Potential Induced Seismicity in the Midcontinent: One State's Experience and Response*

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Abstract

The midcontinent has experienced a dramatic increase in seismic activity in the past several years. Seismic activity in Colorado, Arkansas, and Oklahoma has been linked to saline water disposal from oil and gas production, and led to conversations about anthropogenic versus natural seismicity, regulation of saltwater disposal, and agency, industry, and governmental response. In early 2014, Kansas Governor Sam Brownback appointed a state task force to study and determine an appropriate response to increased seismic activity in south-central Kansas. That task force, which included representatives of the Kansas Geological Survey, Kansas Corporation Commission, and Kansas Department of Health and Environment, developed a response plan that included recommendations for enhanced monitoring and a seismic scoring formula that helps guide agency response to these events. The regional nature of this activity has led to coordination with the Oklahoma Geological Survey and the U.S. Geological Survey. In addition, the KGS has developed public information materials about induced seismicity. Also, Kansas is represented in national efforts to study and address the issue, including work by the Interstate Oil and Gas Compact Commission and Groundwater Protection Council, and development of a statement on induced seismicity from the Association of American State Geologists.

Reference Cited

Buchanan, R.C., K.D. Newell, C.S. Evans, and R.D. Miller, 2014, Induced Seismicity: The Potential for Triggered Earthquakes in Kansas: Kansas Geological Survey, Public Information Circular (PIC) 36.

Potential Induced Seismicity in the Midcontinent: One State's Experience and Response

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American Assn. of Petroleum Geoscientists
Denver, Colorado
3 June 2015

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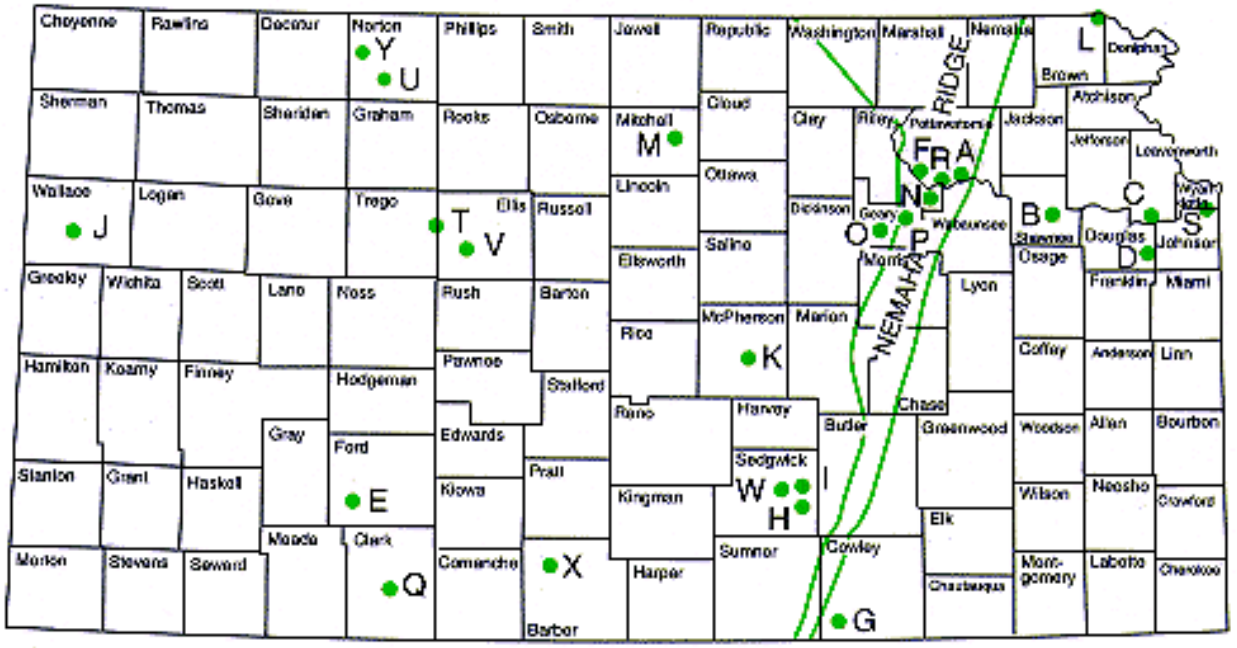
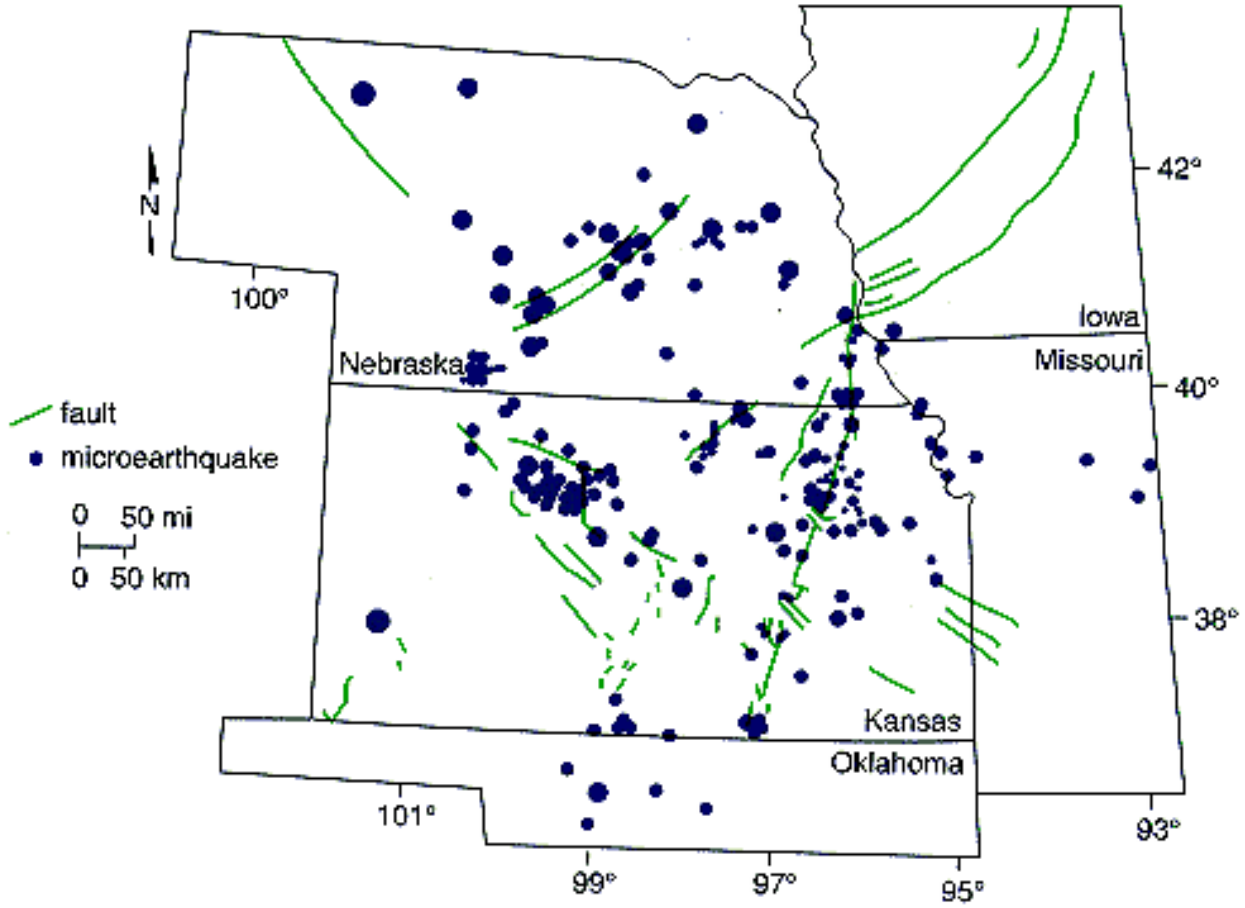
Historic Kansas Earthquakes



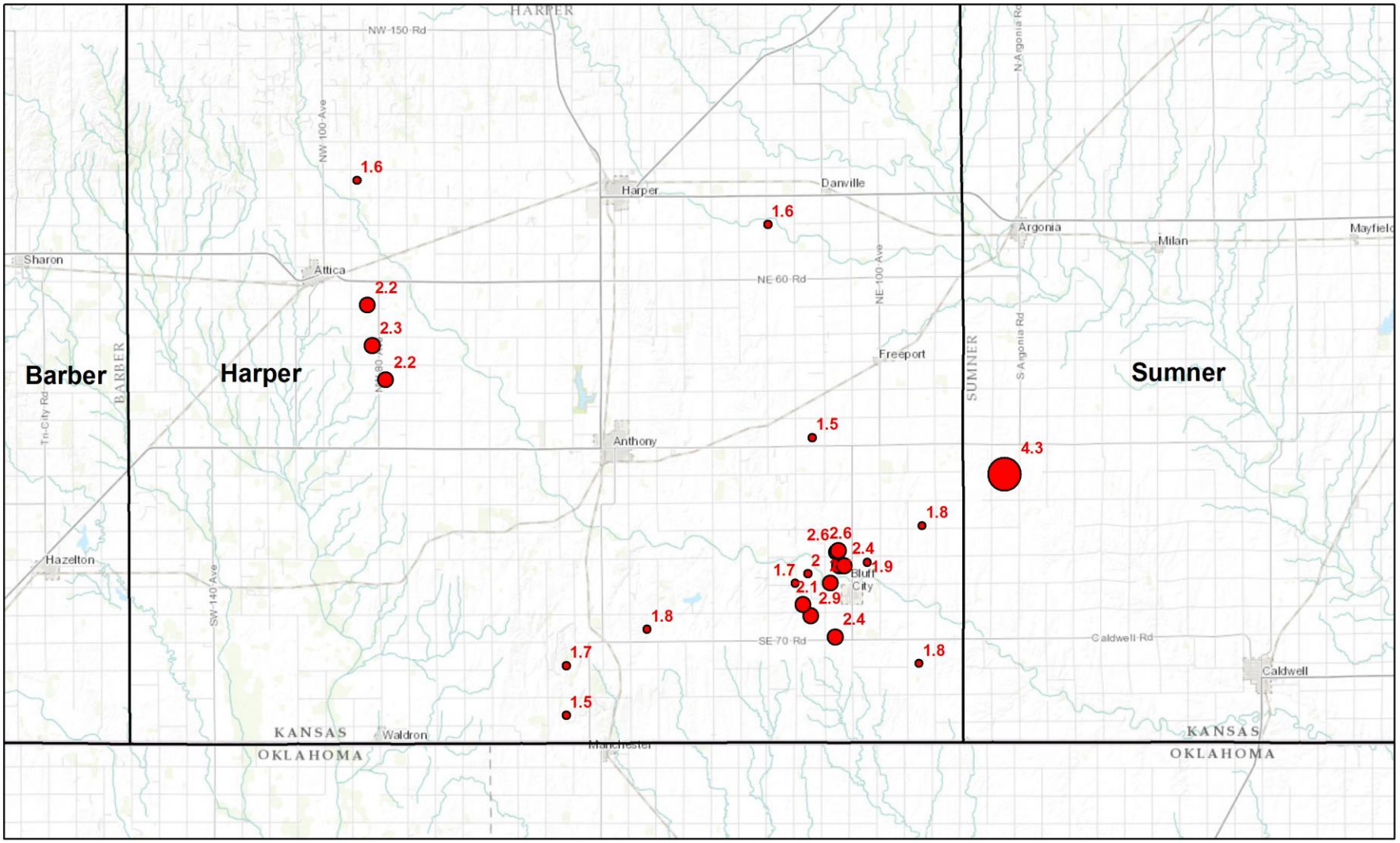
A.	1867	VII	F.	1906	VII	K.	1927	V	P.	1929	V	U.	1933	V
B.	1875	V	G.	1907	IV	L.	1927	VI	Q.	1929	V	V.	1942	IV
C.	1881	III	H.	1919	IV	M.	1928	IV	R.	1929	V	W.	1948	IV
D.	1902	II	I.	1919	IV	N.	1929	V	S.	1931	VI	X.	1956	VI
E.	1904	IV	J.	1926	?	O.	1929	V	T.	1932	V	Y.	1961	V

Midcontinent Micro-earthquakes, 1977-1989



Earthquake Activity - 2013

PRELIMINARY

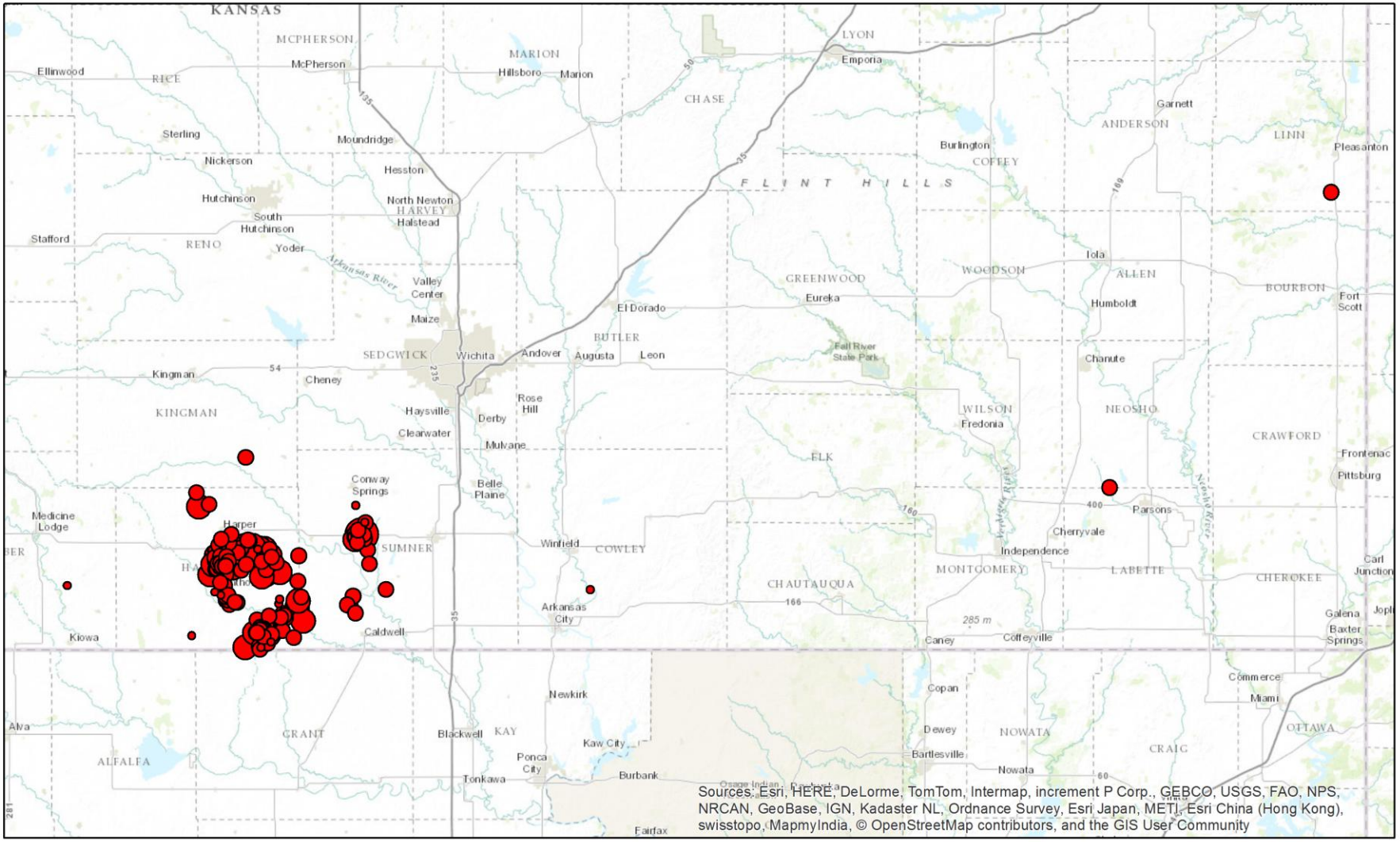


Kansas Geological Survey
Data from Oklahoma Geological Survey, USGS
18 March 2014

0 2.5 5 10 Miles

2014 Earthquakes

PRELIMINARY

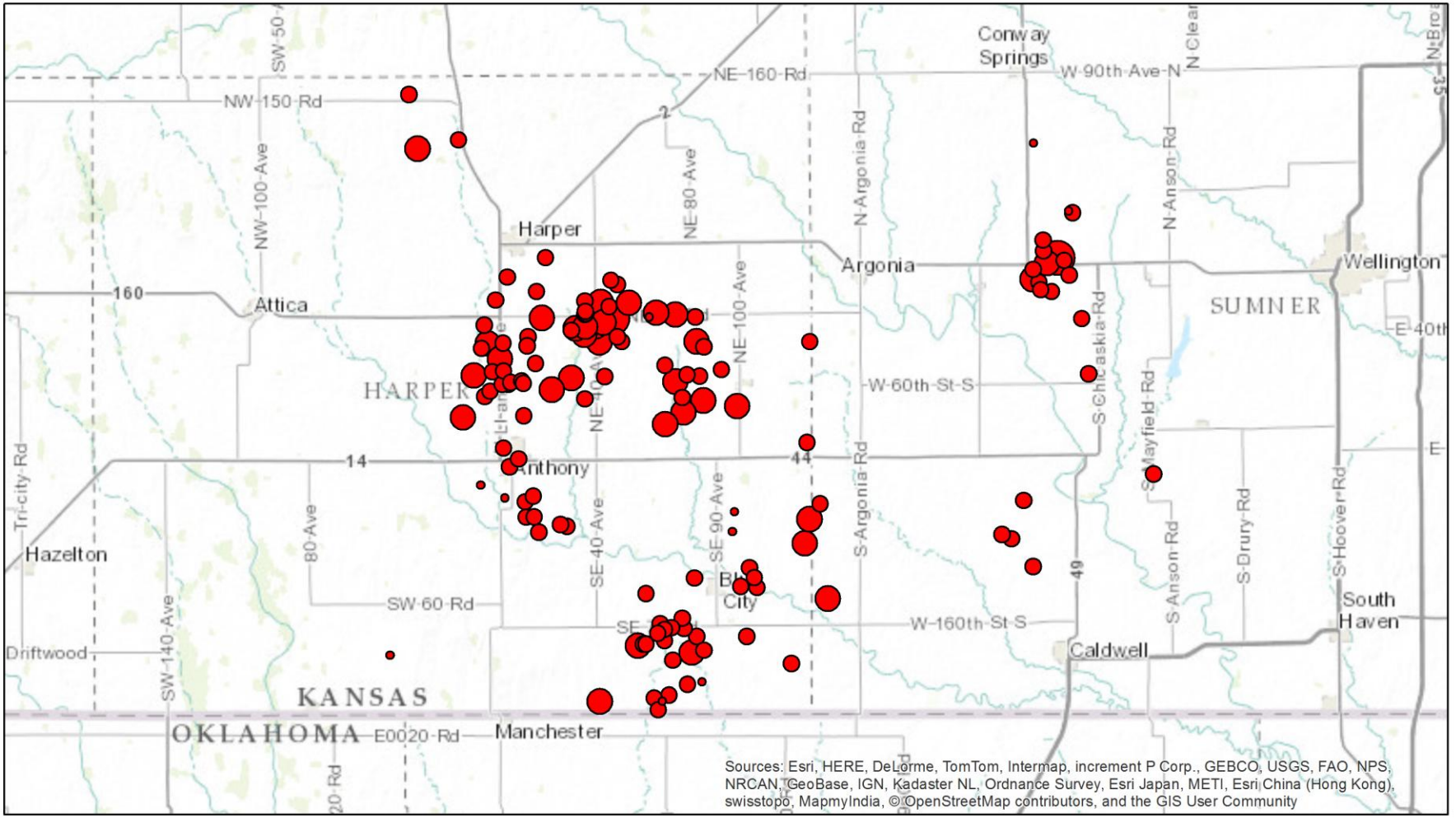


Kansas Geological Survey
Earthquake Data from Oklahoma Geological Survey, USGS
22 January 2015

0 10 20 40 Miles

2014 Earthquakes: Harper & Sumner Counties

PRELIMINARY



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

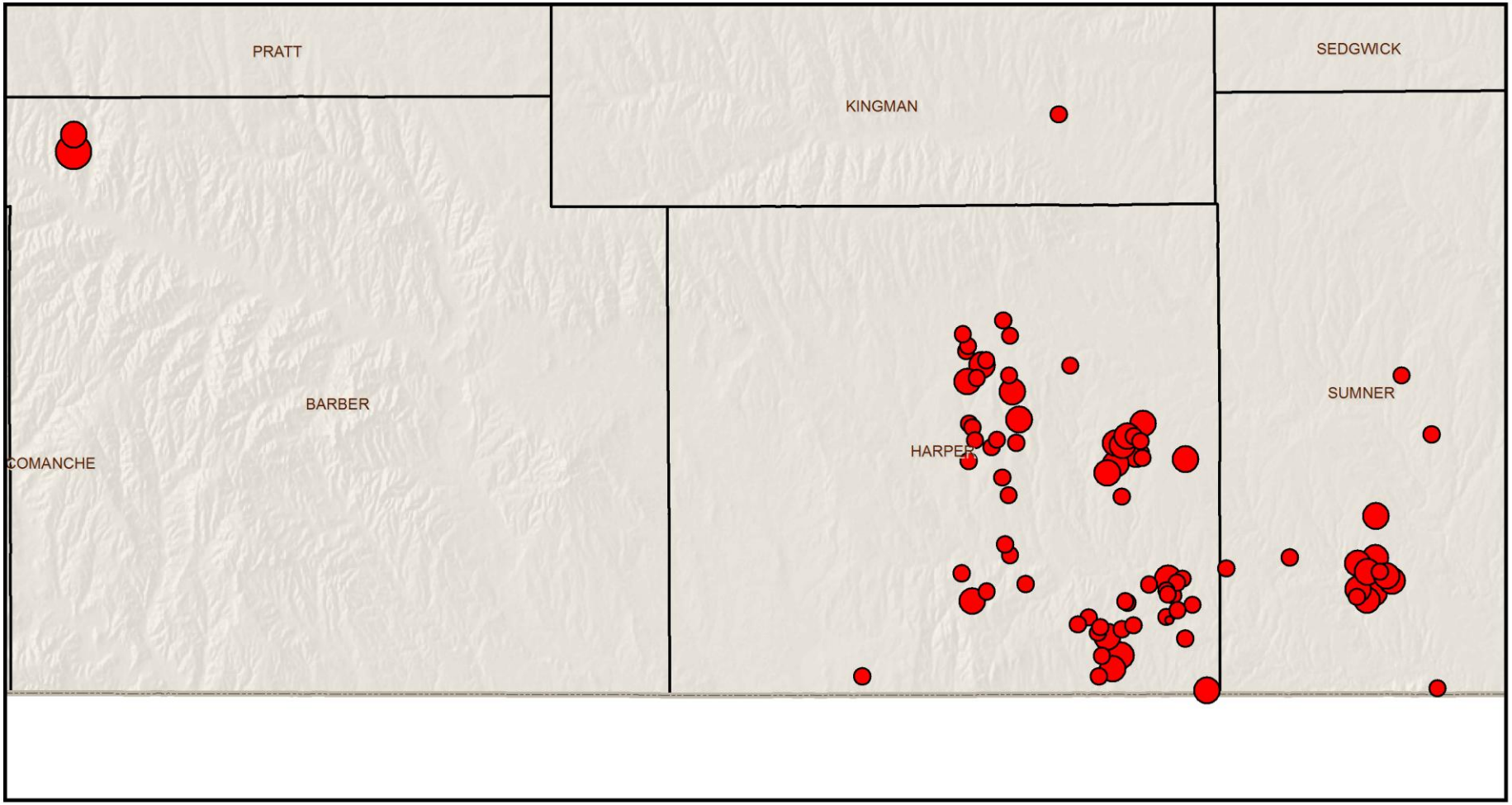
0 2.5 5 10 Miles

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


UNITED
MIL

Kansas Earthquakes - 2015

Preliminary



Kansas Geological Survey
Data from USGS
27 May 2015

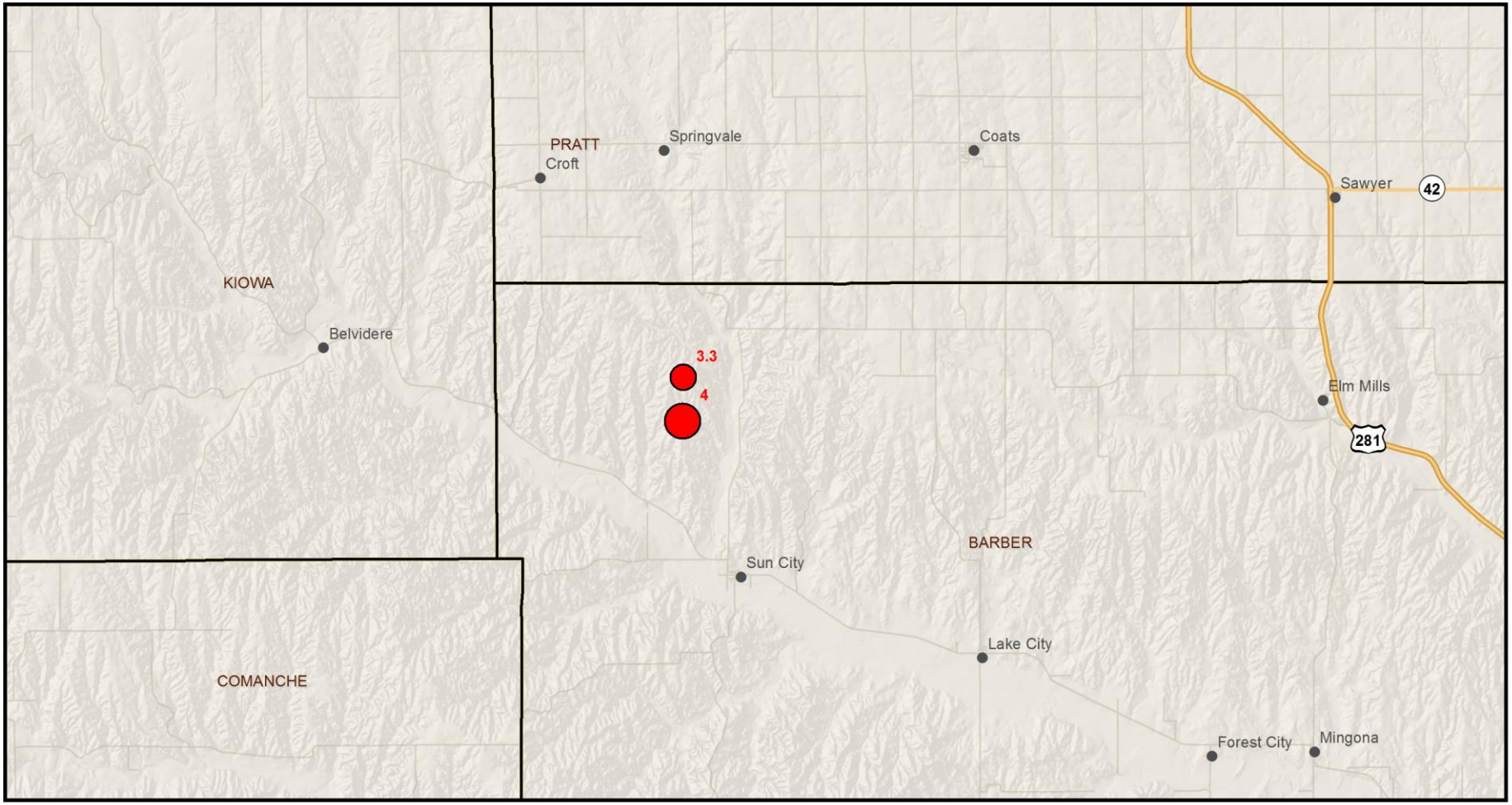
Magnitude

- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9

0 3 6 12 Miles

Kansas Earthquakes: May 23, 2015

Preliminary



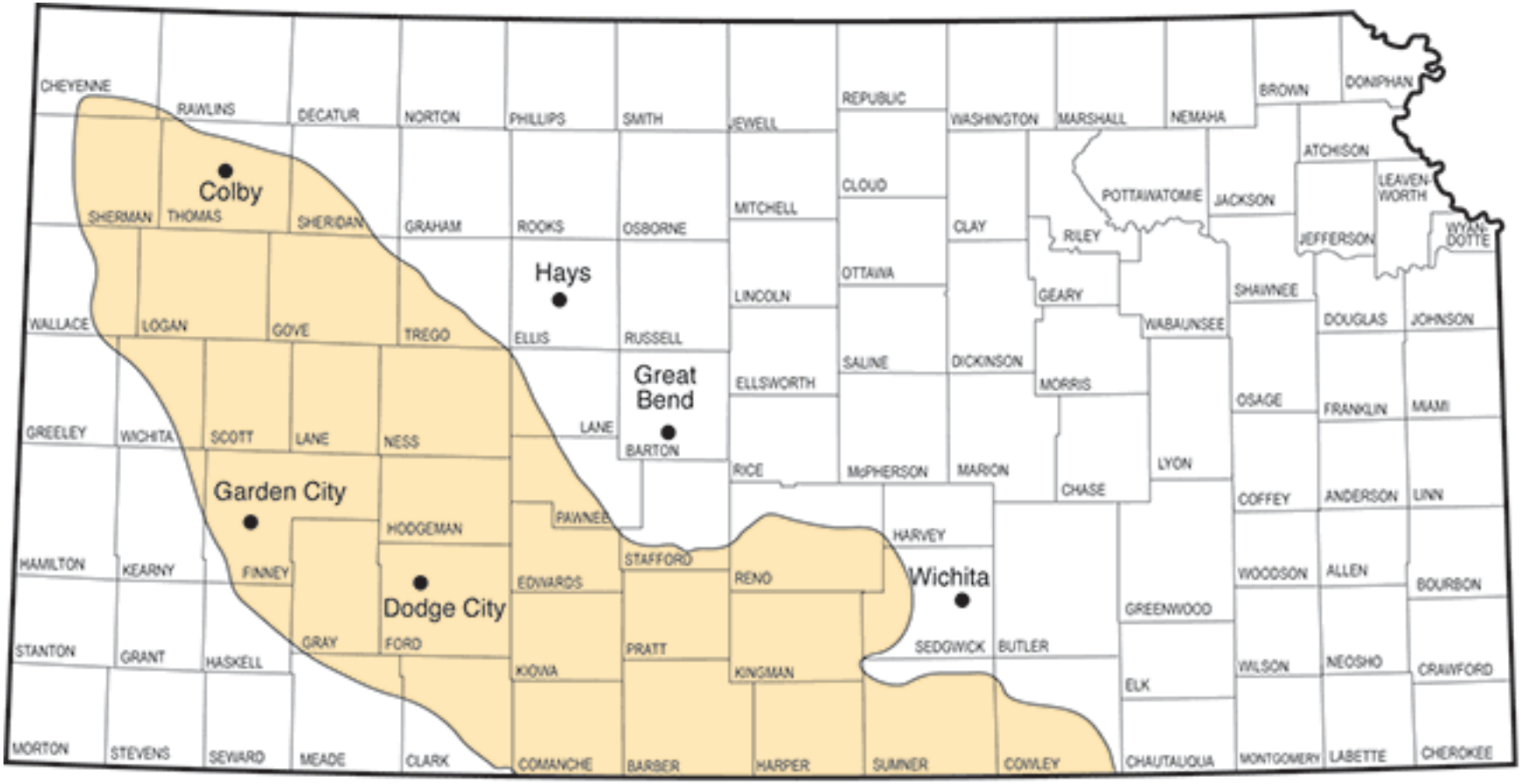
Kansas Geological Survey
Data from USGS
27 May 2015

Magnitude

- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9

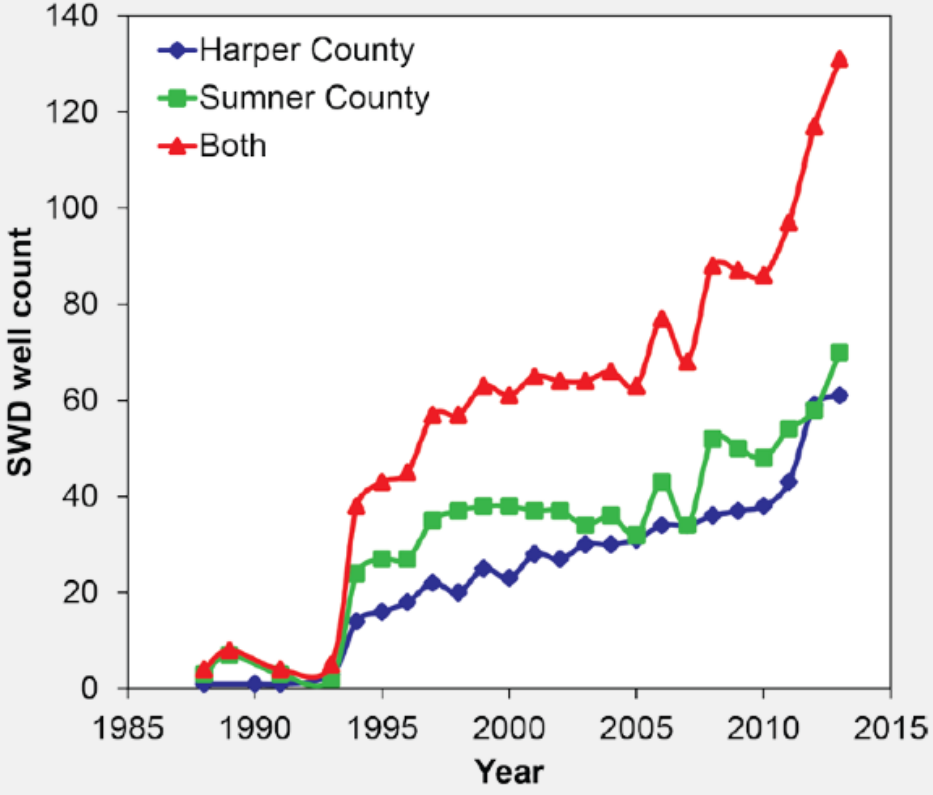
0 1.25 2.5 5 Miles

Mississippian Limestone Play Geology

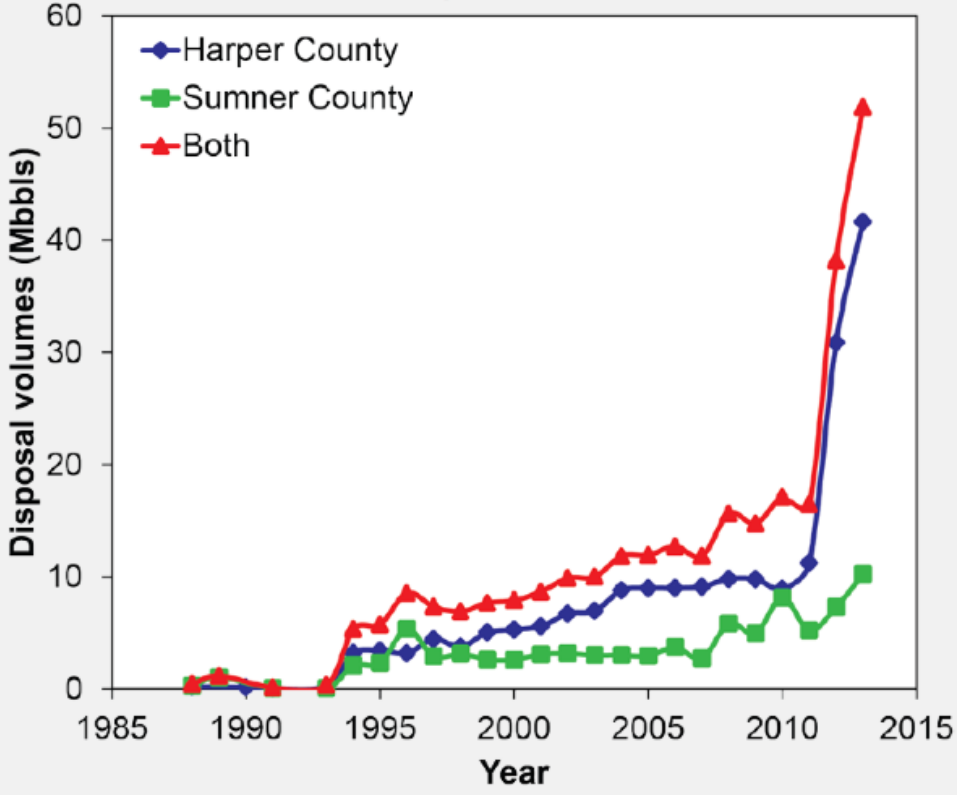


Brine disposal trends

Well count

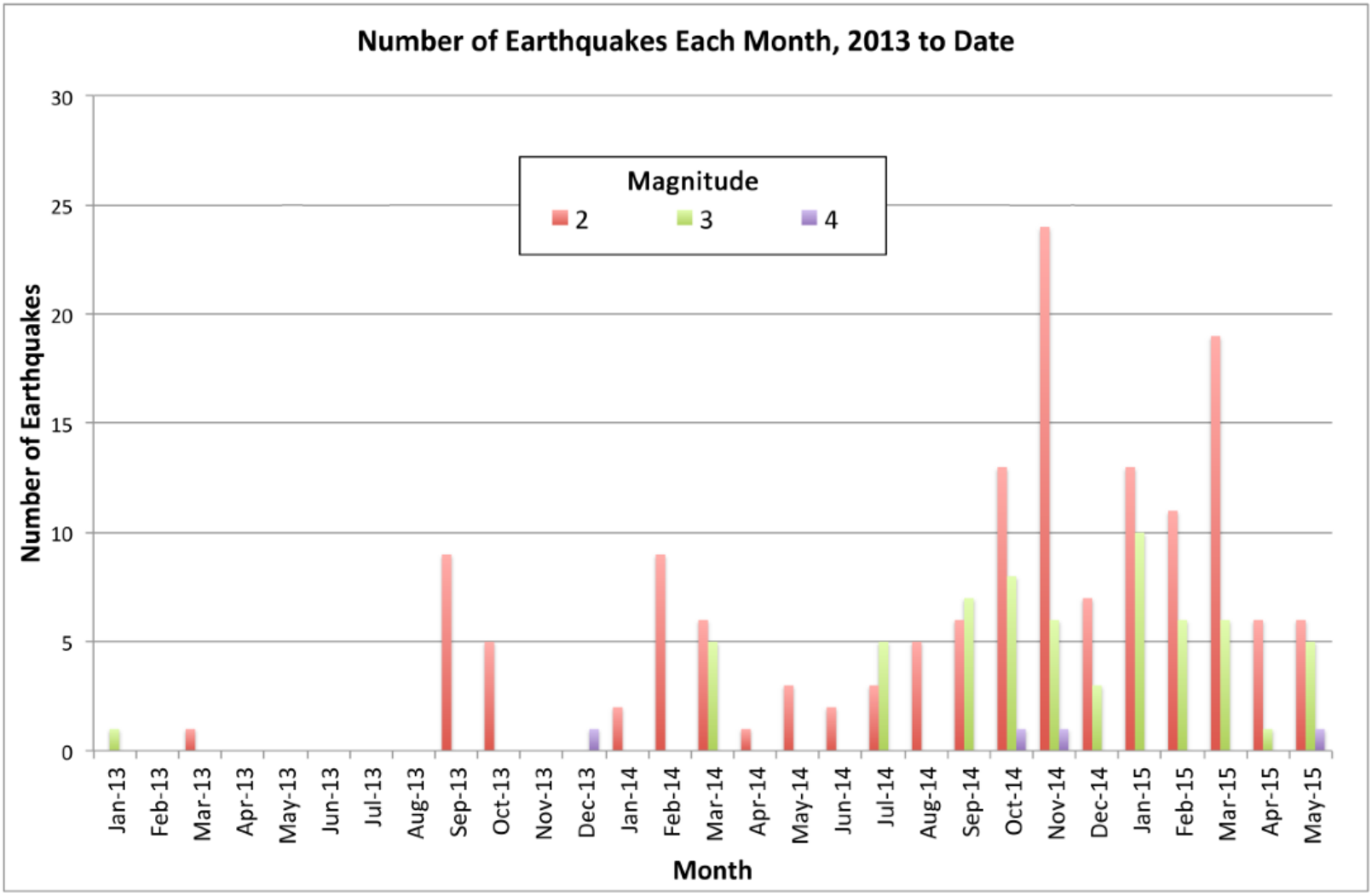


Brine disposal volumes



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

Data courtesy of the KCC



Kansas Geological Survey

Data from U.S. Geological Survey

May 25, 2015

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

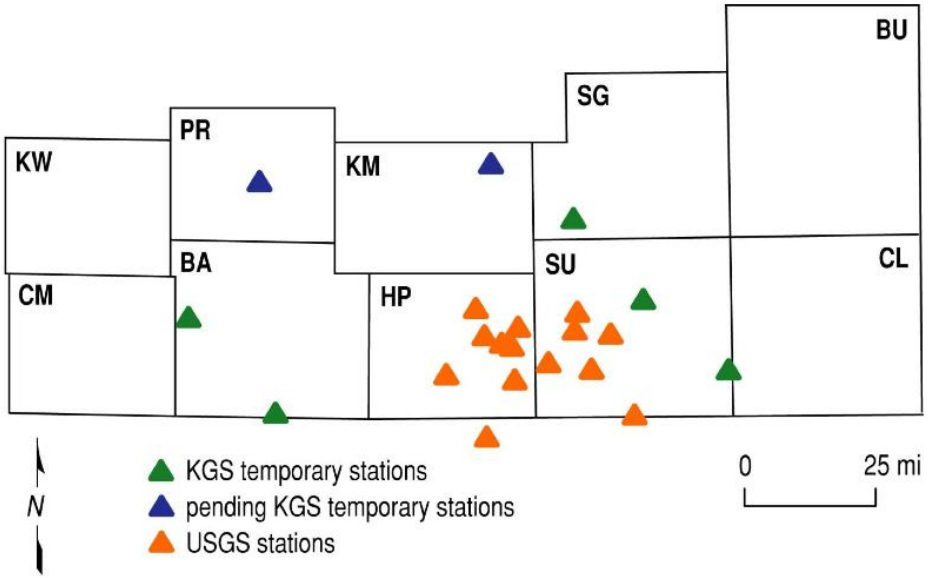
Kansas Seismic Action Plan

September 26, 2014

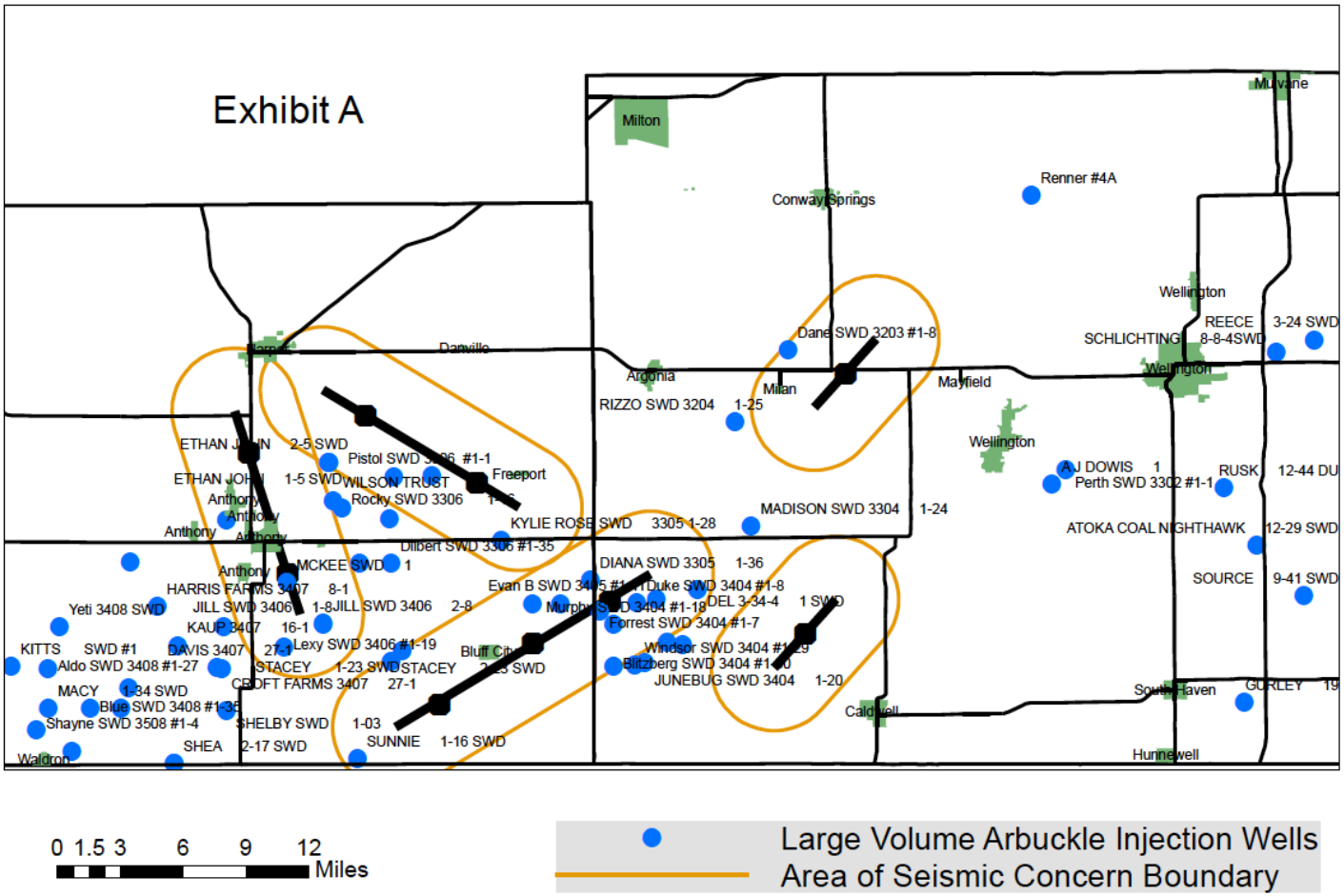
Prepared by

Department of Health and Environment
Corporation Commission
Geological Survey

KGS and USGS Temporary Networks



Large Volume Arbuckle Injection Wells



Courtesy, Kansas Corporation Commission

Associated Issues

- Political
- Legal
- Media
- Public communication

KANSAS GEOLOGICAL SURVEY
Public Information Circular 36 • April 2014

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 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

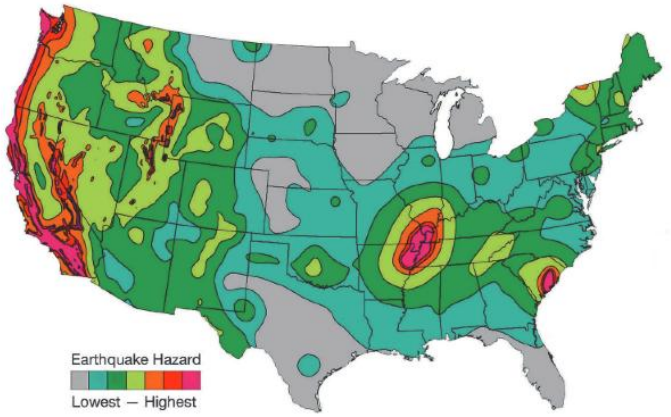


Figure 1—Earthquake hazard maps show the probability that ground shaking, or motion, will exceed a certain level, over a 50-year period. The low-hazard areas on this map have a 2% chance of exceeding a low level of shaking and the high-hazard areas have a 2% chance of topping a much greater level of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

Terms in ***bold*** *are defined in the glossary.*

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Summary

- Felt earthquakes related to hydraulic fracturing are extremely rare.
- Some earthquakes appear to be due to deep fluid injection, including wastewater disposal.
- Need for better reporting of injection data (volumes, pressures), improved seismic monitoring, fault mapping.
- Political, legal, and communication issues equally important.
- State issue.

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