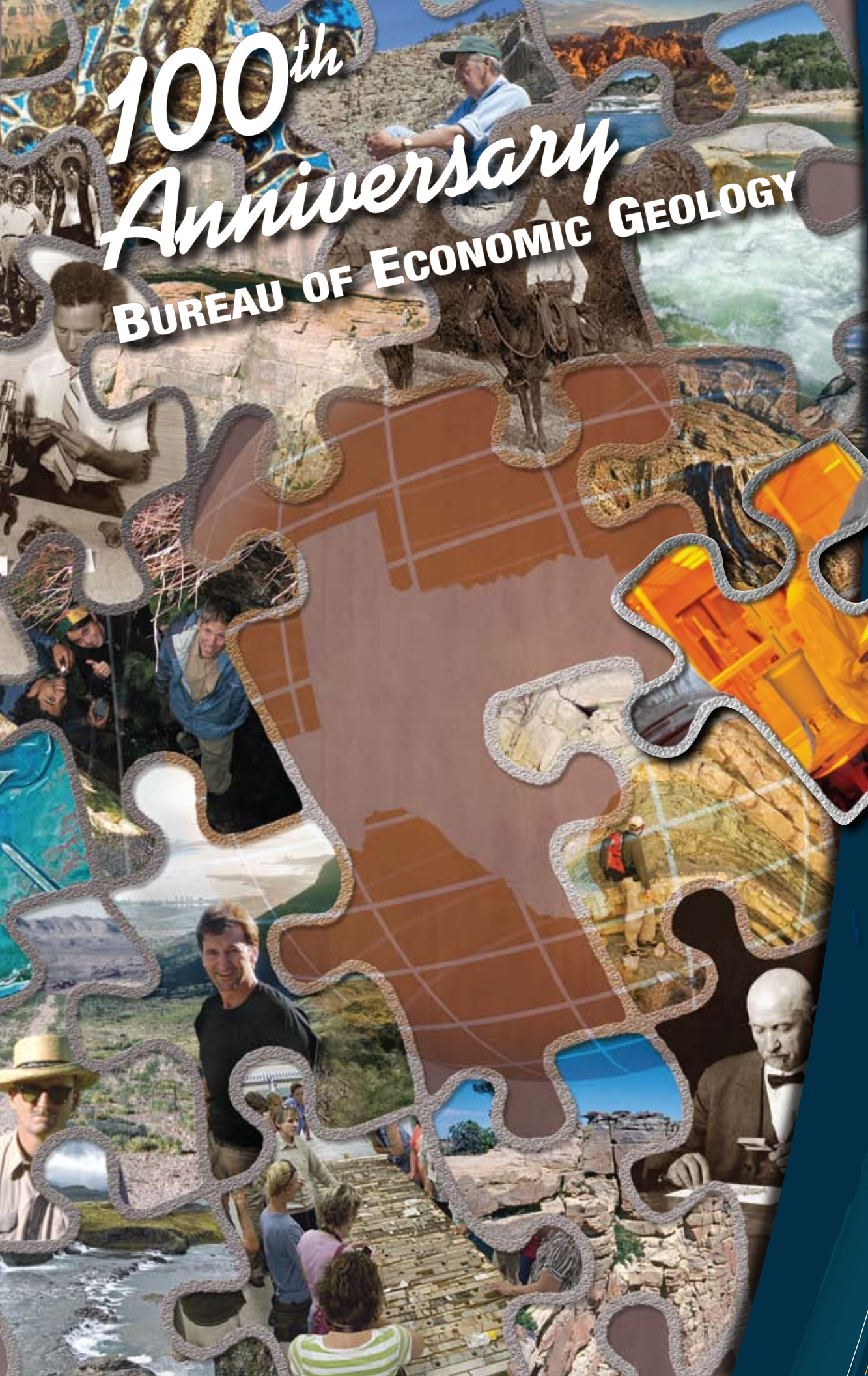

100th Anniversary

Bureau of Economic Geology

Annual Report 2009

100 Years of Scientific Impact

Annual Report 2009

BEG: 100 Years of Scientific Impact

1909-2009

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Director's Message

For an organization to survive and prosper for 100 years is remarkable. To survive is to adapt; to prosper is to grow. The Bureau has both adapted and grown in the past century into what is today a premier global geoscience research and education institution.

We owe much to those who came before. Directors Phillips, Udden, Sellards, and Lonsdale led the Bureau in its first 50 years. Their combined research interests included mining engineering, oil and gas, paleontology, and groundwater resources. Under their leadership the Bureau focused primarily on Texas—its minerals, oil and natural gas, and other resources—a vast, largely unknown frontier. Director Phillips set the stage: "With me, it is Texas first, last, and always, and I do not allow anything to interfere." Later, Director Udden stated with confidence, "I am firmly of the opinion that there will be interesting geologic work to do in Texas for a whole century to come."

The Bureau's second 50 years were led by Directors Flawn, Fisher, Tyler, and me. During this time the Bureau broadened its geologic horizons, began to compete for and attract national and international funding, and grew into the modern organization that it is today. Our central focus is largely unchanged: energy, environmental research, and education. What is learned globally is brought back and applied to challenges in Texas.

Directors help to develop the vision, serve as a "rainmaker" for external funding, and establish the ethical and collegial fabric of an organization. Peter Flawn summed it up well: "Good management required little more than good common sense, treating people the way you would like to be treated, staying ahead of the paperwork, and developing a vision of what your organization should be and where it should go." Directors have a strong influence, but it is the many great scientists and talented staff members who dedicate their careers to serving the Bureau that allow the organization to flourish.

The rich pallet of scientific breakthroughs that have come from Bureau researchers is truly remarkable. Our acknowledged contributions to science include early oil and gas exploration, vertebrate paleontology, paleoecology, coastal-plain concepts, environmental geology, depositional systems, reservoir characterization and reserve growth, carbonate sequence stratigraphy, salt tectonics and geodynamics, fractures and structural diagenesis, multicomponent seismic and seismic imaging, unconventional gas systems, sustainable hydrology, and, most recently, carbon sequestration and subsurface nanotechnology. Such research achievements have built and will maintain our international reputation.

In the *2000 Annual Report* Director's Message, I said, "If we maintain ethics in our approach, quality in our results, pride in our science, laughter in our halls, and an eye on 'new horizons,' then the Bureau family will flourish in the new millennium." As I look back after a decade, I believe that our focus on applied research problems, which often lead back to fundamental questions, continues to serve us well. The combination of talented and diverse people, societal focus and impact, untiring work ethic, and recognition that we are in this together will allow us to build on the strong foundation of the past and to prosper well into the future.

Scott W. Tinker

Bureau Highlights

Bureau Centennial Recognized at the State Legislature

The 81st Texas Legislature adopted resolutions recognizing the Bureau's centennial and 100 years of service as a research unit at The University of Texas at Austin and the Texas Geological Survey. Representative Donna Howard sponsored the resolution in the House and gave the reading on the chamber floor on May 27th. Senator Kirk Watson sponsored the resolution in the Senate and gave the reading on May 28th. In attendance for the readings from the Bureau were Director and State Geologist **Scott Tinker**; Associate Directors **Jay Kipper**, **Ian Duncan**, and **Eric Potter**; and support staff members **Wanda LaPlante**, **David Stephens** (photographer), and **Sigrid Clift**. Angie Long and Gwen Grigsby from President Powers' office played a critical role in working with the legislature to get the resolutions through both the House and the Senate.

FutureGen Facility in Texas

U.S. Energy Secretary Steven Chu announced December 4th that the Bureau of Economic Geology will design and assure compliance with a state-of-the-art CO_2 sequestration monitoring, verification, and accounting program for the $350 million Texas Clean Energy Project. The 8-year, DOE-sponsored program managed by Summit Texas Clean Energy, LLC, will integrate coal-gasification and power-generating technology with carbon-capture technologies to capture 90 percent of the CO_2 at a 400-megawatt plant to be built near Midland-Odessa, Texas. The captured CO_2 will be treated, compressed, and transported by pipeline to oil fields in West Texas for use in enhanced oil recovery (EOR) operations. Much of the groundwork for the Texas Clean Energy Project was done by the Bureau for FutureGen Texas, an earlier DOE coal-gasification/clean-energy initiative.

Sharon Mosher Named Dean of the Jackson School of Geosciences

On June 16, the Jackson School announced that Sharon Mosher, chair of the Department of Geological Sciences in the Jackson School of Geosciences at The University of Texas at Austin since 2007, had been named dean of the School. The School's press release said that

> ...the selection of Mosher, who holds the William Stamps Farish Chair, culminates a national search for a new dean after Eric Barron left to become director of the National Center for Atmospheric Research in July 2008. Professor Charles G. Groat, director of the university's Energy and Earth Resources graduate program and Center for International Energy and Environmental Policy, was interim dean during the search.
>
> "As dean, my goal is to create a cohesive geoscience community that balances academic and research excellence and the broader societal mission of the geosciences," Mosher said.
>
> "I believe the Jackson School has the opportunity to make a lasting and transformative impact on the geosciences, becoming a preeminent geoscience institution and meeting the full potential envisioned by Jack Jackson," Mosher said.
>
> Dean Mosher met with many Bureau staff in small, informal discussion sessions throughout the fall.

Director Tinker said, "I look forward to Sharon's leadership, and we are all excited about contributing to the mission of the Jackson School and realizing Jack Jackson's vision."

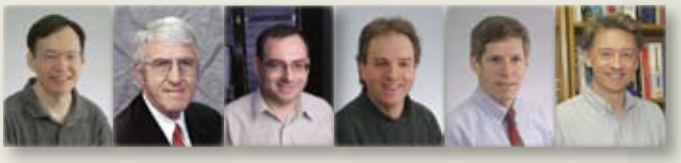
DOE Announces $4.8-Million-Dollar Grant to Bureau for Characterizing Texas Gulf Coast Offshore Reservoirs for Potential CO_2 Sequestration

The Bureau's project to investigate the potential for CO_2 sequestration in the offshore Texas Gulf Coast (the Gulf of Mexico Miocene CO_2 Site Characterization Mega-Transect project), led by Bureau researchers **Ramón Treviño** and **Tip Meckel**, has been funded by a grant from DOE's National Energy Technology Laboratory. Storage opportunities in Miocene-aged formations for Texas Offshore State Lands will be explored. The project will also complete a detailed site assessment of promising reservoirs for storage of anthropogenic CO_2 emissions. Bureau team members, including Meckel, Treviño, and 11 other Bureau staff members, are partnering with the UT Institute for Geophysics, Los Alamos National Lab, the UT Petroleum Geosystems Engineering Department, Sandia Technologies, and the Environmental Defense Fund in the venture.

The project began in discussions between Railroad Commissioner Michael Williams and **Bureau Director Scott Tinker** and was championed by Representative Warren Chisum (and Senator Kirk Watson of Austin), who in the 2009 legislative session sponsored a bill initiating five studies leading to commercial sequestration projects. Subsequent discussions between senior General Land Office (GLO) staff, including GLO Commissioner Jerry Patterson and Bureau scientists **Ian Duncan**, **Sue Hovorka**, and Tip Meckel, resulted in an agreement to pursue DOE funding as a component of fulfilling the vision outlined in the Chisum-Watson bill. A key component of success of the DOE proposal was GLO's commitment of $1,200,000 of cost share for the project.

Bureau Director Scott Tinker informed Commissioner Patterson, Representative Chisum, and other stakeholders in the grant's success. Dr. Tinker noted: "This DOE award, combined with our recent State of Texas Repository grant from the GLO, establishes the largest and most important CO_2 sequestration characterization effort in the nation. Texas uses a tremendous amount of energy to produce industrial products for the nation. As a result, Texas also produces CO_2. This offshore-characterization grant work brings together State, Federal, industry, and university partners to study how and where large volumes of CO_2 could potentially be stored deep beneath the Earth's surface. I am very proud of our carbon team and our national and international partners."

New RPSEA Proposal Award Recipients



On June 6, the Research Partnership to Secure Energy for America (RPSEA) announced award recipients, and the Bureau was named in 4 of the 15 programs chosen. A total of 92 proposals were submitted in the two categories of Small Producer Program and Unconventional Energy Program. Total funding to the Bureau over a 3-year period is expected to exceed $3.5 million. Programs selected include (1) "Development Strategies for Maximizing East Texas Oil Field Production," **Fred Wang**, PI, with project participants Danmark Energy L.P. and John Linder Operating Co., LLC; (2) "Evaluation of Fracture Systems and Stress Fields within the Marcellus Shale and Utica Shale and Characterization of Associated Water-Disposal Reservoirs: Appalachian Basin," **Bob Hardage**, PI, with project participants The University of Pittsburgh, Chesapeake Energy Corporation, Jeter Field Service, RARE Technology, Austin Powder Company, AscendGeo, AOA Geophysics, Inc., and Seismic Source; (3) "Multiazimuth Seismic Diffraction Imaging for Fracture Characterization in Low-Permeability Gas Formations," **Sergey Fomel**, **Peter Eichhubl**, Randy Marrett, **Steve Laubach**, and Jon Olson, co-PI's, with project participant Bill Barrett Corporation. For the program "Barnett and Appalachian Shale Water Management and Reuse Technologies," the Project Leader is Gas Technology Institute, and the Bureau is a project participant (**J.-P. Nicot**, subcontract leader), along with Texerra, Geopure, Barnett Shale Water Conservation and Management Committee, and Appalachian Shale Water Conservation and Management Committee.

GCCC's Cranfield Study—Giant Step in Carbon Sequestration

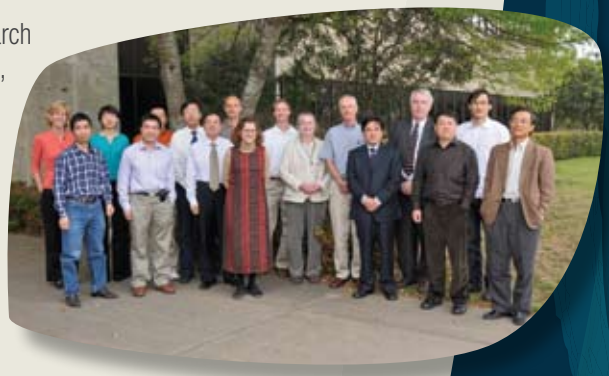
The Bureau of Economic Geology Gulf Coast Carbon Center (GCCC) is currently conducting a $34-million, multiyear field study of sequestration and monitoring strategies for long-term storage of carbon dioxide, having recently completed two 10,700-ft wells into the Lower Tuscaloosa Formation in Cranfield field, Mississippi. The first of its kind in smart-well construction, the project has allowed Bureau collaboration with four national labs, as well as the U.S. Geological Survey. Denbury Resources in Plano is hosting the project, which began in July 2008—a 1,000,000-metric-ton/year sequestration of CO_2, which is a milestone that has been met. GCCC is monitoring the injection project to document that CO_2 is effectively retained in the reservoir and plans to use these data to increase confidence and decrease costs of monitoring future geologic carbon sequestration projects. DOE NETL is funding the project, which is part of a Southeast Regional Carbon Sequestration (SECARB) partnership led by the Southern States Energy Board.

New DOE Funding

Three Bureau scientists were recently notified by the Department of Energy (DOE) that their proposed research projects will be funded. **Bob Hardage** has been selected by DOE to investigate "Improving the Monitoring, Verification, and Accounting of CO_2 Sequestered in Geologic Systems with Multicomponent Seismic Technology and Rock Physics Modeling," with a 3-year program that began in November. **Ian Duncan**, Associate Director for Earth and Environmental Systems, was selected by DOE's National Energy Technology Laboratories for his proposed 4-year research program, "Developing Comprehensive Risk Assessment Frameworks for Geological Storage of CO_2," which also began in November. **Steve Laubach's** proposal, "Predicting Fracture Porosity Evolution in Sandstone," was selected by DOE's Basic Energy Sciences group for funding—a 3-year program that started in December.

Delegation from China Hosted by Bureau

On March 23, the Bureau hosted a delegation from the Research Institute of Petroleum Exploration and Production (RIPED), the research arm of China's national oil company, PetroChina. Bureau scientist **Hongliu Zeng** served as liaison and guide to the five-member delegation, who toured Bureau facilities and attended presentations by Bureau scientists **Ian Duncan**, **Eric Potter**, **Sue Hovorka**, **Becky Smyth**, **Tip Meckel**, **Bob Loucks**, and **Jerry Lucia**. Carbon sequestration and enhanced oil recovery were the focus of most discussions between the Bureau and RIPED, as the two groups met to explore the possibility of future joint research.



Tinker, Hovorka, and Hardage in the News

On Sunday, March 15, **Bureau Director Scott Tinker's** photo appeared in the Austin American Statesman in an ad for U.T.'s State of Tomorrow. "He told CO_2 emissions where they could go," reads the caption under the photo of Scott, hard hat in hand, standing in front of a Texas power plant. The blurb goes on to tout the Bureau and our GCCC group "…pioneering discoveries in carbon sequestration, one of several promising new technologies helping to find global solutions that work for our energy needs and for the environment." A year-long TV ad also ran on all major networks.

Research Scientist **Sue Hovorka** was featured in the lead story, "above the fold," in the UT Daily Texan on September 11. "UT Takes on Carbon Research" is the title of the article about the Jackson School receiving a $1 million grant from DOE, in which Sue is heavily quoted. "Instead of putting carbon back into the atmosphere, we can put another building next to the power plant and sequester it. That way, it's making a closed loop. A lot of people are afraid of sequestration. I think that's ignorance. Most people don't know that the Earth is layered, and there are impermeable zones where anything you inject into the ground will stay in the ground." http://www.dailytexanonline.com/top-stories/ut-takes-on-carbon-research-1.1874272.

In November, while **Bob Hardage** (left) was in Canada to present four Centennial lectures, Satinder Chora (right), of the Canadian Society of Exploration Geophysicists (CSEG), interviewed him. In the December issue of the *CSEG Reporter*, the interview, along with several color photos of Bob, was published, in which Bob details his background, work ethic, and philosophy, for example, on writing papers. "Fortunately I have access to an excellent Graphics Section at the Bureau, and I keep a good number of those people employed by the graphics jobs I give them," Bob says. For the rest of the interview, which includes other "attaboys" about the Bureau, see http://www.cseg.ca/publications/recorder.cfm.

RCRL Goes Spelunking

On January 13th a group of RCRL researchers visited Longhorn Caverns near Marble Falls to investigate an age-old research question concerning the relationship between fractures and caves, which is a focus area of the Carbonate Reservoir Characterization Research Laboratory. The caverns provide an excellent example of the effect of fractures on cave-passage control. Researchers included *(from left to right in photo)* Randy Caber, **Bob Loucks**, Jerry Bellian (kneeling), **Chris Zahm**, Nabiel Eldam, **Cari Breton**, and Joseph El-Azzi. Photo by **Jerry Lucia**.

Bureau Retreat

On December 16, all Bureau staff participated in a 1-day retreat. Updates on administrative, research, and development activities were given in a series of short presentations, with open dialog throughout. It was a day full of spirited discussion, good food, and camaraderie.

AEC Funding Reaches $6 Million

The Bureau-managed Advanced Energy Consortium (AEC) funded more than $6 million in nanotechnology research in 2009. After a 5-month technical evaluation of proposals submitted to AEC from around the world, proposals from these institutions were selected as winners: The University of Texas at Austin, Rice University, Boston University, Harvard University, University of Alberta (Canada), Tufts, Northeastern, California Institute of Technology, Pennsylvania State University, Louisiana State University, University of Oklahoma, Northwestern University, University of Michigan, University of Calgary, UFABC (Brazil), 3M, Oxane Materials, and the Alberta Research Council. AEC intends to fund specific research projects at these institutions for periods ranging from 1 to 3 years. Funds have been reserved for additional solicitations and directed research projects to be announced. AEC's focus is on the application of nanotechnology to the exploration and production of oil and gas. The goal of the research consortium is to develop subsurface nanosensors that can be injected into oil and gas well bores. By virtue of their very small size, these sensors will be able to migrate out of the well bores and into pores of the surrounding geological structure to collect data about the physical characteristics of hydrocarbon reservoirs. The data collected will enable a more efficient exploitation of hydrocarbon resources.

Ghana Delegation Welcomed by CEE

At the end of July, CEE welcomed a delegation from Ghana led by the Honorable Emmanuel Armah-Kofi Buah, Deputy Minister of Energy and Member of Parliament. The delegation visited Houston as part of a 12-day Oil and Gas Development Orientation Visit organized by the U.S. Trade and Development Agency (USTDA). Since 2004 CEE has been working in Ghana and the greater West Africa region under USAID. CEE's role is evolving as Ghana becomes an oil and gas producer and, most likely, an exporter.

In the fall CEE was asked by USAID to assess the oil and gas sector in Ghana to help decide how Ghana's emerging oil and gas industry could be best managed. The final report, to be completed in 2010, will also recommend to USAID how to plan an integrated energy assistance program for Ghana. Assessment began on November 9, when the survey team arrived in Accra, Ghana. For more, see http://www.jsg.utexas.edu/news/rels/110609.

25 Years Strong!

On November 19, 1984, the Bureau staff officially moved into a brand-new building on the UT Pickle Research Campus (then called the Balcones Research Center), and 18 of the folks who moved in on that day still work here. Prior to the move, Bureau staff had been working in three different locations for several years—Bureau North (the 5th floor of the Geology Building), Bureau South (a remodeled furniture warehouse at 13th and Lavaca), and Bureau West (the bottom two floors of the Tri-Towers dormitory west of campus). In addition to having terrific new space to work in, the new building made it much easier to interact with each other. Visiting the Cartography or Editing Department was now simply a matter of visiting the 2nd floor instead of riding the Bureau shuttle to Bureau North. Pictured left to right: **Steve Ruppel**, **Frank Brown**, **Tucker Hentz**, **Daniel Ortuño**, **Amanda Masterson**, **Becky Smyth**, **Eddie Collins**, **Seay Nance**, **Martin Jackson**, **Bob Morton**, **Shirley Dutton**, **Wanda LaPlante**, **John Ames**, **Pat Downs**, **Jeff Paine**, **Jamie Coggin**, and **Scott Hamlin**.

Submarine Mass Movements and Their Consequences

The 4th International Symposium on Submarine Mass Movements and Their Consequences was hosted by Dr. Lorena Moscardelli here at the Bureau November 7–12 as part of the International Geoscience Programme (project 511), a joint endeavor of UNESCO and the International Union of Geological Sciences. A total of 55 oral presentations and 40 posters were presented during the conference, from regional characterization of submarine mass movements to geotechnical properties and tsunami modeling. Presentations were recorded and will be available online in 2010 (http://www.beg.utexas.edu/indassoc/dm2/Conference2009/prelim.htm). A total of 122 scientists from academe, industry, and government from 11 countries attended the conference. *Submarine Mass Movements and Their Consequences*, 4th ed., Springer, part of a series on advances in technological hazards research and containing 64 peer-reviewed papers on topics of the meeting (available for sale, Bureau Bookstore) was available at the meeting. A preconference field trip was conducted on Saturday, November 7—Geology, Frontier History, and Selected Wineries of the Hill Country Appellation, Central Texas—and a postconference virtual field trip was held on Thursday, November 12.

The Bureau Celebrates 100 Years

On October 9, 1909, the Board of Regents of the University of Texas established the Bureau of Economic Geology as a research unit of the university and the geological survey of Texas. One hundred years later, the Bureau thrives as a vibrant, global, geoscience research institution.

To commemorate its Centennial year, the Bureau hosted a celebration in August, bringing together more than 200 staff, alumni, and guests at a reception and dinner, and then held a Centennial Symposium on water and energy for the 21st century to an overflow crowd exceeding 300. The Bureau also named a slate of Centennial Distinguished Lecturers to deliver talks and workshops throughout the year to global audiences, reaching thousands of attendees; created a timeline of historical events featured on the Bureau website; published *Earth's Art*, a spectacular, large-format book of photographs and stories by current and former staff created to highlight Bureau research and researchers; and introduced a podcast series, "Time on Earth," featuring interviews with geoscientists on current issues.

Proudly summing up the spirit of the Centennial, Bureau Director Scott Tinker said, "The Bureau has earned its place in history as a leader in geoscience research. We are eager to define and meet future research frontiers in the coming century." For more, go to http://www:beg.utexas.edu/100/.

Distinguished Lecturers

The Bureau asked its senior scientists to serve as Centennial Distinguished Lecturers, and Public Information Geologist Sigrid Clift publicized the program and oversaw its scheduling. Invitations to host Centennial Lectures went out to several dozen key societies, universities, and companies. The Bureau's distinguished lecturers gave 57 presentations in 10 states around the U.S., Canada, Africa, and Mexico. A total of 3,756 people attended these events, and all the lectures were well received.

Senior Research Scientist **Shirley Dutton** kicked off the Centennial Lectures by speaking at the Houston Geological Society Northsiders' Group luncheon meeting on Tuesday, January 20. Shirley spoke on "Reservoir Quality and Pore-Type Evolution in Tertiary Wilcox Sandstones of the Northern Texas Gulf of Mexico Coast during Burial from 0.2 to 6.6 km." On September 29, Shirley also presented at GCAGS in Shreveport.

Sergey Fomel presented two Centennial lectures titled "Seismic Data Patterns" at ConocoPhillips in Houston on July 15th and at the Bay Area Geophysical Society in San Ramon, California, on July 8th. He presented to a full room of 50 to 60 people at each event. Sergey presented the same lecture to Shell in Houston on September 28. On November 11, Sergey gave his lecture "Predictive Painting of 3D Seismic Volumes" at the Permian Basin Geophysical Society monthly luncheon meeting. Approximately 30 people attended the event, and, as a gesture of appreciation from PBGS, Sergey was presented with a commemorative plaque containing a slice of Permian core. On December 8th, Sergey gave the final presentation of the Bureau's Centennial Distinguished Lecture program to 40 people at the Calgary Society of Exploration Geophysicists.

On February 18, the program featured **Jerry Lucia's** presentation of "Locating Remaining Oil in Carbonate Reservoirs: the Reservoir Characterization Problem" at the Engineering Division of Earth Sciences, Universidad Nacional Autónoma de México (UNAM), Mexico City. Approximately 500 faculty members, students, and representatives from Mexico's Secretariat of Energy attended. UNAM faculty member and Texas-Ex Dr. Ricardo Padilla y Sánchez hosted the event. On April 20, Jerry gave his lecture at the Houston Geological Society Northsiders' Group monthly luncheon meeting. Approximately 80 HGS members attended the presentation. On September 17, Jerry presented his lecture to ConocoPhillips in Houston. This lecture was attended by 60 geologists, geophysicists, and engineers and was followed by a lively question-and-answer period. Finally, on November 10, Jerry presented his lecture to more than 90 people at the monthly Dallas Geological Society luncheon in Farmers Branch.

On February 20, **Steve Laubach** gave his first Centennial lecture titled "How Fractures in Sedimentary Rocks Open and Seal: Insights from Structural Diagenesis" at the University of New Mexico, Department of Earth & Planetary Sciences. Approximately 40 faculty members and students attended the event. On May 19 he spoke to 75 attendees at Conoco Phillips, Houston.

On February 26, **Lesli Wood** gave her first lecture at the University of Arizona (UA) in Tucson. Her topic: "Mars: A History of Flowing Water and Moving Sediments." UA is a center for much of the recent research on Mars. Approximately 20 graduate and undergraduate students and faculty from the UA Geology Department attended the talk. On April 28 in Midland Lesli presented her talk at the SW Section AAGP Meeting to an audience of 125.

Steve Ruppel was invited to give his Centennial Lecture, titled "Understanding Black Shale Successions: Lessons and Questions from the Barnett and Other Paleozoic Mudrocks," on March 4 at Chesapeake Energy in Oklahoma City, where more than 100 Chesapeake scientists heard him speak. On May 7, Steve gave his lecture to approximately 40 staff, faculty, and students at the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) at New Mexico Tech in Socorro. On June 23, Steve gave his lecture to a standing-room-only group of 50 geoscientists at USGS Headquarters in Reston, Virginia.

Senior Research Scientist **Mike Hudec** presented a Centennial Lecture in March at Penn State University in State College, Pennsylvania. Titled "Structural Style and Evolution of Thrust Systems Driven by Spreading of Allochthonous Salt Sheets," the talk was attended by 35 faculty and students of Penn State's Department of Geosciences. On April 21 Mike visited the Universidad Nacional Autonoma de Mexico in Mexico City to give his lecture to approximately 175 faculty and students.

On March 26th, **Sue Hovorka**, Senior Research Scientist, presented a Centennial Lecture on carbon sequestration as part of the Earth and Planetary Science Department's Randolph Bromery Departmental Lecture Series at Johns Hopkins University in Baltimore. The lecture, attended by 35 members of a very diverse faculty whose interest in carbon capture and storage is high, began with the sounding of a Chinese gong. On April 9, Sue visited the Department of Geosciences at the University of Arizona in Tucson to give her lecture titled "Put it back: Geologic Sequestration for Greenhouse Gas Emissions Reductions." Approximately 30 graduate students took an active role in hosting and attending the department colloquium. In June Sue presented at the AAPG Convention in Denver.

On April 16, **Martin Jackson** visited Marathon Oil Company in Houston to give his Centennial lecture titled "How and Where is the Sigsbee Escarpment Advancing?" to 40 geoscientists. A question-and-answer session and detailed discussions with small groups followed the lecture.

Gene Fritsche, Program Chair of the 2009 Pacific Sections AAPG-SEPM-SEG Convention, invited the Bureau to sponsor a half-day session titled *100th Anniversary of the Texas Bureau of Economic Geology*. Four Bureau Centennial Distinguished lecturers traveled to Ventura, California, and gave a total of five presentations at the session, which included **Shirley Dutton** (Session Chair), "Reservoir Quality and Pore-Type Evolution in Tertiary Wilcox Sandstones of the Northern Texas Gulf of Mexico Coast during Burial from 0.2 to 6.6 km"; **Bob Loucks**, "Geology of the Mississippian Barnett Shale-Gas Play in Texas: Regional Setting, Sedimentology" and "Pore Networks, and Origins of Reservoir Heterogeneity in Paleokarst Reservoirs, Key to Understanding Production"; **Ian Duncan**, "Risks and Benefits of Geologic Sequestration of Carbon Dioxide"; and **Lesli Wood**, "A Martian History of Standing Water and Moving Sediments." More than 350 people attended the session.

Hongliu Zeng and **Bob Loucks** were invited to Beijing, China, to present several Centennial Lectures to various groups. Bob's tour included BGP, a component of PetroChina (April 17), RIPED of PetroChina (April 21), and the China University of Petroleum (April 20). Approximately 560 people listened to his presentation, "Origins of Reservoir Heterogeneity in Paleokarst Reservoirs; Key to Understanding Production." Hongliu presented one lecture at the China University of Petroleum, "Frequency-Dependent Seismic Stratigraphy and Thin-Bed Resolution" (April 29) and one lecture at RIPED, "Seismic Sedimentology: Concepts and Applications" (May 5) to an audience of 185. On October 19 Bob presented his lecture at Marathon Oil in Houston to 70 attendees.

After a lecture on May 19 to the Northsiders Group in Houston, Centennial Distinguished lecturer **Bob Hardage** gave a total of four lectures in October: "Seismic Stratigraphy to the Full-Elastic Wavefield" to the Geophysical Society of Tulsa on the 10th and the Geophysical Society of Houston on the 21st. He presented a combination of "Expanding Seismic Stratigraphy" and "Deepwater Hydrates in the Gulf of Mexico" to the Southwest Louisiana Geophysical Society of Lafayette on the 13th and "Deepwater Hydrates in the Gulf of Mexico" to the Geophysical Society of Houston on the 20th. Approximately 140 people attended these events. In November, Bob talked on "Seismic Stratigraphy to the Full Elastic Wavefield" at a meeting of the Denver Geophysical Society on the 12th, at the University of Calgary on the 17th, and for the Canadian Society of Exploration Geophysicists on the 18th in Calgary. On the 19th, Bob presented his seismic stratigraphy lecture as well as his lecture "Deep-Water Hydrates" at the University of Alberta, Institute for Geophysical Research. More than 160 people attended these events.

The Bureau hosted two special Centennial Lecture events at the Houston Research Center. On May 23, four lectures on the general theme of the Gulf of Mexico were presented. Speakers included **Martin Jackson**, **Mike Hudec**, **Shirley Dutton**, and **Sergey Fomel**. The second event occurred on August 20th. Four of the Bureau's lecturers gave presentations: **Steve Ruppel** ("Understanding Black Shale Successions: Lessons and Questions from the Barnett and other Paleozoic Mudrocks"), **Bob Loucks** ("Geology of the Mississippian Barnett Shale-Gas Play in Texas: Regional Setting, Sedimentology, and Pore Networks"), **Charlie Kerans** ("A Global Perspective on Carbonate Hydrocarbon Reservoirs: Challenges and Potential"), and **Lesli Wood** ("Deltas on Mars: A Martian History of Standing Water and Moving Sediments"). More than 100 people from companies that support Bureau research attended the special events. Thanks to HRC employees **Randy McDonald**, **Darrell Haynes**, and **Richard Gutierrez** for providing key logistical support.

Director Scott Tinker helped celebrate the Centennial by delivering some 50 keynote and invited lectures in 10 countries (or 11, including Texas!). As President of the American Association of Petroleum Geologists, he traveled widely and spoke often on the theme of "Global Energy: Build Bridges, Not Walls." Another of Scott's favorite topics—dispelling common myths about energy.

1901
Bureau's precursor, University of Texas Mineral Survey, under the direction of William B. Phillips, created.

1909
University of Texas Board of Regents officially activates the Bureau of Economic Geology with William Battle Phillips as Director (the term "economic" recommended by Phillips).

1923
J. A. Udden's observations lead to the drilling of Santa Rita No. 1.

1933
Classic stratigraphic study published, The Geology of Texas, v. 1, Stratigraphy, authored by E. H. Sellards, F. B. Plummer, and W. S. Adkins.

1944
Sellards contacts Congressman Lyndon B. Johnson regarding appropriations for converting government's magnesium plant at the Balcones Research Center to synthetic fuel production.

1961
Bureau publishes first Annual Report (a summary of 1960 activities).

Bureau of Economic Geology: The First 100 Years

To honor its alumni and accomplishments, the Bureau dedicated a section of its website to historical information. Profiles and photos of the Bureau's eight directors—W. B. Phillips, J. A. Udden, E. H. Sellards, J. T. Lonsdale, P. T. Flawn, W. L. Fisher, Noel Tyler, and S. W. Tinker—give a sense of the challenges each administration faced and the adaptive and creative leaders who kept the Bureau thriving. Information about recipients of the Alumnus/a of the Year Award—W. E. Galloway, Doug Ratcliff, C. G. Groat, P. T. Flawn, M. E. Milling, W. L. Fisher, and Susie Doenges—expands the story of key players in Bureau history.

These individuals, most of whom are still active in the geosciences, contributed greatly to the organization and left a legacy of research breakthroughs, publications, public service and outreach, and a reputation for excellence. A timeline of key events in the Bureau's history (see excerpts below) is posted as well, along with vintage photos. We also feature select publications and revisit Bureau facilities through the years. As we celebrate our centennial, we invite you to visit our website to read about highlights of the first hundred years of the state geological survey and first organized research unit of the University of Texas.


William Battle Phillips
Director
1909–1915


Johan August Udden
Director
1915–1932


Elias Howard Sellards
Director
1932–1945


John Tipton Lonsdale
Director
1945–1960


Peter T. Flawn
Director
1960–1970


William L. Fisher
Director
1970–1994
Interim Director
1999–2000


Noel Tyler
Director
1994–1999


Scott W. Tinker
Director
2000–present

Centennial Coffee-Table Book: *Earth's Art*

An important part of the Bureau's Centennial was the printing of a coffee-table book titled *Earth's Art: Celebrating the Centennial of the Bureau of Economic Geology, 1909–2009*. Edited by S. E. Laubach and S. W. Tinker, the book has a handsome hardback cover and colorful book jacket, with 142 oversized color pages of photo-essays depicting Bureau research areas of interest and landscapes that have inspired pursuit of geology as a career. It is for sale in the Bureau bookstore.

In the book's preface, Director Tinker says "There is no art more beautiful than that which nature has created: Earth's art." The book consists of 70 two-page color photo-essays by former and current Bureau employees on wide-ranging locales and research topics: oil and gas exploration and recovery, core curation, seismic data acquisition, coastal inundation, salt and salt tectonics, karst, nanogeoscience, the Superconducting Super Collider, economic minerals, petroleum geoscience, volcanoes, carbonate rocks, sandstones, continental margins, wetlands, storms and floods, gas hydrates, fractures, folds, faults, coalbed methane, mountain building, cathodoluminescence, rivers and water resources, carbon sequestration, energy policy, clean coal, and more. Within, one can find biographical sketches of the eight Bureau Directors, along with "What is the Bureau of Economic Geology?"—Perspectives on the Bureau as seen by teachers and students, librarians, graduate students, government officials, private citizens, the University, the oil and gas industry, and past and present Bureau staffers.

Earth's Art is international in its coverage from Texas—West Texas, the Permian Basin and the Texas Trans-Pecos, North-Central Texas and the Barnett Shale, the Texas Coast and Gulf of Mexico, Central Texas and the Hill Country, the Rolling Plains; across the country—the Grand Canyon, Utah, Nevada, Colorado, Oregon, Wyoming; throughout the world—the Ethiopian Rift Valley, Morocco, Scotland, Arabia, Brazil, the Bahamas, Iceland, Greenland, the Canadian Arctic, the Orinoco Delta, Oman; and, finally, intragalactic—the Moon!

Bureau of Economic Geology: Timeline highlights

1962
Bureau publishes best seller Guidebook 6, Texas Rocks and Minerals, by R. M. Girard.

1973
Historical monitoring of Texas shoreline begins. Lignite and Geothermal programs are launched.

1979
Former Director P. T. Flawn appointed President of The University of Texas at Austin. Legislature names Bureau to the Texas Energy and Natural Resources Advisory Council.

1983
Texas Oil Atlas is published.

1985
Board of Regents fund University Lands project. Low-Level Waste study begins.

1989
Bureau launches National Natural Gas Atlases program. Texas Natural Gas Atlas is published.

2001
Bureau joins Jackson School of Geosciences.

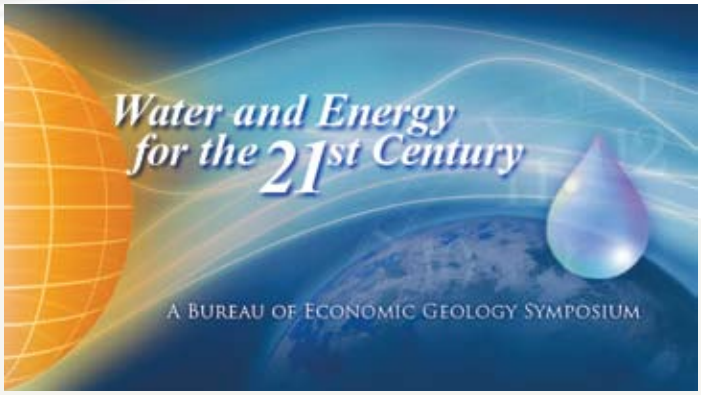
Centennial Podcasts

During the Bureau Centennial year, podcasts have been recorded and are available on the Bureau website, http://www.beg.utexas.edu. The podcast series, a creation of Bureau geophysicist **Paul Murray** and dubbed "Time on Earth," has three aims:

1. To increase public understanding of geosciences. Outside the world of the working scientist, the process of science remains misunderstood, mischaracterized, and largely mysterious to the general public. On this program, we present the work of geoscience directly from practicing geoscientists in a way that is accessible to the public.
2. To demonstrate how geoscience is interwoven into the most important issues in our world. If one glances at the headlines of the day, it is difficult to find a major story that isn't somehow related to geoscience: energy on the global market, oil, gas, water resources, sustainability, climate change, droughts, floods, hurricanes, natural disasters, and more.
3. To highlight cutting-edge research in all branches of geoscience that may provide solutions to our most pressing Earth resource problems. Time on Earth gives geoscientists an opportunity to speak directly to the public in a way that informs and entertains.

Podcast episodes include interviews with **Bureau Director Scott W. Tinker** on the value of the Bureau's work in its 100th year and scientists **Sue Hovorka**, **Becky Smyth**, and **Tip Meckel** on the Gulf Coast Carbon Center's efforts to minimize the effects of greenhouse gases through carbon capture and sequestration. Other episodes feature scientists **Bridget Scanlon** of the Center for Sustainable Water Resources and Robert Mace of the Texas Water Development Board, **Michelle Foss** of the Center for Energy Economics, and **Bill Ambrose, Bob Loucks**, and **Uschi Hammes** on Project STARR: How Oil and Gas Help Pay for Public Education in Texas. Hosted and produced by Murray, "Time on Earth" is made possible through the resources and financial support of the Bureau Centennial Program and is available on iTunes and other podcast media sources.

Bureau Centennial Symposium



On August 7 an overflow crowd of more than 300 filled the AT&T Conference Center to attend the Bureau's Centennial Symposium on "Water and Energy for the 21st Century." A panel of experts and policy makers examined issues and possible answers to managing future energy and water needs and to creating an infrastructure for sustainable resources, at both the regional and global scale. The event was hosted by Bureau Director Tinker, who welcomed the guests and provided an overview of symposium goals, as well as a look at "The 21st-Century Bureau." Former Bureau Directors Drs. William Fisher and Peter Flawn provided retrospectives on the Bureau's emergence as a world leader in research, and Dr. Juan Sanchez, Vice President for Research at UT-Austin, offered his congratulations on the Bureau's many accomplishments in its first 100 years. Guest speakers included Dr. Steve Koonin, U.S. Under Secretary of Energy for Science; Dr. Peter Gleick, President of the Pacific Institute; Victor Carrillo, Chairman of the Railroad Commission of Texas; and Elizabeth Ames Jones of the Railroad Commission. In the afternoon session, the focus turned to Texas' energy and water needs and policies. A roundtable panel included Dr. Chip Groat, Director of the Center for International Energy and Environmental Policy; Mark Vickery, Executive Director of the Texas Commission on Environmental Quality; Dr. Robert Mace, Deputy Executive Administrator of the Texas Water Development Board; Dr. Tad Patzek, Chair of Petroleum & Geosystems Engineering at UT-Austin; Dr. Chuck Williamson, retired CEO of UNOCAL; and Amy Hardberger, Attorney for the Environmental Defense Fund. A video summary of the event is being made available in the Bureau's Media Center.

The 20th-Century Bureau*

William L. Fisher

The early history of the Bureau of Economic Geology dates to 1858, when the first of several state geological surveys was created. Much of that early history recorded on-again, off-again efforts, jousted by the vagaries of 19th-century Texas politics. The last of the state geological surveys at the end of the century, headed by Edwin Dumble, produced substantial published research, but contributions of the others were modest at best.

In 1901 the Texas Legislature asked the University of Texas to assume responsibility for the mission of the previous state surveys, and the Board of Regents created the Texas Mineral Survey, an entity within the university but reporting directly to the board. Meeting the fate of previous geological surveys, within 4 years the legislature withdrew funding, and the new Texas Mineral Survey met its demise. But, importantly, the University believed that having an organization with a direct involvement in the resources and economy of the state was in its best interest, and so in 1909, the Bureau of Economic Geology was created, the first organized research unit of the University. It continues to this day as the oldest and longest running research unit of The University of Texas at Austin.

At the beginning of the 20th century, a number of the various state geological surveys around the nation assumed administrative relationships in varying degrees with their respective major state universities. Natural resources were then, and still are, very much of political concern, and a university climate was seen as necessary if the geological frameworks and fundamental research, so important to prudent resources identification and development, were to be worked out.

But like very few other state surveys, the Bureau became not only affiliated with, but a distinct administrative unit of, the University of Texas. And while over its history, the political winds have sometimes blown, the university setting allowed the emphasis of the Bureau to be always on geological research. And the Bureau became the best of its kind, with contributions to fundamental science, and to the applied science of geology, and an authoritative resource for the public and its elected and appointed officials.

The Bureau has made its place in Texas and the nation under some fairly special, if not unique, conditions.

One, it has functioned with a research-level staff within the university without the benefit of academic tenure conveyed to their academic colleagues, and yet has always been able to attract some of the nation's best and brightest geologists.

Two, for most of its history the Bureau has operated in the university's budget as a line-item appropriation, with legislative and gubernatorial scrutiny but without the back-up of statutory existence or an organic act.

And finally, over the last half of its existence, it has operated with upward of 90 percent of its operating budget from other than appropriated funds (i.e., external funds).

But these conditions served to weld the Bureau into an institution where everyone was to some degree dependent on colleagues. It kept the Bureau always in the real world, kept the competitive edge always there, and kept a measure of relevance always in mind. It was a gutsy business plan, but Bureau directors and staff made it work and work very well. And it freed the Bureau to grow as much as it desired and in directions it wanted to go.

The first Bureau director was Battle Phillips, who also headed the Texas Mineral Survey. He served for 6 years before departing for the presidency of the Colorado School of Mines. In launching the program, he made one recruitment, who, in many ways, set the research pace and temperament of the Bureau until this day, namely Johan Udden, Oscar Professor at Augustana College. Udden had worked part time for the Mineral Survey, but when he came to Texas he was 52 and suffering from diabetes. Four years later (1915) he was the second director of the Bureau.

At the time, Texas was coming into its own in oil exploration and discovery. While the earlier resource base of lignite and hard minerals was important, the emergence of oil exploration had massive geologic dimensions. Udden quickly saw that the practicing oil man was focusing on prospects and local problems, many of which could only be understood in a broader geologic framework through mapping and regional geological synthesis, and that was the relationship and symbiosis he sought and set.

* Text of a talk given by former Director William L. Fisher at the Centennial Symposium.

Udden developed a subsurface laboratory (the first in the nation) with people to bring science out of well cuttings and to add a third or subsurface dimension to the state's geology. The core barrel and the electrical log were in the future. He quickly recognized the importance of micropaleontology, and out of this lab came the world's first applied sedimentologists and micropaleontologists. Many moved to industry, and their work became the backbone of the industry during much of the next 30 years.

Udden is also credited with recognizing the potential value of seismography in oil and gas exploration that was to become, and today remains, a mainstay in energy and mineral exploration.

Under Udden the first geological map of the state was produced, and 50,000 copies were quickly sold.

And it was Udden who championed the potential of oil in the Permian Basin and in Trans-Pecos Texas. In fact, he promoted the drilling of the discovery well for Big Lake field on University Lands—Santa Rita #1. A replica of that rig stands just three blocks east of here on the UT campus, as well it should. The Permanent University Fund, then modest with income from grazing fees for goats, suddenly had substantial wealth from oil, and later gas, royalties. It was Udden and the Bureau that started the fund to its current endowment of a whopping $11 billion.

And for all of this and more in barely 6 years' time, the legislature was to cut the Bureau budget by 35 percent in 1921 and another 25 percent in 1925.

Among the people that Udden recruited was the then State Geologist of Florida, Elias Sellards, and with Udden's health failing, Sellards basically took over Bureau management in 1925, and with Udden's death in 1932, became the third director of the Bureau. Sellards' scientific interest was anthropology as well as geology. He spearheaded creation of the Texas Memorial Museum [now the Texas Natural Science Center] and served as its director as well as director of the Bureau until his retirement in 1945.

Sellards recruited some very prominent scientists to the Bureau, among them Walter Scott Adkins, a well-known Mesozoic stratigrapher and paleontologist, and Virgil Barnes and Henryk Stenzel, both of whom would become Bureau research icons. As well he brought Fred Plummer, a paleontologist and petroleum engineer from industry. Adkins, Plummer, and Sellards were to author the *Geology of Texas*, one of the grandest geological syntheses in Texas history. Plummer founded the Department of Petroleum Engineering at UT.

Udden, Plummer, Sellards, and Stenzel were prominent in the AAPG and principals in the founding of SEPM, which originally stood for Society of Economic Paleontologists and Mineralogists, which was, of course, the basic product of Udden's first Subsurface Laboratory.

In 1945 John Lonsdale was named the fourth director of the Bureau. A hard-rock petrologist, he had served with the Bureau from 1925 to 1928 before he left to head up the departments of geology at Texas A&M and later Iowa State. In the Lonsdale Bureau the research stalwarts were Stenzel, Barnes, and Plummer. In 1949 he recruited a Yale man working with Phil King by the name of Peter Flawn, who was to leave some deep tracks at the Bureau and the University.

During the early 1930's through much of the 1960's, the Bureau continued to emphasize regional stratigraphic and structural studies, paleontological investigations, and continuing reports on mineral resources. The research of Virgil Barnes and associates on the Ellenburger was seminal, and it was Barnes with colleague Preston Cloud who basically established the field of paleoecology.

Henryk Stenzel made pioneering studies in Tertiary stratigraphy and paleontology, including the first recognition of condensed zones (now a fundamental concept in stratigraphy and sedimentology) and the classic evolutionary study of the *Ostrea selliformis* stock.

Peter Flawn's reports on the economic and structural geology of the Trans-Pecos were followed by his classical study of the Ouachita Fold Belt, a report still widely cited.

With the sudden death of John Lonsdale in 1960, Peter Flawn was named the fifth director of the Bureau. After a decade as director he began his spectacular career in higher administration, twice serving as president of UT Austin.

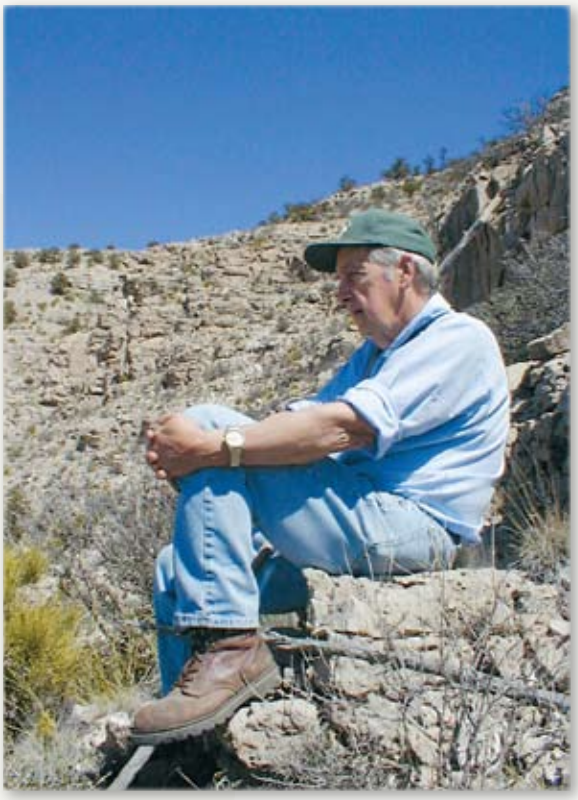
Although I was recruited by Lonsdale in 1960, my first years and early research were during Flawn's tenure. The first half of the 1960's the Bureau followed its historical mode, but with an ambitious program of mapping the state at 1:250,000, which was initiated by Flawn.

Then, during the last half of the decade, two major thrusts were made. First was the application of the just-developing science of process sedimentology flowing out of the corporate research labs in Houston and the development at the Bureau of the concept of depositional systems, a fundamental approach in stratigraphy and sedimentology until this day. I must say this novel approach initially came out of some rather routine mineral survey work, as a lot of Bureau scientific innovation did. Principals here were Frank Brown, Joe McGowen, Bill Galloway, and myself.

Second was a major thrust in the just-beginning field of environmental geology, an area keen to Flawn who was busily writing one of the very first books on the subject with the launching of the monumental Environmental Atlas of the Texas Coastal Zone project by the previously mentioned depositional-systems principals, along with Chip Groat.

In 1970, as Flawn moved to central administration, I was named the sixth director of the Bureau. Environmental issues were becoming prominent, and with our coastal work we were in a good growth situation. But with the OPEC embargo and the quadrupling of oil prices in the fall of 1973 (an event that largely coincided with the peaking of oil and gas production in the U.S.), interest in energy boomed almost over night.

As a natural resource research agency, the Bureau would either catch the environmental and energy winds of the time or become marginalized. We decided to aggressively pursue opportunities with external funding, and within a decade the Bureau's staff had increased fivefold and its budget sevenfold in real terms.



We soon launched major programs in geothermal resources, uranium resources, and the fuel of long ago in Texas—lignites—while still doing extensive environmental work.

In 1975 and 1976 I took leave to serve as Assistant Secretary for Energy and Minerals in the U.S. Department of Interior, while Chip Groat served as Acting Director of the Bureau. Chip enlarged the environmental and geothermal push and started the first effort in high-level waste disposal.

Shortly after my return, we had serious discussions with the newly created Department of Energy about the role of the Bureau in a much-enlarged activity in waste disposal, and for the next decade we were extensively involved in high-level waste disposal and later, for the State, low-level waste disposal as well. While these were mission-specific programs, a lot of good science spun out as well, including, for example, Martin Jackson's salt modeling and Bridget Scanlon's vadose hydrology research from the west Texas low-level work.

The coastal zone environment atlas was finished, and we moved to the study of coastal hazards and, notably, into research on coastal dynamics, ably led by Bob Morton.

But while environmental issues like those of the coastal zone and waste disposal were major efforts, oil and natural gas, the energy base of Texas and the nation, were to come into strong focus in the 1980's and continue to this day.

With the Gas Research Institute we launched basic studies in nonconventional gas resources—lower permeability tight sands and coalbed methane.

We completed a series of critically compiled atlases on oil and gas reservoirs in Texas and the offshore Gulf of Mexico, as well as gas nationwide with GRI and DOE.

We entered the area of resource assessment—first in natural gas resources. An optimistic assessment changed the entire outlook for U.S. natural gas, then believed to be rapidly diminishing.

But a major emphasis of our work was in reservoir characterization. By then, nearly all of Texas' oil reserve additions, and much of its natural gas, were coming from improved recovery in existing reservoirs. The Bureau was to champion reserve growth, long recognized but little appreciated as a potentially major source of reserve additions. Industry's subsequent emphasis on reserve growth was to lead to 75 percent of all oil reserves globally over the past 30 years being added from reserve growth, and estimates made of future additions showed about half coming from reserve growth. Thus, in another global resource issue, the Bureau set the pace.

In early 1986 the global price of oil fell to remarkably low levels. Industry had to cut back in a lot of the work it did, and research was one area cut heavily.

The Bureau was able to transform this downturn into an opportunity that was mutually beneficial (back to the symbiosis of Udden) by creating Industrial Associates groups in which several companies could subscribe to work on selected themes done by the Bureau. These were to become essential cores in Bureau research and remain a vibrant realm of Bureau research to this day.

Two such units were formed in the late 1980's—the Reservoir Characterization Research Laboratory, led first by Noel Tyler and later by Charlie Kerans, and the Applied Geodynamics Laboratory, dedicated to salt modeling and salt tectonics and led by Martin Jackson. Others were to follow, but these two became centers of worldwide recognition in carbonate geology and salt tectonics and remain so today.

The extensive work between the Bureau and Brazil's state-owned Petrobras, which started in the early 1970's, gave the Bureau an important international role. The Bureau's international work has expanded through the years with both specific projects and Industrial Associates involvement and remains strong today.

I left the Bureau in 1994 to go full time with our academic department and geology foundation, and Noel Tyler became the seventh director of the Bureau. Tyler continued many of the thrusts of the 80's and 90's and also substantially enlarged the Bureau's international involvement. When Tyler stepped down in the summer of 1999, I came back as interim director to close out the 20th century and to recruit a director for the beginning of the 21st. That turned out to be Scott Tinker, who became the eighth director of the Bureau in January 2000.

The Bureau in the 20th century can claim a proud and most effective record, with service to the state and the nation and research reports, maps, and atlases published by the Bureau or published with the leading scientific publishers in the country. The hundreds of thousands of Bureau publications, purchased by individuals and institutions not only in Texas, but throughout the world, were our product and our legacy.

Any list of major contributions necessarily slights some significant work. But I would like to conclude by citing at least a few.

1. Development of applied sedimentology and paleontology in the teens, showing the clear interface of science and resource development
2. Promotion of Santa Rita #1 in the 20's and the beginning of the Bureau's contribution to the Permanent University Fund
3. The grand syntheses in the *Geology of Texas* in the 30's
4. Initiation of the subscience of paleoecology in the 30's
5. Recognition of condensed zones in stratigraphy in the 50's
6. Pioneering environmental geology and coastal zone dynamics in the 60's and to follow
7. Development of the concept of depositional systems in the 60's, now a fundamental part of stratigraphy, sedimentology, and resource exploration
8. Geologic mapping of the state at 1:250,000 in the 60's and 70's
9. The early use of seismic in stratigraphic analysis with Petrobras in the 70's
10. Development of the concept of systems tracts, a basic component of sequence stratigraphy in the 70's
11. Recognition of the much-enlarged potential of reserve growth in oil and gas reserve additions in the 80's, which was to become a major phenomenon in Texas and the world
12. Pioneering studies of nonconventional natural gas resources in the 80's, now nearly 50 percent of U.S. gas additions
13. Development of novel concepts in salt tectonics initially in the 80's, now being applied worldwide
14. Development of dynamic carbonate stratigraphy in the 1980's, now applied to fundamental science and to practical resource exploration and development
15. Major advancements in diagenesis and fracture analyses, initiated in the 90's.

By the end of the 20th century, the Bureau could claim to be one of the best, if not the best, fundamental and applied geologic research organization in the world. It continues today, and that is a good reason to celebrate a centennial.

The 21st-Century Bureau*

Scott W. Tinker

THE 21ST CENTURY UNIVERSE

As geologists, when we look to the future, we first consider the past. Our past provides perspective, context, and analogs concerning such things as scale, population, and time and human advancement.

Scale

In terms of scale, Earth is larger than our neighboring rocky planets, but it is some 1,300 times smaller, by volume, than Jupiter, the largest planet. It is 1.3 million times smaller, by volume, than our Sun. Of course our Sun is smaller than some of the giant stars; for example, Antares has a radius over 400 times that of our Sun, making its volume over 100 million times greater than that of the Sun! Earth is small indeed.

If we look beyond our solar system, although the number of stars cannot actually be counted, astronomers and physicists use the amount of light in the Milky Way Galaxy (luminosity) and the mass of the galaxy to estimate its number of stars, which is somewhere between 100 and 200 billion! Even more mind boggling is the estimated number of galaxies in the universe—around 100 billion. To visualize this number, venture to the NASA/IPAC Extragalactic Database (http://nedwww.ipac.caltech.edu/). The scale of the universe is so astounding that it makes me want to come back to Earth! On Earth we encounter something else that is counted in billions—human beings.

Population

Earth's population today is approaching 7 billion (fig. 1). To gain perspective on that number, 7 billion seconds ago the year was 1787! For a different perspective on the magnitude of 7 billion, if every person on Earth were to stand shoulder to shoulder at the equator, they would encircle the Earth approximately 100 times! When the Bureau was formed in 1909, the Earth's population would have encircled the Earth only about 30 times; it was not until 1927 that global population reached 2 billion. In the 90 years since, we have added almost 5 billion people to Earth's population. We are adding a billion people every 13 years. That is about 150 "net" (births minus deaths) humans every minute of every hour of every day of every year. Said differently, it would take only 2 minutes to fill the 300 seats in an auditorium with new people. In the half hour it takes you to read this article, we would fill fifteen 300-seat auditoriums with additional people on Earth!

As we look to the future, it is not just the number of people that is important, but also how they are distributed. Only about 15 percent of the world's people live in economically developed countries. Another 75 percent live in nations that are "developing," and the remaining 10 percent live in under- or undeveloped nations. In the developed nations, the mode is represented by the 35 to 45 age group. Not so in the developing nations, where the mode is the under-10 age group. In other words, we have a very large number of very young people on Earth, in nations that are now industrializing.

There is much that can be drawn from these trends. But for our purposes, we must recognize that a growing global population, compounded by a greater percentage of people in developing nations requiring energy and water, presents a resource challenge that cannot be ignored. World population growth rates, which hovered mostly between 1.5 and 2 percent from 1950 to 1990, have now begun to decline and are expected to continue to do so until around 2080. In 2080, the global population growth rate, for the first time, should go negative. Population is projected to be somewhere in the vicinity of 12 billion. Resource demand, environmental stress, and economic implications of declining population growth define some of the grand human challenges of the 21st century. To understand how we might handle these in the future, it is instructive to look at the past.

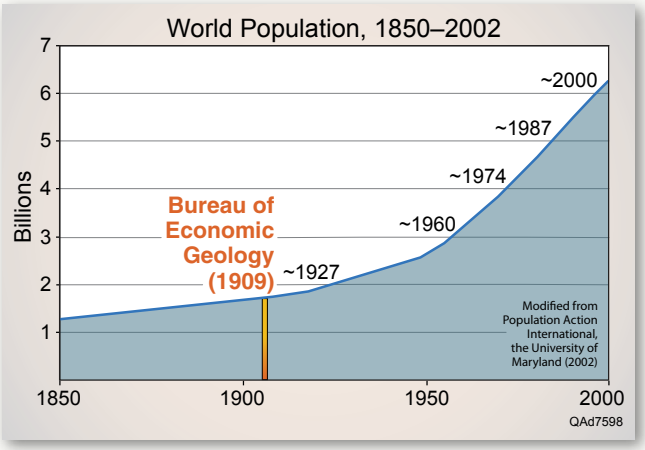


FIGURE 1.

* Text of a talk given by Director Scott W.Tinker at the Centennial Symposium.

Time and Human Advancement

Let us briefly examine the age of the Earth, with a specific longer-term view of climate and a nearer-term look at the technological advancements of humans. Earth is just over 4.5 billion years old. The oldest microbial fossils are dated around 3.5 billion years before present. Animal life evolved and migrated from the sea onto land in the Paleozoic Era.

Climate has been changing since the Earth began. The early Paleozoic Era was a greenhouse time, during which temperatures were significantly warmer and greenhouse gases more elevated than today. The late Paleozoic saw icehouse conditions, in which temperatures were cooler and polar ice advanced to lower latitudes. The Mesozoic was again a greenhouse time during which elevated CO_2 levels contributed to the growth of large plants and animals, such as dinosaurs!

Cooling began again in the Cenozoic, and in the last 4 million years, which represents less than 0.1 percent of Earth's total history, we observe an overall cooling trend with approximately 50 northern hemisphere glaciation cycles, each lasting between 60 and 100 thousand years. It was during this time that the first evidence of the genus *Homo* occurred, documented by struck stone tools found in East Africa dating back 2.4 million years (Ma). Subsequent discoveries include a knife in Ethiopia dating back 1.4 Ma, and spears in Germany, 400 thousand years (ka).

Focusing on the last 400,000 years (0.01 percent of Earth's history), we see four well-documented glacial-interglacial cycles (fig. 2), with the interglacial warm component representing only about 20 percent of the total cycle. Human advancements include evidence of burial in Africa around 200 ka, lithic blades in Africa and the ancient Near East around 100 ka, ships used by settlers of New Guinea around 60 ka, and mining (the first geologists!) in Swaziland and Hungary around 40 ka.

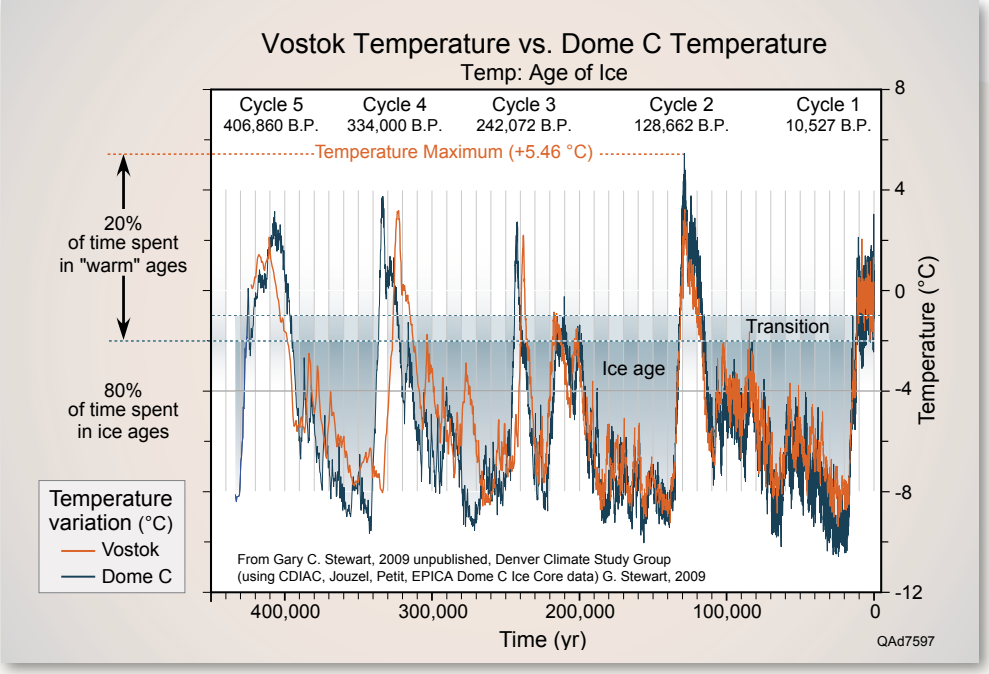


Figure 2.

Focusing on the period from 40,000 (0.001 percent of Earth's history) to 4,000 years ago, we see the later stages of the glacial component of climate cycle 2, followed by the present-day interglacial period that we enjoy today, which began some 16,000 years ago (fig. 3). During the glacial component, ice advanced to lower latitudes (the states of Wisconsin, Minnesota, and Michigan were partly covered by ice), and global sea level was considerably lower than its present level, which opened land bridges and allowed human migration between continents.

The point of this brief climate look back is that it is during the warm climate that we have enjoyed for over 11,000 years that humankind has seen its most remarkable technological advancements. Highlights of advancements that relate specifically to water, energy, and "protogeologists" in rough chronology include ceramics (Moravia), agriculture and alcohol (Fertile Crescent), metalworking (Mesopotamia), irrigation (Fertile Crescent), beer (Sumer), stone-paved streets (Iraq), writing (Sumer), cement (Egypt), wheel and axle combination (Mesopotamia), plumbing (Indus Valley), step pyramids (Egypt), and the aqueduct (Egypt and India).

If we focus further on the period from 4,000 (0.0001 percent of Earth's history) to 400 years ago, we begin to see the evolution of "modern" technology. Inventions include coins (China), maps (Greece), water wheels (India), the compass (China), a rudimentary seismometer (China), water purification (Arabian chemists), the water turbine (Arab Empire), oil wells (Azerbaijan), kerosene (Iraq), bridges, milling and diversion dams (Iran), the magnifying glass (Ibn al-Haytham), the magnetic compass (Shen Kuo in China), the hydropowered forge (Al-Andalus), the programmable analog computer (Al-Jazar), the astronomical compass (Yemeni sultan al-Ashraf), the terrestrial globe (Martin Behaim), and the compound microscope (Zacharias Janssen).

Finally we come to the past 400 years (less than 0.00001 percent of Earth's history). To put that proportion in perspective, 400 years in the life of the 4.5-billion-year-old Earth is equivalent to just under 2.4 minutes in the life of a 50-year-old person. Selected energy, water, and science highlights from the past 400 years of human advancement appear in table 1.

What can be learned from this brief glimpse of scale, time, population, and human advancement that might help develop a better sense of where we are headed? Looking into the future 100 years to 2109, we might ask: Will there be cars? What fuel will they run on? Will the primary electricity "fuel" be renewable? Will climate have

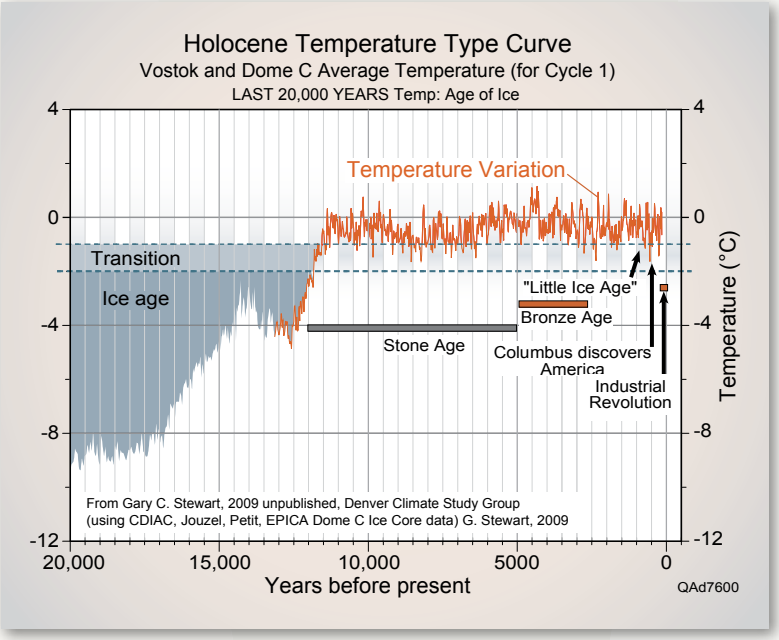


FIGURE 3.

TABLE 1.
400 YEARS OF HUMAN ADVANCEMENT

1600's: Slide rule: William Oughtred
1700's: Watt steam engine: James Watt
1700's: Oil lamp: Aimé Argand
1804: Locomotive: Richard Trevithick

1 BILLION PEOPLE ON EARTH

1821: Electric motor: Michael Faraday
1826: Internal combustion engine: Samuel Morey
1831: Electrical generator: Michael Faraday, Ányos Jedlik
1835: Incandescent light bulb: James Bowman Lindsay
1859: Oil drill: Edwin L. Drake
1876: Gasoline carburetor: Gottlieb Daimler
1880: Seismograph: John Milne
1883: Two-phase (alternating current) induction motor: Nikola Tesla
1886: Gasoline engine: Gottlieb Daimler
1893: Radio: Nikola Tesla
1895: Diesel engine: Rudolf Diesel
1902: Air conditioner: Willis Carrier
1907: Helicopter: Paul Cornu
1908: Geiger counter: Hans Geiger and Ernest Rutherford
1909: Bureau of Economic Geology established!
1914: Liquid fuel rocket: Robert Goddard
1922: Radar: Robert Watson-Watt, A. H. Taylor, L. C. Young

2 BILLION PEOPLE ON EARTH

1937: Jet engine: Frank Whittle and Hans von Ohain
1941: Computer: Konrad Zuse
1942: Nuclear reactor: Enrico Fermi
1942: Undersea oil pipeline: Arthur Hartley, Anglo-Iranian Oil Company
1945: Nuclear weapons: Manhattan Project
1947: Transistor: William Shockley, Walter Brattain, John Bardeen
1949: Radiocarbon dating: Willard Libby
1952: Fusion bomb: Edward Teller and Stanislaw Ulam
1955: Hard drive: Reynold Johnson, IBM
1958: Integrated circuit: Jack Kilby and Robert Noyce
1959: Bureau of Economic Geology turns 50

3 BILLION PEOPLE ON EARTH

1960: Laser: Theodore Harold Maiman
1961: Human spaceflight: Yuri Gagarin, Sergey Korolyov, Kerim Kerimov
1969: First astronaut moon walk: Neil Armstrong
1971: Space station: Kerim Kerimov
1971: Microprocessor: Federico Faggin and Ted Hoff
1971: Magnetic resonance imaging: Raymond V. Damadian
1972: Computed tomography: Godfrey Newbold Hounsfield
1973: Ethernet: Bob Metcalfe and David Boggs
1973: Personal computer: Xerox PARC

4 BILLION PEOPLE ON EARTH

1974: Hybrid vehicle: Victor Wouk
1980: Compact disc: Philips Electronics, Sony Corporation
1982: Artificial heart: Robert Jarvik
1983: Internet: first TCP/IP network: Robert E. Kahn

5 BILLION PEOPLE ON EARTH

1990: World-Wide Web: Tim Berners-Lee
1993: Global Positioning System: U.S. Department of Defense

6 BILLION PEOPLE ON EARTH

2001: Human genome sequenced: U.S. DOE and NIH

warmed and polar ice melted or will natural cooling have begun? Will global population be controlled by policy (can economic growth happen without population growth)? Will there have been a world war and, if yes, over what will it have been fought: idealism, religion, resources, human error, or some combination of these? Will resources be rationed and according to what international laws? Will we mine resources from other planets? Will humans colonize the sea, Moon, Mars, or space? Will we prescribe our health future? Will major league athletes be completely genetically enhanced? Will the U.S. still be a major economy? What other countries will rise as "superpowers," if superpowers exist at all?

Baseball great Yogi Berra is credited with saying "Forecasting is hard, especially about the future!" Certainly any attempt to predict key inventions at the turn of the 22nd century is folly, at best. However, in the spirit of good fun, at the turn of the 21st century might we see technology such as language chip implants? Hydrogen hover cars? Solar-charged super capacitors? Optically implanted PDAs? A three-pill-a-day nutrition plan? Marine colonization? Thought-controlled homes? Or perhaps might we see the first power line installed in rural Liberia?!

A GLOBAL CONTEXT

I have been fortunate in my 50 years to have traveled the world extensively, having visited some 40 countries on 6 continents. From these experiences I have observed that humans, individually, are fundamentally good, even though in groups we have demonstrated the willingness to hide behind large organizational constructs—government, religion, and industry—to propagate harm against one another and to the environment. I also recognize that today the world is culturally, economically, socially, and politically connected.

As we look to the coming century, I see a few fundamental trends that could drive human behavior and perhaps provide some context into the global challenges that we will face. Again, these trends are simply my thoughts by way of establishing context.

Cultural blending as Asia expands

For the past few decades the people of Asia, particularly China and India, have been slowly and predictably expanding their presence around the world. Over one-third of the world's population is Chinese and Indian, so the quest for land and resources should come as no surprise. As this peaceful expansion continues, it is inevitable that cultural blending will occur as people from historically different cultures interact.

Religious convergence *and* extremism

Along with cultural blending will come religious convergence. Already there is a growing global trend toward secularity (about 16 percent—and growing—of the global population declares no religion) as global interconnectedness allows for a broadening awareness of other faiths and systems of belief. This trend will most likely cause continued angst in religious extremists, but most likely in ever-smaller factions, to a level where violent acts based on religious extremism will be minimized.

Redistribution of wealth

As the economies of Asia (including Russia) grow, European and U.S. economies will become relatively less dominant. Combined with physical relocation and cultural and religious blending, there will most likely be a marked redistribution of global wealth. This could come as a contraction in U.S. wealth or as overall global economic growth, such that other countries rise to the level of U.S. prosperity. Much depends on the ability of political leaders to resist building walls (nationalism) and instead build cross-cultural bridges.

Redefinition of class boundaries

As cultural blending and redistribution of wealth proceed, historical class boundaries will be redefined. Currently over 1.5 billion people are without 20th-century conveniences, such as on-demand electricity and water. Most of these people live in undeveloped or underdeveloped nations and are very young. The successful redistribution of wealth will result in a growing global middle class.

Educational expansion

One of the results of cultural, religious, and economic blending will be continued access to education. This is a very positive outcome because education is correlated to economic prosperity, cultural and religious tolerance, life expectancy, reduction in family size, and environmental awareness.

Increased life expectancy

With increased education and continued medical advances will come increased life expectancy, partly from better nutrition and exercise and partly from advancements in medicine and genetics. More people will be living longer—healthier lives are both a challenge and an opportunity.

Natural resource stress and demands

One of the great challenges of the coming century, as the world levels out at a population of around 12 billion people, will be access to

natural resources. Certain natural resources are finite, by which I mean resources that, once used, are converted to something else that is not usable in the same form. Combusted gasoline is one such resource. Aluminum is not, as it can be recycled and used again. The world contains the natural resources to sustain human life on Earth, but these resources must be used very differently than how we have used them in the past. Efficiency and sustainability must become the mantra of the future, which does not mean a reduction in quality of life necessarily, but it does mean adapting the way we do things going forward.

Nuclear energy (and nuclear weapons) expansion

In terms of energy, we will transition slowly away from the combustion of certain fossil fuels (coal and oil) toward alternate energy forms representing more continuous sources of motion and heat but with substantially lower energy density: solar power, wind, hydro power, waves, tides, geothermal energy, and some forms of cellulosic biomass. These low-energy -density alternate-energy fuels require much greater surface infrastructure. I believe natural gas and nuclear energy will play a very prominent role. Both are globally abundant and have the potential to serve as large-scale, "base-load" (continuous) sources of electricity. These base-load fuels will be required until we develop the technology to store and transmit electricity more efficiently, thus allowing industrial-scale solar power, wind, and other low-density fuels to serve the continuing needs of a growing population.

I hold out hope that cultural blending, religious convergence, redistribution of wealth, and expansion of education will allow this energy transition to be smooth.

Other presenters at the Centennial Symposium

Dr. Sharon Mosher, Dean, Jackson School of Geosciences
Dr. William Fisher, Professor and Barrow Chair, Jackson School of Geosciences
The Honorable Victor Carrillo, Chairman, Railroad Commission of Texas
Dr. Steve Koonin, Undersecretary for Science in the Department of Energy
Dr. Peter Gleick, President, Pacific Institute
The Honorable Elizabeth Ames Jones, Commissioner, Railroad Commission of Texas
Dr. Chip Groat, Director, Center for International Energy and Environmental Policy (CIEEP)
Mr. Mark Vickery, Executive Director, Texas Commission on Environmental Quality (TCEQ)
Dr. Robert Mace, Deputy Executive Administrator, Texas Water Development Board (TWDB)
Dr. Tad Patzek, Chair, Petroleum & Geosystems Engineering, The University of Texas at Austin
Dr. Chuck Williamson, CEO (ret.), Union Oil Company of California (UNOCAL)
Ms. Amy Hardberger, Attorney, JD, Environmental Defense Fund
Dr. Juan Sanchez, Vice President for Research, The University of Texas at Austin

Challenges and timeless characteristics

The global context that I have discussed suggests two challenges that the world will face as we move through the 21st century.

The first is natural resources, including energy, water, food, minerals, aggregates, and the environment, and the second is natural processes, including natural and induced hazards, climate variability, coastal change, marine development, and competition of species. Resources and processes are at the heart of Bureau expertise and interest. As such, we are actively engaged in energy research (including oil, natural gas, coal, geothermal energy, geologic approaches to energy storage, and energy economics), hydrogeology, natural hazards, and carbon sequestration. By way of example:

- We own and operate airborne and ground-based lidar that collects continuous topographic position information and allows for the reconstruction of continuous outcrop data.
- We are working with ever-higher resolution 3-D, 4-D, and multicomponent seismic data and pushing the limits of seismic imaging to enhance oil and natural gas recovery, including resource recovery from unconventionals.
- We are integrating surface and space-based remote sensing data to provide for significantly enhanced interpretation and analysis of near-surface hazards, such as sinkholes, subsidence, and coastal change.
- We are working at the very small micro- and nanoscale, to try to develop small, smart sensors to help characterize the interwell space in the subsurface more accurately.

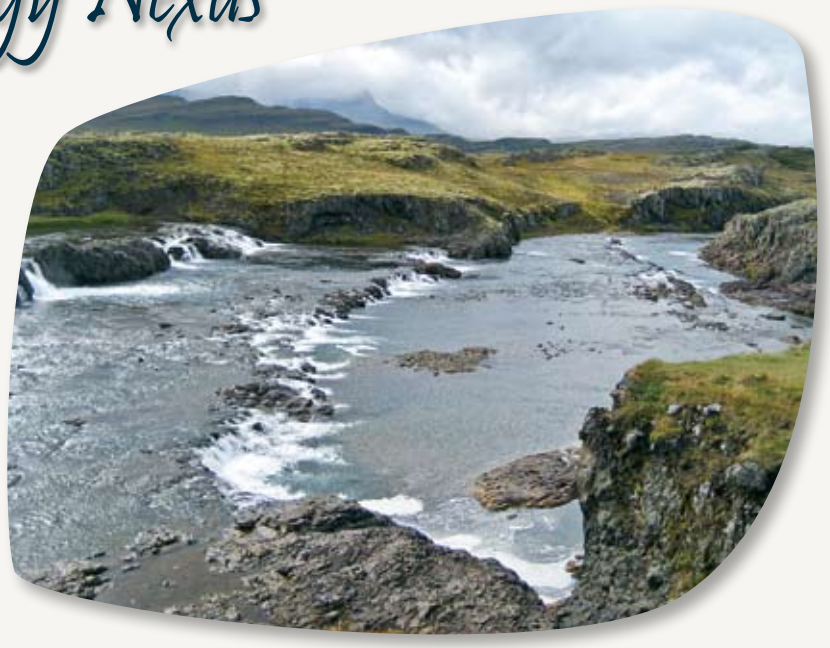
Equally important are the human characteristics that have allowed the Bureau to excel during the past century and that will allow us to remain at the front of the pack in the coming century. These include curiosity and the willingness to engage in debate; the drive to stay current and relevant; a work ethic driven by curiosity and the hunger to attract external funding; the desire and ability to work at the boundaries of disciplines and to integrate results into a common whole; the flexibility to adapt to change; and, finally, a passion for the rocks and the Earth.

These are the timeless attributes of the men and women who have worked successfully at the Bureau for the past century, and these are also undoubtedly the traits of those who will be successful at the Bureau in the next 100 years.

Happy 100th Birthday, Bureau of Economic Geology!

The Water-Energy Nexus

Bruce Cutright



On the Bureau of Economic Geology's 100th anniversary, it is fitting to reflect on the Bureau's accomplishments and to ask "What will the focus be for the future?" Historically the Bureau has been a leader in defining the parameters necessary for effective water supply development and basic and applied research involving energy. The very structure of the Bureau, organized into the Earth and Environmental research group and the Energy research group, reflects the importance of these two research directions.

Looking ahead to the next 100 years, it is obvious that the two fields of water and energy will become increasingly intertwined, and only multidisciplinary efforts will be able to comprehensively address their interrelated constraints, demands, and potential. It takes energy, after all, to collect, treat, store, and distribute water, and it takes water to extract, refine, produce, and supply energy. It is surprising that the two have rarely been integrated in research approaches.

The energy sector is the single largest user of water resources in the nation, accounting for nearly half of all water withdrawals. Irrigation, public water supply, and industry are left to divide the remaining share. On the other hand, dams, groundwater pumping, public-water-supply distribution, and publicly owned treatment works consume energy, estimated at 55 billion kilowatt hours in 2005 and expected to grow by more than 50 percent by 2050. We are already using most of the accessible, good-quality water resources. So, as our demands on water resources grow, our need to upgrade lower quality water to drinking water standards will require more energy for each volume delivered. Further, development of unconventional natural gas resources and engineered geothermal systems both require significant volumes of water for hydrofracturing formations. The Trinity aquifer in north-central Texas is currently the source of water necessary to develop the Barnett Shale, which is now a contributor to accelerating decline in water levels within the aquifer. How significant is this contribution, and are there alternatives, such as water reuse or deep brines? This topic is currently being studied by Bureau researcher J.-P. Nicot, and his findings will be critical to agricultural and municipal water use in the same area.

These are good illustrations of the joint dependency of energy and water, not to mention the environmental fragility that results from that interdependence. Many authors have aptly described this interdependence as the *water-energy nexus*.

What are the key issues in the water-energy nexus—the factors that are driving expansion in demands of both conventional and unconventional energy resources and straining our available water supplies? Fundamentally, population growth and growing prosperity are the most critical factors, with climate change and increasing development of renewable energy resources definitely in the mix. The world population tripled during the 20th century, while per capita water use increased by a factor of six. As the standard of living has improved, individuals and countries have increased their use of water and energy.

Examining the record of water usage in the U.S. over the last few decades reveals some promising trends. Total domestic water use has remained nearly constant over the last 2 decades, even though population has grown from approximately 250 to 300 million in the

same time period. These data are the result of conservation efforts and mandatory restrictions on what are judged as nonessential uses of water, such as car washing and landscape irrigation. Water reuse has expanded considerably in this same period of time, and recycled water is now commonly used for irrigation and power-plant cooling. Prior to 1950, water recycling constituted less than 2 percent of total water use, increasing over the last 50 years to more than 20 percent irrigation water and nearly 17 percent total water use. The lesson is that if supplies had been abundant, development and strenuous implementation of conservation efforts would not have occurred. These observations illustrate that our fresh-water resources are limited and that we have reached a point where resource limitation is driving our use and development.

From the dwindling-water-resource perspective, it is the uncertainties that are difficult to deal with. Flood control and water-supply reservoirs are all designed and operated on the basis of average annual rainfall and streamflow data. And yet recent years have seen widely fluctuating weather in many areas—from flooding to drought to everything in between. Droughts and diminished water supplies contribute to our growing uncertainties in maintaining a reliable supply of water. The history of the American desert brings to mind those lands west of the Mississippi where Charles Dana Wilber convinced a generation in the late 1800's that "rain follows the plow." Land without water has a pristine beauty, but the heartbreak of the pioneers can still be felt in abandoned homesteads and farm equipment.

Social attitudes have contributed to our current situation in water usage patterns. We suffer from attitudes derived from a legacy of riches in both energy and water. Ample water resources and abundant hydrocarbon reserves have been the foundation of development of our modern industrial civilization. Would we have shifted freight transport from rail to trucks if fuel had not been cheap and abundant? Why would anyone grow cotton in Arizona if we did not believe that water was basically inexhaustible? And the Age of Petroleum has enabled us to produce energy-intensive materials, such as aluminum, steel, plastics, and chemicals that are all dependent on petroleum. It has required nearly 100 years to transition from a wood-and-coal-based energy economy to the petroleum economy we enjoy today. This century will see a revolution in energy sources as transformative as the industrial revolution. Our world economy will be powered by a mix of energy supplies, with hydrocarbon resources diminished but still critical to maintaining our well-being and standard of living.

What are the alternative energy resources that have the most promising potential to meet our demands for both liquid fuel and electricity? Predicting the future is not easy! Solar, wind, geothermal, and nuclear power generation certainly have the greatest potential for contributing to our electric-power generation base, whereas biofuels, including corn-based ethanol and algal-derived fuels, have the greatest potential for supplementing the transportation fuel supply. Coal-to-liquid fuels could conceivably replace petroleum, although at a substantial increase in cost, carbon dioxide emissions, and water use. Natural gas and coal are, and will continue to be, significant parts of the overall energy supply, but their role in 50 to 100 years must include controls on carbon dioxide emissions. Automobiles will most likely transition to battery power over the next 50 years, whereas biodiesel and electricity will provide the power for freight movers and trains. We expect geothermal energy to be the long-term winner in base-load electric power supply in the absence of radical new (and unanticipated, less expensive) technological improvements in nuclear or solar. Wind and solar are handicapped by their intermittent nature and

high cost of backup power systems or storage technologies.

Although we may be able to shift our reliance on petroleum resources to renewable energy resources, no substitute for or alternative to water exists. Are we missing a critical component of national concern by not recognizing and acting on the importance of the link between water and energy? We must bring a greater awareness of the limitations on the available water supply and on the energy requirements to supplement this supply from less desirable, lower quality sources.

Dams for flood control and storage of wet-season flows for use in the dry season are no longer being built because of environmental, aesthetic, or political concerns. Maintenance of minimum flows and levels for protection of sensitive ecosystems and species has effectively reduced our ability to develop new surface-water reservoirs of significant volumes. Every major regional aquifer in the U.S. is showing signs of overpumping, as evidenced by long-term declines in water tables or hydraulic heads in confined aquifers. The USGS water-use assessment predicts that at least 36 states will experience moderate to severe water shortages and drought within the next 5 years.

These facts, added together, clearly document that we are at risk of exhausting readily available fresh-water resources. Although we will develop brackish- and saline-water resources to augment existing supplies, we will pay more, both economically and energywise, for water treatment. We can be smarter in how we manage our water resources through integrated water resource management techniques, but the clear conclusion is that the elasticity of our water supply is diminishing. Increasing demands, or temporary deficiency in supplies, will put stress on our economy and productivity, and additional supplies will have to come from treatment of lower quality resources or from enforcement of more stringent conservation measures.

We continue to increase our reliance on alternative energy resources that have imbedded water costs far exceeding more traditional sources of energy. For example, consider corn-based ethanol biofuel. The Energy Policy Act of 2005 and the Energy Independence Act of 2007 incorporated a Renewable Fuels Standard that mandates a 400-percent increase in the use of biofuels in transportation-related gasoline and diesel by the year 2022. A significant part of biofuel production is in midwestern and western states, from Texas to South Dakota, that rely on the Ogallala-High Plains aquifer for much of their irrigation supply. In 2008 these states' biofuel water requirements accounted for 1.19 trillion gallons. Biofuel production seems to be a worthy cause, but at what cost? This volume of water represents approximately 18 percent of the estimated annual depletion rate of the entire Ogallala aquifer in 2000. Biofuel production is now competing with food production for the available water supply, and stored groundwater is being sacrificed to support increasing demands on a limited water resource to support what is perceived as a renewable energy resource. Corn-based ethanol, using corn grown as an

irrigated crop, has been shown to use tens to hundreds of gallons of water per gallon of fuel and produce no net positive energy. Careful analysis of seemingly renewable energy resources must be part of our thoughtful transition to the future.

The historical transition that occurred in the U.S. at the beginning of the 20th century from coal and wood as primary sources of energy to our present use of oil, natural gas, nuclear energy, and hydropower took decades. Our push to become less dependent on petroleum will also take decades, but this transition will involve moving from an energy source that is highly concentrated to multiple, diffuse sources of energy that are only marginally economic. The lower energy density of these renewable energy resources requires that we carefully account for all costs associated with their development—especially increased use and cost of water.

Development of marginal sources of water will be required to meet increasing water demands of some of these alternative energy resources. Additional water supplies can be derived through better resource definition, wastewater reuse, desalination of brackish groundwater or saline water, and better storage of excess wet-season flows for use in the dry season. In some cases, energy and industrial sectors have already begun to shift to these lower quality water sources. The additional costs associated with capturing and treating the water necessary for these alternative energy resources is only now being quantitatively defined. Unfortunately, the agricultural sector cannot afford the financial burden of converting brackish- or saline-water supplies to usable irrigation water. Agriculture's only choices are conservation, rain-fed crops, or extinction.

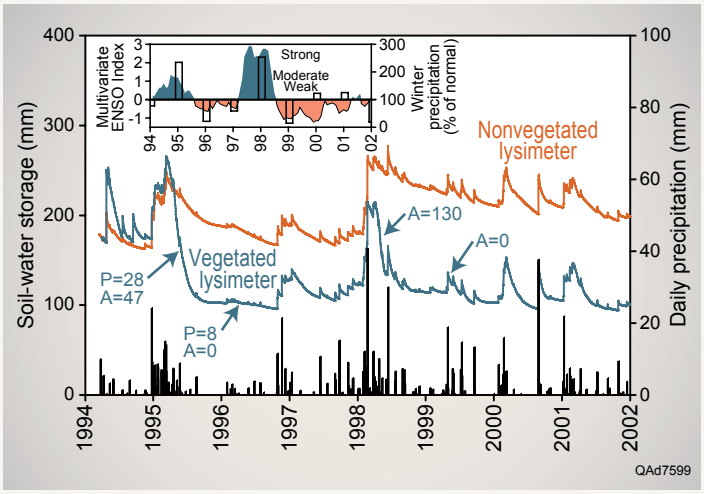
However high-quality water supplies are allocated, the incremental cost of additional supplies will significantly increase because we'll have to rely on lower quality sources and higher levels of treatment.

An alternative methodology for managing our available water supplies has the potential to provide huge reservoirs of high-quality water with minimal environmental impact, and it needs further investigation. Aquifer storage and recovery wells (ASR) make use of permeable geologic units underground to store wet-season excess flows for use in the dry season. ASR wells are widely used in Florida and California, but only a few have been installed in Texas. The National Ground Water Association provided a brief overview of the potential usefulness of ASR wells and why they have not been used more widely:

Expanding ASR to store and recover treated surface water, untreated groundwater or treated waste water would serve to conserve waters that would ultimately go unused. However, such groundwater augmentation efforts are currently being resisted. Legislation authorizing the use of non-drinking water for ASR recharge has been blocked in several states at least in part due to concerns about aquifer contamination and human health. Current federal regulations requiring that recharge waters meet all primary drinking water standards at the wellhead prior to recharge also may make it prohibitively expensive to recharge anything but potable water. Acceptance of this potentially important source of drinking water requires answers to many technical, economic, and regulatory questions.

The benefits of ASR technology are substantial when compared with the costs of construction and maintenance of surface-water reservoirs. For one thing, evaporation is negligible, and there is no risk of dam failure. Environmental impact is minimal as well. ASR systems work best in sand aquifers, but they have nonetheless been widely applied in South Florida in highly permeable limestone aquifers. ASR wells are a central component of the Comprehensive Everglades Restoration Project and are planned to provide storage of more than 1.7 billion gallons per day using 330 wells. Can this technology be transferred to the Edwards aquifer in Texas or to the Ogallala aquifer throughout the midwest? The answer is probably yes, but without detailed research and policy support, we cannot be definite.

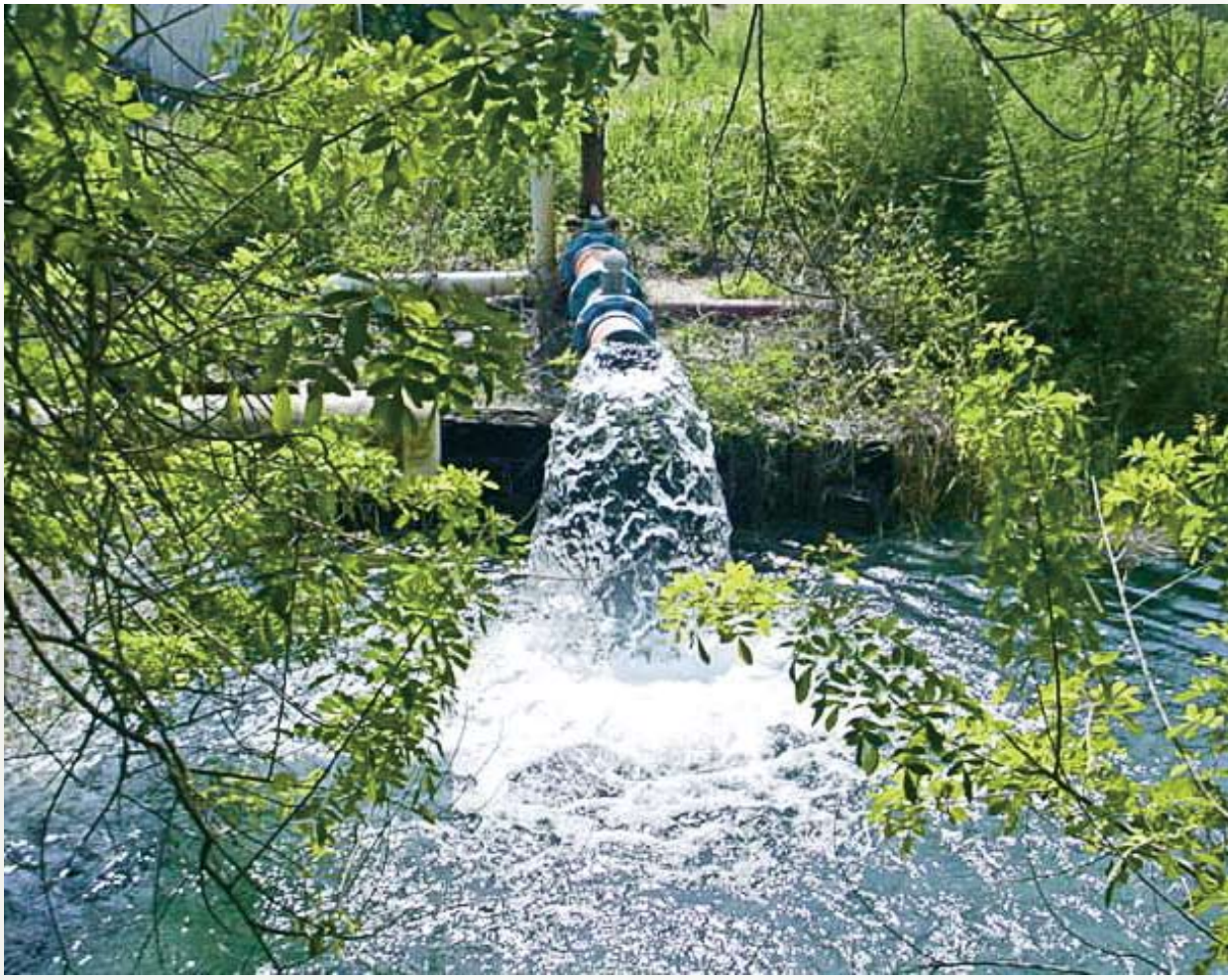
The water-energy nexus is a fascinating phenomenon that need not be as foreboding as one might imagine. We can take advantage of the symbiotic relationship that exists between water and energy to solve the crisis inherent in each. And the Bureau of Economic Geology is working toward doing just that.



The Bureau is currently expanding and strengthening its focus on the water-energy nexus, which has shown to be critical to our economic growth and quality of life. The strengths of the Bureau's research staff lie in water, energy, geologic analysis, fluid flow in deep geologic zones, climatic impacts on available water resources, and land-use changes. All drive the interdisciplinary investigations that define how we respond to the changing environment of water, energy, and climate. Addressing the issues of water scarcity and food production requires interdisciplinary capabilities, including hydrology, agricultural engineering, hydrogeology, and sophisticated remote-sensing methodologies. More important, the information collected must be put into a spatial perspective of global to local scale, and a temporal perspective of seasonal, annual, and millennial timescales. A recent study has provided evidence of a direct link between interannual variability of water supplies and economic development, illustrating that uncertainty in available water directly impacts the stability of governments and societies. The scientific findings of this and other studies are translated into policies that lead to, and support the development of, sustainable water resource programs. These programs incorporate the economic and social aspects of managing a limited but renewable resource under aggressively competing demands.

The Bureau's Bridget Scanlon is conducting research to define available water-quantity and -quality aspects of water resources using remote sensing, field studies, and links to climate variability and land-use change. Her research leads the nation in understanding recharge in arid areas under varying land-use conditions. Results of these studies have implications for development of sustainable water-resource programs throughout the world and potential impact on alternative energy development through biofuels. Effective management of a resource is impossible without adequate understanding of quantities, quality, and variability. Scanlon's focus is on water scarcity due to limited availability or degraded water quality, increasing demand for adequate and sanitary water supplies required by an expanding population, water demand for biofuel production, and sustainable production in the context of land use and climate change.

Another Bureau researcher, Bruce Cutright, is focusing on water supply and the interface between water and energy. He brings substantial experience in aquifer storage and recovery (ASR) wells and deep-flow systems analysis to addressing problems in supply demands in water-scarce situations. Cutright is addressing how we can respond when demand exceeds supplies. Not limited by size of surface reservoirs, aquifers can provide storage from wet to dry seasons, as well as from wet to dry years, without the evaporative losses that handicap surface reservoirs. In addition, high-quality water can be stored in brine aquifers if needed, ensuring that aquifer storage and recovery systems do not simply displace good-quality water



with other good-quality water. Examining chemical interactions of stored water with in situ fluids and storage-aquifer lithology is an important area of investigation. Cutright has also been active in developing fundamental capabilities in geothermal energy in nonmagmatic areas. Geopressured zones in the subsurface of the Northern Gulf of Mexico are attracting renewed interest in development of moderate-temperature binary heat-exchange systems. Development of these reservoirs requires similar analyses as development of petroleum reservoirs, but heat extraction is the goal.

Jean-Philippe Nicot has recently begun to focus on water use in the Trinity/Woodbine aquifer system and demands on this system from enhanced oil and gas development. Historically water levels in this area have declined as much as 800 ft from earlier undeveloped times; now, agricultural, municipal, and energy development is extracting water from a once-artesian system. Nicot has also focused on the utility of desalination systems in providing either primary or supplemental drinking-water supplies. As with any technology, there are benefits as well as problems to be overcome. Nicot works with the Texas Water Development Board and Texas Commission on Environmental Quality to address issues of disposal of saline concentrate water from desalination systems, as well as other issues with water supply and groundwater-quality protection.

The water-energy nexus is important in coastal areas as well. Long-term rising sea level has adversely impacted coastal areas and increased concerns about saltwater intrusion into coastal aquifers. Jeff Paine is addressing this issue. The Bureau gained international recognition in the 1970's by using depositional-system concepts to map depositional environments of coastal-plain sediments of Texas. These maps provided a new tool for comprehensive coastal-zone management. Today we continue to map coastal environments using advanced technologies such as lidar, radar, multispectral imagery, digital photos, GIS, and RTK GPS positioning.

The coming decade promises to be one in which the Bureau of Economic Geology establishes the link between energy and water resources and provides bridges to the future through careful and documented research for intelligent water and energy use.

Public Outreach and Education

Industry Day at the Bureau

In April 2008, more than 45 representatives from 30 oil and gas companies attended the Bureau's first Industry Day. The event was designed as an informal way for companies to become familiar with petroleum energy research being conducted at the Bureau. Some of the visitors were old friends and supporters, but a substantial number of guests were less familiar with the Bureau and got a chance to learn about its mission and research in an open-house setting. Bureau researchers and graduate students gave presentations throughout the day. At the second annual event in April 2009, researchers and graduate students from the Jackson School Department of Geosciences and Institute for Geophysics also participated, with a total of 40 industry professionals representing 18 companies attending.

Bureau Hosts Scientific Software Day

The Third Annual Scientific Software Day, organized jointly by the Texas Advanced Computing Center (TACC) and the Jackson School of Geosciences, was held May 21–22, with close to 50 participants attending. The keynote speaker was Victoria Stodden, Postdoctoral Associate in Law and Kauffman Fellow in Law at the Information Society Project at Yale Law School, who spoke on "The Impact of Computational Science on the Scientific Method." Later in the fall, she and **Sergey Fomel**, the Bureau cofounder of Scientific Software Day (along with Victor Eijkhout, TACC, and Michael Tobis, UTIG), joined a roundtable discussion there at Yale on data and software sharing. Sergey hopes that such discussions will shape the future of computational science (including computational geophysics) as we know it.

Explore UT

On March 7, seven GCCC staff presented a booth showing "What to Do with CO_2" (http://www.beg.utexas.edu/education/co2_outreach/co2_outreach03.htm) at Explore UT. GCCC student Alex Urquhart amazed a crowd of students by floating soap bubbles on CO_2 gas, showing that gas is real, although invisible. Photo by Changbing Yang.

Earth Science Week/Career Fair

Since the inception of National Earth Science Week (ESW), which was established by the American Geological Institute in 1998, earth scientists in Austin, Texas, have been spreading the word about the impact that they make in our daily lives. The program has grown throughout the years, and today events are organized by the Austin ESW Consortium, which is chaired by Sigrid Clift and includes members from earth-science-related organizations and companies in the Central Texas area.

The 10th annual career fair for 350 middle school students was held in October at the Commons Conference Center at the UT Pickle Campus, thanks to a generous donation from UT. **Scott Tinker** gave the opening ceremony presentation on climate change, the theme for 2009 ESW. During ESW students had the chance to learn about careers in petroleum geology, paleontology, hydrology, hydrogeology, meteorology, geodesy, robotics, environmental science, sustainable energy resources, engineering, and earth science education. More than 60 earth science volunteers, including 25 Bureau researchers and staff, took time from their busy schedules to participate in the fair as career presenters, exhibitors, and tour guides.

Success of Austin ESW depends on many factors, including a group of dedicated organizations and volunteers who provide financial and in-kind support for the program. In 2009, $1,900 was raised for the career fair and the Austin Public Library earth science book drive through generous contributions from Anvil Energy LLC, the Bureau, the Lower Colorado River Authority, the Subsurface Library, and the Texas Space Grant Consortium. In-kind support came from the American Geological Institute, UT, the UT Commons Conference Center, and the UT Jackson School of Geosciences. The consortium greatly appreciates the support of the sponsors and volunteers who make Austin ESW possible.

Texas High School Coastal Monitoring Program

The Texas High School Coastal Monitoring Program (THSCMP) is an ongoing Bureau project designed to help coastal residents develop a better understanding of dune and beach dynamics on the Texas coast. Bureau researchers (with **Tiffany Caudle** as the moving force behind the project) work with high school and middle school students and teachers, showing them how to measure topography, map vegetation lines and shorelines using Global Positioning Systems (GPS), and observe weather and wave conditions. As participants in an actual research project, students enhance their science education and provide coastal communities with valuable data on the changing shoreline.

The THSCMP is currently in its 12th year of operation. Participating schools are Ball High School on Galveston Island (12 years in the program), Port Isabel High School in South Texas (11 years), Port Aransas High School on Mustang Island (11 years), Van Vleck High School (5 years), Palacios High School (4 years), and students participating in the Spanish Science Club at Tidehaven Middle School (5 years). In April, seventh-grade Ambassadors from the Innovation Academy at Cunningham Middle School in Corpus Christi participated in their first field trip with THSCMP. Beginning in fall 2009 and through 2010, all 78 eighth graders enrolled at the Innovation Academy will participate in one of the three field trips throughout the academic year. Cunningham Middle School will be studying the beaches of North Padre Island.

Ball High School was unable to collect data during the 2008–2009 academic year because impacts of Hurricane Ike destroyed or made inaccessible the Galveston study sites. Ball High School students are once again collecting data in the 2009–2010 academic year, which will provide valuable information regarding the recovery of beaches and dunes following this devastating hurricane. The impacts of Hurricane Ike were witnessed along the entire Texas Gulf coast. Even South Padre Island had dune erosion from storm surge. Students participating in THSCMP during the 2008–2009 academic year were able to help document changes to their beach/dune system caused by Ike and monitor the recovery on their islands.

THSCMP is a unique educational program in that students collect real-world data that are used by working scientists to address coastal issues. Students understand that they are working on a real research project and are collecting scientifically valid data that will eventually appear in a scientific publication. This fact is a major point that makes this program different from other field trips or laboratory exercises. Asking students to conduct experiments that have real consequences seems to make a difference to them, and it probably improves the quality of the data.

Benefits from this project accrue to coastal communities that are directly affected by beach erosion and beach-erosion public policy. Data from this project are accessible through the THSCMP website, CMP project reports, and scientific journal articles. For more information, please visit the program's website at http://coastal.beg.utexas.edu/thscmp/.

Awards and Honors

The Bureau congratulates three scientists who have recently been informed that they are 2010 recipients of three prestigious AAPG Awards. Research Professor **L. Frank Brown, Jr.**, will receive the Sidney Powers Memorial Award. **Martin Jackson**, Senior Research Scientist, will receive the Robert R. Berg for Outstanding Research Award. Senior Research Scientist **Bob Hardage** will receive the Distinguished Service Award. Frank Brown also received special recognition this year from the Geological Society of South Africa for his contributions to the knowledge of offshore South African geology. Bob Hardage was further recognized, this time by the Society of Exploration Geophysicists (SEG), who named him an Honorary Lecturer, as well as First Vice President of the Executive Committee. In addition, Bob was given an SEG Award of Appreciation.

Bill Ambrose, along with co-authors **Tucker Hentz**, **Flo Bonnaffé**, **Bob Loucks**, and **Fred Wang**, received word from GCAGS that their paper, "Strategies for Optimized Oil Recovery in Fluvial-Dominated Deltaic Reservoirs in the Lower Woodbine Group, East Texas Field," was awarded First Place in the Thomas A. Philpot Excellence of Presentation Award. The notification said that their "…coverage of the subject was most educational." **Vishal Maharaj** and **Lesli Wood** won Third Place in the same competition for "A Quantitative Paleo-Geomorphic Study of the Fluvio-Deltaic Reservoirs in the Atoka Interval, Fort Worth Basin, Texas, U.S.A.," which is based on Vishal's M.S. research. These awards will be presented at the meeting of the GCAGS in San Antonio next year.

A new Bureau award for outside publication was instituted in 2009. For publishing first-authored papers in peer-reviewed journals in 2008, **Sami Akasheh**, **Bill Ambrose**, **Eddie Collins**, **Ruarri Day-Stirrat**, **Mike DeAngelo**, **Shirley Dutton**, **Peter Flemings**, **Sergey Fomel**, **John Gates**, **Fares Howari**, **Martin Jackson**, **Farzam Javadpour**, **Carey King**, **Bob Loucks**, **Angie McDonnell**, **Tip Meckel**, **Lorena Moscardelli**, **J.-P. Nicot**, **Steve Ruppel**, **Bridget Scanlon**, **Ramón Treviño**, **Changbing Yang**, **Hongliu Zeng**, and **Tongwei Zhang** were the first recipients of the Bureau of Economic Geology Author Achievement Award.

Research Scientist **William Ambrose** was presented with the Distinguished Service Award from the Energy Minerals Division of AAPG at the 2009 Annual EMD Luncheon in Denver on June 10. The award was given to Bill in recognition of his having served as EMD President, President-Elect, Gulf Coast Councilor, and Chair of the EMD Coal and Nominations Committees.

Research Associate **Bruce Cutright** received the Phoenix Award from the Midtown Miami Project for revitalization of blighted, contaminated lands for productive, new use. The impact of the site that Bruce developed was to take an area of 56 acres that was an eyesore and produce nearly zero taxable income to the city and turn it into a site that provided over 3,000 jobs and projected over $700 million in taxes for the city.

The 2006 paper "Geological and Mathematical Framework for Failure Modes in Granular Rock," published by Bureau scientist **Peter Eichhubl** with Atilla Aydin and Ronny Borja of Stanford University in the *Journal of Structural Geology* (v. 28, no. 1), has been recognized by the journal as the most cited paper over the past 5 years.

For the eighth time in the past 5 years, a talk by Bureau geophysicist **Sergey Fomel** was selected by the Society of Exploration Geophysicists (SEG) as one of the top 30 presentations at the Society's annual meeting. Selected for special recognition from more than 1,200 papers, Sergey's talk "Predictive Painting of 3D Seismic Volumes" was first presented at the 2008 SEG Conference in Las Vegas. Sergey also served as Guest Editor of *Computing in Science and Engineering* for a special issue on "Reproducible Research." And he was named recipient of the John E. "Brick" Elliott Centennial Professorship by the Jackson School.

Research Scientist Associate **John Hooker** received a GDL Fellowship of $2,500 for a proposal titled "Fracture Scaling in Sedimentary Rocks." The project entails comparing fracture scaling data from Scotland and Argentina in order to study the fundamental ways in which fracture systems evolve as rocks are pulled apart.

Senior Research Scientist **Martin Jackson** was the Keynote Speaker at the 7th Petroleum Geology Conference, Geological Society of London and the Energy Institute, London, United Kingdom. Martin was also Keynote Speaker at the Plenary Session of the American Association of Petroleum Geologists Meeting in Cape Town, South Africa.

Bureau Research Associate **Farzam Javadpour** received word this year that he had won a Best Paper award from the *Journal of Canadian Petroleum Technology* for his paper titled "Nanotechnology-Based Micromodels and New Image Analysis to Study Transport in Porous Media."

Senior Research Scientist **Steve Laubach** appeared among the *Journal of Structural Geology* Top Reviewers of 2008. The journal remarked that "these reviewers have contributed more than the usual in high quality reviewing and have also significantly helped the Journal by submitting timely, high quality review reports and, as a consequence, reduced the average time of processing of manuscripts—a permanent challenge for any scientific journal." Steve also received an Award of Appreciation as Outstanding Technical Editor from the Society of Petroleum Engineers. Steve has served as SPE's Associate Editor and Editorial Review Committee member for *SPE Reservoir Evaluation & Engineering* since 1998.

Recent Bureau retiree **Jerry Lucia** was given the Southwest Section AAPG 2009 Cheney Award "for singular contributions to and achievements in the science of petroleum geology of the southwest region" at the April 2009 Southwest Section AAPG Convention in Midland. Past recipients include Grover Murray, George Asquith, and Bob Hardage, also from the Bureau.

Publication Sales Manager **Amanda Masterson** was awarded a Certificate of Appreciation by the Gulf Coast Association of Geological Societies for her work on its behalf. Amanda is always in attendance at annual meetings, not only as a Bureau representative, but also as an agent for GCAGS and its publications. For the past 5 years Amanda has chaired the GCAGS Publications Committee, and since 2001 she has conducted sales and distribution of GCAGS products and those published by its eight member societies.

Senior Research Scientist **Kitty Milliken** was recipient of The University of Texas at Austin Bronze Award of the Innovative Instructional Technology Awards Program (IITAP). IITAP celebrates and rewards faculty efforts to incorporate technology in their teaching. Kitty's entry was titled "Sandstone Petrology: A Tutorial Petrographic Image Atlas."

Bob Reedy and **Bridget Scanlon** won the 2009 Bureau of Economic Geology Publication Award "in recognition of exemplary publication of scientific or economic impact" for their paper titled "Semiarid Unsaturated Zone Chloride Profiles: Archives of Past Land-Use Change Impacts on Water Resources in the Southern High Plains, United States," which was published in *Water Resources Research*, v. 43.

Awarded 2009 Outstanding Researcher by the Jackson School, Senior Research Scientist **Steve Ruppel** was lauded by Interim Dean Chip Groat during the presentation ceremony:

Steve's initial research focused on the stratigraphy, sedimentology, and petroleum resource potential of the Ordovician–Mississippian succession in the Texas Panhandle. This work stands as the only comprehensive treatment of the depositional history, organic matter character, and thermal maturation history of Mississippian rocks in the region. Steve has turned his research focus to the Permian. His study of the oil-rich early Guadalupian Grayburg Formation produced a basinwide model for the sequence stratigraphic architecture and diagenesis of this platform succession and also defined the presence of a major lowstand depositional event in the Midland Basin. Steve combines outcrop, subsurface, paleontologic, and organic analysis of sequences, resulting in understandings that range from depositional environments characteristics and diagenesis to petroleum generation. His Permian stratigraphic research, conducted in outcrops of west Texas and in the subsurface, has resulted in the delineation of models that characterize sea level history in waning icehouse depositional systems. He has an outstanding record of productivity and influence on developing integrated understandings of important geologic systems.

Steve Ruppel and **Bob Loucks** received the President's Certificate for Excellence in Presentation at the AAPG EMD Luncheon in Denver. Their presentation was titled "Shell and Grain Layers in the Barnett Shale: Event Deposition or in-situ Accumulations?"

Bureau scientists **Wayne Wright**, **Xavier Janson**, and **Ruarri Day-Stirrat** were recently appointed as new editors of the *SEPM Sedimentary Record* for the next 3 years. Wayne said that they would be soliciting papers worldwide before long.

The Quantitative Clastics Laboratory (QCL), headed by Lesli Wood, has once again announced a full slate of student winners of awards both from inside and outside the Jackson School. Outside Jackson School competitive award winners include **Vishal Maharaj**, who was selected as one of only 15 from more than 100 entries to present his research at the 2009 AAPG Student Oral Awards Competition at the AAPG Meeting in Denver in July; **Darren Burton**, who received a $3000 AAPG Grants-in-Aid Research Award; and **Jessica Morgan** and Vishal Maharaj, who each received a ConocoPhillips SPIRIT Scholarship Award. Jackson School award winners were Vishal Maharaj, who won the $3500 Michael Bruce Duchin Centennial Memorial Endowed Presidential Scholarship, and **Kurtis Woolf**, Jessica Morgan, and **Brian Kiel**, who each received a full semester's funding from Hess, ConocoPhillips, and BP, respectively.

Former Bureau Editor-in-Chief **Susie Doenges** was named the first Bureau of Economic Geology Alumna of the Year. The award was created in 2003 by Director Scott Tinker to honor former Bureau employees who make significant contributions to society after leaving the Bureau. Recipients are recognized for their accomplishments as leaders, positive influence as role models, and commitment to maintaining ties to the Bureau family. This year, Susie kindly volunteered to edit the Bureau's Centennial coffee-table book, *Earth's Art*.

Jennifer Logan, Administrative Associate and doyenne of the Bureau's 2nd floor, has claimed the UT 2009 Outstanding Staff Award. Among the few chosen from across the university out of hundreds nominated this year, Jennifer joins an elite group within the Bureau who have received this honor in the past. In 2002, she shifted her career goals to focus more on education and outreach.

Bureau Transitions

Joel Lardon Bids Bureau Adieu

August 31 was Media Services Manager **Joel Lardon**'s last day at the Bureau before retiring, and he was feted at an ice cream party in his honor. Joel started at the Bureau in 1985 following his graduation with a BAAS from Texas State University (formerly Southwest Texas State University). At that time, all work was produced on drafting tables using pen and ink, drafting machines, straight edges, curves, and Leroy lettering sets. Color and black-and-clear Zipatone cut with X-acto knives was used for shading, colors, and screens. In 1988 MAC computers were introduced to the Cartography Department. Joel was put in charge of deciding which software would be best for all the products created by the department. Before long everybody was producing work on computers. Joel became supervisor of the Graphics Department (no longer Cartography) in 1996, and in 2000, Editing and Graphics merged into the Media Department, and Joel emerged as its leader. A winner of the UT Staff Award for Excellence, Joel was well respected, both as a supervisor and as a co-worker. Many's the night that Joel could be discovered burning the midnight oil laminating and trimming posters, and rarely would anyone beat him to the door in the morning! When crunch time came before an AAPG convention or a looming contract deadline, Joel was there, not merely delegating assignments, but working alongside everyone in Media. His buff-colored Ropers will be tough to fill. Bureau Scientist **Shirley Dutton** says of Joel: "Because Joel Lardon is such an effective supervisor of the Graphics Services group at the BEG, that small group of people prepares an enormous number of illustrations for us. Joel keeps the work flowing quickly and efficiently, meeting the short deadlines we usually give him." [Thanks to Kerza Prewitt for memories of the Cartography Department.]

In Memoriam

We mourn the loss of retired Bureau staff member **Robert Sanchez**, who died on Friday, July 17, 2009, at age 57. Beginning at the Austin Core Research Center in February of 1986, Robert was a licensed forklift operator, commercial vehicle driver, and field worker for many Bureau research projects. He was promoted to Warehouse Manager in 1998. Retired since January, Robert was an accomplished amateur photographer, fisherman, and gardener. He is survived by his wife of 40 years, Susie Sanchez, his sons Mark and Robert Jr., and five grandchildren, as well as many cousins, nieces, and nephews. A memorial service was held in Bastrop on July 20. Director Scott Tinker said "Robert was a special part of the Bureau family, a key member of the core research center staff, and above all a gentleman. He will be missed by all of his Bureau friends." Donations in Robert's memory can be made to Hospice Austin (http://www.hospiceaustin.org/site/pp.asp?c=bdJPITMyA&b=14551).

New Research Staff

Hector Ricardo Castrejon-Pineda has recently joined the Bureau for a year as a Research Fellow. Ricardo has a B.S. in Geophysical Engineering and an M.I. in Exploration Geophysics, both from Universidad Nacional Autónoma de Mexico, where he has been a Professor since 1989, teaching, among other things, well log interpretation. Ricardo's main focus is petrophysics.

David Chapman has signed on to work with Sean Murphy in the Bureau's Advanced Energy Consortium. David manages multiyear, cross-university research projects, drawing on proven strengths in technical and business development, with 15 years' experience in advanced technology with Motorola, Intel, Research Triangle Institute, and SEMATECH. David has an M.B.A. from University of North Carolina at Chapel Hill, Kenan-Flagler Business School, and M.S. and B.S. degrees in Materials Science from North Carolina State University.

Postdoctoral Fellow **Roman Kazinnik** holds degrees in Physics and Mechanics from St. Petersburg University, Russia; Computer Science from Technion, Israel; and a Ph.D. in Applied Mathematics from Tel Aviv University, Israel. Roman specializes in geophysical data analysis, mathematical and computational methods for solving problems in processing of geophysical data and in seismic imaging of the Earth's interior, and developing new geophysical algorithmic techniques using theoretical seismology, applied mathematics, computational statistics, signal processing, etc.

A new postdoc member of the Applied Geophysics Laboratory, **Gang Luo** has research interests that include salt tectonics, fluid flow, geomechanics, and finite element modeling; fault interactions and earthquake triggering; crustal/lithospheric stress and strain evolutions during earthquake cycles; and rheology and crustal/lithospheric geodynamic processes. Gang has M.S. and B.S. degrees from Peking University, Beijing, P.R. China, and a Ph.D. from the University of Missouri.

Maria Nikolinakou graduated with an Sc.D. degree in Geotechnical Engineering from MIT in 2008. She also has a 2001 M.Sc. in Geotechnical Engineering from MIT. Her 1999 Civil Engineering degree is from National Technical University of Athens, Greece. Maria is interested in geomechanics and salt tectonics, constitutive modeling of Earth materials, and numerical modeling of oil reservoirs. Maria is a new postdoctoral fellow at the Bureau.

Nathan Sheffer is a postdoctoral fellow assigned to Bridget Scanlon's team who, before coming to the Bureau, was self employed as a geology consultant and air-photo deciphering expert. Nathan has a B.Sc. in Geology, an M.Sc. in Geomorphology, and a Ph.D. in Hydrometeorology—all from The Hebrew University of Jerusalem, Israel. Nathan concentrates his interest in developing tools for spatiotemporal recharge evaluation, groundwater contamination, paleoflood hydrology and climate, and fluvial geomorphology.

Jeff Sprowl, Database Analyst, has begun working for the STARR team. A graduate of The University of Texas at San Antonio, Jeff holds a B.A. in Geology. His interests lie in database management, well log analysis, and geologic mapping. Jeff has worked as a Geological Assistant at U.S. Enercorp Exploration & Production, San Antonio; a Geological Technician at Balcones Energy Library, San Antonio; and as a Geologist Intern at Horizon Exploration in Houston.

Harinarayana Tirumalachetty is a Senior Research Fellow, who has worked for a year as a Visiting Scientist with Bob Hardage. Hari's research interests include deep electromagnetics, marine electromagnetics, geothermal studies, hydrocarbon exploration, and land mangetotellurics. He holds a Master's degree in Geophysics from Andhra University, India, and two Ph.D.'s—one from the Indian School of Mines in India and one from Edinburgh University, U.K.

Harikishan Jayanthi, new Postdoctoral Fellow in Bridget Scanlon's group, received his M.E. in Hydraulics & Irrigation Engineering at the University of Roorkee, India, and his Ph.D. in Irrigation Engineering at Utah State University, Logan. Hari's expertise includes application of ground and remote sensing techniques for estimation of crop water requirements and crop yield estimation, risk evaluation of agricultural droughts, satellite monitoring of irrigation progression and crop productivity in command areas, and agricultural drought monitoring using satellite and ground data.

New Support Staff

David Boling, new Accounting Technician working with Beth Ellison, originally hails from Waco, but he's been in Austin since coming to school here when he was 18. David has done coursework in Business at Austin Community College, and he's worked in many departments at UT, including Computer Sciences, the LBJ School, and the University Development Office.

Gwen Hebert is Julie Duiker's new assistant in Contracts and Grants. With a Bachelor of Arts degree in Social Work, Gwen has spent more than 10 years in the public health field. Most recently she was a project coordinator for medical research studies.

Cathy Brown is the new Media Manager now that Joel Lardon has retired. A graduate of the University of Houston in Graphic Design, Cathy has taken coursework in business management and performance consulting, and she is process improvement certified. Cathy previously worked for Dell and the UT College of Communications. She was also an independent consultant.

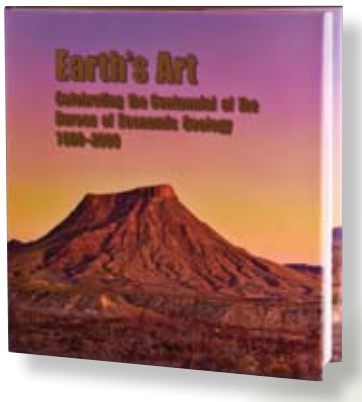
Melissa Garcia is a new Human Resources assistant working with Caryn Mills as Student Employment Coordinator. Melissa has a long history with UT, having worked in the Office of Student Financial Services/Student Employment Referral Services as the Hirealonghorn.org website administrator, as well as the Office of the President. Melissa lists as her fortes HR/Student Employment Services and Database Management.

Liz Hill-Aiello, a recent graduate of UT with a Bachelor of Arts degree in English, is now an Administrative Associate at the Bureau. While still in school, Liz participated in the English Honors program and volunteered as a Peer Educator. Later she was part of UT's Division of Recreational Sports. Here at the Bureau Liz works as a Reporting Specialist for Julie Duiker in the Contracts and Grants Office.

Bureau Publications

The Bureau produced three new publications in 2009.

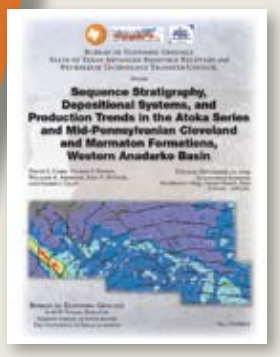
Earth's Art: Celebrating the Centennial of the Bureau of Economic Geology, 1909–2009, edited by Stephen E. Laubach and Scott W. Tinker, with contributions by multiple authors. Hardback cover and color book jacket. 142 oversized color pages of photo-essays depicting research areas of interest. SR0017, ISBN-10: 0-615-30851-1, $50. For more details see the Coffee-Table Book section on the Bureau Centennial, p. 8.



Chronostratigraphy of Cenozoic Depositional Sequences and Systems Tracts: A Wheeler Chart of the Northwest Margin of the Gulf of Mexico Basin, by L. Frank Brown Jr. and Robert G. Loucks. 28-p. text and 42- × 62.5-inch Wheeler stratigraphic chart.

A chronostratigraphic chart (Wheeler chart) was constructed of the Cenozoic strata of the northwest margin of the Gulf of Mexico basin (Texas coastal area). This sequence stratigraphic framework divides outcrop and subsurface lithostratigraphic units (members, formations, and groups) into 50 chronostratigraphic (sequence) and lithogenetic (depositional systems) packages. The framework links the outcrop with the more extensive subsurface stratigraphy. The diagrammatic paleoslope systems-tract profiles provide the subsurface geologist with an inferred but integrated view of the depositional elements that define each principal siliciclastic impulse of sediment delivered into the basin. Although absolute ages on the chronostratigraphic chart are equivocal, they do place the sedimentary record into a logical outcrop-to-deep-basin relative perspective.

The chronostratigraphic chart was constructed for the benefit of not only subsurface petroleum geoscientists, but also academic and other researchers working on outcrop stratigraphy, sedimentology, paleontology, and petrography. This nonproprietary chronographic chart ought to encourage Gulf Coast geoscientists either to modify the chart with their own proprietary data or release their own proprietary chronostratigraphic documents. Through further enhancement of the Wheeler chart, a deeper understanding of the architecture and depositional history of the Gulf of Mexico can be achieved, thus leading to a more complete understanding of the petroleum systems of the Gulf of Mexico.



Sequence Stratigraphy, Depositional Systems, and Production Trends in the Atoka Series and Mid-Pennsylvanian Cleveland and Marmaton Formations, Western Anadarko Basin: PTTC Texas/Southern New Mexico Region Workshop, Sequence Stratigraphy, Depositional Systems, and Production Trends in the Atoka Series and Mid-Pennsylvanian Cleveland and Marmaton Formations, Western Anadarko Basin, (SW0019), by David L. Carr, Tucker F. Hentz, William A. Ambrose, Eric C. Potter, and Sigrid J. Clift, summarizes a joint Bureau-PTTC workshop, including an in-depth study of general Atokan reservoir geology, production trends, and petrography of this recently revitalized play in Ochiltree and Lipscomb Counties, Texas, and Ellis County, Oklahoma. Also discussed in the workshop were the sequence-stratigraphic framework, depositional facies, and production trends of the perennially active Cleveland and Marmaton Formations in the same area. Presentations were complemented by a core workshop during which attendees got a hands-on perspective of key Atoka and Cleveland cores, along with a detailed review of depositional and reservoir facies. A CD-ROM of workshop presentations from the workshop is also provided.

Peer-reviewed Publications by Bureau Researchers

Articles in Peer-Reviewed International Journals

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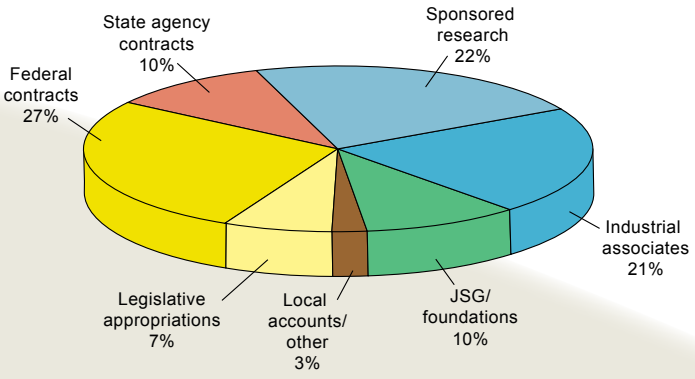

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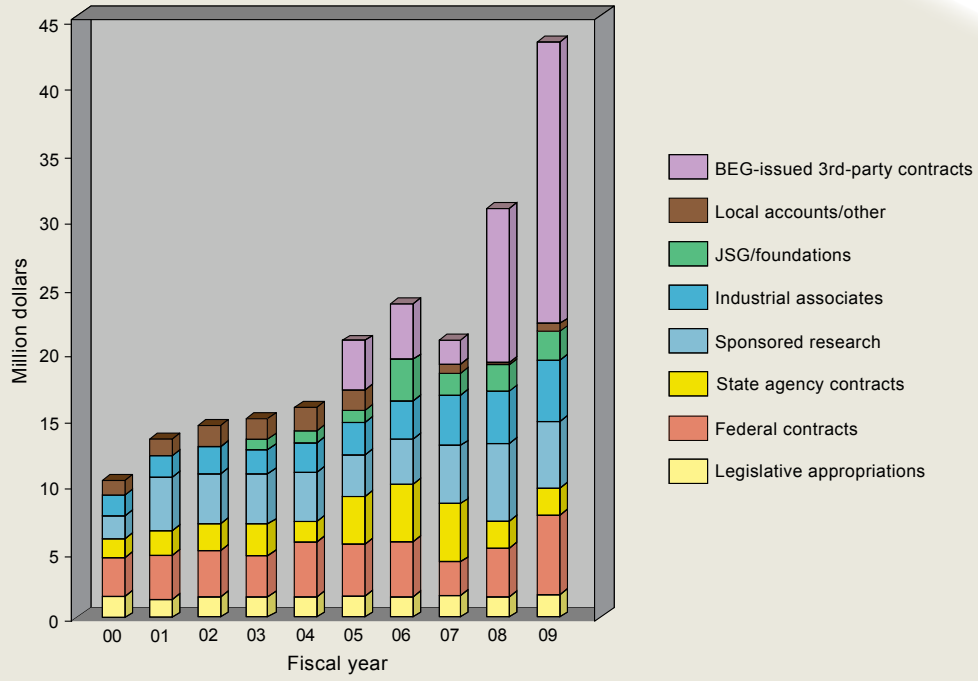

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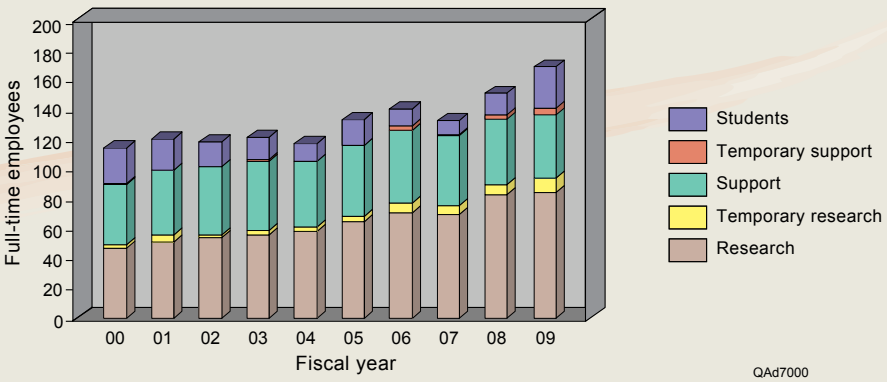

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