Oceanic Transform Fault Seismicity Earthquakes of a Different Kind

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

*Higher Predictability*

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

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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)
Are oceanic transform faults fully coupled?

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

**Effective Area of Seismic Slip**

\[
\Sigma M = \mu AD \\
\Sigma M/t = \mu A_E(D/t) \\
A_E = \Sigma M/(t\mu V)
\]
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
Computed magnitude-frequency curves are calculated assuming tapered Gutenberg-Richter distribution, L’s & V’s.

**Observed Scaling Relations**

15% Coupling
$M_C$ scales as fault area to the $1/2$ power

**Global CMT Data from 65 faults 2000-2005**

Scaling between Tectonic and Seismic Parameters

Full Coupling
$M_C$ fills entire fault area

15% Coupling
$M_C$ fills entire fault area
Short Term Earthquake Predictability
McGuire, Boettcher, and Jordan, 2005, Nature

9 Mw ≥ 5.5, Mar. 1996 - Nov. 2001

Discovery Quebrada
Gofar

Latitude (°S)

Longitude (°W)

Water Depth (m)

2500 3000 3500
Simple prediction algorithm-
Mw ≥ 5.5 are preceded by a foreshock within 1 hour and 15 km
Simple algorithms can achieve large (500-1000) probability gains over random!
Seismic Cycles and Earthquake Predictability
McGuire, 2008, BSSA

Molchan error diagram for r=15 km:

- Alarms following every hydroacoustically detected event
- ETAS Simulation
- Random guessing
- 99% Confidence bound for random guessing
Using our Scaling Relations $M_C$ for East Pacific Rise faults we expect

<table>
<thead>
<tr>
<th>L (km)</th>
<th>V(cm/yr)</th>
<th>$M_C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>14</td>
<td>6.0-6.2</td>
</tr>
<tr>
<td>70</td>
<td>14</td>
<td>5.8-6.0</td>
</tr>
</tbody>
</table>

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

- $M_W \geq 5.5$
- $4.5 \leq M_W \leq 5.5$
- Hydroacoustic detection
McGuire’s 2008 Quebrada-Discovery-Gofar OBS Experiment
McGuire’s 2008 Quebrada-Discovery-Gofar OBS Experiment

September 18, 2008, $M_W 6.0$ Gofar Earthquake

- $M_W \geq 5.5$
- $4.5 \leq M_W \leq 5.5$
- Hydroacoustic detection
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.
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.