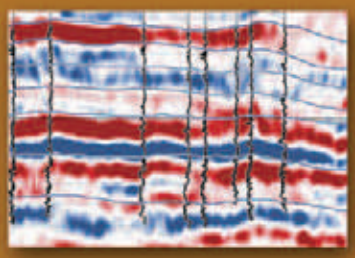
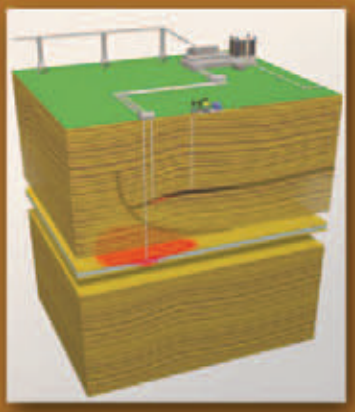
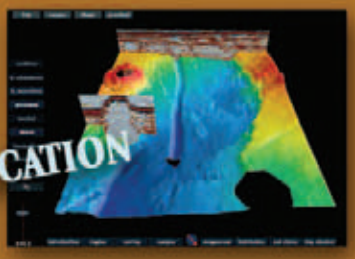
# Annual Report 2005






## Bureau of Economic Geology

Scott W. Tinker, Director
John A. and Katherine G. Jackson School of Geosciences
The University of Texas at Austin
Austin, Texas 78713-8924

# Bureau of Economic Geology

## Director's Message

It seems I spend half my time in an airplane. Travel these days is not very glamorous. Drive to the airport; shuttle to the terminal; process through security; pack onto an airplane; tram to a connecting flight; bus to a rental car lot; drive to a hotel; metro to a meeting; taxi to another meeting; do the "day job" well into the night. Repeat.

In fact, I am writing this message on a Monday-morning flight to the Geological Society of America meeting in Salt Lake City, where, among other things, I will summarize the notes of our 3-day liaison visit to DC at the Association of American State Geologists midyear meeting. From Salt Lake to New York City, where I join a small group of folks tackling the issue of how to restructure the Department of Energy's oil and gas program. From NYC to DC to help lead a 2-day National Academy workshop on "Peak Oil" with speakers from all over the world. The plateau of conventional oil production presents a great energy challenge for the world. Home by midnight on Friday.

Why all the travel? The Bureau is a global enterprise, and as Director, I represent one face of the Bureau: business development, conferences, lectures, meetings, committee duties, you name it. In reality, much of the content of these meetings could be handled by an efficient teleconference. However, there is a component that requires face-to-face contact—and that component centers on establishing trust.

The Bureau is trusted for delivering high-quality science to those who address global issues. For the Bureau to prosper, we must maintain trusted relationships in government, industry, and academia around the world. If we are successful, our science will have an impact on issues ranging from energy resources and policy, to carbon capture and climate change, to water resource characterization and use, to natural hazard mitigation and response, and beyond.

Impacting lives with trusted science. That is the Bureau. And that bold mission drives all of the outstanding folks who call the Bureau home.

"Ladies and gentlemen, the Captain has signaled our final approach into Salt Lake City. Please turn off and put away all electronic devices, including laptop computers . . ."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### Main cover image:
Cross section of the Texas Gulf Coastal Plain created for the Houston Museum of Natural Science Weiss Energy Hall exhibit. Based on researchers' current knowledge of regional geology, this slice of earth from Dallas to offshore Houston helps students understand how Earth's many formative events are represented in its subsurface structure.


### Contents

# HIGHLIGHTS

## Bureau Taking on Larger Role among State Geologists

As the state geological survey of Texas, the Bureau has long been active in the Association of American State Geologists (AASG), which brings together state geologists from the 50 United States and Puerto Rico. With Bureau Director Scott Tinker serving as president-elect of AASG during a time of major natural disasters along the Gulf coast, rising fuel costs, diminished support for energy research and development, and dwindling infrastructure for storage of cores and other geologic material, the time has never been better for AASG to deliver a united message. AASG travels to Washington, D.C., in March and September every year for a 3-day blitz of liaison meetings and briefings in an effort to bring science to the decision-making process. As president-elect, Scott is responsible for setting the meetings, summarizing the notes, and following up with letters and action items. In addition, AASG has created a series of AASG fact sheets to leave behind in Washington on topics ranging from the value of comprehensive geologic mapping to the need for analyzing and protecting vital groundwater resources. In the process of summarizing notes from all 50 meetings, Scott remarked, "If even just a few of the folks we visited are exposed to a science message that they had not heard or considered before, our trip will have been worth it."

Information about AASG and copies of the fact sheets may be viewed at the AASG Web site at www.stategeologists.org.

## Bureau Scientists Named JSG Research Fellows

The JSG Research Fellows program, begun in 2002–03, is overseen by the Steering Committee of the Jackson School. Fellows, who are nominated by the research units and selected on the basis of supporting credentials, are provided a salary and research support supplement. The Steering Committee established three levels of fellowships for the 2005–06 year: Senior Research Fellowships, Research Fellowships, and Young Scientist Fellowships. Eight Bureau scientists were named fellows for 2005–06:

### Senior Research Fellowships

Martin P. A. Jackson, *Senior Research Scientist*
Charles Kerans, *Senior Research Scientist*

### Research Fellowships

Susan D. Hovorka, *Research Scientist*
Stephen E. Laubach, *Senior Research Scientist*
Bridget R. Scanlon, *Senior Research Scientist*

### Young Scientist Fellowships

Sergey Fomel, *Research Scientist*
David R. Pyles, *Research Associate*
Paul Sava, *Research Associate*

## Center for Energy Economics Settles into New Home at Bureau

The Center for Energy Economics (CEE) joined the Bureau in June 2005, moving from its former affiliation with the University of Houston,

where it was known as the Institute for Energy, Law and Enterprise. CEE conducts research both in the United States and abroad. Taking an applied economics approach, CEE has a mission to educate stakeholders on matters related to energy economics and commercial frameworks in which to develop energy. The CEE also supports key Bureau programs, a role that will increase as it becomes fully integrated into the Bureau and The University of Texas at Austin community.

A delegation from the Turkish energy regulator, in the United States attending CEE's extended training program, during their trip to Washington, D.C. Pictured with the group, after a meeting hosted by the office of Congresswoman Eddie Bernice Johnson, are, *front center,* Dr. Michelle M. Foss, head of CEE; *third from right,* Ms. Shirley J. Neff, Center for Energy Marine Transportation and Public Policy, School of International and Public Affairs, Columbia University; *far left,* Ms. Jennifer Stiddard, Congresswoman Johnson's Legislative Aide; and *back center,* Mr. Murat Gokcigdem, Congresswoman Johnson's Chief of Staff/Legislative Director.

CEE's work covers a large geographic area and diverse topics. This past year, CEE held meetings with domestic and international visitors and conducted a multinational annual capacity-building program, New Era in Oil, Gas & Power Value Creation; wrote documents ranging from short, thought-provoking pieces to comprehensive briefing papers; and upheld its tradition of turning ideas into actions. Some of the activities in FY05 are highlighted below.

CEE's efforts to examine the role of liquefied natural gas (LNG) in the North American and global economies and to inform the public of LNG safety and security issues have continued to achieve great outcomes. In FY05, CEE staff participated in more than a dozen public forums on LNG, and CEE is relied upon by a broad cross section of the news media for information on this subject. CEE's briefing papers and LNG Web site (www.beg.utexas.edu/energyecon/lng) provide an independent, objective, and widely accessible knowledge base on LNG, educating many stakeholders involved in developing this industry. CEE's knowledge base formed the platform for an LNG white paper prepared for the National Association of Regulatory Utility Commissioners (NARUC) by ICF Consulting.

CEE is well poised to aid the international community in defining energy sources and setting up frameworks for successful commercial development. In FY05, CEE completed two grants from the U.S. government, one in Bangladesh (Association Liaison Office) and one in Ghana (U.S. Agency for International Development). In Bangladesh, CEE staff worked with the country's leading technical university—Bangladesh University of Engineering & Technology. CEE staff helped introduce an energy economics course into the curriculum, trained three university professors in the United States, and organized training for many more energy professionals. With help from CEE, the Resource Center for Energy Economics and Regulation (RCEER) at the University of Ghana is now working to become a leading research institution for energy industry issues in Ghana. The RCEER has developed public information materials such as "The Guide to Electric Power in Ghana" and "The Natural Gas Primer," programs for university and professional courses on energy economics, and an energy database, a unique effort for Ghana's energy sector. CEE is actively searching for other international energy partnerships while continuing to mentor its existing associates.

CEE's New Era program, held May 9–20, 2005, brought together 19 delegates from 13 countries—Angola, Bangladesh, Chile, Gambia, Ghana, Honduras, Kenya, Mexico, Nigeria, Trinidad & Tobago, Turkey, the United States, and Venezuela. This year, the senior level of participants and their diverse backgrounds made the program especially interesting. New Era is supported by U.S. government agencies and international organizations, as well as leading multinational energy companies. As with previous New Era sessions since 2001, this year's program allowed CEE to build new partnerships and expand its reach across the global energy industries. One spillover was a customized New Era program held in Port Harcourt, Nigeria, for energy sector professionals.

The CEE continues to expand and improve its Web site. A new public forum—"Think Corner"—reserves space for CEE staff and its global network to provide insights, commentaries, and research on global energy industry, market, and policy developments. Many other functions for the Web portal, such as interactive conferencing and "energy 101" materials, are under development.

In addition to its ongoing programs, the CEE has begun supporting core initiatives of the Bureau. The CEE provides economics and policy research to the Gulf Coast Carbon Center to support the emerging $CO_2$ value chain, whereby $CO_2$ is used for enhanced oil recovery while reducing greenhouse gases. CEE staff helped present the May 26 workshop on Opportunities and Issues in Carbon Markets. CEE also supports the Bureau's State of Texas Advanced Resource Recovery program and is a resource for the Bureau's leadership role in developing the Texas proposal for FutureGen.

Underlying all CEE projects is the philosophy that developing people—giving them the knowledge that enables them to harness their energy resources wisely—is the key to energy sector and energy enterprise development anywhere in the world. CEE research staff, led by Michelle Michot Foss, are Gürcan Gülen, Mariano Gurfinkel, Ruzanna V. Makaryan, Dmitry Volkov, and Miranda L. Ferrell Wainberg.

## Serving the Geological Community at the Houston Research Center

The Bureau has curated core and rock material for more than 70 years. Preserving these invaluable geologic resources and making them accessible for current and future research are an integral part of the Bureau's mission. These geologic materials, more than 1.8 million boxes of cores and samples, are available for public use at sample repositories in Austin, Houston, and Midland. The Bureau's newest and largest repository is the Houston Research Center (HRC).

The HRC was originally built and operated by Amoco, then subsequently acquired by BP, who donated the facility to the Bureau in late 2002. The complex includes more than 6 acres of land, 108,000 square feet of warehouse and office space, equipment, and conference rooms. Randy McDonald supervises the warehouse and maintains the collections and facility. Onsite geologist Beverly Blakeney DeJarnett provides geological support to the public and conducts research utilizing the BEG collection. The HRC also has a technical library, which was donated by Unocal Exploration & Production in April 2004. This extensive collection houses more than 80,000 volumes emphasizing geology, geophysics, and petroleum engineering. Valued at nearly $5 million, the collection is maintained by professional librarian Marie Cassens and is open to the public. Marie also schedules all workshops and seminars held at the HRC.

Dr. Charlotte Sullivan from the University of Houston shows cores to attendees at a SIPES short course at the HRC.

Through the efforts of Bureau staff and friends and colleagues in industry, awareness of the HRC has increased dramatically since it opened, and the facility is becoming a hub for members of the geological community in Houston. With its large and well-equipped conference rooms and core-viewing areas, the HRC is used increasingly by Bureau scientists and guests from industry and academia to conduct core workshops and hold meetings, seminars, and classes. Among the outside users are the American Association of Petroleum Geologists, Baker Energy, Halliburton, Houston Geological Society, Petroleum Technology Transfer Council, SEPM (Society for Sedimentary Geology), Society of Independent Professional Earth Scientists (SIPES), and the U.S. Department of Energy.

Amid its other holdings, the HRC provides dedicated space for storing terrestrial cores and samples procured by scientists conducting research projects funded through the National Science Foundation's Earth Science Division. The HRC curates this material and facilitates continued access to, and use of, the material by researchers and educators.

For more information about its collections and efforts to preserve geologic material for research, visit the HRC's Web page at www.beg.utexas.edu/crc/houston.htm.

## Awards and Honors

**Bill Ambrose** is the new president-elect of the Energy Minerals Division (EMD) of the American Association of Petroleum Geologists (AAPG). His term of office, 2005–06, will be followed by a 1-year term as EMD president in 2006–07. One of the three divisions of AAPG, EMD was founded in 1977 and serves as an international forum for those working in exploration, development, and production of unconventional energy resources, including coal, coalbed methane, gas hydrates, geothermal energy, oil shale, tar sands, and uranium. Bill served as councilor for the Gulf Section of EMD—the largest of the regional sections of EMD in the United States—from 2003 to 2005. As councilor, he prepared semiannual reports summarizing energy mineral commodities and activities (meetings and presentations) for EMD members in the Gulf Coast area and represented EMD at annual and sectional conventions.

**L. Frank Brown** was one of 11 distinguished researchers from across The University of Texas at Austin nominated for the University Cooperative Society's Research Excellence Award, which is given yearly to a faculty member or staff researcher who has maintained a superior research program over the years.

Former Bureau scientist Mark Vining and **Sigrid Clift** received the A. L. Cox Best Poster Award for their poster titled "Computer Modeling of the Evolution of Linked Fluvial and Coastal Erosion and Deposition" at the Southwest Section American Association of Petroleum Geologists annual meeting.

**Sergey Fomel** presented a paper at the 2004 Society of Exploration Geophysicists Annual Meeting in Denver that was judged by fellow SEG members to be among the top 20 best papers presented at the convention. Sergey's paper is titled "Theory of 3-D Angle Gathers in Wave-Equation Imaging."

**Robert J. (Bob) Graebner,** Senior Research Fellow and member of the Exploration Geophysics Laboratory, was unanimously chosen by members of both the Society of Exploration Geophysicists (SEG) Honors and Awards Committee and the Executive Committee to receive SEG's highest honor, the Maurice Ewing Medal. This medal is awarded "from time to time to a person who . . . is deserving of special recognition through having made major contributions to the advancement of the science and profession of exploration geophysics." The award was presented to Bob at the SEG International Exposition and 75th Annual Meeting in Houston, Texas, November 6–11, 2005.

**Charles G. "Chip" Groat** (left) was given the 2005 Bureau of Economic Geology's Alumnus of the Year Award by Scott Tinker at the annual meeting of the American Association of Petroleum Geologists in Calgary. Chip worked at the Bureau from 1968 to 1978, conducting environmental and mineral resources research in West Texas and the Gulf Coast and serving as Associate Director. He was director of the U.S. Geological Survey from 1998 to 2005 and returned to the University to head the Center for International Energy and Environmental Policy. He also directs the Energy and Mineral Resources Program.

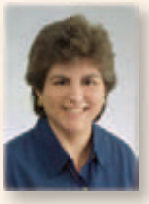
**Bob Hardage** has been chosen to receive the 2006 Monroe G. Cheney Science Award from the Southwest Section of the American Association of Petroleum Geologists. This award is given in recognition of "singular contributions to and achievements in the science of petroleum geology of the southwest region." Bob also received a Certificate of Appreciation from the Texas Board of Professional Geoscientists in recognition of Outstanding Assistance in the Development of the Texas Geophysics Exam.

**Sue Hovorka** was one of three recipients of the Jackson School's 2005 Joseph C. Walter Jr. Excellence Award. This honor is in recognition of Sue's groundbreaking research on the Frio Brine carbon sequestration project and tireless educational outreach. The award, formerly called the Houston Oil and Minerals Corporation Faculty Excellence Award, has been given since 1977 for excellence in research, academic, and administrative efforts.

**Mike Hudec,** who co-directs the Applied Geodynamics Laboratory, has been chosen to receive the 2006 George C. Matson Award from the American Association of Petroleum Geologists for his talk "A Compressional Origin for Minibasins Near the Sigsbee Escarpment, Gulf of Mexico." Mike's talk was judged as the best paper presented at the 2005 annual convention held in June in Calgary, on the basis of both scientific quality of content and excellence in presentation.

The Austin Mayor's Committee for People with Disabilities presented its Employee of the Year Award

to **Tom Markowsi,** who works part time in the Geophysical Log Facility scanning logs and updating the well-log database. The award honors an Austin citizen having a disability whose employment attests to the strengths and talents such employees contribute to the economic life of the community and whose selection would encourage employment of others who have disabilities.



**Lynda Miller,** Contracts and Grants Manager, was awarded a 2005 Jackson School of Geosciences Support Staff Excellence Award. A Bureau employee for almost 20 years, Lynda was nominated for her exceptional performance and service to the unit directorship, research scientists, support staff, and our external clients.

**Steve Ruppel** received the best paper award from the West Texas Geological Society for his oral presentation at the WTGS 2004 Symposium. The paper, co-authored by **Rebecca Jones,** is titled "Lower Leonardian Sequence Stratigraphy and Reservoir Development: Fullerton Clear Fork field, Permian Basin."

**Paul Sava** gave a paper coauthored by **Sergey Fomel**—"Wavefield Extrapolation in Riemannian Coordinates"—that was judged by fellow Society of Exploration Geophysicists members to be among the top 20 best papers presented at the 2004 SEG Annual Meeting in Denver.

Director **Scott Tinker** was honored with the American Association of Petroleum Geologists Distinguished Service Award at the 2005 Annual Meeting in Calgary. The award is "presented to members who have distinguished themselves in singular and beneficial long-term service to AAPG," with an emphasis on long-term and meaningful service to the Association. Scott is currently serving as the AAPG International Distinguished Ethics Lecturer, presenting "The I in BusIness EthIcs" at venues throughout the world.

**Lesli J. Wood** won the 2004 Best Presentation Award from the International Division of the Houston Geological Society for her presentation titled "Quantitative Seismic Geomorphology of Clastic Reservoirs and Systems."

# Changes in Bureau Staff

**Romulo Briceno** is a new Research Scientist Associate II hired to manage the database for the State of Texas Advanced Resource Recovery program. Romulo holds a B.S. degree in chemical engineering from the University Simón Bolívar in Venezuela (1999) and will complete an M.S. degree in energy and mineral resources at The University of Texas at Austin in December. He has been working at the Bureau since 2002, first in the Geophysical Log Facility and most recently as a Graduate Research Assistant helping with a variety of projects.

**Dennis Campa** is a new Administrative Assistant who works half-time in the Office of Publication Sales and half-time in the Geophysical Log Facility.

**Marie Cassens** is the Houston Research Center's new Professional Librarian. Marie has a B.S. in psychology from the University of Houston and an M.S. in library science from the University of North Texas. She has more than 12 years of professional librarian experience.

**Michelle Michot Foss** is Program Manager and Chief Energy Economist and Head of the Bureau's new Center for Energy Economics. Michelle has a Ph.D. in political science with honors from the University of Houston (1995), an M.S. in mineral economics from the Colorado School of Mines (1985), and a B.S. in biology with a geology minor from the University of Louisiana at Lafayette (1976). Michelle was the Executive Director of the Institute for Energy, Law and Enterprise at the University of Houston from 1991 to 2005.

**Julie Fowler** is a new Administrative Assistant assigned to help researchers on the second floor of the Bureau's administration building. She worked as an administrative assistant while completing a B.S. degree (2004) in history, specializing in world cultures, at The University of Texas at Austin.

**Gürcan Gülen** is a new Senior Energy Economist. Gürcan has a Ph.D. in economics from Boston College (1996) and a B.A. in economics from Bogaziçi (Bosphorus) University, Istanbul, Turkey (1990). Prior to joining the Bureau, Gürcan worked at the Institute for Energy, Law and Enterprise, University of Houston Law Center (2002–05), and the Energy Institute, Bauer College of Business, University of Houston (1997–2002).

**Mariano E. Gurfinkel** is a new Project Manager and Associate Head of the Center for Energy Economics. Mariano holds Ph.D. and M.S. degrees in mechanical engineering from MIT and a B.S. degree with honors in mechanical engineering from Universidad Simón Bolívar. He will serve as the team leader for liquefied natural gas research and outreach and will also support the Bureau's State of Texas Advanced Resource Recovery and Gulf Coast Carbon Center research programs, as well as the FutureGen Texas initiative.

**Aisha Hanif** is a new Administrative Associate. Aisha was a program manager at the Institute for Energy, Law and Enterprise, University of Houston Law Center, from 2000 to 2005, helping manage the day-to-day operations of the institute. She attends the University of Houston and is working toward a B.B.A. degree in accounting from the C. T. Bauer College of Business.

**John Hooker** has joined the Bureau as a Research Scientist Associate II, and he will be working on the Jackson School of Geosciences Structural Diagenesis initiative. Fresh from a graduate research assistantship for the Fracture Research and Application Consortium, John received his M.S. in geology from The University of Texas at Austin in 2004 and his B.A. in 2000.

**Charles Kerans,** a Senior Research Scientist at the Bureau who helped establish the Bureau's Reservoir Characterization Research Laboratory and spent 20 years building its internationally renowned reputation, has moved to the classroom to develop the next generation of carbonate specialists. He joined the faculty of the Department of Geological Sciences, appointed as a professor and holder of the Robert K. Goldhammer Chair in Carbonate Geology.

**Daniel Kurtzman,** who recently received his Ph.D. in groundwater hydrology (2005) from the Hebrew University of Jerusalem, Israel, has joined the Bureau's hydrogeology program as a Postdoctoral Fellow. Daniel holds an M.S. degree in environmental sciences (1997) and a B.S. in atmospheric sciences (1994), both from the Hebrew University of Jerusalem.

**Srivatsan Lakshminarasimhan** arrived at the Bureau as a Postdoctoral Fellow in September. He holds B.S. and M.S. degrees and a doctorate in chemical engineering from Indian Institute of Technology (Madras), Indian Institute of Science, and The University of Texas at Austin, respectively. Srivatsan is a member of the Gulf Coast Carbon Center, where he is applying his skills in theoretical and numerical modeling and computational methods.

**Ruzanna Makaryan** is a new Energy Analyst. She has an MBA from the University of Houston, C. T. Bauer College of Business (2003) and a B.A. in linguistics from Turkmen State University, Turkmenistan (1997). Ruzanna was a researcher at the Institute for Energy, Law and Enterprise, University of Houston Law Center, from 2002 to 2005.

**Angela McDonnell,** a new Research Associate, holds a B.S. degree from University College Cork, Ireland (1995), and an M.S. (1996) and Ph.D. (2001) from University College Dublin. She has joined the Bureau's Deep Shelf project.

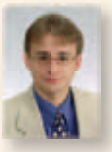
**Francisco Miranda** is a new Postdoctoral Fellow with a Ph.D. in physics from the University of Houston (2004). Francisco also has a B.S.-M.S. degree in physics from the Universidad Complutense, Madrid, Spain (1999), and a B.S-M.S. degree in industrial engineering from Escuela Técnica Superior de Ingenieros Industriales (1999), Madrid.

**Reuben Reyes** has joined the Bureau's Information Technology staff as a Senior Operating Systems Specialist. Reuben is responsible for maintaining the UNIX network. He brings with him experience in clusters, scientific visualization, digital animation, signal processing, and 3-D modeling. Reuben worked previously in conjunction with the Bureau and the Witte Museum to produce the "World of Water" exhibit.

**Natalie Silva** is a new Administrative Assistant. She is a graduate of the University of Houston with a B.A. in public relations and a minor in Latin American studies. Natalie was previously with the Institute for Energy, Law and Enterprise, University of Houston Law Center.

**David M. Stephens,** Photographer/Computer Illustrator at the BEG, retired in August after 31 years of service at The University of Texas at Austin. David began his career by working part time at the Bureau after earning a B.F.A. in studio art/photography. He also worked at the Department of Geological Sciences as a photographer and darkroom specialist. He moved to the Bureau full time in 1991, where he applied his background in conventional photography to digital photography and image processing. David's work endures in the hundreds, perhaps thousands, of photos and other images he has processed for books, posters, articles, Web pages, and various presentations.

**Andrew Tachovsky** is a new Research Scientist Associate working in the Bureau's hydrogeology program. Andrew has a B.S. in civil engineering from the University of Virginia (1995) and an M.S. in civil engineering from The University of Texas at Austin (1997).



**Dmitry Volkov** is a new Energy Analyst. He has an MBA from the University of Houston (2005) and a B.S. in Oriental studies from Moscow State University, Moscow, Russia (2000). Dmitry was a researcher at the Institute for Energy, Law and Enterprise, University of Houston Law Center, from 2003 to 2005.

## *In Memoriam:* Dixon Edge Coulbourn

*May 17, 1962–July 31, 2005*

With sadness the Bureau mourns the loss of a beloved friend and colleague, Dixon E. Coulbourn, who died in a swimming pool accident this summer. Dixon, a native Austinite, began his career at the Bureau in 1987, after earning a B.A. in English in 1984 from North Texas University. He started out working in the administrative group, where his grammar and proofreading skills came in handy. Dixon was Mr. Adaptable. He was always interested in technology and taught himself a lot about computers. He continued to hone his skills until he was reassigned to the IT group, where he became indispensable in troubleshooting UNIX computer problems and maintaining the UNIX network system. He worked his way up to senior network analyst and maintained a network of workstations. Dixon was also renowned in Austin's 1980's punk music scene for *Idle Time*, a fanzine he created using his own photographs and writings that celebrated the enthusiasm of punk rock. Dixon's talents also included kayaking, painting, music, and Web sites. Dixon made many friends through his easy-going nature and will be deeply missed.

# Publications

Bureau scientists publish the results of their research in Bureau publications and professional journals. They also contribute to newsletters and symposia and are sometimes the subject of interviews on scientific topics of current public interest. The articles listed below reflect the broad reach of the Bureau and its diverse staff. In addition to the papers listed, Bureau staff published 2 sets of course notes, 81 abstracts, and 20 contract reports during the year.


Ambrose, W. A., Wawrzyniec, T. F., Fouad, Khaled, Sakurai, Shinichi, Jennette, D. C., Brown, L. F., Jr., Guevara, E. H., Dunlap, D. B., Talukdar, S. C., Aranda-García, Mario, Hernandez Romano, Ulises, Alvarado Vega, Juan, Macias Zamora, Eduardo, Ruiz-Ruiz, Héctor, and Cárdenas-Hernández, Ramón, 2005, Neogene tectonic, stratigraphic, and play framework of the southern Laguna Madre-Tuxpan continental shelf, Gulf of Mexico: American Association of Petroleum Geologists Bulletin, v. 89, no. 6, p. 725–751.

Artman, Brad, and Fomel, Sergey, 2005, Fourier-domain imaging condition for shot-profile migration, *in* Stanford Exploration Project, Report 120, p. 325–332.

Barrick, J. E., Meyer, B. D., and Ruppel, S. C., 2005, The Silurian-Devonian boundary and the Klonk event in the Frame Formation, subsurface West Texas, *in* Barrick, J. E., and Lane, H. R., eds., A standing ovation: papers in honor of Gilbert Klapper: Bulletins of American Paleontology, No. 369, p. 105–122.

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Beshur, Alison, 2005, Gasification plant possible: Corpus Christi Caller-Times, October 7 [summary of presentation made by Scott Tinker about requirements for a federally proposed coal gasification power plant].

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Canérot, Joseph, Hudec, M. R., and Rockenbauch, Konrad, 2005, Mesozoic diapirism in the Pyrenean orogen: salt tectonics on a transform plate boundary: American Association of Petroleum Geologists Bulletin, v. 89, no. 2, p. 211–229.

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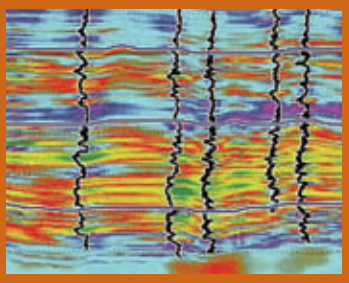


# RESEARCH: *ENERGY*

## Jackson School Royalty Assistance, Fort Worth Basin

Tucker Hentz

Eric Potter

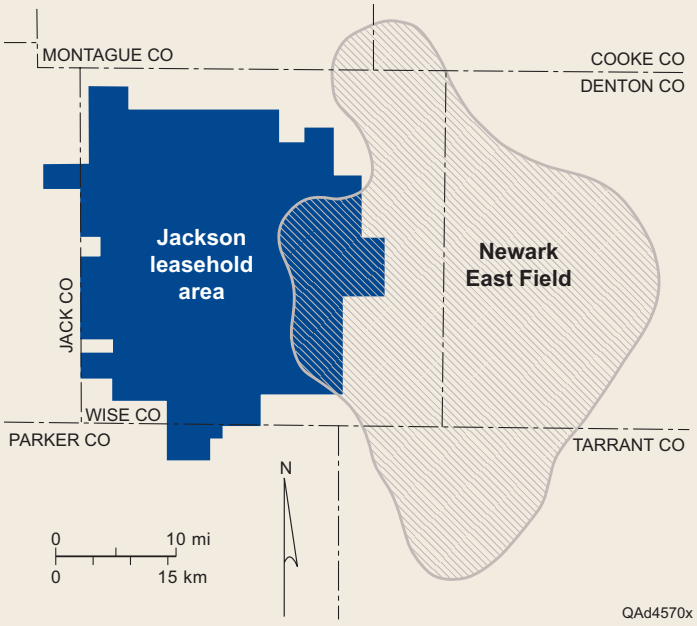
John A. "Jack" Jackson left an amazing legacy to The University of Texas at Austin. A gift from Jack and his late wife, Katie, enabled the establishment of the John A. and Katherine G. Jackson School of Geosciences (Jackson School). And with transfer of the Jackson Estate to create the Jackson Fund in the Geology Foundation came royalty interests in some 1,000 producing wells in the Fort Worth Basin, where in the 1950's Jack was a pioneer in gas discoveries from the Pennsylvanian Bend Conglomerate reservoirs. Those giant reservoirs still produce, but a new exploration play has significant promise for the Jackson School interests.

### *The Barnett Shale*

The Barnett is a Mississippian shale formation in the Newark East field that has become the largest natural gas–producing reservoir in Texas, placing the field among the top five producers in the nation, on the basis of the daily production rate. It is the hottest play in Texas, its play boundaries still being defined by drilling. Favorable economics are enabling royalty owners, producers, service companies, and their shareholders to benefit—Texas-style—from the play.

The Barnett is classified as an unconventional reservoir on the basis of its shale lithology and the necessity for hydraulic fracture stimulation. Unconventional reservoirs, which include coals and shales, now account for 35 percent of natural gas produced in the United States but do not flow commercial amounts of gas unless the wells are stimulated to improve reservoir properties. Production from the Barnett Shale was minimal prior to 1997 because existing wells would not flow gas at rates sufficient to justify costs.

Today, a host of technologies, including laboratory analysis of gas yields from the shale, hydraulic fracturing, 3-D seismic visualization, horizontal drilling, and microseismic monitoring of fracture-stimulation jobs, are helping operators to expand the play.




Newark East field and Jackson School leasehold area in the Fort Worth Basin, Texas.

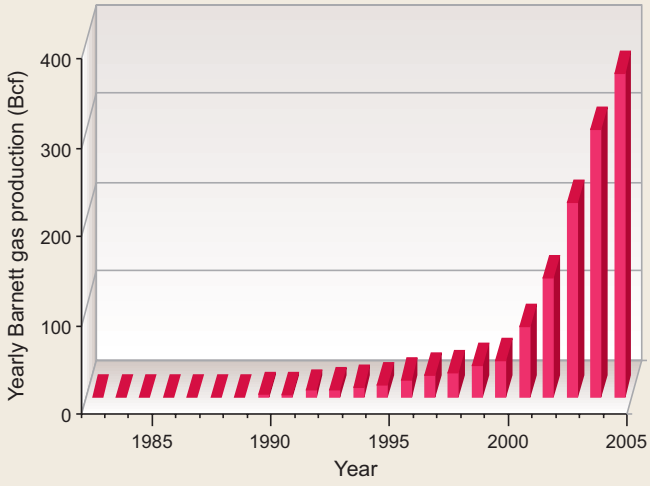
## *Bureau Research*

The Bureau has been conducting research sponsored by the Jackson School for nearly 2 years on the Barnett in Wise County, where Jackson School royalty interests are concentrated. The primary objective is to provide technical analysis that could stimulate additional drilling and production in the royalty area.

Emphasis so far has been on mapping the basic stratigraphic and structural framework; tracking successful drilling in the less developed southern part of the play and mapping similar conditions in Wise County; and remapping the thermal maturity of the formation, which seems to relate directly to gas/oil ratio, one of the key factors controlling gas flow rates.

Research is also under way on aspects controlling gas production from the Pennsylvanian-age Bend Conglomerate, which lies above the Barnett Shale. The objective is to demonstrate additional infield production potential by conducting modern reservoir characterization studies of this giant gas-producing trend, where production began in the 1950's. A pilot study area covering the southwest quarter of Wise County, coinciding with much of the Jackson royalty area, was selected to conduct detailed mapping of conglomerate- and sandstone-rich, reservoir-scale genetic units. Petrophysical analyses of well logs and core samples have complemented the effort. Results to date have defined (1) the depositional fabric and setting of the Bend reservoir units, (2) the relation between producing wells and the areal distribution of units, and (3) the fundamental petrophysical controls on production. The next phase of study will examine the relation between detailed reservoir characteristics and production results to help predict infield development opportunities.

Composing the research team are Eric Potter, Tucker F. Hentz, Jeffrey Kane, William A. Ambrose, Eugene M. Kim, Luciano Correa, Joseph Yeh, Jon Olson of the Department of Petroleum and Geosystems Engineering, and graduate student Mary Bezara.

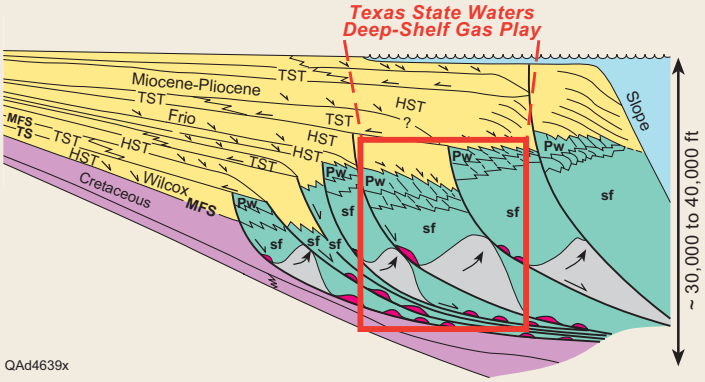



Production curve for Newark East field.

# Stratigraphic Architecture and Sandstone Reservoir Quality in Deep-Shelf Gas Plays of Texas State Waters

Bob Loucks and Shirley Dutton

The deep-shelf gas play in the Gulf of Mexico (GOM) is focusing exploration attention below 15,000 ft in the shallow waters of the offshore Texas State leases. Ultradeep wells are being planned by industry operators for depths from 20,000 ft to greater than 30,000 ft to target large structures below the present-day Texas shelf that contain sandstones deposited in lowstand systems tracts. At these depths the greatest unknown and most critical risk factor is reservoir quality. The ability to predict reservoir quality (porosity and permeability) and physical characteristics of ultradeep reservoir rocks has lagged behind our understanding of other




General sequence-stratigraphic architecture for the Texas Gulf Coast area. The deep-shelf gas play of lowstand deposits is outlined by red box.

parts of the petroleum system such as depositional facies, traps, and petroleum migration.

The Bureau's Deep-Shelf Gas project is supported by a consortium of companies. The major goals are to decrease exploration risk by achieving a better understanding of the uncertainty involved in preservation or enhancement of porosity and permeability at depth and by mapping the general stratigraphic architecture and areas of deep to ultradeep depocenters from 3-D seismic data. Specific goals of this multidisciplinary study are to (1) map the deep stratigraphic architecture from seismic data, (2) map isochrons of deep sedimentary packages, (3) analyze seismic facies of these packages, (4) analyze petrographic and geochemical attributes of rock samples, (5) conduct statistical analysis of porosity/permeability relationships to controlling parameters, and (6) analyze wireline logs for complete vertical data coverage in selected areas.

Data for this project include several thousand thin sections, cores to depths as great as 23,500 ft, and a 3-D seismic data volume (supplied by Seismic Exchange, Inc.) of State Waters that covers 15 mi by 220 mi (3,300 $mi^2$) of data. The quality of the seismic data allows analysis of the complete Tertiary section down to 8-s two-way traveltime.

Seismic analysis is providing a clear picture of the structural and stratigraphic architecture of the State Waters area. Both extensional and compressional structural features are being mapped and integrated with the sequence-stratigraphic history of the basin. Sand depocenters are being identified, and stratal slicing will be completed on a number of units. The results of these studies will aid in identifying fairways of deeply buried sandstones that may be hydrocarbon reservoirs.

Regional studies in the shallower Tertiary sandstone section have shown that there is significant regional variation in reservoir quality that is controlled by differences in detrital mineralogy, grain size and texture, depositional environments, burial history, and geothermal gradient. Previous Bureau studies resulted in publication of what are still the most complete analyses of geographic and depth trends in mineralogy, grain size, texture, porosity, and permeability in lower Tertiary sandstones from the onshore Texas Gulf Coast. The Deep-Shelf Gas project is now conducting a comparable analysis of regional and depth variations in deep Cenozoic sandstones (>15,000 ft), both from the onshore Texas Gulf Coast and on the inner continental shelf. A major goal is to place the sandstones that are studied into a structural and sequence-stratigraphic framework to understand how reservoir quality is affected by changes in structural styles and depositional setting.

During the first year of this 2-year study, the focus was on the northern half of the Texas coast; during the second year the project will investigate the southern half of the Texas coast. Additional industrial sponsors are invited to join the project in January 2006.

The Deep-Shelf Gas team comprises Shirley P. Dutton and Robert G. Loucks (co-principal investigators), Angela McDonnell, Shinichi Sakurai, L. Frank Brown, Romulo Briceno, and graduate research assistants Patricia Montoya, Ahmad Ismail, and Carla Sanchez.

## State of Texas Advanced Resource Recovery (STARR) Project

Clockwise: Ursula Hammes, Blake Walker, Hugo Castellanos, and Mary Bezara.

The original Project STARR was developed to increase royalty income to the Permanent School Fund by helping operators of State Lands leases to improve efficiency of producing fields using the latest reservoir characterization technologies. During the 2005 regular Texas legislative session, the State increased the budget for Project STARR. In addition to reservoir characterization, the project will now look at new venture studies where regional fairways for drilling exploration wells will be emphasized. Project STARR will also conduct studies to promote exploitation of unconventional resources such as hydrocarbons from shale, tight gas sands, and low-pressure gas. The project will also work in conjunction with $CO_2$ sequestration studies at the Bureau to promote profitable sequestration of $CO_2$ in oil fields through $CO_2$ enhanced oil recovery. Texas State Lands operators are invited to participate in Project STARR to obtain, without cost or obligation, expert

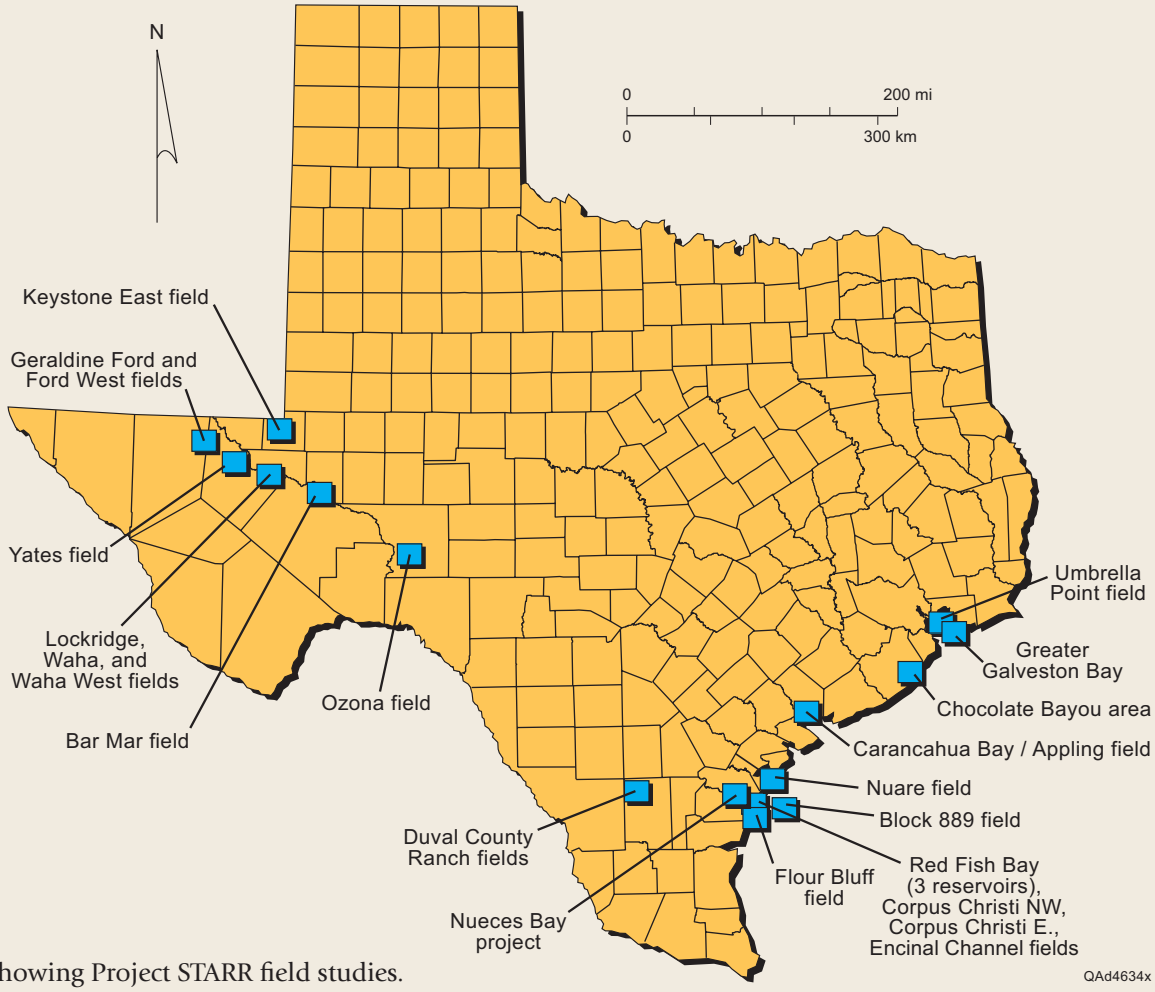
technical advice in developing State Lands oil and gas fields.

The philosophy of Project STARR is to work with State Lands operators to deploy advanced recovery strategies and newly developed technologies on a field-by-field basis to ensure maximal recovery efficiency. Researchers also work with operators to evaluate deeper, higher risk prospects such as reservoirs in the deep-shelf gas play. The deep-shelf gas play comprises offshore Tertiary sandstone reservoirs between the depths of 15,000 and 35,000 ft. The Bureau has strong experience in analysis of 3-D seismic data, including structural and sequence-stratigraphic architectural analyses, stratal slicing, and amplitude anomaly analysis. The STARR group has generated several major publications on sequence stratigraphy and gravity tectonics in the Texas Gulf of Mexico area from these studies.

The most volumetrically significant State Lands oil and gas resources are in the State Waters of the Gulf Coast and State Leases of the Permian Basin. Since 1995, Project STARR studies and data have been used to recommend more than 70 infill wells, 56 recompletions, and 14 step-out wells over the project's 9-year duration. Project STARR has also worked on and identified several prospects in previously undrilled deeper strata. To date, Project STARR has completed or is currently working on studies of 24 fields on State Lands.

Project STARR has contributed to the increase in royalty payments for the benefit of the Permanent School Fund. Over the last 2 years, the program has helped generate $21.3 million in royalties to the Permanent School Fund and $6.3 million in severance tax to the State. Relative to royalty income, Project STARR is revenue positive by a factor of 23.9. This return is higher than that for the last biennium, which produced $9.2 million, for a revenue-positive factor of 10.4.

Project staff are Robert G. Loucks, Ramón Treviño, Ursula Hammes, L. Frank Brown, Shinichi Sakurai, Hongliu Zeng, Khaled Fouad, Romulo Briceno, Stephen C. Ruppel, Shirley P. Dutton, Wayne Wright, David Solo, Mary Bezara, and Hugo Castellanos.




Map showing Project STARR field studies.

# Integrated Geological Synthesis of the Permian Basin

Steve Ruppel

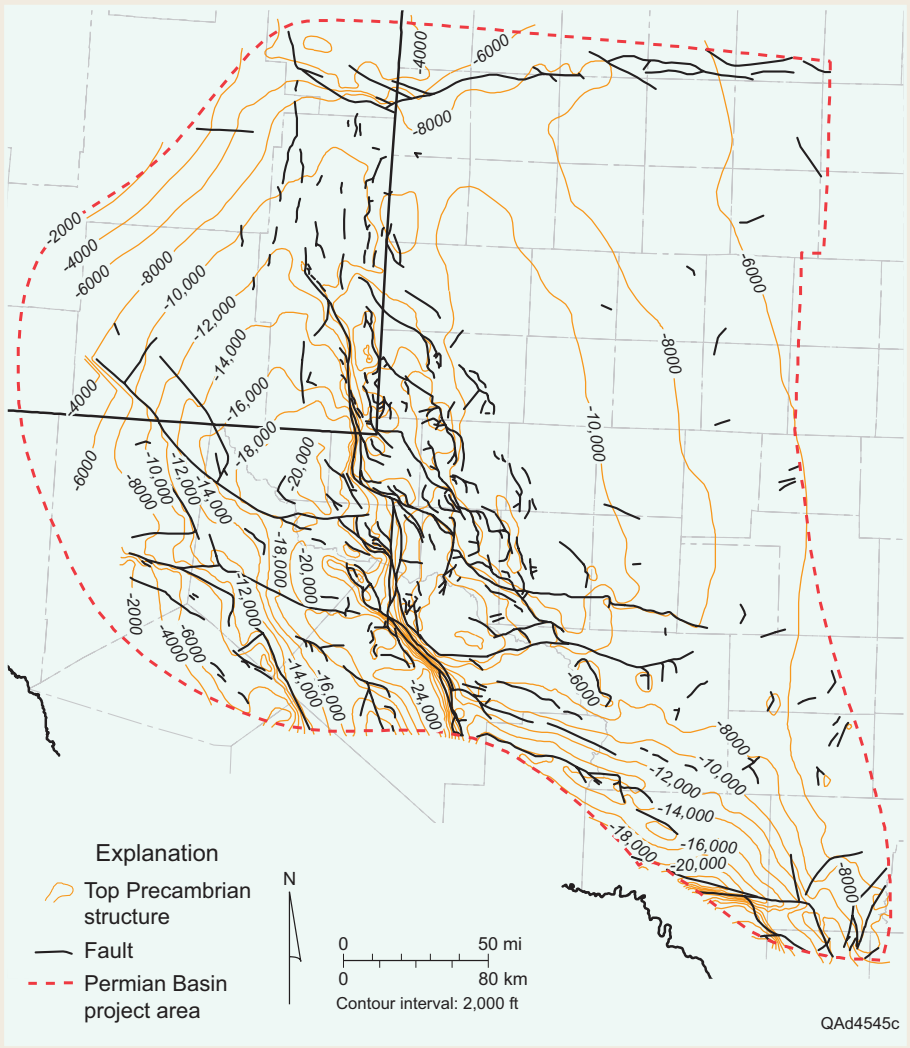
Bureau researchers have begun an integrated analysis of the depositional history and stratigraphic architecture of the Permian Basin. The goals of the program are (1) to produce a detailed, comprehensive history of the Paleozoic depositional and reservoir systems in the Permian Basin and (2) to create spatially integrated databases of depositional, stratigraphic, lithologic, and petrophysical properties for each stratigraphic horizon.

The largest producing basin in the United States, the Permian Basin has 30 billion barrels of mobile oil remaining in existing reservoirs and a projected 3.5 billion barrels of undiscovered oil and natural gas liquids (NGL) resources. Despite the vast remaining resource, no modern, integrated synthesis of Permian Basin geology currently exists. Recovery of this remaining resource has become an increasing challenge as new companies unfamiliar with the basin and its geology have replaced original, data- and expertise-rich major oil companies. A particular problem for these new companies is the difficulty of access to data and the knowledge of how to use the data. The project will address this problem by providing needed fundamental stratigraphic and reservoir-specific data in readily accessible and usable formats.

An integrated synthesis of available data, concepts, and models in the Permian Basin will form a fundamental basis for providing Permian Basin operators with (1) outcrop and subsurface reservoir-specific models to be applied to engineering- and completion-based redevelopment of existing reservoirs, and (2) a detailed regional stratigraphic framework for applying such models to new exploration targets. These data will decrease the risk and increase the efficiency of exploiting the remaining hydrocarbons in the Permian Basin and define new opportunities for drilling. The data will also form the basis for new engineering approaches and completion practices.

The project will involve participation and sponsorship of oil companies active in the Permian Basin. This liaison will accomplish two goals: (1) industry input will assure that the goals of the project are those of greatest value to industry, and (2) it will facilitate more effective technology and data transfer.

Project deliverables will include (1) a comprehensive written analysis of the Paleozoic depositional history, stratigraphy, facies, and structural history of the basin, and (2) data syntheses of selected hydrocarbon-rich plays in the basin. Data, which will include a wide variety of geologic and reservoir




Map depicting the top of Precambrian structure in the Permian Basin. This map, one of many prepared in Arc-GIS for the Permian Basin Synthesis Project, is thought to be the first spatially registered map of its kind.

data, will be spatially integrated into a geographic information system (GIS) for ready data access and use. Data sets will be made available digitally both on CD and through direct access over the World Wide Web. Funding for the project is being shared by the U.S. Department of Energy, sponsoring industry partners, and the Bureau's Reservoir Characterization Research Laboratory and Project STARR.

During the first year of this 3-year project, three depositional episodes have been selected for detailed study: the Carboniferous Barnett Shale, the Upper Devonian Woodford Shale, and the Lower Devonian Thirtyone Formation composed of carbonate and chert. In subsequent years, detailed study is planned for carbonate systems of the Silurian Wristen Formation, the Permian Clear Fork Group, the Lower Ordovician Ellenburger Group, and other depositional intervals, depending on interest.

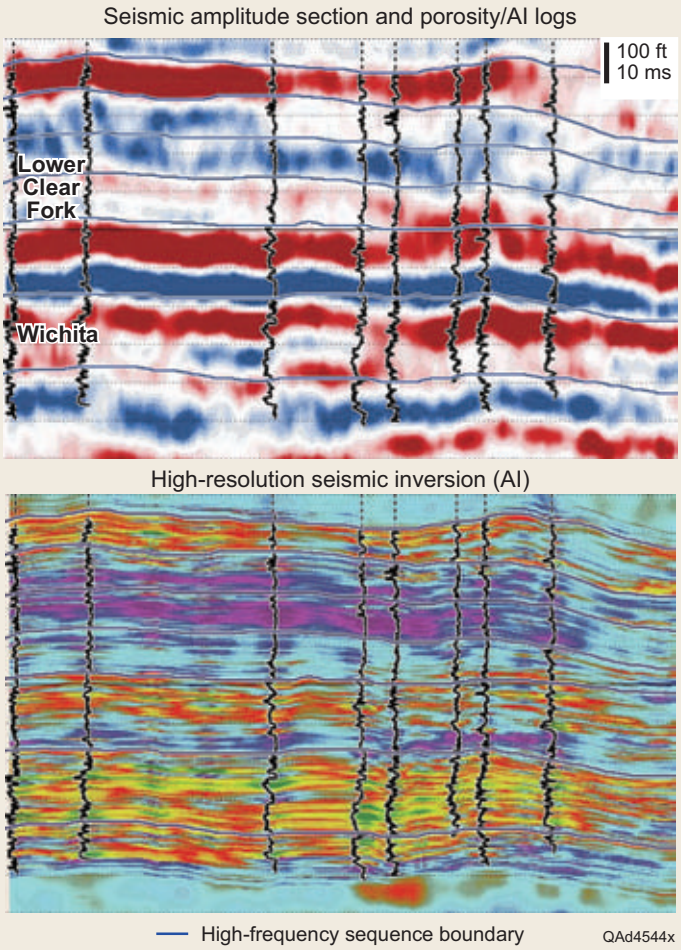
Project staff are Stephen C. Ruppel, Rebecca H. Jones, Robert G. Loucks, Wayne Wright, Charles Kerans, Edgar H. Guevara, H. Seay Nance, Caroline L. Breton, and graduate research assistants Ted Playton, Martin Hanzlik, and David Soto.

# High-Resolution Seismic Inversion for Reservoir Modeling

Hongliu Zeng

Reservoir modeling in a mature oil and gas field helps geologists and petroleum engineers better understand reservoir performance and optimize future in-field drilling activities. In most fields, 3-D seismic is the only physical data control between and beyond wells. A high-quality reservoir model should seamlessly integrate well and seismic information in a high-resolution stratigraphic framework. The use of acoustic impedance (AI) from poststack seismic inversion has become increasingly commonly in reservoir modeling because of its close relation to reservoir properties, mainly thickness, porosity, and permeability.

Generating high-resolution reservoir models from seismic, however, has been a major challenge. The value of seismically derived AI is so far limited, as evidenced by the fact that most applications treat




A high-resolution, acoustic impedance model (bottom) of Fullerton Clear Fork field, West Texas, created by integrating high-resolution wireline log data, low-resolution seismic data (top), and a high-frequency sequence-stratigraphic framework in a progressive inversion procedure.

AI as "soft data" that merely provide "trends" when contouring reservoir properties between wells using "hard" wireline-log data. The "softness" of seismic inversions is the result of the non-uniqueness of the inversion problem: poststack seismic inversion cannot solve for AI and thickness at the same time. It is a formidable task to build an accurate, high-resolution, *a priori* model by interpreting closely spaced geologic boundaries from low-resolution seismic data. Without high-resolution (reservoir-scale) geometric control over the initial model, an inversion cannot eliminate amplitude tuning effects and may impose as much as 40 percent error in AI estimation.

Bureau researchers are using an integrated, multi-disciplinary approach to improve well-seismic reservoir modeling. A thorough study of high-frequency sequence stratigraphy is first conducted using cores, wireline logs, and outcrop analogs.

Sequence boundaries, maximum flooding surfaces, and transgressive surfaces are picked in wells and seismic survey. Reservoir architecture (platformal, clinoformal, etc.) is mapped or predicted. A progressive inversion is designed to improve geometry modeling by building multiple initial models and performing multiple inversions. The first initial model is a generalized model based on a few prominent and reliable geologic boundaries and correlative seismic horizons. The first inversion, performed on the basis of this initial model, usually reveals more geologic detail than the original seismic data. Additional geologic horizons are then added from interpretation of the first inversion to create a new and more accurate initial model that fits better to the geologic model and the interpretation of core, wireline logs, and analogous outcrop. A new inversion based on this improved initial model will image more accurate geologic details. This process may be repeated until inversion resolution is satisfactory for reservoir-model-building applications.

Bureau researchers involved in this study are Hongliu Zeng, Stephen C. Ruppel, and Charles Kerans.

## 3-D Characterization of a Sinuous Slope Channel: the Beacon Channel, Brushy Canyon Formation, West Texas

David Pyles

Slope channels are common bathymetric features on Earth's continental margins. Like river channels, slope channels are commonly sinuous and contain point bars and levees. They form economically significant petroleum reservoirs in many parts of the world, including offshore northern Gulf of Mexico and offshore West Africa. Three-dimensional seismic data, bathymetric data, and well/core data are typically used to evaluate the stratigraphy of these channel systems; however, many of the small-scale stratigraphic features that affect fluid flow—including distribution of shale drapes, gravels, and facies—cannot be resolved using these data. Although outcrops can be used to study the small-scale stratigraphy of these bathymetric features, nearly all outcrops of slope channels are two dimensional. In these 2-D exposures, facies and architectural asymmetry is commonly interpreted to reflect channel sinuosity. Cross-sectional attributes of these exposures can be measured and described, but down-current changes in facies and architecture cannot be fully understood through the limited 2-D view of these exposures. A 3-D problem exposure of a sinuous slope channel is required to address both lateral and down-current changes in stratigraphy of these channels types.

One rare example of a 3-D exposure of an ancient sinuous slope channel is the Beacon Channel in the Permian Brushy Canyon Formation of West Texas. This channel is exposed on five cliff facies within an area of about 1 $km^2$. The channel is 10 m thick and 250 m wide. A digital elevation model, *xyz* and intensity lidar data collected from our BEG ground-based unit, photopanels, 150 m of detailed stratigraphic columns, correlation panels, and thousands of paleocurrent measurements were integrated into a data set that was used to evaluate the stratigraphy of this exposure.

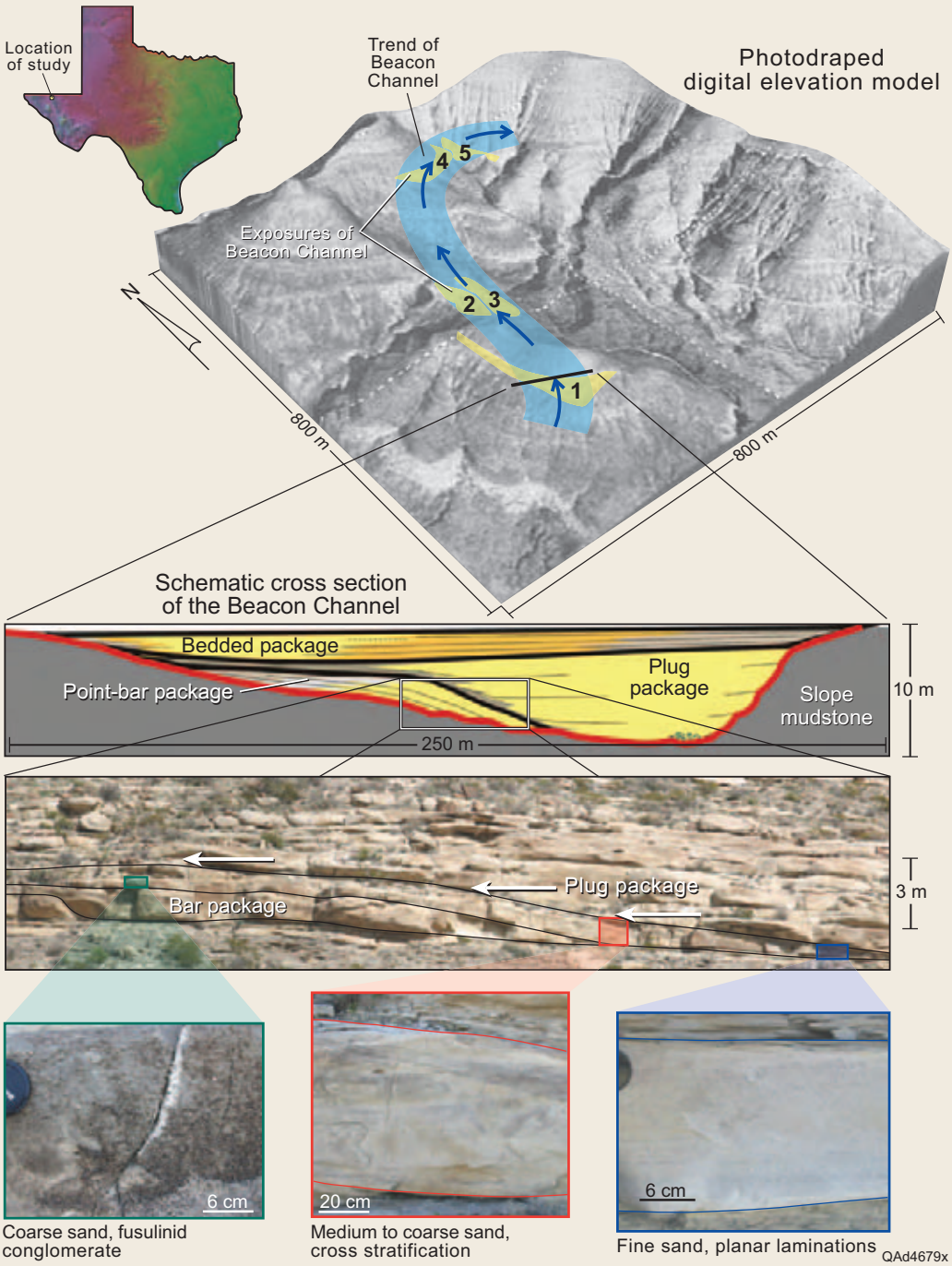
The Beacon Channel is divided into three stratigraphic packages, from oldest to youngest: (1) point-bar package, (2) plug package, and (3) bedded package. Each package has unique stratigraphic architecture and facies, and each records a distinct phase of the channel's evolution.

The point-bar package contains laterally accreting bar forms that are similar in cross section and plan view to river point bars. These features are also observed in many 3-D data sets of sinuous slope channels. In the Beacon Channel, the point bars record a phase of downcutting, sediment bypass, and increasing channel sinuosity. Channel sinuosity (length channel travels between two points divided by the areal distance between the two points) during deposition of this package increased from 1 to 1.20. Although similar in morphology to river point bars, the point bars in the Beacon Channel contain facies and paleocurrent trends that are distinctly different. Although the gravel locally accumulates in the channel thalweg, the coarsest strata in the Beacon Channel point bars are elevated high on the inside bend of the point bar, whereas the finest grained strata are deposited on the lower part. The opposite relationship exists in river point bars. Additionally, paleocurrent data vectors in Beacon Channel point

bars record a secondary flow cell that rotates in the opposite direction of fluvial point bars.

The plug package contains thickly bedded, structureless sandstone and cross-bedded sandstone. These strata lap out onto the lateral margins of the channel. Gravel locally occurs in the channel thalweg. This package records a time of minimal sediment bypass and decreased depth of the thalweg due to filling of the channel. This package maintained the inherited sinuosity of the point-bar package. The package contains the highest net:gross and lowest facies diversity of the three packages.

The upper bedded package contains strata that lap out against the lateral margins of the channel. These strata are the finest grained of all the strata in the channel, and between turbidite beds shale drapes are nicely preserved. Strata in this package completely fill the channel. Like the plug package, the bedded package inherited the sinuosity created during deposition of the point-bar package. Strata directly above this package are laminated siltstones that record the abandonment of the channel.




The Beacon Channel crops out in the Delaware Mountains, West Texas. The photodraped digital elevation model shown here illustrates the location of exposures of the Beacon Channel on five different cliff faces. Correlation of the cliff faces reveals a sinuous plan form to the channel. A schematic cross section summarizes the three stratigraphic packages that construct the Beacon Channel. Detailed photographs of the point-bar package document lateral changes in facies that occur within beds of this package.

The Beacon Channel study is an example of research conducted by the Bureau's Laser-assisted Analogs of Siliciclastic Reservoirs (LASR) team, who are devoted to developing stratigraphic concepts and teaching tools for industrial sponsors by studying outcrops around the world. The effort is led by David Pyles. Other Bureau researchers on the team are Renaud Bouroullec, Mark Tomasso, and Florence Bonnaffe. David Jennette played a major role in setting up this industry-sponsored program. The Beacon Channel study is a collaborative project with Rick Beaubouef, Christine Rossen, and Vitor Abreu of ExxonMobil.

# 3-D Modeling of Mississippian Crinoidal Buildups in the Sacramento Mountains and Comparison with Horseshoe Atoll Reservoirs

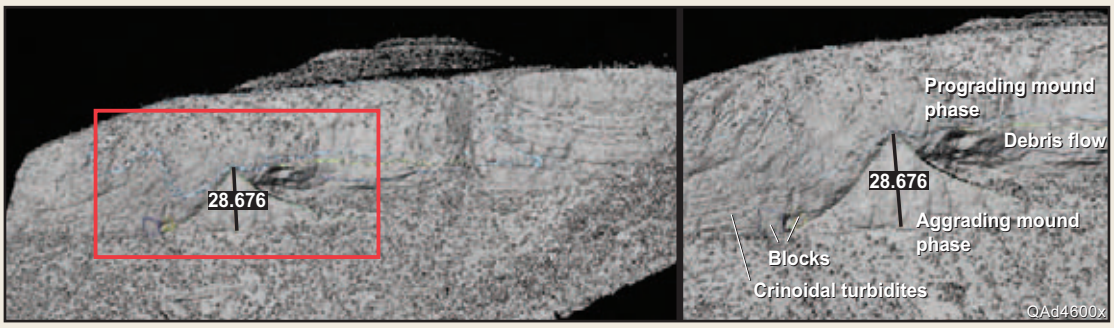
Charles Kerans

For several years, the Reservoir Characterization Research Laboratory (RCRL) has been working to develop new methods for constructing 3-D outcrop analog models by integrating geologic information into high-resolution digital elevation models (DEM's) provided by laser scanning. We are currently gathering data from the well-studied large crinoidal buildups of Mississippian age on the west flank of the Sacramento Mountains, New Mexico. These buildups are thought to be analogs for a portion of reservoirs found in the Horseshoe Atoll trend, a Pennsylvanian-age carbonate reef system in the Permian Basin of West Texas that is a major producer of oil and gas. Previous studies of Pennsylvanian buildups in the Sacramento Mountains have focused on phylloid algal buildups that are also analogous to a portion of Horseshoe Atoll reservoirs.

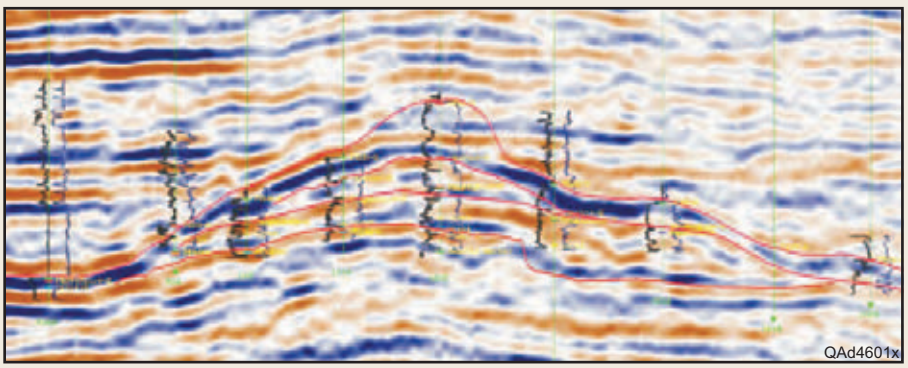
This outcrop study is exploring the potential of using exposures of the Mississippian-age crinoidal buildups as analogs for reservoirs found in the Upper Pennsylvanian-age Cisco Group that are part of the Horseshoe Atoll. Although they are of different geologic ages, numerous similarities exist between these two carbonates, the most important of which is the predominance of deeper water, crinoidal mud-mound facies.

Research is focusing on outcrops of the Lake Valley Group found in Alamo Canyon on the west flank of the Sacramento Mountains. A full 3-D geologic model of this area (3 × 4 km) will be generated using the RCRL's lidar laser scanner. Laser scanning will capture the buildups and overlying prograding ramp grainstone lobes and provide enough lateral control to capture the strike variability of lobe to interlobe facies. The model will incorporate lidar data, photomosaic maps, and measured sections. Gocad software will be used to build the geologic model that will be populated with petrophysical properties using data from Cisco reservoirs in the Horseshoe Atoll.

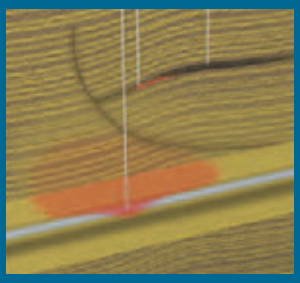
RCRL team members for this project are Charles Kerans, Xavier Janson, and Jerome A. Bellian.




High-resolution DEM of "Tepee Mound" (interpretation based on Dorobek and Bachtel, 2001: Journal of Sedimentary Research, v. 71, no. 6, p. 1003–1016). The colored lines are 3-D lines that correspond to the digitized stratigraphic contacts or limits of sedimentary bodies. Direction of progradation in this view is toward the viewer. This architecture is very similar to what is observed in the subsurface data from the Cogdell field.




South-north cross section through the north dome of Cogdell field illustrating the prograding lobe of crinoidal grainstones and packstones within the Canyon 2 sequence (in area of second and third wells from right-hand side of panel) and the isolated Cisco pinnacle that defines the crest of the field. Log traces depict gamma-ray (left) and porosity (right) values.



# RESEARCH:
## *EARTH AND ENVIRONMENTAL SYSTEMS*

## Modeling Future Changes in Barrier Island Wetlands on Galveston Island, Texas

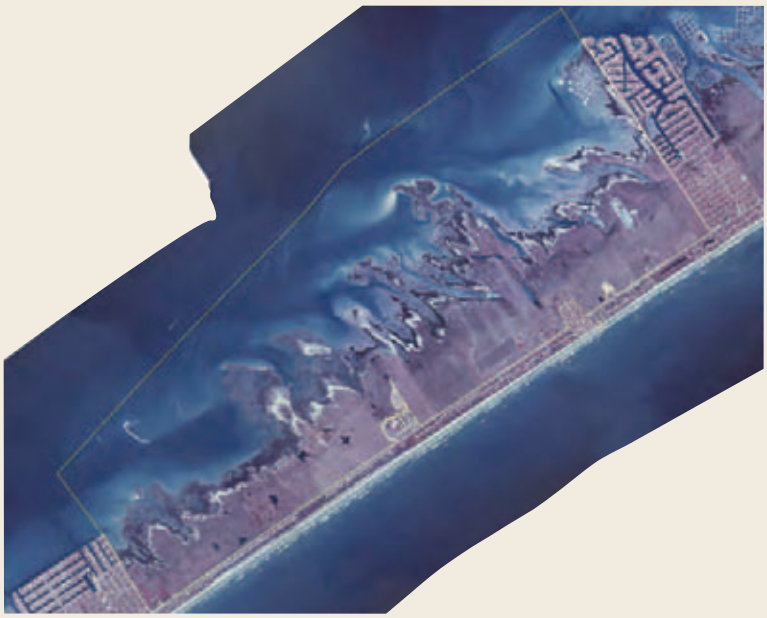
James Gibeaut

Through multiple mapping and research projects, the Coastal Studies Group is seeking to improve our understanding of how barrier islands will respond to sea-level rise over the next 100 years, especially along the Texas coast. During the last 100 years, sea level has risen about 50 cm relative to the land along the coast, which has caused changes in the distribution of wetlands and contributed to shoreline retreat. This relative sea-level rise is caused by global increases in water level and local subsidence of the land. During the next 100 years we can expect that, overall, sea level will rise in Texas by another 50 cm, a significant amount for low-lying, gently sloping barrier islands and coastal plains. And the increase in sea level may be even greater if the global rate of sea-level rise increases, as is predicted by climate change models.

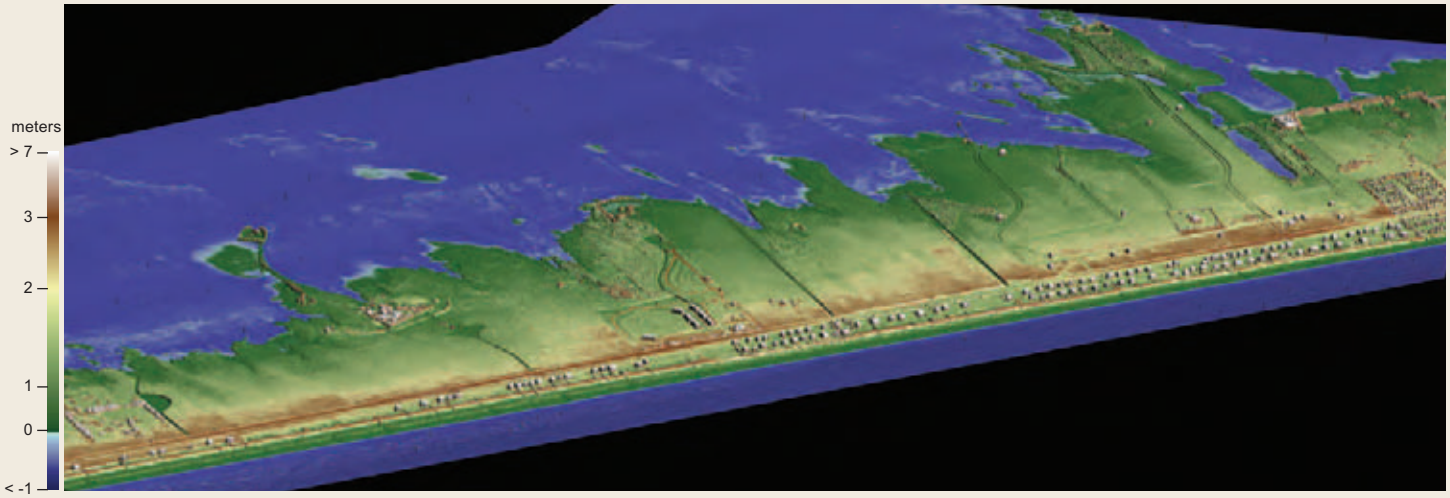
We have been developing a model since 2002 for a portion of Galveston Island to describe how sea-level rise will change barrier island wetlands. We envision this research will lead to a better understanding of how sandy barrier islands respond to sea-level rise and specifically what the future holds for Texas barrier islands. Results from this work will be directly applicable to developing environmental policy.

The model test area is a 7.5-km-long, undeveloped part of the bay side of Galveston Island. The diurnal tide range is 30 cm, and the elevation of the wetland/upland boundary is about 1 m above mean sea level. The average rate of relative sea-level rise (1908–99) is 6.5 mm/yr.

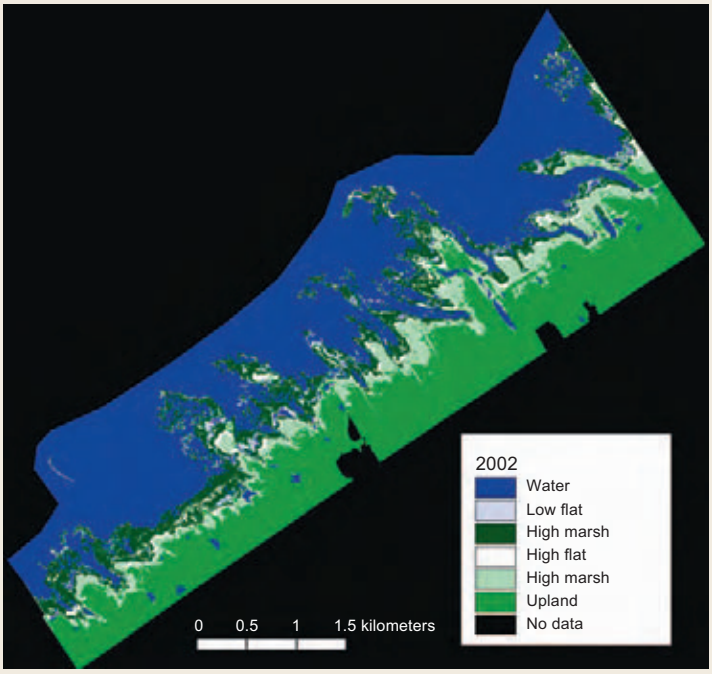
Researchers began by combining a wetland map derived from manual interpretation of color-infrared photography and extensive field checks with a high-resolution (1-m postings and 0.1- to 0.15-m vertical accuracy) lidar-derived digital elevation model (DEM) to topographically quantify the barrier island subenvironments: open water, low flat, low marsh, high flat, high marsh, and upland. Other factors included in the model are vertical sediment accretion and rate of shoreline change caused by waves and currents. The data set forms the basis of an inundation model to determine the most likely transition of wetlands during expected future sea-level rise.



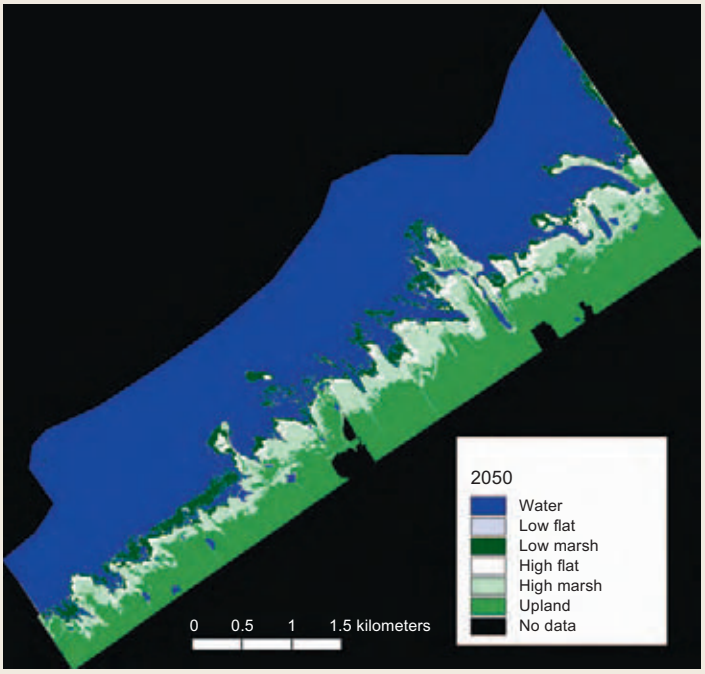
Color-infrared vertical aerial photograph of model test area on Galveston Island taken in 2002. Area has a topographic relief of only 1.5 m, and estuarine marshes and flats are distributed in a complicated pattern across a relict storm-surge-channel geomorphology.




Oblique view of shaded-relief image of a lidar-derived DEM that serves as the foundation of the wetlands change model. Lidar data acquired and processed by the Bureau of Economic Geology.




DEM classified according to wetland type in 2002.




Projected wetland distribution in 2050.

Researchers ran the wetlands model 48 years into the future. The record of mean annual water levels as measured at a bayside tide gauge from 1956 through 2002 was used to calculate sea-level input into the model. Because wetlands are not expected to respond to sea-level fluctuations within a year's time, the running average of the previous 5 years of sea level was used for each model time step.

In 2002, 316 ha of marsh was mapped: 58 percent of the area is low marsh, and 42 percent high marsh. The model predicts that after 48 years, 256 ha of marsh will exist, 32 percent being low marsh and 68 percent high marsh. The total marsh area is predicted to decrease 19 percent—high marsh increasing 35 percent and low marsh decreasing 56 percent.

The model also predicts that marsh will migrate up the gently sloping barrier on the Gulf side and disappear on the bayward side owing to inundation and shoreline retreat. Similar patterns and amounts of change are observed when comparing 1956 and 2002 aerial photographs, which show a 26 percent loss of marsh area. Observed marsh upland migration patterns and an overall similar decrease in marsh area indicate that assumptions in the

model, particularly sedimentation, shoreline retreat, and marsh-elevation relationships, are reasonable.

The prediction of an overall decline in marsh area of 19 percent over 48 years—a conservative estimate because it does not include the effects of any increase in rate of sea-level rise due to climate change—is a major cause for concern. Most of the loss is in low marsh, an important environment for fishery juveniles. Although the high rate of low-marsh decline is partly offset by upland migration in this undeveloped setting, development is now occurring, and more development is proposed in areas where the model projects an upland transition to wetlands.

After the modeling approach is refined, we will apply it to other barrier islands where we have developed the necessary data sets, such as on Mustang Island. Model projections of wetland distributions could be used to establish buffer zones where development is restricted or to guide the acquisition of uplands for conserving future wetlands. The model will also allow experimentation to determine the relative importance of the various processes that determine the style of transition of barrier island environments during sea-level rise.

## FutureGen Texas: The World's First "Clean" Power Plant

Scott Tinker

FutureGen is a U.S. Department of Energy (DOE) initiative to build a 275-megawatt prototype power plant capable of producing hydrogen and sequestering carbon dioxide ($CO_2$), with near-zero emissions, that will turn the nation's abundant coal supply into a decarbonized fuel. The $1 billion research project is intended to enable the clean use of coal while limiting the negative environmental impacts of using this cheap and abundant resource.

The prototype facility will be designed to allow testing of various components and fuel types in all phases of the process, as well as fully measuring, monitoring, and verifying $CO_2$ sequestration according to established protocols developed to validate the technology.

The FutureGen project must locate a host site that will store the $CO_2$ permanently. The DOE objectives call for initially sequestering at least 90 percent of $CO_2$ emissions from the plant, eventually capturing 100 percent, or 1 million tons per year. The plant would prove the effectiveness, safety, and permanence of $CO_2$ sequestration.

The Bureau is coordinating the site-selection process in Texas and leading the State's response to the upcoming DOE Request for Proposals. A FutureGen Texas team, under the direction of State Geologist and Bureau Director Scott W. Tinker and consisting of Bureau staff, key University staff, and consultants, will demonstrate that Texas is uniquely qualified for siting, construction, and operation of the FutureGen project.

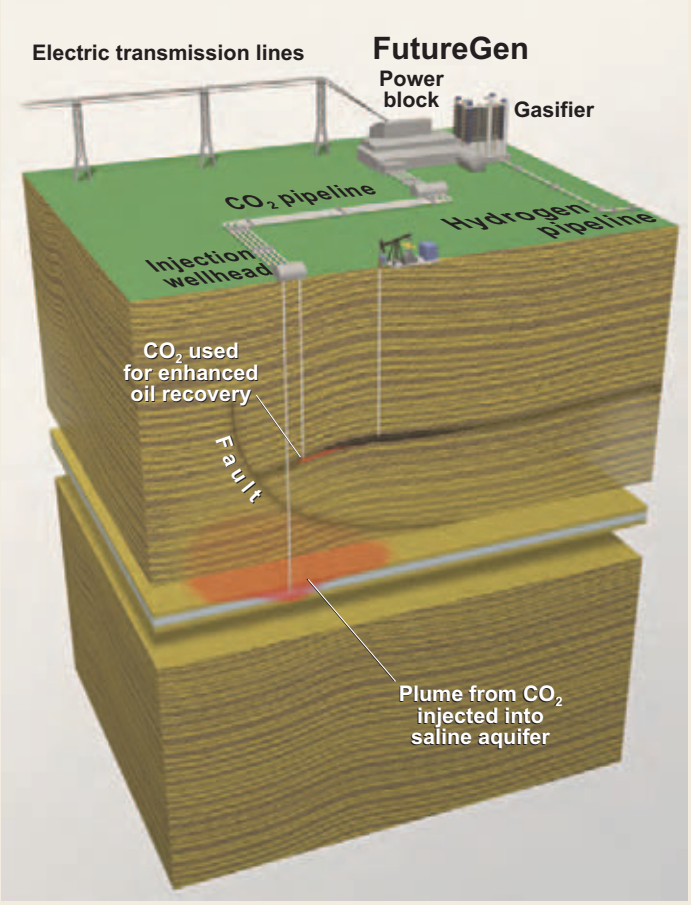



Diagram showing proposed FutureGen site with prototype power facility that will produce electricity and hydrogen with near-zero emissions. Coal is gasified to produce syngas, a mixture of hydrogen and $CO_2$, which can be used as fuel for power generation in a combustion turbine. The $CO_2$ produced by gasification will be used for enhanced oil recovery, and any unused $CO_2$ will be sequestered in geologically secure compartments.

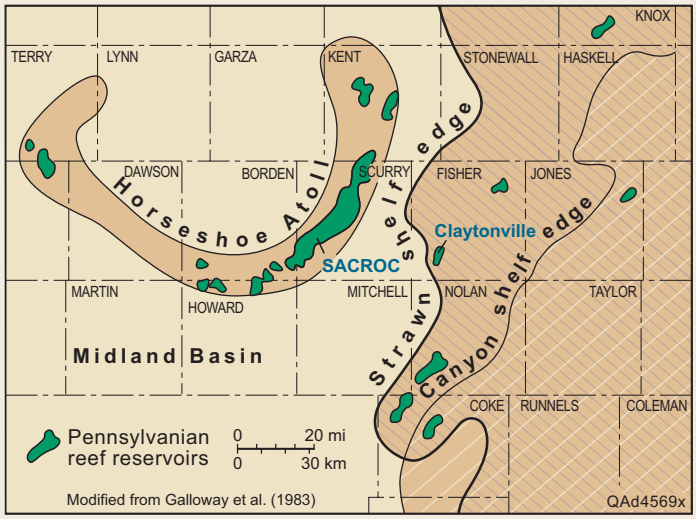
The Gulf Coast region is poised to lead the nation to an energy future that will most likely be based on production of hydrogen from coal. The combination of extensive coal consumption and production; high demand for $CO_2$ for enhanced oil recovery; strong existing markets for hydrogen, methanol, and power; flexibility of available coal types; availability of rail, pipeline, and surface and subsurface infrastructure; longer term storage of $CO_2$ in high-volume brines; and energy history and expertise make Texas the best place for the prototype FutureGen facility. These same features make the Gulf Coast region ideal for extending the FutureGen template to establish a broad, regional power infrastructure for the future.

# Geological and Petrophysical Characterization for $CO_2$ Sequestration in Enhanced Oil Recovery Floods, Permian Basin of West Texas

Mark Holtz

The Bureau is working with the U.S. Department of Energy's Southwest Regional Partnership for Carbon Sequestration to conduct geological and petrophysical characterization of enhanced oil recovery floods in the Permian Basin of West Texas. This 4-year project, conducted with operator Kinder Morgan, will investigate $CO_2$ sequestration in carbonate oil reservoirs.

The study will focus on two sites. Researchers will begin by geologically characterizing portions of the Upper Pennsylvanian Canyon Formation in the Scurry Area Canyon Reef Operators Committee (SACROC) Unit and Claytonville oil reservoir fields. The first field, the SACROC, has undergone $CO_2$ flooding for more than 20 years; the second reservoir, the Claytonville, will begin the flooding process during the project. After baseline data are collected, researchers will extensively monitor the injected $CO_2$—with a focus on the overlying aquifers—to determine if $CO_2$ is leaking from the rock unit in which it is being sequestered.




Study area showing the SACROC and Claytonville reservoirs. Map based on *Atlas of Major Texas Oil Reservoirs*.

## Getting a Picture of the Rocks

Accurate geologic assessments and models of the pilot test reservoirs are critical in order to analyze the storage, and possible leakage, of $CO_2$. Researchers will study and integrate

- Stratigraphic relationships to help define flow units between $CO_2$ injectors and oil producers
- Petrologic analyses (performed at the pore level), coupled with stratigraphic analyses, to define the storage potential and to provide the framework within which all other reservoir experiments are conducted
- Quantitative petrography to assess potential interactions between injected $CO_2$ and subsurface mineralogy, and potential $CO_2$ leakage pathways
- Petrophysical analyses (performed at the pore level) to produce geocellular reservoir models for simulation analyses and to establish the potential capacity for long-term storage of $CO_2$

## Watching for $CO_2$ Leakage

The Permian Basin rock units in which researchers are conducting the pilot test are overlain by salt-water aquifers. This is an ideal setting in which to test for $CO_2$ leakage out of the rock unit into which it is being injected. Researchers will collect detailed baseline water sample data before $CO_2$ injection and then extensively monitor for $CO_2$ movement after injection. Water sampling wells will be drilled

into the overlying aquifer. Groundwater samples will be collected and analyzed for a year prior to $CO_2$ injection to determine the normal seasonal or meteoric-event hydrochemical fluctuations.

Researchers will measure isotopes of dissolved inorganic carbon, trace elements, pH, and other constituents following the Texas groundwater data system sampling procedures. All data will be compiled in a geographic information system to allow easy mapping and transfer of data among researchers and to the U.S. Department of Energy.

Bureau researchers for this project are Mark H. Holtz, Rebecca C. Smyth, Vanessa Nunez, and Caroline L. Breton.

# Arsenic Contamination in Texas Groundwater

Bridget Scanlon

Arsenic contamination in groundwater is a Texas issue and a global issue. Widespread arsenic contamination is present, for example, in Bangladesh, West Bengal, Taiwan, and Argentina. A major public health crisis has resulted from the exposure of more than 21 million people to arsenic contamination in Bangladesh. Arsenic is a known carcinogen that has been linked to skin, bladder, and lung cancers and other vascular diseases. The United States recently lowered the federal standard for arsenic in drinking water from 50 to 10 µg/L, significantly increasing the number of drinking water supplies that exceed regulatory limits for arsenic. Six percent of the wells in Texas contain groundwater that exceeds the new maximum contaminant level (MCL) of 10 µg/L arsenic. Contamination is focused in the Southern High Plains and the southwestern Gulf Coast, where 32 and 29 percent of wells, respectively, exceed the MCL. The Bureau recently conducted a study of groundwater arsenic contamination in Texas for the Texas Commission on Environmental Quality (TCEQ). The primary objectives of the study were to evaluate anthropogenic (caused by humans) and geogenic (caused by natural geologic features) sources of arsenic in the Southern High Plains and southwestern Gulf Coast areas of Texas.

The primary anthropogenic source of arsenic is arsenical pesticides, which were used as defoliants for cotton. Geogenic sources in the High Plains include volcanic ashes in the Ogallala Formation, Cretaceous shales, and saline lakes. Geogenic sources in the Gulf Coast include the volcanic tuffs in the Catahoula Formation and uranium roll-front deposits.

Anthropogenic sources were evaluated by drilling 18 boreholes in the Southern High Plains and 10 in the southwestern Gulf Coast. Soil samples were analyzed for arsenic concentrations and other anions; pressure-head data were evaluated to determine flow directions. Geogenic sources were examined by relating groundwater arsenic concentrations to different geologic units and correlating arsenic concentrations with other oxyanions to assess geogenic sources and mobilization processes.

## *Southern High Plains*

Evidence of arsenical pesticides is apparent in well profiles in cultivated areas. Highest arsenic levels occur in the top 0.5 m and correlate with high concentrations of nitrate and phosphate related to fertilizer applications. These data indicate that arsenic related to arsenical pesticides is restricted to the near-surface zone. In some cultivated areas, however, peak arsenic concentrations occur at depths too great to be the result of pesticide applications. High arsenic levels were also found in rangeland areas never used for cotton farming and where it is unlikely that pesticides have ever been applied. These data indicate a widespread source of water-soluble arsenic in soils in the Southern High Plains that is mostly natural in origin and may be mobilized to contaminate groundwater.

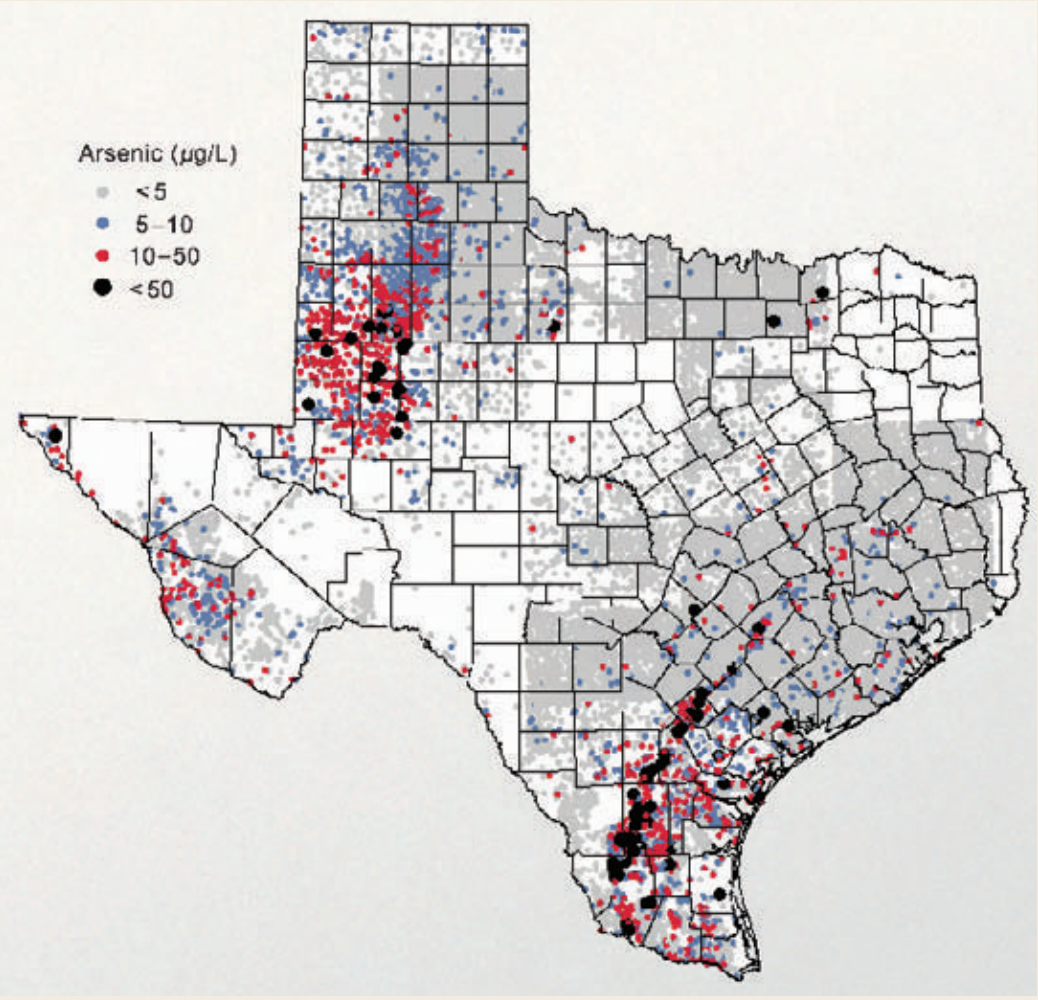
Arsenic contamination is much greater in the southern part of the Southern High Plains (51 percent of wells >10 µg/L)—where total dissolved solids (TDS) are >500 mg/L—than in the northern part (7 percent of wells >10 µg/L)—where TDS are <500 mg/L. The dividing line between the southern and northern section extends from Lubbock, Texas, to Clovis, New Mexico. Groundwater arsenic contamination occurs in generally oxidizing conditions in the High Plains, and arsenic is expected to be in the form of arsenate. Positive correlations between arsenic and other constituents (vanadium, fluoride, molybdenum, boron, selenium) suggest a geogenic rather than

an anthropogenic source. Arsenic concentrations are related to geologic units and are highest in the Ogallala aquifer and much lower in the Dockum aquifer. Arsenic concentrations in the Edwards Trinity (High Plains) aquifer are highest where it underlies the Ogallala and much lower elsewhere. Potential sources of arsenic include volcanic ash beds in the Ogallala, black shales in the Cretaceous (Kiamichi Shale), and saline lakes. Analysis of geophysical logs indicates that high-gamma zones, indicative of volcanic ash beds, are restricted primarily to the southwestern area of the Southern High Plains and are not located with most of the high groundwater arsenic concentrations.

## Southwestern Gulf Coast

Water-soluble arsenic levels are variable in the unsaturated zone in the southwestern Gulf Coast. Highest levels (≤1,854 µg/kg) were found in an area where cotton-gin waste was plowed into fields. Restriction of elevated arsenic that is probably related to gin waste to the upper ~ 2 m of the soil zone suggests that gin waste is an unlikely source of groundwater arsenic. High chloride concentrations below the arsenic peak indicate that there is little water movement below this zone; therefore, arsenic from the gin waste is unlikely to reach the groundwater. In another profile, high arsenic concentrations in the shallow subsurface that correlate with high nitrate suggest fertilizer or arsenical pesticide sources. High arsenic concentrations were found throughout an irrigated profile. The remaining profiles had low arsenic levels (<10 µg/kg) that showed no systematic variation with land use or depth. These data suggest that arsenical pesticides are an unlikely source of groundwater arsenic contamination in this region.

High groundwater arsenic concentrations in the southwestern Gulf Coast area extend as far west as the Catahoula Formation outcrop. Arsenic concentrations are highest in the Jasper aquifer (48 percent >10 µg/L), which immediately overlies the Catahoula Formation, and are much less in younger stratigraphic aquifers (Evangeline aquifer, 21 percent >10 µg/L, and Chicot aquifer, 27 percent >10 µg/L). Therefore, volcanic ashes associated with or reworked from the Catahoula Formation are the most likely source of high arsenic concentrations in the southwestern Gulf Coast aquifer. Correlations between arsenic and other oxyanions typically associated with volcanism (vanadium, molybdenum), as well as the general decrease in arsenic contamination away from this formation, strongly support this hypothesis.



Arsenic distribution in groundwater across the State of Texas.

Although only an initial assessment of arsenic contamination in the Southern

High Plains and southwestern Gulf Coast, this study shows that arsenic reservoirs in the unsaturated zone are important because they could be mobilized by artificial recharge or other mechanisms. Future studies will evaluate geogenic sources by conducting geophysical logging and stratified aquifer sampling. These data will allow higher resolution linkages between geologic units and arsenic levels in groundwater. If arsenic contamination can be linked to specific geologic units, drinking water wells can be remediated and future wells can minimize arsenic contamination by avoiding groundwater production from zones high in arsenic.

Researchers involved in this project are Bridget R. Scanlon, Andrew Tachovsky, Robert C. Reedy, Jean-Philippe Nicot, H. Seay Nance, and Rebecca C. Smyth. Student assistants are Randi Ashburn, Kelley Keese, and Lance Christianson.

# Geologic Mapping for the STATEMAP Program

Eddie Collins

The goal of the Texas STATEMAP projects, part of the National Cooperative Geologic Mapping Program administered by the U.S. Geological Survey, is to produce geologic maps of areas of Texas where knowledge of the geologic framework is of vital importance. Study areas for the Texas program typically include areas having specific environmental and natural resource concerns, urban and rural corridors undergoing population growth, and areas of critical aquifers and their recharge areas.

## *Two Current Mapping Projects*

Researchers are currently mapping two barrier island areas of the Texas Gulf Coast, Galveston and Mustang Islands, to provide information that will aid in the planning of land use and management of these islands. Within these barrier island settings, natural and man-induced processes, including erosion along the Gulf shore, subsidence caused by active surface faults, dredged channels, road construction, regional subsidence, and sea-level rise, can rapidly change island environments, such as beach, dune, wetland, and upland areas. These maps will aid in evaluating shoreline changes, changes in geologic depositional environments, and changes in land use. Airborne lidar data are being used with aerial photography and field observations for this study.

A second project is the geologic mapping of a portion of the Brazos River Valley and the associated aquifers within Robertson and Milam Counties. In this study area, the Brazos River alluvial aquifer, a prolific alluvial aquifer, intersects three other significant Texas aquifers—Carrizo-Wilcox, Queen City, and Sparta. These aquifers supply much of the water required for urban, rural, and agricultural needs in the region. This geologic map can be used to evaluate the area's geologic framework, to aid in understanding the physical and hydrologic relationships between the aquifers, and to provide geologic information useful for managing water quality and availability.

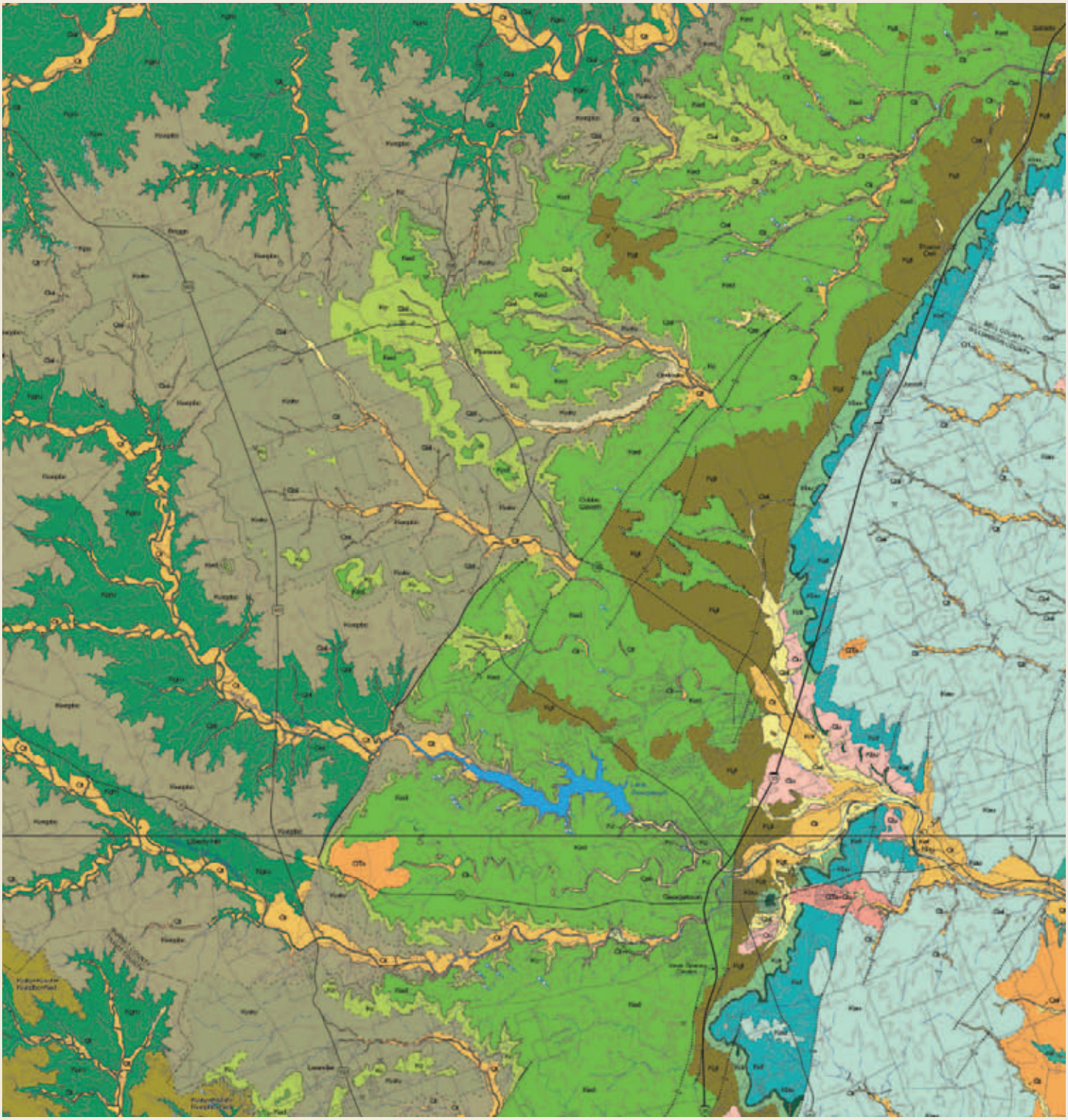
## *Recently Completed Maps*

The *Geologic Map of the Del Rio, Texas, Area*, an open-file 1:100,000-scale map, was completed in 2005. The map area, bordering the Rio Grande in south-central Texas, includes Del Rio, Amistad National Recreation Area, and major transportation routes from Mexico. This area contains Cretaceous bedrock and late Tertiary to Quaternary surficial deposits. It lies within the southern Edwards Plateau part of the important Edwards limestone aquifer, and the area also includes part of a smaller aquifer, the alluvial Uvalde aquifer. This map is intended to be used by professionals and laypersons as a source of general geologic information for land and resource use and management. It provides general data for those interested in sources of construction materials, engineering properties of near-surface materials, groundwater resources, areas of recharge, and geologic hazards, such as flooding, erosion, and expansive soils.

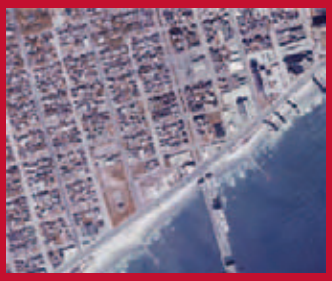
The *Geologic Map of the West Half of the Taylor, Texas, 30 × 60 Minute Quadrangle: Central Texas Urban Corridor, Encompassing Round Rock, Georgetown, Salado, Briggs, Liberty Hill, and Leander*, and its accompanying text booklet are scheduled to be published during late 2005 as part of the Bureau's Miscellaneous Map series. This map and booklet illustrate and describe the physical geology of a

Central Texas area that is undergoing rapid urban and suburban growth. The study area contains Cretaceous bedrock, the northern segment and recharge zone of the regionally important Edwards aquifer, and a part of the regional Balcones Fault Zone.

Bureau staff involved in the STATEMAP projects are co-principal investigators Jay A. Raney, Edward W. Collins, and James C. Gibeaut, and researchers Thomas A. Tremblay, Rachel Waldinger, Tiffany L. Hepner, Rebecca C. Smyth, Roberto Gutierrez, and William A. White.



Map illustrating the surface geology of the northern Edwards aquifer segment along the Interstate 35 corridor of Round Rock, Georgetown, and Salado, Central Texas. This map will soon be published as part of the Bureau's Miscellaneous Map series.



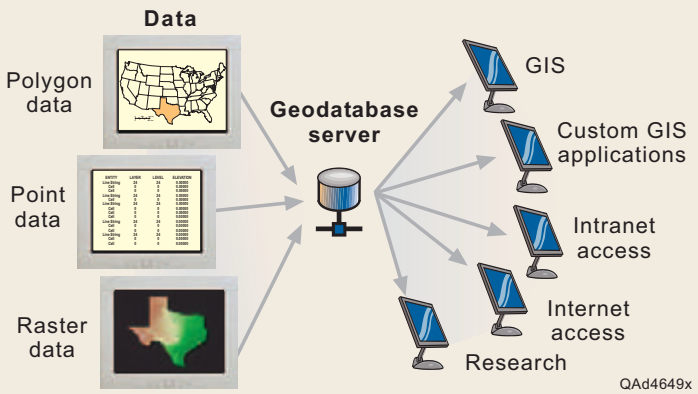
# TECHNOLOGY APPLICATION

## Developing a GIS Database Infrastructure

David Jordan

A new group has formed at the Bureau to manage and make accessible the huge amount of spatial data acquired by the Bureau in its research. The new geographic information systems (GIS) team is led by David Jordan, who works with the Bureau's GIS specialists: John Andrews, Caroline L. Breton, Romulo Briceno, Thomas A. Tremblay, and Rachel Waldinger. Much of the vast data stored at the Bureau contains spatial attributes that can be viewed in a mapping system. The GIS group is designing and implementing new systems and technologies to store these large geographic data sets and make them available to all users. New GIS infrastructure being developed by the group is designed to replace relatively old and inefficient means of storing and providing spatial data with robust, secure, easily expandable storage methods.

Why is this issue important? As the state geological survey for Texas, the Bureau is responsible for providing geographic data related to the state's geologic and other resources to the public. These data are also needed internally by researchers and other users to support projects and administrative activities. The GIS group is working to implement technologies and strategies to handle the current load and to anticipate future growth in this area.




Data are the foundation of a GIS infrastructure.

The term "GIS database" can refer to nearly any type of geographic data that can be accessed with GIS or mapping software—from older storage methods, like locally stored shapefiles and georeferenced image files, to newer, more robust spatially enabled network-based relational databases. This network-based method of storing geographic data is the foundation of the Bureau's GIS database system. Environmental Systems Research Institute, Inc.'s (ESRI) Spatial Data Engine (ArcSDE) software acts as a translator between relational database software and GIS software, allowing geographic data sets to be stored in a relational database. These systems can store any type of GIS data—from point, line, and polygon files, to large raster data sets, and even ASCII data. The advantages of this system include the ability of users to access small parts of large data sets without accessing the entire data set, better support for multiple users, and the capability to edit data without compromising the original version.

Another advantage of using a centralized GIS database is that data can be customized for different applications. Data layers can be provided for pure GIS applications using GIS software, the data being utilized directly by the software. Custom GIS applications can also be programmed to access the data so that no GIS skills are necessary to use it. Web-based applications can be created to provide geographic data to the public, for example, to search for geologic sample holdings by displaying sampling locations on an interactive map.

An example of the power and value of GIS technology is the Bureau's study of natural and man-made features of the Texas coast. The Padre Island National Seashore and the Galveston Coastal Hazards Web sites rely on aerial photography to provide reference information for their online map services. These digital images are quite large—as much as 20 gigabytes per image—and require large amounts of processing power to provide them in the map service.

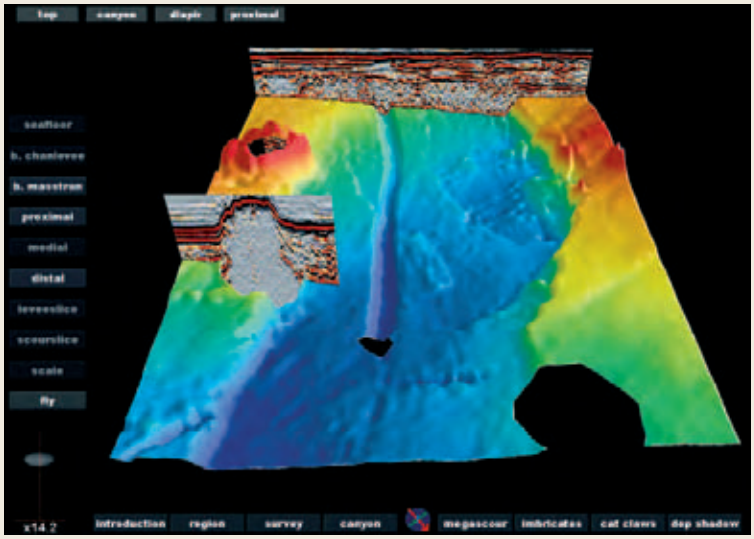
As part of the Texas Commission on Environmental Quality's (TCEQ) Surface Casing study, the Bureau has created an online mapping service for well drillers to obtain surface casing information in four counties in Central Texas. The pilot study focused on a single county and utilized locally stored data sets because of the limited geographic extent of the study area. The addition of three counties to the study area presented an opportunity to use the new GIS database infrastructure. Because of the size of the counties, new methods were needed to keep the response time of the horizon queries low. The horizons were stored as raster images in the geodatabases, speeding up response time considerably.

The Bureau is working toward providing GIS data in a more streamlined, secure, and customizable way with new database technologies. These new methods will provide new and up-to-date GIS database infrastructures to store, visualize, analyze, and share data more effectively and efficiently without sacrificing data integrity.

## Interactive 3-D Visualization of Earth Science Models

John Andrews

Much of the research performed at the Bureau relies on data of considerable spatial complexity. For example, data representing well locations, faults, seismic volumes, and many subsurface features might all be managed in a complex database and viewed, manipulated, and studied using a wide range of geoscience software. Traditionally, research findings involving these data have been delivered to the public through print media or digital files and through Web pages showing static images or animations captured from the project. Over the past year, however, the Bureau has developed an interactive, 3-D, Web-based viewer to share our research with the public in a visually rich format that gives viewers much more control over the images. Now anyone having access to a Web browser on a computer can view the data in different layers and from different perspectives.




Stratigraphic horizon and seismic data as depicted in Bureau's interactive, Web-based 3-D viewer.

Software written by Bureau staff has made it possible for these data to be transformed into an *a la carte* menu from which viewers can make their choices. Essentially, the individual data components—fault polygons, seismic slices, topographic horizons, and the like—are exported from their native file format and converted, individually, to Virtual Reality Modeling Language (VRML). The data components are then compiled into a single Web project using Bureau-written software to achieve an interactive feel that puts the data, literally, at the user's fingertips. Practically any geoscience data can be converted to this format. The above image, for example, was captured from a project examining debris-flow processes and deposits; seismic panels and a stratigraphic horizon are visible, as are numerous buttons and slide bars designed to facilitate interactive viewing. Other data sets can be manipulated in a similar manner to make the possibilities limitless for creative ways of looking at and interpreting data.

Bureau researchers involved in Web-based interactive 3-D visualization are John Andrews, Lesli J. Wood, James C. Gibeaut, Susan D. Hovorka, and David Pyles.

# PUBLIC OUTREACH AND EDUCATION

## Working with Texas Museums

As we face the challenges of resource management, global climate change, catastrophic natural events, and more, the need for a well-informed public has never been greater. Despite the need for geoscientists, our schools struggle to include even basic earth sciences in their curricula, and the number of students choosing careers in the geosciences remains disappointingly low. Through its outreach programs, the Bureau provides a valuable service in public education with an added benefit of giving students a glimpse of careers in the earth sciences. In the past year the Bureau developed alliances with some important new outreach partners: Texas' public museums.

Created in partnership with the Jackson School of Geosciences and the Houston Museum of Natural Science for display in the museum's Weiss Energy Hall, "Texas: The Underground Story—The Origin of Texas Oil and Natural Gas" uses advanced computer animation to demonstrate the formative geologic processes that created the Gulf of Mexico and the Texas Gulf Coast. Authored by Renaud Bourellec, David Jennette, and Ryan Crow, and produced by Scott Rodgers, the short video explains the events that created the Texas Gulf Coast over the past 200 million years to make it one of the world's richest reservoirs of oil and natural gas. With more than 2 million visitors annually, the Houston Museum of Natural Science offers an unequaled venue for high-quality outreach.

The "World of Water" exhibit, created in partnership with and funded by the Witte Museum in San Antonio, uses the Bureau's advanced imaging capabilities to take visitors on a journey through the Edwards aquifer. Tracking the flow of water from its origin as rainfall in the Hill Country to its final destination in our homes, this unique three-screen exhibit winds through the aquifer and gives a close look at its rare and exotic life forms. Created by Bureau scientist Susan D. Hovorka and Marise McDermott of the Witte Museum, the project was a collaborative effort that also included the National Speleological Society, the Texas Memorial Museum, and many other professional groups. Visualizations are based on real data gathered by Bureau remote-sensing specialist Jerome A. Bellian using terrestrial lidar scanning technology in subterranean caves in the Edwards Formation. Raw data were processed by John Andrews and Reuben Reyes as surfaces and then "mapped" with photographs and artists' renditions to recreate the karsted aquifer environment. Computer models of the blind catfish that dwell within the aquifer were based on computed tomography (CT) scans of real specimens. The exhibit will be viewed by more 220,000 visitors this year. Through support of the Guadalupe–Blanco River Authority, digital media and TEKS-based classroom materials will also be distributed to schools within the Edwards watershed.

The Bureau also provided presentations and exhibits for other museums in the state. "Drawn from Experience: Landmark Maps of Texas" appeared at the Bob Bullock Texas State History Museum in early 2005. Reviewing the history of Texas through 400 years of maps, the exhibit gave visitors a look at the changing face of Texas, as well as the evolving methods used to map it. The Bureau provided animations demonstrating lidar mapping of coastal changes and a look at the varied geology of the Austin region.

In addition, the Bureau continued to support the American Geological Institute's Earth Science Week in the Midland Public School System with a series of virtual reality presentations at the Midland Petroleum Museum. The program includes a variety of visualizations created at the Bureau, including a virtual tour of the Big Bend region, views inside the Edwards and Ogallala aquifers and an oil reservoir, and a study of fluid-flow simulation through rock.

Other collaborative programs with these and other museums are now in the planning stage. As museums seek high-quality scientific content to address important regional issues the Bureau will maintain a high profile in its public outreach efforts. Museums offer an excellent venue in which to engage the interest and imagination of our youth, an important first step in creating career tracks into the world of the earth sciences.

## The Texas High School Coastal Monitoring Program: A Project in Education, Public Awareness, and Coastal Management

The Texas High School Coastal Monitoring Program (THSCMP) is an ongoing Bureau project designed to help coastal residents develop a better understanding of the dune and beach dynamics on the Texas coast. Bureau researchers James C. Gibeaut and Tiffany L. Hepner work with high school and middle school students and teachers, showing them how to measure topography, map vegetation lines and shorelines with Global Positioning Systems (GPS), and observe weather and wave conditions. As participants

in an actual research project, the students enhance their science education and provide coastal communities with valuable data on their changing shoreline.

The THSCMP, in its ninth year of operation, receives funding from the Texas Coastal Management Program. Participating schools are Ball High School on Galveston Island (9 years in the program), Port Isabel High School in South Texas (7 years in the program), and Port Aransas High School on Mustang Island (7 years in the program). During the 2004–05 school year, the program added two schools in the Bay City region. Van Vleck Middle School and students participating in the Spanish Science Club at Tidehaven Middle School started collecting data on Matagorda Peninsula. Bay City High School will also join the program during the 2005–06 academic year. Bureau researchers and students make at least three field trips to survey sites in their coastal regions. The Bureau envisions a network of coastal schools conducting scientific beach studies and then sharing their observations with other students, schools, and the public using the Internet. For more information, visit the program's Web site at http://txcoast.beg.utexas.edu/thscmp/.

## Earth Science Week

The annual Austin Earth Science Week Career Fair is in its sixth year. This year's career fair was held for 350 middle school students and their teachers at the University's Commons Conference Center at the J. J. Pickle Research Campus on October 11, 2005. Scott W. Tinker gave the opening ceremony presentation. This annual event, organized by the Austin Earth Science Week Consortium and coordinated by researcher **Sigrid Clift,** also included a book drive for the Austin Public Library, for which more than $2,500 was raised to purchase much-needed earth science books, and the third annual summer lecture series that featured "Roving the Plains of Mars and Mapping the Moons of Saturn," by John M. Curchin, and "The ABC's of Austin—Aquifers, Bats, and Caves," by Julie Jenkins and Jennee Galland.

## Petroleum Technology Transfer Council (PTTC)

The mission of the PTTC program is to provide technology transfer opportunities for small independent oil and gas producers in Texas. The PTTC Texas Region, which is managed by the Bureau, sponsored or cosponsored nearly 20 events in 2005. These events included workshops and symposia on stranded gas, reserve writedowns, horizontal well technologies, coalbed methane applications, the Barnett Shale, reservoirs and seals, improved profits through best managed practices, and sand control. Highlights included cosponsorship of the third annual Barnett Shale symposium, the third annual reservoir engineering workshop, and the ninth annual $CO_2$ conference in Midland, Texas. The PTTC Texas Region is directed by **Scott W. Tinker. Sigrid J. Clift,** Eric C. Potter, and Sylvia Jennette provide support for the program.

## Geologic Wonders of Texas

"Geologic Wonders of Texas" is the title of an online public outreach module created by Bureau researchers and staff for UTOPIA, an ambitious initiative designed to open the University's doors of knowledge, research, and information to the public. This online field trip includes Dinosaur Footprints, Central Texas, Galveston Island, and the Franklin Mountains, additional resources, and lesson plans. The module can be viewed on the Bureau's Web site at www.beg.utexas.edu/UTopia/geowonders.html.

## 3-D Virtual Reality

**John Andrews** and **Scott Rodgers** frequently take to the road with the Bureau's portable 3-D virtual reality system for technology transfer and outreach to researchers, students, and the public. Topics include the Edwards aquifer, Central Texas geology, Big Bend National Park, and flyovers created using lidar and Ilris laser scanning technology.

## Online $CO_2$ Outreach Module

**Susan D. Hovorka** has created a new online module titled "Audience-Pleasing Physical Models to Support $CO_2$ Outreach," which is posted on the Bureau's Web site. The objective of these materials is to provide the carbon capture and storage (CCS) research and outreach community with easily transferable demonstrations designed to increase public understanding and acceptance of issues related to greenhouse gas and CCS processes.

## Teaching and Community Involvement

**Mark Holtz** was once again part of the teaching staff at a summer program hosted by the Los Alamos National Laboratory in Santa Fe, New Mexico, titled "Research Experience in Carbon Sequestration." The program is designed to engage undergraduates, graduates, and early career professionals in carbon sequestration science. Last year's 10-day program involved 20 students from the United States and Norway.

Associate Director **Eric Potter** led his second annual field trip through Great Hills Park in northwest Austin on April 23. Eric, an active park volunteer, discussed the stratigraphy, springs and creeks, and geologic processes that created the canyon where Great Hills Park is located. Bureau researcher Sigrid Clift assisted Eric with the field trip.

**Rob Reed** served as a rock and mineral "identifier" at both Texas Memorial Museum Identification Day events this year, wherein experts from all over Central Texas are on hand to look at and identify natural objects such as fossils, rocks, and insects that visitors bring in for identification.

# Public Information Resources

In addition to being a research unit of The University of Texas at Austin, the Bureau serves as the Texas Geological Survey. In this role, the Bureau maintains the following public resources and facilities: Core Research Centers, Data Center (composed of the Geophysical Log Facility and the Reading Room), and Publication Sales. These facilities are open to the public Monday through Friday from 8:00 a.m. to 5:00 p.m. Comprehensive information about these resources can be found on the Bureau's Web site at www.beg.utexas.edu under the menu Public Resources.

## Core Research Centers

The Core Research Centers (CRC's) are the Bureau's research and storage facilities in Austin, Houston, and Midland that house core and rock material donated to the University. Public facilities include core examination rooms, processing rooms for slabbing core, and office space. For more information, please call the Austin CRC manager at 512-471-0402, or visit the Bureau's Web site.

## The Data Center

The Data Center, comprising a Reading Room and Geophysical Log Facility, is located on the first floor of the Bureau's headquarters in Austin. The Reading Room maintains a collection of geological reference materials, including periodicals, maps, well logs, publications, and reports from various governmental and nongovernmental earth science entities. For information, please call **Sigrid Clift,** the Bureau's public information geologist, who manages the center, at 512-471-0320.

The Geophysical Log Facility (GLF) is the official well-log repository for the Railroad Commission of Texas, which by law receives a copy of geophysical logs from every new, deepened, or plugged well drilled in Texas since September 1985. An estimated 800,000 logs are archived at the GLF, including the RRC collection and donated logs from industry and Bureau research projects. Other data sets available at the GLF include well records and scout tickets from hundreds of thousands of Texas wells. GLF is converting logs into electronic images, and logs are also available as paper copies by contacting the GLF Manager, **Daniel Ortuño,** at 512-471-7139.

## Publication Sales

The Bureau publishes and sells maps and reports of research conducted by Bureau staff from 1915 to the present. In 2001 we also began handling the sales of select Gulf Coast Association of Geological Societies (GCAGS) publications and those of member societies. The Publication Sales office is located on the first floor of Bureau headquarters in Austin. Orders for publications can be made either in person or by mail, telephone, fax, or e-mail, or through our Web site at www.beg.utexas.edu. For information, please call **Amanda R. Masterson,** the Publication Sales manager, at 512-475-9513. Free copies of the current year's List of Publications, Annual Report, and Midyear Report are available upon request.

# Support Staff

## Administrative

**Wanda LaPlante** is the Assistant to the Director. **Sharon Campos** supervises the administrative staff who are responsible for general administration of the Bureau. Sharon and her employees handle payroll, personnel, accounts payable and receivable, purchasing, travel and reimbursement, and countless other tasks for the Bureau's 140+ employees.

## Contract Management

Contract Manager **Lynda Miller** and her staff help researchers prepare budgets and proposals and serve as liaisons for funding agencies. Contract management includes financial reporting, database and records management, and the documentation of progress and submission of deliverables.

## Facilities Management

The day-to-day management of the building is the responsibility of Facilities Manager **George Bush**. His team provides behind-the-scene support for inhouse meetings, conventions, daily mail service, maintenance of Bureau vehicles, office moves, and inventories of basic equipment.

## Media Technology

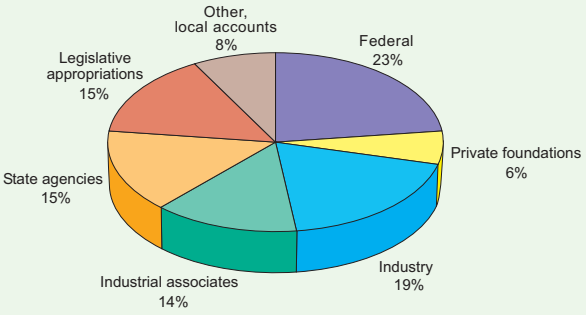
The Media Technology department, led by **Joel Lardon,** comprises the Bureau's Graphics, Editing, Web, and Virtual Reality Laboratory services.

## Information Technology

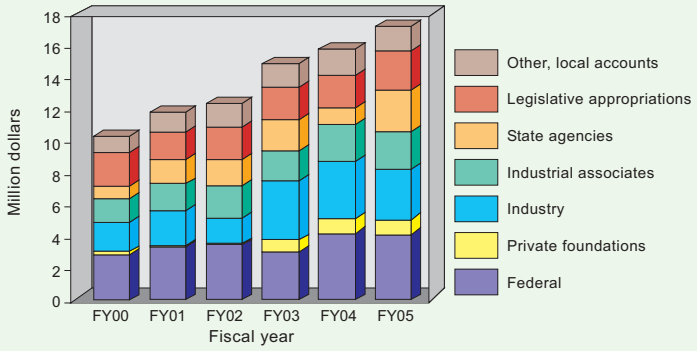
The Information Technology group, led by **Ron Russell,** provides vital computer technology assistance to Bureau researchers and staff. Geoscience software support comes from Landmark Graphics Corporation via the Landmark University Grant Program, Dynamic Graphics, GeoGraphix, GeoQuest, GMA, Green Mountain Geophysics, GX Technology, Hampson & Russell, Midland Valley, Neuralog, Paradigm, Petra, Seismic MicroTechnology, and Terra Science.

# BUREAU FINANCES AND STAFF

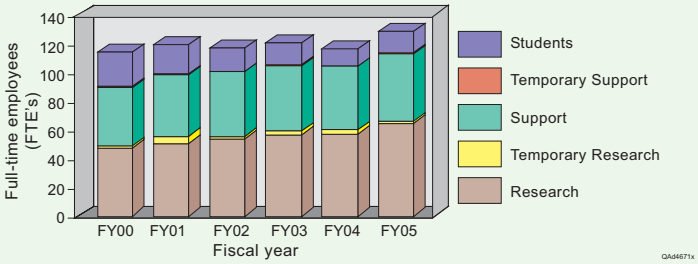
## *Sources of Funding*




## *Six-year Budget Trends*




## *Staff Trends*




# Bureau Advisory Committee

The Bureau's Advisory Committee was created in 2000 to provide counsel and advice to the Bureau Director and staff concerning research programs, mission, research opportunities and directions, and administrative structure. The Committee's 10 members have diverse backgrounds and expertise representing a broad spectrum of geologic interests. The Committee meets twice a year at Bureau headquarters in Austin. Current members of the Advisory Committee are listed below:

**Russell G. Slayback,** Chairman
Chairman
Leggette, Brashears & Graham, Inc.

**Thomas D. Barrow**
President
Thomson-Barrow Corp.

**Annell R. Bay**
Regional Exploration Director, Americas
Shell Energy Resources Company

**Paul Ching**
Director EP R&D
Shell International Exploration and Production

**Richard J. Chuchla**
Geoscience Manager, ExxonMobil Exploration

**L. Decker Dawson**
President, Dawson Geophysical Company

**James W. Farnsworth**
Vice President, North America Exploration
BP America, Inc.

**James A. Gibbs**
Chairman of the Board
Five States Energy Company, L.L.C.

**William E. Gipson**
President
Gas Fund, Inc.

**Charles R. Williamson**
Chairman of the Board and CEO
Unocal Corporation

**The University of Texas at Austin**
**Bureau of Economic Geology**
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