Table 2. Modified Mercalli (MM) Earthquake-Intensity Scale (modified from Wood and Neumann, 1931)

I	Not felt except by a very few under especially favorable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings. Automobiles may rock slightly.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, doors, windows disturbed. Automobiles rocked noticeably.
V	Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all; many frightened and run outdoors.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction. Shock noticed by persons driving automobiles.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings; great in poorly built structures. Fall of chimneys, stacks, columns. Persons driving automobiles disturbed.
IX	Damage considerable even in specially designed structures; well-designed frame structures thrown out of plumb. Buildings shifted off foundations. Ground cracked conspicuously.
X	Some well-built wooden structures destroyed; ground badly cracked, rails bent. Landslides and shifting of sand and mud.
XI	Few if any (masonry) structures remain standing. Broad fissures in ground.
XII	Damage total. Waves seen on ground surfaces.

EXPLANATION

- ★ ACO — Semipermanent field station: includes station abbreviation
- ▲ FNO — Radio telemetry seismograph station; includes station abbreviation
- ⊙ TUL/LNO — Oklahoma Geophysical Observatory; includes station abbreviations
- ■ WMOK — United States Geological Survey field station; includes station abbreviation
- × Earthquake epicenter (1897-2002)
- Major fault and/or fault zone

Table 3. Oklahoma Earthquakes with Magnitudes ≥4.0

Date	Origin time (UTC)[a]	County	Nearest town	Intensity MM[b]	Magnitudes[c] 3Hz	bLg	DUR	Lat. °N	Long. °W
1952 Apr 09	1629 15	Canadian	El Reno	VII		5.0[d]		35.4	97.8
1939 Jun 01	0730	Hughes	Spalding	IV		4.4		35.0	96.4
1997 Sep 06	2338 01.99	Coal	Stonewall	VII		4.4	3.7	34.676	96.499
1926 Jun 20	1420	Sequoyah	W Marble City	V		4.3		35.6	94.9
1959 Jun 17	1027 07	Comanche	NE Faxon	VI		4.2		34.5	98.5
1995 Jan 18	1551 39.90	Garvin	Antioch	VI	4.1	4.2		34.712	97.542
1998 Apr 28	1413 01.27	Comanche	NW Richards Spur	VI		4.2		34.809	98.402
1956 Oct 30	1036 21	Rogers	Catoosa	VII		4.1		36.2	95.8
1961 Apr 27	0730	Latimer	Wilburton	V		4.1		34.9	95.3
1929 Dec 28	0030	Canadian	El Reno	VI		4.0		35.5	98.0
1959 Jun 15	1245	Pontotoc	Ada	V		4.0		34.8	96.7
1990 Nov 15	1144 41.63	Garvin	Lindsay	VI	4.0	3.9	3.0	34.761	97.550

[a]UTC refers to Coordinated Universal Time, formerly Greenwich Mean Time. The first two digits refer to the hour on a 24-hour clock. The next two digits refer to the minute, and the remaining digits are the second. To convert to local Central Standard Time, subtract 6 hours.

[b]Modified Mercali (MM) earthquake-intensity scale.

[c]Magnitude is a measure of earthquake size, determined by taking the common logarithm (base 10) of the largest ground motion recorded during the arrival of a seismic-wave type and applying a standard correction for distance to the epicenter. Three magnitude types—mbLg (similar to Richter magnitude), m3Hz, and mDUR—are used by the OGS to determine the size of Oklahoma earthquakes (Lawson and Luza, 1995).

[d]The El Reno earthquake had a Gutenberg-Richter magnitude (mb) of 5.5.

EARTHQUAKES OF OKLAHOMA

Kenneth V. Luza, Oklahoma Geological Survey

In Oklahoma, ground motion due to earthquakes is recorded at 10 widely separated locations. The main recording and research facility, station TUL, is near Leonard, Oklahoma, in Tulsa County. About 50 minor earthquakes are located in Oklahoma each year, but only one or two typically are felt. Before 1962, only 59 Oklahoma earthquakes were known either from historical accounts or from seismograph stations in other states. The first seismographs were installed in 1961. From 1962 through 1976, 70 earthquakes were added to the earthquake data base. By 1977, 9 seismograph stations throughout Oklahoma were detecting and locating earthquakes. Over 1,550 earthquakes were located in Oklahoma from 1977 through 2002.

Earthquake Size

The most common ways to express the size of earthquakes are by their intensity and magnitude. The intensity, reported on the Modified Mercalli (MM) Scale, is a subjective measure based on eyewitness accounts (Table 2). Intensities are rated on a 12-level scale ranging from barely perceptible (I) to total destruction (XII). The scale is used to evaluate the size of historical earthquakes. Earthquake magnitude is related to the seismic energy released at the hypocenter, and based on the amplitude of earthquake waves recorded on instruments that have a common calibration. To determine the size of earthquakes, the Oklahoma Geological Survey uses three magnitude types: mbLg (similar to Richter magnitude), m3Hz, and mDUR (Lawson and Luza, 1995).

Historical Earthquakes

The New Madrid, Missouri, earthquakes of 1811 and 1812 probably are the earliest historical earthquake tremors felt in present-day southeast Oklahoma. Prior to statehood, the earliest documented earthquake epicenter in Oklahoma was on October 22, 1882. The earthquake, although it cannot be located precisely, produced MM VIII intensity effects near Fort Gibson, Indian Territory. The earliest documented locatable earthquake occurred near Jefferson in Grant County on December 2, 1897 (Stover and others, 1981).

On April 9, 1952, the largest known Oklahoma earthquake (with the possible exception of the 1882 Fort Gibson earthquake) occurred near El Reno in Canadian County (Table 3). The magnitude-5.5 earthquake caused a 50-ft-long crack in the State Capitol Office Building in Oklahoma City, and was also felt in Austin, Texas, and Des Moines, Iowa. The earthquake was felt in an area of 140,000 square miles, and produced MM VII–IX intensity effects near the epicenter.

Earthquake Distribution

Typical Oklahoma earthquake magnitudes range from 1.8 to 2.5, with shallow focal depths (less than 3 miles). Earthquakes have occurred in 72 Oklahoma counties; Washington, Nowata, Craig, Adair, and Jackson Counties have had no known earthquakes. Over 880 earthquake events have occurred in the Anadarko Basin since 1897. The majority are concentrated in a 25- by 37-mile area nearly parallel to a deep, subsurface fault zone in west McClain and Garvin Counties and southeast Grady County. Over 90% of the earthquakes in this zone have occurred since 1977. The apparent increase in seismic activity is due, in part, to improved earthquake detection. Only a few earthquakes have occurred in the shelf and deeper portions of the basin.

Before 1976, over half of Oklahoma earthquakes were located in Canadian County; most occurred in the El Reno vicinity, which also is the site of numerous earthquakes since 1908. Canadian County still experiences small-magnitude earthquakes each year. Another principal area of seismic activity is in Love, Carter, and Jefferson Counties. The first reported earthquake there occurred in 1974; several small earthquakes have been felt in the region since then. The Arkoma Basin in southeast Oklahoma is also seismically active. About 90% of all earthquakes there were located with seismometers. Typical magnitudes are less than 2.5.