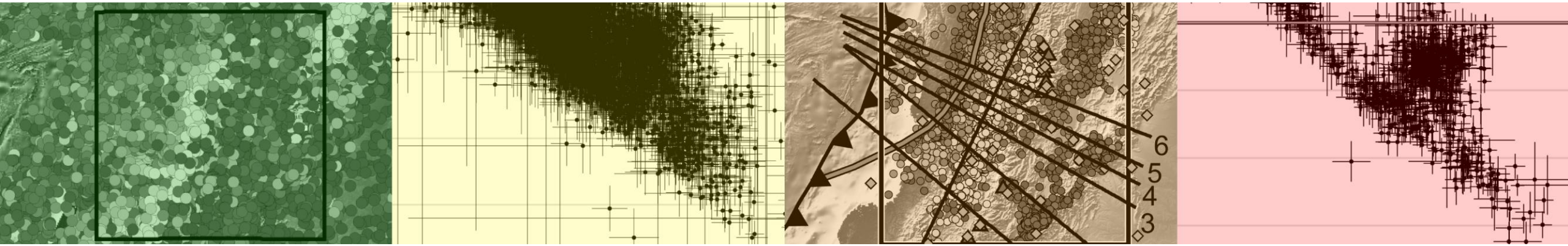
Observing the Structure and Effects of Terrane Accretion at Depth through Patterns of Seismicity in Colombia's Cauca Cluster



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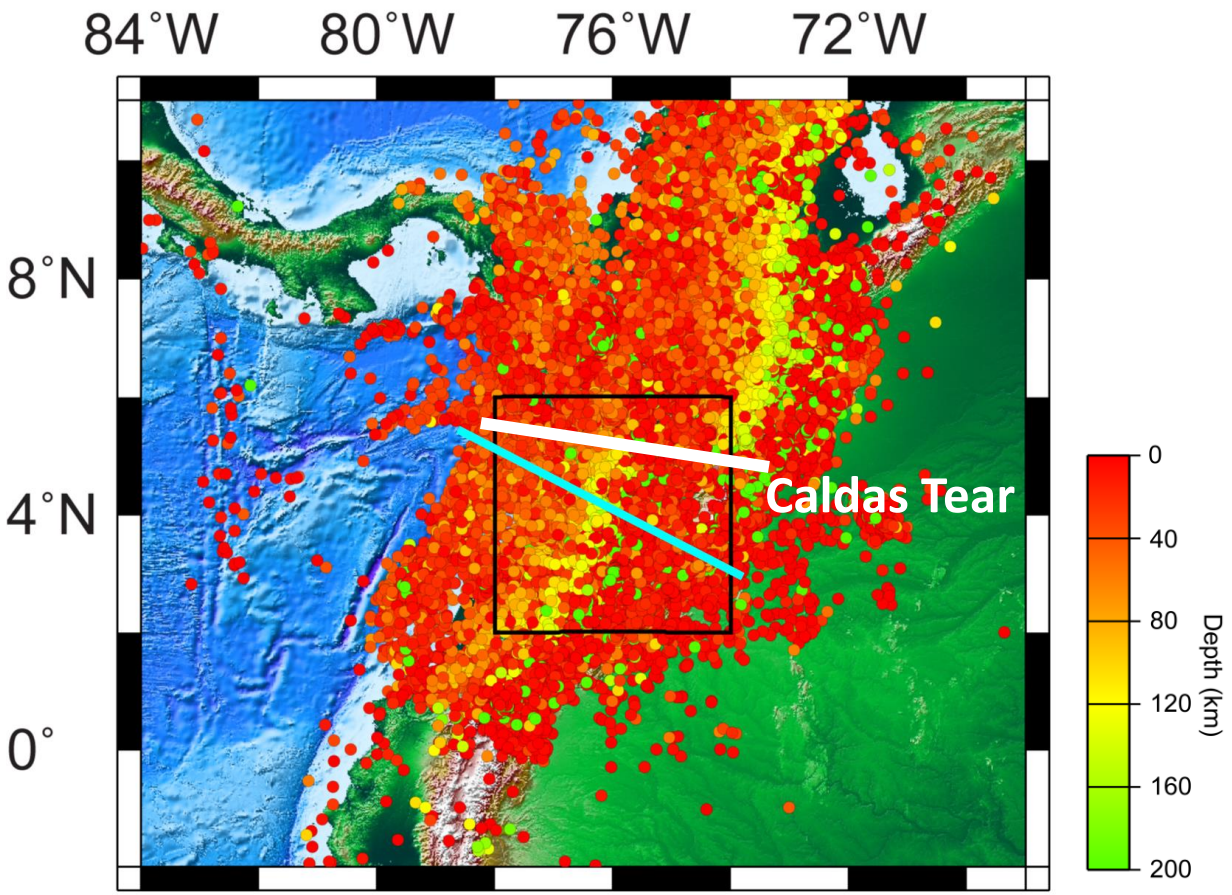
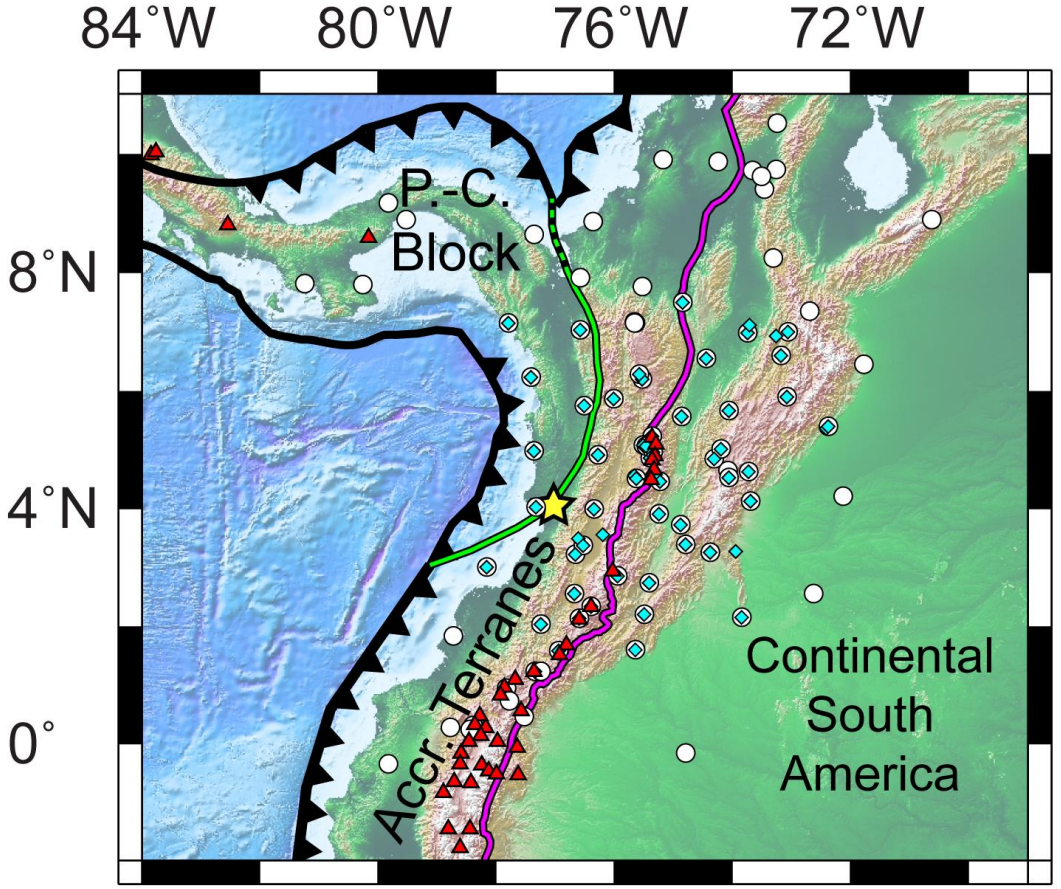
Funding provided by
NSF EAR-1760802

AGU Fall Meeting 2021
#DI51A-05

Cauca Region Bounded By Offset in Slab Seismicity, Centered on Clockwise-Rotating Panama-Choco Block Accretion



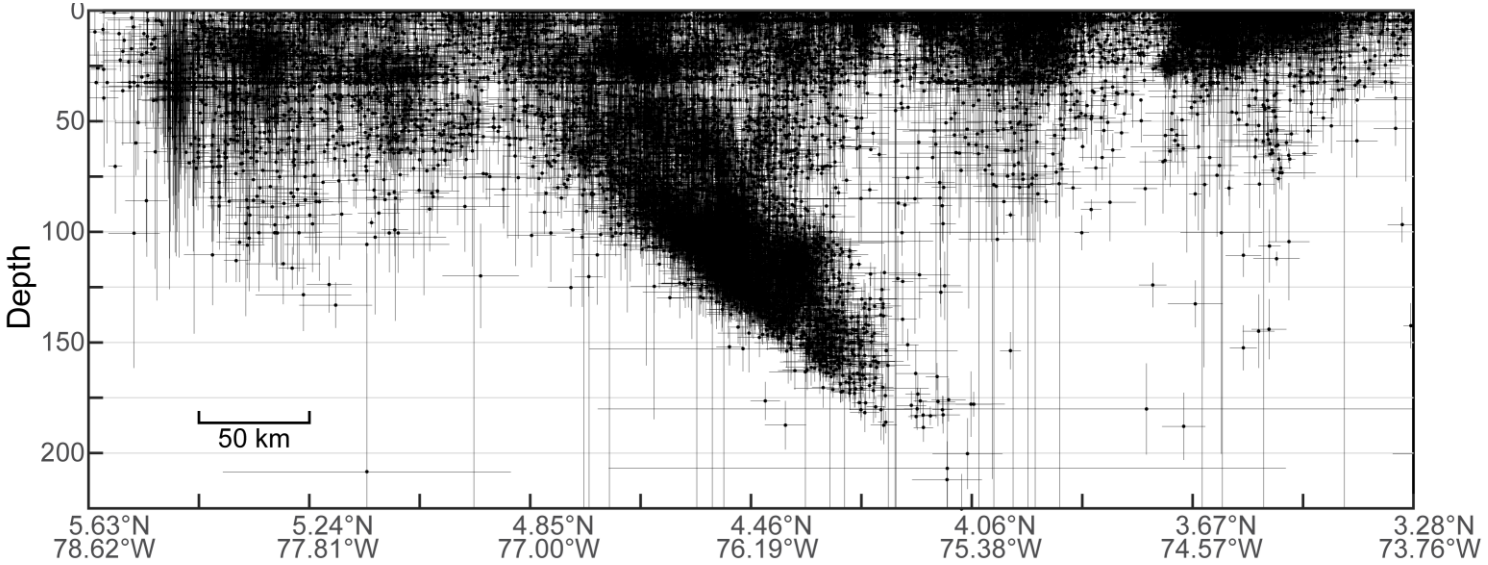
Red Sismológica Nacional de Colombia 2010-2019 EQs



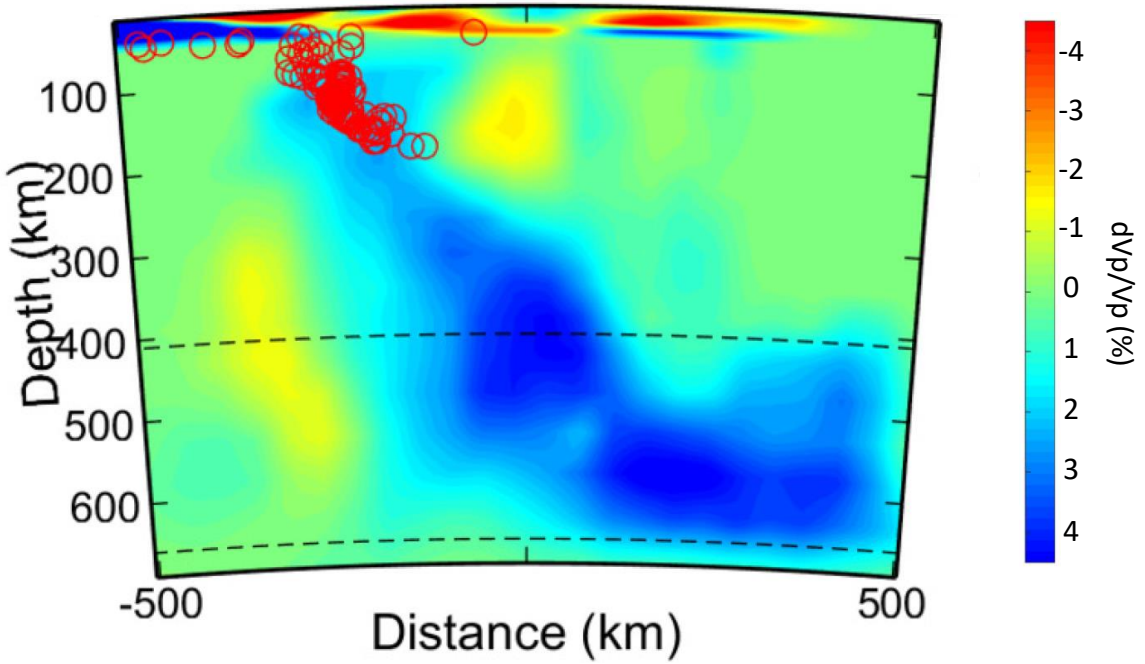
P.-C. Block Initial Collision, ~38 Ma
Station Used in E.Q Source Analysis
Station Used in E.Q Relocation
Holocene Volcano

P.-C. Block and suture modified from León et al., 2018; accreted terranes boundary modified from Cochrane et al., 2014; P.-C. Block initial collision point modified from Montes et al., 2019 and Barat et al., 2014; volcanoes from Global Volcanism Program, 2013; Caldas Tear from Vargas and Mann, 2013.

Red Sismológica Nacional de Colombia 2010-2019 Catalog of Cauca Cluster



P-wave Tomography through Cauca Cluster

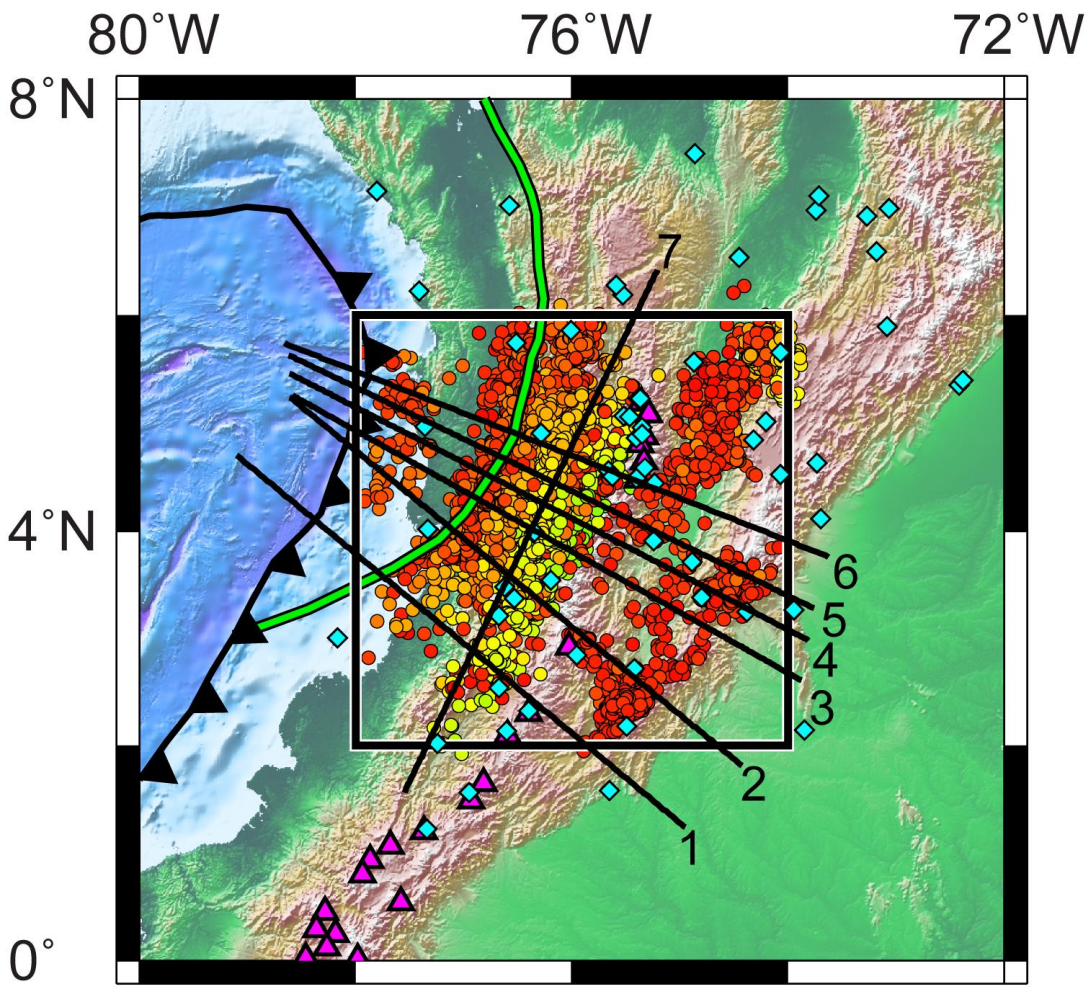


Tomography from Sun et al., 2022

Continuous Slab from Surface to Mantle Transition Zone

- Both Local Seismic Catalog and Regional Tomography Show Continuous Slab Dipping ~40°
- Global and Local Seismic Catalog Show Significant Seismicity in Mantle Above Slab
- No Evidence for Slab Tearing, Contrast with Northern Colombia
- Seismicity Dominated by Small Events, RSNC Catalog Vastly Larger than e.g. NEIC (17,484 vs. 127 events)

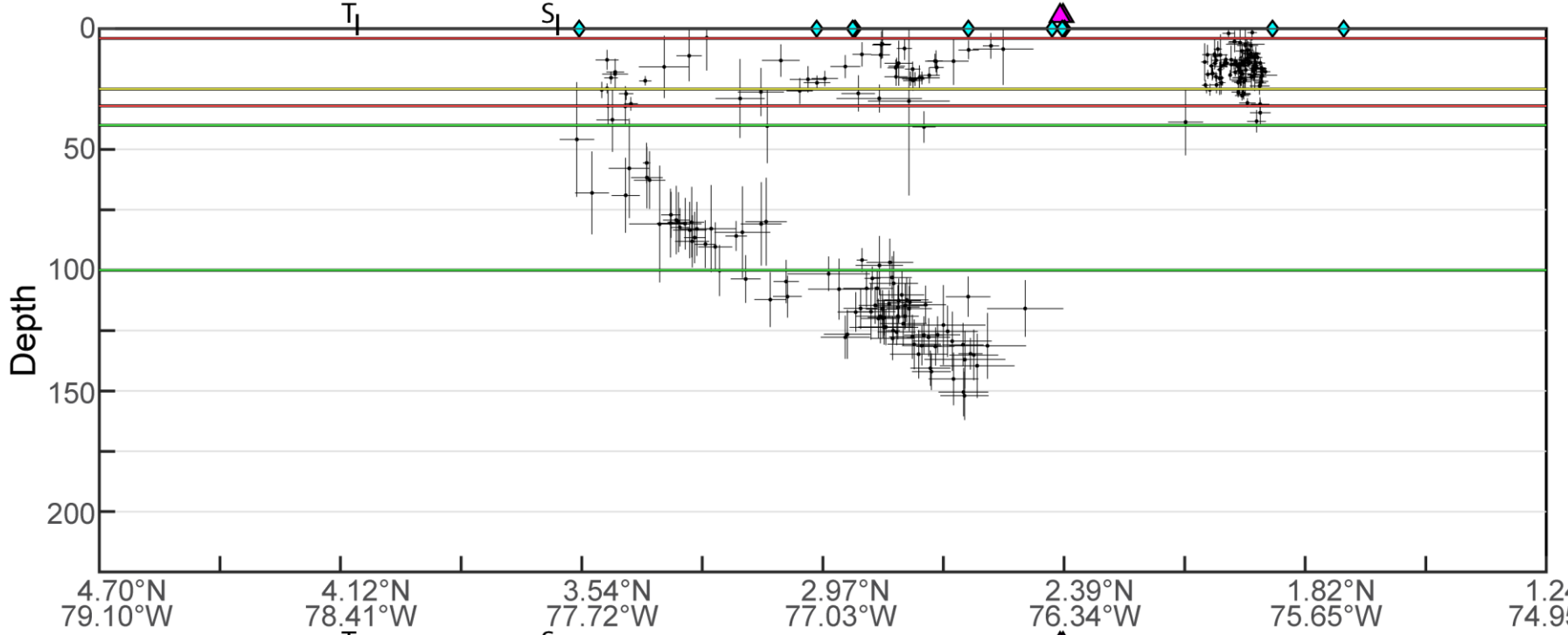
Relative Relocations Highlight Spatial Relationships within Seismicity

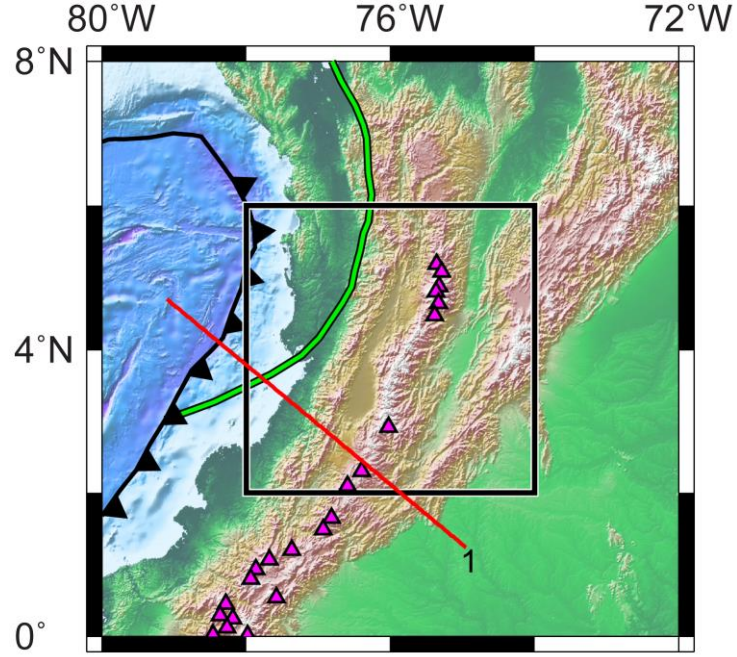


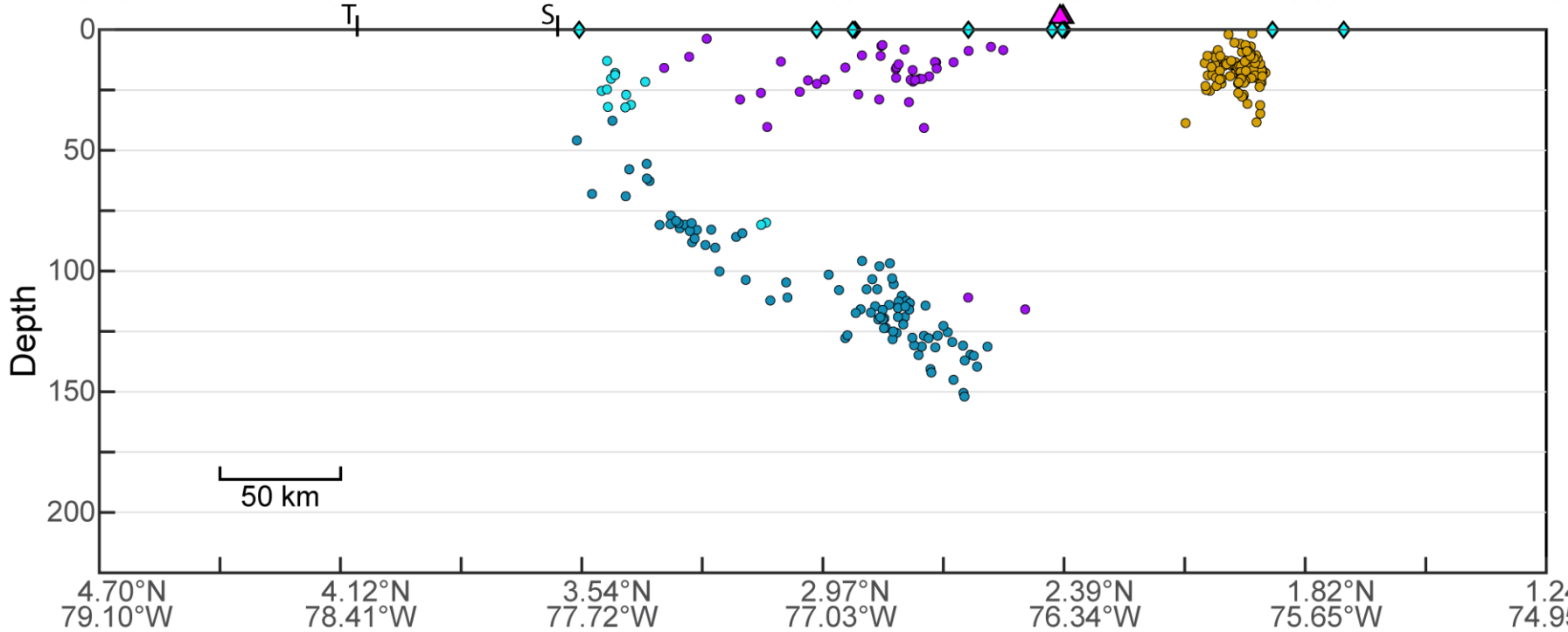
Panama-Choco suture (green) modified from León et al. 2018; Holocene volcanoes from Global Volcanism Program, 2013

- Relative Earthquake Relocation (HypoDD*) Solves for Interconnected "Constellation" of Event Pairs—Need 8+ Observations per Pair
- Relationship of Events in a "Constellation" are Robust, Absolute Location Velocity Model Dependent†
- 11,540 Events >10 km Depth → 7,294 w/ Sufficient Observations → 6,671 Successfully Relocated

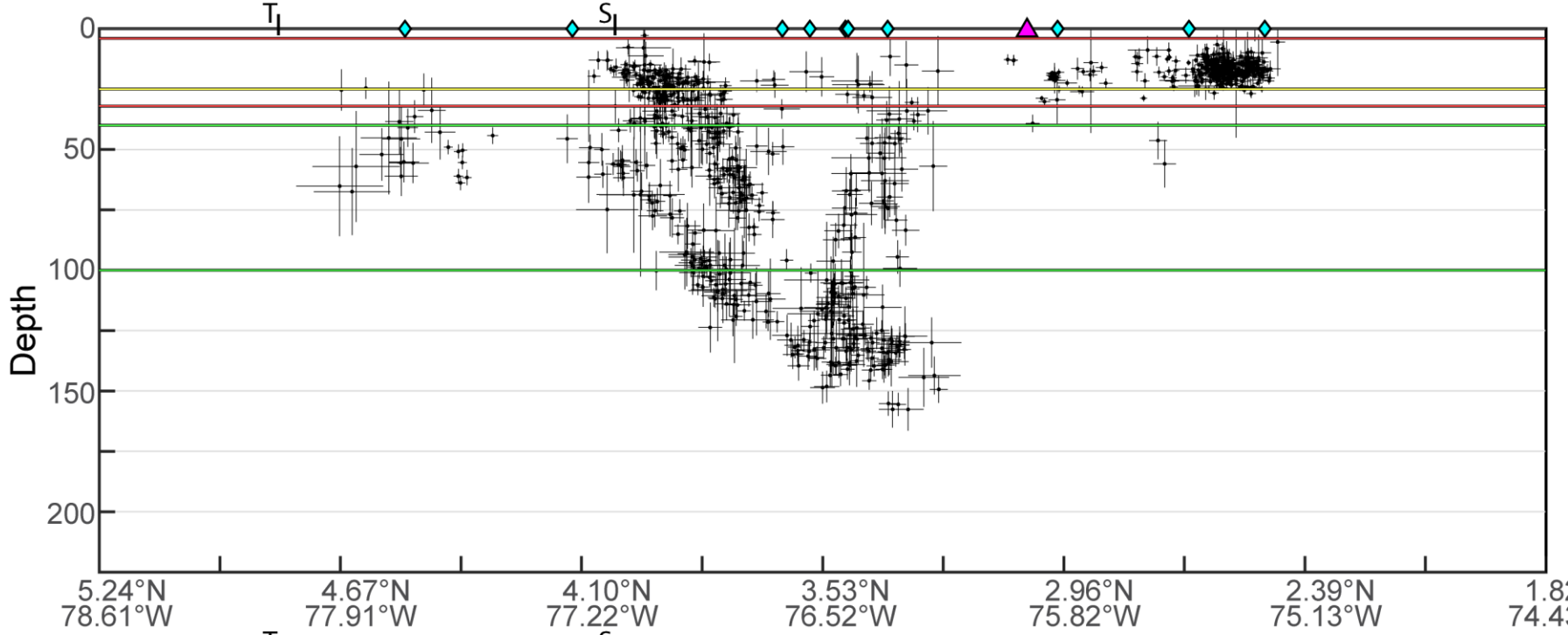
*Waldhauser & Ellsworth (2000); †Model from Ojeda & Havskov (2001)

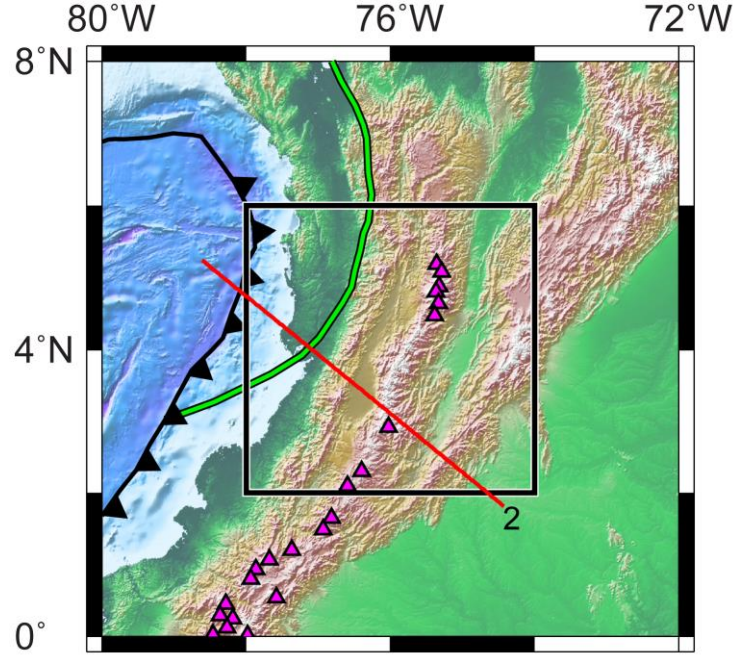


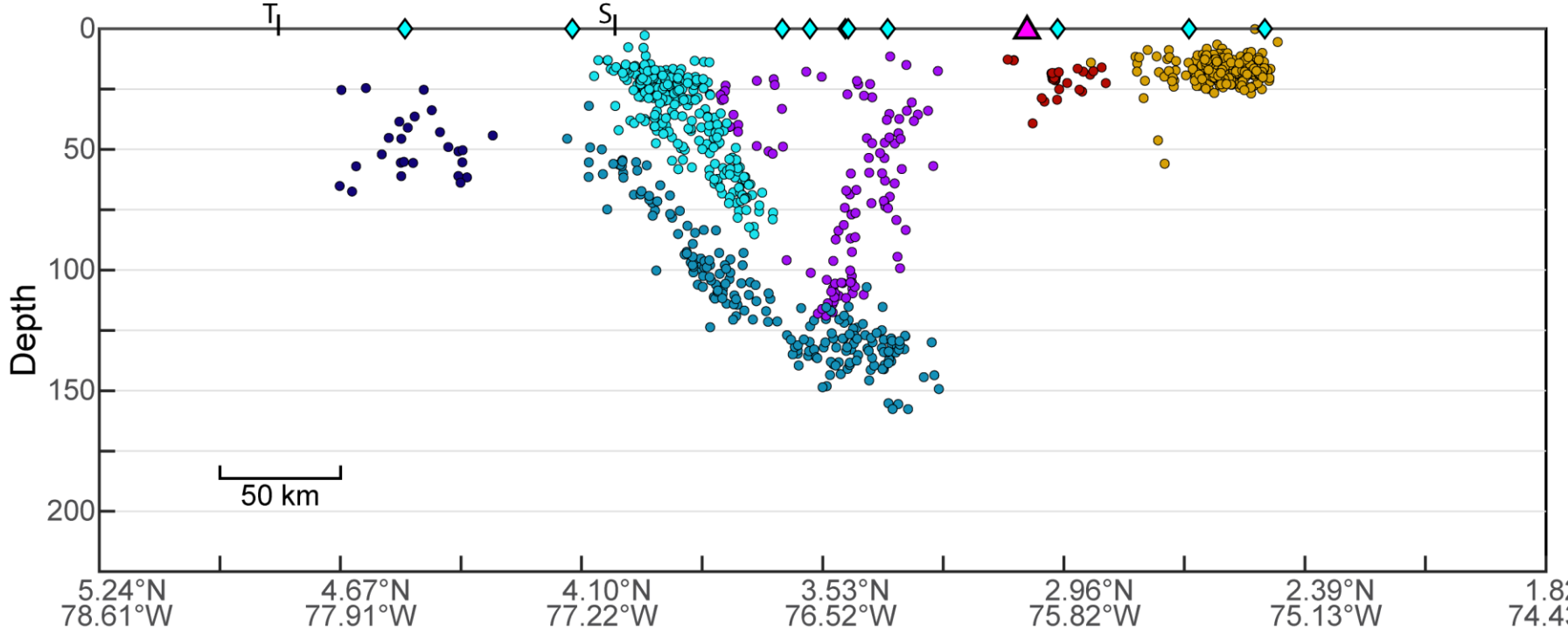




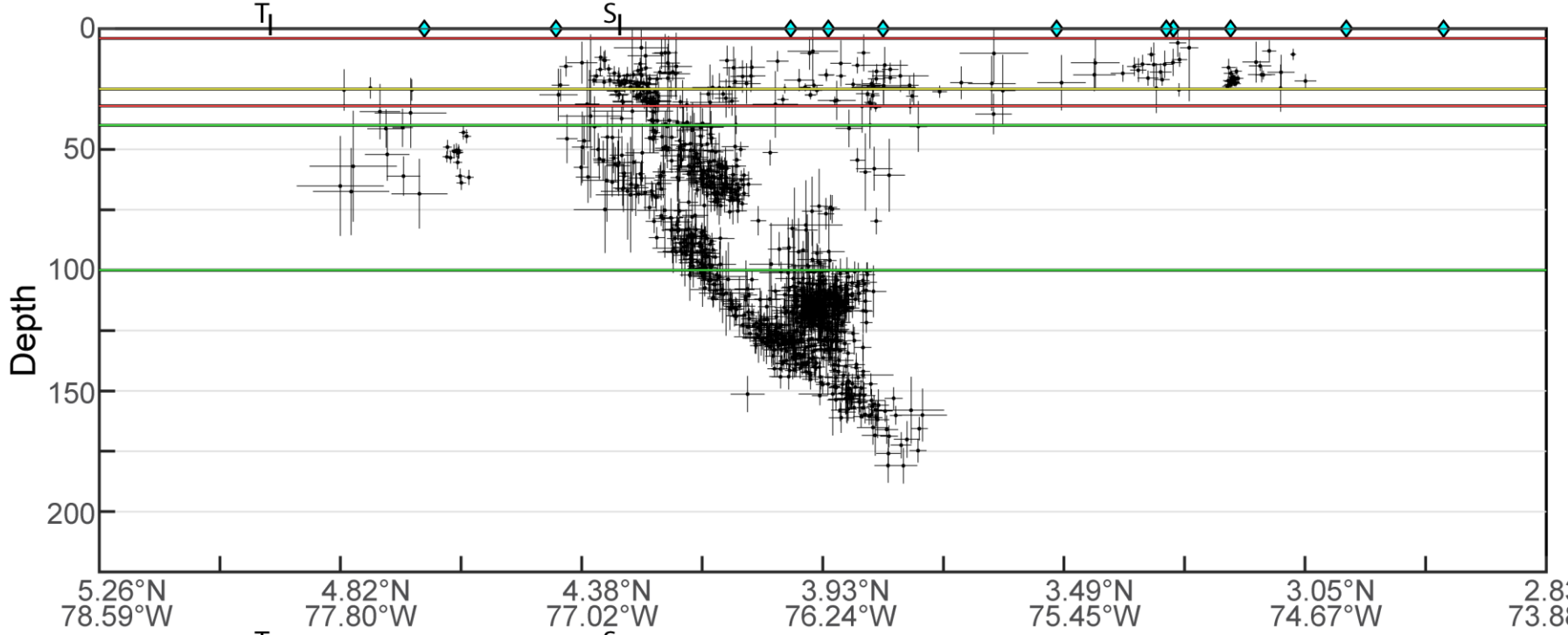
- ~30° Plane of Seismicity, **Slab**
- **Slab** has Little Activity
- **Supra-Slab** Seismicity Limited to 25-30 km depth

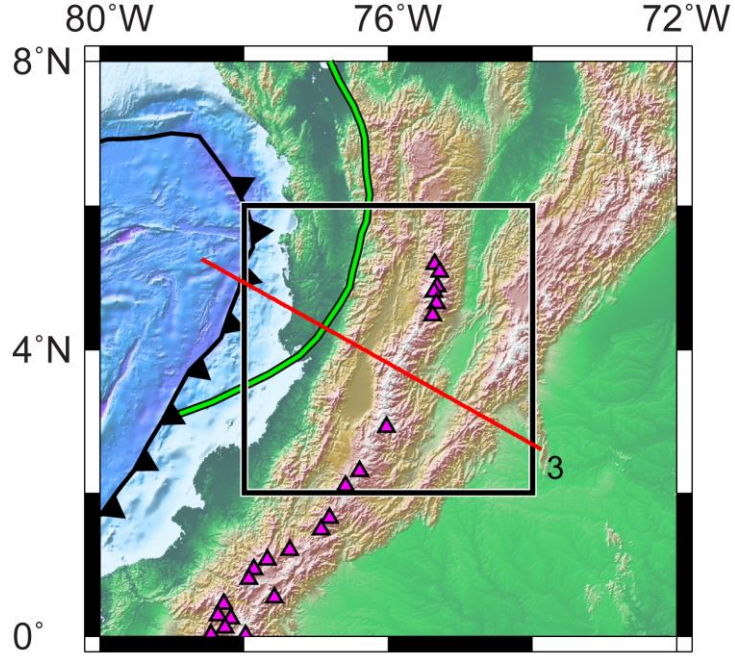


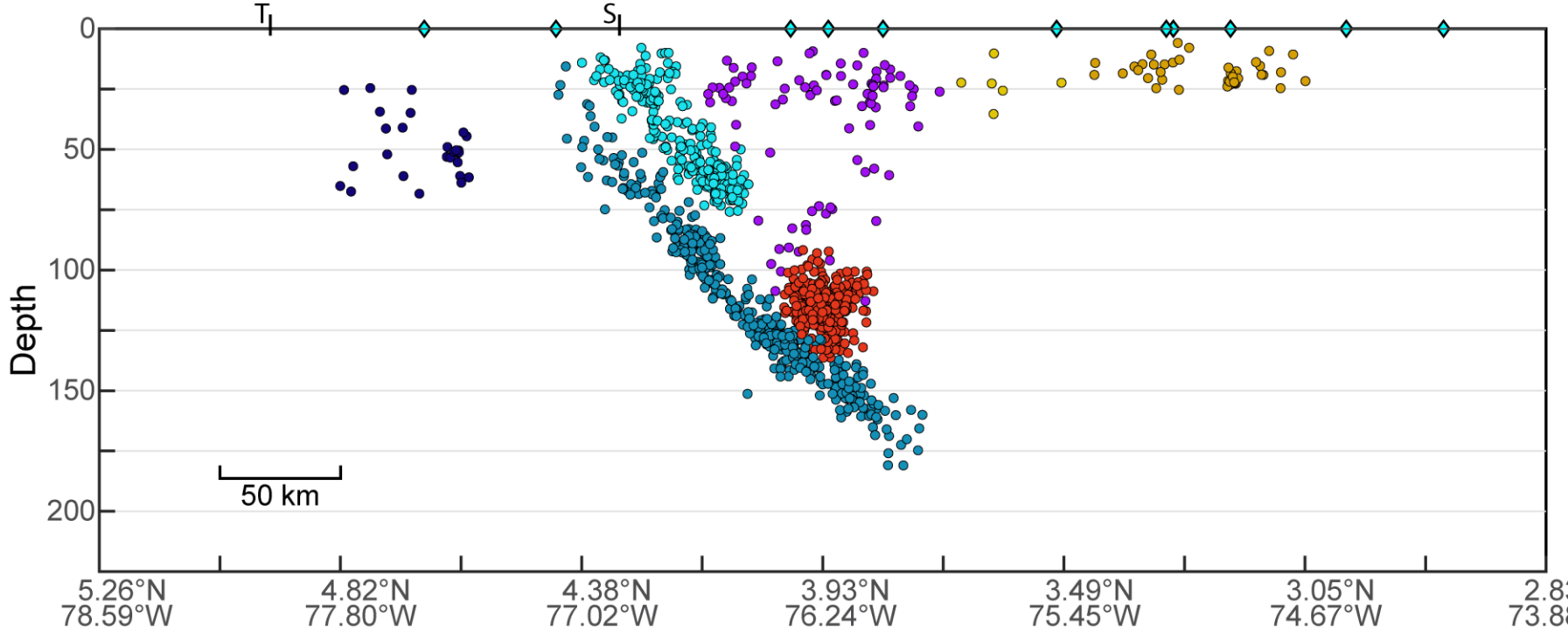




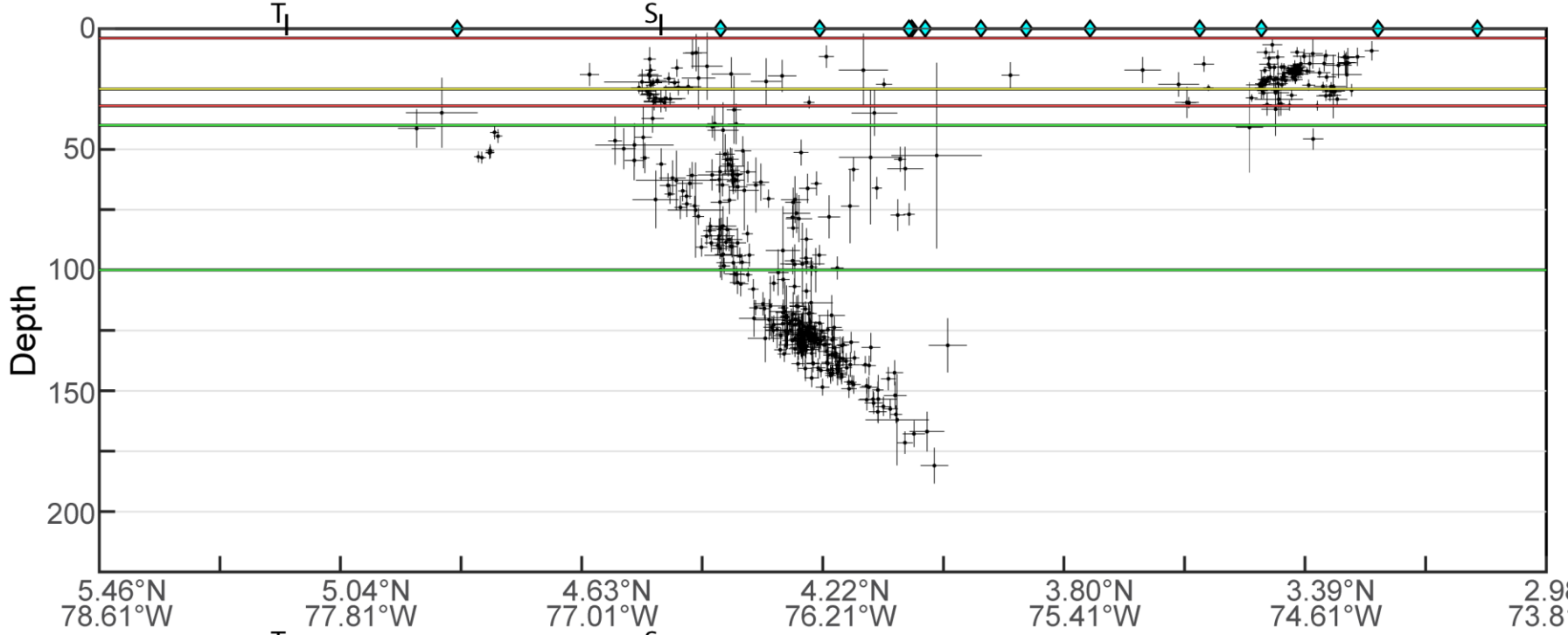
- Cluster West of Volcanoes
- **Supra-Slab Plane** of Seismicity Truncates at Suture
- **Slab** to Crust **Conduit**?

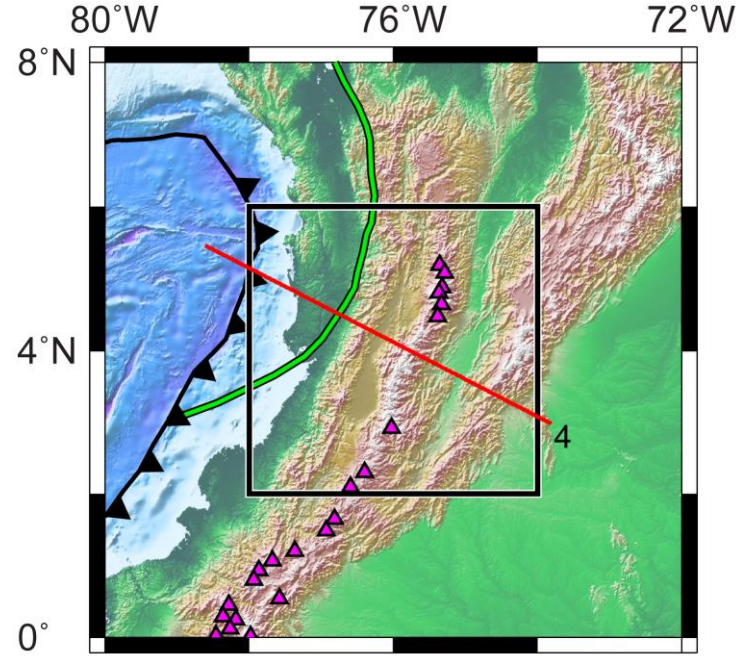


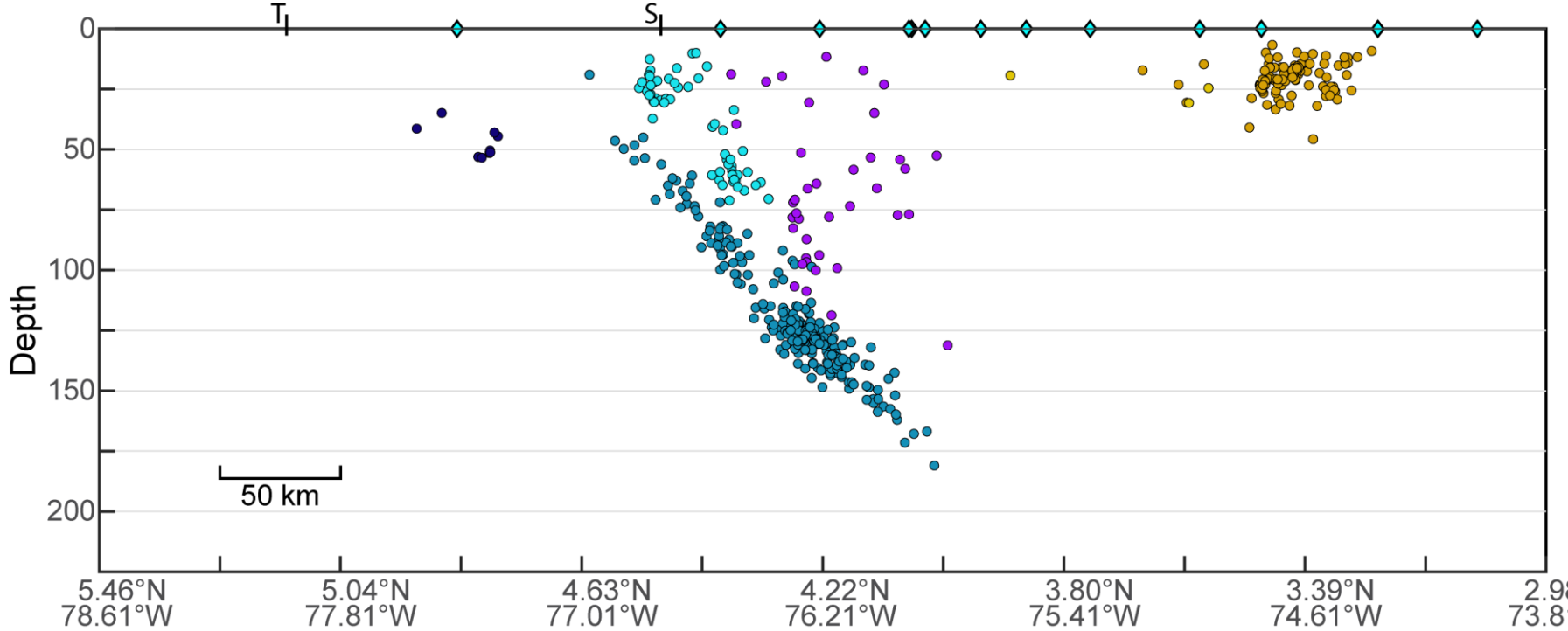




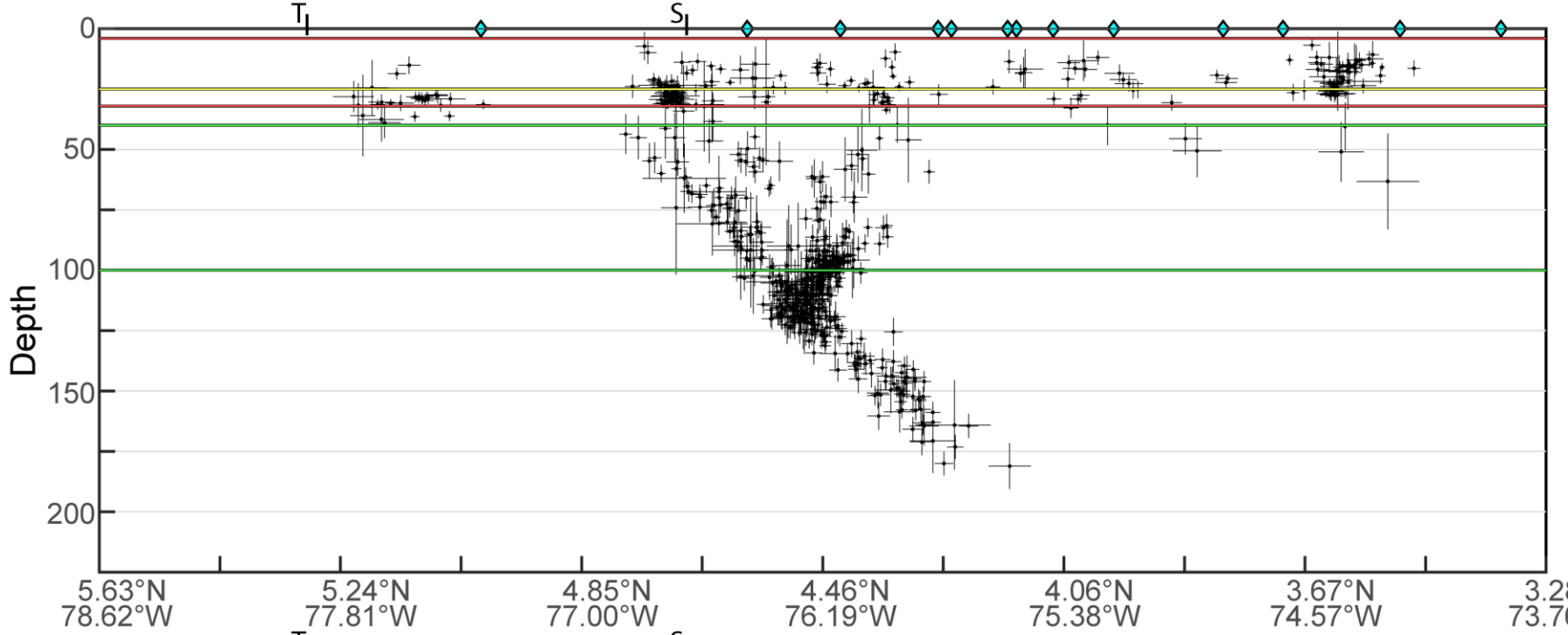
- No Volcanoes
- **Supra-Slab Plane** of Seismicity Truncates at Suture
- 100-125 km Depth “**Ball**” of Seismicity above **Slab**

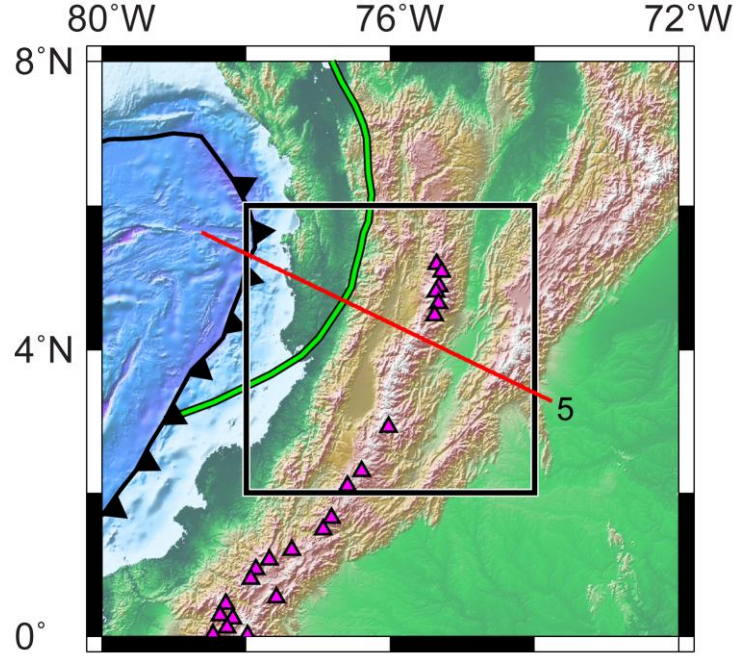


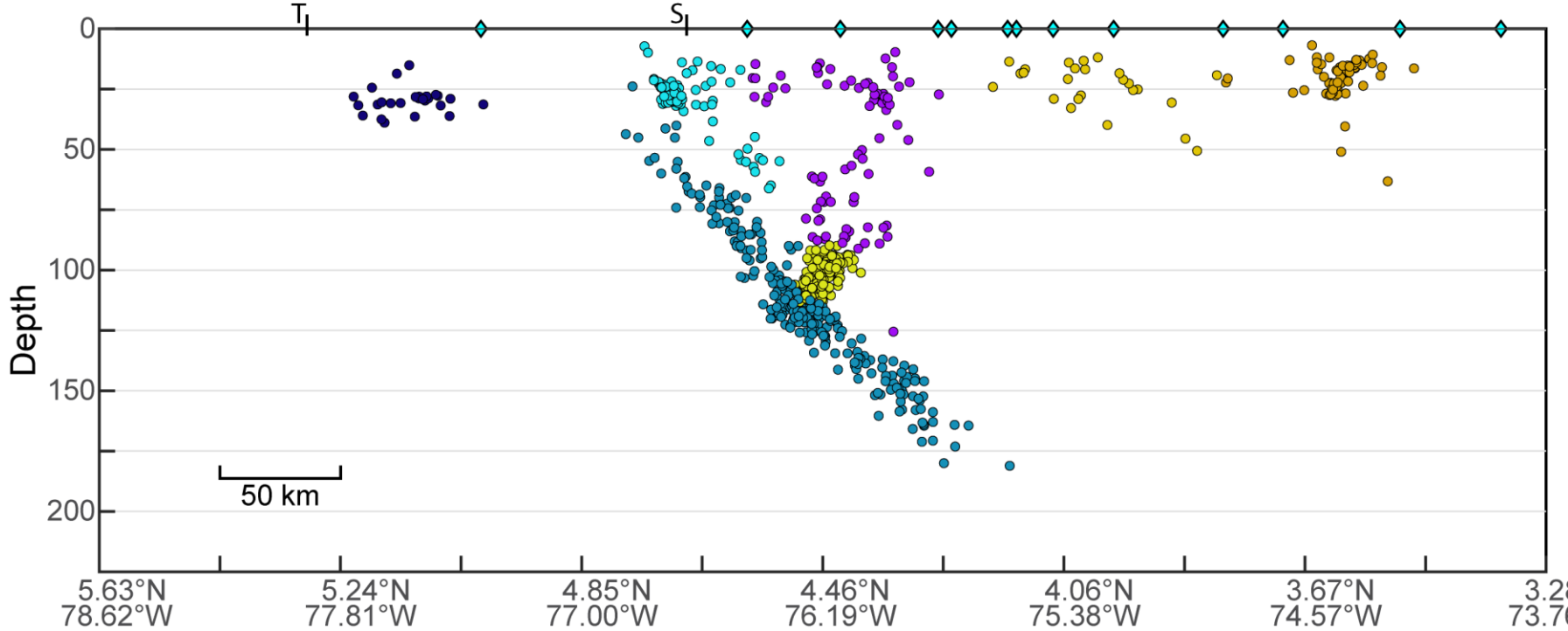




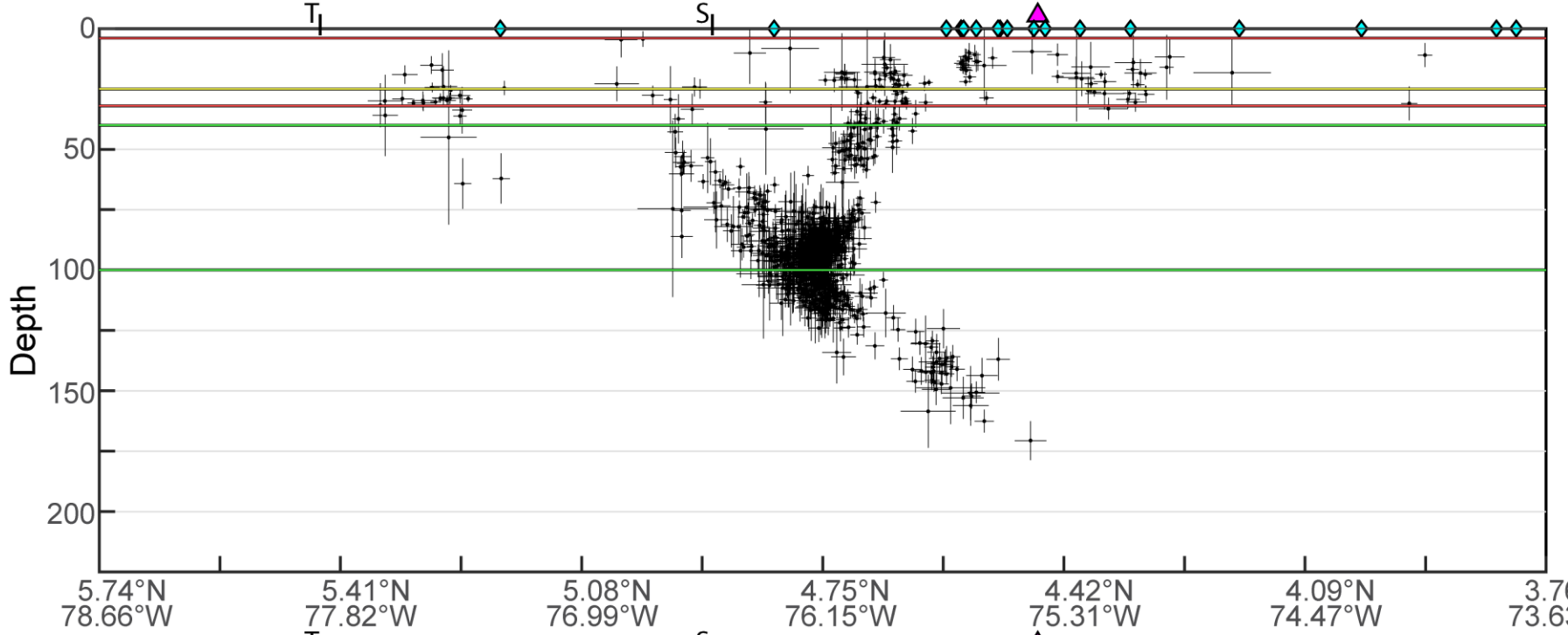
- No Volcanoes
- Weak **Supra-Slab Plane** of Seismicity Truncates at Suture
- No “Ball” of Seismicity above **Slab**

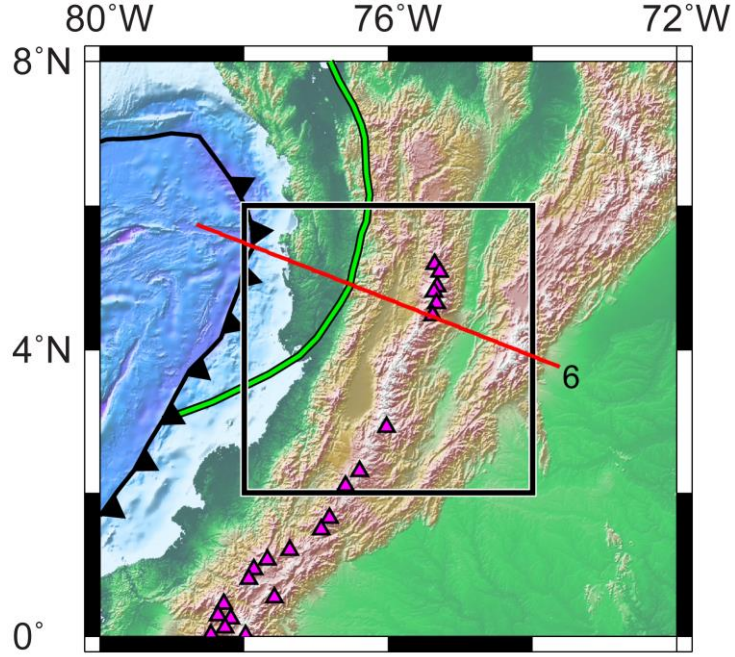


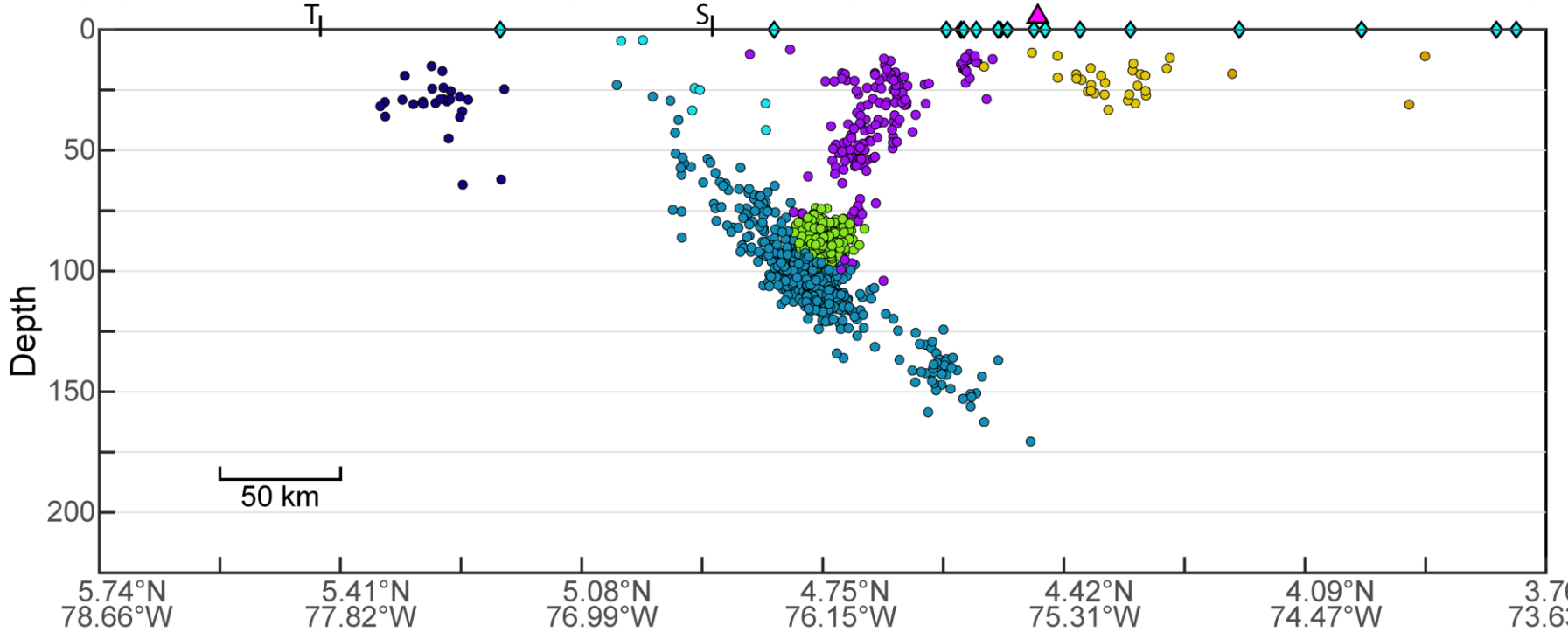




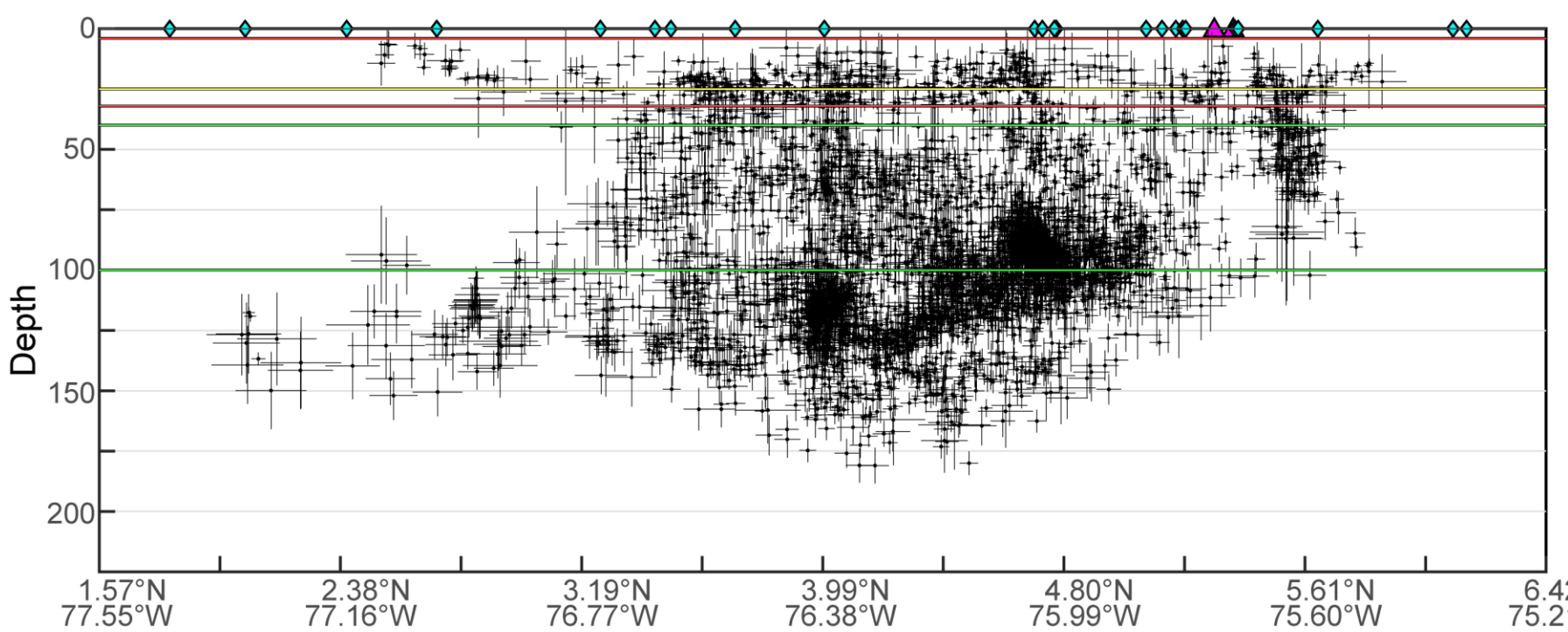
- No Volcanoes
- Weak **Supra-Slab Plane** of Seismicity Truncates at Suture
- 90-110 km "**Ball**" of Seismicity above **Slab**, w/ **Conduit**?

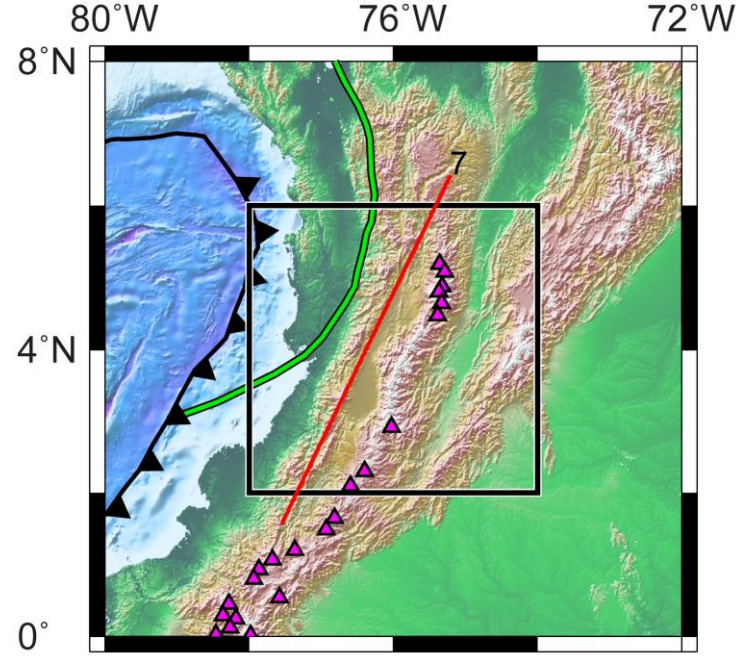


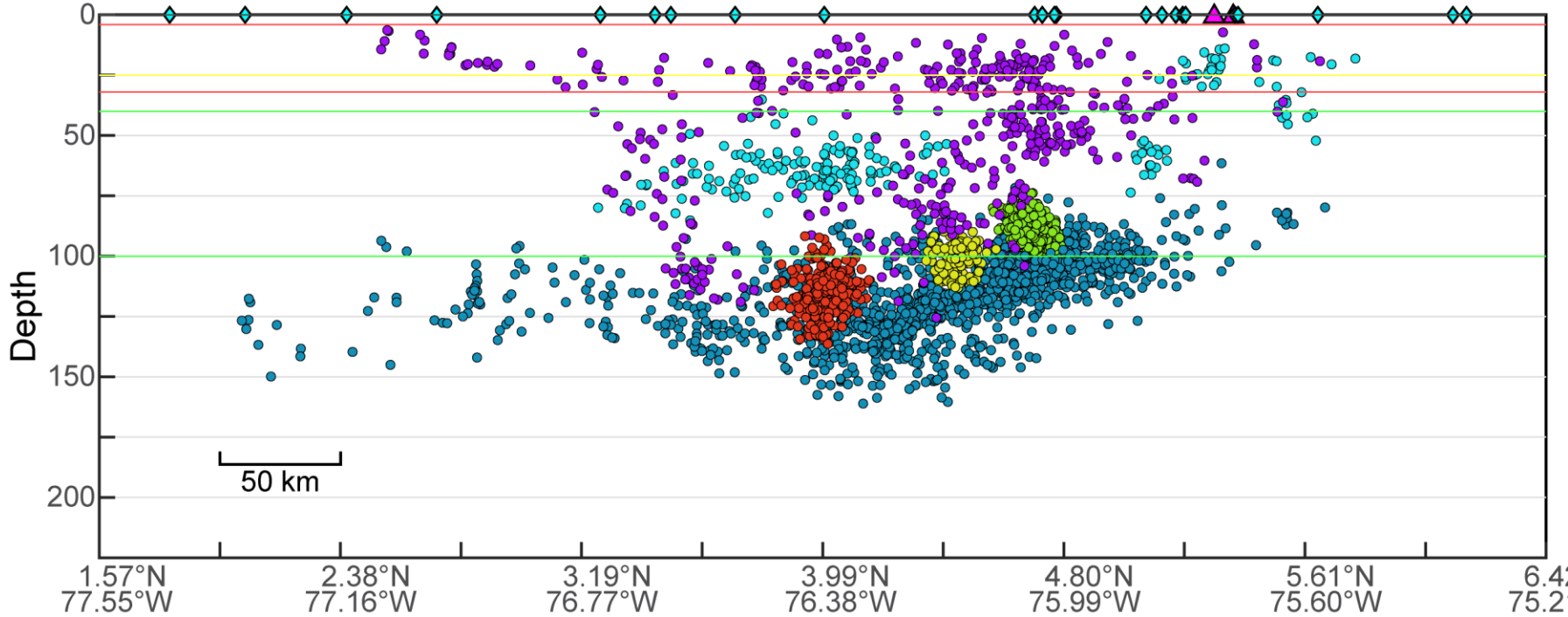




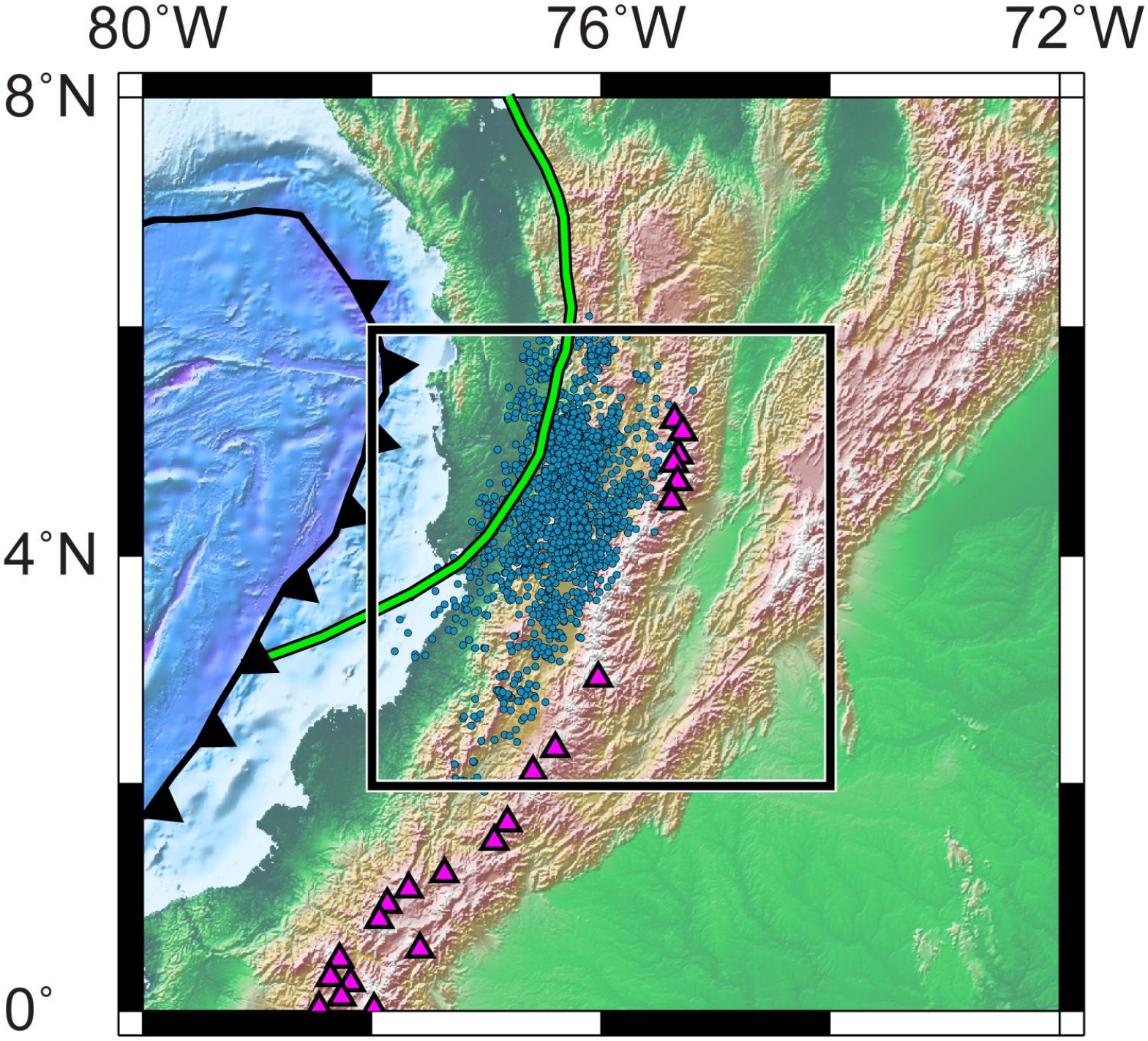
- Cluster West of Volcanoes
- No Supra-Slab Plane of Seismicity
- 75-100 km "**Ball**" of Seismicity above **Slab**, w/ **Conduit**?



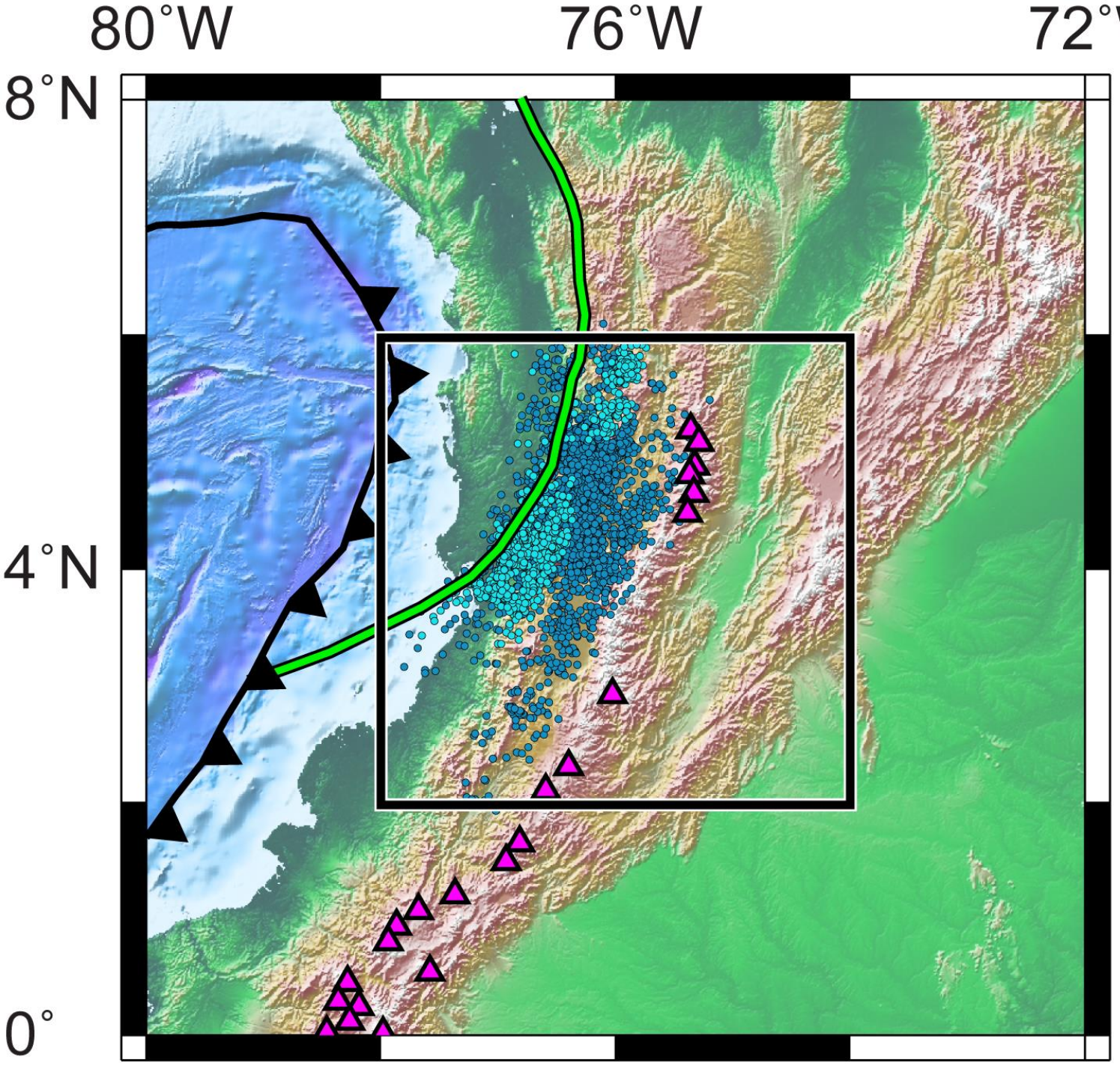




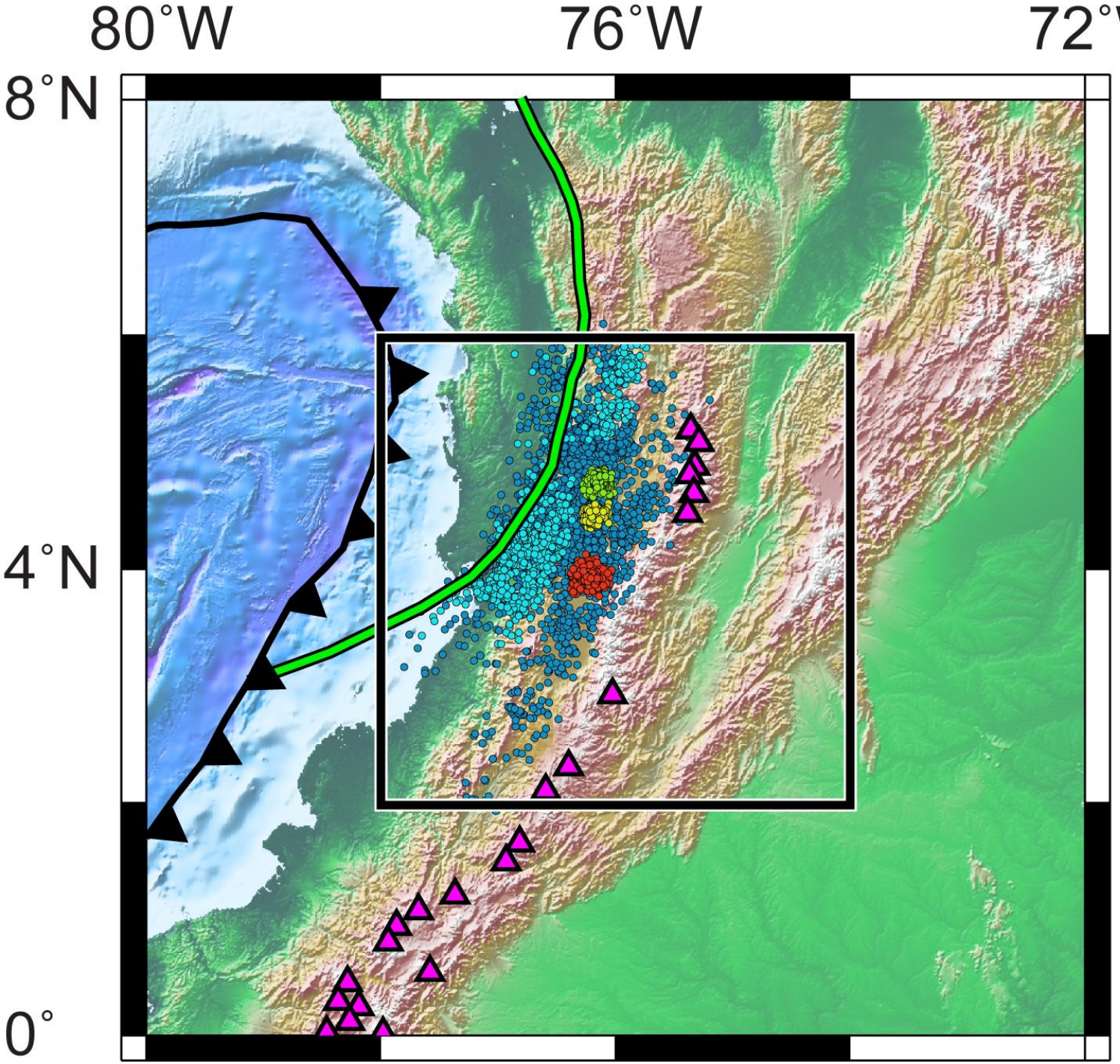
- "**Balls**" of Seismicity Follow Dip of **Slab**
- No **Supra-Slab** Seismicity South of 3.19°N
- **Slab** to Crust **Conduits**?



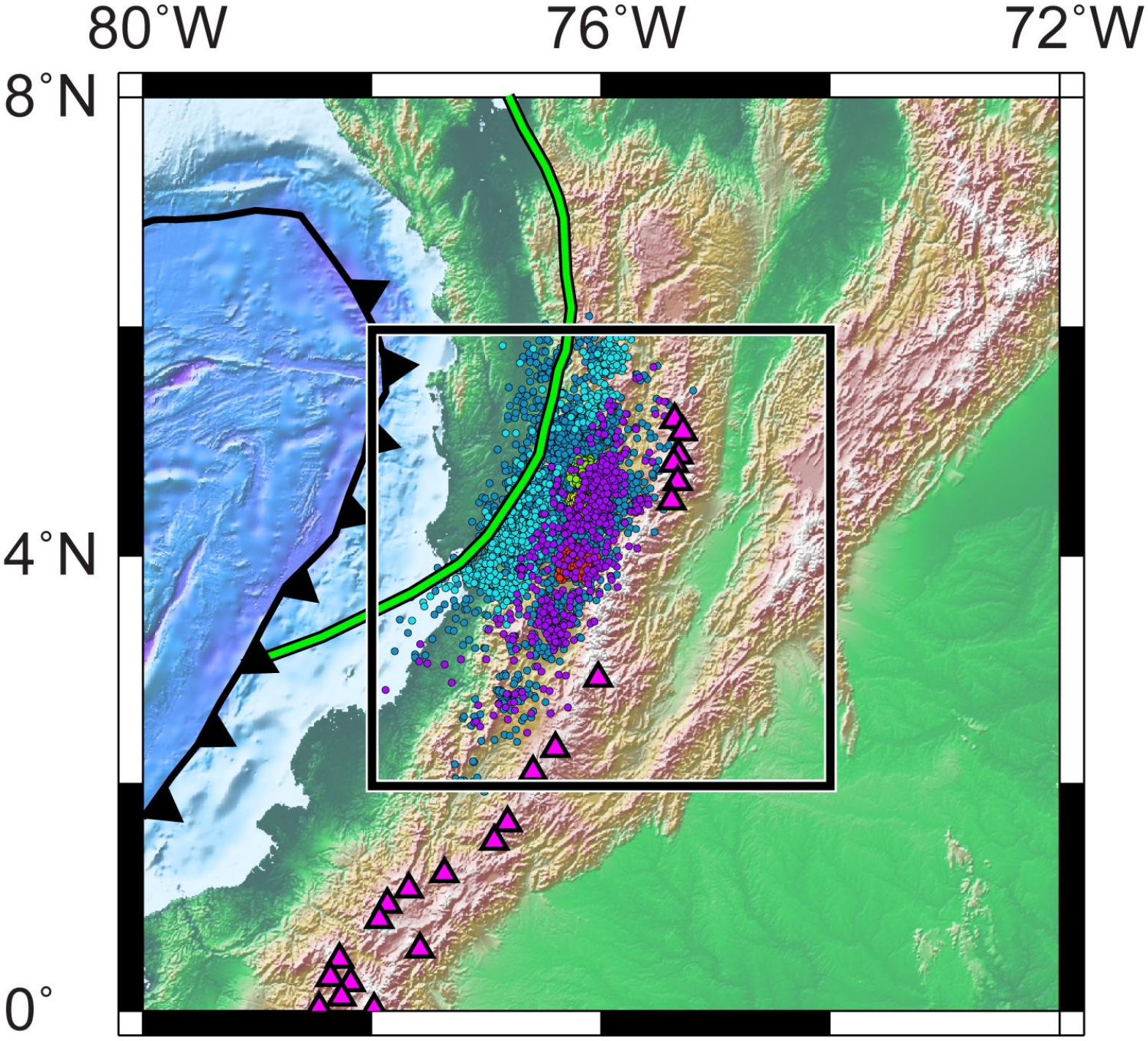
- **Slab** Seismicity Concentrated within Cluster
- Gap between Trench and **Slab** Seismicity may be Megathrust Related
- **Slab** Seismicity Ceases Trench-ward of Volcanic Arc



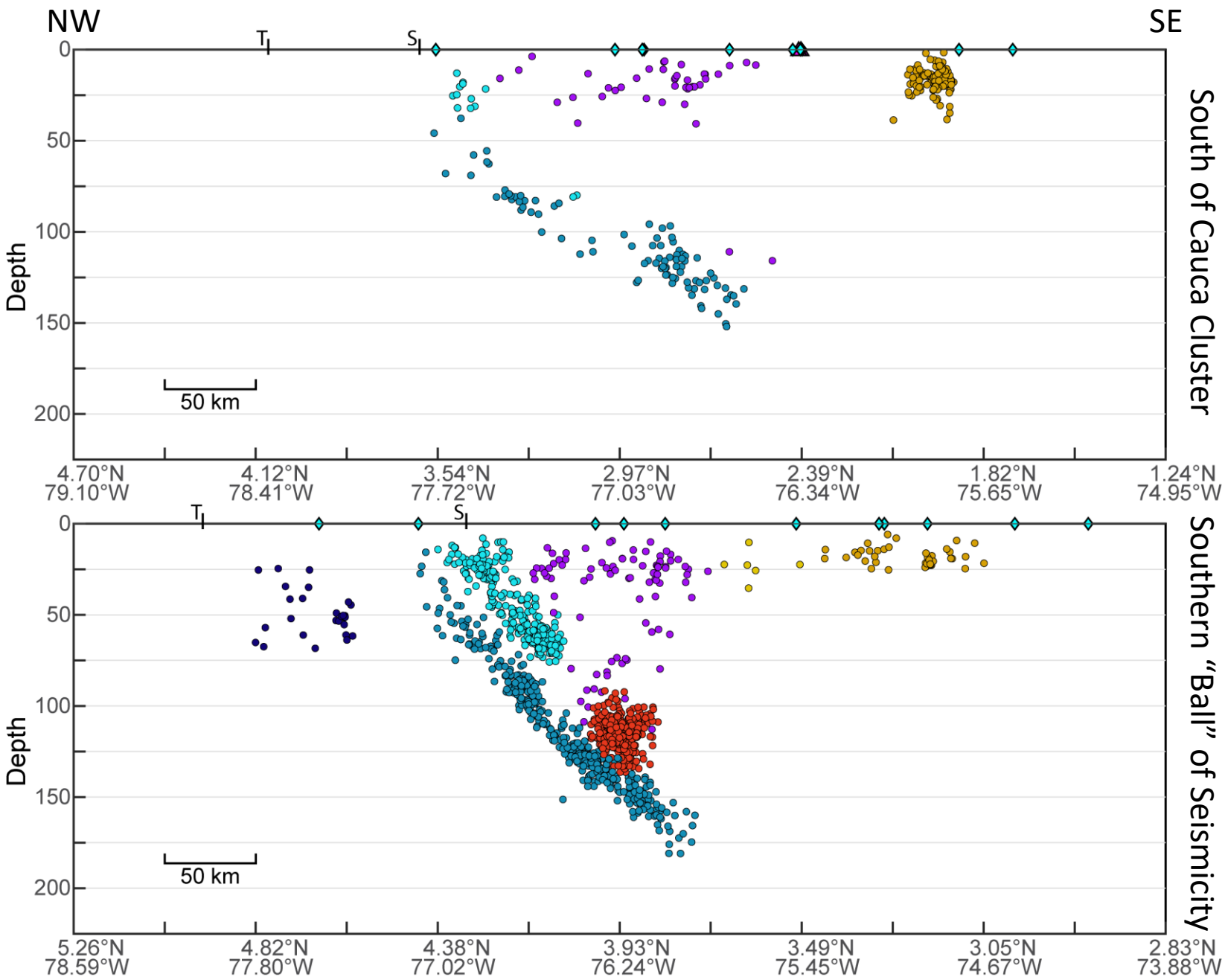
- **Supra-Slab Plane** of Seismicity Consistently Ends at Panama-Choco Suture
- Northern Portion Largely at Crustal Depths, may be Deeper Part of Known Strike-Slip Fault
- Southern Part Dips to South-South East



- "**Balls**" of Seismicity Spatially Separated from **Supra-Slab Plane**
- "**Balls**" of Seismicity lie Directly Above Area of Intense **Slab** Seismicity
- Follow Trend Distinct from Arc Trend, ~100 km from Arc—Not Likely Related to Arc Volcanism



- **Remaining Supra-Slab** Seismicity Largely Limited to Area Above or Near "**Balls**"
- Rare South of Cluster
- Majority Well Away from Volcanic Arc, little overlap with **Supra-Slab Plane**
- Shallower Continuation or Equivalent of "Balls"?



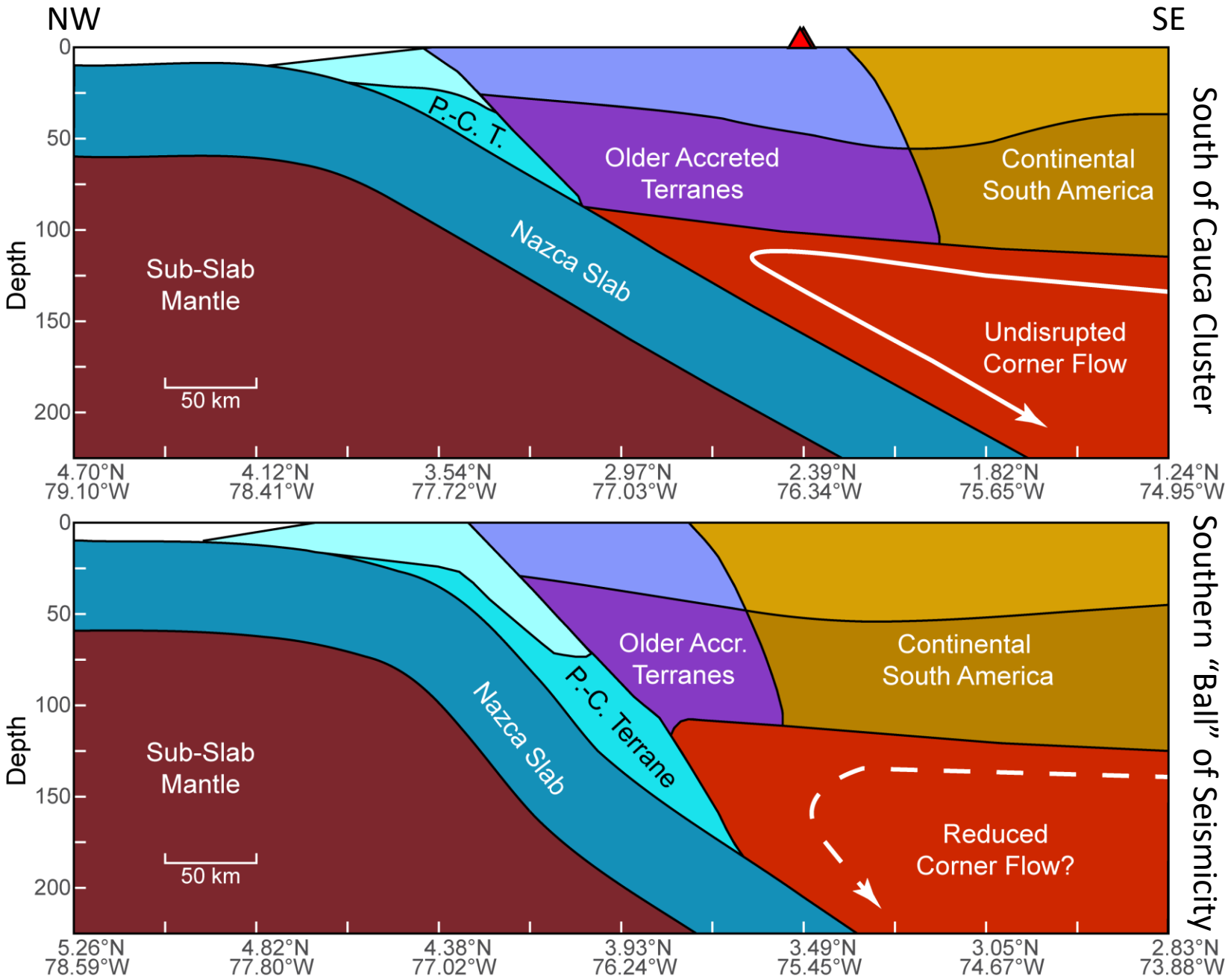
Forearc after Meissnar et al., 1976; crustal thicknesses after Poveda et al., 2015; lithosphere thickness after Blanco et al., 2017; sutures modified from Cochrane et al., 2014 and León et al., 2018

Supra-Slab Plane of Seismicity: Subducted Continuation of Panama-Choco Block

Nazca Slab Deflected, Thermally Shielded by Panama-Choco Block

Other Supra-Slab Seismicity Occurs within Panama-Choco Block & Lithosphere of Accreted Terranes

Panama-Choco Block May Reduce/Disrupt Mantle Wedge Corner Flow—Disrupt Arc



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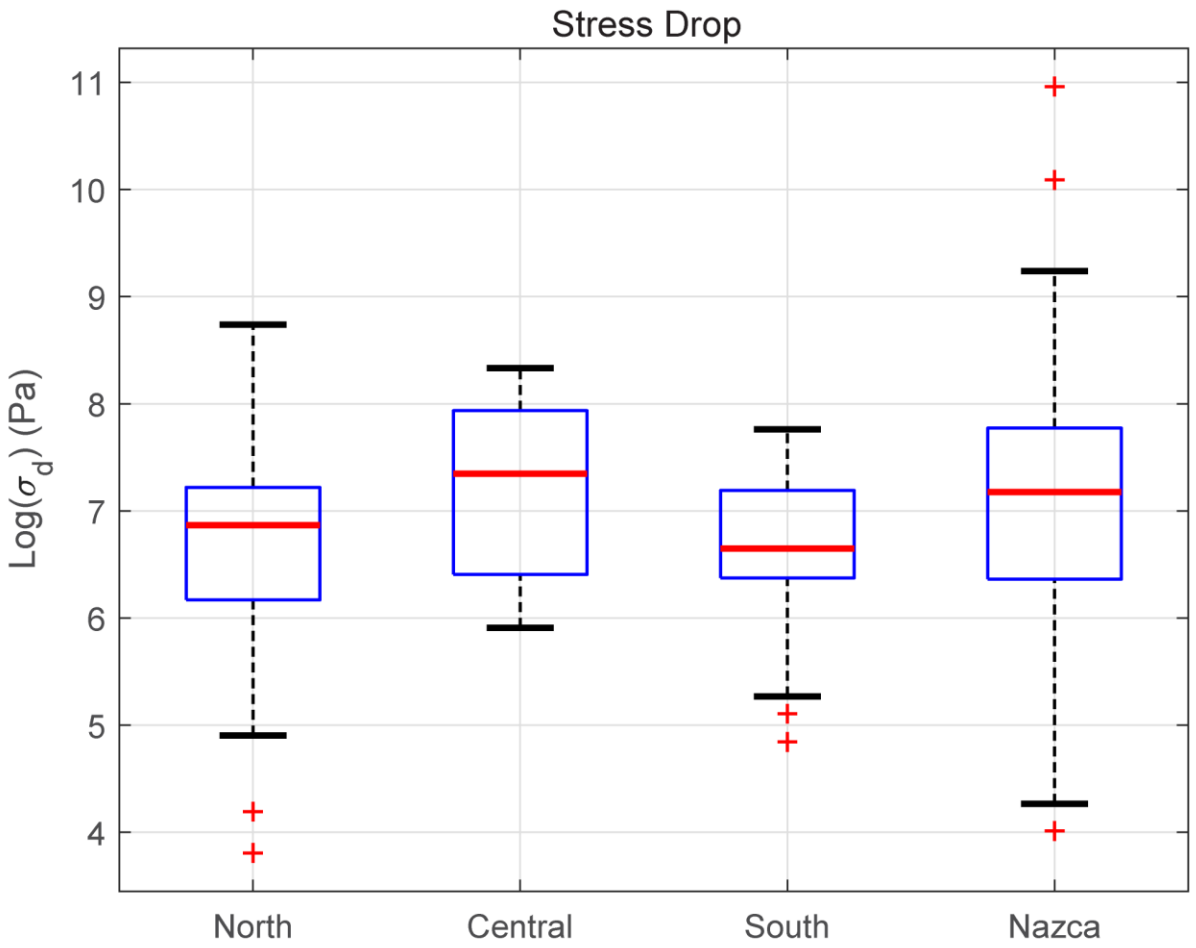
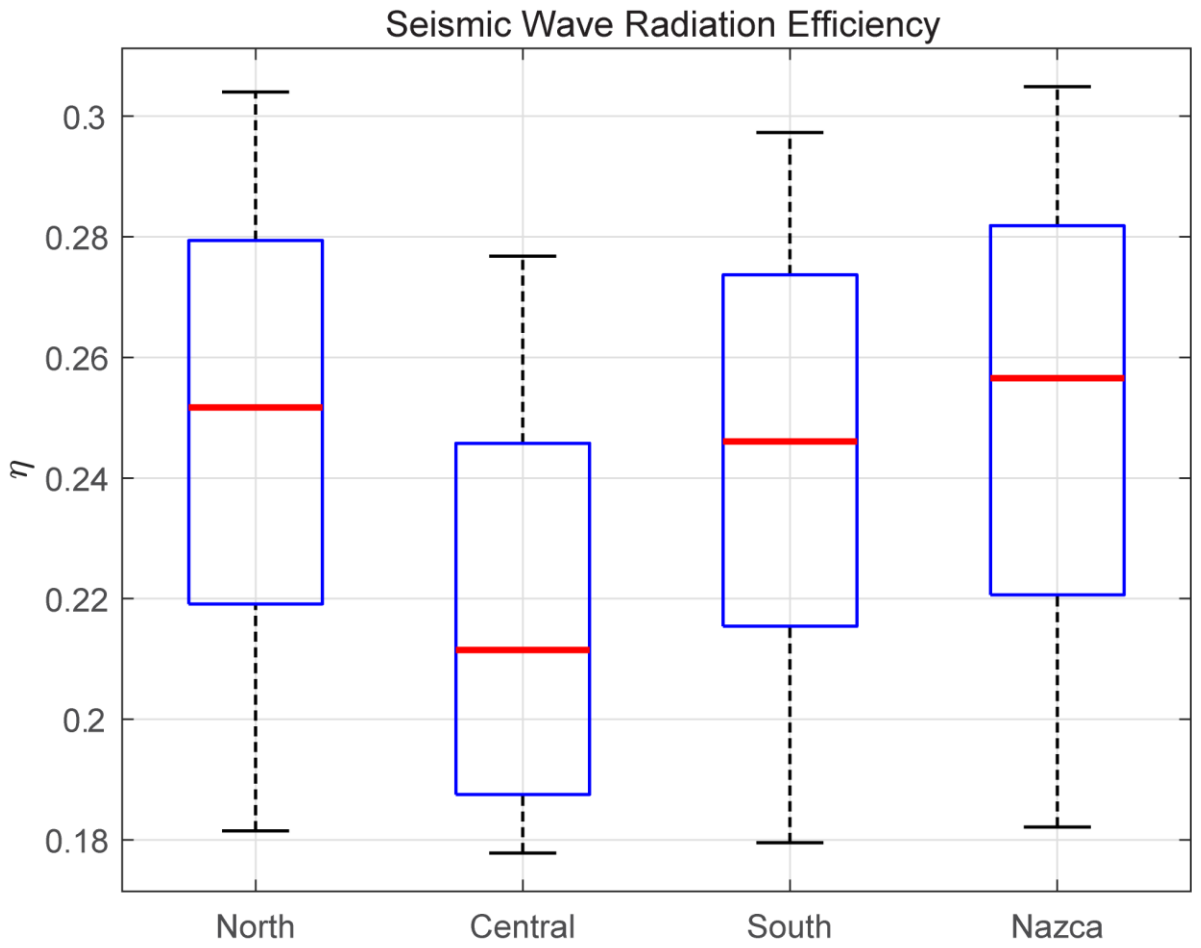
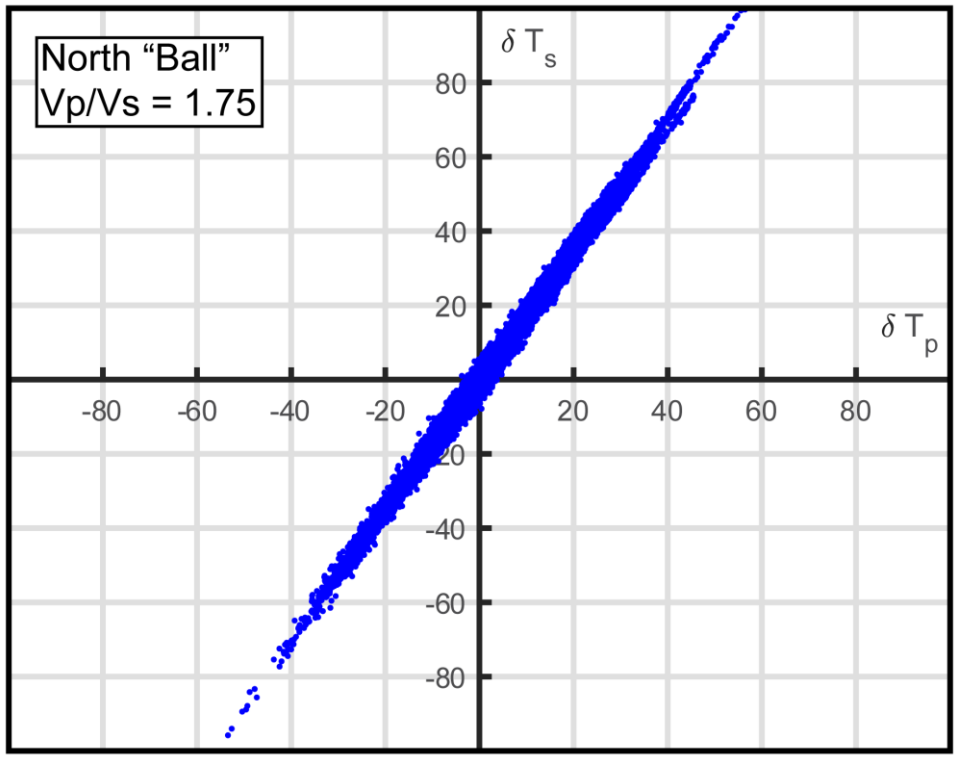
What Drives Cauca Cluster Seismicity?



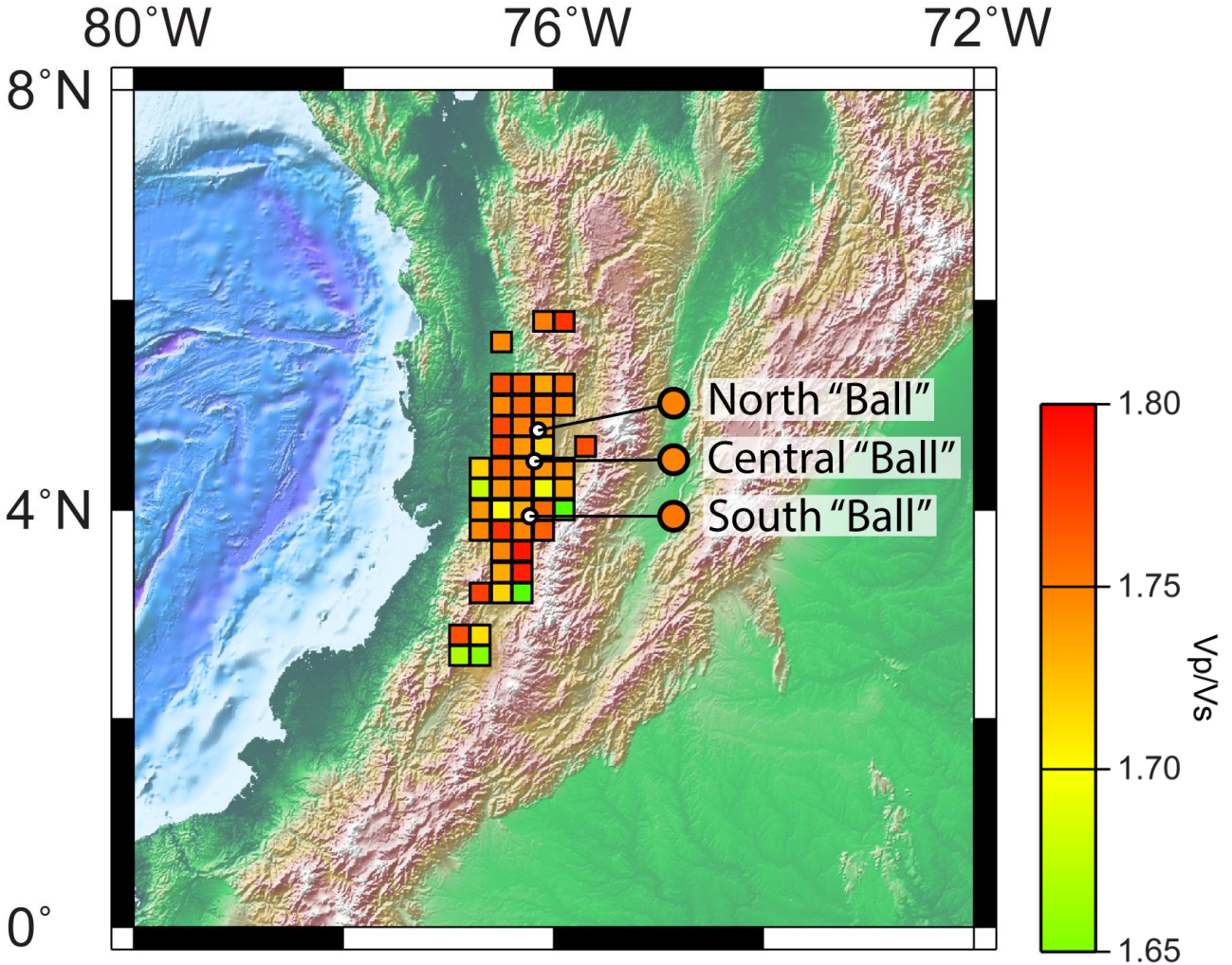


Moderate to high stress drops and normal radiation efficiencies consistent with fluid related mechanism.

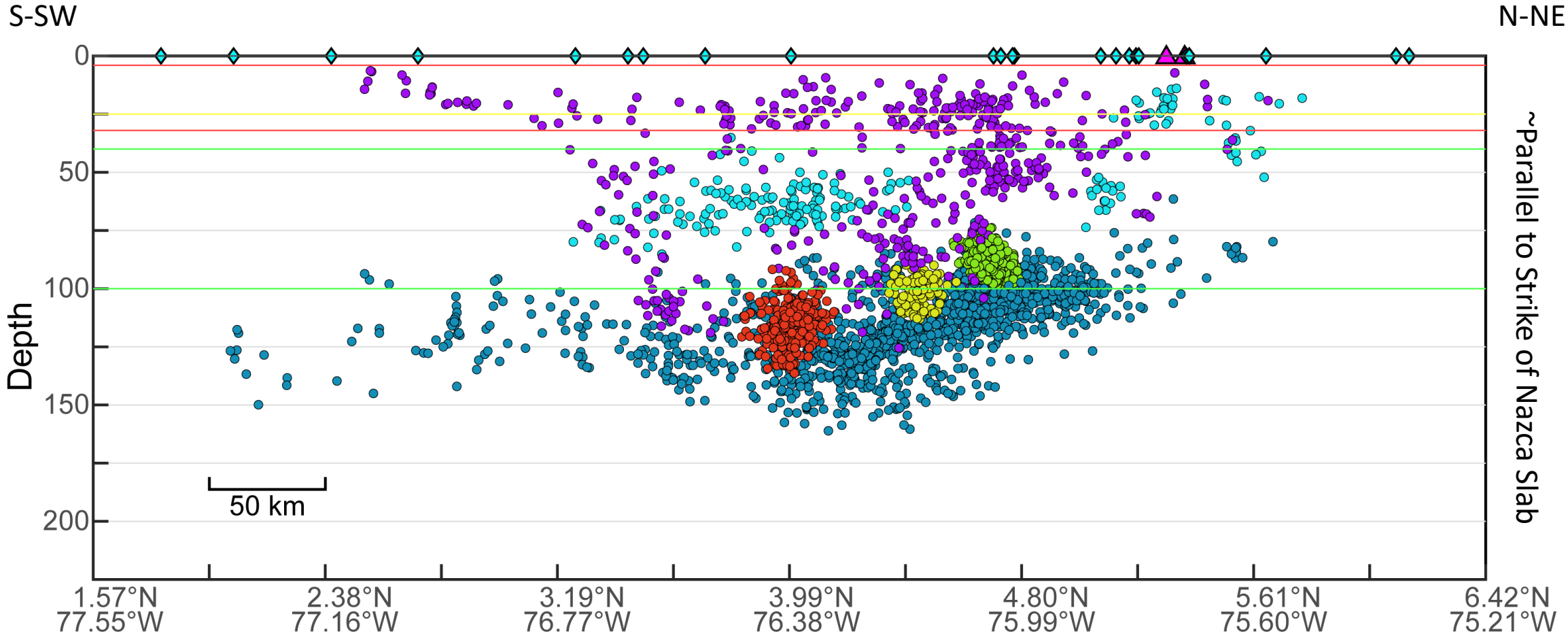
What Drives Cauca Cluster Seismicity?



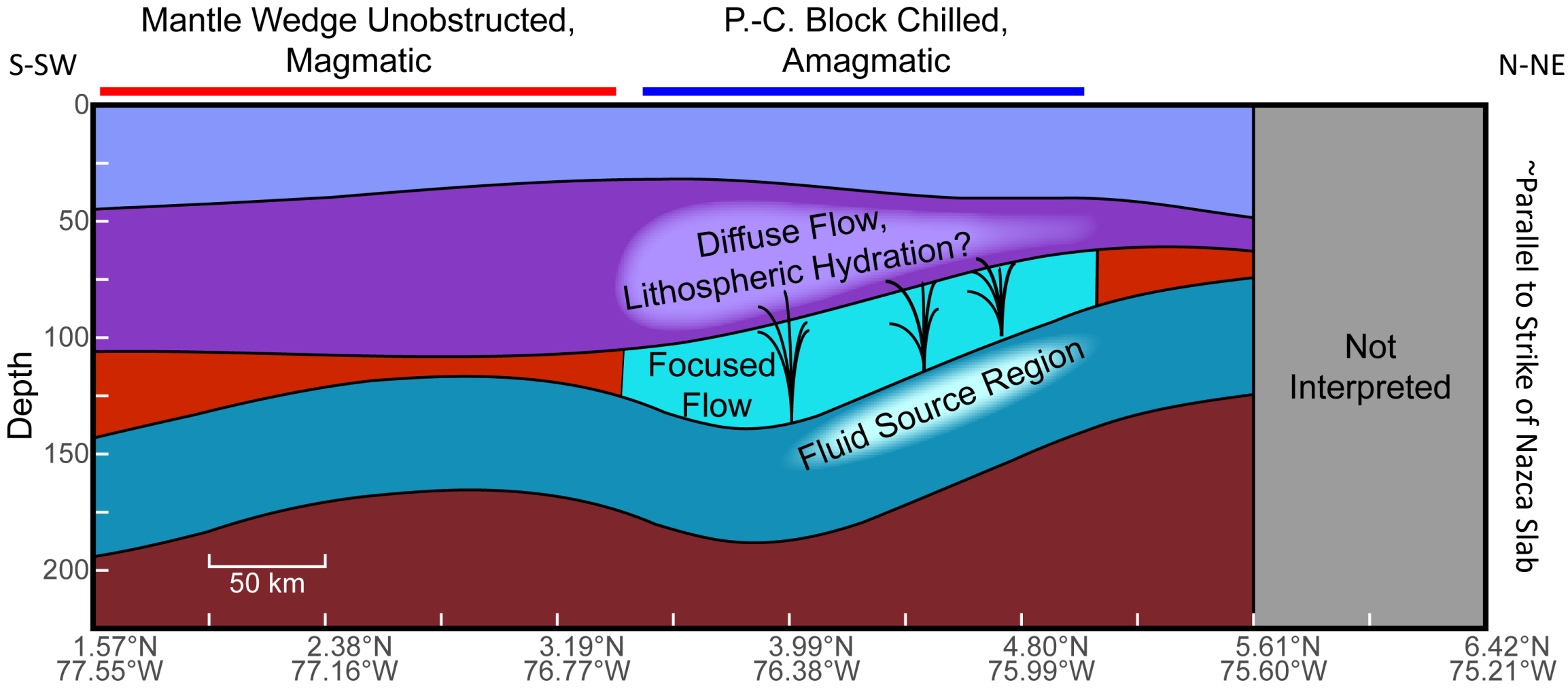
Typical mantle materials at corresponding depths have a Vp/Vs of ~1.70-1.75



Vp/Vs shows little evidence for extensive fluids around earthquake sources, however extensive faulting may allow rapid drainage.



The Cauca Cluster represents a location in which the partial subduction of the now accreted Panama-Choco terrane has disrupted typical mantle wedge processes. Thermal shielding from the terrane and its disruption of mantle wedge corner flow prevent magmatism, while fluids draining from the slab into the overriding plate drive supra-slab seismicity.



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