EARTHSCOPE SEMINAR
PAPER SUMMARY
APRIL 9, 2007
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PAPER TITLE: Fine-scale structure of the San Andreas fault zone and location of the SAFOD target earthquakes

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Overview

A primary goal of the San Andreas Fault Observatory at Depth (SAFOD) project is to drill into the rupture patch of a magnitude 2 earthquake, a task requiring that the estimated hypocenter be determined to within 100 meters of the absolute fault location. This paper seeks to quantify the accuracy of hypocenter location by comparing results from three separate tomographic inversion methods as well as a "virtual" earthquake method.

Data

- Earthquake and explosion arrival time collected by short period instruments, consisting of 90,000 arrival times (65%P, 35%S) from 800 local earthquakes and 100 explosions:
  - SAFOD Pilot Hole borehole geophones
  - PASO (Parkfield Area Seismic Observatory)
  - Berkeley High Resolution Seismic Network
  - USGS Central California Seismic Network
- Gravity data of [*McPhee and Jachens*, 2004]

Methods

- Joint inversion of data for earthquake locations and 3D V_p and V_p/V_s structure using 3 tomographic inversion codes:
  - *simul2000* – 3D model with 1-km grid and 2D model with 500 m grid near the fault
  - *tomoDD* – double difference to determine a 1-km grid model
  - *tomoGRAV* – 1D starting model, 200 m grid; jointly fits arrival times and gravity data
- Locations of "virtual earthquakes" using shots and borehole geophones

Results

- Crustal structure in the vicinity of the SAF in Parkfield is consistent between the different inversions with a sharp horizontal velocity gradient that steps several hundred meters at 2 km depth near fault.
- The tomography and resistivity models are consistent and both show inferred regions of high fluid content.
- Average location estimate place the desired earthquake 1 km E and 1.3 km N of the SAFOD Pilot Hole at 2.9 km below the surface with a scatter of ~100 m horizontally and ~180 m vertically
- "Virtual earthquakes" method locates the hypocenter with an accuracy of 50 m near the SAFOD Pilot Hole.

Implications

- Further improvement of location accuracy is needed for targeting the rupture patch; the SAFOD project requires the hypocenter be located with ~100 m accuracy.
- Virtual modeling suggests this is possible with future improvement of velocity structure and improvement of the models.

Additional Thoughts

- Active source experiments near the SAFOD borehole will improve velocity models and reduce disagreement among the models
- "Virtual" experiments will continue to improve source location and knowledge of regional structure.