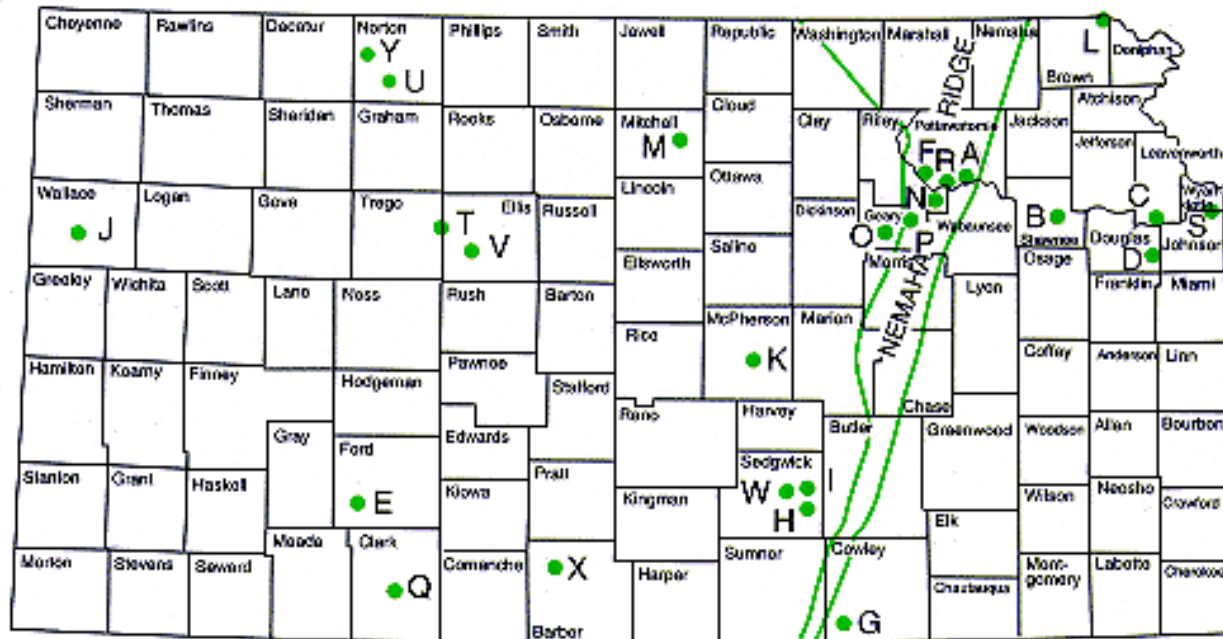


Recent Seismic Activity in Kansas: Events and Responses

Rex Buchanan
Kansas Geological Survey
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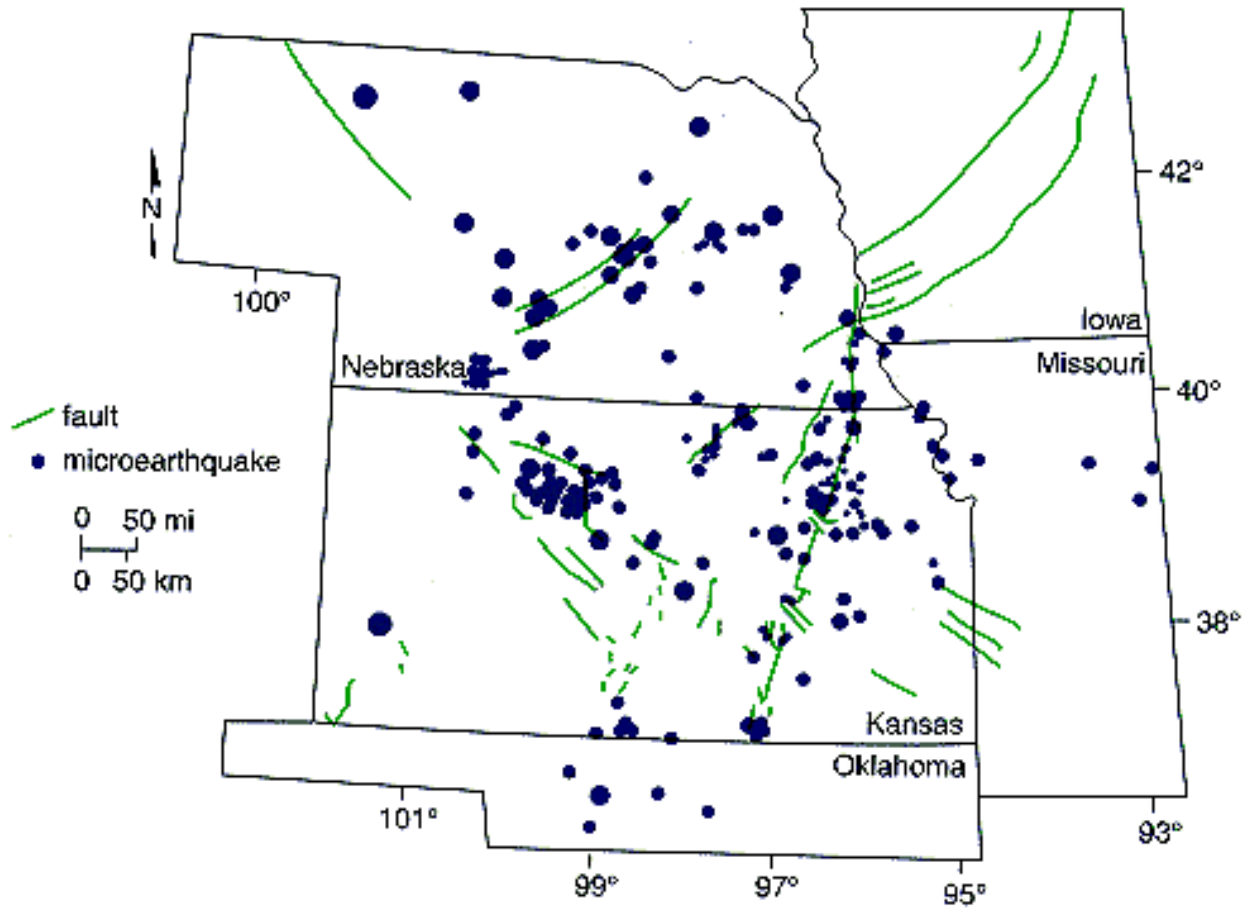
American Geosciences Institute
Critical Issues Webinar: Induced Seismicity in the Midcontinent
7 April 2015

Historic Kansas Earthquakes



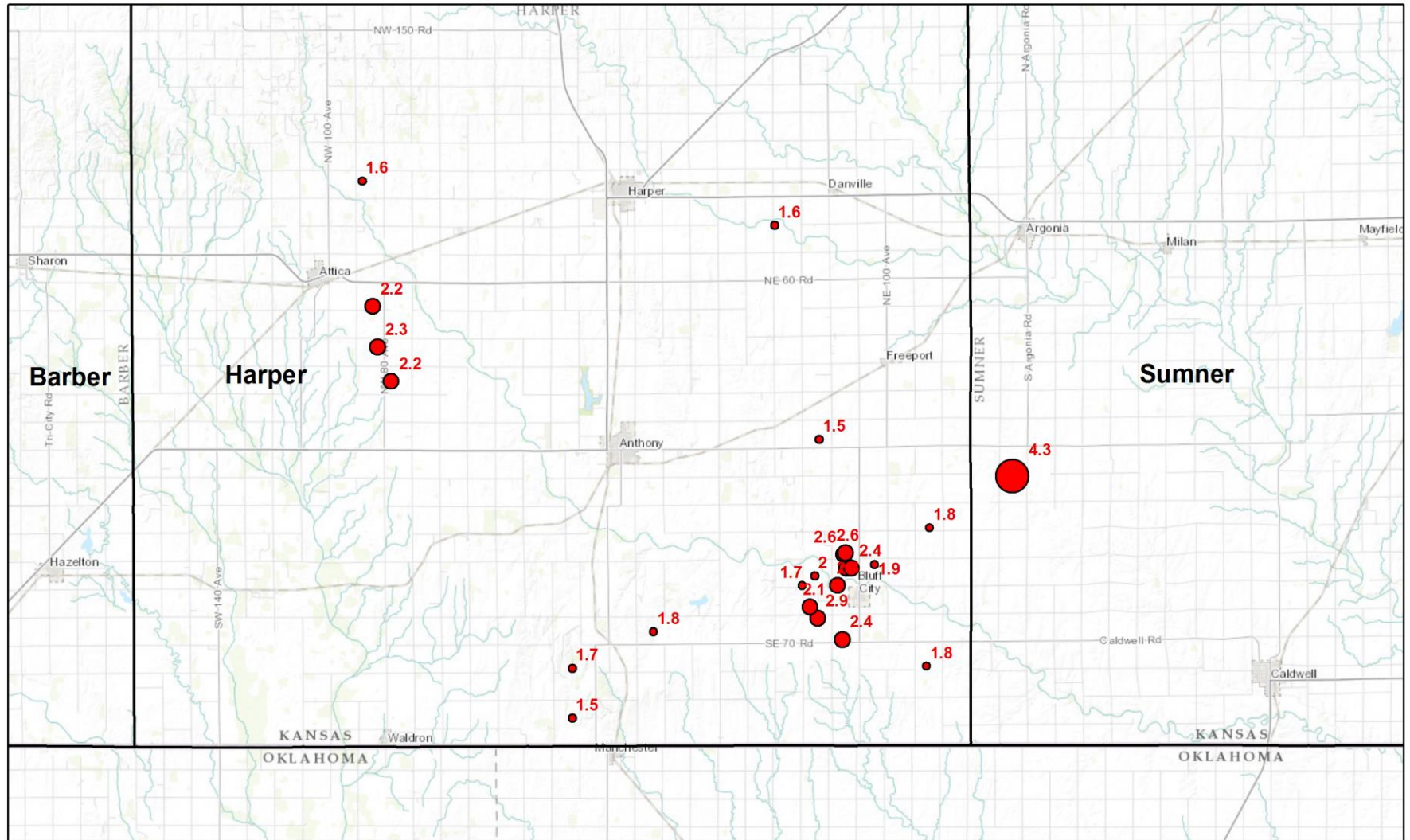
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B. 1875 V	G. 1907 IV	L. 1927 VI	Q. 1929 V	V. 1942 IV
C. 1881 III	H. 1919 IV	M. 1928 IV	R. 1929 V	W. 1948 IV
D. 1902 II	I. 1919 IV	N. 1929 V	S. 1931 VI	X. 1956 VI
E. 1904 IV	J. 1926 ?	O. 1929 V	T. 1932 V	Y. 1961 V

Midcontinent Micro-earthquakes, 1977-1989



Earthquake Activity - 2013

PRELIMINARY

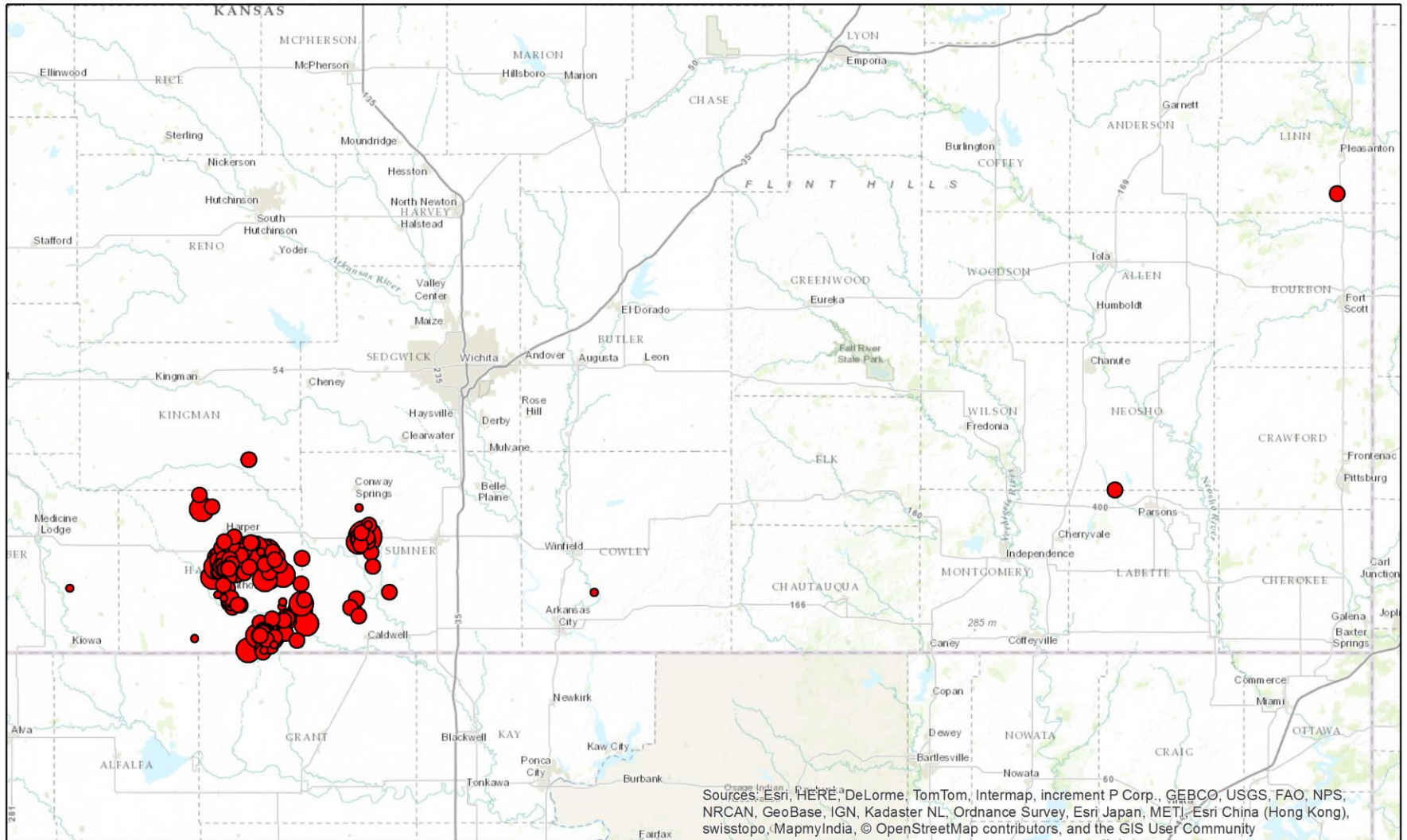


Kansas Geological Survey
Data from Oklahoma Geological Survey, USGS
18 March 2014

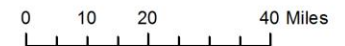


2014 Earthquakes

PRELIMINARY

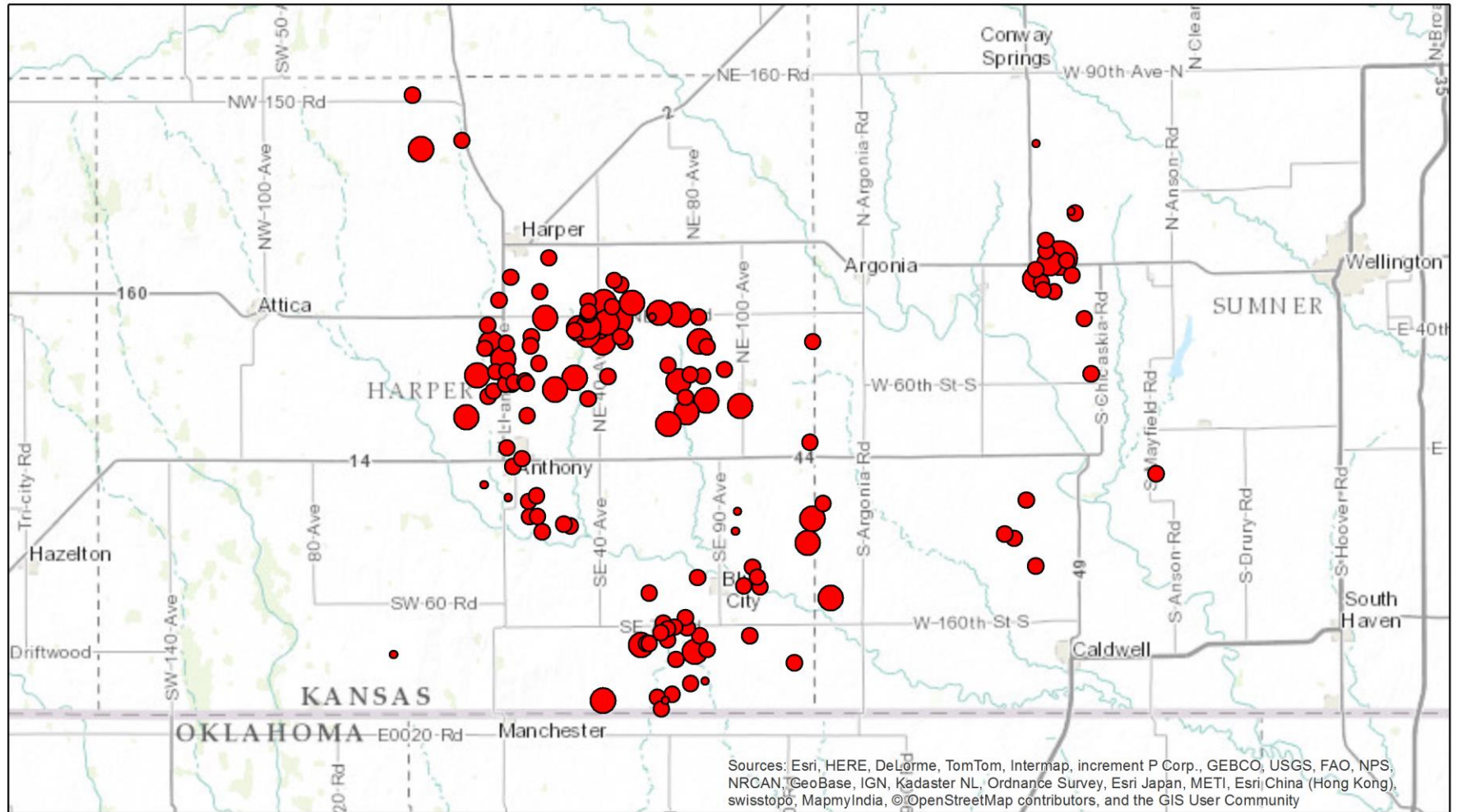


Kansas Geological Survey
Earthquake Data from Oklahoma Geological Survey, USGS
22 January 2015



2014 Earthquakes: Harper & Sumner Counties

PRELIMINARY



Kansas Geological Survey
Earthquake Data from Oklahoma Geological Survey, USGS
22 January 2015

0 2.5 5 10 Miles

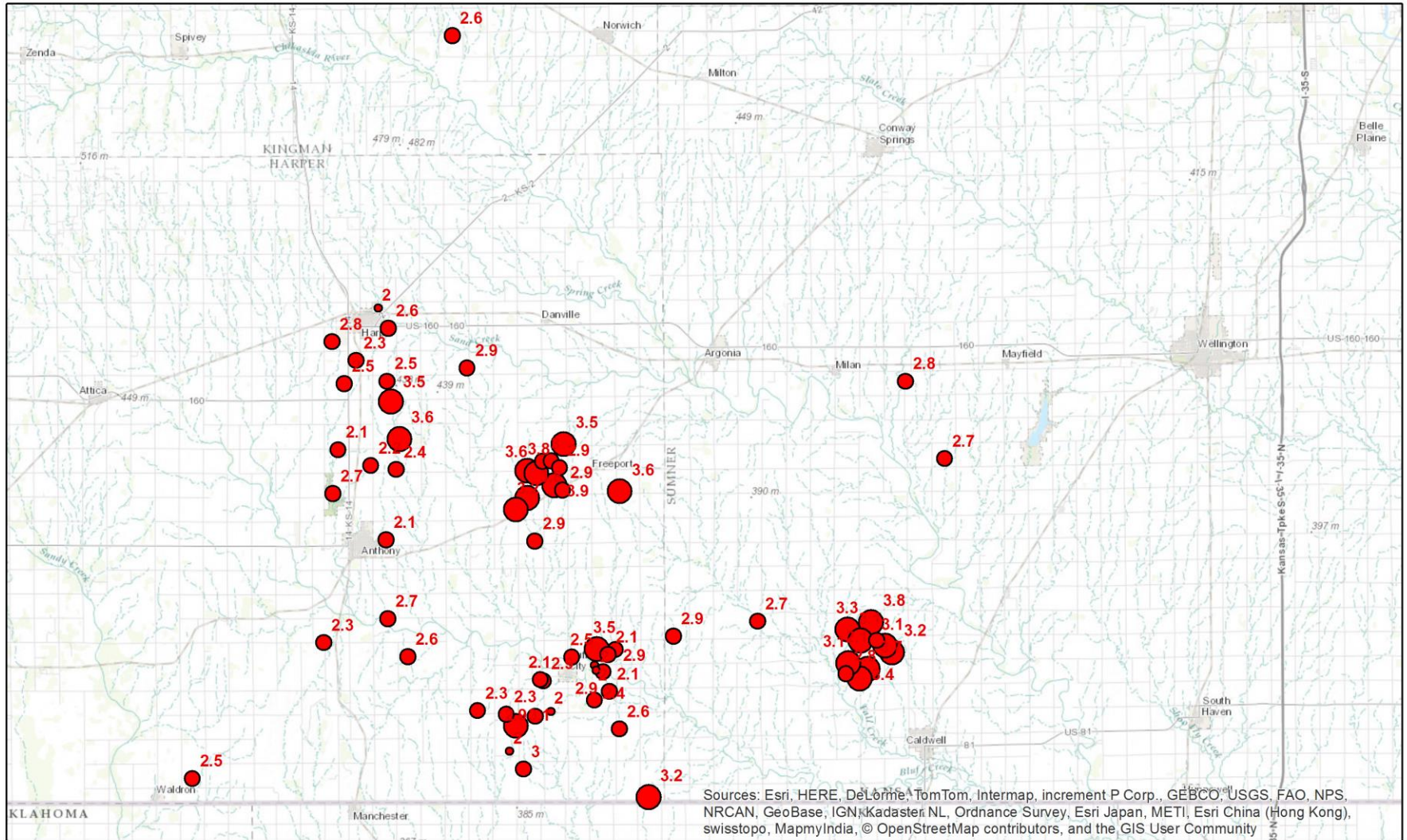
- 1.0 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0





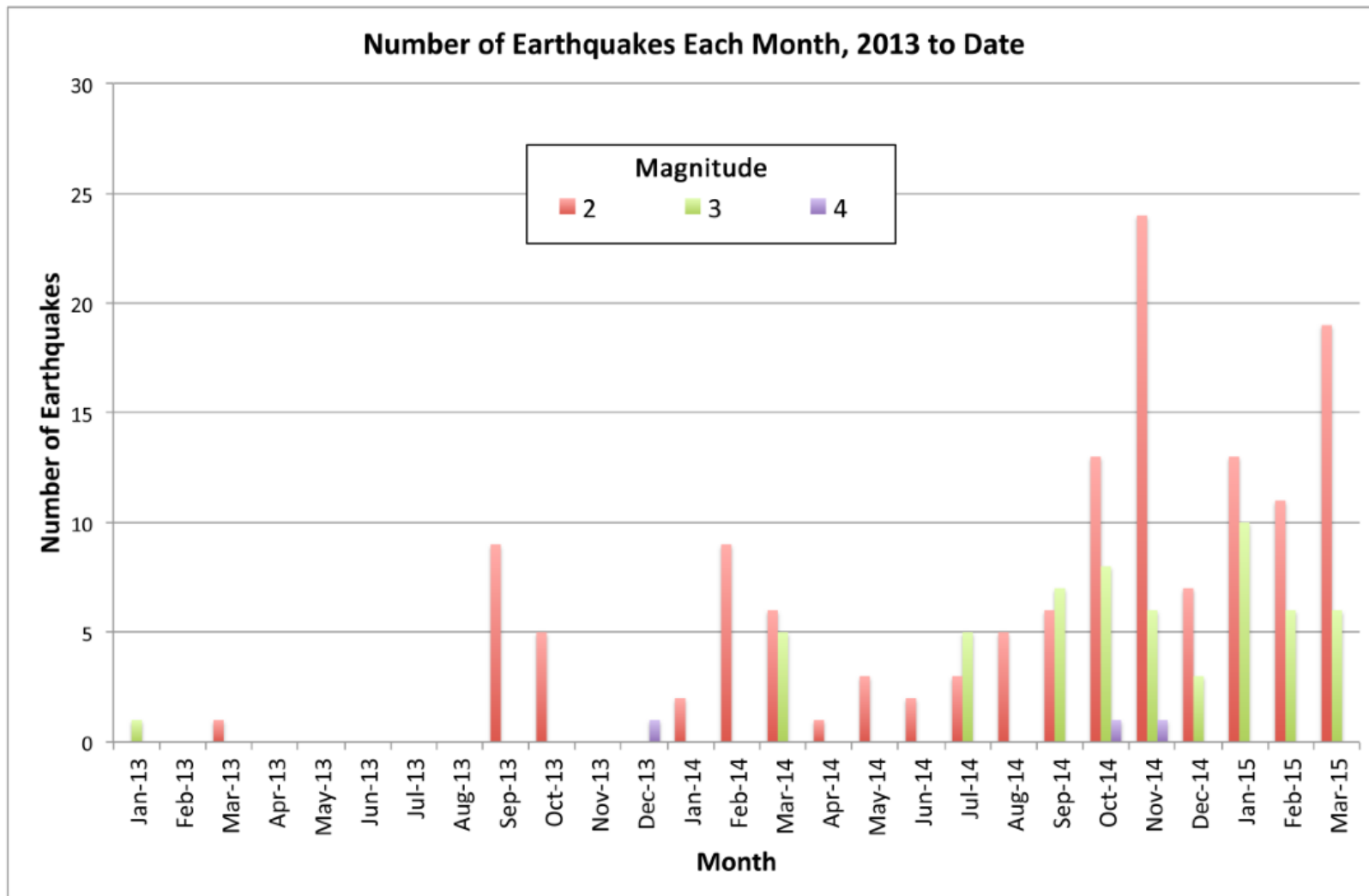
2015 Earthquakes

PRELIMINARY

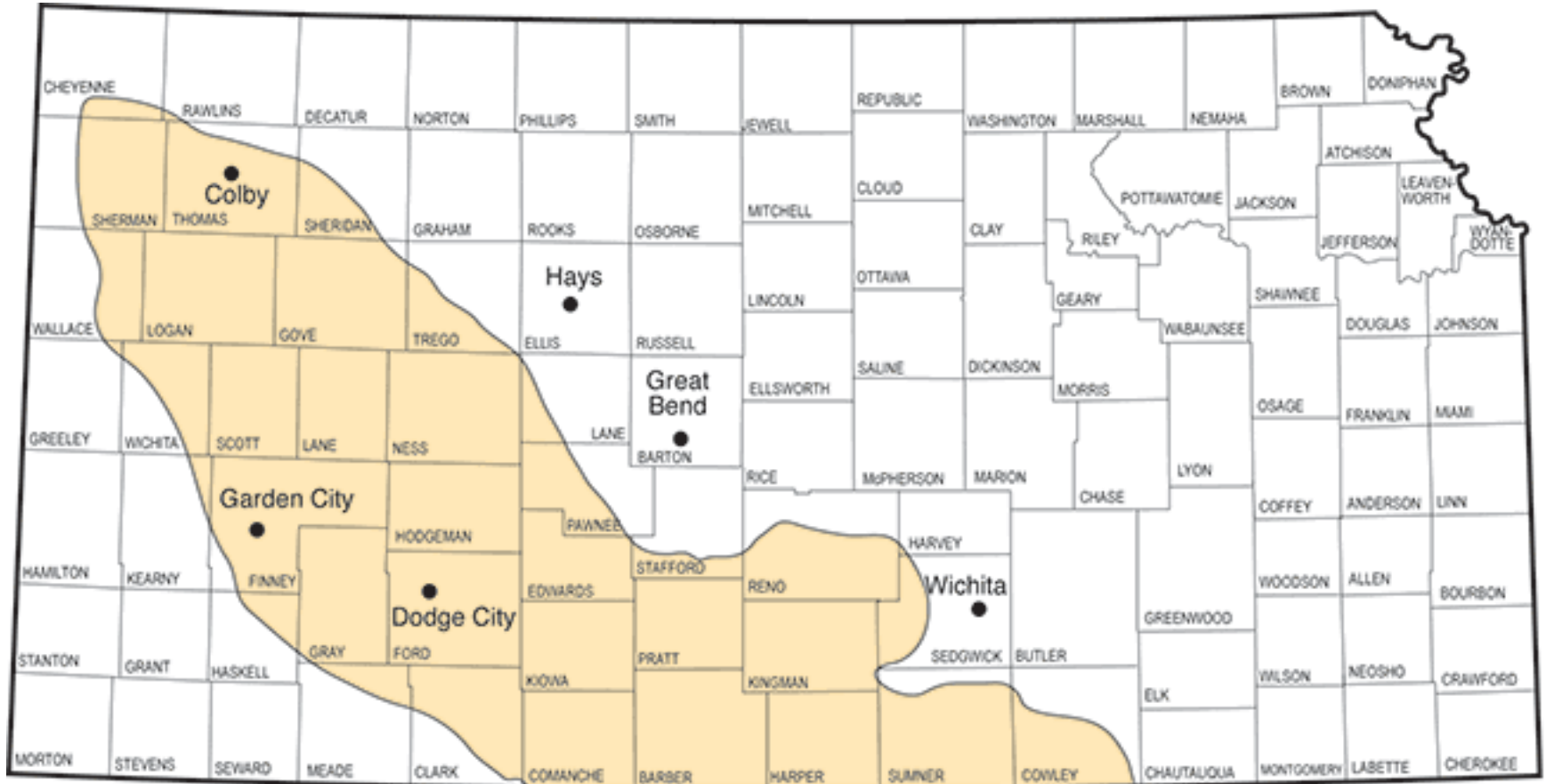


Kansas Geological Survey
Earthquake Data from USGS
30 March 2015



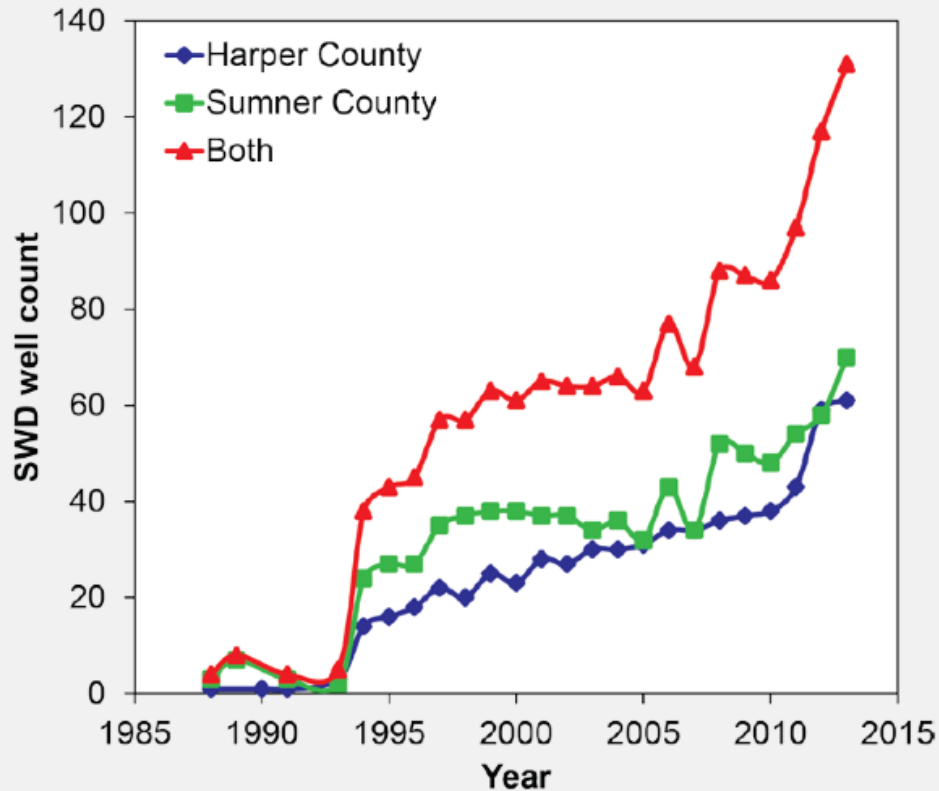


Mississippian Limestone Play Geology

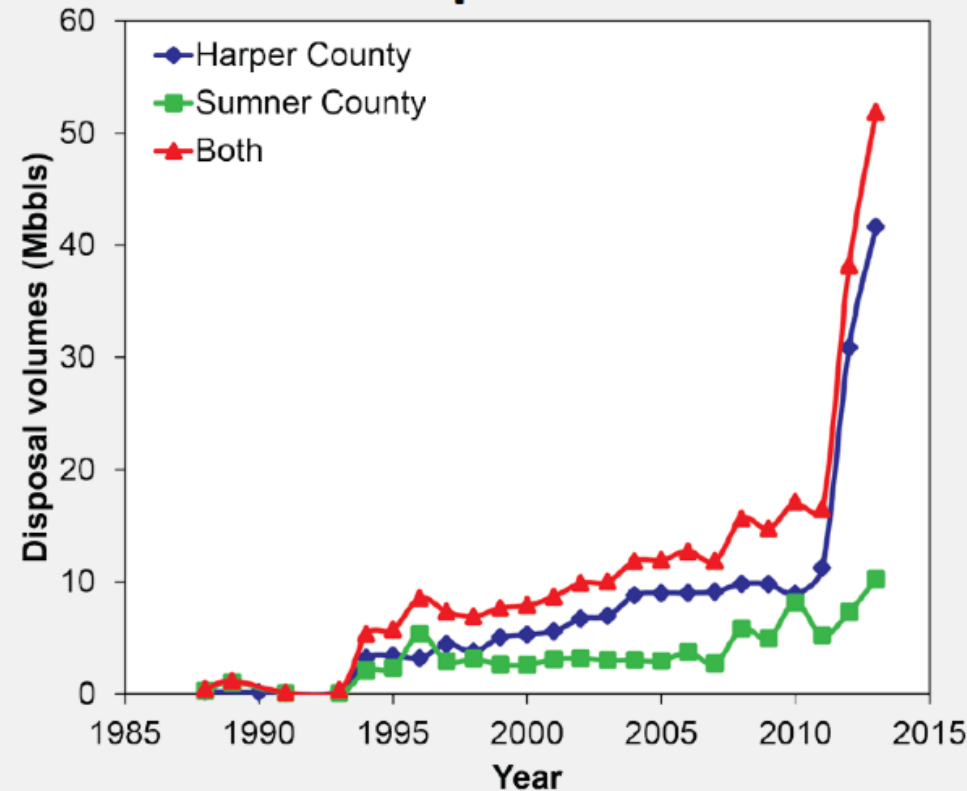


Brine disposal trends

Well count



Brine disposal volumes



- Well count has doubled since 2005
- 6-fold increase in yearly disposal volumes since mid-1990s
- Yearly volumes have tripled since 2011

Kansas Responses

- Governor's Task Force on Induced Seismicity
KGS, KCC, KDHE
 - 1) enhanced monitoring
 - 2) Seismic Action Score
- USGS, OGS, University of Missouri
- Permanent network
- Public information, legislative interaction
- Interstate Oil and Gas Compact
Commission/Groundwater Protection Council

Kansas Seismic Action Plan

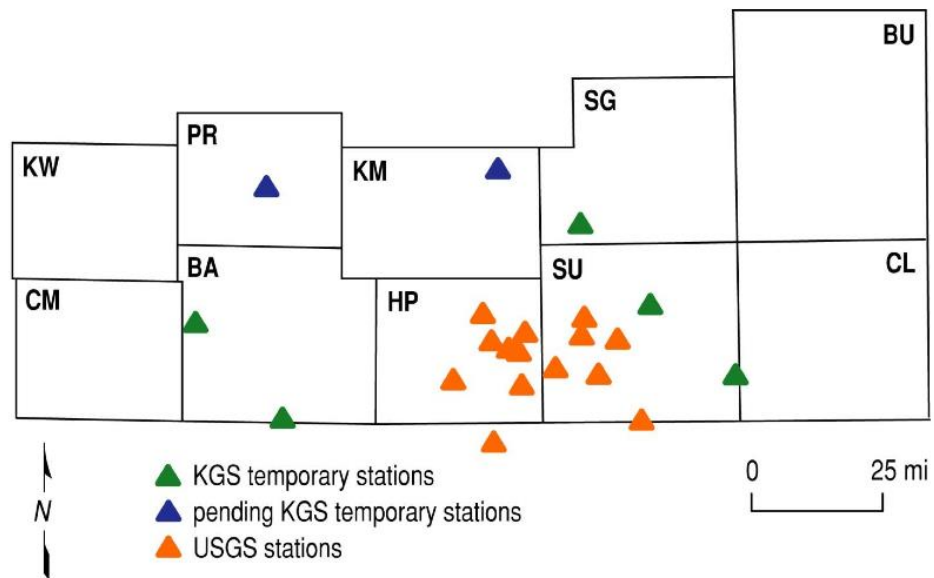
September 26, 2014

Prepared by



Department of Health and Environment
Corporation Commission
Geological Survey

KGS and USGS Temporary Networks



Induced Seismicity: The Potential for Triggered Earthquakes in Kansas

Rex C. Buchanan, K. David Newell, Catherine S. Evans, and Richard D. Miller, Kansas Geological Survey

Introduction

Earthquake activity in the Earth's crust is known as seismicity. When linked to human activities, it is commonly referred to as "induced seismicity." Industries that have been associated with induced seismicity include oil and gas production, mining, geothermal energy production, construction, underground nuclear testing, and impoundment of large reservoirs (National Research Council, 2012). Nearly all instances of induced seismicity are not felt on the surface and do not cause damage.

In the early 2000s, concern began to grow over an increase in the number of earthquakes in the vicinity of a few oil and gas exploration and production operations, particularly in Oklahoma, Arkansas, Ohio, Colorado, and Texas. **Horizontal drilling** in conjunction with **hydraulic fracturing** has often been singled out for blame in the public discourse. Hydraulic fracturing, popularly called "fracking," does cause extremely low-level seismicity, too small to be felt, as do explosions associated with quarrying, mining, dam building, and other industrial activities. Although the actual process of hydraulic fracturing has been suspected of inducing larger earthquakes a few times worldwide, the U.S. Geological Survey has found no evidence to suggest that it has contributed much to increases in the rate of earthquakes (Hayes, 2012).

Felt earthquakes associated with any oil and gas production activities are rare. In the United States, only a small fraction of the hundreds of thousands

Terms in bold are defined in the glossary.

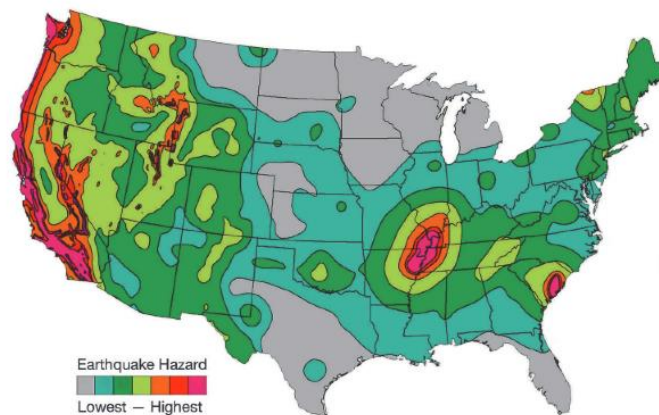


Figure 1—Earthquake hazard maps show the probability that ground shaking, or motion, will exceed a certain level, over a 50-year period. The low-hazard areas on this map have a 2% chance of exceeding a low level of shaking and the high-hazard areas have a 2% chance of topping a much greater level of shaking (modified from USGS, 2008).

of wells currently in operation have been suspected of inducing earthquakes large enough to be felt or cause damage (National Research Council, 2012). Most often, detected seismic activity associated with oil and gas operations is thought to be triggered when wastewater is injected into a disposal well. In the disposal process, waste products—such as saltwater produced with oil and gas and recovered hydraulic fracturing fluids—are injected into deep and confined porous rock.

Identifying a link between earthquakes and human activities is difficult. Complex subsurface geology and limited data about that geology make it hard to pinpoint the cause of many seismic events in the midcontinent, particularly in regions historically prone to naturally occurring low-level seismic activity. In south-central Kansas, for example, several small earthquakes have been

recorded near disposal wells starting in September 2013, about three years after horizontal drilling activities in the **Mississippian limestone play**—and associated water disposal—had crossed over the state line into Kansas from Oklahoma. However, the region also experienced several small historical earthquakes long before the increased oil activity, making it difficult to determine the cause of the recent seismic events. Although some areas of Kansas are at greater risk of seismicity than others, whether natural or induced, none of the state is in a high-hazard earthquake zone (fig. 1).

Scientists continue to monitor and evaluate possible instances of induced seismicity. In states with significant increases in seismic activity, including Oklahoma, monitoring has increased in localized areas where unusually high rates of seismicity have occurred near oil and gas production activities. To

For More Information

- Kansas Seismic Action Plan:
http://kcc.ks.gov/induced_seismicity/state_action_plan.htm
- KCC Order Concerning Class II Injection Wells in Harper and Sumner counties: <http://estar.kcc.ks.gov/estar/ViewFile.aspx/15-770%20Order.pdf?Id=05630050-78a3-4800-a08b-85202375305a>
- Kansas Geological Survey Resources on Induced Seismicity:
<http://www.kgs.ku.edu/PRS/Seismicity/index.html>
- Association of American State Geologists Fact Sheet on Induced Seismicity:
<http://www.stategeologists.org/temp/AASG%20Induced%20Seismicity%20Statement%20Update%2002-25-15.pdf>

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