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EQPRO
Earthquake Probabilities and Occurrence Megaproject

FY05
Ruth Harris, Andy Michael, Ross Stein, Pat McCrory, Paul Reasenberg,
Brad Aagaard, Joe Andrews, Bill Bakun, Nick Beeler, Joan Gomberg,
Tom Hanks, Jeanne Hardebeck, Mal Johnston, Bruce Julian, David Lockner,
Art McGarr, Carolyn Morrow, Fred Pollitz, Bob Simpson, Bill Stuart,
Michael Barall, Serkan Bozkurt, Shinji Toda,
Chung-Han Chan, Alexei Czeskis, Elliot Grunewald, Haruhisa Nakamichi,
Marlene Nyst, Chris Rollins, Nan Shoshtak, Sharon Terwilliger,
Jim Dieterich, Delphine Fitzenz

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EQPRO Chain of Command (Simplified Linear Version)





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FY05 EQPRO Tasks

Understanding Fault System Behavior for Physics-Based Hazard Assessments
Leader: *Andy Michael*
Fault systems, stress state, fault mechanics, earthquake locations (historic and modern), velocity structure, basic earthquake probabilities research
Michael, Bakun, Beeler, Dieterich, Gomberg, Hardebeck, Julian, McGarr

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Validating Models of Stress Transfer for Use in Determining Earthquake Probabilities
Leader: *Ross Stein*
Stress Triggering and Earthquake Probabilities
Stein, Beeler, Gomberg, Hardebeck, Johnston, Lockner, Michael, Morrow, Pollitz

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Earthquake Nucleation, Growth, and Termination: Model Development and Testing
Leader: *Ruth Harris*
Rupture Dynamics
Harris, Aagaard, Andrews, Johnston, Simpson

Partitioning Plate Motions and Earth Deformations into Fault Slip and Earthquakes
Leader: *Pat McCrory*
Fault systems behavior and plate tectonics
McCrory, Pollitz, Stuart

Application of Earthquake Probabilities to Hazard Assessment and Risk Reduction
Leader: *Paul Reasenberg*
Earthquake probabilities and transfer of that knowledge
Reasenberg, Michael, Hanks

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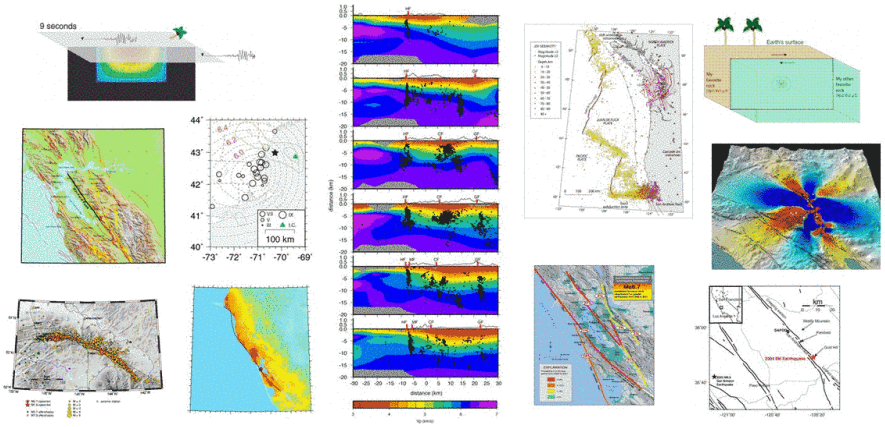
We Work and Collaborate Internationally, but Focus our Efforts on Answering U.S. Earthquake Hazards Questions



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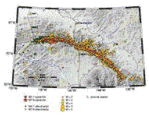
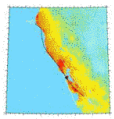
Some Exciting New Highlights

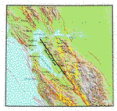
Alaska Earthquake Hazard



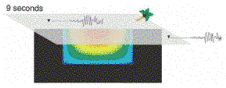
1906 Centennial Project



Hayward Fault Project



Rupture Dynamics Code Validation



Parkfield Earthquake Experiment

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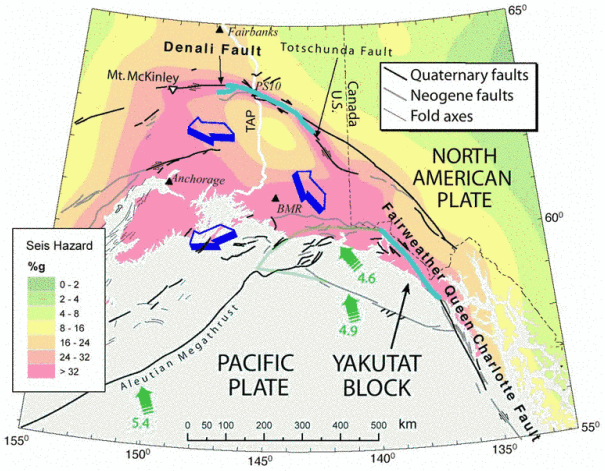
The New Alaska Hazards Map

Project Leader: Rob Wesson

Objective:
To update the Alaska seismic hazards map

Figure from Eberhart-Phillips et al., Science, 2003



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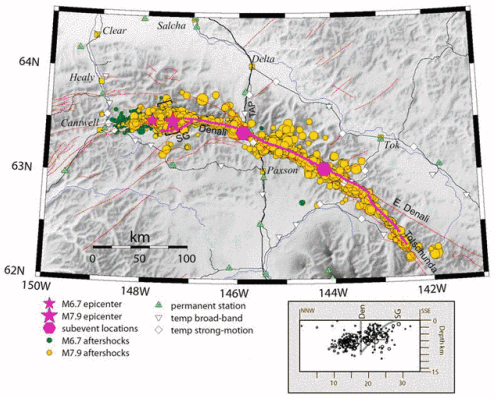
Alaska
Time-Dependent Hazards

What is the stress transfer effect of the 2002 M7.9 Denali Earthquake on other Faults in Alaska?

Figure from Eberhart-Phillips et al. Science, 2003



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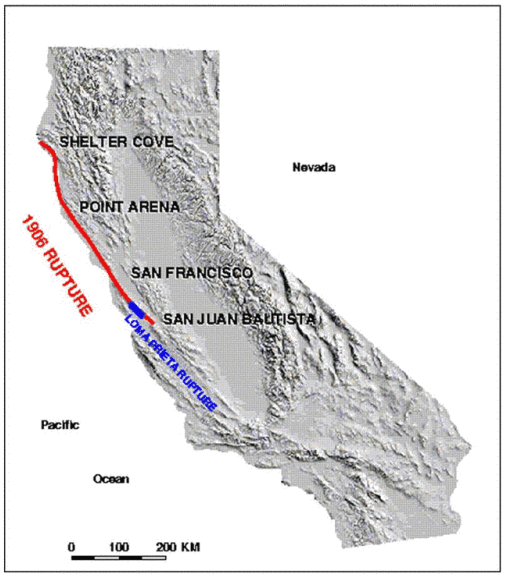
1906 M7.8 San Francisco earthquake



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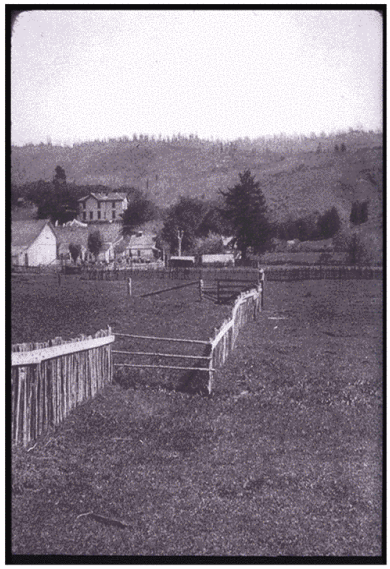
1906 Earthquake Effects



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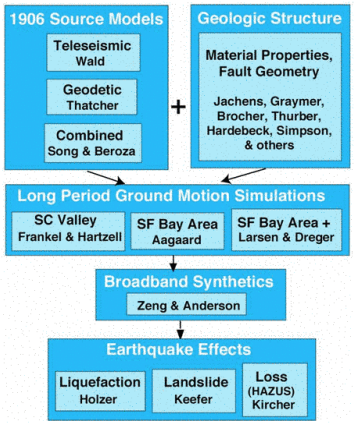
1906 Centennial Project

Project Leader:
Mary Lou Zoback

Some Objectives:
*To better understand 1906
*To show how a 1906 quake or another new SAF quake would affect the current infrastructure of the San Francisco Bay Area & beyond

Figure from Aagaard



QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

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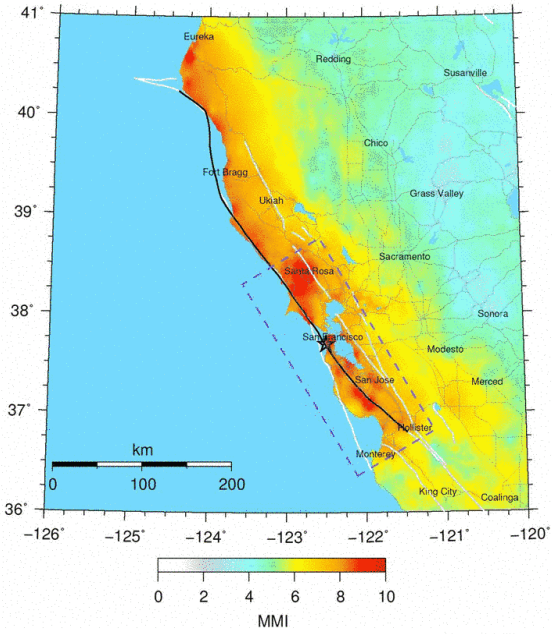
1906 Centennial Project

Ground Truth for 1906
[Boatwright & Bundock, 2005]
Intensity Map for Northern CA

Boatwright & Bundock 1906 Intensity Map



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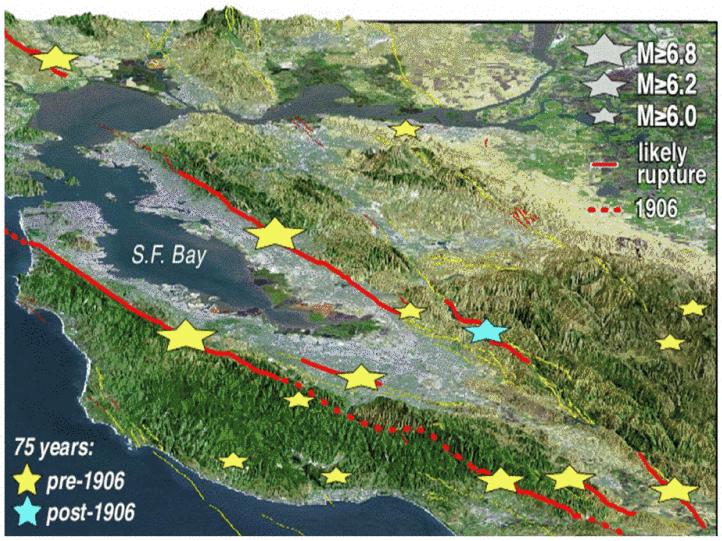
In the 75 years before the 1906 Earthquake, M6 events were common
In the 75 years after 1906, significantly fewer M6 earthquakes occurred =
1906 Stress Shadow [Simpson & Reasenberg, 1994; Harris & Simpson, 1998, etc.]



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Following 1906 the S.F. Bay Area had a relaxing existence for decades, due to the **1906 Stress Shadow**

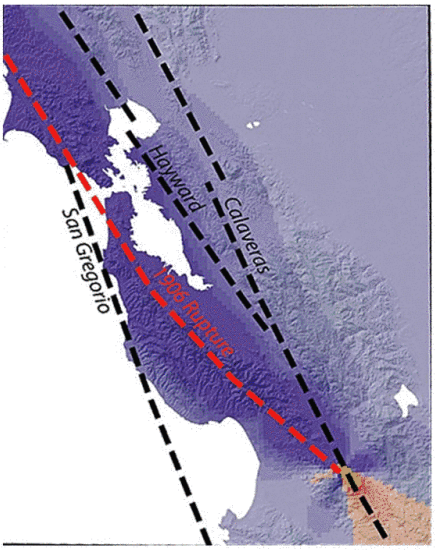

Figure from Stein, Modeling by Harris & Simpson, 1998; Parsons, 2003

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HOWEVER,
It's Over….

Stress transfer calculations show parts of the Hayward fault near or exceeding the stress levels that existed right before the 1868 M7 Hayward fault earthquake

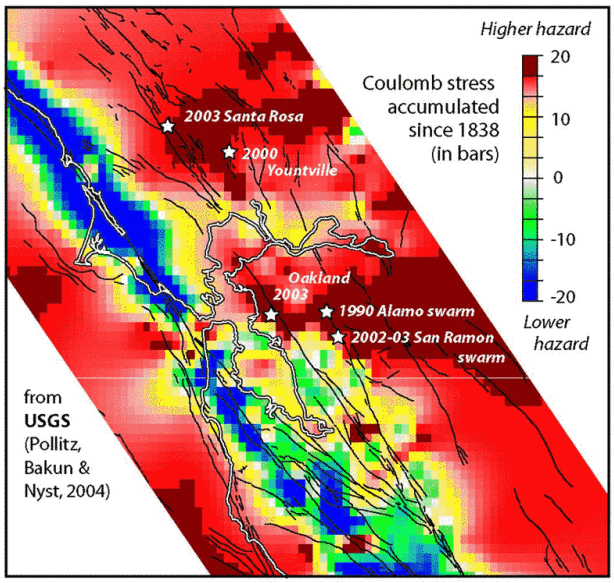

Figure from Pollitz/Stein

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The Hayward Fault Project

Project Leader: Diane Moore

Objective:
To better understand the earthquake behavior of the Hayward fault, our highest hazard fault in the S.F. Bay Area

WG02 Questions:
What might confine or nucleate HF quakes?
Where is the aseismic slip?

Our Additional Question:
What causes the aseismic vs. locked behavior?

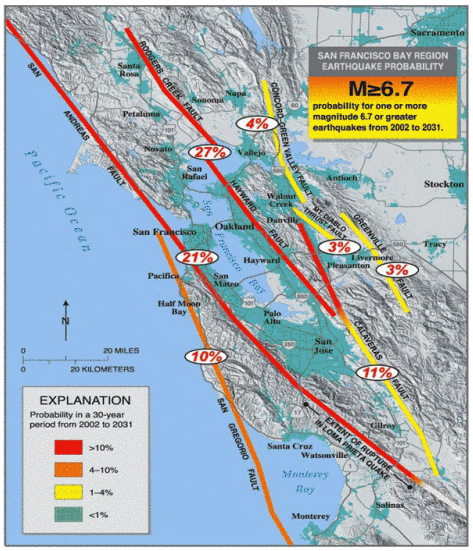

Figure from WG02 [2003]

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The Hayward Fault Project

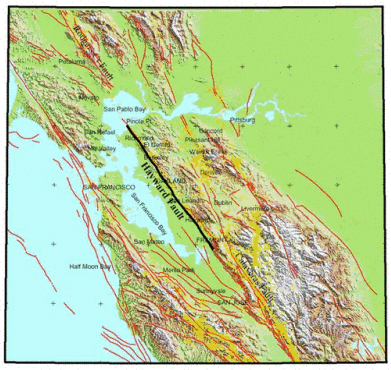
Geologists and geophysicists are working together using interdisciplinary approaches to try to unravel the mysteries of the Hayward fault.

Progress to date:
*Workshop
New 3D geology/geophysics model
*New finite-element study

Proceedings of the Hayward Fault Workshop, Eastern San Francisco Bay Area, California, September 19-20, 2003

Edited By David A. Ponce[1], Roland Bürgmann[2], Russell W. Graymer[1], James J. Lienkaemper[1], Diane E. Moore[1], and David P. Schwartz[1]

Open-File Report 03-485



2003

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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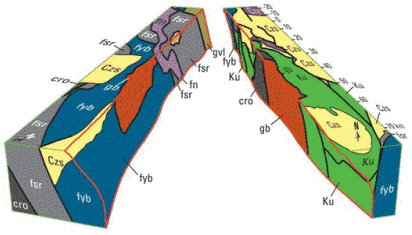
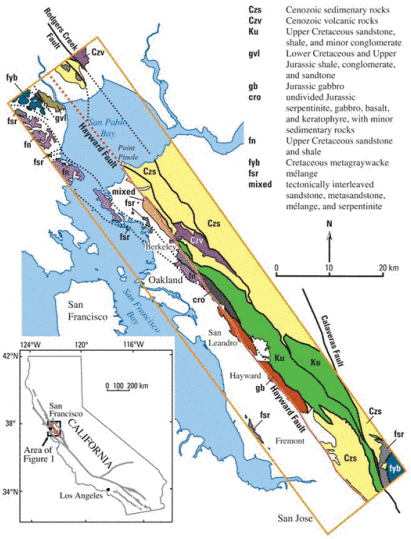
The Hayward Fault Project

3D Geologic Map of the Hayward Fault

Figures from
Graymer et al., Geology, 2005





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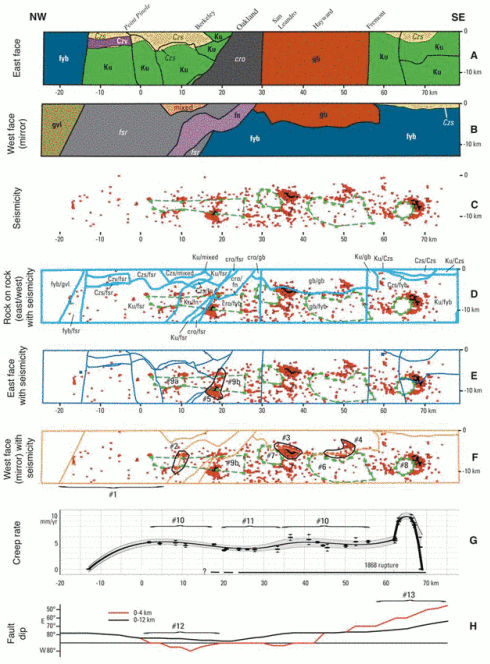
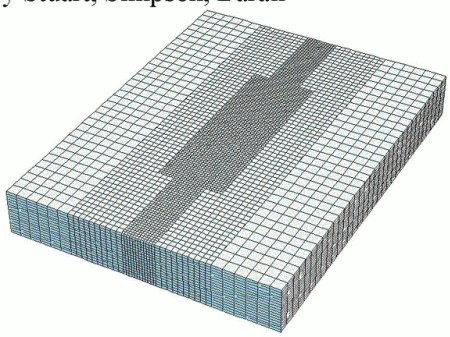
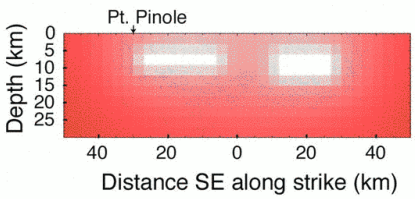
Graymer et al., Geology, 2005



Finite-Element Modeling
by Stuart, Simpson, Barall



Hayward Fault Slip



SESAC April 2005

Rupture Dynamics Code Validation

Project Leader: Ruth Harris

Objective:
To compare and validate the methods used to simulate Physics-Based earthquake rupture dynamics so they can confidently be applied to solving earthquake hazards problems (e.g., NGA-H)

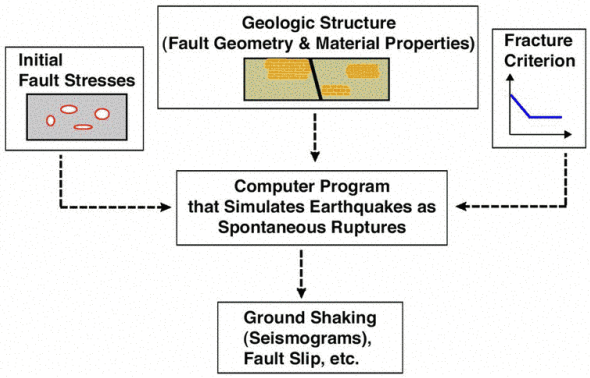


Figure from Harris & Archuleta, EOS, 2004

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The Parkfield Earthquake Experiment

Project Leader: John Langbein

Objective:
To record the geologic processes that occur on and near the San Andreas fault before, during, and after (the complete cycle of) an M6 earthquake

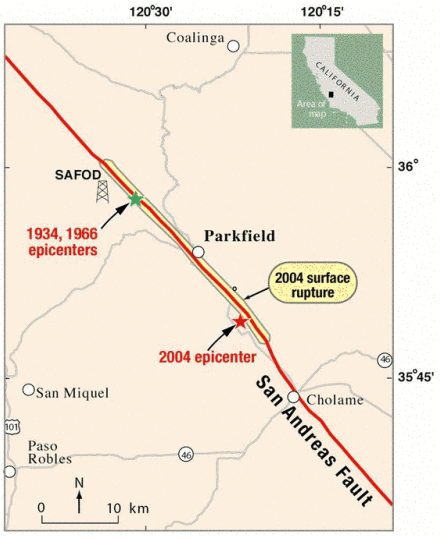
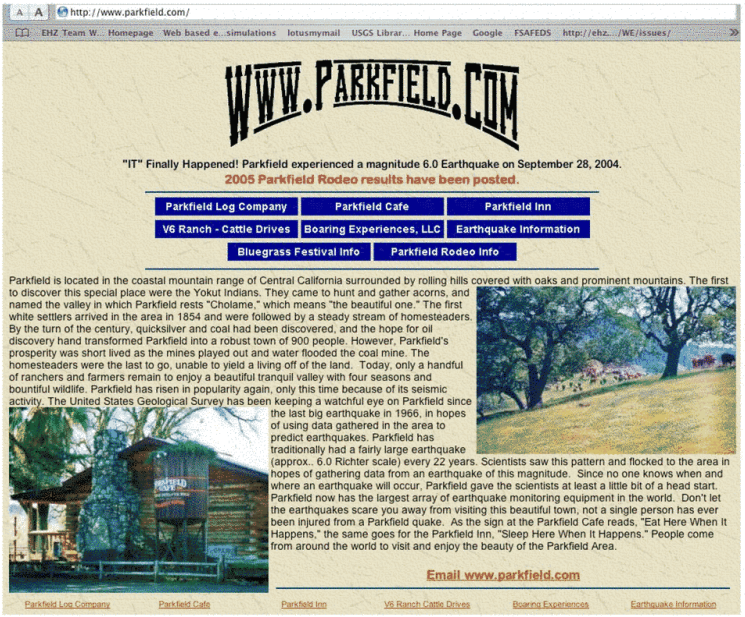


Figure modified from Bakun et al., Nature, accepted

The 2004 M6 Parkfield earthquake is the world's best recorded earthquake to date.

A wealth of preseismic, coseismic, postseismic data has been recorded.

There was No short-term precursory activity on the San Andreas fault.



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The End

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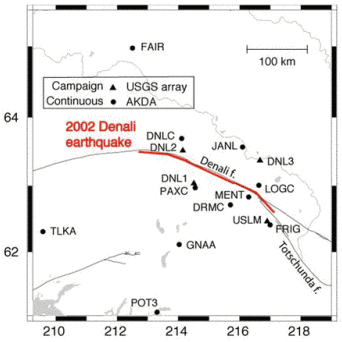
Alaska
Time-Dependent Hazards

Method Part 1:

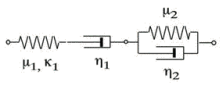
Pollitz uses a slip model of the 2002 Denali earthquake + GPS postseismic measurements to infer a rheology for this region of Alaska

He then calculates the viscoelastic stress transfer due to the 2002 Denali quake at the sites of other faults.

Figures from Pollitz



Preferred transient mantle rheology



$\eta_1 = 2.8 \times 10^{18}$ Pa s

$\eta_2 = 1.0 \times 10^{17}$ Pa s

$\kappa_1 = 150$ GPa

$\mu_1 = \mu_2 = 70$ GPa

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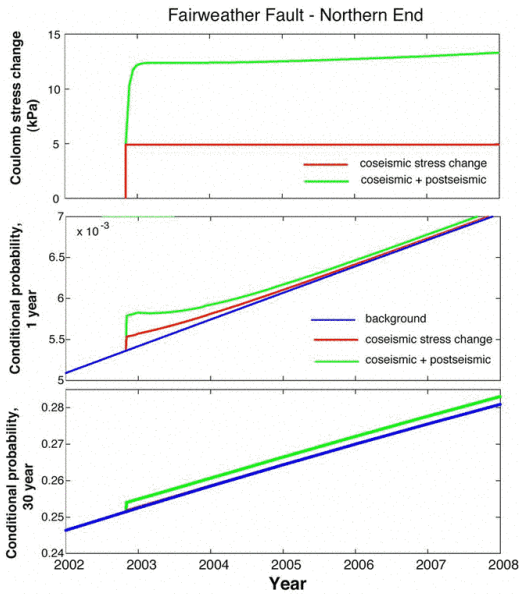
Alaska
Time-Dependent Hazards

Method Part 2:
Hardebeck determines time-dependent quake probabilities using Pollitz stress transfer calculations -
Shown here for 2002 Denali and the Fairweather fault

Her probability model employs Fairweather fault slip-rate and background (time-dependent) probability and
assumes Dieterich [1994] rate-state behavior for the relationship between stress change and time to failure.

Figure from Hardebeck



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