Significant (Induced?) Earthquakes in the Central and Eastern US Since 2008

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683 M4+ EQs 2008–Present

M4+ Earthquakes 2008-Present
M4+ Earthquakes in CEUS

- 39 in CEUS
- 13 Tectonic
- 8 Induced
- 18 Potentially Induced
- 5 M≥5
Seismicity Rate Doubled
2001–2011 – This Appears to Come from 3 regions


- Oklahoma: N = 112
- Guy, Arkansas: N = 56
- Raton Basin: N = 93
- Remainder of Midcontinent: N = 245

Expected Number = 234
Cumulative Number of Earthquakes for $M \geq 3$

Observed
Linear Fit
2001–2009 Fit
2009–present Fit
Oklahoma

- The largest earthquake in Oklahoma prior to the November earthquake was M 5.2.
- Recorded history is less than 200 years.
- Between 1960 and 2008 only 1 to 2 M>3 earthquakes occurred per year.
- Since 2009, there have been over 100 M 3+ earthquakes.
- Does the increase in activity reflect a natural or man-made cause?
- Was the November M 5.6 earthquake natural or triggered?
- Could a larger earthquake occur?
Induced Earthquakes on the Rise?

- Increasing demand for cleaner energy means more activities requiring injection of fluids at depth.
  - EGS (Enhanced Geothermal Systems)
  - Waste liquid disposal
  - Geothermal production
  - Tight shale gas exploitation (disposing of “fracking” fluids)
  - Coal-bed methane production
  - Carbon dioxide sequestration
- Earthquakes caused by these operations are becoming more widespread.
- Induced Earthquakes Have Exceeded 6.5

Recent Earthquakes in the CEUS
- Trinidad, CO 8/22/2011 Mw 5.3
- Mineral, VA 8/23/2011 Mw 5.8
- Snyder, TX 9/11/2011 Mw 4.4
- Fashing, TX 10/20/2011 Mw 4.8
- Prague, OK 11/06/2011 Mw 5.6
- Ardmore, SD 11/14/2011 Mw 4.0
- Youngstown, OH 12/31/2011 Mw 4.0

M4+ Earthquakes 2008-Present
Background Seismicity & Designated Induced Seismicity Regions

Induced Earthquakes are Presently Removed from the Hazard Maps