Kansas Geological Survey's

Earthquake Highlights

July 2016 with KGS earthquake catalog covering January 1–June 30, 2016 Issue 2

Shelby L. Peterie, Richard D. Miller, Julio B. Gonzales, John W. Intfen, and Rex C. Buchanan
Kansas Geological Survey Open-file Report 2016-21

Kansas Seismic Monitoring Network Status Report

Escalation of earthquake activity in south-central Kansas that began in 2013 prompted a three-year program by the Kansas Geological Survey (KGS) to install and bring on-line both temporary and permanent networks with the objective to fully appraise the state's current seismicity and monitor for change. This process started in November 2014 with the installation and continuous operation of a temporary network designed to detect magnitude 1 or less earthquakes with epicenters generally located within a ten-county area in the south-central part of the state. The six stations that make up that network were installed and are operated by the KGS with recording equipment contributed by the Kansas Corporation Commission (KCC). To improve our understanding of statewide seismic activity, operation of a permanent regional network began in April 2016 with the purchase and installation of six stations by the KGS. A temporary station has also been installed near Bushton and has been operating for ten months. The temporary KCC/KGS network, KGS permanent network, and additional stations operated by the KGS collectively make up the Kansas seismic monitoring network.

Earthquake Highlights is published biannually by the Kansas Geological Survey. Earthquake locations and key characteristics are archived and accessible to researchers and the public providing the most accurate, sensitive, and timely earthquake data possible for Kansas. Some preliminary analysis and observations are included with the release of data and are designed to inform decision makers and Kansas residents/taxpayers as to existing or emerging areas with felt, or the potential for felt, earthquake activity.

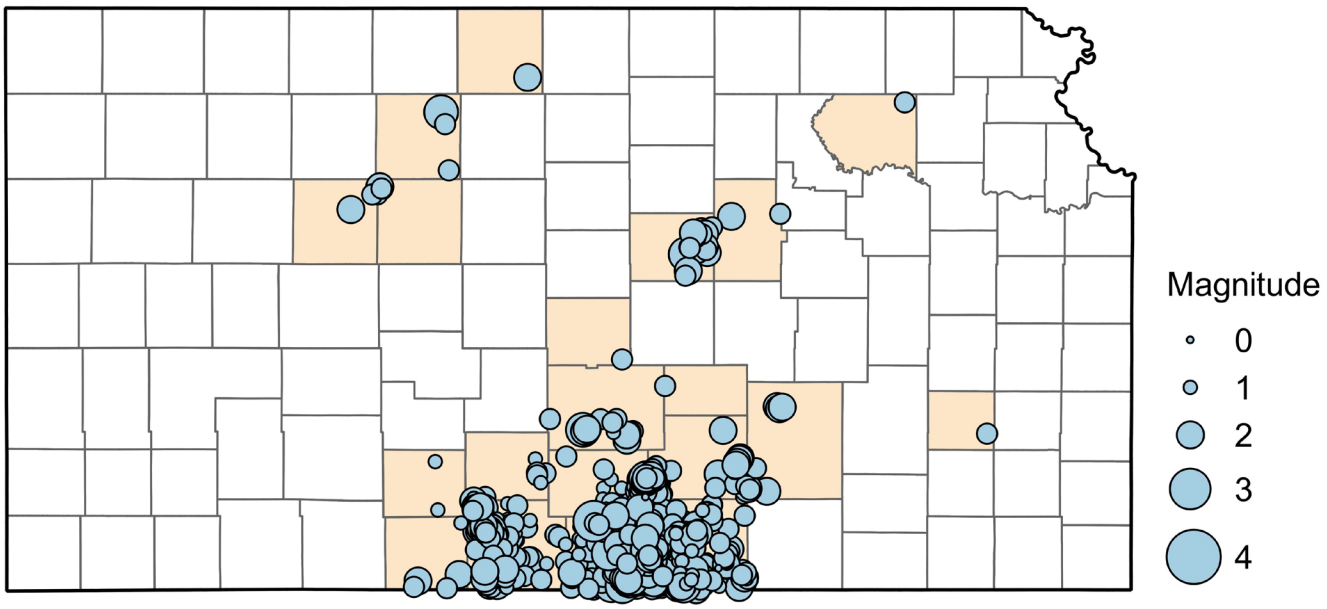

Figure 1. The Kansas seismic monitoring network recorded 1,858 earthquakes in 20 counties (tan) from January through June 2016.

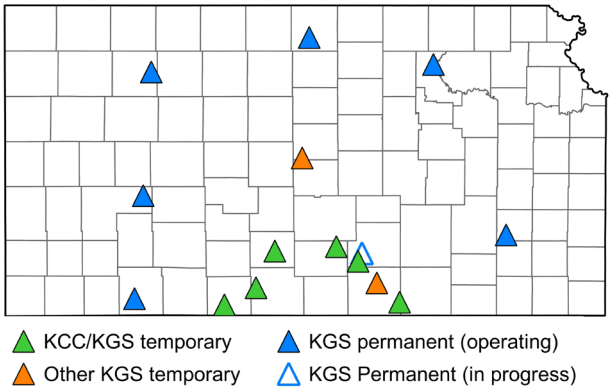

Figure 2. Seismic stations operated by the KGS.

Overview and Network Update

During this six-month reporting period, 1,858 earthquakes in 20 counties (Figure 1) were recorded with duration magnitudes (M) ranging from 0.0 to 3.1 (*see* Appendix A, online). All cataloged earthquakes were located manually. Earthquake locations were occasionally and subtly augmented with data from other publicly available datasets. Overall earthquake activity during the six-month period is lower than during the second half of 2015. Most of the cluster areas identified in the previous reporting period have continued to persist, although earthquakes within these clusters have decreased in frequency, magnitude, or both, and their spatial locations are generally more diffuse. Seismicity in south-central Kansas and clusters in Barber County, Saline County, and additional areas of interest are briefly discussed in this status report.

Sensitivity analysis of stations in the KCC/KGS temporary network indicated excessive noise at station CM01 located near Buttermilk in Comanche County. This station was decommissioned in April 2016, and the seismic monitoring equipment was moved to a quieter site nearby (about 0.5 km away), resulting in reduced cultural noise and improved performance. All stations in the temporary network (Figure 2) have operated from January 1 through June 30 with better than 99% continuous data streams and within designed operational sensitivity and signal-to-noise ranges. Installation of permanent network stations began in April 2016. Six stations are operational; an additional station is undergoing the permitting process and is on track to be installed by early summer.

Areas of Interest

South-Central Kansas

More than 75% of the earthquakes recorded in Kansas during the current reporting period (January through June 2016) have epicenters in Harper and Sumner counties. Spatially concentrated earthquake clusters that define areas with elevated levels of seismicity are evident and have been observed in these counties since early 2014. Seismic activity continues to persist in south-central Kansas, but changes in seismicity have been observed. Earthquake magnitudes have decreased and the total number of earthquakes is down relative to 2015. Additionally, patterns in earth quake clusters during this six-month reporting period differ from the previous six months (Figure 3). Last year, areas with active swarm-like or linear clusters were generally quite distinct with relatively small (less than 5 km) location variance (Figure 3a). So far this year, clusters appear more diffuse, most notably in Harper County. Earthquake locations in Sumner County have shifted slightly and appear to be concentrated along the inferred western margin of the Nemaha Ridge (Figure 3b).

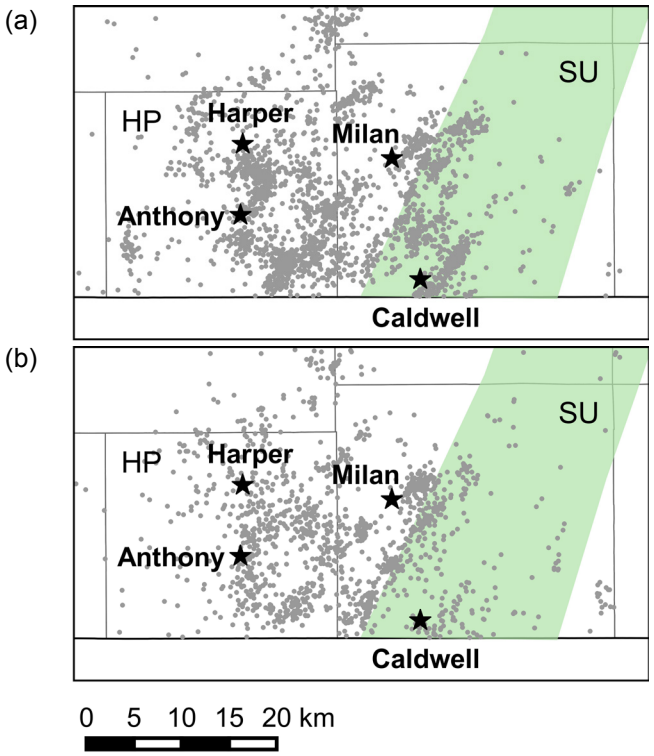

Figure 3. Earthquakes (gray dots) located in south-central Kansas during six-month recording periods from (*a*) July through December 2015 and (*b*) January through June 2016. The Nemaha Ridge is shown in green.

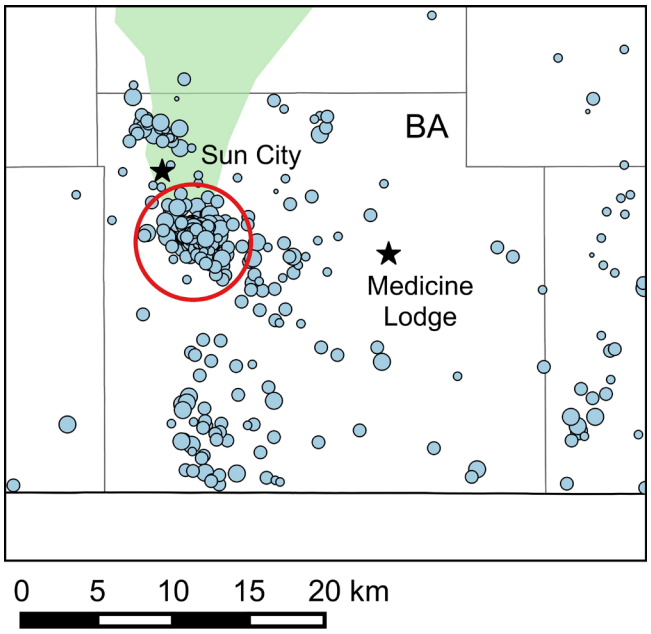

Figure 4. Earthquakes located in Barber County from December 2015 through May 2016. More than 100 earthquakes occurred in a cluster southeast of Sun City (red circle). The Central Kansas Uplift is shown in green.

Sun City Area

Overall, the frequency and magnitude of earthquakes in Barber County have decreased relative to the previous reporting period. However, a new cluster emerged in late 2015 southeast of Sun City at the inferred southern tip of the Central Kansas Uplift (Figure 4), a regional structure with faults and folds associated with late-Mississippian uplifting (Merriam, 1963). More than 150 earthquakes were recorded since December 2015 within about a 6 km radius, more than half of which have origin times during the months of May or June. The largest earthquake in this grouping was a M 2.6 on December 28, 2015 (Table 1). More than 100 of these events have a Seismic Action Score (SAS) exceeding 17, which indicates spatial and temporal clustering with other earthquakes that may suggest potentially induced seismicity (Kansas Department of Health and Environment et al., 2015).

Saline County

Twenty earthquakes have been recorded in Saline County since September 2015—all but two of which occurred in 2016—ranging from M 1.6 to 2.5 (Table 2). Several events also occurred in neighboring McPherson and Dickinson counties (Figure 5). These earthquakes have low SAS (less than 17), indicating spatial and temporal characteristics more consistent with natural earthquakes. All of these events occurred near the Midcontinent Geophysical Anomaly (MGA), a geologic structure formed during a period of late Precambrian rifting (Ocola and Meyer, 1973) that is bounded by faults (Serpa et al., 1984) and has previously been associated with natural earthquakes (Hildebrand et al., 1988). Although no earthquake activity has been recorded in Saline County (until now) since instrumented monitoring began in Kansas in 1977, the recent events appear to be more consistent with expectations for natural fluctuations in the frequency and magnitude of earthquakes associated with the MGA.

Sedgwick and Butler Counties

Thus far in 2016, 20 earthquakes have been observed in eastern Sedgwick and western Butler counties ranging from M 1.3 to 2.2 (Table 3), generally below felt levels. Epicenters of these earthquakes are located near the Nemaha Ridge and surrounding Humboldt fault zone (Figure 6), structures that have been associated with historic earthquakes (Hildebrand et al., 1988). Similar to the SAS for earthquakes observed in Saline County, the SAS for these events are low and the clustering characteristics are mostly consistent with expectations for natural earthquakes. However, due to their proximity to suspected induced seismicity in nearby Harper and Sumner counties, we will continue to scrutinize this area.

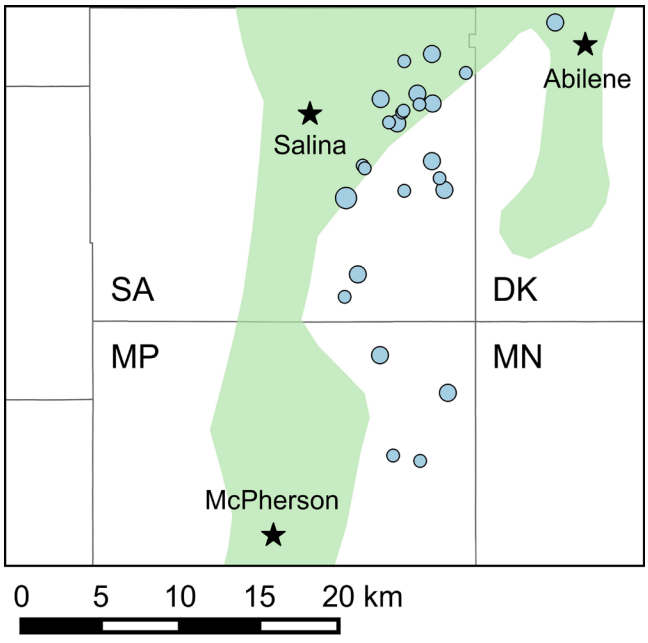

Figure 5. Earthquakes located in and around Saline County from 2015 to present. The Midcontinent Geophysical Anomaly (*center*) is shown in green.

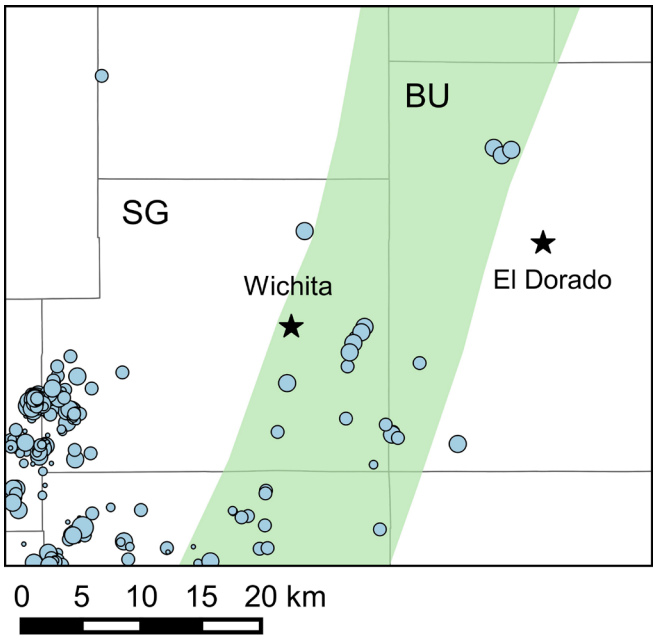

Figure 6. Earthquakes recorded from January through June 2016 near the Wichita area along the Nemaha Ridge (green).

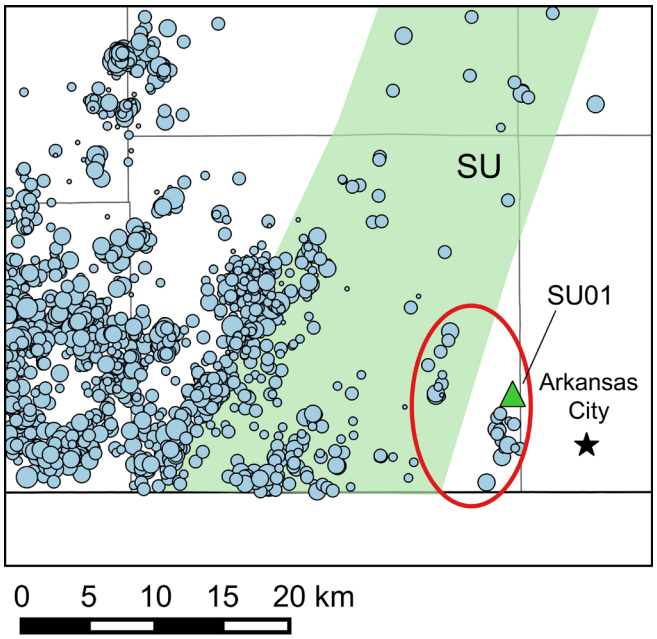

Figure 7. Earthquakes recorded near station SU01 in Geuda Springs from January through June 2016 (red circles).

Geuda Springs Area

Two small clusters emerged in late 2015 near Geuda Springs, west of Arkansas City (Figure 7). Magnitudes of these earthquakes ranged from 0.6 to 2.2 (Table 4). These clusters were most active in March 2016, with activity tapering off quickly.

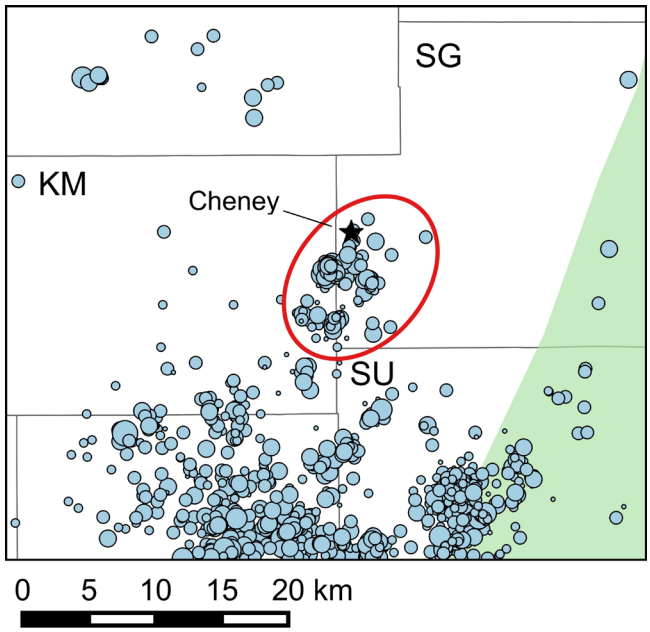

Figure 8. Earthquakes recorded near Cheney from January through June 2016 (red circle).

However, numerous earthquakes that are too small to be located (i.e. recorded on too few stations) continue to be observed at nearby station SU01. Similar to the earthquakes recorded in Sedgwick and Butler counties, these events occurred near the Nemaha Ridge and Humboldt fault zone, have low SAS, and may represent natural seismic activity.

Cheney Area

The northern edge of the apparent high-seismicity zone extends into eastern Kingman and western Sedgwick counties near Cheney (Figure 8). Sensitivity of the KCC/KGS temporary network is high near Cheney due to the proximity of stations KM01 and WSK. In 2015, less than 10% of the earthquakes were M 2.0 or greater. Although the frequency of earthquakes is approximately the same as the average rate in 2015, the distribution of magnitudes has changed with more than 25% M 2.0 or greater in 2016 (Table 5). Although this could be an indication of an increasing magnitude trend, it may simply represent a short-term fluctuation in magnitude.

Summary

Seismic activity continues to persist in south-central Kansas, but changes in seismicity have been observed. Relative to 2015, an overall decrease in earthquake magnitudes and a slight reduction in frequency of events have been observed. The pattern of earthquake epicenters in Harper County generally

appears more diffuse, and the majority of the activity in Sumner County has occurred along the western margin of the Nemaha Ridge, a geologic structure that spans the state and is characterized by a complex set of faults and fractures. A new, active cluster has emerged southeast of Sun City, and other clusters have emerged east of Freeport, near Geuda Springs, and along the Nemaha Ridge in Sedgwick and Butler counties. Activity in Saline County and neighboring McPherson and Dickinson counties, although seemingly new in the context of the current earthquake network, occurs along the eastern edge of the Midcontinent Geophysical Anomaly—a structure known to be bounded by faults and associated with historic, natural earthquake activity.

Of the more than 1,800 earthquakes located by the Kansas seismic monitoring network so far in 2016, 35 were also located by the USGS and reported in the National Earthquake Information Center (NEIC) global earthquake bulletin (Preliminary Determination of Epicenters, PDE) (Table 6). Magnitudes estimated by the NEIC are calculated using different methods and are, on average, 0.2 orders of magnitude larger than the duration magnitudes estimated by KGS. For the set of 35 earthquakes reported by both the KGS and the NEIC, the SAS computed based on only NEIC data in 2016 are, on average, 30% lower than the SAS computed based on only KGS data. The NEIC generally reports earthquakes of M 2.5 or greater, whereas the KCC/KGS network routinely locates earthquakes well below M 2.5. Spatial and temporal clustering of earthquakes of less than M 2.5 is the main factor in the higher SAS reported for KGS earthquakes.

References

Hildebrand, G.M., D.W. Steeples, R.W. Knapp, R.D. Miller, and B.C. Bennett, 1988, Microearthquakes in Kansas and Nebraska 1977–1987: *Seismological Research Letters*, **59**, 159–163.

Kansas Department of Health and Environment, Kansas Corporation Commission, and Kansas Geological Survey, 2015, Kansas Seismic Action Plan, September 24, 2014; Amended January 21, 2015, http://www.kgs.ku.edu/PRS/Seismicity/2015/Seismic_Action_Plan.pdf.

Merriam, D.F., 1963, The geologic history of Kansas: Kansas Geological Survey, Bulletin 162.

Ocola, L.C. and R.P. Meyer, 1973, Central North American Rift System: 1. Structure of the axial zone from seismic and gravimetric data: *Journal of Geophysical Research*, **78**, 5173–5194.

Serpa, L., T. Setzer, H. Farmer, L. Brown, J. Oliver, S. Kaufman, J. Sharp, and D.W. Steeples, 1984, Structure of the southern Keweenawan rift from COCORP surveys across the Midcontinent Geophysical Anomaly in northeastern Kansas: *Tectonics*, **3**, 215–228.

Table 1. Earthquakes located by the Kansas seismic monitoring network southeast of Sun City from December 2015 through June 2016. Yellow highlighting indicates SAS of 17 or greater, and green indicates earthquakes also reported in the NEIC global earthquake bulletin (Preliminary Determination of Epicenters, PDE).

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2015-12-02 10:58:23	37.305	-98.841	5.0	2.0	1.8	1.6	0	151	11.0
2015-12-13 15:44:23	37.314	-98.835	5.0	1.6	2.2	2.6	0	301	15.6
2015-12-14 05:45:10	37.320	-98.822	5.0	1.8	1.3	1.9	0	278	17.2
2015-12-14 06:13:51	37.320	-98.856	5.0	1.6	2.1	2.0	0	145	16.6
2015-12-15 04:32:11	37.307	-98.856	5.0	2.1	1.7	1.3	0	142	18.4
2015-12-15 16:20:16	37.337	-98.864	5.0	2.1	2.0	1.8	0	140	19.4
2015-12-15 17:05:16	37.294	-98.839	5.0	1.9	1.4	1.1	0	148	18.6
2015-12-16 05:03:09	37.322	-98.857	5.0	2.2	2.1	1.8	0	137	19.8
2015-12-16 05:30:30	37.304	-98.848	5.0	2.0	2.1	1.6	0	146	19.0
2015-12-16 06:18:26	37.324	-98.863	5.0	1.9	5.1	4.9	0	151	18.6
2015-12-17 18:43:06	37.310	-98.848	5.0	1.8	1.7	1.7	0	144	14.2
2015-12-19 19:03:18	37.310	-98.853	5.0	1.7	2.2	2.1	0	166	14.9
2015-12-19 23:12:59	37.293	-98.850	5.0	1.9	1.2	0.9	0	179	15.6
2015-12-21 10:46:59	37.314	-98.845	5.0	2.0	2.2	1.9	0	165	16.0
2015-12-21 10:53:42	37.294	-98.842	5.0	2.0	2.2	1.6	0	148	16.0
2015-12-23 23:03:58	37.304	-98.840	5.0	2.2	2.0	1.7	0	146	17.8
2015-12-24 04:24:54	37.281	-98.822	5.0	2.1	2.6	1.9	0	151	18.4
2015-12-24 07:17:18	37.309	-98.841	5.0	2.0	2.2	1.8	0	166	18.0
2015-12-24 23:23:12	37.305	-98.856	5.0	1.8	2.3	2.0	0	169	16.2
2015-12-28 16:00:53	37.303	-98.834	5.0	2.6	2.1	1.7	0	154	16.8
2015-12-31 10:05:18	37.327	-98.847	5.0	2.2	2.1	1.9	0	140	15.8
2016-01-08 05:25:32	37.289	-98.818	5.0	1.5	2.7	3.5	0	231	17.3
2016-01-08 18:14:10	37.328	-98.845	5.0	2.0	1.9	1.9	0	143	17.0
2016-01-09 00:22:19	37.313	-98.827	5.0	1.7	1.8	1.6	0	149	16.9
2016-01-17 10:38:46	37.317	-98.835	5.0	2.0	2.3	1.9	0	144	16.0
2016-01-18 05:32:49	37.317	-98.846	5.0	2.0	1.3	1.2	0	142	16.0
2016-01-18 11:33:56	37.317	-98.849	5.0	1.4	1.6	1.6	0	163	14.0
2016-01-19 22:41:42	37.267	-98.825	5.0	1.8	3.4	1.1	0	179	15.2
2016-01-20 07:21:15	37.311	-98.829	5.0	2.0	1.5	1.2	0	150	17.0
2016-01-21 01:52:18	37.310	-98.848	5.0	1.7	1.3	1.2	0	146	14.9
2016-01-23 09:52:26	37.313	-98.846	5.0	1.7	1.8	1.5	0	144	13.9
2016-03-06 05:41:08	37.314	-98.886	5.0	1.2	4.4	2.6	0	184	6.4
2016-03-20 11:26:17	37.316	-98.811	5.0	1.7	3.6	3.6	0	167	13.9
2016-04-03 03:24:30	37.311	-98.857	5.0	1.8	2.9	2.5	0	164	15.2
2016-04-03 06:58:47	37.314	-98.852	5.0	1.4	2.6	2.1	0	142	15.0
2016-04-03 07:38:38	37.311	-98.866	5.0	1.2	3.8	3.1	0	140	13.4
2016-04-23 05:28:27	37.275	-98.899	5.0	1.4	1.9	1.6	0	173	14.0
2016-04-25 17:01:43	37.299	-98.898	5.0	1.5	2.4	2.4	0	156	13.3
2016-05-15 05:22:36	37.280	-98.874	5.0	2.0	2.0	1.6	0	170	19.0
2016-05-15 06:36:24	37.313	-98.901	5.0	1.8	1.7	1.9	0	168	18.2
2016-05-15 16:39:29	37.290	-98.877	5.0	2.0	2.0	1.6	0	147	19.0
2016-05-15 17:45:14	37.300	-98.905	5.0	1.9	4.9	2.0	0	196	18.6
2016-05-15 17:51:57	37.301	-98.908	5.0	2.1	1.7	1.3	0	126	19.4
2016-05-15 18:40:59	37.314	-98.883	5.0	1.8	2.3	1.9	0	144	18.2
2016-05-15 20:52:21	37.321	-98.899	5.0	2.1	2.9	3.3	0	141	19.4
2016-05-16 10:30:20	37.299	-98.879	5.0	1.9	2.2	1.6	0	145	18.6

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-05-16 20:09:17	37.303	-98.872	5.0	1.8	1.8	1.3	0	145	17.2
2016-05-18 05:14:47	37.306	-98.938	5.0	2.0	1.2	0.8	0	212	16.0
2016-05-19 03:28:01	37.303	-98.942	5.0	1.5	2.1	1.8	0	152	15.3
2016-05-19 08:26:19	37.324	-98.898	5.0	2.0	1.4	1.2	0	139	16.0
2016-05-20 12:33:54	37.332	-98.904	5.0	1.8	2.4	1.8	0	139	17.2
2016-05-20 17:16:48	37.309	-98.860	5.0	1.9	1.5	1.3	0	145	17.6
2016-05-21 01:37:27	37.348	-98.848	5.0	1.6	3.9	4.6	0	326	16.6
2016-05-21 12:12:15	37.343	-98.834	5.0	1.9	2.0	1.4	0	207	17.6
2016-05-23 05:06:19	37.286	-98.887	5.0	1.8	1.5	1.2	0	159	18.2
2016-05-23 09:36:26	37.304	-98.879	5.0	1.8	1.5	1.2	0	141	18.2
2016-05-23 15:00:57	37.314	-98.881	5.0	2.0	2.1	1.6	0	132	19.0
2016-05-23 15:10:39	37.292	-98.861	5.0	1.7	2.4	1.8	0	147	17.9
2016-05-23 15:53:51	37.299	-98.885	5.0	1.6	2.3	1.9	0	145	17.6
2016-05-23 15:57:03	37.285	-98.855	5.0	1.8	2.5	1.8	0	149	18.2
2016-05-23 18:09:17	37.317	-98.871	5.0	2.1	2.6	1.9	0	155	19.4
2016-05-24 08:20:08	37.307	-98.866	5.0	2.3	1.6	1.4	0	143	20.3
2016-05-24 11:12:07	37.295	-98.858	5.0	1.5	2.0	1.9	0	168	17.3
2016-05-24 13:50:58	37.310	-98.856	5.0	2.5	1.1	0.9	0	144	20.3
2016-05-24 23:43:21	37.316	-98.868	5.0	2.0	1.3	1.1	0	138	19.0
2016-05-25 05:56:46	37.316	-98.897	5.0	1.7	1.0	1.2	0	155	17.9
2016-05-25 09:51:43	37.315	-98.894	5.0	1.8	1.1	1.0	0	145	18.2
2016-05-25 10:14:39	37.292	-98.874	5.0	2.1	2.8	2.2	0	147	19.4
2016-05-25 11:05:30	37.310	-98.868	5.0	1.9	1.1	0.8	0	161	18.6
2016-05-25 21:16:36	37.316	-98.883	5.0	2.0	1.8	1.7	0	130	19.0
2016-05-25 23:37:21	37.256	-98.822	5.0	1.7	2.3	1.8	0	177	17.9
2016-05-26 00:36:58	37.315	-98.873	5.0	2.0	1.5	1.5	0	155	19.0
2016-05-26 02:33:38	37.328	-98.899	5.0	2.0	1.9	2.1	0	133	19.0
2016-05-26 03:29:23	37.280	-98.841	5.0	1.9	1.6	1.2	0	172	18.6
2016-05-26 08:24:41	37.309	-98.875	5.0	1.8	1.1	1.0	0	139	18.2
2016-05-26 08:27:51	37.291	-98.850	5.0	1.9	2.1	1.7	0	148	18.6
2016-05-26 11:55:56	37.296	-98.870	5.0	2.0	1.4	1.2	0	146	19.0
2016-05-26 13:37:41	37.251	-98.826	5.0	1.9	2.0	1.5	0	155	18.6
2016-05-26 16:08:22	37.320	-98.911	5.0	2.1	1.4	1.8	0	129	19.4
2016-05-26 16:16:55	37.307	-98.873	5.0	1.5	1.0	1.4	0	216	17.3
2016-05-26 19:26:40	37.309	-98.914	5.0	1.8	2.2	2.2	0	148	18.2
2016-05-26 21:05:35	37.286	-98.865	5.0	1.6	1.7	1.3	0	183	17.6
2016-05-27 01:44:58	37.308	-98.849	5.0	1.8	2.1	1.7	0	210	18.2
2016-05-27 02:01:37	37.295	-98.861	5.0	2.1	1.4	1.0	0	147	19.4
2016-05-27 02:32:18	37.257	-98.836	5.0	1.7	3.0	2.0	0	154	17.9
2016-05-27 03:02:54	37.334	-98.886	5.0	1.8	2.3	1.5	0	159	18.2
2016-05-27 13:21:16	37.314	-98.858	5.0	2.0	2.4	1.8	0	144	19.0
2016-05-28 10:22:33	37.289	-98.870	5.0	1.6	2.6	1.9	0	168	17.6
2016-05-29 03:59:16	37.304	-98.884	5.0	1.1	3.3	4.8	0	213	16.2
2016-05-29 04:18:10	37.284	-98.861	5.0	1.5	1.9	1.8	0	183	17.3
2016-05-29 05:05:36	37.293	-98.841	5.0	1.6	2.2	1.9	0	183	17.6
2016-05-29 12:03:36	37.269	-98.845	5.0	1.5	3.5	3.1	0	187	17.3
2016-05-30 19:13:17	37.307	-98.870	5.0	1.9	2.2	1.9	0	142	15.6
2016-05-31 00:02:39	37.278	-98.880	5.0	1.8	2.3	1.9	0	183	15.2
2016-06-04 05:40:22	37.272	-98.838	5.0	2.0	2.2	1.7	0	173	15.0

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-06-05 01:51:17	37.313	-98.870	5.0	1.4	3.0	2.9	0	158	17.0
2016-06-05 09:52:31	37.294	-98.861	5.0	1.9	1.6	1.2	0	147	18.6
2016-06-05 10:27:59	37.290	-98.858	5.0	2.4	2.8	2.1	0	148	20.8
2016-06-05 10:28:11	37.276	-98.827	5.0	2.2	1.8	1.3	0	173	19.8
2016-06-05 14:40:50	37.314	-98.863	5.0	1.8	1.5	1.3	0	139	18.2
2016-06-05 17:17:34	37.296	-98.873	5.0	2.0	2.9	2.2	0	146	19.0
2016-06-05 18:38:24	37.299	-98.875	5.0	1.5	1.9	1.8	0	166	17.3
2016-06-05 18:39:43	37.266	-98.837	5.0	1.5	1.9	1.3	0	174	17.3
2016-06-05 18:46:13	37.297	-98.856	5.0	2.0	1.5	1.0	0	147	19.0
2016-06-05 21:17:58	37.314	-98.873	5.0	1.5	1.9	1.9	0	156	17.3
2016-06-05 22:22:41	37.318	-98.868	5.0	1.0	1.7	1.8	0	155	16.0
2016-06-06 22:54:34	37.303	-98.869	5.0	1.8	3.6	2.8	0	145	18.2
2016-06-07 03:23:20	37.287	-98.864	5.0	2.1	2.0	1.6	0	148	19.4
2016-06-07 04:03:31	37.281	-98.852	5.0	1.4	2.1	1.7	0	171	17.0
2016-06-07 11:05:52	37.299	-98.857	5.0	1.9	2.3	1.9	0	146	18.6
2016-06-07 11:20:42	37.318	-98.882	5.0	1.4	1.2	1.3	0	149	17.0
2016-06-08 02:06:06	37.278	-98.850	5.0	1.9	3.6	2.9	0	150	18.6
2016-06-08 02:24:39	37.302	-98.861	5.0	1.8	2.9	2.3	0	146	18.2
2016-06-08 03:25:21	37.290	-98.901	5.0	1.7	3.3	3.4	0	178	17.9
2016-06-08 04:07:27	37.311	-98.855	5.0	1.8	1.9	1.6	0	144	18.2
2016-06-08 04:23:35	37.316	-98.878	5.0	1.6	3.1	4.6	0	206	17.6
2016-06-08 06:29:11	37.301	-98.885	5.0	1.7	2.3	1.9	0	162	17.9
2016-06-08 08:11:49	37.285	-98.844	5.0	1.4	2.9	2.4	0	170	17.0
2016-06-08 10:54:57	37.300	-98.861	5.0	1.5	1.4	1.3	0	167	17.3
2016-06-08 10:56:47	37.316	-98.878	5.0	1.9	2.0	2.0	0	132	18.6
2016-06-08 12:21:59	37.293	-98.860	5.0	1.7	1.6	1.4	0	168	17.9
2016-06-08 13:16:50	37.300	-98.833	5.0	1.4	2.1	1.9	0	168	17.0
2016-06-08 18:39:02	37.300	-98.859	5.0	1.8	2.0	1.5	0	146	18.2
2016-06-08 20:43:10	37.314	-98.867	5.0	1.8	3.0	2.9	0	158	18.2
2016-06-08 20:52:16	37.314	-98.875	5.0	2.2	1.9	1.6	0	155	19.8
2016-06-09 05:35:58	37.295	-98.861	5.0	1.7	1.7	1.3	0	155	17.9
2016-06-09 06:19:26	37.314	-98.848	5.0	1.8	2.2	1.9	0	144	18.2
2016-06-09 06:30:47	37.339	-98.888	5.0	1.5	3.5	5.0	0	174	17.3
2016-06-09 06:35:00	37.280	-98.864	5.0	1.8	1.9	1.3	0	170	18.2
2016-06-10 20:10:05	37.313	-98.869	5.0	2.3	2.2	1.9	0	138	19.3
2016-06-10 20:13:54	37.308	-98.870	5.0	2.0	2.9	2.4	0	141	19.0
2016-06-10 21:41:36	37.306	-98.860	5.0	1.7	3.1	2.5	0	166	17.9
2016-06-11 00:18:08	37.293	-98.853	5.0	1.9	2.2	1.7	0	148	18.6
2016-06-11 03:23:10	37.306	-98.873	5.0	1.9	2.7	2.3	0	162	18.6
2016-06-11 08:05:59	37.302	-98.866	5.0	1.5	2.5	2.0	0	166	17.3
2016-06-11 09:15:14	37.284	-98.854	5.0	1.4	3.1	2.4	0	170	17.0
2016-06-12 19:53:27	37.339	-98.907	5.0	1.8	2.8	3.0	0	153	18.2
2016-06-13 05:53:50	37.302	-98.859	5.0	2.3	2.0	1.7	0	146	19.3
2016-06-13 06:05:33	37.305	-98.862	5.0	2.2	2.0	1.5	0	145	18.8
2016-06-13 06:14:32	37.300	-98.871	5.0	1.5	3.7	2.9	0	166	17.3
2016-06-13 06:51:14	37.300	-98.871	5.0	1.5	3.7	3.6	0	166	17.3
2016-06-13 09:11:16	37.307	-98.869	5.0	1.6	2.5	2.4	0	163	17.6
2016-06-13 19:18:57	37.276	-98.858	5.0	1.5	3.2	2.6	0	171	17.3
2016-06-14 01:18:22	37.302	-98.884	5.0	1.8	2.6	2.2	0	161	18.2

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-06-15 10:09:37	37.310	-98.865	5.0	1.9	2.2	1.6	0	142	14.6
2016-06-16 16:07:55	37.339	-98.881	5.0	1.5	1.7	1.6	0	159	14.3
2016-06-16 19:10:26	37.352	-98.888	5.0	1.9	1.8	2.1	0	129	15.6
2016-06-22 09:19:57	37.299	-98.851	5.0	2.2	1.7	1.4	0	147	16.8
2016-06-22 09:25:32	37.336	-98.893	5.0	2.0	1.8	1.4	0	119	18.0
2016-06-22 21:14:49	37.270	-98.851	5.0	1.7	3.8	1.4	0	179	15.9
2016-06-23 05:19:11	37.318	-98.887	5.0	1.5	1.9	1.7	0	145	15.3
2016-06-29 13:39:09	37.301	-98.879	5.0	1.8	2.2	1.7	0	144	14.2

Table 2. Earthquakes located by the Kansas seismic monitoring network in Saline County from January through June 2016. Green indicates earthquakes also reported in the PDE.

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2015-09-29 17:51:38	38.907	-97.435	5.0	2.0	3.4	3.8	0.0	289	7.0
2015-12-29 05:08:11	38.899	-97.475	5.0	1.8	2.4	2.5	0.0	289	6.2
2016-01-03 14:24:40	38.863	-97.456	5.0	2.1	4.3	4.6	0.0	286	9.4
2016-02-10 05:22:10	38.830	-97.485	5.0	2.4	2.6	2.8	0.0	284	8.8
2016-02-19 13:43:15	38.886	-97.386	5.0	1.9	7.0	7.4	0.0	288	6.6
2016-02-23 21:23:13	38.852	-97.434	5.0	2.1	4.0	4.4	0.0	286	11.4
2016-03-03 22:12:37	38.842	-97.478	5.0	1.8	1.9	2.0	0.0	285	13.2
2016-03-03 22:13:52	38.844	-97.476	5.0	1.8	5.2	4.5	0.0	285	15.2
2016-03-23 04:35:52	38.756	-97.417	5.0	2.4	3.9	4.7	0.0	279	8.8
2016-03-26 01:06:05	38.788	-97.435	5.0	2.1	2.3	2.9	0.0	281	13.4
2016-04-04 12:34:14	38.747	-97.559	5.0	2.5	4.7	5.2	0.0	277	9.3
2016-04-04 12:36:13	38.755	-97.475	5.0	1.9	3.0	3.5	0.0	278	13.6
2016-04-05 12:21:53	38.769	-97.424	5.0	1.9	5.3	6.4	0.0	280	14.6
2016-04-05 12:53:34	38.851	-97.453	5.0	1.6	5.6	4.9	0.0	301	10.6
2016-04-14 09:57:28	38.783	-97.535	5.0	1.8	2.5	2.7	0.0	280	14.2
2016-04-14 10:29:01	38.831	-97.497	5.0	1.9	2.6	2.8	0.0	284	16.6
2016-04-14 11:27:30	38.857	-97.509	5.0	2.2	2.2	2.3	0.0	286	15.8
2016-05-22 11:48:27	38.662	-97.542	5.0	2.2	1.4	1.6	0.0	269	7.8
2016-06-18 02:50:08	38.780	-97.532	5.0	1.8	2.6	2.6	1.0	280	6.2
2016-06-27 03:52:11	38.637	-97.561	5.0	1.8	1.7	2.7	2.0	330	6.2

Table 3. Earthquakes located by the Kansas seismic monitoring network from January through June 2016 in Sedgwick and Butler counties in an area outside previously reported seismicity zones.

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-01-16 18:59:28	37.608	-97.345	5.0	2.1	1.5	2.0	0.0	204	7.4
2016-01-28 22:23:02	37.517	-97.023	5.0	2.0	1.2	2.0	0.0	242	7.0
2016-03-02 06:34:40	37.835	-97.312	5.0	2.0	1.2	1.9	0.0	220	7.0
2016-03-08 13:17:10	37.535	-97.145	5.0	1.6	1.1	1.5	0.0	259	5.6
2016-03-13 06:52:02	37.959	-96.955	5.0	2.0	1.4	2.1	0.0	253	8.0
2016-03-13 13:18:52	37.948	-96.940	5.0	2.2	2.8	4.4	0.0	254	10.8
2016-03-15 09:32:57	37.956	-96.922	5.0	2.1	3.3	4.8	0.0	256	11.4
2016-03-21 00:37:47	37.486	-97.182	5.0	1.3	2.7	3.5	0.0	250	6.7
2016-03-21 11:04:23	37.531	-97.147	5.0	2.1	1.3	1.9	0.0	225	11.4
2016-03-31 10:26:25	37.555	-97.234	5.0	1.8	2.2	3.0	0.0	214	12.2
2016-04-04 12:58:20	37.638	-97.095	5.0	1.7	2.6	3.9	0.0	234	5.9
2016-04-11 12:05:53	37.546	-97.159	5.0	1.9	3.6	4.9	0.0	258	12.6
2016-04-17 11:52:40	37.535	-97.363	5.0	1.6	1.7	3.2	0.0	280	5.6
2016-04-23 08:30:39	37.526	-97.136	5.0	1.6	2.8	3.7	0.0	260	9.6
2016-05-09 22:16:03	37.692	-97.199	5.0	2.0	2.1	3.2	0.0	224	9.0
2016-05-09 22:28:13	37.676	-97.216	5.0	1.8	1.4	2.2	0.0	222	10.2
2016-05-10 03:07:05	37.633	-97.231	5.0	1.9	4.5	4.8	0.0	259	12.6
2016-05-11 03:33:19	37.684	-97.205	5.0	2.1	1.4	2.2	0.0	223	14.4
2016-05-11 04:12:31	37.668	-97.220	5.0	2.1	2.1	3.2	0.0	221	16.4
2016-05-12 11:05:58	37.654	-97.227	5.0	2.0	1.6	2.4	0.0	220	15.0

Table 4. Earthquakes located by the Kansas seismic monitoring network near Geuda Springs from January through June 2016.

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-01-22 09:26:30	37.214	-97.267	5.0	2.0	1.7	1.9	0.0	180	9.0
2016-01-22 12:22:22	37.202	-97.270	5.0	1.9	1.7	1.8	0.0	174	10.6
2016-01-22 13:00:03	37.187	-97.283	5.0	1.8	2.1	1.9	0.0	162	12.2
2016-02-17 14:14:54	37.046	-97.180	5.0	2.0	2.5	2.2	0.0	263	7.0
2016-02-26 00:27:20	37.068	-97.181	5.0	1.6	2.7	1.4	0.0	302	7.6
2016-03-01 04:04:02	37.081	-97.188	5.0	1.9	2.6	1.8	0.0	255	11.6
2016-03-02 01:28:15	37.083	-97.189	5.0	2.2	3.6	2.6	0.0	255	14.8
2016-03-03 15:58:03	37.099	-97.188	5.0	1.7	2.5	1.7	0.0	243	13.9
2016-03-04 21:43:27	37.012	-97.206	5.0	2.2	1.8	2.9	0.0	313	15.8
2016-03-04 23:34:04	37.057	-97.178	5.0	1.4	3.2	2.1	0.0	306	13.0
2016-03-08 09:06:26	37.130	-97.290	5.0	1.5	1.3	0.7	0.0	182	6.3
2016-03-09 04:00:44	37.144	-97.281	5.0	1.5	2.0	1.1	0.0	171	10.3
2016-03-09 15:08:48	37.082	-97.184	5.0	1.8	2.2	1.7	0.0	259	15.2
2016-03-09 22:06:49	37.104	-97.183	5.0	1.8	2.7	1.7	0.0	243	15.2
2016-03-10 04:47:48	37.128	-97.291	5.0	2.0	1.6	1.1	0.0	181	11.0
2016-03-10 08:57:12	37.156	-97.280	5.0	1.4	1.5	1.0	0.0	161	11.0
2016-03-12 00:24:50	37.062	-97.170	5.0	2.0	2.6	2.1	0.0	274	15.0
2016-03-12 14:18:28	37.094	-97.168	5.0	1.4	6.1	3.6	0.0	306	14.0
2016-03-13 06:44:26	37.057	-97.150	5.0	1.7	2.8	3.0	0.0	289	14.9
2016-03-16 05:14:29	37.127	-97.282	5.0	1.3	1.4	0.8	0.0	184	12.7

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-03-16 14:20:31	37.131	-97.291	5.0	2.1	1.5	0.9	0.0	181	15.4
2016-03-19 23:09:43	37.090	-97.163	5.0	1.3	3.2	2.1	0.0	315	13.7
2016-03-20 13:21:41	37.058	-97.158	5.0	1.1	4.3	3.2	0.0	282	13.2
2016-03-22 10:45:19	37.140	-97.287	5.0	1.4	2.4	1.3	0.0	174	13.0
2016-04-03 16:32:54	37.129	-97.281	5.0	0.6	1.5	0.9	0.0	183	11.4
2016-04-25 03:13:17	37.090	-97.160	5.0	1.9	4.1	2.5	0.0	316	6.6
2016-04-26 20:40:18	37.077	-97.188	5.0	1.6	4.8	2.6	0.0	257	7.6
2016-05-11 02:56:51	37.169	-97.304	5.0	1.6	2.8	2.1	0.0	167	5.6

Table 5. Earthquakes located by the Kansas seismic monitoring network near Cheney from January through June 2016. Yellow highlighting indicates SAS of 17 or greater, and green indicates earthquakes also reported in the PDE.

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-01-01 09:02:24	37.549	-97.760	5.0	2.1	2.3	1.8	0.0	152	16.4
2016-01-05 20:38:19	37.522	-97.875	5.0	1.0	1.4	1.9	0.0	133	12.0
2016-01-07 08:34:02	37.515	-97.853	5.0	2.1	1.8	1.7	0.0	104	15.4
2016-01-12 15:20:02	37.530	-97.797	5.0	0.7	1.9	2.0	0.0	193	11.5
2016-01-12 21:03:11	37.514	-97.801	5.0	2.0	2.2	1.9	0.0	102	17.0
2016-01-13 03:49:34	37.516	-97.804	5.0	1.7	1.9	1.6	0.0	115	17.9
2016-01-13 08:30:08	37.505	-97.813	5.0	1.8	1.9	1.8	0.0	98	18.2
2016-01-14 00:18:55	37.515	-97.809	5.0	1.4	1.2	1.3	0.0	113	15.0
2016-01-14 00:33:36	37.495	-97.811	5.0	0.5	1.7	2.2	0.0	147	11.3
2016-01-14 02:21:31	37.509	-97.817	5.0	2.0	1.9	1.8	0.0	100	18.0
2016-01-14 02:40:19	37.510	-97.806	5.0	2.0	2.0	1.8	0.0	100	18.0
2016-01-15 15:56:39	37.498	-97.813	5.0	2.2	1.8	1.5	0.0	131	16.8
2016-01-16 14:39:13	37.567	-97.750	5.0	2.0	2.0	1.9	0.0	146	19.0
2016-01-16 17:54:05	37.568	-97.752	5.0	2.0	2.0	1.9	0.0	146	18.0
2016-01-16 20:00:27	37.566	-97.761	5.0	2.1	1.8	2.0	0.0	158	18.4
2016-01-16 20:07:07	37.559	-97.744	5.0	1.4	1.4	1.3	0.0	169	14.0
2016-01-16 20:13:20	37.569	-97.756	5.0	2.0	1.6	1.5	0.0	145	18.0
2016-01-16 22:17:44	37.536	-97.769	5.0	1.4	2.1	2.0	0.0	185	14.0
2016-01-20 03:50:51	37.505	-97.814	5.0	2.0	0.9	1.1	0.0	113	16.0
2016-01-20 03:56:38	37.506	-97.818	5.0	1.1	1.6	1.9	0.0	114	16.2
2016-01-20 04:01:08	37.504	-97.817	5.0	1.2	1.2	1.5	0.0	141	16.4
2016-01-20 07:33:59	37.515	-97.811	5.0	1.5	1.3	1.3	0.0	113	16.3
2016-01-20 07:55:35	37.520	-97.798	5.0	0.8	1.7	2.0	0.0	134	14.6
2016-01-20 19:58:56	37.488	-97.790	5.0	0.9	1.7	2.2	0.0	157	15.8
2016-01-21 11:17:10	37.505	-97.837	5.0	1.3	1.4	1.7	0.0	209	13.7
2016-01-23 16:28:22	37.618	-97.741	5.0	2.0	1.6	1.8	0.0	164	15.0
2016-01-26 14:54:02	37.566	-97.828	5.0	1.7	1.4	1.2	0.0	145	13.9
2016-01-26 15:06:11	37.568	-97.824	5.0	0.6	0.8	0.9	0.0	147	11.4
2016-02-12 10:22:07	37.600	-97.714	5.0	1.5	2.5	2.2	0.0	204	13.3
2016-02-14 05:49:40	37.556	-97.748	5.0	1.9	1.7	1.3	0.0	163	14.6
2016-02-21 14:31:19	37.562	-97.736	5.0	1.8	1.8	1.7	0.0	176	14.2
2016-02-27 11:42:17	37.558	-97.752	5.0	1.3	1.2	1.2	0.0	164	13.7
2016-02-27 17:21:19	37.552	-97.743	5.0	1.2	0.9	1.0	0.0	162	13.4
2016-02-28 01:39:39	37.476	-97.806	5.0	1.0	1.2	1.6	0.0	159	11.0
2016-03-06 08:41:34	37.520	-97.865	5.0	2.3	1.6	1.5	0.0	107	16.3

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-03-06 08:57:46	37.524	-97.864	5.0	1.2	0.9	1.5	0.0	129	12.4
2016-03-08 22:42:01	37.624	-97.656	5.0	1.9	1.2	1.2	0.0	173	8.6
2016-03-09 08:08:20	37.582	-97.811	5.0	1.3	1.1	1.1	0.0	163	12.7
2016-03-10 12:00:23	37.513	-97.866	5.0	1.8	1.8	1.8	0.0	103	14.2
2016-03-11 11:55:58	37.648	-97.754	5.0	1.6	2.7	1.9	0.0	217	10.6
2016-03-11 21:07:33	37.619	-97.778	5.0	1.5	2.9	2.1	0.0	201	14.3
2016-03-13 17:43:21	37.559	-97.838	5.0	0.7	1.5	1.8	0.0	137	12.5
2016-03-13 20:01:33	37.488	-97.842	5.0	1.1	0.8	1.1	0.0	143	13.2
2016-03-20 19:32:28	37.610	-97.781	5.0	1.3	6.5	4.7	0.0	195	16.7
2016-03-20 19:47:06	37.579	-97.812	5.0	1.4	2.0	1.8	0.0	160	17.0
2016-03-21 00:26:00	37.579	-97.818	5.0	2.8	1.3	1.2	0.0	136	18.8
2016-03-21 00:28:15	37.581	-97.815	5.0	1.2	1.9	1.7	0.0	160	16.4
2016-03-21 00:47:07	37.575	-97.806	5.0	1.8	1.8	1.7	0.0	159	18.2
2016-03-21 01:09:35	37.585	-97.809	5.0	1.9	1.0	1.0	0.0	166	18.6
2016-03-21 02:05:03	37.568	-97.816	5.0	1.9	1.2	1.3	0.0	131	18.6
2016-03-21 02:12:02	37.576	-97.812	5.0	0.8	1.1	1.3	0.0	158	13.6
2016-03-21 03:07:53	37.583	-97.806	5.0	1.6	1.9	2.1	0.0	165	17.6
2016-03-21 03:27:47	37.588	-97.805	5.0	1.6	1.5	1.5	0.0	169	17.6
2016-03-22 02:05:42	37.568	-97.830	5.0	1.4	1.2	1.4	0.0	145	15.0
2016-03-24 18:30:27	37.511	-97.867	5.0	0.3	3.5	4.0	0.0	220	14.1
2016-03-24 23:52:33	37.566	-97.819	5.0	0.3	1.9	2.2	0.0	148	13.1
2016-03-24 23:53:38	37.536	-97.840	5.0	0.5	4.5	4.2	0.0	205	13.3
2016-03-25 08:07:26	37.516	-97.808	5.0	1.4	1.9	1.4	0.0	129	14.0
2016-03-25 13:22:33	37.555	-97.827	5.0	1.3	3.9	3.9	0.0	194	13.7
2016-03-30 06:12:20	37.580	-97.810	5.0	1.6	0.9	1.1	0.0	162	17.6
2016-03-30 09:00:46	37.573	-97.815	5.0	1.0	1.1	1.3	0.0	154	14.0
2016-03-30 11:10:46	37.574	-97.832	5.0	2.6	1.8	1.8	0.0	131	19.8
2016-03-30 11:32:27	37.575	-97.810	5.0	1.3	2.0	2.2	0.0	158	16.7
2016-03-30 12:56:37	37.576	-97.814	5.0	2.1	0.8	0.9	0.0	135	18.4
2016-03-30 13:56:47	37.586	-97.809	5.0	1.6	2.4	2.1	0.0	166	17.6
2016-03-30 17:13:35	37.591	-97.815	5.0	1.9	1.5	1.9	0.0	142	18.6
2016-03-30 18:48:29	37.591	-97.815	5.0	2.2	1.7	1.9	0.0	142	18.8
2016-03-30 19:28:18	37.569	-97.807	5.0	1.9	1.6	1.8	0.0	133	18.6
2016-03-30 20:29:59	37.612	-97.786	5.0	1.5	3.1	2.3	0.0	195	17.3
2016-04-04 20:19:22	37.503	-97.849	5.0	1.2	1.5	1.7	0.0	124	12.4
2016-04-15 09:26:20	37.633	-97.779	5.0	1.5	1.8	2.0	0.0	212	13.3
2016-04-18 17:45:30	37.561	-97.824	5.0	1.2	1.3	1.6	0.0	143	12.4
2016-04-23 03:13:05	37.598	-97.764	5.0	1.8	2.0	2.2	0.0	159	15.2
2016-04-23 11:47:28	37.596	-97.770	5.0	1.2	2.1	2.1	0.0	190	13.4
2016-04-24 02:04:37	37.566	-97.744	5.0	1.4	1.5	1.4	0.0	177	16.0
2016-04-24 15:11:46	37.556	-97.748	5.0	1.3	1.1	1.1	0.0	163	13.7
2016-04-25 22:26:38	37.569	-97.788	5.0	1.9	4.2	3.4	0.0	137	15.6
2016-04-26 13:50:17	37.562	-97.747	5.0	1.9	4.0	3.7	0.0	170	15.6
2016-04-26 21:56:38	37.586	-97.808	5.0	1.1	2.1	2.1	0.0	141	12.2
2016-04-28 13:19:48	37.559	-97.801	5.0	0.7	2.8	3.1	0.0	186	11.5
2016-04-30 09:08:15	37.561	-97.792	5.0	1.5	1.0	1.0	0.0	153	13.3
2016-05-04 15:23:03	37.581	-97.790	5.0	1.4	2.6	2.6	0.0	169	15.0
2016-05-05 09:40:12	37.579	-97.805	5.0	1.5	1.9	1.6	0.0	162	16.3
2016-05-05 09:53:46	37.573	-97.817	5.0	1.5	2.1	1.8	0.0	154	16.3

origin time (UTC)	latitude	longitude	depth (km)	magnitude (MC)	latitude error (km)	longitude error (km)	depth error (km)	gap	SAS
2016-05-05 11:00:06	37.566	-97.824	5.0	2.0	4.1	2.1	0.0	189	16.0
2016-05-14 05:24:01	37.579	-97.815	5.0	1.6	1.9	1.6	0.0	159	14.6
2016-05-14 06:38:36	37.580	-97.829	5.0	2.2	1.3	1.3	0.0	135	16.8
2016-05-14 06:40:05	37.591	-97.827	5.0	1.9	1.3	1.7	0.0	140	16.6
2016-05-14 19:33:15	37.585	-97.819	5.0	2.5	1.9	1.9	0.0	139	18.3
2016-05-16 18:10:17	37.539	-97.771	5.0	1.4	1.6	1.7	0.0	139	13.0
2016-05-24 21:07:48	37.503	-97.716	5.0	1.9	1.7	1.7	1.0	150	13.6
2016-05-24 23:06:59	37.494	-97.745	5.0	2.4	1.7	1.8	2.0	96	16.8
2016-06-06 23:57:04	37.508	-97.746	5.0	1.8	1.9	1.4	3.0	124	12.2
2016-06-08 08:02:45	37.585	-97.776	5.0	2.3	1.9	1.8	4.0	149	16.3
2016-06-15 05:58:22	37.574	-97.815	5.0	2.2	1.2	1.3	5.0	134	14.8
2016-06-15 12:41:39	37.519	-97.839	5.0	2.0	1.8	1.8	6.0	112	16.0
2016-06-20 09:36:19	37.538	-97.857	5.0	1.7	0.7	0.7	7.0	119	11.9
2016-06-21 18:02:10	37.577	-97.823	5.0	1.8	2.0	1.8	8.0	155	18.2
2016-06-21 18:42:16	37.585	-97.822	5.0	2.4	1.1	1.1	9.0	138	20.8
2016-06-21 18:53:51	37.578	-97.816	5.0	1.3	1.6	1.9	10.0	158	16.7
2016-06-21 19:11:46	37.582	-97.831	5.0	2.4	1.1	1.1	11.0	135	20.8
2016-06-21 19:39:05	37.579	-97.827	5.0	2.2	1.9	1.8	12.0	154	19.8
2016-06-21 21:28:05	37.592	-97.795	5.0	2.4	2.0	2.1	13.0	147	20.8
2016-06-22 00:21:27	37.583	-97.811	5.0	2.3	1.5	1.6	14.0	139	20.3
2016-06-22 00:27:04	37.581	-97.833	5.0	2.4	1.8	1.9	15.0	134	20.8
2016-06-22 01:29:29	37.577	-97.816	5.0	1.9	1.1	1.0	16.0	157	18.6
2016-06-22 03:03:51	37.581	-97.812	5.0	1.8	0.9	0.9	17.0	161	18.2
2016-06-22 13:30:40	37.580	-97.823	5.0	1.7	1.5	1.2	18.0	156	17.9
2016-06-22 13:49:29	37.573	-97.816	5.0	2.3	1.0	1.0	19.0	133	20.3
2016-06-22 14:23:51	37.577	-97.815	5.0	1.0	1.1	1.2	20.0	158	14.0
2016-06-22 22:13:09	37.577	-97.813	5.0	2.2	1.4	1.6	21.0	136	19.8
2016-06-23 01:25:48	37.571	-97.810	5.0	1.3	1.2	1.5	22.0	155	15.7
2016-06-25 23:14:56	37.583	-97.821	5.0	2.7	1.7	1.7	23.0	137	18.3
2016-06-25 23:21:01	37.600	-97.788	5.0	2.2	1.6	2.0	24.0	152	18.8
2016-06-25 23:38:15	37.576	-97.807	5.0	2.1	1.5	1.3	25.0	159	17.4
2016-06-26 05:08:02	37.571	-97.815	5.0	1.2	0.8	0.9	26.0	153	12.4
2016-06-26 06:47:37	37.570	-97.827	5.0	2.1	1.6	1.6	27.0	130	17.4
2016-06-27 09:13:50	37.573	-97.804	5.0	1.4	1.7	1.0	28.0	260	14.0
2016-06-27 09:38:57	37.578	-97.821	5.0	2.4	1.8	1.9	29.0	135	17.8
2016-06-27 13:17:24	37.573	-97.818	5.0	1.6	1.4	1.3	30.0	154	14.6
2016-06-28 00:43:58	37.585	-97.821	5.0	2.3	1.9	1.9	31.0	138	17.3
2016-06-29 03:07:49	37.487	-97.825	5.0	0.8	0.6	0.9	32.0	117	11.6
2016-06-30 00:44:39	37.586	-97.766	5.0	1.8	2.0	1.9	33.0	153	16.2
2016-06-30 08:32:13	37.580	-97.816	5.0	1.3	1.8	1.7	34.0	159	14.7
2016-06-30 15:24:32	37.585	-97.817	5.0	1.7	1.8	1.9	35.0	139	15.9

Table 6. Earthquakes located by both the KGS and the USGS (reported in the NEIC global earthquake bulletin PDE) from January through June 2016. Yellow highlighting indicates SAS of 17 or greater.

KGS origin time (UTC)	KGS magnitude	KGS SAS	USGS magnitude	USGS SAS
2016-01-01 12:25:58	2.4	19.8	2.1	15.4
2016-01-14 15:17:54	2.4	18.8	2.3	8.3
2016-02-04 03:47:28	2.4	20.8	2.6	10.8
2016-02-05 00:28:31	1.6	17.6	1.8	8.2
2016-02-10 20:57:39	2.2	19.8	3.1	13.6
2016-02-21 23:52:20	3.0	20.0	2.9	12.4
2016-02-25 02:39:43	2.5	18.3	2.5	12.3
2016-02-28 12:46:15	2.1	16.4	2.5	12.3
2016-03-14 23:53:53	2.6	17.8	2.6	10.8
2016-03-15 03:07:51	2.1	16.4	2.2	9.4
2016-03-15 23:11:36	2.4	16.8	2.5	10.3
2016-03-18 16:18:10	2.3	17.3	2.7	11.3
2016-03-19 21:34:49	2.8	18.8	3.0	15.0
2016-03-21 00:26:00	2.8	18.8	2.8	11.8
2016-04-01 16:35:02	2.1	15.4	1.9	6.6
2016-04-02 23:26:16	2.4	19.8	2.3	8.3
2016-04-04 12:34:14	2.5	9.3	2.8	11.8
2016-04-05 15:43:13	2.0	17.0	2.6	12.8
2016-04-08 20:30:38	2.3	17.3	2.5	12.3
2016-04-23 04:05:03	2.3	16.3	2.2	7.8
2016-05-01 05:37:42	2.9	19.4	3.4	17.6
2016-05-02 03:04:49	2.5	18.3	2.4	12.8
2016-05-03 20:21:02	2.5	17.3	2.6	10.3
2016-05-14 06:38:36	2.2	16.8	2.5	10.3
2016-05-14 19:04:42	2.8	18.8	2.8	11.8
2016-05-24 13:50:58	2.5	20.3	2.6	10.8
2016-05-24 21:46:47	2.4	17.8	2.5	10.3
2016-06-01 18:13:26	2.9	18.4	3.1	15.6
2016-06-02 08:11:38	2.7	17.3	2.5	12.3
2016-06-05 17:08:26	2.5	16.3	3.2	16.2
2016-06-11 07:27:09	3.1	20.6	3.5	15.3
2016-06-15 00:55:40	2.5	17.3	2.7	11.3
2016-06-21 23:32:58	2.6	17.8	2.6	14.8
2016-06-25 23:14:56	2.7	18.3	2.6	10.8
2016-06-26 18:35:38	3.1	20.6	3.4	15.6

Appendix A (online only). Earthquakes located by the Kansas seismic monitoring network from January through June 2016. Yellow highlighting indicates SAS of 17 or greater, and green indicates earthquakes also reported in the NEIC global earthquake bulletin (PDE). The appendix is available at http://www.kgs.ku.edu/ Geophysics/Earthquakes/Newsletter/EQ_Highlights_Issue_2_July2016_Appendix_A.pdf.