PROGRAM UPDATE — April through June 2018

These quarterly reports provide information on the TexNet seismic monitoring program and the Center for Integrated Seismicity Research (CISR). The information is intended to be a high-level summary of this complex project and is written for a broad audience with an interest in seismicity monitoring and research in Texas.

Network Installation and Operations

- The Bureau has increased the number of permanent TexNet broadband seismic stations to 25, which brings the TexNet "backbone" seismic network to 42.
- 33 portable TexNet seismic stations are currently deployed in areas of ongoing seismic activity, including the DFW area, northeast of Snyder, the Delaware Basin, and the Eagle Ford operating area.
- Using CISR funds, and in partnership with the New Mexico Bureau of Geology and Mineral Resources, 3 portable seismic stations are now deployed in the New Mexico portion of the Delaware Basin, in addition to the 33 stations already in TX. These additional sensors will improve earthquake detection- in Texas.
- Due to a recent increase in small magnitude seismicity in the Azle area, SMU deployed temporary station AZVM, located north of the former site of AZDA. Station information can be found at the IRIS Data Management Center.
- The Bureau is tracking the number of unique users that visit the TexNet Earthquake Catalog. The number of visits per month from April through June was 1037, 1165, 1082, respectively.

Synopsis of April-June 2018 Seismicity in Texas

- During April-June, TexNet reported 1651 earthquakes, 50% of which occurred in the Delaware Basin region. The remainder occurred northeast of Snyder, in the DFW area, and southeast of San Antonio. Of the 1651 events, 537 earthquakes, down to $M_L \geq 1.7$, are finalized and 763 are provisionally located.
- The highest local magnitude event of $M_L=3.6$ occurred in Johnson County, northwest of Venus.
- During April-June, the SMU seismic networks and catalog reported 144 earthquakes in North Texas. Of these, only 2 small magnitude (<ML1.0) earthquakes occurred in the Irving-Dallas area, and 3 earthquakes (all >M1.0) occurred in the Azle area, with the largest event being a M2.3. In northeast Johnson County, the Venus sequence generated a M3.6. That event had 71 aftershocks.

Partnerships

- The TexNet Seismology research team at the Bureau has initiated collaboration with the University of Texas at El Paso to monitor and study earthquakes in the region of Pecos, TX.

Research

- *Seismology*
  - The Bureau is currently correlating the 3D crustal velocity model covering north and west Texas, with geophysical measurements.
  - SMU implemented the matched filter method to detect over 3500 new events in Azle, TX, extending from 2013-present. This work deepens the catalog of small events available for the study of the evolution of seismicity at Azle.

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- In preparation for publication of the SMU North Texas earthquake catalog and network history, and for inclusion in the TexNet Historic Texas Seismicity catalog, all network data operations have been checked with IRIS, all earthquakes and associated phases in the catalog have been verified, velocity models have been updated and implemented, and all magnitudes have been updated.
  - UTIG and SMU are using data from the Lajitas seismic array to catalog earthquakes in the Permian Basin region and have completed automated event detection analysis during the 2000 through 2017 timeframe.
- *Geologic Characterization* (all Bureau)
  - Fluid injection and production data have been finalized and/or updated for the Fort Worth Basin, Eagle Ford operating area, and the Permian Basin region and are available upon request.
  - A preliminary integrated geological model and Petrel Geomodel of injection intervals in the Delaware Mountain Group in the Delaware Basin has been completed.
  - A new project to characterize the vertical stress in the Permian Basin region was initiated. This will be used to assess fault slip potential.
  - A new fault interpretation and tectonic map for the Delaware Basin region is in progress.
  - Construction of an integrated geological model of deep injection units in the Delaware Basin has been initiated.
- *Hydrogeologic and Geomechanical Analysis*
  - Construction of the Fort Worth Basin hydrogeologic model by the Bureau is complete and computations to estimate pore pressure evolution have begun.
  - Texas A&M researchers submitted the paper "Coupled Fluid Flow and Geomechanical Modeling of Seismicity in the Azle Area (North Texas)" to the SPE ATCE 2018 and have begun streamline-based pore pressure modeling of the Fort Worth Basin using a regional model provided by the Bureau.
  - A new project has been launched at the Bureau to model the pore pressure evolution of the Delaware Mountain Group in the Delaware Basin.
  - Work has started by UT-PGE to examine surface subsidence and subsurface stress change in the Delaware Basin due to oil and gas production, wastewater injection and water flooding, and shallow water withdrawal. Modeling will examine how these geomechanical changes might influence seismicity. Modifications have been made to the fluid injection-seismicity simulator to run the simulations more efficiently, so that larger problems and longer time periods can be examined. A publication has been accepted for the SPE ATCE 2018.
- *Seismic Hazard and Risk*
  - A 1-km deep Vs profile at station PB02 in Pecos was developed via active ground shaking and ambient noise testing. A field campaign to collect active- and passive-source surface wave data at 9 other sites in West Texas was completed and data processing was initiated.
  - An approach is being developed to statistically relate injection rates to seismicity rates and to quantify the statistical confidence in that relationship. This approach was presented in a poster at the 11th National Conference on Earthquake Engineering in Los Angeles in June.
  - Kurkowski completed his MS thesis, which included development/validation of computational models to simulate seismic damage to brick veneers commonly employed in residential construction in Texas and application of these computational models to develop seismic fragility functions.

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Outreach

- Training on the Earthquake Management System used by TexNet took place June 25-29, at the Bureau.
- Savvaidis presented the TexNet and TexNet-CISR Seismology Research programs and results at the
  - SSA Annual meeting, May 14-17, 2018 in Miami, FL
  - GEESDV meeting, June 10-13, 2018 in Austin, TX
- Hennings and Savvaidis presented the TexNet and TexNet-CISR Research programs at the 2018 AAPG SW Convention in El Paso, TX.
- Hennings presented the TexNet and TexNet-CISR Research programs to the Texas Alliance of Energy Producers at their 2018 Regulatory Seminar in Wichita Falls, TX.
- Hennings presented "Development of a Deterministic Seismicity Potential Assessment of the Fort Worth Basin" at the 2018 AAPG ACE in Salt Lake City, UT.
- Rathje presented a Keynote Lecture entitled, "Seismicity in Texas: Action, Reaction, and Proaction" at the ASCE Geotechnical Earthquake Engineering and Soil Dynamics conference, which was held June 10-13, 2018 in Austin, TX.
- The 2Q:2018 TexNet Technical Advisory Committee meeting was conducted by conference call on June 14, 2018.

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