EAST PACIFIC RISE VOLCANOES FINALLY LINE UP

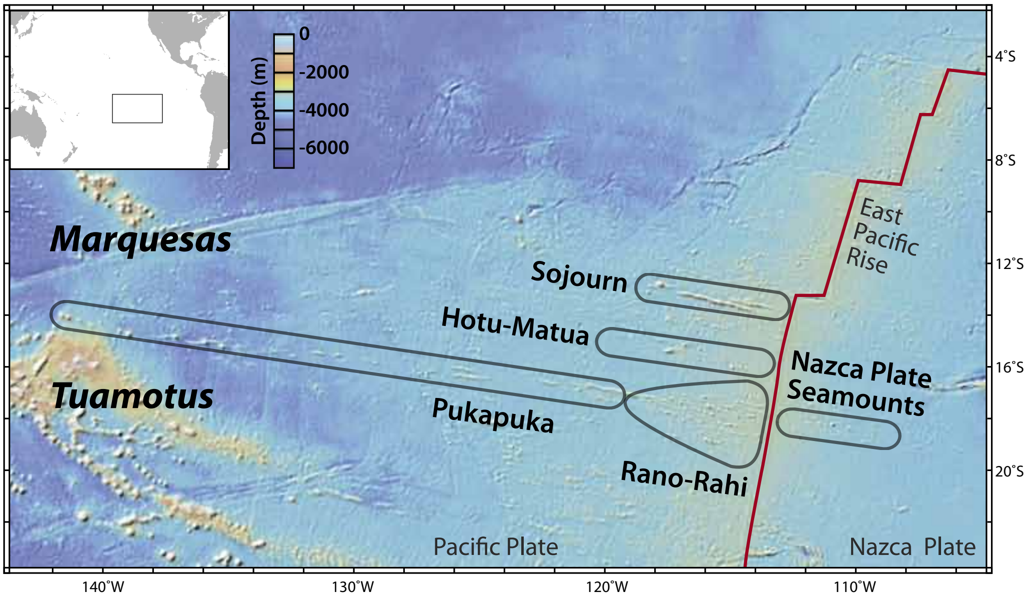
Hawaii's island chain makes scientific sense: As the Pacific plate moves westward over a stationary deep mantle plume known as a hot spot, upwellings of magma have left a trail of islands whose relative ages match up with the rate of plate motion. But elsewhere in the Pacific, the relationship between plate motion and volcanic chains is not as clear. Near the East Pacific Rise in the southeast Pacific, for example, a trail of seamounts appears to have formed not only much faster than the Pacific Plate is moving, but also in the opposite direction.

Many theories have attempted to explain how the Pukapuka, Hotu-Matua and Sojourn seamounts formed in parallel, west-east trending ridges perpendicular to the boundary between the Pacific Plate and the Nazca Plate. But none has been able to account for either the rapid pace or the direction of ridge propagation or the directionality of the chain, until now.

The westward-moving Pacific Plate diverges from the eastward-moving Nazca Plate at a mid-ocean ridge spreading center. The seamounts of the East Pacific Rise sit mainly on the Pacific Plate with a few trailing onto the Nazca Plate.

"The East Pacific Rise is distinct from many other volcano chains in the world," says Maxim Ballmer, a geophysicist at the University of Hawaii at Manoa and lead author of the new study in Geology. "These ridges display an age progression that's much faster than the rate of plate motion."

Unlike in Hawaii, where the age progression of the islands matches up with a rate of Pacific Plate motion of about seven centimeters a year, the seamounts of the East Pacific Rise display an age progression closer to 22 centimeters per year, a discrepancy "that has been a long-standing enigma in geophysics," Ballmer says.



The source of a series of parallel volcanic ridges running perpendicular to the mid-ocean ridge between the Pacific and Nazca plates may now be explained.

Both: Kathleen Cantner, AGI

HOODOOS PROVIDE EARTHQUAKE CLUES

Short-term instrumental records don't necessarily provide accurate hazard assessments in earthquake-prone areas, so scientists are always on the lookout for new physical evidence — rock falls and tsunami deposits, for example — that can extend our understanding of past seismic activity. Now, a group of geophysicists has suggested that fragile, spindly rock pillars known as hoodoos might serve as a helpful source of new data.

Abdolrasool Anooshehpoor of the U.S. Nuclear Regulatory Commission and colleagues from the University of Nevada at Reno studied two intact hoodoos in particular, both located near the Garlock Fault in California's Red Rock Canyon. The researchers analyzed high-resolution 3-D digital projections of the hoodoos and performed laboratory tests of the mechanical strength of pieces of the same rock from which the pillars were made. They found that ground motion during the last major earthquake — thought to have been a magnitude-7.4 event that occurred within the last 550 years — probably did not exceed about one-third the acceleration due to Earth's gravity (the conventional unit of measurement to describe ground motion). Had it done so, the hoodoos likely would have broken.

In this instance, the ground motion they determined agreed with the existing U.S. Geological Survey (USGS) seismic hazard assessment for the area, which is based on the best-available understanding of past behavior. But the USGS assessments might not always be accurate or precise enough, and this case study demonstrates how hoodoos can be useful to check existing predictions, the team suggested in the Bulletin of the Seismological Society of America.

Timothy Oleson

Hoodoos such as this one in California's Red Rock Canyon might help researchers better understand ground shaking during past earthquakes.

Abdolrasool Anooshehpoor

The other part of the enigma is that the seamounts of the East Pacific Rise began forming away from the mid-ocean spreading ridge and the source migrated east towards the ridge."The textbook thinking is that the plate drags the asthenosphere, so in this case the asthenosphere would have to be slowly moving to the west," he says. But that's not what the team found. "According to our model, it looks like the asthenosphere is moving independently of the plate, being pushed very vigorously eastward."

Ballmer and his colleagues developed a new model to explain the source of the unusual seamount ridges: shear-driven upwelling. In this case, shear-driven upwelling occurs as the Pacific Plate moves over heterogeneous underlying asthenosphere. As the plate moves over adjacent zones of weaker and stronger mantle, lateral tension develops and creates shearing motions in the plate. This shearing leads to upwelling and decompression melting in the mantle, which creates the seamounts.

Shear-driven upwelling accounts for the source of the magma, Ballmer says. But to explain the motion, the team had to find another source. They looked west of the East Pacific Rise to an area known as the South Pacific Superswell, thought to be underlain by anomalously hot mantle.

When two fluids, one of which is hotter and weaker than the other, come in contact they form fingers, Ballmer says. So when the hotter material of the Superswell encounters the cooler mantle near the East Pacific Ridge, the elongating fingers create a channelized flow through the asthenosphere, moving from west to east. That then creates heterogeneity in the asthenosphere and pushes the source of the volcanism — the shear-driven upwelling — rapidly eastward, toward the Nazca Plate. "This would explain the fast age progression in the direction of the mid-ocean ridge," Ballmer says.

"Many models have been proposed to explain these ridges and none has been convincing, until now," says Mark Behn, a geodynamicist at Woods Hole Oceanographic Institution in Massachusetts who was not involved in the new study. The team's explanation "is very plausible," he says.

Previous efforts to explain the East Pacific Rise volcanoes have included ideas such as a lithospheric cracking model, in which elongate cracks in the crust account for why the volcanoes appear as ridges and not discrete cones, and a density-dependent small-scale convection model. No past hypothesis has stood up to geochemical or geophysical testing, Ballmer says.

Next, Behn would like to see the new model applied elsewhere in the world, to see if it could be used to explain volcanic phenomena in other settings. "There are lots of other places where there doesn't seem to be a deep mantle plume and this might be a viable mechanism." Ballmer also thinks the new mechanism may have applications to locations where hot spots sit close to mid-ocean ridges, such as the Hollister Ridge near the Louisville hot spot in the South Pacific.

Mary Caperton Morton