EARTHQUAKE!

Oklahoma is one of the most tremor-prone areas in the country, and when the quakes occur, OGS scientists can tell you exactly where and how strong they are.

By Debra Levy Martinelli

Mythology is replete with explanations for how and why earthquakes occur.

Greek lore holds that when Poseidon, the god of the sea, was in a bad mood, he would strike the ground with a trident, causing earthquakes and other calamities. He also used earthquakes to punish and inflict fear upon people as revenge.

In Norse mythology, Loki, the god of mischief and strife, was punished for murdering the god of beauty and light by being bound in a cave with a poisonous serpent placed above his head dripping venom. Loki's wife stood by him with a bowl to catch the poison, but whenever she had to empty the bowl, the poison would drip on Loki's face, forcing him to jerk his head away and flail against his bonds, causing the earth to tremble.

An old Siberian legend postulates that the Earth rests on a sled driven by a god named Tuli and pulled by a team of dogs who have fleas. When the dogs stop to scratch, the Earth shakes.

In 2011, science tells us that earthquakes occur in response to forces that build up over long periods of time when two bodies of rock slide past each other. A large earthquake produces slips measured in tens of meters (the March 11 earthquake in Japan, for example, had displacements as large as three meters); a small one can produce a quake with displacements as tiny as a millimeter.

Oklahoma has had—and continues to have—its share of earthquakes. The earliest documented tremor occurred prior to statehood on October 22, 1882, near Fort Gibson. The state's largest recorded earthquake, a 5.5 magnitude near El Reno on April 9, 1952, caused damage to the State Capitol Building in Oklahoma City and was felt as far away as Austin, Texas, and Des Moines, Iowa.

The second largest, with an epicenter approximately five miles east of Norman, occurred at 9:06 a.m. on October 13, 2010. With a magnitude of 4.7, the tremor was felt as far north as Kansas City and as far south as Dallas.

At the Oklahoma Geological Survey, housed in the basement of OU's Sarkeys Energy Center, research seismologist Austin Holland was working nonstop, assimilating and analyzing data and fielding a barrage of media inquiries. On that sunny fall morning, he patiently and repeatedly explained the what, when, where, why and how in terms an anxious public could readily understand.

Earthquakes are assessed based upon data collected at seismic stations, each of which is equipped with a seismometer (also known as a seismograph) that records ground motion as seismic waves go by. The OGS currently has nine seismic stations deployed around the state.

"The wave signal is converted into data we can shoot through the air via modem or satellite and receive into our central recording computers," explains Holland. "We analyze that data and make some assumptions to determine how much energy was released in the earthquake to arrive at the magnitude number."

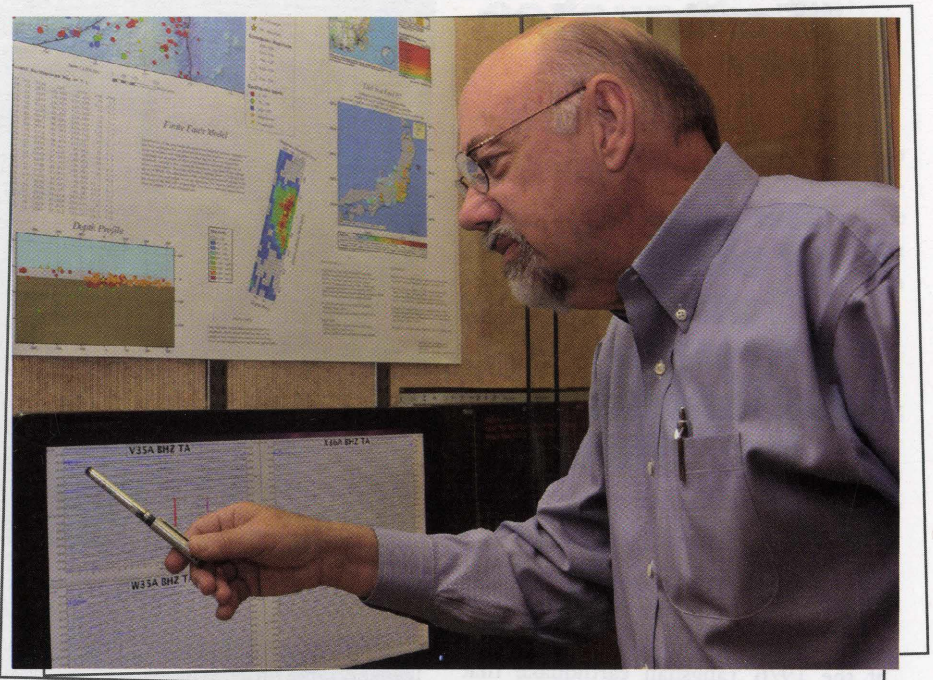
Pointing to a United States Geological Survey map of earthquake hazard areas in the continental United States, Holland shows that the West Coast, the New Madrid Fault in the Mississippi Valley and the Charleston, South Carolina, vicinity are the most active. "The next brightest spot on the map is Oklahoma. We're No. 2 in the mid-continent area and No. 4 or 5 in all of the lower 48 states," he explains.

The OGS began running seismograph stations in Oklahoma in partnership with volunteers in 1961. The OGS Observatory in rural Tulsa County south of Leonard is part of a national network of state-of-the-art seismic observatories. The comprehensive geophysical observatory records the state's earthquakes, as well as those with magnitudes of 5.5 or greater anywhere in the world.

The OGS has recorded and located more than 2,500 earthquakes in the state since 1977. Until recently, the most recorded in a single year was 167 in 1995. In 2009, there were 43 felt earthquakes, 27 of which occurred in Oklahoma County. Many smaller ones also were recorded that year.

The trend continued in 2010. On January 15, two earthquakes nine minutes apart rocked eastern Oklahoma County near Jones. They measured 4.0 and 3.8 magnitude, respectively.

As fate would have it, OGS Director



Robert Taylor

Oklahoma Geological Survey Director Randy Keller, an internationally renowned geophysicist, examines recent earthquake activity recorded in Oklahoma and displayed in Sarkeys Energy Center. Such activity in the state and around the world is recorded daily by OGS.

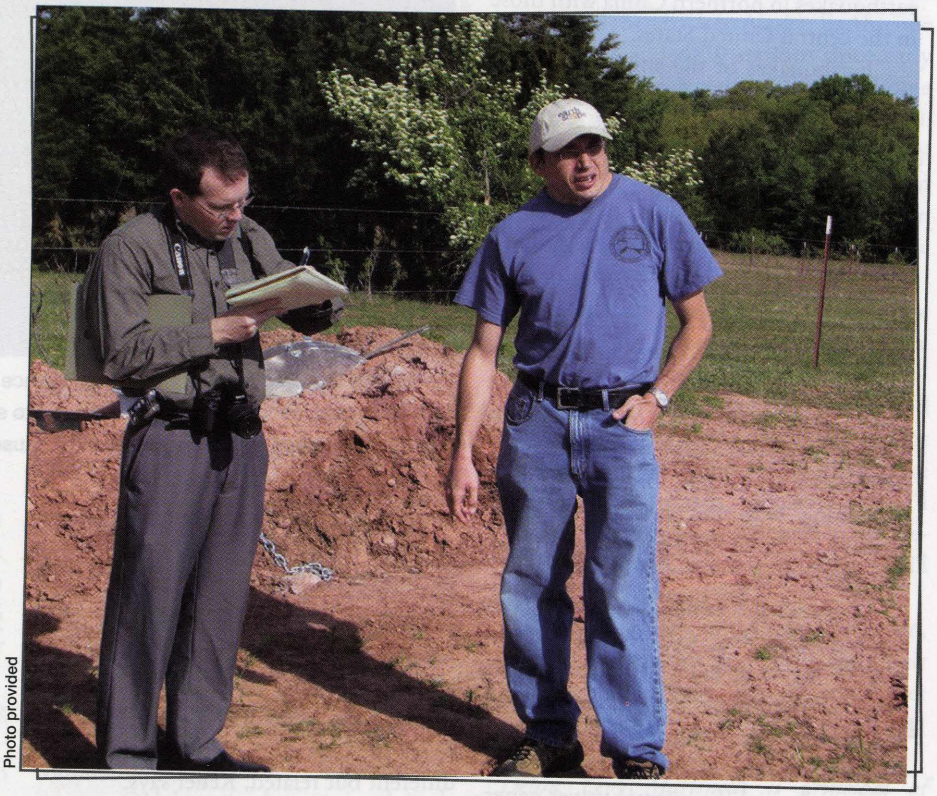
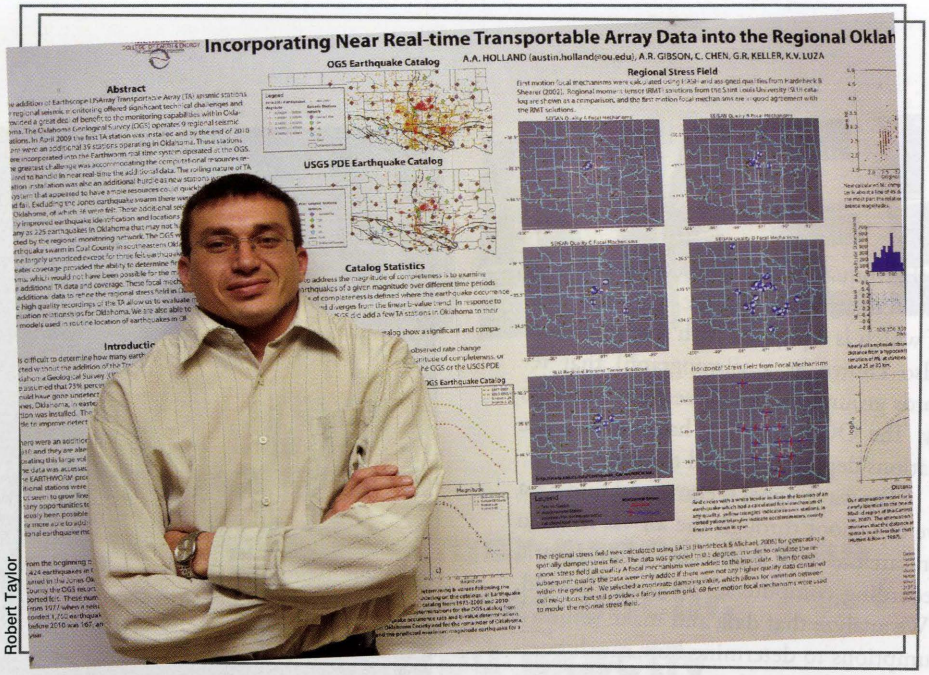


Photo provided

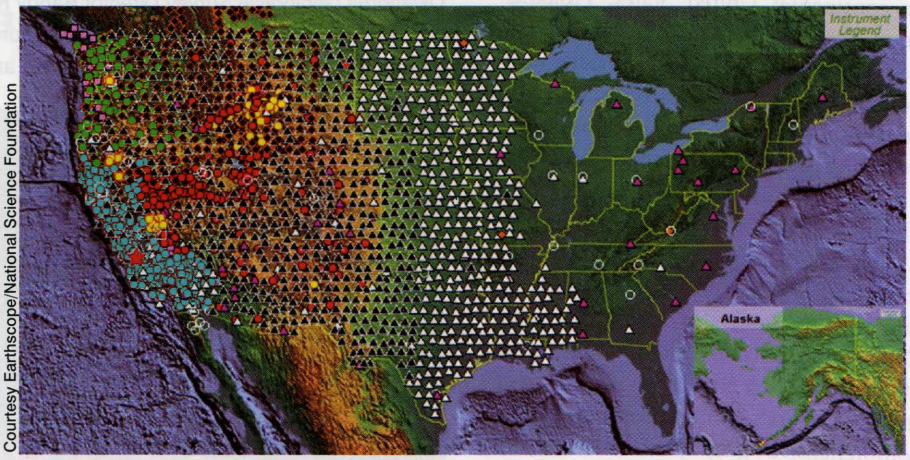
OGS's Austin Holland, right, answers a reporter's question at the installation of a seismograph in a field near Jones, Oklahoma.

"Earthquakes of the size of the Jones events have the potential of occurring almost anywhere in Oklahoma at any time"



Robert Taylor

The poster shown here with OGS research seismologist Austin Holland was presented in April at the Seismological Society of America meeting, displaying charts and figures of new research on Oklahoma earthquakes from data gathered by the Earthscope Transportable Array Stations.



Courtesy Earthscope/National Science Foundation

Earthscope is a program of the National Science Foundation that deploys thousands of seismic, GPS and other geophysical instruments to study the structure and evolution of the North American continent and the processes that cause earthquakes and volcanic eruptions.

Randy Keller, an internationally renowned geophysicist, and a group of OU students were in China when the Jones quakes occurred, studying the location of the 1976 Tangshan earthquake that claimed an estimated half million lives. The project was part of a National Science Foundation grant aimed at comparing earthquakes in northern China with those in the central United States.

"Earthquakes of the size of the Jones events have the potential of occurring almost anywhere in Oklahoma at any time," Keller says. "On average, about 50 measurable earthquakes occur each year in Oklahoma, with only a few strong enough to be felt."

For Holland, who had been on the job just more than a week, it was his first experience as the OGS's media point person for earthquake information. "I didn't realize there are so many news outlets in Oklahoma. It was a little overwhelming," he recalls with a smile. "I'm accustomed to talking with the media, but since January 15, it has been on average of once or twice a week."

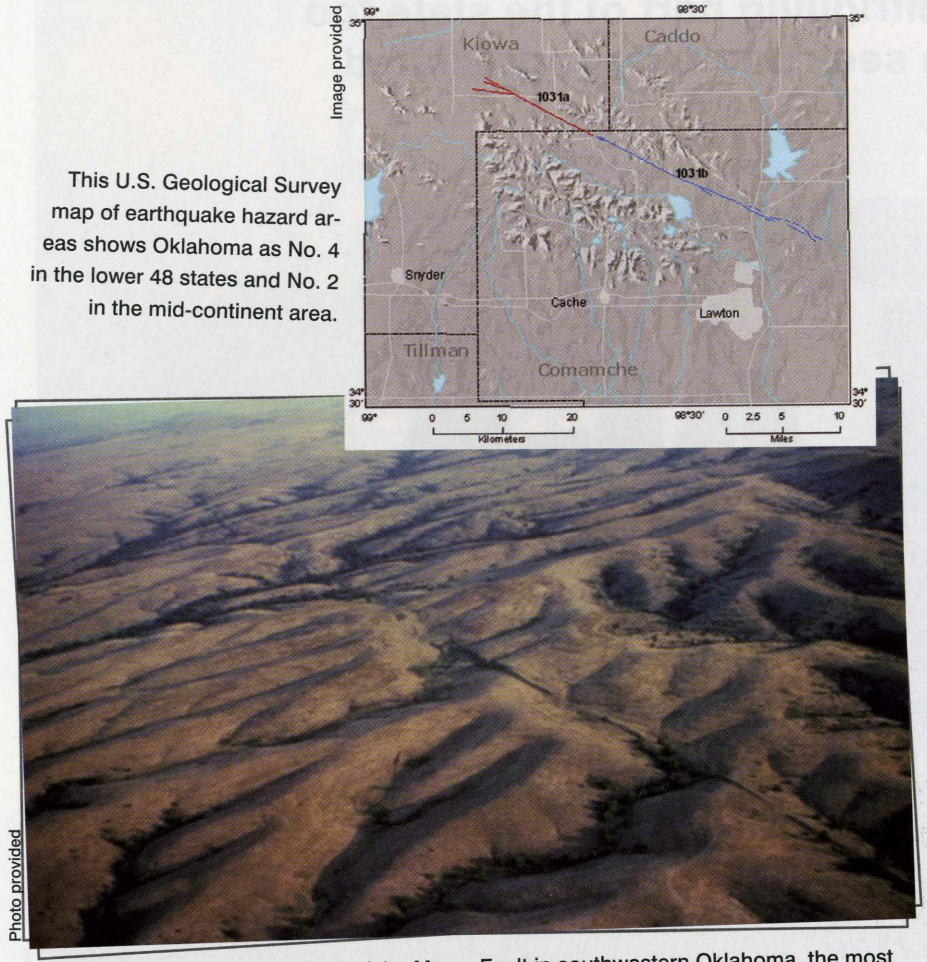
One message Holland always tries to drive home is that there is not just one way to arrive at a magnitude, which is why those numbers vary among recording agencies. "Arriving at a magnitude involves recording the actual rupture of the earthquake and the seismic waves generated by that rupture that get transmitted and using certain tools to evaluate that information. There are many ways to do that," he explains.

The methods used by both the USGS and the OGS are among a handful of scientifically accepted magnitude measurement standards. The Surface Wave Magnitude standard adopted by the OGS also is used by the USGS for the first magnitude measurement it assigns. The relatively few standard methods are slightly different but related, Keller says.

On October 13, 2010, the USGS estimated the Norman earthquake at a 4.3 magnitude. The OGS's initial estimate was 5.1, which later was revised to 4.7.

"The 4.7 number, which measures amplitude of the surface quake, was fairly consistent among seismic stations in the state. But there always are going to be differences in magnitude estimates," explains Keller. "At the OGS, we track all of the magnitudes issued, which can help us as we move forward."

The depth of an earthquake correlates to the extent of damage on the Earth's surface. Typically, the closer a quake's epicenter is to the surface, the more shaking



This U.S. Geological Survey map of earthquake hazard areas shows Oklahoma as No. 4 in the lower 48 states and No. 2 in the mid-continent area.

An aerial photo shows the track of the Meers Fault in southwestern Oklahoma, the most famous fault east of the Rocky Mountains.

it can cause. The October 13 earthquake measured eight miles below the surface, which, in earthquake terms, is still fairly shallow. Only two minor injuries were reported as a result.

"There are lots of nuances in measuring and analyzing earthquakes," Holland relates. "I want people to understand that there is no single reason for magnitude estimates, so they shouldn't get hung up on them," he says, adding that the OGS website contains a prominent disclaimer to that effect.

Keller likens the physics of measuring earthquakes to that of measuring tornadoes. "For a tornado, the scale is based on wind speed. For earthquakes, it's the release of stress in the earth," he explains. "Neither method results in perfect measures. But it's even more difficult to observe the deep earth than the atmosphere."

In terms of geological faults, Oklahoma does not have anything close to, say, the San Andreas Fault in California. In fact, none of Oklahoma's faults are considered to be major. But there are so many known faults of varying size throughout the state that if all of them were to be drawn on a map, many areas would be completely filled in. "There are too many to count," Holland says, "and we don't even know about all of them."

The state's largest—and, Keller says, the most famous east of the Rocky Mountains—is the Meers Fault in southwestern Oklahoma, where an earthquake 1,200 to 1,300 years ago ruptured to the surface, causing a three- to five-meter slip (3.28 to 5.46 yards).

"The Meers Fault is the only fault in Oklahoma that has any surface expression," he says. "It is so prominent it can be seen from the air. And it is large enough for water to seep in, allowing vegetation to grow."

The OGS constantly strives to provide the most precise earthquake information possible. Those efforts are being aided by Earthscope, a multi-year initiative of the National Science Foundation through which thousands of seismic, GPS and other geophysical instruments are being deployed to study the structure and evolution of the North American continent and the processes that cause earthquakes and volcanic eruptions. Through Earthscope, the OGS is "adopting" four new seismographic stations to complement its existing nine.

"Working eastward from the West Coast and then back to Alaska, Earthscope already has added 39 stations since early 2009," Holland explains. "The Oklahoma stations were installed by the end of 2010. There is an array of 400 stations leapfrogging across country, from the southern coast to the Canadian border and then into Alaska. Each station will stay in place for about two years."

Holland and Keller will make good use of the valuable information the Earthscope stations will provide. "Our goal is to learn as much as possible about earthquakes and earthquake processes in Oklahoma so that we can understand and reduce earthquake risks to Oklahomans," Holland says. "I don't think prediction will come in my lifetime, but increasing that knowledge will help us move toward prediction."

Probably not something Poseidon, Loki or Tuli and his dogs, even with their considerable mythical powers, could ever have accomplished.

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