

4-2009

Oceanic Transform Fault Seismicity Earthquakes of a Different Kind

Margaret S. Boettcher

University of New Hampshire, Durham, Margaret.Boettcher@unh.edu


Jeffrey McGuire

Woods Hole Oceanographic Inst.

Thomas Jordan

Earth Sciences, Department of Southern California

Follow this and additional works at: <https://scholars.unh.edu/ccom>

 Part of the [Oceanography and Atmospheric Sciences and Meteorology Commons](#)

Recommended Citation

Boettcher, Margaret S.; McGuire, Jeffrey; and Jordan, Thomas, "Oceanic Transform Fault Seismicity Earthquakes of a Different Kind" (2009). *International Workshop on Statistical Seismology*. 503.

<https://scholars.unh.edu/ccom/503>

This Conference Proceeding is brought to you for free and open access by the Center for Coastal and Ocean Mapping at University of New Hampshire Scholars' Repository. It has been accepted for inclusion in Center for Coastal and Ocean Mapping by an authorized administrator of University of New Hampshire Scholars' Repository. For more information, please contact nicole.hentz@unh.edu.

Oceanic Transform Fault Seismicity- Earthquakes of a Different Kind...

Higher Predictability

***Short-term, Long-term,
and with respect to tectonic parameters***

Margaret Boettcher, University of New Hampshire

Collaborators

Jeff McGuire, Woods Hole Oceanographic Institution

Tom Jordan, University of Southern California

April 15, 2009

6th International Workshop on Statistical Seismology, Lake Tahoe, CA

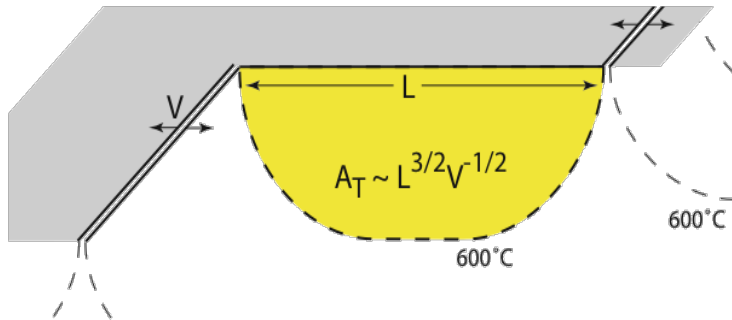
Scaling between Tectonic and Seismic Parameters

Boettcher and Jordan, 2004, JGR

Tectonic Parameters (L, V, & A_T)

65 Ridge Transform Faults

L ≥ 75 km (totaling ≈ 16,000 km)



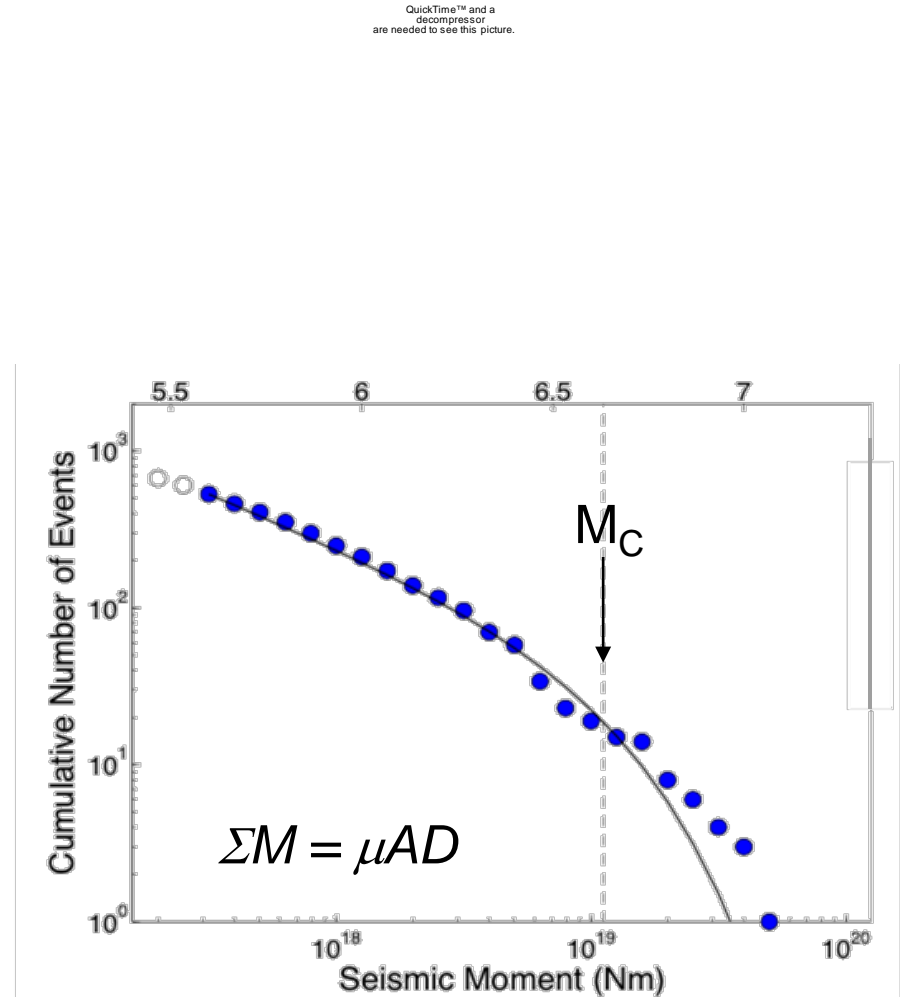
Seismic Parameters (M_C , ΣM , N_0 , & β)

ISC Catalog 1964-1999

Global CMT 1976-2001

$$N(M) = N_0 \left(\frac{M_0}{M} \right)^3 \exp \left(\frac{M_0 - M}{M_C} \right)$$

(Kagan and Jackson, 2002, GJI)

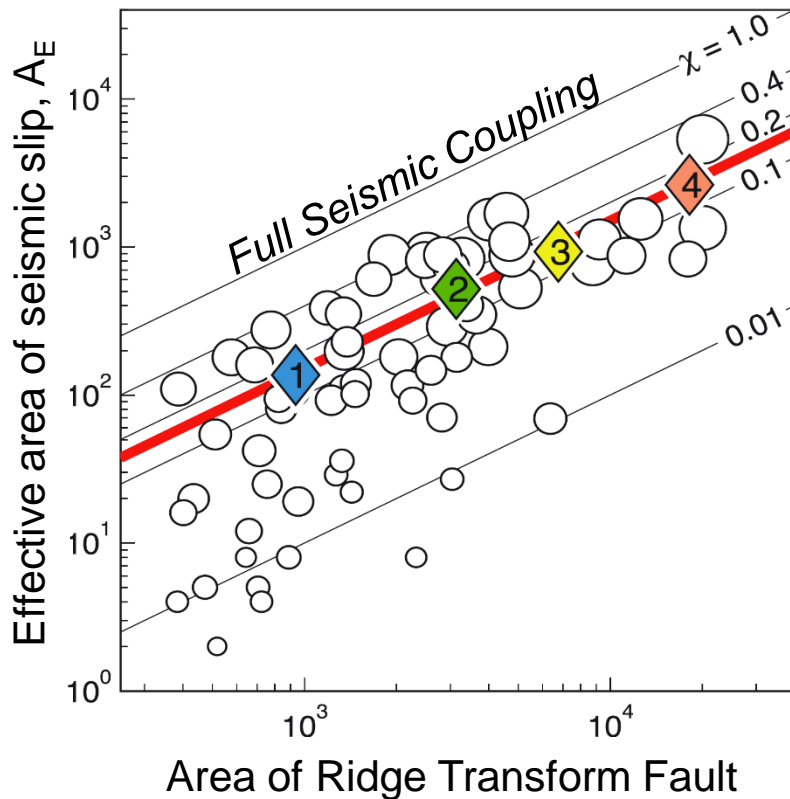


Scaling between Tectonic and Seismic Parameters

Boettcher and Jordan, 2004, JGR

Are oceanic transform faults fully coupled?

➔ No, on average, only ~15% of slip is accommodated seismically

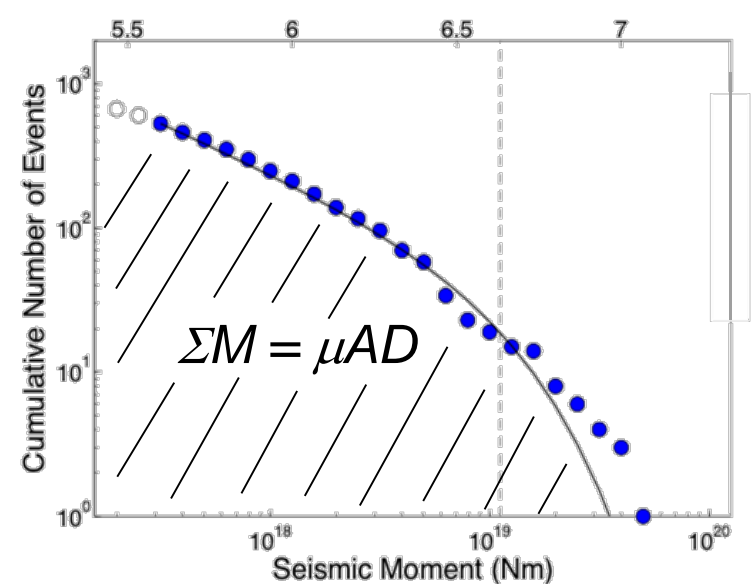


Effective Area of Seismic Slip

$$\Sigma M = \mu A D$$

$$\Sigma M/t = \mu A_E (D/t)$$

$$A_E = \Sigma M / (t \mu V)$$

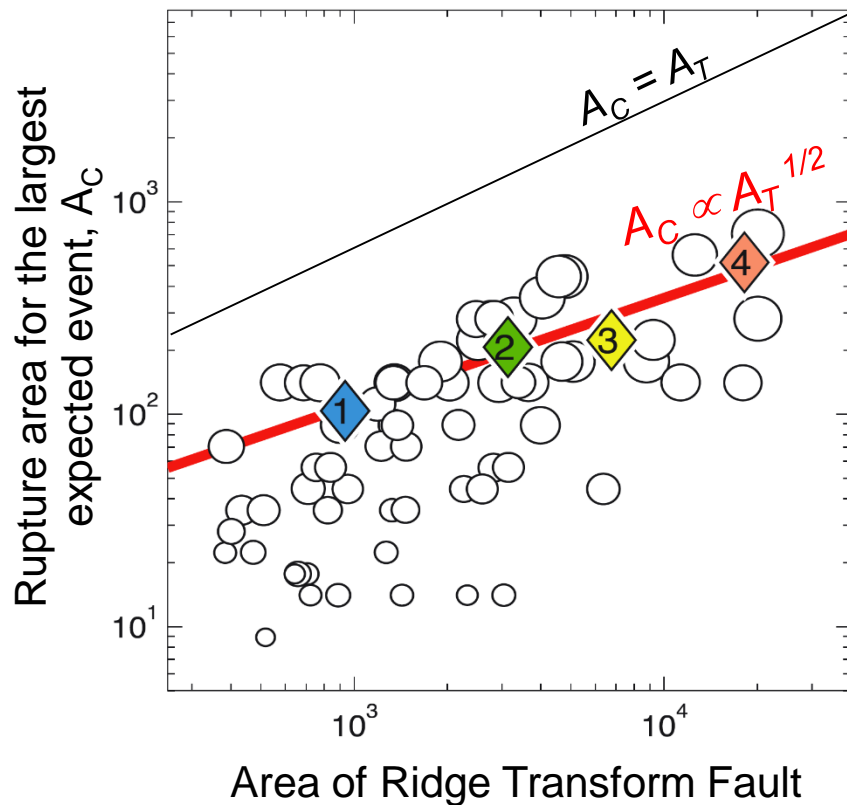


Scaling between Tectonic and Seismic Parameters

Boettcher and Jordan, 2004, JGR

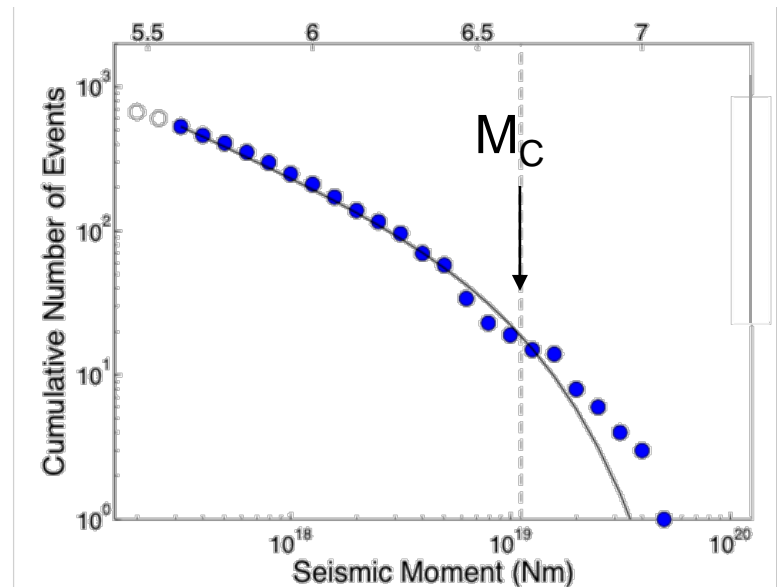
Will the largest event (M_C) rupture the total fault area?

➔ No... and furthermore A_C scales as $A_T^{1/2}$



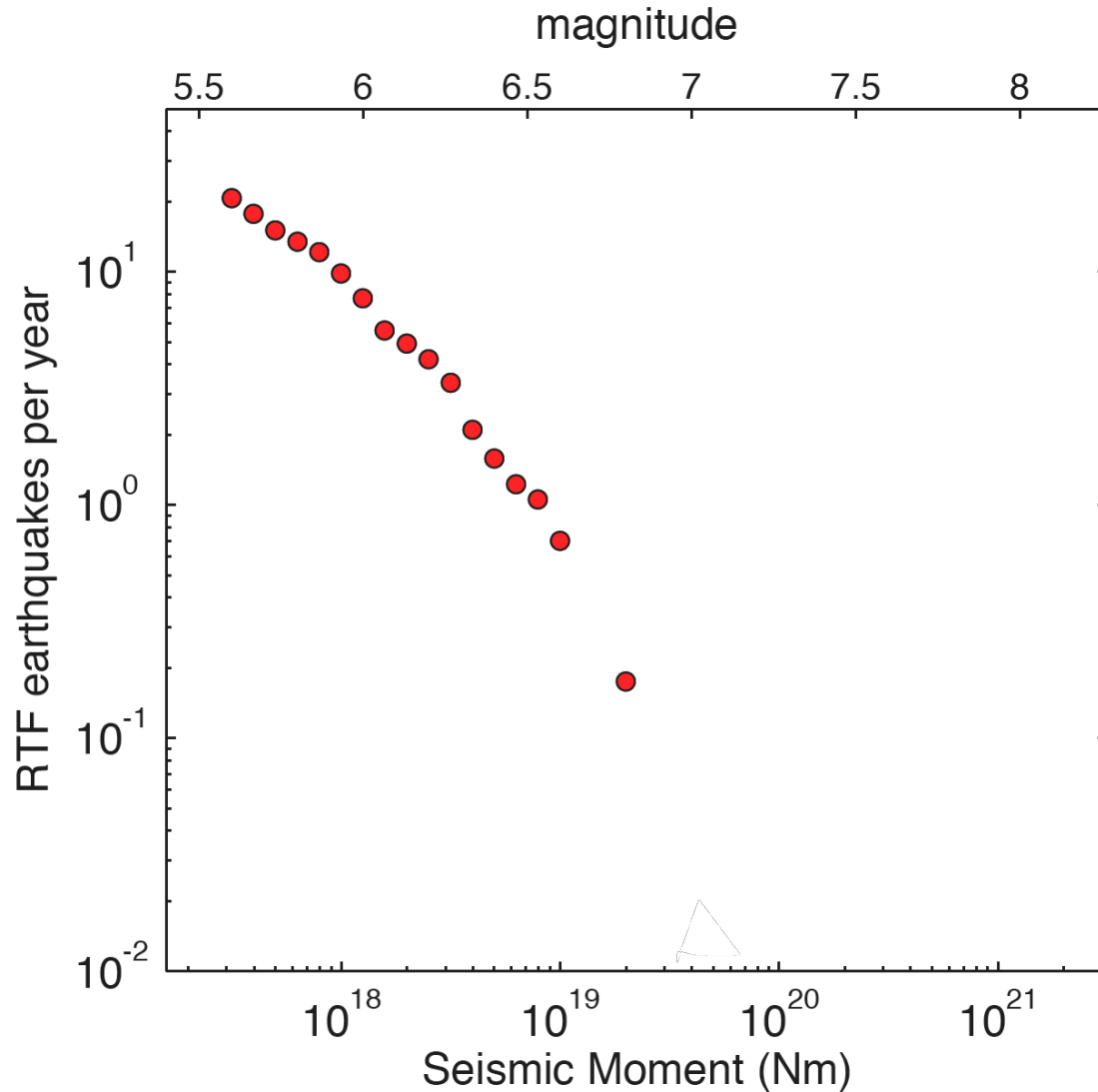
Rupture Area of Largest Expected Event

$$A_C = M_C / \mu D_C$$



Scaling between Tectonic and Seismic Parameters

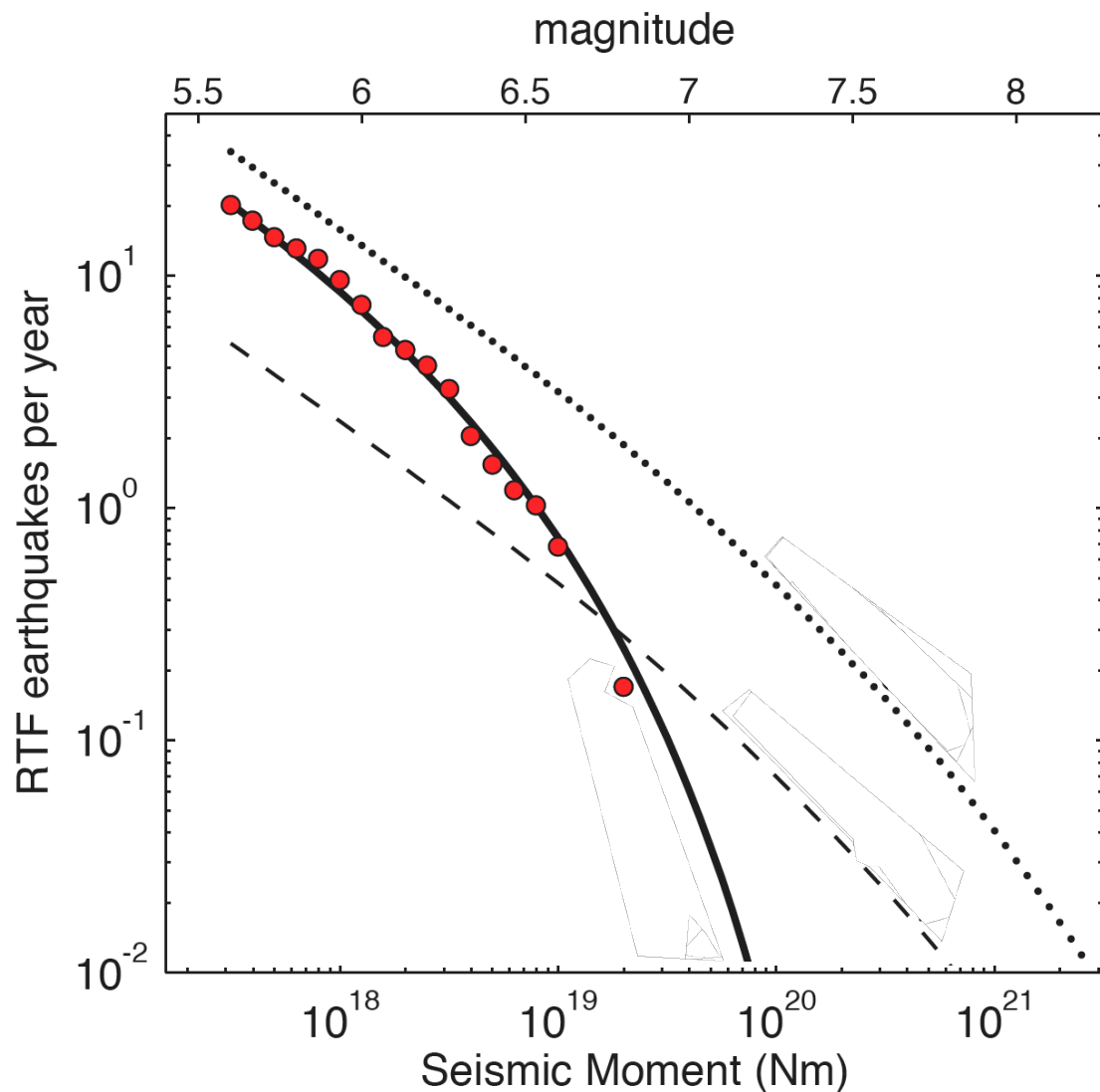
Global CMT Data from 65 faults 2000-2005



Scaling between Tectonic and Seismic Parameters

Global CMT Data from 65 faults 2000-2005

Computed magnitude-frequency curves are calculated assuming tapered Gutenberg-Richter distribution, L 's & V 's



Full Coupling

M_C fills entire fault area

15% Coupling

M_C fills entire fault area

Observed Scaling Relations

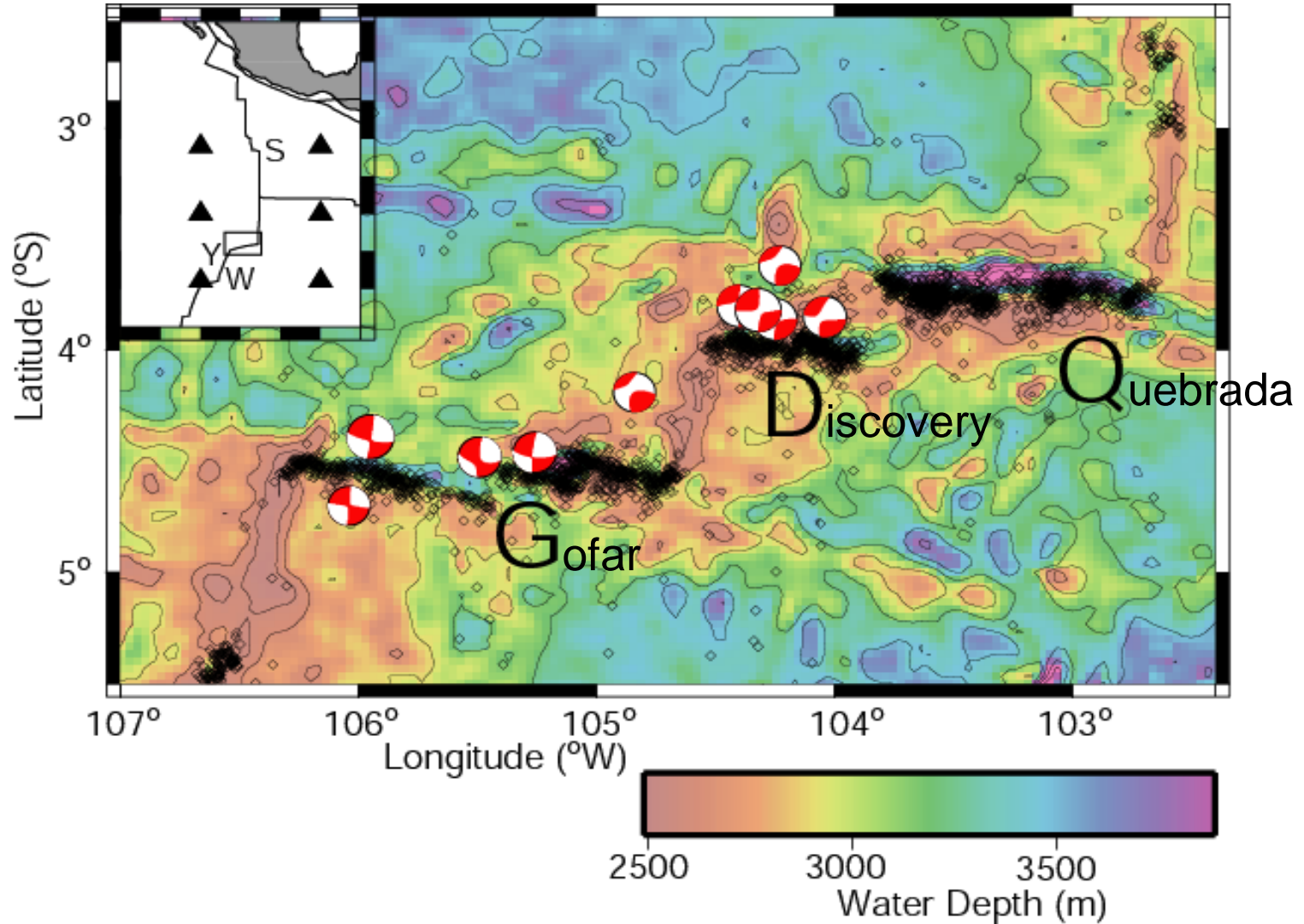
15% Coupling

M_C scales as fault area to the 1/2 power

Short Term Earthquake Predictability

McGuire, Boettcher, and Jordan, 2005, Nature

9 Mw \geq 5.5, Mar. 1996 - Nov. 2001

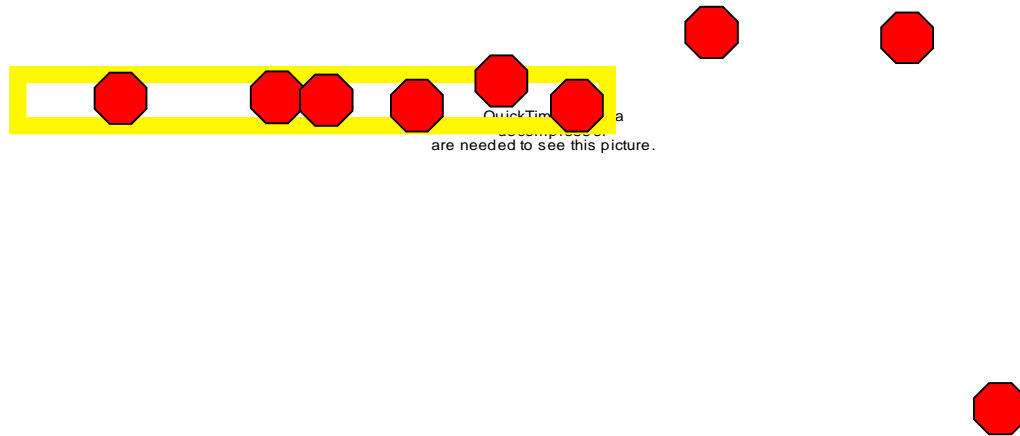


Short Term Earthquake Predictability

McGuire, Boettcher, and Jordan, 2005, Nature

Simple prediction algorithm-

$M_w \geq 5.5$ are preceded by a foreshock within 1 hour and 15 km

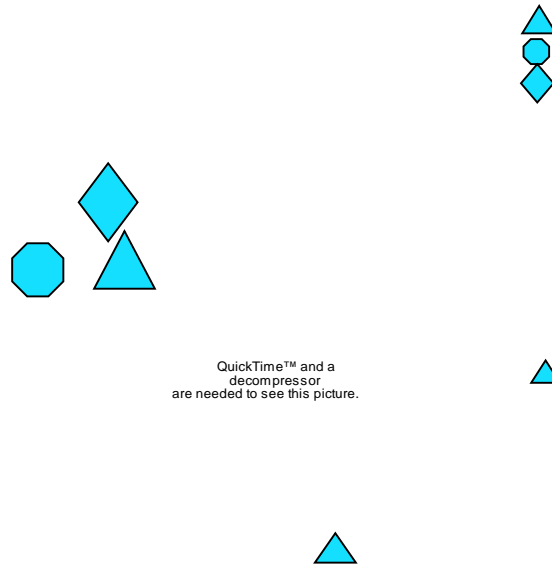


Short Term Earthquake Predictability

McGuire, Boettcher, and Jordan, 2005, Nature

Simple algorithms can achieve large (500-1000) probability gains over random!

Failure to predict probability, $1-P(F|M)$



Probability of alerts, $P(F)$

Seismic Cycles and Earthquake Predictability

McGuire, 2008, BSSA





QuickTime™ and a
decompressor
are needed to see this picture.

Short-Term
Predictability

QuickTime™ and a
decompressor
are needed to see this picture.

Long-Term
Predictability

Molchan error diagram for $r=15$ km:

-  Alarms following every hydroacoustically detected event
-  ETAS Simulation
-  Random guessing
-  99% Confidence bound for random guessing

Long Term Earthquake Predictability

Using our Scaling Relations M_C for East Pacific Rise faults we expect

L (km)	V(cm/yr)	M_C
120	14	6.0-6.2
70	14	5.8-6.0

*Average slip in $M_W \approx 6.0$ is approximately
50-100 cm*

Short Seismic Cycles, 5-10 years

Seismic Cycles and Long-Term Predictability

McGuire, 2008, BSSA



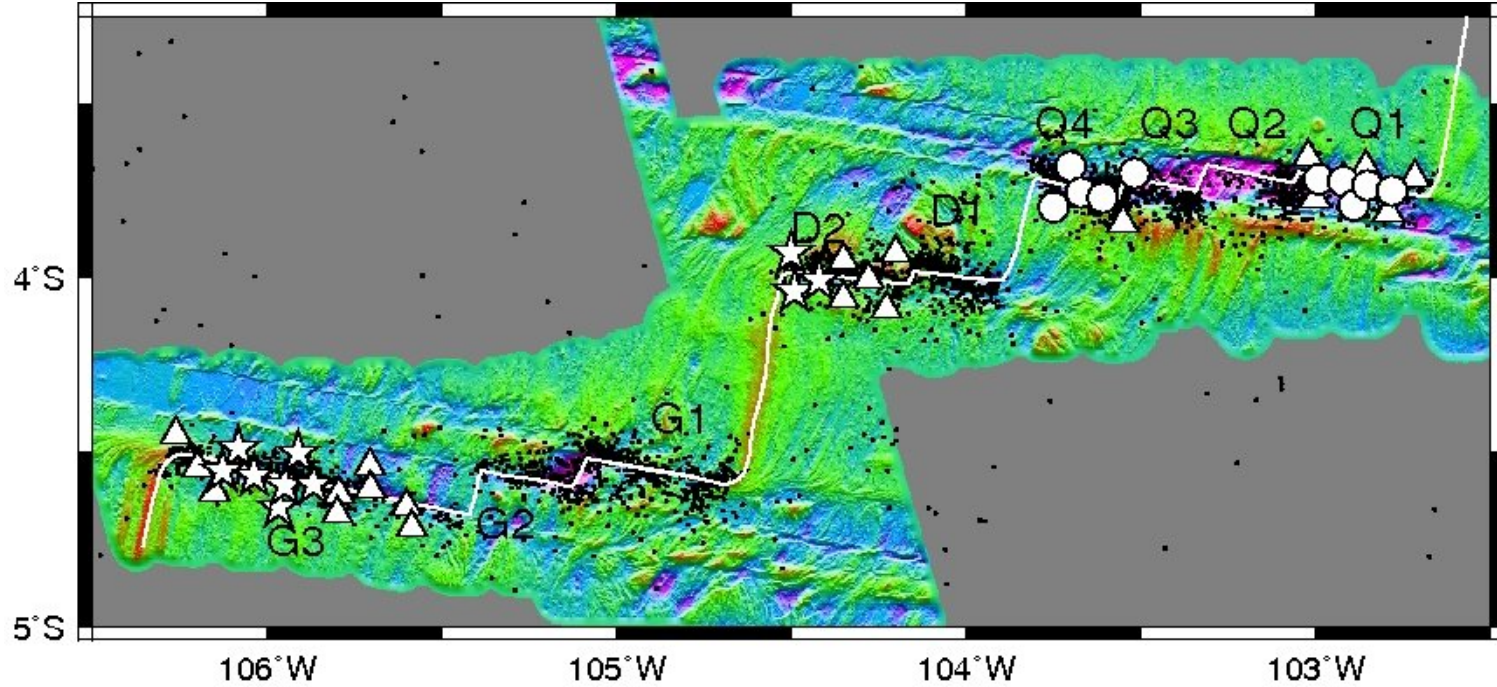
QuickTime™ and a
decompressor
are needed to see this picture.

● $M_W \geq 5.5$

● $4.5 \leq M_W \leq 5.5$

● Hydroacoustic detection

McGuire's 2008 Quebrada-Discovery-Gofar OBS Experiment



QuickTime™ and a decompressor are needed to see this picture.



McGuire's 2008 Quebrada-Discovery-Gofar OBS Experiment

September 18, 2008,
 M_W 6.0 Gofar Earthquake



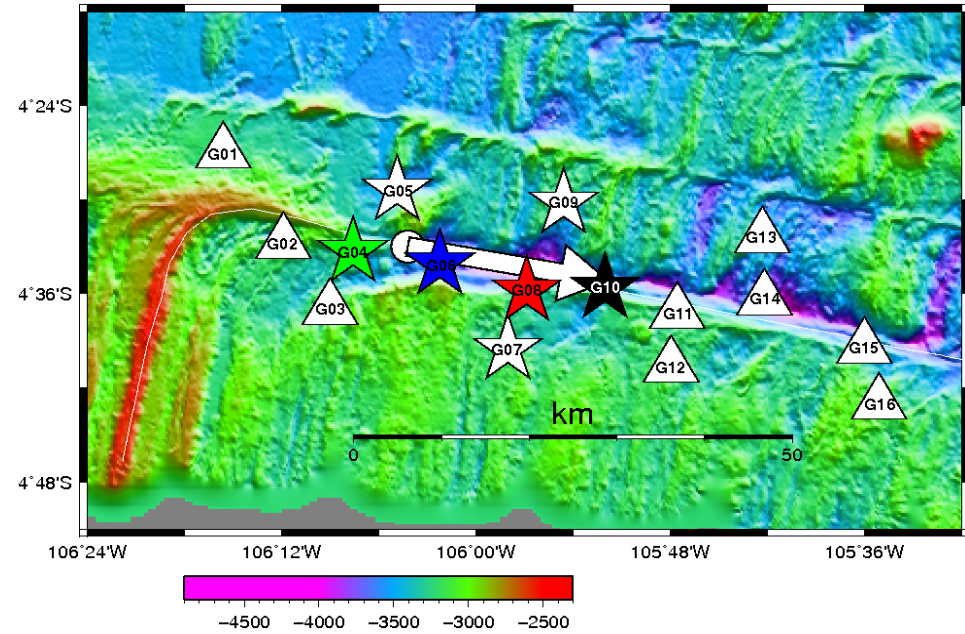
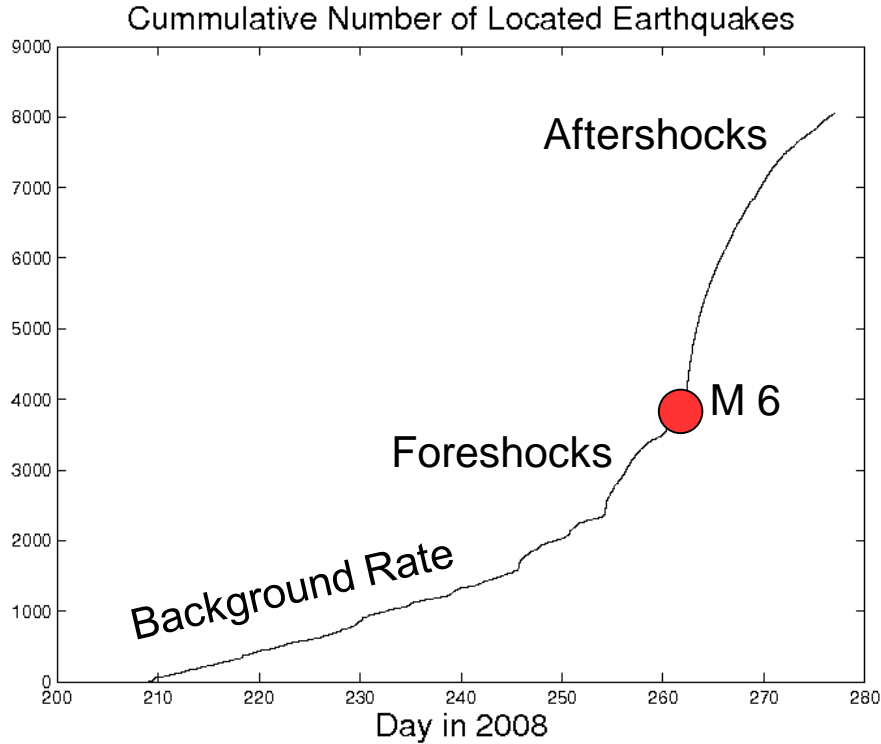
QuickTime™ and a
decompressor
are needed to see this picture.

● $M_W \geq 5.5$

● $4.5 \leq M_W \leq 5.5$

● Hydroacoustic detection

September 18, 2008, Mw 6.0 Gofar Transform Earthquake

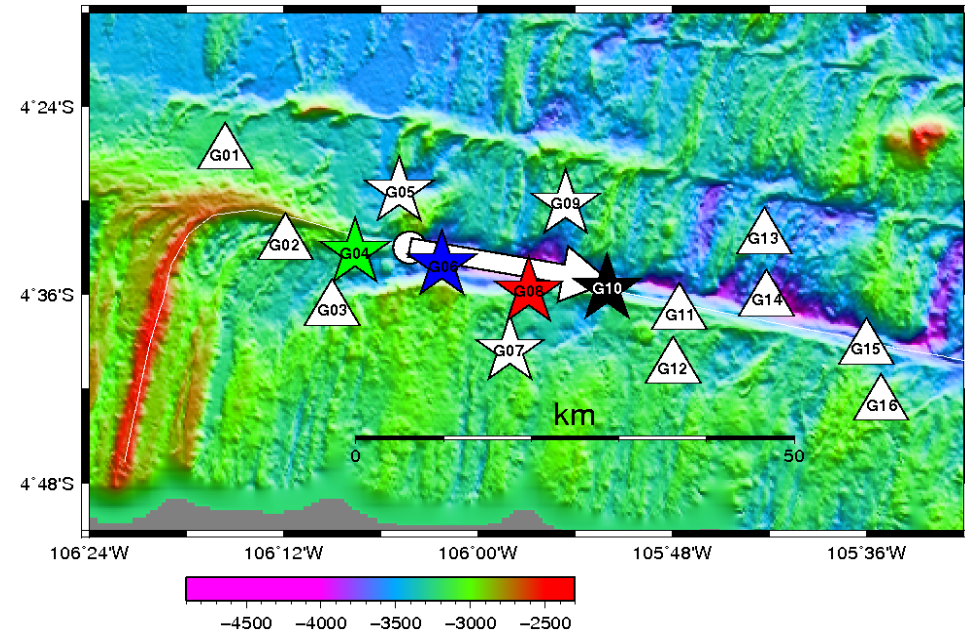
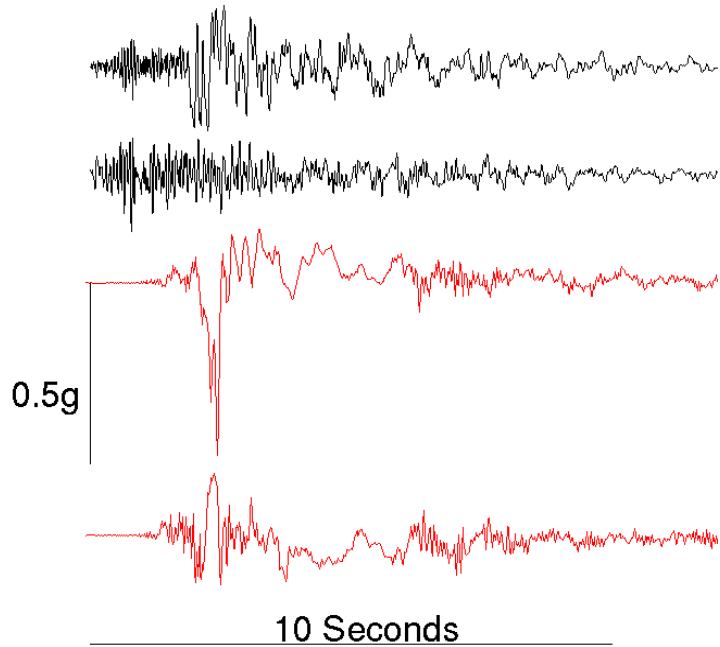


High rate of foreshocks for about one week before the M6.

We will be able to locate ~5000 foreshocks in the last week before the rupture and use this spatial information to evaluate the presence or absence of aseismic fault slip.

September 18, 2008, Mw 6.0 Gofar Transform Earthquake

Parkfield FZ6 and Gofar G06 Accelograms



Very smooth rupture to the east, probably at a velocity approaching the S-wave speed.
=> low fracture energy

A finite-fault model will give us information about the friction law and the spatial relationship between the foreshocks and mainshock slip.

09/18/2008 M_w 6.0 Gofar Earthquake: Horizontal Component Velocity Records

