Understanding Internal Geodynamics of Southern Costa Rica via Force Diagrams

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Abstract

By using existing earthquake data and seismic analytic software (SEISAN) we create a description of focal mechanisms for groups of well-located earthquakes in southern Costa Rica. The mapping of focal mechanisms is essential for understanding the stress state at depth, which in turn, offers information about the internal dynamics that lead to the deformation reflected by the presence of earthquakes. This will address key questions such as the mechanism for creating high elevations and the relative motion of the different parts of the region.

Background

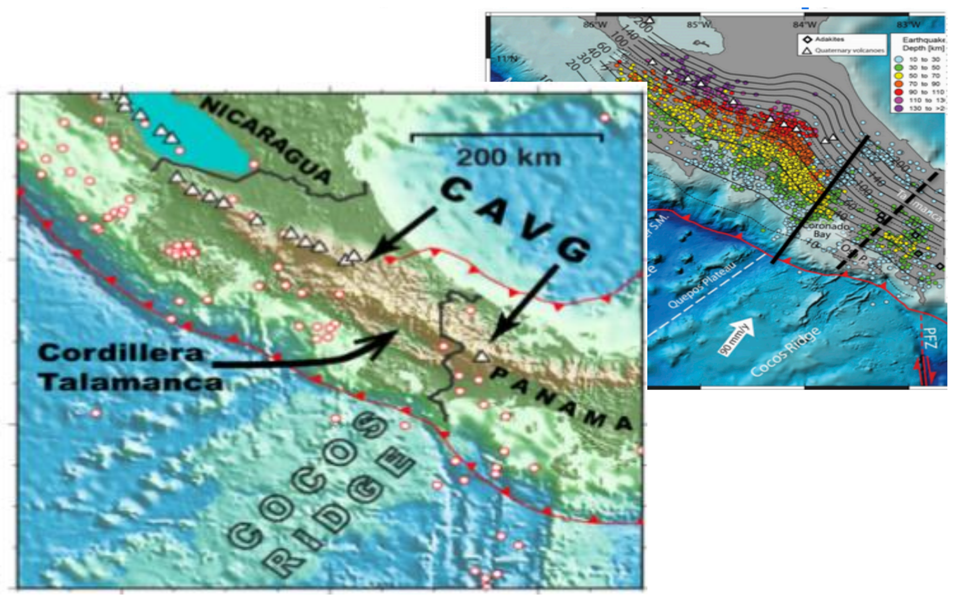

Figure 1
Map outlining features of Costa Rican seismology
Left: Triangles - Active volcanoes, red circles - earthquakes, lines with triangles - tectonic plate motion
Right: Earthquakes in CR color sorted by depth

Costa Rica (CR) is a narrow landmass with an oceanic crust colliding in from the west and a passive margin to the east. There is a line of volcanoes that extend halfway along country's length in northern and central parts. In the southern part of CR, there is a mountain range, the Cordillera Talamanca (CT), which is a relatively tall and young structure, but has no presently active volcanoes. Cocos Ridge, on the western side of CR, most likely collides and sinks beneath southern CR, but no present-day evidence such as active volcanoes or deep earthquakes in areas we would expect exists. This implies that about ~ 10 million years ago, volcanic activity changed drastically in southern CR but not northern. The drastic elevations near the CT pose a threat to the lives of CR citizens and infrastructure via devastating landslides and earthquakes.

Results

Quality force diagrams tell us which parts of the earth were pulled and which parts were pushed. Obtaining a large number of quality diagrams was not possible from the data set. Although the original data included 98 seismic events (98 potential diagrams) we were only able to produce 13 high quality and 5 moderate quality diagrams.

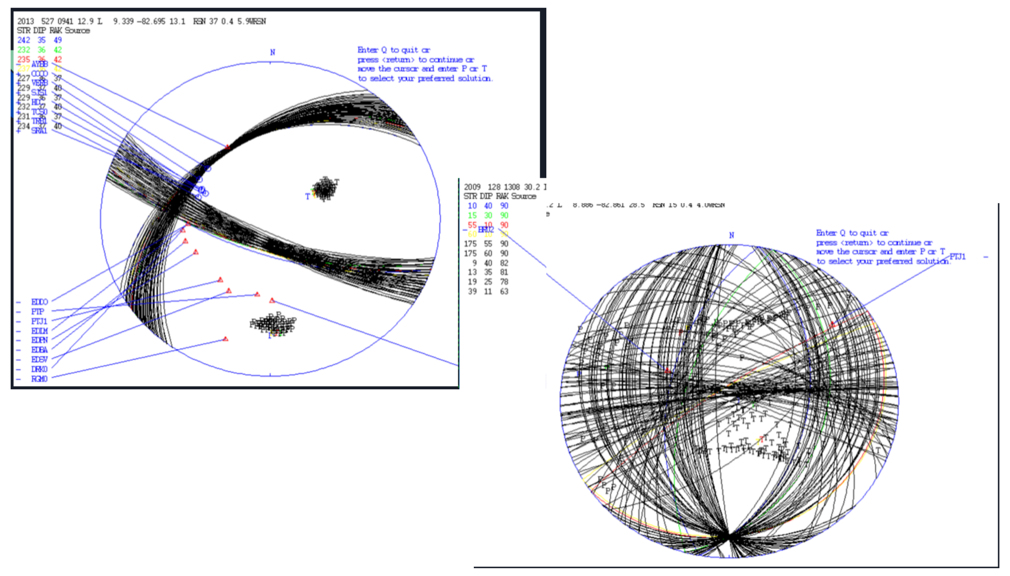

Figure 2
High quality mechanism (left) vs very low quality mechanism, which is is not usable for out data (right). Almost 80% of our data resembled the figure on the right

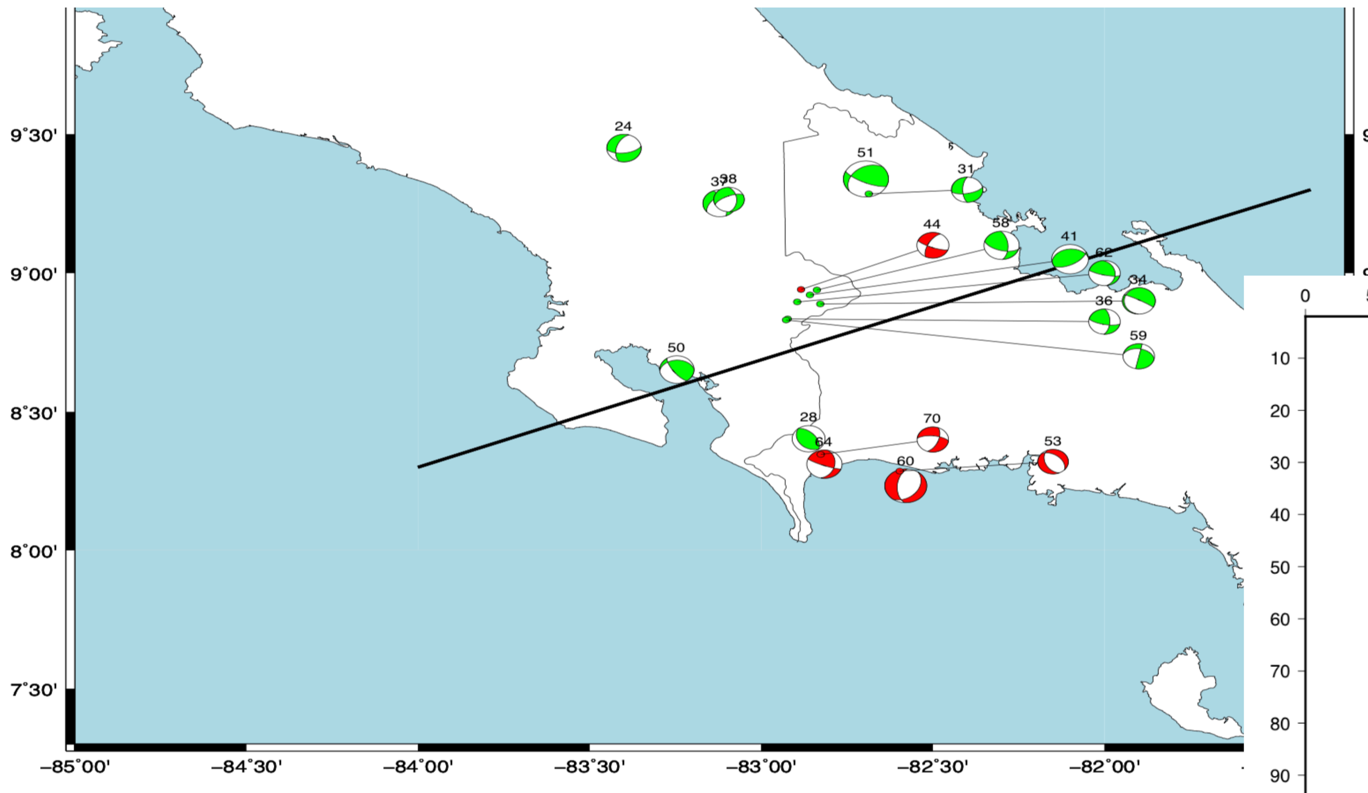

Figure 3
Well determined force diagrams with high degree of accuracy (green) and moderate degree of accuracy (red) placed on a map of Costa Rica

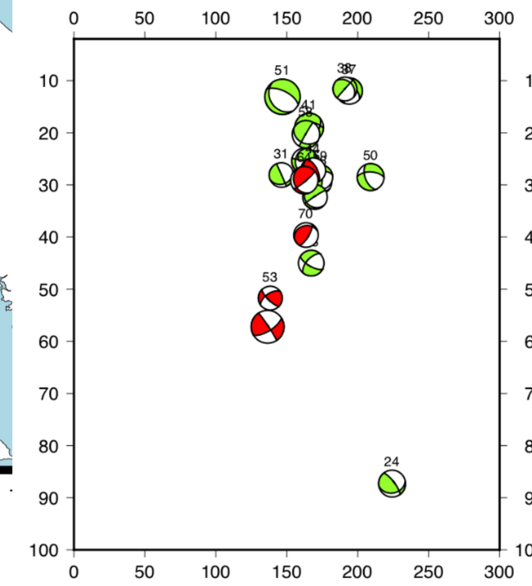

Figure 4
Same focal mechanisms projected onto a vertical cross-section for at-depth analysis

Because there exists few well located earthquakes at the CT, it is nearly impossible to analyze the area directly. However, from these results, we begin to see patterns, particularly events 34 , 36, 41, 44, 59, and 62 near the Panamanian border, and events 31 and 51 near the top of the page. From this picture we see that there seems to be a force pushing upwards at these locations. This is consistent with present observations of high elevations in those areas. Although a complete picture of mid to southern Costa Rica cannot be drawn at present time, the project is on-going and will be carried out by futures members. Once enough earthquakes have been accurately identified and categorized, interpretation of the data will be left to the project advisors.

References

•Havskov and Ottemoller, SeisAn Earthquake analysis software, Seis. Res. Lett., 70, 1999.
•GREAT Project Proposal, Vadim Levin

Methods

Costa Rica currently employs over 130 seismic stations throughout the country. Each station records the motion of the ground in all three directions, and each axis is treated independently for data analysis. In this project, we concern ourselves strictly with the Z-axis (up and down motion) to determine characteristic properties of the detected seismic wave.

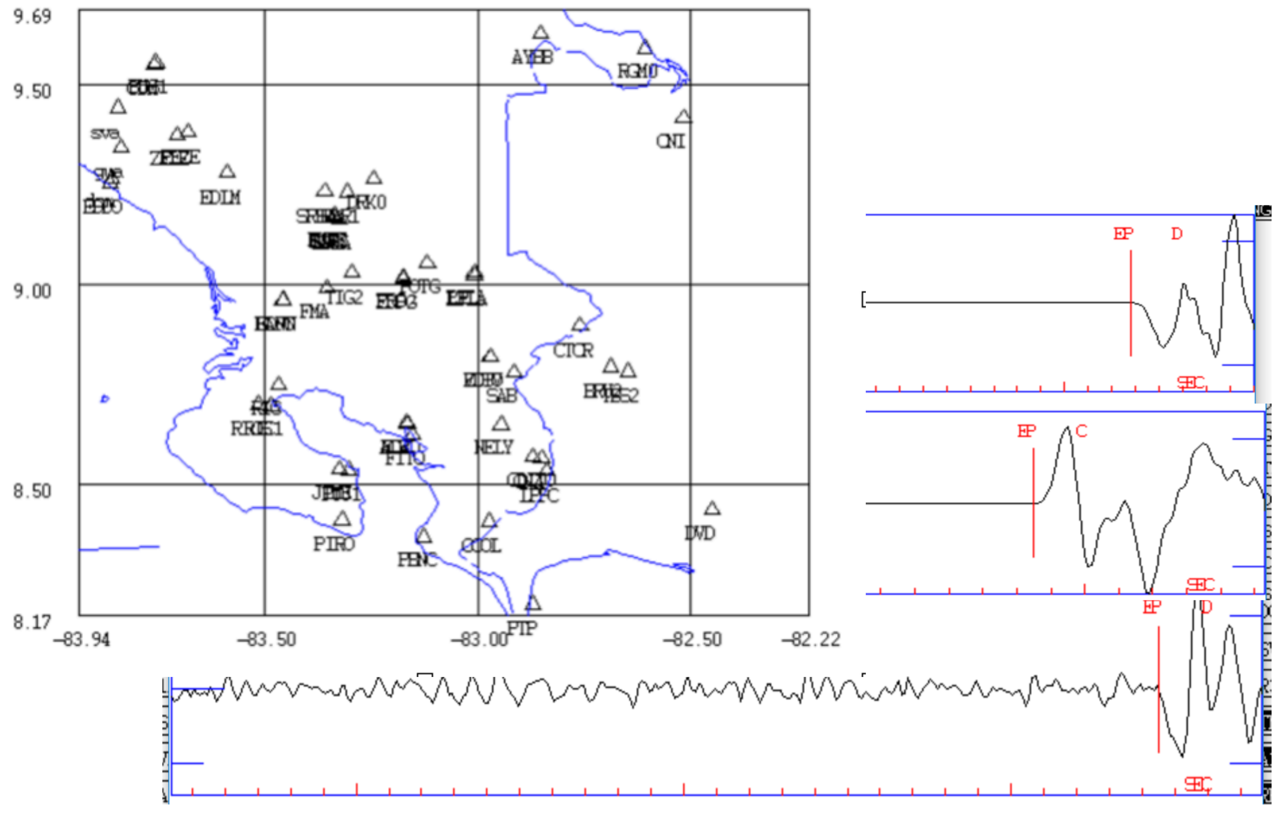

Figure 2
Top left: Map of Costa Rican Seismic Stations used in this study
Bottom right: Sample seismic waves as interpreted in SEISAN

1. First, each seismic event is detected, with a degree of confidence, by at least 30 detectors.
2. Then we determined if the first wave that was initially detected was an up (C) or down (D) wave in each detecter.
3. Using the information from step 2, we can tell which areas of the earth were pulled and which areas experienced a push. This lets us construct a diagram, which informs us of the general forces at the location of the earthquake.

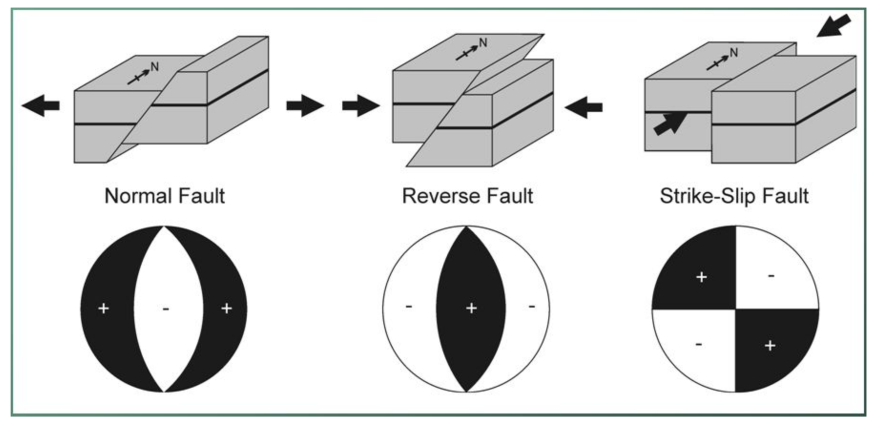

Figure 3
Simple example of focal mechanism and the information that can be extracted from it

4. We collect all the diagrams that are catalogued and place them onto a map of CR. This is what allows us to determine the general structure of the internal forces at particular locations.