'Caldas tear' resolves puzzling seismic activity beneath Colombia

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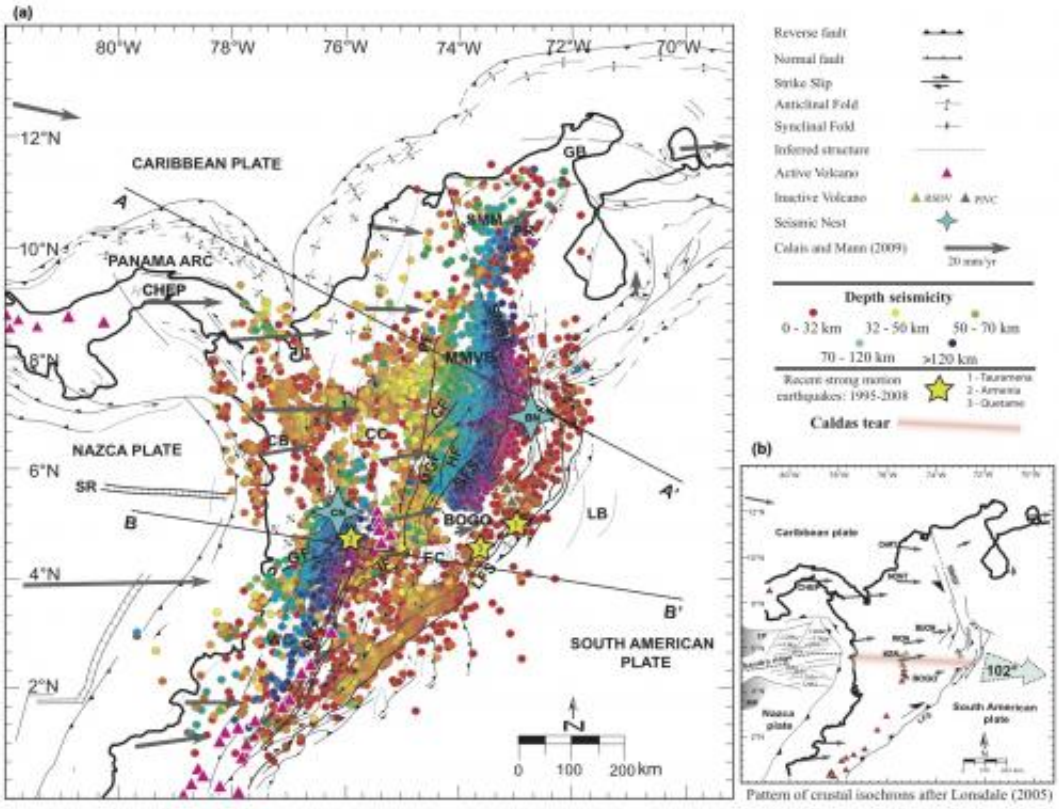

This is a tectonic map of northwestern South America and Panama showing plate boundaries and neotectonic fault systems and selective distribution of hypocentral solutions of ~30,000 earthquakes extracted from the entire catalog of the CNSN. Credit: *BSSA*

Colombia sits atop a complex geological area where three tectonic plates

are interacting, producing seismicity patterns that have puzzled seismologists for years. Now seismologists have identified the "Caldas tear," which is a break in a slab that separates two subducting plates and accounts for curious features, including a "nest" of seismic activity beneath east-central Colombia and high grade mineral deposits on the surface.

In a paper published in the June issue of the *Bulletin of the Seismological Society of America* (*BSSA*), researchers Carlos Alberto Vargas of the Universidad Nacional de Colombia and Paul Mann of the University of Houston relied on recorded earthquake data from the Colombian National Seismological Network database and tomographic data to reveal a clearly defined, prominent tear.

"This paper attempts to provide a unifying concept of how the deformation is proceeding on a regional scale in Colombia," said Mann.

The complex regional tectonic activity includes movement of three plates: the Caribbean plate that is subducting or being forced beneath Colombia in the north; the Panama block or Panama plate that is colliding with Colombia in the central part of the country; and the Nazca plate, which is an oceanic plate that is subducting beneath the southern part of Colombia from the Pacific.

While Colombians have experienced earthquakes in the past 20 years, none has been exceedingly large, despite the complex zone of convergence beneath it.

"Unlike the high seismicity to the south of the Caldas tear, there are few destructive earthquakes north of the tear, which suggests that there is an accumulation of stresses that could trigger strong motion events resulting from the frontal collision of the Panamanian Arc against Colombia," said Vargas.

Surficial evidences of the Caldas tear are related to mineral deposits, hydrocarbon occurrences and geomorphological anomalies. Credit: *BSSA*

The authors used the Colombian Seismic Network's database of more than 100,000 seismic events to identify the prominent tear, where the slab is broken along a very distinct break, separating the Nazca oceanic plate, which is coming from the Pacific, from the Panama plate, which is an old island arc (Sandra ridge) that pushes into Colombia from the west.

"We think that this Panama block is acting as an indenter. It's a block of thick crust that doesn't subduct easily, rather it subducts at a shallow angle," said Mann. "And because it's thick crust, it acts like a fist or an indenter that's pushing into the whole country of Colombia and northwest South America."

Vargas and Mann suggest the crust that preceded the indenter or colliding Panama block is being ripped apart from the indenter, which is crust that cannot easily subduct. The Caldas tear forms the southern edge of the indenter, separating it from the Nazca plate. The indenter is breaking from the crust that preceded it, forming the Bucamaranga nest, which is a dense area of seismic activity in a small volume of crust at about 140 km depth.

Using tomographic data, the authors inferred that the Caribbean plate crust to the north is subducting at a very shallow angle and producing relatively little deep seismicity. Tomography is a way to map the geometry of a subduction zone on the basis of differences in the seismic attenuation of crusts. Colder subducting crust, for example, will have a lower attenuation than the surrounding mantle. The Caribbean plate in the north is subducting at a slower rate than the Nazca plate in the south, where seismic activity is greater.

"In the center of it all is the indenter – an incredibly important feature for Colombia and for assessing its earthquake hazard," said Mann.

Colombia features large strike slip faults that form a V-shaped pattern, which is symmetrical about the Panama plate. Vargas and Mann relate the upper crust strike slip faults to the indenter, which they suggest is pushing the crust further east than in areas in the north and south.

The Caldas tear is reflected in the landscape. The Magdalena River, which runs northward, changes from broad valleys to steeper relief gorges as it crosses the tear, suggesting to researchers that the tear may propagate to the surface. There is an alignment of small volcanoes along the tear that have an unusual composition, distinctly different than seen in the volcano arc in the south.

"We have found that this tectonic structure not only controls the

distribution of major mineral deposits, but has also come to control the geometry of several sedimentary basins, and the distribution of hydrocarbons retained in them," said Vargas.

"Tearing and breakoff of the subducted slabs as the result of a collision of the Panama arc-indenter with northwestern South America," appears in the June 2013 issue of *BSSA*.

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