Approaching the 5th anniversary of the 2002 M7.9 Denali Fault Earthquake

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Photo by W. Wallace
Earthquake Sequence

- Started with the M6.7 Nenana Mountain earthquake on October 23, 2002
- The main Denali event on November 3, 2002 started with the M7.2 thrust sub-event on previously unknown splay fault
- Continued as right-lateral strike slip event along main Denali fault
- Rupture transferred onto Totschunda branch
Internet Community Intensity Map

Microseismic study

- Not detailed enough
- Maximum Intensity VIII

By A. Martirosyan, 2003
- Maximum reported Intensity - IX
Measured Surface Offsets

- Total of 342 km of surface faulting
- Maximum horizontal 8.8 m
- Maximum vertical ~2.8 m

Haeussler et al., 2004
Directivity Effects

Energy from the largest subevent (#3) propagated mainly to the southeast.
Plot by A. Frankel (USGS)
Co-seismic Motions (from GPS)

By S. Hreinsdottir et al., 2003
Co-seismic Motions (from GPS)

S. Hreinsdottir, 2006
Sub-surface Slip Distribution

- Dreger et al., 2002-2003
- Based on regional seismic data and GPS displacements
ShakeMap

- Produced within days of the quake
- Based on ~50 measurements in the state (2/3 from Anchorage)

- By D.Wald (USGS), 2003-2004
- Composite dataset: ground motion measurements, microseismic survey, slip distribution
Distal effects

- Felt as far as Washington State (~1,000 km away)
- Triggered seismicity at volcanic and geothermal centers (up to 3,000 km away)
- Seiches in distant lakes and pools (up to 3,000 km away)
Early Aftershocks

2 hours of data = 40+ M>=4 aftershocks

After S. Estes and S. McNutt
Aftershock Statistics

Cumulative Number:
>40,000 Recorded aftershocks

Magnitude vs log time, minutes

Magnitude of completeness

Decay rate

aftershocks1.mat - b(t), n_i = 150

Mc=1.5
Regional Seismicity

Before 2002
Regional Seismicity and Recorded Aftershocks
**b-** and **a-values** for the aftershock sequence

- **b-value**
- logN = a.bM
- **a-value** (activity rate)

- **b-value** is mapped on 0.1x0.1° grid with the nearest 150 events per sample.
- The highest **b-values** (b=1.4) are found near the epicenter. The eastern part of the rupture is characterized by much lower **b-values** (b=0.7).

- **a-value** is computed for volumes of radii 5 km. The highest activity is near the epicenter. The eastern part of the rupture is characterized by lower aftershock productivity.
Seismicity rate changes

- We observe a significant increase in the seismicity rate within the epicentral region of the M7.9 event (node A).
- A less sharp decrease in the seismicity rate is observed ~100 km north of the M7.9 epicenter (node B).

- Seismicity rate change (or β-value) is mapped on 0.1x0.1° grid with the nearest 100 events per sample using seismicity with M>=1.6.

We observe a significant increase in the seismicity rate within the epicentral region of the M7.9 event (node A). A less sharp decrease in the seismicity rate is observed ~100 km north of the M7.9 epicenter (node B). Seismicity rate change (or β-value) is mapped on 0.1x0.1° grid with the nearest 100 events per sample using seismicity with M>=1.6. The time period 1989-2000 is compared with 2000-09/2002.
Focal mechanism data

P wave first motion and Moment tensor inversion
Stress Field: Maximum Horizontal Compressive Directions

Faulting Style:
- Strike-slip
- Normal to strike-slip
- Normal Reverse
- Reverse to strike-slip
- Unknown
Conclusions

• The M7.9 2002 Denali fault earthquake was a complex event.
• Rich aftershock dataset is still being assembled.
• It will take ~9 more years for seismicity to go back to the background level.

• The 2002 Denali earthquake is being used as a model event to forecast rupture effects in other areas, such as rupture of the San Andreas fault in California.