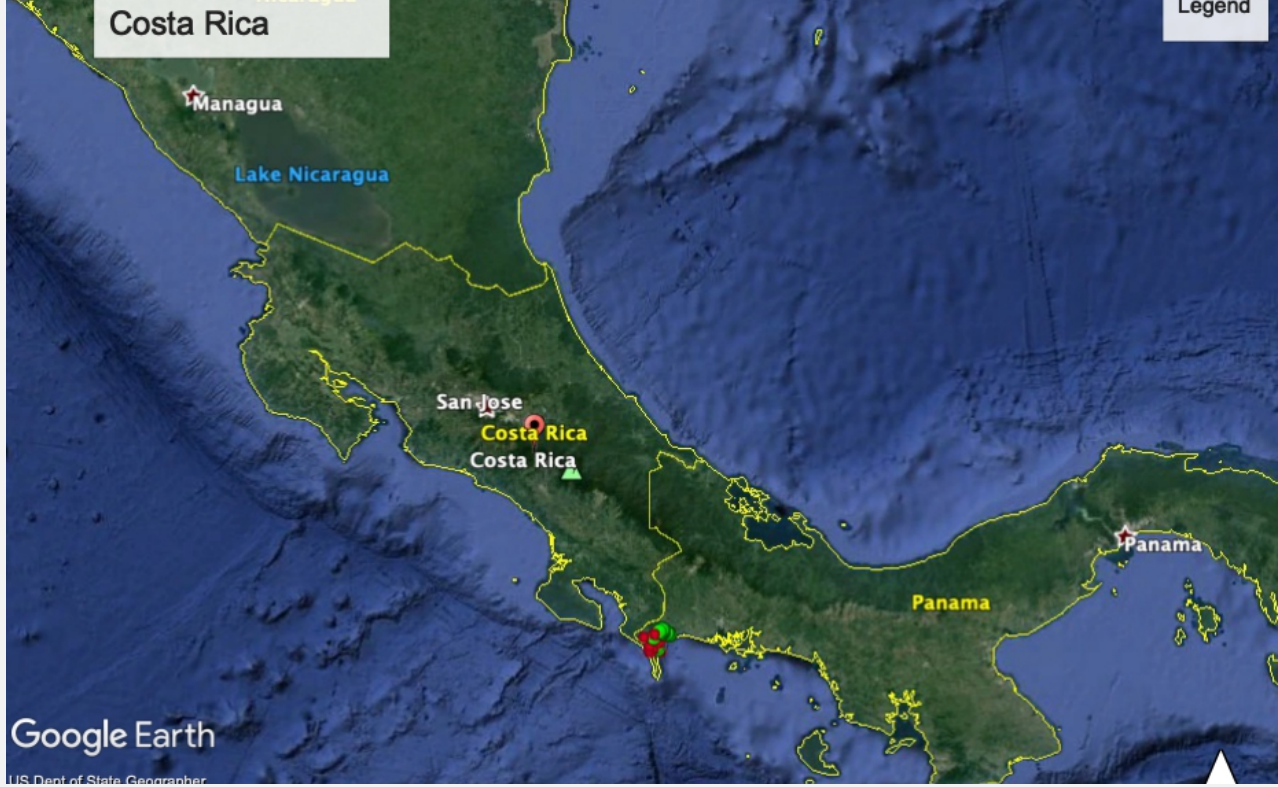

Summer 2019 Panama/Costa Rica border earthquake sequence: distribution of sources, nature of faulting and tectonic significance.

Joyce Franco, Dr. Vadim Levin, Dr. Ivonne Arroyo

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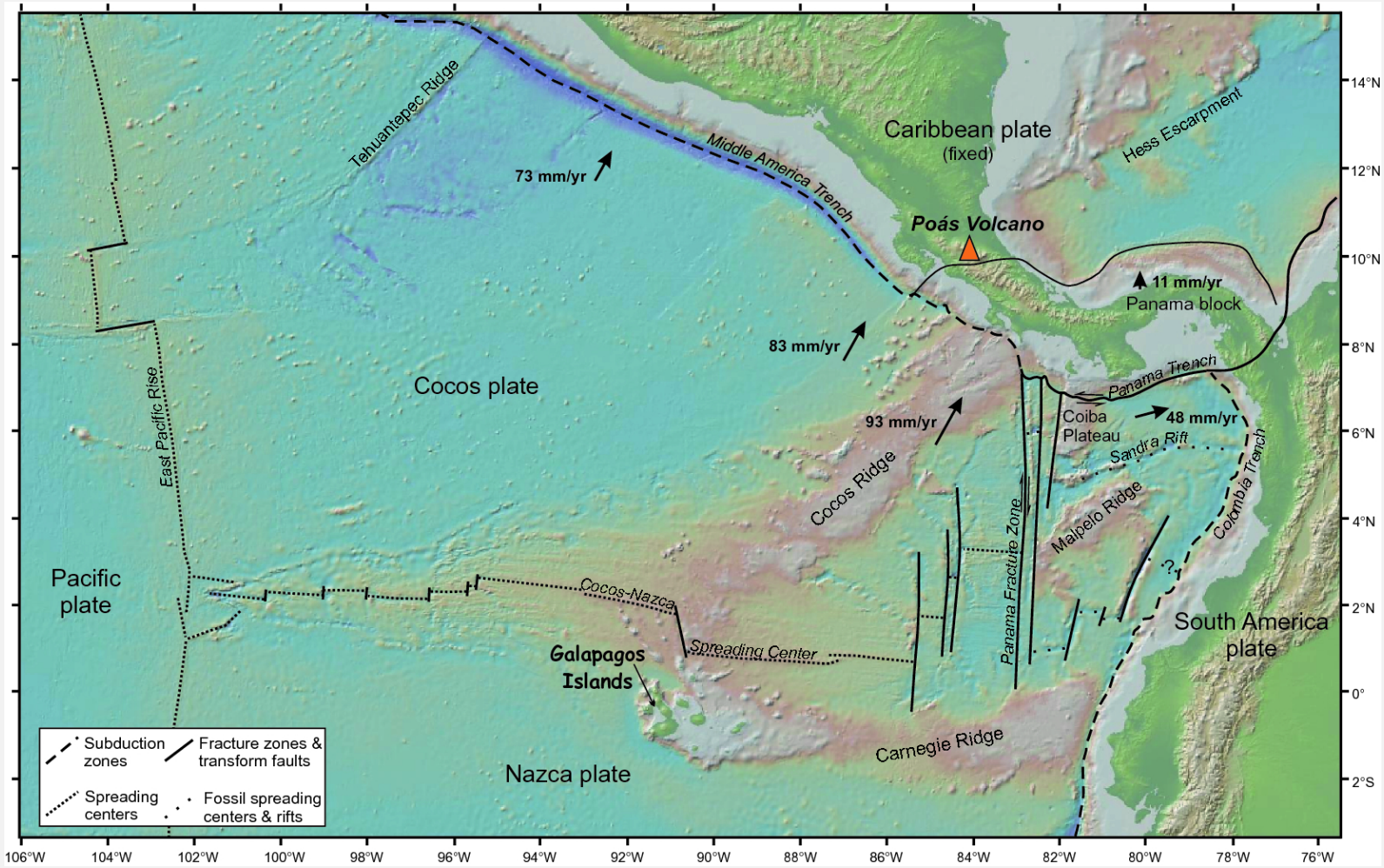
Background: Tectonic Setting of Southern Costa Rica

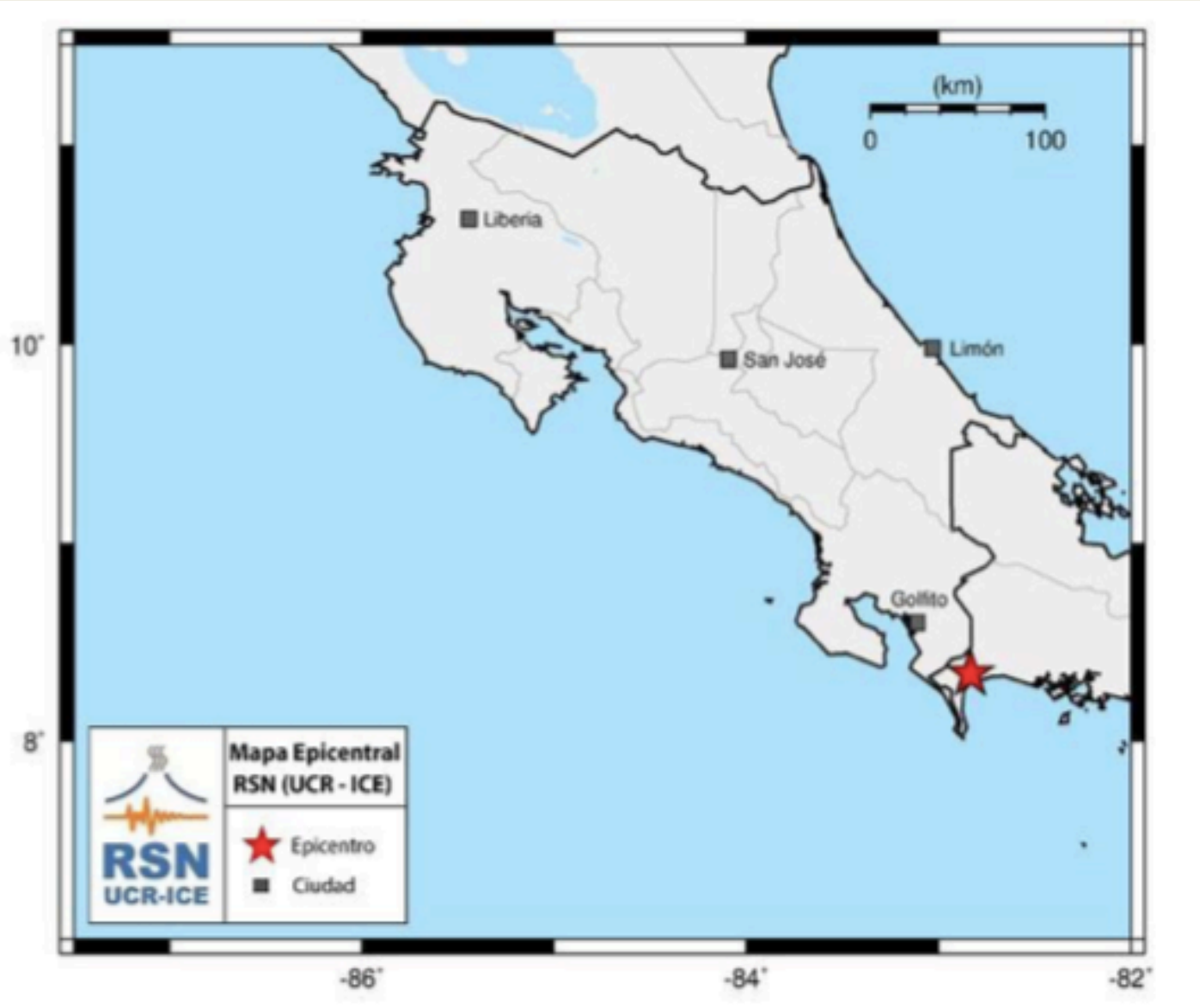


Bathymetry, topography (http://www.geomapapp.org (Ryan et al. 2009)), and tectonic plate configuration in the region surrounding the Costa Rica. Arrows show plate motions with respect to the Caribbean plate (DeMets et al. 1990; DeMets 2001).

- **Plates involved in Costa Rica's tectonism:**
- **Cocos Plate, Caribbean Plate, Nazca Plate, the Panama microplate. Also, the Panama Fracture Zone**
- The Cocos Plate subducts with a convergence direction of N25^{o} – N30^{o}E with respect to the overriding Caribbean Plate.
- The Panama Fracture Zone marks the boundary between the Cocos plate and Nazca Plate and forms a triple junction between the Cocos, Nazca and Caribbean Plates
- The current motion of the Panama block is 11mm/yr. to the N with respect to the Caribbean plate

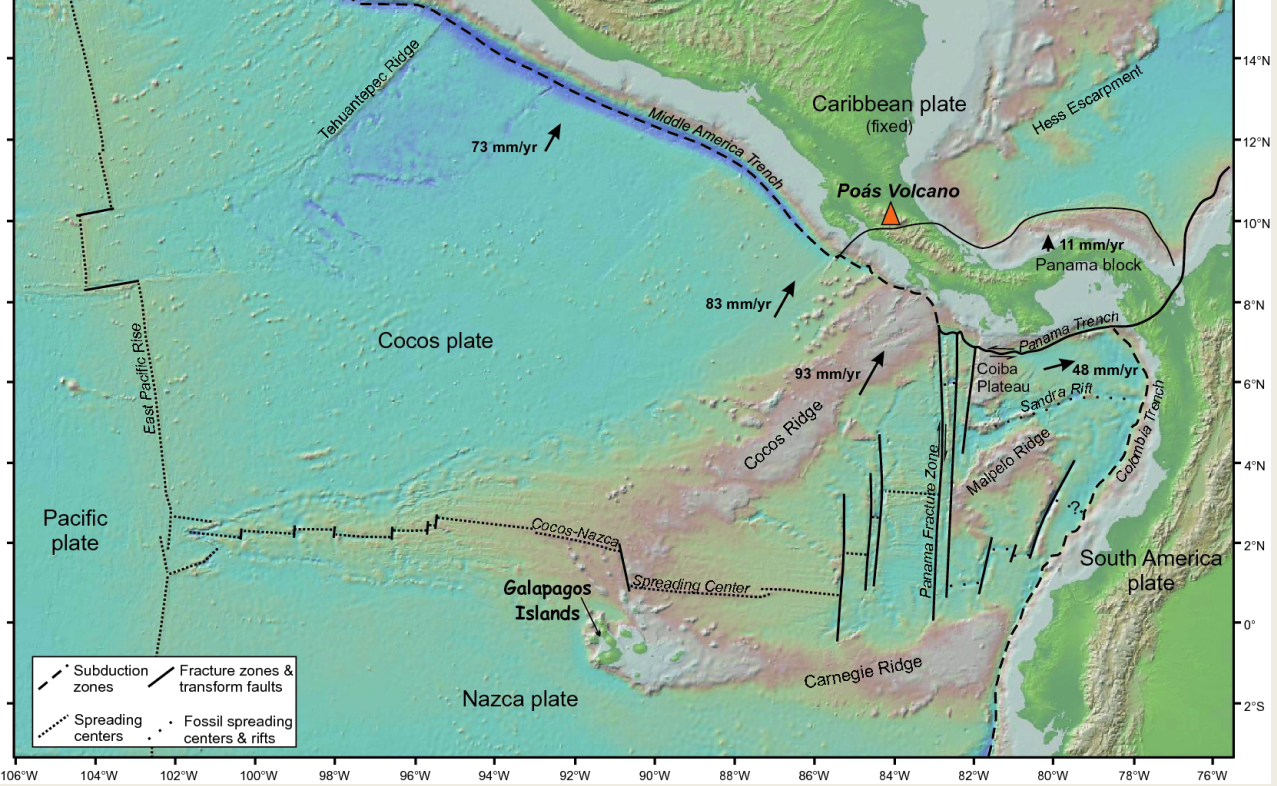
Goals for 2019

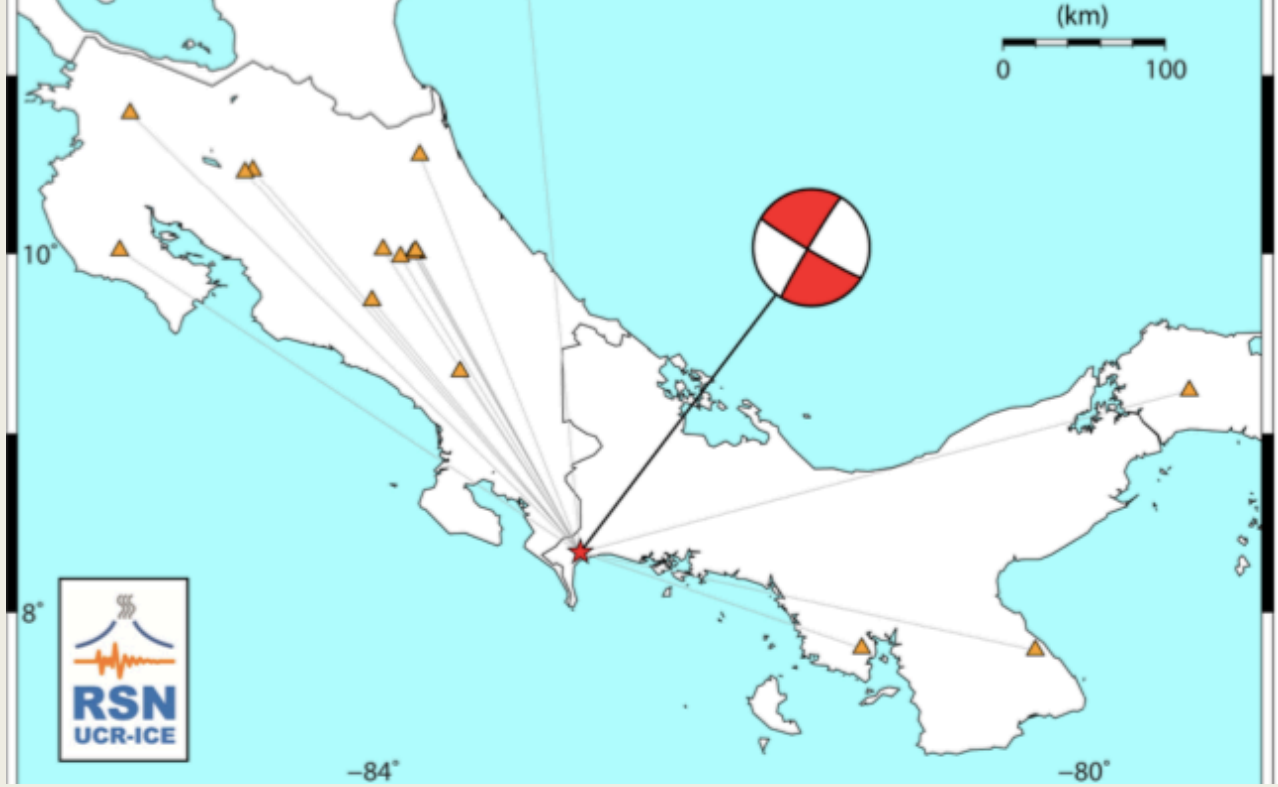
- Understand the tectonic setting of Costa Rica and nature and significance of earthquakes
- Learning how to use earthquake data to interpret important characteristics of the crust and subduction zones
- Learn how to use SEISAN to be able to access earthquake data such as hypocenters, depth, magnitude, polarities etc.



BACKGROUND: 6.4 Magnitude earthquake and aftershocks

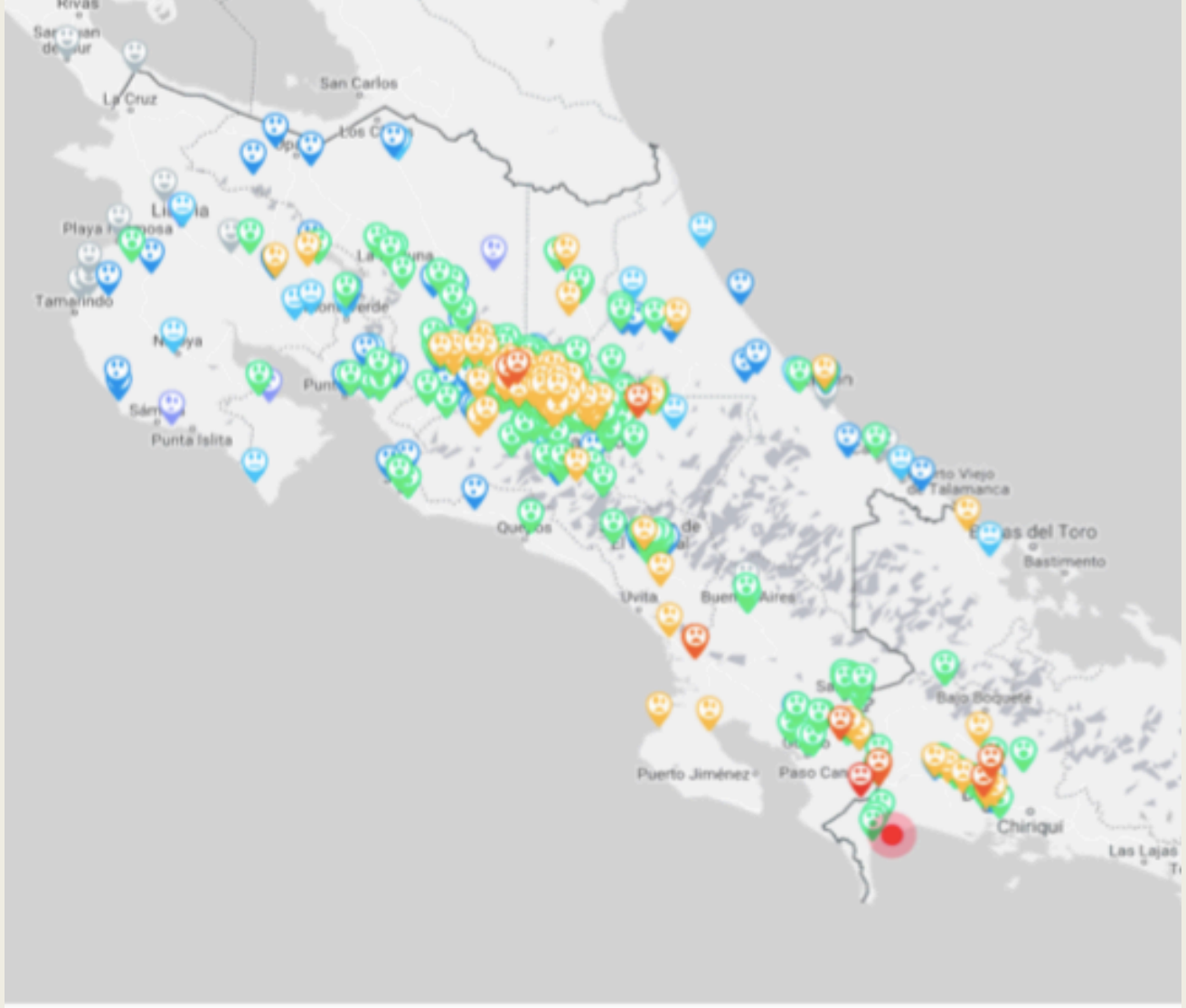
- **MAIN EARTHQUAKE PRELIMINARY DATA**
- **Time :** June 25,2019 at 11:23pm
- **Location:** Panamanian territory, 11 km northeast of Puerto Armuelles and 14 km southwest of Laurel de Corredores.
- **Preliminary Depth:** 29 km
- **Magnitude:** 6.4





BACKGROUND: 6.4 Magnitude earthquake and aftershocks

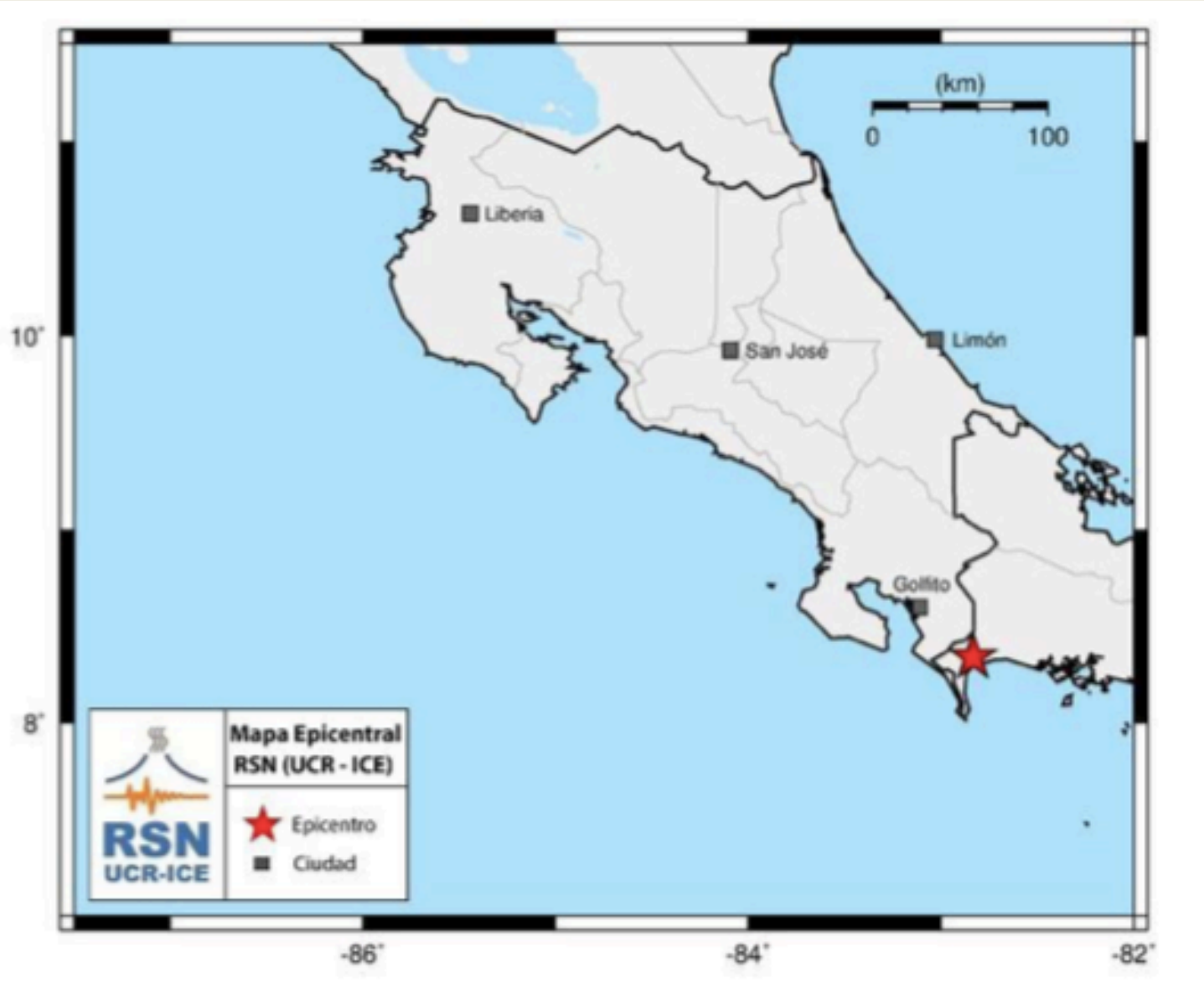
- MAIN EARTHQUAKE PRELIMINARY DATA
- **Source:** Interaction between the subduction of the Cocos plate under the Panama microplate accompanied by the presence of the Panama Fracture Zone



BACKGROUND: 6.4 Magnitude earthquake and aftershocks

- MAIN EARTHQUAKE PRELIMINARY DATA
- Intensity

- Records obtained from RSN interactive app **¿Lo sentiste?**



BACKGROUND: 6.4 Magnitude earthquake and aftershocks

- **JUNE-JULY 2019**

260 aftershocks

- **AS OF JANUARY 2020**

465 aftershocks

- **Magnitude:**

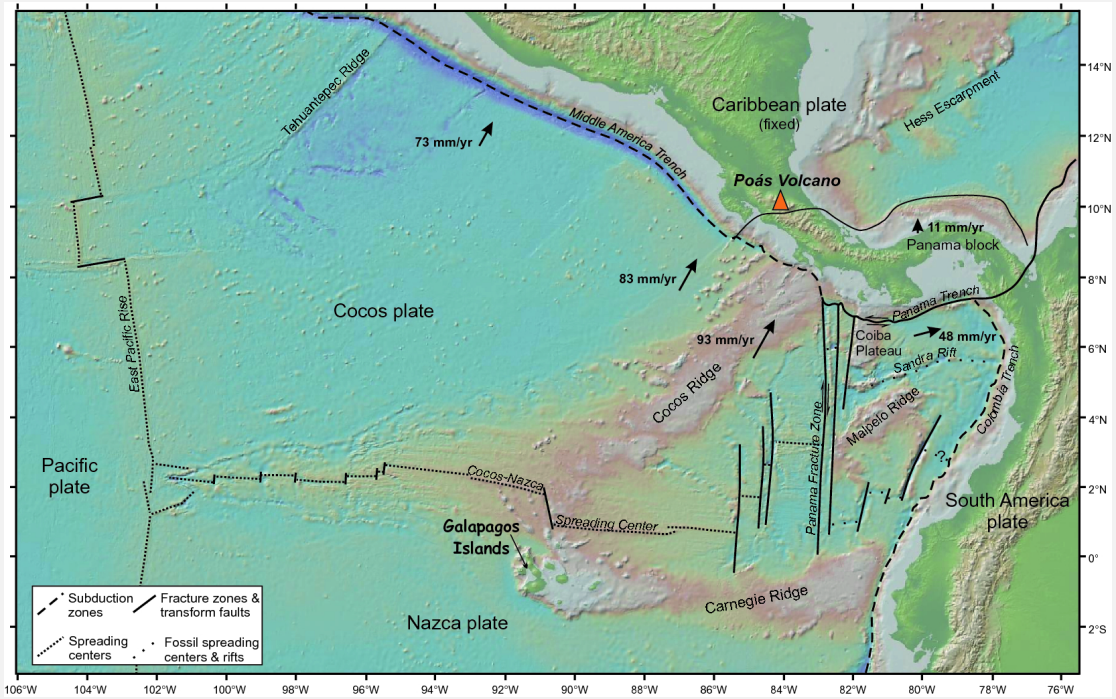
2.5 and higher

- **Depth:**

9 to 33km

Importance of studying the 6.4 Magnitude earthquake and aftershocks

- The seismicity in the region increased in 2019
- **Past Earthquakes** of magnitude larger than 7 occurred in the years 1904, 1934, 1941 and 1983
- **Recent earthquakes** near the border with Panama: a 6.2 in 2002 and a 6.6 in 2003 in Burica. A 6.3 earthquake in 2008 at the Costa Rica-Panama border (near Puerto Armuelles)
- This research project aims at understanding the source of seismic events, tectonic setting and behavior of plates in southern Costa Rica



MAIN EARTHQUAKE PRELIMINARY DATA

- **Source:** Interaction between the subduction of the Cocos plate under the Panama microplate accompanied by the presence of the Panama Fracture Zone (boundary between the Cocos Plate and Nazca plate

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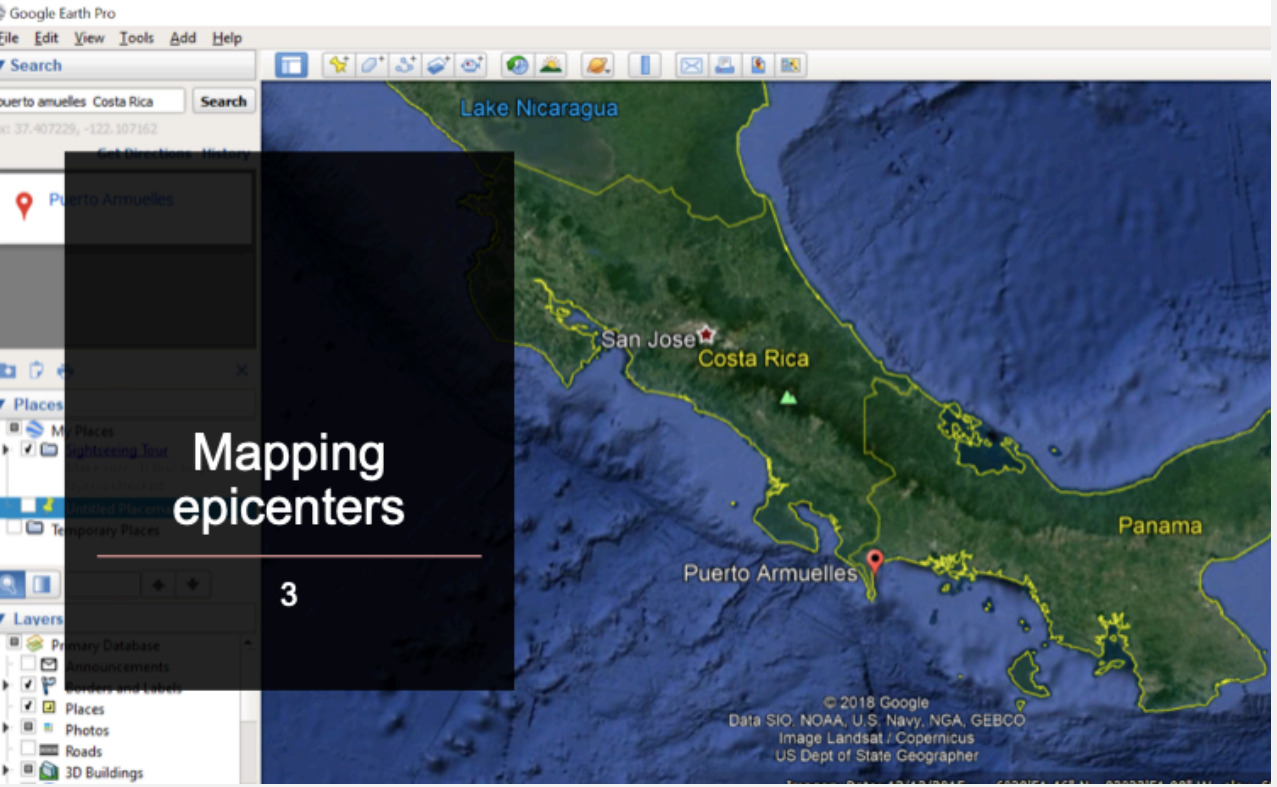
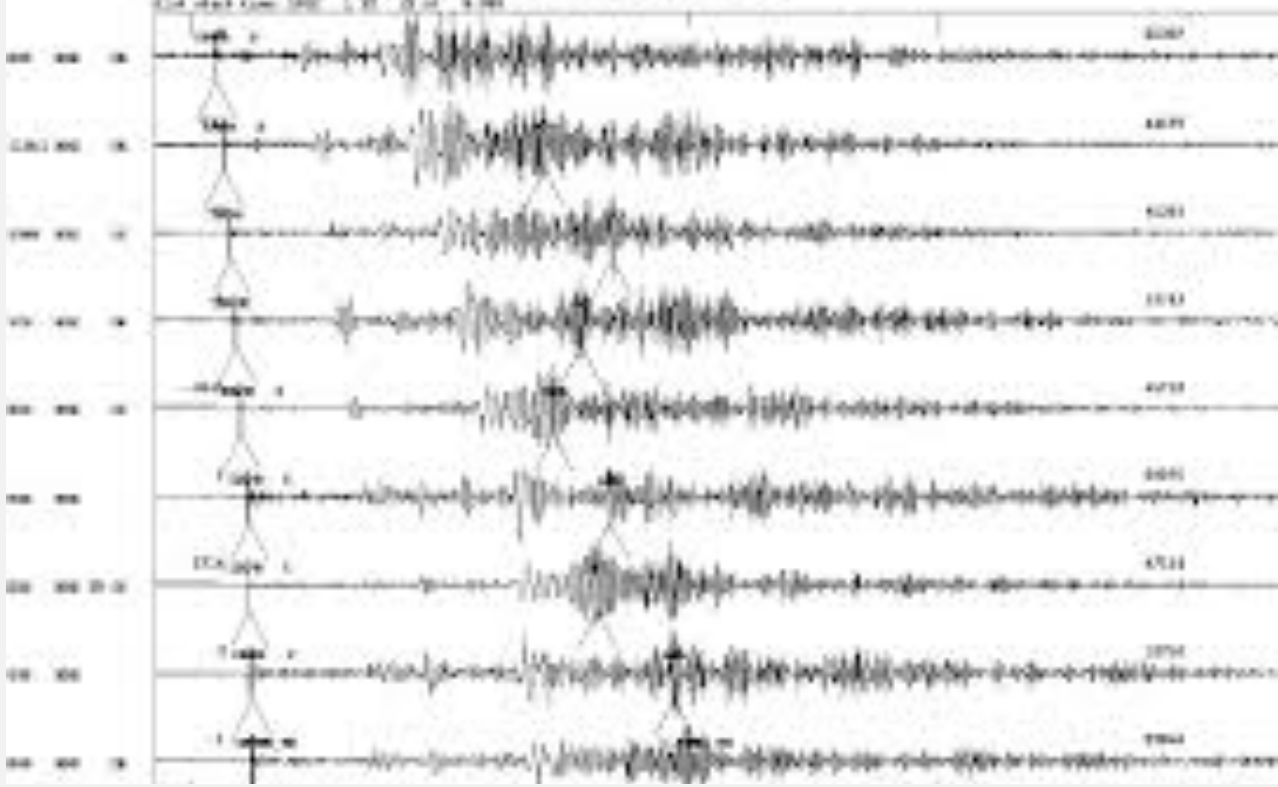
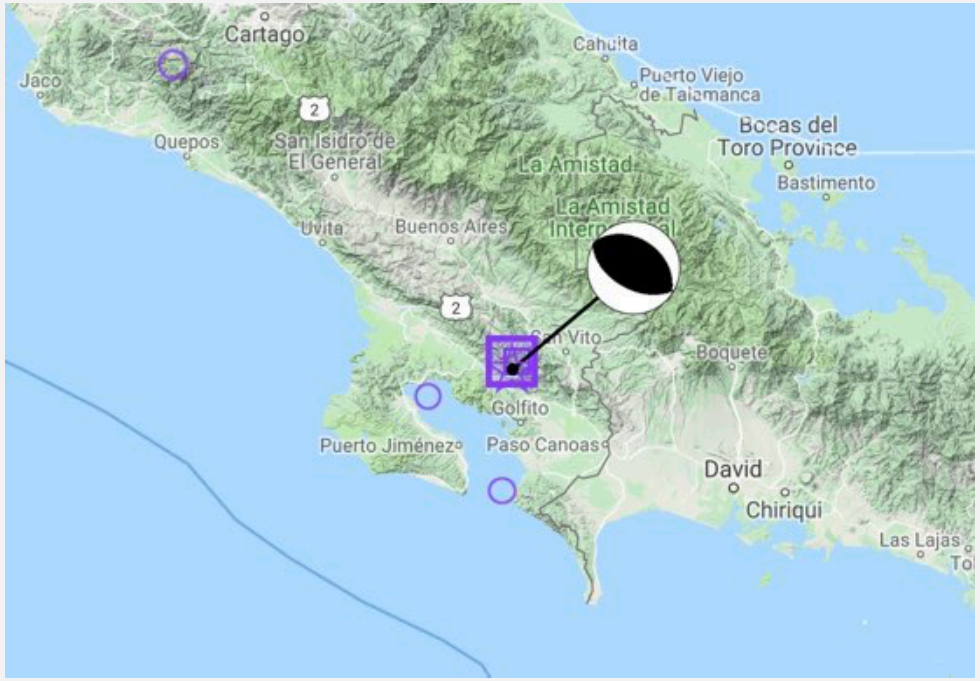
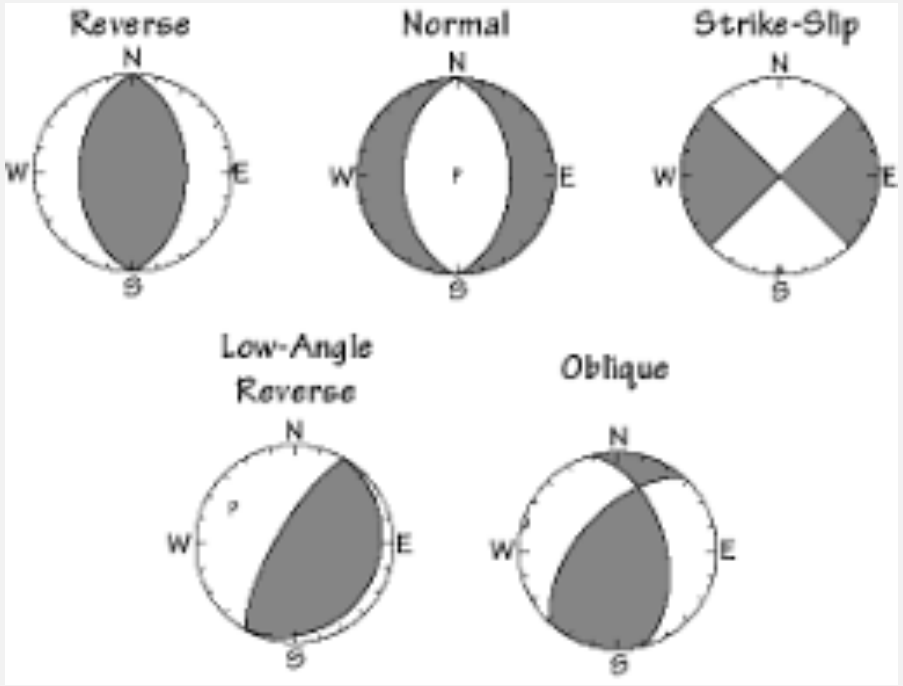
SUMMARY OF MY WORK WITH THE RSN





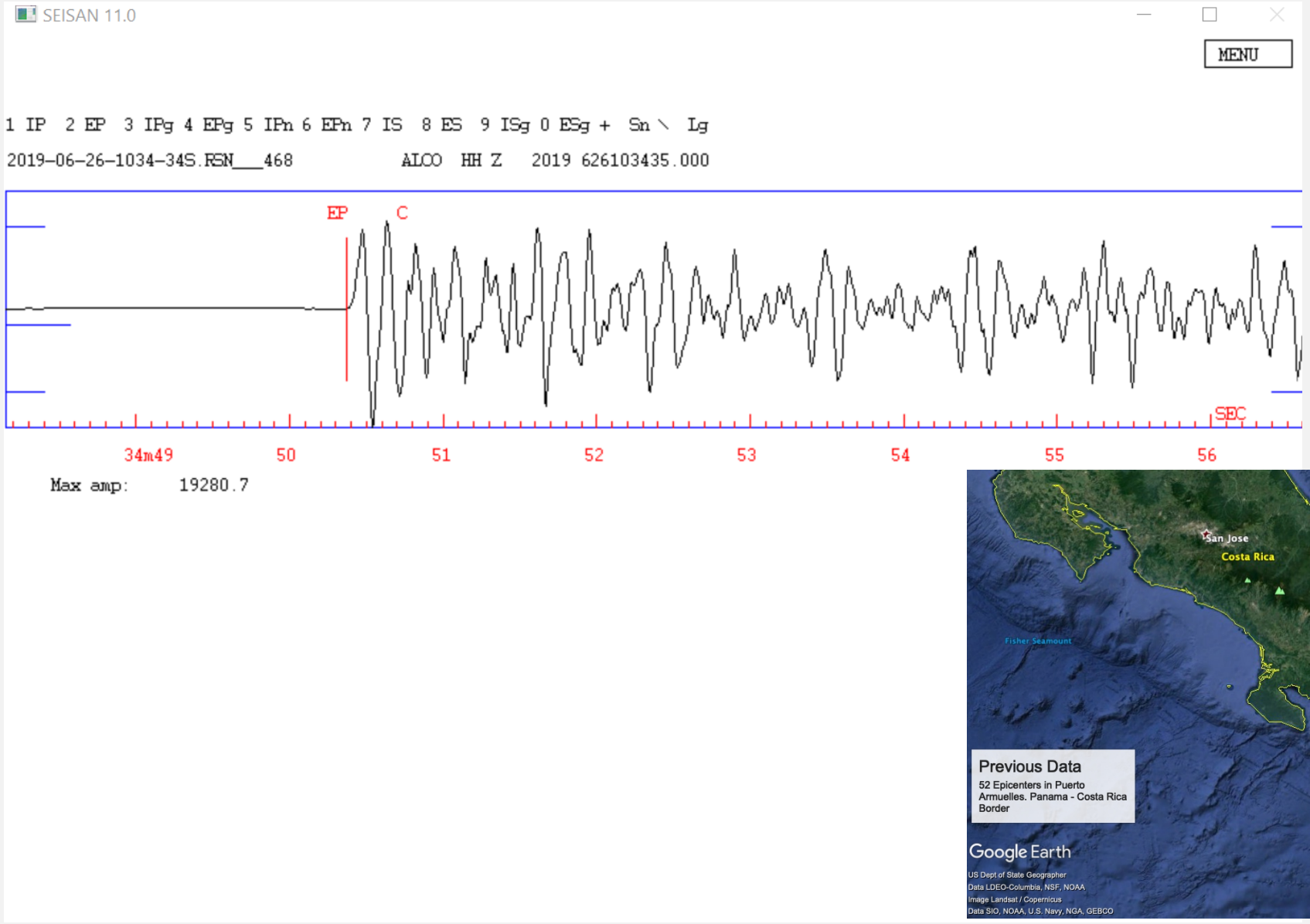
- REVISING WAVEFORM DATA OF THE 6.4 MAGNITUDE EARTHQUAKE SEQUENCE.
- PICKING OF FIRST WAVE ARRIVALS OF EARTHQUAKES OF MAGNITUDE LARGER THAN 3.5 AND COVERAGE GAP OF <220 DEGREES ON SEISAN TO IMPROVE LOCATION OF EPICENTERS
- MAPPING OF 52 EVENTS OUT OF 260 EVENTS THAT OCCURRED BETWEEN JUNE 25,2019 AND JULY 25,2019.



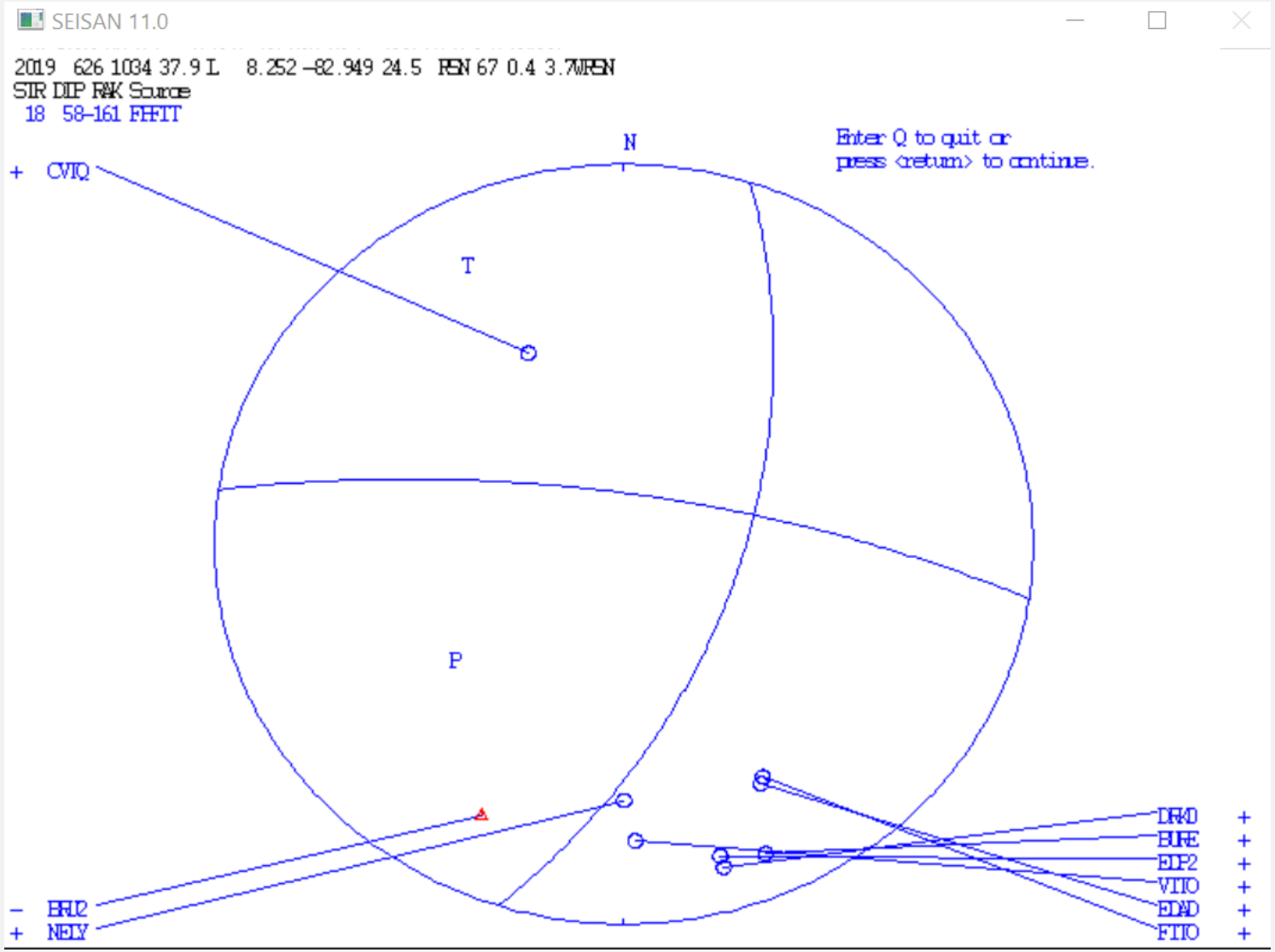


- POLARITIES AND FOCAL MECHANISMS TO EXPLAIN CRUSTAL DEFORMATION
- PLOTTING FOCAL MECHANISMS ON GMT

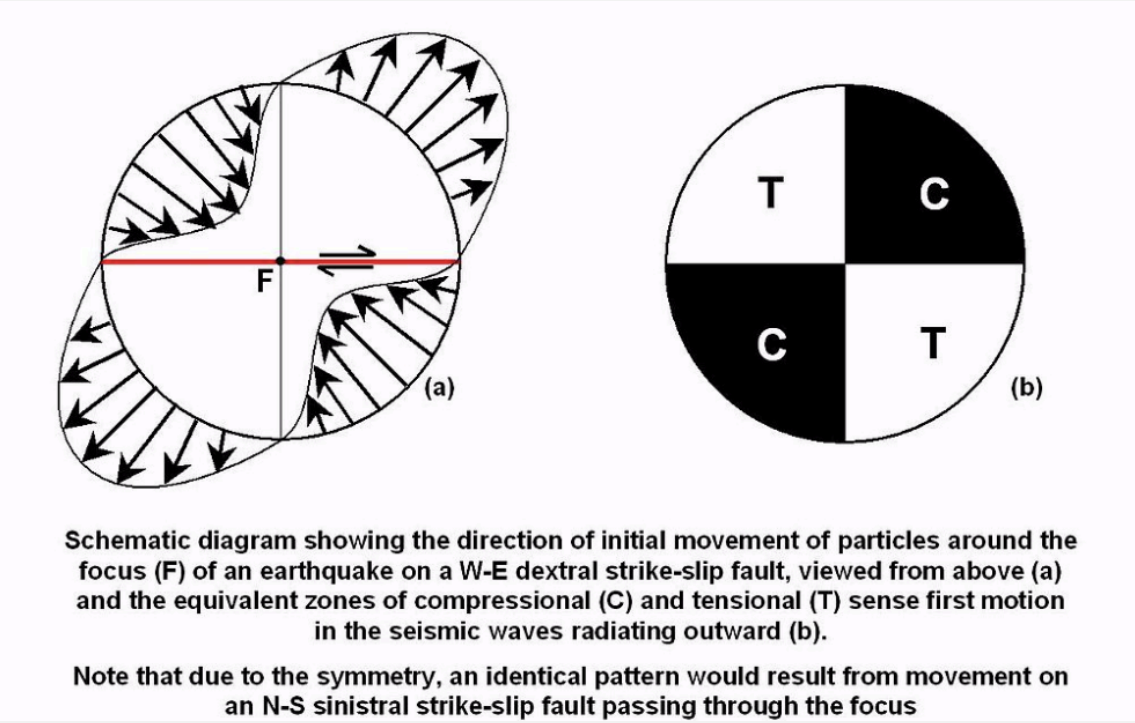
Understanding Seisan



Understanding Seisan

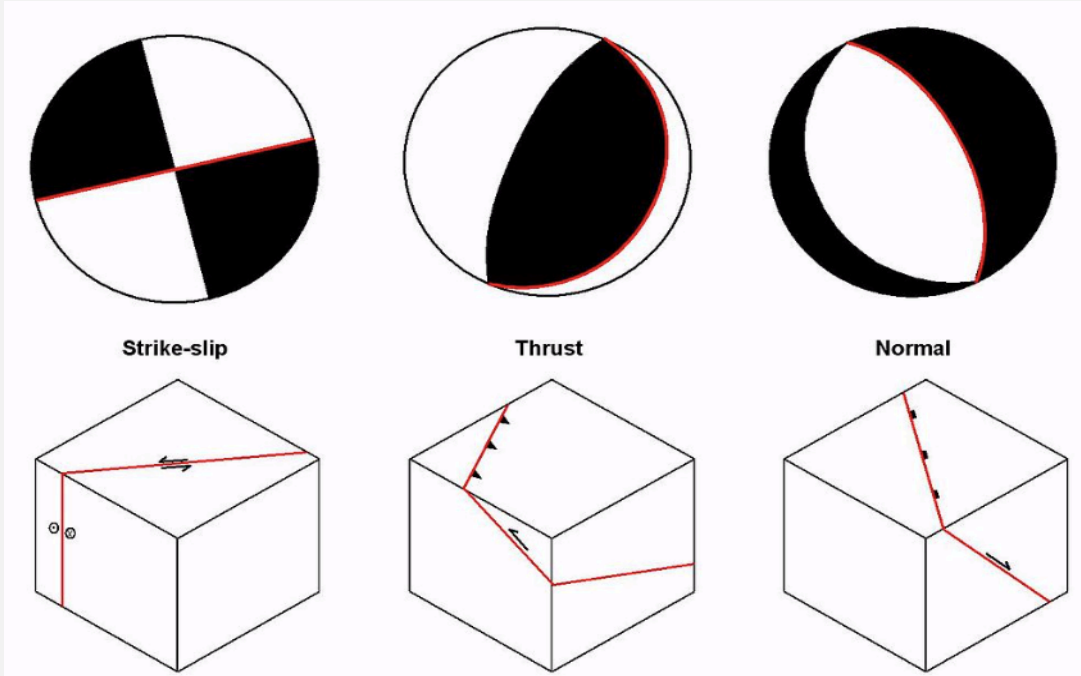


Background: FOCAL MECHANISMS



Schematic diagram showing the direction of initial movement of particles around the focus (F) of an earthquake on a W-E dextral strike-slip fault, viewed from above (a) and the equivalent zones of compressional (C) and tensional (T) sense first motion in the seismic waves radiating outward (b).

Note that due to the symmetry, an identical pattern would result from movement on an N-S sinistral strike-slip fault passing through the focus



Types of 'beachball plot' associated with different fault end-members (nodal plane in red parallel to fault)

- Focal mechanisms determines the type of deformation in the source region


Legend
Revised Data
Chiriqui
Gulf of Dulce
Bugaba District
David District
Puerto Armuelles
Revised Data
52 Epicenters in Puerto Armuelles. Panama-Costa Rica border
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2019 Google
US Dept of State Geographer
Image Landsat / Copernicus
Burica Canyon
N
30 mi

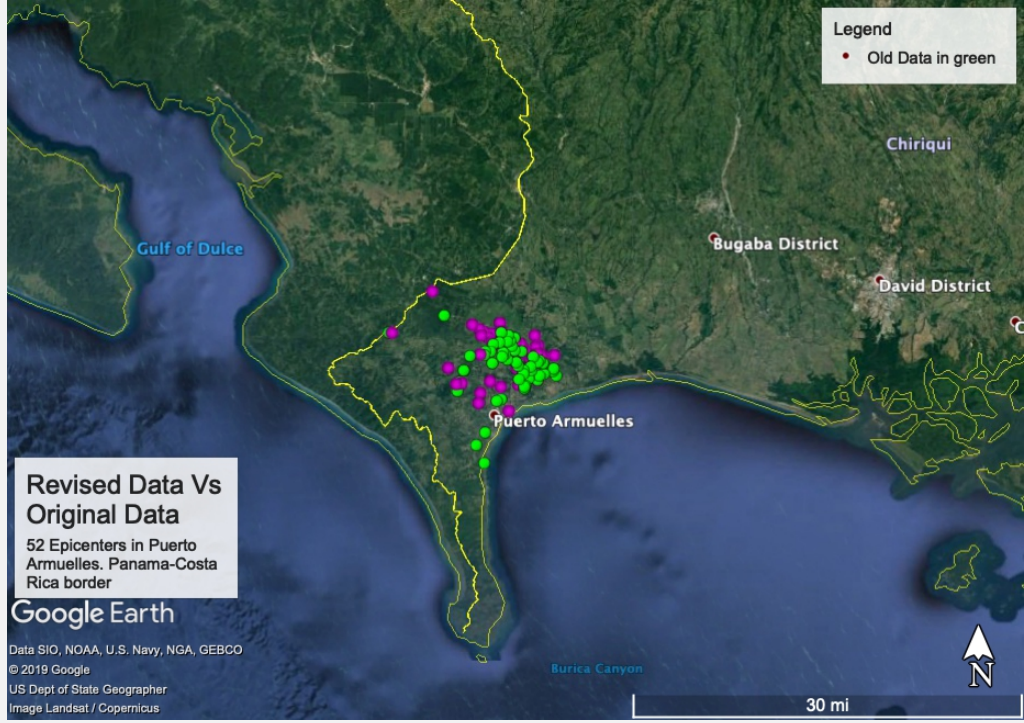

Legend
Old epicenters
Chiriqui
Gulf of Dulce
Bugaba District
David District
Puerto Armuelles
Previous Data
52 Epicenters in Puerto Armuelles. Panama-Costa Rica border
Burica Peninsula
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2019 Google
US Dept of State Geographer
Image Landsat / Copernicus
Burica Canyon
N
30 mi

RESULTS


Gulf of Dulce
Bugaba District
David District
Puerto Armuelles
Burica Canyon
Revised Data
52 Epicenters in Puerto Armuelles. Panama-Costa Rica border
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2019 Google
US Dept of State Geographer
Image Landsat / Copernicus
N
30 mi


Legend
Old Data in green
Chiriqui
Gulf of Dulce
Bugaba District
David District
Puerto Armuelles
Revised Data Vs Original Data
52 Epicenters in Puerto Armuelles. Panama-Costa Rica border
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2019 Google
US Dept of State Geographer
Image Landsat / Copernicus
Burica Canyon
N
30 mi

	Revised					Old Data			
EVENT #	Latitude	Longitude	Depth (Km)	Magnitude		Latitude	Longitude	Depth (Km)	Magnitude
1	8.351	-82.882	32.4	3.7		8.343	-82.885	32.5	3.7
2	8.322	-82.818	30.6	3.8		8.322	-82.818	30.6	3.8
3	8.317	-82.839	10.6	3.6		8.313	-82.833	11.7	3.6
4	8.319	-82.903	22.8	3.6		8.349	-82.894	29	3.6
5	8.315	-82.859	11.2	3.9		8.301	-82.859	10.4	3.9
6	8.336	-82.918	20.5	3.8		8.32	-82.906	23.3	3.9
7	8.365	-82.869	21.3	3.6		8.299	-82.864	22.2	3.7
8	8.308	-82.882	20.5	4		8.264	-82.877	21.8	4
9	8.373	-82.866	15	4.9		8.362	-82.868	23.3	5
10	8.354	-82.841	25.2	3.7		8.337	-82.826	29.5	3.7
11	8.374	-82.869	15	3.7		8.35	-82.878	25.4	3.6
12	8.372	-82.881	15	3.4		8.354	-82.877	25.9	3.5
13	8.384	-82.891	18.9	3.9		8.333	-82.901	19.3	4
14	8.421	-82.936	20.9	3.4		8.394	-82.923	27.8	3.5
15	8.372	-82.821	25.1	3.5		8.342	-82.818	31.2	3.5
16	8.35	-82.799	27.5	4.4		8.335	-82.8	30.1	4.4
17	8.351	-82.848	28.2	3.6		8.345	-82.852	28	3.6
18	8.37	-82.86	19.7	3.6		8.355	-82.844	27.9	3.6
19	8.37	-82.873	20.7	3.6		8.354	-82.871	27.8	3.7
20	8.321	-82.871	19.1	3.9		8.25	-82.887	17.3	4
21	8.365	-82.86	26.3	4.3		8.365	-82.852	32.4	4.3
22	8.288	-82.85	22.1	4		8.23	-82.878	20.3	4
23	8.376	-82.86	25.2	3.5		8.369	-82.844	31.2	3.5
24	8.363	-82.858	26.7	4.2		8.348	-82.858	30.5	4.2
25	8.362	-82.864	26.7	4.9		8.366	-82.849	32.3	4.9
26	8.364	-82.85	19.9	3.4		8.342	-82.842	28.4	3.5

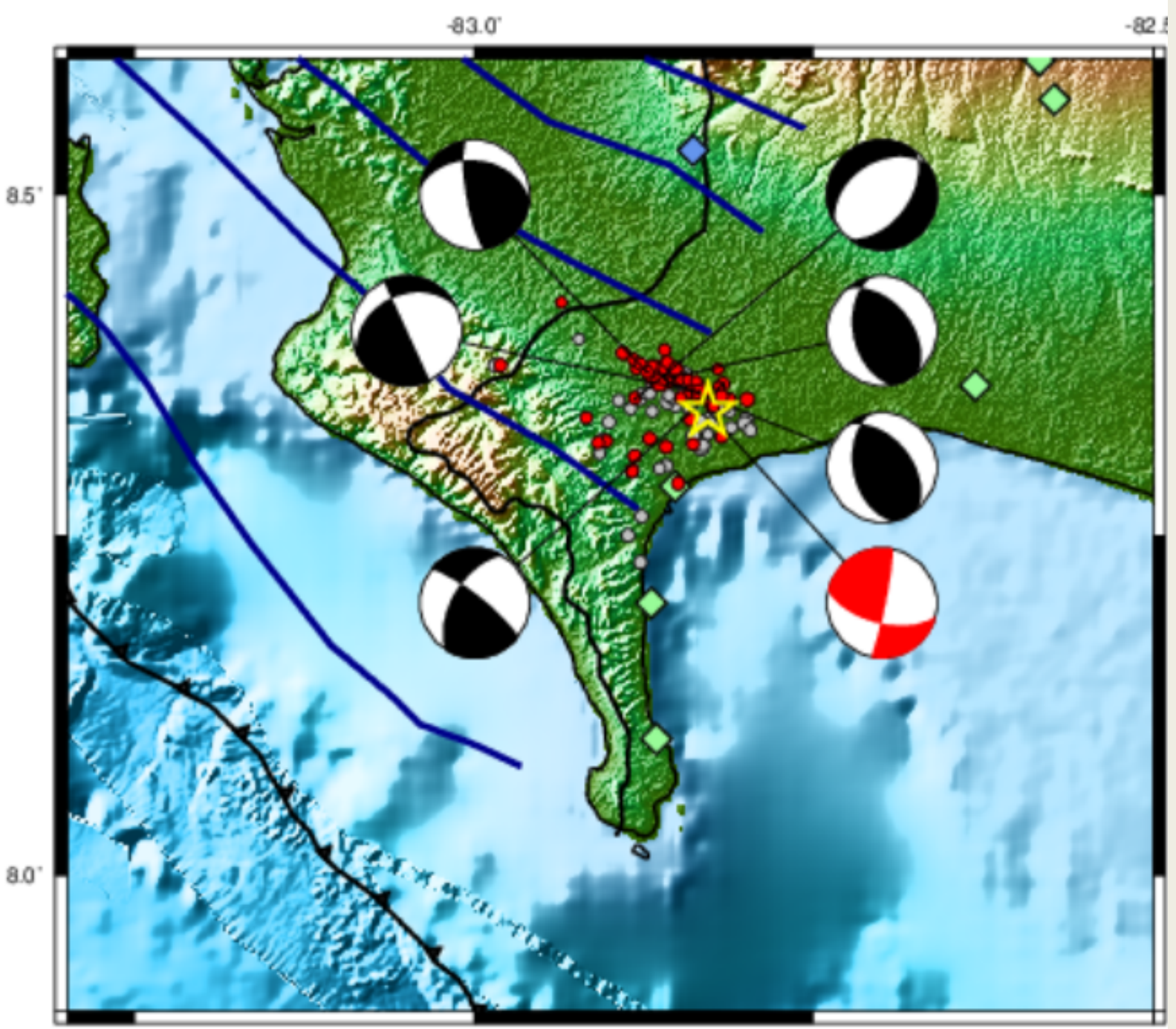


RESULTS: LATITUTE, LONGITUDE AND DEPTH

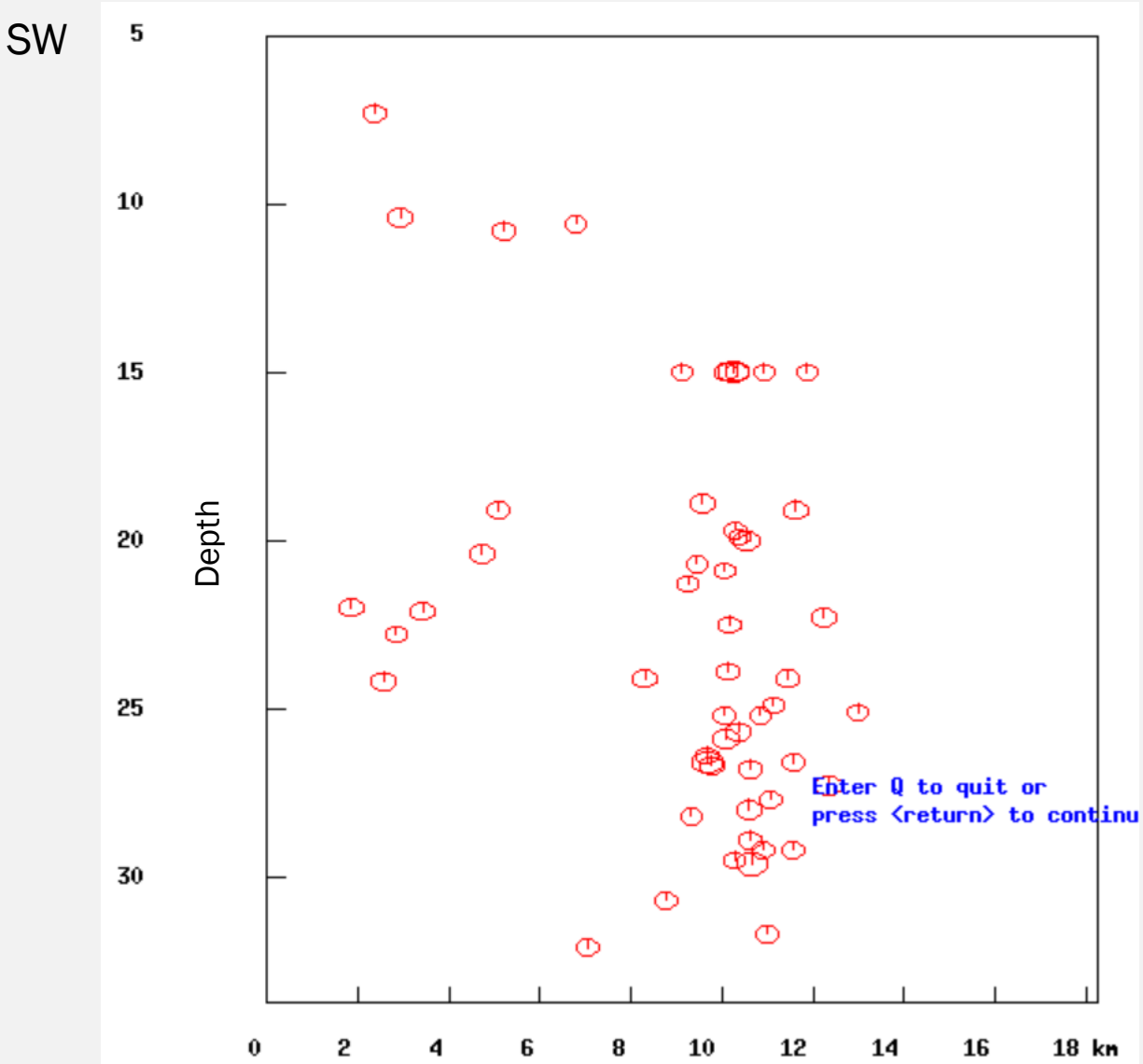
	Revised					Old Data			
EVENT #	Latitude	Longitude	Depth (Km)	Magnitude		Latitude	Longitude	Depth (Km)	Magnitude
27	8.318	-82.909	7.3	3.8		8.31	-82.908	7.7	3.8
28	8.349	-82.813	19.2	4.2		8.332	-82.801	22.4	4.2
29	8.35	-82.812	29.2	3.6		8.341	-82.812	30.1	3.6
30	8.361	-82.817	22.3	4.1		8.327	-82.797	27.6	4.1
31	8.379	-82.883	22.2	3.6		8.364	-82.861	28.4	3.6
32	8.352	-82.83	28.9	5		8.315	-82.833	30.7	5
33	8.365	-82.848	28.9	3.8		8.338	-82.84	31.3	3.8
34	8.373	-82.86	25.6	4.1		8.36	-82.847	30	4.1
35	8.386	-82.86	26.8	3.7		8.375	-82.859	31	3.7
36	8.372	-82.853	15	3.6		8.351	-82.855	28.2	3.7
37	8.364	-82.842	29.2	3.6		8.354	-82.836	30.6	3.7
38	8.376	-82.878	26.4	3.6		8.341	-82.869	31.6	3.6
39	8.359	-82.82	15	3.5		8.348	-82.823	26.5	3.5
40	8.352	-82.818	23.9	4		8.344	-82.816	28.9	4
41	8.358	-82.834	26.8	4		8.329	-82.834	29.8	4
42	8.355	-82.841	23.9	3.7		8.333	-82.825	32.3	3.7
43	8.335	-82.841	24.1	4		8.316	-82.832	28.2	4
44	8.346	-82.826	29.5	3.5		8.324	-82.828	31.6	3.5
45	8.352	-82.835	28.3	4.3		8.323	-82.839	29.4	4.3
46	8.297	-82.884	24.1	4.1		8.297	-82.884	24.1	4.1
47	8.375	-82.981	10.4	4.1		8.375	-82.985	10.6	4.1
48	8.363	-82.837	24.9	3.5		8.327	-82.816	27.1	3.5
49	8.355	-82.835	20	4.4		8.333	-82.834	23.3	4.5
50	8.377	-82.858	27.7	3.8		8.353	-82.857	28.7	3.8
51	8.372	-82.852	31.7	3.9		8.372	-82.851	31.1	3.9
52	8.345	-82.824	15	3.7		8.329	-82.811	15	3.7

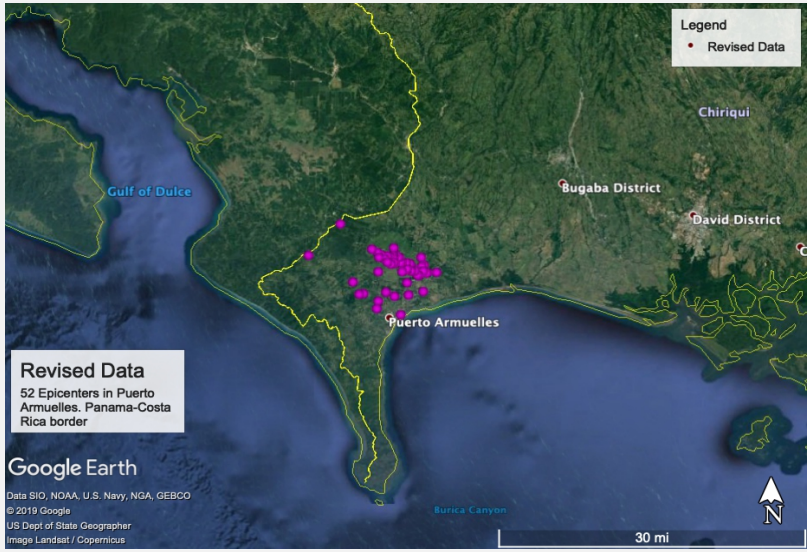
RESULTS: LATITUTE, LONGITUDE AND DEPTH

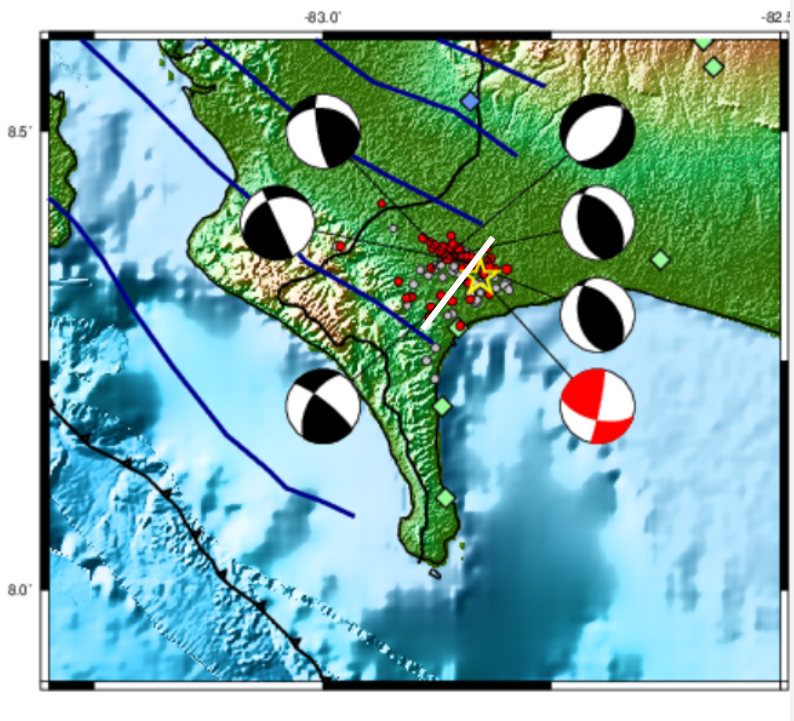
RESULTS: FOCAL MECHANISMS



Results: Cross-section



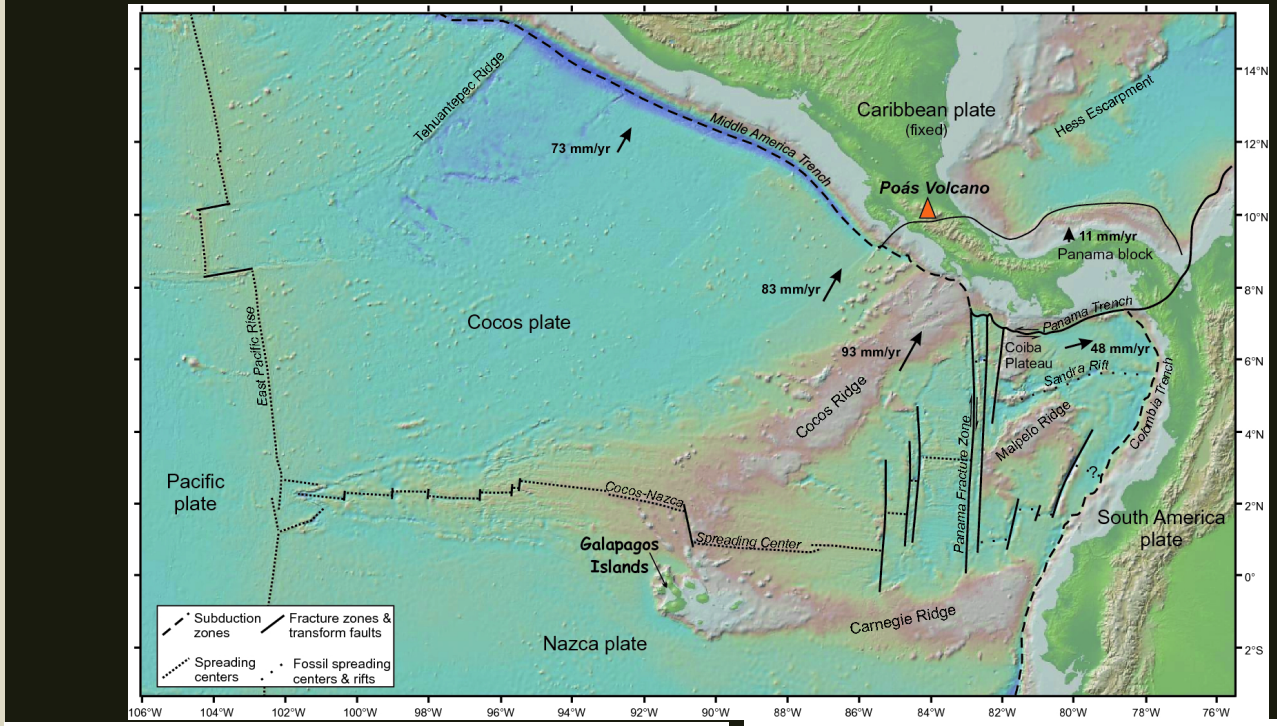


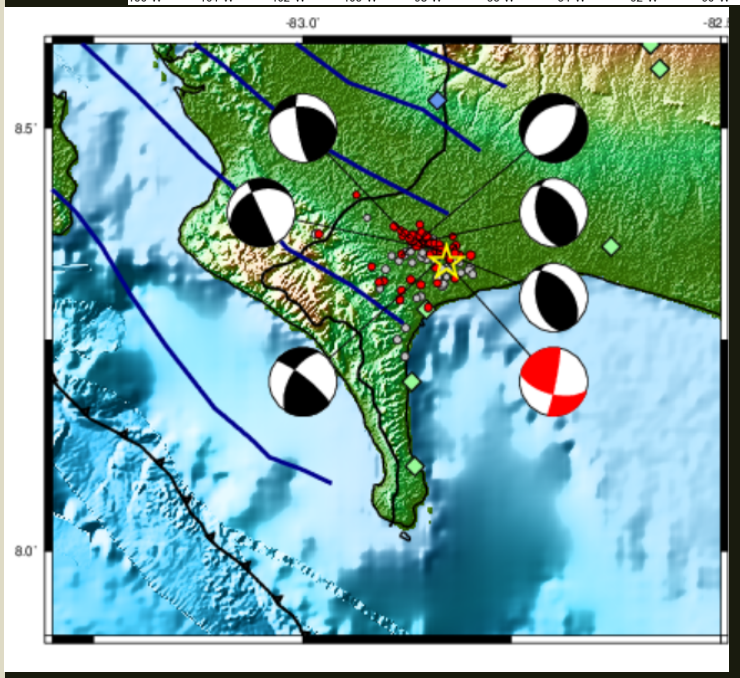


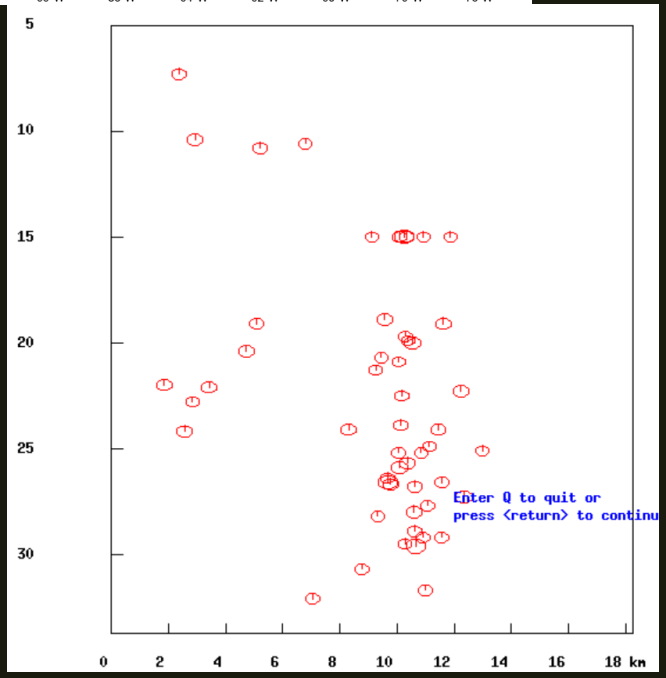
RESULTS: Interpretation of Focal Mechanisms

- **Possible sources:**

1) A fault striking NW-SE within the Cocos plate
2) Subduction of the Cocos plate beneath the Panama microplate
3) Minor faults







Goals for 2020

- Further analysis and interpretation of results
- Testing accuracy of results by comparison to current models
- Include other events to the dataset following the same procedure to have a larger and consistent dataset







References:

- Overview of Tectonics and Geodynamics of Costa Rica by P. Vannucchi and J.P. Morgan
- RSN reports page