Introducing the Cajon Pass Earthquake Gate Area

Julian Lozos
California State University, Northridge
A Modern Chaconne: A Structural and Harmonic Analysis of “Hotel California”

Julian Lozos
California State University, Northridge
The Earthquake of December 8th, 1812: A Case for the Cajon Pass Earthquake Gate Area

Julian Lozos
California State University, Northridge
Earthquake Gates

- Critical point in a fault system that may (or may not) stop rupture or may control which way a rupture goes.
- Do gates swing the same way every time?
Cajon Pass

A junction between primary plate boundary faults, in a densely populated region.
Some Key Questions

• How do fault interactions affect the probability of through-going earthquakes?

• How much does the geometry of the component faults modulate this?

• How do previous ruptures affect future rupture paths and probabilities?

• Does the current stress field represent recent rupture history?
The Earthquake of December 8th, 1812

• Heavy damage at Mission San Gabriel, 40 deaths at Mission San Juan Capistrano.

• Initially considered a Newport-Inglewood event.

• Reassigned to the San Andreas based on tree ring evidence.

• Since identified in many San Andreas paleoseismic trenches.
I cannot definitively prove anything here.
Modeling Approach

- 3D fully dynamic rupture modeling.
  - Finite element method (FaultMod, Barall, 2009).
- Realistic initial conditions:
  - Fault mesh with complex geometry.
  - Complex regional velocity structure (SCEC CVM).
  - Regional stress field from seismicity studies.
- Vary initial stress amplitudes until models produce slip consistent with paleoseismic records.
Model Geometry
Model Geometry
Regional Stresses

Maximum horizontal compressive stress orientation in southern California

Yang and Hauksson, 2013
On-Fault Stresses

- Additional heterogeneity from fault geometry.
## Physical and Computational Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_p$</td>
<td>From SCEC CVM</td>
</tr>
<tr>
<td>$V_s$</td>
<td>From SCEC CVM</td>
</tr>
<tr>
<td>Density</td>
<td>From SCEC CVM</td>
</tr>
<tr>
<td>$\mu_{\text{static}}$</td>
<td>0.6</td>
</tr>
<tr>
<td>$\mu_{\text{dynamic}}$</td>
<td>0.2</td>
</tr>
<tr>
<td>$d_0$</td>
<td>0.4 m</td>
</tr>
<tr>
<td>Principal stresses</td>
<td>Variable (Best fit: $\sigma_V = 30$ MPa, $\sigma_{NS} = 36$ MPa, $\sigma_{EW} = 12$ MPa)</td>
</tr>
<tr>
<td>Stress orientation</td>
<td><strong>SAF</strong>: N5E north of junction, N15W south of junction; <strong>SJF</strong>: N12E</td>
</tr>
<tr>
<td>Element size</td>
<td>200 m in near field, 400 m in far field</td>
</tr>
<tr>
<td>Nucleation radius</td>
<td>3000 m</td>
</tr>
</tbody>
</table>
Slip in the Early 1800s

- **Pallett Creek**: 1857, 1812
  - Slip: 2 - 6 m
- **Wrightwood**: 1857, 1812
  - Slip: 2.5 - 4.5 m
- **Cajon Creek**: 1857, 1812
  - Slip: ~4 m
- **Pitman Canyon**: 1812
  - Slip: 3 - 4 m
- **Plunge Creek**: No surface rupture
- **Burro Flats**: Several cm on secondary structures
- **Colton**: early 1800s
  - Slip: Large liquefaction features
- **Quincy**: early 1800s
  - Slip: 1.8 - 3 m
- **Mystic Lake**: early 1800s
  - Slip: 1.8 - 3 m
Model Slip Distributions

Nucleation:
- SAF at Pallett Creek M7.50
- SAF at Junction with SJF M7.51
- SAF at Plunge Creek M6.20
- SAF at Burro Flats M6.58
- SJF at Junction with SAF M7.48
- SJF at Mystic Lake M7.49
Ground Motion: SAF north

Peak horizontal particle motion (m/s)
Ground Motion: SAF at junction

Peak horizontal particle motion (m/s)
Ground Motion: SJF south

Peak horizontal particle motion (m/s)
Coulomb Stress: SJF south
• Ground motions consistent both with Mission records and with PBRs.
• Stress changes consistent with northward-propagating EQ sequence.
Implications for 1812
Implications for SAF-SJF Interactions

• The San Andreas and San Jacinto can rupture together.
  • Even if they didn’t in 1812, it’s physically plausible under current conditions.
  • Corroborated by paleoseismology and PBRs.

• How loaded is the San Andreas Fault south of its junction with the San Jacinto Fault?

• Does this change the most likely Really Big One for southern California?

• How often does this happen? Is this a usual pattern?
Now, we want to add more detail, clarity, and length to the Cajon Pass story.
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Cajon Pass Fault Geometry

Cajon Pass Earthquake Gate Area

New CFM-5.2 faults inferred 1812 rupture

Nicholson et al., 2017
Dip on the Southern San Andreas Fault et al., 2012
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Recent Rupture History

1857
1812 (December 8)
1800
~1690
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Yang and Hauksson, 2013
Cajon Pass Panel Discussion

3 - 4 PM today, in this room.