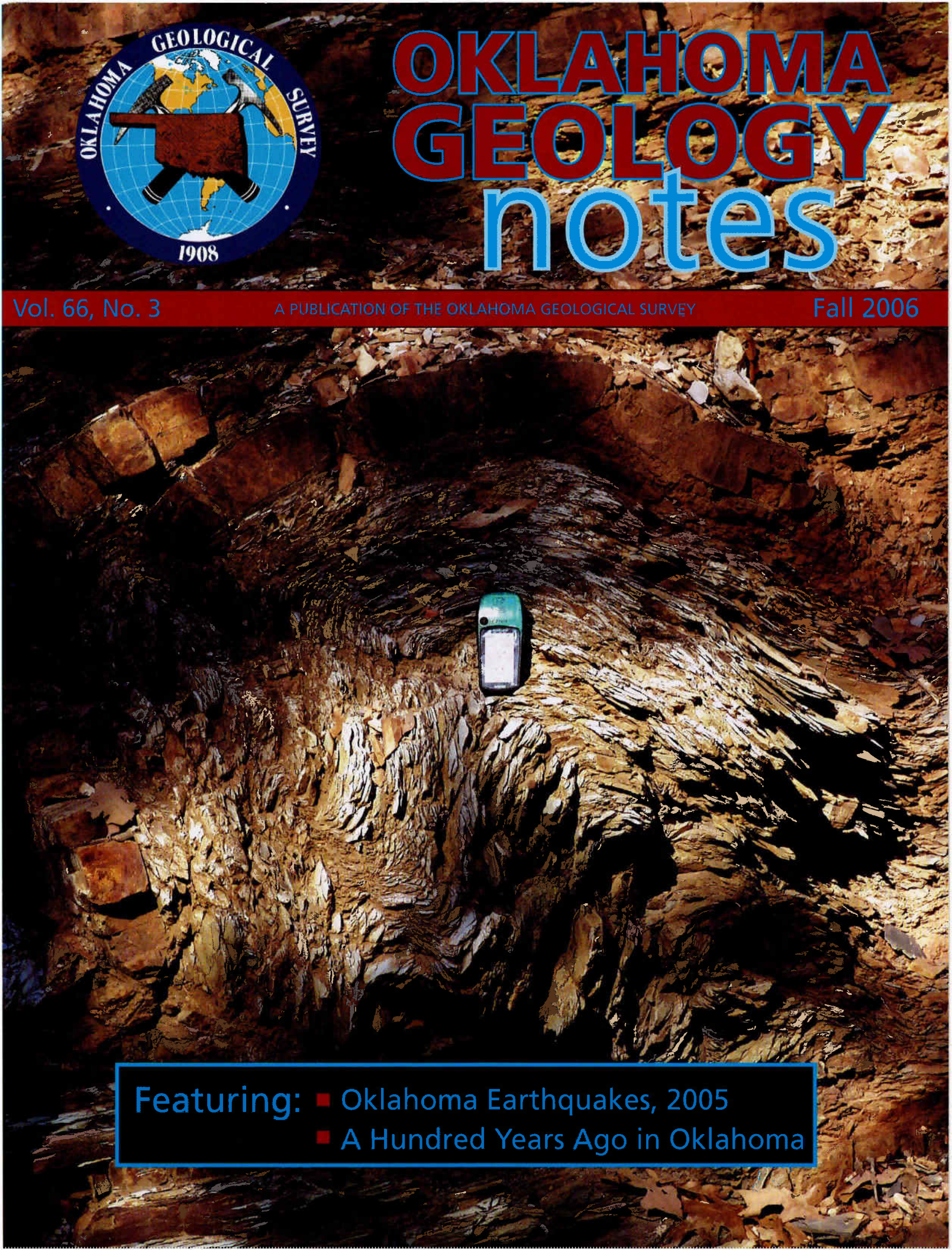
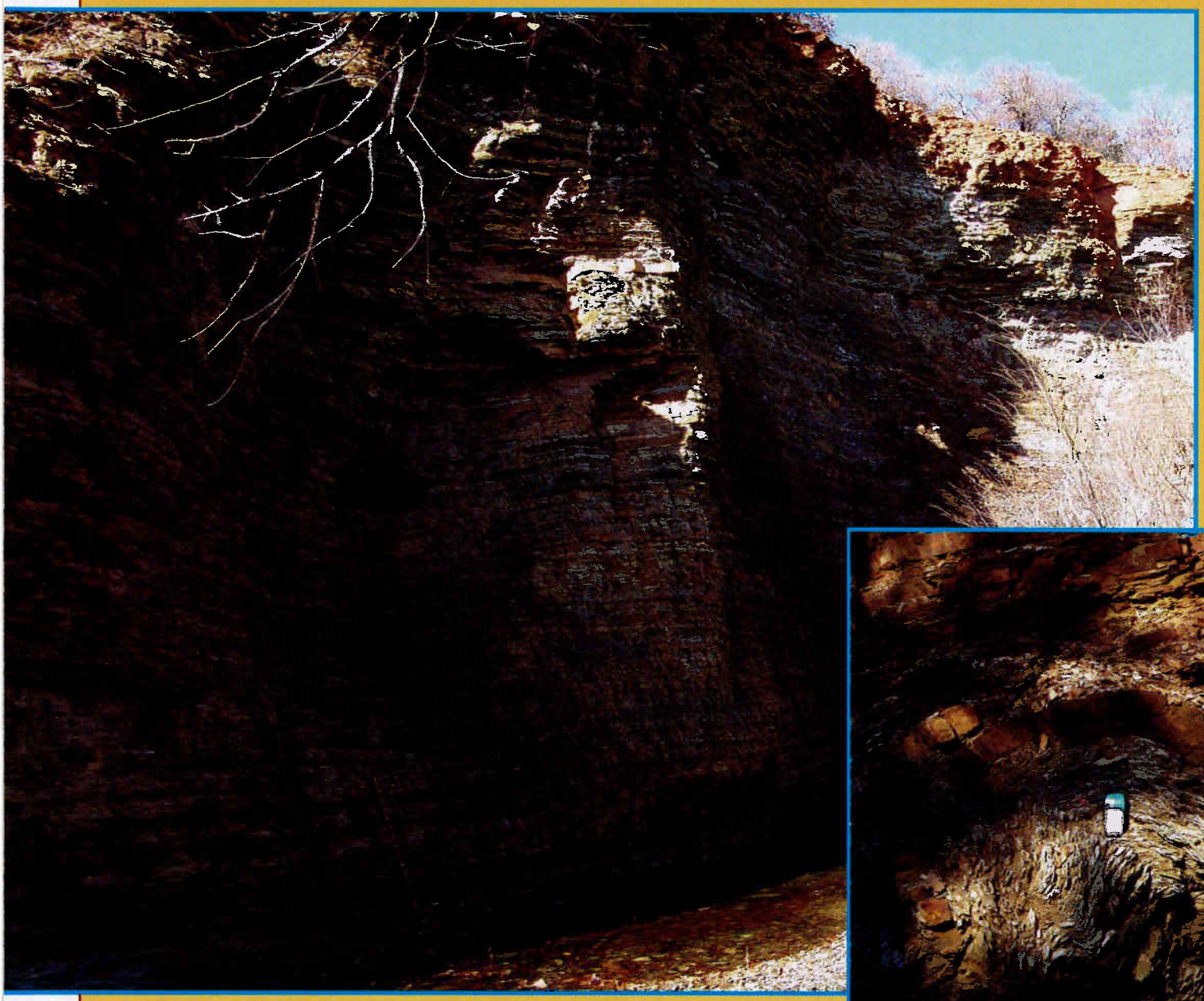


OKLAHOMA GEOLOGY notes

Vol. 66, No. 3 A PUBLICATION OF THE OKLAHOMA GEOLOGICAL SURVEY Fall 2006

Featuring:
- Oklahoma Earthquakes, 2005
- A Hundred Years Ago in Oklahoma

—On the Cover



Woodford Shale — Exposure of Woodford Shale in the Arbuckle Mountains. In the wake of the financial success associated with production of natural gas from the Barnett Shale in Texas (Fort Worth Basin), eyes are looking northward to the natural-gas potential of the Upper Devonian - Lower Mississippian Woodford (Chattanooga) Shale of Oklahoma. The main image shows a natural high wall of the Woodford. The bank-forming resistance of the Woodford is related to the siliceous nature of the shale, a characteristic that also influences the susceptibility of the formation to fracturing (rod in photo left of inset is 1.5m in length). The inset (see front cover) shows complex folding and faulting associated with lateral shortening in the Woodford. The feature is located near the basal contact of the Woodford with underlying Hunton Group carbonates (note GPS for scale).

Photos by Stanley T. Paxton, U.S. Geological Survey

OKLAHOMA GEOLOGY NOTES, ISSN 0030-1736, is published quarterly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, abstracts, notices of new publications, and announcements of general pertinence to Oklahoma geology. Single copies, $1.50; yearly subscription, $6. Send subscription orders to the Oklahoma Geological Survey at 100 E. Boyd, Room N-131, Norman, OK 73019.

EDITORIAL MATTER: Short articles on aspects of Oklahoma geology are welcome from contributors; please direct questions or requests for general guidelines to the *NOTES* editor at the address above.

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OKLAHOMA GEOLOGY notes

Vol. 66, No. 3 Fall 2006

Publication Date: June, 2007

—from the Director....

Recent Oklahoma Earthquake Activities

The Oklahoma Geological Survey has been examining data collected from a number of recent small earthquakes in the Midwest City/Del City area. Most of these events have magnitudes less than 2.0 on the Richter scale. The Oklahoma Geological Survey does not have adequate instrumentation to determine the depths and precise locations of these events. Their magnitudes and associated sonic booms suggest that the origins of the earthquakes occur at shallow depths.

There is speculation that some of these events may be related to the production of large volumes of fluids being produced for crude oil and the corresponding re-injection of the brines into deep formations. At present, there are no data to support that theory. The fact that the brine is being injected under a vacuum suggests that that theory is less plausible. Also, if the locations of the epicenters are correctly plotted, then the events to date are some distance away from the petroleum operation. However, the data at present are inadequate to arrive at a conclusion concerning the petroleum operation.

The Oklahoma Geological Survey continues to examine the situation. Additional equipment located in the vicinity of the petroleum operation will be used to obtain more accurate epicenter locations and related information under the assumption that additional events will occur in this area.

The Oklahoma Geological Survey is dedicated to developing a clear and accurate analysis of the geology of Oklahoma. We welcome any and all comments from the public on this or any other geological issue.

Charles J. Mankin
Director, Oklahoma Geological Survey

OKLAHOMA GEOLOGICAL SURVEY OBSERVATORY
OKLAHOMA EARTHQUAKE CATALOG 2007

DATE (UTC)			TIME (UTC)			COUNTY	ST	MM	MAGNITUDES		LATITUDE	LONGITUDE	DEPTH	SM
YYYY	MMM	DD	HH	MM	SS.SS				3Hz	bLg	DUR	deg (N)	deg (W)	km	
2007	JAN	08	21	46	02.91	COAL	OK		3		2.5	34.536	-96.429	5.00R	OC
2007	JAN	09	08	25	02.71	JEFFERSON	OK				2.2	34.033	-97.643	5.00R	OC
2007	JAN	09	10	32	40,68	JEFFERSON	OK				2.1	34.133	-97.836	5.00R	OC
2007	JAN	15	11	16	34.20	CADDO	OK				2.5	34.864	-98.328	5.00R	OC
2007	FEB	11	14	09	05.3		OK		F		1.8	35	-97		
2007	FEB	12	18	32	34.35	CLEVELAND	OK		F		3.0	35.215	-97.271	5.00R	OC
2007	FEB	18	18	29	35.90	JEFFERSON	OK				2.0	33.999	-97.607	5.00R	OC
2007	MAR	13	11	11	28.27	COAL	OK				2.0	34.679	-96.155	5.00R	OC
2007	**MAR**	**14**	**15**	**54**	**23.59**	**ATOKA**	**OK**				**2.3**	**34.245**	**-96.147**	**5.00R**	**OC**

Oklahoma Earthquakes, 2005

James E. Lawson Jr.
Oklahoma Geological Survey Observatory, Leonard

Kenneth V. Luza
Oklahoma Geological Survey

INTRODUCTION

More than 930,000 earthquakes occur throughout the world each year (Tarbuck and Lutgens, 1990). Approximately 95% of these earthquakes have a magnitude of <2.5 and usually are not felt by humans (Table 1). Only 20 earthquakes, on average, exceed a magnitude of 7.0 each year. An earthquake that exceeds a magnitude of 7.0 is considered to be a major earthquake and serious damage could result. (See the Catalog section, below, for a discussion of earthquake magnitude.)

Earthquakes tend to occur in belts or zones. For example, narrow belts of earthquake epicenters coincide with oceanic ridges where plates separate, such as in the mid-Atlantic and eastern Pacific Oceans. Earthquakes also occur where plates collide and/or slide past each other. Although most earthquakes originate at plate boundaries, a small percentage occurs within plates. The New Madrid (Missouri) earthquakes of 1811-12 are examples of large and destructive intraplate earthquakes in the United States.

The New Madrid earthquakes of 1811-12 were probably the earliest historical earthquake tremors felt in what is now southeastern Oklahoma (then part of Arkansas Territory). Before Oklahoma became a state, the earliest documented earthquake occurred on October 22, 1882, probably near Fort Gibson, Indian Territory, although it cannot be located precisely (Ross, 1882; Indian Pioneer Papers, date unknown). The Cherokee Advocate newspaper reported that at Fort Gibson "the trembling and vibrating were so severe as to cause doors and window shutters to open and shut, hogs in pens to fall and squeal, poultry to run and hide, the tops of weeds to dip, [and] cattle to lowe" (Ross, 1882, p. 1). These observations indicate Modified Mercalli (MM)-VIII intensity effects. (See the following section on Distribution of Oklahoma Earthquakes for information about the MM earthquake-intensity scale.) The next documented earthquake in Oklahoma occurred near Jefferson, Grant County, on December 2, 1897 (Stover and others, 1981). The next known Oklahoma earthquake happened near Cushing, Payne County, in December 1900. This event was followed in April 1901 by two additional earthquakes in the same area (Wells, 1975) at plate boundaries, a small percentage occurs within plates. The New Madrid (Missouri) earthquakes of 1811-12 are examples of large and destructive intraplate earthquakes in the United States.

The largest known Oklahoma earthquake (with the possible exception of the 1882 earthquake) occurred near El Reno, Canadian County, on April 9, 1952. This magnitude-5.5 (mb, Gutenberg-Richter) earthquake caused a 50-ft-long crack in the State Capitol Office Building in Oklahoma City. It was felt throughout Oklahoma and in parts of seven other states. The total felt area was about 362,000 km^2 (Docekal, 1970; Kalb, 1964; von Hake, 1976); Des Moines, Iowa, and Austin, Texas, were at the northern and southern limits. From 1897 through 2002, 1,697 earthquakes were located in Oklahoma.

INSTRUMENTATION

A statewide network of nine seismograph stations was used to locate 21 earthquakes in Oklahoma for 2005 (Fig. 1). The network consists of a central station (TUL/LNO), four radio-telemetry seismograph stations (FNO, RLO, SIO, VVO), and four field stations (ACO, MEO, OCO, PCO). The U.S. Geological Survey

TABLE 1. — ESTIMATED NUMBER OF WORLDWIDE EARTHQUAKES PER YEAR BY MAGNITUDE (Modified from Tarbuck and Lutgens, 1990)

MAGNITUDE	PER YEAR	ESTIMATED NUMBER EARTHQUAKE EFFECTS
<2.5	>900,000	Generally not felt, but recorded
		Minor to moderate earthquakes
2.5-5.4	30,000	Often felt, but only minor damage detected
		Moderate earthquakes
5.5-6.0	500	Slight damage to structures
		Moderate to major earthquakes
6.1-6.9	100	Can be destructive in populous regions
		Major earthquakes
7.0-7.9	20	Inflict serious damage if in populous regions
		Great earthquakes
≥8.0	1-2	Produce total destruction to nearby communities

(USGS) established a seismograph station, WMOK, 19 km southwest of the Oklahoma Geological Survey's (OGS) station at Meers (MEO). WMOK does not record continuously. When triggered by moderately strong ground motion, WMOK transmits a short segment of data to the National Earthquake Information Service in Golden, Colorado. WMOK is used mostly for distant earthquakes, although it sometimes records some of the larger Oklahoma earthquakes. Because WMOK is so near MEO, its arrival times do not improve the accuracy of location of Oklahoma earthquakes.

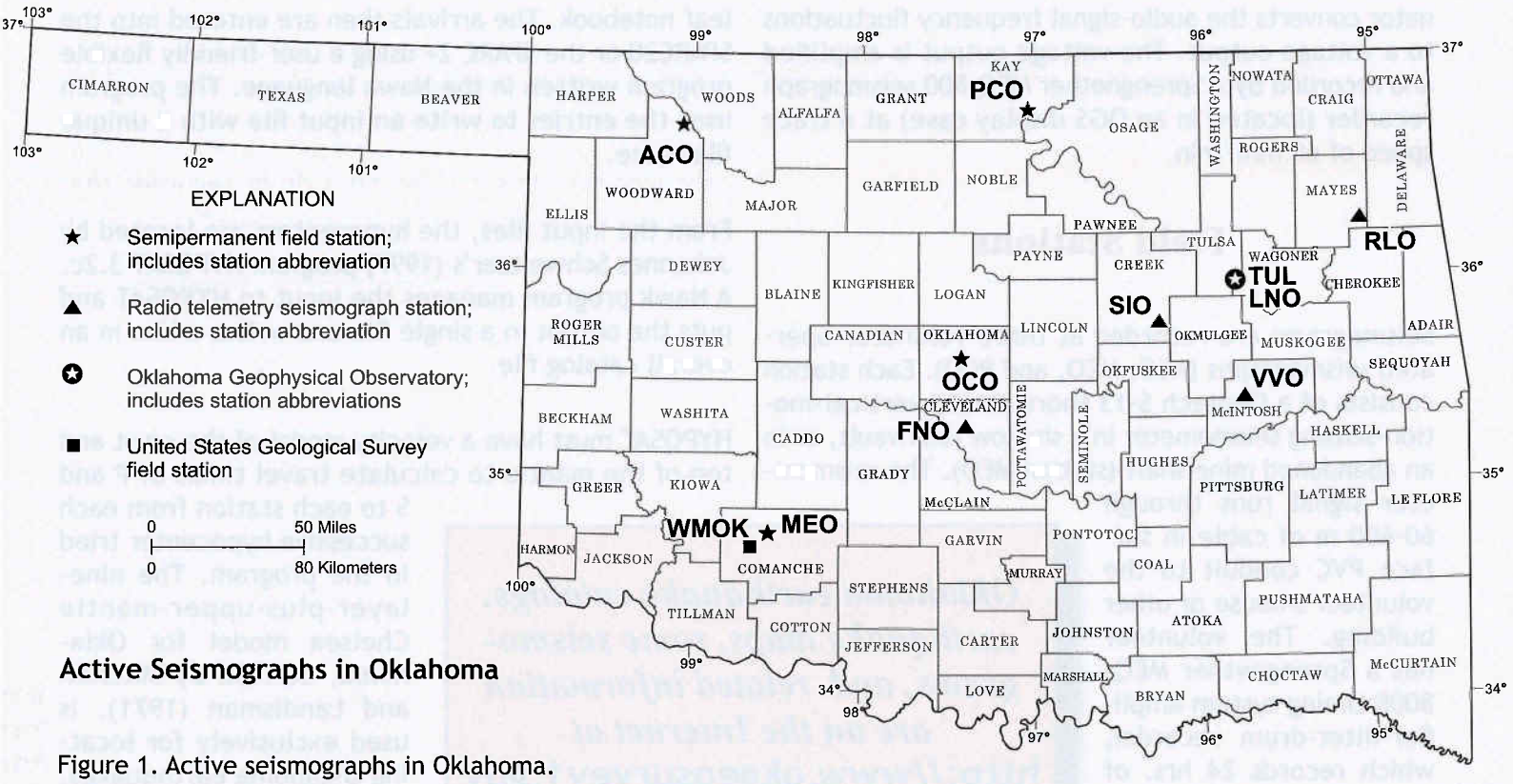
Central Station

The OGS Observatory station, TUL/LNO, is about 3.2 km south of Leonard, Oklahoma, in southeastern Tulsa County. At this site, digital and analog (paper) records from all stations are analyzed to detect, identify, and locate Oklahoma earthquakes. Seismometers at the central station are installed on a pier in a 4-m-deep underground walk-in vault, and in an 864-m-deep borehole. The vault is designated by the abbreviation TUL, and the borehole has the international station abbreviation, LNO. In the vault, three Baby Benioff seismometers and a 3-component Guralp CMG3-TD seismometer record vertical, north-south, and east-west ground motion. Each Baby Benioff seismometer produces signals recorded on a drum recorder that uses a heat stylus and heat sensitive paper. (The original drum recorders used light beams to record on photopaper. The drum recorders were converted to ink recording, and later to more reliable recording on heat sensitive paper.)

The Guralp CMG3-TD ultra-broadband seismometer senses everything from the solid earth tides with their mHz frequencies to the high frequencies of Oklahoma earthquakes, which may approach 100 Hz. The CMG3-TD seismometer has a Global Positioning System (GPS) time receiver and digitizers in the case. The three digitizers each produce 200 samples per second. The CMG3-TD in the vault is a temporary replacement for the similar borehole seismometer, which currently is being rebuilt under warranty at the Guralp factory in the United Kingdom. When the borehole seismometer is operating again, it will provide the 200-sample-per-second signals from the central station that are used to detect and locate earthquakes in Oklahoma.

A Guralp eight-channel rack digitizer records the remote stations (RLO, VVO, and SIO) at 200 samples per second. Data are digitized and recorded by Guralp SCREAM software running on a PC. These samples are assembled into time-tagged data-compressed packets and transmitted at 38,400 bits per second to the Guralp SCREAM data acquisition software. Guralp SCREAM software, which runs on a PC, uncompresses the packets, organizes them into one-hour files on a disk, and will display one or more windows containing one or several moving traces. The windows may contain as little as one second or as much as 24 hours of ground motion. All digital data are archived on writable CD-ROMs. About two new CDs are added each week.

SCREAM sends slower packets (20 samples per second, and four samples per second) to another PC running SCREAM, and to the University of Indiana via the internet. From Indiana, the packets are sent continually or in once-per-day batches to a number of secondary schools in the United States. The slower packets lack the high frequencies characteristic of Oklahoma earthquakes, but are very useful for studying teleseisms (distant earthquakes), which occur daily in the Earth's seismic belts. For distant earthquakes above magnitude 6, packages of the 20-sample-per-second, vertical, north-south, and east-west signals containing



Active Seismographs in Oklahoma

Figure 1. Active seismographs in Oklahoma.

about one hour of recording are made at the Observatory. These are sent by internet file transfer protocol to the PEPP (Princeton Earth Physics Project) data base, which is used primarily by American secondary schools.

Radio Telemetry Stations

Three radio-telemetry stations, (1) at Rose Lookout (RLO) in Mayes County, (2) at the Bald Hill Ranch near Vivian (VVO) in McIntosh County, and (3) at the Jackson Ranch near Slick (SIO) in Creek County, have Geotech S-13 seismometers in shallow tank vaults. The seismic signals are amplified and used to frequency modulate an audio tone that is transmitted to Leonard with 500-mW FM transmitters at various frequencies in the 216-220-MHz band.

Antennas on a 40-m-high tower near the OGS Observatory receive signals from the three radio-telemetry sites. These electrical signals are carried 350 m overland to the outside of the Observatory building. In a box on the outside wall, the electrical signals are converted to optical signals. The optical signals are sent through ~6 m of plastic fiber into the building, where they are converted back to electrical signals. This optical link is used to prevent wires from carrying lightning-induced surges into the building and damaging digitizers and computers.

The radio-telemetry signals are frequency-modulated audio tones. Discriminators convert the tones back into a voltage similar to the voltage produced at the field seismometer. These voltages are recorded on a 48-hour-paper-seismogram drum recorder, one recorder per station. The paper records are used mainly to backup the computer system.

The radio-telemetry signals are transmitted to three channels (one channel per station) on the Guralp rack digitizer. Each digitizer channel produces 200 samples per second. The digitizer includes a GPS satellite receiver. The signals are assembled in memory into timed packets. The packets are transmitted to a PC running Guralp SCREAM data acquisition software.

A fourth radio-telemetry station, FNO, was installed in Norman in central Oklahoma on April 28, 1992. The seismometer, Geotech S-13, is on a concrete pad, about 7 km northeast of Sarkeys Energy Center (the building that houses the OGS main office). A discrimi-

nator converts the audio-signal frequency fluctuations to a voltage output. The voltage output is amplified and recorded by a Sprengnether MEQ-800 seismograph recorder (located in an OGS display case) at a trace speed of 60 mm/min.

Field Stations

Seismograms are recorded at three volunteer-operated seismographs (ACO, MEO, and PCO). Each station consists of a Geotech S-13 short-period vertical-motion-sensing seismometer in a shallow tank vault, or in an abandoned mine shaft (station MEO). The seismometer signal runs through 60-600 m of cable in surface PVC conduit to the volunteer's house or other building. The volunteer has a Sprengnether MEQ-800B timing system amplifier-filter-drum recorder, which records 24 hrs. of seismic trace at 1 mm/min in a spiral path around the paper on the drum. A time-signal radio receiver tuned to the National Institute of Standards and Technology and high-frequency radio station WWV is used to set the time. The volunteers mail the seismograms to the Observatory weekly (or more often, if requested). When an earthquake is felt in Oklahoma, the volunteer operators FAX seismogram copies to the Observatory so that the earthquake can be located rapidly.

Oklahoma earthquake catalogs, earthquake maps, some seismograms, and related information are on the Internet at http://www.okgeosurvey1.gov

Station OCO, which contains equipment similar to that at the volunteer-operated stations, is at the Omniplex museum in Oklahoma City. Omniplex staff members maintain the equipment and change the seismic records daily. OGS Observatory staff help interpret the seismic data and archive the seismograms with all other Oklahoma network seismograms.

DATA PROCESSING AND ANALYSIS

Data are processed on two networked Sun UNIX workstations—a SPARC20 and a SPARC 2+. All network digital and analog short-period (frequencies > 1 Hz) and broadband seismograms are scanned for earthquakes in and near Oklahoma. The arrival times of P and S phases are recorded on a single-page form in a loose-leaf notebook. The arrivals then are entered into the SPARC20 or the SPARC 2+ using a user-friendly flexible program written in the Nawk language. The program uses the entries to write an input file with a unique file name.

From the input files, the hypocenters are located by Johannes Schweitzer's (1997) program HYPOSAT 3.2c. A Nawk program manages the input to HYPOSAT and puts the output in a single file and writes a line in an overall catalog file.

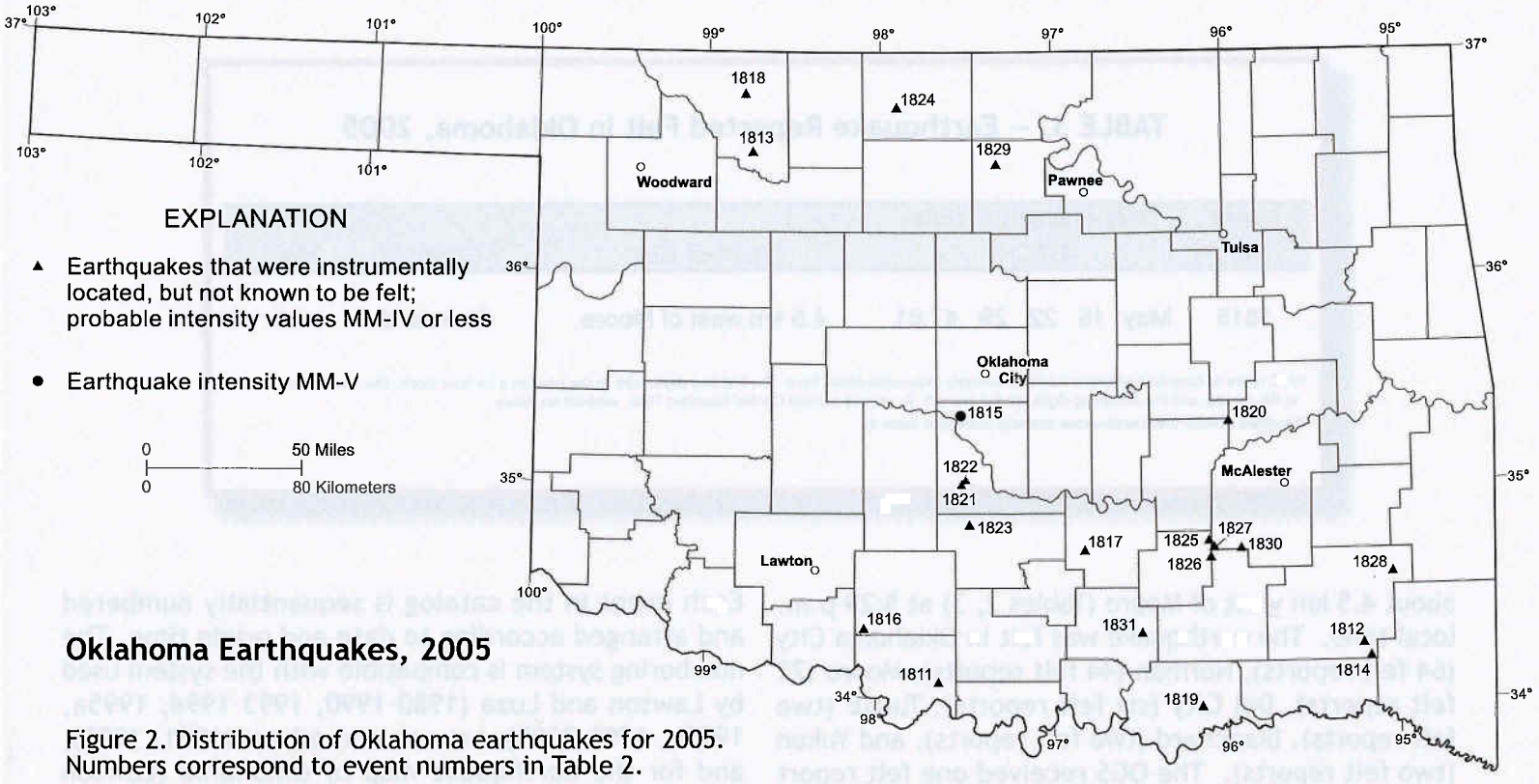
HYPOSAT must have a velocity model of the crust and top of the mantle to calculate travel times of P and S to each station from each successive hypocenter tried in the program. The nine-layer-plus-upper-mantle Chelsea model for Oklahoma, derived by Mitchell and Landisman (1971), is used exclusively for locating Oklahoma earthquakes. This model and three other Oklahoma models are outlined on the Observatory Web site at http://www.okgeosurvey1.gov/level2/geology/ok.crustal.models.html.

Each hypocenter is usually run in a preliminary form using the first four or so P and/or S arrivals from about four stations. Later, after all seismograms have been read, a final location is determined. The solutions are added manually to a catalog on the Observatory Web site at http://www.okgeosurvey1.gov/level2/okeqcat/okeqcat.2002.html.

DISTRIBUTION OF OKLAHOMA EARTHQUAKES, 2005

All Oklahoma earthquakes recorded on seismograms from three or more stations are located. In 2005, 21 Oklahoma earthquakes were located (Fig. 2; Table 2). One earthquake was reported felt (Table 3). The felt and observed effects of earthquakes generally are given values according to the Modified Mercalli Intensity scale, which assigns a Roman numeral to each of 12 levels described by effects on humans, man-made constructions, or natural features (Table 4).

On May 16, a magnitude 2.8 (mbLg) earthquake (event no. 1815) occurred in northwestern Cleveland County



Oklahoma Earthquakes, 2005

Figure 2. Distribution of Oklahoma earthquakes for 2005. Numbers correspond to event numbers in Table 2.

TABLE 2. — Oklahoma Earthquake Catalog for 2005

Event no.	Date and origin time (UTC)[a]	County	Intensity MM[b]	Magnitudes m3Hz	Magnitudes mbLg	Magnitudes MDUR	Latitude deg (N)	Longitude deg (W)	Depth (km)	
1811	Feb 4 2 31 49.87	Jefferson		1.9		1.7	34.070	-97.682	5.00R[c]	C[d]
1812	Feb 6 15 59 14.48	Pushmataha		3.2	3.5		34.238	-95.238	5.00R	C
1813	Feb 12 8 45 50.56	Woods		2.4	2.5	2.6	36.504	-98.676	5.00R	C
1814	Apr 22 5 17 4.09	Pushmataha		3.1	3.0	2.9	34.179	-95.192	5.00R	C
1815	May 16 22 29 47.61	Cleveland	V		2.8		35.325	-97.531	5.00R	C
1816	May 19 1 2 43.58	Stephens			2.5		34.320	-98.069	5.00R	C
1817	Jul 25 13 9 9.01	Pontotoc				2.2	34.685	-96.818	5.00R	C
1818	Aug 21 5 55 20.59	Woods				2.7	36.808	-98.765	5.00R	C
1819	Aug 25 6 57 1.63	Bryan				1.9	33.946	-96.171	5.00R	C
1820	Sep 29 1 20 55.12	McIntosh				1.9	35.280	-95.986	5.00R	C
1821	Oct 22 7 29 58.60	McClain				1.3	34.981	-97.496	5.00R	C
1822	Oct 22 7 50 39.90	McClain				1.6	35.003	-97.484	5.00R	C
1823	Oct 26 2 42 4.28	Garvin				1.6	34.795	-97.468	5.00R	C
1824	Oct 28 9 42 29.73	Grant				2.3	36.733	-97.899	5.00R	C
1825	Nov 1 5 51 10.04	Coal				1.3	34.729	-96.108	5.00R	C
1826	Nov 28 9 25 25.71	Coal				1.8	34.643	-96.098	5.00R	C
1827	Nov 30 14 27 44.81	Pittsburg				1.6	34.681	-96.067	5.00R	C
1828	Dec 5 11 37 58.68	Pushmataha				1.9	34.562	-95.024	5.00R	C
1829	Dec 8 21 57 17.66	Noble				1.9	36.462	-97.297	5.00R	C
1830	Dec 13 7 11 36.40	Pittsburg				1.9	34.687	-95.904	5.00R	C
1831	Dec 18 6 19 7.35	Johnston				2.2	34.279	-96.478	5.00R	C

[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 six hours.

[b]Modified Mercalli (MM) earthquake-intensity scale (see Table 4).

[c]5.00R indicates that the depth was restrained to 5.00 km from the beginning of the calculation.

[d]C refers to the Chelsea velocity model (Mitchell and Landisman, 1971).

TABLE 3. – Earthquake Reported Felt in Oklahoma, 2005

Event no.	Date and origin time (UTC)[a]	Nearest City	County	Intensity MM[b]
1815	May 16 22 29 47.61	4.5 km west of Moore	Cleveland	V

[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 six hours.

[b]Modified Mercalli (MM) earthquake-intensity scale (see Table 4).

about 4.5 km west of Moore (Tables 2, 3) at 5:29 p.m. local time. The earthquake was felt in Oklahoma City (64 felt reports), Norman (44 felt reports), Moore (22 felt reports), Del City (six felt reports), Tuttle (two felt reports), Blanchard (two felt reports), and Yukon (two felt reports). The OGS received one felt report from Purcell and another report from Newalla. The earthquake was felt over 4,600 km^2. This earthquake produced MM-V effects in Oklahoma City, Norman, Moore, Del City, Blanchard, Purcell, and Yukon (Fig. 3). Felt reports near the epicenter stated: "heard booming sounds"; "felt a jolt"; "saw water sloshing in fish tank".

In 2005, earthquake-magnitude values ranged from a low 1.3 (MDUR) in McClain County (event no. 1821) to a high of 3.5 (mbLg) in Pushmataha County (event no. 1812). Three earthquakes were located in Pushmataha County in 2005. Other counties that experienced multiple earthquakes include Coal, McClain, and Woods.

CATALOG

For both preliminary and final locations, the catalog of Oklahoma earthquakes is in HTML (world wide web) format; one HTML page contains all earthquakes that occurred in one year (a single page lists earthquakes for multiple years prior to 1977). For absolute uniformity, the catalog is stored only in HTML format. One copy is on a ONENet server. (ONENet is the network of the Oklahoma Regents for Higher Education.) The server copy, at the world wide web address http://www.okgeosurvey1.gov, is used both for public distribution and for in-house reference. A second (backup) copy is on a Sun SPARC20 workstation at the Observatory in Leonard, Oklahoma.

Each event in the catalog is sequentially numbered and arranged according to date and origin time. The numbering system is compatible with the system used by Lawson and Luza (1980-1990, 1993-1994, 1995a, 1995b, 1996-2005), Lawson and others (1991, 1992), and for the *Earthquake Map of Oklahoma* (Lawson and Luza, 1995b). The sequential event number is not found on the world wide web catalog.

May 16, 2005,
Cleveland County Earthquake
Modified Mercalli Intensity Values

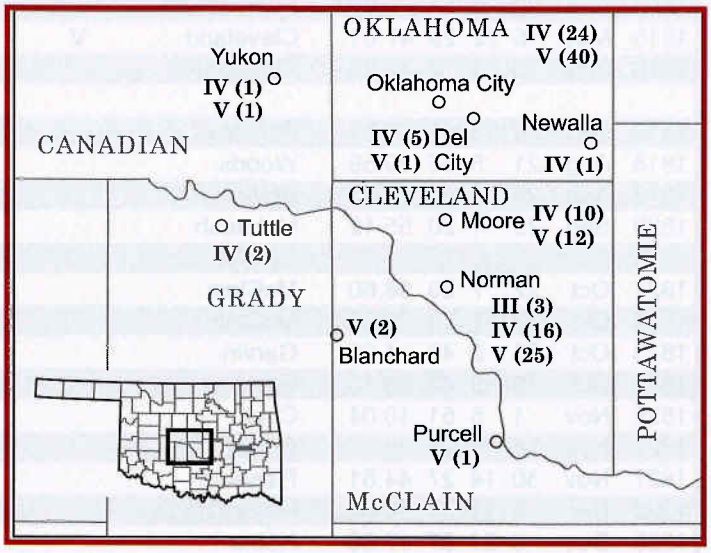


Figure 3. Modified Mercalli (MM) intensity values (Roman numerals) for the May 16 (UTC time) earthquake (event no. 1815) in Cleveland County (Tables 2, 3). Numbers in parentheses indicate the number of felt reports for each location.

The dates and times for cataloged earthquakes are given in UTC. 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 seconds. To convert to local Central Standard Time, subtract six hours.

Earthquake magnitude is a measurement of energy and is based on data from seismograph records. The magnitude of a local earthquake is determined by taking the 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. An increase of one unit in the magnitude value corresponds to a tenfold increase in the amplitude of the earthquake waves. There are several different scales used to report magnitude. Table 2 has three magnitude scales, which are mbLg (Nuttli), m3Hz (Nuttli), and MDUR (Lawson). Each magnitude scale was established to accommodate specific criteria, such as the distance from the epicenter, as well

Table 4. — Modified Mercalli (MM) Earthquake-Intensity Scale (Abridged) (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.

as the availability of certain seismic data.

For earthquake epicenters located 11-222 km from a seismograph station, Otto Nuttli developed the m3Hz magnitude scale (Zollweg, 1974). This magnitude is derived from the following expression:

$$m3Hz = \log(A/T) - 1.63 + 0.87 \log(\triangle),$$

where A is the maximum center-to-peak vertical-ground-motion amplitude sustained for three or more cycles of Lg waves, near 3 Hz in frequency, measured in nanometers; T is the period of the Lg waves measured in seconds; and $\triangle$ is the great-circle distance from epicenter to station measured in kilometers.

In 1979, St. Louis University (Stauder and others, 1979, p. 28) modified the formulas for m3Hz. The OGS Observatory has used this modification since January 1, 1982. The modified formulas have the advantage of extending the distance range for measurement of m3Hz out to 400 km, but they also have the disadvantage of increasing m3Hz by about 0.12 units compared to the previous formula. Their formulas were given in terms of $\log(A)$ but were restricted to wave periods of 0.2-0.5 sec. In order to use $\log(A/T)$, we assumed a period of 0.35 sec in converting the formulas for our use. The resulting equations are:

(epicenter 10-100 km from a seismograph)

$$m3Hz = \log(A/T) - 1.46 + 0.88 \log(\triangle)$$

(epicenter 100-200 km from a seismograph)

$$m3Hz = \log(A/T) - 1.82 + 1.06 \log(\triangle)$$

(epicenter 200-400 km from a seismograph)

$$m3Hz = \log(A/T) - 2.35 + 1.29 \log(\triangle).$$

Otto Nuttli's (1973) earthquake magnitude, mbLg, for seismograph stations located 55.6-445 km from the epicenter, is derived from the following equation:

$$mbLg = \log(A/T) - 1.09 + 0.90 \log(\triangle).$$

Where seismograph stations are located between 445 and 3,360 km from the epicenter, mbLg is defined as:

$$mbLg = \log(A/T) - 3.10 + 1.66 \log(\triangle),$$

where A is the maximum center-to-peak vertical-ground-motion amplitude sustained for three or more cycles of Lg waves, near 1 Hz in frequency, measured in nanometers; T is the period of Lg waves measured in seconds; and $\triangle$ is the great-circle distance from epicenter to station measured in kilometers.

The MDUR magnitude scale was developed by Lawson (1978) for earthquakes in Oklahoma and adjacent areas. It is defined as:

$$MDUR = 1.86 \log(DUR) - 1.49,$$

where DUR is the duration or difference, in seconds, between the Pg-wave arrival time and the time the final coda amplitude decreases to twice the background-noise amplitude. Before 1981, if the Pn wave was the first arrival, the interval between the earthquake-origin time and the decrease of the coda to twice the background-noise amplitude was measured instead. Since January 1, 1982, the interval from the beginning of any P wave (such as Pg, P*, and/or Pn) to the decrease of the coda to twice the background-noise amplitude has been used.

Earthquake detection and location accuracy have been greatly improved since the installation of the statewide network of seismograph stations. The frequency of earthquake events and the possible correlation of earthquakes to specific tectonic elements in Oklahoma are being studied. It is hoped that this information will provide a more comprehensive data base that can be used to develop numerical estimates of earthquake risk that give the approximate frequency of earthquakes of any given size for various regions of Oklahoma. Numerical risk estimates could be used for better design of large-scale structures, such as dams, high-rise buildings, and power plants, as well as to provide the information necessary to evaluate insurance rates.

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—Special Oklahoma Centennial Series

A Hundred Years Ago in Oklahoma January 1907

Compiled by
Kenneth V. Luza
Oklahoma Geological Survey, 2007

Oklahoma began a yearlong centennial celebration in January 2007. A monthly summary of the following articles and/or wire-service stories provides some insight into what took place locally, nationally, and worldwide in 1907. Some period photographs are included to show what Oklahoma looked like 100 years ago. Articles with information about geology and mineral resources are emphasized. These articles, or their abridged versions, were abstracted for republication from the **Daily Oklahoman** *(now* **The Oklahoman***), an Oklahoma City newspaper, unless otherwise specified. Every effort was made to preserve the original tone and expression of each feature. In some cases type-setting errors possibly may have been overlooked that led to misinterpreting the reporter's meaning or intent.* **The articles are republished with permission from *The Oklahoman*.**

On June 16, 1906 U.S. Congress passed the Oklahoma Enabling Act. It permitted the people of Oklahoma Territory (OT) and Indian Territory (IT) to join and write a constitution. Fifty-five delegates were elected from Oklahoma Territory; fifty-five from Indian Territory; and two from the Osage Nation. Democrat delegates won 100 convention seats; Republicans won eleven; and one Independent was elected. An organizational meeting was held by the delegates in Guthrie, Oklahoma, on Monday, November 19, 1906. William H. Murray was elected president of the convention. His majority floor leader was Charles N. Haskell. On November 20, the delegates began to draft a new constitution. The members of the Oklahoma constitutional convention could receive compensation for only 60 days, as provided in the Oklahoma Enabling Act.

Some of the agenda items before the convention included the establishment of three branches of government—executive, judicial, and legislative—commissions that regulate various activities, voter laws, and county boundaries and county seats. Prior to statehood, Oklahoma Territory had 25 counties. Indian Territory was divided into 26 recording districts with a city designated as the recording center (Morris and others, 1976, pl. 57).

Many of the delegates campaigned for, and were in favor of, laws

(Jim Crow) for separate coaches, waiting rooms, and public schools for whites and Negroes. President Theodore Roosevelt and many congressional leaders threatened to withdraw support for statehood if these laws were incorporated into the state constitution. The issue became the subject of numerous newspaper articles for several months.

Oklahoma City's population was 4,152 in 1890. In 1907 the population reached 32,452 and almost doubled by 1910 when the population had increased to 64,205 (U.S. Department of Commerce Bureau of Census, 1913).

R. E. Stafford was the editor and E. K. Gaylord was the business manager for the **Daily Oklahoman**. *It had a daily average circulation of 17,594 in December 1906, and cost 5¢ at the newsstand or 45¢ per month when delivered by carrier. The newspaper was published daily except for Monday. Want ads cost a penny per word.*

Tuesday, January 1, 1907, p. 1

NO AVAILABLE LAND FOR A SCHOOL FUND

CAN'T BE SET ASIDE IN INDIAN TERRITORY AS THEY BELONG TO INDIANS

Tahlequah, I. T., Dec. 31—Every person who has concern as to the schools of the new state looks with apprehension upon the situation that will arise when the state government is effective and three-fourths of the land non-taxable on account of the Indian title. It is feared that this will curtail the school tax to such a degree that the state will be unable to maintain a successful system of rural schools.

Judge J. H. Shepherd of south McAlester and A. Grant Evans of Muskogee are the two most prominent workers for removal of restrictions on account of the schools. Both in Washington and in Indian Territory, they have repeatedly called attention of senators and congressmen to the fact that Indian Territory can not have good schools with the land non-taxable.

January 1, 1907, p. 10

Overholser Opera House at 213-219 West Grand presents Louis James as Falstaff in the Merry Wives of Windsor.

Prices: Matinee: Adults 75¢–$1.00 Children 25¢–50¢ Evenings: 25¢–$1.50

January 1, 1907

Many of the Oklahoma City merchants began advertising their mid-winter clearance sales on Wednesday. Baum's, a women's clothing store, on 130 West Main St. offered suits and coats for $10.00, alterations free. Barth & Myer, men's and boys' clothing store on 122 West Main St., has men's overcoats, raincoats, and suits from $7.50 to $30.00. The Enders Co., 221-223 W. Grand next to Overholser Opera House, sells furniture, carpets, rugs, matting window shades, tile, and grates. A ten day introductory sale starts Wednesday morning. Housel-Barron, men's and women's shoe store at 220 West Main St., sale starts tomorrow. Prices range from $2.75 to $5.00. All their stock is new. No old shop worn or miss-mated shoes.

Wednesday, January 2, 1907, p. 1

NEW OIL GUSHER IS FLOWING 2000 BARRELS PER DAY

WORLD OF OILY WEALTH OPENED BY CROW CO. AT SAPULPA

Sapulpa, I. T., Jan. 1—An oil gusher flowing 80 barrels an hour and exceeding anything on record in the Indian Territory oil fields was brought in within 2 1/2 miles of this city last night by the Crow Oil and Gas company, composed entirely of Sapulpa men. The well is the fourth to be located in a field, all within a mile of each other, and in section five, two miles east and one-half mile south of Sapulpa.

Of the other three wells opened in this field within the last three weeks, two are flowing 5,500 barrels per day each and the third 1,200 barrels. The well brought in last night is flowing approximately 2,000 barrels per day.

January 2, 1907, p. 5

Local weather data for the *previous day* [emphasis added] was provided by J. P. Slaughter, section director of the United States weather station at Epworth University (*now Oklahoma City University*). Yesterday's high was 42° and the low was 31°.

January 3, 1907

Mid-winter clearance sale continues today and for eighteen more days. Kennedy Dry Goods Company, 226-228 West Main St., sacrifice sale of winter goods begins today, Wednesday, at 8 o'clock. "Our extensive purchases of new spring goods will commence to come in about the middle of this month and room must be made."

Thursday, January 3, 1907, p. 1

Shah of Shahs 800 Wives Wailing for Dying Ruler

No Improvement in Condition of Shah

Teheran Jan. 2—Muzaffer-ed-Din, Shah of Shahs, ascended the throne of Persia May 2, 1896, the day after his father, the famous Nasr-ed-Din, was assassinated by a religious fanatic.

Reputed to be the wealthiest monarch in the world, the Shah's reign has been clouded by a malady, which would not yield to medical treatment. The Shah has been a reformer during the ten years of his reign, and the only concessions, which the Persians have obtained for four thousand years, have been made by him. A reign, which began most inauspiciously, has continued in peace and quiet.

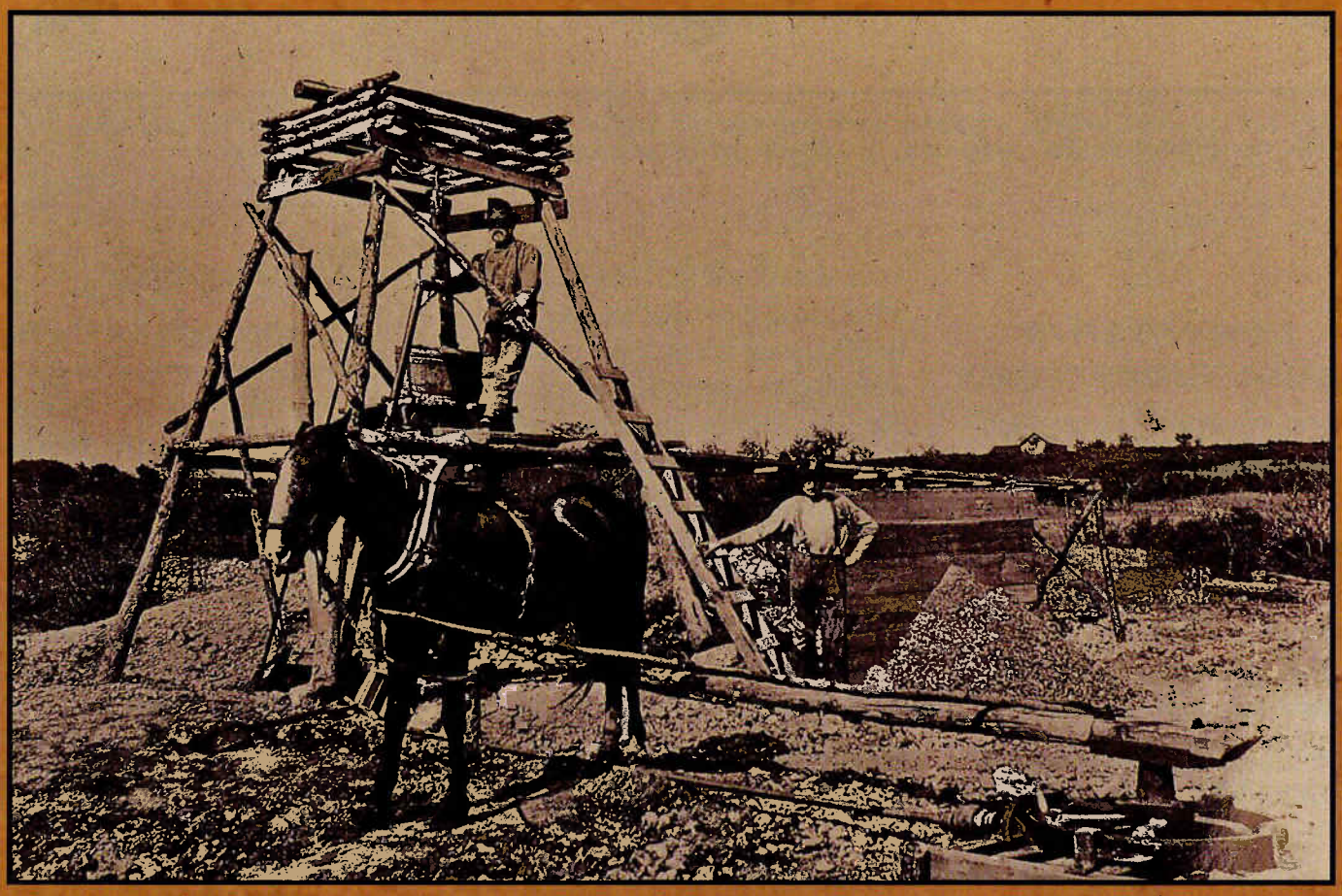

Figure 1. Hoisting lead-zinc ore to the surface from a mine in the Tri-State Mining District. *(Photograph courtesy Picher Mining Museum.)*

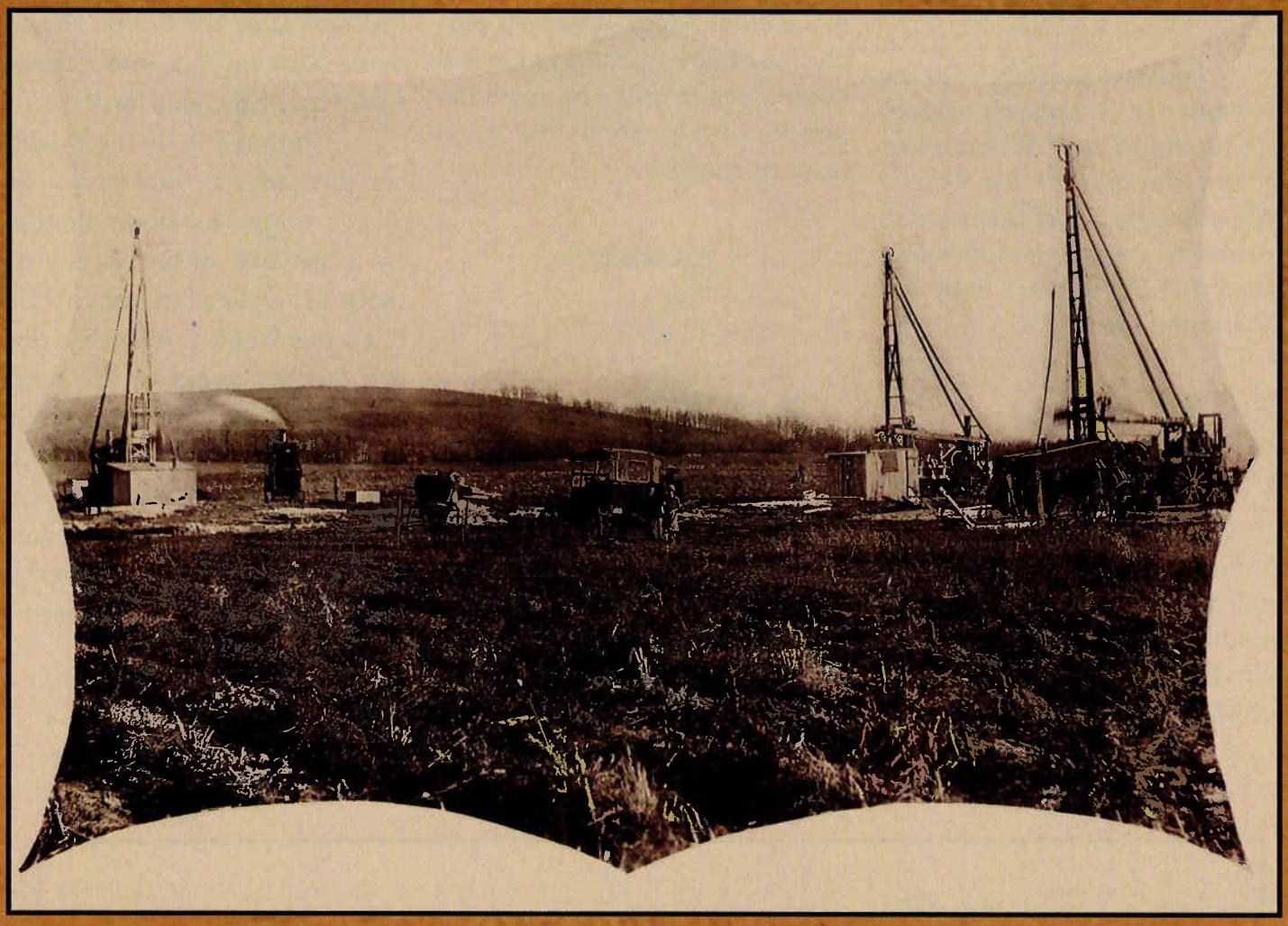

Figure 2. Cable-tool drill rigs prospecting for lead-zinc ore deposits in the Tri-State Mining District near what is now Picher, Oklahoma. *(Photograph courtesy Baxter Springs, Kansas Heritage Center and Museum.)*

January 3, 1907, p. 1

CONVENTION RECONVENES TODAY

TO CHANGE COUNTY NAMES SLASH ON OKLAHOMA SIDE

Constitution Makers Reassemble after Holiday Recess and Remainder of Session Promises to be Marked by Most interesting Features

WILL LOCATE COUNTY SEATS TEMPORARILY; URGES INITIATIVE AND REFERENDUM ACTION

Guthrie, Okla., Jan 2—It is learned tonight from a constitutional convention delegate that an attempt will be made tomorrow to change the names of Harper, Alfalfa, and Craig counties and among the new names suggested are Vest, Voorhees, Fields, and Edison.

Friday, January 4, 1907, p. 3

TO PROHIBIT SALE OF MINERAL LANDS

SENATOR NELSON WANTS IT HELD UNTIL MINERAL IS EXHAUSTED

Washington, Jan. 3—Senator Nelson today introduced a bill to prohibit the sale of lands on which are situated beds of coal, lignite, asphalt, petroleum, and natural gas in the government domain until such deposits have been exhausted. Provision is made for leasing for terms not exceeding one year for the purpose of having them explored. Persons making explorations and discoveries are to be given the preference in the right to lease and work the deposits.

January 4, 1907

Knight, Helton & Beck, men's clothing store on 117 West Main St., offers overcoats and raincoats from 7.50 to 26.25, suits from $7.50 to $26.75, and shirts from 75¢ to $1.75. They are sale agents for Hart, Schaffner & Marx clothing and L. Adler Bros. & Co. clothing.

Sunday, January 6, 1907

(Note: Sunday is when most merchants advertised in the newspaper. A majority of the stores that regularly advertised in the newspaper were located on West Main St. Mellon's department store and the Lion store street addresses are from 1907 Oklahoma City Directory).

The Parisian, ladies' outfitters on 114 West Main St., announces the greatest muslin underwear and lawn waist sale to begin on Monday January 7th at 8:30 a.m. Most items are offered for less than a dollar. The Lion store, 124-126 West Main St., great reduction sale of women's clothes begins Monday. Coats are on sale from $6.25 to $22.50 and children's dresses from 24¢ to $4.00. A. F. Fricke jewelry store on 210 West Main St. is offering a ten per cent discount on all jewelry, diamonds, cut glass, watches, silverware, and novelties. Mellon's department store on 204-206 W. Main St. annual January white sale begins Monday at 8 o'clock sharp. The Johnston Company on 303-305 West Main St. has a special sale of lace curtains, portieres, and draperies. Nottingham lace curtains are on sale from $2.50 to $3.45. Columbus Buggy Co. announces it is the time of year to have your vehicle painted, new trimming, and rubber tires put on and put in shape for spring use. "Remember we are headquarters for this kind of work and have the best equipped shop in the city." Aurora Bargain Store on 25-27 W. Main St. has dress goods and silks for sale. Most items are under a dollar. Holtzschue Mercantile Company, main store at 113 West Main St. and Maywood store at 6th & Harrison, offers canned goods such as apricots, plums, raspberries, strawberries from 25¢ to 30¢ a can, or $2.60 to $4.00 a dozen.

Tuesday, January 8, 1907, p. 4

OUR MINERAL WEALTH

The latest issue of the *Manufacturing Record* of Baltimore devotes a page to the discussion of mining in Oklahoma, quoting largely the findings of Prof. Charles N. Gould of Oklahoma University, who asserts that the new state has coal, asphalt, gypsum, salt, stone of all varieties, clay of all kinds, and sand adapted for all purposes, besides lead, zinc, and iron in possibly paying deposits, with sporadic samples of copper, gold and silver. Oil and gas are also mentioned as among the rich stores of earth in the new state.

The writer relates that nearly all coal deposits are located in the eastern part of the state, there being 12 to 15 workable veins, some 200 miles in length.

Attention is directed to an almost inexhaustible supply of asphalt discovered in the Arbuckle Mountain district; hundreds of veins varying from 50 to 100 feet in width, miles in length, and undetermined in extent.

It is claimed that the gypsum deposits are the richest in the world, it being estimated by Prof. Gould that there are 123,000,000,000 tons of this mineral within 100 feet of the surface in the counties of Canadian, Kingfisher, Blaine, Woodward, Comanche, Washita, Caddo, Custer, Dewey, Day [now parts of Ellis and Roger Mills counties], Roger Mills, and Greer. Five mills are now in operation with a daily output of 1,050 tons, the average price of the finished product at the mill being $4.50 per ton, with a ready demand for all that is offered. It is prognosticated that this industry will reach enormous proportions in the new state, only about $250,000 being now invested.

The new state has seven salt plains or marshes, with an inexhaustible quantity of saline water, two buckets of which will make one bucket of salt, while an extensive deposit of rock salt has been discovered in the Wichita Mountains. The salt industry in Oklahoma is in its infancy.

Lead and zinc, geologists agree, exist in paying quantities in the northeastern counties of the new state, but are undevel-

oped on account of government restrictions intended for the protection of the rights of the Indians.

The probable removal of restrictions, it is indicated, will develop the mineral resources of that part of the new state now known as Indian Territory. It is generally believed that the coal deposits are almost inexhaustible in extent.

Oklahoma, as the writer says, presents a wonderful virgin field for the investment of capital with abundant assurance of rich returns.

(Note: Charles N. Gould became the first director of the Oklahoma Geological Survey in 1908. **The Oklahoman** *reprinted this article on Sunday, January 7, 2007, page 14 A.)*

Wednesday, January 9, 1907, p. 2

SHAH OF PERSIA DIED LAST NIGHT

London, Jan 8—*The Daily Mail's* correspondent at Teheran in a telegram sent last night at 11:50 o'clock says: "The Shah of Persia, died this evening, though no public announcement of the fact will be made until tomorrow (Wednesday)."

(Note: A lengthy article follows with a discussion of the geopolitical dynamics taking place in Western Europe and Russia).

Thursday, January 10, 1907, p. 1

Oil Land Lease Brings $10,000 and 25 Per Cent of All the Production

Muskogee, I. T., Jan 9—John D. Burrow of Sapulpa today became 21 years of age and the first act of his majority was to close a lease on 160 acres of land he owns for $10,000 cash and 25 percent of all the oil produced on the lease. This considered one of the best, if not the best, lease that has ever been made in the oil fields.

This lease was taken by Harmon & Webber. Burrow was offered $15,000 cash and the usual royalty of ten per cent, but chose the $10,000 with 25 per cent royalty. There is a well within 1,000 feet of this land now producing 900 barrels per day. The oil sand is 1,400 feet down and in this section is 100 feet thick.

January 10, 1907, p. 8

BOTH TERRITORIES IN GRIP OF STORM

WIRES DOWN AND TRAFFIC DELAYED—SUFFERING AMONG LIVESTOCK

Tulsa, I. T., Jan. 8—Telegraph and telephone wires are out of commission, railroad traffic is blocked and county roads are nigh impassable from a severe storm raging all last night and part of today. The rain eventually turned into sleet and it is believed that damage has been done to fruit trees with buds swelling as the result of the recent warm spell.

Enid, Okla., Jan. 9—The worst sleet storm in the history of Oklahoma prevails here today. Telegraph and telephone wires are in terrible shape. This city was cut completely off from the outside world until 1 o'clock this afternoon. For three miles east the telephone company has not a single pole standing and in the city full 50 poles broken in two. There is much suffering among livestock, owing to sudden change from yesterday.

(Note: January 12, 2007, Oklahoma was subjected to an ice storm that crippled the State with over 100,000 residences left without power. Several counties were declared disaster areas eligible for Federal Emergency Management Agency [FEMA] assistance.)

January 10, 1907

Durham & Co. music store on 310 N. Broadway sells pianos, guitars, mandolins, and talking machines. Victor No. 1 with 1 dozen records costs $26.20 and a Victor No. 2 with a dozen records costs $34.20. Guitars are offered from $3.00 to $4.00 and mandolins of all grades from $2.50 to $15.00.

Friday, January 11, 1907, p. 1 and 3

Choctaws and Chickasaws Offering to Sell Segregated Coal-Asphalt

Lands to State for Twelve Million

Guthrie, Okla., Jan. 10—The Choctaw and Chickasaw Indians are willing to sell to the new state of Oklahoma the segregated coal and asphalt lands, according to a statement made by Boone Williams of Lehigh, a delegate to the constitutional convention.

"The Indians have offered to sell these lands to the state," said Mr. Williams, for "$122,000,000 [*sic*]. They will take $5,000,000 in cash and accept three per cent bonds for the balance." Delegate Williams has been advocating the sale of the coal and asphalt lands so that the surface might be disposed of to actual settlers.

The enabling act, granting joint statehood to the two territories, gives to the new State the sum of $5,000,000 cash as a school appropriation for Indian Territory, offsetting in part at least the mammoth school land holdings of Oklahoma Territory. The state is at liberty, it is held by many, to apply this fund in purchasing the segregated lands, if the revenues there-from are applied to the support of the schools.

A resolution was introduced early in the session by Delegate Boone Williams memorializing Congress to sell separately the surface and the coal rights of the land, thus permitting immediate settlement. A committee was named to draft such a memorial.

(Note: Before the Choctaw and Chickasaw Indians took their allotments of land they made a treaty with the Government whereby the land that was underlain with coal/asphalt was segregated or set apart for the benefit of the Nations as a whole. The coal/asphalt land could not be allotted by any individual citizen of either Nation. The total amount of land segregated was 437,743 acres. This land lies in what are now LeFlore, Haskell, Latimer, Pittsburg, Atoka, Coal, and Carter counties. U.S. Department of Interior, specifically the U.S. Geological Survey [USGS], was responsible for the management of these lands. Joseph A. Taff, geologist for the USGS, spent six years studying and mapping the coal deposits in Indian Territory. His work, which was published in 1901, 1902, 1903, and 1905, and A. H. Purdue (1907) produced some of the first detailed geologic maps [scale 1:125,000] of what is now Oklahoma.)

Sunday, January 13, 1907, p. 1 and 8

TO APPOINT COMMISSION

CONVENTION TAKES FIRST STEP TOWARD BUYING SEGREGATED LANDS

Guthrie, Okla., Jan. 12—By adopting in committee of the whole a resolution providing for the appointment of a commission of five persons to investigate the value of the lands and enter into negotiations with the proper authorities of the Choctaw and Chickasaw Nations. They shall report as early as practical under the circumstances the result of said investigation and negotiations to the governor.

Tuesday, January 15, 1907, p. 12

WILL FAVOR GRAVITY CLAUSE IN OIL INSPECTION LAW

Kansas and Oklahoma Oil Should be Admitted on Lower Gravity

Guthrie, Okla., Jan. 14—Frank A. Ashton, territorial oil inspector, will favor a clause in the state oil inspection laws admitting into the state the Kansas and Oklahoma oils at a lower gravity than those of Pennsylvania, Ohio, and Indiana. When the Oklahoma inspection laws were drawn and passed by the legislature, nearly five years ago, there were in fact two companies operating in this territory—Waters-Pierce of St. Louis and National of Kansas City. The independent companies, as a rule, have come into existence since that time.

In regard to Mr. Ashton's recommendations for a gravity clause in the inspection laws, he shows that the Pennsylvania crude oil, straight run, has a refining gravity of from 45 to 48 degrees; the Ohio Indiana oil a gravity of 45 to 47; the Kan-

sas-Oklahoma oils from 41.5 to 43.5; the Beaumont oil a gravity of 38.5 to 40.5. The present required gravity test in Oklahoma is 44 degrees.

Wednesday, January 16, 1907, p. 1

EARTHQUAKE DEVASTATES THE CITY OF KINGSTON PICTURESQUE CAPITAL RUINED AND DESOLATE AND MANY LIVES LOST

Gigantic Earth Quiver Tears Down Magnificent Buildings and Flames Spring from Massed Wreckage of Twisted Iron and Wood Carry on the Work of Destruction

Kingston, the picturesque capital of the Island of Jamaica, has been devastated by a violent earthquake. Details of the disaster are lacking, as direct communication with the stricken city has been cut off. The land lines had been reconstructed to within five miles of Kingston on Tuesday evening, and from meager reports received through such channels as were open it has been learned that many of the most important buildings have been destroyed and that there has been serious loss of life.

January 16, 1907, p. 1

LONDON RECEIVES CONFIRMATION OF AWFUL DISASTER

London, Jan. 15—The Colonial office tonight received confirmation of the terrible disaster which has overtaken Kingston, Jamaica, in a dispatch from Hamar Greenwood, M. P., sent from Holland Bay, at the east end of the island.

The telegram says Kingston has been ruined by an earthquake, which occurred without warning, Monday afternoon (January 14, 1907) at 3:30 o'clock. A very great number of buildings and dwellings were destroyed either by the earthquake or the consequent fire.

January 16, 1907, p. 1

Felt in Washington

Washington, Jan. 15—The weather bureau officials stated that the seismograph recorded a slight earthquake yesterday. The motion, it was stated, was but one-fiftieth of an inch. The disturbance began 3:38.23 p. m. The stronger motion was from east to west and lasted from 3:34 to 3:52.

January 16, 1907, p. 5

SURVEYING FOR THE BIG GAS PIPE LINE

WILL LAY NINETY-FIVE MILES OF TWELVE INCH PIPING

The surveying force on the natural gas pipe line under the direction of Civil Engineer F. H. Peckham reached a point 18 miles from the city yesterday. The surveying crew under the direction of Civil Engineer J. Gus Patton is at work four miles west of Sapulpa.

Twenty-five car loads of pipe have been received here and will be stored in the local railroad yards until hauled to the right of way of the new pipe line. Six inch pipe will be used in the city and 12 inch for the 95 miles between the big gas well near Sapulpa and Oklahoma City.

January 16, 1907, p. 12

OIL INSPECTION A MONEY MAKER

NEARLY A $1,000 TURNED INTO TREASURY DURING MONTH OF DECEMBER

THE VALUE OF THE NEW LAW

Fees Under Old Statutes Went into Pocket of Territorial Oil Inspector

Guthrie, Okla., Jan. 15.—Frank A. Ashton, territorial oil inspector, has filed with Governor Frank Frantz his financial report for the month of December, showing the sum of $955.65 turned into the territorial treasury from inspection fees. This is the record breaker, no former

month during the four years that the present inspection law has been on the statute books showing nearly so well.

Thursday, January 17, 1907, p. 1

1,000 DEAD; 95,000 HOMELESS KINGSTON EARTHQUAKE HORROR IS INCREASING

St. Thomas, D. W. I., Jan. 16.—Reports received here from Jamaica say that it is estimated that 1,000 persons have been killed by earthquake and fire and that 95,000 persons are homeless. The damage in Kingston alone is placed at $10,000,000.

January 17, 1907, p. 7

OKLAHOMA CITY STATE FAIR AND EXPOSITION

ORGANIZED

First Exhibition This Year—Will Purchase Roomy Grounds

Oklahoma City will have a state fair this year. Preliminary arrangements were inaugurated yesterday at a meeting of representative business men of this city and farmers of this county.

Organization will be effected at a meeting to be held tomorrow afternoon at 4 o'clock at the chamber of commerce. Every citizen of Oklahoma City is requested to be present at this meeting.

The movement is not merely for the purpose of establishing a local institution; it is a state fair, and it is desired to have stockholders from every part of the new state.

Several tracts of land adjacent to Oklahoma City were considered, the matter of transportation and water supply being important in the selection of grounds. The first exhibit to be held at Colcord Park will include the finest cotton display yet made in the southwest.

(Note: Some of the people mentioned in the article included S. C Heyman, C. G. Jones, S. B. Finley, Frank H. Shelley, Emil Bracht, J. W. Shellenberger, J. J. Goggerty, and C. W. McKeand. Many of these people owned businesses on West Main St. in Oklahoma City.)

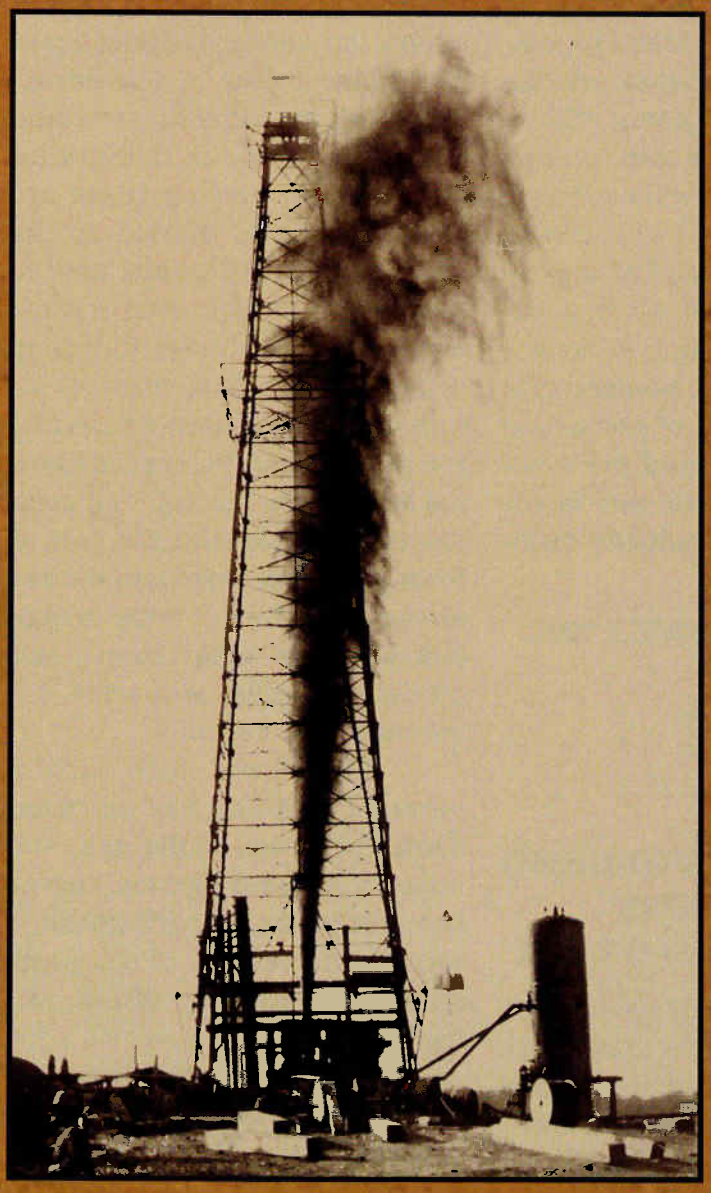

Figure 3. Oil gusher. *(Photograph courtesy University of Oklahoma Western History Collection.)*

Friday, January 18, 1907, p. 7

GREAT FLOOD WARNING IS OUT

WATER BELOW CAIRO IS RUNNING ABOVE FLOOD STAGES OVER ENTIRE LENGTH

New Orleans, Jan 17.—Washington has sent out a flood warning for the lower Mississippi Valley, the Mississippi River below Cairo running above flood stages over practically its entire length, and it is said that additional rise now coming down the Ohio will prolong and accentuate the lower Mississippi flood conditions.

Saturday, January 19, 1907, p. 1-2

TELLS CAUSE OF KINGSTON QUAKE

"EARTH WILL FLY TO PIECES"

OKLAHOMA CITY GEOLOGIST'S VIEW ON JAMAICA CAPITAL DISASTER

SINKING NATURAL SEQUENCE

PROF. L. HOWELL LEWIS SAYS NEW PLANET EVENTUALLY WILL BE FORMED

That the earthquake at Kingston, Jamaica, was of subaqueous volcanic origin according to Prof. L. Howell Lewis, a geologist and philosopher of this city, whose essays and dissertations on such topics have given him some prominence.

Expressing his views on the Kingston disaster he said:

"This old earth on which we are crawlers, on account of the many earthquakes and volcanic actions which have followed so closely on the heels of each other in the past few years, I believe is becoming very, very weak. The great liquid molten mass in the interior will render the crust of the earth so thin that, some day it will fly all to pieces, and fall into space. The various pieces will be attracted by other bodies, increasing their specific gravity, or will be drawn together by an unknown force, and the creation of a new planet will be started out of the old pieces. Whether mankind will ever people this new planet I will leave to some one wiser than I to say."

"In the first place, I believe that all things in nature move on from their beginning to their highest point of perfection and after having filed the function they were intended to fill, precipitously or gradually disintegrate.

CONTINUED ON PAGE TWO

January 19, 1907, p. 2.

SUBMARINE VOLCANO WAS CAUSE OF KINGSTON QUAKE

So (it is) with this earth on which we live. In the excellence of her physical structure she has thousands of years since reached her climax, and now she is in a rapid stage of decadence."

"The elements have for thousands of years been destroying the exterior by oxidation and in other ways, and the great molten liquid mass is gradually destroying the interior of her crust, to the extent that at this time the earth's crust is only thought to be on an average in thickness of twenty miles. Of course in some places it must be much thinner, more especially is it thinner where the sea is the deepest, but its want of thickness is made up to an extent by the density of the stones which form it."

"I believe that the superincumbent weight of the water where the sea is deepest, upon the thinnest part of the earth's crust, and the great mass of molten liquid matter in the interior of the earth, moving in an opposite direction therein as the earth moves on its axis, tend to rupture the earth's crust in some weak fault line under the deep seas. When done, there is an upheaval of the crust, caused by the pressure of the earth's internal heat, vents through the crust are there made and the lava is forced through them into the sea above, and when coming in contact with the water soon cools off and cements, as it were, the mouth of the crater."

"I believe that such a volcanic eruption has occurred somewhere out in the sea, and instead of the seismical waves brought on by an earthquake, it was the movement of the earth created by volcanic action, as I have described."

"The latest reports from Kingston say that a new horror is added to the situation; that the

city is slowly sinking into the sea; that the bottom of the harbor is materially changed, or, in other words, the harbor is much shallower. These later advices tend to strengthen rather than otherwise my opinion as to the character of the physical disturbances which caused the destruction of this city."

"I have already explained that the disturbances in Jamaica were most likely from volcanic energy. The sinking of the earth's crust under the city is a natural sequence following volcanic action. The floor of the ocean at the point most materially affected was thrown upward, forming perhaps a number of great mountains, now covered by the sea."

"It is natural to conclude that anywhere near the flanks of these mountains the earth's crust was weakened and would, many hours after the first volcanic shocks, slip and slide wherever the weakest fault lines happened to be in the earth. Some of these faults lines must have been under the city of Kingston."

January 19, 1907, p. 1-2

NEARLY MILLION EVERY YEAR

TWO OKLAHOMA CITY MEN LIKELY TO BECOME MILLIONAIRES FROM OIL

OWN 24 WELLS IN GLENN POOL

PRODUCTION IS 5,000 BARRELS DAILY SELLS AT 39 CENTS A BARREL

Two Oklahoma City men, C. F. Colcord and Robert Galbreath, have joint incomes and aggregate something more than $700,000 per annum if continued at the present rate.

The Glenn pool, near Tulsa and Sapulpa, is shipping or rather piping, probably 20,000 barrels of crude oil each 24 hours. "We own 24 producing wells there being about 125 in the pool. All of these are gushers. We could ship more oil if the pipes had more carrying capacity."

January 19, 1907, p. 3

STATE WOULD PURCHASE LAND

WILL APPEAL TO CONGRESS NOT TO ENACT LAWS THAT WOULD INTERFERE

COMMITTEE MAKES REPORT

Intended That State Should Sell Mineral Rights to Benefit the School Fund

Guthrie, Okla., Jan. 18—The committee on segregated coal and asphalt lands of the constitutional convention this morning submitted a report and draft memorial to the president and congress.

January 19, 1907, p .8

HUNDREDS OF BODIES RECOVERED FROM RUIN

ESTIMATED DEATH LIST WILL EXCEED 1,000 PEOPLE IN STATE OF TERROR

New York, Jan. 18—Admiral Davis reported that Kingston was almost entirely destroyed; that 400 persons were killed, and that 500 were in the hospitals.

January 19, 1907, p. 7

RIVER THREATENS TO DESTROY SMALL TOWN

PEOPLE FLEE FROM SHAWNEETOWN, ILL. THOUSANDS HOMELESS ALONG OHIO

Springfield, Ill., Jan. 18—Shawneetown, a village of 1,500 population on the bend of the Ohio River near the Indiana and Kentucky state lines, is threatened with a repetition of the great flood of 1898, which devastated the country for miles around, and caused loss of life and great suffering.

Sunday, January 22, 1907, p. 1

WILL HAUL OIL TO TEXAS IN TANK CARS

FIRST REAL MOVEMENT TO RELIEVE CONGESTION IN TULSA OIL FIELDS

Tulsa, I. T., Jan. 19—The Gulf Pipe Line Company an-

nounced that trains comprising 100 tank cars left Beaumont, Tex., today bound for Tulsa oil fields. Shipments by rail of 5,000 barrels to Texas daily have been arranged for here, to begin immediately.

Tuesday, January 22, 1907, p. 1

SEGREGATED LANDS MEMORIAL ADOPTED

ASK CONGRESS AND PRESIDENT NOT TO INTERFERE WITH PURCHASE

Guthrie, Okla., Jan. 21—Coming up as special order of business at the afternoon session of the constitutional convention the memorial to the president and congress, submitted by the committee on coal, oil, gas, and timber lands, regarding the purchase by the state of the segregated coal and asphalt lands, was adopted.

January 22, 1907, p. 3

FLOODED DISTRICTS IN KANSAS RELIEVED

LATE REPORTS, LAST NIGHT STATED THAT WATERS ARE RECEDING

Kansas City, Jan. 21—Reports from the flooded areas of Kansas indicated that most of the swollen rivers and streams are receding, that the weather is clear and cold and unless another rain storm follows soon the danger of flood damage is remote.

Tulsa, I. T., Jan. 21—The Arkansas river, swollen by three weeks rain, this morning gauged 9 feet 9 inches, the highest point in eight years. The high water is littered with debris of every description and watchmen have been stationed on all bridges to keep the piers clear of drift. No danger to lowlands is anticipated.

Thursday, January 24, 1907, p. 1

MINE BLOWUP KILLS TWENTY FOREIGNERS

FRIGHTFUL DISASTER OCCURS IN COLORADO COMPANY SUPPRESSES NEWS

Trinidad, Col., Jan 23—Twenty miners are reported killed by an explosion in a Colorado Fuel & Iron Company mine at Primero, twenty miles west of here, this morning. Late reports state that the mine is badly wrecked.

January 24, 1907, p. 8

LOSS OF LIFE IS NOW PUT AT TWO THOUSAND

PRESIDENT HAS DISMISSED UNPLEASANT *(DIPLOMATIC)* JAMAICAN INCIDENT

Washington, Jan. 23—According to a cablegram from American Vice Consul Orrett dated Jamaica, Jan 21; estimated loss of life over 2,000; fire loss $5,000,000. Loss by earthquake impossible to estimate as no building in city or surrounding district escaped.

Friday, January 25, 1907, p. 1

MANY MINES SUFFER ENFORCED IDLENESS

OPERATORS SAY COMPANIES IN COMBINE ARE CAUSE OF TROUBLE

Guthrie, Okla., Jan. 24—The statement is made by J. Hamp Willis, Indian Territory mineral trustee, with headquarters at Kingston, that everything in the mining line, especially in the Chickasaw Nation, is at a standstill at the present time. He visited all the mining towns, getting data regarding output and conditions for his quarterly report.

The shortness of cars for hauling the product and the scarcity of labor have united in causing the trouble, and in some instances a complete shutdown has resulted. In the Ardmore district, the only company in operation is an asphalt concern, whose output is about 400 tons for the quarter, a greatly decreased output.

The opinion is expressed by Mr. Willis that the output of the mining companies in Indian Territory has been interfered with greatly by large mining concerns and trusts.

January 25, 1907, p. 4

MINING LEASES

The Baxter Royalty company of Baxter Springs, Kan., controls 3,720 acres in the lead and zinc fields of the Quapaw Reserve, I. T., and offers favorable leases to operators seeking locations for lead and zinc mining.

For full particulars address E. T. McCarthy, President, Baxter Springs, Kansas.

(Note: The feature above was an advertisement made to appear like an article in the newspaper.)

Saturday, January 26, 1907, p. 1

OKLAHOMA RAILROADS HAVE REDUCED THE COAL RATES

New rate changes, reducing the freight rate on coal from the Arkansas and Indian Territory mines to points in Oklahoma, were announced by Division Freight Agent, J. E. Bell of the Rock Island yesterday. The new rates will go into effect on March 1, under the terms of the Hepburn bill, which requires that 30 days notice be given before any proposed changes become effective.

January 26, 1907, p. 2

ALL MINE WORKERS ASSURED OF SAFETY

CHILD LABOR PROHIBITED CORPORATION OWNERSHIP IS STRICTLY BARRED

Guthrie, Okla., Jan. 25—Inspection of mines, oil and gas wells in the state of Oklahoma will be under the supervision of a chief inspector, who must be a practical miner, elected by the people, under the provisions of a report from the committee on mines, mining, and oil submitted to the constitutional convention this morning.

The inspector is to be elected for a term of four years, and the legislature may provide for the appointment of assistant inspectors as they are needed.

The legislature shall also provide for proper ventilation of the mines, construction of means of escape and such other provisions as may be necessary to protect the health and safety of the workmen, and may also provide for the drainage of the mines, the prevention of wanton waste of coal and other minerals and oil and gas, and the protection of the streams and rivers from pollution.

Neglect or failure of the mine owner to comply with the regulations makes him responsible for all damage to the life and health of employees.

Employment of boys under the age of 16 years and women and girls of any age around mines is prohibited. Eight hours is made the maximum working day, excepting in cases of emergency.

Sunday, January 27, 1907, section 2, p. 5

The Oklahoman *published 6 pictures of some buildings damaged in Kingston, Jamaica, from the earthquake.*

Tuesday, January 29, 1907, p. 1

200 LIVES SNUFFED OUT IN TERRIFIC MINE EXPLOSIONS

Horrifying Disaster Occurs in Prussia, Flames Baffle Rescuers

Explosion in France

Saarbruick [*sic*, Saarbrücken], Rhenish [*sic*, Rhineland?] Prussia, Jan. 28—A firedamp [combustible gas, mostly methane] explosion occurred this morning in the Reden coal mine at St. Johann-on-Saar, opposite Sarbruick [*sic*, Saarbrücken], and caused the loss of from 150 to 200 lives. The mine is owned by Prussian government.

Lens, France, Jan. 28—A terrific explosion of fire damp occurred in a mine at Lievin in the Courrieres district, and Vassiere, the chief engineer, and two of his assistants were killed.

Thursday, January 31, 1907, p. 1

EARTH QUIVERS IN VANDALIA ILLINOIS

St. Louis, Jan. 30—A public official from Vandalia, Ill., says every building in Vandalia was shaken by an earthquake at 11:30 o'clock tonight. Many persons were aroused from deep sleep. The shock was accompanied by a loud rumbling.

January 31, 1907, p. 2

VAST TREASURES CONTAINED IN SEGREGATED COAL LANDS

Muskogee, I. T., Jan. 30—Oklahoma will draw its coal supply from the eastern one-third of the state. How much coal there is in this section no one can estimate. There is an area embracing 445,000 acres that is underlain with coal and was segregated by the government for its coal. Congress gave the Secretary of Interior $50,000 to find out what the coal land was worth, but he does not know yet. Five United States senators spent two weeks here and they recommended that the coal lands were worth about $20,000,000. The Choctaw and Chickasaw Nations, which own the land, agreed to sell it for $12,000,000.

But this is not half of the coal land in the territory. Coal is being found all over the eastern half of the new state. Hundreds of oil well prospectors have drilled right through fine veins of coal and paid no attention to them. At Tahlequah, Porum, Vinita, Copan, Miami, and many other points, there are good coal banks practically undeveloped.

The developed coal lands of the new state are in Pittsburg, Coal, Latimer, LeFlore, Haskell, Okmulgee, and Tulsa counties. In these counties during the last fiscal year there was produced 2,966,812 tons of coal. The tonnage of the various counties and the coal shipping points follow.

Pittsburg County has 18 coal companies operating and shipped 1,186,575 tons of coal last year from McAlester, Craig, Savannah, Carbon, Chambers, Baker, Haileyville, Pocahontas, Hartshorne, Buck, Edwards, Dow, Krebs, and Anderson.

Coal County shipped 643,222 tons with four companies operating at Coalgate, Midway, and Lehigh.

Latimer County, with eight companies operating, shipped 533,447 tons from Red Oak, Wilburton, Hughes, and Lutie.

LeFlore County, with six companies operating, produced 221,272 tons, shipping from Bokoshe, Williams, Howe, Panama, Poteau, and Sutter.

Haskell County, with one company operating at McCurtain, shipped 177,079 tons.

Okmulgee County has six companies operating at Henryetta, and the total output was 103,171 tons.

Tulsa County, with two companies operating, shipped 48,970 tons from Broken Arrow and Tulsa.

In addition to these companies, there are several small companies that produced 47,000 tons of coal during the year.

A majority of the coal tonnage, 2,722,200 tons, was produced from the leased mines in the segregated coal lands. There are 111 leases in effect there, but not nearly all of them are operating. There have been no leases made in the segregated lands since 1902 and the first ones were made in 1889. Some of the first made ran for thirty years. There will be no more leases made until it is finally determined what disposition shall be made of the coal lands.

The tonnage reported here does not represent an average year's output from the fact that beginning in April of 1906 there was a general strike in the mining district and practically all of the mines were closed down for nearly four months during which time little coal was produced.

(Note: The actual tonnage given in the article is 2,960,736. The difference probably comes from not accurately reporting the production from small companies).

January 31, 1907

OKLAHOMA CITY EATERIES HAVE A LARGE PATRONAGE

Four thousand residents

of Oklahoma City eat their meals at places other than their own homes. Sixty per cent of them are men, 40 per cent are women.

Oklahoma City has more than 70 public eating houses. One of these had not closed its doors for seven years. Night and day, it offers nourishment. The place has no key. No key is needed.

In addition to these places more than 100 boarding houses care for the hungry clerks and the bachelor business men. All of the large hotels have many regular boarders.

Many restaurants have their busiest time at night. Some of them have large patronage from the employees of the morning newspapers. Night telegraph operators also contribute to the business of these lunch rooms, which are active places of business when most of the town is in slumber. A few never close. The hamburger stands operate continuously. Night and day shifts keep the sizzling pans ever ready to tempt the hungry workman and gather in his nickel. And the nickel business, if conserved, enables the lunch stand man to eventually become the proprietor of a more pretentious place.

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New OGS Publication

OF 1-2007 Woodford Gas Shale Field Trip

A new Open File publication associated with the May 23rd, 2007, Woodford Gas Shale Conference and May 22nd and 24th field trips is now available from the Oklahoma Geological Survey.

OF 1-2007, Woodford Gas Shale Field Trip, by Brian J. Cardott, Richard D. Andrews, Galen W. Miller, and Stanley T. Paxton, contains field trip stops featuring several examples of Woodford Shale and supporting information. This 52-page publication contains 21 pages in color.

The cost of OF 1-2007 is $15, with an additional $2 for postage if mailed. To obtain a copy, call the OGS publications sales office at (405) 360-2886, email them at ogssales@ou.edu, or stop by the sales office at 2020 Industrial Blvd., Norman.

—Meet the Staff...

Oklahoma Geological Survey Staff Profile: Amie Gibson

If an earthquake occurs anywhere in Oklahoma, chances are Amie Gibson would be involved in some way. Amie is a Seismic Research Specialist I for the Oklahoma Geological Survey working at the Oklahoma Geophysical Observatory near Leonard, Oklahoma. If an earthquake is felt in Oklahoma it generates from 2 to 200 reports on the OGS seismic website. Amie reads and sorts these reports and assigns a Modified Mercalli Intensity to each one. She lists the locations of Modified Mercalli Intensities and makes a map of their locations before submitting the information to the main OGS office in Norman.

Before coming to the Observatory, Amie had done little work with computers, but now she can tear them apart, rebuild them, repair them, and upgrade the seismic stations from analog to digital; all in a day's work. She learned her skills on the job with the help of the notes from previous technicians at the OGO, by reading lots of books, and with help and guidance from Jim Lawson, OGS Chief Geophysicist, and James King, another OGO Seismic Specialist at the OGO. Amie enjoys the challenge of keeping the equipment running and traveling to the remote seismic stations, as well as the peace and quiet of the Observatory and the outlying sites. According to Amie, none of this would be possible without liking the people with whom she works.

To understand the scope of Amie's job, consider that she maintains remote seismic telemetry stations in Oklahoma at the following places: Rose Lookout Mountain (RLO), Vivian Mountain (VVO), Slick (SIO), and Leonard Observatory (LNO). Maintenance includes building and repairing the seismic equipment for the telemetry stations, as well as for the Observatory and volunteer stations at Franklin (FNO), Ponca City (PCO), Meers Observatory (MEO), Alabaster Caverns State Park (ACO), and the OmniPlex in Oklahoma City (OCO).

Part of Amie's job is to convert analog, volunteer-operated stations to complete digital upgrades, replacing the MEQ-800 paper, micro-earthquake recorder with a digitizer, computer, and near real-

time internet packet for broadcasting to the Leonard Observatory.

Amie monitors all incoming digital signals on a daily basis, to distinguish normal ground noise from local earthquakes and quarry blasts, as well as earthquakes that occur in other parts of the world. Using diagnostic tools such as a spectrogram, Amie determines if there is anything suspicious about the data, either in the field or at the Observatory. "As an example," she explains, "a sharp line showing up in the spectrogram can mean that 60 HZ power is somehow leaching into the system."

Observing the data-gathering computers, Amie makes sure that the software is running correctly. Occasionally she has to make the call to completely reconfigure the computer while it is still running to solve any problem, and at the same time, avoid any data loss. She also observes the storage capacity on various disks to ensure that the computer does not run out of space on any of the data channels. Another task that allows Amie to demonstrate her inventiveness, as well as being innovative, is in the design of equipment connections. She designs, constructs, and tests cables connecting one equipment module to another.

Public service and public relations is another part of the job for which Amie is well-suited. She answers numerous questions about earthquakes from the many emails and telephone calls citizens make to the Observatory. It is Amie's responsibility to prepare and distribute press releases for felt earthquakes in Oklahoma.

Amie took hold of the job and has made it her own; she applies an enthusiasm and energy to the job that is infectious. This is confirmed when you listen to her talking about her adventures on trips she makes to remote locations to repair seismic equipment. The adventures include encounters with snakes and other "critters" she meets on trail rides she and her horses make around the state, as well as when talking about her work at the OGO.

"It is nice that you have the ability to see a problem and fix it. Jim expects you to solve problems and take care of things without having to be told. I like to work that way," she said.

"It is a great job!" she states emphatically. "I really like this job." But if there is a down side to her job, it is the Oklahoma summer heat. She quickly tells you about her distaste for ticks and snakes when it is really hot.

Before joining the OGO staff, Amie was a student at the University of Tulsa studying geology and english, then working for three years as an insurance agent in the Tulsa area. Then one day someone told her about the job at the Observatory and Amie went for an interview. Amie impressed Jim Lawson with how much she knew about the function of the OGO, making his hiring decision easier.

Outside of her Observatory activities, Amie is a confirmed horse lover, and goes on extended trail rides whenever time allows. She has been riding since she was four-years-old, and her horses are an important part of her life. She owns three quarter horses and a miniature donkey named Nacho. Amie enjoys taking care of them before coming to work every morning.

Amie recently got married to the "love of her life", Marcus, and the couple lives in Bixby, Oklahoma.

She loves to read books too, and reads "anything that has a true spin to it. I like books based on facts; and I love Thoreau." She and Lawson both are avid readers and have a standing agreement that keeps them on good terms with the local library: "We're just a couple of nerds up here and we take each other's library books back!" she says with a laugh. That special insight helps one understand how Amie adapted and grew into the position of Seismic Research Specialist.

Upcoming Meetings

2007

AUGUST

28—30 Petroleum Engineering for Non-Engineers, taught by Norman J. Hyne; Houston, Texas. Information: The University of Tulsa, Continuing Engineering & Science Education, 600 S. College Avenue, Tulsa, OK 74104; phone: (918)631-3088. E-mail: cese@utulsa.edu.

SEPTEMBER

9—11 AAPG Mid-Continent Section Annual Meeting, *New Ideas - More Oil & Gas*, Wichita, Kansas. Sponsored by Kansas Geological Society. Information: Ernie Morrison; EMorrison@MULLDRLG.com; phone: (316)264-5368. Website: http://www.aapg.org/meetings/midcont07.pdf.

11—13 Fundamentals of Titles, Leases & Contracts, taught by Lewis G. Mosburg, Jr.; Houston, Texas. Information: The University of Tulsa, Continuing Engineering & Science Education, 600 S. College Avenue, Tulsa, OK 74104; phone: (918)631-3088. E-mail: cese@utulsa.edu.

18—20 Petroleum Engineering for Non-Engineers, taught by Norman J. Hyne; Denver, Colorado. Information: The University of Tulsa, Continuing Engineering & Science Education, 600 S. College Avenue, Tulsa, OK 74104; phone: (918)631-3088. E-mail: cese@utulsa.edu.

22—23 Planning and Operating a Land 3-D Seismic Survey, taught by J. Bee Bednar; San Antonio, TX. Information: Society for Exploration Geophysicists, (918)497-5500; PO Box 702740, Tulsa, Oklahoma 74170-2740; e-mail: web@seg.org; website: http://seg.org.

22—23 Seismic Anisotropy: Basic Theory and Applications in Exploration and Reservoir Characterization , taught by Ilya Tsvankin and Vladimir Grechka; San Antonio, TX. Information: Society for Exploration Geophysicists, (918)497-5500; PO Box 702740, Tulsa, Oklahoma 74170-2740; e-mail: web@seg.org; website: http://seg.org.

22—23 Seismic Data Processing, taught by Steve Hill; San Antonio, TX. Information: Society for Exploration Geophysicists, (918)497-5500; PO Box 702740, Tulsa, Oklahoma 74170-2740; e-mail: web@seg.org; website: http://seg.org.

22—23 3D Seismic Attributes for Prospect Identification and Reservoir Characterization, taught by Kurt Marfurt; San Antonio, TX. Information: Society for Exploration Geophysicists, (918)497-5500; PO Box 702740, Tulsa, Oklahoma 74170-2740; e-mail: web@seg.org; website: http://seg.org.

22—23 Migration Without Math (OK Maybe a Little Greek Math) , taught by Andreas Cordsen and Peter Eick; San Antonio, TX. Information: Society for Exploration Geophysicists, (918)497-5500; PO Box 702740, Tulsa, Oklahoma 74170-2740; e-mail: web@seg.org; website: http://seg.org.

23—28 Society for Exploration Geophysicists (SEG) International Exposition & 77th Annual Meeting, San Antonio, Texas. Sponsored by Kansas Geological Society. Information: 8801 S. Yale, Tulsa, OK 74137; phone: (918)497-5538, Fax: (918)497-5557; website: http://meeting.seg.org/.

OCTOBER

3—6 2007 Precious Metals Symposium, Tucson, Arizona. Information: website: http://www.smenet.org/meetings/.

6—9 AAPG Rocky Mountain Section 56th Annual Meeting, *Exploration Discovery Success*, October, Snowbird, Utah. Information: website: http://www.aapg.org/meetings/index.cfm#sections.

11—12 Basics of Well Log Interpretation, taught by George R. Bole; Tulsa, Oklahoma. Information: The University of Tulsa, Continuing Engineering & Science Education, 600 S. College Avenue, Tulsa, OK 74104; phone: (918)631-3088. E-mail: cese@utulsa.edu.

17—28 Appraisal of Oil & Gas Properties, taught by John Gustavson & Ed Moritz; Houston, Texas. Information: The University of Tulsa, Continuing Engineering & Science Education, 600 S. College Avenue, Tulsa, OK 74104; phone: (918)631-3088. E-mail: cese@utulsa.edu.

23—25 Problems and Pitfalls in Joint Operating Agreements, taught by Lewis G. Mosburg, Jr.; Houston, Texas. Information: The University of Tulsa, Continuing Engineering & Science Education, 600 S. College Avenue, Tulsa, OK 74104; phone: (918)631-3088. E-mail: cese@utulsa.edu.

28—31 Geological Society of America, Annual Convention, *Earth Sciences for Society — Beginning of the International Year of Planet Earth,* Denver, Colorado. Information: Geological Society of America, P.O. Box 9140, Boulder, CO 80301; (303)447-2020; fax (303)357-1071; e-mail: meetings@geosociety.org. Website: http://www.geosociety.org/meetings/2007/.

NOVEMBER

6—9 14th Annual International Petroleum Environmental Conference, Houston, Texas. Information: The University of Tulsa, Continuing Engineering & Science Education, 600 S. College Avenue, Tulsa, OK 74104; phone: (918)631-3088. E-mail: cese@utulsa.edu.

13—15 Petroleum Engineering for Non-Engineers, taught by John Farina; Houston, Texas. Information: The University of Tulsa, Continuing Engineering & Science Education, 600 S. College Avenue, Tulsa, OK 74104; phone: (918)631-3088. E-mail: cese@utulsa.edu.

—Oklahoma Abstracts

The Oklahoma Geological Survey thanks the Geological Society of America for permission to reprint the following abstracts of interest to Oklahoma geoscientists. The following abstracts are of papers presented in the Tar Creek symposium at the South-Central GSA meeting in March 2006.

HISTORY OF THE PICHER MINING FIELD

KEHELEY, ED, Keheley & Associates, Inc, 2020 South 640 Road, Quapaw, OK 74363, keheley@datalinkok.com

The Picher Mining Field is located in southeastern Cherokee County, Kansas and northeastern Ottawa County, Oklahoma. Approximately 45 sections in T28N-29N, R22E-R24E, contain mine workings in the Oklahoma portion of the field. Up to 30 percent of the mining field in Oklahoma was located on restricted Indian lands requiring lease arrangements managed by the U. S. Department of the Interior (DOI). DOI lease restrictions required more mine shafts and mills to be constructed than was necessary to remove and mill the ore. During the mining period 1891-1970 U. S. Bureau of Mines records show that 181,048,872 tons of crude ore were removed from the mines producing 8,879,818 tons of zinc and 1,679,222 tons of lead concentrates. The remaining 170,500,000 tons consisting of mine and mill tailings were spread over approximately 7,000 acres.

Mining practiced in the Picher Mining Field is commonly referred to as random room-and-pillar mining where rooms were excavated and pillars were left to support the mine roof. Approximately 1,200 vertical mine shafts between 90 and 350 feet were sunk to intercept the main ore horizons. Milling depended primarily on specific gravity methods, including jigs and tables. In the 1920s the flotation process became the primary means for extracting concentrates from the finely ground ore remaining from the initial milling process and remilling tailings. By the late 1920s, 227 mills were operating in the mining field. By the late1930s most of the higher grade ore had been mined and most tailings piles remilled. Several central mills were built to replace the smaller, less efficient mills in order to extend the life of the field.

The amount of ore mined annually continued to decrease in the 1950s and 60s until 1970 when all mining ceased and all pumps were removed from the mines. The abandoned mine workings continued to fill with water until 1979 when the entire underground workings in the field were flooded.

GEOLOGY OF THE PICHER FIELD IN OKLAHOMA

LUZA, KENNETH V., Oklahoma Geological Survey, University of Oklahoma, Energy Center, 100 E. Boyd St., Rm. N-131, Norman, OK 73019-0628, kluza@ou.edu

The rock formations exposed at the surface in the Picher mining field include Mississippian and Pennsylvanian units that are nearly flat, with a low regional northwest dip of about 20-25 ft/mi. At a few places, sharply defined structural features are accompanied by appreciable dips (up to 70 degrees). The Miami Trough, Bendelari Monocline, and Rialto Basin are three prominent structures that dominate the main part of the Picher Field.

Mississippian rocks units, principally the Boone Formation, are host for most ore deposits. The Boone is composed of fossiliferous limestone and thick beds of nodular chert. This formation, which is 350-400 ft thick in the Picher area, is subdivided into seven members (in ascending order): St. Joe Limestone, Reeds Spring, Grand Falls Chert, Joplin, Short Creek Oolite, Baxter Springs, and Moccasin Bend. Beginning with B near the top of the Moccasin Bend and ending with R in the Reeds Spring, 16 beds are distinguished. The Quapaw Limestone (Meramecian) locally overlies the Boone. The Chesterian Series, represented by the Hindsville Limestone, Batesville Sandstone, and Fayetteville Shale, forms a disconformable contact with the Boone and/or Quapaw Limestone. Both the Hindsville and Batesville are mineralized locally.

Pennsylvanian formations of the Krebs Subgroup (lower division of the Cherokee Group) were deposited on a post-Mississippian erosion surface. The formations consist of alternating terrestrial fine-grained sandstone, shale, and thin coal beds and include the McAlester Formation, the Savanna Formation, and the basal Bluejacket Sandstone Member of the Boggy Formation.

Ore deposits in the Picher Field occur mainly in the upper half of the Boone Formation. A majority of the mine workings are within the M bed. Other important ore zones occurred within the K, G, H, and E and Chesterian beds; and sheet ground (or low-grade blanket deposits) occur within the Grand Falls Chert Member. Stope heights varied from 10-20 ft. to over 100 ft. The main ore minerals were sphalerite and galena; the zinc to lead ratio for the ore, based on total production from the field, was about 4.1:1.

TAR CREEK OKLAHOMA SUPERFUND SITE AND ITS MANY CHALLENGES

LUZA, KENNETH V., Oklahoma Geological Survey, University of Oklahoma, 100 E. Boyd St., Energy Center, Rm. N-131, Norman, OK 73019-0628, kluza@ou.edu

The Tar Creek Superfund Site is in Ottawa County, northeastern Oklahoma, near the Oklahoma/Kansas border. The site consists of approximately 43 square miles (27,520 acres) and is part of the Tri-State Mining District which includes parts of northeastern Oklahoma, southeastern Kansas, and southwestern Missouri. Five small mining communities, Picher, Cardin, Quapaw, Commerce, and North Miami are within the superfund site.

More than 2,500 acres are underlain by underground lead/zinc mines in the Oklahoma part of the Picher field. When the mines were abandoned in 1970, they filled with water. In 1979, acid mine water containing high concentrations of heavy metals began discharging into Tar Creek from natural springs, boreholes, and open mine shafts. In 1980, Governor Neigh of Oklahoma established a Tar Creek Task Force to investigate the drainage of acid mine water into Tar Creek. The Task Force requested the site be added to the National Priorities List in 1981; the site was listed in 1983. From 1984 to 1986, dikes were built to divert surface water around collapsed mine shafts and 88 abandoned deep wells were plugged to prevent migration of acid mine water into the Roubidoux aquifer.

Significant quantities of mill waste were generated by processing lead/zinc ores. The mill waste, chiefly composed of chert fragments 0.75 in. or less in diameter, was referred to as "chat" by the miners. The chat was used for railroad ballast; a base for roads, parking lots, and concrete slabs; and concrete and asphalt aggregate. Studies by the Oklahoma Department of Environmental Quality and University of Oklahoma reported high concentrations of lead, zinc, and cadmium in the smaller particle sizes of chat. In 1995, U.S. Environmental Protection Agency began to remove chat from yards, streets, and dirveways in the five mining communities in response to elevated blood-lead levels in children.

In 2000, Governor Keating of Oklahoma created a task force to develop a comprehensive remediation plan for Tar Creek. In 2003, a plan was developed to include stream restoration, maximum chat utilization, land remediation and restoration, and mine-hazard attenuation. Some of the many challenges for the Tar Creek Superfund Site include size, legal issues, ownership, health and safety issues, data availability, land use, and the potential for subsidence.

SUBSIDENCE EVALUATION OF TAR CREEK SUPERFUND SITE

MARTELL, JIM, Tulsa, OK 74128, James.Martell@usace.army.mil

The Picher Mining Field of northeastern Oklahoma was the location of extensive lead-zinc mining from 1904 to 1970. Mine waste accumulations and acid mine drainage from the now-abandoned lead-zinc mines have become an environmental issue that has been the focus of environmental restoration activities since 1979. The area was designated by the Environmental Protection Agency (EPA) as the Tar Creek Superfund Site in 1983. Extensive underground openings left from the historic mining activity have also resulted in surface subsidence that presents a serious hazard

to public safety, the environment and current and future land use. The subsidence problem has not been systematically addressed as part of the environmental restoration activities. In 2000 Oklahoma Governor Frank Keating established the Tar Creek Task Force to develop a holistic plan for addressing issues identified for the site. Mine subsidence was identified by the Tar Creek Task Force as a major concern; however, no funding was provided to implement recommendations of the Tar Creek Task Force. In June 2004, Oklahoma Senator Jim Inhofe requested that an evaluation be conducted to assess the potential for future major subsidence in the area. The U.S. Army Corps of Engineers was designated to be the lead agency on the subsidence evaluation project. A technical team was assembled in August 2004 to begin the subsidence evaluation. The evaluation is nearing completion and will be the largest scale subsidence evaluation ever undertaken to date.

Public safety implications of mining related subsidence have been a concern of residents in the Tar Creek Superfund Site for many years. Shaft related and non-shaft related subsidence events have occurred in the Picher Mining Field since the beginning of mining operations and continue to occur. The Tulsa District Corps of Engineers is actively addressing public safety issues associated with extensive historical mining through an aggressive mine shaft plugging program as well as an unprecedented subsidence evaluation of the area.

SURFACE-WATER AND SEDIMENT QUALITY IN TAR CREEK, NEOSHO RIVER AND SPRING RIVER, NORTHEAST OKLAHOMA, 2004-05

DEHAY, KELLI L., Tulsa, OK 74133, kdehay@usgs.gov

The Picher mining district in northeastern Oklahoma was the site of extensive zinc and lead mining from about 1900-1970. Open mineshafts and fully exposed "chat" or "tailings" piles subject the area's surface water to potential trace metal contamination. The Grand-Neosho River Basin carries water from the mining district directly into Grand Lake O' the Cherokees, raising concerns about the water quality of Grand Lake. The United States Geological Survey, in cooperation with the Oklahoma Department of Environmental Quality, the Seneca-Cayuga Tribe and the Wyandotte Nation, collected high flow water-quality and bed sediment data from Tar Creek, Spring River, and Neosho River to characterize water and sediment quality entering Grand Lake O' the Cherokees. Water samples were analyzed for physical properties, major ions, and dissolved and total metals. Sediment samples were analyzed for metals only. Unfiltered water-quality samples contained concentrations of lead ranging from less than 10 to 152 micrograms per liter and zinc concentrations ranging from 7 to 3,100 micrograms per liter. Cadmium concentrations were below detectable limits in most of the samples collected from the Spring and Neosho River sites, but ranged from less than 5 to 15 micrograms per liter at the Tar Creek sites. Bed sediment samples contained larger concentrations of aluminum, iron, zinc and manganese than other constituents. Lead concentrations in the samples ranged from less than 10 milligrams per kilogram to 262 milligrams per kilogram. Fourteen sediment cores were also collected from the Tar Creek floodplain at Tar Creek near 22nd Street Bridge, Miami, OK. All of the core samples had detectable concentration of aluminum, barium, chromium, copper, iron, lead, magnesium, manganese, nickel and zinc. Twelve sediment cores had mean lead concentrations of 15 to 29 milligrams per kilogram but two cores, collected near a slough on the west side of Tar Creek, had mean lead concentrations of 147 and 518 milligrams per kilogram.

ELEVATED BLOOD LEAD LEVELS IN SMALL CHILDREN AT THE TAR CREEK SUPERFUND SITE

OSBORN, MARK, Integris Baptist Regional Health Center, 2019 Birnamwood Drive, Miami, OK 74354, Mark.Osborn@integris-health.com

Elevated blood lead levels in small children have been shown to cause learning disabilities and loss of intelligence quotient (cognitive function). Blood lead data collected by the Indian Health Service at the Tar Creek Superfund Site between February 1992 and May 1993 indicated that 35 percent of the children tested had blood lead levels greater than or equal to10 ug/dL. The actual source(s) of the lead exposure for the children with elevated blood lead levels was unidentified, but several possible sources were noted, including living in proximity to mill tailings (chat) piles and lead-based paint in homes. Investigations of mining waste indicated that the levels of lead, zinc and cadmium found in chat and flotation pond sediments posed a significant risk to human health and the environment. The investigation also found that blood lead levels were significantly higher in the population exposed to mining waste compared to the control group.

From August 1994 to July 1995, the EPA conducted sampling of soils in high access areas (e.g., day care centers, school yards, and playgrounds) and residential properties in the 43 square mile Tar Creek Superfund Site. On August 15, 1995 the EPA issued an Action Memorandum which called for the excavation and on-site disposal of lead-contaminated soil in high access areas.

Remedial actions of the residential areas originally began in June 1996 as an emergency removal and continued into 2005 as a remedial action. Over 2,000 residential yards have been remediated up to a depth of 18 inches in five small communities in the superfund site. Concurrent with yard remediation, an education awareness program was developed to teach

appropriate hand-to-mouth behavior in children. A U. S. Housing and Urban Development Agency lead-based paint abatement program was also initiated as a result of the large number of older homes containing lead-based paint in the area. Blood lead levels have declined at the site; however, the exact contribution of yard remediation has never been fully evaluated. The yard remediation program was expensive and many complaints resulted from poor contractor workmanship.

RESIDENTIAL EXPOSURES TO METALS IN HOMES NEAR THE TAR CREEK SUPERFUND SITE

ZOTA, AMI[1], *SCHAIDER, LAUREL A.*[1], *BRABANDER, DANIEL J.*[2], *WRIGHT, ROBERT O.*[1], *OSBORN, MARK*[3], and *SPENGLER, JOHN D.*[1], (1) Environmental Health, Harvard School of Public Health, Landmark Center West, Room 409, 401 Park Drive, Boston, MA 02215, azota@hsph.harvard.edu, (2) Geosciences Department, Wellesley College, 106 Central Street, Wellesley, MA 02481, (3) Integris Baptist Regional Medical Center, Miami, OK 74354

Metals, such as lead, arsenic, and cadmium, are common contaminants at many hazardous waste sites and may pose a particular risk to young children due to differences in behavior and their increased susceptibility for neuro-developmental impairment. However, few studies have collected systematic data on concurrent exposure to multiple metals during the early stages of life or accounted for potential interactions. As part of the Center for Children's Environmental Health and Disease Prevention Research at the Harvard School of Public Health, we are conducting a longitudinal, multi-media exposure assessment study at the Tar Creek Superfund Site, a mining-related Superfund site contaminated by metal-enriched mining waste. Our objective is to evaluate the relationship between environmental exposures to metals and biomarkers of absorbed metals dose (as measured in blood and hair) in young children living proximate to the site. The residential environments of 50 children under 1 year of age ultimately will be sampled twice at 6 months intervals. From each home, we will collect samples of respirable, airborne particles ($PM_{2.5}$), house dust, drinking water, yard soil, and food. Samples will be analyzed for: lead, zinc, arsenic, iron, cadmium, copper, and manganese.

From July 2005 – December 2005, exposure media in 35 residential homes with children under 9 months of age in Ottawa County, OK were sampled. House dust samples were collected with a portable vacuum cleaner, sieved to <125µm size fraction, and analyzed using XRF. Metal concentrations in dust varied considerably across all homes sampled (Range(ppm)): Pb (10-530), Zn (190-4600), As (9-65), Mn (50-470), Cu (12-1200), and Fe (940- 22000). Zinc dust concentrations were significantly higher ($p<0.05$) in homes located closest to the mining waste piles (1700 ± 1300 ppm vs. 880 ± 500 ppm). Lead dust concentrations were highly correlated with zinc concentrations (spearman correlation coefficient $rS=0.82$, $p<0.0001$) and also showed modest correlations with dust concentrations of As ($rS=0.54$, $p<0.001$), Cu ($rS=0.56$, $p<0.001$), and Fe ($rS=0.67$, $p<0.0001$) suggesting that these metals originated from common sources. Additional data from other environmental media as well relationships between various media will be evaluated as part of this ongoing study.

METALS AND HUMAN HEALTH: THE CHARACTERIZATION OF TOXIC METALS FROM MINE WASTE AT THE TAR CREEK SUPERFUND SITE AND ASSESSMENT OF EXPOSURE TO THE TAR CREEK COMMUNITY

MCCARTHY, KATHLEEN D.[1], *SCHAIDER, LAUREL*[2], *BRABANDER, DANIEL*[1], *SENN, DAVID*[2], and *SHINE, JAMES*[2], (1) Department of Geosciences, Wellesley College, 106 Central Street, Wellesley, MA 02481, kmccarth@wellesley.edu, (2) Department of Environmental Health, Harvard School of Public Health, 401 Park Drive, Boston, MA 02215

The mine waste (chat) piles at the Tar Creek Superfund Site in Northeast Oklahoma contain high concentrations of lead, zinc, and cadmium. Wastes from the mines impact the surrounding ecosystems and continue to pose a potential risk to human health in the area. The objective of this research is to determine the concentration of toxic metals in the mine waste piles, characterize the mineralogy, determine the chemical inter-variation and intra-variation of the chat piles, and assess the risk of exposure of toxic metals to the surrounding community. To meet the objectives, samples of chat have been extracted from the site and analyzed using X-ray fluorescence (XRF), and X-ray diffraction (XRD) techniques. XRF is used to measure the total concentrations and XRD is used to characterize the mineralogical phase of lead, zinc, and cadmium in the chat pile samples. XRD will aid in the explanation of the bioavailability of these metals. Chat pile samples were taken from a 2-4 cm layer below the surface of each pile (in six piles located throughout the Tar Creek Site.) Two to four locations at each pile were sieved into eight different size fractions ranging from >4 mm to <0.037 mm. XRF results demonstrate that the intrapile range in concentration of zinc (approx. 4000-15000 ppm) varies less than the interpile range in concentrations (approx. 5000-25000 ppm.) The results demonstrate consistent increase in Zn, Pb, and Cd concentration with decreasing particle size. In many cases, the metal concentrations in the <0.037 mm fraction were at least an order of magnitude greater than those present in the >4 mm size fraction. The chat in the <0.037 mm size fraction is respirible and important for exposure assessment. Initial XRD results suggest that Galena, Sphalerite, Cerrusite, Hydrozincite and Hemimorphite are some

of the mineralogical phases of the metals of interest present in the chat piles at the <0.037 mm size fraction. Further research will focus on determining if the variation in metal concentration is due to primary mineralogical differences or is the product of differential weathering and other environmental factors. The XRF and XRD data will inform the cooperative project testing soil, water, food, crops, and house dust for exposure assessment.

MINE WASTE PILES AS A SOURCE METAL CONTAMINATION AT THE TAR CREEK SUPERFUND SITE

SCHAIDER, LAUREL A.[1], *SENN, DAVID B.*[1], *BRABANDER, DANIEL J.*[2], *HOLTON, MICHAEL W.*[1], *MCCARTHY, KATHLEEN D.*[2], *SERDAKOWSKI, MARY C.*[1], and *SHINE, JAMES P.*[1], (1) Department of Environmental Health, Harvard School of Public Health, Landmark Center West, 401 Park Drive, Boston, MA 02215, lschaide@hsph.harvard.edu, (2) Geosciences Department, Wellesley College, 106 Central Street, Wellesley, MA 02481

The Tar Creek Superfund Site in northeastern Oklahoma is heavily impacted by decades of lead and zinc mining in the Tri-State Mining area in the early 1900s. A notable feature of this area is the presence of mine waste piles (locally called chat piles) that contain elevated concentrations of Zn, Pb and Cd. Runoff from these piles, together with acid mine drainage (AMD) originating from abandoned mine shafts, contribute to metal loading into Tar Creek. As part of a broader investigation of potential children's health impacts from exposure to metals in mining materials, we assessed metal concentrations and speciation in chat, the contribution of chat pile runoff as a source of metal loading into Tar Creek, factors affecting in-stream mobility of metals, and the potential mobilization of metals from chat piles by wind.

Variations in metal concentration and speciation as a function of particle size were assessed using XRF, XRD and sequential extraction techniques. Total concentrations of Zn, Pb and Cd were found to increase with decreasing particle size (up to 10% Zn and 2% Pb by mass and 200 ppm Cd in the <37 μm size fraction), indicating that particles most likely to be mobilized by wind are highly enriched in these metals. Sequential extraction experiments revealed that the Zn, Pb and Cd in these particles were fairly labile (40-80% solubilized in pH 7 1M MgCl2 or pH 5 acetate buffer solutions) and thus potentially bioavailable for uptake by plants, animals and humans. Additional column leaching experiments will explore the kinetics of metal dissolution, the effect of pH and contact time on metal mobilization, and the potential re-adsorption of mobilized metals as they move through the pile.

Field measurements confirm a high degree of aqueous mobility of Zn, Pb and Cd from chat piles, with surface runoff from chat piles containing highly elevated concentrations of these metals (up to 40,000 ppb Zn, 450 ppb Cd, and 25 ppb Pb). Preliminary mass loading estimates along a 500-m stretch of Tar Creek impacted by chat piles and AMD indicate that chat piles contribute the majority of Cd and Pb to the creek and a substantial portion of Zn, while AMD contributes most significantly to Fe and Zn loading. Once in the creek, metal mobility was related to affinity for ferric hydroxides, which are abundant in the creek.