Oklahoma Geological Survey

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The Prague, Oklahoma, earthquake sequence of 2011, along the Wilzetta Fault zone, included a significant foreshock, a main shock of magnitude 5.7 and numerous aftershocks. It has been suggested that this sequence represents earthquakes triggered by fluid injection. The Oklahoma Geological Survey (OGS) has been working with the Oklahoma Corporation Commission (OCC) to analyze data related to the 2011 Prague sequence, and recently the U.S. Environmental Protection Agency (EPA) has participated in reservoir pressure analysis of the formations into which water is being injected. Based on analysis of earthquake seismology, 3-D reflection seismology, geologic mapping, formation pressure data, and historical Oklahoma earthquake data, the OGS offers the following observations and conclusions:

Observations:

- Relatively large, natural earthquakes occur in Oklahoma, and the U.S. Geological Survey seismic hazard map shows that the seismic hazard for the Prague/Wilzetta area was finite (not zero) prior to the Prague sequence.
- Oklahoma has experienced more than ten magnitude 4.0 or greater earthquakes since the magnitude 5.0+ El Reno earthquake of 1952. This is statistically consistent with the Gutenberg-Richter relationship, which describes the distribution of earthquakes of differing magnitude over time.
- Earthquakes in the Prague area have followed the normal Omori Law aftershock time-decay that is typical of natural seismicity.
- The earthquakes occurred on a segment of the Wilzetta Fault that is favorably oriented for earthquakes to occur as a result of the predominant crustal stress regime in Oklahoma.
- Water injection began in the Prague/Wilzetta area in 1955, increased until 2004-2005 and has remained relatively constant since then. Some researchers have observed that the earthquake activity did not increase over time as injection increased, but rather occurred in a distinct “swarm” more typical of a natural event.
- 3-D seismic recently made available demonstrates an alternative interpretation to the premise of a fault-bounded block, which is the closed compartment postulated by some researchers that would result in increased fluid pressures due to water injection. The 3-D seismic data shows that the local geological structure is not fault-bounded on all sides, which further suggests that water injection is not being restricted.
- This alternative structural interpretation is supported by recent, direct pressure measurements of the geologic formations where water injection activities are being conducted. Measurements, undertaken by the OCC, and reviewed by the EPA, show that the Hunton Formation is in fact under-pressured. Initial results from a separate test in the area of interest indicate that the Arbuckle Formation is also under-pressured.

Conclusions:

- The interpretation that best fits current data is that the Prague Earthquake Sequence was the result of natural causes.
- The Prague Earthquake Sequence, as well as other current and historically active seismic areas in Oklahoma, would benefit from further study, including improved earthquake monitoring and acquisition of formation pressure data.
- Further studies of seismic activity in Oklahoma will result in a better understanding of seismicity statewide.