Breaking up is hard to do: Separation of Fiji and Vanuatu tied to Samoan seamounts

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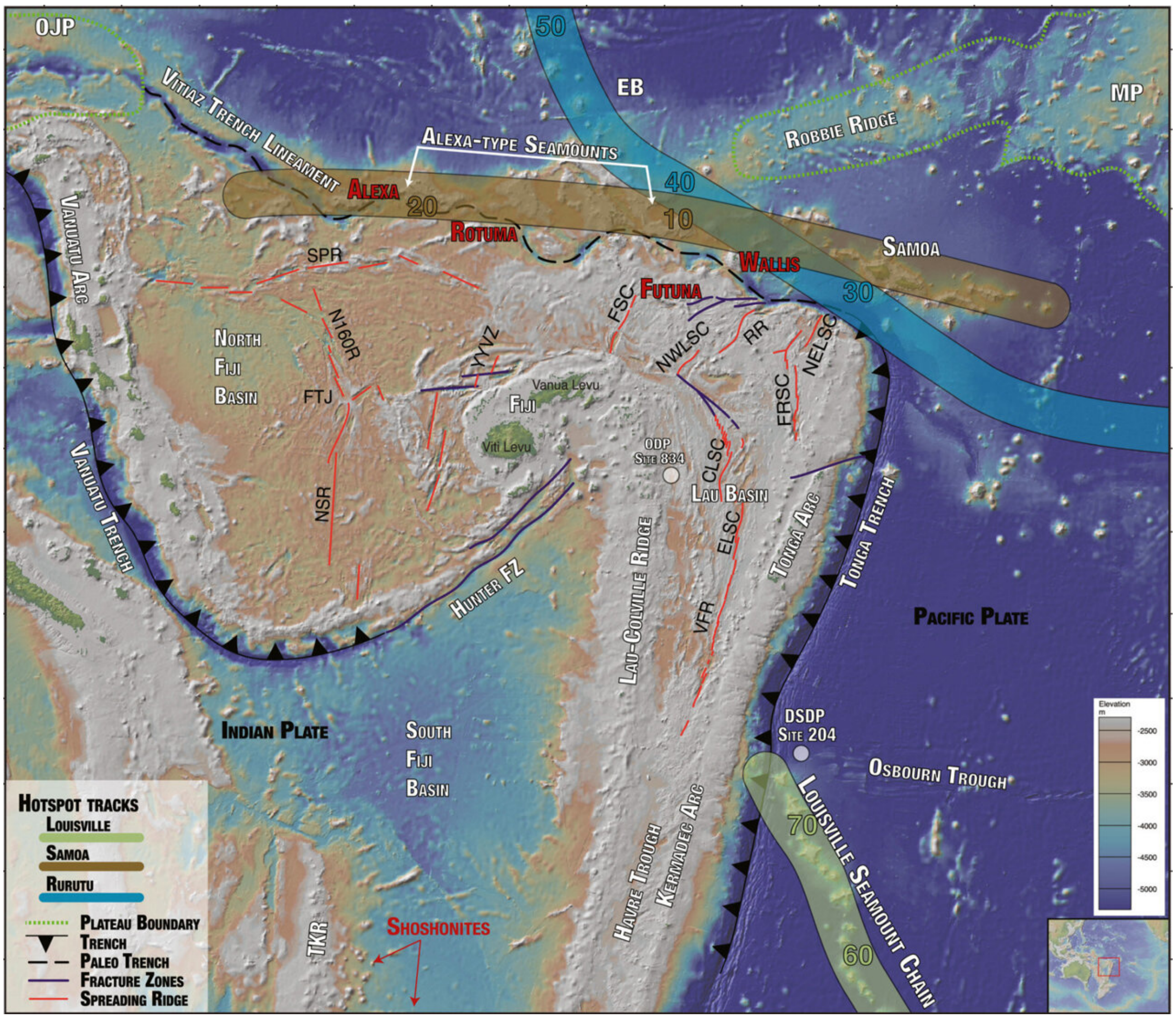

Geochemical analyses link the geologic histories of the South Pacific Islands of Fiji, Vanuatu, and Samoa. This map shows the tectonic features of the area studied. Credit: Gill et al., 2022

The islands of Fiji and Vanuatu rise from the tropical waters of the South Pacific in one of the most tectonically active and geologically complex regions of the world. A new study of volcanism in this area sheds light on the ancient breakup of a long island arc, which swung apart like "double saloon doors." Fiji and Vanuatu started out as close neighbors and ended up 800 miles apart on separate sections of what had once been a continuous arc.

Island arcs form where a plate of the oceanic crust sinks beneath an adjacent plate in a process known as subduction, giving rise to a belt of volcanoes parallel to the trench where the descending plate bends downward. The islands are the tallest peaks of vast underwater mountain ranges built up by volcanic activity in the subduction zone. One such range now goes from New Zealand up to Tonga, then bends westward to Fiji. Another extends from New Guinea down to Vanuatu.

"They all used to be connected to one another, and then they got split apart in the geologic past," explained James Gill, professor emeritus of Earth and planetary sciences at UC Santa Cruz and first author of the new paper. "This paper attributes the breakup to the subduction of the Samoan Seamount Chain."

Samoa, like Hawaii, is part of a linear chain of volcanic seamounts formed as the oceanic crust moves over a "hotspot" in the Earth's mantle, causing a series of volcanoes to grow over that spot. A long chain of seamounts extends to the west of the Samoan islands.

"When that chain of seamounts got pushed down into the Earth underneath the island arc, it caused indigestion in the subduction zone, which ultimately broke it apart," Gill said.

In addition to the seamounts getting hung up in the subduction zone, other complex processes were at work across the island arc, including a reversal of the direction of subduction along part of the arc, the rotation of different segments, and the opening of rifts where seafloor spreading creates new oceanic crust. The Vanuatu Arc rotated clockwise while the fragment of crust bearing Fiji rotated counter-clockwise.

These events (dubbed "double-saloon-door tectonics" by geologist Keith Martin in 2013) began about 10 million years ago and proceeded slowly over millions of years leading up to the present configuration of the islands.

Gill and his coauthors investigated this history by analyzing samples of volcanic rock collected at sites throughout the area in the 1980s by Gill and Peter Whelan, who was then a UCSC graduate student and performed initial analyses of the samples. For the new study, Gill received funding from a Humboldt Research Award to work with researchers at the GEOMAR Helmholz Center for Ocean Research in Germany, who performed modern geochemical analyses to determine the isotopic and elemental composition of the samples.

"These analyses allow us to use isotopes as long-lived tracers to find out what melted to produce the magma that erupted from a particular volcano," Gill explained. "In this case, we can see that the Samoan seamounts are the best match for the rocks that erupted in Fiji at the time this island arc broke apart."

Gill has been studying the geology of the South Pacific islands for more than 50 years, collecting hundreds of volcanic rock samples from remote islands in Fiji, eastern Indonesia, and the Marianas, as well as other sites around the Pacific "rim of fire." Most of those samples are now in curated collections at the Smithsonian Institution and the American Museum of Natural History.

"When I was hired 50 years ago, UCSC was starting a Center for South Pacific Studies, which is one reason why the Arboretum has so many plants from New Zealand and Australia," Gill said. "This paper is part of my career-long efforts to understand the geological evolution of Fiji, and it links the histories of Fiji, Vanuatu, and Samoa."

The paper, "Breaking Up Is Hard to Do: Magmatism During Oceanic Arc Breakup, Subduction Reversal, and Cessation," is published in the December issue of *Geochemistry, Geophysics, Geosystems*.

More information: James Gill et al, Breaking Up Is Hard to Do: Magmatism During Oceanic Arc Breakup, Subduction Reversal, and Cessation, *Geochemistry, Geophysics, Geosystems* (2022). DOI: 10.1029/2022GC010663

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