

Interplay between seismicity, fault architecture, slip modes, and regional tectonics at oceanic transform faults

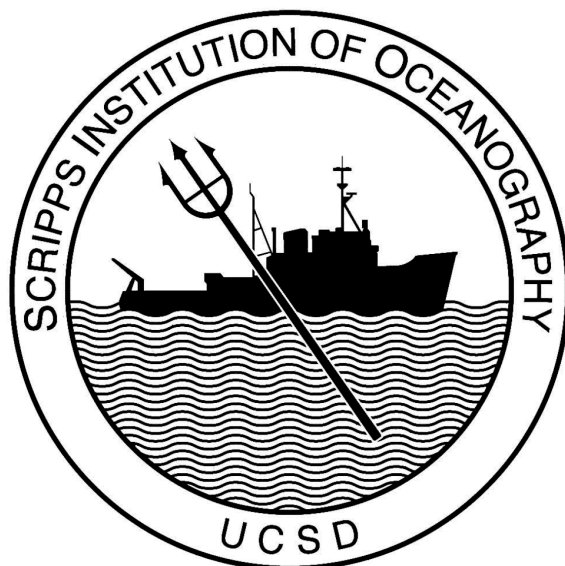
Wenyuan Fan

Associate Professor
Institute of Geophysics and Planetary Physics
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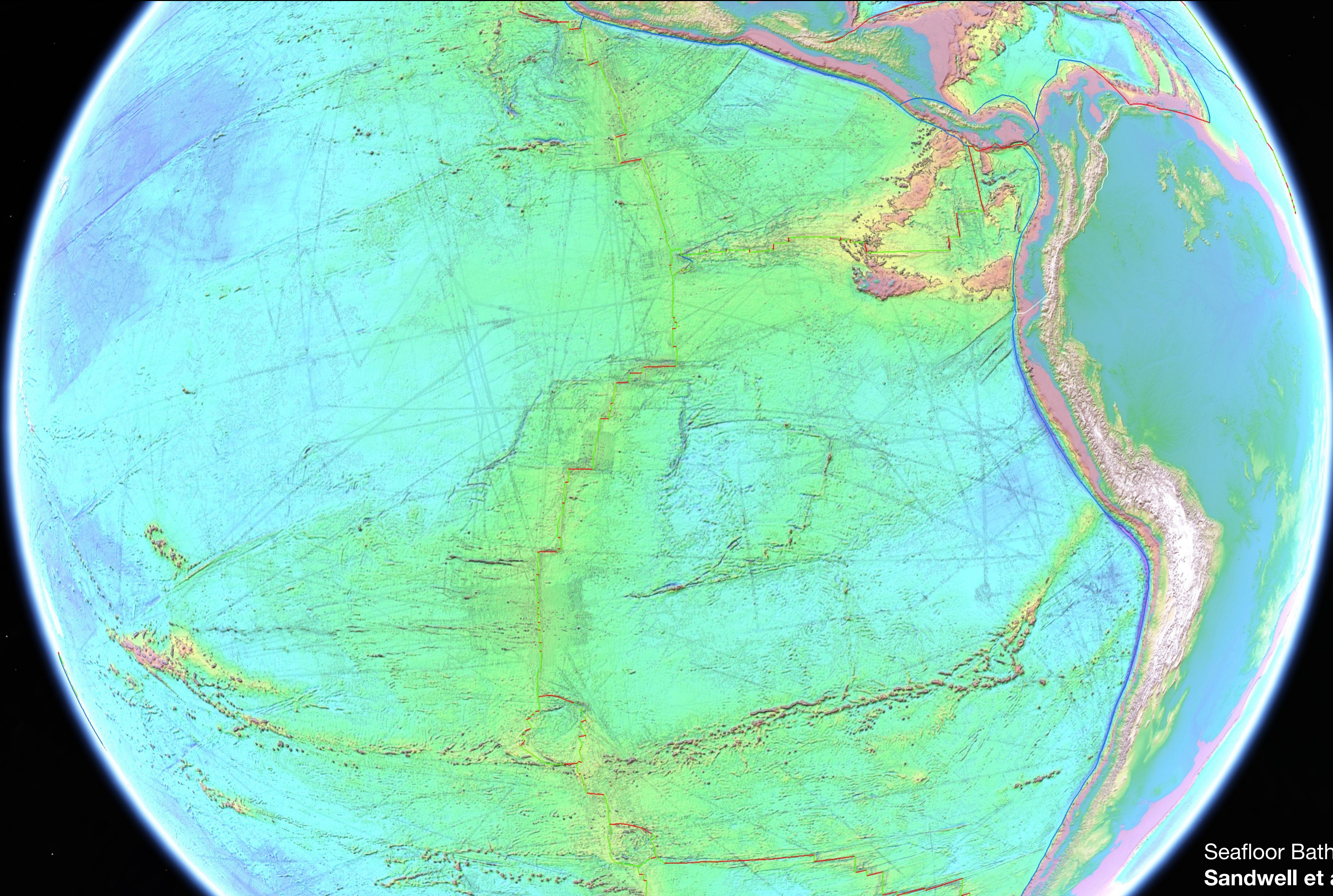
In collaboration with Jeff McGuire, Jianhua Gong, Tianze Liu, the 2008 QDG team, and the 2019-2022 Gofer team



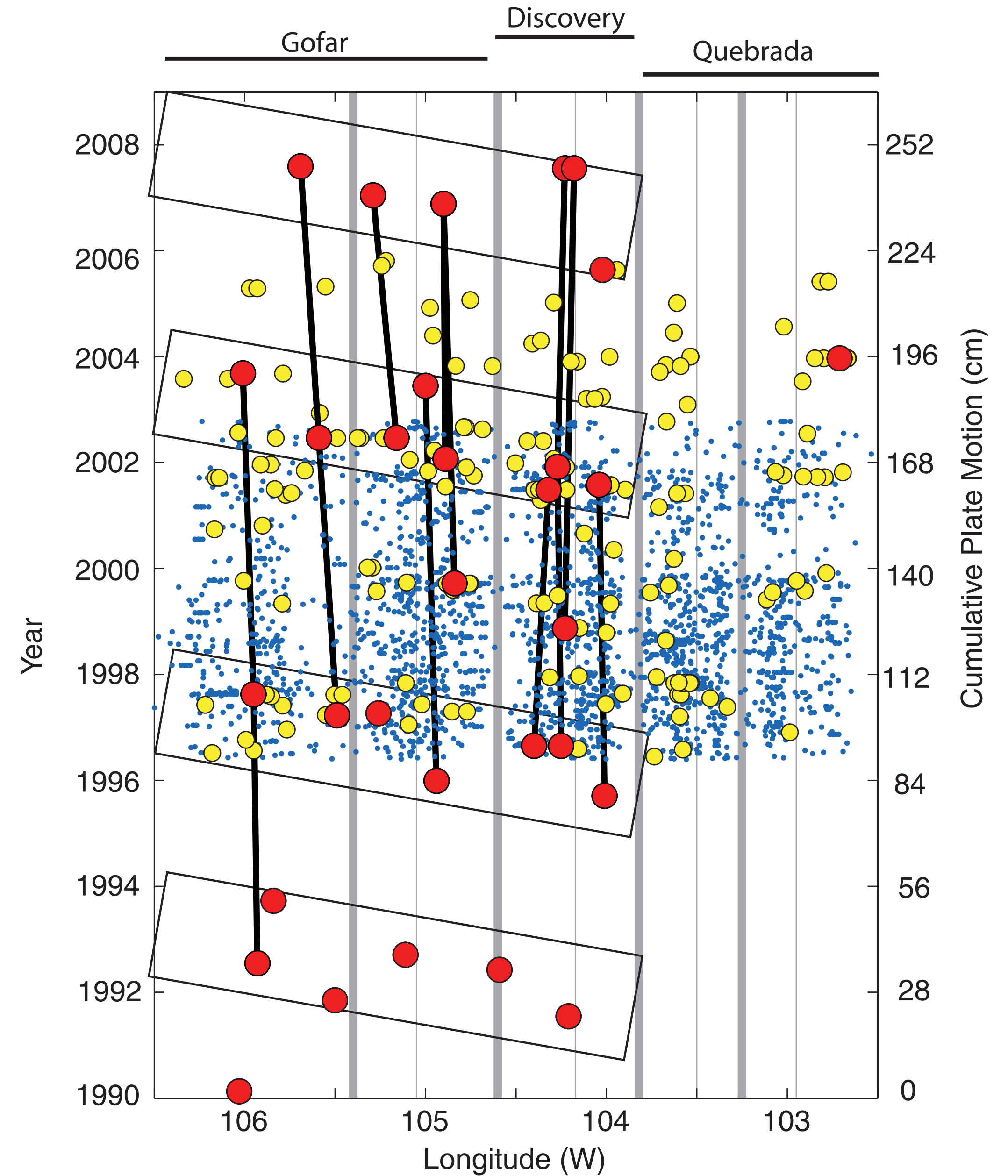
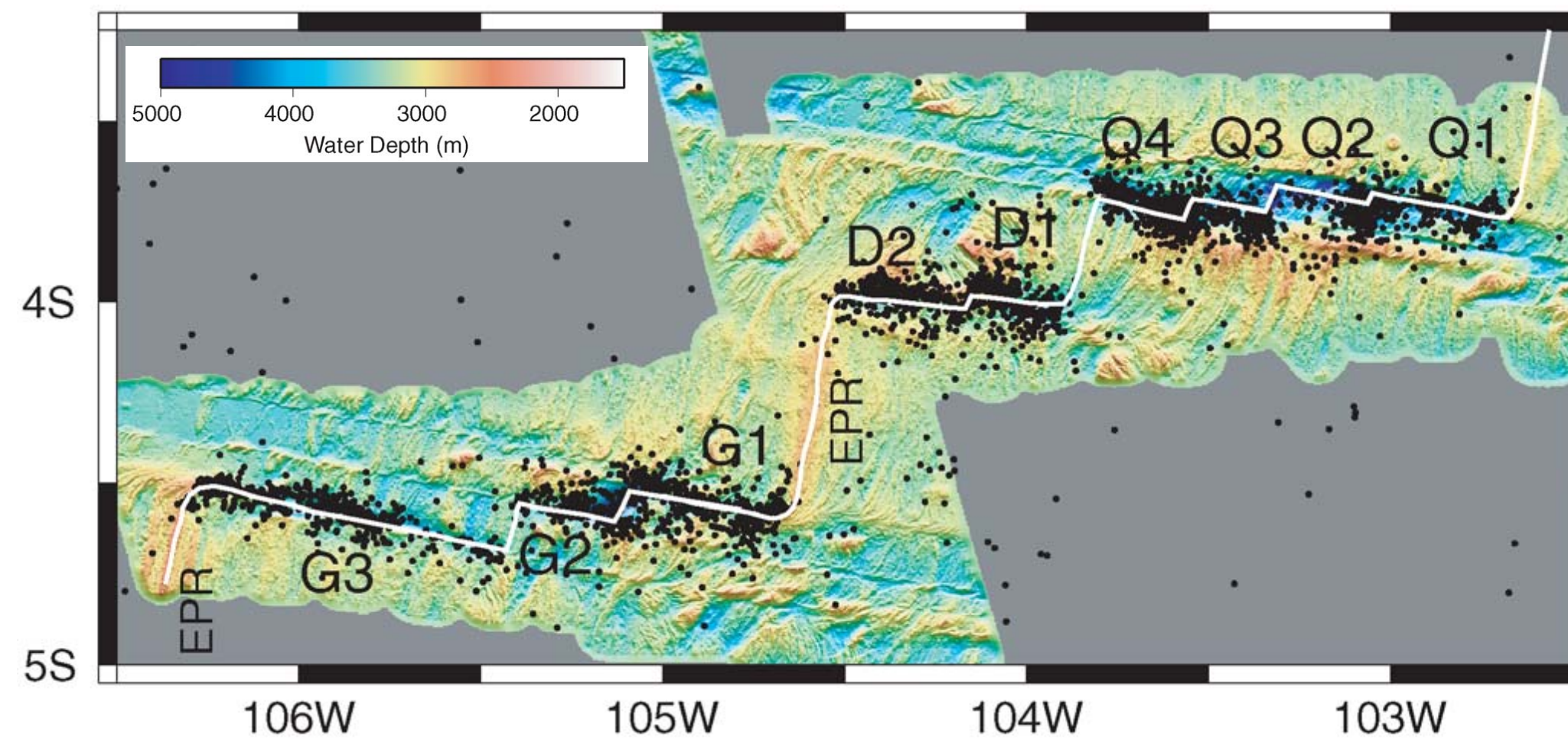
OCE-1833279
EAR-2143413



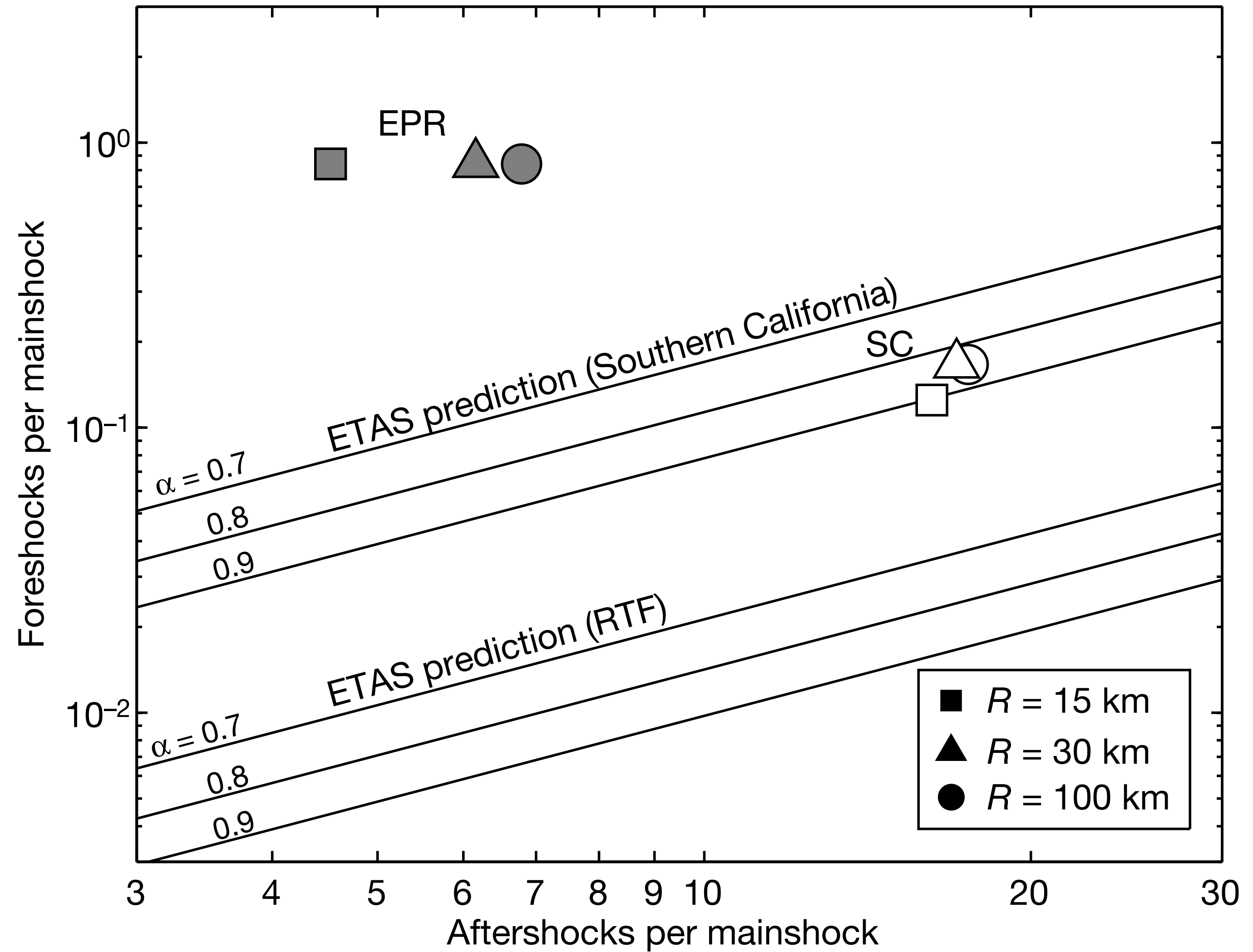
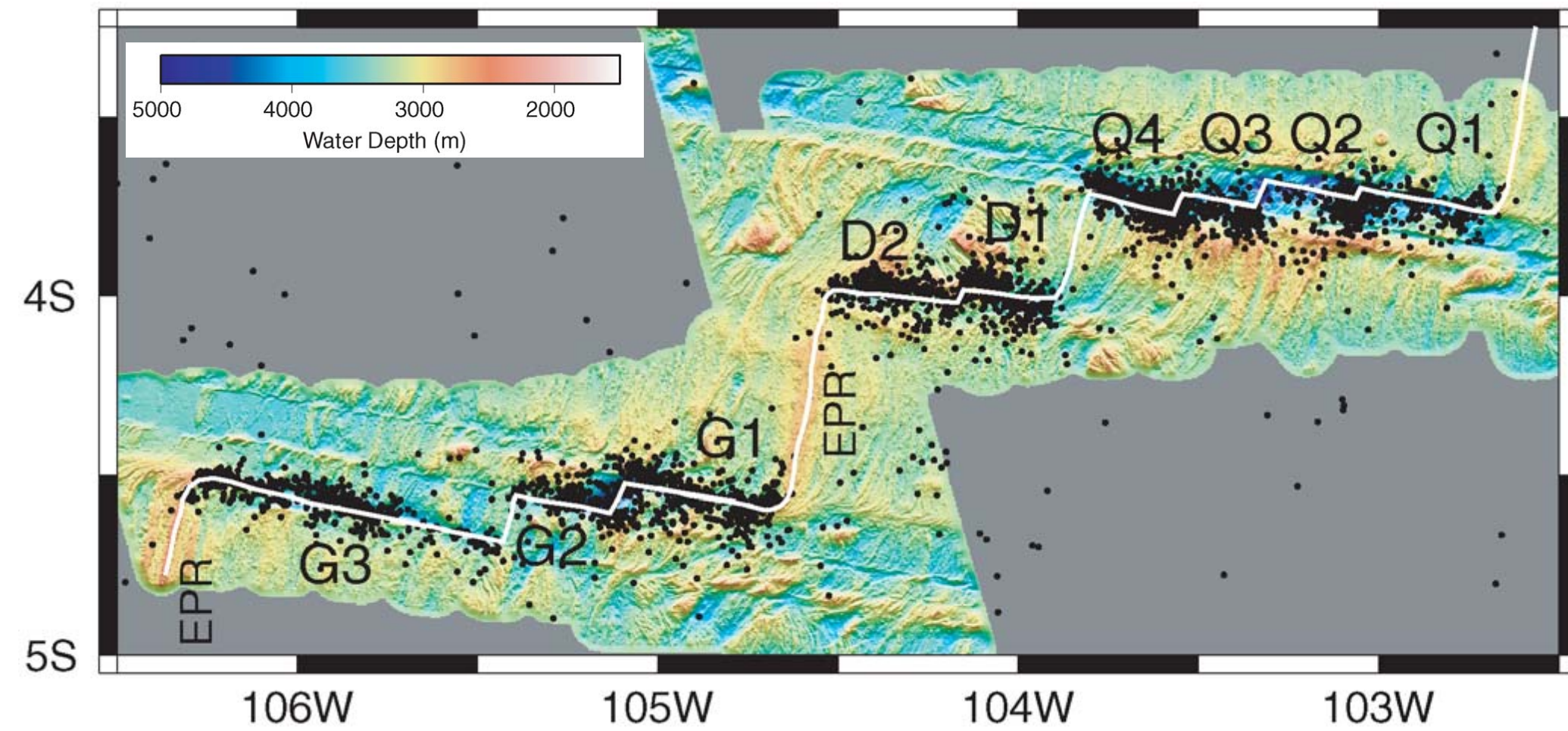
Oceanic Transform Faults (OTF): Witnesses to the Birth and Growth of Tectonic Plates



Large OTF Earthquakes: Quasi-periodic Occurrences with Precursory Foreshocks



Large OTF Earthquakes: Quasi-periodic Occurrences with Precursory Foreshocks

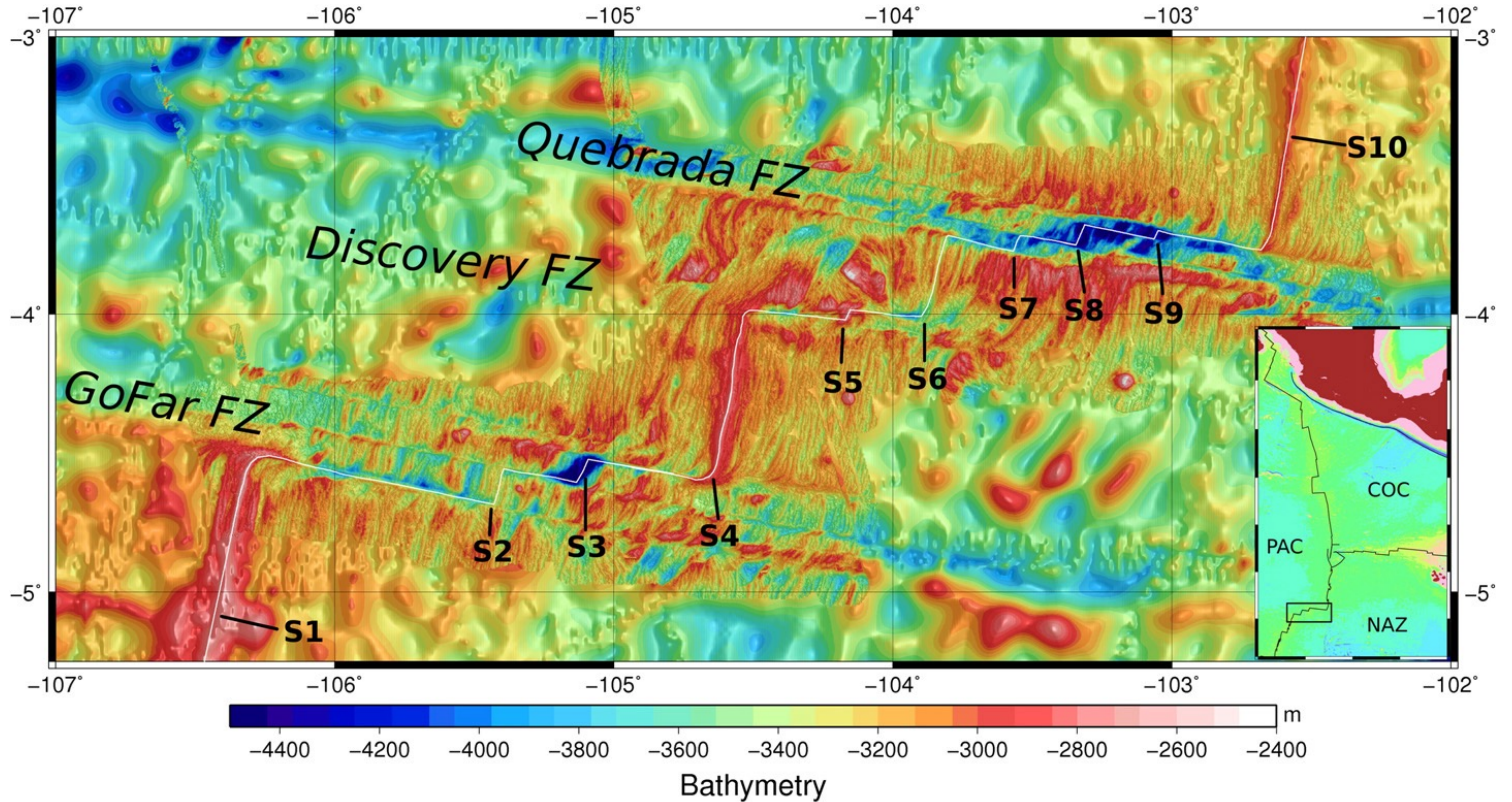


- What fault structure causes the quasi-periodic earthquake behaviors?
- What controls the OTF slip modes and earthquake cycles?
- How does regional tectonics influence the OTF fault architecture and slip modes?

Quebrada-Discovery-Gofar transform faults

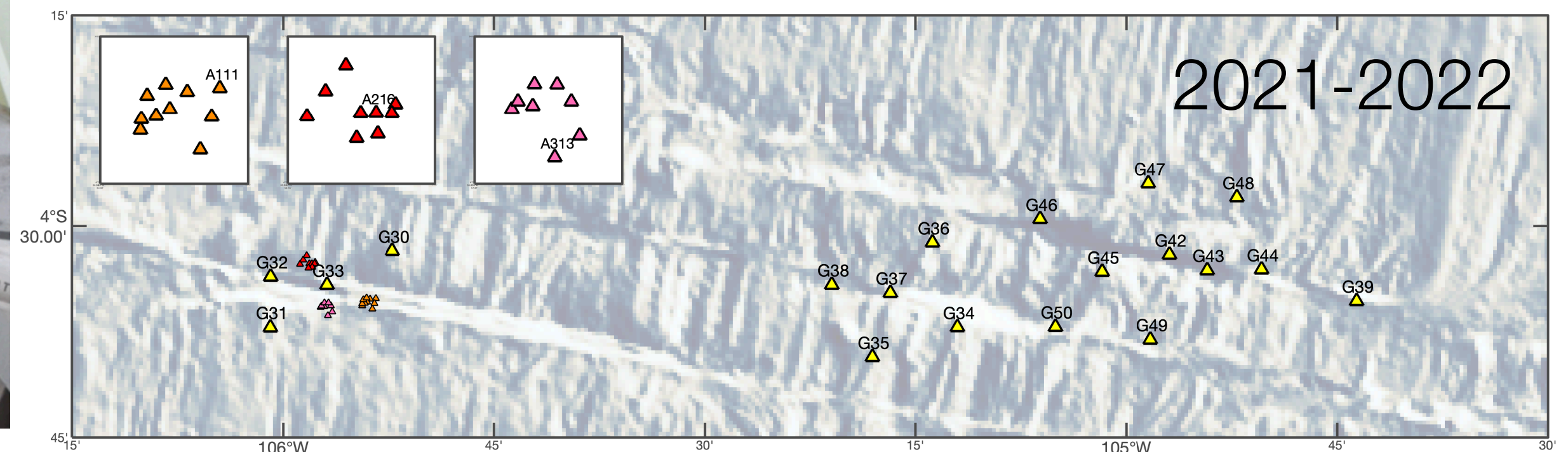
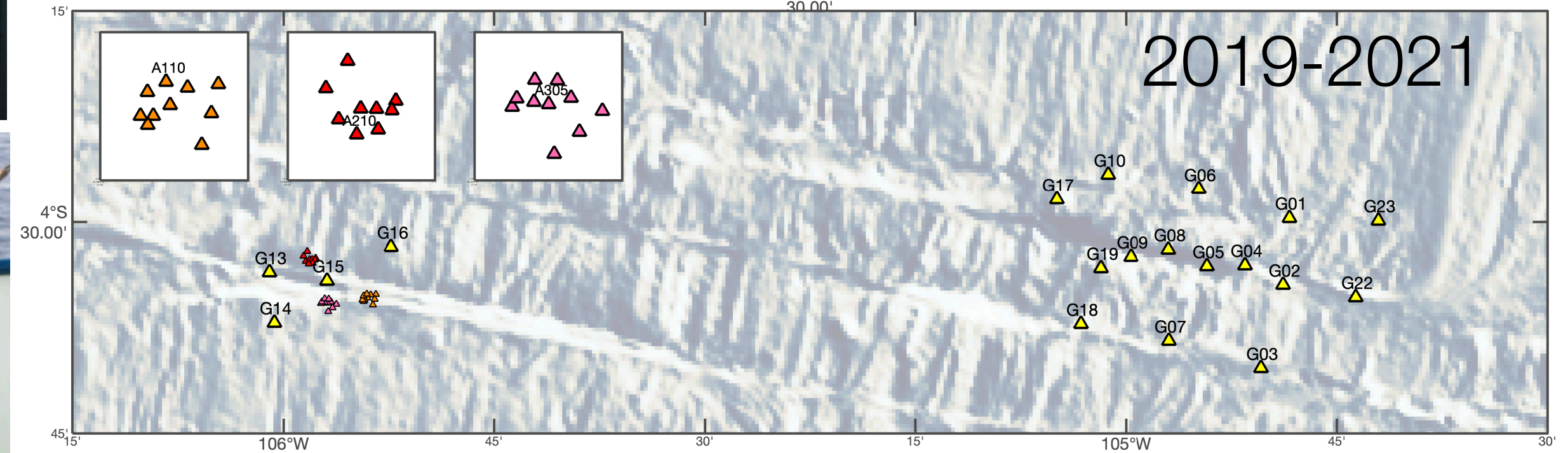
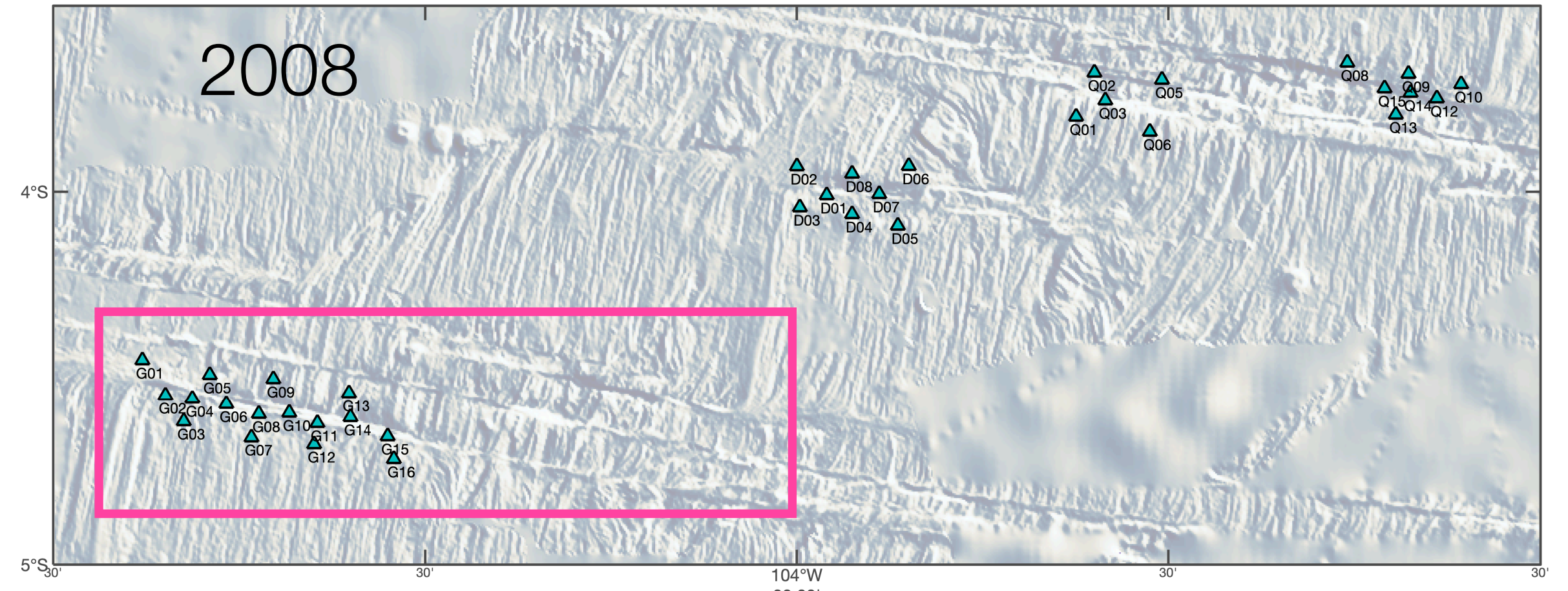
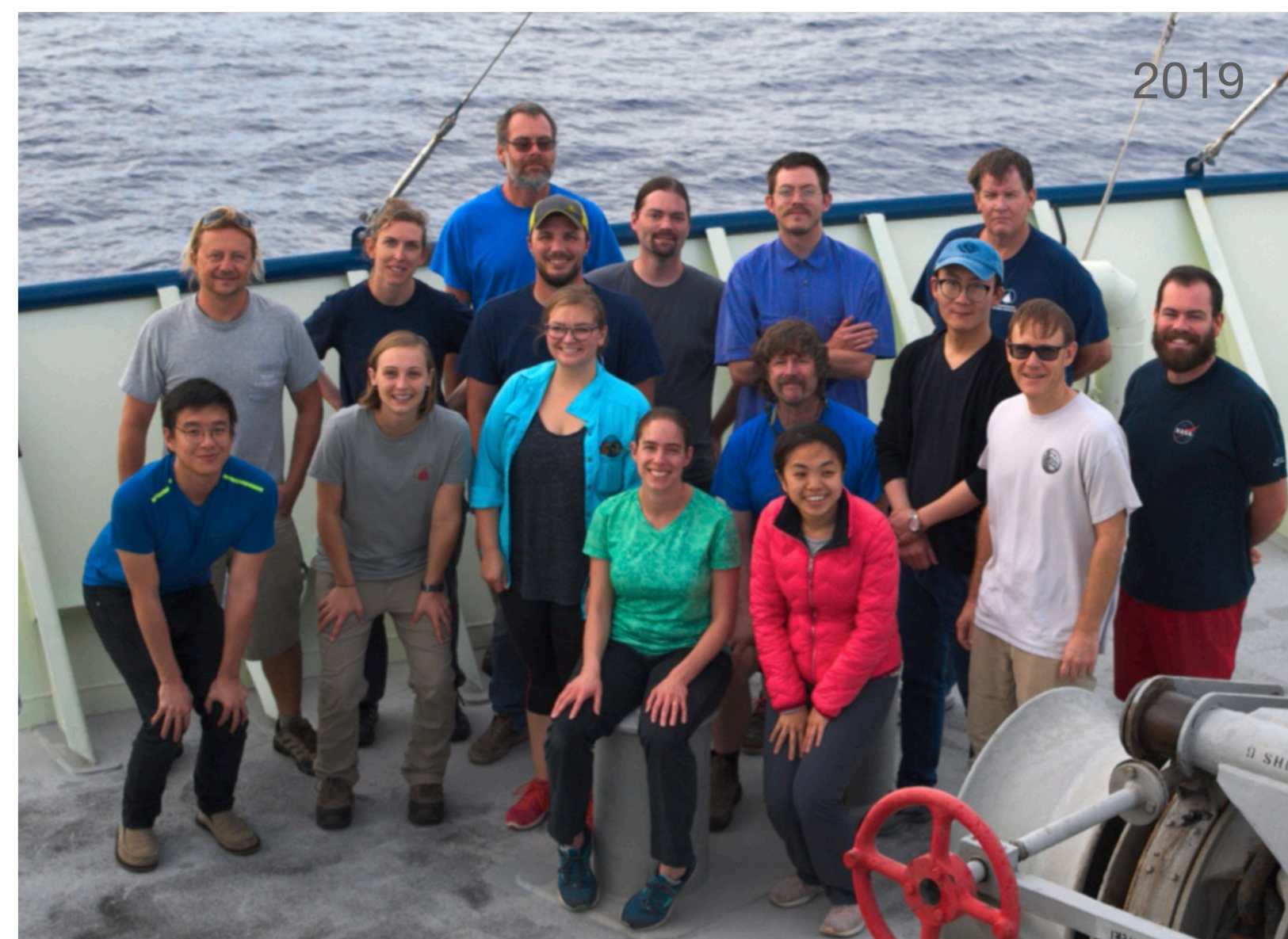


Quebrada-Discovery-Gofar Systems: Closely spaced, Multi-strand OTF Systems

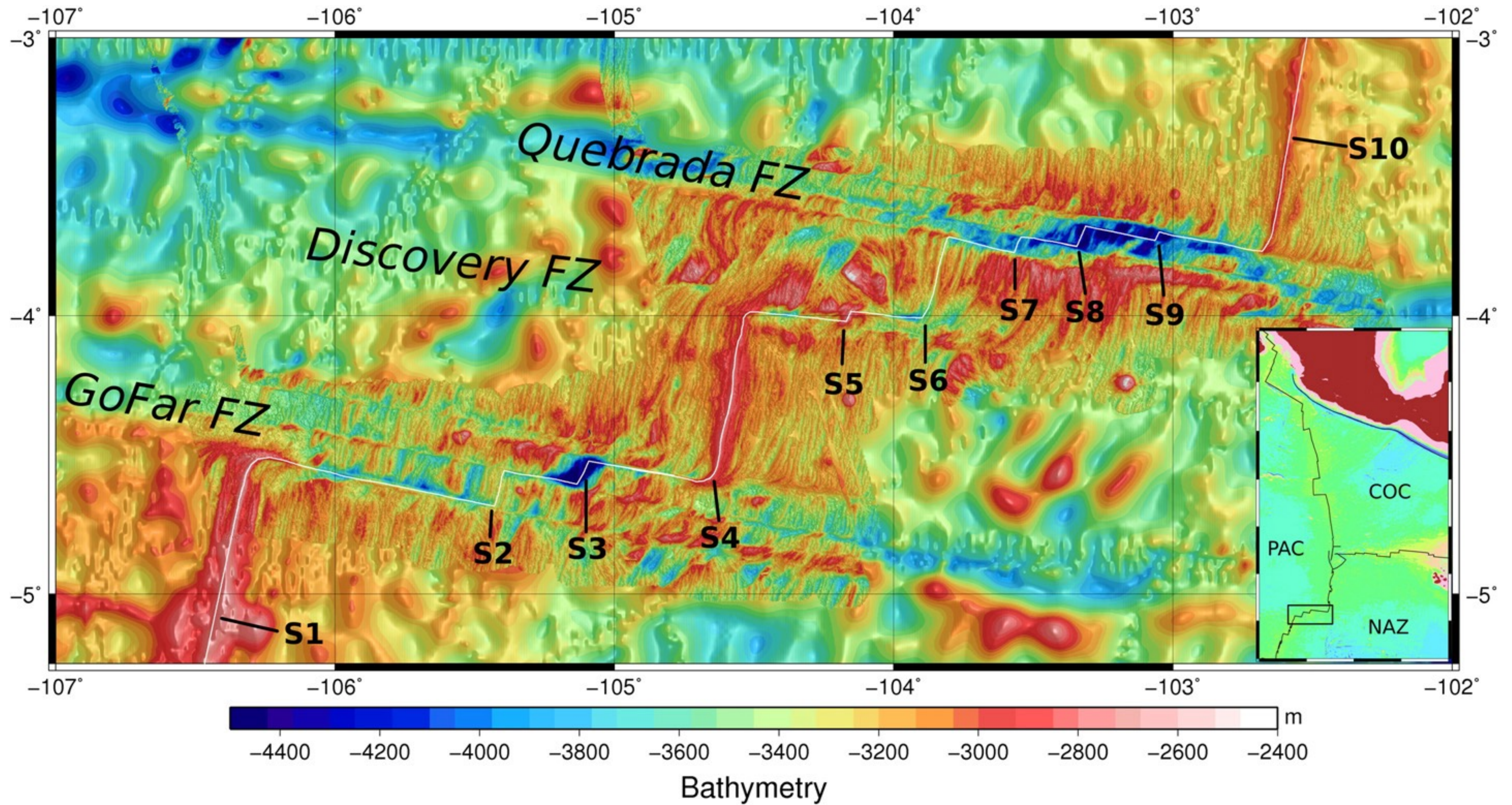


The 2008 Quebrada-Discovery-Gofar and 2019-2022 Gofar Marine Geophysics Experiments

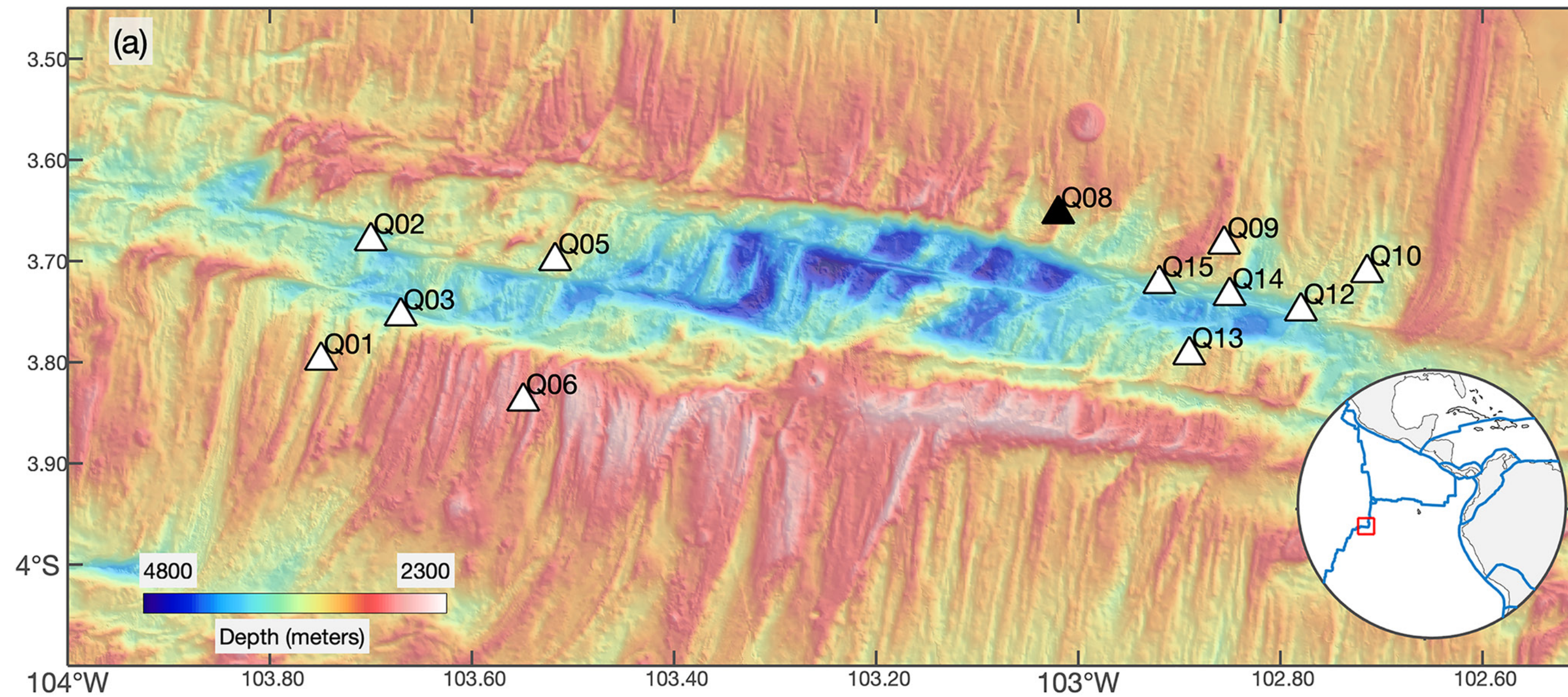
Both experiments successfully captured two anticipated M6 earthquakes



From Quebrada to Gofar

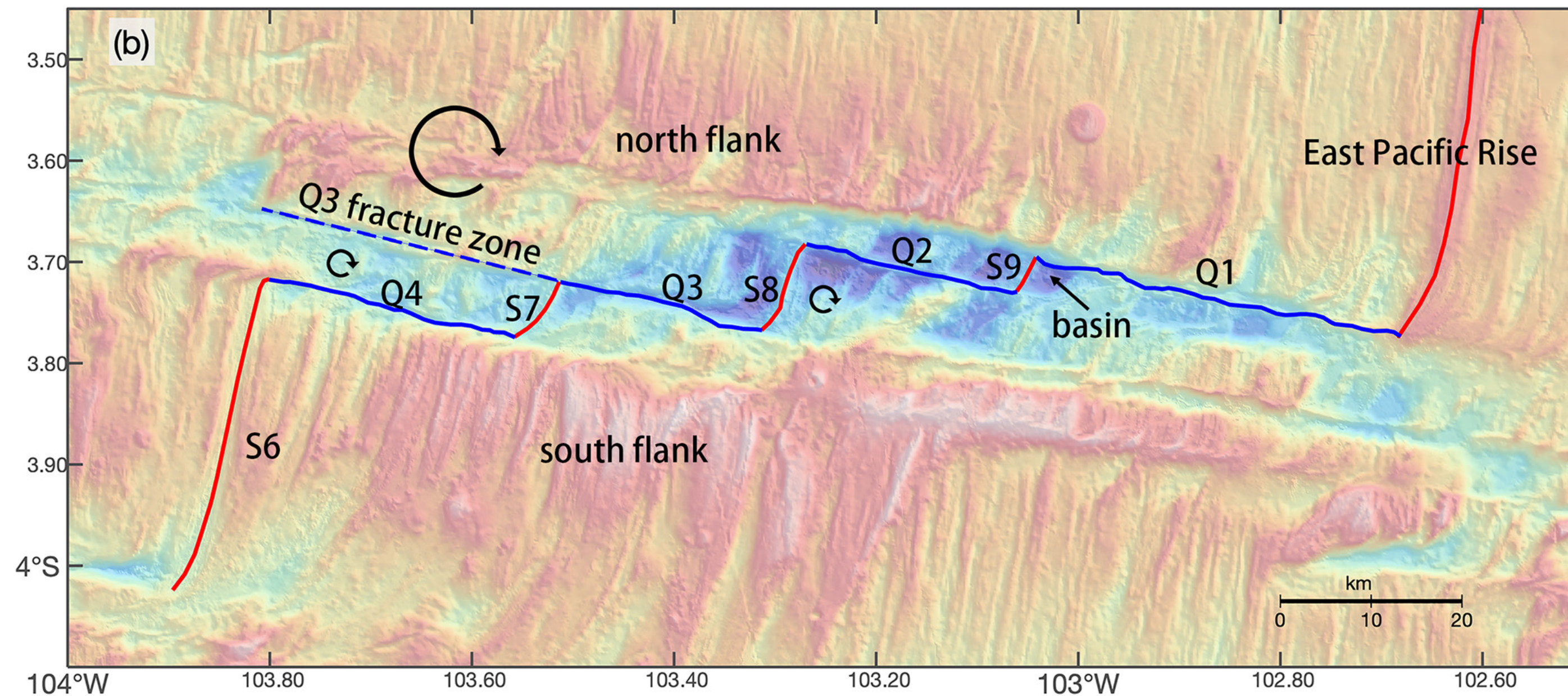


Cold Mantle Temperature and Thin Crust at Quebrada



- Cold Mantle Temperatures Beneath Spreading Centers
- Thin Crust, Approximately 4 km

Pickle et al., *EPSL*, 2009



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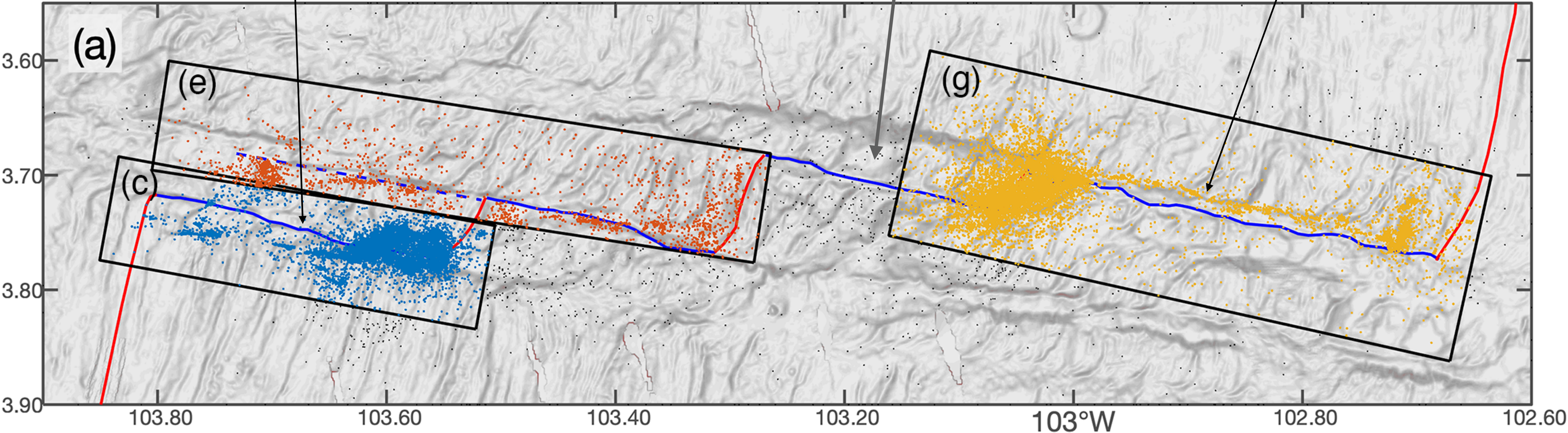
Gong et al., *GRL*, 2022

Earthquakes Unevenly Distributed Across the Four Fault Segments

Q4, dense earthquakes

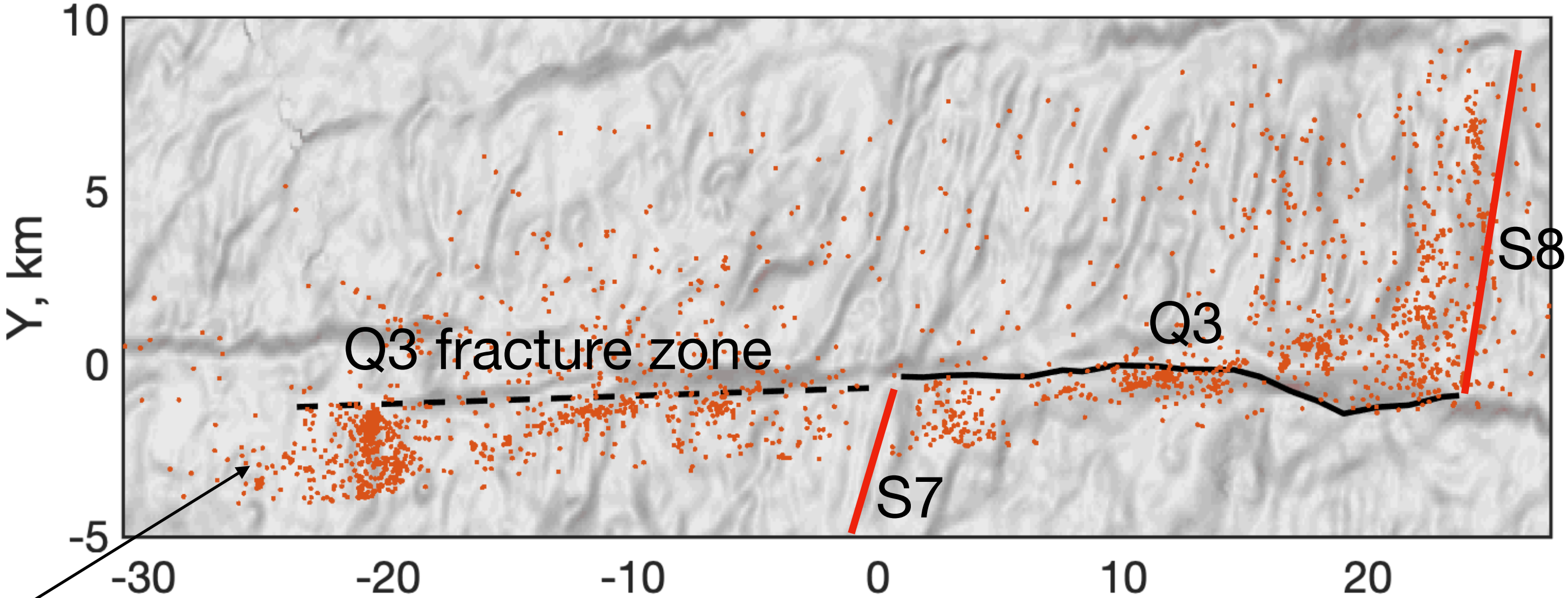
Q2, aseismic or missing events?

Q1, dense earthquakes

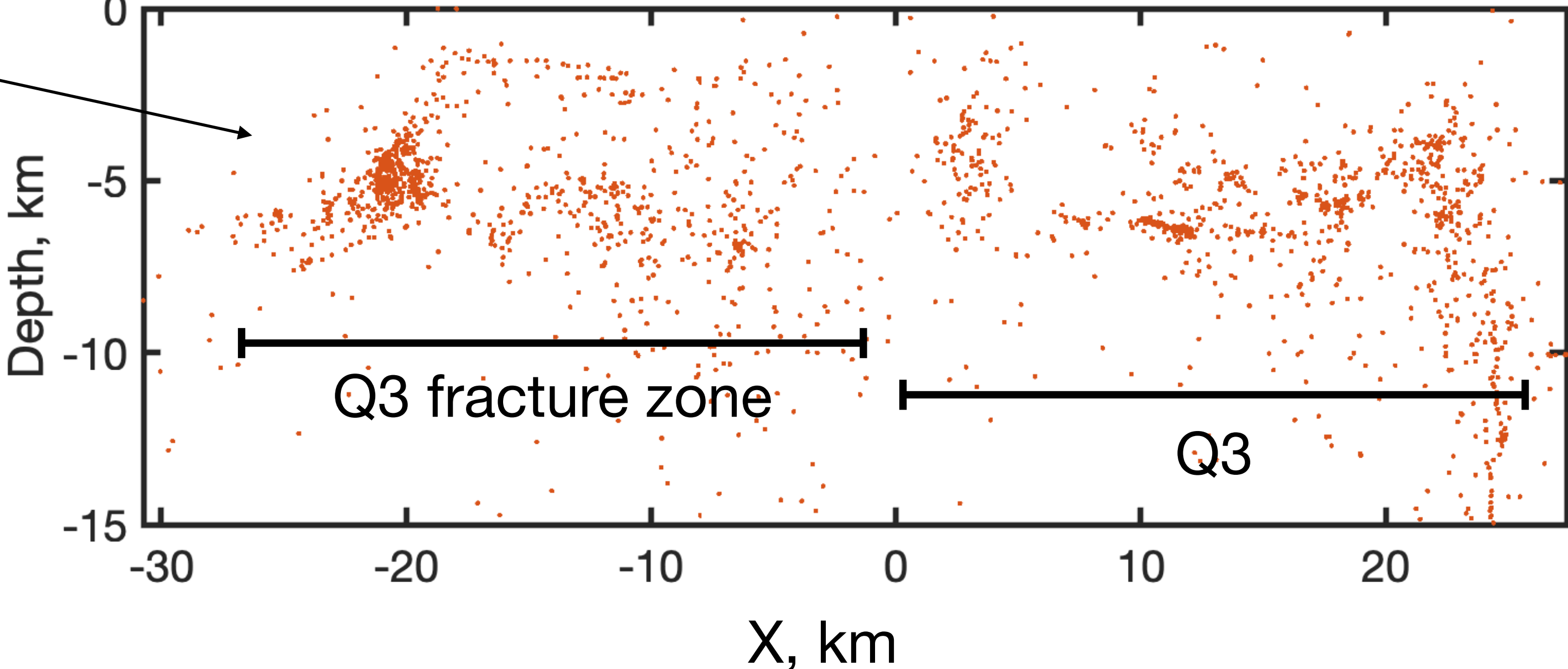
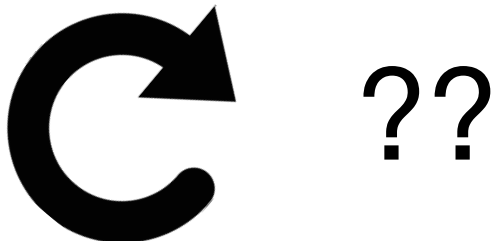


~24,000 earthquakes

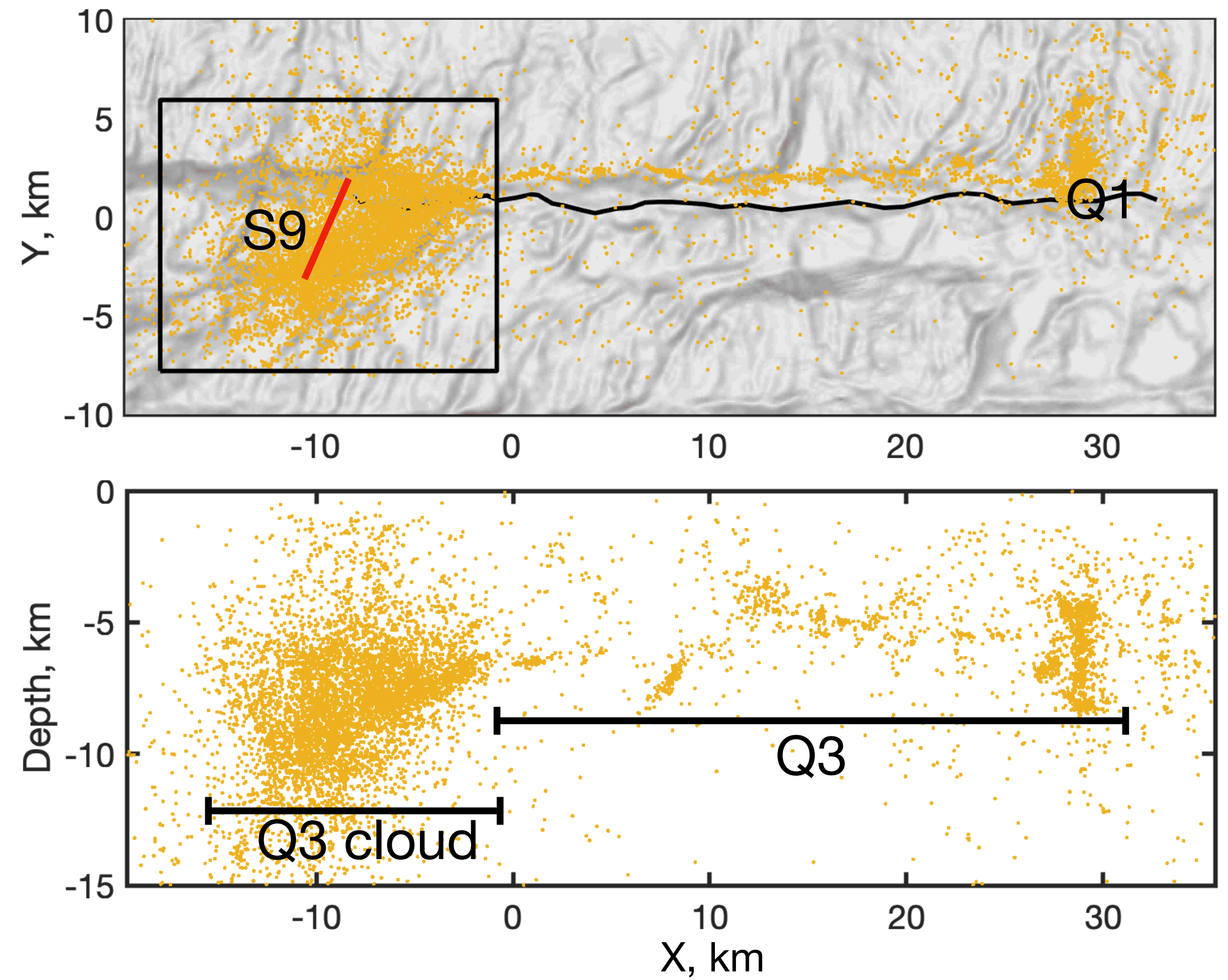
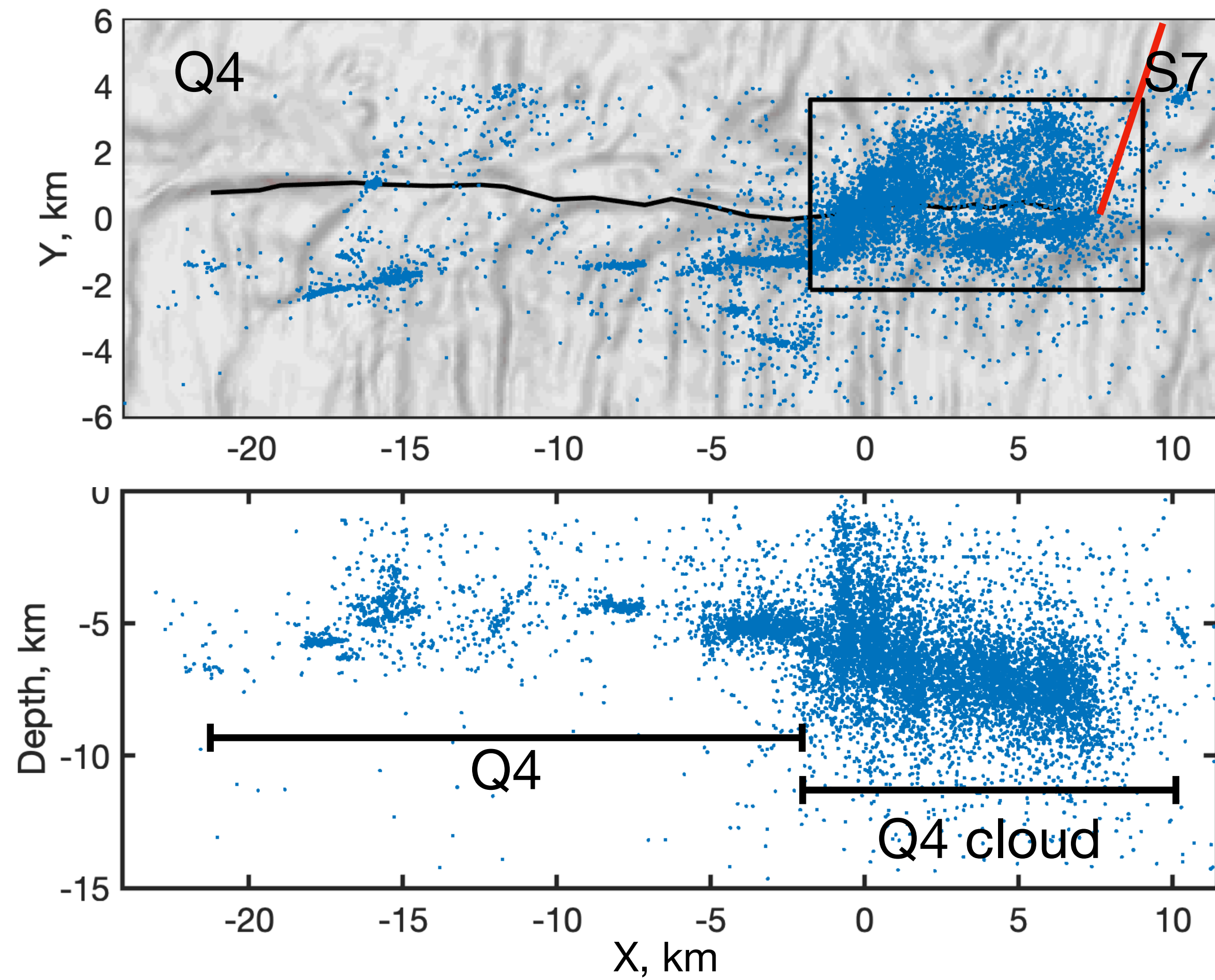
Small-Scale Rotation causes Earthquakes Along the Q3 Fracture Zone



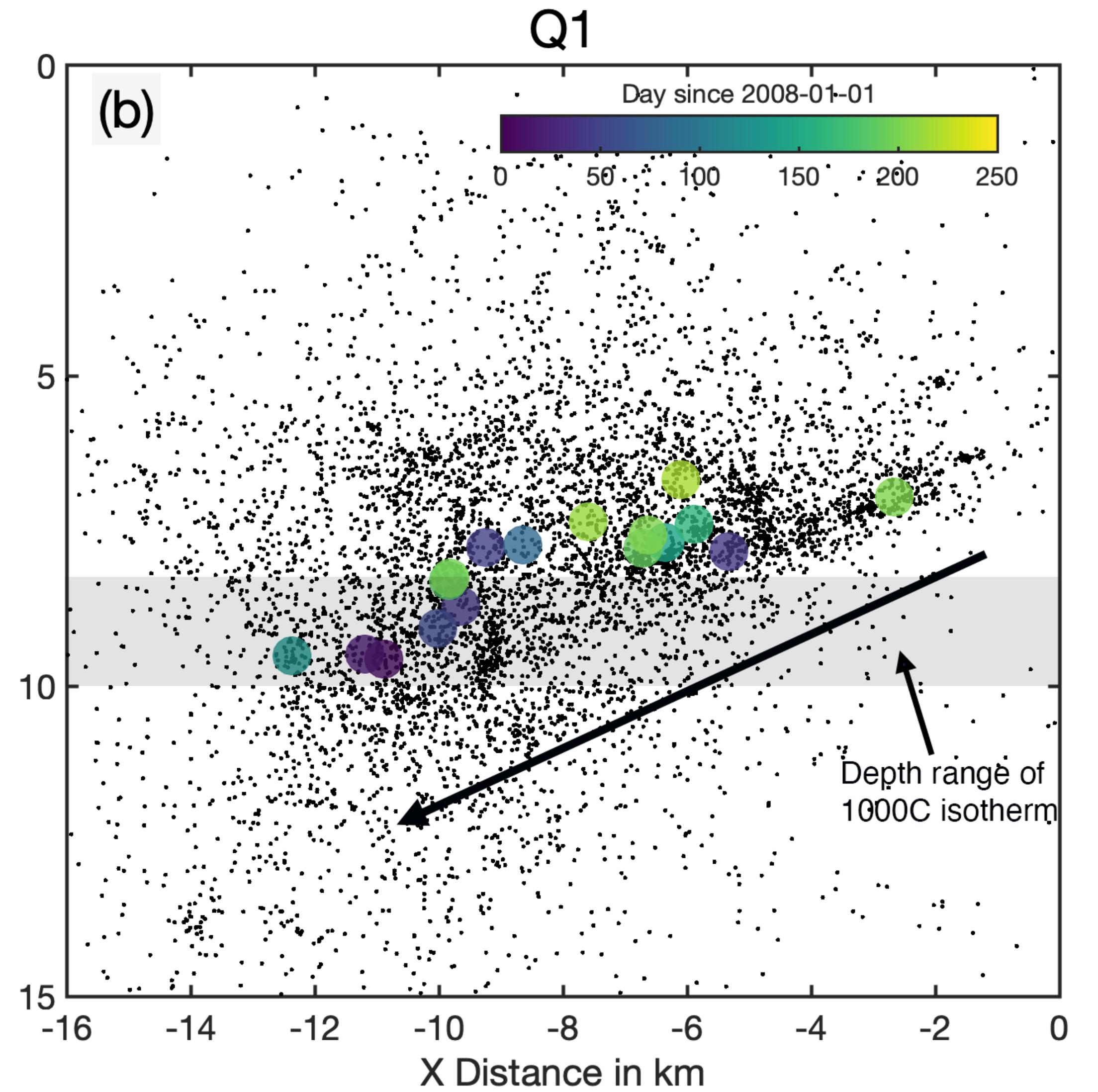
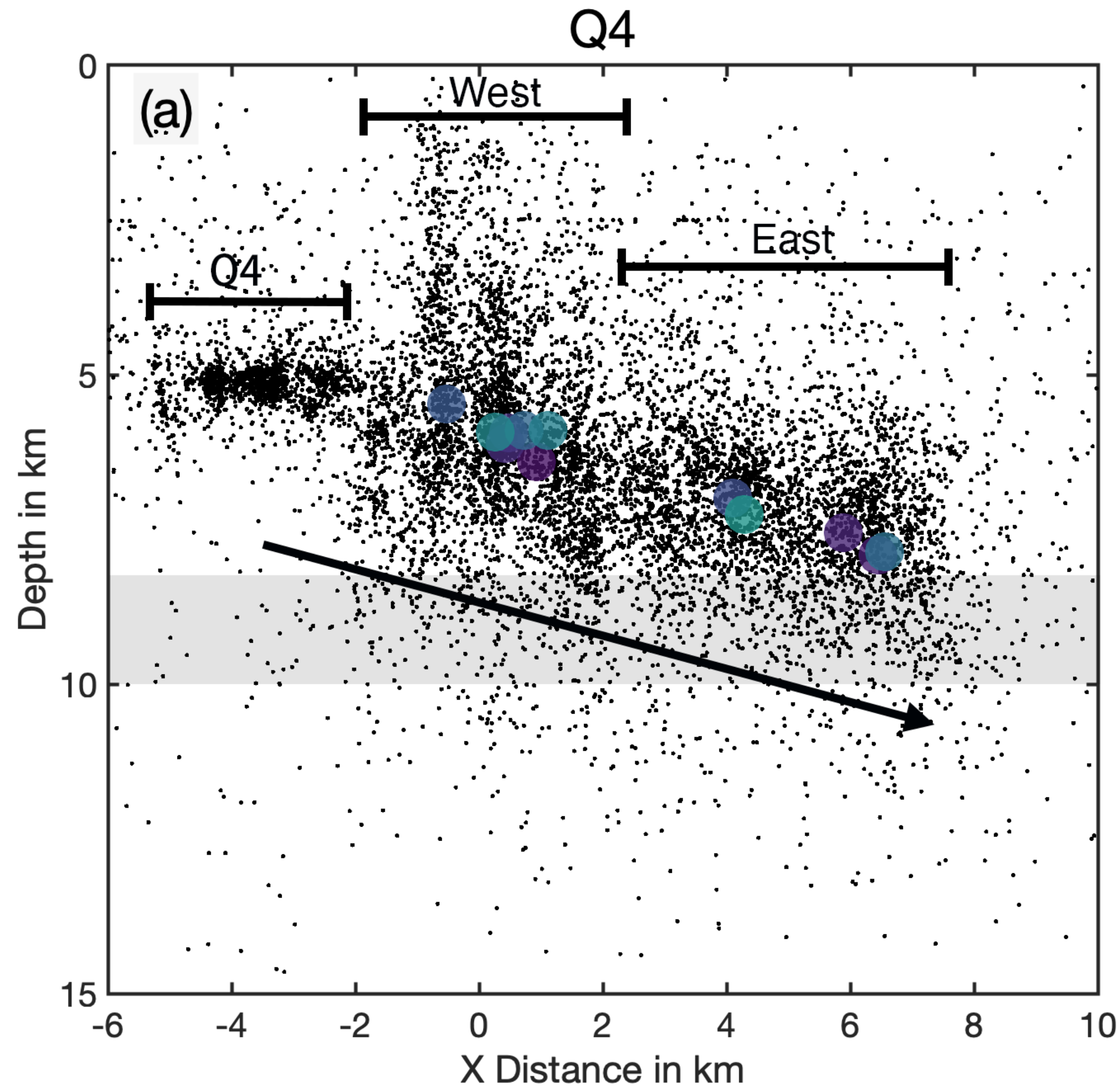
Relative motions between adjacent plates



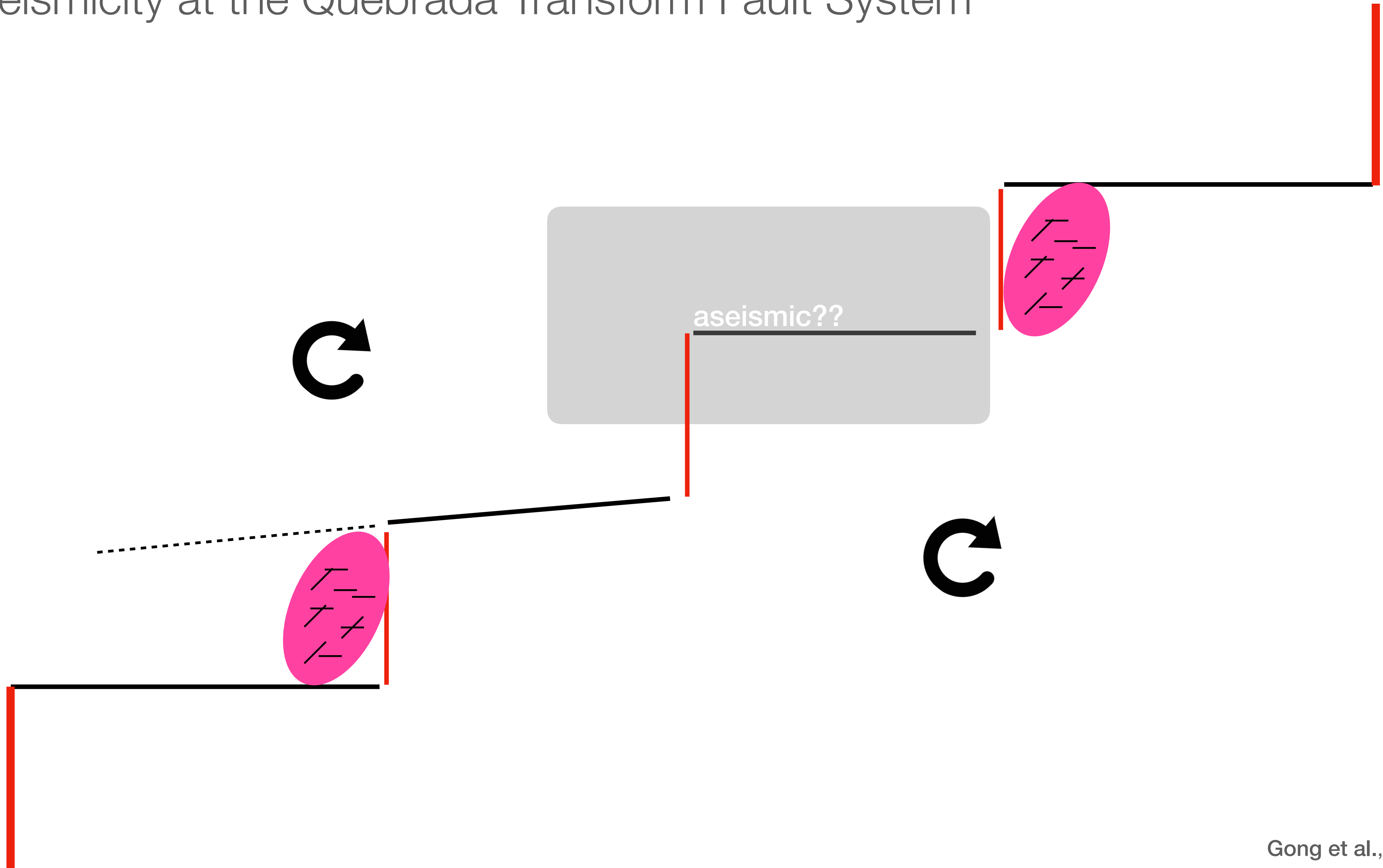
Diffuse Seismicity Clouds at the Inside Corners of Ridge-Transform Intersections



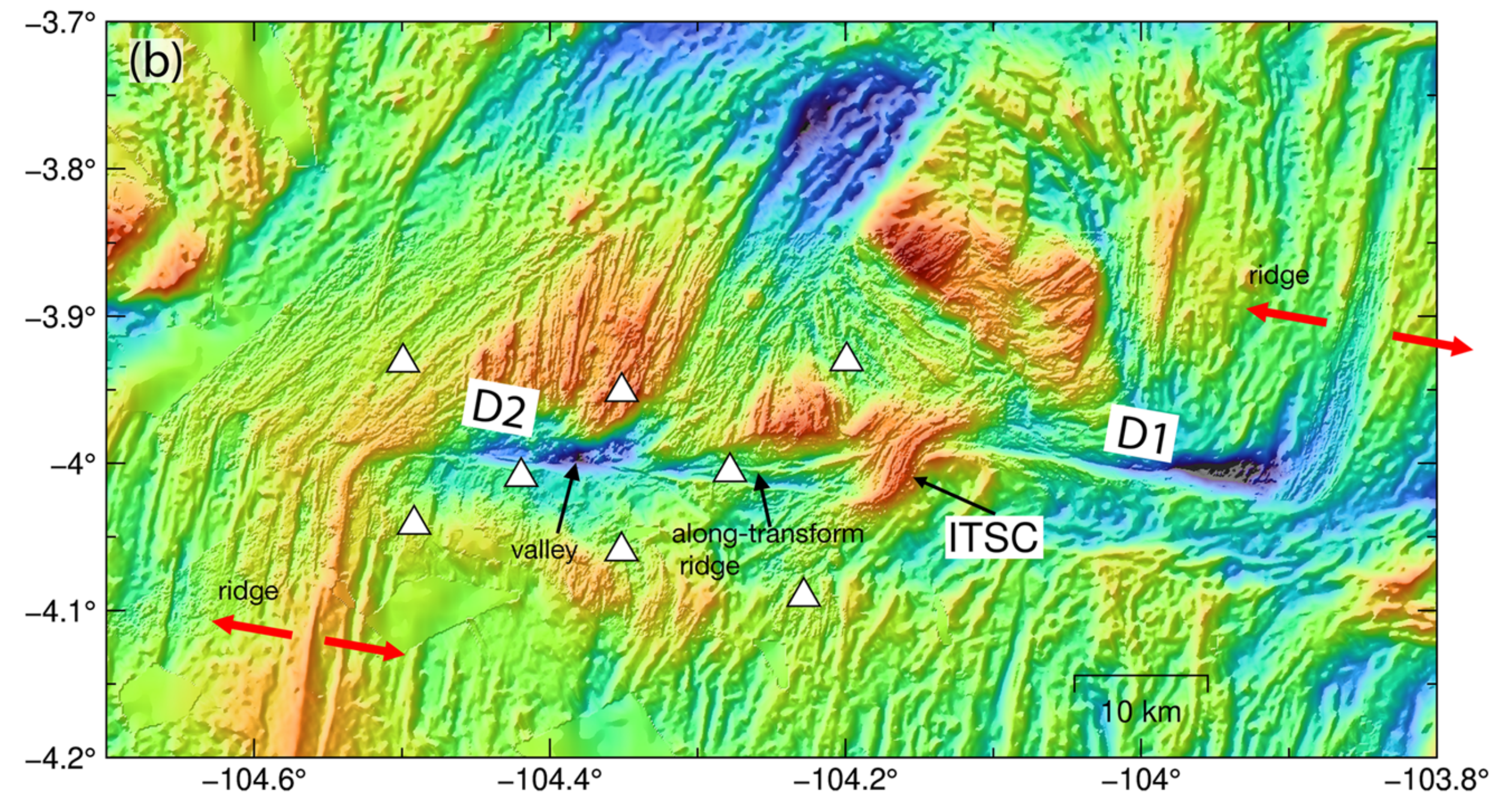
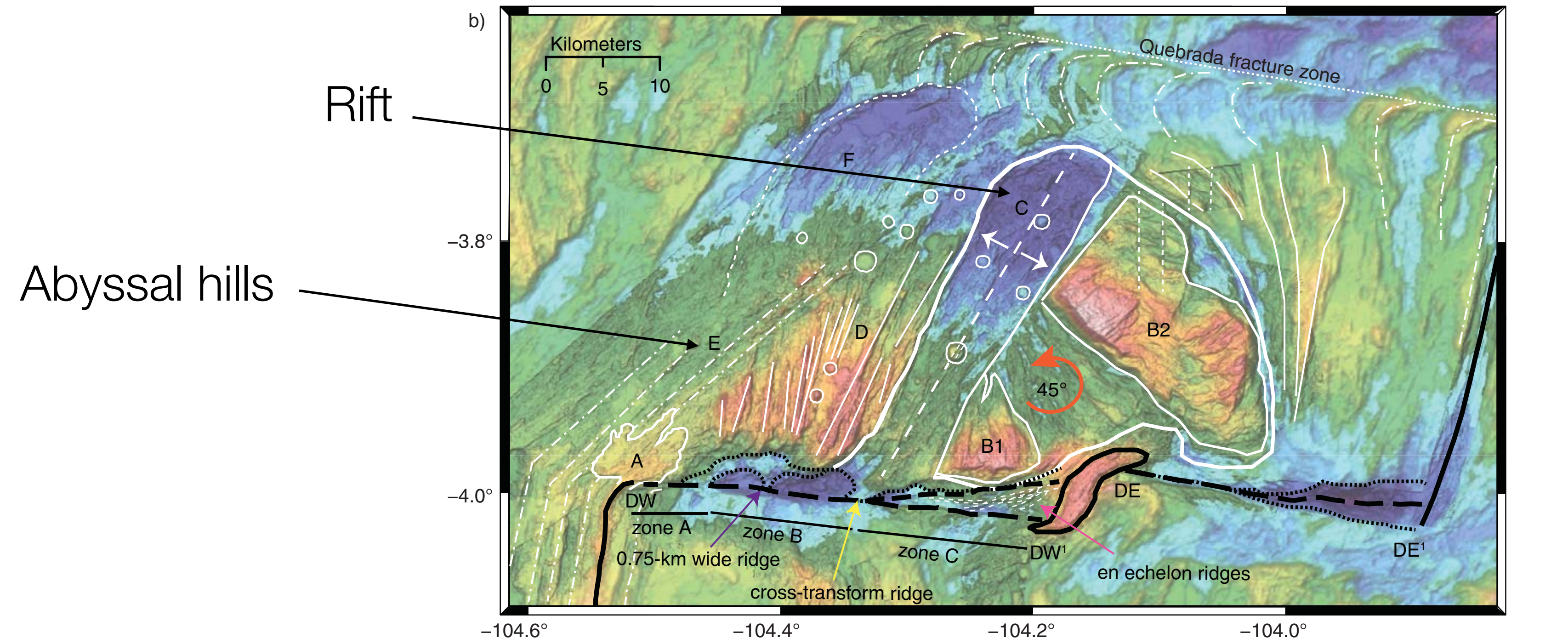
Seismicity Clouds Dip Towards the Intra-Transform Spreading Center



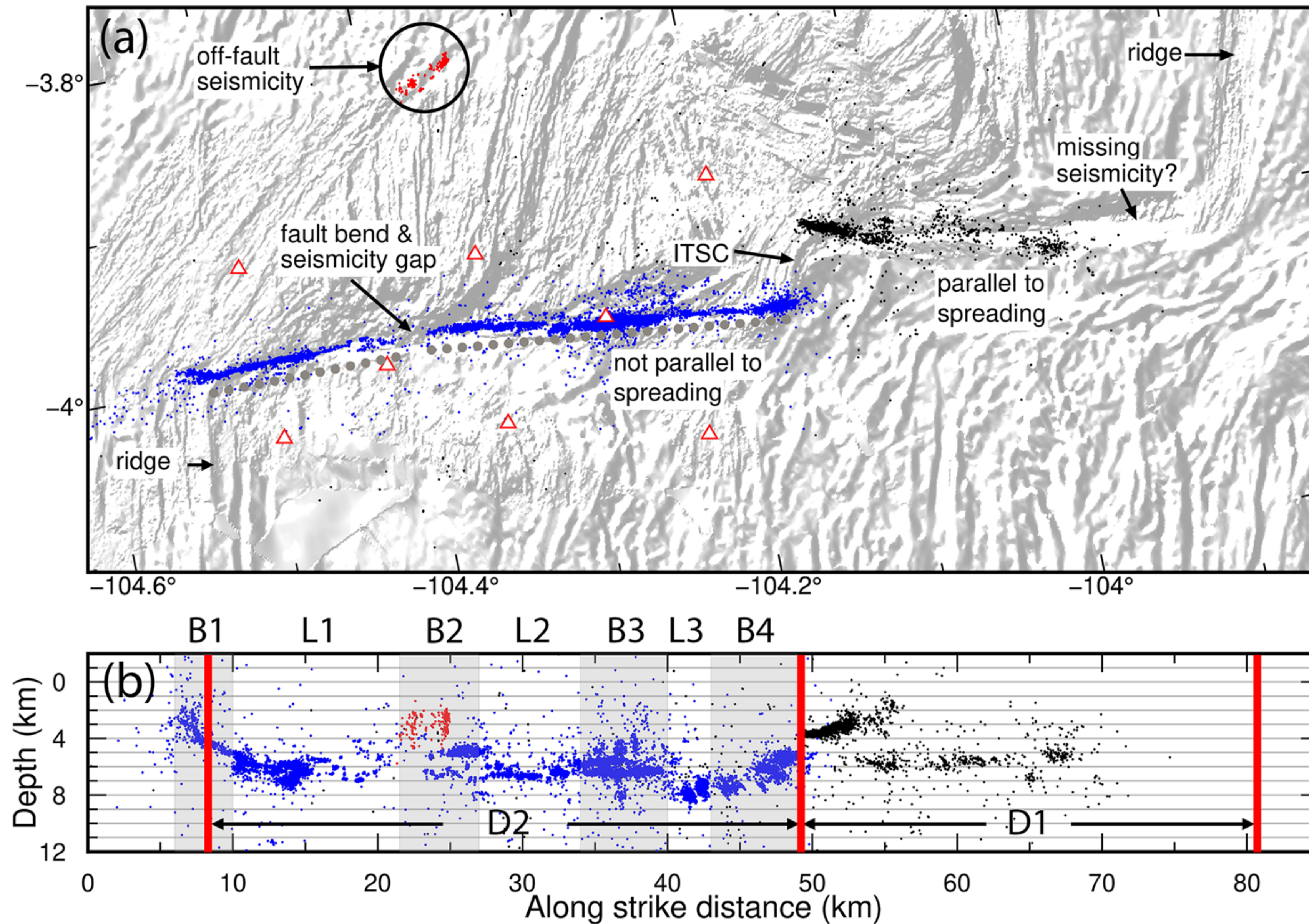
Atypical Small-Scale Plate Rotation and Seawater Infiltration Control Seismicity at the Quebrada Transform Fault System



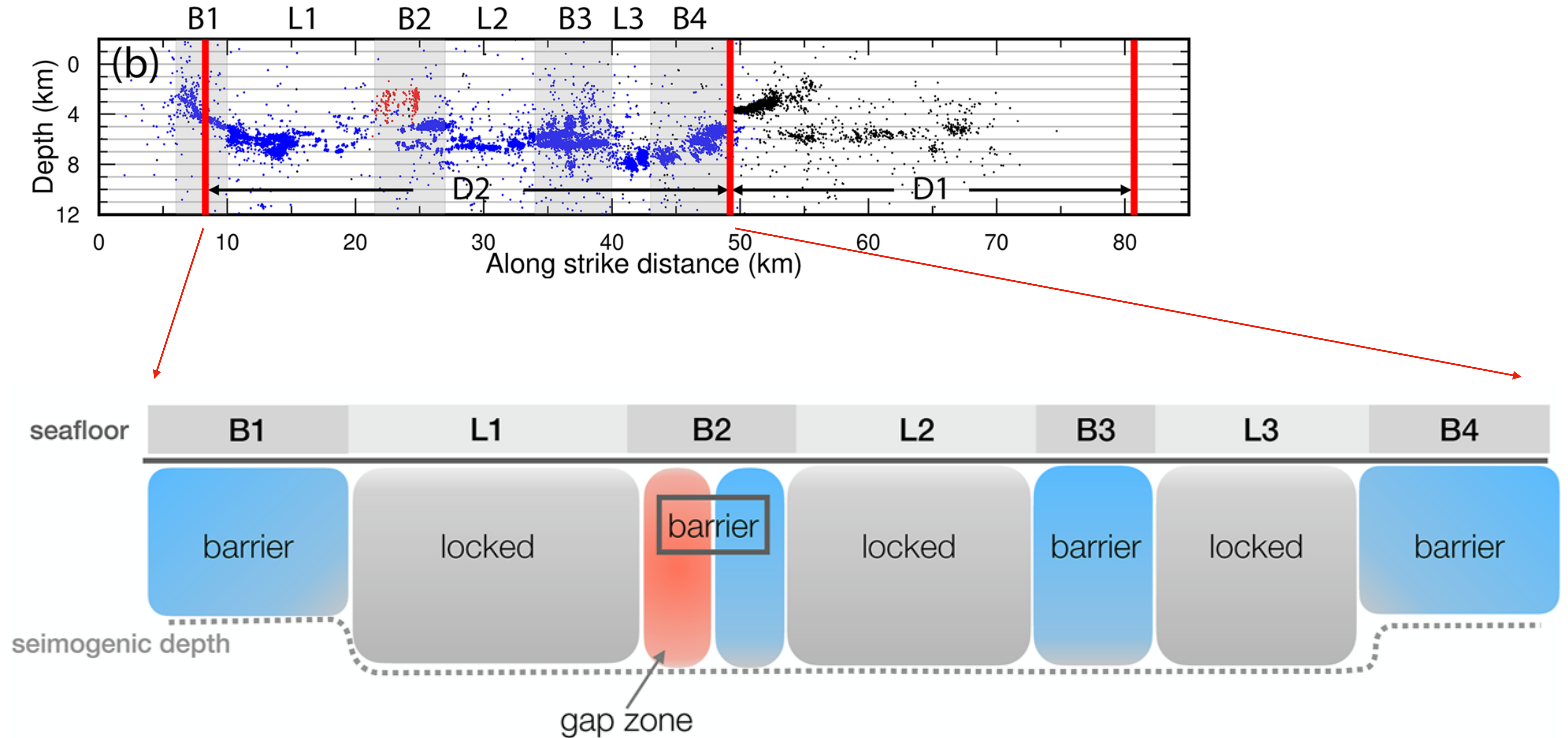
Discovery: What a Mess?



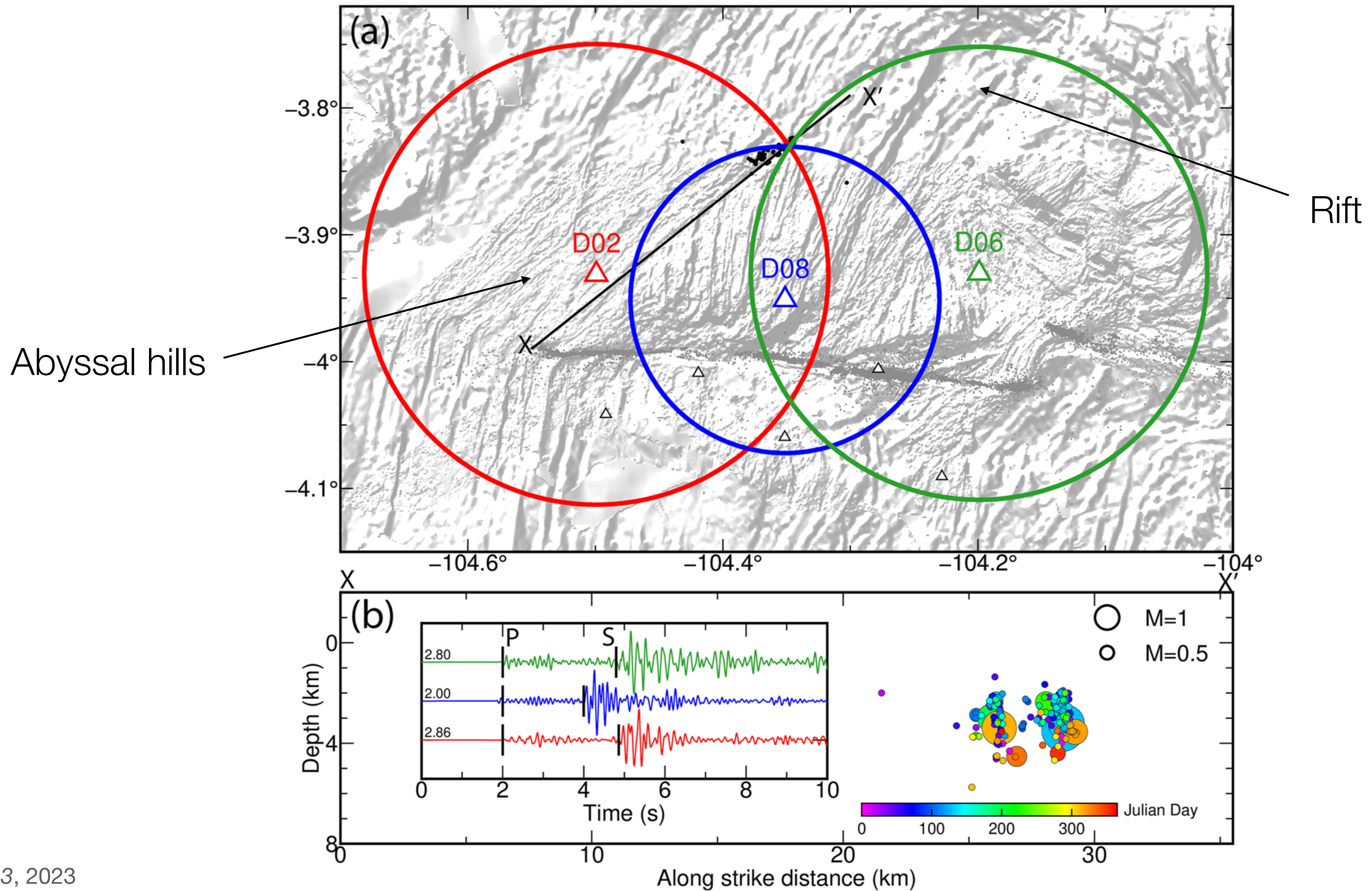
Western Discovery Fault: Segmented and Not Parallel to Spreading



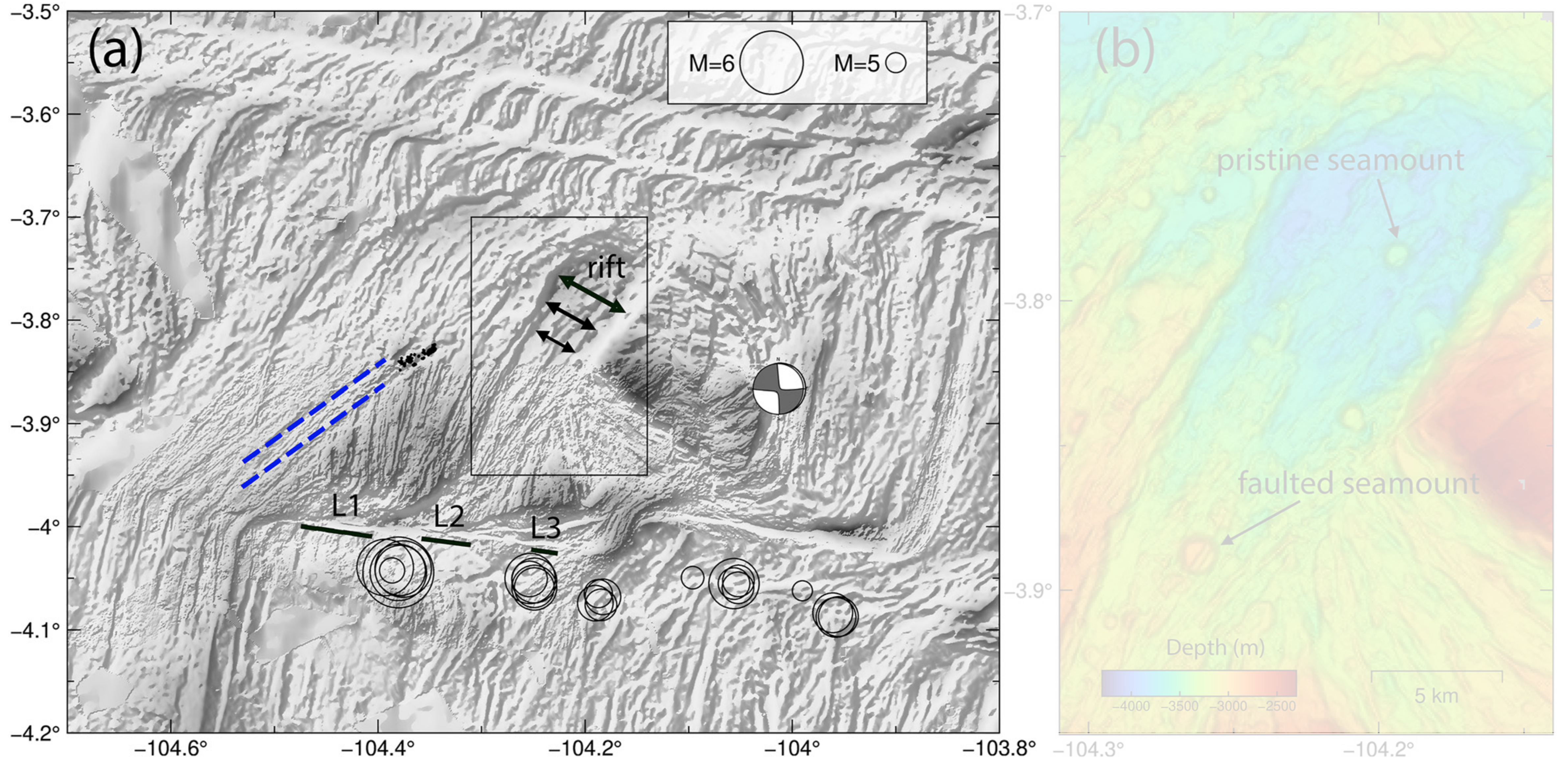
Western Discovery Fault: Alternating Locked and Aseismic Zones?



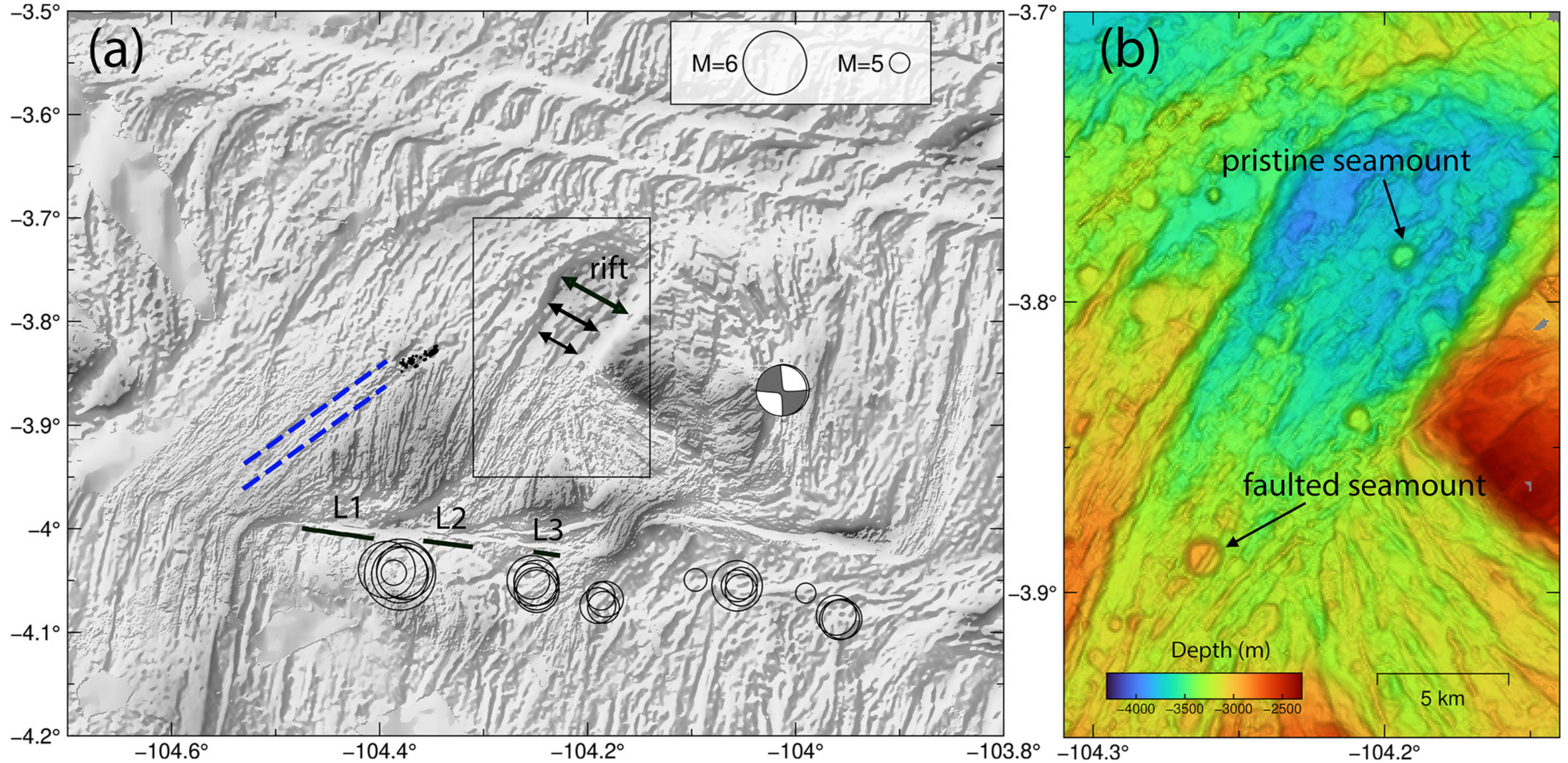
Off-fault Seismicity: Deformation within the Plate?



Rifting influences on-fault and off-fault seismic behaviors

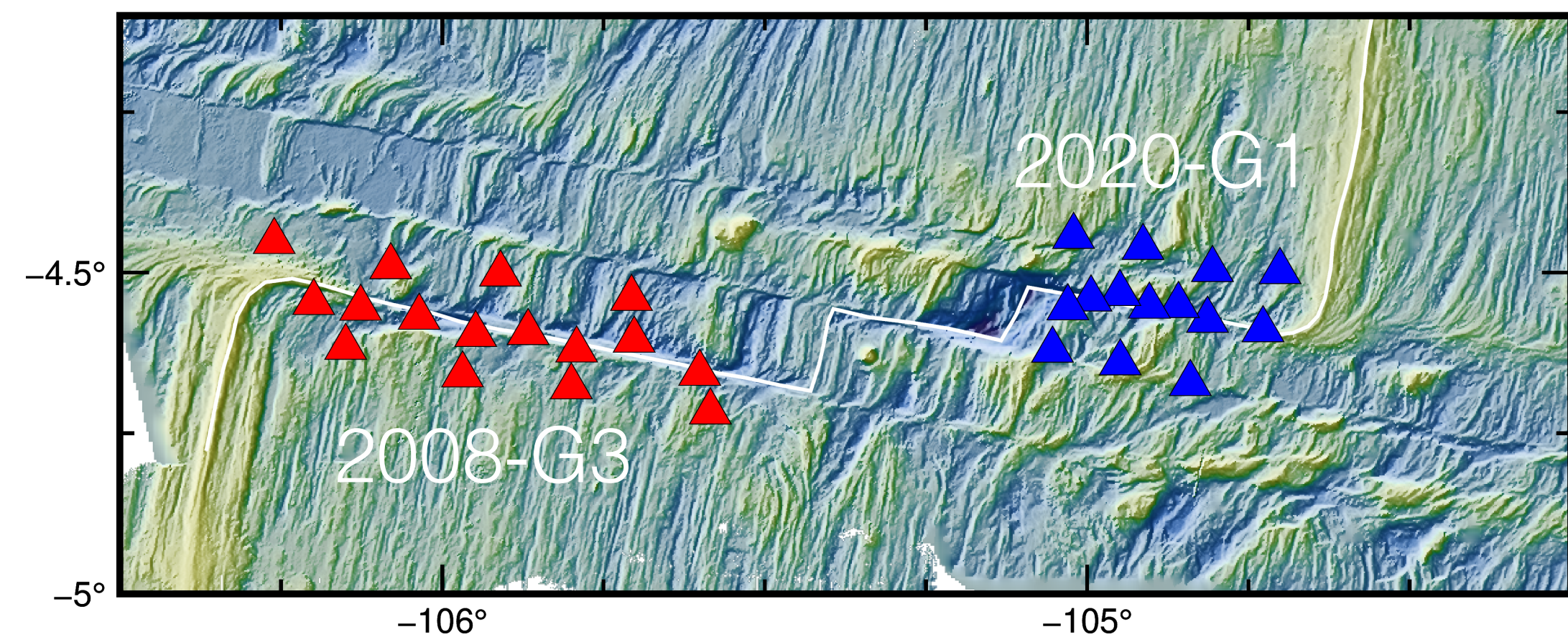
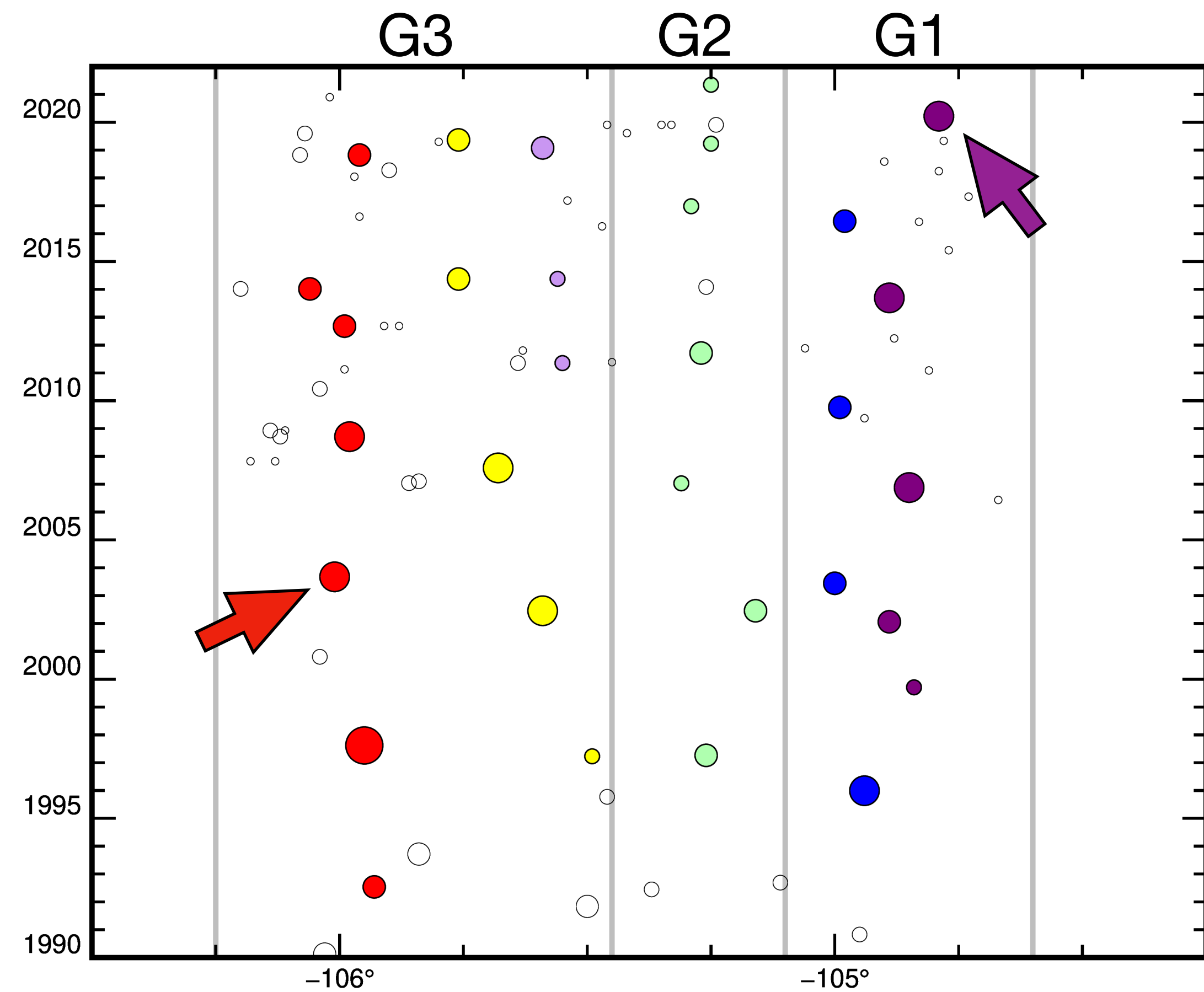


Rifting influences on-fault and off-fault seismic behaviors

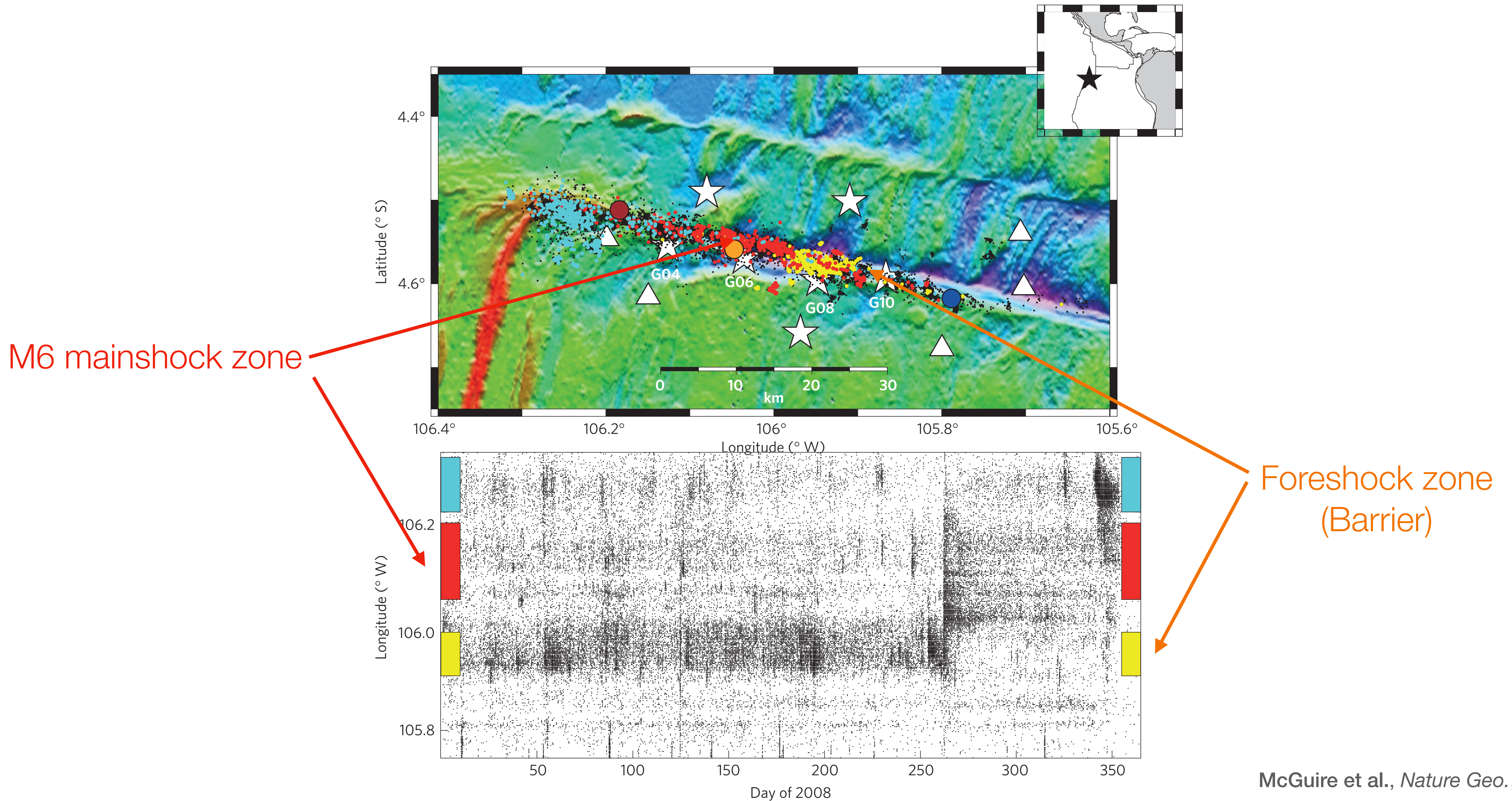


The 2008 Quebrada-Discovery-Gofar and 2019-2022 Gofar Marine Geophysics Experiments

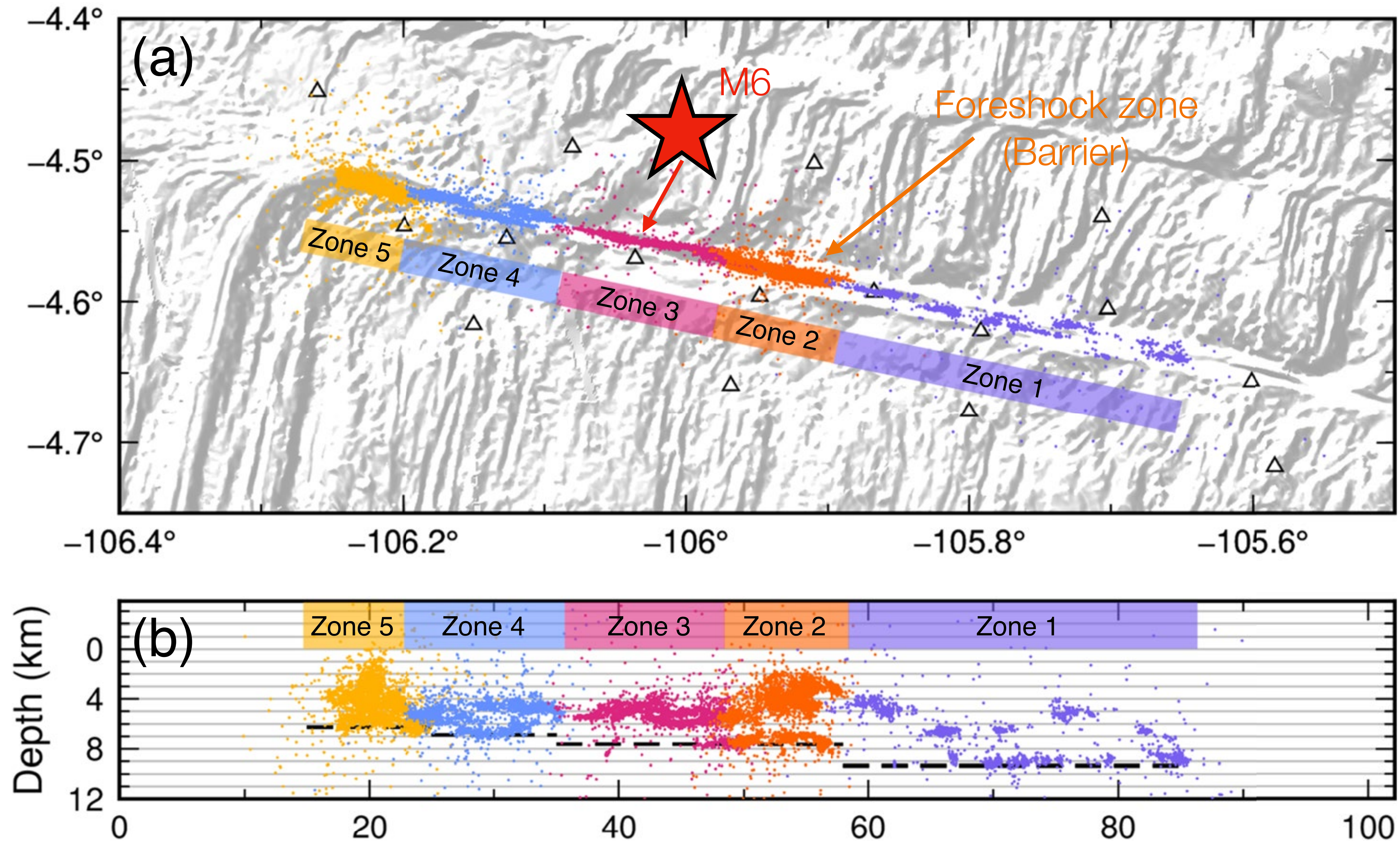
Both experiments successfully captured two anticipated M6 earthquakes



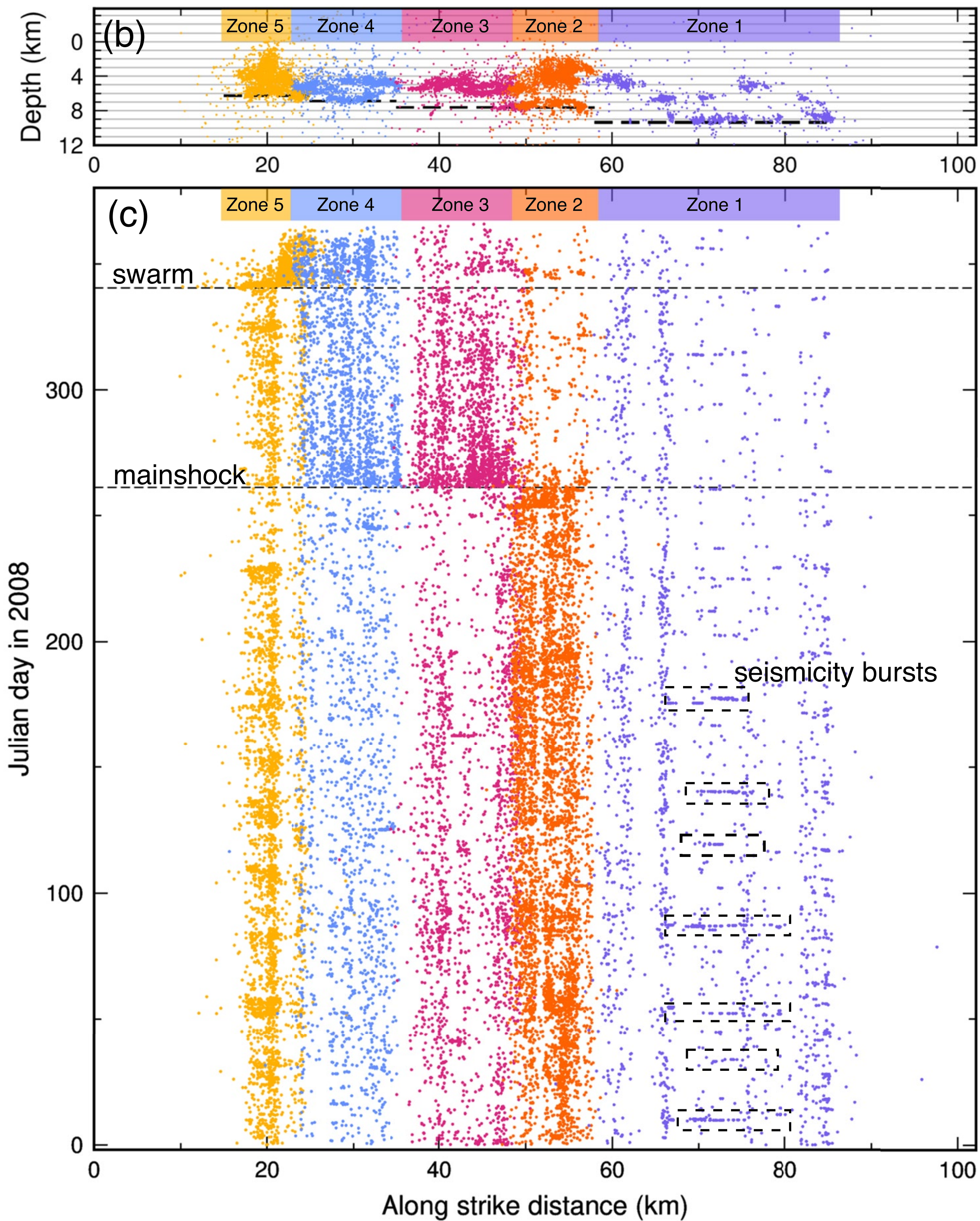
Capturing 2008 M6 earthquake at the westernmost Gofar transform fault (G3)



Westernmost Gofar Fault (G3): Alternating Locked and Aseismic Zones



Earthquake Preparation Process at G3



Nine-month long foreshocks in the barrier zone

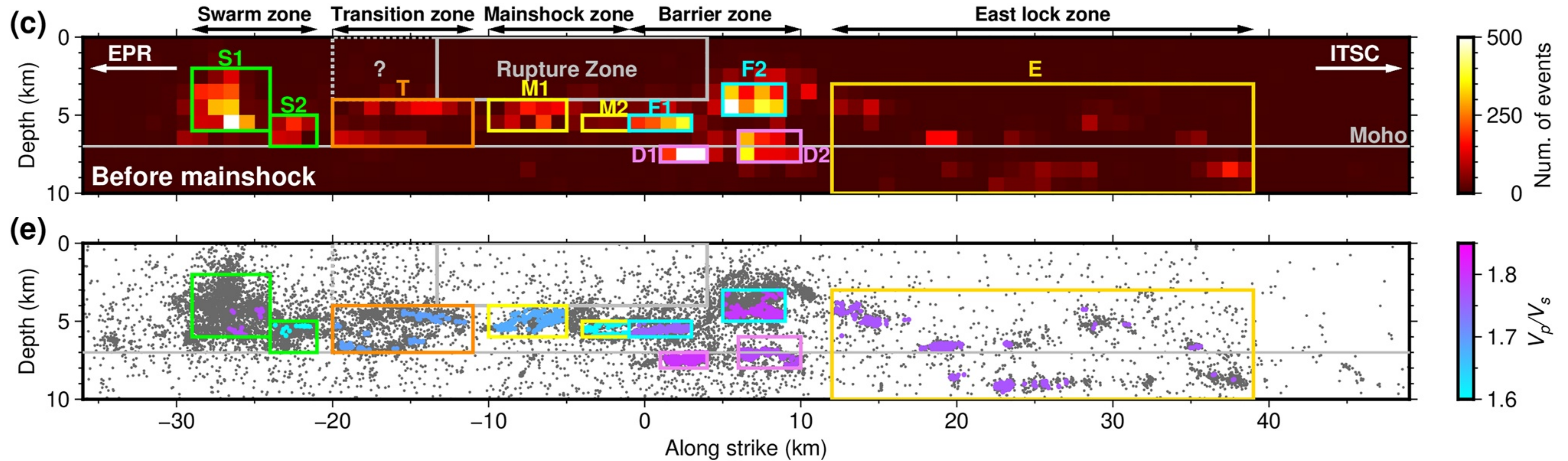


2008 M6 G3 mainshock



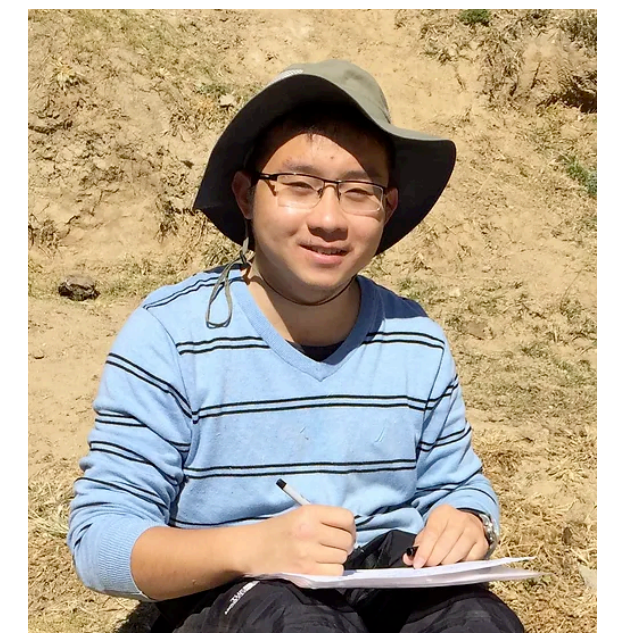
Halt of seismicity in the barrier zone

Fault-Zone Material Variation Controls Different Slip Behaviors



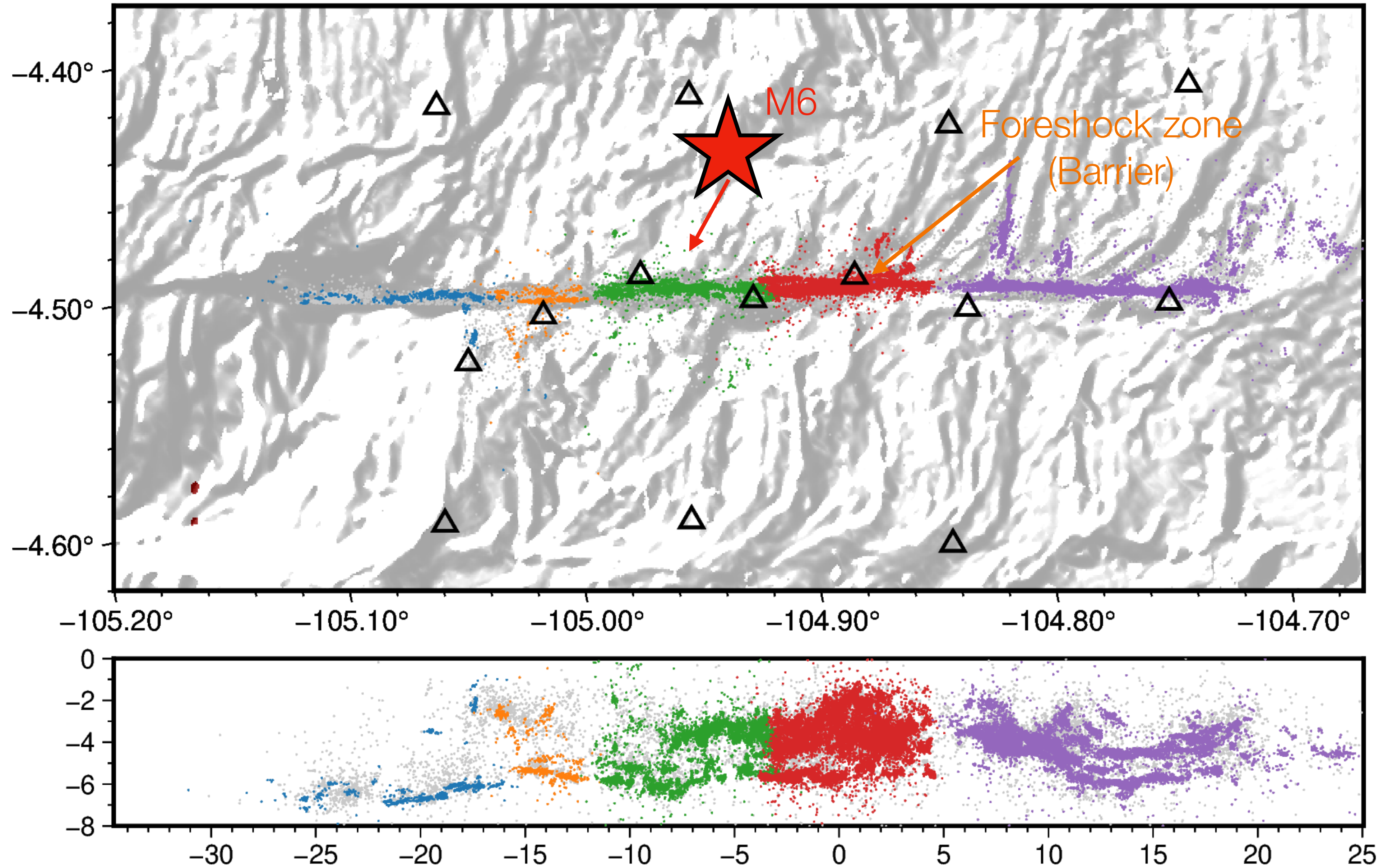
Low High

In-situ V_p/V_s shows contrasting fault zone material properties, likely caused by fluids



Dr. Tianze Liu
WHOI

Capturing 2020 M6 earthquake at the easternmost Gofar transform fault (G1)



Earthquake Preparation Process at G1

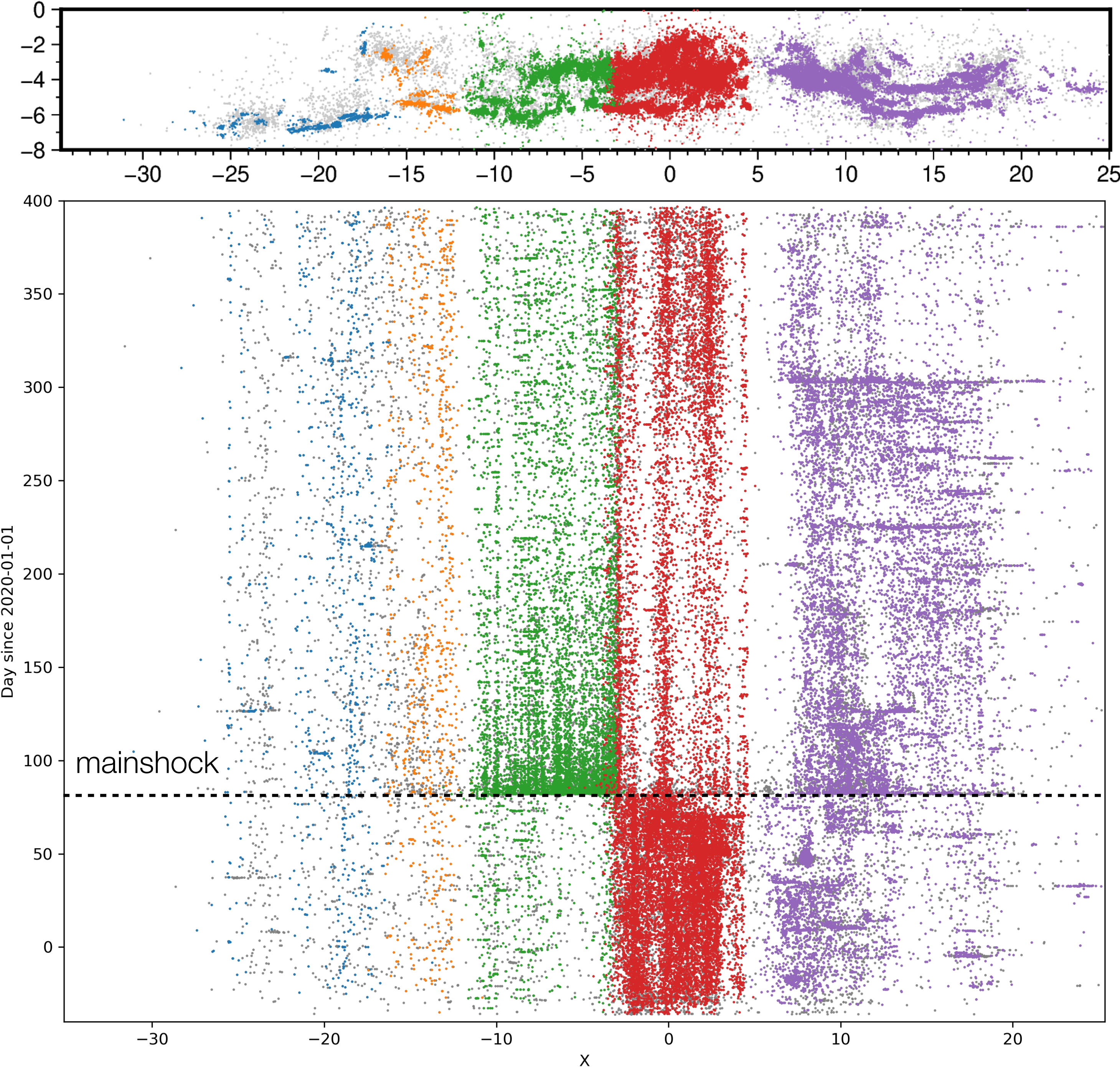
Three-month long foreshocks in the barrier zone



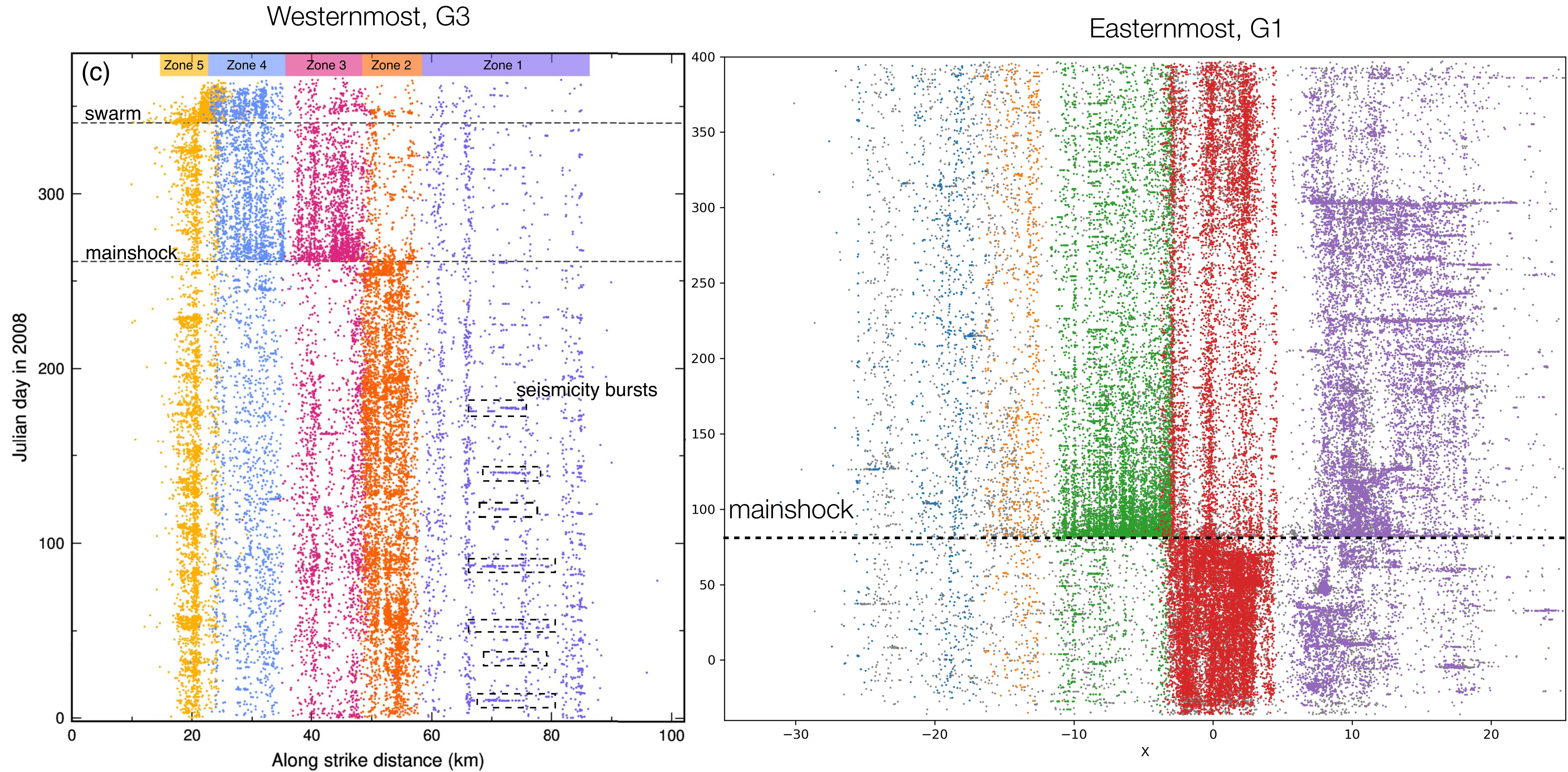
2020 M6 G1 mainshock



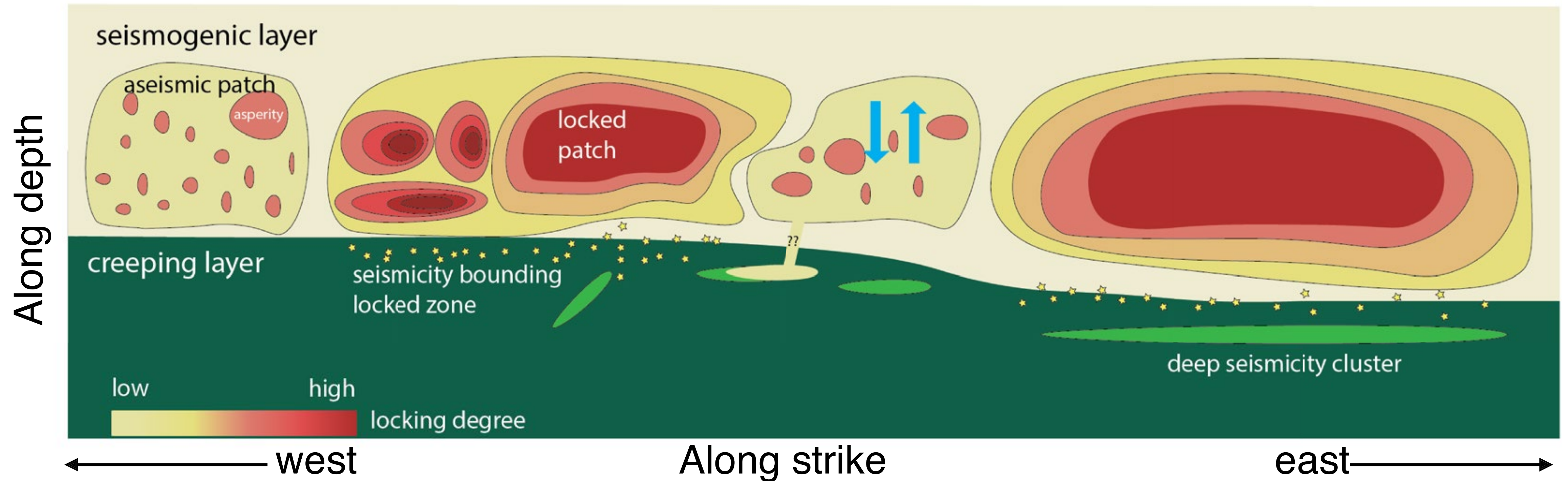
Halt of seismicity in the barrier zone



Consistent Spatiotemporal Patterns: A Repeatable Physical Process Nucleates Earthquakes



- What causes such highly similar fault architectures?
- What controls this repeatable physical process?



Conclusions



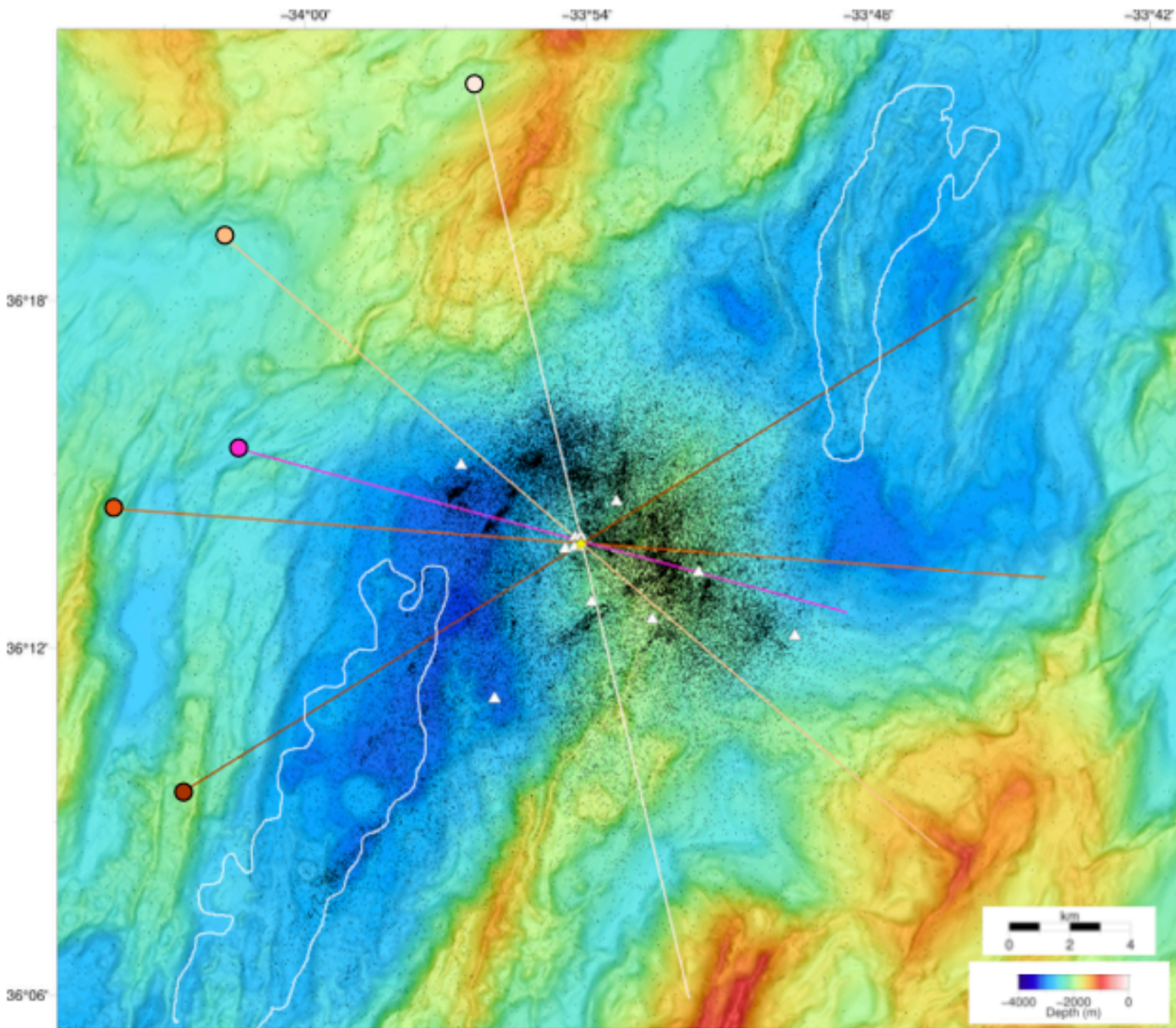
OCE-1833279
EAR-2143413

- Atypical small-Scale plate rotation and seawater infiltration control seismicity at the Quebrada transform fault system
- Intra-plate rifting influences fault segmentation and off-fault abyssal hill reactivation at the Discovery transform fault system
- We captured not one but two anticipated M6 earthquakes at the Gofar transform fault system
- Barrier zones are a common feature of the Gofar transform faults
- Clear repeatable, precursory physical processes lead to the M6 earthquakes



Evan Anderson
Scripps Institution of Oceanography

V43B-0173: New insights into detachment faulting at the Rainbow massif, Mid-Atlantic Ridge, using microearthquakes detected by machine learning



Dr. Jianhua Gong
Indiana University Bloomington

S13E-0390: Ridge-transform fault interaction controls earthquake swarm activity at the Gofar transform fault

