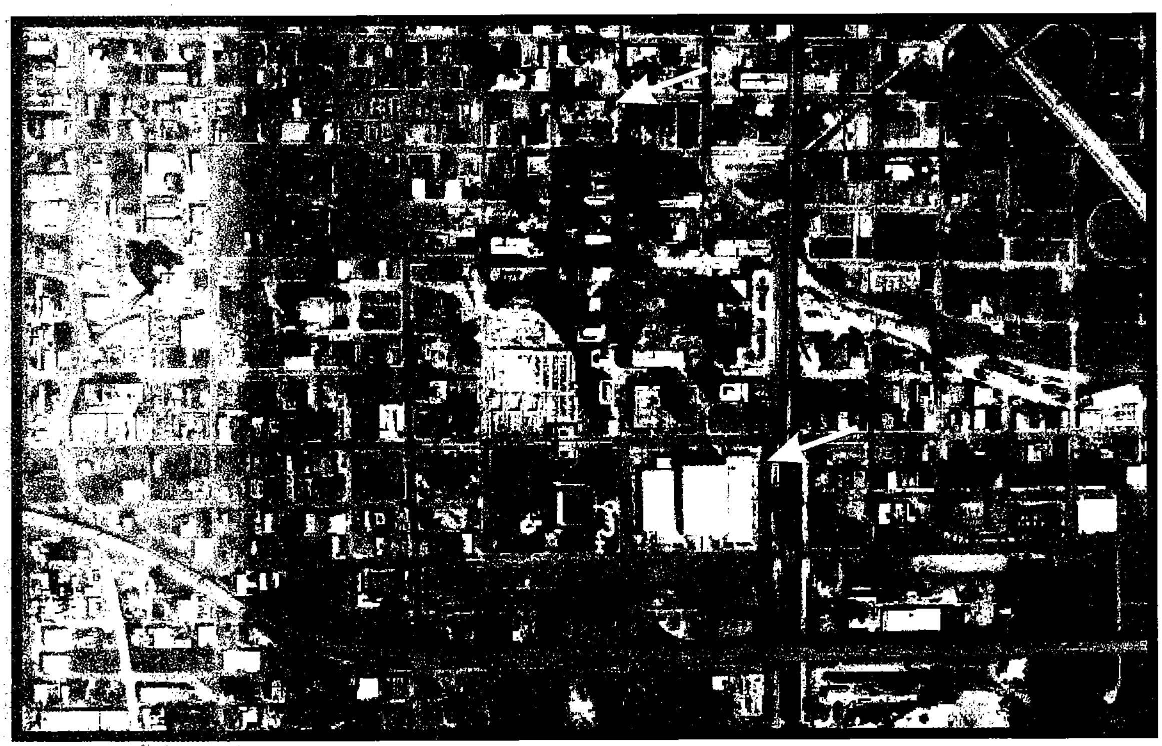
Oklahoma
Geological
Survey

OKLAHOMA GEOLOGY notes

Vol. 61, No. 1 Spring 2001



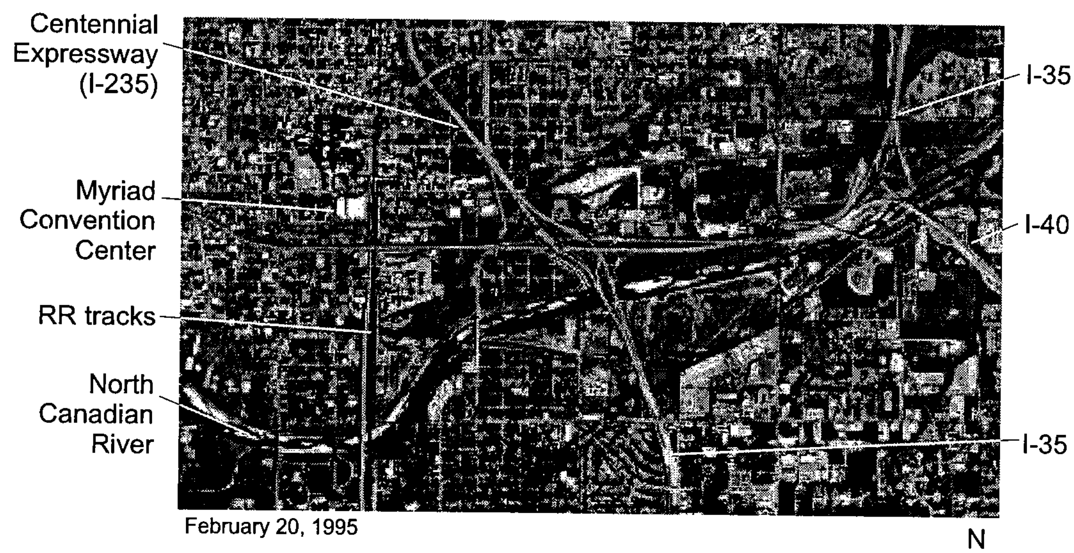
Featuring:
- *Locating geologic maps using the Internet*
- *A brief history of GIS in Oklahoma*

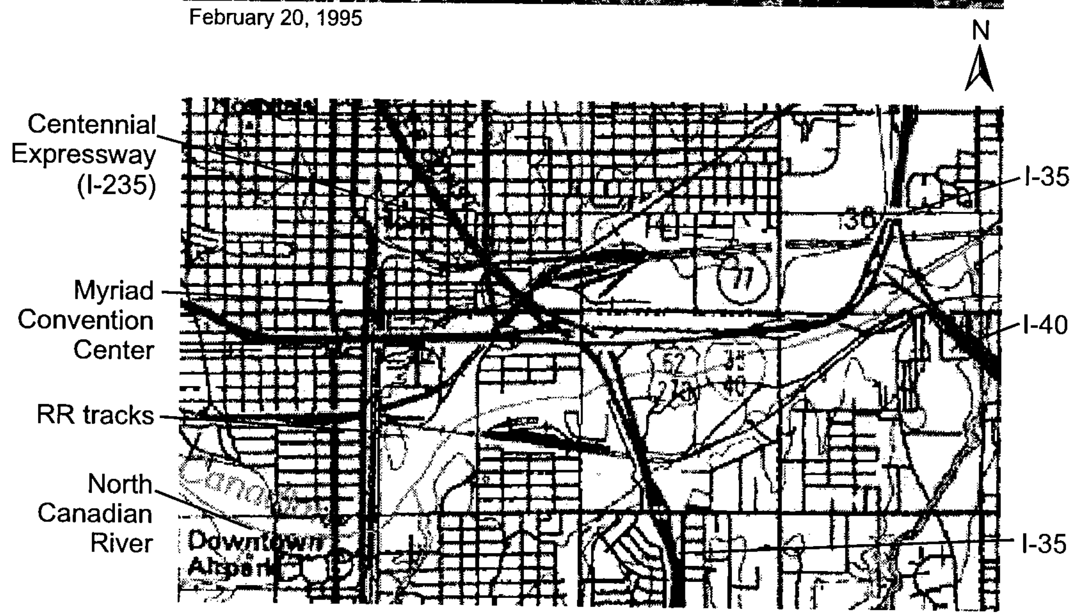
Orthophoto of downtown Oklahoma City

The cover photo is a February 1995 orthophoto (similar to an aerial photograph) of downtown Oklahoma City, showing the Alfred P. Murrah Federal Building (top arrow) and the Myriad Convention Center (bottom arrow). This orthophoto, as well as many others of places throughout Oklahoma and the rest of the United States, can be accessed on the World Wide Web through a U.S. Geological Survey (USGS) Web site described in this issue (see article starting on page 4).

The photo below is a smaller scale orthophoto of a larger part of the Oklahoma City area, including the area shown in the cover photo. The cover photo area is in the northwest corner of the photo below; the light-colored roof of the Myriad can be easily identified in both. The North Canadian River and Interstate Highways 35, 235, and 40 are identified. The second image on this page is a digital raster graphic (similar to a topographic map), showing the same area of Oklahoma City as the orthophoto above it. Digital raster graphics for most parts of Oklahoma are available through the same USGS Web site.

Neil H. Suneson





Oklahoma Geological Survey

CHARLES J. MANKIN
Director

OKLAHOMA GEOLOGY NOTES

EDITORIAL STAFF

Christie Cooper
Managing Editor

Frances Young
Technical Editor

CARTOGRAPHIC STAFF

T. Wayne Furr
Manager

James H. Anderson
Cartographic Technician

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

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

This publication, printed by the Oklahoma Geological Survey, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1981, Section 3310, and Title 74, Oklahoma Statutes 1981, Sections 231–238. 1,500 copies have been prepared for distribution at a cost of $1,584 to the taxpayers of the State of Oklahoma. Copies have been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries.

OKLAHOMA GEOLOGY

Vol. 61, No. 1 Spring 2001

2
Orthophoto of Downtown Oklahoma City

4
Locating Geologic Maps of Oklahoma Using the Internet: A How-To Guide
Neil H. Suneson, Kimberly D. Combs, and T. Wayne Furr

8
A Brief History of GIS in Oklahoma
Bob Springer

11
New OGS Publications

12
OGS Workshop: Revisiting Old and Assessing New Petroleum Plays in the Southern Midcontinent

13
Hunton Field Trip Set for May

13
Sam Friedman Receives EMD Honorary Membership

14
AAPG Spring Student Expo Hosted by OU

16
American Association of Petroleum Geologist Annual Meeting

18
Notes on New Publications

19
Oklahoma Abstracts

Locating Geologic Maps of Oklahoma Using the Internet: A How-To Guide

Neil H. Suneson, Kimberly D. Combs, and T. Wayne Furr
Oklahoma Geological Survey

INTRODUCTION

Readers of *Oklahoma Geology Notes* may find two Web sites maintained by the U.S. Geological Survey (USGS) to be very useful. The first is the USGS National Geologic Map Database, which is managed by the USGS's National Cooperative Geologic Mapping Program in cooperation with the Association of American State Geologists. It is a searchable catalog of paper and digital geologic maps. (At present, most of the maps in the database are paper, but some digital geologic maps are included.) The index is essentially complete for USGS maps, and entries are being added for published maps from some state geological surveys. The catalog can be used to identify what geologic, and other geoscience, maps exist for different parts of the country, including Oklahoma.

Another useful USGS database of mapping information is the Geographic Names Information System (GNIS), which was developed by the USGS in cooperation with the U.S. Board on Geographic Names. It can be used to determine the latitude and longitude of nearly two million named physical and cultural geographic features in the United States. It also provides links to Web sites that show topographic maps and orthophotos of many of those features.

USGS NATIONAL GEOLOGIC MAP DATABASE

A large and growing number of geologic maps of Oklahoma are now part of the USGS national geologic map index. At present, only Oklahoma maps published by the Oklahoma Geological Survey (OGS), as well as by the USGS, have been indexed. Currently, geologic maps in unpublished theses and dissertations from the University of Oklahoma are being entered into the database. Over the next year, the OGS plans to include maps in unpublished theses and dissertations from Oklahoma State University and from the University of Tulsa, as well as maps published in professional journals. This indexing effort is supported, in part, by a grant from the USGS's National Cooperative Geologic Mapping Program.

Anyone with a computer and access to the World Wide Web can use the database to find out what geologic maps exist for different areas in Oklahoma. The URL for the USGS national geologic map database is:

http://ngmdb.usgs.gov/ngmdb/ngm_catalog.ora.html.

An interesting, alternative route to the database takes you through the USGS home page, where you can browse other topics. That route is as follows.

1. Go to **http://www.usgs.gov/**.
2. Go to **Browse Our Topics** and click **Maps**.
3. Click **Geologic Maps**. Then choose either a. *or* b., below:
   a. In the **Search Geologic Maps** box, type **National Geologic Map Catalog** and click **Seek**. Click **USGS National Map Catalog** on the screen that appears.
   b. Scroll down through the many USGS geologic maps until you come to **USGS National Geologic Map Catalog**. (This may take some time. Shortly before this article was published, the catalog was the 57th of 405 entries.) Click **USGS National Geologic Map Catalog**.

At the catalog site (Fig. 1), you can search for maps in a number of ways. Depending on what kind of map interests you, click the box (near the top of the screen) for the appropriate geologic theme; for example, click **General** under **Geology** for geologic maps. The most useful way to search probably is by county. Here is an example:

1. In box 2 (**State or Territory**), scroll down and click **Oklahoma**.
2. In box 3 (**Select by Counties or 100,000 Quads**), click **By counties**. A **County List** window for Oklahoma will appear; scroll to and click on the county or counties that interest you. Click **Done** at the bottom of the **County List** window.
3. Go to box 7 (**Scale**). If you are interested in relatively detailed maps that cover a small area, enter **50000** and click **and larger scale**. If you are interested in relatively generalized maps of a large area, enter **50000** and click **and smaller scale**.
4. In box 11 (**Publisher**), scroll to and click **Oklahoma Geological Survey, U.S. Geological Survey, University of Oklahoma** (OU), or all three. (Note that you may have to follow the instructions under **Help** to select multiple publishers.)
5. Click **Search**.

The list that comes up will show all of the general geologic maps (theme selected at the top of the search screen) for the county or counties of interest (box 3) at the chosen scale(s) (box 7) published by the OGS, USGS, and/or OU (box 11).

The catalog offers a number of ways to search for geologic maps or other maps of Oklahoma (for example, geophysical maps and maps of resources or hazards). You may search using a quadrangle name or latitude-longitude. You may also point and click at a location within Oklahoma on the map of the U.S. (box 1), but the resolution of the map is poor.

In some cases, you may find that a large number of geologic maps appear in the database for an area that interests you, and you are not sure which map is the one you want. For example, let's say that you want a detailed geologic map (scale, 1:50,000 and larger) of Robbers Cave State Park, which you know is in Latimer County. Following the instructions above, you learn that there are 21 maps that might be useful. To limit your search, it would be helpful to know the exact location of Robbers Cave State Park in Latimer County. To use location data in the USGS geologic map database, you need

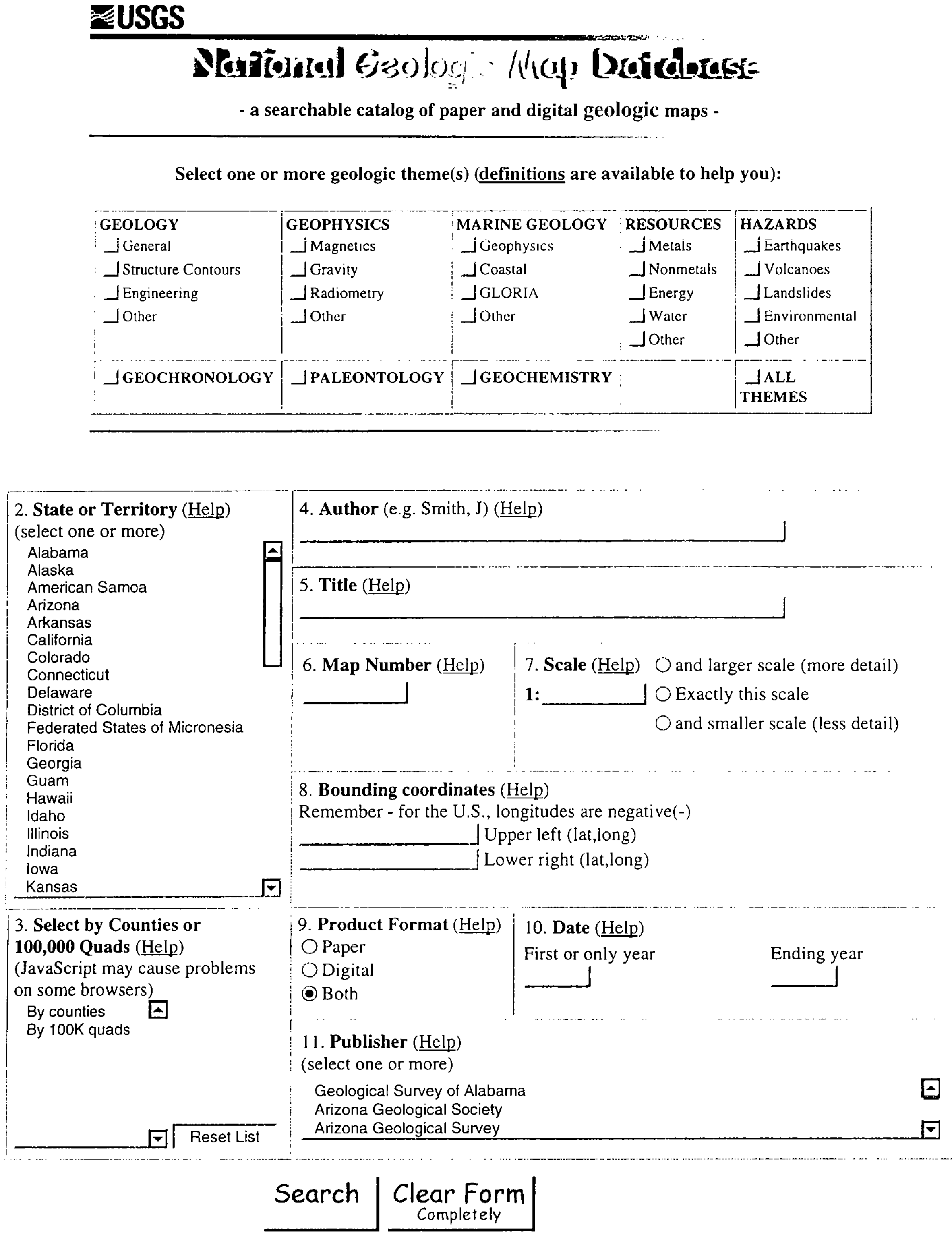


Figure 1. Web page for querying the USGS National Geologic Map Database.

to know the latitude and longitude of the park. To find out, you can use another USGS Web site that lists location data for all named geographic features in the U.S.

USGS GEOGRAPHIC NAMES INFORMATION SYSTEM

To access the USGS Geographic Names Information System (GNIS) database, use its URL, **http://geonames.usgs.gov/gnisform.html**. Or, you may go through the USGS home page:

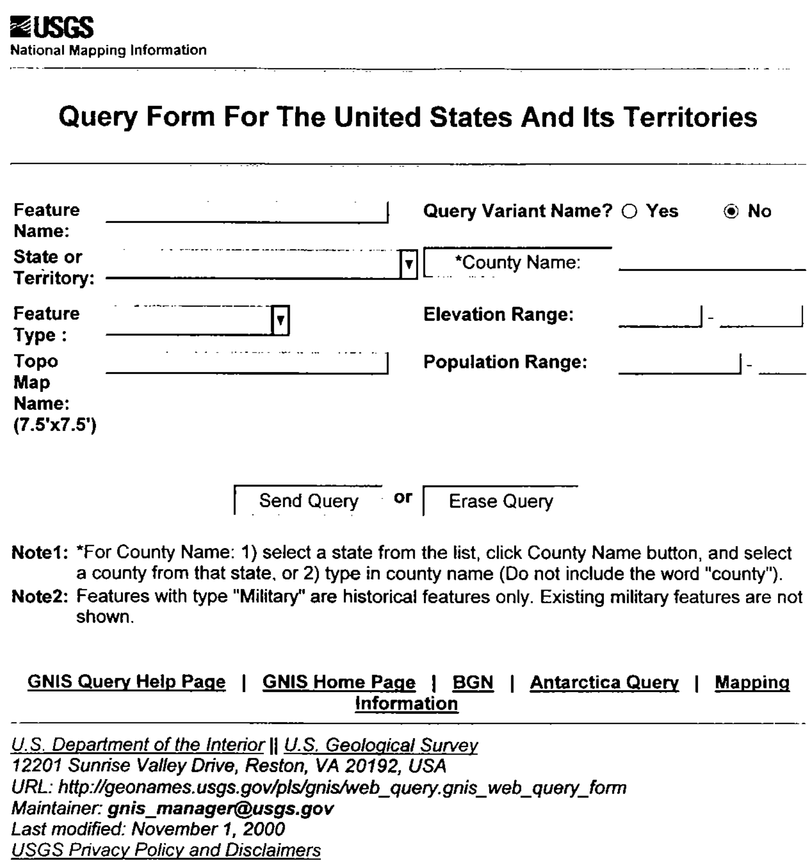
1. Go to **http://www.usgs.gov/**.
2. Go to the box **Explore Our Products and Data** and click **Geographic Names.**
3. Scroll down and click **United States and Territories.**

At the site (Fig. 2), there are several parameters for searches. The most useful are **Feature Name**, **State**, **Feature Type**, **County Name**, and **Query Variant Name?**. (Several parameters are necessary. For example, there are 690 summits [Feature Type] in Oklahoma [State]. Similarly, there are 73 Black Mesas [Feature Name] in the U.S. and Territories, but only two are in Oklahoma. One is a summit and the other is a park.) Here is an example of a search using Robbers Cave State Park:

1. In the **Feature Name** box, enter **Robbers Cave.** (Do not use the genitive apostrophe; normally, it is not used in geographic names.)
2. Click **Yes** for **Query Variant Name?.**
3. In the **State** box, scroll down and click **Oklahoma.**
4. In the **Feature Type** box, scroll down and click **park.** (Note: The USGS wisely does not publish the locations of caves. However, because Robbers Cave is a state park, it is listed under the feature type, **park.**)
5. Enter **Latimer** in the **County Name** box. Do not include the word "county." Or, you may click the **County Name** button and select **Latimer** from the list of Oklahoma counties.
6. Click **Send Query.**
7. Click **Robbers Cave State Park** under **Feature Name** in the screen that appears.

The data that appear show that Robbers Cave State Park is located in two 7.5′ quadrangles, Quinton South and Wilburton. The geographic point at latitude 35°00′10″N., longitude 95°20′28″W. in the Quinton South quadrangle is located in the park. The point at latitude 34°59′12″N., longitude 95° 19′56″W. in the Wilburton quadrangle is also located in the park. To use these data to search the geologic map database, they must first be converted to decimal degrees.

However, before you leave this GNIS site to search for existent geologic maps of Robbers Cave State Park, you may want to view a digitized version of a USGS topographic map (DRG) or an orthophoto (DOQ) (similar to an aerial photograph) of the park. To do this, click **View USGS Digital Raster**


USGS
National Mapping Information

Query Form For The United States And Its Territories

Feature Name: | Query Variant Name? ○ Yes ◉ No
State or Territory: | *County Name:
Feature Type : | Elevation Range: -
Topo Map Name: (7.5'x7.5') | Population Range: -

Send Query or Erase Query

Note1: *For County Name: 1) select a state from the list, click County Name button, and select a county from that state, or 2) type in county name (Do not include the word "county").
Note2: Features with type "Military" are historical features only. Existing military features are not shown.

GNIS Query Help Page | GNIS Home Page | BGN | Antarctica Query | Mapping Information

U.S. Department of the Interior || U.S. Geological Survey
12201 Sunrise Valley Drive, Reston, VA 20192, USA
URL: http://geonames.usgs.gov/pls/gnis/web_query.gnis_web_query_form
Maintainer: gnis_manager@usgs.gov
Last modified: November 1, 2000
USGS Privacy Policy and Disclaimers

Figure 2. Web page for querying the USGS Geographic Names Information System (GNIS) database about named geographic features in the U.S. and its territories.

Graphic (DRG) or **View USGS Digital Orthophoto Quadrangle (DOQ)**. (Note: In order to view an image of some geographic features, you must first click **Show Feature Details and Location.**) You can adjust the scale of the DRG or the DOQ by using the minus or plus boxes at the top of the image. Use the arrows at the sides and corners of the image to adjust the viewing area.

USING GNIS DATA TO SEARCH THE NATIONAL GEOLOGIC MAP DATABASE

Return to the catalog for the USGS national geologic map database (**http://ngmdb.usgs.gov/ngmdb/ngm_catalog.ora.html**) and click **Help** in box 8 (**Bounding coordinates**) for instructions on converting degrees-minutes-seconds of latitude and longitude (from the GNIS database) to decimal degrees (required in the geologic map database). Doing the math, we learn that the two points in Robbers Cave State Park are latitude 35.00°N., longitude 95.34°W. (Quinton South 7.5′ quadrangle) and latitude 34.99°N., longitude 95.33°W. (Wilburton 7.5′ quadrangle). Although these are not the park boundaries (**Bounding coordinates** of box 8), they can be considered to mark the northwest and southeast corners of a small area within the park, and any map that shows the geology for that small area probably shows the geology of the entire park.

1. Go to box 8, **Bounding coordinates**; and in the box labeled **Upper left** (the northwest corner of the area in Robbers Cave State Park), enter **35.00,–95.34.** (Note that all longitudes in the U.S. are negative.)
2. In the box labeled **Lower right** (the southeast corner), enter **34.99,–95.33.**
3. Be sure that boxes 2, 3, 7, and 11 are clicked appropriately (**Oklahoma, Latimer, 1:50000 and larger scale,** and **Oklahoma Geological Survey, U.S. Geological Survey,** and **University of Oklahoma** respectively.)
4. Click **Search.**

Four maps are shown in the database, and a brief review suggests that those by Hemish and others (1990) and Russell (1960) are the most current geologic maps of the Robbers Cave State Park area. Isn't that neat?!

If the GNIS database shows the location of a feature as a point, you can add a couple of hundredths of degrees north or south and east or west to give the geologic map database an area for which to search. For example, suppose you want to know whether there are any geologic maps for Mt. Scott in the Wichita Mountains.

1. Go to the GNIS database, **http://geonames.usgs.gov/gnisform.html.**
2. Enter **Scott** in the **Feature Name** box.
3. Scroll down and click **Oklahoma** in the **State or Territory** box.
4. Scroll down and click **summit** in the **Feature Type** box.
5. Click **Yes** under **Query Variant Name?.**
6. Click **Send Query.**

You learn that the top of Mt. Scott is at latitude 34°44′40″N., longitude 98°31′54″W., which converts to latitude 34.74°N., longitude 98.53°W. in decimal degrees. Because a point cannot be entered in the geologic map database, you might search for a geologic map with the top of Mt. Scott as the northwest corner and latitude 34.73°N., longitude 98.52°W. as the southeast corner.

1. Return to the catalog for the USGS national geologic map database, **http://ngmdb.usgs.gov/ngmdb/ngm_catalog.ora. html.**
2. Click **Geology General.**
3. Scroll down and click **Oklahoma** in the **State or Territory** box.
4. Enter **24000** in the **Scale** box and click **and larger scale.**
5. Enter **34.74,–98.53** beside **Upper left** and **34.73,–98.52** beside **Lower right** in the **Bounding coordinates** box.
6. Scroll down and click **Oklahoma Geological Survey** in the **Publisher** box.
7. Click **Search.**

The search identifies a geologic map of the south base of Mt. Scott by Gilbert (1982). Terrific!

SUMMARY

The USGS maintains two very useful databases of map information, the National Geologic Map Database and the Geographic Names Information System database. Geologic maps of Oklahoma are now part of the national geologic map database. Anyone with a computer and access to the World Wide Web can use these two databases through the USGS Web sites. Especially when used together, these databases are powerful tools for researching existing geologic maps (at various scales) for areas within the U.S. and its territories.

ACKNOWLEDGMENTS

LeRoy Hemish, Bryan Tapp, and Frances Young reviewed early versions of this paper and made many useful suggestions. We sincerely appreciate their efforts.

REFERENCES CITED

Gilbert, M. C., 1982, Stop 4—Mount Scott campground, *in* Gilbert, M. C.; and Donovan, R. N. (eds.), Geology of the eastern Wichita Mountains, southwestern Oklahoma: Oklahoma Geological Survey Guidebook 21, p. 118–123.

Hemish, L. A.; Suneson, N. H.; and Ferguson, C. A., 1990, Geologic map of the Wilburton quadrangle, Latimer County, Oklahoma: Oklahoma Geological Survey Open-File Report 2-90, 1 sheet, scale 1:24,000.

Russell, D. T., 1960, Geology of northern Latimer County, Oklahoma: Oklahoma Geological Survey Circular 50, 57 p.

A Brief History of GIS in Oklahoma

Bob Springer
Oklahoma Conservation Commission

Although Geographic Information Systems (GIS) is a relatively new technology, it offers a promise of improved decision making to both the public and private sectors. The history of GIS in State and local government in Oklahoma is a story of individuals and agencies infused with the vision and foresight to embrace a new, untried technology with impressive results. It also shows the speed at which geographic information technology is moving.

WHAT IS GIS?

A GIS is a computer system (hardware, software, people, and data) that organizes, displays, and analyzes information based on geographical location. A GIS makes more information available than a single map could legibly display. The information a GIS contains falls into two categories, graphic and nongraphic. Graphic data are the picture information typically found on a map. Property boundaries are an example of graphic data.

Nongraphic data, commonly called attribute data, are made up of words and numbers. Attribute data can be information about anything from real estate deeds to crime statistics to readings from water-quality monitoring. A GIS makes it easy to select and display graphic images that match particular attribute values; it also makes it easy to select attribute data that match graphic features or geographic areas. This compatibility makes GIS a valuable and powerful tool for complex analyses.

GIS AT THE STATE LEVEL—THE BEGINNING

Like many new concepts, GIS came slowly to Oklahoma. During the second administration of Governor Henry Bellmon (1987–1991), the directors and staff of natural resources agencies met at breakfast once a month for informal discussions about issues of mutual concern. They soon discovered that their different agencies commonly had staff in the same geographic area of the State, collecting and analyzing similar data. It was clear that costs could be reduced through increased cooperation and sharing of information.

At about the same time, the first personal computers became available and GIS began moving from the mainframe to the desktop. For the first time, the use of GIS technology became a real possibility for technical and professional staff.

During the term of Governor David Walters (1991–1995), the Oklahoma Ad Valorem Task Force was mandated to develop a mapping and parcel-identification system and a uniform, computer-assisted, mass-appraisal system for real and personal property. The Task Force recommended that the automated mapping and mass-appraisal systems be established in local assessors' offices throughout the State. To ensure that local governments and State agencies could share information via this technology, the Task Force hired Oklahoma State University (OSU) and PlanGraphics (of Frankfort, Kentucky) to study the status of GIS in Oklahoma and to develop a plan to implement the technology.

The four-volume OSU-PlanGraphics report issued in 1991 indicated that State agencies were making maps from about 150 different data files, and that many agencies were using the same or similar data files on a regular basis to make maps (Croswell and others, 1991). These data sets represented a significant investment to the State when analyzing the potential for GIS development in Oklahoma. More than 80% of the data sets used by State agencies included some type of address, which meant that they could be used in a GIS. In addition, nine agencies were already using GIS in some form. The report offered a number of specific recommendations, many of which are still valid today. The most important recommendations for both the short and the long term were to:

- establish a GIS policy committee,
- determine the mission and refine goals,
- seek a mandate from the Governor and Legislature,
- establish a GIS resource center,
- share data, and
- implement data standards.

As a result of this study, Governor Walters established a policy board to encourage the development of GIS in State government. The board, comprised of cabinet-level secretaries, was to make recommendations on ways to coordinate GIS activities. Patty Eaton, then Secretary of the Environment, chaired the board. At the same time, the board established several subcommittees concerned with specific GIS-related issues. Mark Gregory, with OSU's Department of Agronomy, coordinated these subcommittees.

Efforts to make GIS a reality for State agencies received a boost during the 1992 legislative session when Representative Bruce Niemi and Senator Penny Williams, both of Tulsa, introduced House Bill 2488. The bill would have created:

- an Oklahoma geographic information and database policy board,
- the Office of the State Geographer,
- a geographic reference center, and
- a GIS revolving fund.

This bill was defeated, possibly due to disagreement about which agency would house the GIS reference center. However, an interim study to assess the feasibility of GIS in Oklahoma was approved.

THE STATE GIS COUNCIL

Significant progress was made in 1994 with the passage of Senate Bill 722 (Oklahoma Statutes, section 15-1-205-1 of Title 82), cosponsored by Senators Gene Stipe, J. Berry Harrison, and Robert S. Kerr and Representative Mike Mass. This bill required the Oklahoma Conservation Commission to "coordinate the preparation of a Strategy for Developing a Geographic Information System for the State of Oklahoma, focusing on, but not limited to, natural resources." In addition, the bill created the State Geographic Information Systems Council, consisting of 11 members:

- Oklahoma Conservation Commission,
- Department of Environmental Quality,
- Oklahoma Corporation Commission,
- Oklahoma Department of Commerce,
- State Department of Agriculture,
- Oklahoma Water Resources Board,
- Department of Transportation,
- State Geographer,
- Oklahoma Geological Survey,
- University of Oklahoma Center for Spatial Analysis, and
- OSU Environmental Institute.

In 1995, SB 722 was enacted and the size of the State GIS Council was increased to its current 14 members with the addition of the Oklahoma Tax Commission, a representative from Oklahoma's regional universities, and the Office of State Finance. The Digital Orthophoto Base Mapping Fund also was created. It is important to note that no funding was authorized for the day-to-day operations of the State GIS Council.

Probably the most enthusiastic supporter of GIS at the State-agency level was Mason Mungle, former Executive Director of the Oklahoma Conservation Commission. Mungle sparked the effort to establish both the State GIS Council and the revolving fund for digital orthophotography of the State. A true visionary, Mungle saw the potential benefits of GIS not only for his agency, but also for the whole State. Today, current Conservation Commission Executive Director, Mike Thralls, provides continuing support for GIS.

The State GIS Council first met in July 1994 and immediately began efforts to develop a strategic plan for implementing GIS in State agencies. It established several subcommittees to examine specific technical, operational, and financial issues critical to GIS development. These subcommittees made specific recommendations, and, in May 1996, the Council submitted the Oklahoma GIS Strategy to the State Legislature. The eight-part strategy and the Council's actions to implement it are as follows:

1. Identify the information and data needed for a Statewide GIS system. The Council identified the several layers of data that most agencies needed for basic GIS activities, such as, data about transportation, hydrography, and terrain, census information, etc. In cooperation with the U.S. Geological Survey (USGS), the State GIS Council released the *Digital Atlas of Oklahoma*, a CD containing 25 county and statewide data sets. All copies of this very popular CD were sold. The data are now available on several Web sites via the Internet.

2. Standardize base-map reference. Although individual State agencies maintain data in a number of mapping projections, the State GIS Council has adopted the Geodetic Reference System 1980 (GRS 80) as its official ellipsoid (NOAA, 1986).

3. Procure digital orthophoto base-map coverage for the State of Oklahoma. In cooperation with the USGS, the Natural Resources Conservation Service, and the Farm Service Agency, the State GIS Council received funding from the State Legislature and obtained digital orthophotography of the State. Digital orthophotos provide an accurate photographic base map upon which other types of GIS data can be placed. More than 4,800 orthophotos of the State (obtained in 1995) are available on the Internet at Web sites for OneNet and the University of Oklahoma Geo Information Systems (see the list of Web sites for Oklahoma geospatial data in the box below). Another series of orthophotos is planned for 2002, if funding is available.

4. Identify agency responsibility for gathering, maintaining, and disseminating data. The Oklahoma GIS Strategy recommended that each agency, or group of agencies, be responsible for gathering and maintaining its own spatial data, as well as for promoting its use. In addition, each agency, or group of agencies, should prepare metadata for all new data sets. Metadata (data about data) basically defines the "pedigree" of data. It provides information on the identification, sources, accuracy, spatial reference system, attributes, and other characteristics of a data set and is of vital importance when data is shared. In 1999–2000, the State GIS Council sponsored four workshops on metadata.

5. Develop a comprehensive catalogue and clearinghouse of data. The Oklahoma GIS Strategy recommended that there be a centralized source, or catalogue, for searching, evaluating, and accessing Oklahoma spatial data sets, to be located at Oklahoma State University (OSU). The Spatial and Environmental Information Clearinghouse (SEIC) at OSU is a node on the National Spatial Data Infrastructure.

WEB SITES FOR OKLAHOMA GEOSPATIAL DATA

Geospatial Data for Oklahoma

Spatial and Environmental Information Clearinghouse at OSU	http://www.seic.okstate.edu
Geo Information Systems at OU	http://www.geo.ou.edu

Geospatial Data for All States, including Oklahoma

GIS Data Depot	http://www.gisdatadepot.com/index.html
GIS Data on the Web	http://unr.edu/homepage/daved/gislinks.html
The Geography Network	http://www.geographynetwork.com/
OneNet	ftp://okmaps.onenet.net
U.S. Geological Survey	http://www.usgs.gov/

SEIC is a storage center for a variety of Oklahoma geospatial data. Additional data are available through the Web site for the University of Oklahoma Geo Information Systems, as well as a number of others (see the list of Web sites for Oklahoma geospatial data shown in the box on page 9).

6. Establish a GIS Coordinator, with responsibility for coordinating the State's efforts with respect to GIS and data dissemination. This position has not, yet, been established. The Oklahoma Conservation Commission provides administrative support for the State GIS Council.

7. Provide education and public access. The Oklahoma GIS Strategy recommended that the State GIS Council work to inform the public and all units of government about the value of GIS. The Council provides information through monthly Council meetings, a newsletter, and GIS Day at the Capitol, which has developed into a successful tool for informing the Governor and legislators about the value of GIS. The most recent GIS Day at the Capitol was held on February 27, 2001.

8. Coordinate the State GIS Council's efforts to develop GIS with efforts by federal, regional, State, county, and local agencies. The Council realized that it could not operate in a vacuum and that it was vital to coordinate its activities with those of other GIS users. Although its membership is limited to 14 State agencies and universities, the Council welcomes participation by other units of government and by the private sector in all of its activities. In addition, the Council is committed to assisting educators by providing GIS workshops to teachers and librarians. It also provides assistance and data to the Aurora Project, an Oklahoma program that develops Web-based curricula with strong GIS foundations.

CURRENT GIS ACTIVITIES IN OKLAHOMA

The growth of GIS in Oklahoma mirrors that in other states. Cities, counties, regional governments, state and federal organizations, educational institutions, and the private sector are now developing GIS programs. According to a survey completed in August 2000 by the Association of Central Oklahoma Governments, the 21 cities, counties, and State agencies that responded are actively developing and using geospatial data (ACOG, 2000). Similar activities are taking place in other regions of the State, with varying degrees of sophistication and success. Several universities offer GIS classes, and the Department of Geography at OSU offers a Certificate in Geography open to all majors. GIS is even being taught in some middle and high schools as a tool for better understanding relationships between people and places.

SOCIETAL GIS

The term "societal GIS" was coined by the president of a leading GIS software firm to denote the use of GIS data by the general public. A few years ago, the general public was grateful for any access to geospatial data. Today, inexpensive—but, powerful—computers, sophisticated software, and free Internet access to GIS data make it possible for individuals, as well as organizations of any size, to harness the power of GIS. Increased public access and sophistication, in turn, place additional demands on government agencies to provide high quality data.

The State GIS Council views itself as an entity that can assist users of GIS by providing information, coordination, and advice. At its meetings, the GIS Council offers information on state and federal initiatives, presentations on GIS activities from all sectors, and the chance for attendees to network with GIS users from a variety of fields. It is perhaps this networking that provides the most important vehicle for interagency cooperation, data sharing, and advice from those who have experience in handling "sticky" GIS problems. Council meetings are generally held on the first Friday of each month at the offices of the Oklahoma Water Resources Board, 3800 N. Classen, in Oklahoma City. More information on meeting schedules and topics can be obtained by contacting Bob Springer, phone (405) 521-4534, email: bobs@okcc.state.ok.us.

CHALLENGES

Since Senate Bill 722 was enacted in 1995, the only GIS funding provided by the State Legislature has been for the purchase of digital orthophotography of the State in 1995. Funds for updating the orthophoto database will need to be appropriated soon. The USGS has proposed to provide a new series of orthophotographs in 2002, at an anticipated cost of more than $4.5 million. (It is possible that competition from the private sector—through new processing techniques and the ability to produce orthophotos from satellites—may reduce this cost.)

Since its inception, the State GIS Council, itself, has received no administrative funding. Lack of such funds hampers its efforts to maintain and disseminate GIS data and to coordinate GIS activities throughout the State more effectively. In many other states, similar councils are funded by annual appropriations. Such a yearly appropriation by the Oklahoma State Legislature to the State GIS Council would enable the Council to offer greatly expanded services, particularly in assisting government agencies, the private sectors, schools, and the general public and in providing large amounts of GIS data over the Internet.

THE FUTURE

The digital age has given new value to information, including geographic information. The Internet will provide easy access to GIS data on a worldwide basis, and some experts predict that GIS will be linked directly to spreadsheet software in the future. Increasingly, GIS will influence the context in which decisions are made because it gives the general public, as well as official decision makers, direct access to geospatial information and the ability to analyze it.

REFERENCES CITED

Association of Central Oklahoma Governments, 2000, ACOG GIS survey results: Association of Central Oklahoma Governments, Oklahoma City, 11 p.

Crowell, P. L.; Smith, C. R.; and Kruzich, Rosanne, 1991, State of Oklahoma plan for GIS development: PlanGraphics, Inc., Frankfort, Kentucky, 38 p.

National Oceanic and Atmospheric Administration, 1986, Geodetic glossary: National Geodetic Information Center, Rockville, Maryland, 12 p.

new OGS publications

SPECIAL PUBLICATION 2001-1

- *by* Richard Andrews and others
- Paperbound, laminated cover
- 123 pages
- $20

Springer Gas Play in Western Oklahoma

Based on an entirely new study, this volume presents information on petroleum occurrence, exploration, and development in rocks of the Springer formation in Oklahoma. The material contained in this publication was covered in a workshop held in April 2001 by the OGS, in cooperation with the Petroleum Technology Transfer Council. Richard D. Andrews is the principal author of this report, which is part of a continuing series that provides information and technical assistance to Oklahoma's oil and gas operators. Walter J. Hendrickson, John V. Hogan, Paul W. Smith, Charles E. Willey, and Ronald J. Woods of Geological Data Services also contributed.

This study is intended to aid in the regional understanding of the Springer, including the stratigraphic nomenclature as used at the outcrop and projected throughout the Anadarko and Ardmore basins. The report focuses on strata directly below the Morrow Group and above the lower Chesterian Chester limestone/Caney Shale. This investigation is intended to complement the report on the Morrow gas play by Andrews (OGS Special Publication 99-4). The study was aided by field investigations conducted in conjunction with the Oklahoma Geological Survey's Springer field trip and guidebook by Hemish and Andrews (OGS Guidebook 32, described below).

This volume includes regional maps of the various Springer sandstone zones (including the Cunningham, Britt, and Boatwright), in addition to the equivalent carbonate deposits in northwest Oklahoma and the Panhandle. Other regional work included in this study are shelf-to-basin cross sections, a map showing fields with production from the Springer, a Springer structure map, and a production allocation map based on current stratigraphic interpretations by Geological Data Services (data acquired from IHS Energy Group).

The report also features three field studies that represent typical Springer gas reservoirs and their geology, depositional environment, production characteristics, and engineering parameters. Two of these studies pertain to the traditional marine sandstone reservoirs, while the third pertains to the Springer Britt and Boatwright carbonates that often are referred to as "Chester."

GUIDEBOOK 32

- *by* LeRoy A. Hemish and Richard D. Andrews
- 37 pages
- Paperbound, laminated cover
- $5

Stratigraphy and Depositional Environments of the Springer Formation and the Primrose Member of the Golf Course Formation in the Ardmore Basin, Oklahoma

A companion to the special publication described above, this guidebook presents information on selected sandstone units in the Springer formation, which straddles the Mississippian–Pennsylvanian boundary, and units in the lower Golf Course Formation (Morrow equivalent of the Pennsylvanian) in the Ardmore basin of south-central Oklahoma.

The guidebook was prepared for a field trip held by the OGS in April 2001 to show surface to subsurface correlations in regard to reservoir quality, log characteristics, and interpretation of depositional environments. The goal of the field trip was to help participants understand methods for making interpretations of depositional environments and facies changes that will help them successfully predict the potential of a reservoir rock. Guidebook authors LeRoy A. Hemish and Richard D. Andrews led the field trip.

SP 2001-1 and **Guidebook 32** can be purchased by mail from the Survey at 100 E. Boyd, Room N-131, Norman, OK 73019; fax 405-325-7069. To mail order, add 20% to the cost for postage, with a minimum of $2 per order.

All OGS publications can be purchased over the counter at the OGS Publication Sales Office, 1218-B W. Rock Creek Road, Norman; phone (405) 360-2886, fax 405-366-2882, e-mail ogssales@ou.edu. Request the OGS *List of Available Publications* for current listings and prices.

OGS Workshop

Revisiting Old and Assessing New Petroleum Plays in the Southern Midcontinent

Oklahoma City, Oklahoma, May 8–9, 2001

A two-day program co-sponsored by the OGS and the National Petroleum Technology Office of the U.S. Department of Energy will examine new ideas and approaches to the improved recovery of known accumulations and the discovery of new reservoirs. Presentations will address depositional systems, diagenetic and/or tectonic history, reservoir architecture, exploration concepts appropriate to the region, and methodologies and techniques for improved recovery.

This is the 14th workshop in an annual series designed to aid in the search for, and production of, our oil and gas resources. It will be held at the Meridian Convention Center in Oklahoma City. The program is listed below:

ORAL PRESENTATIONS

Petroleum Developments in the Southern Midcontinent—An Overview, by Charles J. Mankin, *Oklahoma Geological Survey,* and Robert A. Northcutt, *Independent Geologist*

Petroleum Charge to the Mill Creek Syncline and Adjacent Areas, Southern Oklahoma, by Alton A. Brown, *Consultant*

Computer Modeling of a Small-Scale Inversion Feature: Milroy Field, Oklahoma, by Richard Banks, *Scientific Computer Applications,* and Robert Harmon, *C. E. Harmon Oil*

Finding Simpson Sand Production with 3-D Seismic in Southern Oklahoma, by Bob Springman, *Independent/Consulting Geophysicist*

Surface and Subsurface Evidence Indicates a Possible Sub-Thrust Play Beneath the Arbuckle Mountains, by R. P. Wilkinson, *Consulting Petroleum Geologist*

Tectonic Development of the Central Ouachita Mountains: Structural Analyses in the Potato Hills, Oklahoma, by Galen W. Miller and Kevin J. Smart, *University of Oklahoma*

Arkoma Basin Coalbed-Methane Potential and Practices, by John H. Wendell, Jr., *Wendell & Associates*

Application of Microbially Enhanced Coalbed Methane (MECoM) to Stimulate Coal Gas Production, by Andrew R. Scott, *Altuda Geological Consulting*

Finding New Pays in Old Plays: Recent Geochemical Exploration Successes from Texas, Oklahoma, and Kansas, by Dietmar Schumacher, Daniel Hitzman, and Brooks Rountree, *Geo-Microbial Technologies*

Interpreting Seismic Data from the Wichita Mountains Frontal Zone with the Help of Ray-Trace Modeling, by Jan M. Dodson, Roger A. Young, and Kevin J. Smart, *University of Oklahoma*

Size-Frequency Effects and Reservoir Structure, by Evgeni M. Chesnokov, *University of Oklahoma*

Hunton Transition Zone in Oklahoma: A Case Study in the West Carney Field, Lincoln County, Oklahoma, by David Chernicky and Scott Schad, *New Dominion*

Understanding Regional Chimneyhill Correlations and Its Impact on Reservoir Predictability, by Kurt Rottmann, *Consulting Geologist*

Bypassed or Unrecognized Production in Recently Discovered Hartshorne Gas Reservoirs and Recognition of Important Reservoir Facies, Arkoma Basin, Oklahoma, by Richard D. Andrews, *Oklahoma Geological Survey*

Case Study: AVO Analysis in a High Impedance Atoka Sandstone, North Arkoma Basin, McIntosh County, Oklahoma, by Mohamed A. Eissa and John P. Castagna, *University of Oklahoma*

Compartmentalization, Seal Hierarchy, and Sequence Stratigraphy of the Overpressured Interval in the Anadarko Basin, by Z. Al-Shaieb, J. Puckette, and A. Close, *Oklahoma State University*

3-D Applications in South-Central Oklahoma: Imaging and Exploiting Complex Structure: Knox, Chitwood, Bradley, and Cement Fields, Grady, Stephens, and Caddo Counties, Oklahoma, by Larry Lundardi, *Chesapeake Energy Corporation*

Integration of All Possible Existing Data to Best Model an Old Oilfield and thus Create Development Sites Overlooked, by Bert A. Weimer, *Weimer Consulting*

Influence of Fracturing Fluid Rheology on the Productivity of Stimulated Oil and Gas Reservoirs, by Naval Goel and Subhash Shah, *University of Oklahoma*

Enhanced Oil Recovery with Downhole Vibration Stimulation, Osage County, Oklahoma, by Robert V. Westermark, *Seismic Recovery,* and J. Ford Brett, *Oil and Gas Consultants International*

POSTER PRESENTATIONS

Microstructural Analysis in the Ouachita Frontal Zone and Arkoma Basin: Southeastern Oklahoma, by Jason W. Currie and Kevin J. Smart, *University of Oklahoma*

Ray Trace Modeling Can Enhance Seismic Interpretation of Complex Subsurface Structures: An Example from the Wichita Mountains Frontal Zone, Southern Oklahoma, by Jan M. Dodson, Roger A. Young, and Kevin J. Smart, *University of Oklahoma*

Can Time-Lapse Seismic Data Help in Managing Unconsolidated Oil and Gas Reservoirs?, by Frederic Gallice and John Castagna, *University of Oklahoma*

Characterization of High Molecular Weight Biomarkers in Crude Oils, by Michael Hsieh and R. Paul Philp, *University of Oklahoma;* and J.C. Del Rio, *Instituto de Recursos Naturales y Agrobiologia*

Characterization of Solid Bitumen within Hitch Field, Southwest Kansas, by Dongwon Kim and R. Paul Philp, *University of Oklahoma*

Tectonic Development of the Central Ouachita Mountains: Structural Analyses in the Potato Hills, Oklahoma, by Galen W. Miller and Kevin J. Smart, *University of Oklahoma*

REGISTRATION INFORMATION

The fee for advance registration (*by April 30*) is $60, and includes lunches and a copy of the proceedings; late and on-site registration is $70. Students rates are available.

For more information, contact Brian Cardott, Oklahoma Geological Survey, 100 E. Boyd, Room N-131, Norman, OK 73019; phone (405) 325-3031 or (800) 330-3996. For registration forms, contact Tammie Creel or Jan Coleman at the same location and numbers.

Hunton field trip set for May

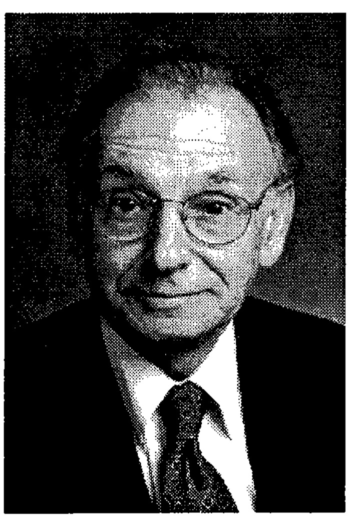
A one-day field trip examining the Hunton play is scheduled to run two days, Tuesday, May 22, and Wednesday May 23, to follow up on the Hunton workshop presented last October in Norman, Oklahoma. The workshop is co-sponsored by the Oklahoma Geological Survey and the Petroleum Technology Transfer Council.

The field trip will be led by Tom Stanley, an OGS geologist and author of the accompanying guidebook (OGS Guidebook 33), *Stratigraphy and Facies Relationships of the Hunton Group, Northern Arbuckle Mountains and Lawrence Uplift, Oklahoma.* It will include eight stops situated in the northern part of the Arbuckle Mountains and the Lawrence uplift. The purpose of the field trip is to acquaint the participants with all of the important oil and gas producing facies of the Hunton Group, which formed under a carbonate-ramp-style depositional regime. These producing intervals include the Frisco and Bois d'Arc Formations, and shallow-water carbonate members of the Chimneyhill Subgroup. Some stops also will include a look at nonproducing intervals of the Haragan and Henryhouse Formations. Detailed surface descriptions of these producing and nonproducing units will be used to augment those lithostratigraphic properties necessary for the formation of good carbonate reservoirs. In turn, the eight surface exposures will be related to subsurface logs, via comparison with measured gamma-ray profiles.

The field trip will begin and end at the parking lot of the Holiday Inn in Ada, Oklahoma. The cost is $50, which will include transportation for the day, beverages, lunch, and the guidebook. For more information about the Hunton field trip, contact Michelle Summers, Oklahoma Geological Survey, 100 E. Boyd, Room N-131, Norman, OK 73019; phone (405) 325-3031 *or* (800) 330-3996; fax 405-325-7069.

The Hunton is one of the more important oil and gas producing sequences of Oklahoma. More than 200 people attended the Hunton workshop. The publication from the workshop, OGS Special Publication 2000-2, *Hunton Play in Oklahoma (Including Northeast Texas Panhandle),* by Kurt Rottmann and others, is available from the Survey for $17, plus $3.40 shipping and handling. Copies are available from the OGS by mail at 100 E. Boyd, Room N-131, Norman, OK 73019; by phone at (405) 360-2886 *or* (800) 330-3996; or by e-mail at ogssales@ou.edu. Copies can be purchased over the counter at 1218-B W. Rock Creek Road in Norman, Oklahoma.

Sam Friedman receives EMD Honorary Membership



Samuel A. Friedman

Samuel A. Friedman, retired senior coal geologist at the Oklahoma Geological Survey, has been honored by the Energy Minerals Division (EMD) of the American Association of Petroleum Geologists by being awarded Energy Minerals Division Honorary Membership. This award is the Division's highest award and is based on service and excellence in the geology of energy minerals. Approval of this award was given at the Fall Leadership Meeting of EMD in November 2000. The award will be presented at an awards banquet to be held in conjunction with the AAPG annual meeting in Denver, June 3–6.

The purpose of the EMD is to advance the science of geology as it relates to any earth materials, other than conventional oil and gas (namely coal, coal-bed methane, uranium, oil shale, tar sands, and geothermal fluids), capable of being used for energy production.

Throughout his career, Friedman has served the AAPG EMD in many capacities and has been honored with numerous awards. Friedman was active on the AAPG Committee on Energy Minerals (1974–77), before EMD became a division, and was a founding member of EMD in 1977. He served as EMD vice-president (1980–81), vice-president/president-elect (1989–90), president (1990–91), and was the first EMD councillor for programs (1978). In addition to having chaired many committees, he served as associate editor for coal for the AAPG *Bulletin* and as editor of the EMD newsletter. Friedman received the EMD Distinguished Founders Award in 1994, and in 1995 he was presented the AAPG Distinguished Service Award "in recognition of and appreciation for his dedicated, thoughtful, and quality excellence in geology and his lifelong service to AAPG."

AAPG Spring Student Expo hosted by OU

The American Association of Petroleum Geologists held its first Spring Student Expo at the University of Oklahoma on March 16–17, 2001. The Spring Expo is a followup to the highly successful Fall Expos, held annually at Rice University in Houston.

Student Expos provide an opportunity for employers from small to mid-size companies to recruit potential employees. The Spring Student Expo offers an additional opportunity for larger companies, who formally recruit on campus each fall, to meet future employees.

Co-sponsored by the OU School of Geology and Geophysics, Oklahoma Geological Survey, and Sarkeys Energy Center, the Spring Expo was attended by 91 students. Among the 32 students who showcased their work in poster presentations, two University of Oklahoma students received awards. Galen Miller won 3rd Place for his poster, and Jan Dodson received Honorable Mention. Congratulations to them!

Abstracts for the five poster presentations pertaining to Oklahoma geology are reproduced here.

Galen Miller and Jan Dodson

3rd Place Award for Best Poster

Tectonic Development of the Central Ouachita Mountains: Structural Analyses in the Potato Hills, Oklahoma

GALEN W. MILLER and *KEVIN J. SMART* [Assistant Professor], School of Geology and Geophysics, University of Oklahoma, Norman

The Ouachita Mountains are part of a 2,000+ km long orogenic system that represents the Late Paleozoic closure of the Iapetus Ocean following collision of Laurentia and Gondwana during the final assembly of Pangea. Although the Ouachitas share similarities with the Appalachians, this fold-thrust belt lacks a strong Early Paleozoic carbonate "strut" and is dominated by a thick shale-dominated package. While the final stages of closure have been studied in the reasonably well-exposed Pennsylvanian and younger strata of the Frontal Ouachitas, the earlier history is masked by a lack of exposure to older stratigraphy. In this work, we have examined the western Potato Hills region of the Central Ouachitas with the intention of providing greater insight into the tectonic evolution of the Ouachitas.

Within the Potato Hills, pre-orogenic Ordovician through Mississippian shales and cherts are exposed in an otherwise younger sequence of Mississippian and Pennsylvanian sandstones and shales. Recently completed 1:24,000-scale mapping together with mesostructural analyses document the deformation of the pre-orogenic strata in the Ouachita Mountains. The Potato Hills exhibit a series of doubly plunging anticlines and synclines orientated roughly 065°–085° that plunge more steeply to the west. The deformation intensity in the Potato Hills, as shown by multiple scales tight folds and a weakly developed cleavage, is considerably greater than in the surrounding Central Ouachitas. As such, the Potato Hills strata may hold clues to the initial stages of Ouachita deformation.

Honorable Mention

Ray Trace Modeling Can Enhance Seismic Interpretation of Complex Subsurface Structures: An Example from the Wichita Mountains Frontal Zone, Southern Oklahoma

JAN M. DODSON, ROGER A. YOUNG [Associate Professor], and *KEVIN J. SMART* [Assistant Professor], School of Geology and Geophysics, University of Oklahoma, Norman

The Wichita Mountain Front (WMF) is part of the linear trend in southern Oklahoma that extends from the Arbuckle Mountains in south-central Oklahoma through the Wichita Mountains to the buried Amarillo Mountains in the Texas Panhandle. Intense subsurface deformation exists along the WMF, including overturned beds and crystalline basement rocks thrust over Paleozoic sedimentary rocks. Dipmeter data indicate 180° changes in dip direction. Correct migrations of seismic data are vital to accurate interpretations; but they cannot be achieved without well-defined velocity models. Velocity models are in turn based on interpretations of the data. Seismic ray tracing can confirm or condemn an interpretation. Accurate interpretations are a prerequisite to improving exploration successes.

A synthetic seismic data set paralleling an actual seismic line was created with ray-tracing software by building a viable cross section using all available data, including well data and seismic data. X,Z coordinates and layer velocities are specified as are ray propagation parameters (such as attenuation, and shear or compressional waves). Ray paths were calculated and analyzed to determine where reflections occurred in the subsurface and their corresponding CMP location. Arrival times and reflection amplitudes were convolved with a wavelet to produce synthetic traces for comparison to actual seismic data.

Two alternate velocity models were constructed to demonstrate that a lack of data, or an inaccurate interpretation produce ambiguous results. The synthetic data set was migrated with the exact velocity grid used to create the data; then the data set was migrated with the alternate velocity models. Comparing the three resulting migrations to the actual seismic data confirmed that the more accurate migration velocity model produced the clearest result. The most accurate migration, however, does not accurately position all reflection events.

Microbial Processes in a Sulfide-Bearing Spring near Zodletone Mountain in Southwestern Oklahoma

BRIAN CAMPBELL, School of Geology and Geophysics, University of Oklahoma, Norman; *JOHN SENKO*, Dept. of Botany and Microbiology, University of Oklahoma; *LEE KRUMHOLZ*, Institute for Energy and the Environment and Dept. of Botany and Microbiology, University of Oklahoma; *WILLIAM ERNEST SANDERS*, Vastar Resources, Houston; and *THOMAS DEWERS*, School of Geology and Geophysics, University of Oklahoma

A sulfide spring in southwestern Oklahoma hosts a variety of microbial and geochemical processes. Containing approximately 9,000 mg/L total dissolved solids, it discharges at approximately 19 L/min year round and is chemically anomalous relative to surrounding ephemeral springs. Methane bubbles continually at the source. From the source, a stream flows approximately 20 m and discharges into Stinking Creek. Spring water contains sulfide at 8.0 mM but little sulfate, whereas the creek water is oxidized, with negligible sulfide content and higher sulfate. Along the stream, active populations of photosynthetic bacteria occur. As a result of biological sulfide oxidation, sulfide minerals form a (slightly radioactive) precipitate at nearby locations.

Shallow cores were taken along the profiles of the stream and creek; sulfate reduction rates were measured in each core. Along the stream, sulfate reduction rates reached 18 nmol/g/day but decreased dramatically with depth. The creek featured lower sulfate reduction rates (1–8 nmol/g/day), suggesting lower primary productivity. At the confluence of stream and creek, sulfate reduction rates peaked (15–55 nmol/g/day). In this region of confluence, the highest levels of microbial productivity occur, as nutrient and respiratory electron acceptor-rich waters encounter waters rich in high-energy microbial substrates (sulfide and methane).

Inverse chemical modeling suggests the spring's chemistry results from the mixing of deep-seated oil field brine, possibly ejected along frontal thrust faults of the Wichita Mountains, with shallow meteoric waters. Additional determining factors are the oxidation of large amounts of organic matter (i.e., suspected subsurface oil seeps) and gypsum dissolution (from nearby Permian evaporites).

The Signal Mountain Formation, Southern Oklahoma Aulacogen: Depositional Environment and Source Rock Potential in a Cambro–Ordovician Carbonate

ROBERT J. CRITCHFIELD and *NOWELL R. DONOVAN*, Dept. of Geology, Texas Christian University, Fort Worth, Texas

The Signal Mountain Formation in the Arbuckle Group contains lithologies that have high TOC values. While average TOC values are ~0.43%, values >1.00%, are found in thin carbonaceous shales. S2/S3 values range from 1.29 to 30.51. Tmax values confirm oil window maturity with values from 440°C to 453°C. Two locations tested S1/TOC values in excess of 100 (>300). HI and OI indices confirm type 1 kerogen, i.e., organic matter of algal origin.

The Signal Mountain depositional environment was marine, below fair weather wave base and shelf to slope. Typical lithologies comprise burrow-mottled pelbiomicrites. Ichnofacies include *Thalassinoides* and *Cruziana*. Also present are glaucobiosparites, wackestones, mudstones, and intraformational conglomerates.

At times the sea floor was anoxic. Rocks deposited under these conditions lack bioturbation, and are fine-grained, laminated pelbiomicrites and thin (<2 in. [5 cm]) black shales. The presence of an anoxic environment is further supported by the preservation of organic matter. These beds yield the highest TOC values.

The total thickness of black shales is about 45 feet (~13.5 m) in a formation thickness of 900 feet (~280 m). Thus about 5% of the rock volume averages ~1.0% TOC. We conclude that the Signal Mountain Formation may have generated commercial quantities of hydrocarbons. The burial history of the Formation suggests that it entered the oil window ~470 million years ago. This is significantly earlier than other source rocks in the southern Oklahoma area.

Microstructural Analysis in the Ouachita Frontal Zone and Arkoma Basin: Southeastern Oklahoma

JASON W. CURRIE and *KEVIN J. SMART*, School of Geology and Geophysics, University of Oklahoma, Norman

The Ouachita tectonic belt extends >2,000 km from western Alabama through Mississippi, Oklahoma, and on through to the Marathon region of southwestern Texas. The Ouachita tectonic system, like the Appalachians, formed following collision of Laurasia and Gondwana during the final assembly of Pangea in the Late Paleozoic. The Ouachita Mountains are the exposed part of the Ouachita tectonic system. The clastic-dominated Cambrian to Early Pennsylvanian sequence in Ouachitas contrasts with the Appalachians and its thick, lower Paleozoic carbonate sequence. My study area offers an opportunity to study foreland structural processes in a clastic-dominated fold-thrust system.

The Oklahoma Ouachitas have been generally subdivided into three zones based upon structural styles and stratigraphy, from north to south, into the Frontal Zone, the Central Ouachitas, and the Broken Bow Uplift. The Choctaw fault separates imbricated Pennsylvanian strata in the Ouachita Frontal Zone from the mildly deformed, Pennsylvanian and younger Arkoma Basin. Although, macrostructures in the frontal zone have been well studied for the past 70 years, the complete kinematics of this system, particularly small-scale processes, remains incomplete. Here, microstructural analyses are used to more fully constrain the kinematic development of the Frontal Zone and Arkoma Basin, and thereby help resolve the controversy and questions that surround the explanation in the structural style of the Ouachita Mountains. The data set yields information on variations in shortening direction and intensity along with data on the relative timing of thrust movements.

The target units are the Pennsylvanian Spiro sandstone in the frontal zone and Pennsylvanian Krebs Group sandstones in the Arkoma Basin. These units are well exposed in the study area, and provide appropriate markers for detailed microscale strain analysis. Appropriate sample localities will be selected in the study area with the aid of a digitized geological map. Oriented samples will be analyzed with thin sections that are photographed under transmitted light and cathodoluminescence. Normalized Fry and Rf/ϕ) methods will yield finite strains that can be analyzed with maps and cross-sectional profiles. Abundance and relative timing of microscale deformation mechanisms will be determined via systematic point-counting of microstructures. This work complements on-going research on Ouachita structural development and provides a starting point for more complete and systematic kinematic analyses of the Ouachita tectonic system.

AAPG Annual Convention

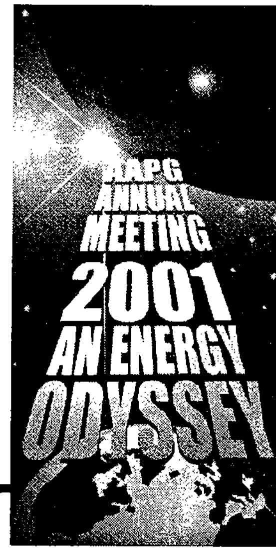
Denver, Colorado
June 3–6, 2001

On behalf of the Rocky Mountain Association of Geologists and the 2001 Coordinating Committee, I invite you to attend the 2001 convention of the American Association of Petroleum Geologists in Denver, June 3–6. Denver is the Mile High City, located in a spectacular setting at the foot of the Rocky Mountains, and convention participants can enjoy the beautiful panorama of the Rockies.

The theme of our meeting, "2001: An Energy Odyssey," underscores a dynamic period for the hydrocarbon industry. Our energy journey into the 21st century begins with concerns about oil and gas supplies and includes debates regarding the environmental impact of energy exploration and development.

The convention will provide an opportunity for you to continue your education and improve your skills. The technical program has been developed along themes of natural gas, petroleum systems, structure and tectonics, reservoir geology and characterization, depositional systems and stratigraphy, technology, business, and global environmental issues.

Plan on attending pre- and post-convention field trips or short courses. Optimize your 2001 Odyssey by visiting world-class outcrops of the Rocky Mountains and Colorado Plateau. Trips will extend in all directions from Denver and range from one-day excursions to eight-day adventures—odysseys in their own right! We are also offering many new and timely short courses.



In addition, SEPM will commemorate its 75th anniversary with a 1½-day, pre-meeting symposium titled "Sedimentary Systems in Time and Space—New Horizons." The symposium comprises invited talks that will address the exciting future directions of sedimentary geology in the 21st century.

The exhibition hall will feature more than 300 commercial and non-profit exhibits, the Prospect & Property Marketplace, the International Pavilion, the Career Center, and the Virtual Café.

Special entertainment will occur on Tuesday evening at Colorado's aquarium, Ocean Journey. The spectacular views of the Colorado Mountains at sunset and the lights of downtown will add to your enjoyment.

The convention truly has something for everyone. Please join us in Denver for a wonderful time.

Stephen A. Sonnenberg
General Chairman

Convention Agenda

Technical Program

Monday, June 4

The Executive Perspective on the Energy Odyssey of the 21st Century
Recent Advances in Structure and Tectonics
New Insights into the Origin, Migration, and Alteration of Petroleum
3-D and 4-D Seismic Case Studies
Frontier Deepwater Provinces—Global
Coalbed Methane
The Roles of Climate, Sediment Supply, and Structure on Sequence Development: Global vs. Local Controls
Late-Breaking E&P Activities around the World
Petroleum Systems in Extensional/Transtensional Settings
Pores to Reservoirs: Diagenesis in the 21st Century
CO_2 Sequestration I
Frontier Deepwater Provinces—Gulf of Mexico
Predicting, Detecting, and Characterizing Fractures
Using Ichnofacies to Delineate Stratigraphic Sequences, Interpret Environments, and Improve Reservoir Characterization

Tuesday, June 5

Giant Oil and Gas Fields of the Decade
Petroleum Systems in Compressional/Transpressional Settings
Approaches to Reducing Greenhouse Gas Emissions
Recent and Emerging Gas Plays around the World
SEPM Research Symposium 2001: A Delta Odyssey
Petroleum Systems of the South Atlantic
New Opportunities in Mature Basins around the World
Seismic Geomorphology of Clastic Sedimentary Systems
Evolution of Ideas and Technologies: Impact on Petroleum Exploration
Gas in the Rockies
High-Resolution Sequence Stratigraphy and Reservoir Characterization
Sediment Transport Processes Applied to the Interpretation of Deepwater Systems
Horizontal and Underbalanced Drilling for New Reserves
Sedimentary Responses to Tectonics: Linking Process to Stratigraphy I — Sedimentary Responses to Fault Displacement

Wednesday, June 6

Selected Outstanding Presentations from around the World

New Insights on Fluvial Systems and Architectures
The Wide World of Natural Gas: Origins, Modes of Occurrence, and Marketability
Marketing in the 21st Century in the Oil and Gas Exploration Business
Petroleum Systems in Canada and Mexico: Mexico
Advances in Carbonate Exploration and Production: Approaches, Methods, Technologies
Sustainability Forum: Integration of Metrics and Applications
Sedimentary Responses to Tectonics at Continental Margins: Linking Process to Stratigraphy II — Impact of Faults, Plumes, and Salt
Regional Framework of Deepwater Systems
Linked Extensional–Compressional Systems
Geologic Process Modeling: Recent Advances and Future Directions
CO_2 Sequestration II
Petroleum Systems in Canada and Mexico: Canada
Shoreline and Shelf Sand Bodies: Modern and Ancient Analogs for Reservoir Models
Character and Sequence Stratigraphy of Lacustrine Systems
Sedimentary Responses to Tectonics: Linking Process to Stratigraphy III — Sedimentary Responses to Compression

Short Courses

Pre-Convention

Ichnology and Sedimentology in a Sequence Stratigraphic Framework: Integrated Facies Models for Subsurface Analysis, *June 2–3*
Tight-Gas Fluvial Reservoirs: A Case History from the Lance Formation, Green River Basin, Wyoming, *June 2*
Petroleum Systems Approach to Resource Assessment, *June 2*
Basin-Centered Gas Systems—An Underevaluated Exploration Frontier, *June 2*
Surface Exploration for Oil and Gas in Mature Basins—Assumptions, Applications, and Recent Advances, *June 3*
Fold-Thrust Belts: Petroleum Potential, Global Setting, Geodynamic, *June 3*
Prospect Evaluation "Surgical Theater" and Workshop, *June 2–3*
How to Evaluate Carbonate Reservoirs from Well Logs, *June 2–3*
Deep-Water Sands, Integrated Stratigraphic Analysis—A Workshop Using Multiple Data Sets, *June 2–3*
Remedial Technologies for the New Millennium, *June 3*
Office 2000 for the Geoscience Professional, *June 2*
Production Decline Analysis and Economics for Geologists, *June 3*
Health Impacts of Coal—Should You Be Concerned?, *June 3*
Coalbed Methane—From Prospect to Production, *June 3*
3-D Seismic Interpretation: A Primer for Geologists, *June 2–3*
Practical Reservoir Characterization for the Independent Operator, *June 1–2*
Structural and Stratigraphic Interpretation of Borehole-Imaging Logs, *June 3*
Practical Interpretation Concepts, *June 2–3*

Post-Convention

E&P Methods and Technologies: Selection and Applications, *June 7–9*
Core Workshop: Petroleum Plays and Systems in the National Petroleum Reserve, Alaska, *June 7–8*

Field Trips

Pre-Convention

Geology of National Parks and Monuments of the Colorado Plateau, *May 25–June 2*
Beyond the Cross-Section: 3-D Deformation of Classic Foreland Structures, Wyoming, *May 31–June 3*
Traverse the Colorado Front Range—Denver, Colorado Springs, South Park, and Return, *June 2*
A Geological Reconnaissance of Dinosaur Ridge and Vicinity, *June 3*
Resource Development and Infrastructure in Harmony with the Environment—Two Colorado Examples, *June 2–3*
Energy Resources and Changing Land Use, Front Range of Colorado, *June 3*

Post-Convention

Sequence Stratigraphy Revealed by Cretaceous Outcrops of the Western Interior, Ferron Sandstone, Fall River Formation, and Muddy Sandstone (Utah, Wyoming, and South Dakota), *June 7–14*
Grand Canyon Geology via the Colorado River, Arizona, *June 10–18*
Reuse, Renew, Recycle—Two Colorado Cases: Rocky Mountain Arsenal National Wildlife Area and the National Renewable Energy Laboratory, *June 7*
Coalbed Methane Exploration and Resource Development, Raton Basin, Colorado, *June 6–8*
Sedimentology, Sequence Stratigraphy, and Basin Evolution of the Green River Formation in the Uinta and Washakie Basins: Insights for Lacustrine Hydrocarbon Systems, *June 6–10*
Stratigraphy, Facies Architecture, Paleoecology, Paleogeography, and Reservoir Characteristics of the Salt Wash Member of the Morrison Formation, Central Utah, *June 7–10*
Carbonate Reservoir Producibility: From High-Resolution Sequence Stratigraphy to Fluid Flow Simulation, Paradox Basin, Utah, *June 7–11*
The Petroleum System, Sequence Stratigraphy, Reservoir Compartmentalization and Geophysics, Central Denver Basin, Colorado, *June 7*
Book Cliffs Sequence Stratigraphy: The Desert and Castlegate Sandstones, *June 6–10*
Geology of Glen Canyon and Rainbow Bridge via Lake Powell, Utah–Arizona, *June 7–11*
Sequence Stratigraphy, Dolomitized Reservoirs, and Breccia Styles of the Lower Mississippian Madison Formation, Wyoming, *June 7–9*
Reservoir Rocks and Structural Traps of the Wyoming Foreland Basin Petroleum System, *June 6–8*

For more information about the annual meeting, contact AAPG Annual Convention, P.O. Box 979, Tulsa, OK 74101; World Wide Web: www.aapg.org/meetings/annual2001. *Preregistration deadline is April 26, 2001.*

notes on new publications

A Compilation of Existing Data for Aquifer Sensitivity and Ground-Water Vulnerability Assessment for the Caddo Indian Tribe in Parts of Caddo and Canadian Counties, Oklahoma

USGS Water-Resources Investigations Report 00-4089

The U.S. Environmental Protection Agency is working with the Caddo Indian Tribe to develop a Pesticide Management Plan to prevent contamination of ground water that may result from the registered use of pesticides. The purpose of this project was to assist the Caddo Indian tribe in developing a Pesticide Management Plan for about 900 mi^2 in parts of Caddo and Canadian Counties, Oklahoma, by providing information about aquifer-sensitivity and ground-water vulnerability assessment methods and digital data that can be used to develop assessment maps.

Written by Carol J. Becker, this 33-page report includes a CD-ROM containing six digital datasets that describe various hydrologic components of the aquifer: aquifer boundaries, ground-water level elevations, hydraulic conductivity, net recharge, surficial geology, and land-surface elevations, and eight data files that describe physical and cultural features and boundaries in the study area. Additionally, the CD-ROM contains files of depth to ground-water measurements and nitrogen concentration in ground water, retrieved from the U.S. Geological Survey National Water Information System database. The report also describes digital data and information from other sources that can be used with assessment methods. An annotated list of aquifer sensitivity and ground-water vulnerability assessment methods and a list of pesticides associated with some of the crops grown in Caddo County are included.

Order WRI 00-4089 from: U.S. Geological Survey, Water Resources Division, 202 N.W. 66th St., Bldg. 7, Oklahoma City, OK 73116; phone (405) 843-7570; fax 405-843-7712. A limited number of copies are available free of charge.

Reconnaissance of the Hydrology, Water Quality, and Sources of Bacterial and Nutrient Contamination in the Ozark Plateaus Aquifer System and Cave Springs Branch of Honey Creek, Delaware County, Oklahoma, March 1999–March 2000

USGS Water-Resources Investigations Report 00-4210

The results of a reconnaissance investigation of the hydrology and water quality in streams and ground water near Honey Creek, Delaware County, are described in this report.

The report characterizes: (1) the hydrogeologic units in the region and the directions of ground- and surface-water flow with maps of water-table altitudes during greater and lower stream flow and maps showing gaining and losing reaches of the streams; (2) the quality of water with diagrams comparing differences in water chemistry and bacterial counts between wells, and tables describing the distribution of fecal bacteria, antibiotic resistance in *Escherichia coli*, and ribotypes of *E. coli* in the ground and surface water; and (3) indications of probable sources of bacteria and nitrate detected in the ground water. The 66-page report was written by Jamie L. Schlottmann, Ralph Tanner, and Mansour Samadpour.

Order WRI 00-4210 from: U.S. Geological Survey, Water Resources Division, 202 N.W. 66th St., Bldg. 7, Oklahoma City, OK 73116; phone (405) 843-7570; fax 405-843-7712. A limited number of copies are available free of charge.

Selected Trace Metals and Organic Compounds and Bioavailability of Selected Organic Compounds in Soils, Hackberry Flat, Tillman County, Oklahoma, 1994–95

USGS Open-File Report 97-0828

Prepared by M. F. Becker in cooperation with the Oklahoma Department of Wildlife Conservation and the Oklahoma Geological Survey, this report contains 12 pages.

Order OF 97-0828 from: U.S. Geological Survey, Information Services, Open-File Reports, Box 25286, Federal Center, Denver, CO 80225; phone (303) 202-4210. Cost is $5 for a paper copy and $5 for microfiche, plus $3.50 per order for handling.

Oklahoma abstracts

The Oklahoma Geological Survey thanks the American Association of Petroleum Geologists and the Geological Society of America for permission to reprint the following abstracts of interest to Oklahoma geologists.

Detailed Reservoir Modeling on a Basinwide Scale and Implications on the Decision Making Process

PAUL W. SMITH, WALTER J. HENDRICKSON, and *RONALD J. WOODS,* Geological Data Services, Oklahoma City, OK 73108

More than 4,000 wells producing from the sandstones belonging to the Morrow Group (Pennsylvanian) and underlying Springer Group (Mississippian–Pennsylvanian) were the subject of detailed reservoir analysis within portions of the Anadarko Basin (USA). Within the study area, these reservoirs will ultimately produce more than 8 TCF gas, with individual completions >25 BCF gas. Because the area has been drilled by many companies, a large variation in the drilling and completion techniques has been observed, consequently, large variation in the results exists. Detailed stratigraphic correlation resulted in accurate reservoir nomenclature throughout the study area that allowed the examination by specific reservoir and within subsets of wells with similar parameters.

The results were unexpected and should have significant impact on the decision making processes in both exploration and development efforts. For example, mud balance influences how much mud invades a zone. When it is combined with pH of the water, the mud pH demonstrates the more impact on ultimate recovery than any single drilling or completion factor examined. Interestingly, mud water loss (typically below 8 ml) did not appear to have much impact upon this observation. Another observation suggests that the practice of perforating selected intervals of a reservoir had a direct relationship to ultimate recovery—usually not favorable. Extensive stratigraphic correlations, detailed geologic analysis, and the findings presented demonstrate that changes in the decision making process should result in opportunities for significant infield development, trend extensions, and the further exploration in what may be considered a "drilled out" play.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 85, p. 389–390, February 2001.

Petroleum Charge to the Mill Creek Syncline and Adjacent Areas, Southern Oklahoma

ALTON A. BROWN, Consultant, Richardson, TX

Woodford-generated oil is produced from fields in the Mill Creek Syncline, north of the Arbuckle Uplift, yet none of the preserved Woodford source rock in the syncline is thermally mature. The burial and tectonic history of the Ardmore Basin and Arbuckle Uplift were analyzed to understand where this oil came from.

Geohistory models of the deep Ardmore Basin demonstrate that Woodford oil generation initiated during Early Desmoinesian, reached peak oil window by middle Desmoinesian, and entered the gas generation zone during Late Pennsylvanian. An estimated 40 billion barrels of oil were generated from the Woodford Formation in the central and eastern Ardmore Basin.

Uplift of the Arbuckle Anticline and related structures initiated during Late Desmoinesian, after initiation of Woodford oil generation in the Ardmore Basin. Ardmore Basin oil generated before uplift could migrate to the Mill Creek Syncline by updip, stratal migration. After Late Desmoinesian deformation, the migration pathway was destroyed, and north-migrating oil seeped to the surface south of the uplifts. Woodford oil charge to the Mill Creek Syncline could only have occurred during the Desmoinesian. Stratigraphic evidence supports this timing. The Buckhorn asphalt is actually a sea-floor oil seep of Early Middle Desmoinesian age, demonstrating petroleum migration at this time. Major asphalt deposits are truncated by Late Virgilian strata, indicating charge prior to late Virgilian. Asphalt deposits form a migration chain documenting south to north migration.

Almost all Woodford-sourced oil accumulations in Southern Oklahoma date from the Pennsylvanian or Early Permian. Although Woodford shale over much of the western Ardmore Basin is now in the oil window, generation and migration since the Pennsylvanian has been negligible due to absence of renewed burial. Characteristics of older accumulations include large seepage anomalies, incomplete fill due to longer duration of leakage, and thick residual saturation zones which make identification of productive zones more difficult.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 85, p. 385, February 2001.

A Model for the Discovery of a Hydrocarbon Bearing Listric Fault System

DAVID P. STAPP, Independent Consulting Geologist for Black Oil Company, Inc., Addison, TX

The occurrence of hydrocarbon-trapping listric fault systems has been known in the latter history of oil and gas exploration. The fault mechanisms associated with these types of structural occurrences are not simple expressions of linear/hinge type movements. The after-reaction of a major structural component is not necessarily a rare situation and has been well recognized in the exploitations of hydrocarbons. Such an example of a listric fault system in a highly complex basinal area has been identified in the Marietta–Ardmore Basin of Southern Oklahoma and North Texas. We conclude that the simultaneous action of the generation of the Sherman Anticline and a listric fault system in Grayson County, Texas, has generated a small but very prolific structural/stratigraphic accumulation of hydrocarbons. The asymmetrical Sherman anticline lies about four miles southwest of the Ouachita thrust front, with its axis more or less parallel to the thrust front, suggesting that the final or thrusting movements may have influenced its structural development. The movement of this feature probably induced the generation of a listric fault with rollover folds which are very important structural traps in the John Hudgins lease of Grayson County, Texas. Being located toward the foreland portion of the basin, these folds are probably within a passive margin of the basin. The gravitational action thus formed longitudinal folds as a result of movement on the listric fault system. Thus the accumulation of hydrocarbons in the clastic sequences of lower Pennsylvanian age (Baker and Davis) formations has occurred in these rollover folds, especially since the Baker is sourced by the Atoka shales just below and the Davis is recognized by most geologists familiar with this basin as petroliferous. The identification of this listric fault system was isolated from a 3-D seismic program coupled with a regional geologic and geophysical foreknowledge of the character of the basin. Characterization of this fault system in such a structural trap has provided the basis for the revelation of a new oil and gas field, and the resulting optimization of well placement for optimum reservoir drainage.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 85, p. 390, February 2001.

Pitfalls in the Use of Piercing Points for Slip Estimates, Wichita and Arbuckle Uplifts

CHRISTOPHER R. SAXON, Chevron U.S.A., 11111 Wilcrest, Houston, TX 77099

Numerous workers have made use of piercing points to estimate slip direction and magnitude for the Wichita and Arbuckle Uplifts. Due to the subsurface nature of these uplifts, most studies have relied on offsets of isopach contour lines as piercing points.

These studies have yielded inconsistent results, with extreme variability in both magnitude direction of slip. This paper examines methods used in previous studies, identifies factors which control slip estimates, examines the control and reliability of the data used in the slip estimates, and questions the use of highly subjective interpretational data as piercing points. Problems which plague previous estimates include: poorly documented fault geometry, inappropriate horizons used as piercing points, use of subjective contour interpretations as piercing points, insufficient well control, and inappropriate restoration methods. Piercing point arguments have been applied to two models of fault geometry for the region: high-angle faulting associated with wrench faults and low-angle oblique-slip thrusts. The author finds no credible evidence amongst the published data which support significant amounts of lateral slip for either model.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-316.

Felsic Magmatic Cycles and Rifting Rates

JOHN P. HOGAN, Dept. of Geology and Geophysics, University of Missouri–Rolla, Rolla, MO 65409; and *CHARLES M. GILBERT*, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019

The A-type felsic igneous rocks of the Cambrian Southern Oklahoma Aulacogen (SOA) are part of a recurring sequence of extrusion-intrusion: rhyolite followed by finer-grained granites then rhyolite followed by coarser-grained granites. The granites all intrude at the same general stratigraphic/structural horizon. This horizon is between a lower eroded mafic layered complex and the upper earliest rhyolites. The felsic magmas forming these igneous units are sufficiently similar that the question arises: what causes some magmas to erupt at the surface and others to intrude along this horizon? The concepts of Crustal Magma Trap (CMT) and Magma Driving Pressure (MDP) offer an explanation which may have general applicability.

The CMT in this rift environment was formed by accumulation of rhyolites on the mafic complex. Variations in MDP for similar magmas are functions of source depth and rifting rate. Deeper source depths generate higher MDPs. Faster rifting rates also effectively cause higher MDPs. For the SOA, plausible arguments exist for a source depth (pooled magma sufficient to rise toward surface) of around 15 km. Thus if source depth can be held constant, then the most likely factor causing high MDP is fast extension. Where MDP is high, felsic magma will penetrate many CMTs and erupt as rhyolite. Slower extension favors intrusion of granites. In this cycle, coarser granites intrude finer granites because the CMT is at a higher pressure due to the increased buildup of rhyolite with the next phase of more rapid extension.

Study of such felsic sequences in other extensional environments could potentially also yield closer ties between tectonism and magmatism.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-399.

Early Permian Sedimentation Patterns Related to the Transition Between the Wichita Uplift and the Anadarko Basin

R. NOWELL DONOVAN, *KATHY COLLINS*, and *STEVE BRIDGES*, Dept. of Geology, Texas Christian University, Fort Worth, TX 76129

During the Phanerozoic, a dominant tectonic control in southern Oklahoma has been a N60W-trending zone of crustal rupture, recognized in a general sense as the Southern Oklahoma aulacogen. A Cambrian igneous phase was followed by Early Paleozoic definition of a linear depocenter. Quantitatively, most of the rocks deposited during this period were carbonates. During the upper Paleozoic, the aulacogen differentiated into a series of linear uplifts and basins. As a result of this partial inversion, erosion of the lower Paleozoic sedimentary sequence, as well as parts of the igneous basement, took place in the Wichita uplift.

Sediment shed from this uplift was deposited in the adjacent Anadarko basin. Tectonic definition drew to an end in the earliest Permian and the topographic relief of the area was gradually reduced. Increasing aridity in the Permian led to the gradual cessation of weathering and eventual entombment of the landscape. Distinctive continental facies include fault scarp recession breccias, talus deposits, and braided alluvium. Fissure-related karst is a feature of the Permian land surface. In a climate that became increasingly arid, numerous calcretes record periods of geomorphic and hence tectonic stability. The increased frequency of calcretes in sections in and adjacent to the Wichita uplift suggests that such sections are condensed by comparison to sections farther to the north in the Anadarko basin. In condensed sections numerous hiati are present and reworked clasts of calcrete are commonly seen. In addition, in some cases the Permian land surface is directly mantled by calcrete.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-465.

Pennsylvanian Deformation in the Ring Top Mountain Area, Eastern Slick Hills, Southern Oklahoma

J. FAIRBANKS and *R. N. DONOVAN*, Dept. of Geology, Texas Christian University, Fort Worth, TX 76129

The Slick Hills in southern Oklahoma, which are part of the Southern Oklahoma aulacogen, are formed from Lower Paleozoic rocks that were intensively deformed during the Pennsylvanian, when the original aulacogen-defining faults were reactivated. Dominant structural grain is WNW–ESE. The Hills are divided into eastern and western ranges by the Blue Creek Canyon fault (BCCf), an oblique (left lateral) high angle reverse fault. Fault throw varies from ~2,000 to ~9,000 ft, with stratigraphic displacement down to the southwest. In a regional context, the BCCf is an oblique back thrust which, in the Ring Top Mountain area, has a north–south trend. This anomalous bend in the BCCf trace probably resulted from the reactivation of a Cambrian fracture pattern in the igneous core of the Wichita uplift. This bend has created a restraining bend in the Frontal fault zone between the Wichita uplift and the Anadarko basin. Two further faults, the Ketch Creek fault (KCf) and the Ring Top thrust, plus some intense small scale folding, take up part of the strain.

The restraining bend had the effect of creating a zone of nearly pure compression in the Ring Top Mountain area immediately east of the BCCf. Failure involving the igneous basement is recorded by the KCf, whereas the Ring Top thrust records detachment at a low level in the Cambrian sedimentary section. When traced to the north, the KCf terminates into a series of folds and several approximately east/west normal faults develop in the northern part of the Eastern Slick Hills at precisely the position where the BCCf resumes its region northwest/southeast trend.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-384.

Mantle and Crustal Xenoliths from the Prairie Creek Lamproite Province, Arkansas

D. DUNN, D. SMITH, and *F. W. McDOWELL*, Dept. of Geological Sciences, University of Texas at Austin, Austin, TX 78712; and *S. C. BERGMAN*, Dept. of Geosciences, University of Texas at Dallas, Richardson, TX 75080

Crustal and mantle xenoliths have been recovered from diamond bearing olivine lamproite at the Black Lick and Twin Knobs satellite pipes in southwestern Arkansas. The xenoliths are less than 3 cm fragments of rock crushed during evaluation of the diamond contents of the lamproites. Major element mineral chemistry of over 20 peridotite xenoliths have been analyzed by electron probe. Spinel peridotite and garnet peridotite xenoliths represent relatively depleted mantle lithosphere; olivine compositions range from Fo90 to Fo92.6 and average Fo91.2. All but three peridotite xenoliths record depths less than about 100 km and temperatures below ~900°C. Calculated values near and below 800°C may represent blocking temperatures rather than ambient mantle conditions, as indicated by zonation within pyroxene grains and by discrepancies between thermometers. The two samples from greatest depth are among the most depleted, one with Fo92.4 olivine and 8.4 wt% Cr_2O_3 in garnet, and hence the depleted root extends below the ~150 km depth they record. Calculated values for these two xenoliths are about 4.5 GPa and 960°C, similar to those on xenolith geotherms for Archean cratons. These xenoliths document that a cool and depleted mantle root was present below southwestern Arkansas in the Cretaceous.

The xenolith assemblage documents characteristics of an extension of the midcontinent craton below southwestern Arkansas. Crustal xenoliths are predominantly amphibolite; gabbro, granite, rhyolite, and gneiss are less common, and granulite is rare. The granitoid association is like that of the 1.2–1.4 Ga granite-rhyolite terrain exposed in the Arbuckle Mountains of southeastern Oklahoma. K-Ar isotopic ages of amphibole from four xenoliths are: 1.48 Ga, 1.43 Ga, 1.43 Ga, and 1.31 Ga. These cooling ages confirm continental crust of 1.4 Ga in age extends below tbe lamproite localities and that thermal effects of the younger Grenville and Ouachita orogenies were insufficient to reset the amphibole ages.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-386.

Sandstone Petrography of the Atoka Formation (Middle Pennsylvanian) and the Timing of the Ouachita Orogeny, Southern Midcontinent, United States

JASON E. COMBS, WALTER L. MANGER, and *DOY L. ZACHRY*, Dept. of Geosciences, University of Arkansas, Fayetteville, AR 72701

The Atoka Formation (Middle Pennsylvanian) is the only lithostratigraphic unit recognized in all three provinces comprising the Paleozoic area of the southern midcontinental margin (Arkansas and Oklahoma): Ozark dome, Arkoma basin, Ouachita orogen. The Atoka Formation in the Arkoma foreland basin represents the transition in deposition from epeiric "shallow" water conditions to an oceanic trough setting along the southern midcontinent. The lower Atoka Formation is characterized by mature quartz arenites comprising recycled, highly spherical grains derived by reworking older strata mixed with first cycle quartz from a cratonic source. In outcrop, this interval contains marine fossils and bioturbation suggesting deposition in a stable upper shelf setting. The lower Atoka exhibits a blanket geometry across the southern Ozarks and the northern Arkoma basin, but changes facies into flysch in the southern Arkoma basin and Ouachita orogen. The middle and upper Atoka Formation contains quartz sandstones that are immature, sublitharenites characterized by MRFs, feldspars and chert, but lacking populations of reworked quartz. In outcrop, these intervals lack significant strata deposited in open marine conditions based on absence of macrofossils and fossil detritus in the sand fraction. The middle Atoka Formation is dominated by shale, while the upper Atoka is dominated by quartz sandstone in both surface exposures in the southern Ozarks and northern Arkoma basin. There is a pronounced thickening of the middle and upper Atoka Formation into the southern Arkoma basin, where sandstones tend to characterize both intervals. Coeval deposits in the Ouachita orogen comprise flysch of essentially equal amounts of sublitharenitic-subarkosic sandstones and shale.

Timing of the Ouachita orogeny has been problematic. Previous studies agree on a Pennsylvanian age for the main portion of the orogeny, but initiation of deformation in the Mississippian and continuation into the Permian have found some support. Character of the Atokan sandstones and their distribution suggest that the initiation of the Ouachita orogeny did not occur until middle Atokan time, increasing in activity into upper Atokan time. Basin fill and compressional tectonics were complete by the end of the Desmoinesian.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-9–A-10.

Rifting of the Argentine Precordillera from Southern Laurentia: Palinspastic Restoration of Basement Provinces

WILLIAM A. THOMAS, Dept. of Geological Sciences, University of Kentucky, Lexington, KY 40506; *ROBERT D. TUCKER*, Dept. of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130; and *RICARDO A. ASTINI*, Cátedra de Estratigrafía y Geología Histórica, Universidad Nacional de Córdoba, Córdoba, Argentina

Ages of basement rocks support the interpretation that the Argentine Precordillera was rifted from the Ouachita embayment of southern Laurentia. The Laurentian Grenville province (~1.0 to 1.3 Ga) and its northwestern boundary with the Granite-Rhyolite province (1.3–1.4 Ga) are documented both west and east of the Ouachita embayment; whether the rifted margin of the Ouachita embayment crosses the Grenville Front to older basement is not known. New U-Pb zircon and baddeleyite analyses confirm ages of 1317 ± 2 to 1323 ± 1 Ma for granite and gabbro in the St. Francois Mountains (Ozark uplift) and 1364 ± 2 Ma for granite in the Arbuckle uplift, north and west of the Ouachita embayment, respectively. Grenville-age basement rocks are known from xenoliths in Tertiary plutons in the central Precordillera and from the Pie de Palo basement uplift on the east. New U-Pb zircon analyses yield ages of 1205 ± 1 and 1204 ± 2 Ma for basement rocks at Ponon Trehue in the southern Precordillera.

In the northern Precordillera, west-facing Ordovician slope deposits contain olistoliths, including synrift conglomerate of basement-rock clasts. U-Pb zircon ages of basement clasts are 1367 ± 5 and 1370 ± 2 Ma, identical to age of basement of the Arbuckle uplift, suggesting palinspastic restoration in which the northwest corner of the Ouachita embayment crossed the Grenville Front and incorporated older Laurentian basement into the northwest corner of the Precordillera. This restoration places the Precordillera tightly within the Ouachita embayment, and eliminates the possibility of other basement terranes between Laurentia and Precordillera.

Time of rifting is constrained by new dates of synrift rhyolites in the Arbuckle uplift along the Southern Oklahoma fault system which is parallel with the Alabama-Oklahoma transform fault between Laurentia and the Precordillera. Arbuckle synrift rhyolites yield U-Pb zircon ages of 536 ± 5 and 539 ± 5 Ma, consistent with ages of 530 to 535 Ma for synrift igneous rocks of the Wichita Mountains farther west along the Southern Oklahoma fault system.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-505.

Were Ancestral Rockies Tectonics Driven by Appalachian–Ouachita Collisions? Temporal and Kinematic Constraints

WILLIAM A. THOMAS, Dept. of Geological Sciences, University of Kentucky, Lexington, KY 40506; and *ROBERT D. HATCHER, JR.*, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996

Ancestral Rockies structures are dominated by large vertical separation on reverse and strike-slip faults bracketed between early Pennsylvanian and middle Permian time; timing and slip sense vary locally. These basement structures on the southwestern Laurentian craton are linked to the eastern margin of Laurentia by the Southern Oklahoma fault system, which had a similar faulting history. Most, if not all, of the late Paleozoic faults reflect reactivation of older basement faults during times of suitable stress orientation.

Times, orientations, and styles of collisions varied along the Appalachian–Ouachita margin of Laurentia but generally overlapped the time span of Ancestral Rockies and Southern Oklahoma faulting. Alleghanian (Appalachian) orogenesis reflects continent-continent collision from the Newfoundland promontory to the Alabama promontory. Southwest-directed, dextral transpression through the Appalachian internides (latest Devonian to early Permian) rotated to cratonward-directed thrusting from the Pennsylvania embayment to the Alabama promontory (middle Mississippian to early Permian). Transpressional-rotational collision and juxtaposition of promontories and embayments along the pre-collision continental margins produced temporally variable stress distribution.

Ouachita arc-continent collision began in middle Mississippian time and migrated westward along the southwest side of the Alabama promontory into the Ouachita embayment, where southward subduction of Laurentia ended in the middle Pennsylvanian. In contrast, arc-continent collision in the Marathon embayment began in middle Mississippian and continued into early Permian time. Geophysical data show that a remnant ocean within the Ouachita embayment was not completely closed, suggesting primarily vertical tectonic loading rather than compressional deformation of the continental margin.

Coincidence of timing of Appalachian–Ouachita collisions and intracratonic faulting in the Ancestral Rockies suggests a genetic association. Orientation and magnitude of compressional stress transmitted into Laurentian crust varied significantly through time, suggesting potentially complex patterns of reactivation of old basement faults.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-384.

Regional Context of Ancestral Rockies Tectonism

WILLIAM R. DICKINSON, Dept. of Geosciences, University of Arizona, Tucson AZ 85721

Thc geotectonic causation of Pennsylvanian basins and associated uplifts of the Ancestral Rockies remains unclear because the deformational province forms neither a discrete belt nor a coherent domain, and no close modern analogues are evident. Ancestral Rockies structures disrupted the Laurentian continental block along trends lying at high angles to the Mesoamerican (Ouachita) continental margin and to Precambrian age belts defining the basement grain of the craton. Direct analogy with internal disruption of modern Eurasia in response to stresses propagating from the collision of the Indian subcontinent fails because interior Asia forms part of the overriding plate at the Himalayan suture, whereas Laurentia was part of the underriding plate at the Ouachita suture. Moreover, Ouachita orogenesis emplaced an overthrust accretionary prism atop the edge of the continental block, but did not involve basement thrust sheets reflective of forceful crustal interaction, as observed in the Himalayas. Relating Ancestral Rockies tectonism to any events along the Cordilleran margin is unpromising because deformation postdated the Devonian–Mississippian Antler orogeny and predated the Permian–Triassic Sonoma orogeny. During mid-Mississippian to mid-Permian time, terrestrial platforms, marine shelves, the oceanic Havallah basin, and a dormant offshore remnant arc intervened between tectonic elements of the Ancestral Rockies and any subduction system associated with Cordilleran–Paleopacific interaction. Analogy with subduction-related deformation of the Cretaceous–Paleogene Rockies is frustrated by lack of evidence for Pennsylvanian arc magmatism along the Cordilleran margin, apart from an island-arc assemblage in the Klamath Mountains, by evidence for extension rather than contraction provided by the Havallah basin, and by geochronology showing that the Permian–Triassic arc of eastern Mexico postdated final closure of the Ouachita suture in earliest Permian time. The timing of Ancestral Rockies development, coincident with sequential closure of thc Ouachita suture (east to west), suggests that intracontinental strain was induced by stresses associated with continued subduction of westerly parts of Laurentia after more easterly parts had locked against Gondwana.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-384.

Laramide-Style Structure and Ancestral Rockies Origin of Middle-to-Late Paleozoic Deformation in the Central Midcontinent, USA

J. H. McBRIDE and *W. J. NELSON*, Illinois State Geological Survey and Dept. of Geology, University of Illinois, 615 E. Peabody Dr., Champaign, IL 61820

Despite the fact that the Illinois basin is one of the world's most heavily studied intracratonic basins, little is known about the structure of folds and faults affecting lower Paleozoic and Precambrian rocks. This is because of a lack of outcrops and because, until recently, few seismic reflection profiles were available. In order to understand the origin and structural style of deep Paleozoic and basement deformation, we have pursued a vigorous program of collecting seismic profiles from the central U.S. Midcontinent previously shot by the petroleum industry.

The dominant structures in the Illinois basin are mostly N- and NW-trending, asymmetrical anticlines and monoclines, such as the La Salle anticlinorium. Limited outcrop data from the eastern flank of the adjacent Ozark dome show mostly reverse faults and attendant monoclines. Reflection profiles over the major folds and monoclines of the Illinois basin reveal deep-seated faults penetrating lower Paleozoic strata and underlying basement that propagate up into the cores of folds. The asymmetry of some folds as expressed in Mississippian and Pennsylvanian strata suggests the possible presence of a deeper, facilitating reverse or thrust fault. A distinct forward hinge point typically appears at the top of Precambrian basement beneath folds mapped in Paleozoic strata. Truncated and offset intra-basement reflectors below this hinge imply a reverse fault within Precambrian rocks.

These results demonstrate how deep faulting has facilitated folding of basin sediments in a style analogous to late Cretaceous Laramide-style fault-propagation folding in the Rocky Mountain foreland and Colorado Plateau. Both the style and timing of the deformation match those of the "Ancestral Rockies" orogeny of the southern Midcontinent and Rocky Mountains.

Deformation in the Illinois basin has generally been attributed to the nearby late Paleozoic Appalachian–Ouachita (Alleghanian) orogeny, even though the Illinois basin's compressive block structural style is foreign to the Appalachian foreland, and basin structures were most active before the Ouachita collision (Desmoinesian) and the climax of the Alleghanian orogeny (early Permian). Illinois basin structures underwent major uplift during latest Mississippian through early-middle Pennsylvanian time, with continued uplift through late Pennsylvanian and probably into Permian time.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-465.

The Effect of High Sedimentation Rates on Density and Lithological Distribution of Natural Fractures in Carboniferous, Clastic Rocks of the Western Ouachita Mountains

AMY E. WHITAKER, Dept. of Geosciences, Pennsylvania State University, University Park, PA 16802

Natural hydraulic fractures occur where elevated pore pressures overcome the compressive forces of the earth and induce a net tensile stress. The goal of this project is to map the mechanical response of sandstone of a continental deltaic sequence to compaction-induced fluid pressures under sedimentation rates exceeding 1 km/Ma. Specifically, this investigation aims to develop a model that predicts the distribution and density of natural hydraulic fractures in sandstones as a function of specific sedimentation rates and to further constrain the conditions under which pore fluid pressures become large enough to fracture the rock.

We hypothesize that natural hydraulic fractures develop in sediments where the sedimentation rate exceeds the ability of the sediment to drain trapped pore fluids. As the rate of sediment accumulation increases, this threshold should be attained in increasingly permeable sediments. In eastern Oklahoma, the Carboniferous sequence of Stanley Group, Jackfork Group, and Atoka Formation was deposited at sedimentation rates up to and exceeding 1 km/Ma. These units are ideal for elucidating the relationship between fracture development and sedimentation rate, as their relative sedimentation rates are well documented.

The first phase of this project, undertaken in June 2000, was a field investigation in Oklahoma, visiting Stanley, Jackfork, and Atoka outcrops and characterizing joint development. The field data will be used to produce a joint probability analysis for the various lithologies for specific sedimentation rates and then compared to joint data sets from the Appalachian Plateau, where Alleghanian tectonic compaction rates were comparable.

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 84, p. 1876, November 2000.

Ouachita Mountains Tectonic Development: Insights from Meso- and Macroscale Structural Analyses in the Potato Hills, Southeastern Oklahoma

GALEN W. MILLER and *KEVIN J. SMART*, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019

The Ouachita Mountains are part of a 2000+ km long orogenic system that represents the Late Paleozoic closure of the Iapetus Ocean following collision of Laurentia and Gondwana during the final assembly of Pangea. Although they share similarities with their counterpart the Appalachians, the Ouachita fold-thrust belt is characterized by clastic-dominated stratigraphic package that lacks a strong Early Paleozoic carbonate "strut." Also, the Ouachita history appears less complicated than the Appalachians in that only the final collisional event is recorded in the geologic record. Frontal Ouachita exposures of Pennsylvanian and younger strata offer opportunities for analyzing the latest stages in the Ouachita evolution. The early tectonic evolution, however, is less clear since only small areas expose strata that might record these events. In this work, we have examined the Potato Hills region of the Central Ouachitas with the intention of providing greater insight into the tectonic evolution of the Ouachitas.

Within the Potato Hills, pre-orogenic Ordovician through Mississippian shales and cherts are exposed in an otherwise younger sequence of Mississippian and Pennsylvanian sandstones and shales. Recently completed 1:24,000-scale mapping together with mesostructural analyses document the deformation of the pre-orogenic strata in the Ouachita Mountains. The Potato Hills exhibit a series of doubly plunging anticlines and synclines orientated roughly 070–085 that plunge more steeply to the west. This near-surface geometry is consistent with previous interpretations of hanging-wall deformation above a deeper folded thrust system. The deformation intensity in the Potato Hills, as shown by multiple scales tight folds and a weakly developed cleavage, is considerably greater than in the surrounding Central Ouachitas. As such, the Potato Hills structures may offer clues to the early stages of Ouachita deformation that have heretofore only been hinted at in areas such as the Broken Bow and Benton Uplifts.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-384.

Deposition and Diagenesis of Mississippian Chat Reservoirs, North-Central Oklahoma

SUZANNE M. ROGERS, Independent Geologist, 1308 N.W. 183rd Terrace, Edmond, OK 73003

The Mississippian "chat," present at the unconformity between the Pennsylvanian and Mississippian in north-central Oklahoma and south-central Kansas, is a weathered and/or detrital interval of highly porous or hard, tight chert at or near the top of the Osagean. Hydrocarbon exploration and development of these rocks has been going on for more than 50 years. Study of well logs and completion records of more than 6,600 wells in north-central Oklahoma shows that the chat is widespread but not continuous and that chat reservoirs are very heterogeneous.

The depositional environment and diagenetic alteration of the chat suggest it formed through a combination of uplift and either erosional detritus or weathering-in-place of Osagean Mississippian cherty limestone. Fossiliferous clasts found in chat cores were likely eroded in a high-energy environment such as that found above wave base in Mississippian shallow seas. The limestone clasts were transported by small-scale debris flows into a lower energy environment and deposited in a lime mud matrix. The chat-producing trend beginning in T25N, R3E in Osage County, Oklahoma, and extending eastward beyond the study area for about 20 mi suggests a relationship between probable shelf-edge erosion and the development of a chat reservoir. Other chat deposits formed from the weathering-in-place of Mississippian limestone on structural highs.

Thin sections reveal that diagenesis resulted in partial replacement of calcite shells and cement with silica following the debris flow. Preserved original fossil structures suggest molecule by molecule silica replacement of calcite. Dissolution of remaining calcitic material, possibly by meteoric water, created secondary porosity and a potential hydrocarbon reservoir.

The chat appears on well logs as a low-resistivity zone having low density and high porosity that, by normal interpretation methods, would calculate wet and nonproductive. Oil and gas produced from such zones are generally accompanied by salt water. Examination of drill cuttings can indicate whether the zone is highly porous or dense chert, with the former needed for a quality reservoir.

Commercially productive zones generally have a minimum porosity of 25–30% and water saturations less than 80%. Micrologs provide indications of permeability that in core analysis is low (0.1 to 50 md; average <20 md). Completion techniques should be designed for a siliceous reservoir containing detrital clays and no carbonate. Fracture treatment can generate additional permeability. Ultimate recovery from unitized fields having tens of wells ranges from 1 to 4 million bbl of oil and 1 to 3 bcf gas. Individual wells in good-quality reservoirs have produced more than 150,000 bbl of oil and varying amounts of gas from depths of 3,000 to 5,000 ft (914–1,524 m).

Reprinted as published in the American Association of Petroleum Geologists *Bulletin*, v. 85, p. 115–116, January 2001.

Evidence for Late Holocene Episodic Dune Reactivation in Central Oklahoma

GREGORY SCOTT, USDA-NRCS, 4900 W. Oklahoma St., Suite 300, Woodward, OK 73801; and *KENNETH LEPPER*, Dept. of Physics, Oklahoma State University, Stillwater, OK 74078

Extensive deposits of eolian sand occur on the northeast side of the Cimarron and North Canadian Rivers in Oklahoma. Dune fields occur on all levels of the fluvial terraces and are subject to reactivation during drought. Previous soil/stratigraphic studies showed that dunes along the Cimarron have a complex history of accumulation and truncation throughout the Holocene.

During times of stability, the surface soil horizon accumulates organic matter. Subsequent sand deposition buries the surface, preserving a soil horizon that can be radiocarbon dated, but only the buried surface horizon has enough carbon to date. In many cases buried surfaces fail to accumulate sufficient carbon for dating, or are truncated prior to burial. Because radiocarbon dates organic matter that accumulates over many hundreds of years, its application is restricted for time periods dominated by eolian processes. In contrast, optically stimulated luminescence (OSL) dating can provide depositional ages for the sediments themselves. Eolian sediments are optimal for OSL dating and the technique has been effectively utilized in numerous studies of eolian deposits in the U.S. Within a region of similar climate, physical weathering and soil development can provide another method to estimate the age of eolian landforms.

In this study radiocarbon dating, OSL dating, and soils data have been used in a complementary fashion to investigate the timing of Late Holocene eolian episodes in Central Oklahoma. Selected dune deposits adjacent to the Cimarron and North Canadian Rivers were examined and sampled. In at least one case, a set of stratigraphically paired samples was obtained from a buried A horizon for radiocarbon and from an overlying C horizon for OSL dating. Correlation of the dates from different depths in the dunes was used, where possible, to estimate accumulation rates. The results of this study are compared with similar work in adjacent states and discussed in the context of local versus regional activity.

Reprinted as published in the Geological Society of America *2000 Abstracts with Programs*, v. 32, no. 7, p. A-22.