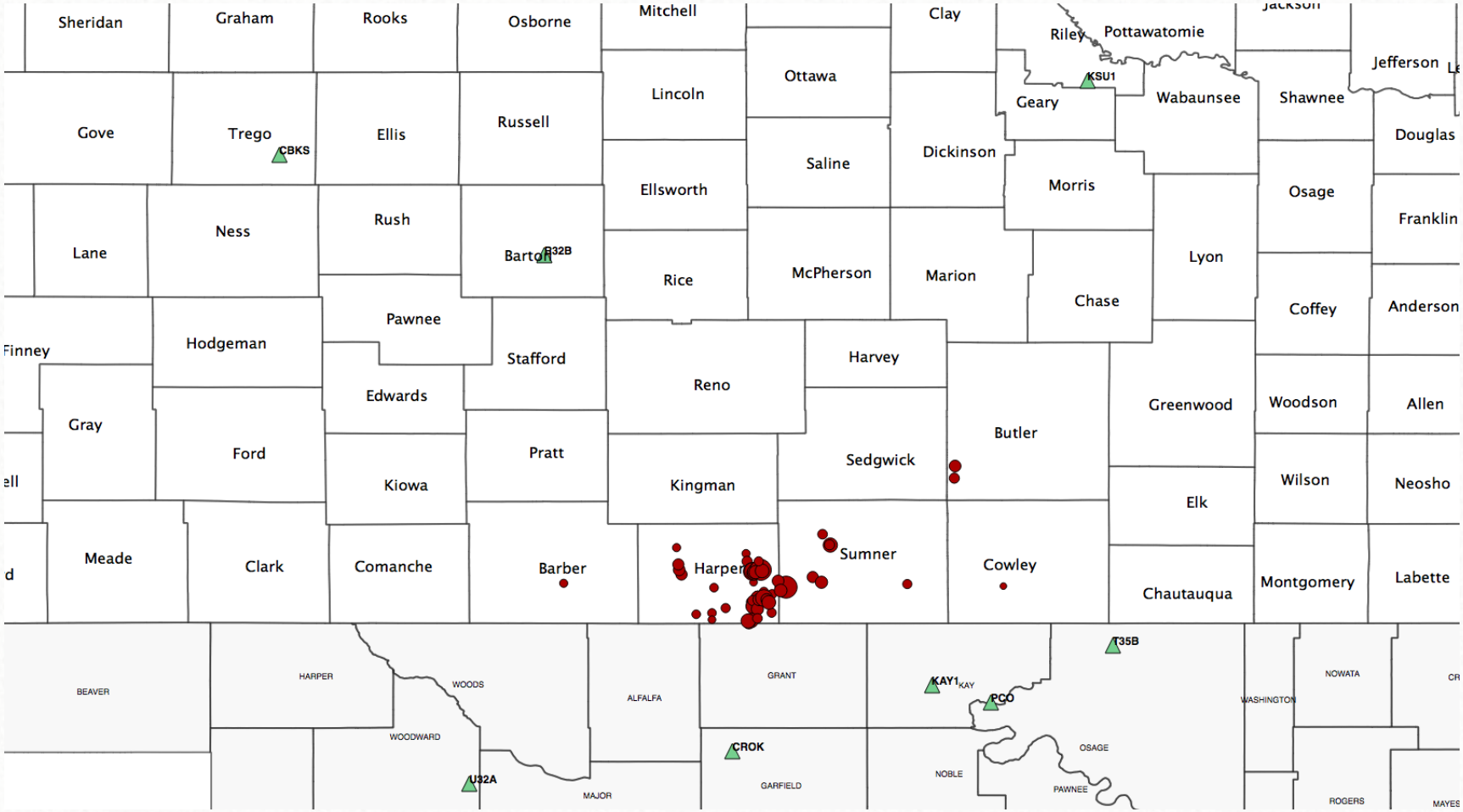
Potential for Induced Seismicity in Oklahoma

Austin Holland

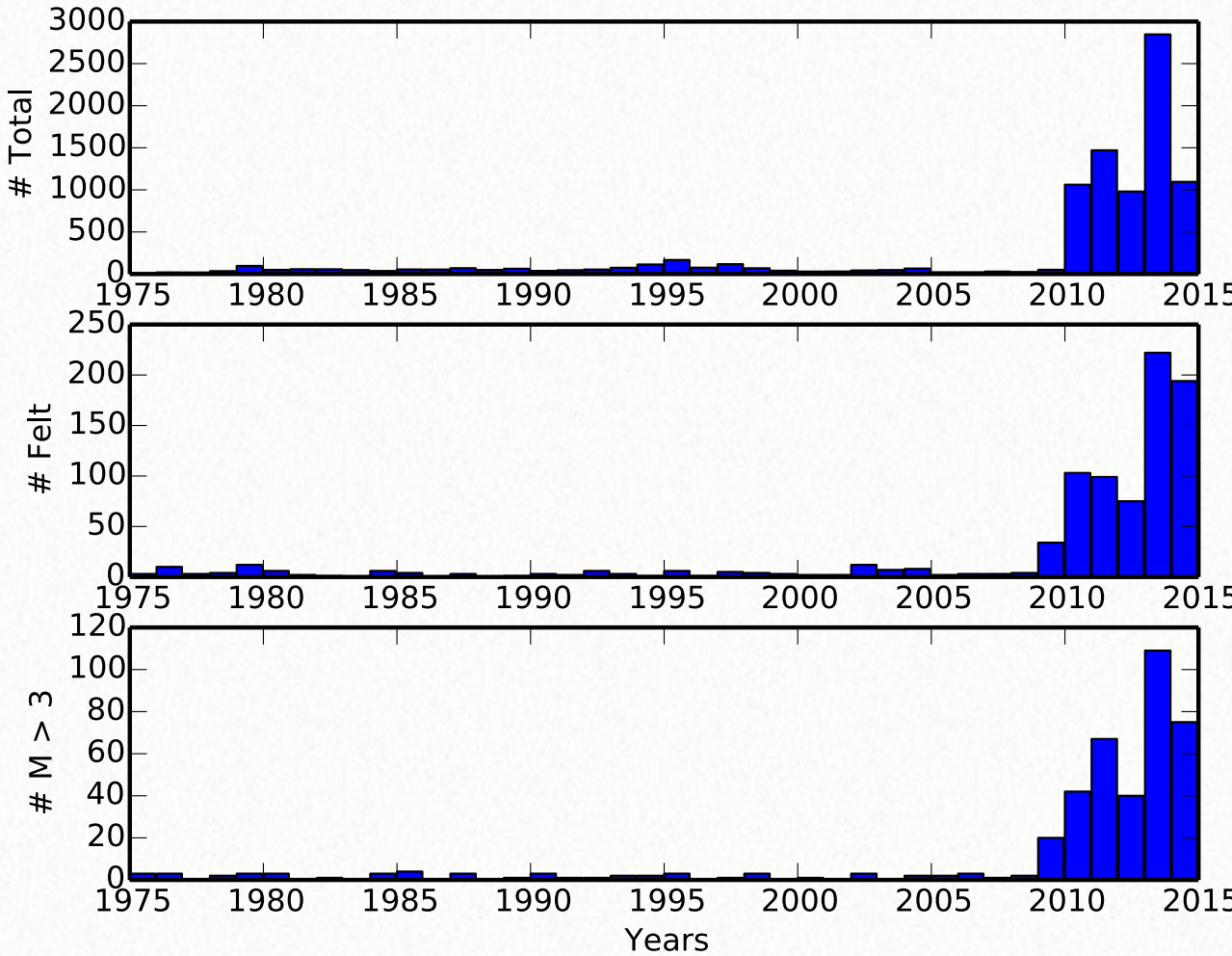
Oklahoma Geological Survey

KS Earthquakes and Seismic Stations

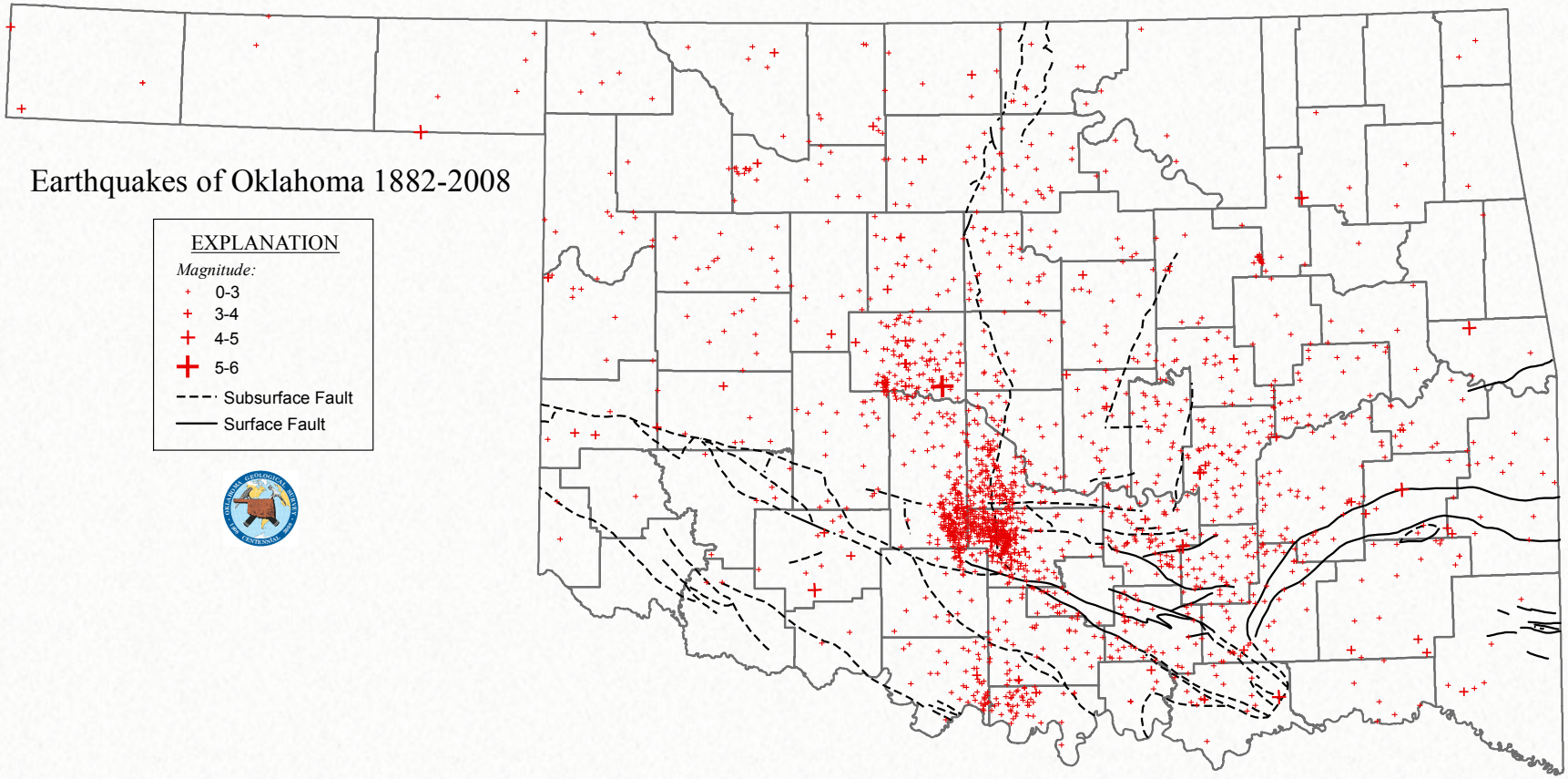


Seismicity Rate Increases in Oklahoma

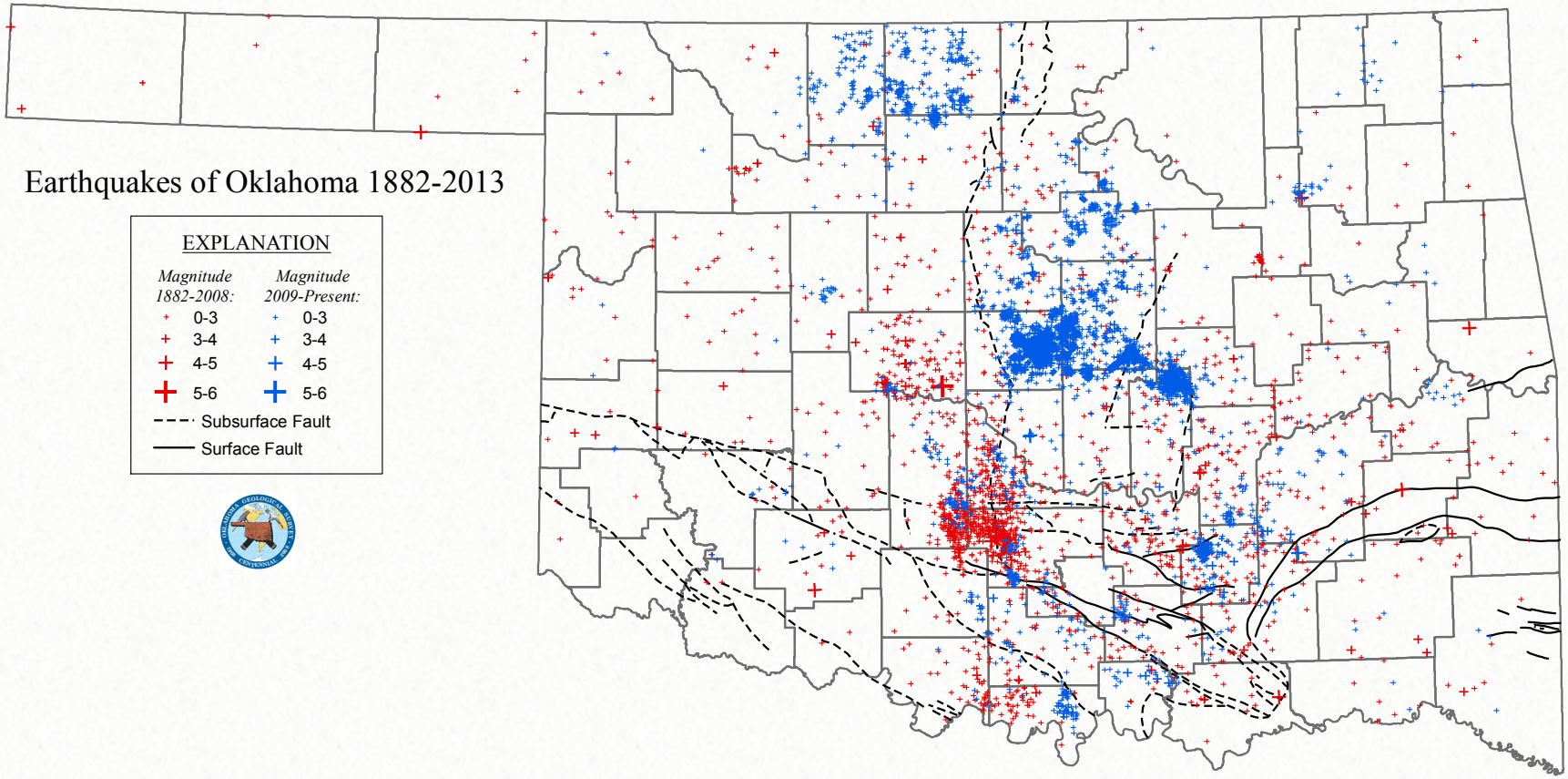
- Earthquake rates began accelerating in 2009
- And have continued to accelerate with a plateau 2010-’12
- Earthscope and temporary networks coincident with rate increase
- Increase is real because
  - # M>=3
  - # Felt Earthquakes



Earthquakes 1882-2008

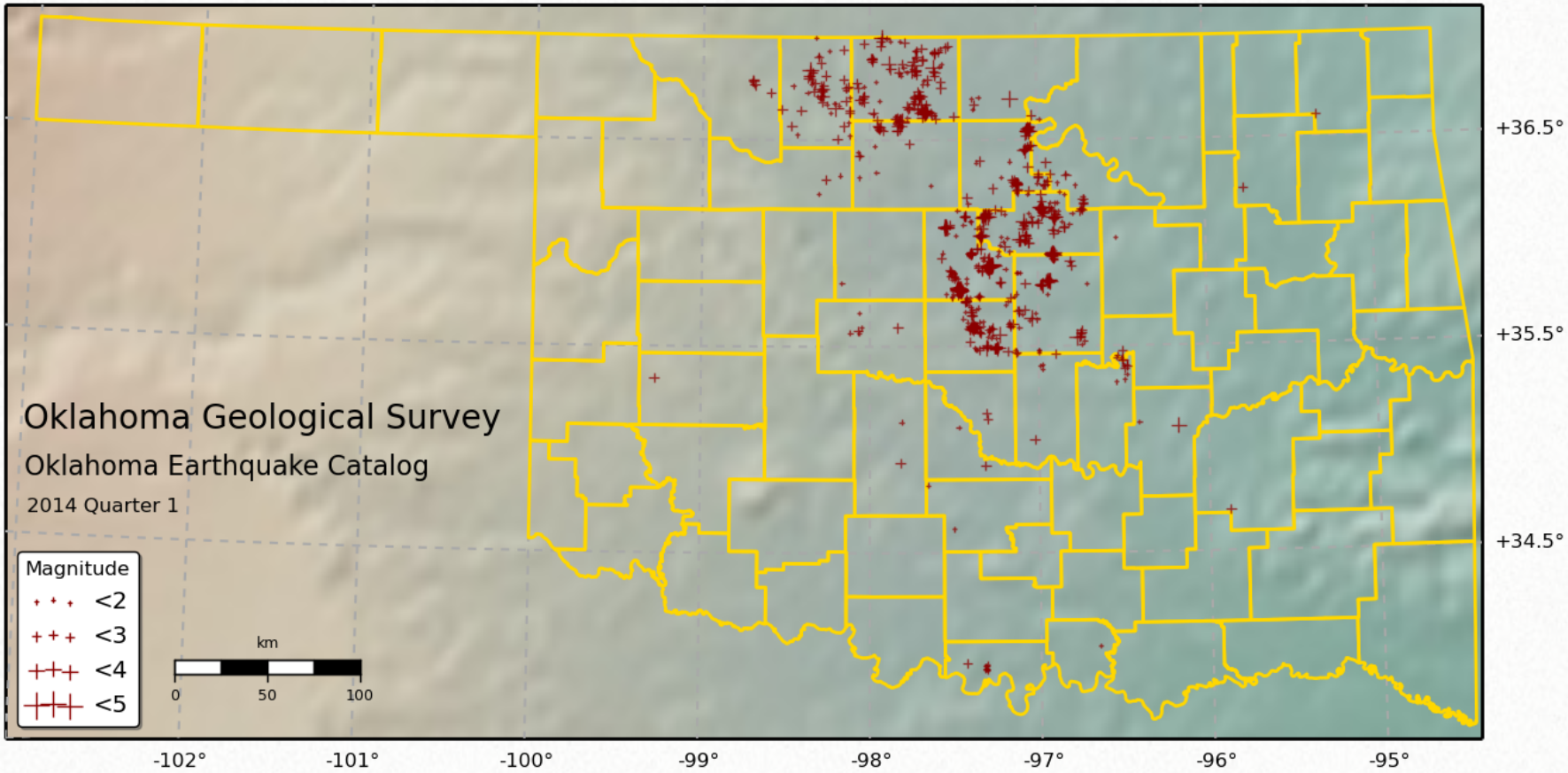


Earthquakes 1882-2013



Draft

2014 Earthquakes



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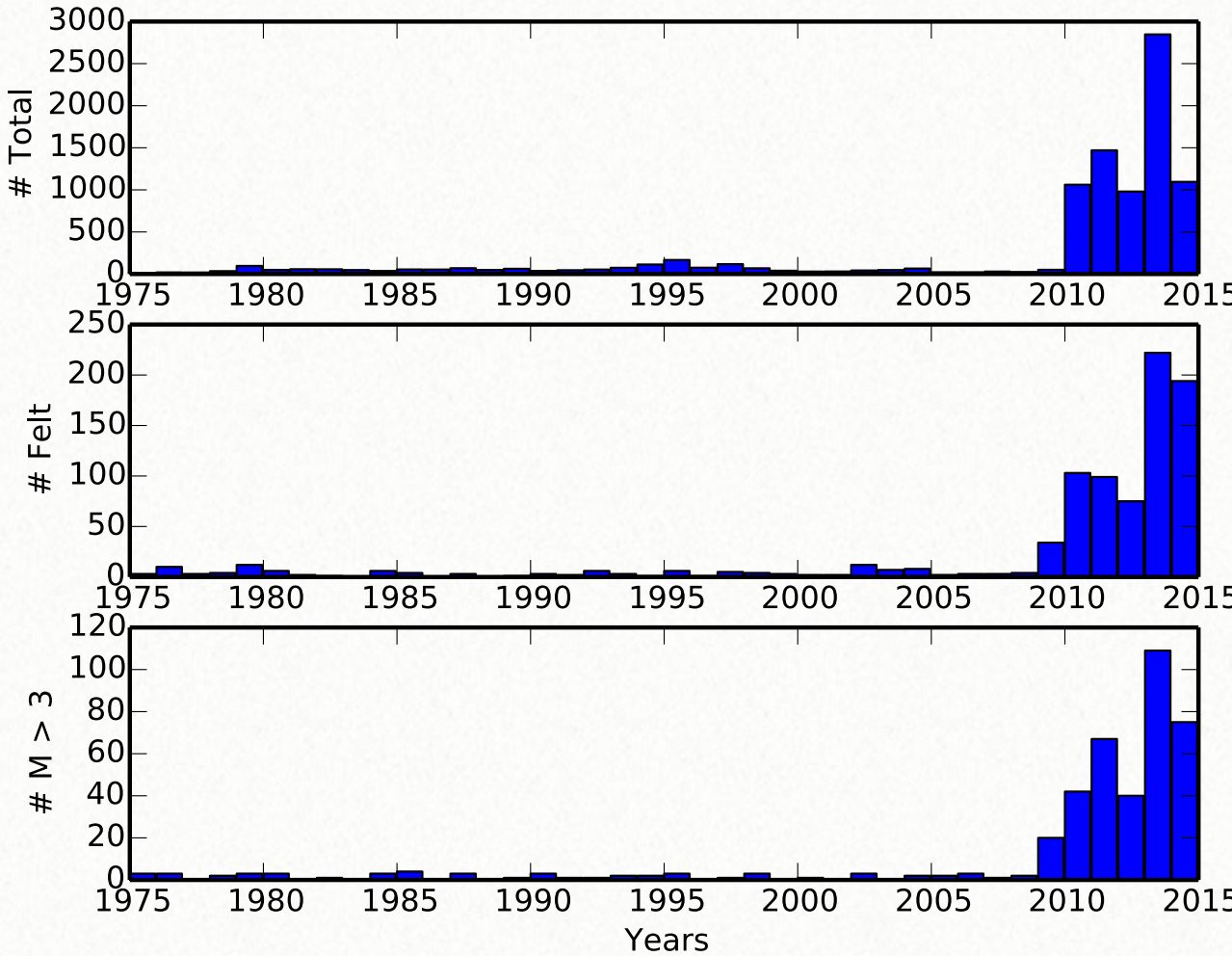
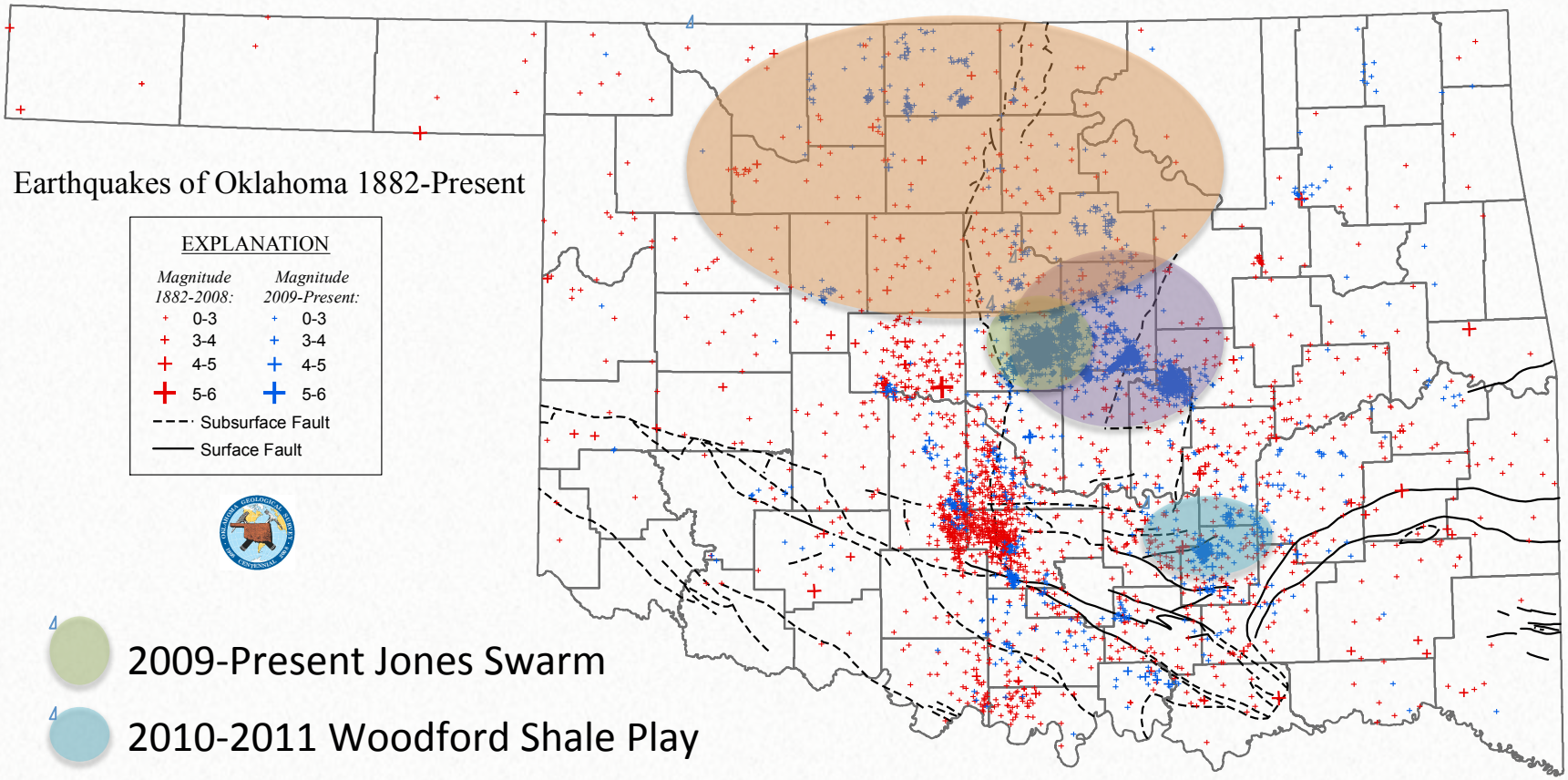


Earthquakes 1882-Aug. 2013

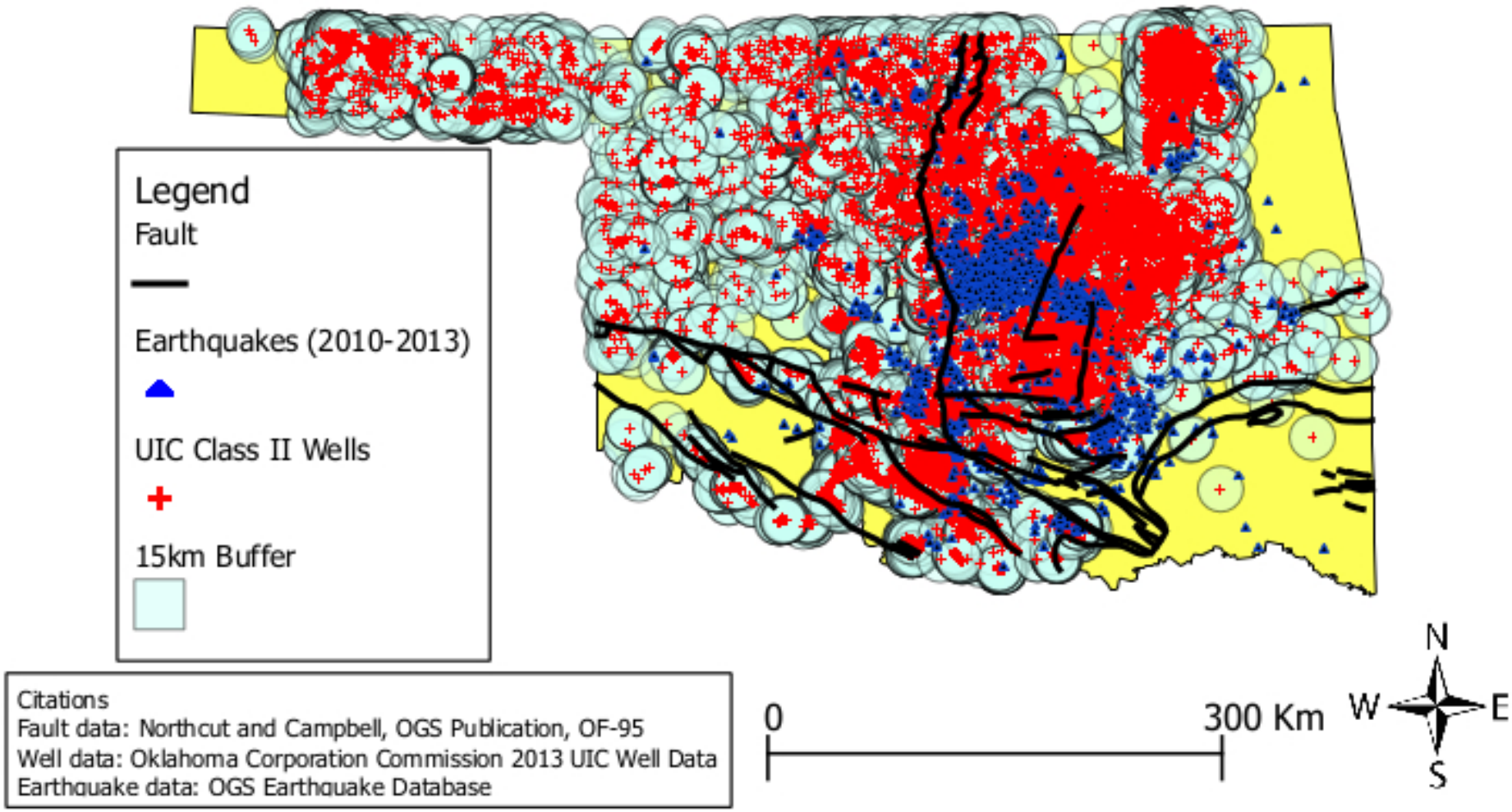


2009-Present Jones Swarm

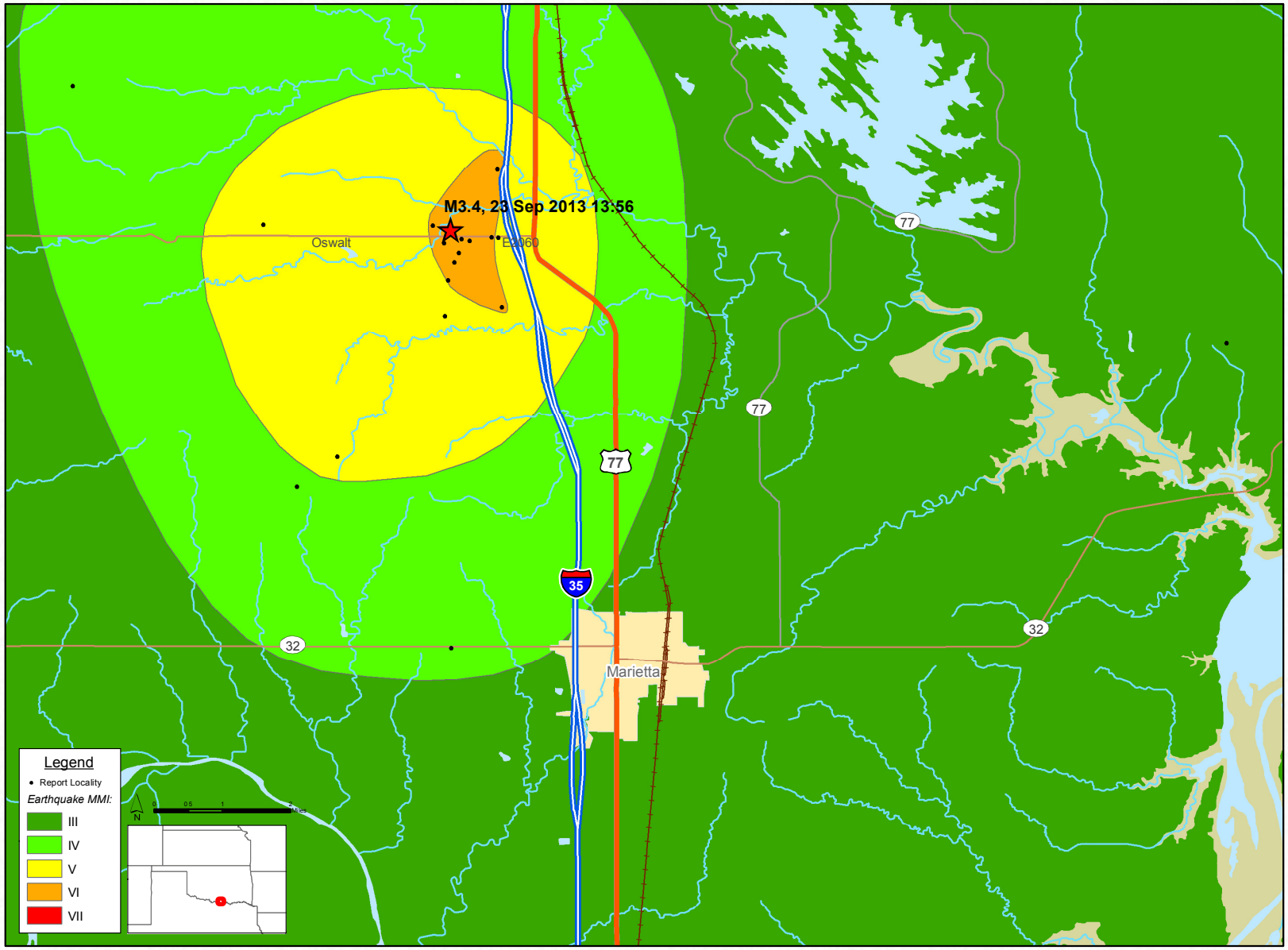
2010-2011 Woodford Shale Play

2011-2012 M5.6 Prague & Hunton Dewatering

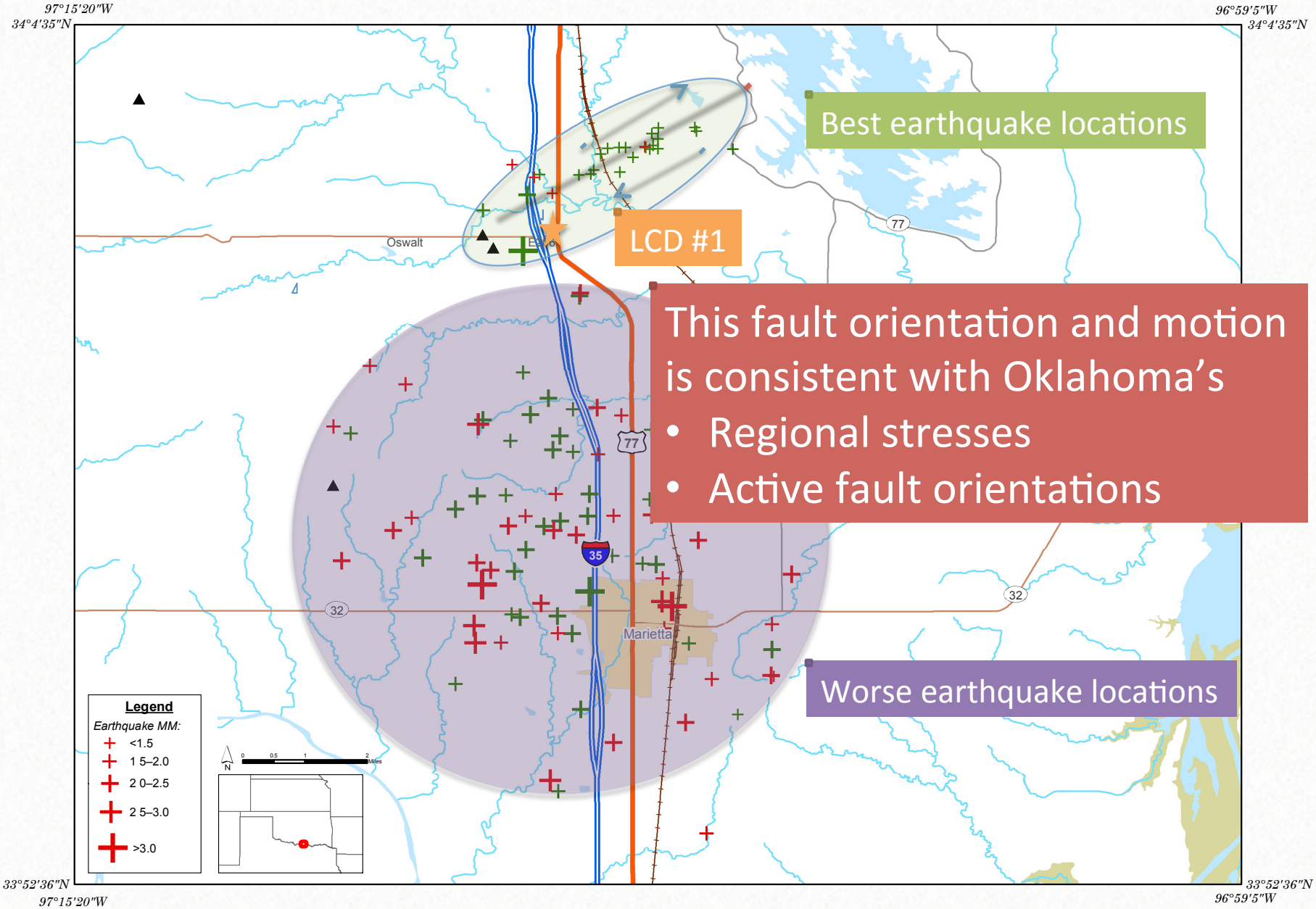
2012-Present Mississippi Lime Play


Legend
Fault
Earthquakes (2010-2013)
UIC Class II Wells
15km Buffer
Citations
Fault data: Northcut and Campbell, OGS Publication, OF-95
Well data: Oklahoma Corporation Commission 2013 UIC Well Data
Earthquake data: OGS Earthquake Database
0
300 Km
N
W
E
S

Minor Damage from Magnitude 3.4



Created 4:00 PM (CST) 09/26/2013

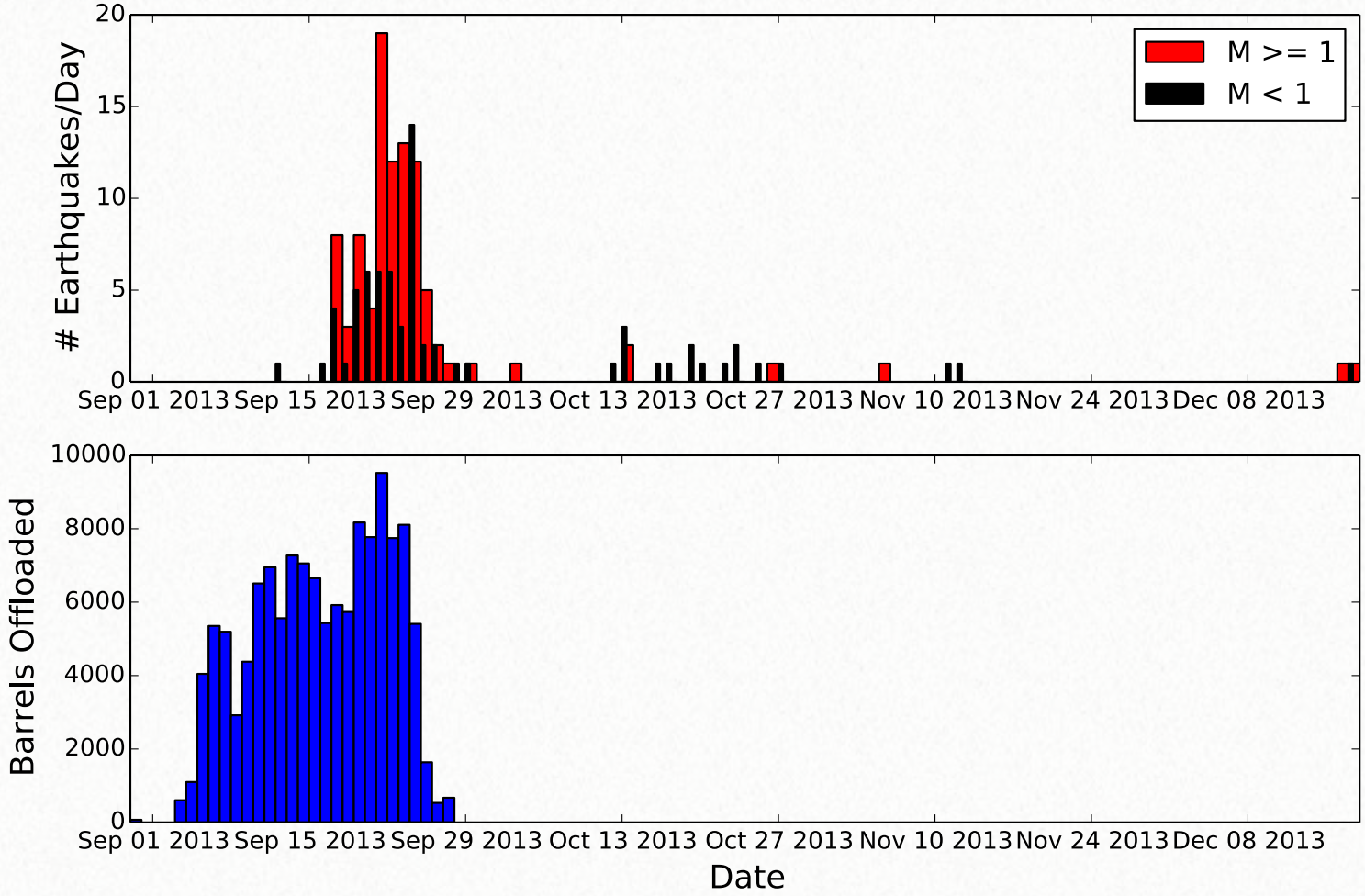


This fault orientation and motion is consistent with Oklahoma's

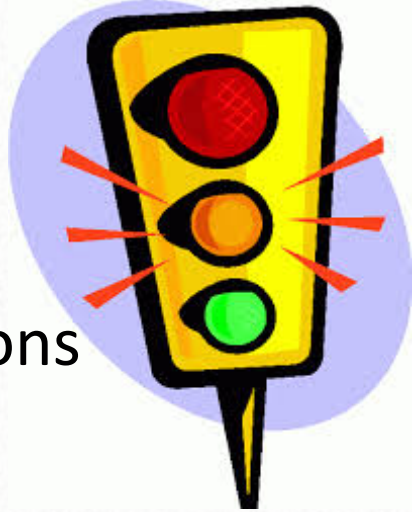
- Regional stresses
- Active fault orientations

Worse earthquake locations

Love County Injection and Earthquakes



Current Status

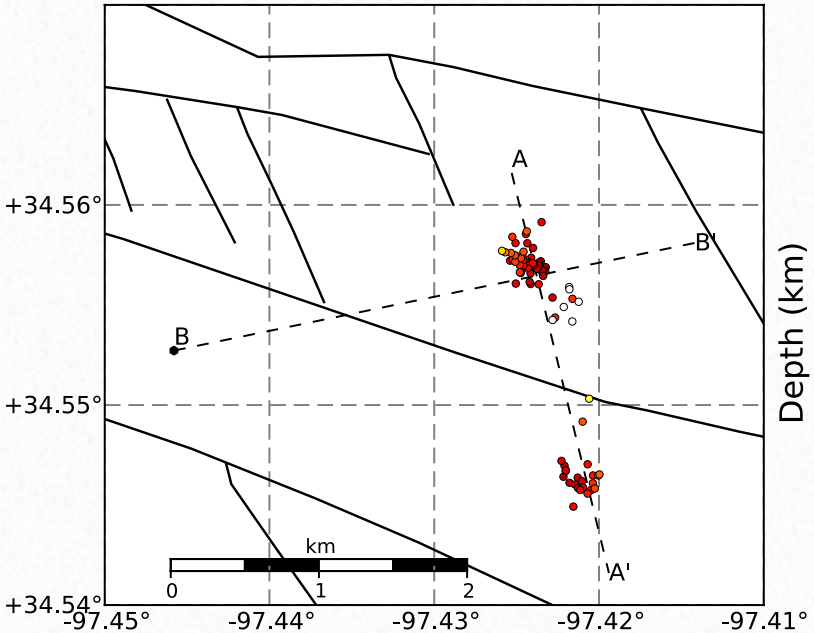


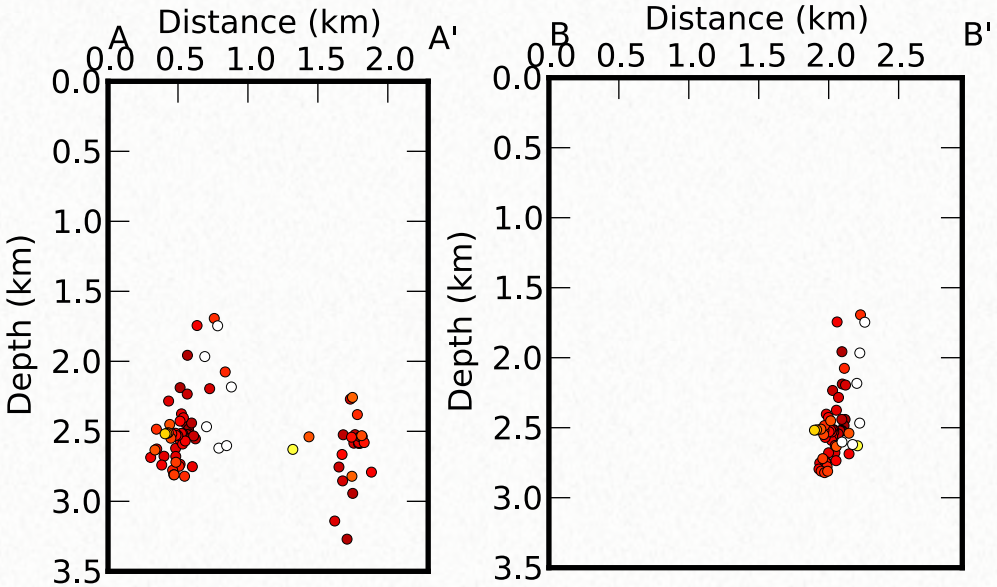
- The OCC has placed a yellow light on operations at the Love County Disposal Well #1 (LCD #1)
  - 1,000 bbls/day and 375 psi
  - This level is based off of the operators ability to run on one pump at 375 psi
  - Required to install a continuous pressure monitor
- Operator has stopped injecting, because at 1,000 bbls/day the operation is not economical
- There is another disposal well within 0.5 miles which is waiting to see what happens before going operational
  - Closer to the earthquakes than the LCD #1
  - Already drilled but not completed
  - Under same restrictions as LCD #1

Potential of Induced Seismicity from UIC Class II Wells

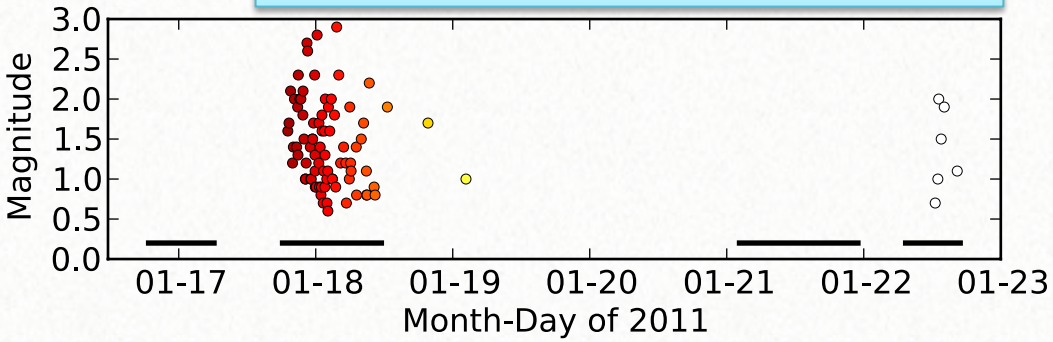
- 99% of Oklahoma's earthquakes occur within 15 km of a UIC Class II well
  - More than 80% of Oklahoma is within 15 km of a UIC Class II well (It would be hard not to have spatial correlations)
- Given the rate of known cases of induced seismicity (1:4,000) it is unlikely that the entire earthquake rate increase in Oklahoma is due to fluid injection from oil and gas
  - More than 4,000 UIC Class II SWD wells in Oklahoma
  - A couple of potential cases that have caused damage Prague & Love County, other potential cases identified and being documented
- Seismicity rate change of this scale may be unprecedented
  - If the majority of these earthquakes are induced this would be an even greater departure from what has been observed previously
- Developing a set of best practices, draft is available at:
  - http://www.gwpc.org/sites/default/files/event-sessions/Holland_Austin.pdf

Earthquakes triggered by hydraulic fracturing



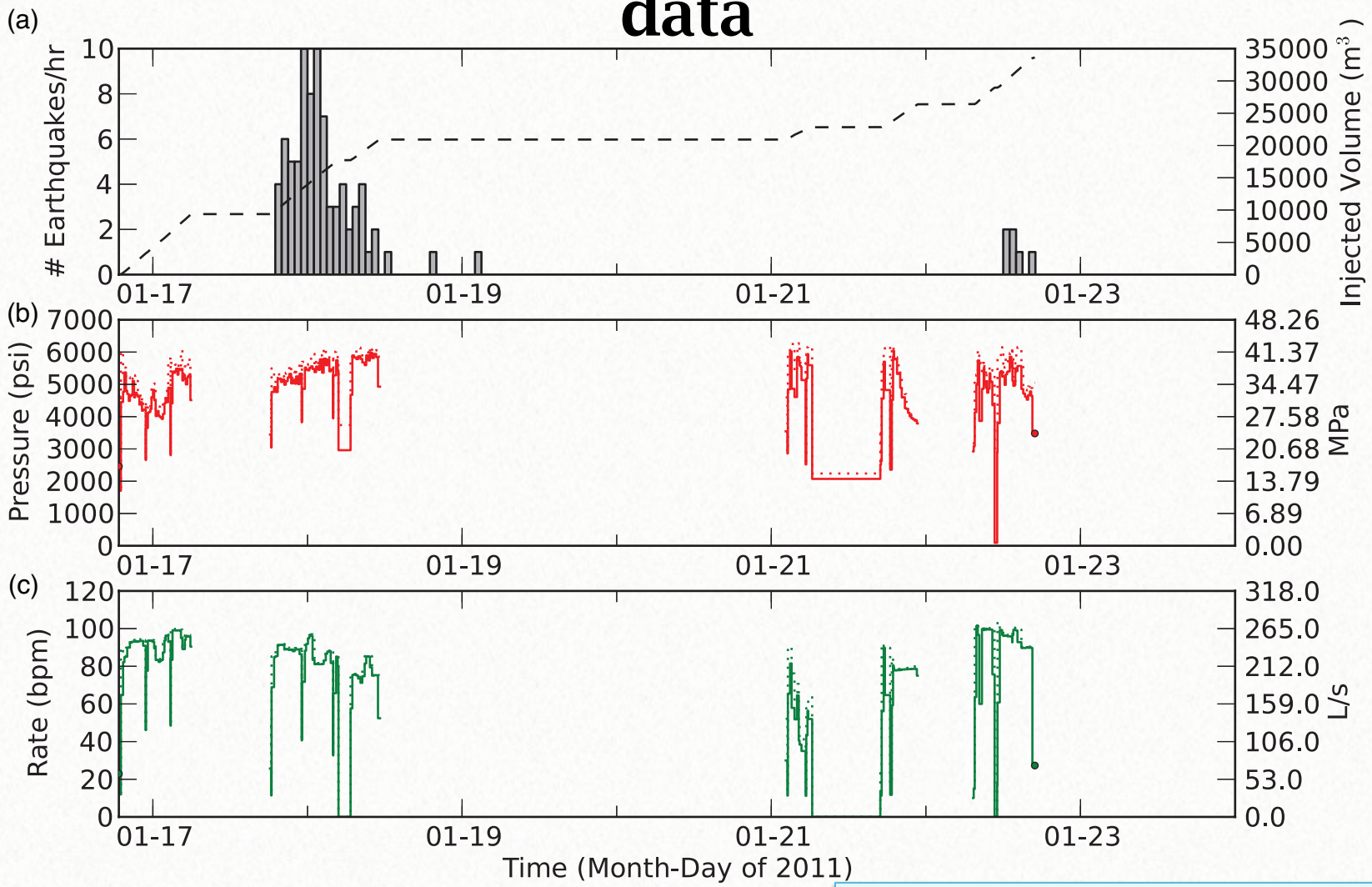


Holland, Bull. Seismol. Soc. Amer. (2013)



- Several earthquakes felt by one local resident
- Largest earthquake M 2.9
- 11 earthquakes >= M 2.0

Identification is “easy” when you have more information; took ~6 months to get injection data



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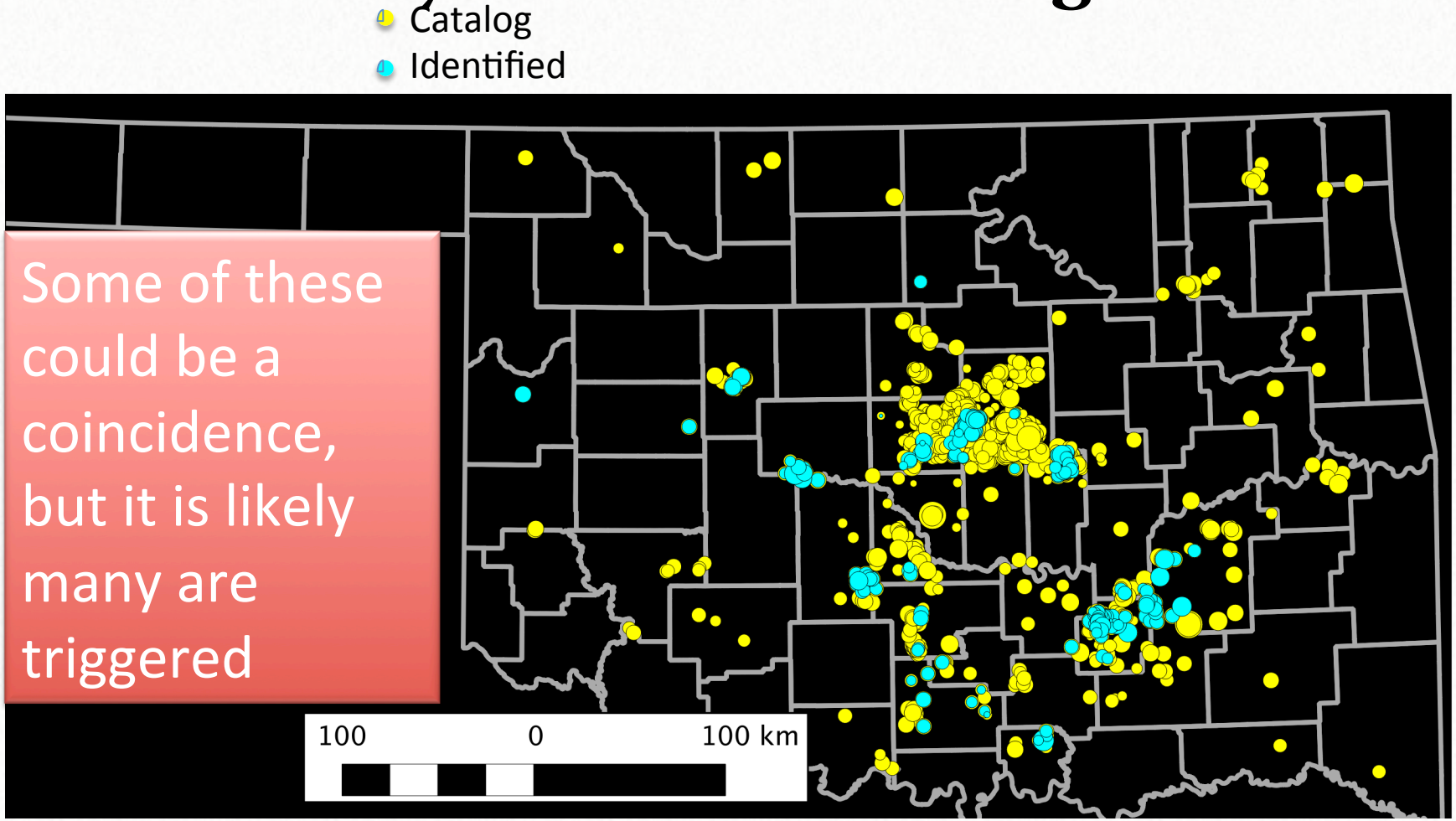
Potentially induced earthquakes from hydraulic fracturing



Earthquakes Triggered by Hydraulic Fracturing

- Generally, not considered the greatest risk for significant earthquakes
  - The number of earthquakes identified is greater than the number of earthquakes that would have been observed over the same time period prior to 2009
  - ~10 % of earthquakes for the study time
- Only a few of these cases have been identified fairly concretely, could be coincidences
- Still observing earthquakes likely triggered by hydraulic fracturing (some felt)
  - Looking at these in more detail

Questions or Comments?

austin.holland@ou.edu

(405) 325 - 8497