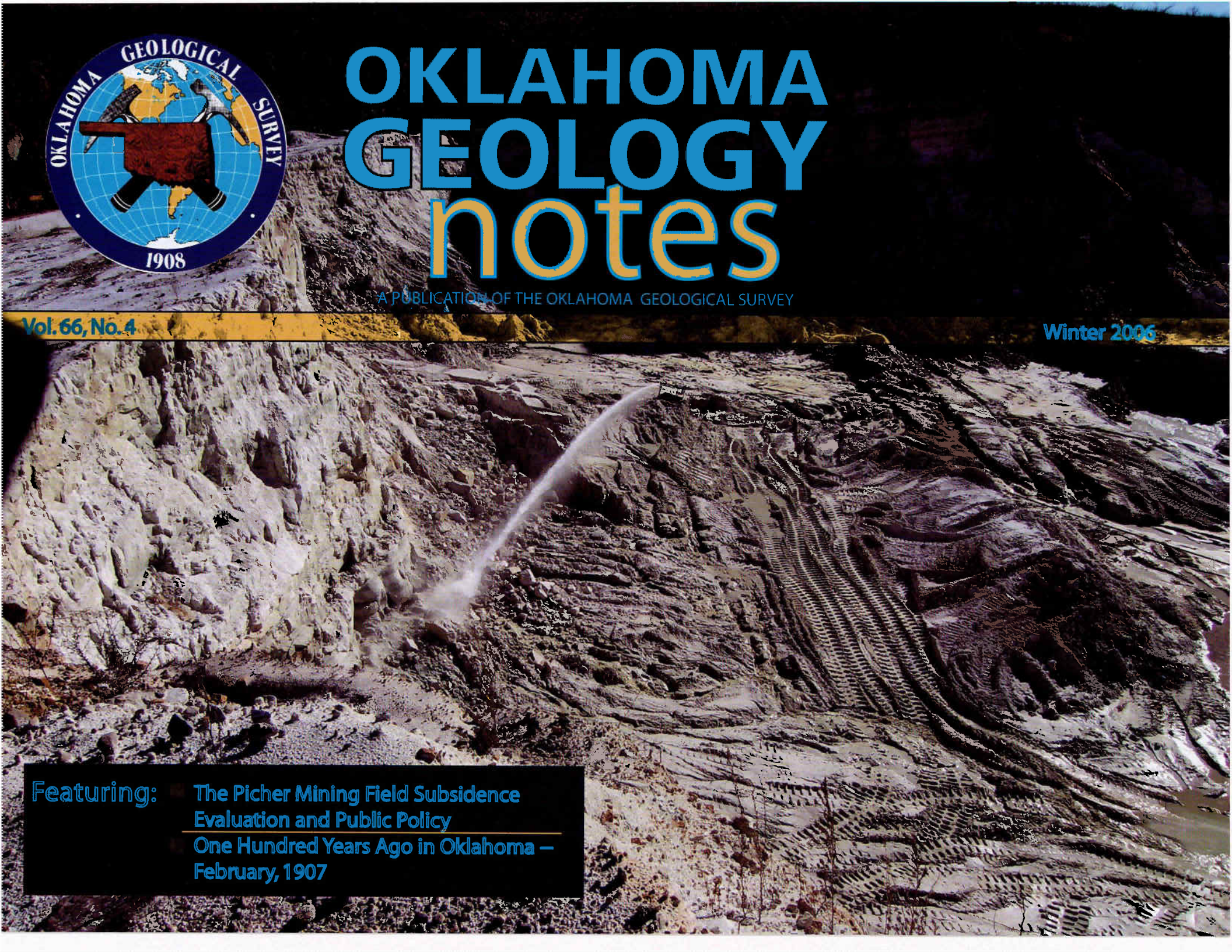

OKLAHOMA GEOLOGY notes

A PUBLICATION OF THE OKLAHOMA GEOLOGICAL SURVEY

Vol. 66, No. 4

Winter 2006

Featuring:

—On the Cover

US Silica Company Mill Creek Quarry – Upper Oil Creek Formation (Ordovician) at Mill Creek in Johnston County is fine-grained, well-sorted sandstone, which is poorly cemented with clay minerals. The economic bed ranges from 30 to over 100 ft thick and is relatively flat. Oil Creek sand is composed of nearly pure silica making it ideal for making glass. Unwanted colors in glass are prevented because the sand contains very low amounts of iron oxide and other contaminants. Clay and other cementing agents occur only in small amounts making hydraulic mining methods possible.

After stripping any overburden, miners drill and blast the sandstone bed to loosen it and provide additional surface area for effective hydraulic mining. High-pressure water monitors wash the sand from the mine wall (front cover) to a series of slurry pumps (photo above) that transport the sand to the processing plant. The sand stream is dewatered and silt and slimes removed before drying.

Natural gas discoveries in Oklahoma provided the major impetus for building new glass plants in the Tulsa and Okmulgee areas. By 1918 producers were shipping high silica sand from Mill Creek to the glass plants. Today US Silica Company mines high silica sand about six miles north of Mill Creek. Traditional uses of the silica sand include glassmaking, foundry applications, and proppants. Grinding mills produce silica flour for use in plastics, polishes and cleansers, paints, ceramic frits and glazes, fiberglass, precision castings, and more.

Photos by Sue Britton Crites, Oklahoma Geological Survey

OKLAHOMA GEOLOGY notes

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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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Figure 1. A 100-ft diameter, 60-ft deep collapse associated with a mine shaft on the Harrisburg lease west of Cardin, Oklahoma. *Photo by Kenneth V. Luza.*

The Picher Mining Field Subsidence Evaluation and Public Policy

Kenneth V. Luza
Oklahoma Geological Survey

W. Ed Keheley
Keheley & Associates

Figure 2. A 30-ft circular, non-shaft related collapse that developed on the Admiralty No. 1 lease in 2005-2006. *Photo by Kenneth V. Luza.*

ABSTRACT

Lead-zinc ore deposits were mined in the Picher Mining Field for almost 70 years. The mining era left a legacy of open mine shafts, shaft-related and non-shaft-related collapses, more than 40,000 exploratory drill holes, hundreds of abandoned deep-water wells drilled into the Roubidoux aquifer, large areas prone to subsidence, acid-mine water drainage from the mines, poor water shed drainage, and millions of tons of mill tailings containing lead, zinc, and cadmium spread over 5,000 acres. The U.S. Environmental Protection Agency added the site to the National Priorities List on September 8, 1983. The Oklahoma portion of the Picher Mining Field, about 41 square miles, became known as the Tar Creek Superfund Site.

Serious public health issues, which included potential contamination of the Roubidoux aquifer, a major aquifer used by municipalities in northeast Oklahoma, with mine water and elevated blood-lead levels in children, were the major focus of federal and state agencies at Tar Creek for the past 27 years. Public safety issues in the Picher Mining Field also include large areas prone to subsidence and hundreds of mine shafts either open or in some stage of collapse. These public safety issues were not addressed in depth until recently.

In August, 2004, the U.S. Army Corps of Engineers assembled a Subsidence Evaluation Technical Team to evaluate subsidence potential of the Picher Mining Field in Oklahoma. The areas of primary concern were major transportation corridors and residential areas in Picher-Cardin, Hockerville, and Quapaw. The report was released on January 31, 2006. Exhibits depicted the location of mine workings, shafts, non-shaft collapses, roof falls, and estimated maximum subsidence. This information was overlaid on 1 in. = 200-ft scale high resolution color photographs for each section. The study defined estimated maximum subsidence as the maximum amount of subsidence (in ft) that could occur at a given surface location as a result of collapse of the underground mine workings. The maximum amount of subsidence that could propagate to the surface was based on stope heights, and the thickness and bulking characteristics of the overlying strata.

A total of 286 numbered sites and/or clusters in the study area were identified on 20 exhibits that could have some degree of surface vertical settlement if the mine workings would completely collapse. A 150-ft buffer zone was drawn around the sites to account for mine map and location inaccuracies, and draw angle. In Picher, the sites contained 139 residential structures, 11 business structures, 13 public use structures/facilities, 53 streets, and 25 locations under or within 150 ft of a major transportation corridor.

An analysis of variables associated with past surface collapse and non-collapse case studies was used to determine the most important factors that control subsidence. The most important variables determined by the analysis were 1) stope width, 2) stope height, 3) combined thickness of the Boone Formation and overlying Chester rock units above the stope, and 4) stope depth. These variables were used to estimate the probability of subsidence for 133 areas identified on the estimated maximum subsidence maps. Those areas included public use facilities, residences, businesses, and transportation corridors within the 150-ft buffer zone. Three probability categories were used to estimate the potential for subsidence: > 50%, 20-50%, and < 20%. The results were presented on maps at the same scale as the exhibits in a series of figures in the report.

The results, findings, and conclusions were used to develop both general and specific recommendations for the study area. The general recommendations constituted minimum approaches to safety for the area. The team provided a series of options, and their associated costs, for policy makers to consider in a cost-benefit analysis assessment to determine the most cost effective option(s) in the best interest of public policy.

The subsidence evaluation report changed the approach for addressing hazards and risks in the Picher Mining Field. In the past, public health hazards were the principal issues of concern. Now, public safety hazards and public health hazards are jointly considered in formulating public policy. After reviewing the report, policy makers concluded that removing residents from the sites was the safest and the most cost effective option. This option, which is voluntary, affects 695 residences, businesses, and public use facilities. Property appraisals for the buyout began in November 2006.

Introduction

The Picher Mining Field is located in northeastern Oklahoma and southeastern Kansas and was part of the Tri-State Mining District (Oklahoma, Kansas, and Missouri). The Tri-State Lead-Zinc District was one of the foremost mining districts in the world. Mineral production began with the discovery of lead near Joplin, Missouri, in 1848. A later discovery in 1891 in Peoria, Oklahoma, expanded mining into Ottawa County. In 1914, Eagle-Picher announced the discovery of rich lead-zinc ore deposits near Picher, Oklahoma. By 1920, the area was known as the Picher Mining Field. The eventual depletion of high-grade ore deposits in the 1930s and the consequent lowering of mine-run ore grade caused a gradual decline in the Tri-State District's output of lead and zinc until the early 1970s when the mining field closed.

Mining was random room-and-pillar method where rooms were excavated and pillars were left to support the mine roof. Initial extraction ratios were about 85%. As mining depleted the ore, the mining companies performed a second stage of mining that included pillar shaving (trimming) or the complete removal of pillars, which were left during earlier mining. After the higher-grade ore was removed, the mining companies often subleased mine workings to independent miners, who removed the last remnant of ore from roofs, walls, pillars, and floors. Final extraction ratios, which varied from mine to mine, approached 100%.

Depths of mine workings vary from 100 ft (east) to 400 ft (west). 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.

The mining era left a legacy of open mine shafts, shaft-related and non-shaft-related collapses (Figs. 1 and 2), more than 40,000 exploratory drill holes, hundreds of abandoned deep-water wells drilled into the Roubidoux aquifer, large areas prone to subsidence, acid-mine water drainage from the mines, poor watershed drainage, and millions of tons of mill tailings containing lead, zinc, and cadmium spread over 5,000 acres. The U.S. Environmental Protection Agency (EPA) added the site to the National Priorities List (NPL) on September 8, 1983. The Oklahoma portion of the Picher Mining Field, about 41 square miles, became known as the Tar Creek Superfund Site (Tar Creek).

Public Health Issues

Serious public health issues, which included the potential to contaminate the Roubidoux aquifer, a major aquifer used by municipalities in northeast Oklahoma, with mine water and elevated blood-lead levels in children, were the major focus of federal and state agencies at Tar Creek for the past 27 years. EPA issued its first Record of Decision (ROD) for the Site on June 6, 1984. This ROD called for preventing the downward

Figure 3. The 1967 collapse in Picher, Oklahoma, that caused damage to personal property. *Photo courtesy of the US Bureau of Mines.*

migration of mine water into the Roubidoux aquifer. Initially, 66 well sites in Kansas and Oklahoma were identified for closure. Forty-three wells were plugged and their sites restored (IT Corporation, 1985). During remediation, an additional 17 well sites were found; 14 were cleared and plugged (Engineering Enterprises, Inc., 1986).

The impact of elevated blood-lead levels in children six years or younger is the primary public health concern in the Tar Creek Superfund Site since 1994. In 1992-1993, the Indian Health Service collected blood-lead data from children living in the area. They found that 34% of Native American children had elevated blood-lead levels above federal standards (Ackerman, 1994). The EPA identified mill tailings that contained high concentrations of lead, zinc, and cadmium as the primary source of lead. In response, between August 1994 and July 1995, the EPA conducted a soil sampling program in residential yards and public use areas to determine the extent of lead contamination. Because of widespread mill tailings throughout the Site, many residential yards and public use areas in several communities showed elevated lead levels in sufficient quantities to require removal.

In June 1996 a soil remediation (removal) program was quickly initiated in the affected communities by the EPA with the participation of the state of Oklahoma. Soil contaminated with lead was removed up to 18 in. deep in hundreds of residential yards and public use areas, and replaced with uncontaminated soil. From 1996 to 2006, over 2,100 residential yards were remediated at a cost of over $150 million. Major sources of lead from tailings piles, flotation ponds, dry mill ponds, and remaining chat-pile bases were not considered as part of the initial EPA response. The EPA has plans to address the mill tailings in the future.

In June, 2004, Governor Brad Henry signed the Tar Creek relocation bill that established the Lead Impacted Communities Relocation Assistance Trust (relocation trust authority) and authorized $3 million to relocate families with children 6-years-old and younger in the towns of Picher, Cardin, Hockerville, and Zincville. The voluntary plan gave families the opportunity to sell their property to the State at the average market value in Ottawa County. The plan helped renters find and finance new rental property for 12 months. Landlords received a 12-month stipend. Fifty-two families participated in the 2004-2005 program.

Public Safety Issues

Published field surveys, discussions with former miners, and analyses of mine maps raised significant questions about the stability of underground mine workings. Public safety issues associated with unstable mine workings were not addressed in depth until recently.

Shaft- and non-shaft-related subsidence events occurred in the Picher Mining Field during its productive years as well as after mining ceased in 1970. Field surveys in 1981-1983 (Luza, 1986) and 2004-2005 (Luza and Keheley, 2006) indicate at least 1,193 shafts exist in the Oklahoma portion of the Picher Mining Field. There are 511 shafts open or in some stage of collapse, and 104 non-shaft-related collapses. Some existing collapse features have enlarged while others that previously were filled by 1981-1983, have re-collapsed. Many collapse features were improperly filled with decomposable material and/or mill tailings such as chat and flotation fines. Several of these filled collapses later re-collapsed when the fill material migrated down into mine workings. In the fall of 2004, the U.S. Army Corps of Engineers (Tulsa District) began a program to plug and/or cap open and dangerous mine shafts. By the end of 2005, 62 shafts were plugged and/or capped.

Fortunately, most subsidence events have occurred in rural areas; however, there are some notable exceptions. On July 21, 1967, 18 persons occupied houses that were affected by a 1.5-acre collapse on the Netta White lease north of Picher High School (Fig. 3). Five occupants suffered minor injuries as a result of the collapse. Two houses were in the center of the collapse, and one house on the lip of the collapse was tilted 25° from the horizontal. An attached garage of a fourth house on the rim of the collapse broke away from the house and was severely crumpled. The surface near the center of the collapse dropped about 25 ft. On May 12, 1971, a mine shaft on the Black Hawk lease collapsed between two homes in the Picher federal housing complex. The shaft was filled and fenced before any injuries occurred. Another mine shaft collapsed beneath the Leatherman home on Alta Street in Picher on March 10, 1974. One room of the house fell into the shaft opening. Fortunately, no injuries occurred. On May 31, 1978, a cave-in was observed about 8 a.m. on the south side of East A Street. By noon the cave-in had reached the center of the road. The cave-in area was about 90 ft long, 40 ft wide, and

50 ft deep. One fatality in an automobile accident is attributed to the non-shaft collapse of May 31.

Tar Creek Superfund Site residents expressed their concerns about the potential for subsidence to Oklahoma Senator Jim Inhofe in the spring of 2004. In June 2004, he requested an assessment of the Picher Mining Field for potential subsidence. The U.S. Army Corps of Engineers was designated the lead agency on the subsidence evaluation project. A Subsidence Evaluation Technical Team, composed mostly of engineers and scientists, was assembled in August 2004 to begin the subsidence evaluation (Table 1). The report was released January 31, 2006 (U.S. Army Corps of Engineers, 2006). On that day, city and county officials and the news media were briefed. In the evening, a public hearing was held in the Picher High School Gymnasium.

The report had a profound impact in shaping public policy for the Tar Creek Superfund Site. The following sections describe the evaluation process, results, and recommendations for mitigation and/or avoidance of areas that have a potential for subsidence.

Evaluation Process

The U.S. Army Corps of Engineers gave the Subsidence Evaluation Team one year to conduct the initial assessment. Areas of primary concern were major transportation corridors and residential areas in Picher-Cardin, Hockerville, and Quapaw. Transportation corridors were U.S. Highway 69 from the junction of U.S. Highways 69 and 69A north through Picher to the Kansas state line; U.S. Highway 69A through Quapaw

Table 1. Subsidence Evaluation Team Organization

Organization	Team Member
Government	
U.S. Army Corps of Engineers, Tulsa District	Jonna Polk
	James Martell
U.S. Department of Interior, U.S. Geological Survey	David Fittermen
	Mark Becker
	Bill Ellis
U.S. Department of Interior, Office of Surface Mining	Len Meier
Oklahoma Conservation Commission (OCC)	Mike Sharp
Oklahoma Department of Environmental Quality (DEQ)	David Cates
	Mary Jane Calvey
Oklahoma Geological Survey (OGS)	Ken Luza
U.S. Department of Interior, Bureau of Indian Affairs	Charles Head
Quapaw Tribe	Tim Kent
Contractor Support	
Montgomery, Watson, Harza (MWH)	John Redmond
	Bruce Narloch
	Andrew Rossi
SubTerra, Inc.	Chris Breeds
Keheley & Associates, Inc.	Ed Keheley
Wood Metallurgical Consultants	Frank Wood
Others Contributing to the Evaluation Process	
Oklahoma Department of Environmental Quality (DEQ)	Kelly Dixon
U.S. Department of Interior, Bureau of Indian Affairs	Bob Coleman
U.S. Army Corps of Engineers, Tulsa District	Adman Crisp
U.S. Department of Interior, Office of Surface Mining	Paul Behum
Montgomery, Watson, Harza (MWH)	John Pellicer
U.S. Department of Interior, Bureau of Land Management	Doug Cook
Miami Integris Baptist Hospital	Dr. Mark Osborn

to the Kansas state line; East 20 Road (A Street) from the west side of Picher to the junction with Highway 69A; and Cardin Road from the junction with U.S. Highway 69 to the junction north of Commerce (Fig. 4). Areas within 150 ft of these transportation corridors were included in the study. Residential areas and transportation corridors are referred to collectively as the study area. Areas of secondary concern which were set aside for future evaluation, included railroads, power lines, natural gas transmission lines, rural areas, and nonresidential areas.

The 4,400-acre study area is located in all or parts of sections 13-17, 19-24, 26, 28-33, and 35 in T. 29 N., R. 23 E.; and sec. 19, T. 29 N., R. 24 E. Portions or all of 63 mines/leases were evaluated for subsidence potential (Table 2). A traditional subsidence evaluation, which utilizes field surveys to determine mine stratigraphy, structure, and rock-mass properties, was not possible because the mine workings were flooded. Detailed geologic reports for most mines in the study area did not exist and/or were not available. The Subsidence Evaluation Team used mine maps and drill-hole logs to determine subsurface stratigraphy and geometry of underground mine workings. Fortunately, hundreds of detailed mine maps, at scales from 1 in. = 40 ft to 1 in. = 100 ft, and thousands of drill-hole logs were collected and microfilmed by the former U.S. Bureau of Mines. The collection resides at Missouri Southern State University in Joplin, Missouri.

The evaluation process began in September 2004. In the initial stages of the evaluation process, an attempt was made to locate mine maps for the study area. Maps were found in mining museums, at federal and state agencies, and in private collections. Over one thousand mine maps of various scales and vintages were located and inventoried. An ongoing project by the Oklahoma Conservation Commission to scan mine maps and to convert microfilm drill-hole logs into digital databases was expanded for the study. Over 40,000 drill-hole logs were converted into digital images. Six subgroups were created to perform specific tasks:

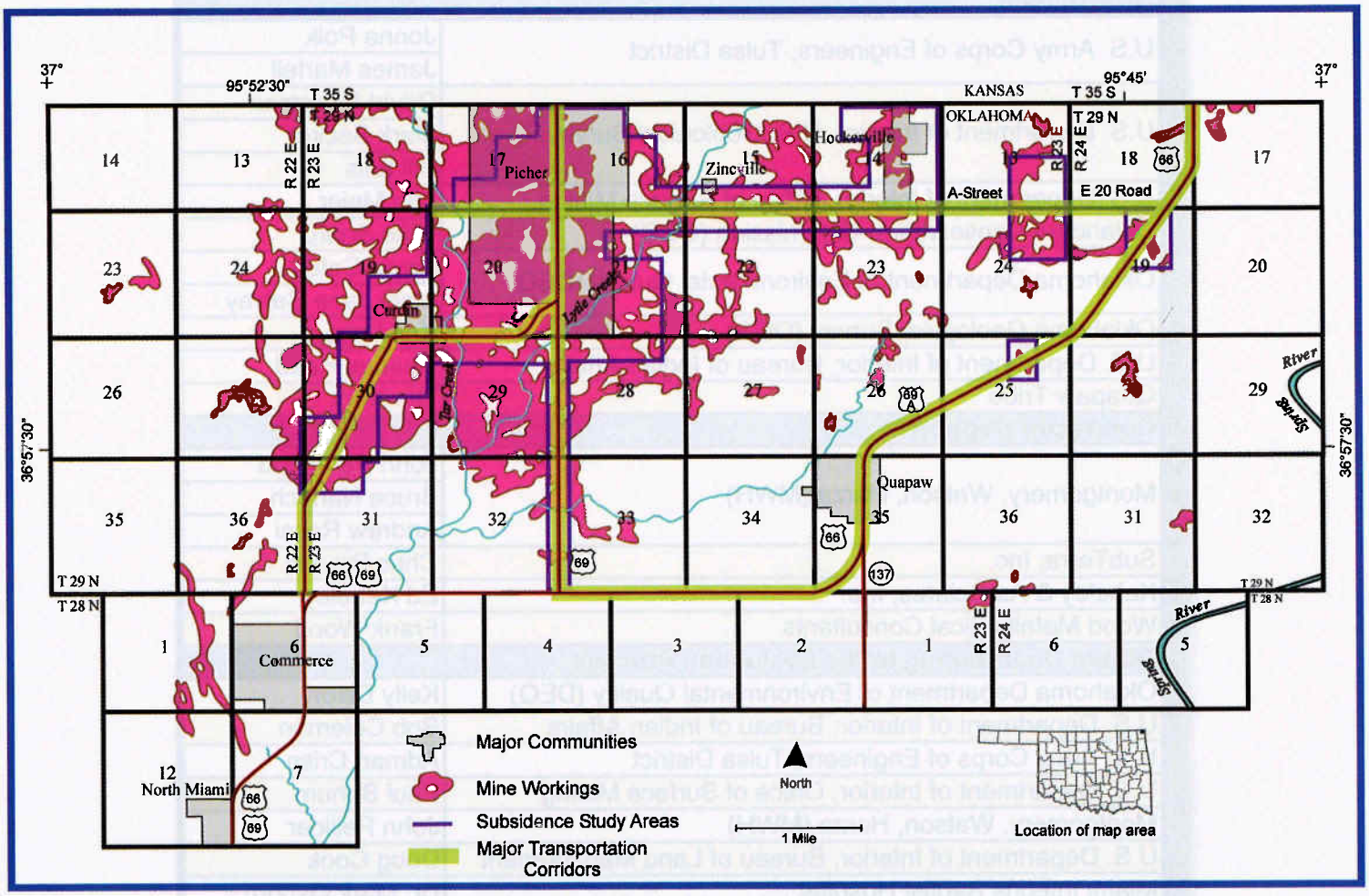

Figure 4. Major transportation corridors and areas evaluated for subsidence potential.

Table 2. Mines/Leases Located in the Study Area.

Mine/Lease	Section	Township	Range	Mine/Lease	Section	Township	Range
Scott	13	29N	23E	Eudora Whitebird	21	29N	23E
Farmington	14	29N	23E	No. 1 Black Eagle	21	29N	23E
Lucky Jenny	14	29N	23E	Royal	21	29N	23E
Dobson	14	29N	23E	Indiana	22	29N	23E
Niday No. 1	14	29N	23E	Dardene	22	29N	23E
Brester	15	29N	23E	Azetc	23	29N	23E
Beck	15	29N	23E	St Louis No. 4	24	29N	23E
Eudora Whitebird	16	29N	23E	Alice Greenback	26	29N	23E
Commonwealth	16	29N	23E	Birthday	28	29N	23E
Swift	16	29N	23E	Federal-Fort Worth	28	29N	23E
Netta White	17	29N	23E	Skelton	28	29N	23E
Piokee	17	29N	23E	New Chicago No. 1	28	29N	23E
Big Chief	17	29N	23E	Midas	30	29N	23E
Otis White	17	29N	23E	Beck	29	29N	23E
Crawfish	17	29N	23E	Skelton	29	29N	23E
Goodwin	17	29N	23E	Barbara J.	29	29N	23E
Cardin Townsite	19	29N	23E	Rialto	29	29N	23E
John Beaver	19	29N	23E	Baby Jim	29	29N	23E
Dorothy Bill No. 2	20	29N	23E	Blue Goose No. 2	30	29N	23E
Vantage	20	29N	23E	Hum-Bah-Wat-Tah	30	29N	23E
West Netta	20	29N	23E	Jay Bird	30	29N	23E
East Netta	20	29N	23E	Lucky Bill	30	29N	23E
Kenoyer	20	29N	23E	Bennie	30	29N	23E
Bialto	20	29N	23E	Ritz	30	29N	23E
Barbara J.	20	29N	23E	Tom L.	30	29N	23E
Oko	20	29N	23E	Woodchuck	30	29N	23E
Premier	20	29N	23E	Southside	31	29N	23E
Golden Hawk	20	29N	23E	Wesley Smith	32	29N	23E
Grace Walker	21	29N	23E	John Hunt	33	29N	23E
New York	21	29N	23E	Craig	33	29N	23E
Black Hawk	21	29N	23E	Malsbury	19	29N	24E
Premier	21	29N	23E				

1) Back Analysis Subgroup—refined the initial list of variables; selected case study areas of previous mine collapses for back analysis; interpreted mine maps, drill-hole logs, and other sources of information to determine and tabulate the values of selected variables for use by the forward analysis subgroup.

2) Forward Analysis Subgroup—used variables from back-analysis case studies to develop a predictive tool.

3) Drill-hole Analysis Subgroup—located and tabulated drill-hole log information for the study area; determined drill-hole collar elevations; and interpreted the logs for depths to various geologic units.

4) Communications Subgroup—prepared briefings; scheduled and presented the subsidence report to lawmakers and the public.

5) Bureau of Land Management (BLM) and Geologic Documents Scanning Subgroup—scanned into digital format the BLM mine map collection and geologic documents.

6) Map Scanning and Acquisitions Subgroup—identified, inventoried, and scanned additional map collections.

Table 3. Summary of Subsidence Locations (numbered sites) by Category within the 150-ft Buffer Zone

Residences or Structures	Major Transportation Corridors	Residences or Structures and Major Transportation Corridors	Parks & Playgrounds	Other
54	33	13	3	183

The large size of the study area and the quantity of available data made it necessary to adopt a systematic process of data collection and assimilation. Data requirements were dictated by the selected predictive tools and by the need to prepare and provide a comprehensive database of underground mines, mine shafts, and existing subsidence features. Selected resources were indexed and scanned into electronic format, including:

- 264 geology and mining related articles and documents pertaining to the Picher Mining Field (scanned by the U.S. Army Corps of Engineers)
- 173 mine maps (scanned from BLM archives)
- 397 documents (scanned from BLM archives)
- 348 mine maps (scanned from the Picher Mining Museum in Picher, Oklahoma) and
- more than 500 other maps (scanned from Missouri Southern State University archives in Joplin, Missouri).

Mine map images provided by the OCC were digitized to create Mine Vector Graphics (MVGs). The MVG is a vector representation of a scanned mine map including separate matching Digital Elevation Models (DEMs) that represented elevations of separate mine workings. These data were geo-referenced to the Oklahoma State Plane North coordinate system, NAD 83. Subsurface geology was determined from an analysis of 3,800 drill-hole logs. The data acquired and generated for the Picher Mining Field subsidence evaluation were assembled and incorporated into a Geographic Information System (GIS), which was used to develop a Conceptual Site Model. The GIS model evaluated the potential subsidence and probability of subsidence in the study area. This model was intended to serve as a resource, and the basis for future studies and management programs in the Picher Mining Field.

The Subsidence Evaluation Team identified two primary products that could convey useful information on the extent, probability, and magnitude of mine subsidence within the Picher Mining Field. The two types of information were

1) maps presented as exhibits (U.S. Army Corps of Engineers, 2006, v. 2) that showed the locations of mine workings, mine shafts, and the potential maximum subsidence; and

2) maps presented as figures to show estimated probability of subsidence.

Type one information (maps presented as exhibits) was overlaid on 2004, high resolution, color photography at 1 in. = 200-ft scale for each section.

Estimated maximum subsidence was defined for this study as the maximum amount of subsidence (measured in ft) that could occur at a given surface location as a result of the collapse of underground mine workings. If mine workings collapsed, the maximum amount of subsidence observed on the surface was based on stope heights and the thickness and bulking characteristics of overlying strata. A bulking factor of 1.2 was used for the overlying strata. Maximum estimated subsidence values were grouped into six categories that ranged from < 2 ft to > 50 ft.

A total of 286 numbered sites and/or clusters (Table 3) in the study area that could have some degree of surface vertical settlement if the mine workings would completely collapse, were identified on 20 exhibits (U.S. Army Corps of Engineers, 2006, v. 2). A 150-ft buffer zone was drawn around the sites to account for

mine map and location inaccuracies and an angle of draw. (Note: The angle of draw is used in coal mining subsidence. This angle is assumed to bisect the angle between the vertical and the angle of repose of the material. For nearly flat coal seams, the angle is about 20°). In Picher, numbered sites contained 139 residential structures, 11 business structures, 13 public use structures/facilities such as churches, parks, a city maintenance facility, a lodge facility, and the Picher Mining Museum, 53 streets, and 25 locations under or within 150 ft of a major transportation corridor.

For example, the analysis indicated that Reunion Park (Fig. 5) in downtown Picher had the potential for maximum subsidence greater than 50 ft. Reunion Park is located on the south side of the East Netta mine. Detailed mine maps indicated that a large pillar near the center of the void beneath the intersection of Main and Second Streets was 94 ft high and less than 50 ft in diameter. Adjacent to the pillar, the mine void reached a maximum height of 106 ft. In February 1950, the Eagle-Picher Mining and Smelting Company issued notices to tenants to vacate five city blocks (8.45 acres) in the heart of the business district of Picher within 30 days. Mining engineers were concerned that pillars beneath the site were not sufficient to support the mine roof. Within one year, all the buildings and residences were demolished and a high chain link fence was built around the area preventing access. In 1996-1997, the fences were removed and Reunion Park was built. Since 1997, the park was used as the site of the annual miners' reunion in Picher where about

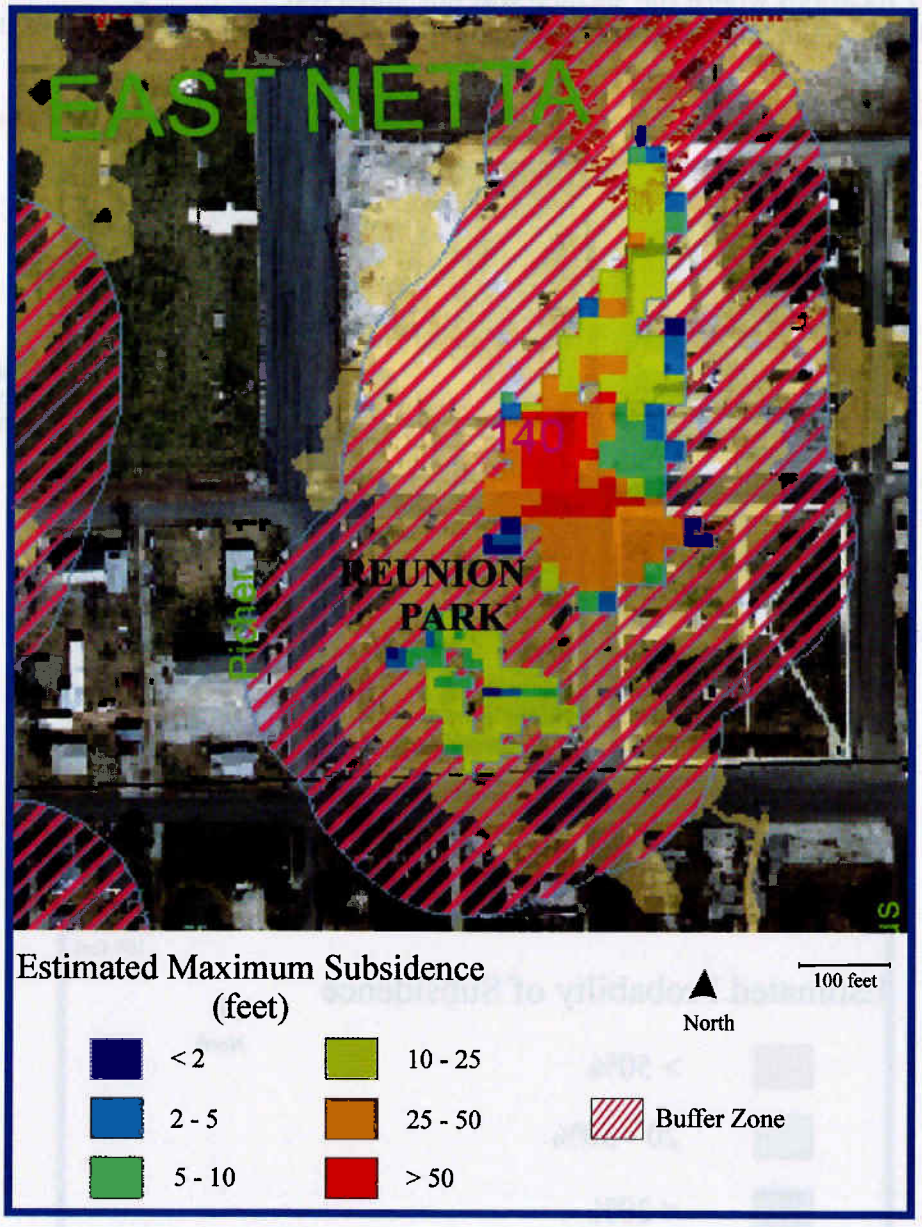

Figure 5. Estimated maximum subsidence for Reunion Park, Picher, Oklahoma.

1,000 - 1,200 visitors congregated along with a carnival, parking, and venders' booths.

The size of the Picher Mining Field, compressed timeframe for the study, and lack of detailed geologic and rock-mechanics data prevented a detailed analysis of individual sites identified by the estimated maximum subsidence model. An empirical back-analysis approach offered the only viable method to determine the probability of subsidence in the study area. Large subsidence features were back analyzed to determine those factors or combination of factors that may have caused mine-roof failures.

The inventory of mine collapse features by Luza (1986) was used to select a sample of typical collapse features throughout the Picher Mining Field. The Back-Analysis Subgroup evaluated 12 subsidence features and 17 locations where the surface was not impacted by subsidence in 28 case studies. Detailed mine maps, 1 in. = 40 ft to 1 in. =100 ft, and drill-hole logs were used to determine the stope geometry and geologic contacts. Other variables included the presence or absence of roof falls, extraction ratios, and mapped tectonic/geologic features within or near the stope area. A qualitative judgment of high, medium, or low was applied to the confidence of the stope-dimensional data. The judgment was based on the age of the map and the degree of difficulty in interpreting the mine map. The back analysis was intended to record all variables that may contribute to mine collapse throughout the entire region at selected locations.

Variables associated with past surface collapse and non-collapse case studies were tabulated and analyzed statistically by the Forward-Analysis Subgroup. The primary objectives of the statistical analysis were to identify variables that are most highly correlated with large surface collapses and to evaluate the relationships between those variables. The statistical

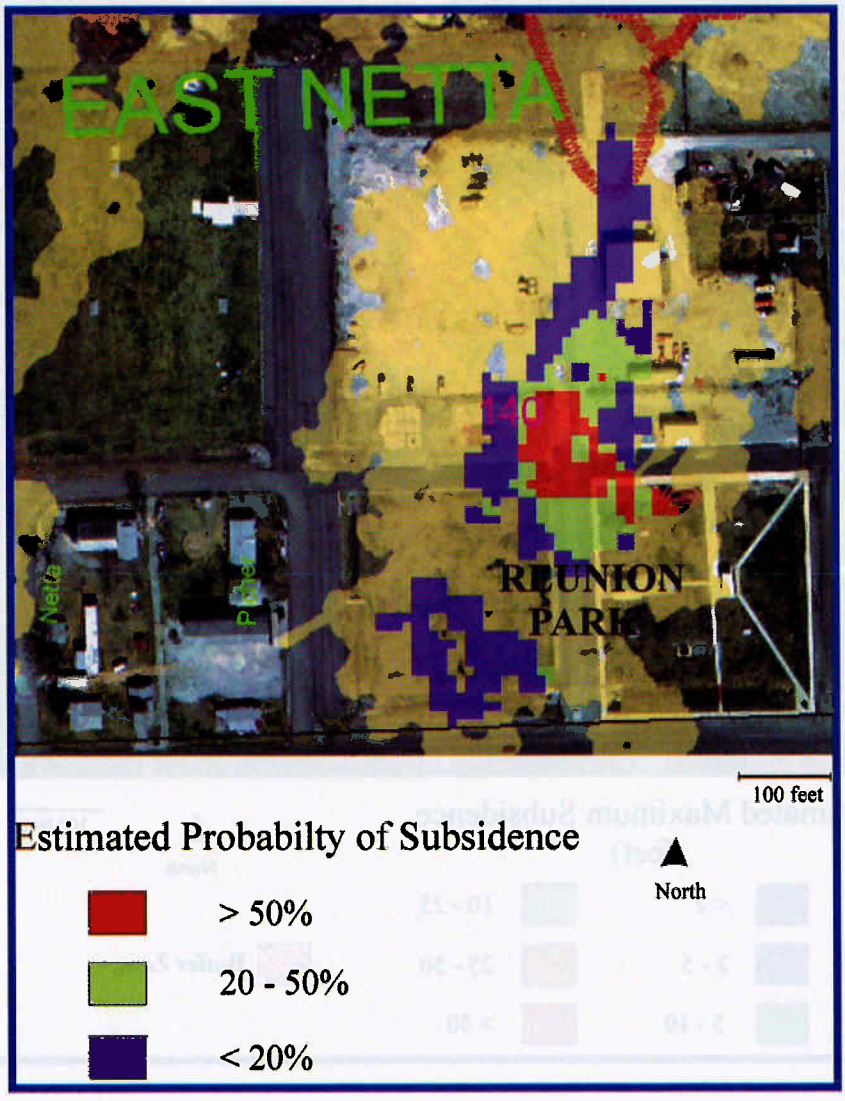

Figure 6. Estimated probability of subsidence for Reunion Park, Picher, Oklahoma.

relationships were used to quantify the probability of large surface collapses that occurred in areas not evaluated as part of the back analysis. The analysis determined that 1) stope width, 2) stope height, 3) combined thickness of the Boone Formation and overlying Chester rock units above the stope, and 4) stope depth were the most important variables to estimate the probability of subsidence. These variables were used to estimate the probability of subsidence for some areas identified on the estimated maximum subsidence maps. One hundred thirty-three areas, which included public use facilities, residences, businesses, and transportation corridors within the 150-ft buffer zone, were evaluated. The evaluation provided a numerical prediction of the probability of future subsidence at these locations. Three probability categories (> 50% [red], 20-50% [green], and < 20% [dark blue]) were used to estimate the potential for subsidence. Results are presented on Figs. 7.3B-7.3K (U.S. Army Corps of Engineers, v. 1, 2006). For example, Reunion Park, which had an estimated potential subsidence > 50 ft, had an estimated probability of subsidence > 50% (Fig. 6).

Summary and Conclusions

From the assembled data and the evaluations performed, the following summarizes the major findings of the study.

- The potential for shaft-related and non-shaft-related subsidence is a very serious threat to the safety and economic well-being of people who reside in and travel through the area. Subsidence can occur with little or no advance warning. Every shaft has the potential to collapse, and the initial opening of a shaft collapse is likely to be the dimension of the shaft itself, growing to as much as 30 ft in diameter.
- The magnitudes of possible subsidence range from just < 1 ft to just > 50 ft at the locations evaluated. Land use determines the potential impact of a subsidence event on the population. For example, a one-foot subsidence in a road has more serious consequences than a similar or even larger subsidence in an agricultural area.
- 3,130 acres in the 4,400-acre study area were not undermined. 1,270 acres were undermined, of which 88 acres displayed greater than nominal potential for subsidence. The 88 acres found to display greater than nominal potential for subsidence were identified at 286 separate locations and/or clusters. Further review of all available information may reveal additional areas that may have potential for subsidence. It is likely that subsidence features exist in the study area but were not identified.
- Methodologies are not currently available to accurately predict when subsidence will occur.
- 473 acres of the 1,390 acres studied in Picher are undermined.
- 17 acres of the 58 acres studied in Cardin are undermined.
- 25 acres of the 231 acres studied in Hockerville are undermined.
- The Subsidence Evaluation Team located no maps of mines in the vicinity of Quapaw, so as a result, the areal extent of underground mines is unknown. The presence of mine shafts and mill sites in the area, however, indicates that some mining has occurred beneath some parts of town.
- 4.5 miles of the 19 miles of major transportation corridors in the study area are undermined.
- 15 shaft-related and 20 non-shaft-related subsidence events have occurred in the study area since the 1982 inventory by the Oklahoma Geological Survey.
- Factors identified as contributing most to non-shaft-related subsidence are stope width, stope height, combined thickness of the Boone Formation and overlying Chester rock units above the stope, and depth of stope. These were used to develop a probability model that predicts the likelihood of future subsidence.
- Current groundwater levels in the study area provide a buoyant effect that reduces the effective load on remnant pillars and mine roofs and therefore may decrease the potential for subsidence. Lowering the groundwater table to levels below mine-roof elevations may locally increase the probability of subsidence. This would probably only occur through pumping; however, water level fluctuations may cause increased shaft-related collapses.
- Thorough evaluation of subsidence potential of a mined area must include careful review of all available mine maps. Mine maps are of different

vintages; and the most recent maps do not always include mine workings shown on older maps. Discrepancies were found on maps for the same lease.

- Map symbols used to indicate different mine levels are inconsistent from lease to lease, and in some cases are inconsistent within the same lease. Interpretation of mine maps is sometimes difficult in areas of multiple-level mining because of overlapping and/or inconsistent map symbols.

- Assay data from exploration drill-hole logs, in places, was used to estimate mine floor and roof elevations.

- Geology varies within short distances, and is indicated by exploration drill-hole logs and available published reports.

- The extraction ratio for many of the mines, calculated from detailed mine maps, is greater than 90%.

- Very little geotechnical and/or rock mechanical data exist to assess the probability of subsidence using available analytical methods.

- Very little documentation is available regarding the shaving or removal of pillars, except for a few isolated cases.

- Details of the mechanics of non-shaft-related subsidence in the study area are poorly understood. Post-mining features (post 1970) in the Picher Mining Field are smaller in size than previous collapses, which suggest a different collapse and subsidence failure mechanism than in earlier collapses.

- Some existing houses in the Picher area do not meet U.S. Department of Housing and Urban Development (HUD) requirements for habitability and/or for financing home improvements and/or sales.

- Some areas in the mining field are not suitable for residential or business development given the safety risks and cost of mitigation.

- No funding mechanism exists for emergency response to subsidence.

Recommendations

The results, findings, and conclusions were used to develop general and primary recommendations for the study area. The general recommendations constitute the minimum safety approaches for the area. Due to the anticipated high cost of some recommendations, the Subsidence Evaluation Team further recommended using a cost-benefit analysis as the primary management tool. The cost-benefit analysis of all available options will determine the appropriate final decision.

The following is a general summary of the recommendations made by the Subsidence Evaluation Team.

- Establish an advisory committee composed of federal, state, and local representatives to assist with the implementation of recommendations contained in the report, and to serve as a technical and/or management resource for policy makers and elected officials.

- Establish a long-term program to locate, map, and record all subsidence events as they occur in the Picher Mining Field.

- Establish a fund to address emergency subsidence events in the Picher Mining Field. The fund should provide for emergency evaluation of subsidence features as they occur and provide an immediate funding source for corrective measures. Existing funding mechanisms do not provide for the ability to respond quickly to emergencies. The fund should be replenished as it is drawn down.

- Continue the current mine-shaft closure program to remove the immediate hazards associated with open shafts, further reduce the potential for additional shaft failures, and minimize the environmental impacts from surface water drainage and unauthorized dumping. Focus mine-shaft closure efforts first on open mine shafts within city limits and near occupied structures.

- Develop and implement a subsidence training program for workers from Picher, Quapaw, Commerce, Ottawa County District 1, and Oklahoma Department of Transportation maintenance staffs. The program should be designed to teach workers to recognize and report subsidence events and how to take appropriate action to address subsidence events as they occur. A similar program was de-

veloped in Joplin, Missouri, and has worked effectively for several years.

- Identify and inspect all shaft-related and non-shaft-related subsidence features being used as dump sites for commercial and household refuse to reduce the environmental impacts of open subsidence features. A priority ranking based on potential environmental impacts should be developed, and additional funding provided to eliminate surface runoff into the sites and, in some instances, to close the sites not currently addressed. Governmental regulatory agencies, cities, and Ottawa County should work together to strengthen regulations, enforcement, and penalties for unauthorized dumping and to develop legal alternatives for trash disposal.

- Federal and state agencies involved in remediation and reclamation of lands at Tar Creek should re-evaluate existing assumptions and approaches used to address hazards in the mining field. Information contained in the report (potential subsidence and mine-shaft failure, underground mine workings, etc.) should be factored into existing projects, plans, and decisions. A process for evaluating current and future land-use plans against existing hazards and the estimated cost for remediation and reclamation should be developed. A plan for restoration and/or final disposition of mined properties, including identification and mitigation of known hazards, should be a product of the effort. Ottawa County and impacted cities should establish a county-city land-use planning process to evaluate current land use and to develop future land use recommendations in the study area. Ottawa County should adopt building standards and land-use guidelines for mined lands.

- HUD regulations related to existing housing and future construction in the mining field should be reviewed to determine their applicability and impact.

- Identify a state agency responsible for maintaining and building upon the GIS developed from the project. GIS information should be made available on the Internet and/or other electronic media.

- Complete the subsidence evaluation for the remainder of the Picher Mining Field. This could include 1) further refinement of the subsidence evaluation model, 2) evaluation of the effects of mine water on the stability of mine workings, 3) development of a better understanding of structural geology, physical, and engineering properties of rock in the area, and 4) evaluation of failure mechanisms for recent smaller, non-shaft subsidence areas.

Given the study's conclusions, measures are required to mitigate the potential adverse impacts to public safety. Areas with higher probabilities of subsidence and greater consequence should be given priority with regard to evaluation and mitigation. The following is a brief listing of the Subsidence Evaluation Team's site-specific recommendations for public use areas, residential/commercial areas, major transportation corridors, residential streets, and rural, agricultural, and undeveloped areas.

Public Use Facilities (maximum estimated subsidence of 5 ft or greater)

- Three options are available: 1) close/relocate the facility, 2) conduct a site-specific evaluation, and 3) conduct a geotechnical evaluation, or perform regular monitoring using visual and/or geotechnical methods. The costs of the evaluation, and possible long-term monitoring should be determined. The benefits of continuing to use these facilities should be evaluated against the risk and overall costs of closure/relocation, the geotechnical evaluation, and long term monitoring.

- Four public use facilities in Picher (grade school playground, youth soccer field, Reunion Park, old Little League Park) should be evaluated to determine if continued use is safe for the residents.

Residential/Commercial Areas

- All mine shafts should be investigated to determine if they are filled with durable material. If not, the shaft(s) should be backfilled and/or plugged with concrete at the rock interface. Such areas should be zoned to restrict future residential, commercial, and/or public use.

- If a structure is located immediately over a shaft, the structure should be relocated and or demolished, or if cost effective, the shaft should be properly sealed.

- Detailed evaluations of site(s) that contain structures located within an Estimated Maximum Subsidence 5 ft or greater and/or within a 150-ft buffer zone are needed to verify the actual subsur-

face conditions. If the site is not safe for continued occupation and/or use, and mitigation is not a feasible option, then relocation and/or demolition should be conducted.

- The small number of mine shafts identified in Quapaw may indicate that the mine workings are not extensive and/or located near the surface. Based on the absence of non-shaft related-subsidence in the past, city workers should be trained to recognize and report any indications of subsidence or shaft failure.

Major Transportation Corridors and Residential Streets

- Even small collapses on transportation corridors and residential streets have potential to cause serious accidents. For transportation corridors and residential streets that have an estimated maximum subsidence of 0-2 ft under or within 150 ft of the road, establish and implement a routine survey grade monitoring procedure, the results of which should be reviewed by a qualified engineer on a prescribed schedule.

- Short-term recommendations include 1) inform transportation and utility managers of potential risk, 2) consider imposing weight restrictions and speed limits on vehicles, and 3) establish alternate routes for school buses.

- Long-term recommendations include 1) geotechnical investigation to determine the stability of the road bed, surface, and right-of-way, 2) training city, county, and state transportation workers to recognize signs of subsidence related to mining, 3) establishing standard notification and road closure procedures if shaft failure or subsidence is occurring in or adjacent to a road and, 4) mitigation if cost effective.

Rural, Agricultural, and Undeveloped Areas

Areas used for pasture and hay or row crops, and undeveloped areas used for hunting, off-road vehicle use, or hiking expose fewer people to dangers associated with subsidence than do roads or residential areas; yet dangers to public safety and property still exist. Undeveloped and lightly developed portions of towns are likely locations for new construction or relocation of existing structures from other areas. It is recommended that no new construction or relocation of residential housing, commercial buildings, infrastructure, or transportation systems be allowed immediately above or within 150 ft of undermined lands until the area is evaluated for potential subsidence.

In addition to the recommendations, the report presents options to address some of the existing subsidence features. Options were divided into four categories and include 1) management approaches that may be used to address subsidence, 2) instrumentation that could be installed for early detection of potential surface collapse, 3) mine geometry characterization to better understand parameters contributing to potential surface collapse, and 4) hazard mitigation options associated with subsidence.

Discussion

The Subsidence Evaluation Team applied scientific principles to define, describe, and quantify potential subsidence in the study areas. Subsurface geology was used to develop a three dimensional model to assess maximum subsidence potential. Over 3,800 drill-hole logs were used to determine the thickness of the Pennsylvanian and Mississippian stratigraphic units that overlie mine workings. Bulking characteristics of overlying strata and stope heights determined whether or not subsidence could propagate to the surface if the mine workings were to collapse. The 1) stope width, 2) stope height, 3) combined thickness of overlying Mississippian strata above the stope, and 4) stope depth were the most important factors needed to estimate the probability of subsidence. Potential maximum subsidence maps and probability figures in the report were used to identify areas that may be a public safety hazard if subsidence occurred. These illustrations made it easier for the public and elected officials to visualize and understand the significance of the public safety hazards, environmental effects, and future land-use issues associated with subsidence.

The subsidence evaluation report changed the approach for addressing hazards and risks in the mining field. The report showed that there was a greater overall risk to the public than was previously recognized. In the past, public health hazards were the principal issues of concern. Now, public safety hazards and public health hazards are both considered when formulating public policy. Regardless of how much the surface was remediated or reclaimed to eliminate lead exposure, the area is not considered a safe place to

live as long as subsidence hazards exist. The land is not usable for residential, business, and/or other public facilities in areas susceptible to subsidence.

The need to address the public safety hazards at Tar Creek played a major role in shaping public policy for the site. Public policy is a set of interrelated governmental decisions, including political decisions, for implementing programs to achieve societal goals. The policy is generally made by the government in the name of the "public" and in some instances may be initiated by the government, but not always accepted by the public. In other instances, public policy may be initiated by the public. If the decision-makers react to incomplete or misleading information, public policy can be easily flawed. At Tar Creek, the public and representatives of federal and state agencies played a major role in developing public policy.

Informed decision-making is facilitated by providing elected officials with alternative solutions for hazard mitigation. Hazards to the public can be 1) eliminated, either by removing the threat to the public, or 2) if the hazards cannot be eliminated, removing the public from the hazards. The report contained a number of solutions, along with associated costs, for hazard mitigation. These data could be used to evaluate the most cost effective method(s) to eliminate the potential hazard(s).

Evaluation team members briefed Senator Inhofe and his staff on the report findings, conclusions, recommendations, and options in January 2006. After a review of the report and assessment of the options, Senator Inhofe concluded that removal of the sites' residents was the safest, most cost effective solution, and in the best interest of public policy. In May 2006, Senator Inhofe announced that he had chosen

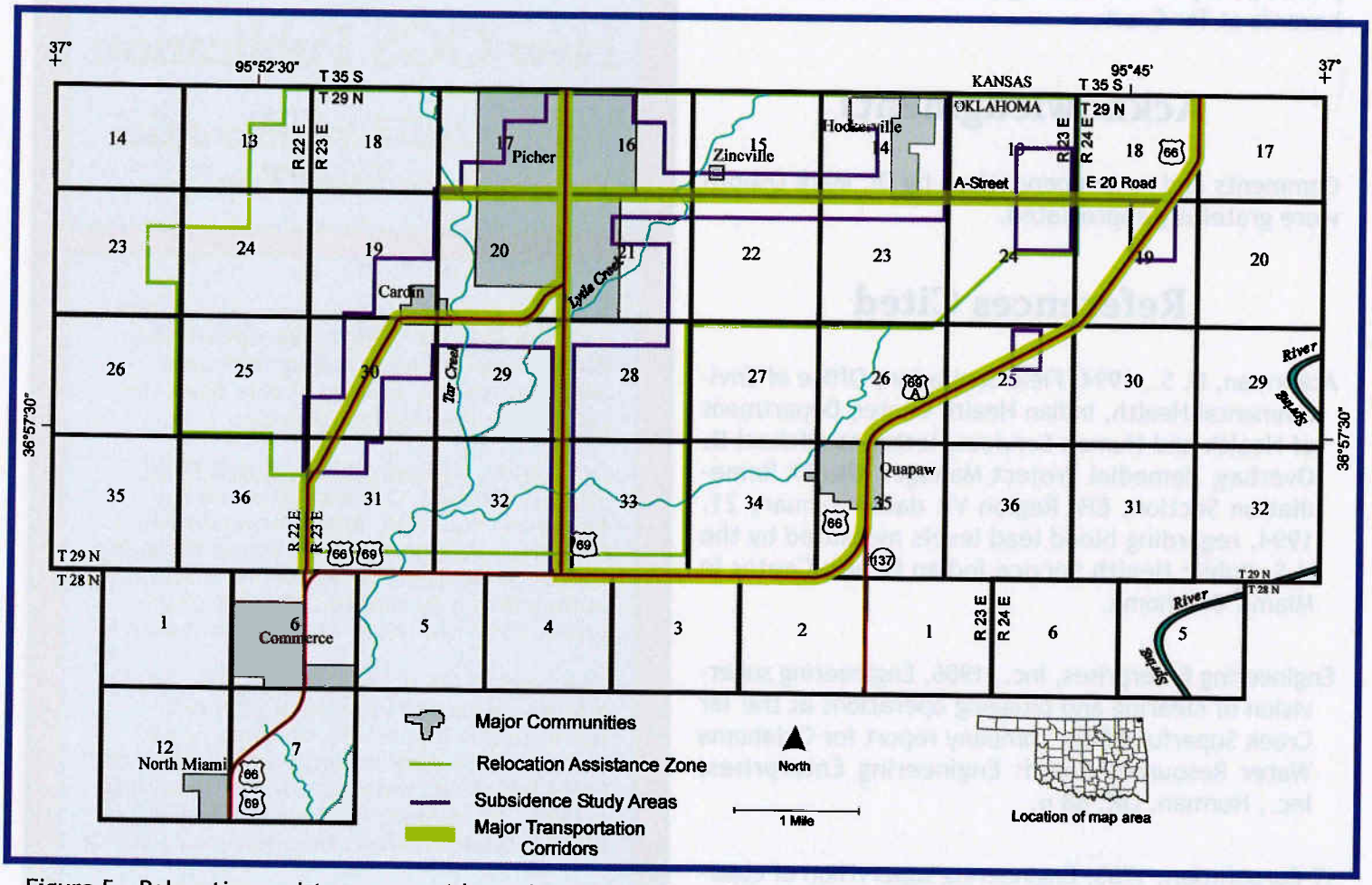

Figure 5. Relocation assistance zone (shown in green) or buyout boundary developed by the Oklahoma Department of Environmental Quality.

the buyout option. This option, which is voluntary, is for residents, businesses, and public-use structures in the most affected areas of the Superfund Site. Oklahoma Governor Brad Henry and Senator Inhofe agreed that the state would manage the buyout using federal funds. In June 2006, Governor Henry signed legislation, Senate Bill 1463, that reestablished the relocation trust authority that was used to relocate families with children 6-years-old and younger in 2004-2005. In July 2006, Governor Henry appointed trust members to manage the buyout. The same boundaries, about 13,000 acres, for the previous relocation were used to determine eligibility by the relocation trust authority (Fig. 5). There are 695 residences, businesses, and public use facilities eligible for the buyout. Appraisals of property for the buyout began in November, 2006.

A comprehensive understanding of geology and the ability to visually relate the mine workings to potential public safety hazards led to the present policy at Tar Creek. The process used at Tar Creek was an excellent example of public, state and federal agencies, and elected officials working together to develop public policy for addressing public health and safety hazards at Tar Creek.

Acknowledgments

Comments and recommendations by Dr. Mark Osborn were gratefully appreciated.

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—Special Oklahoma Centennial Series

A Hundred Years Ago in Oklahoma February 1907

Compiled by
Kenneth V. Luza
Oklahoma Geological Survey, 2007

Oklahoma City shortly after the land run of April 1889. *Forbes Collection, Western History Collections, University of Oklahoma.*

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 and information about geology and mineral resources are emphasized. 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 may have been overlooked and may have led to misinterpreting the reporter's meaning or intent.*

The Daily Oklahoman *had a daily average circulation of 18,147 in February 1907. The newspaper was published daily except for Monday; and cost 5¢ at the newsstand or 45¢ per month when delivered by carrier.* **The articles are republished with permission from *The Oklahoman*.**

In February 1907, several coal-mine disasters in West Virginia and Mexico were reported. Prairie Oil and Gas Company, the Indian Territory branch of Standard Oil, began construction on a 120-acre oil-tank farm near Jenks. Construction companies prepared bids to complete the Panama Canal. Oklahoma City's new $250,000 water plant was near completion. The state fair committee continued to raise money for a state fair and exposition in Oklahoma City. In mid-February, nearly one-half of the 100,000-acre Wichita Mountain Wildlife Refuge was threatened with dev-

Family sitting in front of a dugout circa 1909. *Photo by J.V. Dedrick, Oklahoma Geological Survey Collection, Western History Collections, University of Oklahoma.*

astation by a raging wildfire. The interurban line was extended to Belle Isle Park. Prairie Oil and Gas Company announced daily oil shipments by rail from Glenn Pool to Beaumont, Texas.

Friday, February 1, 1907, p. 1

Millionaire Murderer On Trial For Life

New Sensations in (*Harry K.*) Thaw Trial

BITTER FEELING BREAKS OUT

Three More Sworn Jurors Excused—Garvan To Make Opening Address

New York, Jan. 31.—Sensations were frequent in the Thaw murder trial today, and before the two sessions of court had ended, three sworn jurors in the case, making five in all, [were] summarily excused from the trial panel during the last three days. [*Harry Kendall Thaw, the son of Pittsburgh coal and railroad baron, William Thaw, was accused of the murder of the architect, Stanford White, at Madison Square Garden in 1906.* **The Oklahoman** *published daily accounts of the trial for several weeks.*]

February 1, 1907, p. 6

The Overholser Opera House presents "The One Woman," a study of love and socialism on Sunday, February 3rd. Tuesday, February 5th, Jules Murry presents Creston Clarke in "The Ragged Messenger" at the Overholser Opera House. Prices 25¢ to $1.50.

MUTILATED BODIES COVER THE SHAFT

Charleston, West Virginia, Jan. 31.—The bodies of nine of the victims of Tuesday's (*coal mine*) explosion were brought to the surface today. The bodies were brought up by Edward Pickney, inspector of the mine, and John I. Absolam, district mine inspector, who were the first to go down. Their trip was one of great peril.

February 1, 1907, p. 7

ROCK ISLAND'S BIG PROJECTS

VICE PRESIDENT MUDGE TALKS OF VAST BETTERMENT PLANS

NEW DEPOT PLANS PREPARED

Evasive Answer Indicates Depot Site Has Not Yet Been Settled

"The Rock Island company is planning so many improvements to its property in Oklahoma this year that I fear if I were to attempt to tell you of all I would forget one-half of them," said H. U. Mudge of Chicago, vice president of the Chicago, Rock Island and Pacific railroad. "The temporary bridge over the Cimarron River north of Dover will be replaced by a new steel structure costing $150,000. Many new bridges will be built over the line in the two territories. The yards at Geary and at several other places will be enlarged and track betterments will be made. The plans for the new union passenger station for Oklahoma City are now in the hands of the chief engineer of the Frisco."

Saturday, February 2, 1907, p. 1

WILL RECOMMEND CANCELING OF THE COAL LAND LEASES

Judge Prouty Says Prices on Territory Coal Are Exorbitant

HE TALKS TO GOVERNOR

If People Have Been Robbed They Should Have Full Recourse

Judge Prouty recommended to the Interstate Commerce Commission that it urge President Roosevelt to cancel the leases on coal lands in Indian Territory. He also urged Governor Frantz to personally call upon President Roosevelt and request that the coal land leases be revoked. These expressions were made by the commissioner after he had heard an exposition of the high prices and exorbitant freight rates the people of Oklahoma have been paying for years on coal mined in Indian

Territory and shipped to points in Oklahoma.

February 2, 1907, p. 2

Racket Grocery and Meat Market on 119 North Broadway advertised these specials for Saturday: 20 pounds Best Granulated Sugar $1.00, 7 pounds Michigan Hand Picked Navy Beans 25¢, 4 pounds 70–80 Santa Clara Prunes 25¢, Grape Nuts, per package 10¢, 5 cans Iowa Best Corn 25¢, California Shoulder Hams, per pound 08¢, Dressed Hens, per pound 12¢, Round Steak, per pound 10¢, Loin Steak, per pound 10¢, Good Boiling Beef, per pound 05¢. "Come and sample the National Biscuit Co.'s good things to eat. They are demonstrating for us today."

Sunday, February 3, 1907, p. 1

MEN WITH MONEY BACK CANAL BIDDER

Washington, Feb. 2.—William J. Oliver of Knoxville, Tennessee, the lowest bidder for the construction of the Panama Canal has gotten together as his associates are some of the largest contractors in the United States, most of whom have been engaged on government construction work, running into millions of dollars.

Frederick C. Stevens of Albany, NY, and Washington who has agreed to undertake the financial end of the deal, had an interview with Secretary Taft late today, but neither the secretary nor Mr. Stevens would announce the result.

ANTLERS PEOPLE TERRIFIED BY WEIRD, UNCANNY "GHOST"

Antlers, I. T., Feb. 2.—Kosoma, a little town on the Frisco north of here, has about the worst ghost scare that has ever troubled a town. What is more, Antlers people who have investigated found the ghost a real one, and not only had a good fright,

Cowboys, Oklahoma-Texas Panhandle, circa 1885. *Forbes Collection, Western History Collections, University of Oklahoma.*

but a photograph of the "ghost" as well. This photograph shows a resemblance to the form of a headless man in white, just as the stories have said the ghost appeared.

February 3, 1907, p. 2

SOMETHING BIG "DOING" IN OIL

STANDARD CO. SPENDING MILLION FOR GIGANTIC TANK FARM AT JENKS

REGARD MOVE AS SIGNIFICANT

Does Octopus Intend to Build Big Refinery and Use Arkansas for Transportation

Muskogee, I. T., Feb. 2.—A contract for $100,000 worth of freight in one shipment is something that would make any railroad sit up and take notice. That's the kind of a contract that Midland Valley Railroad has just made. It is for the delivery of 1,000 cars of steel at Jenks, I.T., for the Prairie Oil and Gas Company, the Indian Territory branch of the Standard Oil, where one of the largest tank farms in the country is to be built. The freight from the mills to Jenks is exactly $100 per car.

These tanks when completed will contain 50,000 barrels of oil each and there will be 50 of them, a total of *2,500,000* barrels of stored oil. It will cost over $1,000,000 to build the tank farm, and the oil in the tanks will be worth nearly $2,000,000. And all this [*aimed*] at Jenks, a mere wide place in the road. But Jenks is located in one of the richest known oil pools, the Glenn Pool, and the reason given by Standard people for locating a tank farm there was that the only large tract of land that they could secure title to was at Jenks and [*so*] they bought it. The tank farm will contain 120 acres of land.

February 3, 1907, p. 5

Piersol, The Shoeman, on 119 Main Street advertises his winter clearance sale: This will be our last sale for many months. Our spring goods are now on the road. We mean to make the next few days the greatest sales days in the history of our business.

Every winter shoe goes in this sale. NOTHING RESERVED

Men's shoes $2.98–4.98; women's shoes $2.48–3.98; and children's boy's and girl's shoes $1.23–1.98.

February 3, 1907, p. 6

Dam Rivers for Power; Many big Projects now Undergoing Development

Muskogee, I. T., Feb. 2.—There are now eight water power propositions in Indian Territory under the process of development. Some of them have reached the actual construction stage while others only the preliminary surveys and maps have been made. But all this has occurred since April 26, 1906 and it signifies a new and vastly important development of the new state.

Actual construction is in progress on the dam and water power plant in the Pennington River at Tishomingo, also the big dam in the Washita just east of Chickasha. Maps have been filed on dams at two other points in the Pennington and in the Washita near Berwyn, while at Weleetka maps and surveys have been made for a canal and dam. The biggest power proposition is in the Grand River near Fort Gibson and Muskogee where it is proposed to erect a million dollar plant. Surveys and maps have also been made of the dam and plant in the Illinois River near Tahlequah.

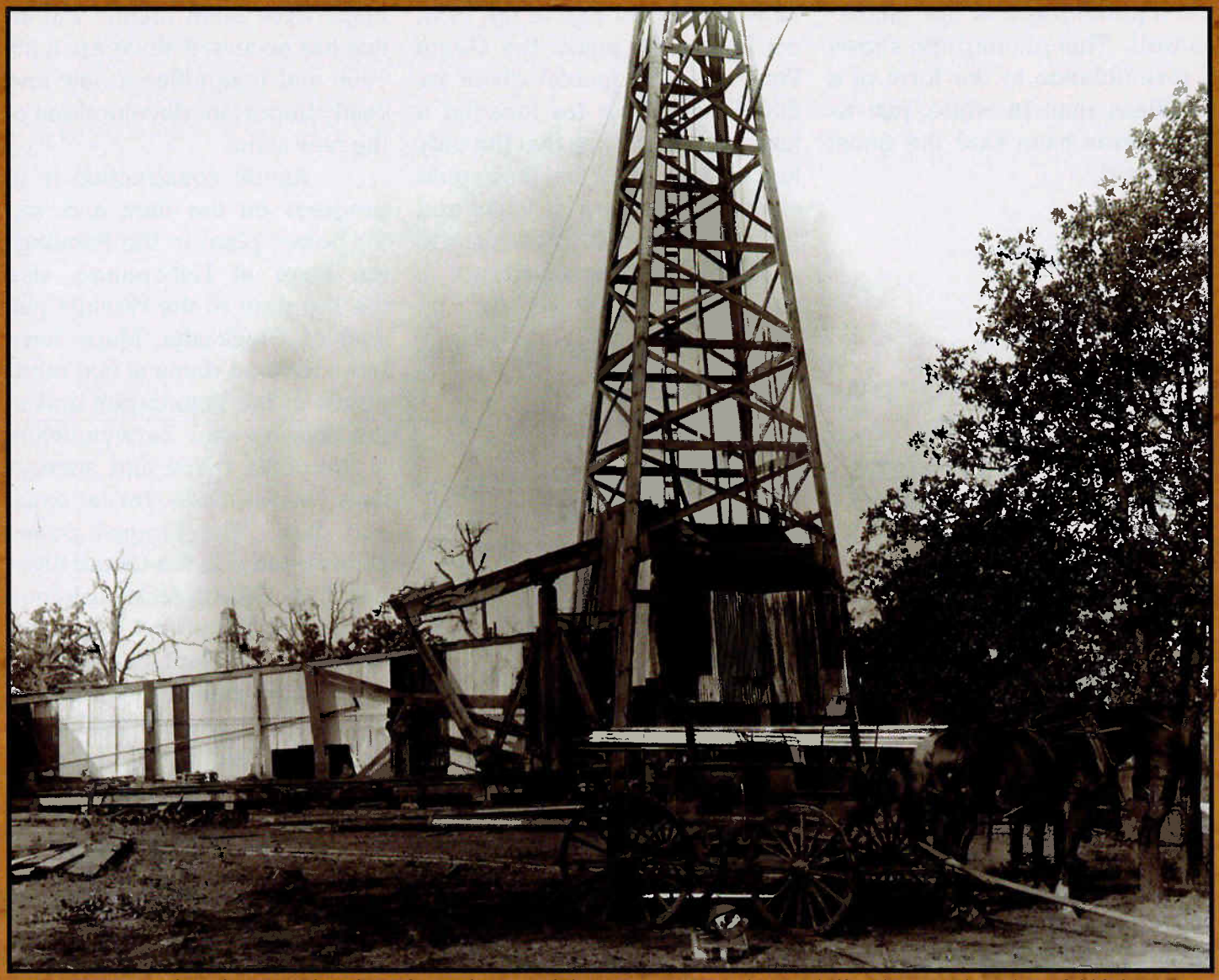
February 3, 1907, p. 19

Utah Mining and Development Company had a half page advertisement promoting the sale of stock at a dollar per share in their Blue Jay and North Star Gold Mines in Piute County, Utah.

Tuesday, February 5, 1907, p. 1

30 PERISH IN W. VA. MINE BLOWUP

Elkins, W. Va., Feb. 4.—The third mine explosion in West Virginia within two weeks occurred today at the Davis Coal and



The nitro wagon beside a wooden derrick, Cushing, Oklahoma. *Western History Collections, University of Oklahoma.*

Coke Company's mine No. 25 near here, and 25 or 30 miners are said to have been killed.

The disaster occurred shortly after 7 o'clock this morning. Late today the first rescue party entered the mine.

February 5, 1907, p. 7

ENGINEERS LOCATE SITE FOR THE FAIR

BUSINESS MEN WARNED TAKE MORE INTEREST IN PROJECT

Engineers began work yesterday investigating the availability of the northwest quarter of school section No. 36, which is located northeast of the city as a state fair site. Their report will embody the advantages of the section for building a mile track and locating buildings necessary for holding a fair.

Secretary F. H. Shelley said "the merchants of this city, the ones who should be vitally interested in it, have thus far failed to show more than a passing interest in it, and should they not have a full representation at the meeting to be held at the Chamber of Commerce on February 12, some other city may be selected as the place of holding it."

February 5, 1907, p. 8

Terrific Snowslide in Colorado Mining Camp Costs Lives of a Dozen

Pueblo, Colo, Feb. 4.—A special to the Chieftain from Salida, Colo., says: at least a dozen lives are believed to have been lost in a terrific snowslide that came down Monarch Mountain about 9 o'clock tonight, completely overwhelming three business houses, and burying their occupants under 50 feet of snow and dirt.

February 5, 1907, p. 12

STANDARD COMPANY IS GRABBING LEASES

REALTY MEN, TO TAKE CHANCE ON GETTING HOLD OF RICH GROUND

South McAlester, I. T., Feb. 4.—Thousands of acres of land are being leased by the Standard Oil Company in the immediate vicinity of this city. Not long ago the Standard leased 10,000 acres and its agents are leasing all that is in sight. That the lands contain both oil and gas goes without saying.

Wednesday, February 6, 1907, p. 1

FORMALLY ORGANIZE CANAL CO.

Oliver "Makes Good" For His Panama Canal Job

COMPANY READY TO DIG

Today was Contractor's Last to Furnish $5,000,000 Capital, $2,000,000 Bond

New York, Feb. 5.—John B. McDonald of this city, the contractor who constructed the subway, was today elected president of the Panama Construction Company. This company was formally organized today for the purpose of building the canal in the event that the contract is awarded by the government to William J. Oliver, one of the contractors, and his associates.

February 6, 1907, p. 7

PLAN THAT INSURES HOLDING STATE FAIR

SECRETARY SHELLEY THINKS WELL OF BUSINESS MEN'S IDEA

"A feasible plan for insuring the holding of the State Fair in this city was suggested to me today," said Secretary F. H. Shelley. "A prominent business man told me that he and an associate would be willing to be two of twenty-five business men to subscribe $1,000 each towards a guarantee. He also said that he knew of one man who was willing to subscribe $5,000.

"If action of that kind could be secured within two weeks the prospect of holding a harness meeting, at least, during the coming summer would be far better than it is now."

Sunday, February 10, 1907, p. 9

EARTHQUAKE MAY HIT THIS PART OF GLOBE

London, Feb. 9.—Hugh Clements, the meteorologist, announces that conditions will be favorable tomorrow for an earthquake in the middle west of the United States: Kansas, Missouri, Oklahoma, Nebraska, Illinois, and Iowa are threatened, he says. The tidal position corresponds to those which caused the earthquakes in Illinois and New Hampshire in February 1883. He said: "The sun and moon are in the same place that they were on several previous occasions which caused a certain tidal shift resulting in earth strains. The strains will be felt especially in the American middle west."

February 10, 1907, p.18

SURVEY FOR SITE OF GIANT OIL REFINERY

STANDARD TO BUILD LARGEST PLANT IN SOUHWEST AT JENKS

Tulsa, I. T.—Oil company is making a survey for the site

of the largest oil refinery in the southwest at the town of Jenks, eleven mines east of Tulsa, according to a report from there today.

The Prairie Oil and Gas Company, a child of the Standard, now owns three immense tracts of land adjoining Jenks and contiguous to the Glenn oil field and has commenced this building of a tank farm, which when completed, will have a storage capacity of 1,000,000 barrels.

Thursday, February 14, 1907, p. 1

700 MINERS THROWN OUT OF EMPLOYMENT

BISBEE MINES CLOSE DOWN

Bisbee, Ariz, Feb. 13.—Seven hundred miners were laid off in Bisbee today. The reason given the men was that there was shortage in fuel and lumber and in order to make some necessary repairs it was decided to close down some of the shafts.

Today the Big Spray shaft of the Copper Queen Company was idle. This is one of the big producing shafts of the district and employs about 500 men. The announcement is made that in all probability the Czar shaft will be idle tomorrow.

There is a general belief that the situation is directly due to the attempt being made by organizers of the Western Federation of Miners to make Bisbee a union camp. The officials of the company, however, refuse to admit that this is the cause of the Company's action. The men laid off are leaving for other camps in Mexico and Nevada.

First topographic party in the Arbuckle Mountains, 1905. E. DeGolyer at the plane table, Key Wolf holding the rod. *Oklahoma Geological Survey Collection, Western History Collections, University of Oklahoma.*

February 14, 1907, p. 10

NEW COAL RATE IS NAMED BY SANTA FE

WILL ENCOURAGE MOVEMENT IN DULL SUMMER MONTHS

J.R. Koontz, general freight agent of the Santa Fe, announces that a storage rate on coal will be maintained by the company commencing April 15 and expiring July 31, 1907, whereby the rate will be reduced 25 cents per ton. This reduction will be on soft coal from the Colorado mines to points in Kansas, Oklahoma, and Indian Territory on the Santa Fe. The object of the reduction during this time is to stimulate the movement of coal during the dull months of the summer, and prevent the ever recurring shortage of coal and difficulties attending the rush orders during the cold weather of winter.

Friday, February 15, 1907, p. 5

CITY WATER PLANT NEARLY COMPLETED

ALDERMAN WARREN SAYS IT WILL BE OPERATING MARCH 15

Oklahoma City's new $250,000 water plant will be in operation by March 15, according to the information obtained by Alderman J. F. Warren upon a visit to the new plant yesterday afternoon.

Men waiting to fill water bottles at Bromide Springs, Platt National Park. *Oklahoma Geological Survey Collection, Western History Collections, University of Oklahoma.*

"The smokestack has been finished, the clear water well is completed and the filtration plant building is ready," said he. "Ten days more of good weather will complete the settling basin."

Sunday, February 17, 1907, p. 7

WHITE TEMPLE HAS SUPERB PIPE ORGAN

MASSIVE MELODY MACHINE WILL BE INSTALLED FOR EASTER SUNDAY

Part of the new $12,000 pipe organ for the Baptist White Temple has arrived. Another car load has been shipped and remaining parts will follow soon. Installation by experts will begin soon, and the organ will be ready to furnish grand melody by Easter Sunday.

This organ will be the finest in the new state and will be the equal of those in the churches of the large cities. Its feature will be a complete system of chimes, and 3,000 pipes will supply the finest music that has ever been heard in this city.

February 17, 1907, p. 8

STATE FAIR FUND REACHES TWENTY-FIVE THOUSAND

State fair subscriptions are being received in substantial amount. With 15 subscriptions of $1,000 each and smaller ones aggregating $10,000, the mark set by the committee has been reached. But the committee will not stop at this figure.

With the funds already subscribed a state fair is assured. Additional subscriptions will be received and eventually the capital stock of $100,000 will be paid up. With that amount Oklahoma can have a state fair and exposition that will take rank with any in the United States.

February 17, 1907, p. 10

OKLAHOMA STATE MEDICAL COLLEGE

PROMINENT PHYSICIANS AND SURGEONS IDENTIFIED WITH THE ENTERPRISE

For the purpose of establishing a second medical college in Oklahoma City, articles of incorporation have been filed with State Secretary Chas. H. Filson, who has granted a charter with headquarters in this city.

The incorporators and stockholders include Dr. W. J. Darnell, Mountain View, Okla., who has been chosen president of the school; Dr. West Moreland, Atlanta, Ga.; Dr. H. H. Baty, Rome, Ga.; Dr. J. R. Phelan, Oklahoma City, secretary of the corporation; and J. P. Eckers of Oklahoma City.

"The Oklahoma State Medical College will be conducted as a regular medical college," said Dr. J. R. Phelan, secretary of the school, yesterday. "The school will be open for a four-year course, commencing next September, and later on it is the intention to establish post graduate courses in laboratory, operative, and work in bacteriology."

Tuesday, February 19, 1907, p. 1

105 PERISH IN MINE DISASTER

DEATH REAPS HARVEST OF HUMAN LIFE

EXPLOSION OF GAS IN MEXICO MINE SENDS MINERS TO ETERNITY

THIRTY BODIES RECOVERED

SCENE OF CATASTROPHE ABOUT 75 MILES FROM EAGLE PASS, TEXAS

Monterey, Mexico, Feb. 18.—A dispatch to the News from Las Esperanzas, Coahuila, says that 105 men probably are dead and many injured as a result of an explosion of gas in the coal mine there.

The explosion at Las Esperanzas occurred at 7 p. m. in the Conquista Mine No. 3.

Thirty dead bodies have been taken out of the wreck, and it is estimated that 75 more are yet in the mine.

Las Esperanzas is located on the line of the International Railway about 75 miles from Eagle Pass, Tex. It is the principal coal center in Mexico and many men, including a large number of Japanese, are employed there.

February 19, 1907, p. 3

MUSKOGEE-LAWTON CONTRACTS ARE LET

WORK ON THE NEW RAILROAD THROUGH TERRITORY TO START IN 30 DAYS

Muskogee, I. T., Feb. 18.—A contract to build one of the most important lines of railroad in the new state has just been let to Southwestern Construction Company. This is the first section of the Kansas City, Oklahoma and Pacific Railroad, which is to be built from Kansas City to the Pacific coast.

The line runs northeast to Joplin and then into Kansas City. To the southwest the line will pass through Muskogee, Weleetka, and Pauls Valley. Bonds to the amount of $6,500,000 have been sold for the construction work. According to Mr. King, it will take two years to complete the line between Muskogee and Lawton.

February 19, 1907 p. 6

GOVERNMENT RESERVE IS THREATENED

HUNDREDS OF CITIZENS FROM NEARBY TOWNS FIGHTING FLAMES

LOSS ALREADY IS THOUSANDS

NATIONAL GAME PRESERVE, CREATED BY CONGRESS, IN DANGER ZONE

Lawton, OK, Feb. 18.—Nearly one-half of the 100,000-acre government forest reserve in the Wichita Mountains 10 miles west of here is threatened with devastation by a raging forest fire. The fire is one of the worst in the history of the southwest, and assisted by strong wind is rapidly eating its way eastward. As a result of the valiant efforts of the supervisor and his assistants the damage which already amounts to thousands of dollars, has been greatly checked.

Forester Morrissey this morning called for aid from the nearby towns and several hundred citizens went to his assistance. It is believed that if the wind changes tonight the damage will be minimized.

Wednesday, February 20, 1907, p. 2

NEW LAW MEANS SHAKEUP IN TERRITORY'S COAL BUSINESS

Muskogee, Feb 19.—A new law prohibits railroads from selling coal from mines which they own and operate and for which they are carriers in Indian Territory especially on segregated coal lands.

It is not generally known, but the railroads are the biggest coal-mine owners in the Choctaw Nation. The railroads discovered this coal long before the government did, and when they built their lines they built them with a definite purpose in view. They have been producing millions of tons of coal annually. They were their own miners, operators, and carriers.

February 20, 1907, p. 5

CITY STORM SEWER SYSTEM WILL BE FINISHED JULY 1

"By July 1, the entire storm sewer system of Oklahoma City will be completed," said City Engineer Burke yesterday. "Work on the First Street, Hudson, Western District, Choctaw, and Maywood system is progressing rapidly because of good weather and I am of the opinion that work on those systems will surely be finished by that date."

Thursday, February 21, 1907, p. 1

SCHOOL LAND MAY BE SOLD

CONVENTION DEBATE RESULTS IN COMPROMISE ON IMPORTANT QUESTION

Guthrie, Okla., Feb. 20.—A compromise was reached on the school land question in the constitutional convention this afternoon whereby the disposal of the school lands is left in the hands of the state legislature.

Gypsum quarry in western Oklahoma. *Western History Collections, University of Oklahoma.*

February 21, 1907, p.6

BELLE ISLE CARS WILL MOVE TODAY

HOURLY TRIPS; FARE TEN CENTS; LIST OF REGULAR STOPS

Interurban car service over the local street railway line to Belle Isle Park will be commenced at 7:05 o'clock this morning. The first interurban car No. 26, labeled "Belle Isle," will start from the downtown offices of the company and make its initial trip on the regular service to the new park. The car will leave the downtown office at five minutes past each hour and for the present only one car will be operated.

The car will make the following stops in the trips to and from the park: Harvey and Grand Avenue, street railway office, Broadway and Grand Avenue, Broadway and Main Street, Harvey and Main Street, courthouse, Sixth and Olie Avenue, Thirty-Seventh Street, Fifty-Ninth Street, and Belle Isle.

A fare of fifteen cents for the round trip will be charged to those purchasing tickets, which will be placed on sale today.

LOSS $1,000,000,000 IN FRISCO DISASTER

INSURANCE COMPANIES COMMITTEE PLACE HUGE AMOUNT AS QUAKE DAMAGE

New York, Feb. 20.—The committee of five representing the thirty-five insurance companies which acted in unison in

settling their San Francisco losses by fire and earthquake has made public the list of net losses by the disaster.

The San Francisco earthquake occurred on Wednesday, April 18, 1906. Estimates of the magnitude ranged from 7.7 to 8.3. The earthquake and resulting fire is remembered as one of the worst natural disasters in the history of the United States. At the time, only 375 deaths were reported. Today, this figure has been revised to an estimate of at least 3,000. Property losses from the disaster were estimated at more than $400,000,000.

Friday, February 22, 1907, p. 1

EFFORT TO SAVE LIVES UNAVAILING

Terrific Seas Break Up Ship With Awful Suddenness

CAUSE AS YET UNKNOWN

List of Passengers Is Lost—No Americans Known to Have Perished

London, Feb. 21.—The worst disaster for many years in the history of the busy channel traffic between England and the continent occurred during a violent gale shortly before 6 o'clock this morning, when the Rotterdam mail steamer, Berlin, from Harwick to Hook of Holland, having safely weathered the hurricane, was wrecked as she was entering port. With one single exception all of her passengers and crew, numbering 143 persons, are dead or clinging hopelessly to the wreck.

February 22, 1907, p. 6

STATE FAIR GROUNDS ARE LOCATED EAST OF THE CITY

"Nothing short of an earthquake can prevent the holding of a state fair in this city next fall," said F. H. Shelley, secretary of the Oklahoma State Fair association, yesterday. The site selection committee reported that after considering all offered they had decided to accept the lease offered by Bath & Rice for the northwest quarter section No. 36, township 12, school land. The site selected has many more advantages and fewer disadvantages than any offered and can be leased for $140 a year.

February 22, 1907, p. 11

SOONERS EXPECTED TO HAVE NO COACH

DEPLETED FINANCES MAKE IT IMPROBABLE—OUTLOOK, HOWEVER, IS GOOD

Norman, Okla., Feb. 21.—At a meeting of the athletic council last evening the advisability of securing a baseball coach was discussed, but no action was taken in the matter. There are several applicants for the position, but from the way the finances stand it is probable that the Sooners will have to do without a coach this year. New uniforms for the team have been ordered and it is thought they will be able to make a much better showing both in appearance and in playing than they did last season.

Saturday, February 23, 1907, p. 2

GROVER TALKS OF PARTIOTISM

DEPLORES DEGENERATION OF RIGHT SPIRIT IN HOLIDAY OBSERVANCES

EULOGIZES GEO WASHINGTION

Points Out Weakness of Government and Need Officials Turning to Other Ideals

Chicago, Feb. 22.—Former President Grover Cleveland addressed an enthusiastic audience this afternoon at the Union League Club.

Mr. Cleveland's address was wholly along patriotic lines. After stating that the American people are but little given to the observance of public holidays, and deploring the fact that the few that are celebrated have degenerated, that of Independence Day into a "revel of senseless noise and dangerous explosions, leaving in its train far more of mishap and accident than lessons of good citizenship or pride of country," Thanksgiving Day has become a day of "feasting and social indulgence," and Christmas a day of "hilarity

Dr. A. H. Van Vleet's field camp in Blaine County, Oklahoma, 1900. Roy Hadsell, standing by tent; Paul J. White, sitting; and Charles N. Gould, right. Gould later wrote *Covered Wagon Geologist*. *Oklahoma Geological Survey Collection, Western History Collections, University of Oklahoma.*

and the interchange of gifts," he praised the club for having delivered Washington's Birthday from neglect or indolent remembrance and eloquently set forth what the day means.

February 23, 1907, p. 6

WOMAN CROSSES CHANNEL IN A BALLOON

London, Feb. 22.—Mrs. Harbord has made a daring dash and successful balloon trip across the channel. The ascent was made at Chelsea [*on*] Thursday night. The balloon crossed the channel in the neighborhood of Calais and descended at 9:30 o'clock this morning at Stavelot, Belgium, in the midst of a violent snowstorm. Mrs. Harbord is the second woman to cross the channel in a balloon.

February 23, 1907, p. 7

HOTEL BUILDING BRINGS $45,000

ANDREW GOODHOLM YESTERDAY PURCHASED RASBACH HOTEL PROPERTY

PLANS GREAT IMPROVEMENTS

Two Additional Stories Will Be Added and Tile Floored Basement—Office Building

Through the real estate agency of Levy Bros., C. A. Russell, owner of the three story building at the corner of Robinson and California Avenues, formerly occupied by the courthouse officials and now occupied by the Rasbach Hotel, yesterday sold the property and lots to Andrew Goodholm of this city for a consideration of $45,000.

This was the largest realty deal reported in realty circles yesterday, although it is understood several large deals are now pending.

ADVERTISE THE FAIR MEETING

NOTICES WILL APPEAR IN TURF, AGRICULTURAL, AND STOCK JOURNALS

DIRECTORS TO MEET MONDAY

Will Apportion Funds to Departments
Arrange for Racing Program and
Adopt By-Laws

Subscribers to agricultural and live stock journals all over the country will soon know that a state fair will be held in this city next October. Secretary Shelley has begun an aggressive campaign of advertising and press work in an effort to make the coming event a big one in every department.

February 23, 1907, p. 12

PIPELINE BUILDERS GET BUSY AT STUART

PROMOTERS EXPECT TO SEND OIL GULFWARD WITHIN A YEAR

Stuart, I. T., Feb. 22.—Five car loads of pipe for the Gulf pipeline were unloaded at this place late yesterday afternoon and early this morning, and work on the oil carrier from the territorial field to the gulf will be pushed as rapidly as possible.

If the plans of the pipeline promoters do not miscarry, oil should be flowing gulfward by this time next year, a condition which will loose the hold of the Standard upon the rich Indian Territory field.

Sunday, February 24, 1907, p. 8

CHICAGO PLAYERS TO REPORT SOON

Chicago, Feb. 23.—President Comiskey of the [*1906*] world's champion White Sox, at last has been able to arrange all the details of the training trip his team will take to the City of Mexico. The junket will be the most elaborate ever made to put a Chicago team in condition for the baseball season. They leave Chicago [*on*] March 5.

President Murphy has written each of his players of the training plans of the Cubs [*1906 National League champions*] and has assured them that as interesting a trip as possible will be made. The Cubs leave here in advance of the Sox, starting for West Baden, Indiana, March 2, and then on to New Orleans.

Most sports stories in the first 2 months of 1907 dealt with boxing and horse and harness racing.

February 24, 1907, p. 14

In the Sunday paper there is usually a column written about the various state universities.

Norman, Okla., Feb. 23—Prof. E. G. Woodruff of the department of geology, who is in Harvard on leave of absence, is arranging for exchange of fossils and minerals between the museums of Harvard and the University of Oklahoma. It is not generally known that some very rare and valuable fossils have been found in Oklahoma particularly in the Arbuckle Mountains.

February 24, 1907, p. 24

MINERAL WEALTH OF THE NEW STATE

AN AUTHORITY SAYS IT EXCEEDS THAT OF PENNSYLVANIA AND MISSOURI

"No other state in the Union will be able to show a larger or more complete display of mineral resources than Oklahoma will have in her exhibit at the Jamestown Exposition," was the statement of Superintendent Thoburn of the Oklahoma-Jamestown Exhibit, yesterday. Continuing, Mr. Thoburn said: "Few, even of her own people, realize the diversity, extent, and richness of Oklahoma's mineral wealth. Missouri has sometimes been called the Pennsylvania of the west, but Oklahoma does not have to accept any such second-handed compliments, for, in both the variety and extent of her mineral resources, she is several laps ahead of either of these great states. She can duplicate nearly every mineral product of either of them, and besides, she possesses a number of others, which are unknown to these states."

Tuesday, February 26, 1907, p. 5

COMMITTEE TO VISIT DALLAS

MANAGEMENT OF OKLAHOMA STATE FAIR SEEK NEEDED INFORMATION

COLLECTING FUNDS FOR FAIR

As Soon as Amount Needed Is Collected Construction Contracts Will Be Promptly Let

Oklahoma's state fair will be modeled after the Texas State Fair, which is held every year at Dallas, and which has proved a great financial success. At a meeting of the board of directors of the state fair association yesterday afternoon, the by-laws and constitution of the organization were adopted; and an executive committee to consist of J. L. Wilkin, O. G. Lee, W. F. Young, C. H. Kellar, and C. P. Sites was selected.

Wednesday, February 27, 1907

WATER SUPPLY FOR LAWTON IS DELAYED

UNITED STATES OFFICIALS SAY THEY CANNOT ACT TILL RED TAPE REELS OFF

Lawton, Okla., Feb. 26.—Critical necessity relative to Lawton's water situation led Mayor Jones to expend $40 in telegraph tolls informing President Roosevelt, Vice President Fairbanks, Secretary Hitchcock, and others in authority of the situation here and urging that some relief be given.

Thursday, February 28, 1907

JIM CROW LAW IS KILLED

CONVENTION "PLAYS SAFE" FOR FEAR OF "BIG STICK"

Measure Is Tabled by Makers of Constitution, 46-31

ENDANGERS STATEHOOD

Declaration of Committee of Attorneys Sways Fearing Ones in Line

Guthrie, Okla., Feb. 27.—By a vote of 46 to 31 the constitutional proposition providing for separate and equal coaches and waiting rooms for the Negro race was laid on the table by the committee of the whole of the constitutional convention this morning.

The action followed the filing of a report from the special committee of lawyers to whom the proposition was referred; advising the committee to incorporate the provision in the constitution would seriously endanger statehood.

OIL COMPANY TO RUN DAILY TEXAS SPECIAL

GLENN POOL PRODUCT TO HAVE QUICK TRANSPORTATION TO BEAUMONT REFINERY

Tulsa, I. T., Feb. 27.—Contracts have been closed by the Prairie Oil and Gas Co., the western branch of the Standard, for a daily oil train from the Glenn Pool to Beaumont, Tex., where the Standard maintains a large refinery. The train will start from Jenks, where a loading rack will be constructed at once, and will make the trip via the Midland Valley and Kansas City Southern. It will be operating within 30 days, and will carry 3,000 barrels of oil daily.

The Gulf Pipe Line Co. has a daily oil train from the Glenn Pool to Port Arthur, Tex., which starts from Kiefer and runs via the Frisco.

—Staff Kudos!

Cardott Receives AAPG EMD Distinguished Service Award

OGS geologist Brian Cardott received the American Association of Petroleum Geologists (AAPG) Energy Minerals Division (EMD) Distinguished Service Award in April 2007, at the organization's annual convention. His award reads: *"In honor and recognition of outstanding leadership and dedicated service to the Energy Minerals Division, having served as President, Vice President, Secretary, Councilor, Chairman for Alternative Energy Technology, Member Services, Website, Nominations, Gas Shale Committee, and compiler of the EMD Procedures Manual."*

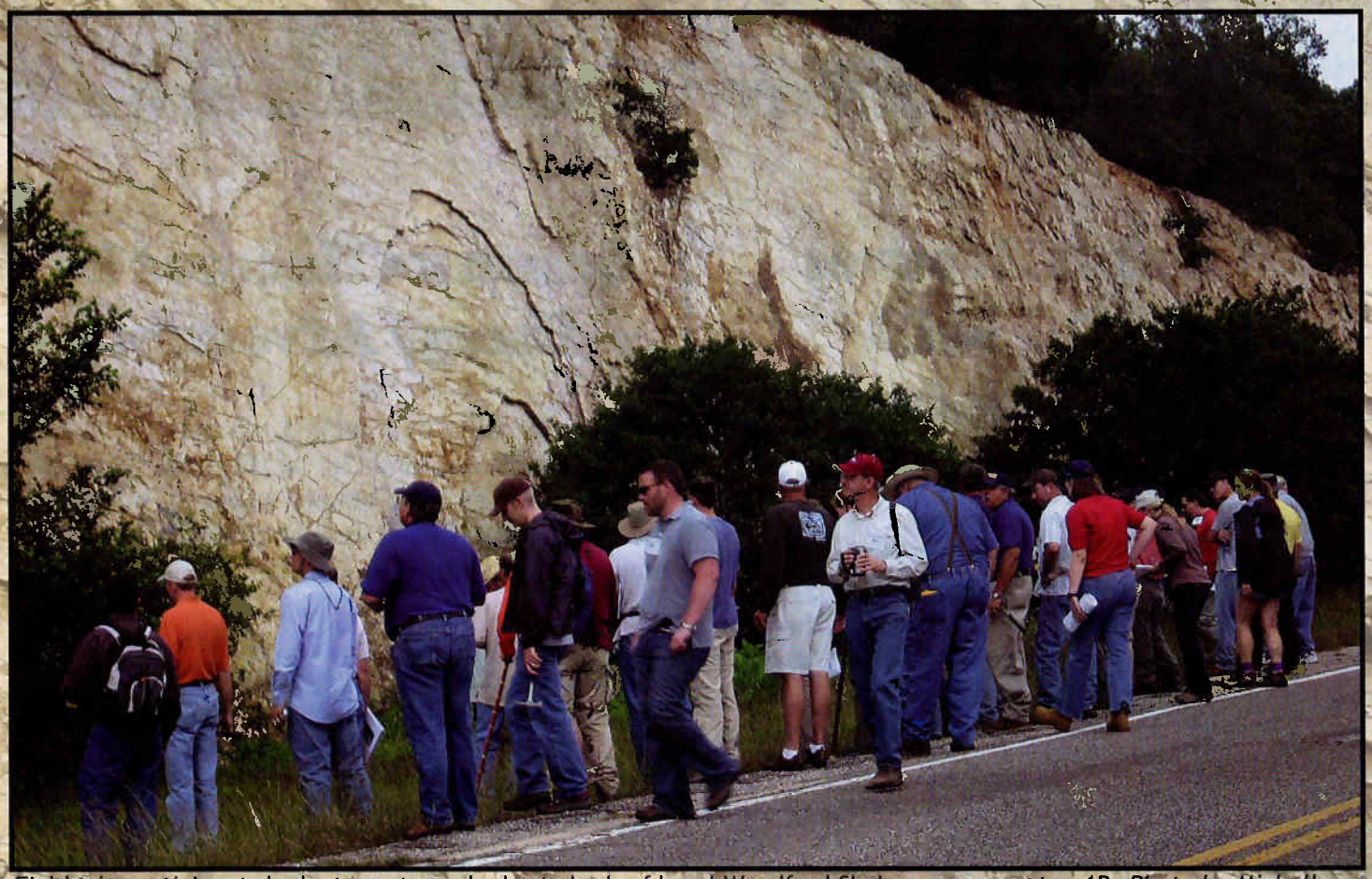
Summers Honored by Energy Advocates

The Energy Advocates kicked off their 2007 Centennial Events on March 26th at the Tulsa Petroleum Club with a "Salute to Women in Energy" that honored women that have worked tirelessly in the energy industry statewide, regionally, and/or nationally.

Oklahoma Geological Survey staff member Michelle Summers was among those honored at this event.

"This has become one of our most popular events in recent history," said Mark Stansberry, President of The Energy Advocates. *"We are proud to give recognition to the women that have made our energy industry great!" "With this year's series of events, we are focusing on all aspects of the energy industry — past, present and the future.*

Christine Hansen, Executive Director of the Interstate Oil & Gas Compact Commission, was the luncheon keynote speaker.



Field trip participants look at overturned, cherty beds of basal Woodford Shale as seen on stop 1B. *Photo by Michelle Summers, Oklahoma Geological Survey.*

The Woodford Gas Shale Conference

Sue Britton Crites, Oklahoma Geological Survey

Over 400 operators, petroleum engineers, geologists, and other professionals in the energy industry attended the "Woodford Gas Shale" conference held Wednesday, May 23, 2007, at the Clarion Meridian Convention Center in Oklahoma City. Brian Cardott, organic petrologist and coal geologist for the Oklahoma Geological Survey (OGS), was the driving force in organizing the Woodford Gas Shale Conference and Field Trip. The OGS had the bittersweet experience of a record attendance while having to turn away walk-in registrants due to lack of space.

This record attendance was a direct reflection of the importance of the Woodford gas shale as a major play in Oklahoma, as well as how eagerly petroleum industry personnel are seeking to better understand the exploitation and development of unconventional resources. In the next 10-12 years, unconventional reservoirs are projected to supply 1/3 of the United States domestic natural gas demand.

According to Harold G. Hamm, President and CEO of Continental Resources Inc. and Chairman of the Oklahoma Independent Petroleum Association, the Woodford Shale has transitioned from merely being in the early stage of evaluation to a prime play for Oklahoma. In the January, 2007, edition of The American Oil & Gas Reporter, Hamm said:

> The Woodford Shale development in eastern Oklahoma went from an exploration idea to a hot development project, driving drilling ac-

...and Field Trip

tivity up by 25 rigs. For the first time, Oklahoma has its very own unconventional resource play! The Woodford will be very good for Oklahoma, its royalty owners, and oil and gas operators.

Recent advances in completion technologies and significantly higher gas prices have elevated the industry's activity in shale gas plays to a high level. Success in the Barnett Shale in the Fort Worth Basin has resulted in development of the largest gas field in North America. This excitement has spread northward across the Red River into the Ardmore Basin in Oklahoma, where the Woodford Shale is in the early production stage.

According to the Petroleum Technology Transfer Council, many questions remain about how to turn Woodford Shale gas-resource potential into production. As in the Barnett Shale, will thermal maturity combined with stimulation technology be the keys to economic production? Or will it be natural fracturing? Or will it be something else entirely? The prime area for this Upper Devonian/Lower Mississippian shale's gas potential lies just a couple hundred miles north of the Barnett, but it is considered to be where the Barnett was 15 to 20 years ago and gas wells have not yet proliferated.

Successful Woodford gas-shale wells require an understanding of source-rock characteristics and reservoir properties, as well as the application of specialized completion techniques. The purpose of this conference was to present the following information on the Woodford Shale in Oklahoma and the status of the play: geology, stratigraphy, electric-log response, source-rock characteristics, reservoir properties, completion practices, hydrocarbon production, and gas-shale plays.

Presentations at the workshop included:

- Woodford Gas Shale in the Arkoma Basin, by Jeff Hall, Devon Energy Corporation
- Oklahoma: Woodford Rising?, by Sam Langford, Newfield Exploration Mid-Continent, Inc.
- Woodford Operational Challenges, by Tim Clawson, Antero Resources Corporation
- Southeast Oklahoma Horizontal Woodford Completion Practices, by Bill Grieser, Sr., Halliburton Energy Services
- Evaluation of the Woodford Gas-Shale Reservoir and Observations Regarding Successful Plays, by Keith Bartenhagen, Schlumberger Data and Consulting Services
- Comparison of Woodford Shale to Other Producing and Prospective Shale-Gas Systems, by Daniel M. Jarvie, Humble Geochemical Services

Ibrahim Çemin, Oklahoma State University, and Galen Miller, Oklahoma Geological Survey, enjoy a lively discussion regarding Miller's Woodford Shale poster.

- Reservoir Characteristics and Gas Production Potential of Woodford Shale in the Southern Midcontinent, by John B. Comer, Indiana Geological Survey
- High Resolution Facies Changes, Lateral Continuity, and Fracturing of the Woodford Shale from Behind Outcrop Drilling, Logging, and Coring, by Nichole Buckner, University of Oklahoma
- Stratigraphic Correspondence Between Shale Properties and Geophysical Well-log Response in the Upper Devonian/Lower Mississippian Woodford Shale of Oklahoma, by Stanley T. Paxton, U.S. Geological Survey
- Overview of Woodford Gas-Shale Play in Oklahoma, by Brian J. Cardott, Oklahoma Geological Survey
- Hydrocarbon Production and Outcrop Characteristics of the Woodford Shale in Southern and Eastern Oklahoma, by Richard D. Andrews, Oklahoma Geological Survey.

Four posters also were presented:

- Thermal Maturation of Woodford Shale in Oklahoma, by Brian J. Cardott, Oklahoma Geological Survey
- Generalized Structure of the Woodford Shale in Eastern Oklahoma, by R. Vance Hall, Staghorn Energy
- The Relationship of the Arkansas Novaculite to the Woodford Shale, by Galen Miller, Oklahoma Geological Survey
- Characterization of the Woodford Shale in Outcrop and Subsurface in Pontotoc and Coal Coun-

Survey conference participants always enjoy meeting with the exhibitors during the breaks. *Photos by Laurie Lollis and Sue Crites, Oklahoma Geological Survey.*

SPONSORS
Woodford Gas Shale

GOLD LEVEL SPONSORS $1,000-$2,499

- Chesapeake Energy Corporation
- Cleary Petroleum Corporation
- Devon Energy Corporation
- Dowdco
- Multi-Chem
- St. Mary Land & Exploration
- Tony Oil Company
- Ward Petroleum Corporation
- Weatherford
- XTO Energy

SILVER LEVEL SPONSORS $500-$999

- CBM Solutions
- Core Laboratories
- Dawson Geophysical Company
- Dominion Exploration & Production, Inc.
- Drilling Info, Inc.
- Fronterra Geosciences
- Geomap Company
- Geo-Microbial Technologies, Inc.
- Halliburton
- IPS-Integrated Production Services
- Jolen Operating Company
- Liberty Pressure Pumping
- Schlumberger
- The Energy Advocates

BRONZE LEVEL SPONSORS $100-$499

- Noble Energy
- Oracle Resources, Ltd.
- Panhandle Oil and Gas Inc.
- Questar Exploration & Production Company
- Spyglass Energy Group LLC
- The GHK Companies

ties, Oklahoma, by Ryan Miller, Devon Energy Corporation.

The one-day field trip, offered on both Tuesday, May 22, and Thursday, May 24, sold out quickly. Approximately 120 field trip participants visited six stops in the western Arbuckle Mountains and eastern Criner Hills in southern Oklahoma. Exposures of the Sylvan, Woodford, and Caney Shales on the north side of the Arbuckle Mountains; Woodford and Caney Shales on the south side of the Arbuckle Mountains; and Woodford Shale in the Criner Hills were viewed to compare and contrast source-rock and reservoir quality for gas shales. The six field trip stops included:

- Stop 1A. Sylvan Shale to Caney Shale Transition. Galen W. Miller, Oklahoma Geological Survey
- Stop 1B. Woodford Shale. Galen W. Miller, Oklahoma Geological Survey
- Stop 2A. Woodford Shale. Brian J. Cardott, Oklahoma Geological Survey
- Stop 2B. The Caney Shale along Phillips Creek on the south side of the Arbuckle Mountains. Richard D. Andrews, Oklahoma Geological Survey
- Stop 3. Complete section of Woodford Shale adjacent to the Henry House Falls Quarry on the south side of the Arbuckle Mountains. Stanley T. Paxton, U.S. Geological Survey Oklahoma Water Science Center
- Stop 4. Woodford Shale exposed in McAlister Cemetery Quarry in the Criner Hills. Stanley T. Paxton, U.S. Geological Survey Oklahoma Water Science Center.

Henry House Falls. *Photo by Michelle Summers, Oklahoma Geological Survey.*

Dedicated field trip co-leader Stan Paxton — not afraid to get his feet wet. What a guy! *Photo by Brian Cardott, Oklahoma Geological Survey.*

Some places are just worth sitting and soaking up the atmosphere. *Photo by Michelle Summers, Oklahoma Geological Survey.*

—Upcoming Meetings

2007

AUGUST

8 Gas Reservoir Evaluation With Limited Data Workshop, taught by Dr. Richard G. Hughes, Louisiana State University. To be held at Moore Norman Technology Center; Norman, Okla.; information: Oklahoma Geological Survey; phone (405)325-3031 or (800)330-3996. E-mail: mjsummers@ou.edu; website: http://www.ogs.ou.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.

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.

18 Oklahoma Oil & Gas Trade Expo, Oklahoma City, OK. Information: Oklahoma Commission on Marginally Producing Oil and Gas Wells (MWC), phone: (405)604-0460 or (800)390-0460; website: www.marginalwells.com.

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.

10—14 Society of Petroleum Engineers (SPE) Annual Conference and Technical Convention, Annaheim, Calif.. Information: SPE, 1888 North Market St., Frederick, MD 21701; phone (301)694-5243 or (866)229-2386; website: http://www.spe.org/atce/2007.

2008

FEBRUARY

TBA Oklahoma Aggregates Association (OKAA) "Aggregates Day at the Capitol", Oklahoma State Capitol Rotunda. Information: OKAA, Jim Rodriguez; phone (405)524-7680; website: http://www.okaa.org.

TBA Oklahoma Aggregates Association (OKAA) 7th Annual Meeting and Field Trip, Clarion Meridian Convention Center, Oklahoma City, Okla.. Information: meeting, Jim Rodriguez, (405)524-7680; fieldtrip, Stan Krukowski, (405)325-3031. Website: http://www.okaa.org.

MARCH

12 Geographical Information Systems (GIS) Day at the Capitol, Oklahoma State Capitol Rotunda. Information: Shellie Willoughby, (405)521-4828; e-mail, shelliew@okcc.state.ok.us.

TBA Granite Wash Workshop, Moore Norman Technology Center; Norman, Okla.; information: Oklahoma Geological Survey; phone (405)325-3031 or (800)330-3996. E-mail: mjsummers@ou.edu; website: http://www.ogs.ou.edu.

MAR 29—APRIL 1 Geological Society of America (:GSA) South Central Section Meeting, Hot Springs, Arkan. Information: e-mail, jbconnelly@ualr.edu; website: http://www.geosociety.org.

APRIL

17 ScienceFest Oklahoma, Oklahoma City Zoo. Information: Karla Beatty, (405)521-6788; e-mail, karlab@okcc.state.ok.us.

20—23 American Association of Petroleum Geologists (AAPG) Annual Convention and Exhibition, San Antonio, Texas. Information: AAPG Convention Department; P.O. Box 979; Tulsa, OK 74101-0979 USA; 1(888) 945-2274 ext. 617 (U.S. / Canada); 1(918) 560-2617. Web site: http://www.aapg.org/.

MAY

11—16 44th Forum on the Geology of Industrial Minerals, Oklahoma City, Okla.; information: Stan Krukowski, Oklahoma Geological Survey; phone (405)325-3031 or (800)330-3996. E-mail: skrukowsi@ou.edu.

OCTOBER

22—23 Oklahoma Gas Shales Conference and Field Trip, Oklahoma City, Okla.; information: Oklahoma Geological Survey; phone (405)325-3031 or (800)330-3996. E-mail: mjsummers@ou.edu; website: http://www.ogs.ou.edu.

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