THE VELOCITY CHANGE CAUSED BY THE 2004 M 6.0 PARKFIELD EARTHQUAKE ON THE SAN ANDREAS FAULT

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2010/10/14
REFERENCE


OUTLINE

- Introduction
- Data and Results
- Discussion and Conclusion
Tectonic background
First array: fall in 2002
2003/1/1

Second array: 2003/10~11
2004/1/1

2004/09/28
M6.0 Parkfield earthquake

Third array: 2004/10~12
2005/1/1
First array: Array A: 35 PASSCAL RT130s and 2-Hz L22 sensors, spacing of 25m.
Array B and C: 9 RT130s, spacing of 50m.(2002)
Data: 3 explosions, PASO experiment, 3 earthquakes

Third array: Array A: 35 PASSCAL RT130s and 2-Hz L22 sensors, spacing of 25m.
Array B and C: 6 RT130s, spacing of 50m.(2004)
Data: 2 explosions, about 1000 aftershocks

(Li et al., 2004)
Second array:
Instruments: 30 RT130s in a 2400-m-long cross-fault array
    12 RT130s for 400 m along the main trace of the SAF
Station spacing: 50m~200m
Time: six-week, from mid-October to the end of November, 2003
Data: over 200 earthquakes with magnitudes less than 2.0
DATA AND RESULTS

- Explosions data
  Repeated shots

- Earthquake data
  Before earthquake
  After earthquake

- Aftershocks data
  Test1: site effect
  Test2: time effect
Repeated shots

First array
• Fall in 2002

Second array
• 2003/10~11

Third array
• 2004/10~12
Traveltimes of P, S, and fault-zone guided were delayed by several tens of milliseconds.
Figure exhibits vertical-component seismograms recorded at three stations of array A for shots in 2002 and 2004.

Moving-window cross-correlation technique (Niu et al. 2003)
Vertical-component seismograms recorded for repeated shot PMM.

\[
dV_s \quad \frac{85\text{ms}}{Vs \quad \sim 6.8\text{s}} = \sim 1.25\%
\]
Travel-time increases, for P, S, and trapped waves measured from cross-correlations of seismograms at array A for repeated shot PMM in 2002 and 2004.
DATA AND RESULTS

- Explosions data
  - Repeated shots

- Earthquake data
  - Before earthquake
  - After earthquake

- Aftershocks data
  - Test1: site effect
  - Test2: time effect
Shear-wave splitting

- polarization direction
- delay time

\( \sigma_H \): maximum horizontal compressive stress
\( \sigma_h \): minimum horizontal compressive stress
\( \sigma_v \): vertical stress
Before earthquake

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After earthquake
DATA AND RESULTS

- Explosions data
  - Repeated shots
- Earthquake data
  - Before earthquake
  - After earthquake
- Aftershocks data
  - Test1: site effect
  - Test2: time effect
21 clusters of repeated aftershocks

1. at least five repeated aftershocks occurring at the same place
2. the location difference among them smaller than 200m
3. the difference in magnitude smaller than 0.5
4. similar waveforms with correlation coefficient higher than 0.8
Test 1: site effect

Cluster 28 at 6.9km depth and 2km northwest of the array site
Cluster 24 at 6.4km depth and ~2km northwest of the array

R283 2004/10/09
R303 2004/10/29
Cluster 6 at 3.9km depth and ~8km northwest of the array.
R289  2004/10/15
R321  2004/11/16
Cluster 6 at 3.9km depth and ~8km northwest of the array.

R289  2004/10/15
R321  2004/11/16

~1.1% within the rupture zone
~0.5% out of the zone
Test 2: time effect

Cluster 29 at 6.5km depth and ~2km northwest of the array.

- R282 2004/10/07 31 days
- R312 2004/11/07
- R334 2004/11/28 28 days
- R362 2004/12/26

Vertical-component seismograms recorded at station W4 of array A
Cluster 28 at 6.9km depth and 2km northwest of the array.

- R284 2004/10/10
- R309 2004/11/04
- R339 2004/12/03
- R353 2004/12/17

Vertical-component seismograms recorded at station W4 of array A.
DISCUSSIONS AND CONCLUSIONS
(Hardebeck and Michael, 2004)
Fault-Zone Rock Damage and Healing Progression

Cumulative Velocity Changes (%)

- $dV_s/V_s = -1.25\%$
- $dV_s/V_s = +1.1\%$

Events:
- Shot PMM (10/16/2002)
- Shot PMM (12/28/2004)
- M6 (09/28/2004)
THANK YOU FOR YOUR ATTENTION.