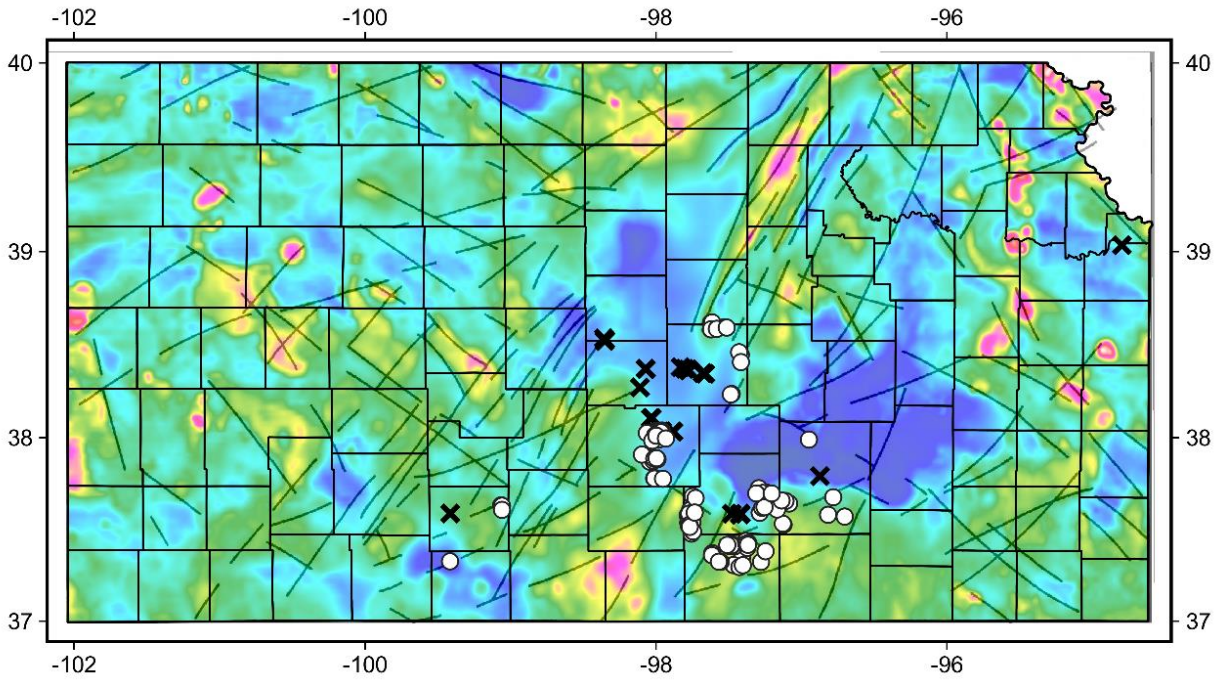
Consortium to Study Trends in Seismicity



July 1, 2019 – June 30, 2020

Annual Report by
Rex Buchanan, Shelby Peterie, Rick Miller

Kansas Geological Survey Open-file Report 2021-5

Cover Figure Caption: Earthquakes (white) located using CSTS stations that otherwise would have not been located by any other seismic network. Correlated with structural trends, the earthquakes provide insight into the stress conditions and relative stability of both unmapped faults and faults interpreted geologic and geophysical datasets.

Kansas Geological Survey
Consortium to Study Trends in Seismicity

2019-2020 Annual Report

NOTICE: This annual report was released in draft to Consortium members, as well as the Kansas Department of Health and Environment, at the Consortium's 2020 annual meeting held virtually on August 12, 2020, and was subject to further review and comment by Consortium members until April 30, 2021. The KGS was then allowed an additional three months to revise the draft annual report and distribute the final annual report.

CONSORTIUM TO STUDY TRENDS IN SEISMICITY
KANSAS GEOLOGICAL SURVEY
Fourth Quarter / Annual Report
July 1, 2019 – June 30, 2020

INTRODUCTION

The Kansas Geological Survey's Consortium to Study Trends in Seismicity (CSTS) is a public-private project aimed at studying trends in seismicity in Kansas. The consortium focuses on areas where public and private entities could benefit from high-sensitivity seismic monitoring. Seismicity has increased significantly in Kansas and the midcontinent since 2013, leading to a need to better define and understand earthquake activity, particularly as it relates to subsurface fluid disposal. The CSTS oversees the operation of a seismic network that records and allows accurate location and magnitude estimates of seismicity for felt earthquakes and particularly for microseismic events that are hundreds of times smaller than can be routinely identified with previous regional seismic networks. Understanding current micro-trends in seismicity and establishing a data-driven awareness of potential factors affecting seismicity should help with industry response, guide governmental oversight, and inform public opinion.

The CSTS is operated by the Kansas Geological Survey (KGS), a research and service division of the University of Kansas with a long history of studying the state's subsurface and seismic issues. Current members of the CSTS are from the state's Class I disposal well community—wells that are used for disposal of municipal and industrial waste and regulated by the Kansas Department of Health and Environment (KDHE). Membership in the CSTS is voluntary; the CSTS objective is understanding seismicity in proximity to member facilities. The CSTS works to establish baseline or background seismicity near those facilities and provide a scientific basis for differentiating natural from induced seismicity. Confidence in distinguishing natural from induced earthquake trends is greatly enhanced through extended monitoring periods with stations near earthquake events.

The following report describes the third year of CSTS activities, including a discussion of membership status; network station installation and operation; earthquakes recorded and identified, and earthquake alerts provided to members; web page development; other activities, especially involving publications, presentations, and meeting attendance; and plans for the coming year. Three quarterly reports were provided to members since the Consortium's annual meeting in July 2019. This current report includes summaries of seismicity and CSTS activities in both in the past quarter (April, May, and June of 2020) and for the past year.

STATUS OF MEMBERS

The CSTS was established with a two-tier membership system. For Tier 1 members the CSTS provides equipment, installation, and monitoring of a seismograph station; maintains a catalog of seismic events, updated weekly, with a goal of providing e-mail alerts within 24 hours or less of any earthquakes greater than magnitude 2 within 30 miles of a facility; provides quarterly reports of monitoring findings; and hosts an annual meeting at which results are discussed and plans formulated for the coming year. Tier 2 members have access to information

related to the general information about the seismicity being studied by the CSTS and can attend the annual meeting, but do not have the right to vote at that meeting or use the reports while still under confidential status.

The CSTS currently has ten Tier 1 members and one Tier 2 member.

STATUS OF NETWORK

The CSTS seismic network currently consists of eleven stations in Ellsworth, Rice, McPherson, Reno, Kiowa, Sedgwick, Butler, and Johnson counties, Kansas (Figure 1). Waveforms for these stations are available for Tier 1 members on the seismic network page of the CSTS website. For each of those locations, ambient noise tests were completed to establish background noise levels. Those tests identified noise from nearby highways, trains, pump jacks, and other facilities that might interfere with earthquake analysis. Stations were relocated with a site-specific ambient noise test when initially deployed in places where noise and vibrations interfered with station response characteristics above a pre-determined threshold. Many of the existing sites are in cemeteries, on government property, or in other locations where noise levels are measured to be low and are likely to remain low. In all cases, KGS has obtained written agreements with landowners of each station location.

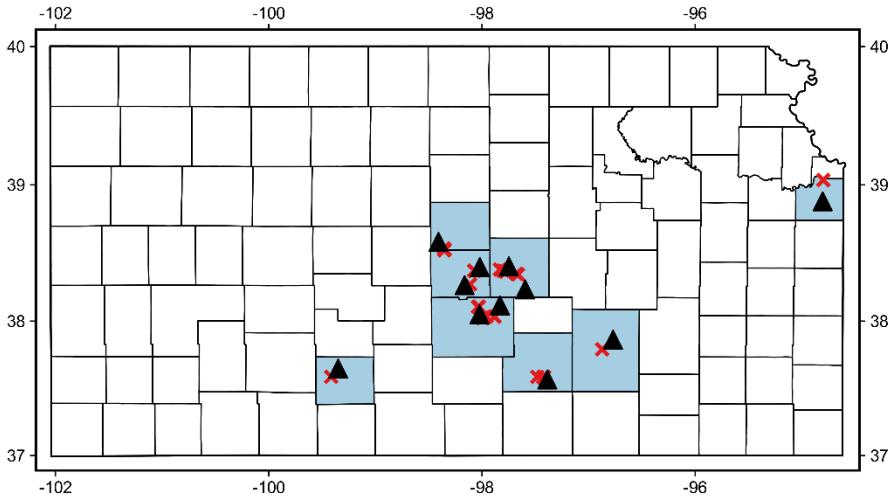


Figure 1. Earthquake stations (black triangles) with member facilities (red X) provide high sensitivity coverage with the potential to identify earthquakes with magnitudes below 0 within 20 miles of each facility.

Each station consists of a seismic sensor that includes a shallowly buried seismometer embedded in a concrete platform atop a gravel layer and a digitizer (Figure 2). Ground motion detected by the seismometer is transmitted back to KGS offices in Lawrence real-time via a cellular modem. That communication system is powered by a solar panel that charges two deep-cycle marine batteries. The footprint for each station is approximately 10 feet by 10 feet. The stations operated over the last year with a better than 98% continuous data stream and within designated operational sensitivity and signal-to-noise ratio.

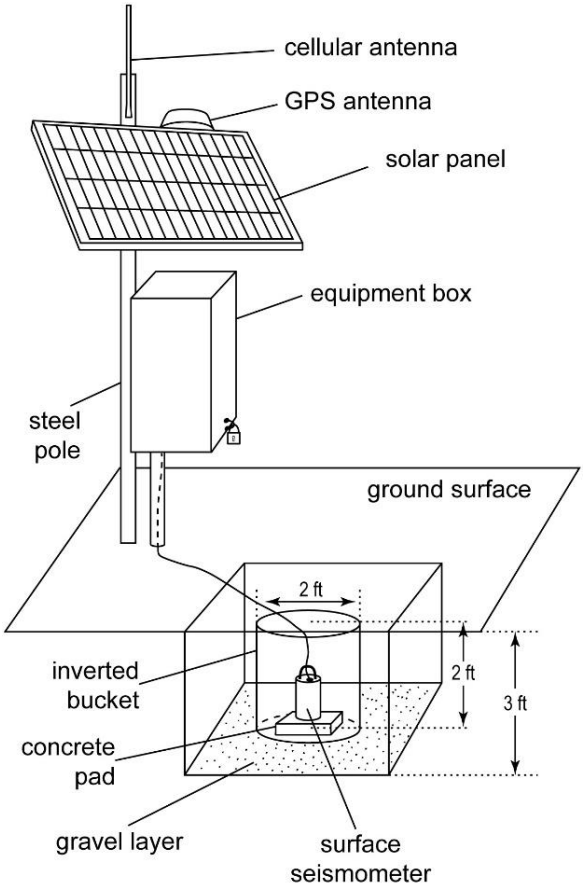


Figure 2. Diagram illustrating a temporary seismic installation.

EARTHQUAKE ALERTS, CATALOG

Earthquakes with magnitudes of 2 or larger represent a threshold above which energy levels provide highly confident automatic analysis for feeds coming from a network as dense as the CSTS network and especially in conjunction with the KGS regional and sub-regional networks. It is therefore reasonable to provide accurate epicenter locations using automated picking routines for each event down to M 2, with results available within minutes of the fault rupture. KGS staff notify CSTS members of a M 2 or larger earthquake within 30 miles of Tier 1 member wells. There were 108 earthquake alerts from July 2019 through June 2020 (Table 1), about the same as the 2018-2019 reporting year. Earthquakes below M 2.5 are generally considered below felt levels. Earthquakes with magnitudes down to 1 can be located with confidence in areas where at least three CSTS stations are within 50 miles of each other.

INTERESTING OBSERVATIONS AND SIGNIFICANT TRENDS

Regional Seismicity (M 2 or larger)

More than 400 earthquakes magnitude (M) 2 or larger were recorded in Kansas during the past year (Figure 2). The overall earthquake rate continued to decline, and the number of regional scale events (M 2 or larger) decreased by about 10% relative to the previous year (457 from July 2018 through June 2019). The vast majority of these events either occurred in parts of the state where historic earthquakes occurred along prominent basement structures or where earthquakes were recorded in recent years. The most notable events were several M > 4 earthquakes occurred near Hutchinson, the largest earthquakes ever recorded in that area.

South-Central Kansas

More than a quarter of the regional-scale earthquakes (M 2 or larger) recorded by the KGS network were located in south-central Kansas (Figure 3). However, the rate of earthquakes in this area has dropped dramatically since the KGS network was installed in 2015. In Harper and Sumner counties 81 M 2 or larger earthquakes were recorded during the past year, about 65% less than the previous reporting period and an overall decrease of about 90% relative to

2015. Earthquake clusters generally occurred in areas where earthquakes were observed in previous years.

From 2015 to 2020, earthquakes migrated from the highly active zones of seismicity in Harper and Sumner counties progressively farther along structural trends into surrounding counties, including Sedgwick, western Butler, Kingman, and Reno counties. Earthquakes along these trends are most likely induced, triggered as a result of elevated pore pressure that effectively reduced frictional resistance along critically-stressed basement faults. Seismicity has increased greatly near Hutchinson in Reno County during this reporting period, with 45 M 2 or larger earthquakes, more than double the number of earthquakes of this size recorded the 2018-2019 reporting year.

Table 1. M 2 or larger earthquakes recorded from July 2019 through June 2020 with epicenters located within 30 mi of member wells.

Origin Time (UTC)	Latitude	Longitude	Magnitude	County
2019-07-04 03:10:00	38.615	-97.582	2.0	Saline
2019-07-08 13:27:00	38.004	-98.010	2.0	Reno
2019-07-08 17:44:00	38.004	-98.000	2.0	Reno
2019-07-08 20:04:00	38.010	-97.997	2.0	Reno
2019-07-12 17:29:00	37.207	-99.457	2.0	Comanche
2019-07-17 03:59:00	37.478	-97.764	2.6	Sedgwick
2019-07-17 22:07:00	37.250	-99.440	2.3	Comanche
2019-07-18 08:06:00	37.482	-97.766	2.2	Sedgwick
2019-07-19 22:49:00	37.409	-97.481	2.0	Sumner
2019-07-24 15:19:00	37.273	-99.439	2.0	Comanche
2019-08-14 13:44:00	38.006	-98.002	2.9	Reno
2019-08-14 16:57:00	38.006	-97.999	2.2	Reno
2019-08-15 06:21:00	37.479	-97.752	2.0	Sedgwick
2019-08-16 12:59:00	38.014	-98.000	4.6	Reno
2019-08-16 13:10:00	38.012	-98.000	3.4	Reno
2019-08-16 13:28:00	38.014	-97.992	3.0	Reno
2019-08-16 13:30:00	38.014	-97.988	3.1	Reno
2019-08-16 13:43:00	38.010	-97.991	3.1	Reno
2019-08-16 17:18:00	38.015	-97.999	2.0	Reno
2019-08-16 18:26:00	38.019	-97.993	2.2	Reno
2019-08-16 19:55:00	38.015	-97.997	2.8	Reno
2019-08-16 19:56:00	38.011	-97.993	2.7	Reno
2019-08-17 01:03:00	38.011	-98.016	3.3	Reno
2019-08-17 03:19:00	38.016	-98.001	2.5	Reno
2019-08-17 05:23:00	38.013	-97.998	2.4	Reno
2019-08-17 06:21:00	38.019	-98.003	2.3	Reno
2019-08-17 07:42:00	38.022	-98.002	2.3	Reno
2019-08-17 09:56:00	38.015	-98.014	3.0	Reno
2019-08-18 08:45:00	38.006	-98.002	4.4	Reno
2019-08-24 06:53:00	37.234	-97.241	2.4	Sumner
2019-08-25 15:35:00	38.723	-97.535	2.1	Saline
2019-08-26 05:29:00	38.719	-97.516	2.0	Saline
2019-08-29 08:40:00	37.736	-97.593	2.0	Sedgwick
2019-08-30 06:08:00	37.251	-97.210	2.0	Sumner
2019-09-01 13:21:00	38.004	-98.004	3.5	Reno
2019-09-02 23:08:00	38.012	-97.990	2.6	Reno
2019-09-04 06:18:00	38.015	-97.999	2.4	Reno
2019-09-13 17:44:00	37.773	-98.016	2.1	Reno
2019-09-14 04:23:00	38.020	-97.997	2.0	Reno
2019-09-14 04:26:00	38.017	-97.989	2.0	Reno
2019-09-15 15:34:00	38.006	-98.008	3.0	Reno
2019-09-20 18:38:00	37.729	-98.008	2.0	Kingman
2019-09-26 18:53:00	37.408	-97.812	2.0	Kingman
2019-09-28 10:21:00	38.682	-97.532	2.0	Saline
2019-09-28 12:32:00	38.010	-98.008	2.2	Reno
2019-09-28 20:16:00	38.008	-98.010	3.0	Reno
2019-09-28 20:19:00	38.001	-98.011	2.2	Reno
2019-10-05 03:25:00	38.704	-97.528	2.5	Saline
2019-10-08 03:09:00	38.015	-98.005	2.7	Reno
2019-10-08 11:25:00	38.739	-97.578	2.3	Saline
2019-10-08 22:48:00	38.638	-97.530	2.0	Saline
2019-10-08 23:50:00	38.678	-97.555	2.0	Saline
2019-10-13 19:06:00	38.667	-97.533	2.2	Saline
2019-10-14 03:46:00	38.681	-97.535	2.0	Saline
2019-10-20 14:49:00	37.567	-97.831	2.2	Kingman
2019-10-21 18:46:00	37.295	-97.420	2.0	Sumner
2019-10-22 18:44:00	37.501	-97.894	2.0	Kingman
2019-10-23 19:04:00	38.008	-98.005	2.3	Reno
2019-10-23 21:39:00	38.004	-98.014	3.4	Reno

Table 1. Continued

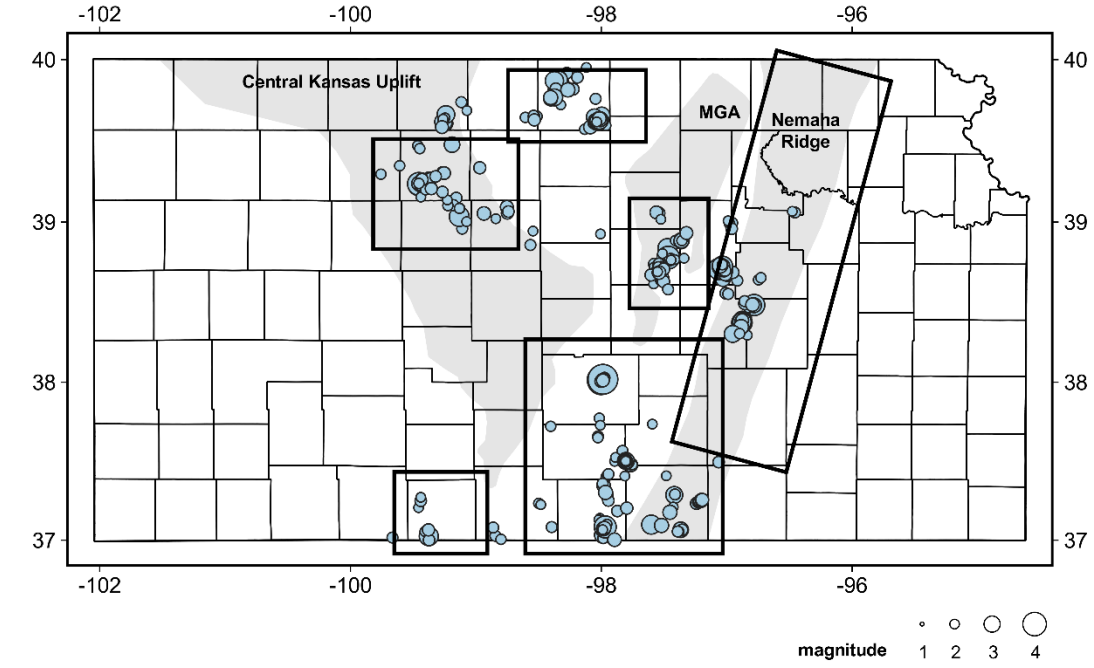
Origin Time (UTC)	Latitude	Longitude	Magnitude	County
2019-10-24 10:26:00	37.526	-97.887	2.0	Kingman
2019-10-28 20:16:00	38.720	-97.579	2.0	Saline
2019-11-02 21:29:00	38.020	-97.998	2.1	Reno
2019-11-03 02:08:00	38.015	-97.997	3.5	Reno
2019-11-03 04:19:00	37.502	-97.802	2.3	Sedgwick
2019-11-08 20:30:00	37.252	-97.226	2.0	Sumner
2019-11-30 07:34:00	37.503	-97.803	3.1	Sedgwick
2019-11-30 08:00:00	37.503	-97.805	2.1	Sedgwick
2019-11-30 09:50:00	37.501	-97.804	2.4	Sedgwick
2019-11-30 09:54:00	37.498	-97.794	2.0	Sedgwick
2019-11-30 18:20:00	37.495	-97.801	2.6	Sedgwick
2019-12-01 09:59:00	37.500	-97.801	2.3	Sedgwick
2019-12-02 19:49:00	37.504	-97.801	2.1	Sedgwick
2019-12-04 09:37:00	38.657	-97.504	2.1	Saline
2019-12-07 17:30:00	38.008	-97.998	2.3	Reno
2019-12-10 01:24:00	38.007	-98.006	2.3	Reno
2020-01-05 05:04:00	37.509	-97.792	2.0	Sedgwick
2020-01-16 23:55:00	38.857	-98.565	2.2	Russell
2020-01-19 19:08:00	38.018	-97.987	4.8	Reno
2020-01-27 08:44:00	38.028	-97.974	2.2	Reno
2020-02-07 17:51:00	38.020	-97.980	2.3	Reno
2020-02-16 22:30:00	37.659	-98.026	2.2	Kingman
2020-02-21 03:50:00	37.650	-98.027	2.1	Kingman
2020-02-28 01:08:00	37.288	-97.418	3.1	Sumner
2020-03-04 09:07:00	38.006	-98.003	2.4	Reno
2020-03-05 23:38:00	37.496	-97.064	2.3	Butler
2020-03-13 13:46:00	37.211	-97.426	2.0	Sumner
2020-03-13 13:55:00	37.178	-97.452	2.7	Sumner
2020-03-14 09:28:00	38.631	-97.504	2.4	Saline
2020-03-20 18:24:00	37.243	-97.203	2.2	Sumner
2020-03-25 00:40:00	37.240	-97.232	2.1	Sumner
2020-03-28 22:06:00	38.730	-97.535	2.7	Saline
2020-03-29 17:50:00	37.497	-97.804	2.7	Sedgwick
2020-03-29 17:54:00	37.504	-97.800	2.1	Sedgwick
2020-03-29 22:07:00	38.720	-97.548	2.1	Saline
2020-03-30 01:26:00	37.504	-97.809	2.5	Kingman
2020-03-30 04:24:00	37.507	-97.808	2.6	Kingman
2020-03-30 23:10:00	37.504	-97.806	2.4	Sedgwick
2020-04-01 00:51:00	37.503	-97.805	2.0	Sedgwick
2020-04-03 10:58:00	38.732	-97.544	2.0	Saline
2020-04-04 06:56:00	37.252	-97.203	2.0	Sumner
2020-04-04 18:30:00	37.248	-97.216	2.4	Sumner
2020-04-05 01:22:00	37.254	-97.204	2.2	Sumner
2020-04-05 01:22:00	37.253	-97.209	2.2	Sumner
2020-04-05 05:52:00	38.705	-97.555	2.1	Saline
2020-04-08 15:05:00	37.247	-97.229	2.0	Sumner
2020-04-09 01:08:00	37.245	-97.215	2.2	Sumner
2020-04-15 12:45:00	37.254	-97.195	2.3	Sumner
2020-04-20 17:09:00	37.261	-97.204	2.3	Sumner
2020-04-21 09:53:00	37.245	-97.217	2.0	Sumner
2020-04-21 13:53:00	37.291	-97.412	2.2	Sumner
2020-04-23 11:50:00	38.018	-97.990	2.3	Reno
2020-04-26 03:13:00	37.247	-97.201	2.0	Sumner
2020-04-28 18:34:00	37.244	-97.211	2.0	Sumner
2020-05-04 01:44:00	37.246	-97.213	2.1	Sumner
2020-05-19 21:50:00	38.581	-97.467	2.2	McPherson
2020-05-21 03:51:00	38.671	-97.603	2.4	Saline
2020-05-27 00:58:00	37.255	-97.210	2.4	Sumner
2020-05-27 20:17:00	38.018	-97.993	2.3	Reno
2020-05-27 22:03:00	37.251	-97.205	2.6	Sumner

Table 1. Continued

Origin Time (UTC)	Latitude	Longitude	Magnitude	County
2020-05-29 12:18:00	37.247	-97.220	2.2	Sumner
2020-05-29 12:19:00	37.244	-97.206	2.1	Sumner
2020-06-03 07:34:00	38.744	-97.541	2.1	Saline
2020-06-03 15:42:00	38.719	-97.523	2.3	Saline
2020-06-05 06:05:00	38.722	-97.545	2.1	Saline
2020-06-07 06:14:00	37.252	-97.201	2.0	Sumner
2020-06-07 17:58:00	38.707	-97.503	2.4	Saline
2020-06-12 16:10:00	38.018	-97.979	2.2	Reno
2020-06-12 20:17:00	38.011	-97.987	2.5	Reno
2020-06-18 19:37:00	37.251	-97.196	2.1	Sumner
2020-06-23 00:25:00	37.257	-97.195	2.5	Sumner
2020-06-23 07:21:00	38.944	-98.544	2.0	Russell
2020-06-29 09:44:00	38.686	-97.540	2.6	Saline
2020-06-29 20:43:00	38.691	-97.551	2.0	Saline

End of table

Figure 2. M 2 or larger earthquakes recorded in Kansas by the KGS seismic network from July 2019 through June 2020 superimposed on the prominent basement structures (gray). Black boxes indicate areas discussed in the text.



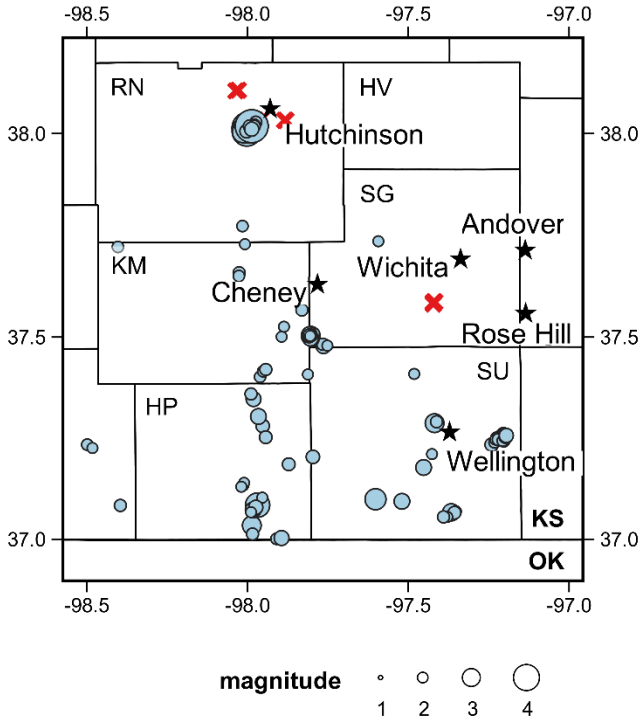


Figure 3. M 2 or larger earthquakes recorded in south-central Kansas from July 2019 through June 2020.

Comanche County

Only seven regional-scale earthquakes occurred in Comanche County during the past year (Figure 4). This is noteworthy because, while only one regional-scale earthquake was recorded from July 2018 to June 2019, more than 60 M 2 or larger earthquakes were recorded in Comanche County from July 2017 through June 2018. Because those events occurred in an area of elevated pore pressure measured in the Arbuckle Group, these events were likely triggered along hydraulically-connected, critically-stressed basement faults. The large reduction in seismicity over the past two years indicates that crustal stresses may be lower here, relative to neighboring Harper and Sumner counties. After the stress on this previously-unidentified fault or set of faults was initially released, the crustal stress applied to these faults was not sufficient during the past year to produce additional earthquakes. That is not to say additional earthquakes are not possible, but rather that the stress accumulated during the past year did not exceed the triggering threshold of these faults. That triggering threshold is variable across the region and related to pore pressure and the magnitude and orientation of the stress field.

Central Kansas Uplift

Similar to the 2018-2019 reporting year, 82 M 2 or larger earthquakes were recorded in areas affected by the Central Kansas Uplift, primarily within three clusters (Figure 5). The most active cluster is located in southwestern Rooks County with more than three dozen events, the largest of which was a M 3.9 on October 17, 2019. The location of this cluster is within 10 km of an area of historic seismicity in the late 1980s that was believed to be induced as a result of deep fluid injection (Armbruster et al., 1989). These three clusters in Rooks and Ellis counties are within 20 km of saltwater disposal wells injecting large volumes of fluid into the Arbuckle Group. Although reliable pressure measurements are not available from wells that penetrate the full thickness of the Arbuckle Group (as in central and south-central Kansas), the earthquake decay rate in this area is low relative to decay rates expected for natural seismicity and, thus, these earthquakes may be induced.

North-Central Kansas (Salina Basin)

About 60 M 2 or larger earthquakes were recorded in Smith, Jewell, and Republic counties during the past year (Figure 6), double the number of events recorded here during the 2018-2019 reporting year. The larger number of events appears to be associated with foreshock and aftershock sequences associated with M 3 or larger earthquakes. At this time, the source of these earthquakes remains unclear, but they appear to occur along faults interpreted from aeromagnetic data.

Midcontinent Geophysical Anomaly

The Midcontinent Geophysical Anomaly (MGA, the largest positive gravity anomaly in North America) is interpreted to be the result of a thick sequence of mafic igneous rocks that formed during major late Precambrian rifting as part of the Midcontinent Rift System. Two ongoing clusters of earthquakes have been recorded along the southeastern margin of the MGA since the KGS network was installed in 2015. More than 30 M 2 or larger earthquakes were recorded in distinct clusters in eastern Saline County (Figure 7). These clusters are discussed in greater detail in the section on local seismicity near McPherson County member wells.

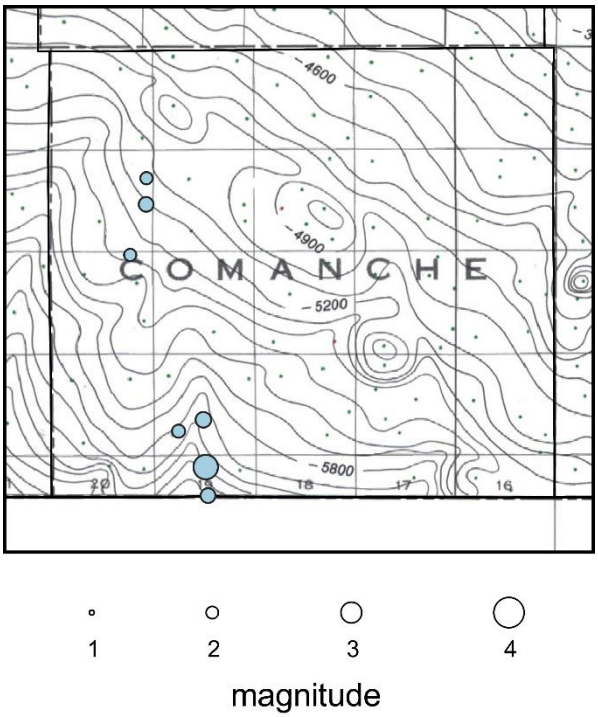


Figure 4. M 2 or larger earthquakes recorded in Comanche County from July 2019 through June 2020 superimposed on Precambrian structural contours (from Cole, 1976).

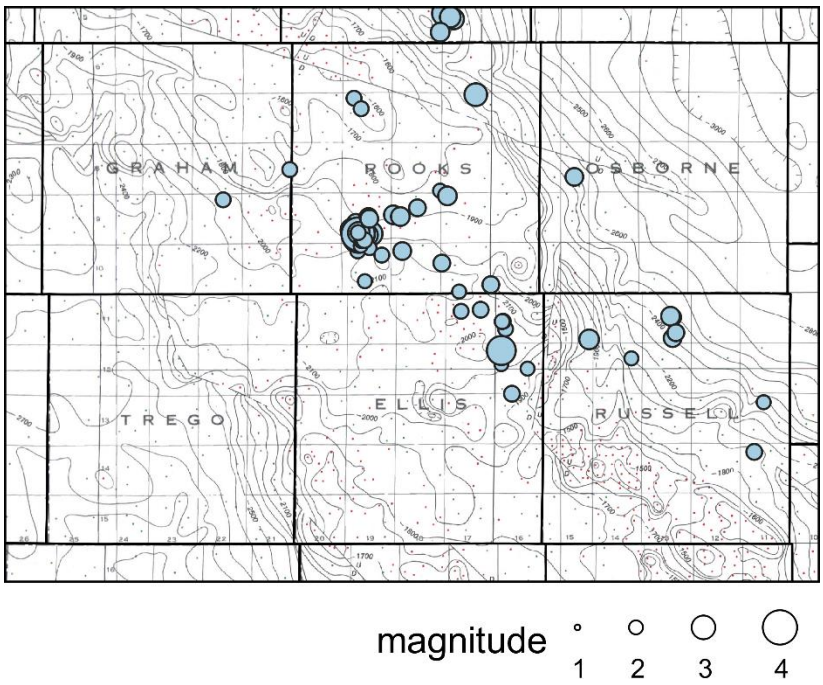


Figure 5. M 2 or larger earthquakes recorded near the Central Kansas Uplift from July 2019 through June 2020.

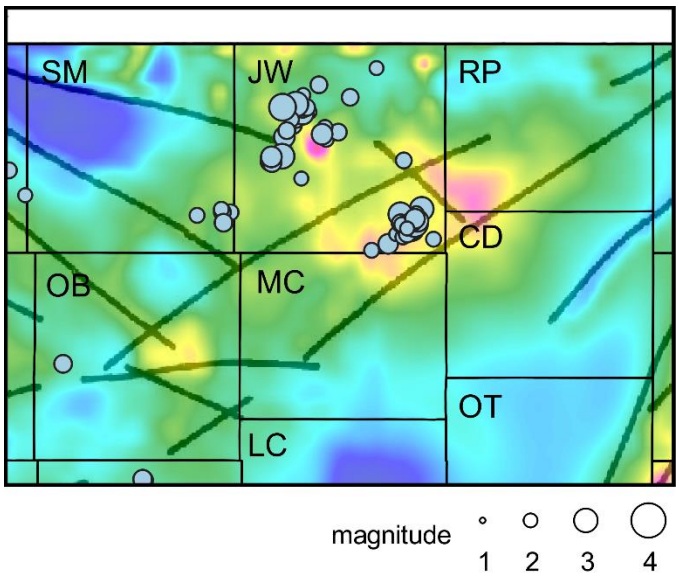


Figure 6. M 2 or larger earthquakes recorded in the Salina Basin from July 2019 through June 2020.

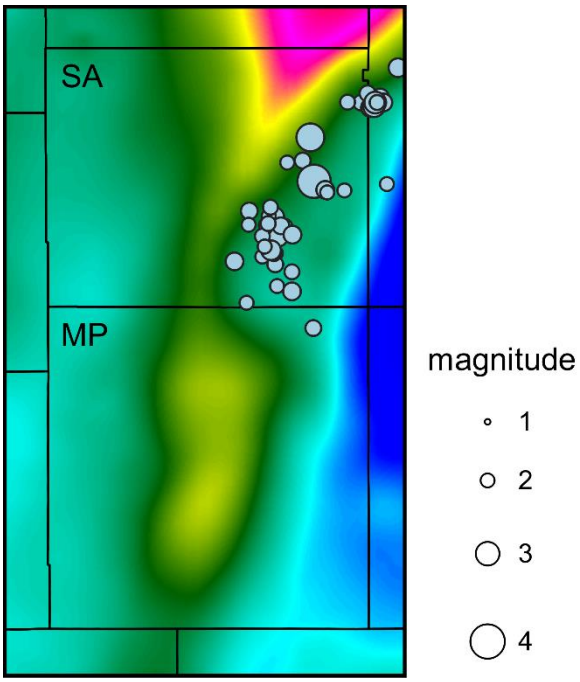


Figure 7. M 2 or larger earthquakes recorded near the Midcontinent Geophysical Anomaly from July 2019 through June 2020 superimposed on the gravity anomaly map of Kansas.

Nemaha Ridge

The Nemaha Ridge is one of the most prominent crustal features in Kansas, extending across the state with a northeast-southwest orientation. The Nemaha Ridge formed during post-Mississippian uplift of Precambrian age granite. A system of normal and reverse faults on the eastern margin of the Nemaha Ridge forms the Humboldt Fault Zone. Transform faults with a northwest-southeast trend intersecting the Nemaha Ridge represent a pre-Phanerozoic crustal extension associated with the Midcontinent Rift System. Dozens of historic earthquakes have been felt or recorded along the Nemaha Ridge, including an estimated M 5.2 near Wamego in 1867.

More than 60 M 2 or larger earthquakes were recorded during the reporting period along the Nemaha Ridge ranging from Riley County to Marion County (Figure 8), about twice as many as the previous year. The apparent increase is due, at least in part, to aftershocks from M 3.7 events in Chase and Dickinson counties. Recursion of events since the current network was installed four years ago is represented by a b-value of 0.85, a value that is well within the range documented for natural recursion. The rate of M 3 or larger earthquakes is unusual relative to more than a decade of monitoring in the 1970s and 1980s and the primary driver of these events is unclear at this time, but the increase in seismic activity may represent a natural temporal fluctuation in seismic rate.

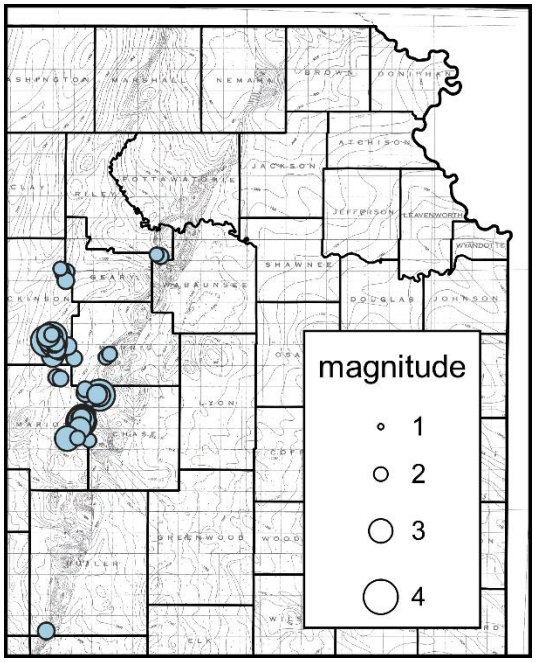


Figure 8. M 2 or larger earthquakes recorded along the Nemaha Ridge from July 2019 through June 2020 superimposed on Precambrian structural contours (from Cole, 1976).

Local Seismicity within 20 mi of Member Wells

During the past year, more than 1,200 microearthquakes (M less than 2) were recorded by the KGS seismic network (with enhanced sensitivity and improved location accuracy with the addition of CSTS stations) (Figure 9). Similar to regional scale earthquakes, the overall number of microearthquakes continued to decline. Microearthquakes make up 92% of the earthquakes logged into the earthquake catalog last year. Analysis of events well below M 2 greatly improves our ability to interpret earthquakes relative to structures and evaluate possible causal factors. Sub M 2 events provide opportunities to forecast, once the recursion relationship in specific areas can be accurately calculated for a given pressure regime.

Kiowa County

Only sparse seismicity was recorded in Kiowa County with five earthquakes within 20 miles of the member well (Figure 10). The majority of these events were recorded at about the same location as a cluster of earthquakes recorded during previous reporting periods. These earthquakes are located northwest of the Sun City earthquake swarm along structural trend consistent with the southwest margin of the Central Kansas Uplift and Pratt Anticline. Rising bottomhole fluid pressure measured in Kiowa County suggests pressure diffusion moving northwest from the Kansas–Oklahoma border, probably along the Pratt Anticline. As in Comanche County, pore pressure changes and crustal stresses are probably lower here, requiring more time to accumulate stress on active faults and, thus, a lower earthquake rate compared to south-central Kansas.

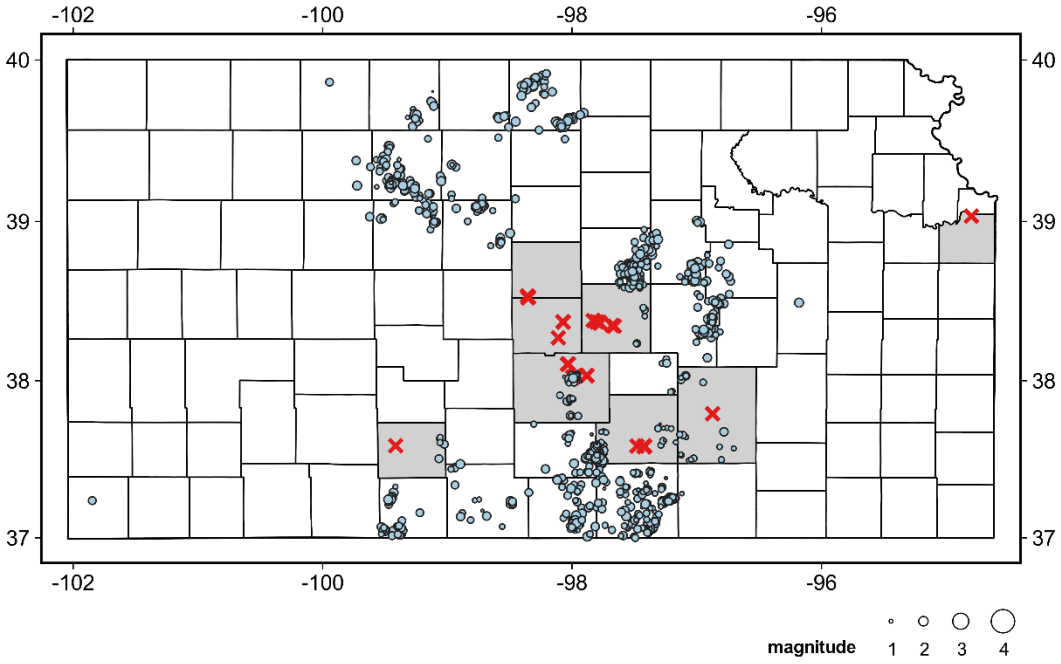


Figure 9. Microearthquakes (M less than 2) recorded in Kansas by the KGS seismic network from July 2019 through June 2020. Gray shading indicates counties with CSTS member wells (red Xs).

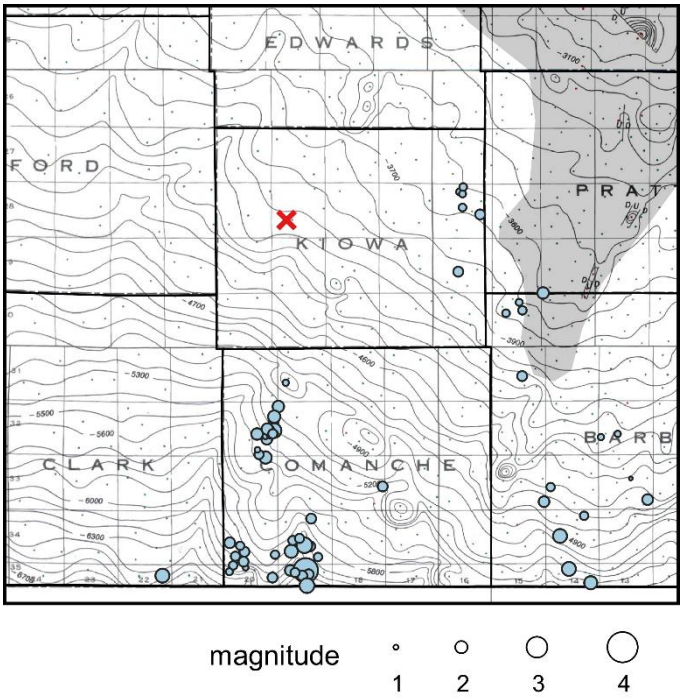


Figure 10. Earthquakes recorded in Kiowa County from July 2019 through June 2020 superimposed on Precambrian structural contours (from Cole, 1976) and inferred Pratt Anticline at the southern end of the Central Kansas Uplift (gray). CSTS member well(s) are indicated by a red X.

Reno County

Two distinct clusters were recorded in Reno County, one southwest of Hutchinson and one east of Arlington (Figure 11). The location of these clusters is consistent with earthquakes recorded during the previous reporting periods. The Hutchinson cluster was the most active with more than 120 earthquakes during the past year with M 0.7 or greater, consistent with earthquakes observed during the 2018-2019 reporting period. The largest event was a M 4.8 on January 19, 2020. Seismic activity occurred in a about a 5 square mile area defining this cluster, more or less regularly throughout the year. As in previous years, this cluster is a dense, circular swarm about 2 mi in diameter. The maximum size of an earthquake is related to the length of the fault that ruptures. Based on the fault trace (a grouping of individual faults in an en echelon orientation) delineated by the Hutchinson earthquakes themselves, it is unlikely an earthquake with the potential to cause major damage is possible within this cluster.

The Arlington cluster is much less active, with only about a dozen earthquakes during the past year. The largest event was a M 2.1 on September 13, 2019. The two earthquake clusters in Reno County all occur within a structural low, bounded by the Central Kansas Uplift to the west and the Voshell Anticline to the east (Figure 11). In late 2016 and 2017, earthquakes progressed from the south along this structural low toward the axis of the Conway Syncline, a south-plunging synclinal fold at the northern margin of the Sedgwick Basin that extends northeast into McPherson County. The northward progression of earthquakes is likely the result of elevated fluid pressure from high-volume saltwater disposal near the Kansas–Oklahoma border (Peterie et al., 2018; Zhai et al., 2020).

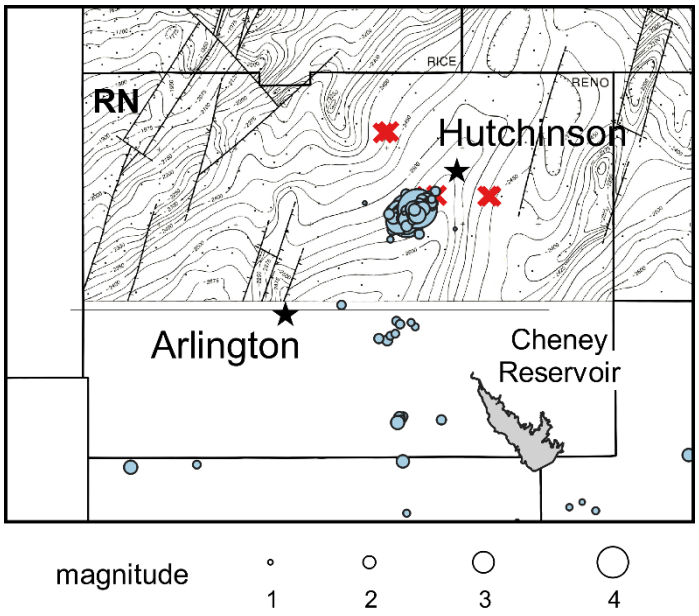


Figure 11. Earthquakes recorded in Reno County from July 2019 through June 2020 superimposed on Arbuckle structural contours (from Berendsen and Blair, 1986). CSTS member well(s) are indicated by a red X.

Rice, Barton, and Ellsworth Counties

No earthquakes were recorded in Rice, Ellsworth, or Barton counties where the current network sensitivity would allow events of about M 1.0 and larger to be located.

McPherson County

Seismic activity within 20 km of member wells in McPherson County was primarily concentrated near the McPherson-Saline border (Figure 13). These events occur near the eastern margin of the Midcontinent Geophysical Anomaly (MGA) along and east of the Salina Fault in Saline County. Seismicity in this area has been ongoing. Since installation of the KGS seismic network in 2015, over 100 M 2 or larger earthquakes have been recorded in this cluster and to the north along the same general structure. Historically, seismicity in this area is spatially and temporally extremely sparse, with only one M 1.7 earthquake on February 9, 1983, about 10 mi to the west. Therefore, persistent seismicity in this area is somewhat unexpected.

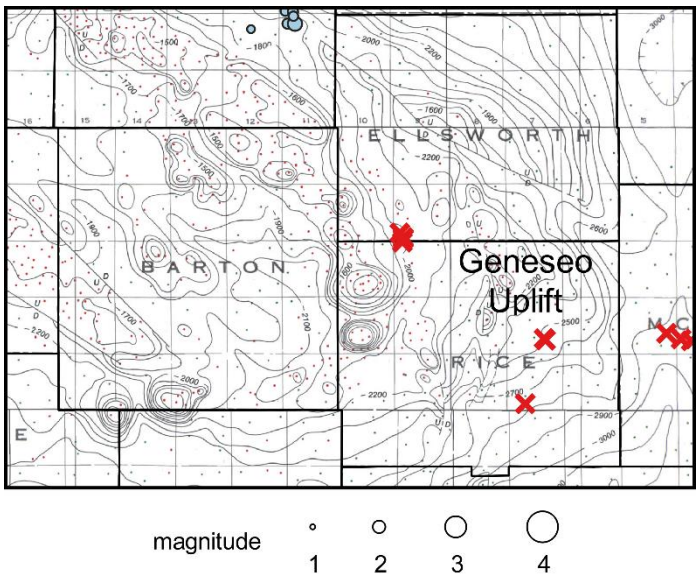


Figure 12. Earthquakes in Barton County (adjacent to Rice and Ellsworth counties) from July 2019 through June 2020 superimposed on Arbuckle Group structural contours (from Berendsen and Blair, 1986). CSTS member well(s) are indicated by a red X.

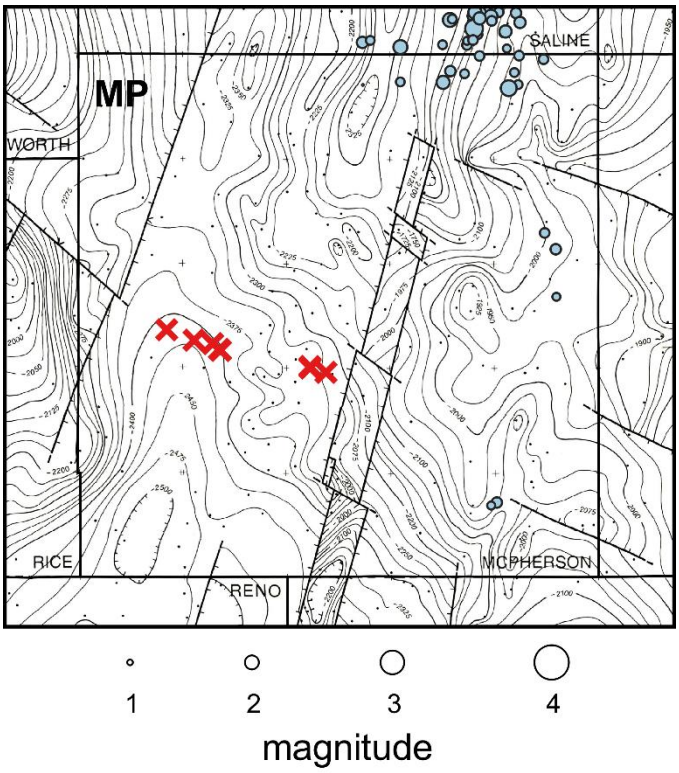


Figure 13. Earthquakes recorded in McPherson County from July 2019 through June 2020 superimposed on Arbuckle Group structural contours (from Berendsen and Blair, 1986). CSTS member well(s) are indicated by a red X.

Clustering of earthquakes and persistent seismicity can be an indicator that elevated pore pressures are influencing seismicity. With a b-value of 1 this cluster is producing earthquakes with magnitudes consistent with the idealize Gutenberg-Richter relationship, which was formulated based on naturally occurring earthquakes. Several dozen Class II saltwater disposal wells operate in the immediate vicinity of the McPherson–Saline earthquakes, more than 10 of which terminate in the Arbuckle Group. However, these wells are relatively low-rate, with the highest-rate well injecting less than 3,000 bbl/day. Therefore, it is unclear what role nearby disposal may play in the elevated seismic activity.

Sedgwick County

Seismic activity in Sedgwick County primarily persisted in previously-identified areas in the southern half of the county (Figure 14), although, at a lower rate than previous years. More than 100 earthquakes above M 0.5 were recorded in the Cheney cluster, most of which occurred in November and December 2019, the largest of which was a M 3.1 on November 30, 2019. Sparse microearthquakes occurred throughout Sedgwick County with little spatial correlation. About 15 earthquakes occurred in 2020 in previously-identified clusters near the border between Sedgwick and Butler counties near Rose Hill and Andover, 15-20 mi to the east of Sedgwick County member wells.

Events recorded in and adjacent to Sedgwick County are likely induced as a result of elevated fluid pressure associated with the high-rate saltwater disposal near Kansas–Oklahoma border. Pore pressures have begun to stabilize, but have not yet started to decrease. While pressure remains elevated above the triggering threshold, the likelihood of continued seismicity remains high.

Butler County

In addition to the earthquakes near the Sedgwick–Butler county line discussed in the previous section, several earthquakes occurred in Butler County primarily during the second quarter of 2020 (Figure 15). Most of these were on the steeply dipping western flank of the Nemaha Ridge and one on the crest of the Ridge in north-central Butler County. These earthquakes do not follow the northeasterly trend of induced earthquakes that have migrated progressively farther from the high-volume saltwater disposal near the southern Kansas border. Although it is possible that pore pressures may be elevated in Butler County, the earthquakes do not follow a clear temporal or spatial trend that would suggest these events were induced. While these events likely represent natural movement of critically-stressed faults, the influence of elevated pore pressures has not been confidently ruled out.

Johnson County

No earthquakes were located within 20 mi of member wells in Johnson County.

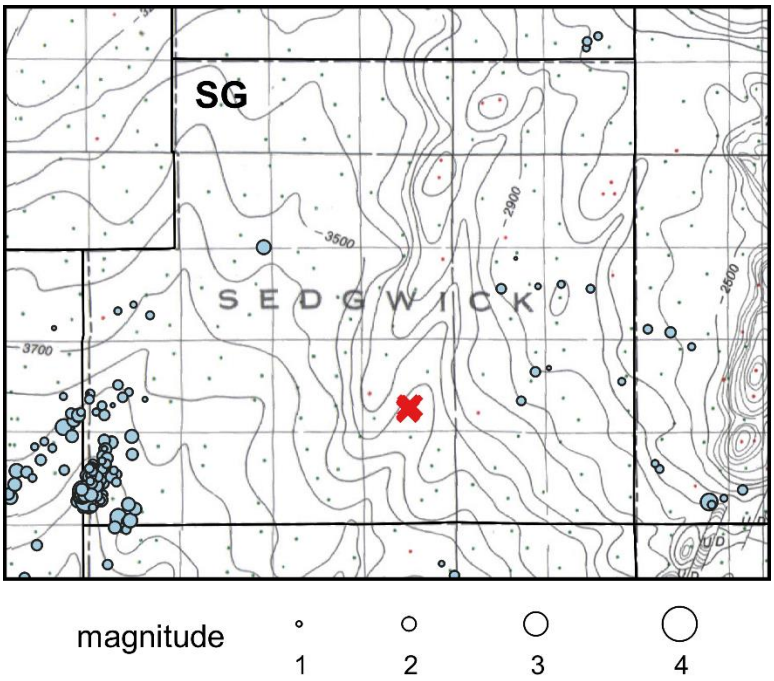


Figure 14. Earthquakes recorded in and adjacent to Sedgwick County from July 2019 through June 2020 superimposed on Precambrian structural contours (from Cole, 1976). CSTS member well(s) are indicated by a red X.

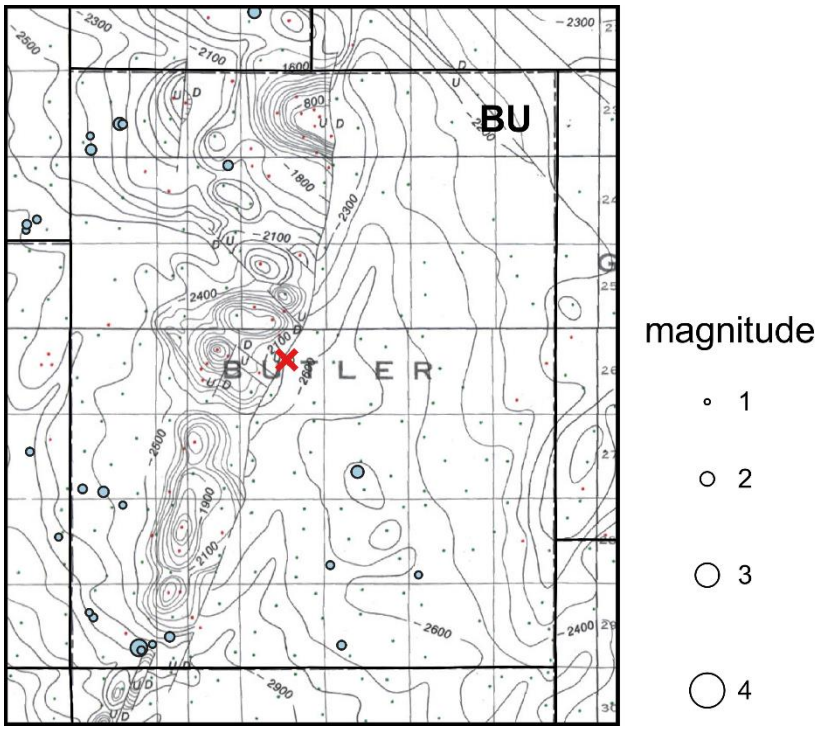


Figure 15. Earthquakes recorded in Butler County from July 2019 through June 2020 superimposed on Precambrian structural contours (from Cole, 1976). CSTS member well(s) are indicated by a red X.

Subnetwork Seismic Events

Locating the epicenter of an earthquake requires detecting P- or S-waves at three or more stations. Subnetwork events are defined as earthquakes that are only recorded on a single or at most two station(s); therefore, the epicenter location cannot be determined uniquely. Rather, the epicenter exists somewhere on a circle centered on the seismic station with radius equal to the calculated distance to the earthquake epicenter. The magnitude of a subnetwork event is estimated from the coda, or duration—the time from the first P-wave arrival until the energy is approximately equal to or drops below the noise floor at that time and station (background noise usually based on pre-event noise levels). More than 1,000 sub-network events were recorded at CSTS stations during this reporting period. Some events may have an anthropogenic origin (for example, underground blasting). However, the majority of these subnetwork events are low-energy microearthquakes that provide valuable insight into the relative stability and stress conditions of faults in close proximity to the station (within about 12 mi).

Station KW02 in North-Central Kiowa County

No subnetwork events were recorded at station KW02 in Kiowa County. As discussed previously in this section, this likely indicates that pore pressure changes and crustal stresses are lower here and not enough time has passed to accumulate sufficient stress to trigger subnetwork earthquakes.

Station EW01 in Southwestern Ellsworth County

Four subnetwork events with magnitudes less than zero were recorded between a distance of about 2 mi to 8 mi (averaging 4 mi) with a magnitude range between M -1.5 and M 0.1 from station EW01 (Figure 16). This may represent continued low-energy movement on the fault that produced nearby historic earthquakes prior to noted increases in pore pressures in the Arbuckle.

Station RC02 in Northeastern Rice County

Station RC02 is located in eastern Rice County near the center of the Geneseo Uplift, an eastern lobe of the Central Kansas Uplift that is bounded by faults mapped on the top of the Arbuckle Group to the north, west, and east (Berendsen and Blair, 1986). Ten subnetwork events with magnitudes from M -1.5 to 0.3 were recorded at RC01 at epicentral distances ranging from about 2 to 11 mi away (Figure 17). This range of distances corresponds to all three fault zones bounding the Geneseo Uplift and, therefore, these events likely have originated from them. Without detailed data on crustal stresses, it is unclear which of these faults may be active in the current stress regime.

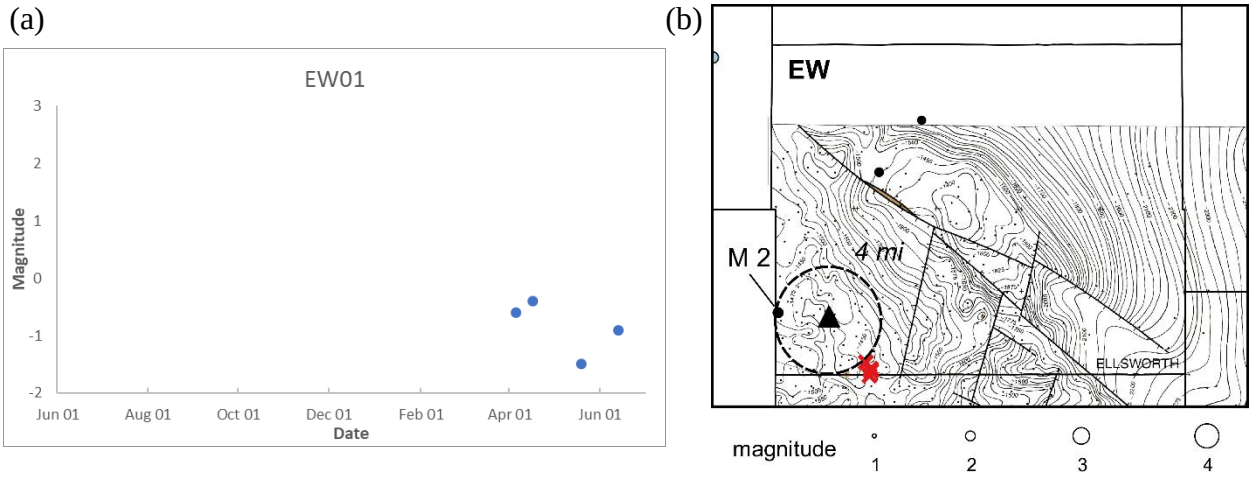


Figure 16. (a) Histogram of subnetwork events recorded at station EW01. (b) Map of historic seismicity (black) in Ellsworth County and epicentral distance of subnetwork events recorded at EW01 superimposed on Arbuckle Group structural contours (from Berendsen and Blair, 1986). CSTS member well(s) are indicated by a red X.

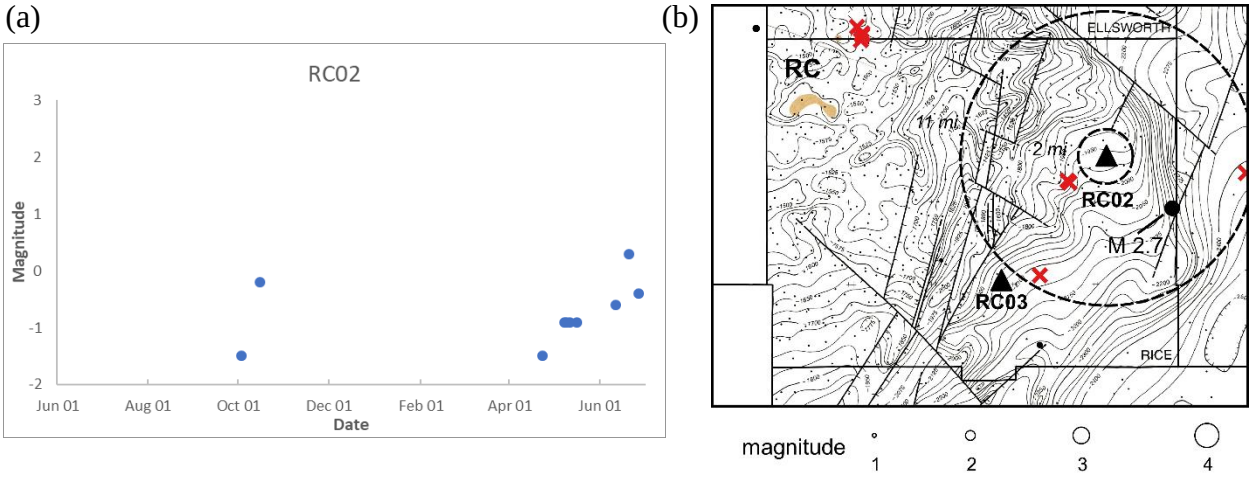


Figure 17. (a) Histogram of subnetwork events recorded at station RC02. (b) Map of historic seismicity (black) in Rice County and epicentral distance of subnetwork events recorded at RC02 superimposed on Arbuckle Group structural contours (from Berendsen and Blair, 1986). CSTS member well(s) are indicated by a red X.

Station RC03 in Southern Rice County

Station RC03 is located in south-central Rice County near the Peace Creek Fault Zone located on the western margin of the Geneseo Uplift. More than 600 subnetwork seismic events were recorded at RC03 with magnitudes ranging from -1.5 to 0.5. The vast majority of these events occur at regular times of day, corresponding to 5AM, 1PM, and 9 PM local time (Figure 18a). This regular timing and clustering at a distance of about 7 mi (Figure 18b) strongly suggest these events have an anthropogenic origin. The amplitude spectrum of small, close-by micro-earthquakes is typically dominated by higher frequencies. The majority of seismic events near RC03 have relatively large amplitudes toward the low frequency end of the amplitude spectrum (Figure 18c).

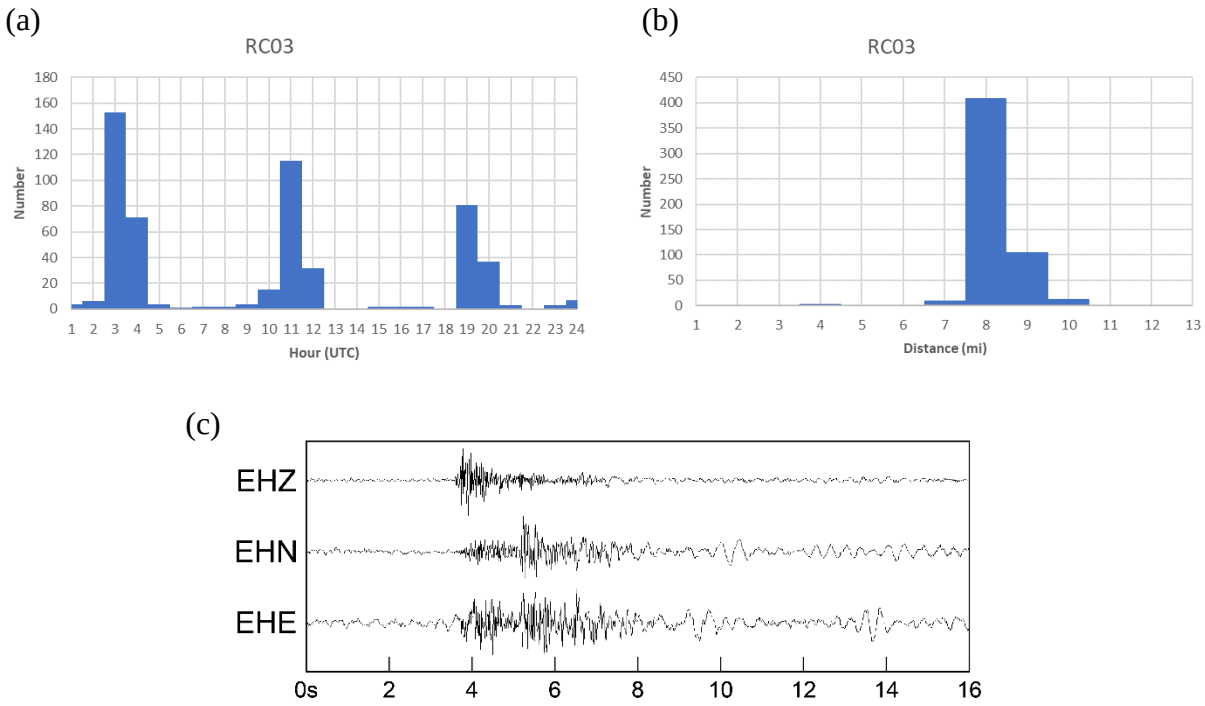


Figure 18. Histogram indicating the (a) time of day (UTC) and (b) epicentral distance of subnetwork events recorded at station RC03. (c) A representative waveform of a subnetwork event recorded at RC03.

Station RN01 in North-Central Reno County

Station RN01 is located 2-3 mi northwest of the dense cluster of earthquakes near Hutchinson. More than 700 subnetwork events were recorded at RN01 with magnitudes ranging from -1.5 to 0.6 (Figure 19a). Like the larger earthquake in the Hutchinson cluster located by the network, these events occurred regularly throughout the year. These events occur at all times of day and the estimated epicentral distances of nearly all these events is about 4.8 mi (Figure 19b). Although this is slightly larger than the 2.8 mi to the center of the Hutchinson earthquake swarm, these microearthquakes almost certainly originate from the same fault or set of faults. The epicentral distance was calculated assuming a fixed earthquake depth of 3 mi, which is a common assumption used to locate earthquakes in the midcontinental U.S. Earthquakes are likely occurring on faults within the shallow Precambrian basement, which is at a depth of about 1 mi in this part of Reno County. Recalculating the epicentral distance using a depth of 1 mi results in an average distance of 3 mi, which is consistent with the location of the swarm of earthquakes located by the KGS regional seismic network. These events are not only consistent with the accepted recursion relationship, but they have provided confidence in suggestions that the focus of the Hutchinson Swarm earthquakes is around 1 mile deep.

With such a high number of subnetwork events all from nearly the same distance, future studies of recursion relationships (b value) should provide some outstanding insights into the size and frequency of future earthquakes as well as how these extremely low energy events provide clues about the 'triggering threshold' and how the lowest levels of stress might be accumulating along this en echelon fault system.

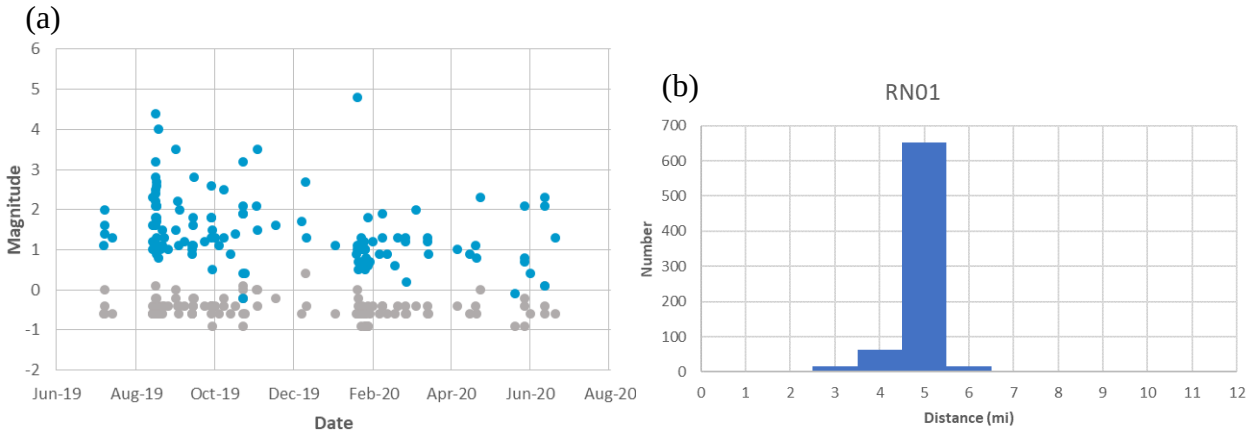


Figure 19. (a) Histogram of earthquakes in the Hutchinson cluster (blue) and subnetwork events recorded at station RN01 (gray). (b) Histogram of the epicentral distance of subnetwork events recorded at RN01.

Station RN03 in Northeastern Reno County

No subnetwork events were recorded at station RN03 in Reno County.

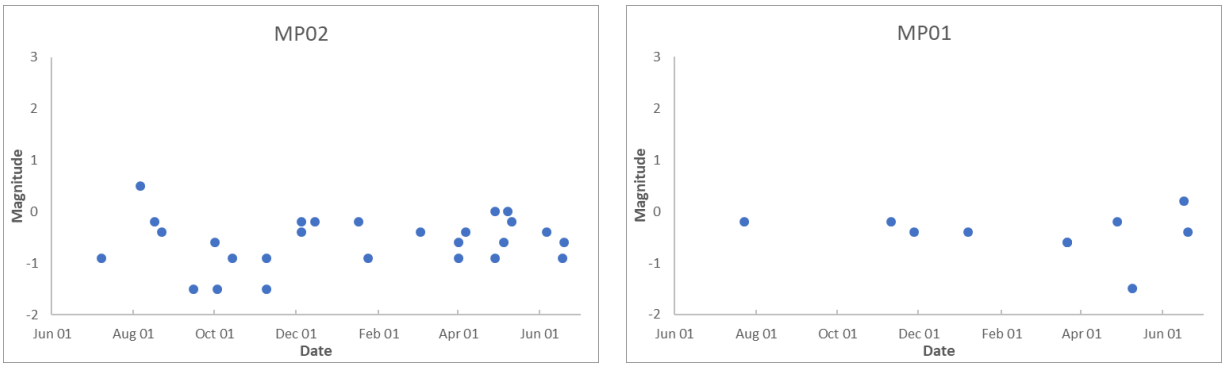
Station MP01 in Central McPherson County

Station MP01 is bounded to the west and east by northeast trending faults mapped in Precambrian and/or Arbuckle Group rocks associated with the Midcontinent Rift System. Ten subnetwork events were recorded at MP01 with magnitudes ranging from -1.5 to -0.6 (Figure 20a). These events occurred at various times of day and most occurred at an epicentral distance of about 4 mi. This distance is consistent with to the location of a M 2.6 earthquake that occurred on November 3, 2014 (Figure 20c). Therefore, these microearthquakes likely represent continued movement on this critically-stressed fault. Given the sparse recursion and measured characteristics of this activity, these events are likely natural.

Station MP02 in Southern McPherson County

More than two dozen subnetwork events were recorded at station MP02 with magnitudes ranging from -1.5 to 0 (Figure 20b). These events occurred at epicentral distances ranging from 1 to 9 mi, the majority of which occurred between 2 and 5 mi from the station. MP02 is bounded to the west by a system of faults associated with the Voshell Anticline, to the southeast by the Halstead Fault, and is surrounded by a number of anticlinal and synclinal structures. The majority of the subnetwork events probably occurred on the Voshell Anticline, which is less than a mile from the station. Given the sparse recursion and measured characteristics of this activity, these events are likely natural. However, events that can be correlated to a mapped structure that has not produced an earthquake with high enough energy to be located on the regional network suggests this area might be at the early stages of stress build up and needs to be monitored with added attention to potential increases in the magnitude of microearthquakes.

(a) (b)



(c)

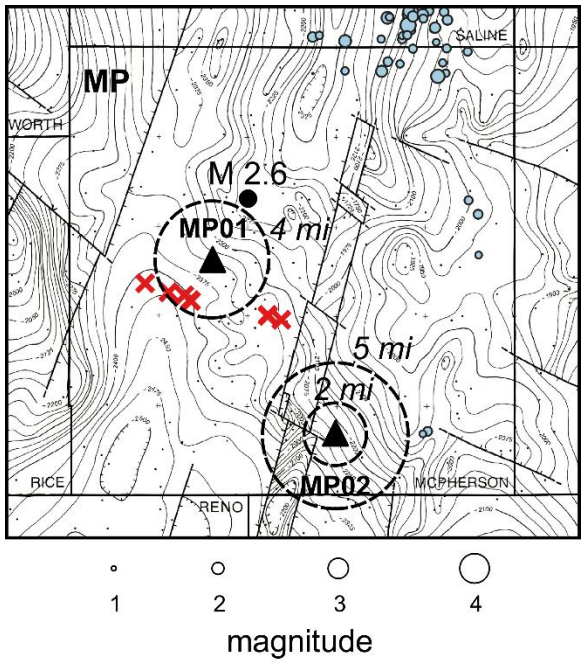


Figure 20. (a) Histogram of subnetwork events recorded at station MP01. (b) Histogram of subnetwork events recorded at station MP02. (c) Map of historic seismicity in McPherson County and epicentral distance of subnetwork events recorded at MP01 and MP02 superimposed on Arbuckle Group structural contours (from Berendsen and Blair, 1986). CSTS member well(s) are indicated by a red X.

Station SG02 in Southern Sedgwick County

About two dozen subnetwork events were recorded at station SG02 with magnitudes ranging from -1.5 to 0.6 (Figure 21a). These events occurred at epicentral distances ranging from 3-10 mi. The more distant subnetwork events likely originated from the cluster of earthquakes about 10 mi south of SG02 in northern Sumner County an area that has been active since 2016 (Figure 21b). These events occurred sporadically throughout the year, likely as a result of currently stabilizing pore pressures. Although pressure remains elevated, it has remained relatively level since 2017. Until pressure declines, earthquakes will likely continue, albeit at lower rates than previous years. Because pressures are still well above the earthquake triggering threshold, even small fluctuations in pressure may generate seismicity in this area.

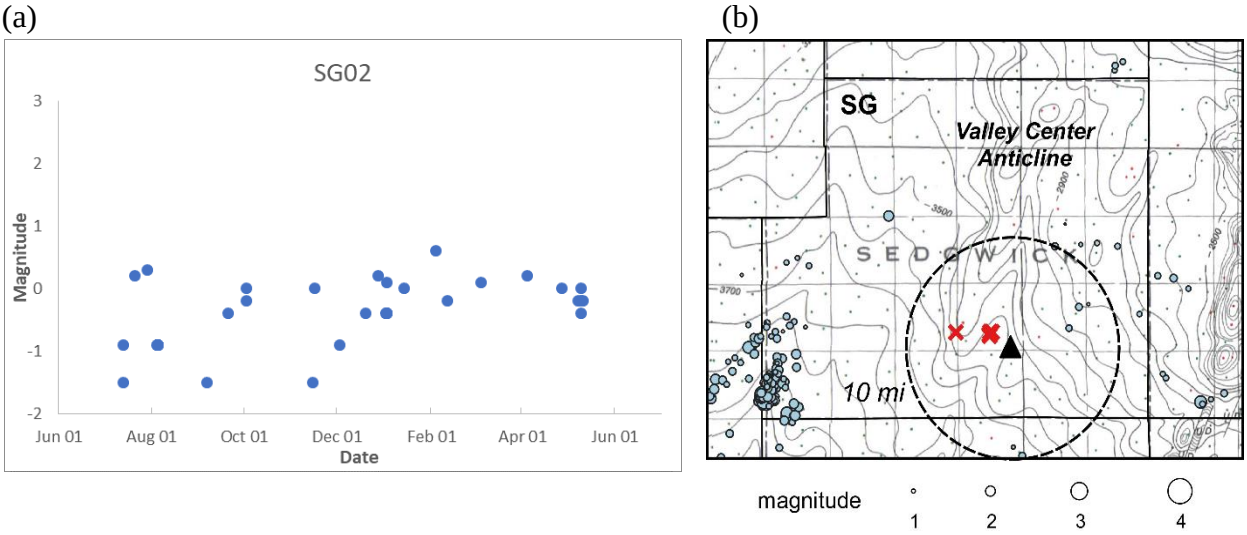


Figure 21. (a) Histogram of subnetwork events recorded at station SG02. (b) Map of earthquakes recorded in Sedgwick County by the KGS network and epicentral distance of subnetwork events recorded at SG02 superimposed on Precambrian structural contours (from Cole, 1976). CSTS member well(s) are indicated by a red X.

Station BU02 in Central Butler County

Only two subnetwork events were recorded at station BU02 with magnitudes of -0.6 and 0.6 with distances of about 6 mi (Figure 22a).

Station JO01 in Central Johnson County

No subnetwork events were recorded at station JO01. This is unsurprising given the stable tectonic regime and limited number of historic earthquakes recorded in this area.

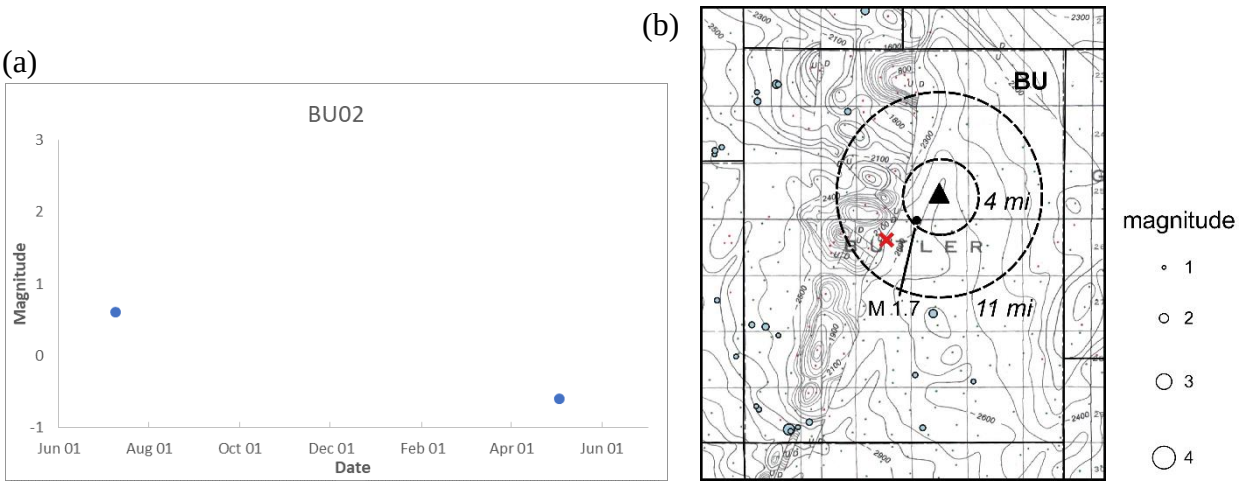


Figure 22. (a) Histogram of subnetwork events recorded at station BU02. (b) Map of earthquakes recorded in Butler County by the KGS network and epicentral distances of subnetwork events recorded at BU02 superimposed on Precambrian structural contours (from Cole, 1976). CSTS member well(s) are indicated by a red X.

Felt Clusters and Their Relationship to Consortium Facilities

Felt earthquakes originating from within the Hutchinson cluster received the most attention from residents and government officials last year in Kansas. Based on recorded and located earthquakes within the 6 square mile cluster with calculated magnitudes 1 and greater since Jan 2019, a pattern or correlation of seismicity versus local injection is hard to confidently establish (Figure 23). Isolating observations to just July and August 2019, it is possible to infer rapid changes in injection volumes recorded over several days (pulsing) seem to correlate with a high rate of seismicity in the month preceding. This observation is reasonable but not conclusive since it does not consider all earthquakes in this cluster and temporally matched injection volumes from local wells. High rates of seismicity have been observed following times without injection volume pulses and injection volume pulsing has occurred without elevated rates or magnitudes of earthquakes.

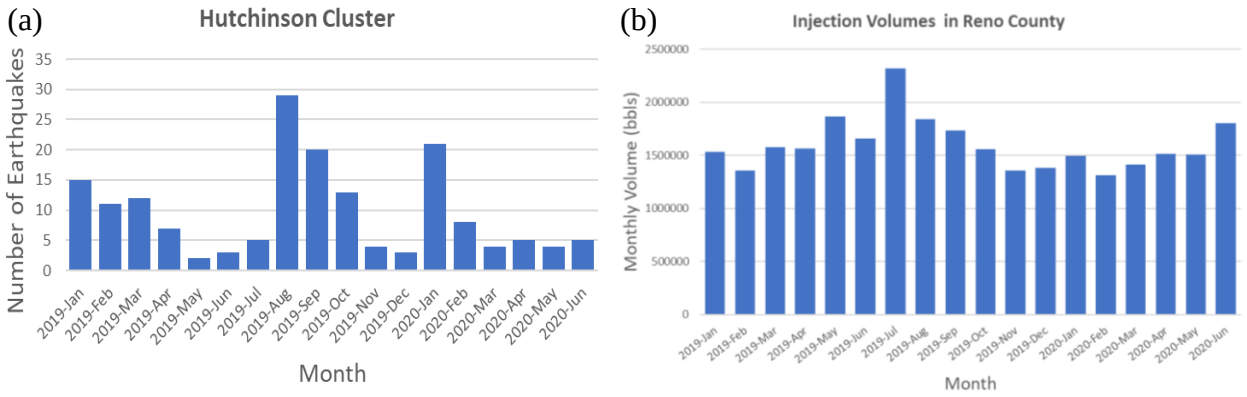


Figure 23. (a) Histogram of the number of earthquakes in the Hutchinson cluster by month. (b) Histogram of injection volumes in Reno County in bbls.

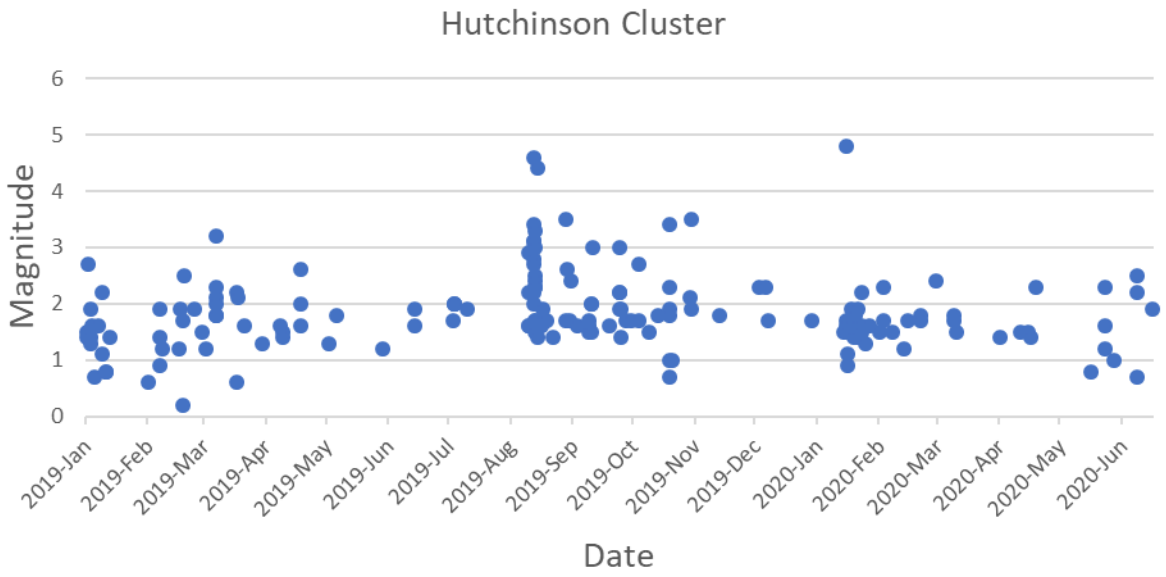


Figure 24. Scatter plot of the magnitude of earthquakes in the Hutchinson cluster vs time.

Five consortium network stations were instrumental in providing data supporting the conclusion that the three M 4 events recorded over the last year cannot conclusively be correlated to injection pulsing alone. Catalysts for these large earthquakes seem to include natural stress field, local fault orientation, irregular (spiking) injection volumes, and an elevated triggering threshold, which is an artifact of pressure changes due to distant injection. Correlating injection volumes and number of earthquakes in a consistent fashion is not possible for the Hutchinson cluster.

Injection volumes in Reno County have fluctuated around 20% over the 18 months from January 2019 to June 2020 (a pattern consistent over the past 10 years) but the seismicity (number of events) has varied by an order of magnitude across the same time window (Figure 24). The two M 4 events in August 2019 were part of a large increase in the total number of recorded events during August and September 2019. A surge in earthquake numbers was logged the two months that followed the two August light earthquakes (earthquakes within a magnitude range of M 4.0 to M 4.9 are classified as light). This surge was accompanied by a gradually decreasing number of total events until the third month when the total number of earthquakes returned to a historic baseline level.

The two M 4 events that occurred in August of 2019 were accompanied by a two month sequence of fore and aftershocks, an occurrence generally consistent with most light and larger earthquakes (Figure 23). The lone M 4 event in January of 2020 has no obvious fore or after shock sequence accompanying it above felt level. Several earthquakes below M 2 that were temporally very near the January event are likely related to the January event, but clearly the pattern of energy release observed during August of 2019 was dramatically different from the energy release in equivalent temporal proximity to the January 4 event.

A marked increase in events occurred in January 2020 around the time of the third M 4 event recorded in the cluster during the 18 months from January 2019 to June 2020 (Figure 23). A slightly elevated number of earthquakes was recorded in February (likely associated it the January M 4 event) relative to the number of earthquakes between February and June. These temporally grouped earthquakes could be a small group of aftershocks. These temporally

grouped events appear within a month or two after the main shock, however very few events can be identified that meet the criteria of foreshocks.

Earthquake recursion relationships are based on past earthquake history associated with a particular trend and useful in determining the size of earthquakes that should be expected from faults responsible for the earthquakes. They are also useful in speculating about the catalyst of an earthquake sequence: natural or induced. A 'b value' of 1 is the expected average for natural occurring earthquakes along a historically established and well sampled trend. A small b value (as observed here for the Hutchinson cluster) indicates a greater number of larger earthquakes than expected based on frequency and size of events (Figure 25). Some studies of natural sequences suggest a low b value is indicative of an upcoming relatively large event. A low b value has also been observed in settings where earthquakes are linked to injection and suggested to be induced. Additionally, the b value curve for the current sample of earthquakes from the Hutchinson cluster suggests earthquakes with magnitudes larger than upper 4s is unlikely.

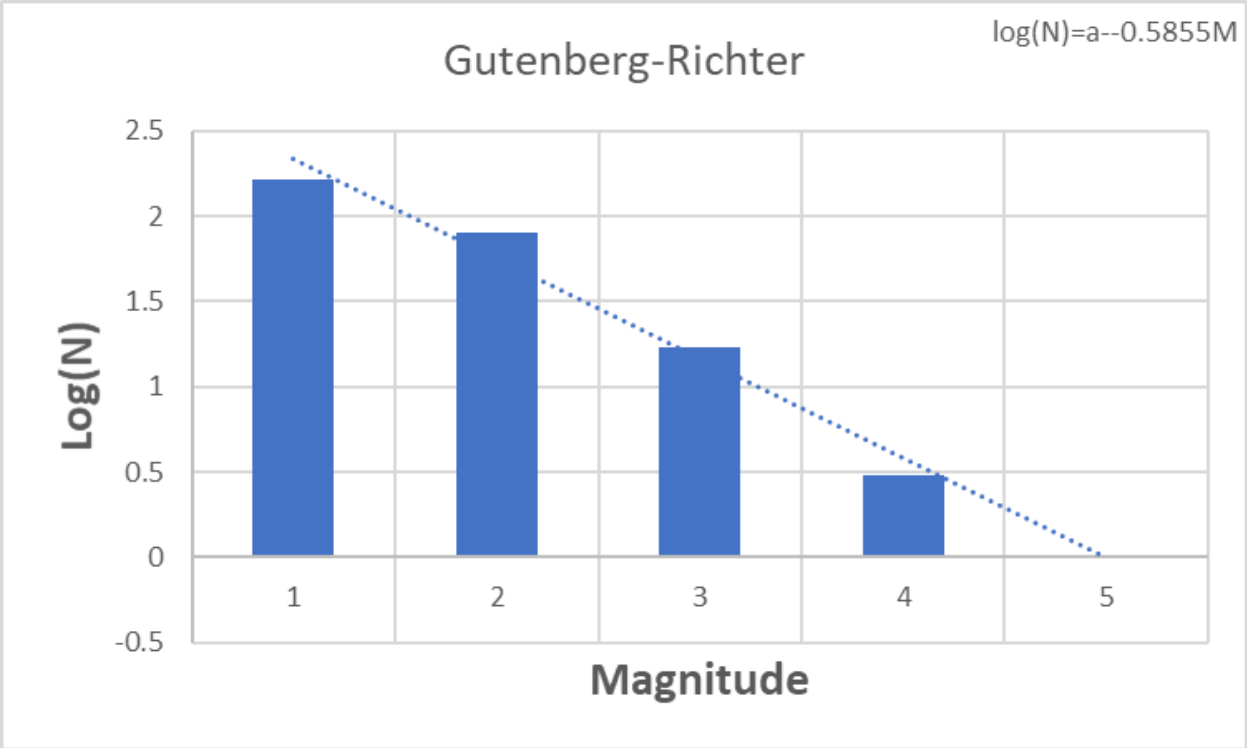
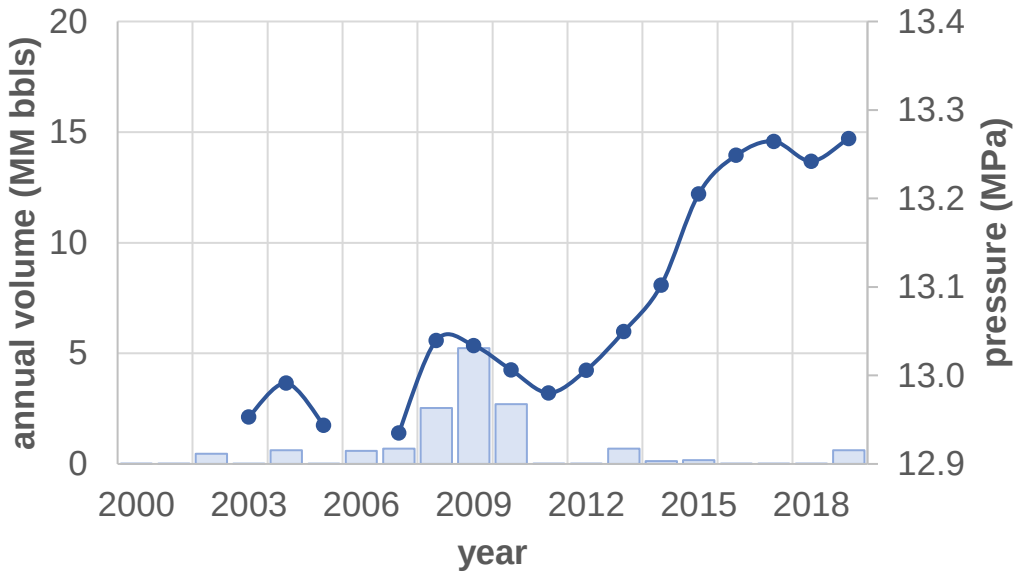


Figure 25. Histogram grouping the log of the number of earthquakes in the Hutchinson cluster into 1 magnitude ranges. The slope of the trend line describes the Gutenberg-Richter b-value for the cluster.

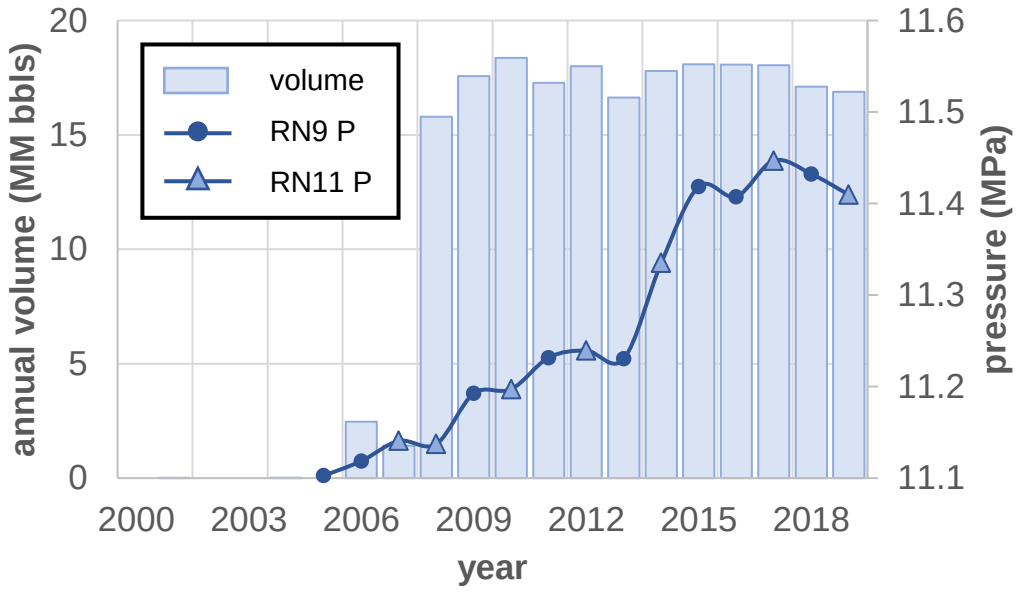
It is simply not possible to correlate annual injection volumes at wells in proximity to the Hutchinson cluster with the bottomhole pressure trends measured in the local wells over the last 10 years (Figure 25). Pumping volumes in wells seeing a rapid increase in rates in 2008 and relatively consistent volumes since then have experienced a gradual increase in bottomhole pressure. In the last couple years a notable stabilizing or decrease in pressure has been measured without associated significant variations in injection volumes from the measured wells. Wells near the cluster with virtually no injection since 2010 have seen a similar increase in bottomhole pressure (Figure 26). Measured increases in bottomhole pressure at wells in Reno County are, at least in part, indicative of increases in basement pore pressures that in 2016 clearly exceeded the

earthquake-triggering pressure within the Hutchinson cluster. Injection practices in Reno County over the last decade are not consistent with pore pressure increases sufficient to exceed the triggering threshold in the Hutchinson cluster. Several studies have determined the increase in bottomhole pressure was/is predominantly driven by injection a couple counties south in proximity to the Kansas/Oklahoma border (Peterie et al., 2018; Zhai et al., 2020).

(a)



(b)



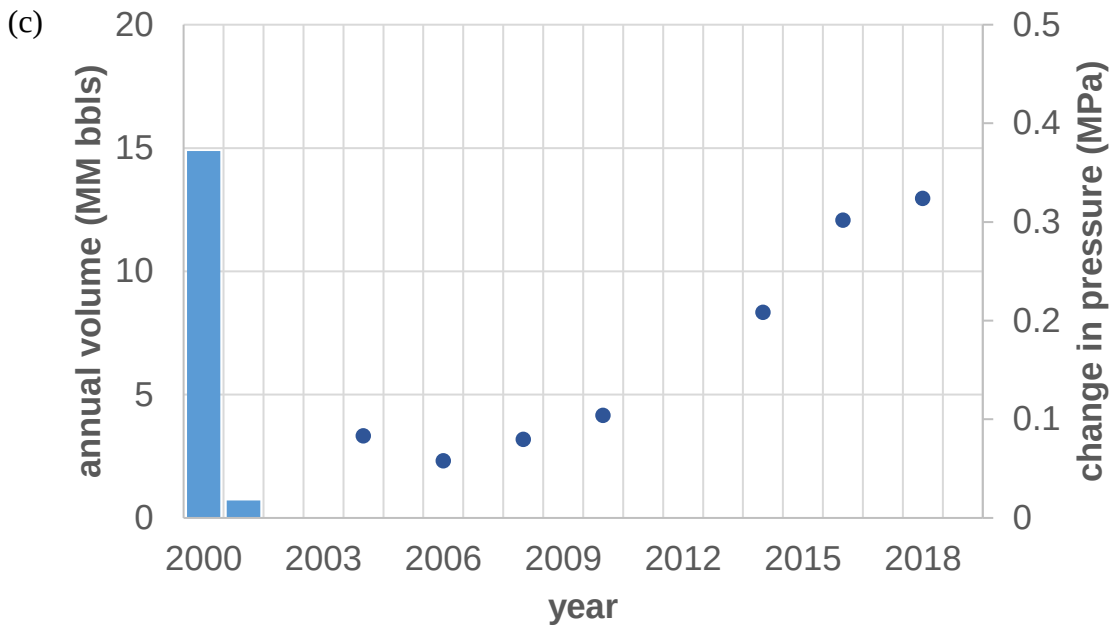


Figure 26. (a) Annual injection volume and pressure in RN8. (b) Annual injection volume and pressure in RN9 and RN11 wells. (c) Annual volume and change in pressure in RN8.

A striking correlation between regional (south-central Kansas) decreases in injection volumes and number of earthquakes is strong evidence for speculation about cause and effect in this case (Figure 27). Although not conclusive, this correlation strongly supports the idea presented in the previous paragraph that the primary drivers for basement pore pressures exceeding triggering thresholds are injection practices along the Kansas/Oklahoma border. As a result of this regional increase in Arbuckle pressures it is possible to identify and map faults that are currently properly aligned with the regional stress field, critically stressed, and can produce measurable earthquakes. To avoid triggering felt earthquakes, these seismically sensitive areas need to be integrated into any plans that might affect injection practices.

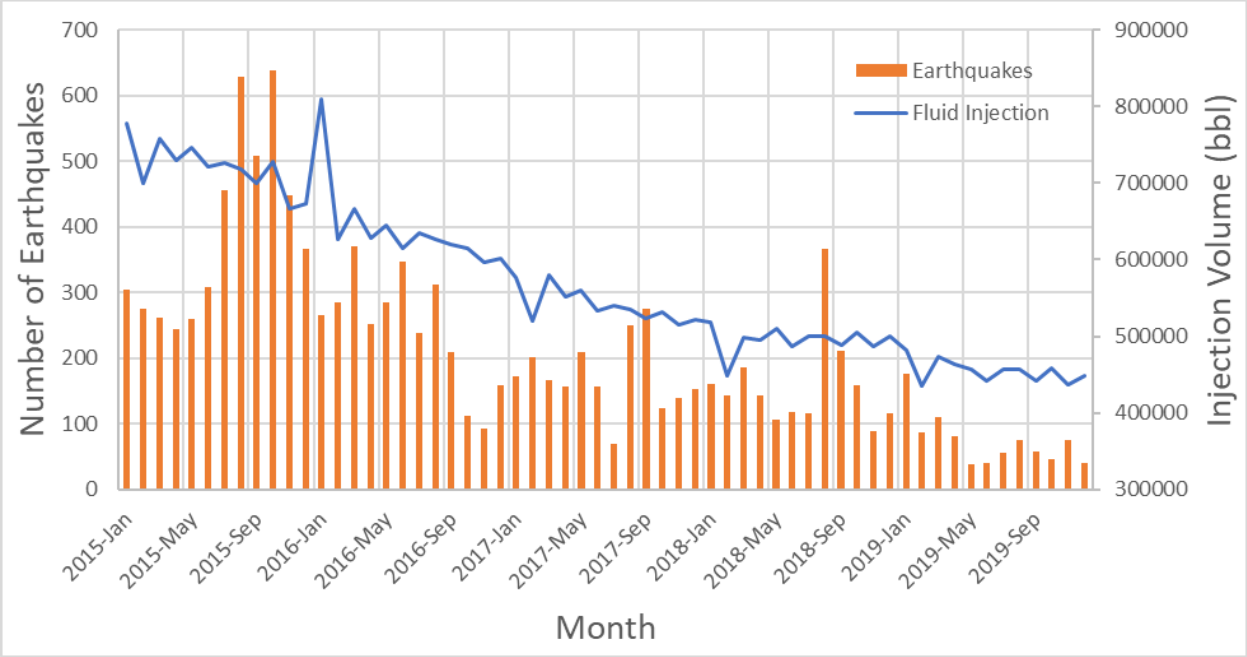


Figure 27. Histogram of the monthly number of earthquakes from 2015-2019 and line chart of the monthly fluid injection volume in south central Kansas.

Based on the magnitude and occurrence of Hutchinson cluster earthquakes it is reasonable to suggest anthropogenic catalysts. But the complexity of the system makes it impossible to conclusively relate injection practices with induced earthquakes. Pulsing injection volumes is known to induce earthquakes (Healy et al., 1968) and the large volume of fluid injected in the second quarter of 2019 within a few miles of the Hutchinson cluster preceded a pair of the largest earthquakes in Kansas history within the Hutchinson cluster (Figure 28). This historically large volume of injected fluid in a relatively short period of time is not unique for this well. Previous large volume injections in 2016 did not result in earthquakes.

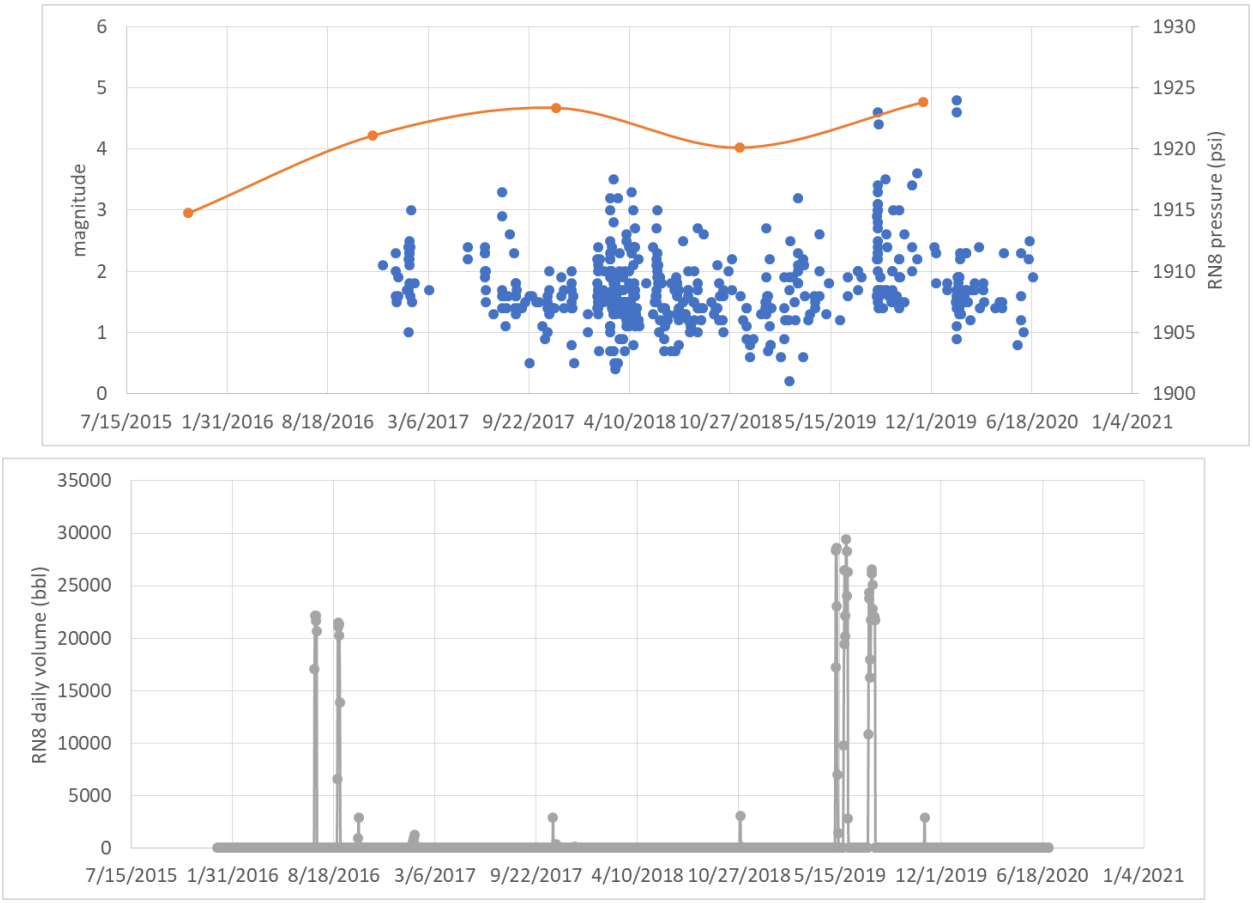


Figure 28. (a) Scatter plot of magnitude of earthquakes in Hutchinson cluster and pressure in RN8. (b) Daily injection volume in RN8.

Over the last year, a consistent cluster of earthquakes less than M 2 occurred in a four township sized area in eastern Sedgwick and western Butler counties (Figure 29). This cluster has not risen to a level of regulatory or public concern, but it is a new and persistent area of seismicity. Most earthquakes located in this cluster relied on the consortium stations to uniquely estimate their location and magnitudes. This is the level of awareness and early detection that allows significant time to investigate the trend and possible triggering mechanisms and allow a mitigation plan to be developed before it ever reaches felt event magnitudes.

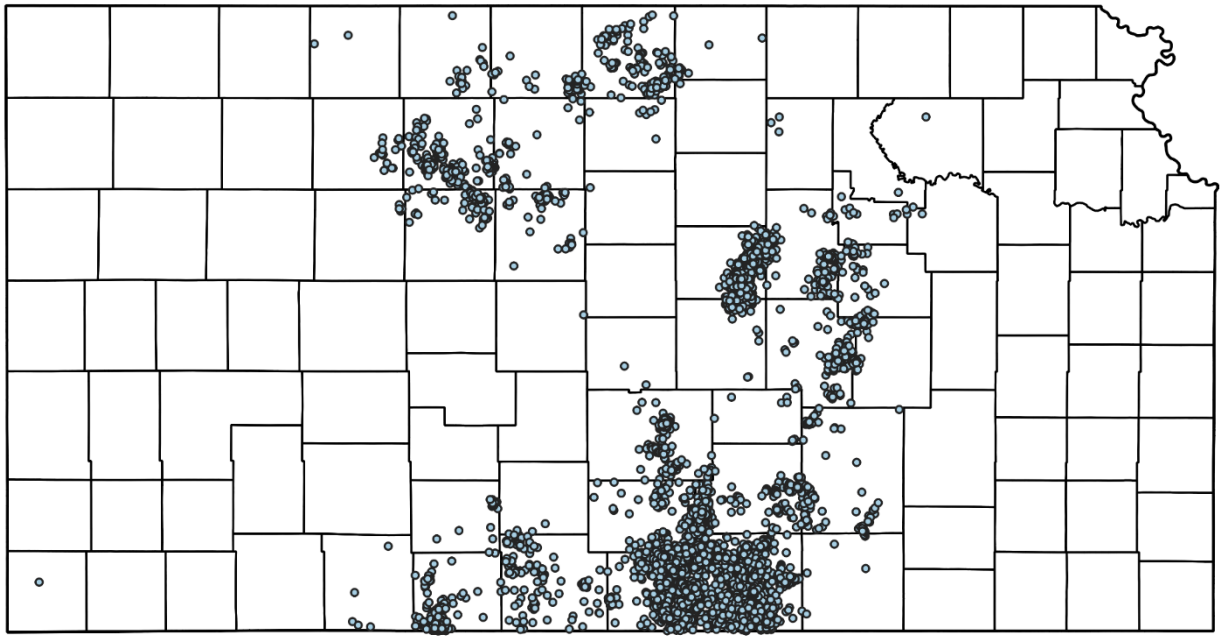


Figure 29. Map of events in Kansas from June 2019-July 2020

A surge in seismicity recorded in Rooks County is currently a mystery and clearly cannot be explained with the disposal data provided the KCC or the historical trends in this area (Figure 30). Injection volumes/rates in this area are submitted annually using a system relying on self-reporting by the operators. Study of b values and other data will help work toward a better understand of this dramatic increase in seismicity starting in 2017 followed by another dramatic increase in seismicity and then a crescendo following a M 4.8 in mid-2019. During the latter part of 2020 the rate and magnitude of earthquakes in this area has markedly decreased to sub felt levels.

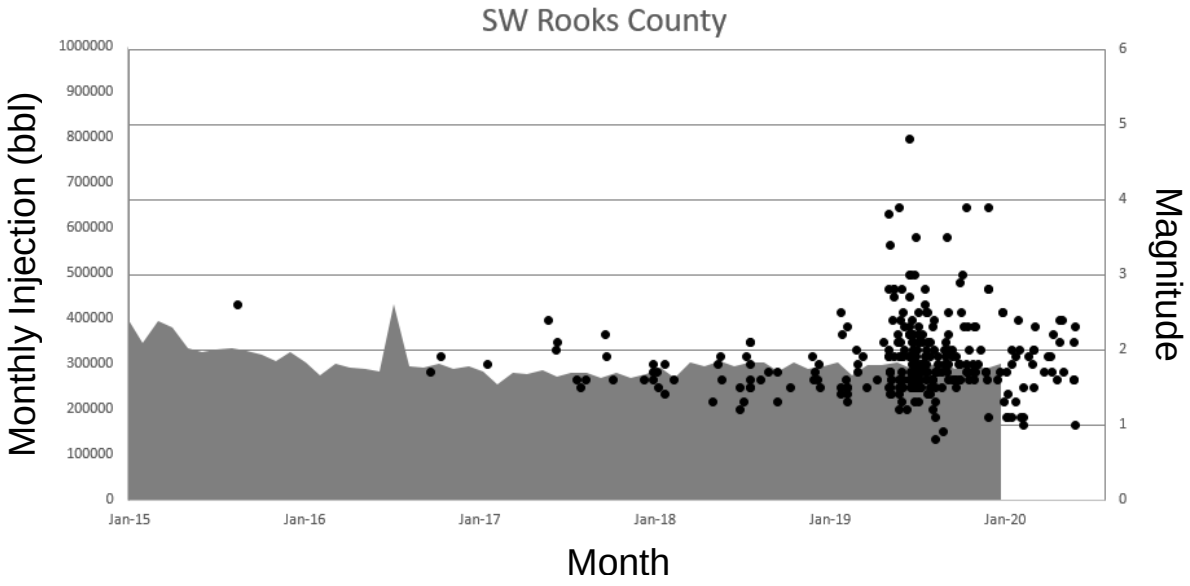


Figure 30. Injection volume and scatterplot of the magnitude of events in Rooks County from 2015-2020.

DISCUSSION

The Arbuckle Group is a deep aquifer that serves as the injection zone for thousands of Underground Injection Control (UIC) wells in Kansas and neighboring Oklahoma. Widespread seismic activity across central Oklahoma and south-central Kansas is primarily attributed to elevated pore pressures along critically-stressed faults in the underlying hydraulically-connected basement. As injection volumes in south-central Kansas decreased over the past four years, pressures in south-central Kansas began to stabilize in 2016 and the earthquake rate likewise levelled off (Figure 31). In 2019 (the most current year with complete pressure data), pore pressures within the Arbuckle Group (and, thus, basement) have stabilized but remained elevated above the earthquake triggering threshold (Figure 32). Therefore, earthquakes will likely persist as crustal stresses continue to load near-critical faults properly aligned with the stress field. Furthermore, injection practices that produce even small pressure fluctuations may contribute to trigger earthquakes on nearby faults.

Four M 4 or greater earthquakes were recorded during the reporting period between July 1, 2019, and this year's CSTS annual meeting in August 2020. These were four of the largest 10 earthquakes since historical record keeping began. During this period we have also seen a dramatic reduction in felt earthquakes and a notable reduction in all earthquakes. This trend is consistent with the reductions in injection volumes and are key indicators that pressures in Arbuckle fluids are decreasing. Based on recursion relationships, M 4 to M 4.9 earthquakes are still possible, but the dramatic drop in smaller events suggests temporal separation between these larger events will likely increase.

Most seismicity in Kansas has remained concentrated in six distinct areas with clustering activity ranging from earthquakes concentrated within a few square miles, to linear groupings of earthquakes along apparent faults that extend over distances as great as 50 miles. Active areas around the Nemaha Ridge and within Jewell/Smith/Republic counties seem to be consistent

relative to the past few years in terms of locations and characteristics. Events in the Saline and Central Kansas Uplift (primarily Rooks County) areas have seen consistent activity principally along trends that are inferred as faults. The south-central (Harper/Sumner counties) area has experienced a reduction in seismicity relative to the previous years' trend. Seismically active areas around Kansas have produced earthquakes at a rate in the last year that has varied from decreasing to increasing without a clear reason for either extreme. Some areas with swarms have experienced various density across the clusters, but the concentration of events has remained within the loosely defined groupings.

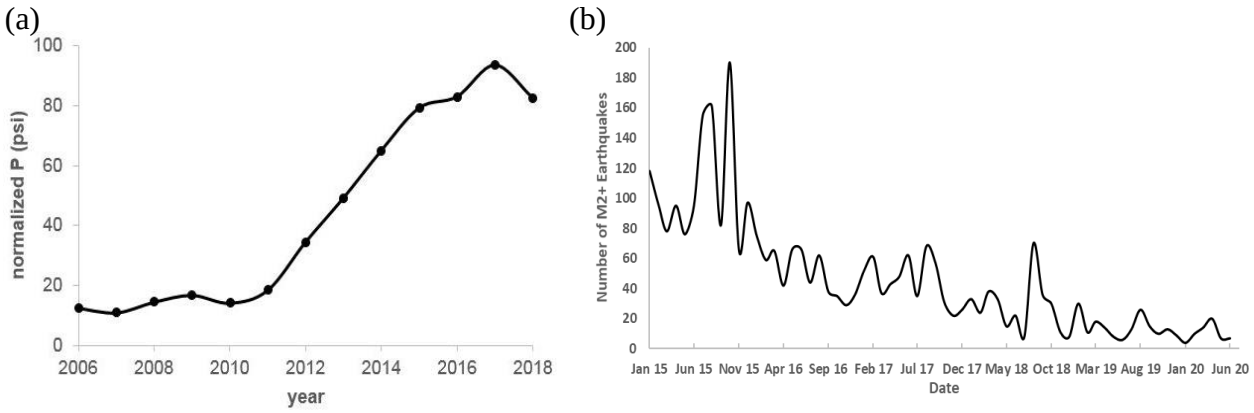


Figure 31. (a) Arbuckle Group pore pressure reported for a well in Harper County. (b) Monthly number of earthquakes M 2 or larger in central and southern Kansas.

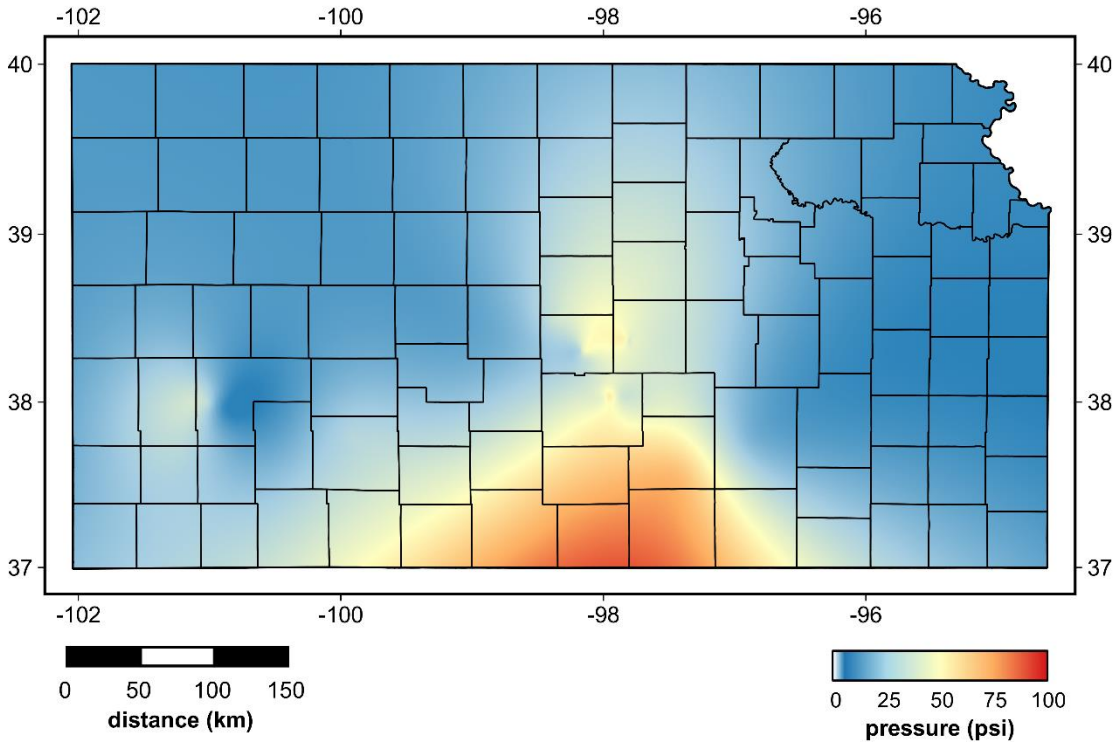


Figure 32. Change in Arbuckle Group pore pressure in 2019 (relative to baseline pressures reported in 2002, or first reported year thereafter).

WEB PAGE CONTENT

The CSTS web page (http://www.kgs.ku.edu/Geophysics/CSTS/index.html) is operated by the KGS. It includes links to information about meetings, publications, network updates, and seismic updates (for Tier 1 members) and information about the seismic network for Tier 2 members. It includes semi-annual newsletters about earthquake activity, along with access to a comprehensive catalog of events, including time, location, magnitude, and the Seismic Action Score (based on evaluation criteria developed by the State's Induced Seismicity Task Force) for each event. The website also includes a series of pictures and accounts of the installation process and gives a feel for the environment and footprint of each consortium station. Currently at least one station has been installed within 20 miles of every Tier 1 member's well (Figure 2). A short discussion and set of pictures are posted on the website documenting the installation process.

OTHER ACTIVITIES

The 2020 annual meeting was held virtually on August 12. The agenda is shown below and a video of the meeting is available on the CSTS web page.

CONSORTIUM TO STUDY TRENDS IN SEISMICITY
Virtual Annual Meeting Agenda – August 12, 2020

Video times	Topic, *Speaker*
0:00:00 – 0:10:40	Welcome and Introduction of Attendees, *Rex Buchanan, KGS*
0:10:40 – 0:38:40	Studying Seismicity in Kansas Monitoring and Consortium Update: Seismicity across the State and impacts on CSTS core mission *Rick Miller, KGS*
0:38:40 – 0:40:00	*Rex Buchanan*
0:40:00 – 1:07:35	Local Seismicity Near CSTS Member Wells, *Shelby Peterie, KGS*
1:07:35 – 1:12:40	Discussion
1:12:40 – 1:15:00	Discussion on CSTS work so far, *Mark Thompson, Enterprise Products*
1:15:00 – 1:32:36	Questions and Additional Discussion

PLANS

With more than three years of recording on all stations, very preliminary searches for associations between subnetwork seismicity and operations at each site is an exercise that was started last year and will continue with the increased number of events to work with. We are looking at injection practices and seismicity at the 0.0 to 2.0 M levels within 10 miles of each

facility to insure our general observations are in fact substantiated with actual well-specific operations and will continue that practice. We acknowledge that it was a bit premature to begin looking at correlations or response characteristics at individual facilities, but some systematic or baseline relationships might begin to emerge as some point. We started that process a bit early just to ensure we have the opportunity to observe the any correlations as they begin to become statistically defensible. We are likely still a few years ahead of having enough data for this kind of detailed investigation.

As the Statewide network has expanded over the last year the infill station near Salina is providing improved location accuracy as well as representing another station that is helping with event triangulation for earthquakes currently too small to be detected on three or more stations.

Preliminary investigations into the potential of incorporating products of the Arbuckle working group with seismic monitoring products (locations, waveforms, depths, distributions—spatial and temporal, etc.) should eventually begin to expand the scope of the CSTS and increase the significance and first order use of CSTS products into a wide range of member needs.

CONCLUSION

This year's trends in seismicity, as they relate to CSTS facilities, are generally consistent with observations reported over the year prior. Clearly the relationship between the price of oil and Class II injection volumes is becoming well established and the temporally staggered correlations between the volumes of produced water disposed of in the Arbuckle and seismicity have been observed to track in a reasonably consistent fashion since 2013. Monitoring seismic activity during this time of reduced disposal volumes and earthquake numbers and sizes is critical and will play a vital role in establishing natural recursion numbers for micro levels and the associated development of expectations for distinguishing natural from induced seismicity.

Natural recursion relationships and earthquake characteristics are most accurately quantified and statistically consistent when studied and averaged over long periods of time. Relying on small sample sizes (less than several years to a decade) for statistical analysis of temporally variable events will likely alias the results and minimize confidence in any future attempts to categorize triggering mechanisms.

Three M 4+ events within the Hutchinson cluster occurred during this reporting period. Those events and the fluid injection records have provide significant insights into the recursion relationship and possible cause and effect associated with large injection rate changes in temporally relevant periods. Highly variable sequences of earthquakes associated with these main shocks are likely indicative of a highly dynamic stress field.

Seismicity in proximity to CSTS member's facilities is sporadic with some events sharing commonality with mapped structures and historic earthquakes. Many groups of earthquakes continue to establish and align with structural trends previously unmapped and with no previous evidence they existed, except CSTS identified earthquake epicenters.

REFERENCES

Armbruster, J.G., D.W. Steeples, and L. Seeber, 1989, The 1989 earthquake sequence near Palco, Kansas: A possible example of induced seismicity (abstract): *Seismological Research*

Letters, v. 60, no. 4, p. 141.
Berendsen, P., and K.P. Blair, 1986, Subsurface structural maps over the central North American rift system (CNARS), central Kansas, with discussion: Kansas Geological Survey, Subsurface Geology Series 8, 16 p.
Cole, V.B., 1976, Configuration of the top of the Precambrian rocks in Kansas: Kansas Geological Survey, Map M-7, scale 1:500,000.
Healy, J.H., et al., 1968, The Denver Earthquakes: *Science*, v 161, no. 3848, p. 27.
Zhai, G., M. Shirzaei, and M. Manga, 2020, Elevated Seismic Hazard in Kansas Due to High-Volume Injections in Oklahoma: *Geophysical Research Letters*, 47, e2019GL085705.

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Appendix A: CSTS Station Locations, Pictures, and Descriptions

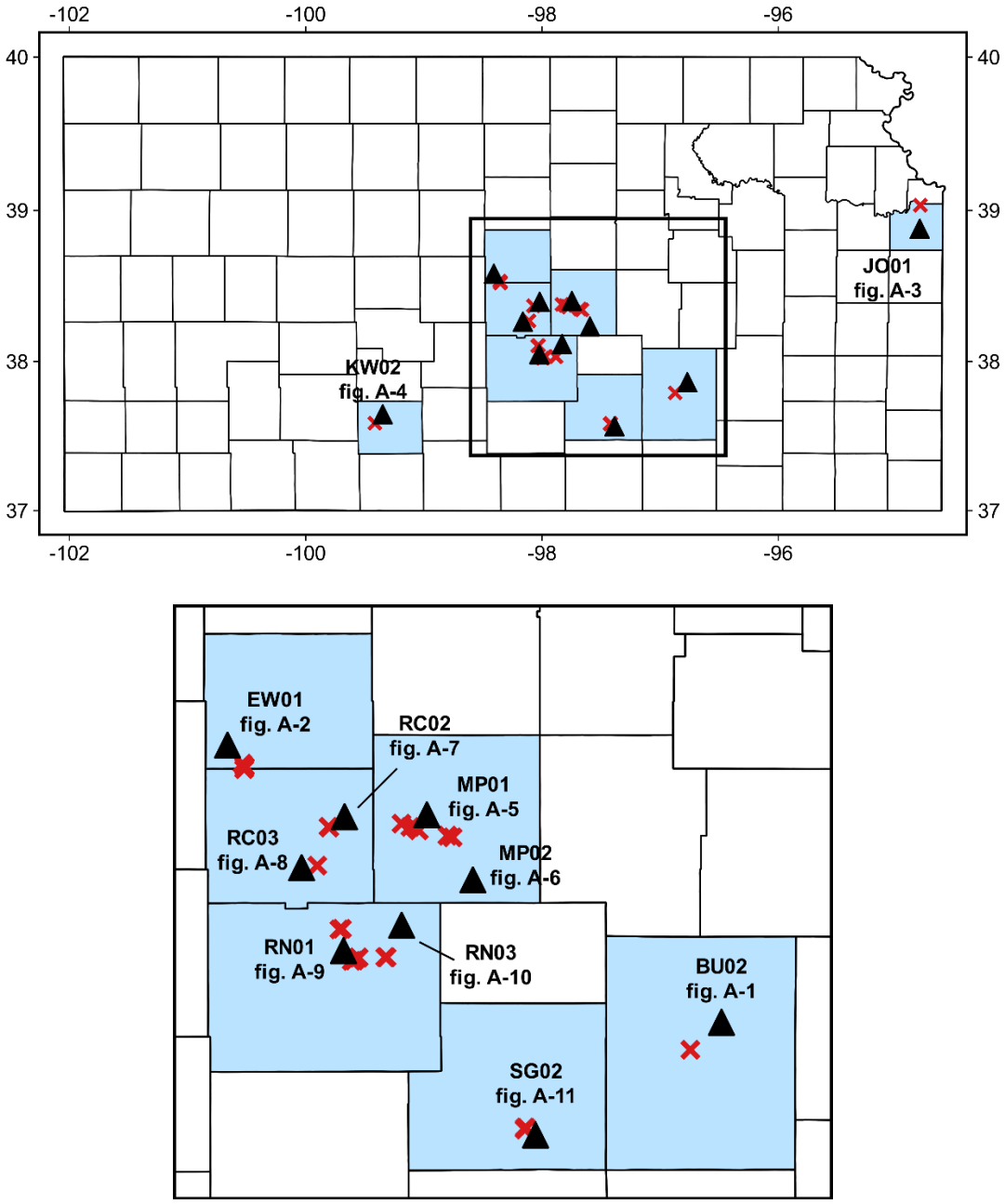

Figure A-0. Base map for pictures of equipment configuration at each station included in this appendix. Top figure is State of Kansas with the bottom figure enlargement of black box in upper figure. Black triangles are earthquake stations and red Xs are each member's injection facility location(s).

Figure A-1. BU02 is located in the El Dorado State Park in northern Butler County. This station is in a pasture near the El Dorado Lake about 4 mi from Interstate 35.

Figure A-2. EW01 is located in southwestern Ellsworth County near the city of Holyrood. The station is in a cemetery about 1 mi from highway Kansas Highway 156.

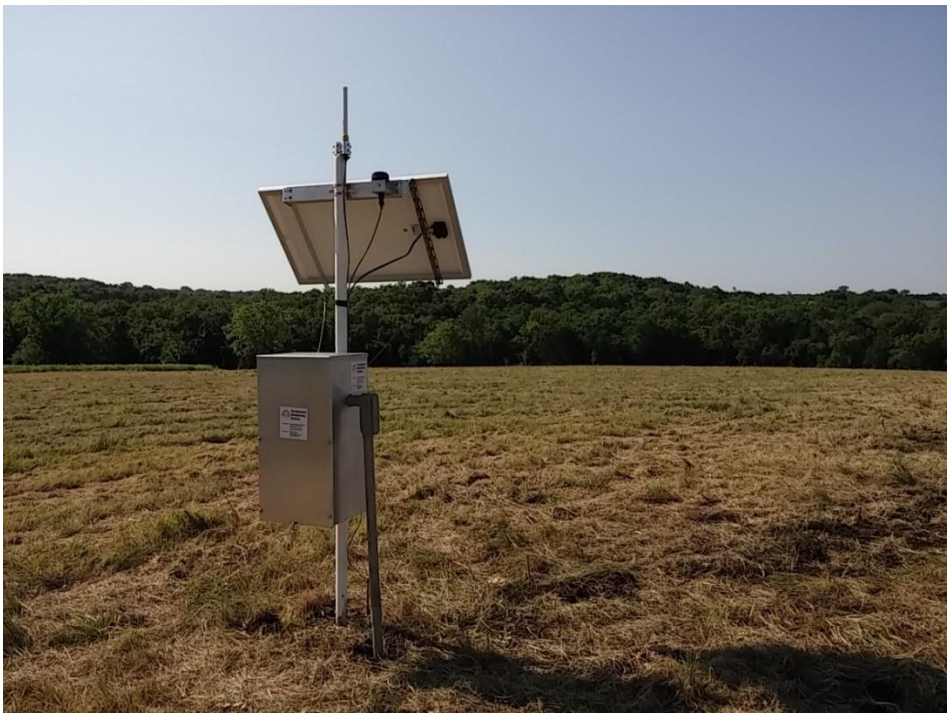

Figure A-3. JO01 is located on the grounds of the Olathe Prairie Center in Johnson County about 4 mi west of Kansas Highway 10. There is light traffic around the station and two rock quarries within about 5 mi.

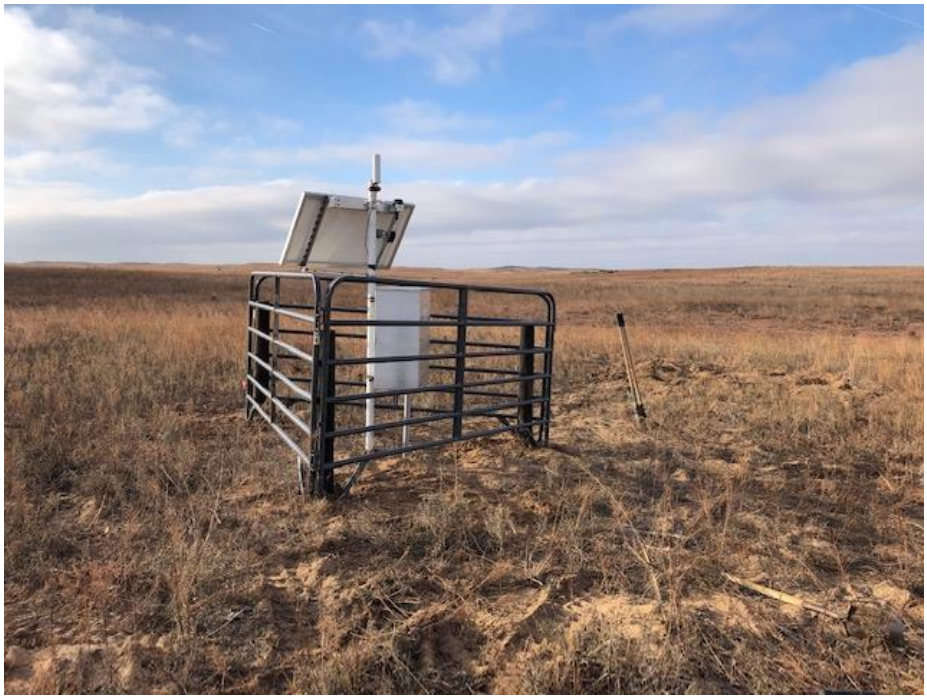

Figure A-4. KW02 is located in northern Kiowa County in a pasture located between Mullinville and Greensburg more than 1 mi from the railroad and highway.

Figure A-5. MP01 is located in the McPherson Valley Wetlands Wildlife Area in McPherson County. The station is northwest of Conway about 2 mi from US Highway 56.

Figure A-6. MP02 is located in south-central McPherson County southeast of the McPherson. The station is in a pasture on the grounds of a local church about 3 mi from Interstate 135.

Figure A-7. RC02 is located in eastern Rice County near the city of Little River. This station is installed in a pasture more than 1 mi from US Highway 56 and Kansas Highway 46.

Figure A-8. RC03 is located in Rice County between Lyons and Sterling. This station is installed in a pasture about 2 mi from highway Kansas Highway 96 and is near a small landing strip.

Figure A-9. RN01 is located in Reno County west of Hutchinson. This station is installed in a cemetery about 2 mi from Kansas Highway 14.

Figure A-10. RN03 is located in Reno County northeast of Hutchinson in Sand Hills State Park. It is installed about 2.5 mi from Kansas Highway 61.

Figure A-11. SG02 is located in Sedgwick County south of Wichita. This station is on the grounds of a local church about 3 mi from Interstate 35 and US Highway 81 and 2 mi from two sets of railroad tracks to the west and east.

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Appendix B: CSTS Earthquake Catalog 7/1/2019 – 6/30/2020

This catalog includes all earthquakes that were uniquely located and within 20 miles of a consortium member facility.

Origin Time (UTC)	Latitude	Longitude	Magnitude
2019-07-04 01:55:00	38.619	-97.623	1.7
2019-07-04 03:10:00	38.615	-97.582	2.0
2019-07-07 23:25:00	38.009	-98.001	1.7
2019-07-08 13:27:00	38.004	-98.010	2.0
2019-07-08 17:44:00	38.004	-98.000	2.0
2019-07-08 20:04:00	38.010	-97.997	2.0
2019-07-09 11:01:00	37.350	-97.408	1.1
2019-07-10 18:53:00	37.324	-97.278	1.7
2019-07-11 10:35:00	37.410	-97.493	1.7
2019-07-13 21:45:00	37.409	-97.462	1.5
2019-07-14 07:56:00	37.633	-99.064	1.3
2019-07-14 09:57:00	37.630	-99.059	1.3
2019-07-14 22:40:00	38.003	-98.002	1.9
2019-07-17 04:58:00	38.447	-97.417	1.6
2019-07-19 07:39:00	37.497	-97.757	1.0
2019-07-19 22:49:00	37.409	-97.481	2.0
2019-07-22 07:18:00	37.493	-97.751	1.5
2019-07-22 08:27:00	37.498	-97.753	0.9
2019-07-24 10:55:00	37.327	-99.416	1.2
2019-07-27 06:14:00	37.422	-97.482	1.3
2019-07-28 00:07:00	37.414	-97.478	1.6
2019-07-29 03:26:00	37.414	-97.482	1.6
2019-07-30 01:46:00	38.236	-97.480	1.6
2019-08-07 01:27:00	38.233	-97.486	1.3
2019-08-07 04:44:00	37.478	-97.757	1.3
2019-08-12 01:18:00	38.621	-97.614	1.4
2019-08-14 13:44:00	38.006	-98.002	2.9
2019-08-14 16:57:00	38.006	-97.999	2.2
2019-08-14 17:00:00	38.012	-97.999	1.6
2019-08-14 17:23:00	38.007	-98.002	1.6
2019-08-15 06:21:00	37.479	-97.752	2.0
2019-08-16 09:09:00	37.417	-97.510	1.4
2019-08-16 12:59:00	38.014	-97.999	4.6
2019-08-16 13:10:00	38.012	-98.000	3.4
2019-08-16 13:28:00	38.014	-97.992	3.0
2019-08-16 13:30:00	38.014	-97.988	3.1
2019-08-16 13:43:00	38.010	-97.991	3.1
2019-08-16 17:18:00	38.015	-97.999	2.0
2019-08-16 18:26:00	38.019	-97.993	2.2
2019-08-16 19:55:00	38.015	-97.997	2.8
2019-08-16 19:56:00	38.011	-97.993	2.7
2019-08-17 00:15:00	38.017	-97.995	1.7
2019-08-17 01:03:00	38.011	-98.016	3.3
2019-08-17 03:19:00	38.016	-98.001	2.5
2019-08-17 05:23:00	38.013	-97.998	2.4
2019-08-17 06:21:00	38.019	-98.003	2.3
2019-08-17 07:42:00	38.022	-98.002	2.3
2019-08-17 09:56:00	38.015	-98.014	3.0
2019-08-17 10:00:00	38.015	-97.997	1.7
2019-08-17 10:02:00	38.021	-97.989	1.5
2019-08-18 08:45:00	38.006	-98.002	4.4
2019-08-18 22:51:00	38.021	-97.986	1.4
2019-08-20 10:56:00	38.017	-97.987	1.6
2019-08-20 18:01:00	37.778	-98.010	1.6
2019-08-20 23:59:00	37.780	-98.007	1.5
2019-08-21 03:13:00	38.019	-97.990	1.7
2019-08-21 13:46:00	38.022	-97.991	1.9
2019-08-21 16:41:00	37.779	-98.013	1.8
2019-08-23 00:42:00	38.017	-98.002	1.7
2019-08-26 10:43:00	38.017	-98.003	1.4
2019-08-27 12:37:00	37.608	-99.059	1.4
2019-08-29 08:40:00	37.736	-97.593	2.0
2019-09-01 06:14:00	38.010	-97.998	1.7
2019-09-01 13:21:00	38.004	-98.004	3.5
2019-09-01 14:49:00	37.778	-98.010	1.2
2019-09-02 23:08:00	38.012	-97.990	2.6
2019-09-03 06:53:00	38.035	-98.003	1.7
2019-09-03 18:50:00	37.989	-96.949	1.5
2019-09-04 06:18:00	38.015	-97.999	2.4
2019-09-06 17:32:00	37.438	-97.382	1.0
2019-09-07 19:55:00	38.008	-98.002	1.6
2019-09-09 06:39:00	38.461	-97.429	1.5
2019-09-13 06:29:00	37.600	-97.753	1.3
2019-09-13 10:04:00	38.015	-97.978	1.6
2019-09-13 11:23:00	37.527	-97.123	1.3
2019-09-13 12:33:00	38.028	-97.986	1.5
2019-09-13 17:44:00	37.773	-98.016	2.1
2019-09-13 21:34:00	38.012	-97.991	1.7
2019-09-14 04:23:00	38.020	-97.997	2.0
2019-09-14 04:26:00	38.017	-97.989	2.0
2019-09-14 05:00:00	38.024	-97.985	1.5
2019-09-14 05:18:00	38.584	-97.622	0.4
2019-09-14 05:36:00	37.401	-97.373	1.3
2019-09-15 15:34:00	38.006	-98.007	3.0
2019-09-20 06:00:00	37.532	-97.128	1.2
2019-09-23 09:57:00	38.009	-98.000	1.6
2019-09-23 17:06:00	37.642	-97.085	1.2
2019-09-28 12:32:00	38.010	-98.008	2.2
2019-09-28 20:16:00	38.008	-98.009	3.0
2019-09-28 20:19:00	38.001	-98.010	2.2
2019-09-28 21:24:00	38.006	-98.006	1.9
2019-09-29 03:27:00	38.012	-97.990	1.4
2019-09-29 04:11:00	38.009	-98.000	1.9
2019-10-01 23:44:00	38.007	-97.999	1.7
2019-10-04 14:34:00	38.007	-98.000	1.7
2019-10-06 04:50:00	38.407	-97.416	1.3
2019-10-08 03:09:00	38.015	-98.005	2.7
2019-10-08 04:59:00	37.994	-98.023	1.7
2019-10-13 10:31:00	38.026	-97.997	1.5
2019-10-17 08:12:00	37.372	-97.613	1.5
2019-10-17 10:50:00	38.011	-98.016	1.8
2019-10-21 14:18:00	37.552	-97.774	1.8
2019-10-21 18:46:00	37.295	-97.420	2.0
2019-10-21 22:25:00	37.308	-97.397	1.9
2019-10-23 18:14:00	38.003	-98.000	1.9
2019-10-23 19:04:00	38.008	-98.005	2.3
2019-10-23 20:35:00	38.012	-98.014	0.7
2019-10-23 21:39:00	38.004	-98.014	3.4
2019-10-23 22:09:00	37.999	-97.999	1.0
2019-10-23 23:45:00	38.007	-98.020	1.8
2019-10-24 12:36:00	38.010	-97.997	1.0
2019-10-28 19:51:00	37.360	-97.615	1.8
2019-11-02 21:29:00	38.020	-97.998	2.1
2019-11-03 01:34:00	38.007	-98.022	1.9
2019-11-03 02:08:00	38.015	-97.997	3.5
2019-11-04 17:10:00	37.299	-97.400	1.9
2019-11-10 05:56:00	37.656	-97.110	1.6
2019-11-10 10:14:00	37.682	-97.748	1.1

Appendix B. Continued

Origin Time (UTC)	Latitude	Longitude	Magnitude
2019-11-10 19:22:00	37.578	-97.782	1.6
2019-11-12 03:59:00	37.867	-98.031	1.7
2019-11-12 04:15:00	37.873	-98.026	1.4
2019-11-12 05:27:00	37.870	-98.043	1.6
2019-11-13 23:11:00	37.875	-98.019	1.4
2019-11-16 17:54:00	37.541	-97.749	1.7
2019-11-17 00:13:00	37.558	-97.750	1.9
2019-11-17 06:05:00	37.595	-97.760	1.5
2019-11-17 14:04:00	38.020	-97.996	1.8
2019-12-07 17:30:00	38.008	-97.998	2.3
2019-12-07 20:29:00	37.490	-97.746	1.8
2019-12-07 21:58:00	37.494	-97.754	1.9
2019-12-07 22:18:00	37.538	-97.779	1.7
2019-12-10 01:24:00	38.007	-98.006	2.3
2019-12-11 12:06:00	38.023	-97.990	1.7
2019-12-13 11:24:00	37.427	-97.367	1.5
2019-12-14 02:51:00	37.776	-97.952	1.6
2019-12-18 06:25:00	37.610	-97.168	1.2
2019-12-21 17:37:00	37.659	-97.137	1.4
2019-12-26 01:16:00	37.382	-97.247	0.8
2020-01-02 02:26:00	37.701	-97.240	1.2
2020-01-02 05:51:00	38.007	-97.998	1.7
2020-01-03 09:41:00	37.592	-97.287	1.4
2020-01-05 05:12:00	37.522	-97.768	1.5
2020-01-06 04:40:00	37.607	-97.766	1.5
2020-01-08 14:13:00	38.595	-97.529	1.6
2020-01-18 02:58:00	38.020	-97.986	1.5
2020-01-19 19:08:00	38.018	-97.987	4.8
2020-01-19 21:09:00	38.023	-97.973	1.7
2020-01-19 21:18:00	38.022	-97.965	1.6
2020-01-20 02:32:00	38.002	-97.995	1.1
2020-01-20 02:38:00	38.021	-97.975	0.9
2020-01-20 04:05:00	38.023	-97.988	1.5
2020-01-22 01:09:00	37.587	-97.772	0.8
2020-01-22 03:26:00	38.038	-97.961	1.6
2020-01-22 15:36:00	38.009	-98.001	1.9
2020-01-23 08:56:00	38.011	-97.983	1.4
2020-01-24 20:07:00	38.027	-97.976	1.8
2020-01-25 00:42:00	38.031	-97.973	1.6
2020-01-25 01:16:00	37.725	-97.294	0.6
2020-01-25 01:17:00	37.699	-97.267	1.0
2020-01-25 09:32:00	38.027	-97.975	1.9
2020-01-25 23:23:00	38.019	-97.982	1.4
2020-01-26 08:15:00	38.028	-97.976	1.4
2020-01-27 01:04:00	38.033	-97.971	1.6
2020-01-27 08:44:00	38.028	-97.974	2.2
2020-01-27 08:54:00	38.023	-97.981	1.5
2020-01-29 22:48:00	38.028	-97.973	1.3
2020-01-31 00:47:00	38.015	-97.984	1.6
2020-02-03 00:50:00	37.307	-97.469	1.0
2020-02-04 16:22:00	37.619	-97.270	1.5
2020-02-05 03:25:00	38.026	-97.982	1.5
2020-02-07 13:04:00	38.029	-97.980	1.7
2020-02-07 17:51:00	38.020	-97.980	2.3
2020-02-11 16:35:00	38.025	-97.973	1.5
2020-02-12 04:32:00	37.890	-98.017	1.5
2020-02-12 11:26:00	37.622	-97.254	0.8
2020-02-16 16:10:00	38.586	-97.582	1.4
2020-02-17 10:06:00	38.024	-97.962	1.2
2020-02-19 12:41:00	38.016	-98.003	1.7
2020-02-20 06:38:00	38.586	-97.537	1.9
2020-02-20 15:51:00	37.422	-97.380	1.6
2020-02-21 01:33:00	37.417	-97.368	1.4
2020-02-25 02:33:00	38.021	-97.975	1.8
2020-02-25 10:45:00	38.012	-98.028	1.7
2020-02-26 07:07:00	38.025	-98.063	0.8
2020-03-04 09:07:00	38.006	-98.003	2.4
2020-03-13 18:32:00	38.007	-97.991	1.7
2020-03-13 20:21:00	37.998	-98.002	1.8
2020-03-14 22:56:00	38.005	-97.994	1.5
2020-03-23 06:39:00	37.676	-96.782	1.8
2020-04-04 23:11:00	37.697	-97.311	1.5
2020-04-05 14:17:00	38.021	-97.974	1.4
2020-04-15 00:49:00	37.324	-97.555	1.3
2020-04-15 11:48:00	38.025	-97.984	1.5
2020-04-19 17:14:00	38.024	-97.965	1.5
2020-04-20 00:59:00	38.029	-97.966	1.4
2020-04-21 06:08:00	37.697	-97.205	1.3
2020-04-23 11:50:00	38.018	-97.990	2.3
2020-04-28 09:00:00	37.296	-97.427	1.4
2020-04-30 08:52:00	37.325	-97.568	1.4
2020-05-06 12:46:00	37.520	-97.774	1.7
2020-05-11 10:55:00	37.526	-97.771	1.3
2020-05-12 03:36:00	37.515	-97.768	1.4
2020-05-19 13:22:00	37.306	-97.403	1.4
2020-05-19 21:50:00	38.581	-97.467	2.2
2020-05-20 14:48:00	38.013	-98.006	0.8
2020-05-24 13:23:00	37.908	-98.097	1.5
2020-05-24 13:23:00	37.883	-97.990	1.3
2020-05-24 13:51:00	37.886	-98.012	1.5
2020-05-25 06:19:00	37.672	-97.728	1.3
2020-05-25 15:59:00	37.888	-97.996	1.3
2020-05-26 02:50:00	37.593	-97.734	0.9
2020-05-27 20:17:00	38.018	-97.993	2.3
2020-05-27 22:32:00	37.989	-97.984	1.6
2020-05-27 23:48:00	37.983	-98.026	1.2
2020-05-28 05:09:00	37.571	-96.703	1.2
2020-06-01 13:40:00	38.010	-97.998	1.0
2020-06-04 06:04:00	37.581	-96.817	1.3
2020-06-12 16:10:00	38.018	-97.979	2.2
2020-06-12 19:35:00	37.995	-97.932	0.7
2020-06-12 20:17:00	38.011	-97.987	2.5
2020-06-16 03:21:00	38.593	-97.514	1.4
2020-06-20 00:58:00	38.017	-97.991	1.9

End of table

Appendix C: Subnetwork Events Catalog

Subnetwork events recorded from July 1, 2019, to June 30, 2020, with epicentral distance within 12 miles of member wells. Epicentral distance is the estimated distance from the earthquake epicenter to the seismic station where it was recorded.

Station	Origin Time (UTC)	Distance (mi)	Magnitude
BU02	2019-07-09 15:28:12	6.8	0.6
BU02	2020-05-03 16:40:02	6.0	-0.6
EW01	2020-04-05 12:50:23	7.7	-0.6
EW01	2020-04-16 22:17:51	5.0	-0.4
EW01	2020-05-19 05:16:19	2.2	-1.5
EW01	2020-06-13 17:00:23	2.2	-0.9
JO01	2019-12-28 14:46:12	6.2	0.1
JO01	2020-05-21 16:24:37	7.6	-0.2
JO01	2020-06-16 16:41:22	7.6	-0.2
JO01	2020-06-25 15:49:34	7.3	-0.4
JO01	2020-06-26 18:57:07	12.0	0.2
KE01	2019-11-25 07:45:01	3.1	-1.5
MP01	2019-07-23 11:02:44	5.4	-0.2
MP01	2019-11-10 04:57:56	5.2	-0.2
MP01	2019-11-27 21:00:40	5.0	-0.4
MP01	2020-01-07 02:34:53	7.2	-0.4
MP01	2020-03-21 18:38:54	6.8	-0.6
MP01	2020-03-21 18:39:46	6.4	-0.6
MP01	2020-04-28 18:28:11	10.1	-0.2
MP01	2020-05-09 20:26:24	2.2	-1.5
MP01	2020-06-17 18:52:03	9.5	0.2
MP01	2020-06-20 00:20:20	5.6	-0.4
MP02	2019-07-08 20:40:57	2.1	-0.9
MP02	2019-08-06 02:30:46	10.3	0.5
MP02	2019-08-17 17:23:02	5.1	-0.2
MP02	2019-08-22 08:34:42	5.2	-0.4
MP02	2019-09-15 00:55:35	2.4	-1.5
MP02	2019-10-01 07:03:55	7.3	-0.6
MP02	2019-10-03 23:17:09	2.1	-1.5
MP02	2019-10-14 19:40:36	3.8	-0.9
MP02	2019-11-09 10:19:32	3.6	-0.9
MP02	2019-11-09 12:01:58	2.2	-1.5
MP02	2019-12-05 10:32:17	7.4	-0.2
MP02	2019-12-05 10:32:17	7.1	-0.4
MP02	2019-12-15 16:44:57	7.4	-0.2
MP02	2020-01-17 11:09:45	4.6	-0.2
MP02	2020-01-24 12:19:53	2.9	-0.9
MP02	2020-03-03 22:38:52	5.1	-0.4
MP02	2020-04-01 16:43:48	2.0	-0.9
MP02	2020-04-01 17:40:45	5.0	-0.6
MP02	2020-04-06 06:02:41	6.3	-0.4
MP02	2020-04-28 19:26:20	3.9	-0.9
MP02	2020-04-28 19:52:24	11.7	0.0
MP02	2020-05-05 13:32:09	10.2	-0.6
MP02	2020-05-08 01:37:01	9.3	0.0
MP02	2020-05-11 20:20:02	10.1	-0.2
MP02	2020-06-06 08:53:26	6.8	-0.4
MP02	2020-06-18 20:10:50	2.9	-0.9
MP02	2020-06-19 07:45:17	4.3	-0.6
RC01	2019-08-21 15:33:50	8.7	0.0
RC02	2019-10-03 02:57:33	1.8	-1.5
RC02	2019-10-15 00:07:59	6.3	-0.2
RC02	2020-04-23 13:15:02	2.4	-1.5
RC02	2020-05-08 03:43:27	3.1	-0.9
RC02	2020-05-09 09:40:45	5.6	-0.9
RC02	2020-05-11 17:48:39	4.0	-0.9
RC02	2020-05-16 03:04:30	4.5	-0.9
RC02	2020-06-11 07:42:13	4.7	-0.6
RC02	2020-06-20 16:58:54	10.8	0.3
RC02	2020-06-27 09:12:21	7.7	-0.4
RC03	2019-07-01 18:23:47	7.2	-0.2
RC03	2019-07-01 18:24:19	7.3	-0.4
RC03	2019-07-01 18:24:53	7.3	-0.4
RC03	2019-07-02 08:51:05	7.1	-0.2
RC03	2019-07-02 08:51:20	7.4	-0.2
RC03	2019-07-03 09:31:16	7.5	0.4
RC03	2019-07-09 18:14:21	7.5	0.1
RC03	2019-07-09 18:15:25	6.9	0.0
RC03	2019-07-10 18:19:57	9.3	0.3
RC03	2019-07-10 18:21:04	6.1	0.3
RC03	2019-07-11 02:12:26	9.3	0.3
RC03	2019-07-11 04:44:43	7.0	0.1
RC03	2019-07-12 02:06:59	7.4	0.4
RC03	2019-07-12 02:07:27	7.2	0.3
RC03	2019-07-12 18:24:39	9.4	0.5
RC03	2019-07-13 18:18:20	7.4	0.1
RC03	2019-07-15 10:19:09	7.2	-0.4
RC03	2019-07-15 10:19:09	7.1	-0.6
RC03	2019-07-15 10:19:14	6.6	-0.6
RC03	2019-07-15 10:19:43	7.6	0.0
RC03	2019-07-17 02:24:12	7.3	0.3
RC03	2019-07-17 10:12:38	7.1	-0.2
RC03	2019-07-17 10:13:22	6.7	-0.2
RC03	2019-07-18 02:18:31	7.3	0.0
RC03	2019-07-18 02:19:22	7.3	0.0
RC03	2019-07-18 02:20:09	7.2	0.1
RC03	2019-07-18 10:22:32	7.3	-0.2
RC03	2019-07-18 10:23:01	7.4	0.0
RC03	2019-07-19 18:16:32	6.7	0.0
RC03	2019-07-23 02:23:34	7.4	0.1
RC03	2019-07-23 02:24:05	7.2	0.1
RC03	2019-07-23 18:18:55	7.2	-0.2
RC03	2019-07-23 18:20:04	7.3	0.0
RC03	2019-07-23 18:20:59	7.1	0.1
RC03	2019-07-24 02:22:32	6.9	-0.2
RC03	2019-07-24 18:13:22	7.4	-0.2
RC03	2019-07-24 18:13:44	7.1	-0.2
RC03	2019-07-24 18:14:22	8.0	0.0
RC03	2019-07-25 10:08:23	7.7	-0.2
RC03	2019-07-25 10:08:42	7.6	-0.2
RC03	2019-07-25 10:09:05	7.3	0.0
RC03	2019-07-26 02:21:31	7.4	-0.2
RC03	2019-07-26 02:22:16	7.4	-0.2
RC03	2019-07-27 02:23:19	7.2	0.1
RC03	2019-07-27 02:23:56	7.5	0.0
RC03	2019-07-27 02:24:55	7.2	0.0
RC03	2019-07-27 10:16:19	6.9	0.0
RC03	2019-07-27 10:17:00	7.2	0.0
RC03	2019-07-28 02:19:25	7.3	-0.2
RC03	2019-07-28 02:19:50	7.4	-0.2

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RC03	2019-07-28 02:20:11	7.2	0.0
RC03	2019-07-30 02:22:59	7.4	0.0
RC03	2019-07-30 02:24:16	7.4	-0.2
RC03	2019-07-30 02:24:41	7.1	0.1
RC03	2019-07-30 02:25:06	7.0	0.0
RC03	2019-07-31 02:11:27	6.9	-0.4
RC03	2019-07-31 02:12:03	7.1	-0.4
RC03	2019-07-31 02:13:48	7.1	-0.4
RC03	2019-07-31 18:18:55	7.3	0.0
RC03	2019-08-02 02:03:24	7.4	-0.2
RC03	2019-08-02 02:04:07	7.8	-0.2
RC03	2019-08-02 02:04:50	7.5	-0.2
RC03	2019-08-02 10:19:09	7.1	-0.2
RC03	2019-08-02 10:19:59	6.8	-0.2
RC03	2019-08-03 02:02:04	6.9	0.0
RC03	2019-08-03 02:06:31	7.2	0.1
RC03	2019-08-04 02:18:44	6.9	0.0
RC03	2019-08-06 02:17:42	7.3	0.4
RC03	2019-08-06 02:18:58	7.2	-0.2
RC03	2019-08-07 09:08:08	7.6	0.0
RC03	2019-08-07 09:08:44	7.1	-0.2
RC03	2019-08-08 10:12:15	7.6	0.1
RC03	2019-08-08 10:12:47	7.3	0.1
RC03	2019-08-09 02:00:00	7.3	-0.4
RC03	2019-08-09 02:00:54	7.2	-0.2
RC03	2019-08-09 10:16:43	9.0	0.1
RC03	2019-08-09 10:17:16	7.3	0.0
RC03	2019-08-11 02:21:44	7.1	-0.2
RC03	2019-08-11 02:21:57	7.2	-0.4
RC03	2019-08-13 02:10:19	7.4	0.1
RC03	2019-08-13 10:19:58	7.3	0.0
RC03	2019-08-13 10:20:16	6.8	-0.2
RC03	2019-08-13 10:20:29	7.2	-0.2
RC03	2019-08-13 10:20:47	7.0	-0.2
RC03	2019-08-14 02:17:46	7.5	0.1
RC03	2019-08-14 02:18:35	7.1	0.1
RC03	2019-08-14 10:09:52	7.3	-0.2
RC03	2019-08-15 05:44:20	7.3	0.0
RC03	2019-08-15 10:17:02	7.7	0.0
RC03	2019-08-15 10:17:33	7.8	0.0
RC03	2019-08-16 02:18:48	7.4	-0.2
RC03	2019-08-16 02:19:19	7.1	-0.2
RC03	2019-08-18 07:23:48	3.9	-0.6
RC03	2019-08-19 10:14:12	7.0	0.0
RC03	2019-08-20 02:17:04	7.3	-0.4
RC03	2019-08-20 02:17:30	6.8	-0.4
RC03	2019-08-20 02:17:54	6.5	-0.4
RC03	2019-08-20 18:18:04	6.9	-0.4
RC03	2019-08-20 18:18:49	7.3	-0.4
RC03	2019-08-21 02:09:13	7.1	-0.4
RC03	2019-08-21 10:15:02	7.3	-0.4
RC03	2019-08-21 18:20:15	7.2	-0.4
RC03	2019-08-21 18:21:25	7.4	-0.4
RC03	2019-08-22 02:15:56	7.2	-0.2
RC03	2019-08-22 02:16:30	6.9	-0.2
RC03	2019-08-22 02:16:57	7.4	-0.4
RC03	2019-08-22 18:21:12	6.8	-0.4
RC03	2019-08-23 10:02:52	8.6	-0.2
RC03	2019-08-23 18:19:04	7.4	-0.2
RC03	2019-08-23 18:19:41	6.8	-0.4
RC03	2019-08-24 04:43:07	7.0	-0.4
RC03	2019-08-25 02:15:48	7.3	-0.6
RC03	2019-08-25 02:16:32	7.0	-0.4
RC03	2019-08-27 02:18:50	7.2	-0.4
RC03	2019-08-27 02:19:45	7.7	0.0
RC03	2019-08-28 02:12:38	7.5	-0.2
RC03	2019-08-28 02:13:54	7.1	-0.4
RC03	2019-08-28 10:19:09	6.9	-0.4
RC03	2019-08-28 18:21:34	7.2	-0.4
RC03	2019-08-28 18:22:04	7.3	-0.4
RC03	2019-08-28 18:22:11	6.7	-0.4
RC03	2019-08-28 18:22:56	7.3	-0.6
RC03	2019-08-28 18:23:31	7.2	-0.4
RC03	2019-08-29 18:15:51	7.2	-0.4
RC03	2019-08-29 18:17:34	7.3	-0.4
RC03	2019-08-30 14:57:12	7.3	-0.4
RC03	2019-08-30 14:58:29	6.9	-0.4
RC03	2019-08-31 00:39:21	7.4	0.0
RC03	2019-08-31 00:40:34	6.9	-0.2
RC03	2019-09-03 10:18:16	7.3	-0.4
RC03	2019-09-04 02:06:43	8.9	0.0
RC03	2019-09-04 02:07:47	7.1	-0.2
RC03	2019-09-04 18:17:11	7.2	-0.4
RC03	2019-09-04 18:18:01	7.0	-0.4
RC03	2019-09-05 10:16:45	7.5	-0.4
RC03	2019-09-05 10:17:21	7.0	-0.6
RC03	2019-09-05 18:21:12	7.2	-0.4
RC03	2019-09-06 02:19:50	7.1	-0.4
RC03	2019-09-06 10:10:11	7.5	0.0
RC03	2019-09-06 10:10:52	7.3	-0.2
RC03	2019-09-07 02:15:10	7.1	-0.4
RC03	2019-09-07 02:16:03	6.9	-0.4
RC03	2019-09-08 02:20:28	7.6	0.0
RC03	2019-09-08 02:21:22	7.1	-0.2
RC03	2019-09-09 10:19:22	7.6	-0.2
RC03	2019-09-10 02:20:00	7.0	0.0
RC03	2019-09-10 18:17:37	7.6	-0.2
RC03	2019-09-10 18:18:28	6.8	-0.2
RC03	2019-09-12 02:18:47	7.2	-0.2
RC03	2019-09-12 02:19:43	7.2	-0.2
RC03	2019-09-12 10:10:06	7.1	-0.2
RC03	2019-09-13 00:42:33	7.3	-0.4
RC03	2019-09-13 00:42:41	7.1	-0.2
RC03	2019-09-16 18:22:28	7.1	-0.2
RC03	2019-09-16 18:23:45	7.6	-0.2
RC03	2019-09-18 02:20:22	7.0	0.0
RC03	2019-09-18 02:21:14	7.5	0.0
RC03	2019-09-18 10:15:29	7.1	-0.2
RC03	2019-09-18 10:15:58	7.2	-0.2
RC03	2019-09-19 10:15:53	7.1	-0.6
RC03	2019-09-19 10:16:29	7.1	-0.4
RC03	2019-09-20 10:11:20	6.5	-0.2
RC03	2019-09-20 10:11:55	7.1	-0.4
RC03	2019-09-20 10:12:23	7.0	-0.4
RC03	2019-09-21 02:08:05	7.3	-0.2
RC03	2019-09-21 02:08:47	7.4	-0.4
RC03	2019-09-24 02:14:03	7.3	-0.6
RC03	2019-09-24 02:14:56	7.3	-0.2
RC03	2019-09-24 02:15:28	7.3	-0.4
RC03	2019-09-24 18:18:34	6.8	-0.4

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RC03	2019-09-24 18:19:19	7.0	-0.2
RC03	2019-09-25 02:18:48	6.6	-0.2
RC03	2019-09-26 02:14:39	6.8	-0.4
RC03	2019-09-26 02:15:22	6.9	-0.4
RC03	2019-09-26 02:16:19	7.3	-0.4
RC03	2019-10-02 02:20:51	7.6	0.1
RC03	2019-10-02 02:22:01	7.3	0.4
RC03	2019-10-02 06:50:29	7.1	-0.2
RC03	2019-10-02 06:50:50	7.1	0.1
RC03	2019-10-03 02:06:55	6.6	-0.4
RC03	2019-10-03 02:19:21	7.2	-0.2
RC03	2019-10-03 10:04:15	6.7	-0.2
RC03	2019-10-03 10:04:36	6.9	-0.2
RC03	2019-10-03 10:05:06	7.0	0.0
RC03	2019-10-03 10:05:28	7.1	0.3
RC03	2019-10-04 10:11:05	7.4	-0.2
RC03	2019-10-04 10:11:38	6.9	-0.2
RC03	2019-10-04 10:11:38	7.2	-0.2
RC03	2019-10-05 10:10:26	7.3	-0.4
RC03	2019-10-05 10:10:50	7.2	-0.4
RC03	2019-10-05 10:11:14	7.2	-0.2
RC03	2019-10-09 01:38:38	6.9	-0.6
RC03	2019-10-09 01:38:38	7.6	-0.6
RC03	2019-10-10 08:23:10	7.5	-0.4
RC03	2019-10-10 08:23:42	7.5	-0.2
RC03	2019-10-12 02:26:56	7.1	-0.2
RC03	2019-10-12 02:27:58	7.2	-0.2
RC03	2019-10-16 02:11:07	8.0	-0.2
RC03	2019-10-16 02:11:34	7.6	0.0
RC03	2019-10-16 18:07:08	6.8	-0.2
RC03	2019-10-16 18:08:02	7.4	0.2
RC03	2019-10-16 18:08:43	7.4	0.3
RC03	2019-10-17 10:09:24	7.4	0.0
RC03	2019-10-19 10:24:20	7.1	-0.2
RC03	2019-10-19 18:19:04	6.7	-0.2
RC03	2019-10-22 02:09:55	7.0	-0.4
RC03	2019-10-22 02:10:41	7.5	-0.4
RC03	2019-10-22 10:08:51	7.3	-0.2
RC03	2019-10-22 10:09:23	7.3	-0.4
RC03	2019-10-23 02:17:39	7.2	-0.2
RC03	2019-10-23 02:18:31	7.3	-0.2
RC03	2019-10-23 02:18:53	7.4	0.0
RC03	2019-10-24 10:09:17	7.3	-0.4
RC03	2019-10-25 02:17:50	7.2	-0.4
RC03	2019-10-25 02:18:19	7.6	-0.2
RC03	2019-10-26 02:38:41	7.3	0.1
RC03	2019-10-29 10:13:18	6.8	0.1
RC03	2019-10-29 10:13:18	6.9	0.1
RC03	2019-10-29 18:17:45	7.3	-0.4
RC03	2019-10-29 18:18:40	7.0	0.1
RC03	2019-10-30 02:02:40	7.5	-0.4
RC03	2019-10-30 02:03:33	7.7	0.0
RC03	2019-10-31 10:13:43	7.1	-0.2
RC03	2019-10-31 10:14:16	7.3	-0.4
RC03	2019-10-31 10:14:30	7.2	-0.4
RC03	2019-10-31 18:14:36	7.1	-0.4
RC03	2019-11-01 09:53:22	6.9	-0.2
RC03	2019-11-01 09:53:42	7.1	-0.2
RC03	2019-11-02 18:18:48	7.2	-0.4
RC03	2019-11-02 18:19:50	7.0	-0.4
RC03	2019-11-05 01:18:06	7.8	0.0
RC03	2019-11-05 01:18:45	7.3	0.0
RC03	2019-11-06 03:19:17	7.2	-0.2
RC03	2019-11-06 09:53:47	7.5	-0.4
RC03	2019-11-06 19:13:58	7.4	0.0
RC03	2019-11-08 03:10:44	7.2	-0.2
RC03	2019-11-08 03:11:24	7.2	-0.4
RC03	2019-11-08 03:11:58	7.0	-0.2
RC03	2019-11-09 03:15:14	6.6	-0.4
RC03	2019-11-09 03:16:15	7.3	0.2
RC03	2019-11-12 03:23:28	7.4	-0.2
RC03	2019-11-12 03:23:40	6.9	-0.4
RC03	2019-11-12 11:14:42	7.3	-0.4
RC03	2019-11-12 11:15:04	6.9	-0.2
RC03	2019-11-13 03:17:00	7.5	-0.4
RC03	2019-11-14 11:15:55	7.7	-0.4
RC03	2019-11-14 19:11:03	6.7	-0.6
RC03	2019-11-14 19:11:50	6.7	-0.2
RC03	2019-11-15 11:10:04	7.1	-0.2
RC03	2019-11-18 11:05:20	7.6	-0.2
RC03	2019-11-18 11:05:52	7.0	-0.4
RC03	2019-11-20 15:10:10	7.5	-0.4
RC03	2019-11-20 15:11:00	6.9	0.0
RC03	2019-11-21 23:47:41	7.0	-0.4
RC03	2019-11-21 23:48:19	6.9	-0.4
RC03	2019-11-21 23:48:50	7.2	-0.4
RC03	2019-11-22 03:20:32	7.7	-0.2
RC03	2019-11-22 03:21:14	7.7	-0.4
RC03	2019-11-23 03:17:25	7.8	-0.2
RC03	2019-11-23 20:16:26	7.0	-0.4
RC03	2019-11-23 20:16:58	7.5	-0.2
RC03	2019-11-25 11:10:13	7.2	-0.4
RC03	2019-11-26 19:16:44	7.4	-0.4
RC03	2019-11-27 11:14:56	7.2	0.1
RC03	2019-11-27 19:24:25	7.1	-0.2
RC03	2019-12-02 10:15:48	6.4	-0.2
RC03	2019-12-02 10:16:17	7.6	-0.4
RC03	2019-12-03 19:21:49	7.4	-0.6
RC03	2019-12-03 19:22:48	7.4	-0.4
RC03	2019-12-04 02:24:58	7.6	0.0
RC03	2019-12-04 03:16:56	7.1	-0.2
RC03	2019-12-05 03:07:10	7.6	-0.4
RC03	2019-12-05 03:17:39	7.3	-0.2
RC03	2019-12-05 03:19:17	7.1	-0.2
RC03	2019-12-07 11:13:51	7.7	-0.2
RC03	2019-12-07 11:14:33	7.4	0.1
RC03	2019-12-10 03:19:35	7.1	-0.4
RC03	2019-12-10 03:20:06	6.8	-0.4
RC03	2019-12-10 03:26:25	7.1	-0.4
RC03	2019-12-10 09:00:59	6.9	-0.2
RC03	2019-12-10 09:01:37	7.1	-0.2
RC03	2019-12-10 19:16:15	7.1	-0.2
RC03	2019-12-10 19:16:49	7.4	0.0
RC03	2019-12-11 03:07:17	6.8	-0.2
RC03	2019-12-11 11:02:31	7.2	-0.4
RC03	2019-12-11 22:55:37	6.5	-0.2
RC03	2019-12-11 22:56:17	7.1	-0.4
RC03	2019-12-12 11:12:19	6.8	-0.4
RC03	2019-12-12 11:12:50	7.6	-0.4
RC03	2019-12-13 11:14:31	6.7	-0.4

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RC03	2019-12-13 11:15:02	7.2	-0.2
RC03	2019-12-16 10:42:12	7.4	0.0
RC03	2019-12-16 10:43:20	7.1	0.1
RC03	2019-12-17 03:07:23	6.9	-0.2
RC03	2019-12-17 19:23:16	7.5	-0.2
RC03	2019-12-18 03:12:17	7.0	-0.4
RC03	2019-12-18 03:12:38	7.4	-0.2
RC03	2019-12-20 11:14:13	7.5	-0.2
RC03	2019-12-23 11:31:23	6.6	-0.2
RC03	2019-12-23 11:31:44	6.9	-0.2
RC03	2019-12-24 03:18:20	7.8	-0.2
RC03	2019-12-24 03:19:55	7.5	-0.2
RC03	2019-12-24 11:02:35	7.8	-0.2
RC03	2019-12-27 19:16:12	8.7	-0.2
RC03	2019-12-27 19:17:07	7.2	0.2
RC03	2019-12-28 03:01:33	7.3	-0.4
RC03	2019-12-31 19:21:15	7.3	-0.4
RC03	2020-01-01 02:06:10	7.8	-0.2
RC03	2020-01-01 03:06:22	7.7	0.1
RC03	2020-01-03 19:21:49	6.9	-0.6
RC03	2020-01-03 19:22:21	7.5	-0.4
RC03	2020-01-03 19:22:56	7.5	-0.6
RC03	2020-01-04 03:09:04	6.8	-0.4
RC03	2020-01-04 03:09:32	7.0	-0.4
RC03	2020-01-04 03:10:03	6.8	-0.4
RC03	2020-01-04 03:10:11	6.8	-0.4
RC03	2020-01-05 02:21:59	7.2	-0.4
RC03	2020-01-05 02:22:58	8.3	-0.2
RC03	2020-01-07 03:13:17	6.6	-0.4
RC03	2020-01-07 03:14:04	7.0	-0.4
RC03	2020-01-07 11:19:42	7.2	-0.2
RC03	2020-01-09 10:53:57	7.0	-0.6
RC03	2020-01-09 10:54:23	7.2	-0.4
RC03	2020-01-09 10:55:58	7.4	-0.4
RC03	2020-01-09 10:56:31	7.0	-0.6
RC03	2020-01-10 11:06:18	6.9	0.0
RC03	2020-01-10 11:16:28	6.7	-0.6
RC03	2020-01-11 19:06:00	7.5	-0.4
RC03	2020-01-11 19:17:36	6.9	-0.6
RC03	2020-01-11 19:18:27	6.5	-0.6
RC03	2020-01-12 03:10:26	7.4	-0.4
RC03	2020-01-12 03:11:16	6.7	-0.6
RC03	2020-01-14 02:56:04	6.5	0.2
RC03	2020-01-14 19:08:38	8.9	0.0
RC03	2020-01-15 03:23:53	7.1	-0.2
RC03	2020-01-15 19:18:51	7.2	-0.2
RC03	2020-01-15 19:19:39	6.8	-0.4
RC03	2020-01-16 11:06:41	7.7	-0.2
RC03	2020-01-16 11:07:06	6.9	-0.4
RC03	2020-01-17 03:02:36	6.8	-0.4
RC03	2020-01-17 03:03:16	7.5	-0.2
RC03	2020-01-17 11:15:02	7.0	-0.4
RC03	2020-01-17 19:06:23	7.1	-0.2
RC03	2020-01-17 19:07:22	7.4	-0.2
RC03	2020-01-21 11:24:44	6.9	-0.4
RC03	2020-01-21 11:24:44	7.0	-0.2
RC03	2020-01-21 11:25:34	7.6	-0.2
RC03	2020-01-21 19:11:43	7.7	-0.4
RC03	2020-01-21 19:12:45	6.6	-0.2
RC03	2020-01-25 04:11:12	7.6	-0.2
RC03	2020-01-27 19:12:39	6.5	-0.4
RC03	2020-01-27 19:13:47	7.2	-0.4
RC03	2020-01-28 09:54:07	7.3	-0.2
RC03	2020-01-29 11:26:58	8.0	0.0
RC03	2020-01-29 19:21:49	8.1	0.2
RC03	2020-01-30 19:08:08	6.9	-0.4
RC03	2020-01-31 03:05:25	7.9	0.1
RC03	2020-01-31 03:05:55	7.4	0.1
RC03	2020-02-01 03:22:36	6.9	-0.2
RC03	2020-02-01 03:23:13	7.0	0.2
RC03	2020-02-02 03:14:07	8.2	0.2
RC03	2020-02-04 10:03:06	7.5	0.0
RC03	2020-02-04 10:03:35	7.1	0.0
RC03	2020-02-04 10:04:06	7.6	-0.4
RC03	2020-02-04 23:16:54	7.1	-0.2
RC03	2020-02-06 03:10:11	6.9	0.0
RC03	2020-02-06 03:12:31	7.2	0.1
RC03	2020-02-06 03:13:21	7.1	0.4
RC03	2020-02-07 02:43:14	7.4	0.1
RC03	2020-02-07 03:21:49	7.4	0.0
RC03	2020-02-08 11:11:34	7.7	-0.2
RC03	2020-02-08 11:11:54	9.9	0.0
RC03	2020-02-09 03:24:31	6.6	-0.6
RC03	2020-02-09 03:25:36	7.5	-0.2
RC03	2020-02-09 03:26:23	6.9	-0.4
RC03	2020-02-11 10:31:31	7.3	-0.4
RC03	2020-02-11 10:31:47	7.7	-0.4
RC03	2020-02-12 20:04:11	8.0	-0.4
RC03	2020-02-14 02:58:01	7.5	0.0
RC03	2020-02-14 03:22:44	7.2	0.0
RC03	2020-02-14 03:23:19	6.8	0.0
RC03	2020-02-18 19:21:20	7.9	-0.2
RC03	2020-02-19 03:13:48	7.6	0.0
RC03	2020-02-19 23:19:58	7.1	-0.4
RC03	2020-02-19 23:20:04	7.3	-0.4
RC03	2020-02-20 10:55:49	7.9	0.1
RC03	2020-02-21 03:23:56	7.1	-0.2
RC03	2020-02-21 03:24:20	7.4	-0.2
RC03	2020-02-24 19:22:19	7.5	-0.2
RC03	2020-02-25 03:22:14	7.5	0.0
RC03	2020-02-25 03:23:07	8.2	-0.2
RC03	2020-02-25 10:37:14	7.5	-0.4
RC03	2020-02-27 03:18:24	7.0	-0.4
RC03	2020-02-27 03:18:35	7.0	-0.4
RC03	2020-02-27 03:18:56	6.8	-0.4
RC03	2020-02-29 03:23:56	7.4	0.0
RC03	2020-02-29 03:24:33	6.4	-0.4
RC03	2020-03-01 02:31:37	7.8	-0.4
RC03	2020-03-02 19:15:29	7.3	0.1
RC03	2020-03-03 03:20:02	7.5	-0.4
RC03	2020-03-03 03:20:11	7.3	-0.4
RC03	2020-03-03 19:10:04	7.7	-0.4
RC03	2020-03-04 03:14:56	7.4	-0.4
RC03	2020-03-04 03:15:20	7.1	-0.6
RC03	2020-03-04 18:53:27	7.4	-0.4
RC03	2020-03-04 18:53:34	7.2	-0.6
RC03	2020-03-04 18:53:51	7.3	-0.2
RC03	2020-03-04 18:54:26	7.9	-0.2
RC03	2020-03-05 03:19:44	7.5	-0.4
RC03	2020-03-05 03:19:58	7.0	-0.4

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RC03	2020-03-06 03:22:38	7.6	-0.2
RC03	2020-03-06 03:23:00	7.9	0.0
RC03	2020-03-06 03:23:24	7.8	-0.4
RC03	2020-03-06 11:04:01	7.3	-0.2
RC03	2020-03-06 19:22:26	7.1	-0.4
RC03	2020-03-06 19:23:14	7.3	-0.4
RC03	2020-03-09 09:55:10	7.7	-0.2
RC03	2020-03-09 09:55:34	6.8	-0.2
RC03	2020-03-09 09:55:53	7.2	-0.2
RC03	2020-03-11 02:10:37	7.1	-0.4
RC03	2020-03-11 10:01:50	7.1	-0.4
RC03	2020-03-11 10:03:15	7.3	-0.4
RC03	2020-03-12 02:18:12	7.2	-0.6
RC03	2020-03-12 02:18:55	7.4	-0.6
RC03	2020-03-12 02:20:28	7.2	-0.6
RC03	2020-03-12 10:16:16	7.3	-0.4
RC03	2020-03-13 02:17:14	7.2	-0.6
RC03	2020-03-13 10:13:00	6.9	-0.2
RC03	2020-03-13 10:14:09	7.4	-0.2
RC03	2020-03-13 18:12:47	7.3	-0.6
RC03	2020-03-14 10:00:59	7.3	-0.4
RC03	2020-03-14 10:22:05	6.9	-0.6
RC03	2020-03-16 18:19:32	7.3	-0.2
RC03	2020-03-16 18:19:52	7.5	-0.2
RC03	2020-03-17 02:16:05	6.6	0.2
RC03	2020-03-17 02:19:21	7.1	0.0
RC03	2020-03-19 02:16:09	8.9	-0.2
RC03	2020-03-19 02:18:39	7.4	-0.4
RC03	2020-03-19 02:18:39	7.3	-0.4
RC03	2020-03-19 02:18:57	7.0	-0.6
RC03	2020-03-19 02:18:57	6.6	-0.6
RC03	2020-03-19 10:14:58	7.1	-0.4
RC03	2020-03-19 18:20:01	7.0	-0.6
RC03	2020-03-19 18:20:53	7.1	-0.6
RC03	2020-03-20 02:20:50	7.3	-0.2
RC03	2020-03-23 10:15:10	7.3	-0.2
RC03	2020-03-23 18:36:04	9.0	0.0
RC03	2020-03-24 02:20:36	6.8	-0.6
RC03	2020-03-24 02:21:27	6.5	-0.6
RC03	2020-03-24 18:28:48	7.1	-0.4
RC03	2020-03-24 18:30:21	7.6	-0.4
RC03	2020-03-24 18:30:52	7.1	-0.2
RC03	2020-03-26 02:21:37	6.8	0.0
RC03	2020-03-26 02:23:13	7.7	0.0
RC03	2020-03-26 02:24:24	6.5	-0.2
RC03	2020-03-27 22:15:59	6.2	-0.6
RC03	2020-03-28 01:45:59	7.6	0.2
RC03	2020-03-28 01:48:27	8.0	0.4
RC03	2020-03-30 18:39:31	7.4	-0.4
RC03	2020-03-30 18:40:15	7.2	-0.6
RC03	2020-03-31 02:34:24	6.9	-0.4
RC03	2020-03-31 02:35:13	7.1	-0.6
RC03	2020-03-31 02:35:57	7.1	-0.6
RC03	2020-03-31 02:39:12	7.2	-0.2
RC03	2020-04-01 02:32:05	6.7	-0.2
RC03	2020-04-01 10:16:51	7.1	0.0
RC03	2020-04-01 10:17:11	6.9	-0.4
RC03	2020-04-01 16:27:19	3.1	-0.4
RC03	2020-04-01 16:27:19	3.1	-0.9
RC03	2020-04-01 18:37:54	7.1	-0.6
RC03	2020-04-02 02:24:43	7.1	-0.2
RC03	2020-04-06 10:13:01	7.1	-0.6
RC03	2020-04-06 10:13:25	7.3	-0.2
RC03	2020-04-07 10:21:18	7.2	0.0
RC03	2020-04-07 18:29:03	6.6	-0.4
RC03	2020-04-07 18:29:55	6.6	0.3
RC03	2020-04-09 02:30:09	8.6	-0.2
RC03	2020-04-09 10:16:10	7.2	-0.4
RC03	2020-04-09 10:16:39	7.1	-0.4
RC03	2020-04-10 10:06:41	6.2	-0.6
RC03	2020-04-14 18:26:23	7.2	-0.6
RC03	2020-04-15 02:16:38	6.9	0.0
RC03	2020-04-15 02:24:55	8.7	-0.2
RC03	2020-04-16 10:08:55	7.2	-0.4
RC03	2020-04-17 10:28:05	6.9	-0.2
RC03	2020-04-17 10:28:05	7.1	-0.4
RC03	2020-04-18 02:13:10	7.3	-0.4
RC03	2020-04-18 02:15:05	6.9	-0.4
RC03	2020-04-21 02:26:21	6.6	-0.4
RC03	2020-04-21 02:27:04	9.0	-0.4
RC03	2020-04-22 02:28:02	7.1	-0.4
RC03	2020-04-22 02:28:39	7.3	-0.4
RC03	2020-04-22 02:29:16	7.8	-0.2
RC03	2020-04-22 02:33:41	5.2	0.0
RC03	2020-04-23 10:19:52	7.3	-0.2
RC03	2020-04-23 10:22:22	7.6	-0.4
RC03	2020-04-23 18:28:32	6.8	-0.4
RC03	2020-04-23 18:28:31	7.5	-0.4
RC03	2020-05-02 02:25:53	7.3	-0.2
RC03	2020-05-05 02:22:26	7.0	-0.2
RC03	2020-05-05 02:28:01	7.3	-0.4
RC03	2020-05-05 02:28:11	6.7	-0.4
RC03	2020-05-05 10:18:09	11.3	-0.4
RC03	2020-05-05 18:24:31	7.0	-0.4
RC03	2020-05-05 18:26:38	7.4	-0.4
RC03	2020-05-06 02:21:26	8.0	-0.2
RC03	2020-05-07 10:21:57	6.3	-0.4
RC03	2020-05-07 10:23:24	6.3	-0.4
RC03	2020-05-07 10:25:02	7.4	-0.2
RC03	2020-05-11 10:21:16	7.3	-0.2
RC03	2020-05-11 10:23:54	7.2	-0.2
RC03	2020-05-11 19:24:14	2.2	-1.5
RC03	2020-05-12 02:28:41	6.7	-0.4
RC03	2020-05-12 02:29:30	7.2	-0.4
RC03	2020-05-14 10:25:24	7.0	-0.6
RC03	2020-05-14 10:25:53	6.8	-0.6
RC03	2020-05-14 18:13:04	7.1	-0.4
RC03	2020-05-16 02:25:56	7.2	-0.4
RC03	2020-05-17 02:19:30	7.0	-0.2
RC03	2020-05-17 02:20:15	6.9	0.0
RC03	2020-05-18 18:23:34	7.7	-0.9
RC03	2020-05-19 10:24:29	7.4	-0.4
RC03	2020-05-19 10:24:54	7.3	-0.4
RC03	2020-05-20 02:23:56	6.7	-0.4
RC03	2020-05-20 02:24:44	6.7	-0.2
RC03	2020-05-20 10:25:21	6.3	-0.2
RC03	2020-05-20 10:25:41	6.9	-0.2
RC03	2020-05-20 10:27:03	7.3	-0.4
RC03	2020-05-20 18:16:34	6.4	-0.4
RC03	2020-05-20 18:18:00	7.6	-0.2

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RC03	2020-05-27 02:21:23	6.7	-0.2
RC03	2020-05-27 02:21:55	7.3	-0.2
RC03	2020-05-27 02:22:37	7.2	-0.4
RC03	2020-05-27 18:28:34	7.7	-0.4
RC03	2020-05-27 18:29:52	7.2	-0.2
RC03	2020-05-28 02:21:11	7.3	-0.6
RC03	2020-06-04 04:51:14	3.4	-0.9
RC03	2020-06-19 07:25:50	5.5	-0.4
RC03	2020-06-19 09:34:06	7.7	0.0
RC03	2020-06-21 23:21:00	8.0	0.0
RC03	2020-06-22 09:37:14	7.0	-0.6
RC03	2020-06-22 09:37:55	7.1	-0.2
RC03	2020-06-23 18:10:30	7.0	-0.4
RC03	2020-06-23 18:21:44	6.8	-0.6
RC03	2020-06-23 18:22:53	6.7	-0.4
RC03	2020-06-24 10:06:05	7.2	-0.4
RC03	2020-06-24 10:06:31	7.4	-0.4
RC03	2020-06-24 19:35:27	7.5	-0.4
RN01	2019-07-04 14:25:52	4.7	0.0
RN01	2019-07-04 21:38:11	5.1	-0.2
RN01	2019-07-05 08:49:45	4.7	-0.4
RN01	2019-07-07 01:23:42	4.6	0.0
RN01	2019-07-07 03:59:57	4.7	0.0
RN01	2019-07-07 09:06:52	4.9	-0.6
RN01	2019-07-08 01:32:28	4.8	-0.2
RN01	2019-07-08 03:22:37	4.6	-0.6
RN01	2019-07-08 10:46:45	5.0	0.1
RN01	2019-07-08 18:02:10	4.8	-0.6
RN01	2019-07-08 18:17:26	5.2	-0.4
RN01	2019-07-08 18:17:44	4.9	-0.6
RN01	2019-07-08 19:03:28	5.2	-0.2
RN01	2019-07-08 20:13:16	6.3	-0.4
RN01	2019-07-08 20:13:42	4.8	-0.6
RN01	2019-07-08 20:17:02	4.9	-0.6
RN01	2019-07-09 01:58:43	4.6	-0.6
RN01	2019-07-09 06:20:49	5.1	-0.2
RN01	2019-07-10 00:37:29	4.5	-0.4
RN01	2019-07-10 01:48:37	4.6	-0.4
RN01	2019-07-10 04:44:49	4.8	-0.4
RN01	2019-07-10 05:23:35	4.7	-0.6
RN01	2019-07-10 05:36:26	5.1	-0.4
RN01	2019-07-10 07:38:28	4.9	-0.4
RN01	2019-07-11 07:43:20	4.6	-0.2
RN01	2019-07-11 10:08:56	5.0	-0.6
RN01	2019-07-12 10:08:22	5.2	0.0
RN01	2019-07-14 05:57:14	4.7	-0.2
RN01	2019-07-14 22:59:42	4.7	-0.2
RN01	2019-07-15 00:44:57	4.7	-0.6
RN01	2019-07-15 09:04:05	4.5	0.4
RN01	2019-07-15 14:44:21	4.9	-0.4
RN01	2019-07-15 17:15:27	4.8	-0.4
RN01	2019-07-15 18:33:36	4.6	-0.6
RN01	2019-07-16 12:12:14	4.8	-0.4
RN01	2019-07-17 09:08:48	4.5	-0.4
RN01	2019-07-18 08:04:08	4.7	0.1
RN01	2019-07-18 10:01:20	4.8	-0.4
RN01	2019-08-15 01:10:20	5.0	0.0
RN01	2019-08-15 15:43:43	5.0	-0.4
RN01	2019-08-16 13:02:27	4.7	-0.4
RN01	2019-08-16 13:03:04	4.6	-0.2
RN01	2019-08-16 13:04:03	4.7	0.0
RN01	2019-08-16 13:04:19	4.9	-0.4
RN01	2019-08-16 13:04:39	4.8	-0.6
RN01	2019-08-16 13:05:30	4.6	-0.4
RN01	2019-08-16 13:07:19	5.0	-0.4
RN01	2019-08-16 13:10:04	4.9	-0.6
RN01	2019-08-16 13:10:16	4.8	-0.6
RN01	2019-08-16 13:12:39	7.8	0.0
RN01	2019-08-16 13:13:14	4.9	-0.4
RN01	2019-08-16 13:13:27	4.7	-0.6
RN01	2019-08-16 13:13:57	4.6	-0.9
RN01	2019-08-16 13:14:04	4.7	-0.6
RN01	2019-08-16 13:14:19	4.6	-0.6
RN01	2019-08-16 13:15:14	5.0	-0.6
RN01	2019-08-16 13:15:25	4.8	0.1
RN01	2019-08-16 13:15:50	4.8	-0.4
RN01	2019-08-16 13:16:01	4.9	-0.2
RN01	2019-08-16 13:16:13	4.8	-0.6
RN01	2019-08-16 13:16:43	4.7	-0.4
RN01	2019-08-16 13:17:02	4.7	-0.6
RN01	2019-08-16 13:17:13	5.7	-0.6
RN01	2019-08-16 13:17:33	5.3	-0.2
RN01	2019-08-16 13:17:58	4.7	-0.4
RN01	2019-08-16 13:18:18	5.2	-0.6
RN01	2019-08-16 13:18:19	5.1	-0.6
RN01	2019-08-16 13:20:04	5.1	-0.4
RN01	2019-08-16 13:20:38	4.8	-0.4
RN01	2019-08-16 13:21:04	4.6	-0.4
RN01	2019-08-16 13:21:16	4.6	-0.4
RN01	2019-08-16 13:22:22	4.7	-0.6
RN01	2019-08-16 13:23:18	4.9	-0.4
RN01	2019-08-16 13:23:19	4.6	-0.4
RN01	2019-08-16 13:24:59	4.8	-0.6
RN01	2019-08-16 13:27:33	4.7	-0.6
RN01	2019-08-16 13:27:39	4.8	-0.4
RN01	2019-08-16 13:28:29	4.6	-0.6
RN01	2019-08-16 13:38:29	4.6	-0.6
RN01	2019-08-16 13:38:39	4.7	-0.6
RN01	2019-08-16 13:39:01	4.8	-0.4
RN01	2019-08-16 13:39:24	4.6	-0.6
RN01	2019-08-16 13:42:37	4.5	-0.4
RN01	2019-08-16 13:45:47	4.5	-0.4
RN01	2019-08-16 13:49:39	4.8	-0.9
RN01	2019-08-16 13:49:42	3.6	-0.9
RN01	2019-08-16 13:53:22	4.4	-0.6
RN01	2019-08-16 13:53:41	4.7	-0.6
RN01	2019-08-16 14:23:31	4.7	-0.4
RN01	2019-08-16 14:27:38	3.5	-0.9
RN01	2019-08-16 14:35:41	4.7	-0.6
RN01	2019-08-16 14:41:36	4.6	-0.4
RN01	2019-08-16 15:32:21	5.5	-0.6
RN01	2019-08-16 15:36:51	4.6	-0.6
RN01	2019-08-16 15:37:32	4.6	-0.6
RN01	2019-08-16 15:44:09	4.6	-0.4
RN01	2019-08-16 15:58:47	4.9	-0.6
RN01	2019-08-16 16:08:18	5.2	-0.6
RN01	2019-08-16 16:23:27	4.8	-0.4
RN01	2019-08-16 16:33:15	4.6	-0.6
RN01	2019-08-16 16:41:22	5.4	-0.6
RN01	2019-08-16 16:41:40	2.5	-0.9

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RN01	2019-08-16 16:54:40	4.7	-0.6
RN01	2019-08-16 17:01:31	5.3	-0.4
RN01	2019-08-16 17:23:10	4.5	-0.9
RN01	2019-08-16 17:30:16	4.7	-0.4
RN01	2019-08-16 17:56:31	4.4	-0.6
RN01	2019-08-16 17:58:00	4.7	-0.4
RN01	2019-08-16 18:05:09	5.2	-0.9
RN01	2019-08-16 18:40:42	4.5	-0.6
RN01	2019-08-16 18:50:29	4.5	-0.6
RN01	2019-08-16 19:55:32	4.8	-0.6
RN01	2019-08-16 19:59:53	4.8	-0.4
RN01	2019-08-16 20:20:25	5.0	-0.6
RN01	2019-08-16 20:24:03	4.6	-0.6
RN01	2019-08-16 20:29:57	5.0	-0.6
RN01	2019-08-16 20:41:55	4.8	-0.6
RN01	2019-08-16 21:05:36	4.8	-0.2
RN01	2019-08-16 21:17:21	4.8	-0.6
RN01	2019-08-16 21:35:56	2.5	-0.9
RN01	2019-08-16 21:40:35	4.6	-0.6
RN01	2019-08-16 22:08:35	5.0	-0.9
RN01	2019-08-16 22:10:42	5.0	-0.6
RN01	2019-08-16 22:11:27	4.8	-0.6
RN01	2019-08-16 23:06:31	5.2	-0.6
RN01	2019-08-16 23:38:20	4.5	-0.4
RN01	2019-08-16 23:40:37	5.1	-0.4
RN01	2019-08-16 23:45:46	4.7	-0.6
RN01	2019-08-16 23:50:28	2.7	-1.5
RN01	2019-08-17 00:45:41	5.0	-0.4
RN01	2019-08-17 00:52:43	4.7	-0.4
RN01	2019-08-17 00:57:29	4.7	-0.4
RN01	2019-08-17 00:59:02	4.6	-0.6
RN01	2019-08-17 01:06:06	5.1	-0.4
RN01	2019-08-17 01:06:34	4.8	-0.6
RN01	2019-08-17 01:07:03	5.0	-0.4
RN01	2019-08-17 01:20:34	4.5	-0.9
RN01	2019-08-17 01:26:47	5.0	-0.6
RN01	2019-08-17 01:56:01	4.6	-0.6
RN01	2019-08-17 02:10:03	5.1	-0.6
RN01	2019-08-17 02:15:17	5.2	-0.6
RN01	2019-08-17 03:24:54	4.7	-0.2
RN01	2019-08-17 03:25:01	3.2	-0.6
RN01	2019-08-17 03:30:29	4.4	-0.2
RN01	2019-08-17 03:42:54	4.6	-0.2
RN01	2019-08-17 04:15:25	4.7	0.0
RN01	2019-08-17 04:15:43	4.7	-0.2
RN01	2019-08-17 04:35:57	5.1	-0.4
RN01	2019-08-17 04:37:29	5.3	-0.4
RN01	2019-08-17 04:47:31	4.6	-0.6
RN01	2019-08-17 04:52:43	4.6	-0.2
RN01	2019-08-17 04:58:59	4.3	-0.2
RN01	2019-08-17 05:45:23	4.7	0.0
RN01	2019-08-17 05:56:56	4.7	-0.6
RN01	2019-08-17 06:20:55	4.6	-0.6
RN01	2019-08-17 06:22:02	4.4	-0.6
RN01	2019-08-17 06:25:40	4.5	0.2
RN01	2019-08-17 06:26:28	4.7	-0.6
RN01	2019-08-17 06:29:59	4.9	0.0
RN01	2019-08-17 06:31:26	4.6	-0.4
RN01	2019-08-17 06:40:49	4.7	-0.2
RN01	2019-08-17 06:55:48	4.3	0.0
RN01	2019-08-17 08:30:49	4.6	0.3
RN01	2019-08-17 08:35:38	4.6	0.2
RN01	2019-08-17 08:55:31	4.5	-0.6
RN01	2019-08-17 09:15:35	4.1	0.4
RN01	2019-08-17 09:16:23	4.6	0.6
RN01	2019-08-17 09:29:15	4.8	-0.4
RN01	2019-08-17 09:29:24	3.8	-0.6
RN01	2019-08-17 09:58:49	4.6	0.2
RN01	2019-08-17 10:06:02	4.7	-0.9
RN01	2019-08-17 10:06:05	4.6	-0.9
RN01	2019-08-17 10:14:51	4.4	-0.6
RN01	2019-08-17 10:21:47	4.8	-0.2
RN01	2019-08-17 10:32:16	4.5	0.2
RN01	2019-08-17 10:42:49	4.9	0.1
RN01	2019-08-17 11:04:00	7.6	0.2
RN01	2019-08-17 11:05:14	5.1	-0.2
RN01	2019-08-17 11:29:27	5.0	0.1
RN01	2019-08-17 11:29:41	4.9	0.0
RN01	2019-08-17 11:49:48	4.7	-0.6
RN01	2019-08-17 12:55:45	4.6	-0.6
RN01	2019-08-17 13:06:10	8.2	-0.4
RN01	2019-08-17 15:19:48	6.0	-0.4
RN01	2019-08-17 15:31:06	4.6	-0.6
RN01	2019-08-17 16:34:55	4.9	-0.6
RN01	2019-08-17 17:09:57	4.8	0.2
RN01	2019-08-17 17:22:18	4.4	0.1
RN01	2019-08-17 17:30:25	4.4	0.3
RN01	2019-08-17 20:04:40	4.4	0.2
RN01	2019-08-17 22:03:44	4.7	-0.6
RN01	2019-08-17 23:36:47	4.8	0.4
RN01	2019-08-18 03:50:11	4.7	0.1
RN01	2019-08-18 04:15:24	4.9	0.4
RN01	2019-08-18 05:25:37	4.6	0.0
RN01	2019-08-18 06:11:25	4.4	0.0
RN01	2019-08-18 06:34:18	4.7	-0.2
RN01	2019-08-18 08:00:15	4.8	-0.2
RN01	2019-08-18 08:49:18	4.6	-0.6
RN01	2019-08-18 08:49:33	4.6	-0.4
RN01	2019-08-18 08:50:06	4.6	-0.2
RN01	2019-08-18 08:50:42	4.8	-0.6
RN01	2019-08-18 08:51:20	5.3	-0.6
RN01	2019-08-18 08:51:40	4.7	-0.9
RN01	2019-08-18 08:52:45	4.6	-0.6
RN01	2019-08-18 08:52:59	4.8	-0.6
RN01	2019-08-18 08:53:11	4.4	0.1
RN01	2019-08-18 08:53:24	5.4	-0.6
RN01	2019-08-18 08:53:44	4.6	-0.2
RN01	2019-08-18 08:55:14	4.7	-0.6
RN01	2019-08-18 08:55:28	4.5	-0.6
RN01	2019-08-18 08:56:38	4.5	-0.2
RN01	2019-08-18 08:57:31	3.8	-0.6
RN01	2019-08-18 08:58:26	4.2	-0.6
RN01	2019-08-18 08:58:33	4.4	-0.6
RN01	2019-08-18 08:58:45	4.6	-0.9
RN01	2019-08-18 08:59:12	5.0	-0.9
RN01	2019-08-18 09:02:02	4.8	-0.4
RN01	2019-08-18 09:02:31	4.8	-0.4
RN01	2019-08-18 09:06:03	4.8	-0.6
RN01	2019-08-18 09:06:16	5.2	-0.6
RN01	2019-08-18 09:14:56	4.9	0.1

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RN01	2019-08-18 09:15:59	4.7	-0.6
RN01	2019-08-18 09:16:25	4.8	-0.6
RN01	2019-08-18 09:19:39	4.8	-0.6
RN01	2019-08-18 09:21:19	4.8	-0.6
RN01	2019-08-18 09:30:17	4.8	-0.9
RN01	2019-08-18 10:12:32	4.8	-0.6
RN01	2019-08-18 11:28:31	4.8	-0.6
RN01	2019-08-18 12:28:35	4.4	-0.6
RN01	2019-08-18 15:01:22	4.9	-0.6
RN01	2019-08-18 16:17:02	4.8	0.0
RN01	2019-08-18 18:57:04	4.5	0.0
RN01	2019-08-18 20:39:30	4.8	-0.6
RN01	2019-08-18 21:06:10	5.2	-0.6
RN01	2019-08-19 00:24:09	3.7	-0.4
RN01	2019-08-19 02:56:34	5.0	-0.6
RN01	2019-08-19 04:22:44	4.9	-0.9
RN01	2019-08-19 04:39:18	4.5	0.0
RN01	2019-08-19 06:23:10	4.7	-0.6
RN01	2019-08-19 08:02:16	4.6	-0.6
RN01	2019-08-19 11:03:01	4.7	-0.4
RN01	2019-08-19 21:16:10	4.6	-0.6
RN01	2019-08-19 22:23:47	5.0	0.3
RN01	2019-08-20 07:08:53	4.5	0.0
RN01	2019-08-20 07:09:07	4.6	-0.2
RN01	2019-08-20 14:58:52	4.4	-0.2
RN01	2019-08-20 16:32:37	4.5	0.0
RN01	2019-08-20 19:21:49	4.5	-0.6
RN01	2019-08-20 20:03:13	4.6	-0.2
RN01	2019-08-20 21:24:54	4.8	-0.6
RN01	2019-08-20 22:57:44	4.5	-0.9
RN01	2019-08-21 00:04:04	4.7	-0.9
RN01	2019-08-21 04:41:21	4.6	-0.9
RN01	2019-08-21 05:22:07	4.8	-0.6
RN01	2019-08-21 06:00:01	4.6	-0.9
RN01	2019-08-21 09:01:39	4.4	-0.6
RN01	2019-08-22 05:07:37	4.4	-0.6
RN01	2019-08-22 05:52:44	4.6	-0.4
RN01	2019-08-22 09:55:50	5.0	-0.4
RN01	2019-08-22 14:04:36	4.9	-0.6
RN01	2019-08-22 14:17:03	5.0	-0.4
RN01	2019-08-22 14:48:48	3.4	-0.6
RN01	2019-08-22 21:31:01	4.5	-0.6
RN01	2019-08-23 05:58:50	4.8	-0.4
RN01	2019-08-23 06:11:34	5.0	-0.4
RN01	2019-08-23 12:14:19	4.7	-0.4
RN01	2019-08-23 16:00:14	5.1	-0.6
RN01	2019-08-23 23:50:58	4.9	-0.6
RN01	2019-08-24 01:27:43	3.3	-0.9
RN01	2019-08-24 03:08:27	4.4	-0.6
RN01	2019-08-24 03:27:07	4.8	-0.6
RN01	2019-08-24 04:28:52	4.8	-0.6
RN01	2019-08-24 08:21:58	4.8	-0.9
RN01	2019-08-24 11:43:52	5.1	-0.4
RN01	2019-08-24 11:52:04	5.0	-0.6
RN01	2019-08-24 12:39:01	4.9	-0.6
RN01	2019-08-24 13:47:07	4.8	-0.4
RN01	2019-08-24 21:23:11	5.1	-0.4
RN01	2019-08-25 19:29:19	4.6	-0.6
RN01	2019-08-26 00:01:55	4.9	-0.4
RN01	2019-08-26 06:01:58	4.6	-0.6
RN01	2019-08-26 07:19:00	4.6	-0.4
RN01	2019-08-26 09:33:43	3.6	-0.4
RN01	2019-08-26 13:53:38	5.1	-0.2
RN01	2019-08-26 21:15:10	4.8	-0.4
RN01	2019-08-26 23:25:34	5.2	0.0
RN01	2019-08-26 23:27:50	4.8	-0.6
RN01	2019-08-27 01:40:40	5.3	-0.2
RN01	2019-08-27 06:42:39	4.3	-0.6
RN01	2019-08-27 11:33:20	4.6	0.0
RN01	2019-08-27 16:14:15	3.4	-0.9
RN01	2019-08-27 17:24:43	2.5	-0.9
RN01	2019-08-27 17:25:34	3.2	-0.6
RN01	2019-08-27 20:51:46	4.9	-0.4
RN01	2019-08-27 22:01:26	4.8	-0.6
RN01	2019-08-27 22:53:38	4.7	0.1
RN01	2019-08-27 23:19:50	4.8	-0.6
RN01	2019-08-28 05:01:42	4.6	0.4
RN01	2019-08-28 08:23:12	5.0	-0.6
RN01	2019-08-28 19:00:34	3.7	-0.6
RN01	2019-08-29 08:02:14	5.1	-0.6
RN01	2019-08-29 08:03:04	4.5	0.1
RN01	2019-08-29 10:28:12	4.8	0.1
RN01	2019-08-29 11:16:56	4.5	-0.2
RN01	2019-08-29 12:20:54	4.7	0.1
RN01	2019-08-29 13:41:28	5.1	-0.6
RN01	2019-08-30 13:05:02	4.9	-0.2
RN01	2019-08-30 14:19:12	4.8	-0.6
RN01	2019-08-30 14:25:30	4.7	-0.6
RN01	2019-08-30 21:58:36	4.8	-0.4
RN01	2019-08-30 22:15:04	5.0	-0.4
RN01	2019-08-31 14:54:59	4.5	0.1
RN01	2019-08-31 17:44:02	4.9	-0.6
RN01	2019-08-31 20:17:23	4.9	-0.6
RN01	2019-08-31 20:38:48	4.9	-0.9
RN01	2019-09-01 01:28:58	4.5	0.2
RN01	2019-09-01 04:18:44	4.6	0.1
RN01	2019-09-01 05:59:28	5.1	-0.2
RN01	2019-09-01 06:20:50	5.2	-0.9
RN01	2019-09-01 07:09:42	5.3	-0.2
RN01	2019-09-01 11:30:10	4.9	-0.4
RN01	2019-09-01 12:16:04	5.3	-0.4
RN01	2019-09-01 12:16:09	4.6	-0.9
RN01	2019-09-01 17:07:08	5.1	-0.6
RN01	2019-09-01 17:44:38	5.0	-0.6
RN01	2019-09-01 17:55:00	4.6	-0.2
RN01	2019-09-01 19:13:11	5.4	-0.6
RN01	2019-09-01 23:22:08	5.4	-0.2
RN01	2019-09-02 04:53:53	5.0	-0.9
RN01	2019-09-02 08:17:58	4.9	-0.4
RN01	2019-09-02 13:40:24	4.8	-0.6
RN01	2019-09-02 19:39:20	5.1	-0.6
RN01	2019-09-03 01:28:51	4.6	-0.4
RN01	2019-09-04 00:16:27	4.5	0.1
RN01	2019-09-04 08:32:59	3.9	-0.4
RN01	2019-09-04 17:15:44	4.5	-0.9
RN01	2019-09-04 18:20:15	4.8	-0.6
RN01	2019-09-04 23:47:00	4.7	-0.4
RN01	2019-09-05 00:44:52	4.9	-0.6
RN01	2019-09-05 15:25:25	4.5	-0.4
RN01	2019-09-06 08:32:23	5.0	-0.6

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RN01	2019-09-06 20:52:27	5.0	-0.6
RN01	2019-09-07 08:09:55	5.0	-0.9
RN01	2019-09-07 08:54:20	4.9	-0.9
RN01	2019-09-07 12:38:16	4.6	-0.9
RN01	2019-09-07 17:24:32	4.9	-0.6
RN01	2019-09-07 18:11:18	4.9	-0.6
RN01	2019-09-07 18:42:17	3.3	-0.9
RN01	2019-09-07 18:42:54	4.9	-0.9
RN01	2019-09-07 19:30:43	5.2	-0.9
RN01	2019-09-08 11:31:36	4.8	0.0
RN01	2019-09-08 13:00:14	4.6	0.0
RN01	2019-09-09 05:29:45	4.6	-0.6
RN01	2019-09-09 18:23:13	4.9	-0.6
RN01	2019-09-09 19:59:12	4.6	0.2
RN01	2019-09-10 00:14:42	4.8	-0.4
RN01	2019-09-10 00:14:52	4.6	-0.4
RN01	2019-09-10 02:24:19	5.0	-0.6
RN01	2019-09-10 04:33:41	4.7	0.3
RN01	2019-09-10 06:03:59	4.7	0.2
RN01	2019-09-10 07:17:23	3.9	0.1
RN01	2019-09-10 10:20:03	4.6	-0.6
RN01	2019-09-11 22:34:45	5.0	-0.4
RN01	2019-09-12 13:21:17	5.1	-0.4
RN01	2019-09-12 16:05:03	5.4	-0.4
RN01	2019-09-12 17:35:43	5.0	-0.4
RN01	2019-09-12 23:07:24	5.4	-0.6
RN01	2019-09-12 23:09:55	5.1	-0.6
RN01	2019-09-13 03:19:23	4.7	-0.6
RN01	2019-09-13 06:12:43	4.7	-0.9
RN01	2019-09-13 09:08:58	5.0	-0.6
RN01	2019-09-13 12:45:31	4.5	-0.6
RN01	2019-09-13 15:59:07	4.8	-0.6
RN01	2019-09-13 19:30:46	5.2	-0.4
RN01	2019-09-13 20:50:19	5.1	-0.6
RN01	2019-09-14 04:30:07	4.5	-0.2
RN01	2019-09-14 04:30:51	4.8	-0.4
RN01	2019-09-14 05:04:11	3.4	-0.9
RN01	2019-09-14 05:37:35	4.6	-0.9
RN01	2019-09-14 06:35:12	4.8	0.0
RN01	2019-09-14 08:19:18	4.7	0.0
RN01	2019-09-14 10:49:45	4.6	-0.4
RN01	2019-09-14 10:59:39	4.7	-0.4
RN01	2019-09-15 05:59:15	5.1	0.1
RN01	2019-09-15 06:00:54	4.9	-0.4
RN01	2019-09-15 15:36:33	4.9	-0.6
RN01	2019-09-15 15:46:49	5.2	-0.4
RN01	2019-09-15 20:37:35	2.7	-0.9
RN01	2019-09-16 03:00:37	4.7	0.0
RN01	2019-09-16 03:57:40	4.8	0.0
RN01	2019-09-17 03:08:14	5.0	-0.2
RN01	2019-09-17 04:08:52	4.4	-0.6
RN01	2019-09-18 01:01:00	4.8	-0.6
RN01	2019-09-18 21:22:07	5.0	-0.9
RN01	2019-09-19 09:10:06	4.8	-0.9
RN01	2019-09-19 09:13:41	4.6	-1.5
RN01	2019-09-19 17:24:49	5.0	-0.6
RN01	2019-09-19 18:45:50	4.5	0.0
RN01	2019-09-20 03:45:01	4.2	-0.9
RN01	2019-09-20 15:34:26	4.7	-0.9
RN01	2019-09-20 15:39:53	4.6	-0.4
RN01	2019-09-21 03:18:34	4.9	0.1
RN01	2019-09-21 10:10:10	4.9	-0.2
RN01	2019-09-21 16:10:43	5.0	-0.4
RN01	2019-09-21 17:07:49	4.5	-0.6
RN01	2019-09-22 01:10:35	5.0	-0.6
RN01	2019-09-22 07:47:05	4.9	-0.4
RN01	2019-09-23 02:23:20	5.0	0.0
RN01	2019-09-23 06:04:14	4.9	-0.9
RN01	2019-09-23 10:20:01	4.8	-0.6
RN01	2019-09-23 10:28:17	4.9	-0.4
RN01	2019-09-23 17:47:11	4.7	-0.6
RN01	2019-09-24 07:07:17	4.9	0.1
RN01	2019-09-24 13:43:08	4.8	-0.6
RN01	2019-09-26 06:55:50	4.6	-0.6
RN01	2019-09-26 07:00:50	4.8	-0.4
RN01	2019-09-26 16:13:53	5.0	-0.2
RN01	2019-09-26 20:32:09	4.5	0.1
RN01	2019-09-27 01:23:09	4.7	-0.6
RN01	2019-09-28 06:19:06	5.0	-0.4
RN01	2019-09-28 12:09:34	4.9	-0.4
RN01	2019-09-28 15:37:31	4.9	-0.9
RN01	2019-09-28 18:30:56	4.9	-0.9
RN01	2019-09-28 20:09:42	5.0	-0.2
RN01	2019-09-28 20:51:48	5.0	-0.6
RN01	2019-09-28 21:49:20	5.0	-1.5
RN01	2019-09-28 21:49:20	4.9	-0.9
RN01	2019-09-28 21:49:21	5.2	-0.6
RN01	2019-09-28 22:02:45	5.3	-0.6
RN01	2019-09-28 22:03:28	5.0	-0.6
RN01	2019-09-28 22:06:23	5.0	-0.9
RN01	2019-09-28 22:07:25	5.0	-0.9
RN01	2019-09-28 22:16:04	5.1	-0.4
RN01	2019-09-28 22:48:09	5.1	-0.6
RN01	2019-09-28 23:14:31	5.1	-0.4
RN01	2019-09-29 04:13:00	4.9	-0.9
RN01	2019-09-29 04:13:30	4.9	-0.4
RN01	2019-09-29 04:13:36	4.9	-0.6
RN01	2019-09-29 04:14:23	4.9	-0.9
RN01	2019-09-29 04:14:39	4.9	-0.9
RN01	2019-09-29 04:14:43	4.9	-0.9
RN01	2019-09-29 04:15:02	5.1	-0.6
RN01	2019-09-29 04:22:46	5.0	-0.9
RN01	2019-09-29 04:25:07	4.9	-0.6
RN01	2019-09-29 04:34:20	5.0	0.4
RN01	2019-09-29 07:53:21	4.8	0.3
RN01	2019-09-29 14:43:48	4.8	0.1
RN01	2019-09-29 14:46:24	5.0	0.1
RN01	2019-09-29 14:46:28	4.7	-0.9
RN01	2019-09-30 02:00:57	4.8	0.2
RN01	2019-09-30 02:02:48	5.1	0.6
RN01	2019-09-30 02:03:01	5.0	-0.2
RN01	2019-09-30 03:20:56	4.9	-0.4
RN01	2019-09-30 04:38:14	4.9	0.2
RN01	2019-10-04 11:17:00	4.8	-0.6
RN01	2019-10-06 03:12:07	5.0	-0.4
RN01	2019-10-10 18:18:56	4.8	-0.6
RN01	2019-10-11 01:43:04	4.9	-0.4
RN01	2019-10-11 04:14:24	5.2	-0.4
RN01	2019-10-13 14:41:42	4.8	-0.6
RN01	2019-10-13 17:44:11	4.3	-0.2

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RN01	2019-10-14 05:13:33	4.8	-0.6
RN01	2019-10-14 14:37:31	4.7	-0.4
RN01	2019-10-16 00:10:59	4.6	-0.6
RN01	2019-10-16 16:12:39	4.5	-0.6
RN01	2019-10-18 05:16:26	5.1	-0.4
RN01	2019-10-20 18:21:01	4.8	-0.4
RN01	2019-10-21 02:38:58	4.9	-0.4
RN01	2019-10-22 07:15:14	4.5	-0.6
RN01	2019-10-23 19:05:02	5.1	0.0
RN01	2019-10-23 19:11:07	5.3	-0.4
RN01	2019-10-23 19:30:44	5.3	-0.6
RN01	2019-10-23 19:33:43	5.5	-0.2
RN01	2019-10-23 19:39:03	5.0	0.2
RN01	2019-10-23 19:40:51	5.1	-0.4
RN01	2019-10-23 19:50:19	4.9	-0.6
RN01	2019-10-23 21:07:06	5.1	-0.2
RN01	2019-10-23 22:26:13	5.1	-0.4
RN01	2019-10-23 22:36:39	5.1	-0.6
RN01	2019-10-23 22:44:58	5.2	-0.4
RN01	2019-10-23 22:54:48	4.9	-0.6
RN01	2019-10-23 23:00:31	6.4	-0.4
RN01	2019-10-23 23:05:52	5.3	0.1
RN01	2019-10-24 00:00:15	5.3	-0.4
RN01	2019-10-24 00:26:59	5.5	-0.6
RN01	2019-10-24 01:08:46	4.9	-0.2
RN01	2019-10-24 01:12:50	5.3	-0.4
RN01	2019-10-24 02:02:30	4.9	-0.4
RN01	2019-10-25 05:14:24	4.8	0.2
RN01	2019-10-25 23:40:47	5.2	-0.6
RN01	2019-10-27 00:37:38	5.2	-0.4
RN01	2019-10-27 13:00:13	4.8	-0.6
RN01	2019-10-29 03:34:37	5.2	0.0
RN01	2019-10-29 05:13:41	4.7	-0.6
RN01	2019-10-30 03:55:05	4.8	-0.6
RN01	2019-10-30 07:16:51	5.3	-0.4
RN01	2019-11-02 12:58:32	5.0	-0.6
RN01	2019-11-02 21:53:29	5.3	-0.6
RN01	2019-11-03 02:15:21	4.7	-0.2
RN01	2019-11-03 02:21:32	5.1	-0.6
RN01	2019-11-03 02:30:52	5.0	-0.9
RN01	2019-11-03 03:01:07	4.9	-0.4
RN01	2019-11-03 03:04:16	5.1	-0.6
RN01	2019-11-03 06:59:28	5.0	-0.9
RN01	2019-11-03 19:56:24	4.3	-0.9
RN01	2019-11-03 21:17:20	5.2	-0.6
RN01	2019-11-07 21:40:27	4.6	-0.9
RN01	2019-11-08 02:08:32	4.8	-0.6
RN01	2019-11-08 06:05:04	5.0	-0.6
RN01	2019-11-08 23:48:32	4.6	-0.6
RN01	2019-11-08 23:48:32	3.9	-0.6
RN01	2019-11-09 03:00:43	4.6	-0.2
RN01	2019-11-09 03:00:43	4.5	-0.6
RN01	2019-11-09 04:54:26	3.5	-0.9
RN01	2019-11-09 12:01:48	5.1	-0.6
RN01	2019-11-09 13:33:33	4.3	-0.9
RN01	2019-11-11 00:55:55	5.2	-0.4
RN01	2019-11-11 10:31:13	8.2	-0.4
RN01	2019-11-15 02:06:00	5.0	-0.6
RN01	2019-11-17 14:08:48	4.7	-0.4
RN01	2019-11-17 14:18:19	5.2	0.0
RN01	2019-11-17 23:52:36	5.0	0.2
RN01	2019-11-19 08:20:12	5.3	-0.6
RN01	2019-11-21 08:38:30	5.2	-0.4
RN01	2019-11-25 02:03:11	4.6	-0.2
RN01	2019-11-25 10:57:17	4.4	-0.4
RN01	2019-11-25 11:05:41	4.8	-0.4
RN01	2019-11-28 15:47:16	5.2	-0.6
RN01	2019-11-28 15:49:35	5.5	-0.4
RN01	2019-11-28 16:17:55	4.6	0.0
RN01	2019-11-28 20:17:43	5.1	-0.6
RN01	2019-11-29 04:51:41	4.9	-0.6
RN01	2019-11-29 05:15:28	5.0	-0.6
RN01	2019-12-07 10:34:26	5.1	-0.4
RN01	2019-12-07 18:03:57	4.8	-0.4
RN01	2019-12-07 18:04:14	5.4	-0.6
RN01	2019-12-09 01:16:45	5.1	-0.4
RN01	2019-12-09 07:56:06	4.7	-0.2
RN01	2019-12-10 05:01:20	5.2	-0.4
RN01	2019-12-10 05:57:22	5.4	-0.6
RN01	2019-12-14 08:11:20	5.1	-0.6
RN01	2019-12-17 12:11:21	4.3	-0.9
RN01	2019-12-17 18:18:06	4.8	-0.4
RN01	2019-12-21 07:06:42	4.0	-0.6
RN01	2019-12-21 09:14:47	4.4	-0.4
RN01	2019-12-21 11:21:22	4.6	-0.2
RN01	2019-12-23 08:21:19	5.1	-0.4
RN01	2019-12-25 07:10:52	3.6	-0.9
RN01	2019-12-27 18:45:01	5.0	-0.6
RN01	2019-12-27 21:21:39	4.9	-0.4
RN01	2019-12-29 01:04:58	5.0	-0.2
RN01	2019-12-30 06:01:14	4.8	-0.4
RN01	2020-01-02 08:50:08	5.4	-0.6
RN01	2020-01-02 12:26:19	4.8	-0.6
RN01	2020-01-02 17:14:20	5.0	-0.4
RN01	2020-01-03 07:04:36	5.0	-0.9
RN01	2020-01-03 10:31:18	5.1	-0.6
RN01	2020-01-03 19:15:39	5.1	-0.6
RN01	2020-01-05 22:42:50	5.0	-0.9
RN01	2020-01-08 06:15:56	4.2	-0.4
RN01	2020-01-08 06:58:55	5.2	-0.4
RN01	2020-01-08 08:56:46	4.7	-0.4
RN01	2020-01-08 09:59:43	4.2	-0.6
RN01	2020-01-10 21:48:47	5.2	-0.6
RN01	2020-01-12 20:33:13	5.2	-0.4
RN01	2020-01-12 20:39:57	4.9	-0.9
RN01	2020-01-13 02:31:34	4.7	-0.6
RN01	2020-01-14 05:47:24	4.8	-0.6
RN01	2020-01-14 05:50:40	5.7	-0.2
RN01	2020-01-20 01:39:46	4.1	-0.2
RN01	2020-01-20 02:40:09	4.6	0.0
RN01	2020-01-20 02:48:39	4.1	-0.2
RN01	2020-01-20 02:53:20	5.2	-0.6
RN01	2020-01-20 03:33:18	4.5	-0.4
RN01	2020-01-20 04:36:19	4.7	-0.4
RN01	2020-01-21 01:37:19	4.8	-0.6
RN01	2020-01-21 02:55:10	4.2	-0.9
RN01	2020-01-21 04:50:12	4.9	-0.9
RN01	2020-01-21 05:02:47	4.4	0.2
RN01	2020-01-23 01:52:43	5.0	0.0
RN01	2020-01-23 02:01:40	4.9	-0.4

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RN01	2020-01-23 03:03:22	4.8	-0.2
RN01	2020-01-23 03:03:44	5.3	-0.4
RN01	2020-01-23 03:51:02	4.8	-0.4
RN01	2020-01-23 04:29:40	4.5	-0.6
RN01	2020-01-23 07:31:06	4.6	-0.6
RN01	2020-01-23 09:07:02	5.2	0.1
RN01	2020-01-23 11:08:42	5.0	-0.2
RN01	2020-01-23 14:20:51	5.0	-0.4
RN01	2020-01-23 18:46:54	4.7	-0.4
RN01	2020-01-23 21:55:28	4.7	-0.4
RN01	2020-01-24 00:33:20	4.0	-0.9
RN01	2020-01-24 00:40:11	5.2	-0.6
RN01	2020-01-24 00:53:27	4.3	-0.6
RN01	2020-01-24 03:07:28	4.9	-0.2
RN01	2020-01-24 03:07:28	5.0	-0.4
RN01	2020-01-24 05:14:13	5.0	-0.4
RN01	2020-01-24 13:22:25	5.3	-0.2
RN01	2020-01-24 13:22:25	5.1	-0.4
RN01	2020-01-24 14:35:08	4.7	-0.2
RN01	2020-01-24 22:58:20	4.9	-0.4
RN01	2020-01-24 22:58:20	5.3	-0.2
RN01	2020-01-25 00:17:11	5.6	-0.2
RN01	2020-01-25 00:29:11	4.7	-0.2
RN01	2020-01-25 00:33:25	4.1	0.0
RN01	2020-01-25 05:36:15	5.5	-0.4
RN01	2020-01-25 06:16:16	5.2	-0.6
RN01	2020-01-25 10:15:07	4.9	-0.6
RN01	2020-01-25 23:23:19	5.6	-0.4
RN01	2020-01-26 15:16:35	4.6	-0.6
RN01	2020-01-27 00:53:52	5.2	-0.4
RN01	2020-01-27 01:06:12	4.9	-0.4
RN01	2020-01-27 03:09:32	5.0	-0.4
RN01	2020-01-27 06:32:04	4.7	-0.6
RN01	2020-01-27 08:47:48	3.4	-0.9
RN01	2020-01-27 20:04:17	5.3	-0.6
RN01	2020-01-27 22:00:50	4.2	-0.4
RN01	2020-01-28 18:39:58	4.9	0.2
RN01	2020-01-28 19:13:25	4.8	-0.6
RN01	2020-01-29 06:53:01	4.5	-0.6
RN01	2020-01-29 22:16:29	5.4	-0.9
RN01	2020-01-30 04:59:51	4.8	0.1
RN01	2020-01-30 12:44:06	4.8	-0.6
RN01	2020-01-30 14:51:35	5.1	-0.6
RN01	2020-01-30 20:52:55	4.9	0.0
RN01	2020-01-31 03:53:15	4.7	-0.4
RN01	2020-02-01 00:04:31	5.2	-0.4
RN01	2020-02-01 12:40:29	4.9	-0.4
RN01	2020-02-01 15:30:09	4.9	-0.2
RN01	2020-02-01 22:18:09	4.8	-0.6
RN01	2020-02-02 03:55:44	5.0	0.0
RN01	2020-02-02 13:40:24	5.2	-0.4
RN01	2020-02-02 16:50:27	4.8	-0.4
RN01	2020-02-03 18:21:40	5.0	-0.4
RN01	2020-02-04 07:45:49	5.2	-0.4
RN01	2020-02-04 22:46:39	5.2	-0.4
RN01	2020-02-05 05:31:47	5.9	-0.9
RN01	2020-02-05 07:07:09	4.8	-0.6
RN01	2020-02-05 16:36:07	4.9	-0.4
RN01	2020-02-05 17:08:45	5.0	-0.4
RN01	2020-02-05 19:27:06	4.9	-0.2
RN01	2020-02-08 03:58:39	4.7	-0.4
RN01	2020-02-09 08:45:01	5.1	-0.4
RN01	2020-02-09 23:44:34	4.5	-0.6
RN01	2020-02-11 06:40:50	4.2	-0.6
RN01	2020-02-12 08:38:11	5.2	0.0
RN01	2020-02-14 03:17:57	5.3	-0.4
RN01	2020-02-15 00:05:58	2.7	-0.9
RN01	2020-02-15 14:48:44	5.1	-0.2
RN01	2020-02-15 18:10:06	4.7	-0.6
RN01	2020-02-15 21:11:56	4.8	-0.2
RN01	2020-02-16 11:26:54	4.2	-0.4
RN01	2020-02-17 16:14:52	4.7	-0.6
RN01	2020-02-18 21:24:28	5.0	-0.4
RN01	2020-02-19 04:32:50	5.0	-0.6
RN01	2020-02-19 05:13:21	4.8	-0.6
RN01	2020-02-19 12:49:40	5.1	-0.4
RN01	2020-02-19 14:50:45	5.1	-0.6
RN01	2020-02-20 11:03:27	5.3	-0.4
RN01	2020-02-20 14:24:32	5.1	-0.4
RN01	2020-02-20 14:24:57	5.6	-0.4
RN01	2020-02-20 14:30:38	5.0	-0.2
RN01	2020-02-20 23:58:37	4.5	-0.2
RN01	2020-02-21 09:11:23	4.9	-0.6
RN01	2020-02-22 12:47:57	4.9	-0.6
RN01	2020-02-22 19:38:02	5.2	-0.4
RN01	2020-02-24 12:50:10	4.6	-0.4
RN01	2020-02-25 21:10:22	4.4	-0.9
RN01	2020-02-26 05:59:09	2.1	-1.5
RN01	2020-02-29 22:50:25	4.6	-0.6
RN01	2020-03-01 01:44:57	5.1	-0.4
RN01	2020-03-01 04:18:46	4.6	-0.6
RN01	2020-03-02 12:47:41	4.9	-0.9
RN01	2020-03-04 01:32:07	4.5	-0.9
RN01	2020-03-04 09:10:49	4.4	-0.6
RN01	2020-03-04 09:16:55	4.2	-0.9
RN01	2020-03-04 09:40:03	5.0	-0.6
RN01	2020-03-04 09:54:28	4.5	-0.9
RN01	2020-03-04 10:20:24	4.6	-0.6
RN01	2020-03-04 10:26:40	4.6	-0.9
RN01	2020-03-04 10:51:15	5.0	-0.9
RN01	2020-03-04 11:11:01	4.4	-0.9
RN01	2020-03-04 15:57:25	5.2	-0.9
RN01	2020-03-04 16:55:01	4.9	-0.9
RN01	2020-03-04 19:02:38	4.8	-0.9
RN01	2020-03-04 20:30:47	4.8	-0.9
RN01	2020-03-04 21:36:40	4.9	-0.6
RN01	2020-03-05 02:50:46	4.8	-0.9
RN01	2020-03-06 07:46:43	5.1	-0.9
RN01	2020-03-06 08:04:03	4.9	-0.6
RN01	2020-03-06 22:58:14	4.8	-0.9
RN01	2020-03-10 16:42:55	4.8	-0.9
RN01	2020-03-11 04:04:02	4.8	-0.6
RN01	2020-03-11 06:54:34	3.5	-0.9
RN01	2020-03-13 12:40:46	4.9	-0.9
RN01	2020-03-13 13:27:12	5.1	-0.6
RN01	2020-03-13 13:37:23	4.9	-0.9
RN01	2020-03-13 13:37:57	5.1	-0.9
RN01	2020-03-13 20:23:07	5.1	-0.6
RN01	2020-03-13 20:43:11	5.3	-0.6
RN01	2020-03-14 07:43:41	4.8	-0.6

Appendix C. Continued

Station	Origin Time (UTC)	Distance (mi)	Magnitude
RN01	2020-03-21 11:33:08	4.6	-0.9
RN01	2020-03-21 13:29:14	5.1	-0.9
RN01	2020-03-21 22:56:13	4.6	-0.9
RN01	2020-03-22 17:12:02	4.7	-0.9
RN01	2020-03-23 11:55:54	4.6	-0.6
RN01	2020-03-24 05:31:52	4.9	-0.9
RN01	2020-03-24 09:40:51	4.4	-0.6
RN01	2020-03-24 12:34:27	5.0	-0.9
RN01	2020-03-24 20:22:18	4.9	-0.9
RN01	2020-04-15 09:47:39	4.4	-0.9
RN01	2020-04-29 09:08:35	5.2	-0.6
RN01	2020-04-29 11:12:58	4.7	-0.6
RN01	2020-04-30 11:19:11	4.8	-0.2
RN01	2020-05-07 04:42:01	4.1	-0.9
RN01	2020-05-07 07:41:03	4.9	-0.6
RN01	2020-05-07 08:45:35	4.7	-0.6
RN01	2020-05-08 04:17:17	4.8	-0.6
RN01	2020-05-08 04:28:03	3.3	-0.9
RN01	2020-05-11 05:17:29	4.7	-0.9
RN01	2020-05-11 05:33:56	5.0	-0.9
RN01	2020-05-16 08:23:51	2.9	-0.9
RN01	2020-05-16 13:31:37	4.8	-0.6
RN01	2020-05-17 14:51:31	4.8	-0.9
RN01	2020-05-19 16:52:16	4.7	-0.9
RN01	2020-05-20 08:01:07	4.9	-0.9
RN01	2020-05-27 20:17:27	5.3	-0.6
RN01	2020-05-27 20:17:35	5.2	-0.6
RN01	2020-05-27 21:30:52	5.2	-0.9
RN01	2020-05-28 08:44:35	5.2	-0.6
RN01	2020-05-28 19:04:26	4.9	-0.6
RN01	2020-06-01 12:21:43	4.9	-0.6
RN01	2020-06-01 23:51:28	5.6	-0.6
RN01	2020-06-02 10:07:40	4.9	-0.6
RN01	2020-06-02 12:17:55	4.8	-0.4
RN01	2020-06-07 07:17:34	5.0	-0.6
RN01	2020-06-12 20:39:30	5.0	-0.2
RN01	2020-06-12 21:33:54	5.1	-0.6
RN01	2020-06-12 21:34:04	5.2	-0.9
RN01	2020-06-13 03:49:11	4.9	-0.9
RN01	2020-06-13 04:38:52	5.0	-0.9
RN01	2020-06-13 04:41:28	10.5	-0.2
RN01	2020-06-16 15:29:24	5.3	-0.6
RN01	2020-06-18 11:47:04	4.5	-0.2
RN01	2020-06-18 13:09:27	4.5	-0.2
RN01	2020-06-20 10:29:36	4.7	-0.4
RN01	2020-06-27 02:03:36	4.9	-0.6
RN01	2020-06-30 10:35:15	4.5	-0.4
RN01	2020-06-30 10:55:28	5.0	-0.6
SG02	2019-07-13 02:48:08	2.9	-0.9
SG02	2019-07-13 02:51:51	3.3	-1.5
SG02	2019-07-21 19:59:50	10.4	0.2
SG02	2019-07-29 03:26:44	11.9	0.3
SG02	2019-08-04 22:36:15	3.0	-0.9
SG02	2019-08-05 04:37:52	2.8	-0.9
SG02	2019-08-05 04:49:00	2.9	-0.9
SG02	2019-08-05 05:41:45	2.7	-0.9
SG02	2019-08-05 11:13:17	2.9	-0.9
SG02	2019-09-06 05:31:34	0.7	-1.5
SG02	2019-09-20 04:51:47	6.4	-0.4
SG02	2019-10-02 05:01:37	8.5	0.0
SG02	2019-10-02 09:23:23	8.1	-0.2
SG02	2019-11-15 06:31:06	2.9	-1.5
SG02	2019-11-16 11:12:11	8.0	0.0
SG02	2019-12-03 13:45:56	2.9	-0.9
SG02	2019-12-20 08:21:22	6.5	-0.4
SG02	2019-12-28 13:51:25	12.0	0.2
SG02	2020-01-02 03:30:44	7.1	-0.4
SG02	2020-01-03 10:22:06	6.2	-0.4
SG02	2020-01-03 10:38:36	6.3	-0.4
SG02	2020-01-03 10:43:48	5.7	-0.4
SG02	2020-01-03 10:44:37	6.4	0.1
SG02	2020-01-14 09:39:21	8.2	0.0
SG02	2020-02-04 16:22:57	9.3	0.6
SG02	2020-02-12 01:38:14	7.9	-0.2
SG02	2020-03-05 23:17:48	11.2	0.1
SG02	2020-04-04 23:11:20	11.5	0.2
SG02	2020-04-27 20:57:06	8.3	0.0
SG02	2020-05-08 08:24:56	8.0	-0.2
SG02	2020-05-10 06:58:31	6.7	0.0
SG02	2020-05-10 16:56:53	8.4	-0.2
SG02	2020-05-10 16:57:00	8.4	-0.4
SG02	2020-05-11 08:23:15	7.7	-0.2

End of table