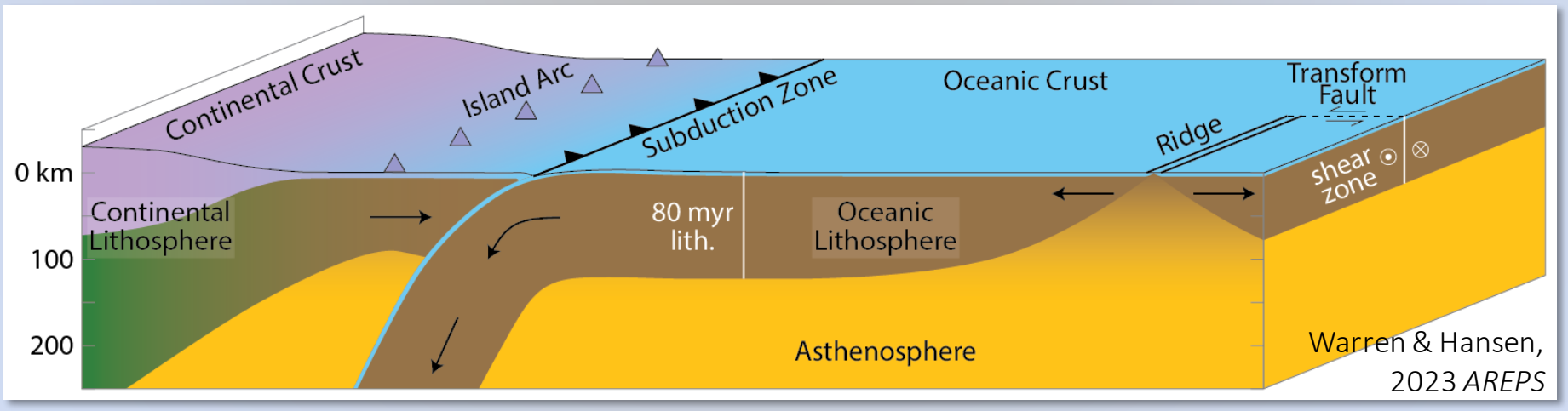
Research Priorities in Marine Geology and Geophysics:

What drives the recurrence of large earthquakes?

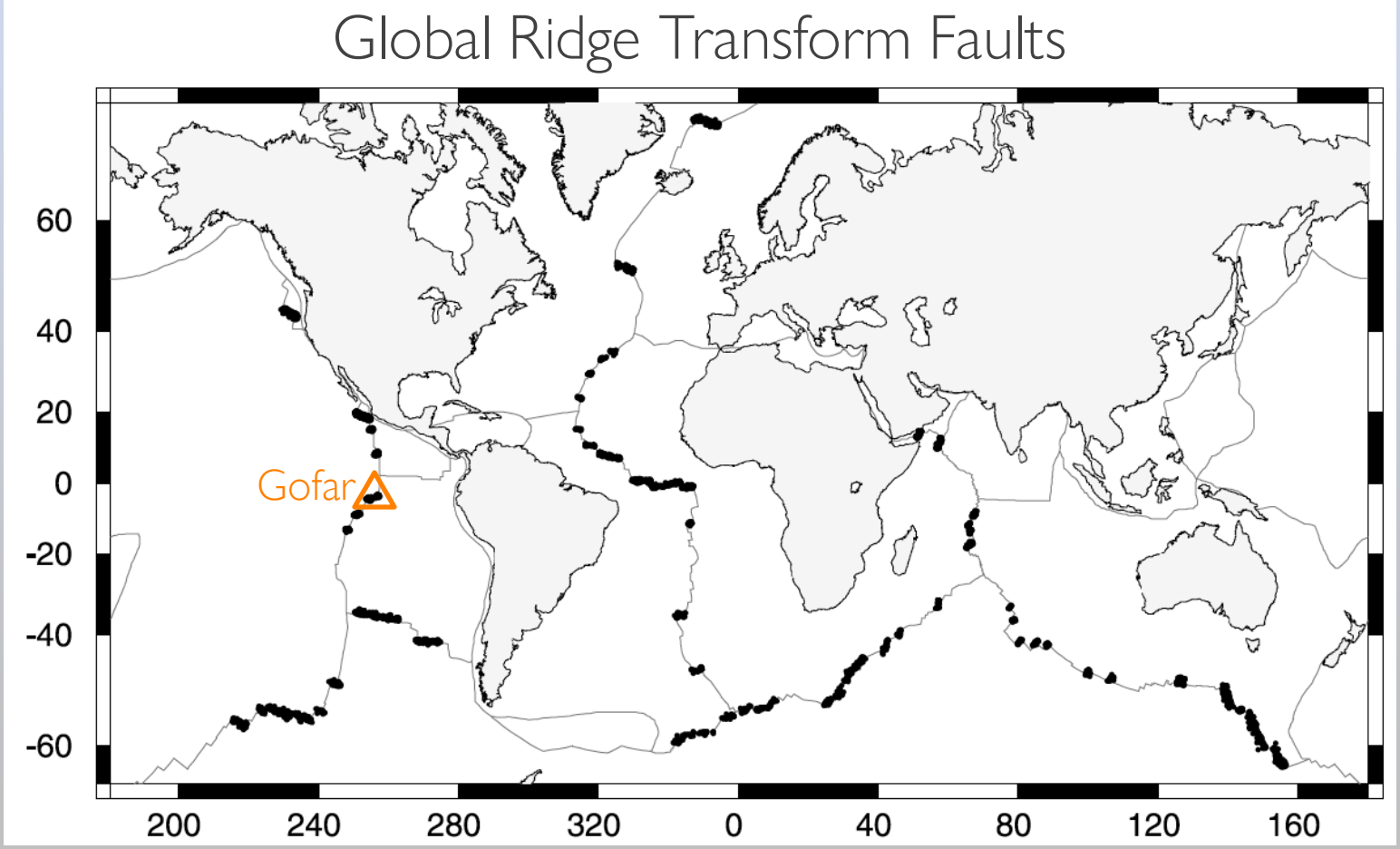
A multidisciplinary study of oceanic transform faults

Jessica M. Warren, University of Delaware



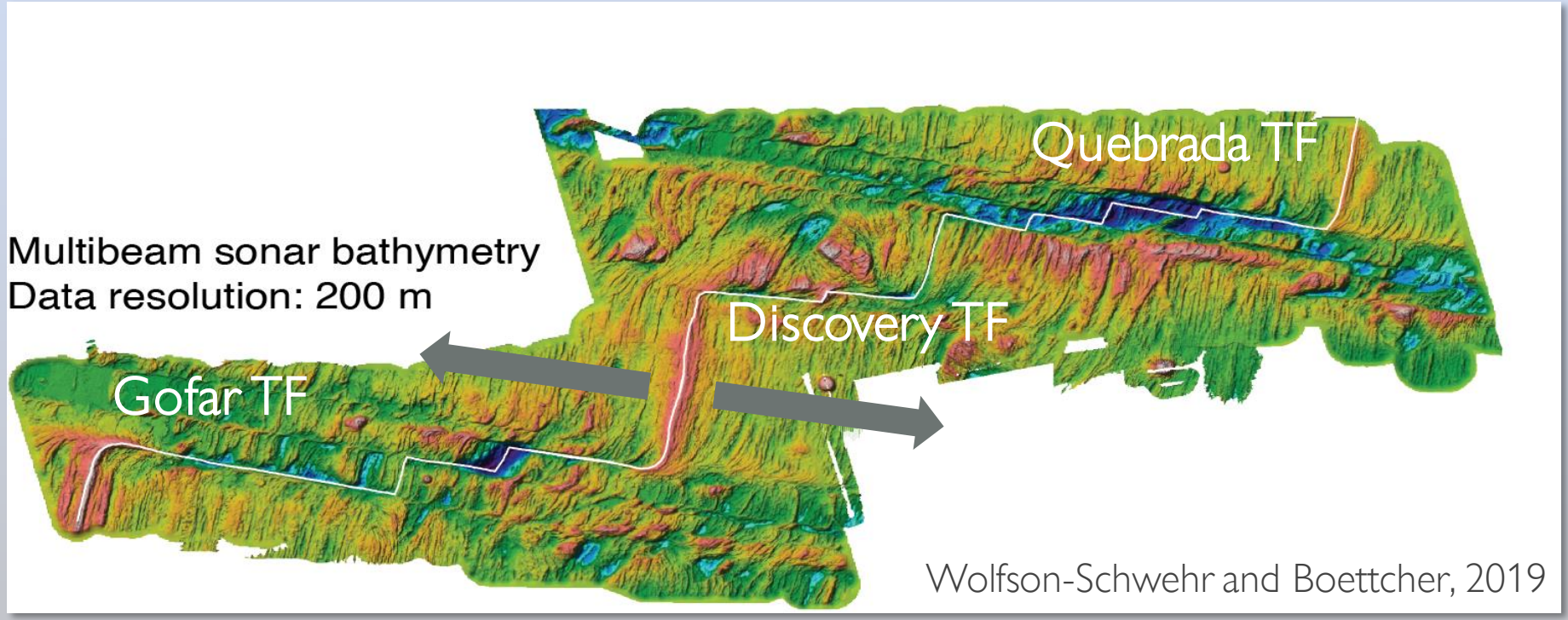
This presentation is based upon work supported by the U.S. National Science Foundation

The seafloor has >16,000 km of transform faults.



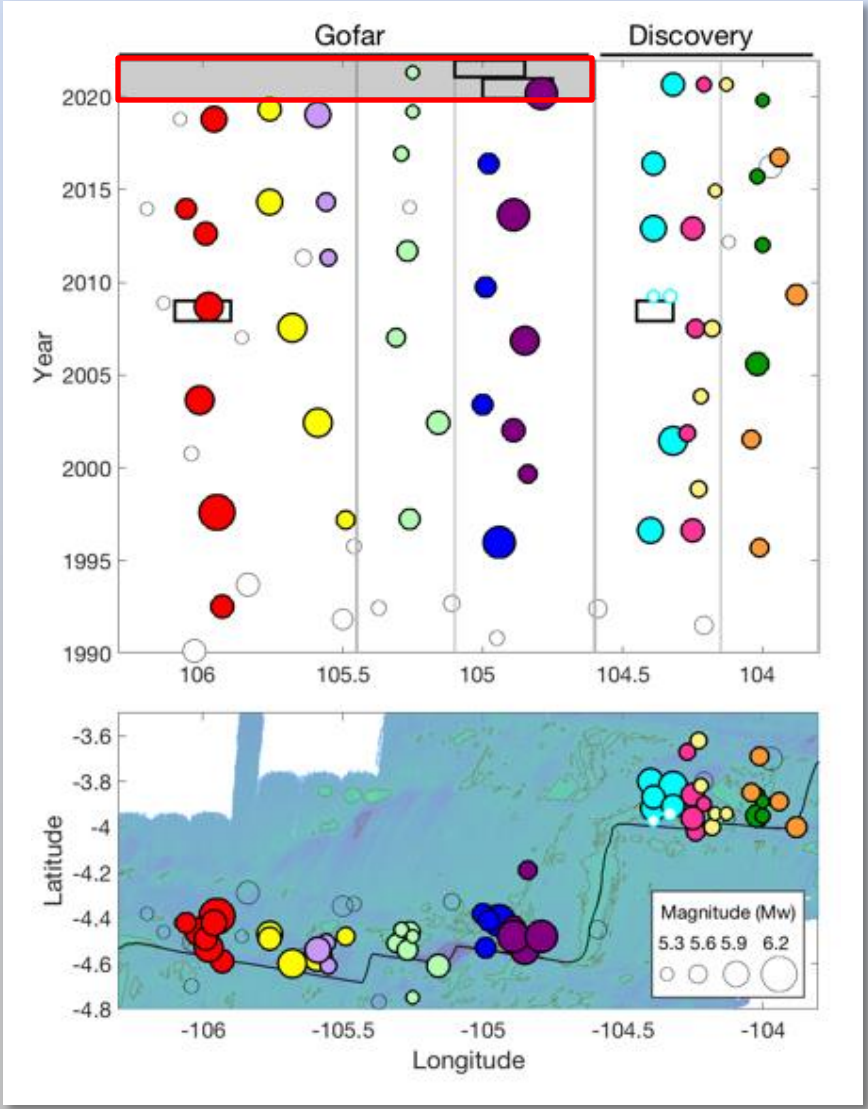
Boettcher & Jordan, JGR, 2004

Gofar-Discovery-Quebrada Transform Faults



- Slip rates of 12 cm per year → 4x faster than the San Andreas Fault!
- Gofar is the most studied oceanic transform fault for seismicity.

These faults allow us to explore the mechanisms leading to earthquakes

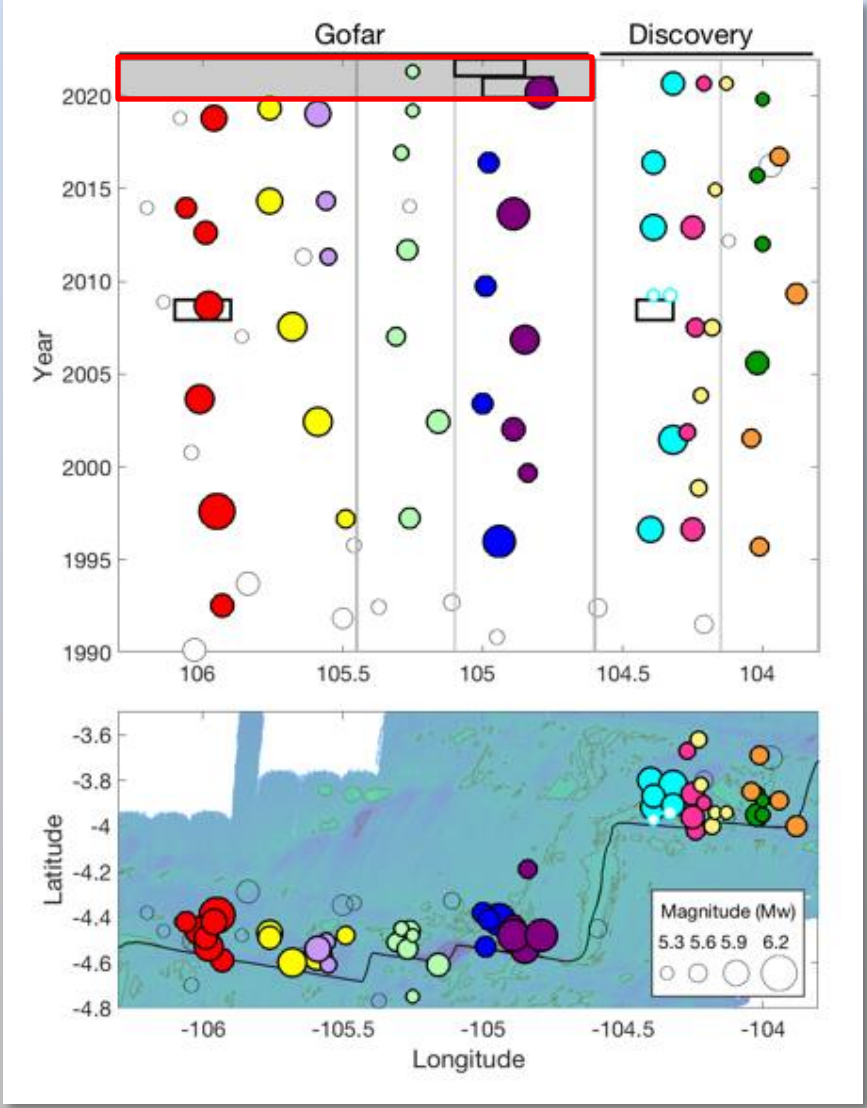


Boettcher et al., in prep.

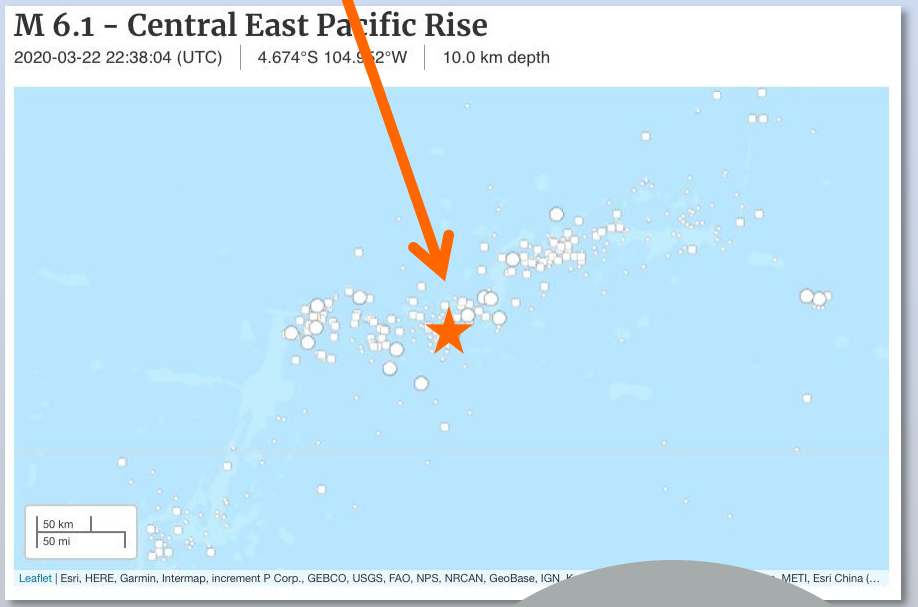
Key observations:

- Repeating earthquakes on seismically active sections.
- No earthquakes in barrier zones, which limit large ruptures.
- The repeating earthquakes are some of the most predictable earthquakes on Earth.

Seismometers deployed December 2019
M6.1 earthquake in March 2020



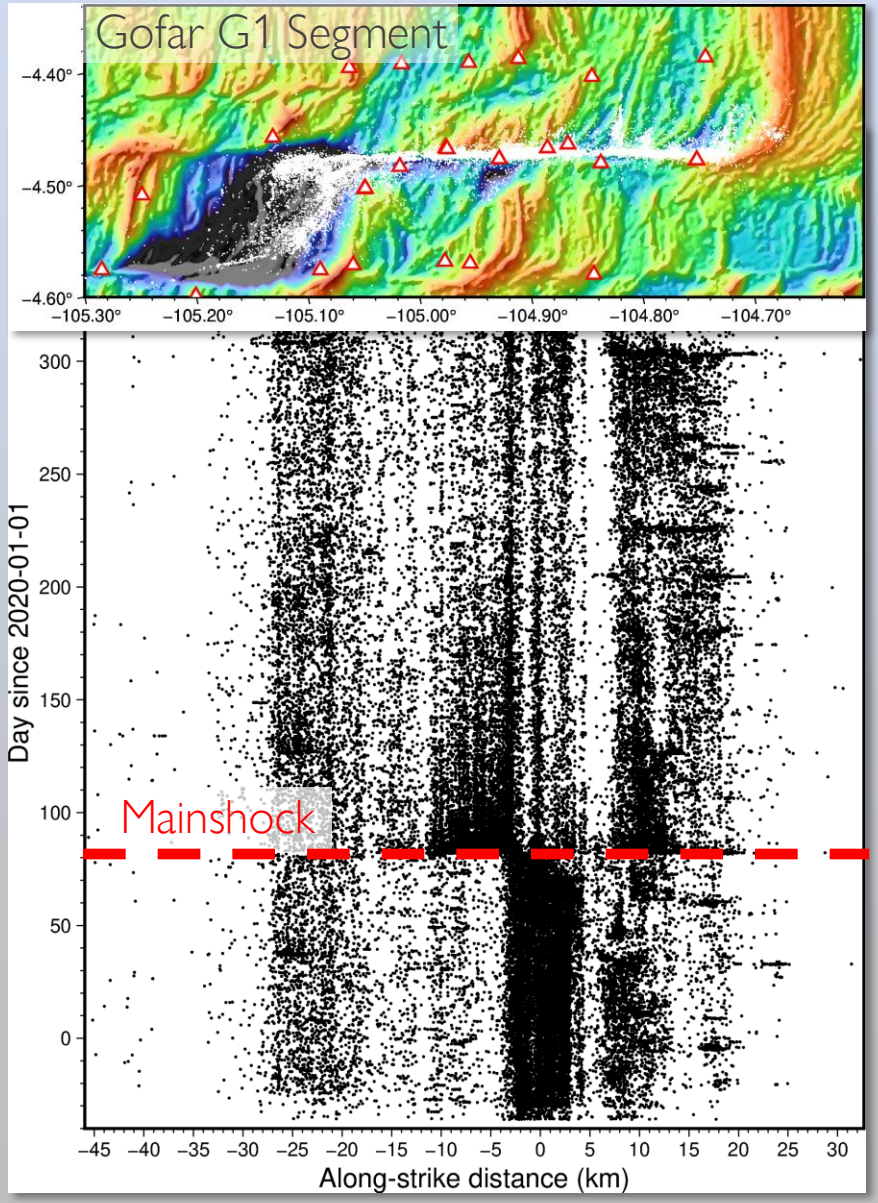
Boettcher et al., in prep.



Margaret Boettcher

Our proposed deployment... covers a significant portion of the expected PDF of each upcoming earthquake.

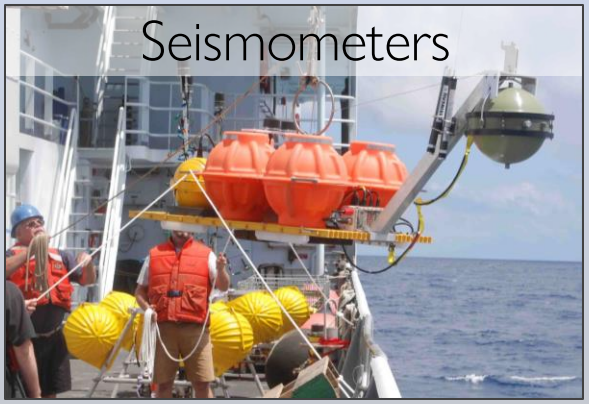
Microseismicity changes following a large earthquake

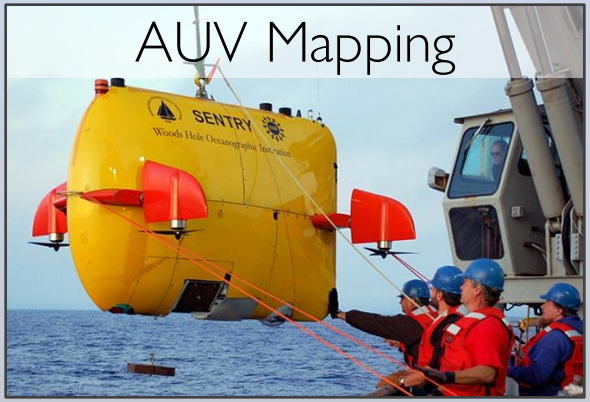


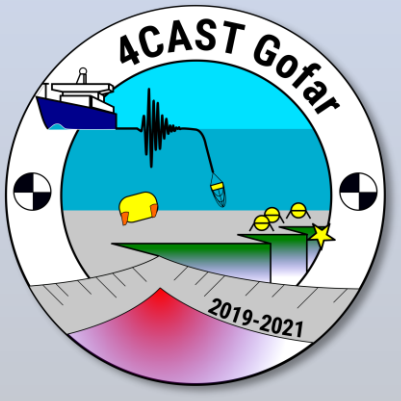
Gong et al., in prep.

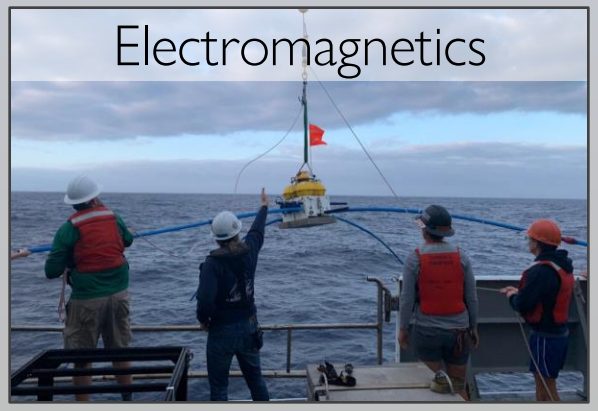
2019-2022 Gofar Transform Fault Experiment

- To identify the role of fluid flow for fault structure.
- To investigate why barrier zones limit large earthquakes.

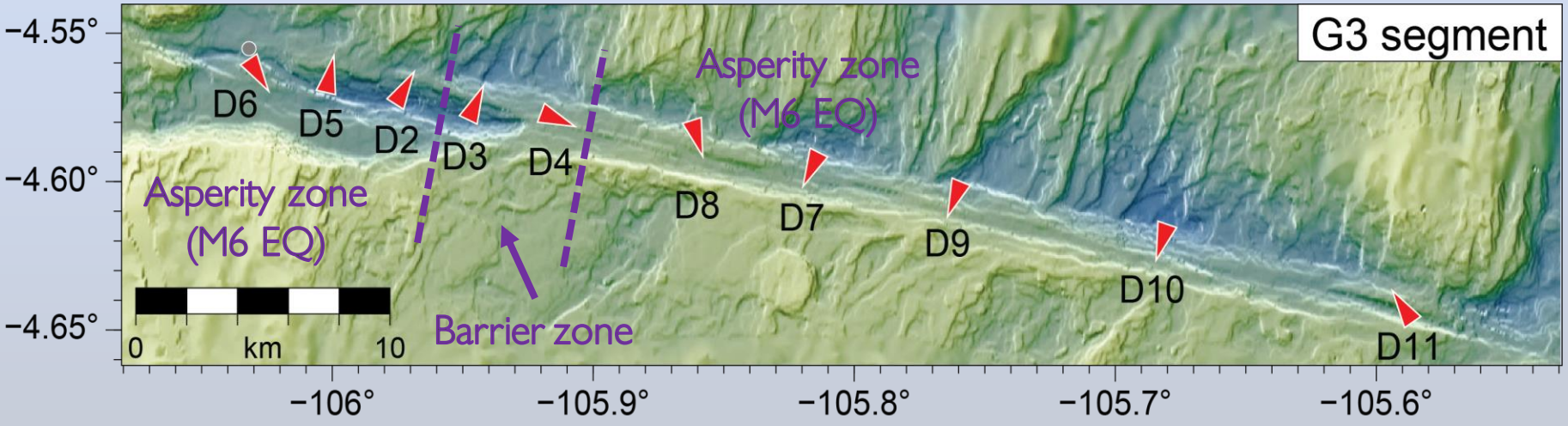


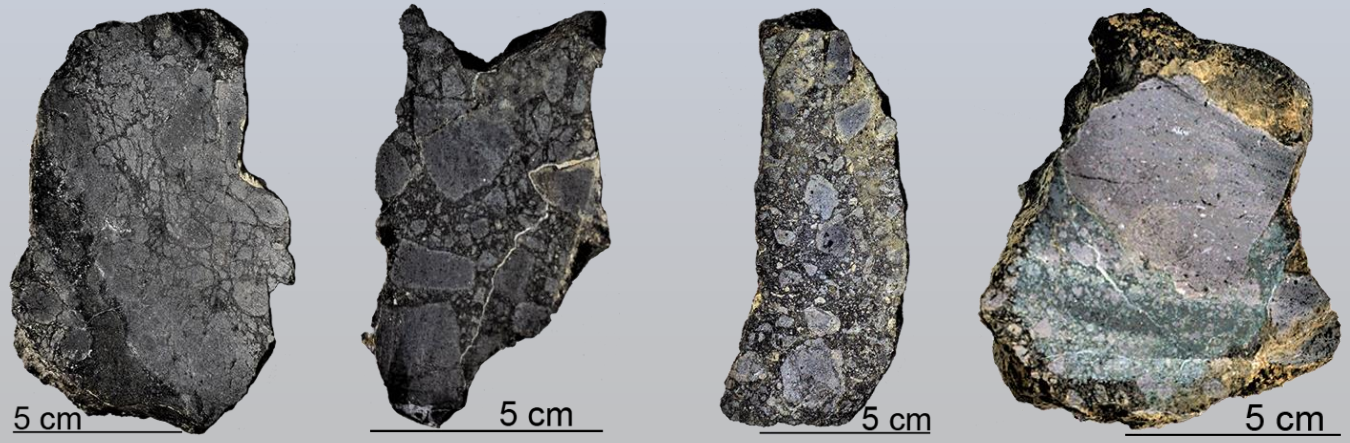






Dredging campaign to recover fault-zone samples

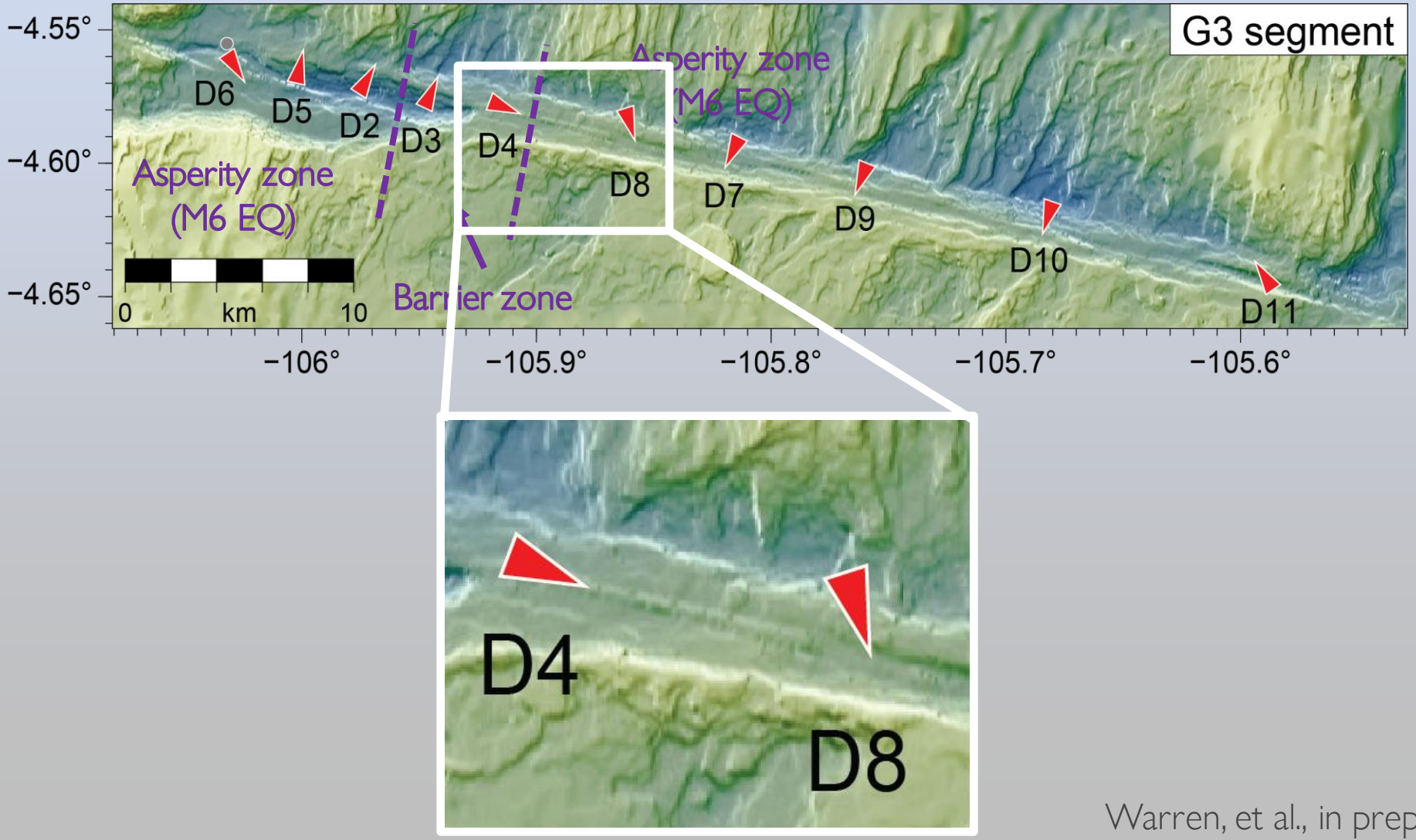




Low degree of brecciation → High degree of brecciation

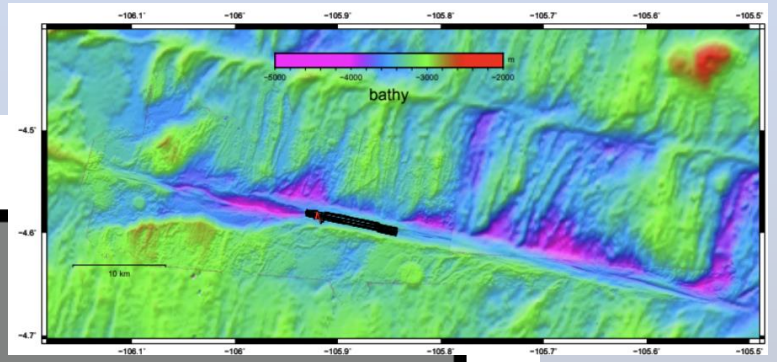
Warren et al., in prep

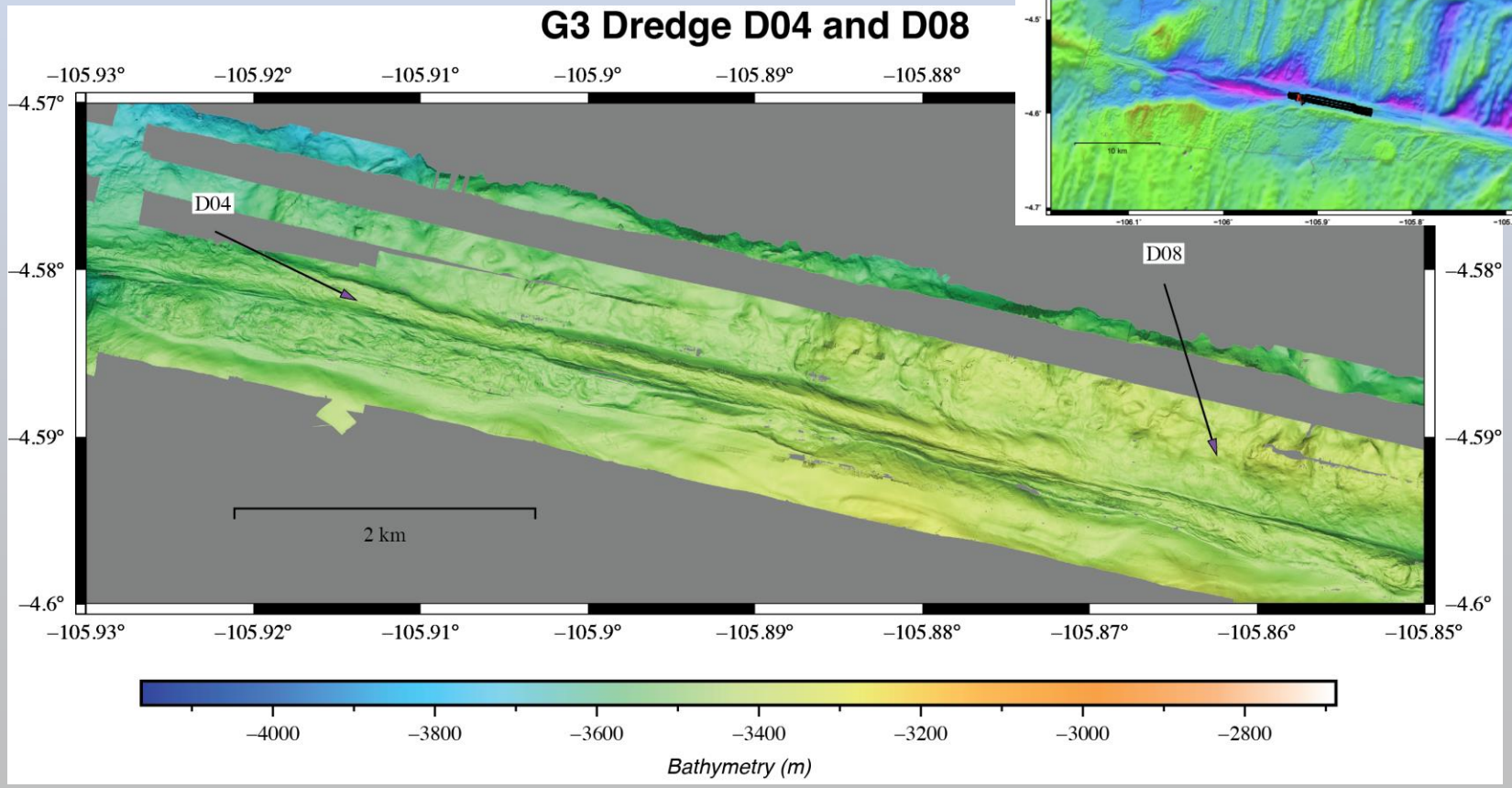
Shipboard bathymetry allows us to guess at the fault location



Warren, et al., in prep

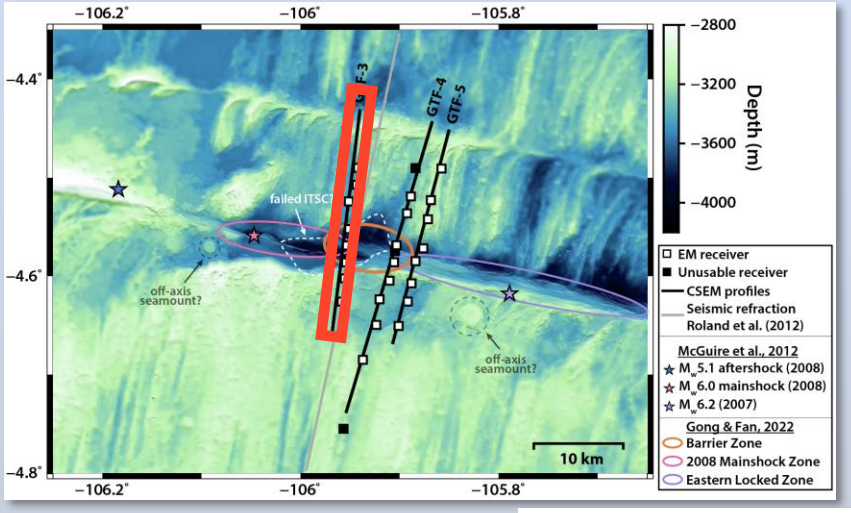
AUV Sentry high-resolution microbathymetry provides detailed view of fault structure





Koenig, Roland, et al., in prep

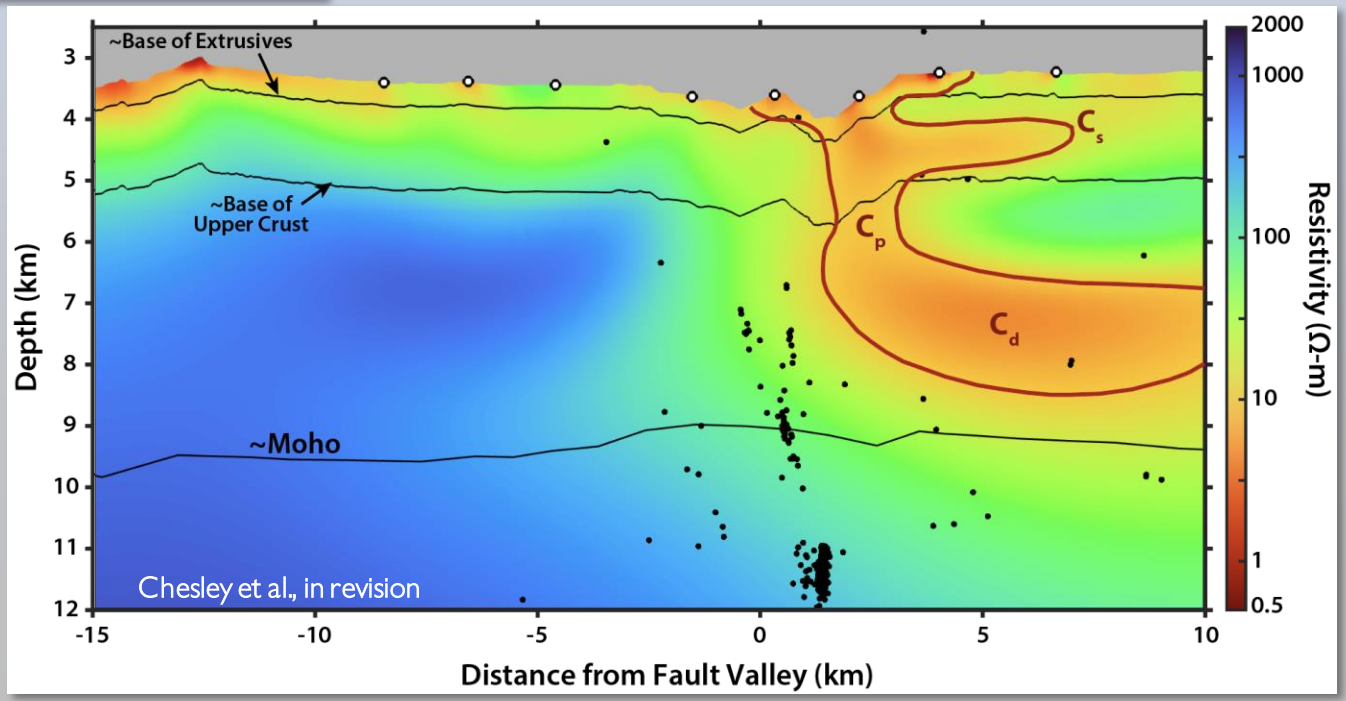
Electrical resistivity reveals conductive anomalies



Anomalies are on the south (younger crust) side of the fault:

- Deep (C_d)
- Shallow (C_s)
- Pipe-like (C_p)

→ Possible flow of brines in the fault.



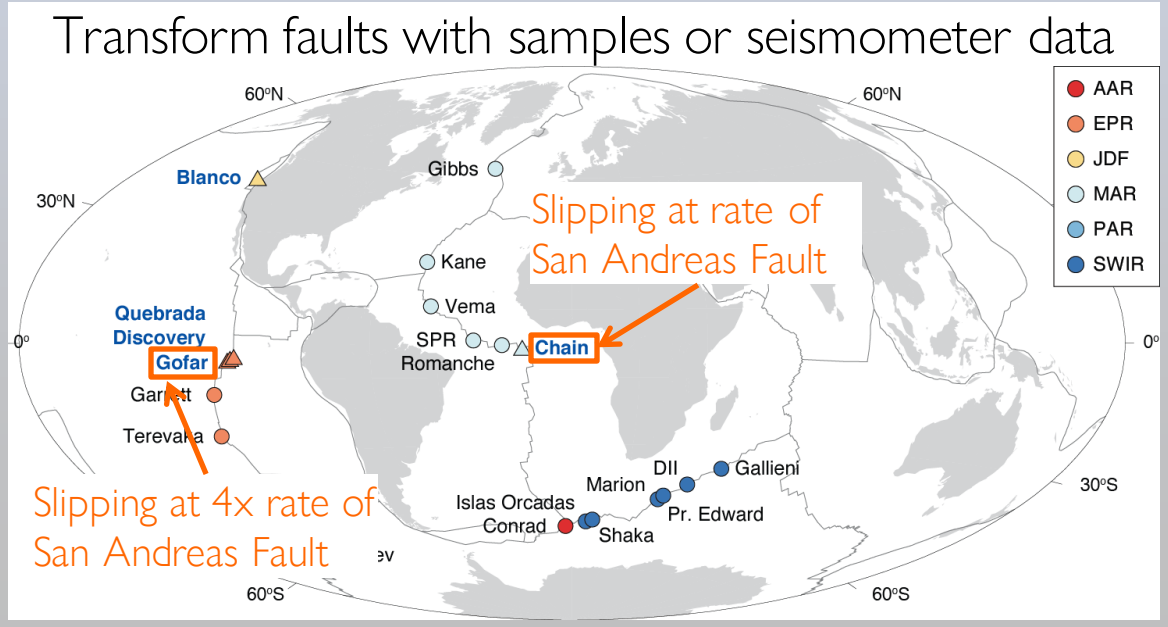
Seismicity from *Gong and Fan 2022* are relocated 2008 EQs w/in 250 m of profile

Chesley et al., in revision

What drives the recurrence of large earthquakes?

To link fluid flow to earthquakes and creep, we need to:

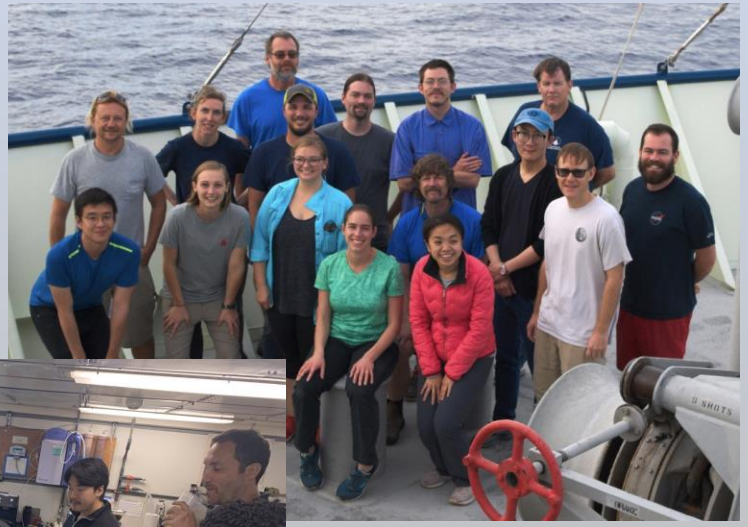
- Sample the rupturing part of the fault.
- Conduct ROV/HOV transects of the fault.
- Study additional faults, particularly faults slipping at similar rates to continental faults.



Kohli et al., 2021

Work force training in multidisciplinary science

- Gofar project involved ~20 undergraduates, grad students, and postdocs.
- They now have careers in academia, industry, government.



Boettcher et al., 2023

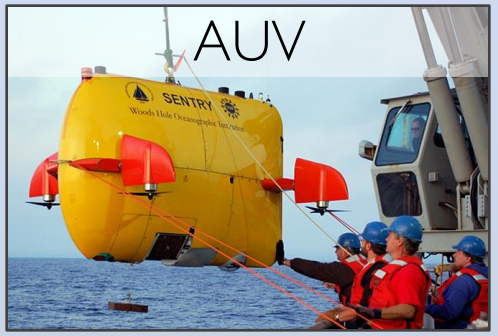
Research infrastructure: Dredging

- Need systems capable of handling large tensions.
- Requires synthetic lines to replace steel wires.
- A-frames and winches upgraded for handling high tensions.
- These upgrades also needed for coring & mooring deployments.
- Use of these systems will increase with IODP going offline.

Research infrastructure: Facilities

Deep submergence (HOV/ROV/AUV):

- State-of-the-art
- Limited availability – upgrade other equipment to take pressure off HOV/ROV/AUV

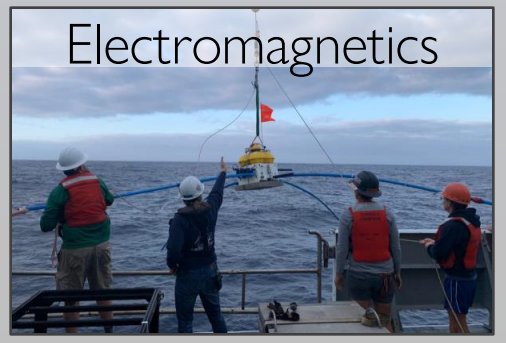


Ocean bottom seismometers

- High demand
- Aging instrument pool

Marine Electromagnetism

- Facility needed



Seafloor geodesy

- Further development needed

Research infrastructure: Ships

Global Class Vessels

- Huge demand for these ships.
- Need increased capabilities.
- Refits would improve some aspects (e.g., synthetic wires).
- Long-term planning needed for the US to remain a global leader in marine research.

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