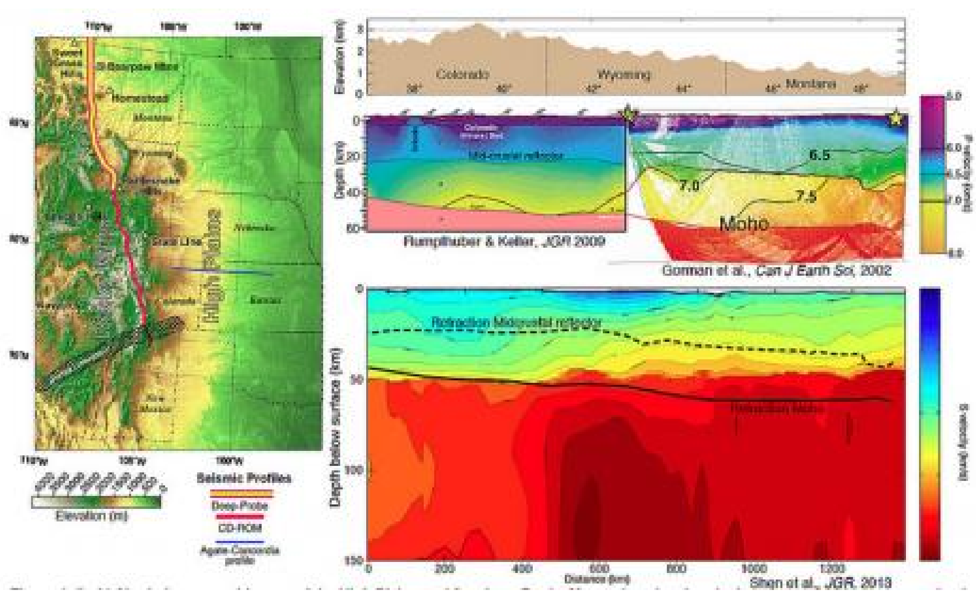
Jones and his colleagues propose the water came from the subducting Farallon oceanic plate under the Pacific Ocean 75 to 45 million years ago. This slab slid underneath the North American continental plate, bringing with it a tremendous amount of water bound in minerals. Trapped and under great pressure and heat, the water was released from the oceanic plate and moved up through the mantle and toward the lower crust. There, it hydrated lower crust minerals, converting dense ones, like garnet, into lighter ones, such as mica and amphibole.

"If you get rid of the dense garnet in the lower crust, you get more elevation because the crust becomes more buoyant," Jones said. "It's like blowing the water out of a ballast tank in a submarine."

Jones had the lightbulb moment for this idea when colleagues, including co-author Kevin Mahan, were describing xenoliths (pieces of crust ejected by volcanic eruptions) from across Wyoming and Montana. The researchers were reviewing the xenoliths' composition and noticed something striking. Xenoliths near the Canadian border were very rich in garnet. But farther south, the xenoliths were progressively more hydrated, the garnet replaced by mica and other less-dense minerals. In southern Wyoming, all the garnet was gone.

Upon hearing these findings, Jones blurted out, "You've solved why Wyoming is higher than Montana," a puzzle that other theories haven't been able to explain.

At the time, Mahan, a CU-Boulder assistant professor of [geological sciences](), noted that the alteration of garnet was thought to be far too ancient, from more than a billion years ago, to fit the theory. But since then, he and another co-author, former CU-Boulder graduate student Lesley Butcher, dated the metamorphism of one xenolith sample from the Colorado Plateau and discovered it had been hydrated "only" 40-70 million years ago.



Shaded topographic map of the High Plains and Southern Rocky Mountains showing the locations of active source seismic profiles. Xenolith localities are shown in triangles. Images to the right of the topographic map show results from various experiments designed to understand seismic structure. Images are from several previously published studies, as indicated.

Past seismic studies also support the new mechanism. These studies show that from the High Plains of Colorado to eastern Kansas, the crustal thickness or density correlates with a decline in elevation, from about 2 kilometers in the west to near sea level in the east. A similar change is seen from northern Colorado north to the Canadian border. In other words, as the crust gets less hydrated, the elevation of the Great Plains also gets lower.

"You could say it's just by happenstance that we seem to have thicker more buoyant crust in higher-elevation Colorado than in lower-elevation central Kansas," Jones said, "but why would crust buoyancy magically correlate today with topography if that wasn't what created the topography?"

Still, Jones is quick to point out that this mechanism "is not the answer, but a possible answer. It's a starting point that gives other researchers a sense of what to look for to test it," he said.

More information: "Continental uplift through crustal hydration." *Geology*, G36509.1, first published on March 3, 2015, DOI: 10.1130/G36509.1

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