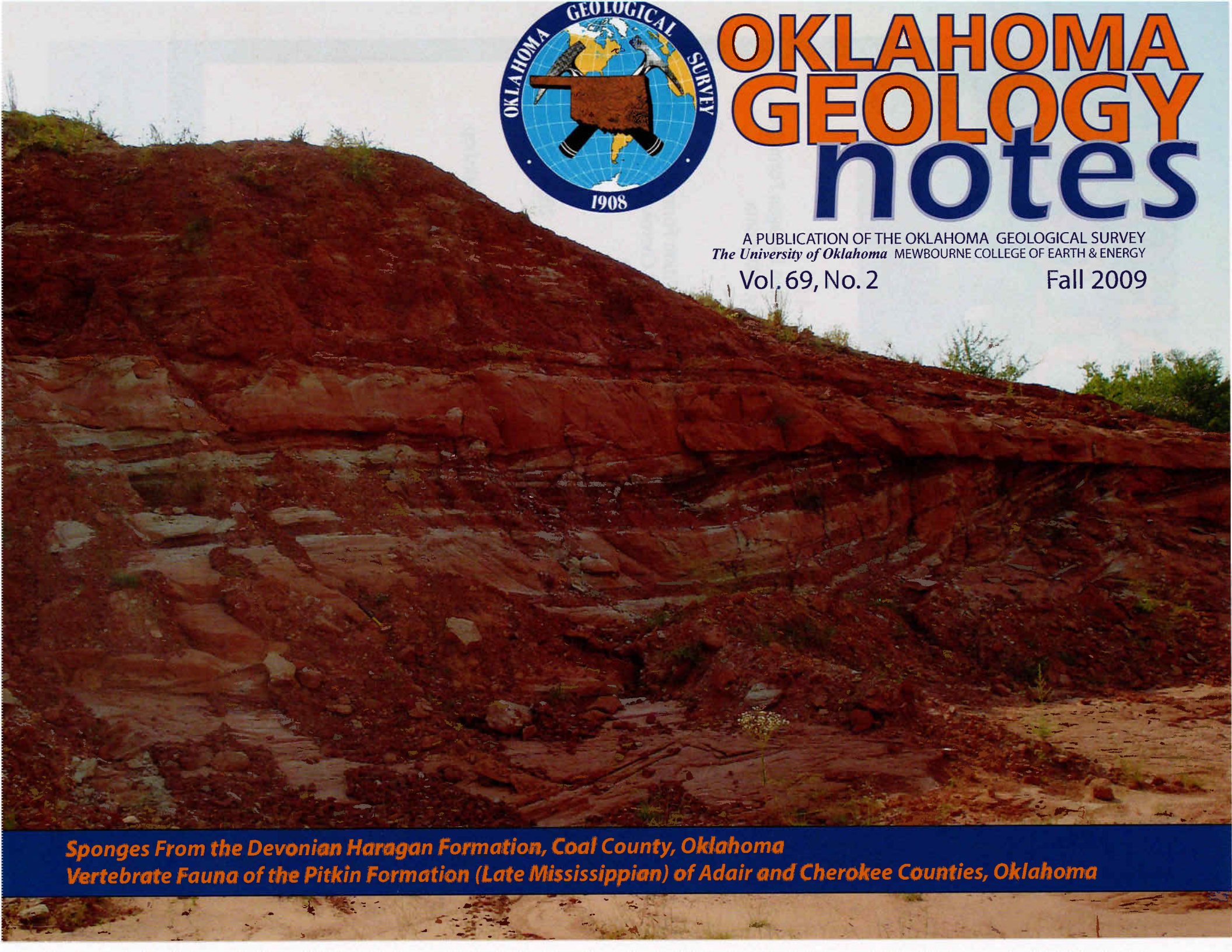

OKLAHOMA GEOLOGY notes

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Sponges From the Devonian Haragan Formation, Coal County, Oklahoma
Vertebrate Fauna of the Pitkin Formation (Late Mississippian) of Adair and Cherokee Counties, Oklahoma

Oklahoma Geological Survey

OKLAHOMA GEOLOGY notes

Vol. 69, No. 2 Fall 2009

On the cover: Permian Duncan Sandstone; Lindsay Southwest 7.5' Quad; ~2 ½ miles northwest of Lindsay. Photo by OGS Geologist Julie Chang.

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Sponges From the Devonian Haragan Formation, Coal County, Oklahoma

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ABSTRACT

Several isolated specimens of the demosponge *Hindia spheroidalis* (Duncan, 1879), two specimens of the fossil hexactinellid sponge *Ceratodictya annulata* (Hall, 1863), and the holotype of *Ceratodictyella erectus* n. gen. and sp. have been recovered recently out of the Devonian (Lochkovian) Haragan Formation from southern Oklahoma. They were recovered from the Black Cat Mountain Quarry and nearby weathered surfaces and associated bedrock exposures in Coal County. The spheroidal specimens of *Hindia* commonly are silicified and range from approximately 10.5 to 24 mm in diameter. *Ceratodictya annulata* (Hall, 1863) is a slender, steeply obconical, chambered sponge with indented interwalls between chambers. Dermal surfaces are marked by distinct but narrow, low, vertical ridges that are separated by gently-impressed to flat-appearing surfaces marked in lower chambers by less prominent, smaller, horizontal ridges. *Ceratodictyella erectus* n. gen. and sp. is a moderate-size, columnar, sponge whose dermal surface is marked with prominent vertical ridges and smaller horizontal ridges that produce a regular reticulate skeletal sculpture.

INTRODUCTION

Sponges for the present study were excavated from quarried exposures of the Lower Devonian, upper Haragan Formation (Lochkovian) at Black Cat Mountain in southwestern Coal County, south-central Oklahoma (Fig. 1). Three quarries in the vicinity, including the principal one in this study, have been sources of well-preserved trilobites, widely known to collectors and professional investigators for decades. Rock exposures in the area form west-facing bluffs and ledges on hills and hillocks. Strata strike generally north-northwest and dip east at six to ten degrees.

This sequence of carbonate strata in Oklahoma was deposited during upper Ordovician through lower Devonian time. The stratigraphy of these beds has been well documented by Amsden (1960) and by him and associates in other papers.

LITHOLOGY AND STRATIGRAPHY

The argillaceous and silty calcilutitic Haragan Formation (Fig. 2) is thin-bedded, in units that range 3-4 inches thick and are richly fossiliferous. It weathers to irregular, nodular beds. Stanley (2001) concluded that the composition of the Haragan sedimentary beds suggests they were deposited in an offshore ramp environment below storm wave-base.

The Cravatt Member of the Bois d'Arc Formation, above the Haragan beds (Fig. 2), is characteristically a fine-textured, argillaceous calcilutite, with intermittent beds of relatively pure calcarenite, even in the lower part. Nodules and small lenses of chert are present throughout the member, which is the characteristic used to distinguish between the Cravatt and Haragan beds (Amsden, 1960). Near the bottom of the Cravatt Member (upper arrow, Fig. 2) is the brown-weathered, tripolitic, or earthy chert to siliceous limestone that grades upward through the member into a solid, frequently fossiliferous vitreous lithology. Some individual cherty beds grade laterally into chert-free strata, which suggests a facies relationship between the two formations.

Amsden (1960) divided his section C1 of the Haragan and Bois d'Arc Formations into units lettered alphabetically upward from the base of each formation (Fig. 2). These distinct lithologic units are of variable thicknesses and are recognizable in Amsden's section and in the study site too. Close proximity of the fossil locality site to Amsden's measured section allows the same units to be recognized in both locations. As a result, the rock column used in Fig. 2 is based on his section C1.

The Haragan-Cravatt formational boundary is between Amsden's Units O and P (Fig. 2). The lower 100 feet of the Haragan beds are covered in this area, but several upper units are exposed. The zone of tripolitic chert, traceable laterally through Unit L of the Haragan Formation (lower arrow, Fig. 2) permits correlation between measured section C1 and the quarry study site. The hexactinellid sponges were excavated from individual Haragan laminae below the upper zone of tripolitic chert, placing them in the range of Amsden's Unit K (see column, Fig. 2). It is possible Amsden's Units I through O correspond with the upper half of the Brachiopod Zone through the lower Bryozoan Zone of the Birdsong Shale Member of the Ross Formation.

LOCATION

The Black Cat Mountain stone quarry, from which the fossils reported here were collected, is located in SW ¼ of Section 9, Township 1 South, Range 8 East, Wapanucka North Quadrangle, in Coal County, southern Oklahoma (Figs.1, 2). These fossils were recovered from the Devonian, Lower Lochkovian, Haragan Formation from the quarry mostly by William Rushlau, with permission of Bob Carroll who has a lease on the property.

The quarry site is indicated by the arrow on the local topographic map (Fig. 1), which includes parts of Sections 8 and 9 (T. 1 S., R. 8 E.) in Coal County, Oklahoma. The closest town to the productive site is Clarita, 1½ miles to the east on County Road E1740. The abandoned Hunton townsite, from which the group of carbonates takes its name, is just off the map to the west-northwest. Part of Amsden's (1960) measured section C1 adjacent to the Hunton townsite is indicated by the dash-dotted horizontal lines in the left center of Fig. 1.

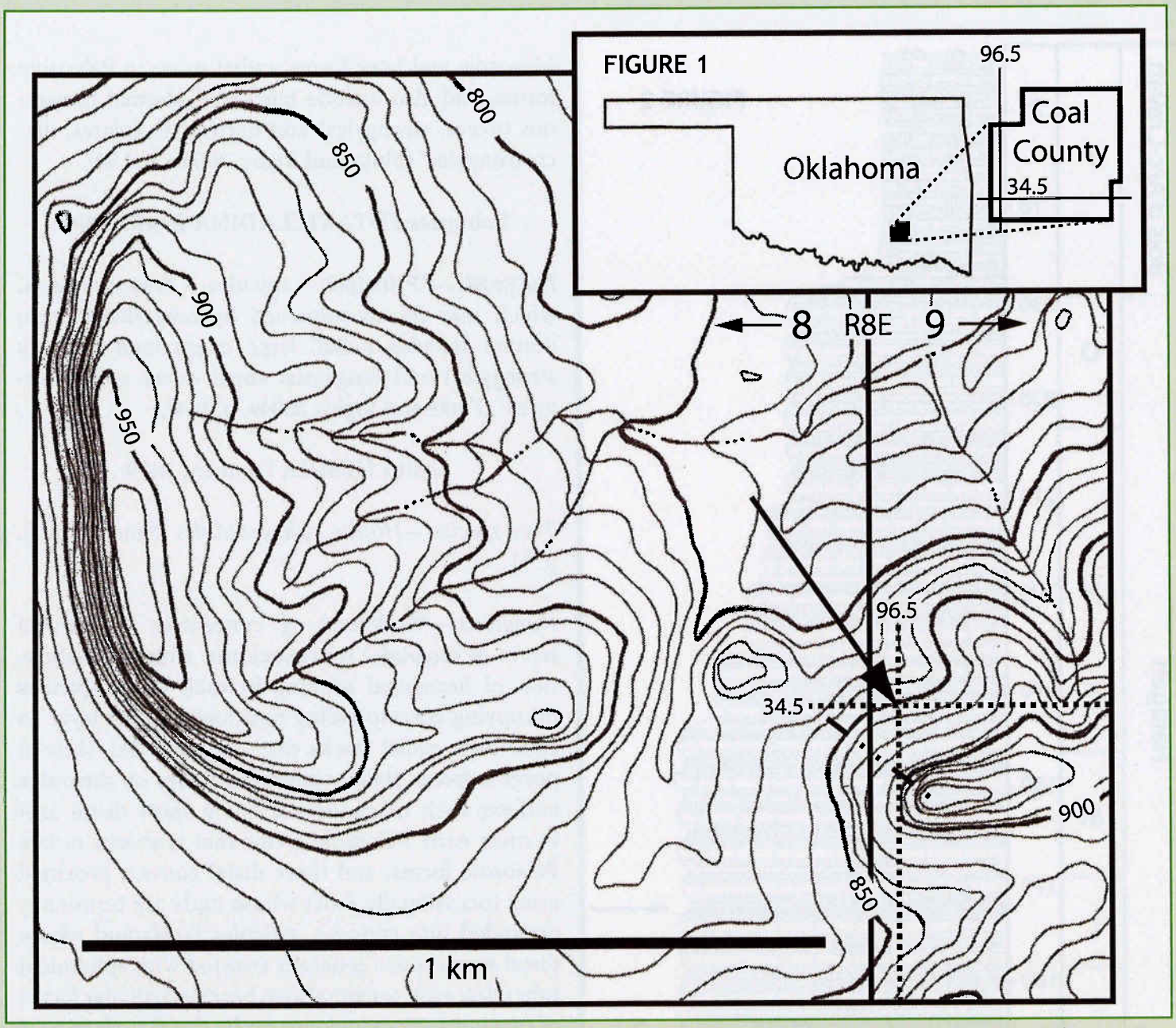


Figure 1. Index map to the Black Cat Mountain Quarry fossil locality area in Sections 8 and 9, numbered at the top, T. 1 S., R. 8 E, in Coal County, southern Oklahoma. The arrow in the lower east part of the large-scale topographic map indicates where the fossils were excavated, at latitude 34.5° N., and longitude 96.5° W., indicated by the dotted lines. The inset outline map of Oklahoma shows the location of Coal County, and the map of Coal County, to the right, shows the latitude and longitude of the Wapanucka North Quadrangle and the locality.

SYSTEMATIC PALEONTOLOGY

Higher level taxonomy applied here is that used in the *Treatise on Invertebrate Paleontology, Part E Porifera (revised), Volume 3* (Finks and Rigby, 2004a and b).

Class DEMOSPONGEA Sollas, 1885
Subclass TETRACTINOMORPHA Lévi, 1953

Diagnosis.—"Principal spicules typically tetraxons, which may be accompanied by oxeas or styles; microscleres are euasters or streptoscleres, which may be accompanied by microrhabds; sigmas are not present" (Finks and Rigby, 2004a, p. 154).

Order STREPTOSCLEROPHORIDA Dendy, 1924

Diagnosis.—"Living form with streptosclere microscleres; lithistid forms built of layers of anapodal spicules, which may be accompanied by other types of desmas (rhizoclones, tetraclones); dermal spicules consisting of radial dichotriaenes and derivatives in

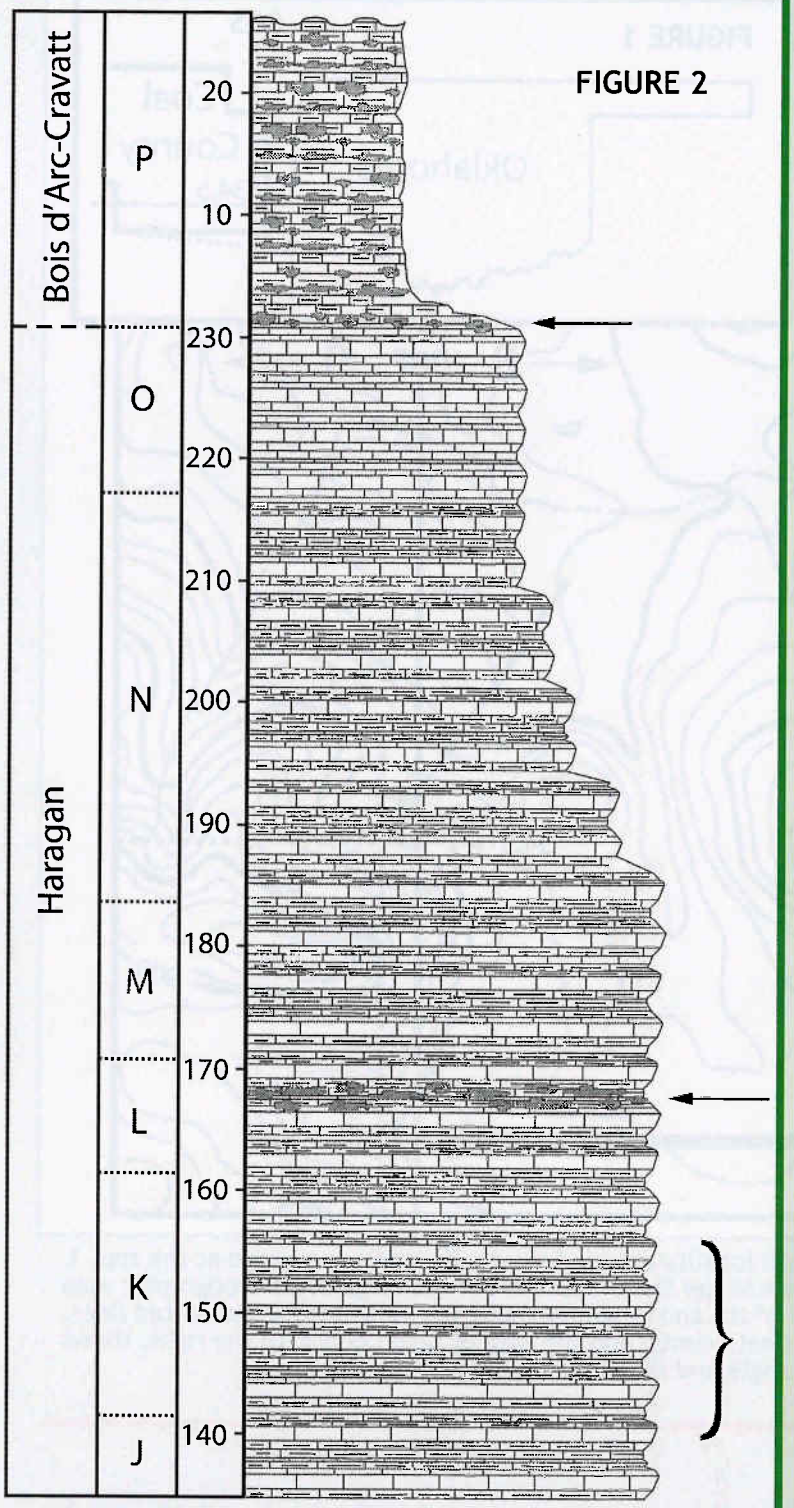


Figure 2. Inferred geologic column of upper Haragan Formation and lower Cravatt Member of the Bois d'Arc Formation, of the Devonian Hunton Group, which crop out around the sponge-bearing study site [Modified from recent observations of G. P. Hansen, based on earlier work by Amsden (1960)]. The bracket in Unit K of the lower Haragan Formation indicates strata from which the sponges reported here were excavated. Thicknesses of the stacked units, in feet, are shown on the left. The arrow in Unit L points to a laterally traceable key layer of brown tripolitic chert, and the upper arrow in Unit P notes the base of the common occurrence of tripolitic chert in the Cravatt Member (Amsden, 1960). The general location of these outcrops is indicated on Fig. 1 by the dotted-and-dashed line south of the fossil locality marked by the prominent arrow.

Mesozoic and later forms, radial oxeas in Paleozoic forms, and also include tangential, dermal monaxons (oxeas, strongyles) and derivatives (plates, discostrongyles" (Finks and Rigby, 2004a, p. 154).

Suborder EUTAXICLADINA Rauff, 1894

Diagnosis.—"Principal spicules tricranoclones, which may be accompanied by megarhizoclones; dermal spicules radial, large oxeas (and possibly strongyles) and tangential small oxeas and strongyles" (Finks and Rigby, 2004a, p. 154).

Genus HINDIA Duncan, 1879

Type species.—*Hindia sphaeroidalis* Duncan, 1879, p. 91.

Diagnosis.—"Skeletons of concentric or parallel layers of anapodal tricranoclones with approximation of hexagonal packing in each layer; spicules occupying corresponding positions in each layer so as to form radial stacks that outline radial, skeletal pores between them, opening as pores on the outer surface; each tricranoclone has a short distal arm in most early Paleozoic forms that is absent in late Paleozoic forms, and three distal convex, proximal arms (occasionally four) whose ends are terminally expanded into concave, articular facets and whose distal surfaces are generally covered with spheroidal tubercles; each proximal arm bearing articular facets of overlying tricranoclones on its distal surface near centrum..." (Finks and Rigby, 2004a, p. 154).

Discussion.—Rigby (2004) proposed that the widely used generic name *Hindia* be retained for the fossil demosponge genus, and that the two senior synonym names, *Sphaerolites* Hinde (1875), and *Microspongia* Miller and Dyer (1878), be suppressed. Finks and Rigby (2004a, p. 154) also subsequently proposed that the generic name *Hindia* be retained. Since then, those proposals of retention of the generic name have been approved.

HINDIA SPHAEROIDALIS Duncan, 1879

(Figures 3.1-3.9)

Calamapora fibrosa ROEMER, 1860, p. 30, pl. 2 (not GOLDFUSS, 1826a, 1826b).

Astylospongia inornata HALL, 1863, p. 70.

Sphaerolites nicholsoni HINDE, 1875, p. 88.

Hindia sphaeroidalis DUNCAN, 1879, p. 91, figs. 1-6; RAUFF, 1894, p. 335, pls. 15-17), figs. 1-4; RIGBY AND WEBBY, 1988, p. 61-63, pl. 26, figs. 1-10; pl. 27, figs. 1-3; FINKS and RIGBY, 2004a, p. 154, figs.112.2a-2c.

Hindia fibrosa (ROEMER) HINDE, 1883, p. 57, pl. 13, figs. 1a, 1b; DE LAUBENFELS, 1955, p. E60, figs. 45.1-45.3; RIGBY and CHATTERTON, 1989, p. 34-35, pl. 7, figs.7-10; RIGBY and CHATTERTON, 1999, p. 17-18, pl. 9, figs. 9-13.

Hyalostelia solivaga ULRICH, 1890, p. 232, pl. 2, fig. 4c.

Microspongia sphaeroidalis grandis HOWELL, 1946, p. 1-2, pl. 1.

Emended diagnosis.—"Spherical sponges ranging to 50 mm in diameter, with most 10-20 mm in diameter. Skeleton of radially stacked tricranoclones with sculptured brachyomes and three cladomes, except where cladomes aborted at canal margins. Canals straight radiating, expanding slightly radially and of three general sizes, each somewhat dependent on diameter of the sponge, with large excurrent canals to 0.7 mm across on sponges 50 mm in diameter; intermediate size canals to 0.55 mm in diameter and smaller canals to 0.35 mm across. Skeletal pores range 0.05-0.10 mm across. Brachyomes point toward exterior and cladomes toward interior. Radiating oxeas may occur in canals" (Rigby and Chatterton, 1999, p. 17-18).

Description.—Several specimens of the species occur in the collection. These range from a small referenced spheroidal form, USNM 535938, which is approximately 10.5 mm in diameter and 7.5 mm tall, to the largest spherical sponge approximately 33-35 mm in diameter. A few sponges have distinctly ovate vertical sections, such as the figured USNM 535930 (Fig. 3.1), which is 12.0-12.5 mm in diameter, with a central vertical height of 5.4 mm, or the larger referenced specimen, USNM 535933, which is 21-24 mm in diameter, with a central height of 11.8 mm.

Several of the partially silicified specimens have the skeletal structure weathered into moderate relief and show the spicular and canal structure of the species very well. The flattened, but vertically ovate, USNM 535930 has such an area (Fig. 3.1). It has well defined canals, such as the exhalant postica that are the largest openings in the dermal surface and are commonly 0.30 mm in diameter, where circular, and 0.30 x 0.42 mm across where transversely elongate. Ostia of probable inhalant canals are the most common openings, are of intermediate dimensions, and range 0.18-0.23 mm in diameter. The smallest canals are 0.10-0.14 mm in diameter and are probably newly formed outer "branches" of inner canals.

Characteristic tricranoclone spicules of the species, as seen here in USNM 535930 (Fig 3.5), have central, erect, brachyomes that range 0.06-0.10 mm in diameter and may extend hollow, node-like up to 0.10-0.12 mm above the ray junction area. The three lateral to outward and downward inclined cladome rays are of various lengths, but extend up to 0.14-0.18 mm long where involved around some of the larger canals. These rays are commonly 0.04-0.08 mm in diameter at midlength, but may expand to 0.10-0.12 mm where they join with the central brachyome, or with cladomes of adjacent spicules.

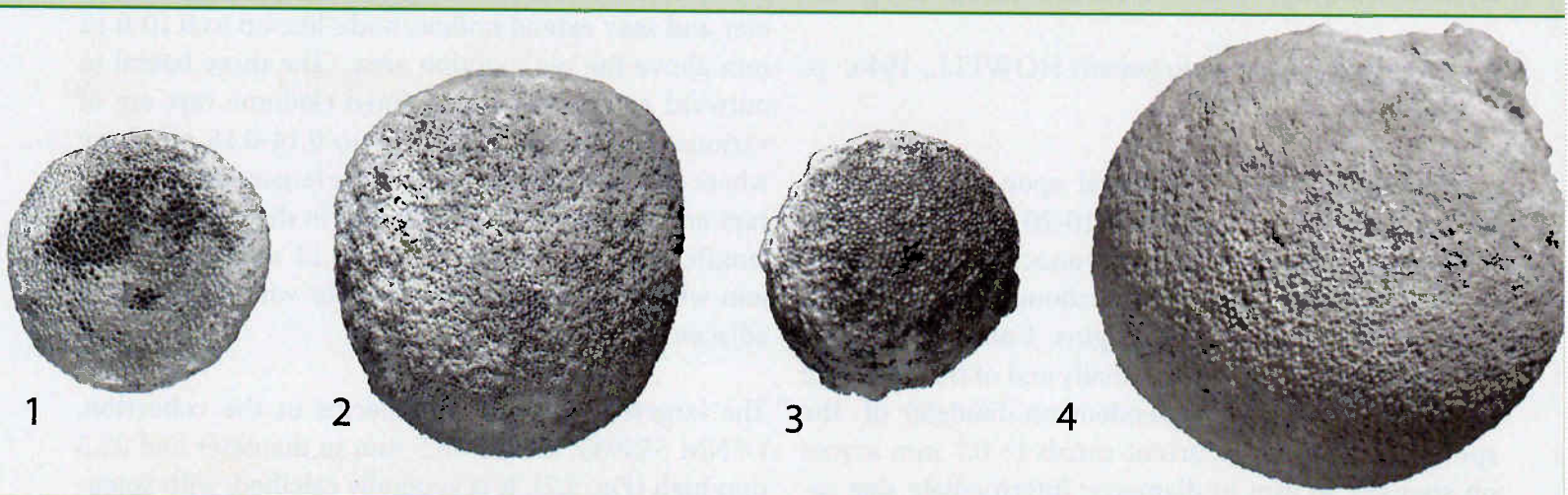
The largest sponge of the species in the collection, USNM 535935, is 25.0-26.5 mm in diameter and 23.3 mm high (Fig. 3.2). It is generally calcified, with spicular elements in the dermal region commonly dissolved, although locally spicules have been calcified, enlarged and distorted, with cladome rays up to 0.5 mm in diameter, which then thicken additionally toward ray junctions or the brachyome, where elements may be up to 0.20 mm in diameter. However, one moderate area of silicified spicules is evident, where brachyomes are 0.10-0.14 mm in diameter. Cladome rays in this area are 0.06-0.08 mm in diameter and 0.05-0.10 mm long. In general, outside this limited silicified area, spicules have generally been dissolved from most of the sponge exterior and hollow "ghosts" mark their former positions.

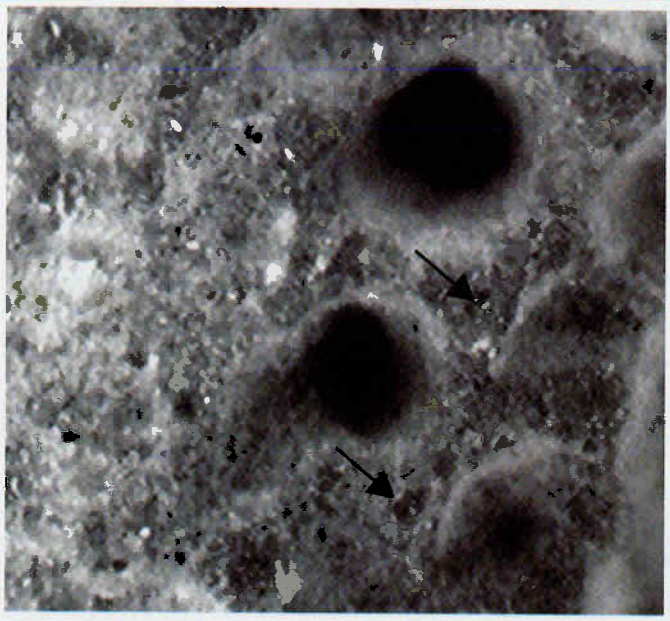
Canal dimensions and spicule structures are moderately well exposed in USNM 535932 (Fig. 3.3), a partially silicified spherical sponge that is 13.8-14.0 mm in diameter and 12.3 mm tall. Large, probably exhalant

canals in the dermal surface are 0.30-0.40 mm in diameter and are irregularly 0.6-1.0 mm apart (Figs. 3.8, 3.9). Most common ostia of possible inhalant canals are 0.23-0.30 mm in diameter; moderately rare smaller ostia are 0.14-0.20 mm in diameter and are also shown in Figs. 3.8 and 3.9. Similar canal development is evident in USNM 535934 (Fig. 3.4), a spherical sponge in which the skeletal structure is preserved as calcareous elements.

A transverse section (Fig. 3.6) is exposed in a cut-and-polished surface through USNM 535931. It was a sponge 23-25.5 mm in diameter and approximately 22 mm tall before being cut. The polished surface shows the radiating canal pattern and skeletal structure typical of the genus. Except for a limited area, spicules have been dissolved and their aligned remnant impressions, 0.04-0.10 mm in diameter, define the radial canals characteristic of the genus and species. Some of the sediment fills of these canals range 0.3-0.4 mm across, as cut in the section, and are like the dermal canal patterns in USNM 535930, for example (Fig. 3.5). Most of these canal fills are approximately 0.2 mm in diameter. A few smaller canal fillings, approximately 0.10-0.15 mm in diameter, are also evident but they may be tangential sections of some of the larger fillings.

FIGURE 3

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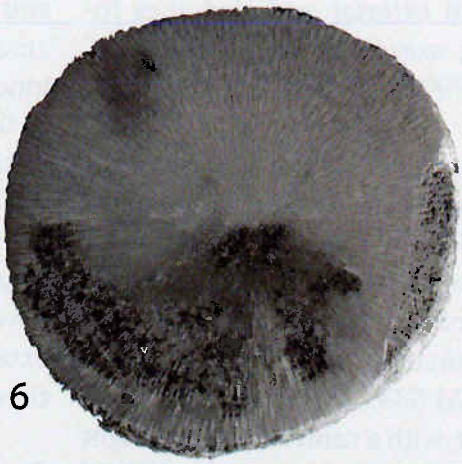
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In one area in the polished surface, sections through rays of the basic tricranoclone spicules are preserved as limonite-stained fragments "floating" in the calcareous matrix.

Polished transverse sections of two relatively large sponges, the figured USNM 535936 (Fig. 3.7) and the unfigured 535937, document the radial skeletal and canal patterns characteristic of the species. In these sponges radial canals are of two general diameters. Tthe smaller probably inhalant canals are approximately 0.2-0.3 mm in diameter near the center of the sponge, and expand to 0.4-0.5 mm in diameter at the dermal surface. The larger exhalant canals are 1.5-2.0 mm apart, as cut in the section, and are irregularly spaced because they are not uniformly nor predictably spaced in any part of the skeleton.

When traced radially, inhalant smaller canals in USNM 535936 (Fig. 3.7) subdivide every 4-5 mm when they are approximately 0.4 mm in diameter and at their largest into two canals approximately 0.2 mm in diameter. These canals enlarge when traced radially for 4-5 mm to where they subdivide again. There are no regular positions in the skeleton where most of the canals subdivide at the same sponge diameter, but such divisions occur throughout the skeleton.

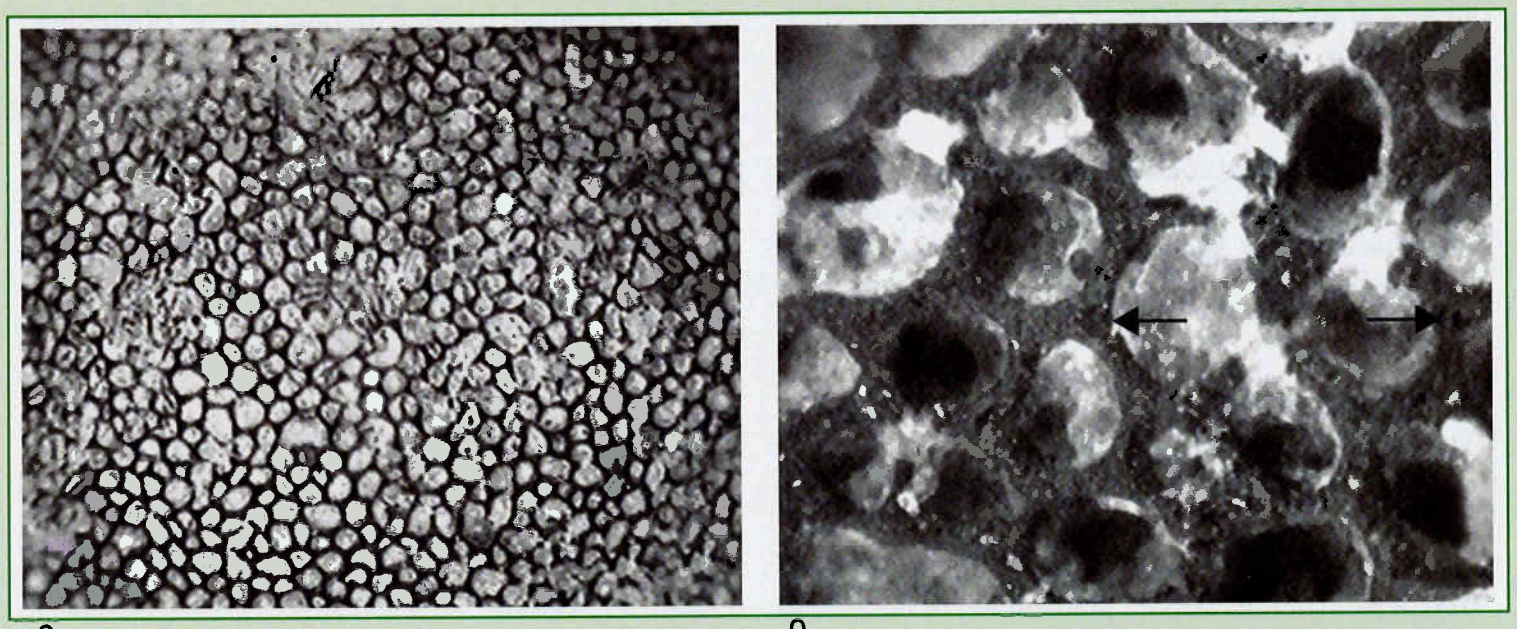

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Figure 3. Photographs of *Hindia sphaeroidalis* Duncan, 1879, USNM 535930-535937; 1, Upper, gently arched and partially silicified, dermal skeleton of USNM 535930; the dark part is silicified, with light matrix filling the radial canal openings surrounded by the dark spicules, and the light outer part of the skeleton is mainly calcified, X 2; 2, Side view of largest, relatively well-preserved, spherical specimen of the species, USNM 535935, in which patches of dark, silicified skeleton are preserved on the lower left, and small black dots over much of the rest of the dermal surface mark areas where the spicular skeletal structure has been dissolved, X 1.5; 3, Arched silicified dermal skeleton of medium-sized spheroidal specimen of the species, USNM 535932, in which the spicule and canal structure is well preserved; see Figs. 3.8 and 3.9 for images of enlarged skeletal detail, X 2; 4, Spheroidal sponge in which the numerous ostia of the radial canals are evident in the calcareously preserved skeleton, USNM 535934, X 2; 5, Photomicrograph of a few spicules and canals of the dermal skeleton of USNM 535930, which shows the radiating cladome rays and the hollow base of some vertical brachyome rays (arrows), X 200; 6, Transverse polished section through a spheroidal specimen, USNM 535931, showing the radial skeletal and canal structure, in part replaced with calcareous elements (light colored) and in part replaced by silica (dark colored), X 2; 7, Photomicrograph of a transverse polished section with a small matrix-filled central opening surrounded by a skeleton with radial larger exhalant and smaller inhalant canals, separated by dark-gray, calcareous spicular elements, in USNM 535936, a spherical example of *Hindia sphaeroidalis* Duncan, 1879, X 3.7; 8, Photomicrograph of part of the dermal skeleton of USNM 535932, showing the dark silicified skeleton of tricranoclones that surround relatively rare, large, exhalant canals, which may occur in irregular clusters, and much more numerous, smaller, inhalant canals that occur between the exhalant openings, X 30; 9, Photomicrograph of exposed details of the dermal skeleton and intervening inhalant canals in the exterior of USNM 535932, with small brachyome rays locally preserved (arrow) at junctions between two cladome rays of the tricranoclone spicules; silicified spicules are preserved with "granular" microtexture, X 200.

The radial structure in the transverse section of unfigured USNM 535937 documents increases in spicule size and radial separation toward the dermal surface. In the innermost 1 mm of the polished sections, near the small open center, 8-9 spicules occur per mm in a single radial series. That number decreases so that at about mid-diameter of the sponge only approximately 4 spicules occur per mm in a single series, and the number decreases to approximately 3.0-3.5 per mm in the outer part of the skeleton, where the canals are also larger.

Material.—Figured specimens USNM 535930-535932, 535934-535936, and seven unfigured reference specimens are in the studied collection.

Occurrence.—The eight figured or cited specimens listed above and additional reference specimens were collected from the quarry in the Devonian Haragan Formation in Coal County, Oklahoma, by William Rushlau.

Discussion.—Skeletal and canal structures of the various specimens in the collection are remarkably uniform and typical of the species, when they are compared with descriptions of early-found and documented type fossils.

Class HEXACTINELLIDA Schmidt, 1870
Order RETICULOSA Reid, 1958

Diagnosis.—"Amphidiscophora in which a dermal skeleton of parallel stauractines, pentactines, or hexactines form a major part of sponge skeleton, and in which microscleres include paraclavules" (Finks and Rigby, 2004b, p. 344).

Superfamily DICTYOSPONGIOIDEA Hall and Clarke, 1899

Diagnosis.—"Reticulosa in which one or more layers of vertical and horizontal bundles of spicules (rhabdodiactines or other hexactine derivatives) are developed beneath dermal layer; dermal skeleton of hexactine derivatives usually differentiated into an outer (possibly autodermal) quadrate mesh of finer spicules and an inner (possibly hypodermal), quadrate mesh of coarser spicules of nested sizes; similar gastral layer, usually of finer spicules, may be developed; rarely both dermal and gastral layers may be suppressed; sponges almost always vasiform; root tuft with bidentate spicule terminations may or may not be present; comitalia of short, stout, curved strongyles and short-shafted bidentate anchors frequently present; zigzag clemes may be present in root tufts and internal spicule bundles; stauractines and pinule-like spicules often present (Finks and Rigby, 2004b, p. 372).

Family DICTYOSPONGIIDAE Hall and Clarke, 1899

Diagnosis.—"Thin-walled Dictyospongioidea with fine, autodermal and hypodermal, quadrate mesh of nested sizes of simple spicules; internal, vertical and horizontal bundles regularly and widely spaced; root tuft may be absent; dermal armor of closely spaced paraclavules may be developed; tripinuli in some genera" (Rigby and Finks, 2004b, p. 372).

Subfamily HYDNOCERATINAE Finks and Rigby, 2004b

Diagnosis.—"Conicocylindrical Dictyospongiidae with annular expansions that may bear quite large protuberances; if prism faces are present, the protuberances are at interfacial angles" (Finks and Rigby, 2004b, p. 382).

Genus CERATODICTYA Hall and Clarke, 1899

Type species.—*Dictyophyton annulatum* Hall, 1863, p. 90.

Diagnosis.—"Sponge conicocylindrical and elongate, bearing transverse annular expansions and contractions; in some species alternate contractions are broader and deeper, causing expansions to be grouped in pairs; surface otherwise smooth and quadrate mesh uniformly fine; spicules not known" (Finks and Rigby, 2004b, p. 384).

CERATODICTYA ANNULATA Hall, 1863
Figures 4.1, 4.4, 4.5

Dictyophyton annulatum HALL, 1863, p. 90, figs.

Ceratodictya annulata HALL AND CLARKE, 1899, p. 117

Diagnosis.—"Sponge slender, very gradually expanding,

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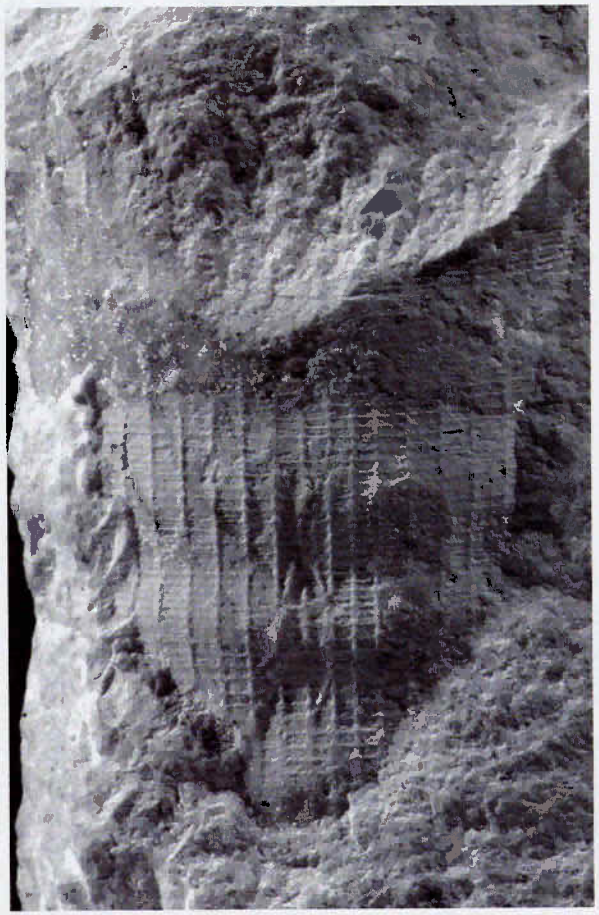

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Figure 4. Photographs of *Ceratodictya* Hall and Clarke, 1899 and *Ceratodictyella* n. gen., **1**, Side view of the entire tall sponge, showing its general chambered obconical form, X 2; **2**, Front of embedded stem with weakly defined horizontal annulae and low vertical ridges, and with remnant of possible dermal layer at the top, X 2; **3**, Back of holotype stem with ridged dermal surface, over which a branched tubular fossil is preserved (Fig. 4.6), along with isolated small snail or cephalopod shells, X 2; **4**, Photomicrograph of lower part of stem showing detailed sculpture with common horizontal, ring-like ridges marking the surface between the thicker vertical ridges, X 5; **5**, Photomicrograph of part of the middle sponge where the dermal surface is marked by common, long, narrow vertical ridges, X 5. 4.1, 4.4, and 4.5, *Ceratodictya annulata* (Hall, 1963), USNM 535938; 4.2, 4.3,4.6, and 4.7, *Ceratodictyella erectus* n. gen. and sp., holotype USNM 535939; **6**, Photomicrograph of part of back of stem showing details of the branched encrusting fossil and, on the right, the low ridge-like dermal elements of the sponge, X 3.5; **7**, Photomicrograph of part of stem front showing coarse vertical ridges and finer, more closely spaced, horizontal ridges in the dermal surface of the sponge, X 2.3.

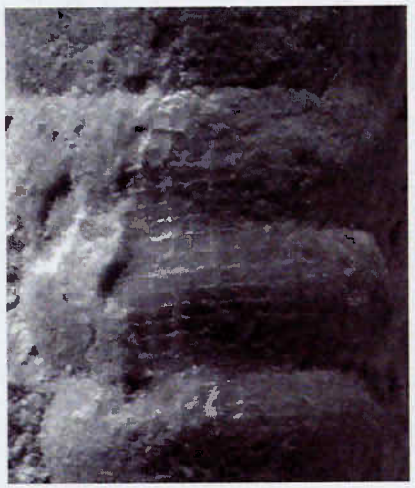

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FIGURE 4

straight or slightly curved; cross-section circular. Surface smooth, annulated by a series of low, horizontal constrictions, varying somewhat in depth, and much narrower than successive swellings of the cup. Over the basal portion of the cup the constrictions occur at much wider intervals.

Reticulation fine, without the strong predominance of any series of spicular bands. The prevailing quadrule appears to measure about 2 x 5 mm, and is repeatedly subdivided.

Dimensions.—The original specimens are three in number and the best of these has a length of 80 mm, and a width of 21 mm. On this specimen there are fine annulations in a length of 63 mm. A somewhat larger, more completely flattened example retains nearly the entire cup, a portion of the base being wanting. The original length of the cup was about 85 mm; the diameter of its aperture 34 mm. The specimen bears but one constriction and hence two annulations, the lower half of the cup being regularly conical" (Hall and Clark, 1899, p. 120).

Description.—Two tall, steeply obconical sponges, USNM 535938 and one in the personal collection of William Rushlau, represent the species in the present collection (Fig. 4.1). The isolated USNM 535930 is 62-63 mm tall and increases in diameter upward from a basal preserved diameter of 2.0 mm to a summit diameter of 8.2 mm, with chamber diameters of 3.5 mm at 30 mm above the base and 7.3 mm in diameter at 45 mm above the base. Basal chambers are approximately 1.5 mm tall, and chamber heights increase upward to approximately 2.5 mm tall at 37 mm above the base and 2.7-3.0 mm in the upper 25 mm of the specimen, where they are less distinct (Fig. 4.1).

Thicknesses of dermal walls are not evident but are probably similar to interwalls between chambers. Such interwalls between the lower chambers are evident at horizontal dermal indentations and are 0.4-0.5 mm thick. Such interwalls are more obscure in the dermal layer in the upper half of the sponge, but locally appear to have the same thicknesses as those below.

Dermal surfaces in USNM 535938 are marked by long, narrow, small vertical ridges that are approximately 0.15-0.20 mm wide and are separated 0.3-0.7 mm horizontally (Figs. 4.1, 4.4). Lower ridge crests are approximately 0.5 mm apart, crest to crest, and are 0.05-0.06 mm high. Approximately halfway from the base to the summit, where chambers are still moderately prominent, these ridges are approximately 0.10 mm high with bases 0.15 mm wide and 0.60-0.65 mm apart. Farther up, where the chambers are less evident, these ridges are 0.70-0.75 mm apart and 0.20 mm high, with bases approximately 0.20 mm wide and appear as iron-stained traces (Fig. 4.4).

Vertical areas between the ridges generally appear flat to gently indented, unless viewed in vertical tangential light. Under such illumination, numerous horizontal, small ridges become evident in the lower part of the sponge (Fig. 4.4). They are lower and narrower than the vertical ridges noted above. These smaller horizontal ridges are approximately 0.3 mm apart and circle the sponge horizontally. They are 0.04-0.06 mm high and wide, as preserved. Similar ridges in the upper part of the sponge are up to 0.10 mm wide and high, but are still 0.20-0.50 mm apart, vertically, crest to crest. Flattened intervening wall segments are 0.10-0.15 mm wide. These combined horizontal and vertical ridges produce a faint, gently reticulate quadrangular dermal pattern.

The other vertical obconical fragment of the species in the collection is less well preserved and is of only the lower 38-39 mm of the sponge. Its encrusted covered base is approximately 2.5 mm in diameter and the fossil expands smoothly upward to a diameter of 8.5 mm, at 26-27 mm above the base. Above that the fragment is broken across, diagonally upward, but it still gives the impression of continuous original upward expansion of the specimen, to approximately 9 mm in diameter at the incomplete broken top.

Individual chambers are not well defined in the fragment and details of the dermal chamber walls are not preserved in the impression. However, most chambers are separated from one another by narrow indentations, 0.2-0.3 mm tall, that mark the original positions of the chamber interwalls. Lower chambers, thus defined, appear to have been 1.5-2.0 mm tall, middle preserved ones range 2.2-2.5 mm tall, and upper preserved ones are 3.0-3.2 mm tall. However, original uppermost chambers are not preserved so total sponge height and range of upper chamber sizes are not known.

Faint rectangular dermal markings, spaced 0.2-0.4 mm apart, are locally preserved on some chamber fillings in the middle and upper parts of the fragment. They are probably impressions of the small, rectangularly arranged, ridges like those evident in the other, better preserved, specimen of the species in the collection.

Material.—The two specimens, USNM 535938 and one in Rushlau's personal collection, are representative of the sponge species.

Occurrence.—The figured specimen and the less well-preserved specimen, described above, were collected from the Black Cat Mountain Quarry in the Devonian Haragan Formation in Coal County, Oklahoma, by William Rushlau.

Discussion.—The tall sponges have prominent chambers, marked by distinct indentations between chambers in the lower part of their skeletons. Upper chambers or annulations are separated less prominently than those lower in the sponges. Illustrations of type specimens of the species (Hall and Clarke, 1899, Pl. 2, figs. 3-6; Finks and Rigby, 2004b, p. 384, figs. 246-2a, b) show their skeletons have a rounded annulate chamber structure somewhat like the upper part of the sponges documented here. The type specimens, thus, appear to be of upper parts of the sponge, rather than near-basal elements like the fossils included here.

CERATODICTYELLA new genus

Type species.—*Ceratodictyella erectus* n. gen. and sp.

Diagnosis.—Moderate-sized, columnar sponges with gently annulate dermal surface marked by prominent, but small, separated, parallel vertical ridges; distinct but smaller and more closely spaced horizontal ridges continuous around dermal surface produce ladderlike reticular surfaces between vertical ridges.

Etymology.—*Ceratodicty*, named for similarity to the associated fossil sponge *Ceratodictya*; *ella*, Latin, *ellus*, little, in reference to the short fragment that is the holotype of the species.

Occurrence.—The holotype, the single known specimen of the genus, was collected from the Black Cat Mountain Quarry in the Devonian Haragan Formation, Coal County, Oklahoma. The quarry is located in Sec. 9, T. 1 S., R. 8 E. and is accessible via Oklahoma County Road E1740.

Discussion.—The genus contrasts with the contemporaneous sample of *Ceratodictya annulata* (Hall, 1863) in the nature of its dermal skeleton. *C. annulata* has both vertical and horizontal low ridges in its dermal sculpture, but they are of essentially the same size and spacing. This contrasts to the ridges in the much larger *Ceratodictyella erectus*, n. gen. and sp., where the vertical ridges are coarser and spaced farther apart than the horizontal ones.

CERATODICTYELLA ERECTUS new gen. and sp.
Figures 4.2, 4.3, 4.6, and 4.7

Diagnosis.—As for genus above.

Description.—The holotype, USNM 535939, is the only known specimen of the species and it consists of a partially embedded ovoid stem that has weakly defined horizontal annulae and low vertical dermal ridges. The fragment is approximately 30 mm tall, with a mid-height transverse ovoid section 21.5 x 35 mm across. Both front and back dermal surfaces (Figs. 4.2, 4.3) are marked by low annulations approximately 6 mm high, with fragmental partial annulations at the top and bottom of the fragment. The back side of the fragment has a small remnant area of the possible outer dermal skeletal layer. These crystalline remnants are 0.2-0.3 mm thick and suggest that the sculpture exposed on the rest of the sponge might be of the inner surface of the dermal layer rather than the exterior.

Both sponge surfaces are marked by prominent, regularly spaced, vertical ridges and smaller horizontal ridges (Figs. 4.2, 4.3, 4.7). The coarser vertical ridges range 1.0-1.5 mm apart, with most spaced 1.0-1.2 mm apart. They have rounded summits, as preserved, and most are approximately 0.2 mm wide and 0.10-0.15 mm high in the crystalline preservation. Broad spaces between the ridges are 0.7-0.8 mm wide and are marked by small horizontal ridges.

The smaller and more closely packed transverse, or horizontal, ridges are 0.08-0.10 mm wide and their microstructure appears to merge into the vertical ridges where they cross (Fig. 4.7). The horizontal ridges range

0.4-0.6 mm apart, but most are uniformly spaced 0.5 mm from similar adjacent ridges. They are all approximately 0.10 mm high. Their ends broaden where they cross, or merge with the coarser vertical ridges. They are more or less traceable around the sponge stem.

The combined vertical and horizontal ridges produce a regular reticulate sculpture to the preserved "dermal" surface of the stem. A few small snail or cephalopod shells, and much larger, branched, tubular fossils are attached or have overgrown parts of both the front and back parts of the sponge (Figs. 4.3, 4.6). This would suggest that the ridged surfaces are exposed dermal surface, rather than an inner skeletal feature, as mentioned above.

Microstructure of the ridges, as preserved, is microcrystalline. No spicules are preserved so taxonomic relationships are not certain. The genus is included in the Dictyospongia because of its regular reticulate skeletal structure.

Etymology.—Erectus, Latin, upright, named for the vertical, erect, structure of major elements of the dermal skeleton.

Material.—The holotype, USNM 535939, is the only known specimen of the genus and species.

Occurrence.—The single specimen of the species and genus, the holotype, was collected from the quarry in the Devonian Haragan Formation in Coal County, Oklahoma, by William Rushlau.

Discussion.—Microstructure of skeletal elements of the sponge, as preserved, is microcrystalline. No spicules are preserved so taxonomic relationships are not certain. The genus is included in the Dictyospongia because of its regular reticulate skeletal structure.

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Vertebrate Fauna of the Pitkin Formation (Late Mississippian) of Adair and Cherokee Counties, Oklahoma

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ABSTRACT:

Teeth, spines, vertebrae, scales and dermal denticles are reported from the Late Mississippian (Chesterian) Pitkin Formation of Adair and Cherokee Counties in eastern Oklahoma. Chondrichthyan teeth are the most common elements found, followed by vertebrae and scales from paleoniscoid fish. The material in this report was recovered from samples of Quaternary cave fill in which it had been redeposited after weathering out of the Mississippian limestones in which the caves developed.

INTRODUCTION:

This is the first report of vertebrate fossils from the Pitkin Formation in Oklahoma. The fossils were collected from three caves within the Pitkin Formation in Adair and Cherokee counties. The Pitkin represents a shallow marine carbonate limestone. It is exposed on the west and south flanks of the Ozark uplift in northeast Oklahoma and northwest Arkansas. In Oklahoma the Pitkin outcrops in Wagoner, Cherokee and Adair counties. The Pitkin and the overlying Pennsylvanian Hale Formation form a conspicuous bluff along major streams and a narrow band shape that forms the basal part of the bluffs encircling the outliers.

Blue-gray limestones with thin shale partings characterize the Pitkin Formation. The limestone weathers to an orange-brown color and it varies in thickness up to 200 feet. The Hale Formation unconformably overlies the Pitkin (Huffman, 1958) and often forms a flat, sandy limestone ceiling to Oklahoma Ozark caves, while the Pitkin forms the cave walls.

The Mississippian fish fossils reported herein were found incidental to screen washing for Pleistocene-Holocene mammals and other small vertebrates for a separate project. The tiny fish fossils were rare compared to the abundant Quaternary micro vertebrates. The Paleozoic fossils included occasional invertebrates (crinoid stalk plates) as well as fish; they clearly weathered out of the limestone cave walls and were redeposited in the Quaternary cave fill.

The only previous reports of Mississippian vertebrates from Oklahoma were made by Croneis (1927) and Zidek (1972; 1973; 1975; 1993). In his report of the sharks from the Fayetteville Formation in Mayes County, Oklahoma, Croneis (1927) described *Cladodus corrugatus, Cladodus ozarkensis, Deltodus cingulatus, Deltodus wortheni,* and *Ctenacanthus sp.* The Fayetteville underlies the Pitkin in eastern Oklahoma. Zidek (1972, 1973) reviewed all of the paleoichthyological reports from Oklahoma up to that time. Zidek (1975) later described Acanthodian scales from the Delaware Creek Formation (Middle Mississippian) of Murray County, and in 1993 he described a new Mississippian Stethacanthid shark from the Caney Shale in Pontotoc County.

All of the new specimens reported herein have been curated in the Vertebrate Paleontology collection of the Sam Noble Oklahoma Museum of Natural History (OMNH). They came from OMNH localities V-1586, V-1587 (Adair County) and V-1588 (Cherokee County). Because of the fragmentary condition of some of the specimens, several can only be identified to genus.

SYSTEMATIC PALEONTOLOGY:

Class Chondrichthyes Huxley, 1880

Subclass Elasmobranchii Bonaparte, 1838

Order Orodontida Zangerl, 1981

Family Orodontidae de Koninck, 1878

***Genus Orodus* Agassiz, 1838**

***Orodus* sp.**

Referred specimens; OMNH 73461 through 73467, 73469, 73470, 73474, 73480, and 73486.

The teeth are relatively stout and crested, with a gently arched profile. An occlusal crest delineates the labial and lingual faces of the crown. There is a large rounded central cusp and one side of the tooth is slightly longer than the other. The teeth are mesio-distally elongated crushing teeth and the crown retains strong cristation. The base is gently convex and has a height equal to that of the crown.

Subclass incertae sedis

Order Petalodontida Zangerl, 1981
Family Petalodontidae Newberry and Worthen, 1866

Genus *Chomatodus* Agassiz, 1838

***Chomatodus parallelus* St. John and Worthen, 1875**

Referred specimens; OMNH 73424 and 73426 through 73429.

The teeth are small in size, laterally elongated, with the upper and lower margins parallel. The crown is symmetrical, rather low, and labio-lingually thin blade-like in appearance. They are rounded at the extremities. The convex face equals in elevation half the entire height of the tooth. The teeth are slightly arched vertically and nearly straight laterally, with a narrow coronal belt consisting of two or three imbrications. The concave face has a rather deep lateral depression. The crest and basal margins are for the greater extent horizontal and parallel. The crown is coated in enamel, which is usually more or less distinctly striated vertically and in worn specimens they have a coarse punctuation. The base is thick and strong, nearly perpendicular to the crown. The interior surface is relatively wide and slightly obliquely beveled from the concave side to the opposite margin.

Order Petalodontia Zangerl, 1981

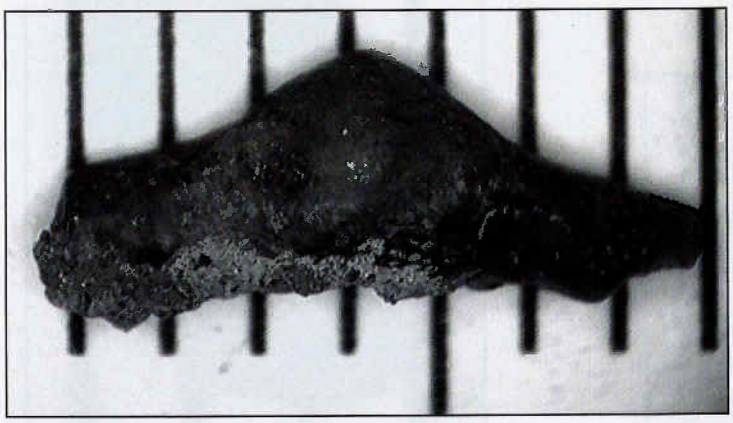
Family Petalodontidae Newberry and Worthen, 1866

Genus *Petalodus* Owen, 1840

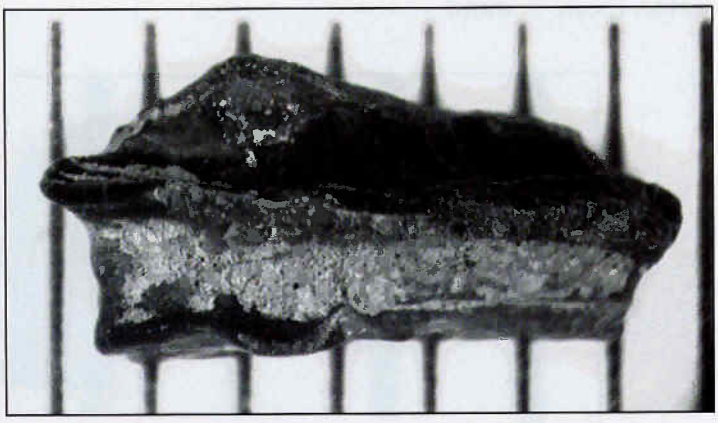
***Petalodus ohioensis* Stafford, 1853**

Referred specimens; OMNH 73431 through 73433.

The tooth has a sigmoid flexure in profile. The crown is broad and triangular, with basally curved extremities and is convex on the labial side and concave on the lingual side.



***Orodus* sp.** OMNH 73470. (Scale in mm.)



Chomatodus parallelus OMNH 73424 (Scale in mm.)

The tip of the crown has a slightly steeper slope than the rest of the cusp and although not serrated, the crown has fine grooves extending down the cutting edge. At the base of the crown, on both the lingual and labial surfaces, there is a band of imbricated and sharp-crested ridges. The root is longer than the crown. It is triangular in shape and comes to a rounded point at its base.

Family Cochliodontidae incertae sedis Owen, 1867

Genus *Venustodus*
St. John and Worthen, 1875

Venustodus leidyi
St. John and Worthen, 1875

Referred specimens; OMNH 73441 through 73443 and 73485.

The crown is platform-like with a prominent lingually imbricated basal ridge. The cusps are stout and conical with the median cusp most prominent. In line with the central cusp are smaller, but well-developed, lateral cusps. The crown is nearly horizontal in profile and it is covered with a thick enameloid. The tooth base is short, restricted, and also platform-like. The basal ridge around the crown edge has three to five parallel imbrications. The tooth base is well-developed and about two-thirds the thickness of the crown. It forms a small angular platform. The flat basal surface is oblique to the vertical axis of the crown.

Subclass Holoceplali Bonaparte, 1832-41

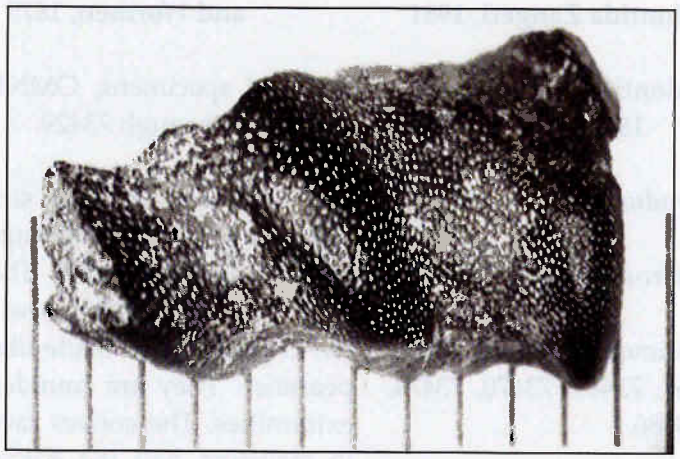
Order Cochilidontiformes Obruchev, 1953

Family Cochliodontidae Owen, 1867

Genus *Deltodus*
Morris and Roberts, 1862

***Deltodus* sp.**

Petalodus ohioensis OMNH 73433. (Scale in mm.)



***Deltodus* sp.** OMNH 73423. (Scale in mm.)

Venustodus leidyi OMNH 73443. (Scale in mm.)

***Helodus* sp.** OMNH 73468. (Scale in mm.)

Referred specimens; OMNH 73418 through 73423, 73482 and 73488.

All of the specimens collected are badly broken and fragmented, so only a general description can be given. The teeth appear to be of medium size. The crown is moderately convex in cross-section. They have a small trough and ridge forming the lingual margin. The crown forms a moderately high dome which is covered by large, well-separated punctae that are aligned in distinct, nearly straight rows.

Subclass Subterbranchialia Zangerl, 1979

Suborder Holocephali Bonaparte, 1838

Order Helodontiformes Patterson, 1965

Family Helodontidae Patterson, 1965

Genus *Helodus*, Agassiz 1838

***Helodus* sp.**

Referred specimens; OMNH 73460 and 73468.

The crown is three times longer than wide and rises gradually into a blunt, labialy-incline with a nearly central summit. The lingual face is convex and the labial face is straight except for on end, which is inflected labialy. There is no evidence of a longitudinal keel or folds on either of the crown faces. The crown has a punctae surface that is well separated from each other, rather than crowded together. The base extends the full length of the crown and is recessed under the edges of the crown.

Subclass Elasmobranchii Bonaparte, 1838

Subfamily Ctenacanthoidea Zangerl, 1981

Family Ctenachanthidae Dean, 1909

Genus *Cladodus* Agassiz, 1843

***Cladodus occdentalis* Leidy, 1859**

Referred specimens; OMNH 73451 through 73457, 73478, 73484, and 73458.

Characteristically the teeth have five cusps: a large central cusp flanked on either side by two lateral cusps. An additional pair of small lateral cusps may sometimes be present adjacent to the central cusp. The central cusp is broad at its base and tapering to the point. In lateral view the cusp is somewhat compressed and exhibits a small but noticeable sigmoid flexure. The cusp is somewhat flatter on the labial side. Longitudinal ridges cover the surface of the central cusp, as well as the lateral cusps. The lateral cusps are conical, with the outer cusps being slightly larger than the inter cusps. The cusps are in line on the labial side of the base and the base lingual to the cusps is broad and slightly convex. Two large knob-like bosses are present on the base-lingual cusps. There are also two baso-labial projections that are present on the base. The tooth base is oblong in shape and dorso-ventrally flattened.

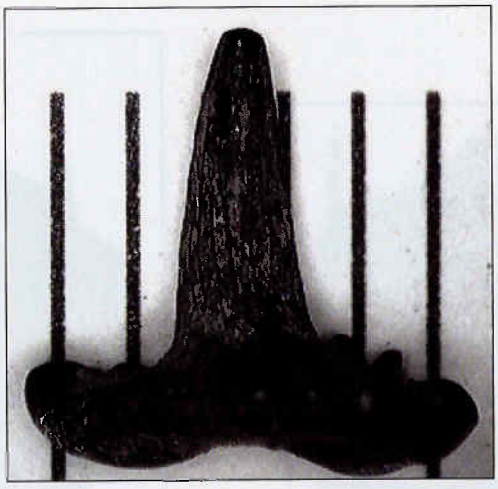
Superorder Euselachii Hay, 1902

Order Ctenacanthiformes Zangerl, 1981

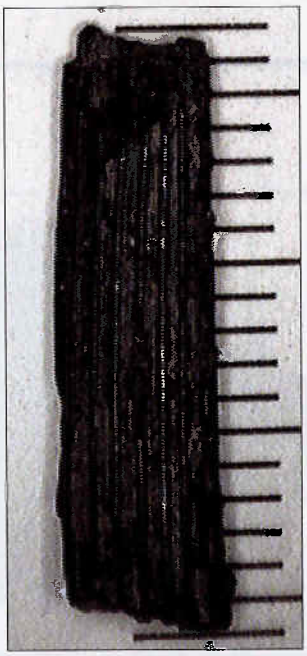
Family Ctenacanthidae Dean, 1909

Genus *Ctenacanthus* Agassiz, 1837

***Ctenacanthus* sp.**



Cladodus occdentalis OMNH 73455. (Scale in mm.)



***Ctenacanthus* sp.** OMNH 73445. (Scale in mm.)

Referred specimens; OMNH 73446 and 73447.

Both of the partial fin spines are long, slender, slightly curved and very gradually tapering. They are laterally compressed. The lateral face is gently convex and converging to the acute anterior edges. The first pair of crestae on either side of the anterior ridge bear delicate, obliquely transverse tubercles, spaced by about twice their diameter. The lateral faces are occupied by about fifteen prominent, rounded or flattened and rarely bifurcated. They very gradually diminish in size posteriorly. The posterior face is slightly channeled. The postero-lateral margins forming prominent rounded angles bearing relatively strong, slightly hooked, sculptured denticales. They are also separated by about twice their diameter.

Super order Euselachii Hay, 1902

Order Ctenacanthiformes Zangerl, 1981

Subfamily Hybondontoidea Zangerl, 1981

Family Hybodontidae Zangerl, 1981

Genus *Petrodus* McCoy 1848

***Petrodus patelliformis* McCoy 1848**

Referred specimens; OMNH 73444 and 73479.

These denticales are conical with a flat base and rounded apex from which several ridges radiate to the base. The width of the ridges increases toward the base and some of the ridges bifurcate midway down the denticale. The base is slightly concave in ventral view and projects as a narrow flange around the circumference of the denticale.

The dermal denticale genus Petrodus is a common Paleozoic chondrichthyan fossil; however, its taxonomic placement is still in question.

Subclass Subterbranchialia Zangerl, 1979

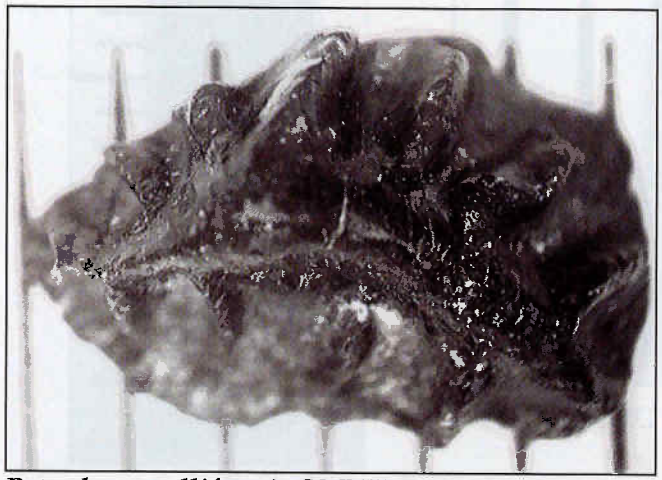
Order Psammodontidae de Koninck, 1878

Genus *Lisogodus* St. John and Worthen, 1875

***Lisogodus serratus* St. John and Worthen, 1875**

Referred specimens; OMNH 73471 and 73472.

The crown has abbreviated lateral extremities which are sharply rounded. There is a large bulbous median crest. The crown is broadly triangular and inclined lingually. The lingual face is small, vertical, and weakly convex. The labial face is larger, nearly flat, and sloping. They have four imbricated transverse ridges at the crown foot. The apex of the crown is blunt and offset distally, making the crown asymmetrical in labial-lingual view. The tooth base is rather short and constricted be-



Petrodus patelliformis OMNH 73444 (Scale in mm.)

Lisogodus serratus OMNH 73471 (Scale in mm.)

low the crown foot, flaring to form a larger, nearly flat basal attachment surface that is oblique to the vertical axis of the tooth.

Genus *Lisogodus*, St. John and Worthen 1875

***Lisogodus* sp.**

Referred specimens; OMNH 73425 and 73459.

The teeth are exceedingly small. The crown is stout, semi-elliptical in outline when viewed from above. The crown is sharp-crested, symmetrical, arched in the center, and when worn it has a heavy striato-punctate appearance. The convex face is nearly vertical, slightly arched laterally. The concave face is equal in height, but is steeper in appearance and only slightly angled downward. The basal margin is well-defined from the root and marked by a proportionately wide coronal band. The coronal band is gently arched upward in the middle and again at the extremities, giving it a wavy appearance. The coronal band on the concave face overhangs the base twice the distance as the other face. One extremity of the teeth is rounded, while the other is more pointed. The crown is covered with a polished enamel layer. The base is well-developed, angular in outline. It is a little narrower than the crown, but almost equal in height. The base posteriorly is slightly oblique to the vertical plane of the crown. The base is rectangular in outline.

Subclass Elasmobranchii Bonaparte, 1838

Order incertae sedis

Family Phoebodontidae Williams, 1985

Genus *Thrinacodus* St. John and Worthen, 1875

***Thrinacodus ferox* Turner, 1982**

Referred specimens; OMNH 73448 and 73449.

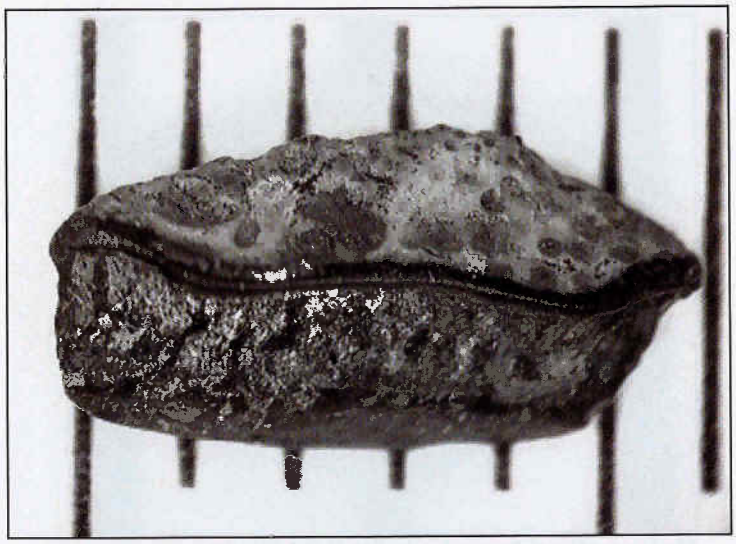
The teeth are very small. The base, which runs posteriorly, is long, vertically flattened, or laterally compressed. It is longer than wide. The anterior face is narrow and abruptly beveled from the basal line of the crown. From the antero-superior extremity of the base project three more-or-less relatively stout, recurved cusps. The exterior pair diverges and the central cusp, which is the largest, is more or less vertical, slightly sigmodally curved; in transverse section it is sub-triangular, compressed in front and rounded behind, with simple cutting edges.

Order Xenacanthida Glikman, 1964

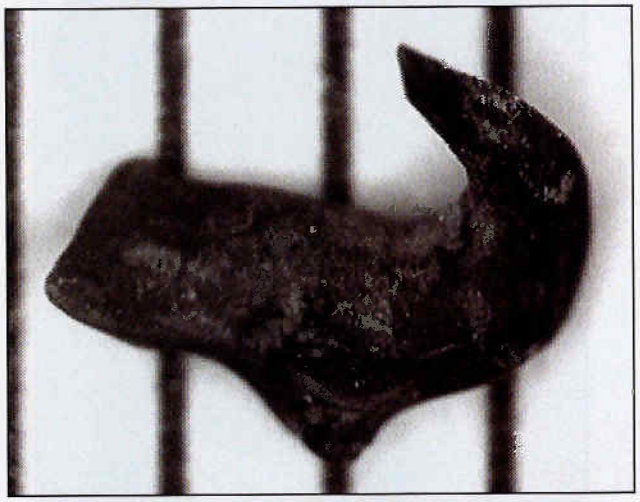
Family Xenacanthiformes Berg, 1955

Genus *Bransonella* Harlton, 1933

***Bransonella tridentata* Harlton, 1933**



***Lisogodus* sp. OMNH 73425 (Scale in mm.)**



***Thrinacodus ferox* OMNH 73448 (Scale in mm.)**

Referred specimens; OMNH 73434 through 73440.

The basal plate is nearly circular, convex, with three pointed anteriorly striated cusps. Viewed anteriorly, the striations carry through from one cusp to the other. Posteriorly a triple-indented notch is developed and anteriorly at the base a short-elongated ridge is developed. The cusps are relatively short and almost straight, the lateral cusps only slightly diverging from the median cusp. The ornamentation of the labial side consists of four sub parallel crestae, running separately from base to tip.

Super order Euselachii Hay, 1902

Subfamily Protacrodontoidea Zangerl, 1981

Family Tamiobatidae Hay, 1902

Genus *Holmesella* Gunnell, 1931

***Holmesella triangularis*, Harlton 1933**

Referred specimen; OMNH 73430.

The outline is trapezoidal. The length is approximately equal to the width. The base is robust and strongly pyramidal. They are asymmetrical, triangular in side view. The ornamentation is faint but distinct with transverse lines. The oral surface is flat and smooth.

DISCUSSION:

The number of fish teeth fossils recovered from the small samples of matrix collected indicates that a substantial number of shark and fish fossils remain to be discovered in Oklahoma's Mississippian strata. The large assemblage of taxa at the three localities is unique for the State. Most of the recovered specimens in this report are the first reported occurrence of the genus and/or species from the Mississippian of Oklahoma.

ACKNOWLEDGEMENTS:

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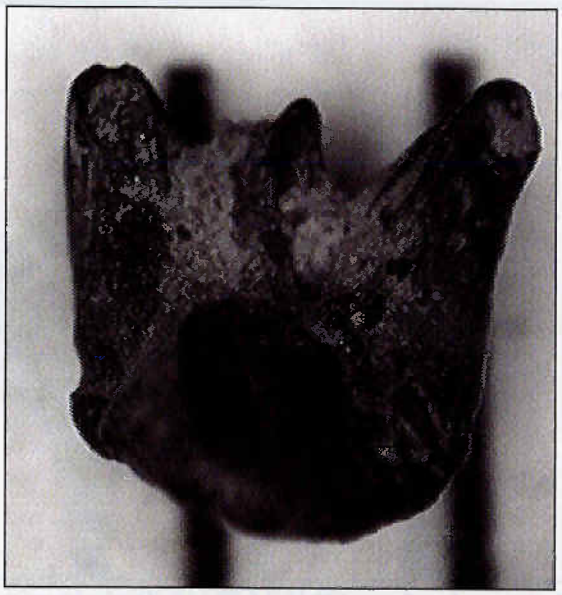

Bransonella tridentata OMNH 73436
(Scale in mm.)

Holmesella triangularis OMNH 73430
(Scale in mm.)

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Table I: VERTEBRATE FAUNAL LIST BY CAVE

AD-14, OMNH V- 1586, Adair County

Paleoniscoid
Deltodus sp.
Chomatodus parallelus
Lisogodus sp.
Lisgodus serratus
Holmesella triangularis
Petrodus ohioensis
Bransonella tridentata
Venustodus leidyi
Petrodus patelliformis
Ctenacanthus sp.
Thrinacodus ferox
Cladodus occdentalis
Orodus sp.
Helodus sp.

Three Forks Cave, OMNH V-1587, Adair County

Orodus sp.
Deltodus sp.
Cladodus sp.
Venustodus leidyi

CZ-9, OMNH V- 1588, Cherokee County

Cladodus sp.
Petrodus patelliformis
Deltodus sp.

The reason for the major differences in the number of different taxa from CZ-9 and Three Forks cave is because of the smaller samples of processed matrix from these two.

Oklahoma Earthquakes, 2006

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INTRODUCTION

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

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

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

The largest known Oklahoma earthquake (with the possible exception of the 1882 earthquake) occurred near El Reno, Canadian County, on April 9, 1952. This magnitude-5.5 (mb, Gutenberg-Richter) earthquake caused a 50-ft-long crack in the State Capitol Office Building in Oklahoma City. It was felt throughout Okla-

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

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

homa and in parts of seven other states. The total felt area was about 362,000 km^2 (Docekal, 1970; Kalb, 1964; von Hake, 1976); Des Moines, Iowa, and Austin, Texas, were at the northern and southern limits. From 1897 through 2002, 1,697 earthquakes were located in Oklahoma.

INSTRUMENTATION

A statewide network of seven seismograph stations was used to locate 20 earthquakes in Oklahoma for 2006 (Fig. 1). The network consists of a central station (TUL/LNO), four radio-telemetry seismograph stations (FNO, RLO, SIO, VVO), and two field stations (MEO and PCO). The U.S. Geological Survey (USGS) established a seismograph station, WMOK, 19 km southwest of the Oklahoma Geological Survey's (OGS) station at Meers (MEO). WMOK does not record continuously. When triggered by moderately strong ground motion, WMOK transmits a short segment of data to the National Earthquake Information Service in Golden, Colorado. WMOK is used mostly for distant earthquakes, although it sometimes records some of the larger Oklahoma earthquakes. Because WMOK is so near MEO, its arrival times do not improve the accuracy of location of Oklahoma earthquakes.

Central Station

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

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

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

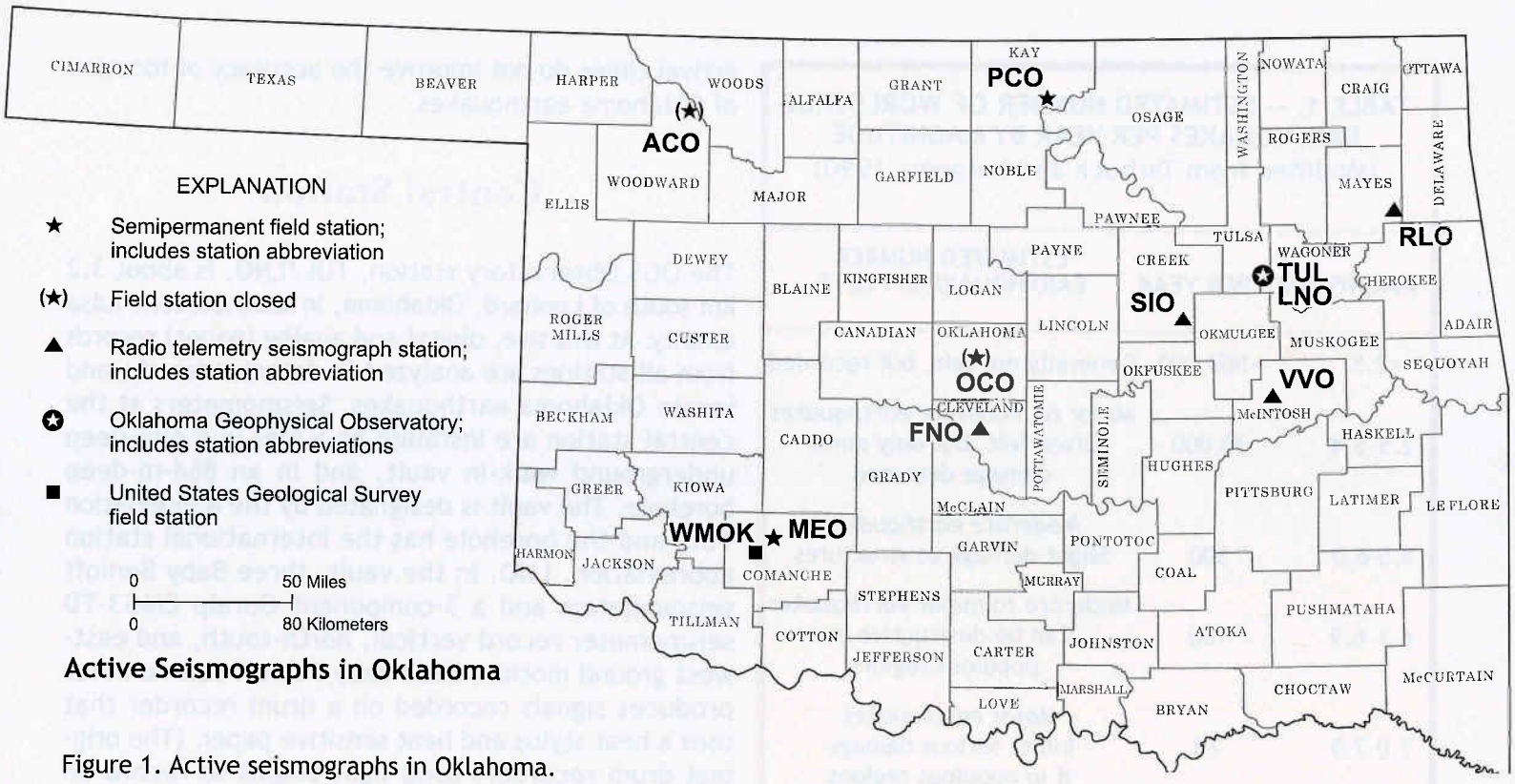

Figure 1. Active seismographs in Oklahoma.

ROMs. About two new CDs are added each week.

SCREAM sends slower packets (20 samples per second, and four samples per second) to another PC running SCREAM, and to the University of Indiana via the internet. From Indiana, the packets are sent continually or in once-per-day batches to a number of secondary schools in the United States. The slower packets lack the high frequencies characteristic of Oklahoma earthquakes, but are very useful for studying teleseisms (distant earthquakes), which occur daily in the Earth's seismic belts. For distant earthquakes above magnitude 6, packages of the 20-sample-per-second, vertical, north-south, and east-west signals containing about one hour of recording are made at the Observatory. These are sent by internet file transfer protocol to the PEPP (Princeton Earth Physics Project) data base, which is used primarily by American secondary schools.

Radio Telemetry Stations

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

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

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

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

timed packets. The packets are transmitted to a PC running Guralp SCREAM data acquisition software.

A fourth radio-telemetry station, FNO, was installed in Norman in central Oklahoma on April 28, 1992. The seismometer, Geotech S-13, is on a concrete pad, about 7 km northeast of Sarkeys Energy Center (the building that houses the OGS main office). A discriminator converts the audio-signal frequency fluctuations to a voltage output. The voltage output is amplified and recorded by a Sprengnether MEQ-800 seismograph recorder (located in an OGS display case) at a trace speed of 60 mm/min.

Field Stations

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

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

DATA PROCESSING AND ANALYSIS

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

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

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

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

DISTRIBUTION OF OKLAHOMA EARTHQUAKES, 2006

All Oklahoma earthquakes recorded on seismograms from three or more stations are located. In 2006, 20Oklahoma earthquakes were located (Fig. 2; Table 2). One earthquake was reported felt (Table 3). The felt and observed effects of earthquakes generally are given values according to the Modified Mercalli Intensity scale, which assigns a Roman numeral to each of 12 levels described by effects on humans, man-made constructions, or natural features (Table 4).

On April 5, a magnitude 3.0 (mbLg) earthquake (event no. 1837) occurred in Love County about 23 km northwest of Marietta (Tables 2, 3) at 1:46 pm local time. The earthquake was felt in Ardmore (106 felt reports), Lone Grove (16 felt reports). The OGS received one

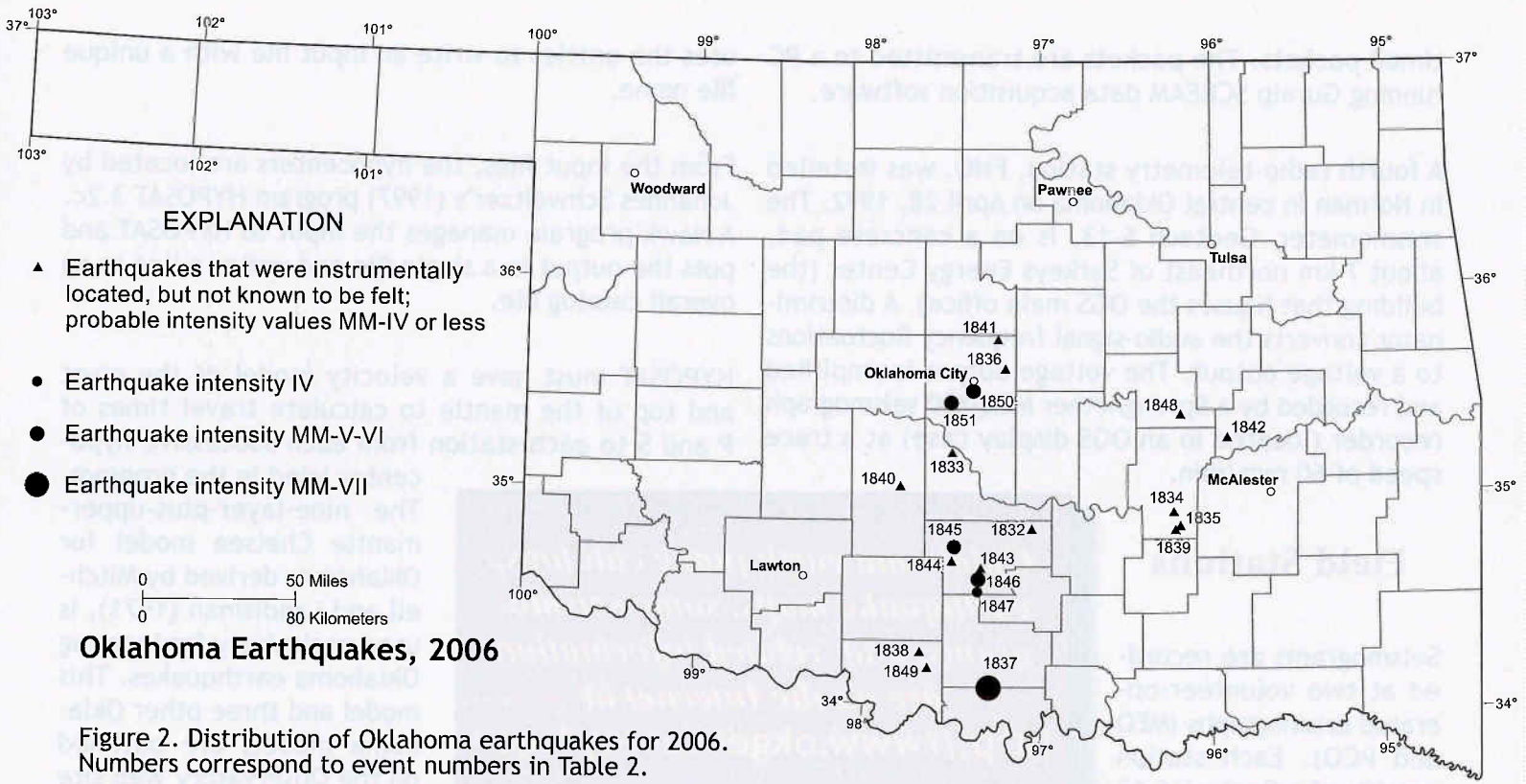

Figure 2. Distribution of Oklahoma earthquakes for 2006. Numbers correspond to event numbers in Table 2.

TABLE 2. — Oklahoma Earthquake Catalog for 2006

Event no.	Date and origin time (UTC)[a]					County	Intensity MM[b]	m3Hz	Magnitudes mbLg	MDUR	Latitude deg (N)	Longitude deg (W)	Depth (km)	
1832	Jan	12	6	37	3.90	Garvin				1.4	34.803	-97.050	5.00R[c]	C[d]
1833	Feb	24	9	28	4.69	McClain				1.6	35.186	-97.500	5.00R	C
1834	Mar	13	22	36	17.99	Hughes				2.2	34.899	-96.211	5.00R	C
1835	Mar	15	8	30	27.11	Hughes				3.0	34.836	-96.178	5.00R	C
1836	Mar	31	3	20	49.43	Oklahoma				2.2	35.597	-97.205	5.00R	C
1837	Apr	5	18	46	23.15	Love	VII		3.0		34.069	-97.314	5.00R	C
1838	Apr	6	5	52	13.87	Jefferson				2.3	34.231	-97.670	5.00R	C
1839	May	13	14	0	48.92	Hughes				2.1	34.826	-96.193	5.00R	C
1840	Jun	19	6	38	54.48	Grady				2.0	35.006	-97.779	5.00R	C
1841	Jul	18	6	39	19.72	Oklahoma				1.3	35.710	-97.236	5.00R	C
1842	Jul	18	23	56	14.96	McIntosh				1.0	35.230	-95.918	5.00R	C
1843	Aug	5	4	15	8.29	Garvin				2.0	34.605	-97.357	5.00R	C
1844	Aug	5	8	49	21.20	Garvin				1.5	34.661	-97.517	5.00R	C
1845	Aug	8	17	56	3.55	Garvin	V			2.2	34.729	-97.490	5.00R	C
1846	Aug	9	9	41	50.94	Garvin	V			2.9	34.589	-97.368	5.00R	C
1847	Aug	16	13	12	39.12	Garvin	IV			2.6	34.508	-97.372	5.00R	C
1848	Nov	2	11	7	3.79	Okfuskee				1.9	35.359	-96.215	5.00R	C
1849	Nov	2	11	12	20.36	Jefferson				2.9	34.153	-97.627	5.00R	C
1850	Dec	21	2	41	14.56	Oklahoma	VI			2.6	35.464	-97.407	5.00R	C
1851	Dec	21	6	14	6.71	Oklahoma	VI			2.7	35.419	-97.499	5.00R	C

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

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

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

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

TABLE 3. — Earthquake Reported Felt in Oklahoma, 2006

Event no.	Date and origin time (UTC)[a]				Nearest City	County	Intensity MM[b]
1837	Apr	5	18 46	23.15	23 km NW of Marietta	Love	VII
1845	Aug	8	17 56	3.55	8 km W of Antioch	Garvin	V
1846	Aug	9	9 41	50.94	9 km SE of Elmore City	Garvin	V
1847	Aug	16	13 12	39.12	12 km S of Elmore City	Garvin	IV
1850	Dec	21	2 41	14.56	Midwest City	Oklahoma	VI
1851	Dec	21	6 14	6.71	Del City	Oklahoma	VI

felt report from Marietta and Davis (Fig. 3). The earthquake was felt over 1,500 km^2; and produced MM-VII effects at one location in Ardmore. The homeowner reported "sounded like the furnace exploded; picked chair up and moved it to the side about one to two inches; very severe movement in my concrete building; can see new cracks in interior and exterior walls". Another felt report from Ardmore stated "sounded like a sonic boom and heard windows rattling; glass breaking; whole house shook". On August 8, a magnitude 2.0 (MDUR) earthquake (event no. 1845) occurred 5 miles west of Antioch, Garvin County. A second felt earthquake (event no. 1846) was located 5 miles southeast of Elmore City, Garvin County (Tables 2, 3). Both earthquakes produced MM-V effects. These earthquakes were felt by people living mostly in Elmore City, Garvin County. In Elmore City, residents reported the earthquakes "sounded like an explosion; thought something hit the house; heard rattling of dishes and windows". On August 16, a magnitude 3.0 (MDUR) earthquake (event no. 1847) occurred 9 miles south of Elmore City, Garvin Gounty (Tables 2, 3). This

April 5, 2006,
Love County Earthquake (Event 1837)
Modified Mercalli Intensity Values

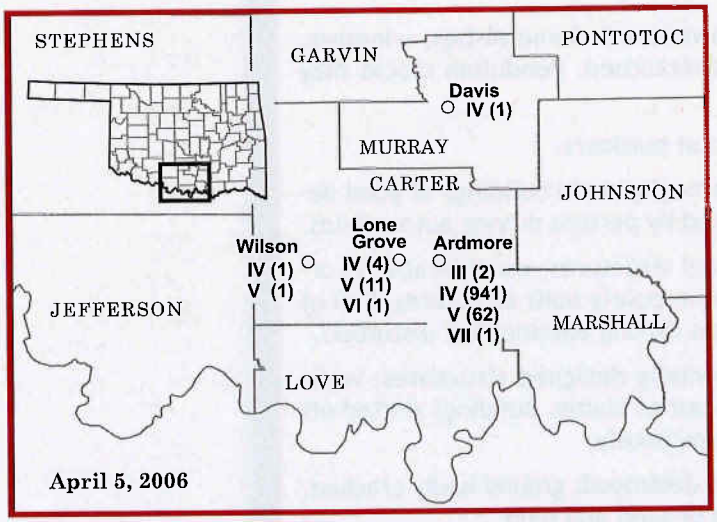

Figure 3. Modified Mecalli (MM) intensity values (Roman numerals) for the April 5 (UTC time) earthquake (event no. 1837) in Love County (Tables 2, 3). Numbers in parentheses indicate the number of felt reports.

December 21, 2006,
Oklahoma County Earthquake (Event 1850)
Modified Mercalli Intensity Values

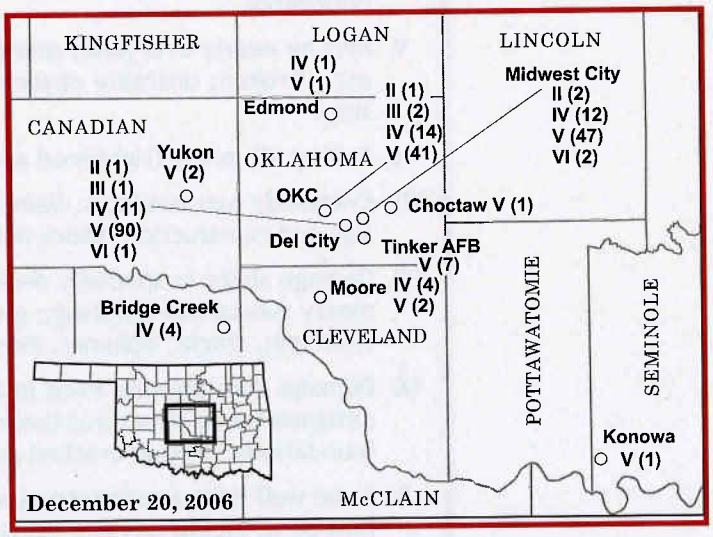

Figure 4. Modified Mecalli (MM) intensity values (Roman numerals) for the December 21 (UTC time; December 20 local time) earthquake (event no. 1850) in Oklahoma County (Tables 2, 3). Numbers in parentheses indicate the number of felt reports.

earthquake produced MM-IV effects. Felt reports from in Elmore City stated "heard loud booming noise like an explosion; and heard the rattling of dishes and windows. These earthquakes probably had felt areas less than 1,000 km^2. On December 20, a magnitude 3.0 (MDUR) earthquake (event no. 1850) occurred near Midwest City at 8:41 pm local time. This earthquake produced MM-V effects. Over 230 felt reports were received from residents in Midwest City, Del City, Oklahoma City, Moore, Bridge Creek, Konawa, Yukon, Mustang, Tinker Air Force Base and Choctaw (Fig. 4). A felt report from Midwest City stated "sounded like the furnace exploded". A felt report from Tinker Air Force Base said "it sounded like a jet exploded". This earthquake was felt over 5,000 km^2. On December 21, a magnitude 3.0 (MDUR) earthquake (event no. 1851) occurred near Del City at 12:14 am local time (Tables 2, 3). This earthquake produced MM-V effects. Over 100 felt reports were received from residents in Midwest City, Del City, Tinker Air Force Base, Norman, and Moore (Fig. 5). The earthquake felt area was over 1,200 km^2. Earthquake felt reports were similar to the December 20 earthquake.

In 2006 earthquake-magnitude values ranged from a low 1.0 (MDUR) in McIntosh (event no. 1842) County to a high of 3.0 (mbLg) in Love County (event no. 1837) and a 3.0 (MDUR) earthquake in Hughes County. Six earthquakes were located in Garvin County in 2006. Counties that experienced multiple earthquakes include Oklahoma, Hughes, and Jefferson.

Table 4. — Modified Mercalli (MM) Earthquake-Intensity Scale (Abridged) (Modified from Wood and Neumann, 1931)

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

December 21, 2006,
Oklahoma County Earthquake Event 1851
Modified Mercalli Intensity Values

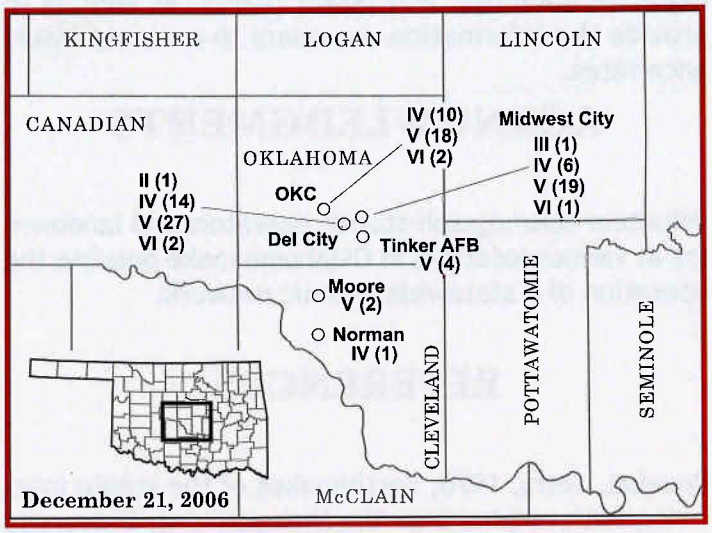

Figure 5. Modified Mecalli (MM) intensity values (Roman numerals) for the December 21 (UTC time) earthquake (event no. 1851) in Oklahoma County (Tables 2, 3). Numbers in parentheses indicate the number of felt reports.

CATALOG

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

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

The dates and times for cataloged earthquakes are given in UTC. UTC refers to Coordinated Universal Time, formerly Greenwich Mean Time. The first two digits refer to the hour on a 24-hour clock. The next two digits refer to the minute, and the remaining digits are the seconds. To convert to local Central Standard Time, subtract six hours.

Earthquake magnitude is a measurement of energy and is based on data from seismograph records. The magnitude of a local earthquake is determined by taking the logarithm (base 10) of the largest ground motion recorded during the arrival of a seismic-wave type and applying a standard correction for distance to the epicenter. An increase of one unit in the magnitude value corresponds to a tenfold increase in the amplitude of the earthquake waves. There are several different scales used to report magnitude. Table 2 has three magnitude scales, which are mbLg (Nuttli), m3Hz (Nuttli), and MDUR (Lawson). Each magnitude scale was established to accommodate specific criteria, such as the distance from the epicenter, as well as the availability of certain seismic data.

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

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

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

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

(epicenter 10-100 km from a seismograph)

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

(epicenter 100-200 km from a seismograph)

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

(epicenter 200-400 km from a seismograph)

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

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

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

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

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

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

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

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

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

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

ACKNOWLEDGMENTS

Volunteer seismograph-station operators and landowners at various locations in Oklahoma make possible the operation of a statewide seismic network.

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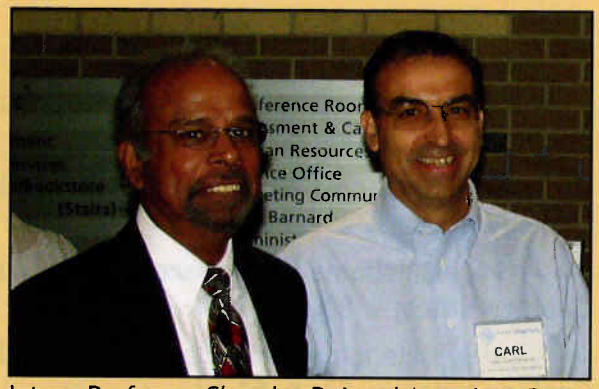
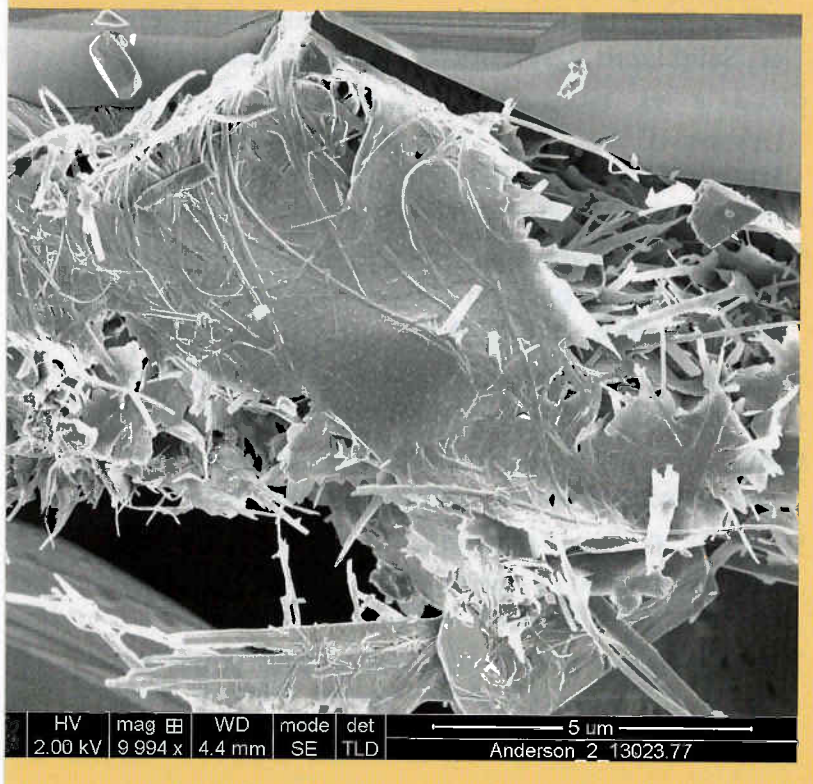
OGS Unconventional Reservoirs Workshop

Carl H. Sondergeld
Associate Dean and Professor
Mewbourne College of Earth and Energy
Mewbourne School of Petroleum and Geological Engineering



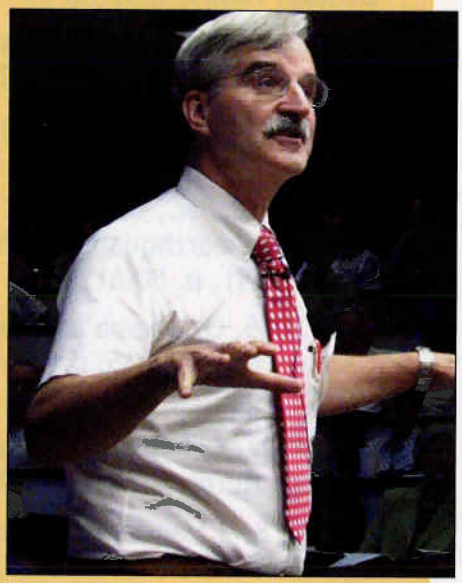
L to r, Professor Chandra Rai and Associate Dean and workshop coordinator Carl Sondergeld. Photos by Sue Britton Crites, OGS.



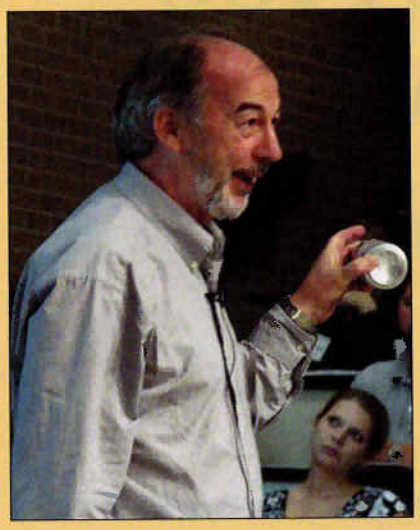
Unconventional reservoirs are becoming increasingly important in the National energy budget for two principal reasons: 1) they contain gas, an environmentally preferred fuel, and 2) conventional resources are on a decline. The largest gas reservoir in the US is a gas shale. A few years ago, shales were seals and more commonly considered problematic.They now are the focus of intense drilling and exploitation. Tight gas sands gained attention when economic incentives helped defray technological costs to economically produce these reservoirs. Both types of unconventional reservoirs exist in Oklahoma.

The objective of this Oklahoma Geological Survey workshop, held on August 20th at the Moore Norman Technology Center, was to share knowledge gained in shale and tight gas sands. The wide spectrum of topics included petrophysical, rock physics, and organic maturity studies, economic evaluation, seismic analysis, NMR log interpretation, perforation design, hydraulic fracturing practice and shale classification schemes. The spectrum of topics provided something for everyone.

Presentations were given by scientists from both the industry and academics. Prof. Chandra Rai (University of Oklahoma) shared detailed petrophysical analyses made on gas shales, describing new techniques to measure porosity. Prof. Kurt Marfurt (University of Oklahoma, shown at below) discussed seismic attributes and then focused on those which seem to correlate with sweet spots in production. John Ely enthusiastically described the success of hydraulic fracturing programs which used slick water. Dr. Ian Watson (above right) de-



August 20, 2009



scribed challenges and ignorance in designing perf in shales. OGS Geologist Brian Cardott (right) gave a detailed overview of the variation in vitrinite reflectivity (kerogen maturity index) throughout the Woodford shale. Dr. Richard Merkel (Newfield) shared his experience in applying NMR logs to understand clay bound water and porosity in tight sands and gas shales. Kent Newsham (Apache) described a process for full cycle evaluation of a tight sand reservoir, the Granite Wash. Dr. Tad Smith (ConocoPhillips, right) convincingly demonstrated the importance of cracks in the analysis of log and seismics in tight sands. Dr. Frank Walles (Devon, bottom right) presented a framework for potential performance classification of gas shales.

This workshop was sponsored jointly by the Oklahoma Geological Society (OGS) and Science Applications International Corporation (SAIC). Michelle Summers along with Sue Crites, Tammie Creel, Laurie Lollis and Jane Weber organized this workshop and are responsible for making it run so smoothly. Over 260 participants attended this one day workshop.

—Special Oklahoma Centennial Series

A Hundred Years Ago in Oklahoma December 1907

Compiled by
Kenneth V. Luza
Oklahoma Geological Survey

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 22,230 in December 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*.**

On December 1, an explosion in United Coal Company's Naomi Mine at Fayette City, Pennsylvania, killed 34 coal miners. This was the beginning of one of the deadliest months for coal-mine fatalities in U.S. history. Monday, December 2, Oklahoma's first legislative session convened in Guthrie's City Hall. On December 5, President Roosevelt order troops from California to Goldfield, Nevada, to protect the gold mines and property of miners and mine owners. An explosion in Consolidated Coal Company's Numbers 6 and 8 mines killed 362 miners on December 6 near Monongah, West Virginia. This was the worst coal-mine disaster in U.S. history. On December 8, natural gas had officially arrived in Oklahoma City. The Great White Fleet (whose ships' hulls were painted white) began its circumnavigation of the world on December 16, 1907, by order of U.S. President Roosevelt. On December 18, Governor Haskell signed Senate Bill No. 1, which mandated separate coaches and waiting rooms with equal conveniences by railroad companies for whites and blacks. Two hun-

West Main Street in Oklahoma City where many of the department stores were located; Mellon's Department store on the right. *Photograph courtesy of the Oklahoma Historical Society.*

dred thirty-nine coal miners died in an explosion near Van Meter, Pennsylvania, on December 19. On December 20, the University of Oklahoma's Administration building was destroyed by fire. The U.S. Army issued their requirements for heavier-than-air flying machines on December 23. Governor Haskell was prepared to send troops to Henryetta if a race war between Negroes and whites occurred.

Sunday, December 1, 1907, p. 1

150,000 CLUB IS TO LAUNCH ITS CAMPAIGN

EVERY CITIZEN WILL BE ASKED TO TAKE ACTIVE PART IN BOOSTING

After many vexatious delays and months of preparation, the Oklahoma City 150,000 Club has been duly launched and will start tomorrow morning, on its mission of development and progress.

The headquarters of the organization is in the Chamber of Commerce rooms, where it will occupy part of their well equipped offices. The first work to be done is enrolling members, upon which depends the degree of usefulness the club will attain. The primary objects of the 150,000 Club are patriotism, civic improvement, advertising, industrial development,

and patronage of home institutions. Investigation has proven that there are many people now in Oklahoma City, not mentioning the hundreds coming in every day, who are almost totally ignorant of the city's resources and its standing as compared with other cities of the state and southwest.

December 1, 1907, p. 1

OKLAHOMA'S FIRST LEGISLATURE CONVENES TOMORROW

HOME OF CONSTITUTIONAL CONVENTION AGAIN MADE THE ARENA OF INTEREST

Guthrie, Okla., November 30.—In that historic chamber of Guthrie's City Hall where recently the fundamental law of the forty-sixth commonwealth was drafted and promulgated, Monday at high noon the first legislative assembly of the state of Oklahoma will convene. Each house will report to the other and announcement of its election and joint report announcing the complete organization of the entire body will be submitted to the governor.

Overholser Opera House, ca. 1907. *Photograph courtesy of the Oklahoma Historical Society.*

December 1, 1907, p. 1

ENTOMBED IN DEEP MINE AS FIRE RAGES

Dry Town, Cal., November 30.—Eleven miners in the Fremont Governor Gold mine are shut off from the surface by a severe fire which is raging at the 1,100-foot level, and all hope of rescuing them alive has been abandoned. The miners were working below the 1,100-foot level.

December 1, 1907, p. 3

LARGEST WELL IN GAS FIELD

Muskogee, Okla., November 30.—A gas well producing 3,000,000 cubic feet of gas every day has been brought-in the oil fields two miles southwest of Muskogee. This is the first gas well of importance that has ever been brought-in in the Muskogee Field, though there has been drilling for oil going on for more than three years. The absence of a heavy gas pressure was one of the notable features of the field, for in most oil fields when a dry well is brought-in, it is almost sure to be a gaser. The discovery of large quantities of gas is important to Muskogee. At present the natural gas supply of the town is piped from the Romona Field, 60 miles away.

December 1, 1907, p. 4

CHRISTMAS TOYS DISPLAYED IN WINDOWS OF THE SHOPS

Christmas is coming. Toys of every character for the tiny tads, for the bigger tads, and gifts for the grown-ups have already made their appearance in the display windows of the stores of the city to feast the eyes of the shoppers, and to make the children of means happy in the expectations of receiving a visit from good old Kris Kringle. Cheap toys and costly toys, Teddy bears and Teddy bear cubs, monkeys, dolls of every size and nationality, dolls that will "go to sleep" for the little mother, china dolls, autos and fire wagons, all piled in confusion with the playhouse effect, are on display.

December 1, 1907, p. 12

SENATORS OF INDIAN BLOOD TAKE DIFFERENT VIEWS ON REMOVAL OF RESTRICTIONS

Muskogee, Okla., November 30.—In Congress this winter there will be two United States Senators of Indian blood, and while they both own Indian allotments in Oklahoma, they will take opposite and radical views upon the greatest Indian question now before congress so far as the Indians of the five civilized tribes are concerned. They are Senator Charles Curtis, of Kansas, a Kaw Indian who has an allotment in the Kaw Reseva-tion, and Senator Robert L. Owen of Oklahoma, who has Cherokee blood and a Cherokee allotment in the oil lands of that Nation. The former will reverse his position of a year ago when he favored the removal of restrictions from Indian lands and this year will bitterly oppose their removal. Senator Owen has pledged to his constituents that he will remove the restrictions form Indian lands, or never again ask for re-election.

December 1, 1907, p. 23

VOLCANIC ASH COVER SNOWY REGIONS

Portland, Ore., November 30.—A special cable to the Oregonian from Nome, Alaska, says:

Nome and probably the entire Seward Peninsula are shrouded in an ashy haze and the ground for miles around is covered with a fine gritty powder, which is believed to be volcanic ash. The storm began several days ago, the dust blowing in from the ocean but at first little attention was paid to the freak of nature, as it was expected that it would soon cease. Instead, however, the fall continued and after a day, it became so dense as to seriously interfere with out-of-door pursuits. Miners coming into town reported that for miles the snow was so impregnated

with ash that sledding was almost impossible. The air is so full of ash that breathing is difficult and the fine powder was sifted in houses and business places to such an extent that it is thick on floors and in everything in the way of goods and household furniture.

Tuesday, December 3, 1907, p. 1

OPENS LEGISLATURE WITH IMPRESSIVE CEREMONIES

SOLONS DEVOTE FIRST DAY TO WORK OF ORGANIZATION; RECEIVE MESSAGE AT NIGHT

Guthrie, Okla., December 2.—In the presence of the senate and house of representatives, sitting tonight in joint session in the City Hall, Governor C. H. Haskell delivered his first message. The governor read slowly and distinctly, giving emphasis to the most important recommendations. The reading was attended closely and with marked interest by the legislators and hundreds of spectators who filled the galleries, halls, and windows.

Speaker Murray presided over the session and President pro-tem Johnston, the democratic house and senate leaders, and other prominent men, occupied conspicuous places.

December 3, 1907, p. 5

HUNTERS RETURN; CAPTURE A BEAR

MUSKOGEE PARTY, BE-

University of Oklahoma women's basketball team, ca. 1905. *Photograph courtesy of the Western History Collections, University of Oklahoma.*

LIEVED TO BE LOST IN MOUNTAINS, RETURNS UNHARMED

Muskogee, Okla., December 2.—President Roosevelt and John Abernathy will have to lay down their laurels. Charley Kimsey, Muskogee's Chief of Police and L. E. Pratt, City Councilman, have killed one bear and captured another alive. The hunting part composed of Kimsey, Pratt, and their wives, believed to have been lost in the mountains of the Choctaw Nation and for whom a searching party was organize, have turned up with a record showing for game killed. This kept them in the mountains so long that the city council threatened to remove Kimsey from office. Friends became alarmed and started to look for them when a long distance telephone message revealed their location and today they arrived in Muskogee.

December 3, 1907, p. 10

COULD GET GAS WITHIN 10 HOURS

WORKMEN NOW ENGAGED IN LAYING PIPES WITHIN THE CITY LIMITS

Workmen are now engaged in laying natural gas pipe from Sixteenth Street to the Rock Island tracks on Central Avenue. With this and the connecting of the line with the city mains at Noble Street, near where the artificial gas plant is now situated, natural gas will be read to be turned into the mains of the city. All of this is in the hands of Oklahoma Gas & Electric Company as the Oklahoma Natural Gas Company has its line completed, with the gas turned in, at Twenty-Third Street.

Wednesday, December 4, 1907, p. 1

RACE SEPARATION IN OKLAHOMA PROVIDED IN FIRST BILLS PRESENTED

STATE LEGISLATURE STARTS TO MOLD JIM CROW LAWS

Guthrie, Okla., December 3.—Taking advantage of the first opportunity to redeem pledges made during the campaign to the Oklahoma legislature already has begun the making of a Jim Crow law for the new state. Many democratic delegates to the constitutional convention were elected upon this platform and the convention was overawed by the attitude of the 'Big Stick' so that it was eliminated as a provision of the constitution. Democrats promised the Jim Crow Law during the state election and now they are keeping their promise to the people.

Jim Crow measures were first to be introduced in both houses today. Senator Graham presented the senate bill and Representative Skeen had the honor in the house. Both measures provide that separate coaches and waiting rooms with equal conveniences shall be provided by railroad companies for whites and blacks. Conspicuous signs are to be placed in such rooms and it shall be unlawful for persons of one race to occupy the waiting room of the other race.

December 4, 1907, p. 11

WILL NOT DISCHARGE RECEIVER FOR OIL CO.

U. S. CIRCUIT COURT OF APPEALS REVERSES DECISION OF LOWER COURT

New Orleans, December 3.—The United States Circuit Court of Appeals, sitting here today, handed down a decision reversing the decision of the United States Circuit Court at Sherman, Texas, in the matter of the State of Texas against Bradley W. Palmer et. al., commonly known as the Waters-Pierce Oil Company ouster case, gave the Texas state courts jurisdiction in the matter.

Friday, December 6, 1907, p. 1

SOLDIERS ARE ORDERED TO PROTECT MINES

ROOSEVELT TAKES HAND—TROOPS GOING TO GOLDFIELD

Washington, December 5.—President Roosevelt tonight instructed General Funston to dispatch a sufficient force of regulars to Goldfield, Nevada, to control the situation there. This action was taken upon receipt of a telegraphic request from the governor of Nevada. The troops will proceed from San Francisco and the strength of the expedition is left to the judgment of General Funston. Goldfield is about fourteen hours by rail from San Francisco.

Carson City, Nev., December 5.—Governor Sparks confirmed the report that he has asked the government for military support to hold the situation in hand both for the protection of the mines and property of miners and mine owners of the camp.

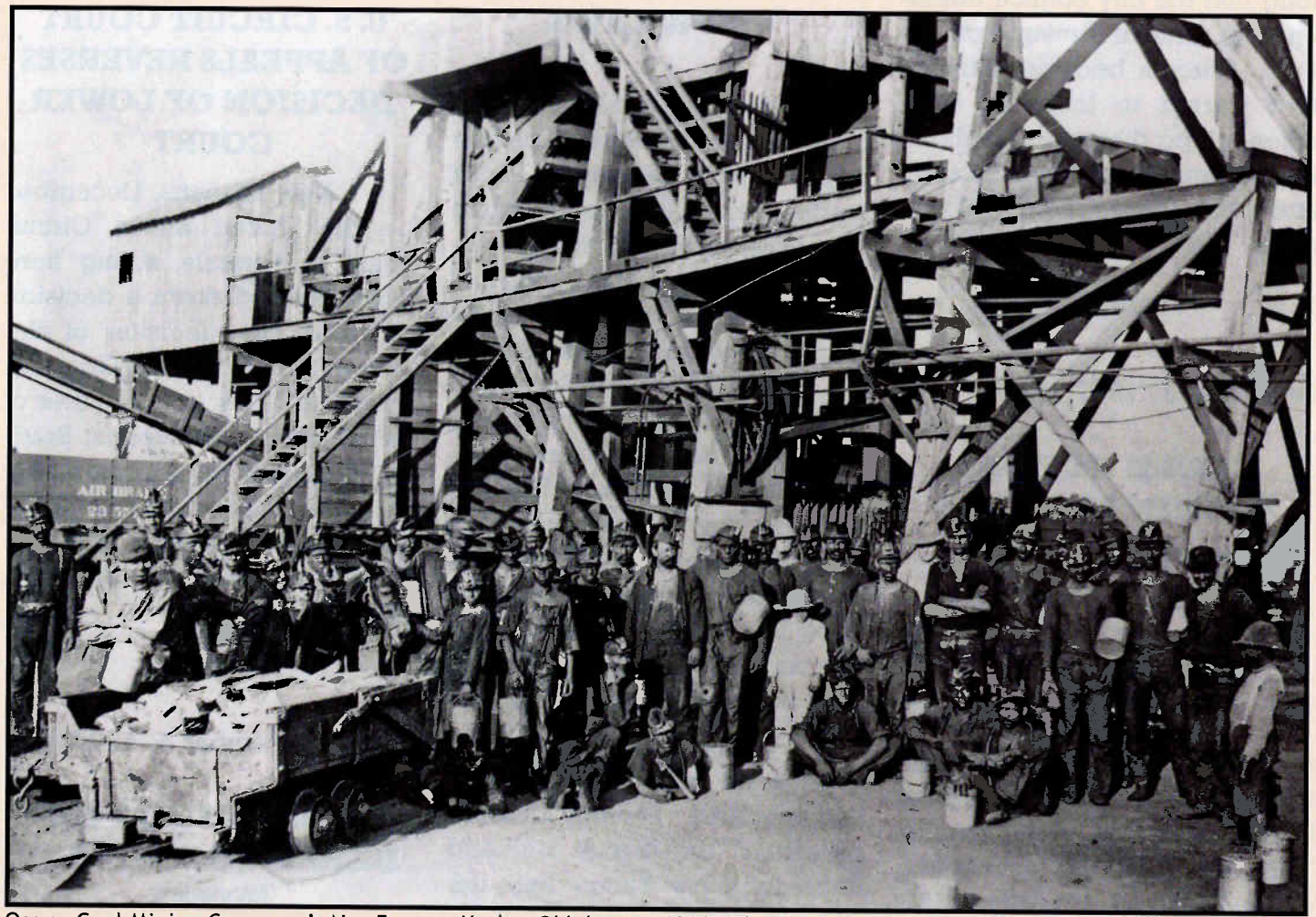
December 6, 1907, p. 1

COUNCIL TO ACT; WILL NOT FALTER

COMMISSION FORM IS STRONGLY FAVORED

MAYOR WILL INSIST UPON A MASS MEETING OF THE PEOPLE

"I am strictly in favor of municipal government by commission in Oklahoma City, and shall endeavor to have some action taken upon the question at the next meeting of the council," says Councilman Helm. "While



Osage Coal Mining Company's No. 5, near Krebs, Oklahoma, 1900. *Photograph courtesy of the Western History Collections, University of Oklahoma.*

I have not taken the matter up with any of the other members I understand that there will be some opposition to the matter when presented. I believe it is a good thing for the city and that the people want it."

"I will insist that a general mass meeting of the people be called to discuss the proposed from of government," says Mayor Scales. "I am personally in favor of it, but have not consulted with other members of the council. I desire a discussion of the measure from participants wholly outside of the council and of 50 members of the committee appointed by the Chamber of Commerce. I want to reach the general voice of the people."

December 6, 1907, p. 6

HARVESTER CO. CONVICTED ON TRUST CHARGE

Topeka, Kans., December 5.—After being out an hour the jury in the case of the state against the International Harvester Company this afternoon returned a verdict against the company on 42 counts. This decision practically charges the company with being a trust and entering into an unlawful combination to control the price of harvesting machinery and to force dealers to handle its products exclusively. The original suit was on 75 counts.

Saturday, December 7, 1907, p. 1

GREATEST LIFE LOSS HORROR IN THE HISTORY OF MINING IN AMERICA

500 DEAD IN MINE

VICTIMS BURIED BENEATH TONS OF DEBRIS

Monongah, W. Va., December 6.—Three charred bodies lying in the improvised morgue, four badly injured men, and 493 men imprisoned by tons of coal, rocks, and mine debris in the depths of the hills surrounding this mining town, with the chances all against a single one of them being alive, is the most accurate summary obtainable tonight of the results of a mine explosion today which in all probability was attended by greater loss of life than any former disaster in the history of the bituminous coal mining industry of America.

The explosion occurred shortly after 10 o'clock today, after the full force of 500 men had gone to work in the two mines affected. These mines are Numbers 6 and 8 of the Consolidated Coal Company, located on opposite sides of the west fork of the river, at this place, but merged in their underground workings by a heading and on the surface by a great steel tipple and bridge. There is much speculation as to the cause of the explosion, but the most generally accepted theory is that it resulted from black damp, scientifically known as methane.

The explosion in Consolidated Coal Company's Numbers 6 and 8 Mines killed 362 coal miners, the worst mining disaster in American history (Humphrey, 1960). A statue was erected in 2007 in Monongah to honor the widows of the 1907 mining accident and to coal miners' widows everywhere (Wikipedia, 2008a).

December 7, 1907, p. 1

TO SHOOT GAS AT 8 O'CLOCK THIS EVENING

ARRIVAL OF NATURAL PRODUCT TO BE THE OCCASION OF CELEBRATION

Natural gas is here. The arrival of cheap fuel will be celebrated by the 150,000 Club at 8 o'clock this evening at Tenth and Central. Mayor Scales will shoot a rocket into the gas main. Flames will leap many feet high. Hundreds of persons, including members of the 150,000 Club will witness the exhibition. A general invitation to the public has been issued. Beginning with December 25, a full supply of gas will be distributed, connections being made in the meantime.

December 7, 1907, p. 1

AWFUL CRISIS BELIEVED

PEOPLE OF GOLDFIELD FEAR CLASH WHEN TROOPS COME

Goldfield, Nev., December 6.—The people of Goldfield are in a state of terror tonight. The town is quiet, but the feeling of unrest that has been apparent since the announcement was made that government troops would be sent here, is growing more pronounced. Officials of the mine workers' union assert that there is no occasion for alarm, but the fact that the governor had declared in his communications to President Roosevelt that he fears an awful calamity has led the people to believe that he is in possession of secret information of some terrible nature.

That there will be a clash between the troops and the miners and that large stores of dynamite have been secreted, to be used in destroying whole companies of the soldiery in a single explosion, is declared by some of the authorities to be the program. Not an iota of information to substantiate this rumor is obtainable nowhere.

Road work, early 1900s. *Photograph courtesy of the Western History Collections, University of Oklahoma.*

December 7, 1907, p. 2

UNION LABOR FORMS PROPOSED MINE LAW

Guthrie, Okla., December 6.—The first step in legislation taken by the organized labor forces of the state was the compiling of Senate Bill No. 25 introduced by Senator Redwine of Pittsburg County, covering the subjects of mines and mining as endorsed by the Chief Mine Inspector and legislative committee of the State Federation of Labor.

December 7, 1907, p. 4

PERMIT GRANTED FOR GAS PLANT

FACTORY BUILDING WILL BE ERECTED AT A COST OF $10,000

Excavation for the Pintsch Gas Plant, which is being erected at Riverside and Mead Streets, east of the city, has been finished. The material is on the ground for the construction and a building permit was taken out last evening.

Kennedy and Hobson, contractors, say the work will be finished by January 10, and their contract calls for its completion not later than January 25.

December 7, 1907, p. 6

OIL MEN PLAN DEFEAT FOR NATIONAL ADMINISTRATION

Tulsa, Okla., December 6.—Fifteen directors of the Mid-Continent Oil and Gas Producers' Association in session here today appointed a committee of five to confer with Secretary of Interior Garfield in regard to rules and regulations governing the leasing of Indian lands, named three oil men and an attorney to lobby in the state legislature for laws conserving their interests, and while they did not give it out for publication it is understood that plans for an organization, with a big bunch of money back of it, were made to support almost anyone hostile to the present national administration.

Sunday, December 8, 1907, p. 1

5,000 PERSONS WITNESS NATURAL GAS SHOOTING

LOUD ROAR PRECEDES FLAMES

In the presence of 5,000 persons composed of prominent citizens, city officials, officers of the Oklahoma Natural Gas Company and the Oklahoma Gas and Electric Company, and members of the 150,000 Club and town boosters at Tenth Street and Central Avenue, gas bursting from a 30-foot pipe with a pressure of 220 pounds was fired at 8:15 o'clock last night.

When a burning bit of waste was thrown into the air by W. L. Tull, chairman of the advertising committee of the 150,000 Club, igniting the volumes of escaping gas, the roar of the blaze was only equaled by the cheers from the throats of the thousands of spectators.

December 8, 1907, p. 1

EARLY BUYING ON LARGE SCALE

TRADE IS GREATEST IN THE HISTORY OF CITY

Their windows aglow with myriads of electric lights, bedecked from head to top most floor in holiday drapings, Oklahoma City's retail stores last night were filled almost to their capacity with a busy, enthusiastic happy crowd—a crowd with one purpose in view. The ragamuffin and the petted child of riches met on common plane. Affluent businessman and common laborer did not shrink one from the other.

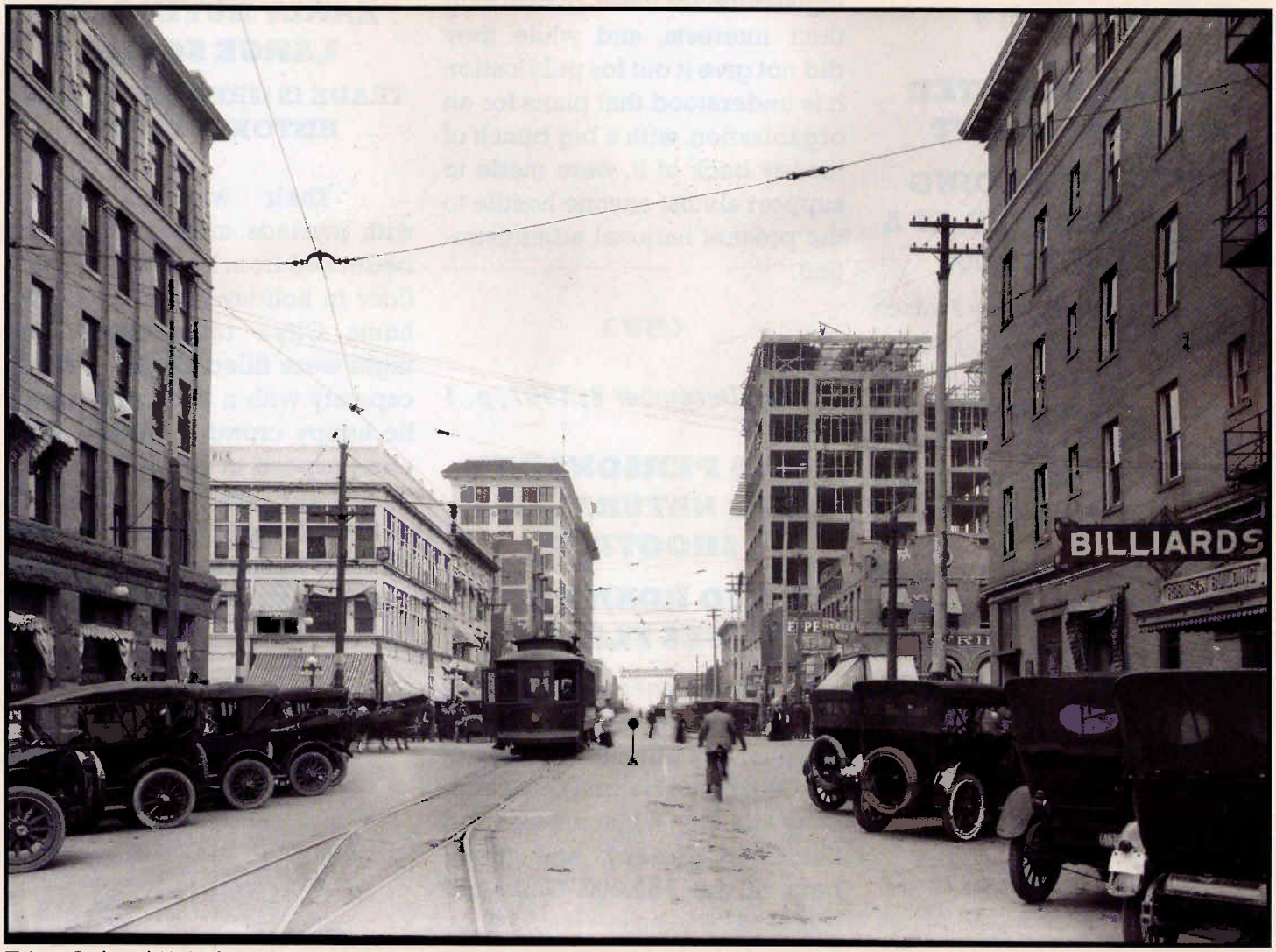
December 8, 1907, p. 1

SEEK TO DEEPEN ARKANSAS RIVER

LEGISLATURE WILL MEMORIALIZE CONGRESS FOR APPROPRIATION

Guthrie, Okla., December 7.—In compliance with a request made by the Trans-Mississippi Congress, during its recent session in Muskogee, the state legislature, next week, will adopt resolutions petitioning Congress to make an appropriation sufficiently large to cover the cost of preparing the Arkansas River for navigation as far into Oklahoma as practicable.

Almost 40 years later, Congress passed the Rivers and Harbors Act authorizing the building of the 450-mile long Arkansas-Verdigris Waterway. Junior Senator Robert S. Kerr, Oklahoma, and Senator John L. McClellan, Arkansas, were instrumental in securing funds to build the waterway. This process took a number of years; and on October 4, 1968, navigation was open to Little Rock. On January 3, 1971 the first commercial barge entered the Port of Muskogee. President Richard M. Nixon was the keynote speaker for the dedication of the McClellan-Kerr Arkansas River Navigation System at the Port of Catoosa on June 5, 1971 (The Encyclopedia of Arkansas History



Tulsa, 3rd and Main Street, ca. 1910. *Photograph courtesy of the Oklahoma Historical Society.*

and Culture, 2007).

December 8, 1907, p. 20

PRECAUTION IS NECESSARY; NATURAL GAS GREAT THING

Fire Chief Kesler issues warning to those contemplating the use of natural gas and lays down several rules which he claims will, if compied with, save both houses and lives from destruction.

"Not a gas pipe in this city has undergone a test or inspection," says Chief Kesler. "This is one of the first things that should be looked after, now that natural gas is to be turned into the pipes. I recommend, first of all, the appointment of a competent gas man to make tests and inspections. Every pipe now laid and to be laid should be examined, as there is nothing more dangerous in the use of natural gas than to permit a leak to exist."

Tuesday, December 10, 1907, p. 1

MINE OWNERS WILL EMPLOY NON-UNIONISTS

GOLDFIELD TO HAVE COLORADO CARD SYSTEM—TROUBLE FEARED ANY TIME

Goldfield, Nev., December 9.—The mines of Goldfield are to be re-opened on Thursday next. The wage scale is to be reduced. No member of the Western Federation will be given employment. Men will be brought here to the number of 500 to take the places of the strikers, meanwhile.

Such is the decision of the executive committee of the Mine Owners' Association today. The change from Wednesday to Thursday was made to allow time to get men from other points to replace strikers. Governor Sparks will come to Goldfield on Thursday. The troops now here are scattered throughout the camp; and will guard the mines. The card system, as used at Cripple Creek, will be introduced. Frank A. Keith, general manager of the Tonopah Mine Company, and other prominent mining men from other camps are here in consultation with the Goldfield owners.

December 10, 1907, p. 3

WILL GIVE OKLAHOMA CITY THE ONLY JUVENILE JUDGE

WOMAN'S CLUBS PREPARE MEASURE TO KEEP YOUNG FOLKS ON STRAIGHT PATH

Guthrie, Okla., December 9.—The legislative committee of the Federation of Women's Clubs of Oklahoma has prepared a charities measure for introduction before the legislature which provides for the care and custody of delinquent and dependent children and the measure will be introduced in the house by Representative Riddle of Chickasha. It was drafted by Mrs. E. F. Riddle of Chickasha, president of the federation legislative committee, and has been examined and endorsed by Miss Kate Barnard, State Commissioner of Charities.

Wednesday, December 11, 1907, p. 1

PHILANTHROPIST AIDS ENDOWMENT

GIVES $2,000,000 TO CARNEGIE INSTITUTE

Washington, D. C., December 10.—Andrew Carnegie has added $2,000,000 to the $10,000,000 endowment fund of the Carnegie Institute. Announcement of the fact was made at a dinner tonight at the New Willard by the board of trustees of the institute, which invited a number of scientists and men prominent in public affairs.

December 11, 1907, p. 3

FIRST FAIR CLEARS $4,000;

WILL ELECT NEW OFFICERS

Oklahoma's first State Fair netted $4,064.16 to the stockholders. The receipts were $41,068.49 and the disbursements $37,004.33. A meeting of the directors will be held at 10 o'clock tomorrow morning, when officers will be elected.

Thursday, December 12, 1907, p. 6

MINE OPERATORS' SCHEME CHANGES

MARTIAL LAW NOT DECLARED IN GOLDFIELD—ONE MINE OPENS TODAY

Goldfield, Nev., December 11.—President Roosevelt's communication from Washington to Colonel Alfred Reynolds, in command of the federal troops at Goldfield which was posted in conspicuous places throughout the city this afternoon by direction of the president, puts a different complexion on the situation here.

This coupled with the fact that General Funston is to arrive in Goldfield tomorrow to view the situation and report to Washington, caused a complete change in the program of the mine operators, who had hoped to be able through Governor Sparks, to have martial law declared in Goldfield tonight, and to re-open the mines tomorrow under the active protection of the United States troops.

December 12, 1907, p. 9

NATURAL GAS TO BRING FACTORIES

CHAMBER OF COMMERCE SECRETARY RECEIVES MANY LETTERS FROM OUTSIDE

Manufacturers, with the promise of natural gas as cheap fuel, are already swamping Secretary McKeand of the Chamber of Commerce with correspondence relating to the opportunity of the establishment of factories in this city. "The field is especially attractive to glass factories as we have a fine quality of glass sand in this section that has never been worked to any extent."

December 12, 1907, p. 10

COWBOYS GATHER TO ROPE STEERS

ROPING CONTEST OPENS IN SULPHUR TODAY—COWBOYS ALREADY ARRIVING

Sulphur, Okla., December 11.—Crowds are gathering in Sulphur to witness the roping contest to be held December 12, 13, and 14. Many expert ropers from the big ranches in Oklahoma, Texas, and New Mexico arrived yesterday and today. Others have wired that they will be here on time. Texas Bud and his bunch of cowboys have pitched their tents and have everything in readiness. Matt Wolf, a banker and ranchman of Davis, will furnish the steers.

Friday, December 13, 1907, p. 2

ACTIVITY BEGUN BY COAL THIEVES

COLD WEATHER GIVES OCCASION FOR CLOSE WATCH BY RAILROAD OFFICERS

Cold weather has increased the activity of coal thieves in the railroad yards of the city. It is estimated by special officers of the railroad companies that thousands of pounds of coal are stolen from the cars every day.

Close watch is kept night and day by the special officers to prevent the thefts, but the uncertainty of the thief's mode of removing the fuel proves a baffling condition for the officers to face. The general plan of action, however, of the thief is to crawl upon the cars in the early hours of the morning while they are being switched about and made into trains. The coal is rolled off on the right-of-way, and later in the day, the thief, apparently an innocent coal picker, appears and sacks up the fruits of his early morning labor.

Saturday, December 14, 1907, p. 1

OVERHOLSER THEATER IS TO BE CLOSED UNLESS LAW IS OBEYED

CITY'S EXECUTIVE WILL EXAMINE INTO THEATER ORDINANCE AND WILL THEN GIVE QUICK INSTRUCTIONS

Unless the proprietors of the Overholser Opera House properly equip the theater with fire escapes, it will be closed, if the city finds it within its power to close it. Mayor Scales will issue an order to Building Commissioner Van Meter this morning, calling upon him to deliver the city's ultimatum to Ed Overholser, manager of the theater.

"If I find that there exists an ordinance aimed specifically at the safe guarding of theater patrons upon the city's statutes as has been represented to me this evening, I will instruct Building Commissioner Van Meter to give the owners of the Overholser Opera House final notice to comply" said Mayor Scales last night.

December 14, 1907, p. 8

$80,000 PAID FOR OIL WELL

W. P. BOWLES PURCHASES INTEREST OF T. H. BASS IN GLENN POOL DISTRICT

Tulsa, Okla., December 13.—One of the biggest deals in oil property made in months in the oil fields of the new state was consummated when W. P. Bowles purchased the interest of T. H. Bass in Glenn Pool. The price paid was $80,000. There are 13 producing wells on this tract of land. Both Bowles and Bass made their fortunes in lucky oil strikes in Beaumont, Texas.

Horse-drawn fire equipment in Oklahoma City. *Photograph courtesy of the Oklahoma Historical Society.*

Sunday, December 15, 1907, p. 1

FIERCE STORM HAS LITTLE EFFECT UPON GIGANTIC SEA WARRIORS

BATTLESHIPS START 'ROUND HORN TOMORROW

MAGNITUDE OF UNDERTAKING OUTRIVALS ALL NAVAL HISTORY—

"TRAINING TO MEET EVERY EMERGENCY IN TIME OF WAR"

Norfolk, Va., December 14.—With coaling and loading of stores of every description complete and with everything in readiness for next Monday morning on their voyage to the Pacific coast, the severe southeast storm which struck the coast, lasting throughout the night and continuing with great intensity during today, had little effect upon the great battleships of the Pacific-bound Atlantic fleet, as they rode safely at anchor through the gale in Hampton Roads except that the choppy seas in a wind of 22 miles an hour made it difficult and at times most uncomfortable for the small launches passing between the fleet and shore and from ship to ship.

Sunday will be a day of farewell greetings at Old Point Comfort. The families of many

Second Administration Building, University of Oklahoma. *Photograph courtesy of the Western History Collections, University of Oklahoma.*

of the officers who go out in the fleet are there and the last visit ashore by the officers will be made Sunday night.

The signal to get under way will be flown from the towering yards of the flagship *Connecticut* shortly before 10 o'clock Monday morning and under the eye of the president, the ships will pass outside the Virginia capes, turn their bows to the south and their course through the eastern end of the West Indies to Trinidad.

December 15, 1907, p. 1

"KU KLUX KLAN" IN CLEVELAND COUNTY" THREATEN MURDER IF BLACKS DO NOT LEAVE

NORMAN PROPERTY OWNER ADVISE NEGROES TO ARM THEMSELVES AND FIGHT WHITE ENEMIES

Norman, Okla., December 14.—Threatening murder if they did not leave, members of a Ku Klux Clan, who style themselves "committy," are causing consternation among a colony of Negroes, 13 miles northeast of Norman on a 220-acre ranch owned by J. C. Dowd and T. C. Cook, of Norman. The Negroes are arming themselves in anticipation of a night attack by whites.

Notices signed by the mysterious "committy" have been posted on the Negro cabins and repeatedly left in their mail boxes. They say that the Negroes will be given until December 28 to gather their crop and leave the country. After that war will be declared.

"It's the work of white farmers we formerly had on the ranch," says J. C. Dowd, one of the land owners. "They want to run them out of the country."

"I have advised the Negroes to arm themselves and repel with force any attempt made to dislodge them from the land. The Negroes are not scared and will not leave. Four more families in addition to the ones now on the land will arrive January 1. We have offered a reward of $100 for the senders of the mysterious notes."

"No attention will be paid to the warning," said Dowd. "The Negroes will stay. We will teach the rowdy whites that they cannot terrorize peaceful citizens without getting in trouble."

December 15, 1907, p. 1

STATE SOCIETY TO BE FORMED; MANY TO COME

HUMANE ORGANIZATION TO BE LAUNCHED IN OKLAHOMA CITY TOMORROW

To organize a State Association of the Humane Societies of Oklahoma and to discuss measures for proposed legislation measures by the state legislature, members of various humane societies of the state and friends of the cause will gather in Oklahoma City tomorrow. The call for the meeting was issued by President A. J. Vance of the Oklahoma City Humane Society.

December 17, 1907, p. 1

DEEP ROAR OF CANNON BIDS ADIEU

PRESIDENT REVIEWS FLEET AS IT BEGINS WORLD FAMOUS TRIP

Old Point Comfort, December 16.—Sixteen hard-hitting, steel-belted American battleships, gun-bristling, and burly of birth, but sparkling white in their immaculate dressings of peace, sailed away today under the dazzling sun of a cloudless winter sky on their famous expedition of 11,000 miles. President Roosevelt on the bridge of his cruiser-yacht, *Mayflower*, personally led the magnificent four-mile line of fighting vessels during the first stage of the voyage. From the anchorage ground in Hampton Roads to the Horseshoe Bend of Chesapeake Bay, his eagle-crested flag of blue pointed the way to the fleet's new home at the Golden Gate.

The Great White Fleet

(whose ships' hulls were painted white) began its circumnavigation of the world on December 16, 1907, by order of U.S. President Roosevelt. Roosevelt wished to demonstrate to the country and the world that the U.S. Navy was capable of operating globally, especially in the Pacific. The fleet travel around South America to San Francisco and then to Honolulu, Guam, Manila, Singapore, Colombo, Suez, Naples, Gibraltar, the Azores, and finally back to the United States, arriving on February 22, 1909. The fleet covered more than 43,000 miles and made twenty port o'calls on six continents (Wikipedia, 2008b).

Wednesday, December 18, 1907, p. 1

BRINGS SCHOOL MONEY HERE

STATE TREASURER STARTS AFTER OKLAHOMA'S FIVE MILLION

Guthrie, Okla., December 17.—At 3:12 p. m. today Governor Haskell penned his signature to the first bill passed by the first legislature of the state of Oklahoma. It was that providing for the transfer of $500,000 of the state's school fund now in the hands of the United States Treasurer. State Treasurer Menefee left tonight for St. Louis to secure the money from the United States sub-treasury. In case of his failure to get it there, he will go to Washington. In any event, Oklahoma will have the money by the first part of next week.

December 18, 1907, p. 2

WIRES DOWN AND GOLDFIELD IS IN A STATE OF TERROR

Goldfield, Nev., December 17.—Goldfield is greatly alarmed tonight over the fact that the feed wires of the Nevada California Power Company are down and the company has been unable to find the break or determine the cause of it. General Funston has cancelled his order for berths for himself and staff on the train and will remain in Goldfield indefinitely.

December 18, 1907, p. 8

WOMEN PLEDGE TO SHOP SOON

MUSKOGEE WOMAN'S HOME MISSION SOCIETY STARTS NOVEL SHOPPING PLAN

Muskogee, Okla., December 17.—Pledging themselves to do their Christmas shopping before December 20, the Woman's Home Mission Society of the First Methodist Church, south, have started a movement to relieve the strain and worry of the last few days before Christmas from clerks and shop girls. An effort will be made to have the women of other churches take similar action and leave the stores to country visitors during the last four days.

December 19, 1907, p. 1

JIM CROW LAW PASSES

Guthrie, Okla., December 18.—At 9:30 tonight Governor Haskell signed the Jim Crow bill. Senator Graham, author of the bill, was present, being especially designated by Lieutenant Governor Bellamy to accompany the senate committee that carried the bill and was presented with the pen the governor used.

December 19, 1907, p. 8

LOCAL TEACHERS WILL SEE WELLS

TULSA WILL HOLD OIL FIELD TRAIN FOR OKLAHOMA CITY

Ample accommodations will be provided for all visiting teachers at the meeting of the State Association which will be held in Tulsa next Thursday and Friday, and the train to Glenn Pool oil wells will be held for the Oklahoma City teachers according to a telegram received by Superintendent J. B. Taylor of the city schools from J. G. Masters, superintendent of Tulsa.

Much concern has been

University of Oklahoma's second Administration Building destroyed by fire on December 20, 1907. *Photograph courtesy of the Photograph courtesy of the Western History Collections, University of Oklahoma.*

evidenced by the Oklahoma City teachers in regard to the probability of their not being able to arrive in time to accompany the party to the oil wells Thursday afternoon, which is to be the first entertaining feature of the meeting.

December 20, 1907, p. 3

DISCOVER NEW WELL

SOUTH OF MANNFORD

Tulsa, Okla., December 19.—At a depth of 1,120 feet oil has been discovered south of Mannford in Creek County, about 20 miles from the Cleveland Field. The oil is a heavy fuel grade of 29 gravity. The first strike is a 60 barrel well, but 15 barrels less than the first well drilled in the Glenn Pool.

For more than a year there has been in progress drilling about Hallett and Jennings, Okla., 12 to 15 miles northwest of the new field and at a depth of 3,000 feet a fail well was brought in on the Arbuckle Farm, three miles northeast of Jennings.

Since operations first began in that locality a great deal of leasing has been done. It is predicted a good oil field will eventually be discovered, extending over a long strip of territory.

December 20, 1907, p. 9

NEVADA MINERS ASK COMPROMISE

Goldfield, Nev., December 19.—Mine owners of Goldfield will accept the invitation of Attorney O. N. Hilton, of the Western Federation of Miners, for a consultation. It is not expected that an agreement will be reached.

Saturday, December 21, 1907, p. 1

OKLAHOMA STATE UNIVERSITY'S MAIN BUILDING PREY OF GASOLINE STOVE BLOWUP STARTS AN $85,000 BLAZE AT STATE'S CHIEF SCHOOL

HEROIC WORK OF FACULTY, SAVES OTHER BUILDINGS—INSURANCE $67,500—INVESTIGATION ORDERED

Guthrie, Okla., December 20.—A joint legislative committee consisting of Senators Thomas, Davis, and Cunningham and Representatives London, Bryan, and Whitson, were appointed tonight to go to Norman and investigate the cause of the university fire.

Norman, Okla., December 20.—Sweeping through corridors freshly coated with oil, as if fanned by a demon, and within four hours after classes had been dismissed for the Christmas holidays, fire caused by a gasoline stove explosion destroyed Administration Hall of the University of Oklahoma this afternoon. Damage to the building and its contents is estimated at $85,000. The total insurance is $67,500.

Heroic work by students of the university, members of the faculty, and citizens of Norman saved the conflagration from spreading to Science Hall and Carnegie Library, valued at $150,000 and containing more than $200,000 worth of laboratory equipment and books. A stiff breeze from the southeast carried the endangering flames directly toward Science Hall.

December 21, 1907, p. 9

ROOSEVELT'S AGENTS HEAR BUT ONE SIDE, SAY MINERS

MINE OWNERS REFUSE—STRIKE BREAKERS IN GOLDFIELD

Goldfield, Nev., December 20.—The Goldfield Mine Owners' Association refused today to recognize the Western Federation of Miners as a labor organization or to deal with the local miners' union as a body. A reply to a letter asking for a conference with Attorney O. N. Hilton was received by Mr. Hilton saying that the executive committee of the Mine Owners' Association would be pleased to receive him as an individual, but that the decision of the mine owners to ignore the Western Federation of Miners in the future is irrevocable. Thus ends in failure the mission of Attorney Hilton, who came from Denver delegated by President Moyer to make a compromise with the mine owners if possible.

Sunday, December 22, 1907, p. 25

MINE OWNERS FEAR DEPARTURE OF SOLDIERS

WORK WIRE ON ROOSEVELT FOR RESCINDING ORDER TO COMPROMISE

Goldfield, Nev., December 21.—The mine operators in Goldfield are loath to leave the task of preserving law and order in the camp in the hands of Sheriff Ingalls. They are using every endeavor to prevail upon President Roosevelt to order a portion of the federal troops to remain in Goldfield indefinitely. Telegrams have been sent at various times today not only from the mine owners, but from officials of the various civic bodies and private individuals, all urging upon the president the necessity of the presence of the troops.

Tuesday, December 24, 1907, p. 1

MR. BRYAN'S ADDRESS HEARD BY CROWD OF 2,000 PEOPLE

GREAT AUDITORIUM PACKED AND SPEAKER IS APPLAUDED

Two thousand persons were gathered in the Auditorium last night to listen to the speech of William Jennings Bryan, the idol of Oklahoma democracy, as he expounded the accepted truths of religion in his lecture "The Prince of Peace."

For two hours the audience listened to the words of sage advice of the one who is greater than ever speak of life from experience and deep study. His teachings of political economy and his analysis of the science of government is only equaled by his exposition of the teaching of the Christ as the "Prince of Peace," judging from the hearty appreciation of the expression of his thoughts by the audience.

December 24, 1907, p. 2

LOUISIANA'S GREAT JETTIES NEARING COMPLETION

New Orleans, December 23.—One of the greatest channel making undertakings in the history of American river improvement will be brought nearly to completion this week when the jetties at the mouth of the southwest pass of the Mississippi River are finished. Those, after some dredging between them is completed, will give the south one of the deepest harbors in the world by opening to the access of the largest steamships afloat the 100 and 200 foot depths of the lower Mississippi River. The harbor thus made accessible has navigable water connection with a dozen states bordering the Mississippi and its tributaries, the Ohio, Missouri, Arkansas, and Red Rivers.

December 24, 1907, p. 5

MARVELOUS WORK ON PANAMA DITCH

RATE OF PROGRESS COMPARED TO WHAT HAS BEEN PERFORMED HERETOFORE

Washington, December 23.—The excavation on the line of the Panama Canal last month aggregating 1,838,486 cubic yards, would have covered ten blocks to a depth of 40 feet. No such work has ever been done before as Colonel Goethals, according to statistics, presented in the official record just received. For instance, it is shown that every 50 working days the commission is moving an amount of material equal to the pyramids of Cheops which consumed the labor of 100,000 men for 20 years in constructing the building and services of the same number of men for ten years in constructing the road connecting the work with the quarry. The commission could build the Suez Canal at the present rate of progress in 3.8 years, though it took ten years to complete. The famous Manchester Ship Canal could be excavated by the American canal workers in just two months.

In 1907, President Theodore Roosevelt appointed George Washington Goethals as chief engineer of the Panama Canal. The canal was completed in 1914, two years ahead of schedule. The Panama Canal was formally opened on August 15, 1914 (Wikipeda, 2008c).

December 24, 1907, p. 5

FLYING MACHINE REQUIREMENTS OF U. S. ARE SEVERE

Washington, December 23.—Far more severe than any other nation is the United States in its requirements in the matter of the flying machines of heavier-than-air type as set out in specifications issued today by General Allen, Chief Signal Officer, upon which inventors are invited to submit bids to be opened February 1 next.

This machine must carry two persons of combined weight of 350 pounds and sufficient fuel for a flight of 125 miles. It must be designed for a speed of at least 40 miles an hour, but a ma-

chine will be accepted of only 36 miles an hour although only 60 per cent of the contract price will be paid therefore. Likewise there is provision for a premium on speed in excess of 40 miles and hour so that at 44 miles the machine would cost the government 120 per cent of the contract price.

Thursday, December 26, 1907, p. 1

ARMED MEN PATROL STREETS TO STOP RACE RIOT; NEGROES FLEE

ASSAULT JAIL FOR SECOND TIME

OFFICERS SPIRIT AWAY TWO AFRICANS WHO ARE CAUGHT

Muskogee, Okla., December 25.—A second attack was made on the jail at Henryetta early this morning by a mob of citizens who sought a one-eyed Negro named Bill Smith, charged with inciting Gardner to commit crime. Sheriff Robertson, however, had spirited the man away from the mob and took him to Okmulgee.

Henryetta, Okla., December 25.—Hundreds of blacks are arming in Wild Cat and other Negro settlements, according to reports received here and are preparing to march on Henryetta to avenge the lynching. Muskogee County Negroes were reported as arming, later reports deny this.

It is now thought that the killing of Bates was part of a conspiracy. Few persons in Henryetta are asleep tonight. Armed guards are patrolling the town, and a race war between rowdy Negroes and whites is expected.

Friday, December 27, 1907, p. 1

WAR OF RACES NOW

SITUATION AT HENRYETTA GROWING DESPERATE AFTER LYNCHING MILITIA IS READY

Guthrie, December 27.—Governor Haskell was in communication with the sheriff of Okmulgee County, in which Henryetta, the scene of serious race troubles, is located, early this morning. While the sheriff believes the greatest danger is passed, he says the situation may become desperate at any time. Governor Haskell is prepared to send Company C, Oklahoma National Guard from Chandler to Henryetta at the first sign of an outbreak.

A band of Negroes from Boley, heavily armed, is reported to be on the way to join the blacks at Wild Cat. Boley is a Negro settlement with about 1,000 inhabitants. No whites are allowed to reside there.

December 27, 1907, p. 10

GAS ORDINANCE IS EMERGENCY

DEPOSITS WILL BE REQUIRED FOR INSTALLATION OF ALL METERS

Gas supply of all houses of the city where the plumbing is found to be deficient, will be cut off immediately as a means of protection to the lives of the inhabitants and property of the city, according to the emergency ordinance adopted by the city council last night. The gas is to remain shut off until the report has been made that the gas connections are entirely safe, at the expense of the gas company.

Quarter-in-the-slot meters of the gas company must go also but deposits of $5 for the installation of house meters and $10 for meters in business houses will be required. This action was requested by the gas company as a means of protection from the transients of the city who failed to pay their bills.

December 28, 1907, p. 2

LAY PLANS TO KEEP FEDERAL TROOPS IN GOLDFIELD

Washington, December 27.—Senator Newlands of Nevada is endeavoring to prevent withdrawal of the government troops from Goldfield until some other means of protection is had. Today he called upon Secretary Taft at the War Department and strongly urged that execution of the order issued by the secretary for the withdrawal of the troops next Monday be suspended until he has had an opportunity to communicate with Governor Sparks and endeavor to induce him to call the Nevada legislature together.

December 29, 1907, p. 1 and p. 2

WATCH, BUT FEAR OF RACE WAR GETS QUIETER

Henryetta, Okla., December 28.—Armed men still patrol the streets here tonight and a close watch is being kept to prevent a raid by the blacks, who, according to reports, were planning to avenge the lynching of James Garden, who was hanged Thursday night for the murder of Albert Bates a liveryman.

People are becoming accustomed to the alarming reports which are being hourly received and no great amount of further trouble with the Negroes is now expected. Every available white man has been sworn in as a special officer and the citizens are ready for any attack the Negroes may make.

December 29, 1907, p. 2

FEDERAL TROOPS ORDERED TO REMAIN IN GOLDFIELD

PRESIDENT ROOSEVELT GIVES GOVERNOR FIVE DAYS TO CALL ON STATE LEGISLATURE TO TAKE ACTION

Washington, December 28.—In accordance with President Roosevelt's instruction the Secretary of War late today sent telegraphic orders to General Funston, commanding the Department of California at San Francisco, countermanding previous orders for the withdrawal of the troops from Goldfield on Monday next.

A special commission appointed by the president to investigate conditions at Goldfield returned today after spending a week in the mining camp. A report will be made to the president on his return from Pine Knot.

President Roosevelt today indicated by telegram to Governor Sparks of Nevada that the federal troops now at Goldfield will be ordered to remain there for a further period of three weeks, provided the Governor within five days issues a call for a special session of the state legislature.

Almost immediately after receiving Roosevelt's telegram, Governor Sparks called a special secession of the Nevada State legislature to resolve security issues in Goldfield. A state police force was organized. On March 7, 1908 federal troops were withdrawn from Goldfield and replaced by state police. The mines gradually reopened (Wikipedia, 2008d).

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—Upcoming Meetings

2010

MARCH

14-17Geological Society of America (GSA) Northeastern / Southeastern Combined Meeting, Baltimore, Maryland. Contact: Noel Potter, (717)528-8485, pottern@dickinson.edu; Chuck Baily: (757)221-2445, cmbail@wm.edu. Website: http://www.geosociety.orghttp://www.geosociety.org/sectdiv/northe/2010mtg/.

APRIL

11-13Geological Society of America (GSA) North-Central / South-Central Combined Meeting, Branson, Missouri. Contact: Thomas G. Plymate, (417)836-5800, TomPlymate@MissouriState.edu; Marcia Schulmeister, (620)341-5983, mschulme@emporia.edu. Website: http://www.geosociety.org/sectdiv/Northc/2010mtg/.

11-14 American Association of Petroleum Geologists (AAPG) Annual Meeting, New Orleans, Louisiana. Contact: (800)364-2274; website: http://www.aapg.org.

21-23Geological Society of America (GSA) Rocky Mountain, Rapid City, South Dakota. Contact: Michael Terry, michael.terry@sdsmt.edu; Larry Stetler, larry.stetler@sdsmt.edu. Website: http://www.geosociety.org/sectdiv/rockymtn/2010mtg/contact.htm.

MAY

16-18American Association of Petroleum Geologists (AAPG) Southwest Section Annual Convention Meeting, Dallas, Texas. Contact: (800)364-2274; website: http://www.aapg.org.

27-29Geological Society of America (GSA) Cordilleran joint with Pacific Section, AAPG, Anaheim, California. Contact: Phil Armstrong, (657)278-3169, parmstrong@fullerton.edu; Curtis Henderson, (562)570-3937, curtis.henderson@longbeach.gov. Website: http://www.geosociety.org/sectdiv/cord/2010mtg/contact.htm.

JUNE

13-16American Association of Petroleum Geologists (AAPG) Rocky Mountain Section Meeting Meeting, Durango, Colorado. Contact: (800)364-2274; website: http://www.aapg.org/meetings/rms/index.cfm.