The 2002 Denali Fault earthquake: insights from geophysics

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The 2002 Denali fault earthquake was the largest on-land strike-slip earthquake in the United States since 1857. It ruptured three faults in sequence, with over 300 km total rupture length. Geophysical investigations have focused on determining the geometry of the fault(s) at depth, deriving a slip model for the earthquake from geodetic displacements and seismic records, determining the pre- and post-earthquake stress fields, and studying the postseismic deformation that was caused by the earthquake. Aftershocks outline, in general, the extent of the rupture, but often result from failure of nearby faults. The aftershocks following this event show considerable geometric complexity. Slip models show that most of the seismic energy was released in two or three zones along the fault, with most slip occurring in the eastern part of the rupture. Geophysical slip models are in good agreement with the surface offset observations made by geologists. Earthquake focal mechanisms before and after the earthquake show that the regional stress field is compressional, with the maximum compressional axis located nearly normal to the Denali fault. The stress field after the earthquake shows almost the same orientation. This suggests that the Denali fault is probably mechanically weak (or has very high fluid pressures within it) to allow it to slip under such a stress field. Finally, following the earthquake we have observed rapid deformation persisting for months, caused by a combination of post-seismic processes including continued slip on the fault, poroelastic relaxation, and viscous relaxation of the lower crust and/or upper mantle.