2000 Comprehensive Report

BUREAU OF ECONOMIC GEOLGY

Scott W. Tinker
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FOREWORD

The Bureau of Economic Geology, established in 1909 as the successor to the Texas Geological Survey and the Texas Mineral Survey, is a research unit of The University of Texas at Austin. It also functions as the State Geological Survey, the Bureau Director representing Texas in the Association of American State Geologists.

Extensive advisory, technical, and informational services relating to the resources and geology of Texas are provided by the Bureau. In addition, the Bureau conducts basic and applied research projects in energy resources, mineral resources and statistics, coastal and environmental studies, land resources, geologic mapping, and a variety of other research programs in areas such as hydrogeology, basin analysis, and geochemistry. Some projects are conducted jointly with other units of the University, as well as with industry and with State, Federal, and local agencies.

The Bureau provides ongoing services to governmental agencies, including reviews of (1) environmental impact statements that are submitted to the Office of the Governor of Texas and (2) permit applications that are submitted to the Surface Mining and Reclamation Division of the Railroad Commission of Texas.

Major reports of the Bureau are published in The University of Texas Publication series; its own series include Reports of Investigations, Geologic Quadrangle Maps, Geologic Atlas Sheets, Environmental Geologic Atlases, Guidebooks, Handbooks, Geological Circulars, Mineral Resource Circulars, and other publications. Publications are sold for a nominal price to recover printing costs. A complete list of publications is available on request.

The Comprehensive Report of the Bureau of Economic Geology outlines the scope and status of current research projects, publications, personnel activities, and services in the area of Texas resources and geology that are available to governmental agencies, industry, and the public.

ON THE WEB

A wealth of information regarding the Bureau of Economic Geology can be found at our Web site, http://www.beg.utexas.edu. Here you can learn about every aspect of the Bureau’s mission, its research, public services, and staff. Download what you need.

When you visit our Web site, you can check upcoming events, read about recent research awards and honors, learn about the Bureau’s large collection of rock cores and well cuttings, and contact any Bureau researcher or staff member by using his or her office e-mail address or telephone or fax number. You can review titles and authors of past and present Bureau publications—and then place an order.

Teachers and students can view earth science projects, print directions and then follow them in a Do-It-Yourself Aquifer Demonstration, determine whether Dirt Is Just Dirt, or study the Texas Rock Cycle. The Bureau’s Web site also contains links to State, Federal, and industry organizations, as well as geologic and earth science resources.

Our Web site, a vital and integral part of the Bureau, is a work in progress; many more exciting enhancements, databases, and links are planned for 2001.
2000 COMPREHENSIVE REPORT

BUREAU OF ECONOMIC GEOLOGY
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DIRECTOR’S MESSAGE

The Texas Bureau of Economic Geology, established in 1909, is the oldest research unit at The University of Texas. Across nine decades, the Bureau has had only seven Directors; I am the eighth. Each Director left a positive mark, a reflection of himself, on the organization. We are extremely fortunate that former Directors Dr. Peter T. Flawn and Dr. William L. Fisher remain actively involved with the Bureau as friends, mentors, and chairman and member, respectively, of the newly formed Bureau Advisory Committee. It is the dedication and spirit of women and men such as these that provide the “solid foundation” on which the Bureau home is built.

Within the Bureau home for nearly a century has lived a diverse, proud family, rich in a history that tells a story of strong patriarchs, dedicated aunts, quirky uncles, tragedy, triumph, conflict, perseverance, tradition, and loyalty. It is an honor to join the Bureau family, and after nearly a year, I have begun to elucidate our mission. 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.

[Signature]

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A NEW ANNUAL REPORT

Along with change in directorship at the Bureau of Economic Geology comes change in our annual reporting. The Bureau will now produce four annual publications, each with a specific purpose and design.

The retooled Annual Report is a new, condensed report intended to highlight selected Bureau projects, introduce staff, and disclose basic financial data. Our second publication, titled Comprehensive Report, is the familiar in-depth account of projects, people, activities, and services of the Bureau during the previous calendar year. Our third publication, another Bureau standby, is the List of Publications. Updated annually, our List of Publications contains every type of publication, including books, maps, and CD-ROM’s, ever produced by the Bureau, plus pricing and ordering information. And completely new to the Bureau will be our fourth publication, a Mid-Year Report. The Mid-Year Report will showcase specific areas of Bureau research, as well as update the reader on Bureau activities during the first half of the current year.

In addition to printed publications, the Bureau’s Web site is a substantial resource for anyone seeking information about the Bureau, its employees, research programs, public services, or the on-line purchasing of publications. Our Web-site address is http://www.beg.utexas.edu.

ADVISORY COMMITTEE

The Advisory Committee to the Bureau of Economic Geology was created in conjunction with the appointment of the new Bureau Director. Members of this 10-person committee represent a broad range of earth science interests. Meeting twice a year, the committee will receive quarterly reports from the Director, and in turn provide counsel and advice to him. The committee took time out from one of their meetings to pose for a photo. Pictured, front row, from left to right are Dr. Thomas D. Barrow, Chairman, Tobin International; Dr. Peter T. Flawn, Committee Chairman, and former Bureau Director and President Emeritus of the University; Mr. L. Decker Dawson, President, Dawson Geophysical Company; and Mr. Russell G. Slayback, Chairman, Legette, Brashears & Graham, Inc. In the top row, from left to right are Dr. John R. Hopkins, Vice President, Conoco, Inc.; Mr. James A. Gibbs, Chairman, Five States Energy Company; Dr. Scott W. Tinker, Bureau Director; Dr. Juan M. Sanchez, Vice President for Research at the University (invited guest); and Dr. William L. Fisher, past Bureau Director (ex officio member). Absent when picture was taken are Mr. Don R. Boyd, independent geologist and oil operator; Dr. Charles G. Groat, Director, U.S. Geological Survey, U.S. Department of the Interior; and Mr. Mark S. Leonard, Shell EP International Ventures Inc.

A GROWING FAMILY

The Bureau hired 21 new staff members and researchers during 2000. Several of these talented people had been Bureau employees in the past, and we are happy to see them return. Others, including the Director, moved from cities and states spanning the country to be a part of the Bureau as it enters the new millennium.

HIGH TECHNOLOGY

Using matching funds provided by the University’s Vice President for Research, the Bureau purchased 15 new dual-monitor, dual-processor Silicon Graphics Octane visual workstations in June. Geoscientists throughout the Bureau use the SGI workstations to enhance geophysical, geologic, petrophysical, coastal, hydrologic, and engineering research.
LIDAR
The Coastal Studies Group took possession of its first LIDAR (Light Detection and Ranging) mapping system in September 2000. This mapping technology has already been used to map damage resulting from Hurricane Mitch in Honduras and to provide a baseline for monitoring change along the Texas coast. The Optech ALTM 1225 LIDAR instrument combines GPS receivers, scanning optics, a pulsed laser, and an inertial measuring device for acquiring topographic data at 15-cm accuracy and submeter data-point spacing.

PEMEX
In May, the Bureau signed an agreement with PEMEX Exploration and Production that was 5 years in the making. A 12-member team of scientists from the Bureau is working in collaboration with PEMEX to study the Miocene-Pliocene sections of the Macuspana and Veracruz Basins of southern Mexico. Results from these high-profile studies will be used to help Mexico meet its natural gas needs in the coming years. The Bureau looks forward to a long-term, productive relationship with our neighbors to the south.

STARR & ULARI
The mission of the State of Texas Advanced Oil and Gas Resource Recovery (STARR) and University Lands Advanced Recovery Initiative (ULARI) programs is to increase incremental oil and gas recovery on State and University royalty lands. Multidisciplinary teams of experts apply high technology in order to understand the geology of producing oil and gas fields, while working in partnership with operators to increase hydrocarbon production. These programs have been extremely successful.

PERMIAN BASIN CORE
The Midland Core Research Center (CRC) received 85,000 boxes of Permian Basin core, which was donated by Altura Energy, Ltd. A 13,500-ft² warehouse extension was added to the core facility to house this large collection of Permian Basin materials. The Midland CRC will soon store and manage all Permian Basin rock samples kept by the Bureau.

GENTLE GIFTS
The Bureau gratefully accepted many technical and public-domain gifts this year. Cutting-edge software systems were donated to the Bureau by Landmark Graphics Corp.; Schlumberger-GeoQuest; Seismic Micro-Technology, Inc.; Green Mountain Geophysics; Geophysical Development Corporation; Hampson-Russell; Paradigm Geoophysical; Geo-Graphix; Flagship Geosciences; Geovariances; CMG; Terrasciences; Badleys Earth Sciences, Ltd.; and Dynamic Graphics, Inc. These software packages are essential to many of the Bureau’s research activities. Multicomponent seismic research data were donated by 4Sight; Harken International, Ltd.; and Vecta Technology, L.P. Western Geophysical donated 2-D seismic data from offshore Kwanza Basin, Angola.
The Core Research Centers (Austin and Midland) received more than 87,000 boxes of core and cuttings from Altura Energy, Ltd.; Crescendo Resources, L.P.; J. M. Huber; Texland Petroleum; and Cabot Oil & Gas Corporation. The Bureau’s Geophysical Log Facility received well log data from both individuals and corporations: the Lower Colorado River Authority, Horizon Resources, James E. Vause, and R. C. Wilshusen and R. D. White. These generous donations of rock material and well logs benefit the citizens of Texas.

A BUSY PLACE...
The Bureau conducted research on nearly 100 projects for 68 different funding agencies during the year 2000. We also trained nearly 800 teachers and provided classroom-related activities to more than 180 students at Bureau facilities and 1,000 students across the state. All of this activity resulted in the publication of nearly 80 technical papers, 5 books, 5 book chapters, and 8 copyrighted software packages. Bureau researchers also delivered more than 40 presentations at industry and earth science conferences throughout the world.
ENERGY

Energy research at the Bureau comprises basic research, basin and field studies, and resource evaluations.

BASIC ENERGY RESEARCH

Reservoir Characterization Research Laboratory (RCRL): Characterization of Carbonate Reservoirs

Charles Kerans and F. Jerry Lucia, principal investigators; James W. Jennings, Jr., and William M. Fitchen; assisted by Jason W. Rush, James J. Corboy, and Md. Rashidul Hassan

The RCRL is a unique integrated group of full-time researchers dedicated to the development of new methods and techniques for characterizing carbonate reservoirs worldwide. The core staff of the RCRL includes specialization in carbonate sequence stratigraphy and facies analysis, carbonate rock fabric facies analysis and petrophysics, and geostatistics and reservoir engineering. The 2001 research program also will focus on the integration of seismic data into subsurface reservoir models through synthetic modeling of key stratal geometries and relationships derived from outcrop data. This research is funded by the following industrial sponsors: Altura Energy Limited, Amerada Hess Corporation, BP-Amoco, Chevron Petroleum Technology, Elf Exploration Production, Exxon-Mobil Production Research Company, Kinder Morgan, Marathon Oil Company, PanCanadian, Petroleum Development Oman LLC, Shell International, TOTAL Exploration Production USA, Inc., and Texaco Inc.

The RCRL has its foundation in rock-oriented studies. Outcrop analogs form the basis of the group’s understanding of the subsurface environment, regardless of scale. Recent examples include seismic-scale outcrop analogs of Permian and Pennsylvanian icehouse carbonate systems, where outcrops in the Sierra Diablo Range of West Texas and the Big Hatchett Mountains of New Mexico have provided a basis for fundamental reinterpretation of 3-D seismic volumes. At the pore scale, CAT-scan images of vuggy carbonates are providing input for quantitative evaluation of this type of pore space on permeability in carbonate systems. A third example of rock-based research in the RCRL this year is the ongoing effort to link rock fabric to relative permeability in carbonate systems. We consider this link fundamental to populating 3-D models of carbonate reservoirs with relevant distributions of petrophysical properties.

This year the RCRL focused on five key areas. Construction of a digital database containing outcrop and subsurface geologic, petrophysical, and engineering data collected over the past 12 years of RCRL studies was initiated in 2000. This relational database is seen as a key element of the program, and has a goal of making available facies dimensions data, spatial grids of petrophysical data, and example petrophysical and wireline log data that will aid the process of populating 3-D model volumes.

Characterization of Cretaceous reservoirs has been a central theme of the RCRL for the past 6 years, balancing the ongoing efforts in the Permian Basin of Texas and New Mexico. Studies of the Yibal field in Oman and the Idd el Shargi South Dome were part of the subsurface application element of the RCRL. Working closely with Petroleum Development Oman, we generated a sequence framework and petrophysical model for the Yibal field using a solid core and log database. Idd el Shargi was the site of a 1996 study of the North Dome that the RCRL conducted cooperatively with OXY Qatar. This year the
1996 study was expanded to the South Dome, where core and log data allowed construction of a new stratigraphic model for the area. Outcrop studies in the Cretaceous are being continued through a joint Total-Fina-Elf group using the Pecos River Canyon outcrops previously examined by the RCRL as the basis for a new accommodation-driven modeling approach.

Development of improved techniques for interpreting fundamental properties of saturation and permeability from wireline logs using the rock-fabric approach continues to be a central theme of the RCRL. Application of these techniques to both Cretaceous data from Oman and Permian data from the South Wasson Clear Fork field furthered the understanding of these systems.

Construction of a detailed 3-D model of the South Wasson Clear Fork using rock-fabric-defined layering schemes is an active element of the model construction and flow simulation effort for RCRL this year. Comparison of simulation results from the sequence- and rock-fabric-based layering scheme developed by the RCRL with similar seismically guided models will provide insights into suggested best practices for model construction and fluid-flow simulation.

Estimating the permeability of vuggy pore space, and touching vugs in particular, represents one of the remaining frontiers in carbonate reservoir characterization. This year a substantial effort has been placed on the development of a method for imaging and quantifying touching vugs using high-resolution X-ray CT scanning in conjunction with the Department of Geological Sciences and the Texas Institute for Computational and Applied Mathematics at The University of Texas at Austin. Use of digital rock volume from the CT scan as input into high-resolution fluid-flow simulation experiments is yielding a first quantitative look at permeability in these complex systems.

### Integrated Outcrop and Subsurface Studies of the Interwell Environment of Carbonate Reservoirs: Clear Fork (Leonardian Age) Reservoirs, West Texas and New Mexico

*F. Jerry Lucia and Charles Kerans, principal investigators; Stephen C. Ruppel, James W. Jennings, Jr., and Stephen E. Laubach; assisted by Tony J. Troutman, Md. Rashidul Hassan, Javier G. Moros, and Zeno G. Philip*

This study of carbonate reservoirs is funded by the U.S. Department of Energy, and matching funds are provided by the Reservoir Characterization Research Laboratory for Carbonate Reservoirs. The objective of this project is to investigate and develop improved engineering and geological methods for characterizing carbonate reservoirs for input into fluid-flow simulators to predict reservoir performance. The project is focused on investigations of interwell heterogeneity in Clear Fork reservoirs of the Permian Basin, West Texas, and New Mexico. Data are being collected and analyzed from the excellent Clear Fork-age outcrops in the Sierra Diablo Mountains, West Texas, and from the South Wasson Clear Fork reservoir, a major Clear Fork reservoir in the Permian Basin. The study addresses three fundamental questions: (1) What are the best methods of predicting the distribution of high- and low-permeability rock-fabric facies? (2) What effect does the fine-scale heterogeneity located within rock-fabric flow units have on recovery? (3) What is the impact of natural fractures on reservoir performance in Clear Fork reservoirs?

Outcrop studies indicate that the basic stratigraphic element is the high-frequency cycle. High-frequency cycles (HFC) have been identified in cores and wireline logs from the South Wasson Clear Fork reservoir and mapped over a 1-mi² area. The cycles are composed of a lower mud-dominated dolostone and an upper grain-dominated dolopackstone, which define rock-fabric flow layers within the HFC's. High and low permeability is maintained by grouping of permeability into the rock-fabric flow units. Small-scale variability from outcrop measurements is converted to variograms and used to construct detailed stochastic simulations of petrophysical properties in the interwell environment. These simulations will be used to study the effects of interwell variability on recovery. Fracture data described from outcrops and cores suggest a fractal relationship between fracture height and aperture width. This relationship will be used to populate the reservoir model with fracture permeability for study.

### Refining the Geologic Time Scale: Integrated Biostratigraphy, Chemostratigraphy, and Sequence Stratigraphy

*Stephen C. Ruppel, principal investigator; assisted by Lance N. Christian and Yong-Joon Park*  

The goals of this project, which was funded by the Texas Higher Education Coordinating Board as
part of the Advanced Research Program, are to de-
velop a high-resolution temporal framework for the
Lower Permian using a synthesis of biostratigraphic,
chemostratigraphic, and sequence stratigraphic data.
Once established, this framework will serve as a pri-
mary reference standard for comparison, correlation,
and dating of equivalent successions worldwide.
This will be accomplished by first developing a high-
resolution sequence stratigraphic architecture for the
Lower Permian in West Texas and then collecting
biostratigraphic and strontium-isotope samples from
within this architecture. The research is being con-
ducted on outcrop and subsurface data sets in the
Permian Basin of West Texas. Outcrop studies are
focused on the Sierra Diablo Mountains of West
Texas, an area that is internationally recognized for
world-class exposures of Permian rocks. These data
are being integrated with cores, seismic, and wireline
log data from the adjacent subsurface.

Major elements of the sequence stratigraphy of
the Wolfcampian and Leonardian sections have been
worked out through integrated studies of outcrop
and subsurface data. Using this sequence stratigraph-
ic framework, we are currently collecting samples
from outcrops and cores for biostratigraphic and
geochemical analysis. Biostratigraphic studies will
focus on fusulinid and conodont faunas: the two
faunal groups that have shown to have great value
in biozonation of the Permian. Geochemical studies
will measure strontium isotope ratios ($^{87}\text{Sr}/^{86}\text{Sr}$)
from anhydrite in cores and conodont elements:
two mineral phases that have proven to be good
preservers of original seawater ocean chemistry.

**Scaling of Fractures in Carbonate Reservoirs
and Relations with Sequence-Stratigraphic
Framework**

*Randall A. Marrett (Department of Geological
Sciences, The University of Texas at Austin) and
Stephen E. Laubach, principal investigators;
assisted by Orlando J. Ortega, Julia F. Stowell,
and Faustino Monroy*

The goals of this project, funded by the Advanced
Research Program of the Texas Higher Education
Coordinating Board, include characterization of
fracture arrays in carbonate strata and relating the
fracture characteristics to fluid-flow observations and
bedding architecture of the sedimentary rocks. One
study area for this project is in the Sierra Madre Ori-
ental Mountains of northeastern Mexico. Two field
campaigns have been carried out, and results of out-
crop analyses are being compared with analogous
work on core extracted from petroleum wells.
We have obtained core samples, associated oil-
production data for several wells from PEMEX
Exploration and Production, and completed fracture
characterization. In addition, a study of fracture
scaling in carbonate outcrops of Central Texas is also
complete. These studies show that fracture apertures
in carbonate rocks follow power-law scaling across
at least four orders of magnitude. These results have
implications for targeting and simulating fractures
in carbonate reservoirs.

**Applied Geodynamics Laboratory (AGL)**

Martin P. A. Jackson, principal investigator;
Bruno C. Vendeville, laboratory manager;
Michael R. Hudic, Daniel D. Schultz-Ela,
and Randy L. Remington;
assisted by Joel H. Le Calvez,
Asif Muzaffar, and Patrick Walsh

Funded by a consortium of oil companies since
1988, the Applied Geodynamics Laboratory (AGL)
investigates tectonic processes relevant to the
location, origin, mechanics, and evolution of struc-
tural hydrocarbon traps. This research has two
principal directions: a program of tectonic modeling
and a seismic-based program.

Tectonic modeling covers a wide range of gravity-
driven tectonics involving combinations of extension
or contraction and mobile salt or shale.

Physical modeling is carried out in the only fully
equipped, university-based tectonic modeling
laboratory in the United States. Computer-controlled
rigs simulate almost any structural style in 2-D or
3-D. Using a combination of overhead photographs,
serial sections, time-lapse videos, and CT scans,
the evolution of structures in the model can be re-
constructed and analyzed.

Mathematical modeling uses *ABAQUS* and
*MARC* for forward modeling in 3-D by simulating
combined brittle and ductile deformation, large
strains, faulting, fluid flow, and thermal effects.
*EarthVision* is used for 3-D visualization, volum-
metrics, mapping, and creation of data volumes from
physical models. Animations and restorations
(*Geosec*) of physical models and mathematical
models illustrate structural evolution.
An AGL project that began at the end of 1998 investigates salt tectonics along the Angolan margin. The project is based on 2-D seismic data, supplemented by well and potential-field data. This project complements the parallel modeling program and involves close interaction with several companies in the AGL consortium. The present area of interest is a geotraverse across the center of the Kwanza Basin from the Angola craton onshore to the abyssal Angola Escarpment. Other regions of interest are the Lower Congo Basin to the north and the Benguela Basin to the south. A major goal is to use the clearly imaged, linked structural systems along the Angolan Margin as a key to understand the poorly imaged subsalt structures in the Gulf of Mexico.

The AGL is currently studying The Grabens, Utah, as a well-exposed and well-constrained example of extensional salt tectonics.

In 2000, the AGL was supported by the following sponsors: Amerada Hess Corporation, Anadarko Petroleum Corporation, BHP Petroleum (Americas) Inc., BP Amoco, Chevron U.S.A. Production Company, ENI-SPA Divisione Agip, Enterprise Oil, ExxonMobil, Marathon Oil Company, PanCanadian Petroleum Limited, Petroleo Brasileiro, Phillips Petroleum Company, Shell International E&P, Inc., Texaco Exploration Production, Inc., TotalFinaElf Exploration Production USA, Union Oil Company of California, and Vastar Resources, Inc.

**Numerical Models of Brittle Grabens Forming above Ductile Rock in Canyonlands National Park, Utah**

*Daniel D. Schultz-Ela, principal investigator; assisted by Patrick Walsh*

The Grabens area of Canyonlands National Park displays interacting extensional faults above a layer of flowing salt. Downcutting of the Colorado River into the evaporites in the last 500,000 years initiated gravity spreading of the overburden down a west-dipping regional slope. The faults are still slipping today, which creates spectacular exposures virtually unmodified by erosion. Numerical modeling and field study of this uniquely well constrained fault system enhances understanding of brittle rock stretching above a ductile layer elsewhere on Earth and other planets.

Our numerical models simulated the observed features well, and they indicate that plate flexure and salt flow control the evolution of the grabens in the following way. Canyon cutting created differential overburden loading that expelled salt and caused grabens to sequentially initiate away from the free canyon face. The combined effects of erosional unloading and salt flow into the canyon flexed the canyon walls upward to form the Meander Anticline. Upward flexure at the canyon wall and adjacent subsidence formed a horst-graben pair having opposite directions of fault propagation; horst faults near the canyon propagated upward from the salt contact, while graben faults farther from the canyon propagated downward from the surface. Subsidence and salt expulsion controlled the development of the remaining updip grabens. The graben-bounding faults propagate downward from the surface, which answers a long-standing debate. Bounding faults are vertical near the surface but dip inward below to converge above the salt contact, as observed in crosscutting tributary canyons. The centers of sedimentary blocks between grabens flexed downward, bounded by uplifted footwalls above the reactive diapirs.

Modeling the evaporites as a visco-elastic material, rather than purely viscous, shows that both the relaxation time and elastic properties of the salt affect the overlying graben spacing. Therefore, spacing is sensitive to viscosity changes, contrary to common, but oversimplified, scaling arguments. Overburden rock properties also affect spacing. Thus,
methods used to infer overburden thickness from observed graben spacing on Earth and other planets may also be too simplistic.

Field observations showed that multiple faults commonly bound each side of individual grabens, indicating that underlying reactive diapirs may be present as shown by the models. Surveyed points along a stratigraphic layer show that horsts subsided as much as 40 m below regional in the most deformed area. Individual horst blocks flexed, rotated toward the canyon, than back-rotated as intervening grabens grew and disrupted the continuity of the overburden. Horst block flexures also vary along strike, and, in some locations, crosscutting anticlines accompany abrupt displacement variations.

Fracture Research and Application Consortium
Stephen E. Laubach, Randall A. Marrett (Department of Geological Sciences, The University of Texas at Austin), and Jon E. Olson (Department of Petroleum and Geosystems Engineering, The University of Texas at Austin), principal investigators; Julia F. Stowell, Kitty L. Milliken (Department of Geological Sciences, The University of Texas at Austin), and Robert M. Reed; assisted by Eloise H. Doherty, Orlando J. Ortega, Faustino Monroy, and Aysen Ozkan

This industry-sponsored research consortium aims to understand and successfully characterize, predict, and simulate reservoir-scale structures. The focus is on fractures and faults that influence the successful extraction of resources. Many faults and fractures are near or below the limits of seismic resolution and are difficult or impossible to characterize adequately using currently available technology. Consequently, fractured reservoirs have been intrac-

table to describe and interpret effectively, posing serious challenges for successful exploration and development.

Geologic Characterization of Fractured Reservoir Block Size Using Microcrack Data
Stephen E. Laubach and Jon E. Olson (Department of Petroleum and Geosystems Engineering, The University of Texas at Austin), principal investigators; assisted by Yuan Qiu, Zeno G. Philip, and Jon Holder

The goals of this project, funded by the Advanced Research Program of the Texas Higher Education Coordinating Board, include characterization of fracture arrays in sedimentary rocks, relating the fracture characteristics to fluid-flow observations, and relating fracture characteristics to the bedding architecture of the sedimentary rocks. Naturally fractured reservoirs represent a large but poorly understood resource in the State of Texas as well as in other hydrocarbon-producing provinces throughout the world. Reservoir-scale fracture networks are difficult to characterize because fracture spacing is typically many times the diameter of a conventional borehole, so that in most cases well bores miss fractures. Because these fractures may nevertheless profoundly influence reservoir behavior, this sampling problem poses a serious challenge to fracture characterization and simulation. This project involves geomechanical modeling and other advanced modeling and characterization methods to improve prediction of fracture attributes in the interwell region. The project successfully used microstructural fracture proxies to define the location of horizons having conductive fractures on a scale suitable for use in reservoir simulation. These results have been used to specify the vertical dimension of simulator cellblocks. Geomechanical modeling, calibrated with subsurface fracture observations and new rock property tests, specifies the spacing of fracture clusters in a way that can be used to define the lateral extent of cellblocks.

Advanced Technology for Predicting the Fluid-Flow Attributes of Naturally Fractured Reservoirs from Quantitative Geologic Data and Modeling
Jon E. Olson, Larry W. Lake (Department of Petroleum and Geosystems Engineering, The University of Texas at Austin), and Stephen E. Laubach, principal investigators

The goal of this research, supported by the U.S. Department of Energy, is to develop new under-
standing and new technology for prediction of fracture pattern attributes related to subsurface fluid flow. The focus of the study is predicting connectivity, clustering, and aperture, fracture pattern attributes that are exceedingly difficult to measure but can be controlling fractures for fluid movement. The project involves a multidisciplinary team.

Combining a New 3-D Seismic S-Wave Propagation Analysis for Remote Fracture Detection with a Robust Subsurface Microfracture-Based Verification Technique

Bob A. Hardage and Stephen E. Laubach, principal investigators; James L. Simmons, Jr., Milo M. Backus, Robert J. Graebner, Jon E. Olson (Department of Petroleum and Geosystems Engineering, The University of Texas at Austin), and Randall A. Marrett (Department of Geological Sciences, The University of Texas at Austin)

This research program, funded by the U.S. Department of Energy, combines seismic shear-wave (S-wave) imaging with a new microfracture-based analysis technique of oriented sidewall cores to create a next-generation technology for detecting and characterizing subsurface fractures. The seismic component of this research is an approach based on proper separation of SH and SV shear modes in nine-component 3-D (9C3D) seismic data. This mode-separation model leads to a robust data-processing technology for detecting fractures when S-waves are recorded by 3-D seismic templates. The seismic calibration portion of the research relies on collecting sidewall cores and then observing and classifying microfractures to calibrate fracture-sensitive seismic attributes. The ability to use microfractures is an advantage of this method because large fractures, typically nearly vertical, have spacing that ranges from a few to thousands of feet. The chances of a vertical well bore penetrating large fractures that dominate reservoir behavior are small, whereas microfractures are abundant and can be observed even in sidewall cores. This research program is based on three theses that will be investigated and reported:

- Nine-component 3-D (9C3D) seismic data can be a powerful fracture-detection technology if the data are processed first to separate S-wave modes into SH and SV components before attempting to create fracture-dependent fast-S and slow-S components.
- Present industry practice for processing multicomponent seismic data is often flawed because strategies emphasize processing in-field coordinates where S-wave modes are mixed and rotation algorithms that create fast-S/slow-S modes are misapplied.
- A rigorous, low-cost, sidewall-core-based analysis of microfractures can be used to verify and calibrate the fracture-predicting capability of multicomponent seismic data.

Seismic Vector-Wavefield Characterization of Complex Reservoirs

Bob A. Hardage, Milo M. Backus, Robert J. Graebner, and James L. Simmons, Jr., principal investigators; Michael V. DeAngelo

The purpose of this program is to develop technologies that will image reservoirs using all components of the seismic wavefield. Research objectives are to develop seismic field-recording techniques and data-processing and data-interpretation software that will result in independent compressional wave (P-wave) and shear wave (S-wave) images of reser-
voir systems. By combining information from P and S seismic images, more insight can be gained into petrophysical rock properties, pore structure, pore-fluid properties, sequence-stratigraphic relationships, and spatial distributions of lithologies, fractures, and anisotropic properties of complex reservoirs.

Through donations provided by industry sponsors, the Bureau has equipment for two 2,000-channel seismic recording systems and access to a fully staffed seismic research crew. These Bureau resources are used to record nine-component, 3-D (9C3D) data over selected test properties. More than 40 mi² of 9C3D research data have been recorded across several onshore prospects. Multicomponent data recorded by ocean-bottom-sensor systems are donated by program sponsors to allow investigations to be extended into marine applications. Research strategy is concentrating on the development of multicomponent data processing and imaging technologies.

Integrating P-Wave and S-Wave Seismic Data to Improve Characterization of Oil Reservoirs

Bob A. Hardage and I. J. Aluka (Prairie View A&M University), principal investigators; Michael V. DeAngelo

The Bureau is a subcontractor to Prairie View A&M University for this study. The objective is to provide Prairie View A&M faculty access to well log and multicomponent seismic databases at the Bureau and introduce seismic stratigraphy and sequence stratigraphy concepts into the Earth Sciences curriculum at Prairie View A&M.

Devine Test Site

Bob A. Hardage and James L. Simmons, Jr., principal investigators; Milo M. Backus and Robert J. Graebner; James A. Doss, Jr., and George T. Bush, site managers

The Devine Test Site is a 100-acre property in Medina County, Texas, approximately 15 mi west of Devine, Texas, that the Bureau is upgrading into a world-class geophysical field laboratory. Key assets of the property are three wells, each 3,000 ft deep, that have been constructed for the specific purpose of downhole geophysical experimentation. An appealing feature of these wells is that two of them are cased with fiberglass, which allows downhole electromagnetic instruments to function as they would in an uncased hole without the impediment of steel casing. No fluid-exchange processes are occurring in the interwell spaces because the nearest oil production is several miles away.

The Society of Exploration Geophysicists has provided 3 years of financial support to help the Bureau upgrade facilities at the Devine Test Site. Several commercial firms pay low-cost fees to use the site for testing new geophysical equipment. Key aspects of the Bureau’s multicomponent seismic research are done on the property.


Bob A. Hardage and James L. Simmons, Jr., principal investigators; Michael V. DeAngelo, Milo M. Backus, Robert J. Graebner, and Paul R. Knox

This research is based on two concepts: (1) marine gas-hydrate reservoirs can be better characterized with multicomponent seismic data than with single-component seismic data, and (2) the elastic constants, shear moduli, and mechanical stability of strata that comprise and overlie marine gas-hydrate accumulations can be determined in a relative sense when multicomponent seismic data are recorded across gas-hydrate targets.

The advantage of using multicomponent seismic data for evaluating gas-hydrate systems is that the integration of P and S seismic attributes provides more information about sequence relationships, lithofacies distributions, and pore-filler material than does the use of P-wave attributes alone. In addition, the P-wave velocity (Vp) and S-wave velocity (Vs) associated with a sequence can be used to calculate key elastic constants of the material within that sequence and thereby infer the shear modulus and mechanical strength of the material. Thus a more detailed and informative characterization of marine gas-hydrate systems will result if gas-hydrate targets are described in terms of integrated P and S seismic data rather than just P-wave data, as is conventionally done in marine environments.

The principal barrier to overcome to image marine gas-hydrate systems with both P and S wavefields is that S waves do not propagate in fluids, and marine gas-hydrates are concentrated in sediment that is overlain by rather deep water. This S-wave illumination problem is overcome in this pro-
gram by utilizing four-component ocean-bottom sensor (4-C OBS) technology to acquire the seismic data. This research is funded by the U.S. Department of Energy.

An Investigation to Document Reservoirs That Can Be Better Detected with Seismic S Waves Than with Seismic P Waves

Bob A. Hardage and James L. Simmons, Jr., principal investigators; Michael V. DeAngelo

Nine-component vertical seismic profile (9C VSP) data are being analyzed from three wells that penetrate Morrow reservoir facies in Texas, Kansas, and Colorado. These data allow both compressional (P) and shear (S) wave images of Morrow stratigraphy to be produced. The research objective is to determine specific stratigraphic depth when P and S reflections are generated and then correlate these findings with subsurface control to define what types of lithofacies sequences are better imaged with S waves than with P waves. The research is funded by the U.S. Department of Energy.

BASIN AND FIELD STUDIES

State of Texas Advanced Resource Recovery (STARR) Project

Robert G. Loucks and Bob A. Hardage, principal investigators; L. Frank Brown, Jr., Randy L. Remington, Ramón Treviño III, Luciano L. Correa, and Daniel L. Mendez

Revenue income to the Permanent School Fund, derived largely from oil and gas royalties from Texas State Lands, has declined over the last decade. However, an enormous hydrocarbon resource base remains on State Lands. In fact, State Lands fields contain more oil and gas than has been recovered over the decades-long history of State Lands production. Rather than being unattainable, however, a large volume of this remaining oil and gas is recoverable through the strategic, or targeted, deployment of advanced recovery technologies. Although advanced technology has historically been the realm of major oil and gas companies, many companies, in pursuing economies of scale, have mostly departed from the mature Texas resource base.

The remaining major and independent producers from State Lands fields have enthusiastically grasped the opportunity thus created. Major companies, who have suffered from staff shortages, and independents, who are largely unsupported by the advanced research and development capabilities that the maturing State Lands resource base desperately requires, are requesting reservoir-characterization assistance from the State of Texas Advanced Oil and Gas Resource Recovery Initiative (Project STARR).

The Bureau, with funding from the State of Texas and support from the General Land Office and the Railroad Commission of Texas, is providing critical technical support. Plays having the best prospects for increased production have been identified and, with the support of allied producers, are being drilled. Project STARR has one major goal — increased royalty income to the Permanent School Fund through the drilling of profitable wells.

To date, 15 fields have been chosen for assessment: Ozona, Geraldine Ford, Ford West, Lockridge, Waha, Waha West, Bar Mar, and Keystone East fields of West Texas; Corpus Christi Bay East, Corpus Christi Bay NW, Encinal Channel, Umbrella Point, Mustang Island 889, and Red Fish Bay fields of the Gulf Coast; and Duval County Ranch field in South Texas. Sixteen Texas operators have been or are still involved in Project STARR: Bass Enterprises, Cross Timbers, Conoco, Hallwood Energy, Hanson Corporation, Killam Oil, Mobil (now ExxonMobil), Panaco, Inc., Pi Energy, Pioneer Natural Resources, Royal, Sabco, Shell, Union Pacific Resources (now Anadarko), Vista Resources, and IBC Petroleum. Project STARR has recommended 58 infill wells, 56 recompletions, and 4 step-out wells under the current program initiative.

Of the targeted opportunities, at least 42 infill wells and 29 recompletions have been drilled on State Lands on the basis of STARR recommendations to date. In the Ozona and Keystone East fields, 40 infill wells have been drilled and 28 recompletions have been undertaken, and incremental oil and gas
reserve growth is estimated at 8.9 Bcf of gas and 2.4 MMbbl of oil. The total royalty generated from the reserves added in these two fields is projected to exceed $10.2 million. In Umbrella Point field, total gas production from the Panaco 74-10 well (a STARR-recommended infill well) exceeded 7.9 Bcf between June 1998 and April 2000. Incremental production from this one infill well alone added $3 million in royalties to the Permanent School Fund.

Texas State Lands operators are invited to participate in Project STARR to receive expert technical advice in developing State Lands oil and gas fields.

Targeting Reserve Growth Opportunities in the Northern Gulf of Mexico Basin: Transferring Secondary Gas Recovery Technology to the Offshore Environment

Lesli J. Wood, principal investigator; Tucker F. Hentz, Hongliu Zeng, and Michael V. DeAngelo; assisted by Cem O. Kilic, Claudia Rassi, Adrian C. Badescu, Ramiro A. Amaya, and Dingshan Zhou

The Bureau has been an active partner with industry in improving natural gas recovery efficiency in complex onshore reservoirs since 1988. Research on onshore Gulf Coast sandstones, sandstones of the Fort Worth Basin, and karsted carbonate reservoirs of the Permian Basin has successfully defined secondary, or incremental, gas recovery based on targeting reservoir heterogeneity. Focusing on offshore gas reservoirs, the Offshore Secondary Gas Recovery (Offshore SGR) project began in late 1998 as a 4-year joint research venture between the Bureau and the U.S. Department of Energy (DOE). The project is an outgrowth of a previous DOE-sponsored Bureau project that produced the two-volume Atlas of Northern Gulf of Mexico Gas and Oil Reservoirs, which was published in 1997.

The goal of the Offshore SGR project is to identify additional natural gas resources in two major mature fields—Tiger Shoal and Vermilion Block 50 (“Starfak”) — in the northern offshore Gulf of Mexico (Federal OCS) through multidisciplinary field- and reservoir-characterization studies. The specific objectives are to (1) fully evaluate the lithostratigraphic, sequence-stratigraphic, structural, petrographic, and engineering attributes of the fields that will lead to additional natural-gas development opportunities, (2) increase reserves, (3) prioritize newly identified prospects and development opportunities, (4) develop and apply new technologies to aid in the future search for reserves, and (5) transfer research methodologies and technologies to the industrial community. Texaco, Inc., the project’s industry partner, has operated the study fields since the late 1950’s and is providing engineering, production, well-log, and uninterpreted 3-D seismic data.

Starfak and nearby Tiger Shoal fields produce natural gas and oil from a siliciclastic section that spans most of the Miocene Series. The succession grades upsection from slope depositional facies to progradational and retrogradational shelf and shelf-edge facies and finally to dominantly aggradational coastal plain facies just a few hundred feet above the reservoir-bearing interval. As many as 36 potential gas and oil reservoirs occur in the two fields in proximal to distal shelf and slope sandstones between 6,000 and 16,000 ft. Recent research results and publications can be accessed via the SGR Web site at http://www.beg.utexas.edu/resprog/sgr/index.htm.

Application of Advanced Reservoir Characterization, Simulation, and Production Optimization Strategies to Maximize Recovery in Slope and Basin Clastic Reservoirs, West Texas (Delaware Basin)

Shirley P. Dutton, principal investigator; assisted by Daniel L. Mendez and Helena H. Zirczy

This study of deep-water turbidite sandstone reservoirs is funded by the U.S. Department of Energy as part of the Oil Recovery Field Demonstration Program for Class III (slope and basin clastic) reservoirs. The objective of the project is to demonstrate that detailed reservoir characterization of slope and basin clastic reservoirs in sandstones of the Delaware Mountain Group in the Delaware Basin of West Texas and New Mexico is a cost-effective way to recover a higher percentage of the original oil in place through geologically based field development. The project is focused on East Ford field, a representative Delaware Mountain Group field that produces from the upper Bell Canyon Formation (Ramsey Sandstone). The field was discovered in 1960 and is operated by industry partner Orla Petco, Inc., as the East Ford unit. Phase 1 of the project, reservoir characterization, was completed this year, and Phase 2, evaluation of a CO2 flood being conducted in the unit, began.

The research effort this year focused on characterization of the Ramsey sandstone reservoir in the
East Ford unit and analysis of the effect of geologic heterogeneity on the CO$_2$ flood. The depositional model of the East Ford unit was revised on the basis of pressure and production information and re-examination of the outcrop data. Overbank splays, which had been recognized in outcrop, are now interpreted as being the main area of sand storage outside of the channels, not levees. Deposits flanking the Ramsey 1 and 2 channels in the East Ford unit are interpreted as consisting of narrow levees and wider overbank splay sandstones. Deposits at the southern end of the field are interpreted to be lobe sandstones in both the Ramsey 1 and 2 intervals.

The depositional model provides a way to predict the distribution of siltstones, which are the most important depositional heterogeneities within Bell Canyon reservoirs. Siltstones occur (1) as widespread sheets that bound high-order cycles, (2) as discontinuous drapes along the base of channels or at the tops of sandstone beds, (3) interbedded with thin sandstones in levee deposits, and (4) overlying erosion surfaces associated with channel avulsion. Even thin siltstones can affect displacement operations in reservoirs. Because of the low permeability of siltstones, limited cross flow of fluids will occur between sandstones separated by siltstone.

The 12.2 MMbbl of remaining oil in place in the CO$_2$ flood area represents the target for enhanced recovery. The CO$_2$ flood began in July 1995, and production response was observed in December 1998. In 1994, before the CO$_2$ flood began, annual production from the field was 9,700 bbl of oil. By 1999, annual production had increased fourfold to almost 39,000 bbl. Daily production from the field increased from 30 to 150 bbl.

**University Lands Advanced Recovery Initiative (ULARI)**

**Stephen C. Ruppel, principal investigator; Steve J. Shi; assisted by Yong-Joong Park**

The University Lands Advanced Recovery Initiative (ULARI), funded by The University of Texas System, works to develop new approaches to the characterization and exploitation of University Lands oil reservoirs in West Texas. To date, more than 3 MMbbl of incremental oil has been produced from the 15 reservoirs studied thus far. Field operators interested in assistance in characterizing and developing their University Lands oil and gas fields are invited to participate in ULARI program.

**Study of Evaluation of Tertiary Plays of the Central and Southeastern Mexico Basins**

**Edgar H. Guevara, principal investigator; William A. Ambrose, Dallas B. Dunlap, Shirley P. Dutton, William M. Fitchen, Khaled Fouad, Mark H. Holtz, Michael R. Hudec, Martin P.A. Jackson, David C. Jennette, Shinichi Sakurai, Luis A. Sánchez- Barreda, Steve J. Shi, Suhas Talukdar (consultant), Timothy F. Wawrzyniec, and Joseph S. Yeh; assisted by Ramiro A. Amaya, Luciano L. Correa, Elshayeb Tarek, Javier García, Robert F. Keirstead, Marel Sánchez, and Han-Ching Wu**

A joint PEMEX Exploration and Production-Bureau study of two basins in southern Mexico started in May. The objective of this 20-month project is definition of gas plays in the Miocene-Pliocene section of the on-land and offshore portions of the 9,100-km$^2$ Macuspana Basin and the 24,500-km$^2$ Veracruz Basin. The project’s database includes 2-D and 3-D seismic surveys and core, log, engineering, and production data. The studies are being carried out by an interdisciplinary team that includes sequence stratigraphers, structural geologists, petrophysicists, and a petroleum engineer. Results of the study will help PEMEX define and focus their exploration efforts aimed at increased gas production and improved ultimate gas recovery from these siliciclastic reservoirs.

**Optimizing Hydrocarbon Recovery from the Matzen Field, Vienna Basin, Austria**

**Paul R. Knox and Edgar H. Guevara, principal investigators; Joseph S. Yeh, Khaled Fouad, Jirapa Skolnakorn, Steve J. Shi, and Dallas B. Dunlap; assisted by Kymberly Rogers**

The Bureau worked with OMV Aktiengesellschaft to help define the remaining unrecovered oil and gas resource in Matzen field, the largest oil and gas field in Central Europe, located about 30 km northeast of Vienna, Austria. Refinements of petrophysical, geological, and geophysical interpretations were used to construct 3-D petrophysical models of each of the 34 high-frequency depositional units identified in the 7 reservoirs studied. V-shale and porosity models are strongly deterministic because each grid node was assigned a directional bias on the basis of geostatistical analysis of geologically interpreted sand maps. Consequently, petrophysical 3-D models adhered both to geophysical log data at well bores spaced
The use of high-frequency genetic stratigraphy and high-quality 3-D seismic data allowed an improved understanding of complex clinoforming strata in the 9th through 13th Badenian reservoirs and, in the case of the 9th Badenian, clearly documented falling-stage stratigraphic sequences. In each high-frequency layer within the major reservoirs, gross sandstone trends and well-log facies analysis produced paleogeographic reconstructions of the linked deltaic, shelf, slope, and basin systems that deposited the reservoir sandstones. The resulting understanding of lateral facies, and consequent lateral reservoir quality variations from distributary channel to splay, shelf-edge delta front, or slope incision channel in this fluvial-dominated deltaic system explained long-standing reservoir behavior anomalies and aided in more efficient targeting of unrecovered mobile oil. Similarly, identification of backstepping high-frequency depositional units in the main 16th Badenian, known as the Matzen Sand, explained anomalous fluid contact behavior during reservoir production. Widespread reworking of sandy braid- or fan-delta deposits during dominant transgression deposited normally graded structureless, bioturbated sandstone beds. Flooding events that bound high-frequency units are represented by thin, extensively burrowed muddy sandstones that are only subtly evident in the spontaneous potential and resistivity logs. Although thin, these sandstones have vertical permeabilities of one to three orders of magnitude lower than the main reservoir facies, resulting in baffles to vertical fluid communication between flow units.

A detailed structural analysis of the 105-km² 3-D seismic volume included attribute mapping and continuity analysis to identify major and subtle faults in this strike-slip setting. Structural features identified include transtensional trailing-edge imbricate fans, a divergent strike-slip graben, transpressional restraining-bend folds, and extensional duplexes. In addition to the major extensional faults mapped in the northwestern area of the field, a series of subtle north- and northeast-trending small displacement strike-slip features were identified that appear to influence reservoir behavior and may compartmentalize producing horizons. Time- and horizon-slicing of 3-D continuity volumes was extremely useful in identifying these features, as well as in identifying map-view fault patterns in the complex extensional graben in the northwest area. Seismic surfaces from Landmark SeisWorks software were merged in Landmark Z-Map with reservoir top depths through a flexing algorithm to create accurate subsea depth structure maps that satisfied all data available.

In summary, the understanding of these mature reservoirs developed through the joint OMV-Bureau project has produced tangible improvements in reservoir production and has helped OMV reservoir engineers understand long-standing anomalous reservoir behavior. Additional improvements in production are expected following reservoir simulation incorporating the 3-D petrophysical models developed through this project. Furthermore, the maps developed by this study are expected to be the primary guide to development of the main oil reservoirs through the remainder of the life of this giant field.

RESOURCE EVALUATIONS

Assessment and Forecasting by Play — Natural Gas Ultimate Recovery Growth and Quantifying the Role of Technology Advancements in Reserve-Growth Additions in the Texas Gulf Coast Basin and East Texas

William L. Fisher, principal investigator; Eugene M. Kim

Natural gas ultimate recovery estimates are initially conservative because of a lack of understanding of geological characteristics of the reservoir or field involved. Natural gas ultimate recovery tends, on average, to increase substantially over time and after much drilling, owing to an improved understanding of the geological characteristics of the res-
ervoir or field and the application of advanced technologies. In recent years, natural gas ultimate recovery growth (URG), the increase in ultimate recovery from fields subsequent to discovery from extensions and infield drilling in existing fields, improved recovery of in-place resources, new pools, and intrapool completions have become a major component of total U.S. annual natural gas reserve additions.

The primary research objectives of this project, funded by the U.S. Department of Energy, are to develop new concepts in (1) realistic and play-specific measures of remaining natural gas URG potential, (2) the assessment of the technology necessary and most amenable to realizing natural gas URG, and (3) the assessment of economic factors involved in realizing natural gas URG in the Texas Gulf Coast Basin and East Texas.

When taken as a total, major fields of the Texas Gulf Coast Basin and East Texas are currently undergoing significant natural gas URG activity. Disaggregation by play unmasks important play-by-play trend variations in natural gas ultimate recovery growth obscured by aggregated analysis of broad geological provinces. Field-level ultimate recovery data were disaggregated into 21 and 10 geologically delineated plays. Significant historical natural gas URG and future potential in the Texas Gulf Coast Basin and East Texas have been quantified, ranked, and forecasted by plays as a factor of both time and drilling activity.

Undoubtedly, URG is a large and crucial component in the future natural gas supply of the Texas Gulf Coast Basin and East Texas, as well as the entire nation. Future research directions include a play-specific economic and technological analysis of currently selected major plays. Natural gas ultimate recovery growth is slowly, but finally, being recognized as one of the most important components of our nation’s future natural gas supply.

Current Hydrocarbon Reserves and Future Reserve Growth on University Lands: Quantification and Economic Evaluation

Eugene M. Kim, principal investigator

Substantial oil and natural gas resources remain on University Lands. Utilizing a play-level analysis, future oil and natural gas production was forecasted to year 2050 in terms of remaining proven reserves, reserve growth, and undiscovered resources. Oil and natural gas resources on University Lands and the production from these resources constitute a major asset of The University of Texas System.

This report is a detailed assessment and economic evaluation of these resources on 2.1 million acres of University Lands in 19 West Texas counties. By characterizing and quantifying the remaining oil and natural gas reserves as well as reserve growth potential and undiscovered resources, a base is established to determine future production potential, trends, and economic values derived from royalty incomes. This evaluation is consistent with the mission statement of University Lands “to maximize the revenue from University Lands by applying intensive management, accounting, conservation, and environmental programs which improve and sustain the productivity of University Lands, protect the interests of The University of Texas System and promote awareness and sensitivity for the environment.”

The most significant results of the assessment of remaining oil and natural gas resources of University Lands are those that have to do with exploration and production trends and location of future growth potential and undiscovered resources, not absolute volumes. Similarly, economic evaluations are best at suggesting the general direction and magnitude of trends rather than making precise predictions.

In contemplating the meaning of the economic analysis, or in using its results for further analytical or planning purposes, one must consider the time context of its methodology. The economic analysis is time dependent. It predicts the price per barrel of oil or thousand cubic feet of natural gas to arrive upon the economic value of the resource to be produced in the future. The likelihood of technological advances means that the estimates of remaining resources are understated. If significant technological advances occur during the development of these resources, as is likely, and if such technology is applied on University Lands, the volume of recoverable resources will increase under the same price assumptions. Alternatively, the estimated resource volumes might be produced at lower prices.

Additional research conducted involved analysis of remaining reserves on the lease level. Lease level analysis was aggregated up to the field level. Further research in attaining the upside potential of the total University Lands oil and natural gas resource base is warranted.

Scott W. Tinker and Eugene M. Kim, co-principal investigators

This project analyzed past natural gas production trends on Federal lands and describes the role of technological advancements on those trends. It also documents the impact of GRI-funded technology research on past natural gas production and forecasts the economic value of continued GRI research on future production and revenue streams.

Studies by the National Petroleum Council have indicated that investment in technology research and development has played a major role in U.S. natural gas production in the past and that this investment must continue to increase in the future if U.S. natural gas production is to keep pace with demand.

Nearly all growth in U.S. and Federal lands natural gas production, the latter of which accounts for more than one-third of the total U.S. production, is expected to come from the deepwater/subsalt plays in the Gulf of Mexico and from unconventional sources such as low-permeability sandstones and coalbed methane. Each of these potential resources is critically dependent on continuing advances in technology to bring natural gas to the market.

Annual natural gas production from Federal lands is forecast to increase from 7.3 to 10.2 Tcf by 2015. This increase in production, however, is dependent on continued development and application of technology, without which production will decline. The value of technology in terms of incremental natural gas production on Federal lands by 2015 is estimated to be 45 Tcf from deepwater/subsalt and unconventional resources alone. This technology-dependent production represents a potential incremental royalty revenue of more than $22 billion—royalty revenue that will not be realized without continued development and application of technology.

Past GRI programs are estimated to have accounted for approximately 15 percent of the total natural gas supply research and development effort in the United States; for unconventional natural gas resources, GRI’s contribution has been even greater. Very conservatively, then, continued technology research and development by GRI can be expected to deliver more than 10 Tcf of incremental production to the total U.S. natural gas supply by 2015. On Federal lands, GRI’s impact is estimated to achieve an incremental production of more than 6.7 Tcf. These scenarios assume a fully funded GRI program through this period.

A benefit/cost analysis of a proposed GRI natural gas technology program funded by a 10 percent annual nomination of the royalty revenue from Federal OCS natural gas production shows extremely positive economics. Using conservative natural gas price, escalation, and discount rate scenarios, this program is projected to produce an internal rate of return of 101 percent with a net present value of $5 billion based on projected incremental natural gas production and royalty revenue on Federal land alone. In relation to the broader impact of GRI technology research and development on total U.S. natural gas production and using the same project economics, the program is projected to produce an internal rate of return of 143 percent with a net present value of $8 billion.

Update of Oil and Gas Reservoir Data Base, Permian and Fort Worth Basins, Texas

Shirley P. Dutton, principal investigator; Andrew R. Scott and Thomas A. Tremblay; assisted by Helena H. Zirczy

This project, funded by the U.S. Geological Survey, updated the play-based database of oil and gas reservoirs in the Permian and Fort Worth Basins. The original delineation of oil plays in Texas was published by Galloway and others (1983) in the Bureau’s Atlas of Major Texas Oil Reservoirs, which classified into plays all oil fields that had produced more than 10 MMbbl of oil through 1981. Gas reservoirs that had produced more than 10 Bcf of gas through 1986 were grouped into gas plays in the Atlas of Major Texas Gas Reservoirs (Kosters and others, 1989). In this study, cumulative production data were updated through December 31, 1998, for reservoirs already in the oil and gas atlas databases, and smaller but significant-sized reservoirs (cumulative production >1 MMbbl of oil or 6 Bcf of gas) were added to the database. All new reservoirs were assigned to plays. The addition of new reservoirs to the database resulted in the modification of existing play boundaries and the delineation of one new oil play (Mississippian Platform Carbonate) in the Permian Basin and
one new gas play (Barnett Shale) in the Fort Worth Basin.

Oil and gas production data used to update cumulative production and to identify additional significant reservoirs to add to the database were obtained from the Railroad Commission of Texas 1998 Oil & Gas Annual Report. Information used to assign new reservoirs to geologic plays was derived primarily from the hearing files of the Railroad Commission of Texas. The oil plays having the greatest number of additional reservoirs whose cumulative production passed 1 MMbbl in the last 5 years are (1) Leonardian Restricted Platform Carbonate, (2) Spraberry/Dean Submarine-Fan Sandstone, (3) Horseshoe Atoll, and (4) Ellenburger Karst-Modified Restricted Ramp Carbonate, all in the Permian Basin. The gas plays having the greatest number of additional reservoirs are (1) Upper Pennsylvanian and Lower Permian Slope and Basinal Sandstone and (2) Strawn Group Shallow-Marine Carbonate, both plays in the Midland and Val Verde Basins, and (3) the Lower and Middle Pennsylvanian Fan-Delta Sandstone and Conglomerate in the Fort Worth Basin.

Deep Basin Coal (Lignite) in Wilcox Group, Sabine Uplift, East Texas: Potential for Unconventional Coal Gas Resource Development

Stephen C. Ruppel, principal investigator; assisted by Thomas A. Tremblay

Because of the recent interest in deep-basin coal gas resources along the Texas Gulf Coast, the Bureau has begun a project to update deep-basin National Coal Resources Data System resource estimates in the region. The goal of this project, funded through a cooperative agreement with the U.S. Geological Survey, is to develop a coal gas resource database and investigate the potential for coal gas resource development. The current program is focused on the Wilcox Group in the area of the Sabine Uplift in East Texas, an area that contains large amounts of deepbasin (220 to 2,000 ft) coal (lignite) and one that has potential for significant coalbed methane development. The area is also strategically located near several cites in Texas and Louisiana for which the deep-basin coal resource may serve as a gas energy source for coal-fired power plants. Exploitation of deep-basin resources for methane generation is an environmentally friendly alternative to coal mining and combustion. This research will provide the Texas natural gas and coal industry with baseline information and may stimulate a new coalbed methane industry in the state.

ENVIRONMENT

Environmental research at the Bureau covers projects dealing with water resources, environmental quality, coastal processes, near-surface geophysics, and geological and terrain mapping.

WATER RESOURCES

Hydrologic Needs Assessment and Technical Support for the Panhandle Regional Water Planning Area

Alan R. Dutton and Robert E. Mace (Texas Water Development Board), co-principal investigators; Robert C. Reedy; assisted by Thet Naing and Liying Xu

The Ogallala aquifer is one of Texas’ major aquifer systems. This study focused on the northern part of the Ogallala aquifer that underlies 18 of the 21 counties of the Panhandle Water Planning Area (PWPA). In the past 50 years, water-level drawdown in parts of the unconfined aquifer has been as much as 190 ft, or about 4 ft per year. Pumping rates for the next 50 years to 2050 have been projected to be greater than previous rates, and additional drawdown is possible.

To support the development of a regional water plan by the Panhandle Water Planning Group (PWPG), we developed a numerical, or computer, model of the occurrence and movement of groundwater in the Ogallala aquifer. We then used the model to assess surpluses and deficits in aquifer resources. Model development was part of a state-wide process of developing water-resource management plans under Senate Bill 1, 75th Texas Legislative Session. This model improved on previous models by (1) covering the Ogallala aquifer within most of each county in the PWPA with detailed resolution, (2) using as much as possible spatially controlled geologic and hydrologic data, and (3) placing of the model edges to minimize their effects on the area of interest in Texas.

The model was calibrated under two sets of conditions: “predevelopment” without appreciable rates of pumping, and “current” conditions, representing 1950 and 1998, respectively. The model calibration error was about 54 ft and includes errors due to the
inherent model simplifications and approximations of recharge, transmissivity, specific yield, base-flow discharge to rivers and springs, and model geometry as well as historical pumping rates. These model errors represent less than 2 percent of the change in hydraulic head across the Texas part of the model.

Using groundwater demands projected by the PWPG and the Texas Water Development Board (TWDB), the model predicts that by 2050 major areas of the aquifer will have less than 50 ft of remaining saturated thickness and that parts of the aquifer in Dallam, Sherman, Hartley, Moore, Potter, and Carson Counties may be dry. Details of this prediction may not be realized because pumping rates were not decreased as water levels fell in this version of the model.

**Evaluation of Interplaya Recharge on the Southern High Plains**

Bridget R. Scanlon, principal investigator; Robert C. Reedy; assisted by Jinhuo Liang

The goal of this monitoring program is to evaluate infiltration in response to precipitation events in an interplaya setting. We evaluated data gathered from an interplaya setting adjacent to Playa 5 and from the interplaya recharge monitoring installation at the Pantex Plant (Pantex installation). Monitoring adjacent to Playa 5 has been ongoing since 1994 and at the Pantex Plant since October 1998. The results of the monitoring program indicate that water currently penetrates readily to depths of 1.7 m in response to rainfall events. Upward water potential gradients at depth suggest an upward driving force for water movement. These data are being evaluated in conjunction with similar data from the Nevada Test Site and other arid settings to determine the time scales over which upward flow may have been occurring. Detailed numerical simulations of nonisothermal liquid and vapor flow are being done to evaluate liquid and vapor fluxes in the subsurface. The monitoring and modeling studies are important for evaluation of potential contaminant transport in interplaya settings.

**Enhanced Recharge in Hale County, Texas**

Bridget R. Scanlon, principal investigator; Robert C. Reedy

Maintaining groundwater resources is a critical issue in the Southern High Plains as a result of increasing demands on groundwater coupled with decreasing groundwater levels. The purpose of this study was to evaluate groundwater recharge from Soil Conservation Service (SCS) reservoirs and to determine whether recharge could be enhanced by increasing the regulated capacity and/or removing surficial sediments from these reservoirs. Field studies and numerical modeling were conducted by scientists at the Texas Water Development Board, and Bureau scientists were involved in data analysis and synthesis. The status of recharge in these reservoirs depends on the amount of surface water collecting in the reservoirs and the ability of this water to move into the subsurface and recharge the Ogallala aquifer. During this study one of the two reservoirs studied remained dry while water collected in the other reservoir as a result of irrigation return flow. These results of the study indicate that the SCS reservoirs could store much more water if the regulated capacity were increased beyond 200 acre-ft/yr. Analysis of water level data in SCS 4 reservoir as a result of ponding indicates that the average infiltration rate is about 1 cm/d. Textural analysis indicates that there is a clay-rich zone in the upper 1 to 3 ft. Removal of this fine-grained zone may further increase recharge.

**Analysis of Roberts County Groundwater Development Projects**

Alan R. Dutton, principal investigator; Robert C. Reedy

The Panhandle Ground Water Conservation District asked the Bureau to analyze the effects of several groundwater-development projects in Roberts
County, Texas, that are in various stages of planning, permitting, construction, and implementation. The projects total more than 426,000 acre-ft/yr (380 million gallons per day). In addition, the Bureau was to evaluate what pumping rate would meet the aquifer management plan goal of having at least half of the present water-in-place remaining in 2050. Analysis was based on volumetrics and on application of a groundwater flow model of the Ogallala aquifer developed for the PWPA. The Bureau found that

- Some areas in the District are predicted not to meet the 50-percent goal even without the additional projects.
- The projects get only about half of their water from their own properties and the other half by drawing water from adjacent properties.
- Projects operated separately can meet the 50-percent goal but leave little room for demand growth. Additional projects operated simultaneously and pumping at an average rate of 1 acre-ft/yr per acre of water rights probably cannot meet the 2050 goal. A pumping rate limited to as low as 0.5 acre-ft/yr per acre of water rights may be needed for the District water management goal to be achieved.
- New hydrogeologic data may become available to justify greater pumping rates locally.

These results represent only possible or theoretical outcomes in that location, schedule, and amount of pumping were generalized in the model.


Bridget R. Scanlon and Alan R. Dutton, co-principal investigators; Robert E. Mace, Robert C. Reedy, Susan D. Hovorka, and Joseph S. Yeh; assisted by Liying Xu

This model development also was part of the state-wide process of developing water-resource management plans under Senate Bill 1, 75th Texas Legislative Session, and focused on the Barton Springs segment of the Edwards aquifer in Planning Region K. We developed a two-dimensional numerical groundwater-flow model for use in evaluating groundwater availability and predicting water levels and spring flow. The model was calibrated for steady-state conditions on the basis of average recharge for 1979 through 1998 and pumpage values for 1989. Calibration for transient simulations used recharge and pumping data for a 10-yr period from 1989 through 1998 that included periods of low and high water levels. Good agreement was found between measured and simulated flow at Barton Springs and between measured and simulated water levels in many of the monitoring wells.

The impact of future pumping and potential future droughts on groundwater availability was simulated using extrapolated pumpage for a 10-year period during which there was normal recharge for 3 years followed by a 7-year drought. Results predict that flow in Barton Springs would become very low (4 cfs) toward the end of the drought. Because of a bias in the simulation results, the combination of drought and future pumpage could result in no discharge at Barton Springs. Additional scenarios included both current pumpage and no pumpage. With current pumpage, spring discharge could decrease to levels similar to those calculated for the end of the 1950’s drought (11 cfs). No pumpage resulted in discharges as low as 17 cfs. Actual flows, which may be about 7 cfs because of the bias in the simulation results, indicate that drought conditions similar to those of the 1950’s would require no pumpage if spring discharges similar to those of the 1950’s are to be maintained.


Alan R. Dutton and Susan D. Hovorka, co-principal investigators; Joseph S. Yeh; assisted by Amy Hobbs

The Edwards aquifer is the major source of water for more than 1.5 million people in the San
Antonio area and provides nearly all of the water used in the region for industrial, military, irrigation, and public supplies. Furthermore, accelerating withdrawals of groundwater are a threat to spring flow at Comal and San Marcos Springs. Both springs supply water to meet downstream needs, sustain Federally listed endangered species, and support local economies through tourism. The objective of this study is to develop an aquifer database, an improved understanding of the hydrogeologic characteristics of the Edwards aquifer, and a calibrated computer model of groundwater flow in the San Antonio segment of the Edwards aquifer. The model will enable water managers to test the effects of alternative, potentially costly management scenarios before enactment. Input simplifications and output enhancements will make the model user-friendly for trained personnel, as well as ensuring that the graphics-rich output is understandable to nonscientists. The U.S. Geological Survey and the Bureau are collaborating to develop the database and computer model on behalf of the Edwards Aquifer Authority. The study, which began late in 2000, will be completed in 2003.

Groundwater Recharge in Texas

Bridget R. Scanlon, principal investigator; Robert C. Reedy; assisted by Jonathan M. Skaggs

Water resources management is a critical issue in Texas because of diminishing supplies and projected rapid increases in population growth (19 million in 1997 to 36 million in 2050). Recent droughts in Texas have focused attention on recharge issues. To manage future water resources it is critical to understand how much water is recharging groundwater aquifers and how this recharge varies spatially within and between the nine major aquifers. This project is being conducted in collaboration with Dr. Marios Sophocleous (Kansas State Geological Survey). This project involved development of a database of all existing information on recharge rates on the basis of physical, chemical, isotopic, and modeling techniques of the nine major aquifer in the state, evaluation of the range of recharge rates for each aquifer based on the techniques used and examination of the appropriateness of each technique, development of a conceptual model for recharge processes in aquifers, determination of which aquifers require additional recharge studies, and recommendation of appropriate techniques for quantifying recharge in these aquifers. Literature review indicates that existing information on recharge rates for the various aquifers is extremely limited. Conceptual models for the different aquifers are being developed. Various techniques for simulating groundwater recharge are also being examined.

ENVIRONMENTAL QUALITY

Optimal Geological Environments for Carbon Dioxide Disposal in Brine-Bearing Formations in the United States

Susan D. Hovorka, principal investigator; Martha L. Romero, Andrew G. Warne, William A. Ambrose, Ramón H. Treviño III, and Thomas A. Tremblay; assisted by Catherine Stahn

Combustion of fossil fuels has been increasing atmospheric carbon dioxide concentration. This increase is widely thought to impact global climate; therefore, methods to reduce carbon dioxide emissions to the atmosphere are under evaluation. One attractive option for reducing greenhouse gas emissions to the atmosphere is to inject gases from point source emitters such as fossil-fuel-burning power plants into the subsurface. Options for subsurface disposal include reuse for enhanced oil recovery, disposal in abandoned reservoirs, or injection into coal seams. The most widely available method for carbon dioxide disposal is injection into unused porous and permeable brine-bearing formations. In this study, funded by the U.S. Department of Energy/National Energy Technology Laboratory, we inventoried the geologic characteristics of 21 brine-bearing formations in the continental United States to provide basic data needed to assess the feasibility, costs, and risks of this sequestration method. We investigated a diverse spectrum of target formations and compiled a GIS database by digitizing published and unpublished data from each basin.

This compilation confirms that in many parts of the United States, unused sedimentary rocks can be found at suitable depths for injection. Depth-related criteria are (1) the target lies below and isolated from fresh water supplies and (2) temperature/pressure conditions are such that carbon dioxide will be supercritical. Brine formation depth is well known in most basins with greatest uncertainties in small and structurally complex areas. In many areas, target depth limits the selection of target formations. Gases are stored by displacing brine from porous rocks.
In many areas, targets with high porosities of 20 to 35 percent and thickness in excess of 100 m were identified, indicating that potentially large volumes of carbon dioxide could be stored. Low porosity is typical of carbonate targets; however, thick and areally extensive rock volumes provide adequate storage.

Permeability structure and distribution at small and large scale, critical factors controlling the rates of pressure buildup and, therefore, rate of injection, are not well known for most brine formations. Data from areas that produce hydrocarbons can be used to make inferences about injectivity characteristics of brine formations.

Effectiveness and safety of geologic sequestration depend on the residence time of injected greenhouse gases. Residence time is controlled by (1) geologic properties of potential pathways for vertical escape through top seal strata and (2) geochemical and hydrologic processes within the target strata. Shale, carbonate, or evaporite seal strata that have potential to isolate the injected gas from potable water or return to the atmosphere were identified in all target basins as well as potential pathways for escape such as faults or domes that penetrate the seal. Detailed information for determining risks of leakage will require additional data collection and analysis. Residence times of saline brines are thought to be on a geologic time scale, but documentation of these rates varies between basins. Flow direction is down structural dip in some basins and out of the basin in others. In hydrocarbon-producing basins, natural flow has been perturbed, creating areas of underpressure, and in some basins information to infer residence time and flow direction has not been collected. Brine chemistry and rock mineralogy data can be used to assess the potential for mineral sequestration.

CO₂ Sequestration in Saline Formations

Susan D. Hovorka, principal investigator; Paul R. Knox

This project is a subcontract to Lawrence Berkeley National Laboratory. We will supply information to help model and assess prospects and environmental issues for geologic sequestration of carbon dioxide removed from flue gas or other industrial processes in unused saline formations. Partners in this project funded by the U.S. Department of Energy include Lawrence Berkeley, Lawrence Livermore, and Oak Ridge national laboratories, Chevron, Texaco, Pan Canadian Resources, Shell CO₂ Company, BP-Amoco, Statoil, and the Alberta Research Council Consortium. The study will assess methods for lowering the cost of geologic sequestration in targeted formations such as brine reservoirs, depleted oil reservoirs, and coal, develop screening criteria and siting guidelines and predict and verify that over the long term, sequestration practices are safe and effective and do not introduce new environmental problems.

The focus of the Bureau contribution will be to supply reservoir-specific data for areas in Texas where opportunities for early pilot projects may arise.

Regional Ecological Resource Assessment of the Rio Grande Riparian Corridor: A Multidisciplinary Approach to Understanding Anthropogenic Effects on Riparian Communities in Semiarid Environments

Jay A. Raney, co-principal investigator; William A. White and Thomas A. Tremblay; Melba M. Crawford (co-principal investigator) and Amy Neuenschwander (Center for Space Research, The University of Texas at Austin); Frank Judd (co-principal investigator) and Robert Lonard (The University of Texas–Pan American); Gene Paull (co-principal investigator) (The University of Texas at Brownsville)

Funded by the U.S. Environmental Protection Agency, this multidisciplinary 3-year study of riparian communities along the Lower Rio Grande valley has several objectives, including (1) acquiring and analyzing high-resolution remotely sensed data from multiple sensors, (2) integrating existing and new field data and remotely sensed data into a geographic information system (GIS), (3) ascertaining
whether the native communities are maintaining themselves and identifying the topographic, edaphic, and other ecological factors that perpetuate these communities, (4) interpreting spatial variations in riparian habitats, including comparisons of the northern and southern banks of the Rio Grande, (5) analyzing temporal changes at specific locations, and (6) developing a foundation for future analysis of riparian floodplain communities by linking local and remotely sensed regional data using GIS.

Riparian ecosystems of the southwestern United States are characterized by high species diversity and are among the most productive ecosystems of North America. The rapid decline of riparian ecosystems throughout the United States has made riparian conservation a focal issue for the public, Federal and State governments, and private organizations.

This study focuses on the lower reach of the Rio Grande from Falcon Dam to the mouth of the river. Detailed local-scale ecological transects of dominant riparian vegetation are being correlated with high-resolution videography and multispectral data to delineate the spatial extent of the riparian community. This will provide ground truth for the classification output from high-resolution (4- to 7-m) hyperspectral and synthetic aperture radar (SAR) data. Classification output from high-resolution imagery will in turn provide the class mixtures for medium-resolution (20- to 30-m) Landsat TM and SPOT multispectral data that cover the entire study area, on both sides of the Rio Grande.

Data on geology, soils, water quality and hydrology, and topographic information from Topographic Synthetic Aperture Radar (TOPSAR), as well as laser altimetry data acquired for the study, are being investigated as additional inputs to the classification process and used to help explain temporal and spatial changes in ecological resources indicated in the remotely sensed data. GIS-based spatial models and statistical modeling results are being used to predict the expected future effects of landscape change on plant distribution, biodiversity, and functional organization at multiple scales of resolution. The developed methodologies will help to guide future assessments of riparian regions.

Progress during the first year was primarily in the areas of data acquisition, preparation of GIS layers for modeling and analysis, current land use and soils mapping, vegetation surveys and ground truthing, and remote data classification.

### Capacity Building for Resource Assessment and Responsible Development, Texas-Mexico Border Area

**Jay A. Raney, principal investigator; Thomas A. Tremblay; assisted by Maria Bondarenko, Wan-Joo Choi, and Han-Ching Wu**

A basic problem in the Texas-Mexico border area is that many natural resource and environmental data sets are available only as printed maps and the data stop at the political boundary between Texas and Mexico, even though the natural systems may continue. This makes it difficult to properly assess many binational issues related to environmental protection, resources assessment, or responsible development. This project, which is coordinated by the Bureau, includes research partners at the Texas universities located along the border with Mexico: The University of Texas at Brownsville, The University of Texas–Pan American, Texas A&M International University, and The University of Texas at El Paso.

As an initial effort, the collaborating faculty and students digitized geologic data for regions of Mexico adjacent to each campus. The Bureau created companion geographic information system (GIS) databases for geologic data in Texas. Stratigraphic units and terminology were simplified to allow creation of a seamless geologic database that includes both Texas and Mexico. Because of the large size of the binational database and the need to have a practical limit to file size, geographic boundaries were arbitrarily chosen to divide the data sets. Although the geologic database is common to all the collaborating universities, each team has been adding data sets of more restricted areas that are of special importance or interest to them. Data sets such as wetlands of the Rio Grande Delta, land use, more detailed geologic maps, and various habitat and hydrographic boundaries continue to be added to the GIS database and integrated with existing digital data. As a final contribution, the Bureau will be adding a limited amount of detailed laser altimetry data. Each of the collaborating universities has also used the project to train students in GIS techniques as well as in more specialized analysis of the data sets. Research staff, faculty, and students have also participated in field trips and workshops to present results and share solutions to various technical issues unique to this project.
Support of the State Energy Conservation Office in Environmental Oversight of the U.S. Department of Energy Pantex Plant

Alan R. Dutton, principal investigator; Bridget R. Scanlon, Robert C. Reedy

Since 1995 the Bureau has participated with other State agencies in supporting the State Energy Conservation Office in environmental oversight of the U.S. Department of Energy’s (DOE) Pantex Plant near Amarillo, Texas. During 2000 the Bureau’s main activities included further hydrological monitoring at Pantex, ongoing assistance in the State review of Pantex documents, and discussing the hydrology of the Ogallala aquifer in the vicinity of the Pantex Plant as part of a public workshop.

The monitoring program is designed to evaluate temporal variability in rates of infiltration and evapotranspiration in the top 1 to 2 m of the subsurface. We will be using these data to determine the potential for upward water movement below this zone in several interplaya settings for use in an environmental review and the design of an engineered cover for the landfill at the Pantex site.

Analysis of Soil Remediation Requirements of Abandoned Centralized and Commercial Drilling-Fluid Disposal Sites

Alan R. Dutton, principal investigator; H. Seay Nance, Rebecca C. Smyth; assisted by Liying Xu

Drilling fluids used in oil and gas exploration and production (E&P) operations may be mixed with drilling additives, cuttings, formation water, and crude oil. Since the mid-1980’s there has been both a decrease in drilling activity and more efficient use of drilling fluid, resulting in a decreased need for offsite disposal of spent drilling fluid. At the same time, environmental regulations were becoming more stringent. Some operators of disposal facilities revamped their operations to come into compliance with new regulations, and other operators chose to close their sites. The legacy of abandoned sites includes uncertainty as to the quantity and character of possible contaminants in spent drilling mud.

Data on the number, acreage, and volume of waste pits, and levels of constituents in the drilling waste and adjacent soil and groundwater are being compiled and evaluated for abandoned, offsite drilling-fluid disposal facilities in Louisiana, New Mexico, Oklahoma, and Texas. The study is sponsored by the U.S. Department of Energy, Federal Energy Technology Center. The American Petroleum Institute has contributed a matching grant, and the Ground-Water Protection Council is providing in-kind services. A preliminary count suggests there may be at least 80 abandoned drilling-fluid disposal sites in these four states. Because data on abandoned sites can be sparse, we are also looking at active or recently permitted sites as well as sites that have been closed under State regulation to better understand potential composition of waste in the remaining abandoned sites. Results should provide a basis for improving the cost effectiveness of assessment and remediation of abandoned sites in these and other states. Cleanup of abandoned sites generally is the jurisdiction of State-funded programs administered by regulatory agencies.

Evaluation of Design, Monitoring, and Modeling of Engineered Covers for Waste Containment

Bridget R. Scanlon, principal investigator; Robert C. Reedy

Engineered covers are required to minimize infiltration into existing and future waste disposal facilities and to reduce infiltration into contaminated sites. This technology is required by municipal and solid waste landfills, hazardous waste landfills, and at a variety of disposal and contaminated sites including U.S. Department of Energy and Department of Defense sites. As many agencies begin to realize that many of their sites cannot be remediated, containment and stabilization are a viable alternative to remediation.

The purpose of our research is to evaluate the performance of different cover designs through field monitoring and numerical modeling. Engineered covers were installed in the Chihuahuan Desert of Texas as part of a proposed low-level radioactive waste disposal facility. The site is no longer being considered for waste disposal and is now used as a field laboratory for this study. The cover designs being evaluated include two end-member designs: a restrictive barrier that consists of a geosynthetic clay liner on asphalt at 1.3 m depth and a conductive barrier that consists of a capillary barrier at 2 m depth. These covers have been vegetated and may also be considered evapotranspiration (ET) covers. Instru-
mentation systems were designed to monitor the water balance components of the barriers, including precipitation, runoff, drainage, and changes in water storage. Potential energy is also being monitored to determine the direction of water movement.

Construction of the covers was completed and monitoring began in late September 1997. Vegetation was established with irrigation during August–September 1998. The performance of cover designs is measured relative to the applied stresses. Precipitation has been below the 30-year annual mean during the monitored period with the result that neither cover has been sufficiently stressed to test its performance limits. Most of the precipitation and applied irrigation water either directly evaporated or was transpired by vegetation with only a relatively small amount of runoff and infiltration. Results to date indicate that both designs have similar water balances and are generally performing equally.

Another aspect of this study is the comparison of different monitoring instruments. We have evaluated electromagnetic (EM) induction as a non-invasive method for monitoring water content. Results have shown that EM is capable of determining water contents accurately at our site when calibrated with measurements using the neutron probe. Heat dissipation sensors have proved to be more reliable and accurate than the more traditionally used thermocouple psychrometers. For measuring water content, time-domain reflectometry has not been very useful at our site compared with the neutron probe because of signal attenuation due to highly conductive soils. Our monitoring systems are capable of capturing spatial and temporal variability and recognizing preferential flow.

Numerical simulations are being conducted with a variety of codes including HYDRUS-1D, SWIM, UNSATH, and VS2DT. Various issues with respect to modeling the performance of engineered covers are being examined, including grid and time step discretization, and processes such as liquid flow, liquid and nonisothermal vapor flow, hysteresis. We will also simulate data sets developed at other sites to evaluate plant transpiration aspects and performance of covers in more humid settings. The results of these modeling studies will provide valuable information on which codes are most appropriate for different climate, soil, and vegetation settings. Verification and validation of numerical models is a critical issue because reliance is placed on numerical simulations to predict long-term performance of covers.

Future work will include the installation of an irrigation system to stress the barriers to failure. Chemical tracer compounds will be applied to monitor and characterize the nature of water flow within the barriers. We will also install transparent pipes in the root zone to monitor root development, depth, and density using a down-hole camera system. The results of this study will be used to validate several numerical simulation codes.

**Plume Research Group: Integrated Regional, Site-Specific, and Theoretical Studies of Groundwater Contaminant Plumes**

_Bridget R. Scanlon, principal investigator_

The current focus of studies conducted under the Plume Research Group is evaluation of methyl tertiary butyl ether (MTBE) contamination related to leaking petroleum storage tanks (LPST). MTBE, leaked from petroleum storage tanks, such as those at gasoline stations, is an environmental concern in Texas and in other states. MTBE is a synthetic solvent that has been added to gasoline since 1979, when it was approved as a blending component by the U.S. Environmental Protection Agency (EPA). A study of MTBE contamination related to LPST sites was originally conducted by Dr. Robert E. Mace in 1998. The database developed for this study has been updated to include more recent information on MTBE and also to include data on benzene, toluene, ethylbenzene, xylene, total petroleum hydrocarbons, and groundwater levels. These data are being evaluated to determine how MTBE groundwater plumes behave over time and to compare MTBE behavior relative to benzene behavior. Processes controlling temporal variability in MTBE concentrations are also being examined, and relationships between MTBE concentrations and groundwater levels are being assessed.

**Spatial and Temporal Variability of Benzene Plumes in Texas**

_Bridget R. Scanlon, principal investigator; assisted by Susan Palachek_

The Bureau evaluated the spatial and temporal variation of benzene plumes in industrial and haz-
ardous waste and superfund facilities using existing databases at the Texas Natural Resource Conservation Commission. The objective of this study was to quantify the spatial dimensions of plumes in different settings and to evaluate temporal variations in plume dimensions to assess the stability of the plumes over time.

There are approximately 1,300 industrial and hazardous waste facilities and approximately 90 State and Federal superfund sites. This provided a vast database to analyze benzene plumes. Some sites were investigating natural attenuation and were included in our study. We optimized our search for sites and initially targeted refinery sites such as terminals and pipelines.

The main product for this study was a database of sites that included spatial and temporal distribution of benzene.

Edwards Aquifer Protection Program
Geologic Assessment
Susan D. Hovorka, principal investigator;
Edward W. Collins

The Texas Natural Resource Conservation Commission (TNRCC) regulates activities that have the potential to compromise water quality in the karstic Edwards aquifer of Central and South Texas through its Edwards Aquifer Protection Program. As part of this program, TNRCC requires contractors preparing to do construction in the Edwards aquifer recharge and transition zones to conduct a geologic assessment to identify and evaluate features such as caves, fractures, and sinkholes that have potential to focus flow of surface water into the aquifer. This project, funded by TNRCC, will document how contractors are currently doing assessments and develop descriptive, quantitative, and literature data sets to help TNRCC improve the effectiveness without compromising the efficiency of the assessments.

Impact of Reservoir Production Characteristics on Subsidence
Fred P. Wang, principal investigator

The U.S. Geological Survey contracted with the Bureau to review existing reservoir data and construct a database that includes pressure decline data, cumulative formation fluid production and injection, production and injection rate information, and other pertinent reservoir information such as pay-zone depth, thickness, average porosity, and secondary recovery history. The data will then be analyzed to determine if there are linkages between the production history of the reservoir and surface deformation. This project was started in late 2000 with a completion date of September 30, 2001.

Evaluation and Validation of EO-1 and Landsat 7 Imagery through an Analysis of Land Cover/Land Use and Rates of Deforestation in Belize, Central America
William A. White, co-principal investigator;
Jay A. Raney, co-principal investigator, and
Thomas A. Tremblay; Melba M. Crawford,
co-principal investigator, and Solar Smith (Center for Space Research, The University of Texas at Austin)

This project, funded through the National Aeronautics and Space Administration’s Earth Observing-1 (EO-1) program, is a 2-year investigation that is designed to evaluate and validate a new satellite imaging system to be launched during 2000. The Bureau of Economic Geology and Center for Space Research will evaluate the newly acquired data in Belize, Central America, where we have previously conducted remote sensing studies in cooperation with the Government of Belize. Managing natural resources in poorly accessible, environmentally sensitive areas impacted by both natural hazards and anthropogenic effects requires the use of remote sensing data for mapping the diverse land cover such as that occurring in Central America. The investigation includes comparing multispectral, panchromatic, and hyperspectral data from EO-1 sensors to Landsat 7 ETM+ data in two areas of Belize where we have recently completed studies of land cover/land use and deforestation using Landsat TM data. At least 14 land cover/land use classes, comprising 6 classes of forests and savannah, 5 classes of wetlands and coastal lands, and 3 classes of developed land, will be classified in central and southern Belize. We will also evaluate the new sensors relative to the existing Landsat TM data in terms of accurate classification of specific types of agricultural land, such as citrus orchards, and certain forest classes, including broadleaf forest regrowth areas, pine forests, and mangroves. In addition, status and trends in land use and deforestation since 1994 will be determined through spatial and temporal analyses of classified imagery.

Spectral data will be classified using both existing statistical methods and new contextual and
multisensor algorithms currently being developed at The University of Texas at Austin for multispectral and hyperspectral data. Classification results will be entered into a geographic information system (GIS) for analysis of land cover and land use distribution and change. Classified areas will be checked for accuracy and consistency using existing maps and previously collected land cover/land use data at Global Positioning System (GPS)-located field survey sites and overflights, supported by additional field verification sites with GPS coordinates. Expected results include a detailed evaluation and validation of the capabilities of EO-1 and Landsat 7 ETM+ data for (1) classifying a diverse set of land cover/land use types and (2) analyzing trends such as rates of deforestation and regrowth.

The proposed work will be conducted in cooperation with the Land Information Centre and Forest Department, Belize Ministry of Natural Resources and the Environment. The methodology and findings will be presented in a workshop for Belize government officials. The Government of Belize has a long-term commitment to the use of optical remote sensing technologies for mapping land cover and land use.

COASTAL PROCESSES

Classifying and Mapping Shoreline Types along the Lower Texas Coast: Laguna Madre and Baffin Bay Areas

William A. White, principal investigator; Thomas A. Tremblay and James C. Gibeaut

Completed in 2000, this project was funded by the Texas General Land Office as part of the Oil Spill Response and Contingency Planning effort by the natural resource trustee agencies in Texas. The purpose of this regional, comprehensive study was to characterize and map different shoreline types that occur along the Gulf of Mexico, in the interior bays, and along the Gulf Intracoastal Waterway. Shorelines along the upper and central coast have been previously classified and mapped by the Bureau. This project focused on the lower coast along Padre Island, Laguna Madre, and Baffin Bay, and it completed the shoreline mapping work for the Texas coast. Results of the study will be used by State and Federal agencies responsible for managing coastal resources.

Shorelines were classified and ranked according to their sensitivity to oil-spill damage. For example, hard, manufactured structures such as seawalls exposed to high-energy waves generally have low sensitivities to oil-spill cleanup activities, whereas wetlands (mangroves and marshes) have high sensitivities because of their importance as habitats for a variety of flora and fauna, and because cleanup activities may be more damaging than the oil itself. The classification scheme also incorporates shore morphologies, slopes, composition, and wave exposure. Shorelines were classified on the basis of physical and biological attributes that were determined from a variety of sources, including low-altitude color video surveys taken in 1999 (by Louisiana State University Center for Coastal, Energy and Environmental Resources), oblique color slides, digital orthophoto quadrangles, U.S. Geological Survey topographic maps, digital files from the U.S. Fish and Wildlife Service National Wetlands Inventory program, and existing Landsat TM imagery. Shorelines, delineated on 1:24,000-scale maps, were spot checked in the field for accuracy, and corrections were made where needed. The mapped shorelines were digitized, and the data formatted in a geographic information system (GIS [ARC/INFO]). Final products of the study include digital files of shoreline classifications, a report that describes shoreline types and presents examples from the study area, and a GIS layer that incorporates photographs of representative shoreline types in the South Texas study area. In the GIS layer, a total of 94 photographs taken from low altitudes and on the ground were scanned and hot-linked to points located relative to the mapped shoreline of the South Texas coast. The final report was completed and submitted to the Texas General Land Office in July 2000.
The Texas Shoreline Change Project

James C. Gibeaut, principal investigator; William A. White, Tiffany L. Hepner, Thomas A. Tremblay, Roberto Gutierrez, John R. Andrews, Rebecca C. Smyth, Jerome A. Bellian; assisted by Douglas S. Sassen, Rachel Waldinger, and Liying Xu

In June 1999, Governor George W. Bush signed into law the Coastal Erosion Planning and Response Act (CEPRA). This act provides $15 million over the 1999-2001 biennium for coastal erosion projects. It authorizes the Texas General Land Office (GLO) to implement a comprehensive coastal erosion response program that can include designing, funding, building, and maintaining erosion projects. The Bureau, with funding from the Texas Coastal Management Program and CEPRA, is working with the GLO in a series of projects to identify and quantify eroding areas along the Gulf of Mexico and coastal bay shorelines. The Texas Shoreline Change Project (TSCP) is addressing the requirements of the CEPRA regarding (1) the identification of “critical coastal erosion areas,” (2) the monitoring of historical shoreline erosion rates, (3) making data accessible on the Internet, and (4) increasing public awareness of coastal erosion issues.

The overall goal of the TSCP is to establish a state-of-the-art regional shoreline-monitoring and shoreline-change analysis program that will help solve coastal erosion and storm hazard problems along the bay and Gulf shorelines of Texas. The TSCP will do the following:

- Provide Texas with a comprehensive, up-to-date, digital database of historical shoreline positions and average annual rates of shoreline change and make the data available to the public through the Internet.
- Provide a regional framework for conducting local studies related to specific erosion control projects.
- Provide data for assessing the susceptibility of the coast to episodic erosion and flooding by storms.
- Make available observations on the causes of shoreline change and make them understandable to the general public through the Internet and paper reports.

The TSCP is being implemented in a series of study areas defined by bay system and Gulf shoreline segments as follows: Brazos River to Pass Cavallo; Port Aransas to North Padre Island (to the north boundary of the Padre Island National Seashore); and Mansfield Channel to Rio Grande. The following bay systems are being studied: Matagorda, Copano/Aransas, Baffin, and Corpus Christi. Work on the Laguna Madre, San Antonio, Sabine Lake, and Galveston Bay Systems will proceed as funds become available.

During 2000, the Bureau conducted detailed topographic surveys of the Gulf of Mexico beaches and dunes using airborne Light Detection and Ranging (LIDAR). LIDAR surveys can rapidly provide the detailed, accurate, and continuous topographic models needed for assessing beach erosion. LIDAR instruments combine a scanning laser, a device that records aircraft motion, and high-accuracy Global Positioning System receivers to obtain a vertical accuracy of 8 to 15 cm and data-point spacing of less than 1 m. We developed a method for extracting the shoreline position from the LIDAR data and are currently analyzing the topographic data to map storm hazard areas. Comparisons of shorelines mapped from historical vertical aerial photography and LIDAR will provide average annual shoreline change rates for the Gulf of Mexico shoreline. For the bay systems, shoreline positions are updated using 1990’s digital orthophotos. A Web site showing shoreline change data using new ARC/INFO Internet Map Server software was developed (http://www.beg.utexas.edu/coastal/intro.htm).

Investigation of Shoreline Change in the Vicinity of Rollover Pass

James C. Gibeaut, principal investigator; William A. White, Roberto Gutiérrez, and Thomas A. Tremblay

The Bureau is providing technical support to the Office of the Attorney General for the State of Texas and the Texas Parks and Wildlife Department in determining the amount and cause of shoreline retreat in the vicinity of Rollover Pass on Bolivar Peninsula. Rollover Pass is a small, artificial tidal inlet connecting the Gulf of Mexico and East Galveston Bay. It was cut in 1954 to enhance fishing in the area, and it is currently stabilized with bulkheads and short jetties. There is concern, however, that the pass has increased beach erosion along the Gulf of Mexico shoreline. This project is investigating shoreline changes before and after the pass was cut to help
determine the effect of the pass on the adjacent beaches. The Bureau is using several types of surveys to measure the shoreline changes, including (1) historical vertical aerial photography, (2) beach profiles (topographic ground surveys), (3) Global Positioning System shoreline surveys, and (4) airborne laser altimeter surveys. All data are being combined so that shoreline movement and beach volume changes can be compared for various time periods.

**Patterns of Shoreline Change and Hurricane Washover on Barrier Islands**

*James C. Gibeaut, principal investigator; Roberto Gutierrez; Tiffany L. Hepner, Rebecca C. Smyth, John R. Andrews, and Melba M. Crawford (Center for Space Research, The University of Texas at Austin)*

Despite the erosional nature of barrier islands and spits, they have become highly developed and continue to develop along much of the U.S. coast. This activity has altered erosional and depositional patterns of shorelines. Development has placed property and lives at risk from coastal storms, sea-level rise, and long-term erosion and has affected coastal habitats. To understand the dynamics of coasts, we need to measure the exchange of sediment between dune, beach, and nearshore environments. What has been lacking, however, is a way to collect detailed and accurate topographic and bathymetric data rapidly along tens of kilometers of shoreline. Recent advances in airborne laser ranging and the application of the Global Positioning System (GPS) can overcome this survey problem.

This 3-year project, funded by the National Aeronautics and Space Administration beginning in 1998, is developing and applying the latest survey technologies to study 150 km of the southeast Texas coast. This shoreline has both natural and developed areas, and its characteristics are typical of barrier coasts, making techniques developed during this project applicable to sandy barrier coasts around the world. We will coordinate four topographic surveying methods: (1) airborne LIDAR surveys having horizontal and vertical accuracy of 10 to 15 cm will provide continuous coverage of the dune and upper beach, (2) kinematic GPS surveys using a vehicle will provide coverage of the upper and lower beach with an accuracy of 1 to 3 cm, (3) conventional total station surveys will extend selected transects from landward of the foredune into the surf zone, and (4) nearshore GPS/echo sounder surveys will extend selected transects to approximately 7 m of water depth at an accuracy of 5 cm. Overlap areas of the different survey data will be compared to evaluate accuracy. We will merge these various data into an optimal digital elevation model.

Researchers conducted LIDAR missions along the southeast Texas shoreline in November 1997, August and September 1998, and May 2000. For the May 2000 surveys, we installed the Bureau’s Optech Inc. ALTM-1225 LIDAR instrument in a Cessna 206 single-engine aircraft operated by the Texas State Aircraft Pooling Board. The Optech ALTM-1225 system combines a pulsed, solid-state laser, an inertial motion unit (IMU), and a geodetic GPS receiver in a compact and modular configuration. The IMU (accelerometers and gyroscopes) monitors the aircraft attitude, and the GPS receiver provides aircraft position data. Rotating optics in the instrument’s sensor head scan the laser across the ground, illuminating a swath under the aircraft. The laser pulses up to 25,000 times per second.

Results show that we can efficiently and accurately acquire beach and dune surveys along hundreds of kilometers of coast using LIDAR. Vertical precision is 8 to 15 cm (root mean square error). Absolute accuracy is also 8 to 15 cm after subtracting a bias error determined by comparing LIDAR data with GPS road surveys. Data-point spacing for these surveys is 1 m, and the mapping swath width is about 600 m, which covers the beach, foredune, secondary dunes, and structures. During the third year of the project, we will compare LIDAR surveys acquired at different times.

Accurately mapping shoreline position and calculating rates of shoreline change have been a problem addressed by coastal geologists for decades. Usually, shoreline position is mapped using vertical aerial photographs. The shoreline is interpreted and drawn on the photograph and then transferred to a base map for comparison with earlier shorelines. Typically, the boundary between wet and dry sand on the beach, which is displayed as a tonal contrast on the photographs, is used as the shoreline. This boundary, however, is affected by recent water level and wave activity and may not be a reliable indicator of shoreline position. There is also error introduced to the shoreline position when it is transferred to the base map. Because LIDAR surveys are GPS based, data do not have to be transferred to a base...
map. Furthermore, we can use a contour line as the shoreline, eliminating the ambiguity present in the wet sand–dry sand boundary. Our results show that a single swath of LIDAR data is adequate to define a contour line as the shoreline. The GPS-based Airborne Laser Terrain Mapping (ALTM) data, however, are produced as heights above the ellipsoid and what should be mapped as the shoreline is an elevation that is related to local sea level. We are continuing research to adjust the LIDAR data to be relative to local sea level and, therefore, to significant beach morphology features such as scarps or berm crests.

Recent Changes in Gulf Shoreline Position, Mustang and North Padre Islands, Texas
James C. Gibeaut, principal investigator;
Thomas A. Tremblay, Roberto Gutierrez,
Rebecca C. Smyth, and Tiffany L. Hepner

This project, which is funded by the Texas Coastal Management Program, is determining the historical rate of shoreline change along the Gulf coast on Mustang and North Padre Islands. The project is providing up-to-date information regarding beach conditions for managing natural resources, planning and protecting shorefront development, and minimizing property damage. Because the physical setting varies along this part of the coast, management strategies need to be prepared for accreting, stable, and eroding beach segments.

The primary objectives of this project are to map the Gulf shoreline position in Nueces and Kleberg Counties using LIDAR to evaluate shoreline movement since 1974, and to calculate the long-term rate of shoreline change using a combination of shorelines since the 1930’s. Previously mapped shoreline positions will be digitized and compiled in a geographic information system so that change calculations and the projection of future shoreline positions can be automated. In 2000, we mapped the shoreline and digitized the earlier shorelines.

Status and Trends of Wetlands on Barrier Islands, Central Texas Coast
William A. White, principal investigator;
Thomas A. Tremblay

Funded by the National Oceanic and Atmospheric Administration through the Coastal Management Program administered by the General Land Office of Texas (GLO), this is a joint project between the Bureau and GLO to determine the status and trends of wetlands on barrier islands along the central Texas coast. Coastal wetlands on barrier islands are essential natural resources that are highly productive biologically and chemically and are part of an ecosystem in which a variety of flora and fauna depend. Scientific investigations to determine status and trends of wetlands will greatly assist in their protection and preservation, directly benefiting long-term productivity and public use.

During this approximately one-and-a-half-year study, the Bureau will use historical and recent aerial photographs supported by field surveys to determine spatial and temporal changes in marshes, mangroves, tidal flats, and water bodies on barrier islands and peninsulas along the Texas coast from Matagorda Bay to Mesquite Bay. Previous studies by the Bureau of Galveston Bay indicate substantial losses in wetlands due to subsidence and associated relative sea-level rise. Some of the losses on Galveston Bay barriers have occurred along surface faults that have become active as a result of underground fluid production. In contrast to the Galveston Bay system, studies of wetlands on barrier islands in the Corpus Christi Bay area by the Bureau and Texas Parks and Wildlife Department show that marshes have expanded as a result of relative sea-level rise. Located between these two bay systems is Matagorda Bay where extensive wetlands on barrier islands and peninsulas have not been recently studied to determine trends. This study will focus on the barriers and peninsulas, including the Colorado River Delta and the associated diversion channel, and will analyze wetland status, trends, and probable causes for trends. Results of the study will improve the understanding of marsh changes on Texas barriers, will pinpoint wetlands threatened by erosion, subsidence, and other processes, and will provide site-specific information for implementing marsh restoration and protection projects. The protection, restoration, enhancement, and creation of coastal wetlands are high priorities of the Coastal Coordination Council.

Coastal Hazards Atlas of Texas: A Tool for Hurricane Preparedness and Coastal Management
James C. Gibeaut, principal investigator;
Thomas A. Tremblay and William A. White

The Texas Coastal Management Program is funding this 4-year joint project of The University of Texas
at Austin, the Texas Department of Public Safety, and Texas A&M University to develop a Coastal Hazards Atlas. The information provided by the Atlas is needed by local governments, State agencies, the general public, and others concerned about responsible development, environmental protection, and emergency preparedness. The Atlas was inspired by an atlas published by the Bureau in 1974 titled *Natural Hazards of the Texas Coastal Zone*. We are completely revising and updating this atlas to include current transportation routes (needed for evacuation planning), hurricane flooding areas, the best available data on shoreline erosion, and new information on subsidence and faulting. The text will be rewritten to emphasize critical information needed by local and State government officials and others interested in coastal zone management. All map data and text will be available on a CD-ROM to allow users to make custom maps with a personal computer and geographic information system (GIS) browsing software.

In 1999, we finished compiling the data for the Galveston Bay and Sabine Lake areas and produced a report and a CD-ROM with GIS files. We also produced 1:24,000-scale maps that depict the average annual rate of shoreline change along the Gulf of Mexico and that show the 1956 and projected 2056 shorelines overlain on 1995 color-infrared photographs. Subdivisions and individual homes visible on these maps dramatically place shoreline change in context for the user. During 2000, we began work on the middle coast from the Brazos River to Corpus Christi Bay.

**NEAR-SURFACE GEOPHYSICS**

Rapid Geophysical Identification and Assessment of Groundwater for the Lower Rio Grande Valley

*Jeffrey G. Paine, principal investigator*

The Rio Grande Water Planning Region, consisting of eight south Texas counties, is subject to severe water shortages during droughts and urgently needs new, shallow groundwater resources to assure adequate water supplies for municipal, agricultural, and industrial uses. These additional resources will provide both immediate and long-term relief to a region that needs assured access to reliable water supplies. In a cooperative project funded by the Texas Water Development Board (TWDB) and the U.S. Bureau of Reclamation, Bureau and TWDB staff applied advanced airborne and ground-based geophysical methods to rapidly and cost-effectively assist south Texas communities in delineating promising water-bearing subsurface units, estimating depth to water, and assessing water quality of potential resources.

Recent work by the Bureau on behalf of the TWDB and the Texas Railroad Commission has demonstrated the effectiveness of airborne and ground-based applications of the electromagnetic induction (EM) method in water-resource investigations. This method, long in use in minerals exploration, has been adapted successfully to identify salinized soil and water in West and North-Central Texas and the Panhandle. The EM method detects changes in the electrical conductivity of the ground that are caused by variations in rock type, water saturation, and water chemistry.

Water prospecting in the Rio Grande region using EM exploits several known relationships. In this part of the Gulf Coastal Plain, near-surface sediments consist of interbedded sand, silt, and clay units deposited in the ancestral Rio Grande delta and associated coastal depositional systems. The most abundant water resources are found in the sand-rich units. These sand bodies and the adjacent clay-rich units are likely to have differing electrical conductivities, enabling water-bearing strata to be detected laterally and vertically with EM equipment. Once the locations and shapes of these sand bodies are delineated with airborne or ground-based instruments, their measured electrical conductivities can be used to estimate water quality. Water high in total dissolved solids has high electrical conductivity; fresh water has low electrical conductivity.

We analyzed electrical conductivity data from two 260-km² airborne geophysical surveys near Raymondville and Edinburg and interpreted hydrological and geological environments within the upper 200 m in these areas. These data show that (a) airborne EM can be used in coastal plain environments to image Cenozoic deposits, (b) water quality can be interpreted from conductivity measurements made using airborne EM instruments, and (c) in this area of fresh to moderately saline groundwater, the conductivity changes associated with water quality are larger than those associated with changes in sediment type. In areas where the water is fresher,
the conductivity changes caused by variations in sediment type will be more significant.

Principal products of this project, which was completed in July 2000, include a summary report and accompanying CD-ROM. The CD-ROM contains a project web and a GIS database that includes conductivity maps at selected depths, surface geology, water well locations, and maps showing favorable drilling locations. The summary report describes the methods used, presents the results of the geophysical surveys, interprets water-resource quality and availability in the study areas, and evaluates the usefulness of the EM method and its potential application elsewhere.

Assessing Lacy Creek Salinization Using Airborne Geophysics

Jeffrey G. Paine, principal investigator

In a project funded by the Upper Colorado River Authority and the Texas Water Development Board, Bureau researchers are using innovative airborne geophysical methods to study potential salinization of Lacy Creek, a tributary of the North Concho River in Sterling County, Texas. Researchers will be evaluating shallow electromagnetic induction (EM) data acquired using Fugro Airborne Surveys’ TEMPEST system, which has been used in Australia to map salinization of cropland. The high-resolution airborne survey will cover an area of 100 km² with a flight-line spacing of 100 m and will provide information on the electrical conductivity of the ground to a depth of about 50 m. These data will be used to delineate the lateral extent and intensity of salinization in the area, indicate whether Lacy Creek is being impacted by salinization, and identify possible sources of salinization. The project is scheduled to be completed by the end of 2001.

Mapping Near-Surface Salinization Using Long-Wavelength AIRSAR

Jeffrey G. Paine, principal investigator

Recent Bureau tests of high-resolution, airborne electromagnetic induction (EM) mapping of near-surface salinization revealed that the method is technically successful but impractically expensive when applied over large areas. Less expensive methods are needed to identify priority areas within major watersheds where soil and water salinization has occurred. This 3-year, National Aeronautics and Space Administration–funded project will examine whether NASA’s airborne synthetic aperture radar (AIRSAR) can be used to rapidly screen watersheds for salinization hotspots, which will allow high-resolution airborne and ground-based EM surveys to be focused on those areas where problems are likely to exist.

We are assessing the utility of the radar method by acquiring long-wavelength AIRSAR reflectivity images at two Texas test sites (one in the Red River watershed near Lake Texoma and another in the Colorado River watershed near San Angelo) where extensive airborne and ground-based EM surveys have already been conducted. These reflectivity images, which are affected by both the roughness of the surface imaged and the electrical properties of the near-surface materials, may reveal an electrical conductivity signature related to the large increase in ground electrical conductivity that accompanies salinization. The first AIRSAR flights over the test areas were completed in 1999 and are currently being analyzed.

Estimating Depth to Bedrock

Jeffrey G. Paine, principal investigator

This project, funded by the Texas Department of Transportation (TxDOT), is an effort to estimate depth to bedrock across the State of Texas using available soil and geologic data combined with noninvasive geophysical tests. Depth-to-bedrock estimates, which are necessary for assessing pavement condition, are currently made from pavement measurements without benefit of information available on near-surface soils and rocks. Considerable effort has been expended over the last few decades by earth scientists to produce maps, cross sections, and soil profiles that focus on the upper few meters of the
subsurface, a critical zone for road design and performance. These data provide a semiquantitative basis for determining regional and local differences in expected bedrock rigidity and depths to bedrock across Texas.

Bureau researchers designed, built, and tested a prototype seismic refraction instrument (the Seismic Refraction Bedrock Analyzer) to rapidly acquire more accurate information on bedrock depth and physical properties beneath pavement. TxDOT employees will be trained to use this instrument routinely to monitor pavement and substrate condition. Other potential geological uses of the instrument include bedrock mapping in areas of poor exposure, detecting sinkholes, and establishing physical properties of rock types for engineering design and construction.

**Feasibility of Geophysically Mapping the Ogallala Perched Aquifer at the Pantex Plant**

*Jeffrey G. Paine, principal investigator*

The U.S. Department of Energy, in its “Protecting the Ogallala Aquifer II” report, suggested that geophysical methods might provide information on the areal extent, thickness, and lithologic variability of a fine-grained zone that perches groundwater beneath the Pantex Plant near Amarillo, Texas. This stratigraphic unit is thought to retard downward migration of groundwater and may prevent contaminants from reaching the main Ogallala aquifer. The Bureau, funded by a grant from the Innovative Treatment Remediation Demonstration program at Sandia National Laboratories, evaluated time-domain electromagnetic induction (TDEM) and seismic reflection for potential application at Pantex. Bureau researchers briefly examined existing seismic reflection data collected in the early 1990’s, conducted TDEM modeling studies, and acquired reconnaissance TDEM data to examine the feasibility of these methods in delineating the lateral distribution and thickness variations of the middle Ogallala fine-grained zone.

**GEOLOGICAL AND TERRAIN MAPPING**

**STATEMAP Project: Geologic Mapping to Support Improved Database Development and Understanding of Critical Aquifers of Texas**

*Jay A. Raney, principal investigator; Edward W. Collins*

The objective of this program is to produce geologic maps that augment the Texas and national geologic map database. The project, part of the U.S. Geological Survey’s (USGS) STATEMAP program, is funded jointly by the USGS and the Bureau. Work during 2000 has been in two Central Texas study areas, the corridor east of Austin and the Edwards aquifer area northeast of Uvalde, Texas. Geologic maps of these areas may be used to address issues related to urban growth, land use and earth resources, water quality, groundwater management, construction practices, engineering properties of near-surface materials, and public education regarding utilization of earth resources and good environmental practices.

The corridor east of Austin is undergoing rapid urban growth and is within part of the Wilcox-Carrizo aquifer, a major aquifer of Texas. Geologic units of the area include the northeast-trending outcrop belts of 3 Upper Cretaceous marine limestone, marl, and calcareous mud units, and 11 Paleocene and Eocene sand- and mud-rich units representing fluvial, deltaic, and marine deposition. Lignite intervals exist within the Wilcox Group, and mining and related land reclamation have occurred for a number of years. Remnant, topographically high gravel and sand deposits (upper Tertiary to Quaternary) and Quaternary terrace deposits of the southeast-flowing Colorado River also occur. Mining of gravel from terrace deposits has met some of the demand from past development of the area, and the potential for future
gravel production still exists. The east half of the area contains the northeast-striking Milano Fault Zone, which is composed of normal faults that form multiple grabens along the zone. The Colorado River, which reached historical flood levels during October 1998, flows across the map area. Two State parks are also within the study area. Maps (1:24,000-scale) completed during 2000 include the Bastrop, Bastrop SW, Coupland, Elgin East, Elgin West, Lake Bastrop, Utley, and Structure quadrangles. Mapping also began on the Beakiss, McDade, Smithville NW, Smithville, Lexington, Fedor, Paige, and Winchester quadrangles.

The Edwards aquifer area northeast of Uvalde, Texas, is an important part of the San Antonio segment of the Edwards limestone aquifer and its recharge and contributing zone. This study area is adjacent to areas mapped for previous STATEMAP subprojects. The general stratigraphy of the area is dominated by Cretaceous shallow-marine shelf deposits onlapped by chalk and calcareous, clastic-slope sediments that thicken and change facies across the region. Upper Cretaceous basic intrusive igneous rocks also exist within the area as well as upper Cretaceous limestone, marl, and shale. Upper Tertiary and Quaternary gravel and sand deposits locally overlie the older strata. The north part of the study area consists of Lower Cretaceous limestone, dolomitic limestone, dolomite, argillaceous limestone, and marl of the Glen Rose Formations and subdivisions of the Edwards Group. Glen Rose strata make up the upper part of the Trinity aquifer. Normal faults of the Balcones Fault Zone cross the central part of the study area. These faults are the main structural control on the geology of the region and on the Edwards aquifer and recharge zone. Most of the normal faults in the study area strike between N40°E and N85°E and are downthrown toward the southeast. The larger faults in the map area have throws between 300 and 500 ft. Edwards aquifer strata of this area are 550 to 650 ft thick. The composite structural relief of these strata across the Northeast Uvalde study area is about 2,000 ft. Most of the south part of the study area is overlain by upper Tertiary and Quaternary gravel and sand deposits. Maps (1:24,000-scale) completed during 2000 include the Blanco Lake, Trio, Utopia, and Vanderpool quadrangles. Mapping also began on the Circle Bluff, Rio Frio, Concan, and Knippa quadrangles.

High-Resolution Elevation Data Capture and Analysis for Honduras

James C. Gibeaut, principal investigator; Roberto Gutierrez, Rebecca C. Smyth, John R. Andrews, Jerome A. Bellian, and Andrew G. Warne

The purpose of this project, funded by the U.S. Geological Survey (USGS), is to conduct airborne Light Detection and Ranging (LIDAR) surveys of 15 selected sites in Honduras for use in flood hazard assessments. This project is part of an effort by the United States to help Honduras recover from the devastation caused by Hurricane Mitch in 1998. Final results include providing accurate, high-resolution digital elevation models of the sites; developing methodologies for acquiring LIDAR elevation data in steep, vegetated terrain; and, very importantly, assisting the USGS and Honduran investigators in the applications of LIDAR and Global Positioning System (GPS) technology for hydrological, ecological, and slope stability investigations.

A state-of-the-art Optech Airborne Laser Terrain Mapping (ALTM) system, together with a Beechcraft U-21 mapping aircraft, is used to gather and integrate three basic measurement sources: (1) laser ranges and associated scan-angle information; (2) aircraft altitude information from an Inertial Measurement System (IMS); and (3) absolute aircraft trajectory derived from a differential, geodetic GPS network. The digital elevation models derived from the millions of laser data points collected during a survey have a horizontal resolution of 1.5 m and vertical accuracy of 15 cm.

High-Resolution LIDAR Digital Elevation Models for Applications Development

Melba M. Crawford (Center for Space Research, The University of Texas at Austin), James C. Gibeaut, principal investigators; Roberto Gutierrez, Rebecca C. Smyth, John R. Andrews, Tiffany L. Hepner, Amy Neuenschwander (Center for Space Research, The University of Texas at Austin); assisted by Rachel Waldinger and Christopher Weed (Center for Space Research, The University of Texas at Austin)

Light Detection and Ranging (LIDAR) is a new technology for acquiring accurate and detailed topography of the Earth’s surface, vegetation cover, buildings, and infrastructure. LIDAR instruments
LIDAR point data are being processed into 1 m × 1 m digital elevation models (DEM). Algorithms for this processing are being developed and tested as well as algorithms for classifying each laser data point as reflecting from either the ground, vegetation, or buildings. The Austin data set is of an urban area with the Colorado River and many creeks. This DEM will be tested with urban flood models. The ability to remove vegetation from DEM’s but keep buildings that substantially affect water flow is being addressed using the Austin data. Port Ingleside is in a low-lying coastal area with new and proposed housing developments. The topography of the Texas coastal zone is very subtle with natural relief of only a few meters on the barrier islands and across the broad plains and wetlands bordering the coastal bays. The coast is also subject to tropical cyclones that can cause storm surges of as much as 4 m and heavy rainfall. Episodic rainfall and storm surges combined with low relief can cause broad areas to be flooded. Because of the low relief, changes in water level of just 0.5 m can drastically change the amount of flooded land. For these reasons, more accurate and detailed topography than what is currently available is needed to improve flood-zone maps. The LIDAR DEM will be used with storm-surge models to see how predicted flood zones shift with the more accurate topographic data.

### Geomorphic Studies of Archeological Sites

**Jeffrey G. Paine, principal investigator**

The Bureau is performing geomorphic studies for the Texas Department of Transportation as needed for archeological investigations. Activities include field investigations and drilling programs for selected locales, analysis of soils data, and short reports of geological observations and conclusions.

The geomorphic studies are conducted to determine the geomorphic character of the locales, the influences on past human activities, and the effects of natural processes on cultural deposits.
EDUCATION

Web-Based Educational Modules Describing Reservoir Characterization Technology
Bob A. Hardage, principal investigator; Scott D. Rodgers, William A. Ambrose, John R. Andrews, Robert E. Barba (consultant), Shirley P. Dutton, Tucker F. Hentz, Mark H. Holtz, Kerza A. Previtt, and Lisa E. Remington

The Bureau is working with the American Geological Institute (AGI) to develop Web-based educational modules that cover all aspects of reservoir characterization. The modules are structured around real data sets that illustrate the principles of reservoir characterization for fluvial depositional environments.

The philosophy of this educational program is to create interactive, game-theory-based modules on the Internet that will allow students to interact with geological, geophysical, and engineering data; make data interpretations; and then receive instruction, depending on the correctness of their answers.

The program will be offered by AGI. The Bureau’s role is to provide the data required for the instruction, create the text and graphics needed to explain the concepts of reservoir characterization, and format the material into a series of interactive modules that can be accessed by Web users.

Earth Science Week
Sigrid J. Clift, Scott W. Tinker, and Carol Knepp (Wild Basin Wilderness Preserve)

Earth Science Week was established by the American Geological Institute in 1998 as part of its mission to increase public awareness and understanding of the earth sciences. It is an annual event, celebrated in the United States and around the world, during the first full week of October. Earth Science Week (ESW) gives geoscientists, teachers, youth leaders, and parents opportunities to help students explore and discover connections between their lives and the Earth.

To celebrate ESW 2000, the Bureau, together with members of the Austin area Earth Science Week Consortium, held the first annual ESW Career Fair Day at the Bureau’s headquarters on The University of Texas at Austin J. J. Pickle Research Campus. More than 300 Austin middle school students spent the day with geologists, geophysicists, paleontologists, hydrologists, meteorologists, geochemists, museum curators, space scientists, engineers, and educators, who gave 20-minute oral presentations and/or hands-on demonstrations of their work. The students took a virtual-reality 3-D tour of the Edwards aquifer, learned the basics of the Global Positioning System, watched the sampling of water from a monitoring well, and were thrilled to see onsite faceting and polishing of gemstones.

More than 40 Bureau staff members participated in ESW Career Fair Day, making it a real Bureau team effort. For more information about Earth Science Week, visit the Texas Earth Science Week Web site at http://www.txearthsciweek.org.

Petroleum Technology Transfer Council
Scott W. Tinker, RLO Director, and Sigrid J. Clift, RLO Assistant Director; Sylvia J. Jennette, Amanda R. Masterson, and Timothy A. Lite II

The Bureau is the Texas Regional Lead Organization (RLO) for the Petroleum Technology Transfer Council (PTTC), a national nonprofit organization
formed in 1994 to identify and transfer upstream technology needs to the domestic independent oil and gas producer. This program is primarily funded by the U.S. Department of Energy’s (DOE) Office of Fossil Energy through the National Petroleum Technology Office and National Energy Technology Laboratory.

Technical information transferred by the PTTC to producers comes from all sectors of the research and development community as well as intermediary providers of technology such as government, universities, DOE, the Gas Technology Institute (formerly Gas Research Institute), professional and trade societies, national laboratories, private companies, and the service industry. Although not directly involved in any research or development, the PTTC works to provide the domestic operators with the connections, education, and tools for the identification of technological problems and solutions.

The Texas PTTC Resource Center began operation in 1995. The Resource Center includes the Bureau’s Reading Room, Map Room, Geophysical Log Facility, and the Core Research Centers located in Austin and Midland. In its capacity as Texas RLO, and in cooperation with the Texas Independent Producers and Royalty Owners Association (TIPRO), the Bureau manages and maintains the Texas PTTC Web site at www.energyconnect.com/pttc, which includes useful information for the independent operators of Texas. Texas operators can gather information such as upcoming events and print a copy of the quarterly newsletter titled ProducerNews.

For the year 2000, the Texas PTTC sponsored or co-sponsored 15 workshops across the state. Topics from low-cost vapor recovery to filing drilling permits with the Railroad Commission of Texas via its Web site were offered; these workshops provide small operators with proven technologies to assist them as they strive to produce more oil and gas.

In the past year, Texas PTTC was given additional funds by PTTC National Headquarters to implement a mentor program for the Permian Basin region. The mentor program is responsible for developing a network of reliable contacts in the region and assisting the Permian Basin operators with their technology transfer needs. The program also provides timely information regarding activities in the region and technical news items for the Texas PTTC newsletter and maintains the Permian Basin page on the Texas PTTC Web site. The mentor program in Texas has been responsible for developing very successful workshops that are applicable to producers not only in the Permian Basin but also in other areas around the United States where the same technology can be applied.

National Geoscience Data Repository System (NGDRS)
Douglas C. Ratcliff, principal investigator

The Bureau provides assistance to the American Geological Institute (AGI) for work related to the National Geoscience Data Repository System (NGDRS). NGDRS is an effort by AGI to properly store and archive geologic materials ranging from rocks to digital data. The Bureau’s Core Research Center and Geophysical Log Facility have been primary focus points for the NGDRS, and data from these entities have been used to establish an on-line information system known as GeoTrek. During 2000, the Geophysical Log Facility added 25,000 geophysical logs to the database with assistance from AGI. In addition, AGI assisted the Bureau in handling 85,000 boxes core donated by Altura Energy, Ltd. This material will be stored in a newly constructed addition to the Midland Core Research Center.

Using GIS Technology to Explore Earth Systems and a Virtual Tour of the Edwards Aquifer
Susan D. Hovorka, principal investigator; John R. Andrews and Scott D. Rodgers; assisted by Catherine Stahn

This geographic information system (GIS) project demonstrates one mechanism for bringing geologic research into the classroom to involve students in current geoscience issues. The Bureau participated in a partnership led by ActiveInk Corporation, a startup at the Austin Technology Incubator, to supply participating public school districts with Web-based interactive projects. This project was funded by a Technology Integrated into Education grant managed by Fabins Independent School District.

Scientists contributed two elements to the Web-based curriculum. One element used newly digitized GIS data of geologic maps from the Border Advanced Technology Program and STATEMAP projects to provide students with geologic maps of their local area. We clipped and generalized the maps to make them Web-ready and provided content and background so that students could understand the geology. We also extracted a wide variety of contextual
information including satellite images, contours and shaded relief maps, soil characteristics, land use/land cover, vegetation, and cultural features to encourage the students to explore for relationships among data sets. ActiveInk then provided the maps to the schools as part of the curriculum.

The second element that we provided to the project is a VRML model of the Edwards aquifer. This 3-D model can be manipulated by students on the computer screen to explore the relationships between human activities at the surface and the resource in the aquifer. Data are derived from a previously completed Bureau study of the structure, porosity, and permeability of the aquifer so that students are looking at accurate and current data. For this project we added labels, patterns, contextual information, and graphics to help the students understand what they are seeing. Like the map data, ActiveInk integrated the model with various activities and experiences for the students.

Water and the Environment in Southwest Texas
Blaine Bennett (Southwest Texas Junior College), principal investigator; Susan D. Hovorka, Violetta Lien (Department of Education, The University of Texas at Austin), and John R. Andrews

This project was funded through the Dwight D. Eisenhower Professional Development program of the Texas Higher Education Coordinating Board to train 16 teachers from 8 different rural school districts about their local water resources. Project goals were to (1) provide the teachers with content about limited groundwater resources in their region and the background and experience to use this very important local issue to meet classroom objectives, (2) increase teacher comfort with inquiry approaches by providing them with inquiry-based labs and modeling inquiry approaches to learning, and (3) employ distance learning technology to facilitate participation by teachers from small and widely separated schools. Participating schools are spread over a predominately rural and sparsely populated area of 10,000 mi$^2$ between San Antonio and the U.S.–Mexican border.

A summer and a fall course were taught using instruction via videoconference to the participants' school buildings in combination with travel for labs and field trips. Videoconferencing to make the course possible was done through SWTNet, managed by Southwest Texas Junior College. Few of the school districts could have separately put together enough teachers to make a class. Field trips featured the truly spectacular array of geologic and groundwater features that can be studied in Southwest Texas, including Hill Country spring-fed rivers, dinosaur tracks, volcanoes, caves, and disappearing rivers. The class participated in monitoring water levels in the Edwards aquifer. Hands-on labs were very well attended, and the teachers struggled with messy and sometimes surprising results that come from a real scientific investigation. In additional to the project staff, local experts in water, soils, fossils, and natural resources presented material to teachers.

Virtual Oil Well—An AGI-Funded K–12 Outreach
Scott D. Rodgers, principal investigator; Susan D. Hovorka, Bob A. Hardage, and Hongliu Zeng

We are midway through the design and development stage of a Virtual Oil Well, an American Geological Institute (AGI)–funded K–12 Web-based outreach project. The goal of this project is to use game-based activities to teach the essential problems and processes of oil and gas exploration and development. The “game” will allow players to explore possibilities, “contract” for assistance, make critical decisions, and observe the results. Web-site mechanics are based around a 3-D data/decision cube that
is programmed in Java. Work to date has been focused on the development of game scenarios, data development, and site hierarchies. Continuing work includes graphical user interface design and initial Web-site production. The Web site is planned to be up and running at the beginning of 2001.

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

*James C. Gibeaut, principal investigator; Tiffany L. Hepner and Roberto Gutierrez; assisted by Yuan Qiu*

The Texas Coastal Monitoring Program engages coastal residents in the study of their natural environment. High school students, teachers, and scientists work together to gain a better understanding of dune and beach dynamics on the Texas coast. Scientists from The University of Texas at Austin provide the tools and training needed for scientific investigation. Students and teachers learn how to measure the topography, map the vegetation line and shoreline, and observe weather and wave conditions. By participating in an actual research project, the students gain an enhanced science education. Furthermore, public awareness of coastal processes and the Texas Coastal Management Program is heightened. The students’ efforts also provide coastal communities with valuable data on their changing shoreline.

The Texas Coastal Management Program, Conoco, and the Exxon Foundation fund the program, which is in its fourth year. During 1999–2000, Ball High School completed its third year in the program, and in 1999 Port Isabel and Port Aransas High Schools were added to the program. We envision developing a network of coastal high schools conducting scientific studies of the beaches and exchanging their observations with other schools and the public through the Internet. More information is available at the program’s Web site, http://inet1.beg.utexas.edu/thscmp/.

*EarthView Texas*

*Jay A. Raney, principal investigator; Scott D. Rodgers and John R. Andrews*

EarthView Texas utilizes the Bureau’s large-screen, virtual reality capabilities and other resources for outreach to teachers, K–12 students, and the general public. Virtual reality displays nicely complement “hands-on” activities and more traditional printed materials that are also part of EarthView Texas. This program was supported in large part by generous donations from the Shell and Hillcrest Foundations and the Eisenhower Grants Program. The 3-D world created in this virtual reality environment allows us to present scientifically accurate data and complex spatial relationships in an exciting and engaging way. The conceptual appreciation for what an aquifer is and how it functions, for example, is much more understandable once a student has “flown” through the Edwards aquifer in EarthView Texas. The subtle relationships among topography, active geologic processes, and habitats become more intuitively obvious after viewing a Texas barrier island in virtual reality. We now have more than 15 data sets that we are able to display. Because our system is mobile, we can take EarthView Texas to remote locations.

Outreach efforts include working with teachers at more than 15 schools in South-Central and Southwest Texas and giving presentations to several hundred teachers at teachers’ conventions and about 600 students at our facilities in Austin. In conjunction with Southwest Texas Junior College, we have promoted improved earth science education in remote and culturally diverse areas of Texas and have presented a virtual tour of the Edwards aquifer to citizens in rural areas who utilize this critical water resource.

Energy Posters for High School Earth Science Curricula

*Stephen C. Ruppel, principal investigator; assisted by Thomas A. Tremblay*

The goal of this project, funded by the American Geological Institute (AGI), is the development of colorful and informative posters to be used by high school teachers of earth science. The specific focus of the posters is energy production and usage in the United States, including both nonrenewable and renewable energy resources. Two posters are being constructed. Each will contain maps, graphs, and charts illustrating historical and current patterns of energy sources, production, and consumption. The posters will be accompanied by a CD-ROM containing source data in an ARC/INFO format for easy access and usage by earth science educators.
CONTRACT AND GRANT SUPPORT

The Bureau maintains formal and informal cooperative arrangements with several governmental entities. Parts of the Bureau’s research program are conducted under The University of Texas at Austin contracts and grants with Federal, State, and private organizations.

Contract-management personnel prepare proposals and budgets, negotiate contracts, and monitor expenditures. During the contract period, technical and financial reports are distributed at monthly, quarterly, and annual intervals. In 2000, the following 93 contracts, each of which had reporting requirements, were active at the Bureau:

FEDERAL

“Advanced Technology for Predicting the Fluid Flow Attributes of Naturally Fractured Reservoirs from Quantitative Geologic Data and Modeling”: supported by the U.S. Department of Energy (joint project with the Center for Petroleum and Geosystems Engineering).

“Analysis of Soil Remediation Requirements of Abandoned Centralized and Commercial Drilling-Fluid Disposal Sites”: supported by the U.S. Department of Energy.

“Application of Advanced Reservoir Characterization, Simulation and Production Optimization Strategies to Maximize Recovery in Slope and Basin Clastic Reservoirs, West Texas (Delaware Basin)”: supported by the U.S. Department of Energy.

“Assessment and Forecasting, by Play, Natural Gas Reserve Appreciation and Quantifying the Role of Technology Advancement in Reserve Growth Additions in the Gulf Coast Basin”: supported by the U.S. Department of Energy.


“Combining a New 3-D Seismic S-Wave Propagation Analysis for Remote Fracture Detection with a Robust Subsurface Microfracture-Based Verification Technique”: supported by the U.S. Department of Energy.


“Development of a Monitoring Station for Estimating Interplaya Recharge”: supported by the U.S. Department of Energy through the Amarillo Natural Resources Center for Plutonium.

“Evaluation and Validation of EO-1 and Landsat 7 Imagery through an Analysis of Land Cover/Land Use and Rates of Deforestation in Belize, Central America”: supported by the National Aeronautics and Space Administration.

“Evaluation of Design, Monitoring, and Modeling Issues Related to Engineered Covers of Waste Containment”: supported by the U.S. Environmental Protection Agency.


“Impact of Reservoir Production Characteristics on Subsidence”: supported by the U.S. Geological Survey, U.S. Department of the Interior.

“Integrating Outcrop and Subsurface Studies of the Interwell Environment of Carbonate Reservoirs: Clear Fork (Leonardian Age) Reservoirs, West Texas and New Mexico”: supported by the U.S. Department of Energy.

“Integrating P-Wave and S-Wave Seismic Data to Improve Characterization of Oil Reservoirs”: supported by the U.S. Department of Energy through Prairie View A&M University.

“An Investigation to Document Reservoirs That Can Be Better Detected with Seismic S Waves Than with Seismic P Waves”: supported by the U.S. Department of Energy through Visos Energy Corporation.

“Mapping Near-Surface Salinization Using Long-Wavelength AIRSAR”: supported by National Aeronautics and Space Administration.


“Patterns of Shoreline Change and Hurricane Washover on Barrier Islands”: supported by National Aeronautics and Space Administration.
“Reconnaissance TDEM Survey of the Perched Aquifer at the Pantex Plant”: supported by Sandia National Laboratories.

“Regional Ecological Resource Assessment of the Rio Grande Riparian Corridor: A Multidisciplinary Approach to Understanding Anthropogenic Effects on Riparian Communities in Semi-Arid Environments”: supported by the U.S. Environmental Protection Agency.

“Sequestration in Saline Formations”: supported by the Lawrence Berkeley National Laboratory.


“A Technology Transfer Program, Texas Region of the Petroleum Technology Transfer Council”: supported by Petroleum Technology Transfer Council.


“Update of Oil and Gas Plays”: supported by the U.S. Geological Survey, U.S. Department of the Interior.

**STATE AND LOCAL**

“Archeological Projects—Assistance to the Texas Department of Transportation”: supported by the Texas Department of Transportation.

“Assessing Lacy Creek Salinization Using Airborne Geophysics”: supported by the Upper Colorado River Authority.

“Capacity Building for Resource Assessment and Responsible Development, Trans-Mexico Border”: supported by the Texas Higher Education Coordinating Board.

“Coastal Hazards Atlas of Texas (two volumes): A Tool for Hurricane Preparedness and Coastal Management”: supported by the Texas General Land Office (two contracts).

“Colorado River Seep Site Investigation, Wharton County, Texas”: supported by the Railroad Commission of Texas.

“Current Hydrocarbon Reserves and Future Reserve Growth on University Lands: Quantification and Economic Evaluation”: supported by The University of Texas System.

“Down to Earth at Mustang Island”: supported by the Texas General Land Office.

“Dyersdale Site Saltwater Investigation, Harris County, Texas”: supported by the Railroad Commission of Texas.

“Edwards Aquifer Protection Program Geologic Assessment”: supported by the Texas Natural Resource Conservation Commission.


“Enhanced Recharge in Hale County, Texas”: supported by the Texas Water Development Board.

“A Ground-Water Management Model for the Edwards Aquifer, Barton Springs Segment”: supported by the Lower Colorado River Authority.

“Groundwater Recharge in Texas”: supported by the Texas Water Development Board.

“Investigation of Shoreline Change in the Vicinity of Rollover Pass”: supported by the Texas Parks and Wildlife Department.

“Numerical Ground-Water Model for the Panhandle Water Planning Area”: supported by the Panhandle Regional Planning Commission.

“Numerical Models of Brittle Grabens Forming above Ductile Rock in Canyonlands National Park”: supported by the Texas Higher Education Coordinating Board.

“A Permeability and Storativity Data Base for the Carrizo-Wilcox Aquifers in Texas”: supported by the Texas Water Development Board.

“Rapid Geophysical Identification and Assessment of Ground Water for the Lower Rio Grande Valley”: supported by the Texas Water Development Board.

“Recent Changes in Gulf Shoreline Position, Mustang, and North Padre Islands, Texas”: supported by the Texas General Land Office.

“Refining the Geologic Time Scale: Integrated Biostratigraphy, Chemostratigraphy, and Sequence Stratigraphy”: supported by the Texas Higher Education Coordinating Board.

“Review of Documents and Dissemination of Environmental Geologic Information Related to Environmental Restoration at the U.S. Department of Energy’s Pantex Plant, Carson County, Texas”: supported by the Office of the Governor of the State of Texas.

“Roberts County Groundwater Analysis”: supported by the Panhandle Ground Water Conservation District.

“San Marcos River Site Investigation, Guadalupe County, Texas”: supported by the Railroad Commission of Texas.

“Shoreline Change in West and Christmas Bays”: supported by the Texas General Land Office.

“Shoreline Types of the South Texas Coast”: supported by the Texas General Land Office.

“Sierra Blanca Ranch Project”: supported by the Texas General Land Office.

“Status and Trends of Wetlands on Texas Barrier Islands”: supported by the Texas General Land Office.

“Technology Center for Oil and Gas Recovery Optimization on Texas State Lands”: supported by the State of Texas.

“Texas High School Coastal Monitoring Program: Ball High School, Galveston, Years 3 and 4”: supported by the General Land Office through Galveston Independent School District (two contracts).

“Texas High School Coastal Monitoring Program: Port Aransas High School, Years 1 and 2”: supported by the Texas General Land Office through the Port Aransas Independent School District (two contracts).
“Texas High School Coastal Monitoring Program: Port Isabel High School, Years 1 and 2”: supported by the Texas General Land Office through the Port Isabel Independent School District (two contracts).

“The Texas Shoreline Change Project—Gulf of Mexico Shoreline from the Brazos River to Pass Cavallo”: supported by the Texas General Land Office.

“The Texas Shoreline Change Project—Gulf of Mexico Shoreline from Mansfield Channel to Rio Grande and Shorelines in Matagorda, Copano/Aransas, and Corpus Christi Bays”: supported by the Texas General Land Office.

“The Texas Shoreline Change Project—Gulf of Mexico Shoreline from Port Aransas to Padre Island National Seashore and Baffin Bay”: supported by the Texas General Land Office.

“University Lands Advanced Recovery Initiative”: supported by The University of Texas System.

“Using GIS Technology to Explore Earth Systems/A Virtual Tour of the Edwards Aquifer”: supported by Fabens Independent School District.

“Water and the Environment in Southwest Texas”: supported by Southwest Texas Junior College.

PRIVATE

“API Support of Analysis of Soil Remediation Requirements of Abandoned Centralized and Commercial Drilling-Fluid Disposal Sites”: supported by the American Petroleum Institute.

“Applied Geodynamics Laboratory”: supported by Amerada Hess Corporation; Anadarko Petroleum Corporation; BHP Petroleum (Americas) Inc.; BP Amoco; Chevron U.S.A. Production Company; ENI-SPA Divisione Agip; Enterprise Oil; ExxonMobil; Marathon Oil Company; PanCanadian Petroleum Limited; Petroleo Brasileiro; Phillips Petroleum Company; Shell International E&P, Inc.; Texaco Exploration Production, Inc.; TotalFinaElf Exploration Production USA; Union Oil Company of California; and Vastar Resources, Inc.

“Carbonate Reservoir Characterization Workshop”: supported by Occidental Oil and Gas Corporation.

“Characterization of Heterogeneity Style and Permeability Structure in a Sequence Stratigraphic Framework in Fluvio-Deltaic Reservoirs”: supported by Japan National Oil Corporation.


“Feasibility Study for the Establishment of a National Geoscience Data System”: supported by the American Geological Institute.

“Fracture Research and Application Consortium”: supported by Chevron Petroleum Technology Company; Conoco, Inc.; Enron Global Exploration & Production, Inc.; Fina Oil and Chemical Company; Japan National Oil; Lariat Petroleum, Inc.; Marathon Oil Company; PEMEX Exploración y Producción, Petrobás America Inc.; Petroleos de Venezuela; and YPF Repsol (Maxus).

“Integration of 3-D Seismic Mioceno-Norte Area”: supported by Petroleos de Venezuela, S.A.

“LIDAR Surveys in Support of Raytheon Demonstration #2”: supported by Raytheon.

“Maintenance of Borehole Geophysics Test Site: The University of Texas at Austin”: supported by the Society of Exploration Geophysicists.

“Optimizing Hydrocarbon Recovery from the Matzen Field, Vienna Basin, Austria”: supported by OMV Aktiengesellschaft.

“Permian Basin Core”: supported by Altura Energy Limited.

“Plume Research Group: Integrated Regional, Site-Specific, and Theoretical Studies of Ground-Water Contaminant Plumes”: supported by the ExxonMobil Foundation.

“Reservoir Characterization Research Laboratory: Carbonate Reservoirs”: supported by Altura Energy Limited; Amerada Hess Corporation; BP-Amoco; Chevron Petroleum Technology; Elf Exploration Production; ExxonMobil Production Research Company; Kinder Morgan; Marathon Oil Company; PanCanadian; Petroleum Development Oman LLC; Shell International; TOTAL Exploration Production USA, Inc.; and Texaco Inc.

“Resurvey of Lower Texas Coast and Lower Rio Grande Valley”: supported by Optech Incorporated.

“Seismic Vector-Wavefield Characterization of Complex Reservoirs”: supported by Harken International LTD, Maxus, PEMEX, and Vecta Technology LP.

“Seismic Vector-Wavefield Imaging”: supported by Vecta Technologies, L.P.

“Spatial and Temporal Variability of Benzene Plumes in Texas”: supported by the American Petroleum Institute.

“Study of Evaluation of Tertiary Plays of the Central and Southeastern Mexico Basins”: supported by PEMEX.

“Support of EarthView Texas by the Hillcrest Foundation.”

“Support of EarthView Texas by the Shell Foundation.”

“Support of the Texas High School Coastal Monitoring Program”: supported by the Margaret Cullinan Wray Trust.

“Workshop on Carbonate and Clastic Reservoirs of the Permian Basin”: supported by Occidental Oil and Gas Corporation.
BUREAU RESEARCH AND SUPPORT STAFF ACTIVITIES

AWARDS AND HONORS

Milo M. Backus
Hollis D. Hedberg Award in Energy, given for exceptional contributions to the understanding of the earth and its resources, by the Institute for the Study of Earth and Man (ISEM) at Southern Methodist University.

Shirley P. Dutton
A. I. Levorsen Memorial Award for the Best Paper, with Particular Emphasis on Creative Thinking toward New Ideas in Exploration, presented at the 2000 Southwest Section American Association of Petroleum Geologists meeting in Midland, Texas.

S. P. Dutton, M. D. Barton, H. H. Zirczy, and W. A. Flanders: “Characterization of reservoir heterogeneity in slope and basin clastic reservoirs, Bell Canyon Formation, Delaware Basin, Texas”

William L. Fisher
Carolyn G. and G. Moses Knebel Distinguished Teaching Award, Department of Geological Sciences, The University of Texas at Austin (by student election).

Charles Kerans
Permian Basin Section SEPM (Society for Sedimentary Geology) Honorary Life Membership.

Robert G. Loucks

R. G. Loucks: “Paleocave carbonate reservoirs: origins, burial-depth modifications, spatial complexity, and reservoir implications”

F. Jerry Lucia
American Association of Petroleum Geologists Distinguished Lecturer.

Lesli J. Wood


LECTURES AND PUBLIC ADDRESSES

For presentations that were published as papers or abstracts, see p. 61–66.

William A. Ambrose
“Correlation of fluvial gas reservoirs in Stratton field, South Texas”: presented to American Geological Institute, Austin, Texas.

“Stratigraphic framework and depositional systems analysis of shoreface and fluvial reservoirs at Corpus Christi Northwest and East Corpus Christi fields, Corpus Christi Bay”: presented to Royal Exploration Company, Inc., Corpus Christi, Texas.

“Resumen de la metodología para el análisis y descripción de nucleos, Cuenca Macuspana”: presented to PEMEX Exploration and Production, S.A., Villahermosa, Mexico.

“Resumen de ambientes de aguas profundas en los nucleos de Coatzacoalcos”: presented to PEMEX Exploration and Production, S.A., Coatzacoalcos, Mexico.

“Resumen de ambientes de aguas profundas en los nucleos de Veracruz”: presented to PEMEX Exploration and Production, S.A., Veracruz, Mexico (with David C. Jennette).

Sigrid J. Clift
“Bureau of Economic Geology Web site”: presented at Texas Environmental Awareness Network (TEAN) meeting, Austin, Texas (with John R. Andrews and Amanda R. Masterson).

“Earth Science Week in Austin”: presented at Texas Informal Science Educators Association workshop at the Conference for the Advancement of Science Teaching (CAST), Texas A&M University, College Station, Texas.

Eloise H. Doherty
“Microfracturing in the Mid-Continent: strain history of quartz-rich sandstone and its relation to diagenesis”: presented to Tulsa Geological Society, Tulsa, Oklahoma.

Alan R. Dutton
“Five geological models illustrate power of virtual reality”: presented to Panhandle Producers and Royalty Owners Association, Amarillo, Texas.

“Numerical simulation of groundwater availability in the Carrizo-Wilcox aquifer in Central Texas: 2000 to 2050 projections”: presented to National Ground Water Association, Southwest Focus Conference, Austin, Texas.

“Development of a groundwater model of the Ogallala aquifer: prediction of 2000 to 2050 saturated thickness for RWPG Region A”: presented to The University of Texas at Austin, Department of Geological Sciences Hydrogeology Seminar, Austin, Texas.
Shirley P. Dutton
“Comparison of Clastic Reservoir Group study areas”: presented at Clastic Reservoir Group Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.
“Controls on cement distribution and permeability in the Sego Sandstone”: presented at Clastic Reservoir Group Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.
“Outcrop characterization of reservoir quality and interwell-scale cement distribution in a tide-influenced delta, Frontier Formation, Wyoming, USA”: presented at Texas Tech University, Department of Geosciences Technical Sessions, Lubbock, Texas.
“Calcite-cement distribution and its effect on fluid flow in a deltaic sandstone, Frontier Formation, Wyoming, USA”: presented to The University of Texas at Austin, Department of Geological Sciences Soft-Rock Seminar, Austin, Texas.
“Outcrop analogs of fluvial valley-fill reservoirs”: presented to American Geological Institute, Austin, Texas.

William L. Fisher
“Energy for this century”: presented to Texas Community College Teachers Association, Annual Meeting, Austin, Texas.
“Global energy resources”: presented to Division of Professional Affairs Panel, American Association of Petroleum Geologists, Annual Meeting, New Orleans, Louisiana.
“The end of resource scarcity”: presented at Society of Independent Professional Earth Scientists (SIPES) Board of Directors Annual Meeting, Austin, Texas.

William M. Fitchen
“Understanding the effects of antecedent topography and differential compaction on the development of play trends in the Permian Basin: an example from Means field, West Texas”: presented at American Association of Petroleum Geologists–European Association of Geoscientists and Engineers (AAPG-EAGE) International Research Conference on Carbonate Reservoir Characterization and Modeling for Enhanced Hydrocarbon Discovery and Recovery, El Paso, Texas, and to The University of Texas at Austin, Department of Geological Sciences Sequence Stratigraphy (Geology 380N), Austin, Texas.
“Future RCRL directions in 3-D geologic modeling and visualization of integrated data sets”: presented at the Reservoir Characterization Research Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

Khaled Fouad
“Structure and stratigraphic framework of the middle Frío shoreface sandstone at Corpus Christi Bay, Gulf of Mexico”: presented to Royal Exploration Company, Inc., Corpus Christi, Texas.

William E. Galloway
“Slope and basin depositional systems”: presented to the University of Nebraska, Lincoln, Economic Geology Seminar 2-day lecture series, Lincoln, Nebraska.
“Sequence stratigraphy 2000”: presented to Society of Independent Professional Earth Scientists, Central Texas Chapter, Austin, Texas.

James C. Gibeaut
“High school science education through fieldwork, collaboration using the Internet, and virtual reality models of the coastal zone”: presented to the Austin Geological Society, Austin, Texas.
“Airborne LIDAR survey operations at The University of Texas”: presented to The University of Texas at Austin, Department of Aerospace Engineering, Austin, Texas.
“Mapping shoreline change in Texas”: presented to the Texas General Land Office, Austin, Texas.

Bob A. Hardage
“State Lands and University Lands programs at the Bureau of Economic Geology”: presented at Petroleum Technology Transfer Council, Technology Transfer Workshop, Midland, Texas.
“Multi-component seismic technology”: presented at Petroleum Technology Transfer Council, Technology Transfer Workshop, Midland, Texas.

Tucker F. Hentz
Technology Center, Morgantown, West Virginia.


Mark H. Holtz


“Application of enhanced oil recovery in CO₂ sequestration”: presented to Chinese Petroleum Corporation, Taiwan.

“The methodology for identifying reserve growth potential through integrated reservoir characterization”: presented to Chinese Petroleum Corporation, Taiwan.

“How to construct 3-D geocellular reservoir models”: presented to National Taiwan Normal University, Geoscience Department, Taiwan.

“Approaches to play analysis and resource assessment”: presented to PEMEX Exploration Department, Veracruz, Mexico.

Susan D. Hovorka


“Strategies for identification of optimal saline formations for sequestration of carbon dioxide in the United States”: presented to ENERGX Conference, Las Vegas, Nevada.

Michael R. Hudéc

“Stratigraphic response to translation across a stepped salt detachment”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Restoration of a regional profile from the Angolan Craton to the abyssal plain, Kwanza Basin”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Quick-look chart for salt restoration”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

Martin P. A. Jackson

“Overview of AGL research for 2000”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Early tectonics and segmentation of the inner Kwanza Basin, Angola”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“The great West African Tertiary coastal uplift: fact or fiction?”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Contraction of pre-existing autochthonous salt structures in deep water”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Spatial statistics of permeability data from carbonate outcrops of West Texas and New Mexico and implications for fluid flow and reactive transport modeling”: presented at the Institute for Mathematics and Its Applications, Minneapolis, Minnesota.

“Permeability spatial statistics and modeling within high-resolution sequence stratigraphic frameworks of shallow water platform carbonates”: presented to the West Texas Geological Society, Midland, Texas.

“Integrated outcrop and subsurface studies of the interwell environment of carbonate reservoirs; Clear Fork (Leonardian age) reservoirs, West Texas and New Mexico”: presented to the U.S. Department of Energy, Denver, Colorado.


“Geostatistics in practice: examples from carbonate outcrops and oil reservoirs of West Texas and New Mexico”: presented to the University of Texas at Austin, Department of Petroleum and Geosystems Engineering (PGE 383), Austin, Texas.

“Geostatistics in practice, part 2: examples from carbonate outcrops and oil reservoirs of West Texas and New Mexico”: presented to the University of Texas at Austin, Department of Petroleum and Geosystems Engineering (PGE 383), Austin, Texas.

“Carbonate permeability layering: detection, modeling, and measurement scales”: presented at the annual fall meeting of the Carbonate Reservoir Characterization Research Laboratory Industrial Associates, Austin, Texas.

“An approach for capillary pressure modeling in carbonate systems”: presented at the annual fall meeting of the Carbonate Reservoir Characteriza-
Charles Kerans

“Carbonate sequence stratigraphy and reservoir characterization for Permian and Cretaceous carbonate systems”: presented to Shell International Exploration and Production, Rijswijk, Netherlands.

“Carbonate sequence stratigraphy”: series of five lectures presented to The University of Texas at Austin, Department of Geological Sciences, Sequence Stratigraphy (Geology 380N), Austin, Texas.


“Stratigraphy and reservoir architecture of Shuaiba reservoirs, Middle East”: presented to Saudi Aramco, Dharan, Saudi Arabia.

“Comparison of reservoir architectures of Idd el Shargi North Dome and South Dome”: presented to OXY Qatar, Doha, Qatar.

“Sedimentology and stratigraphy of the Yibal Shuaiba field and relation to Shuaiba fields in the Bab intrashelf basin”: presented to Petroleum Development Oman, Muscat, Oman.

“Mechanical stratigraphy”: presented to Petroleum Development Oman, Muscat, Oman.


“Sequence geometry and stratal architecture as indicators of reservoir heterogeneity styles”: presented at American Association of Petroleum Geologists–European Association of Geoscientists and Engineers (AAPG-EAGE) International Research Conference on Carbonate Reservoir Characterization and Modeling for Enhanced Hydrocarbon Discovery and Recovery, El Paso, Texas.

“Outcrop analogs, a requirement for ‘next-generation’ reservoir models: examples from San Andres, Abo, and Wolfcamp units”: presented at Permian Basin Section–SEPM workshop, The Impact of Integrated Sedimentology and Stratigraphy on Reservoir Characterization and Field Management Strategies, Midland, Texas.

Stephen E. Laubach

“Fracture architecture of siliciclastic reservoirs: examples from Venezuela, Colombia, and Bolivia”: presented to Apex Petroleum, Denver, Colorado.

“Core analysis methods for fracture reservoirs with examples from carbonate reservoirs”: presented to Fina Oil & Chemical, Houston, Texas.

“Results of a study of the Dakota Sandstone”: presented to Conoco, Austin, Texas.

“Fracture petrology and fracture quality assessment”: presented to The University of Texas at Austin, Center for Petroleum Geosystems Engineering (PGE 383-17), Austin, Texas.

“On scaling and diagenetic attributes of reservoir samples”: presented to FRAC Industrial Associates, New Orleans, Louisiana.

“Structural analysis of selected deep Val Verde Basin reservoirs”: presented to Conoco, Midland, Texas.

“Structural analysis of the deep Austin Chalk”: presented to Chevron USA, Houston, Texas.

“Innovations in fracture characterization and modeling of clastic and carbonate reservoirs”: presented to Petroleum Technology Transfer Council, Midland, Texas.

“Summary of fracture attributes in dolomite”: presented to geological staff, PEMEX Exploration and Production, S.A., Ciudad del Carmen, Mexico.

“Mechanical stratigraphy”: presented to The University of Texas at Austin, Center for Petroleum Geosystems Engineering (PGE 383-17), Austin, Texas.
for Petroleum Geosystems Engineering (PGE 383-17), Austin, Texas.

Robert G. Loucks

"Introduction to BEG reservoir characterization activities on State Lands": presented at Permian Basin Section–SEPM (Society for Sedimentary Geology) workshop, The Impact of Integrated Sedimentology and Stratigraphy on Reservoir Characterization and Field Management Strategies, Midland, Texas.

"Ellenburger paleocave reservoirs: origins, burial-depth modifications, spatial complexity, and reservoir implications": presented at Permian Basin Section–SEPM (Society for Sedimentary Geology) workshop, The Impact of Integrated Sedimentology and Stratigraphy on Reservoir Characterization and Field Management Strategies, Midland, Texas, and at The University of Texas at Austin, Department of Geological Sciences Technical Sessions, Austin, Texas.


"Depositional and diagenetic framework for exploration in larger foraminiferal nummulite deposits, Lower Eocene Metaoui Group, offshore Tunisia": presented to The University of Texas at Austin, Department of Geological Sciences Soft-Rock Seminar, Austin, Texas.

F. Jerry Lucia


"Carbonate fabrics, the link between descriptive geology and numerical models": presented Shell International Exploration and Production, Rijswijk, The Netherlands.


"Carbonate diagenesis: the key to predicting the three-dimensional distribution of petrophysical properties in San Andres/Grayburg and other carbonate reservoirs in the Permian Basin": presented at Permian Basin Section SEPM (Society for Sedimentary Geology) luncheon, Midland, Texas.

"Rock fabrics, petrophysical rock typing, and wireline logs in carbonate reservoirs": presented to Petroleum Development Oman, Muscat, Oman.

"Rock fabric approach to carbonate reservoir characterization": series of presentations given to Agip, Milano, Italy.

"Origin and petrophysics of carbonate rock fabrics": presented on American Association of Petroleum Geologists Distinguished Lecture Tour.

"Dolomitization: a porosity-destructive process": presented on American Association of Petroleum Geologists Distinguished Lecture Tour.

Jeffrey G. Paine

"Perched groundwater leakage: geophysics scoping evaluation": presented at Innovative Treatment Remediation Demonstration meeting, Pantex Southeast Groundwater Project, Amarillo, Texas.

"Perched groundwater stratigraphic control": presented at Innovative Treatment Remediation Demonstration meeting sponsored by Sandia National Laboratories, Amarillo, Texas.

"Identifying and assessing ground water in the Lower Rio Grande Valley, Texas, using airborne electromagnetic induction": presented at Rio Grande Water Planning Group (Region M) meeting, Harlingen, Texas; to Executive Administrator, Texas Water Development Board, Austin, Texas; and to Texas Water Development Board and U.S. Bureau of Reclamation, Austin, Texas.

"Imaging Cenozoic coastal-plain deposits and predicting ground-water quality using airborne 3-D EM": presented at Texas A&M University, College Station, Texas.

Jay A. Raney


Stephen C. Ruppel

"Use of borehole imaging logs for high-resolution of facies, cyclicity, and reservoir architecture: Block 9 and Fuhrman-Mascho fields": presented at Petroleum Technology Transfer Council Short Course, Reservoir Characterization Technologies for the Next Millennium: Virtual Reality, Multicomponent Seismic, Fracture Modeling, and Borehole Imaging, Midland, Texas.


"Using integrated technologies for successful targeting of remaining oil resources on University Lands: successes and opportunities": presented at Permian Basin Section–SEPM workshop, The Impact of Integrated Sedimentology and Stratigraphy on Reservoir Characterization and Field Management Strategies, Midland, Texas.

"Conodont-based strontium isotope chemostratigraphy of the Paleozoic: pushing the relative age-dating envelope": presented to Department of Geological Sciences, The University of Tennessee, Knoxville, Tennessee.

Bridget R. Scanlon

"Results of numerical simulations of groundwater flow for the Barton Springs segment of the Edwards aquifer": presented to Lower Colorado River Authority and Regional Water Planning Group K.

"Overview of techniques for quantifying recharge": presented at National Ground Water Association Meeting, Austin, Texas.

“Numerical modeling and monitoring of engineered covers”: presented at U.S. Environmental Protection Agency, Cincinnati, Ohio.

“Numerical simulations of engineered cover performance for waste containment”: presented at The University of Texas at Austin, Department of Geological Sciences, Seminar Series, Austin, Texas.

“Comparison of different numerical codes for simulating unsaturated flow”: presented at University of Nevada, Reno, Department of Hydrology, Reno, Nevada.

“Basic principles of unsaturated zone hydrology”: presented to The University of Texas at Austin, Department of Geological Sciences, field class, Austin, Texas.

Daniel D. Schultz-Ela

“Folding by salt drag around rising diapirs”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Grabens in the field and in models: subsidence history, controls on spacing, and fault-displacement variations”: presented at the Applied Geodynamics Laboratory Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

James L. Simmons, Jr.

“Radial-Transverse (SV-SH) coordinates for 9-C 3-D seismic reflection data analysis”: presented at the Geophysical Society of Houston, Symposium on Multicomponent Seismology, Houston, Texas, and to Geophysical Society of Houston, Special Interest Group on Seismic Data Processing, Houston, Texas.

“Information content in seismic reflection data”: presented to The University of Texas at Austin, Department of Geological Sciences, Austin, Texas.

Rebecca C. Smyth

“Analysis of soil remediation requirements at abandoned oil field waste disposal sites in Louisiana, Oklahoma, New Mexico, and Texas”: presented at Ground Water Protection Council Annual Meeting, Houston, Texas.

Julia F. W. Stowell


“Fracture spatial distribution: research update”: presented at Fracture Research and Application Consortium, Spring Applications Workshop, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.


“Scaling analysis of fractures in the Austin Chalk”: presented to Chevron USA Production Company, Wilcrest, Houston, Texas.

“Fracture spatial organization: empirical analysis and scaling”: presented to Department of Geological Sciences, Hardrock seminar series, The University of Texas at Austin, Austin, Texas.

“Fracture spatial organization: empirical analysis and scaling”: presented to the School of Environmental and Applied Sciences, The University of Derby, Derby, United Kingdom.

Scott W. Tinker

“Historical and future impact of BEG reservoir characterization and implementation programs in West Texas”: presented at Permian Basin Section-SEPM (Society for Sedimentary Geology) workshop, The Impact of Integrated Sedimentology and Stratigraphy on Reservoir Characterization and Field Management Strategies, Midland, Texas.

“Can we believe what we see? Seismic signatures in prograding systems”: presented at Permian Basin Section-SEPM (Society for Sedimentary Geology) workshop, The Impact of Integrated Sedimentology and Stratigraphy on Reservoir Characterization and Field Management Strategies, Midland, Texas.

“The value of upstream technology in the petroleum industry”: invited keynote luncheon address presented at Gulf Coast Association of Geological Societies, 50th Annual Convention, Houston, Texas.

“BEG: present and future?": presented to The University of Texas at Austin, Institute for Geophysics, Austin, Texas.


Bruno C. Vendeville

“Sediment progradation as a tectonic process in salt basins”: presented to Dalhousie University, Geology Department, Halifax, Nova Scotia.

“Salt tectonics 101”: presented to Dalhousie University, Geology Department, Halifax, Nova Scotia.

“2D and 3D modeling of geological settings where salt tectonics is triggered sediment progradation”: presented at the Eastern Mediterranean 2000 Workshop (TotalElfFina and BPAmoco), Paris, France.

William A. White

“Evaluation of EO-1 imagery through an analysis of land cover/land use and deforestation in Belize, Central America, by the Bureau of Economic Geology and the Center for Space Research”: presented at National Aeronautics and Space Administration Science Validation Team meeting, Goddard Space Flight Center, Greenbelt, Maryland.
Lesli J. Wood
“Structure, stratigraphy, and sedimentary processes of the eastern offshore Maturin Basin, Venezuela”: presented to Petróleos de Venezuela, S.A. (PDVSA), Caracas, Venezuela.

“Play and prospect development: state of the art in hydrocarbon exploration”: presented to IHRDC Business Management Program, Boston, Massachusetts.

“Project business drivers for offshore secondary gas recovery research”: presented to the U.S. Department of Energy, Federal Energy Technology Center, Morgantown, West Virginia.

“Resource assessment in mature basins for regional understanding”: presented to ExxonMobil, Austin, Texas.

“Regional stratigraphy and architecture of the Sego Sandstone”: presented at Clastic Reservoirs Group Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Accommodation principles and their control on sequence development”: presented at Clastic Reservoirs Group Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Tidal bar architecture”: presented at Clastic Reservoirs Group Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Subsurface mapping of the Sego and associated units”: presented at Clastic Reservoirs Group Industrial Associates meeting, The University of Texas at Austin, Austin, Texas.

“Seismic attributes analysis”: presented to The University of Texas at Austin, Department of Geological Sciences, Introduction to Petroleum Workstations (Geology 391), Austin, Texas.

Hongliu Zeng

BUREAU OF ECONOMIC GEOLOGY SEMINARS
Patricia A. Alfano
Co-coordinator, summer seminar series

William A. Ambrose
“Interactive multidisciplinary continuing education Web site” (with Bob A. Hardage and Scott D. Rodgers)

“Reservoir development and exploration”

L. Frank Brown, Jr.
“Sequence stratigraphy of siliciclastic exploration and reservoir characterization: some personal observations (and probable bias) about misuse of basic sequence and stratigraphic principles”

Patricia O. Downs
Co-coordinator, summer seminar series

Alan R. Dutton
Introduction to hydrogeology of Texas

“Modeling 2000–2050 availability of groundwater in the Ogallala aquifer, northern Texas Panhandle”

Shirley P. Dutton
“Outcrop characterization of diagenetic heterogeneity in deltaic reservoir analogs”

“The rock family”

James C. Gibeaut
“Coastal geology”

Bob A. Hardage
“Interactive multidisciplinary continuing education Web site” (with William A. Ambrose and Scott D. Rodgers)

Mark H. Holtz
“Recognition of compartmentalization and reserve-growth potential in a structurally and stratigraphically complex reservoir, Barrancas Norte field, Cuyana Basin, Argentina”

Susan D. Hovorka
“Sedimentary processes”

Martin P. A. Jackson
“Deformation in the Earth’s crust”

“Tertiary coastal uplift in West Africa: pivotal event or illusion?”

David C. Jennette
“Architectural analysis of deep-water channels and sheets, Ross and Gull Island Formations, Western Ireland”

James W. Jennings, Jr.
“Carbonate permeability heterogeneity and fluid flow modeling”

Paul R. Knox
“A falling-stage systems tract from delta plain to basin floor: variable clastic depositional styles and stacking architecture in the 9th Badenian reservoir, Matzen field, Vienna Basin, Austria”

Stephen E. Laubach
“New insights: dolomite diagenesis”

“Deformation of the Earth”

Coordinator, seminar series (January–May)

Robert G. Loucks
“Depositional and diagenetic framework for exploration in larger foraminiferal nummulite deposits, Lower Eocene Metlaoui Group, offshore Tunisia”

F. Jerry Lucia
“Carbonate rock fabrics, permeability, and petrophysical magic”

Sally Macrae
Information coordinator, seminar series

Jeffrey G. Paine
“Imaging Cenozoic coastal-plain deposits and predicting ground-water quality using airborne 3-D EM”

Scott D. Rodgers
“Interactive multidisciplinary continuing education Web site” (with William A. Ambrose and Bob A. Hardage)
Jay A. Raney
“Why I used to care about igneous rocks”

Stephen C. Ruppel
“Geologic time”

Bridget R. Scanlon
“Overview of unsaturated flow studies for radioactive waste containment in the Chihuahuan Desert of Texas”

James L. Simmons, Jr.
“Fracture detection using seismic”

Julia F. W. Stowell
“Specifying lengths of horizontal wells”

Scott W. Tinker
Weekly presentations on Bureau affairs and open Q&A

Bruno C. Vendeville
“Sediment progradation as a tectonic process in salt basins”

Timothy F. Wawrzyniec
Coordinator, seminar series (August–December)

Lesli J. Wood
“Understanding sedimentary geology”
“Influence of structure on deep marine reservoir development”

Organizer, First Annual Texas Environmental Awareness Network (TEAN) Internet Expo.
Co-chairperson, Austin Earth Science Week.

Edward W. Collins
Past-President and Executive Board Member, Austin Geological Society, July 1999–July 2000.
Leader, field trip, “Introduction to the geology of Austin, Texas,” Texas Community College Teacher’s Association Annual Convention Field Trip.

Susann Doenges
Member, Technical Advisory Board, Bureau of Economic Geology.
Member, Robert W. Hamilton Book Award Committee, The University of Texas at Austin.

Alan R. Dutton
Member, Ground-Water Protection Committee, Texas Natural Resource Conservation Commission, representing the Bureau of Economic Geology.
Member, Technical Advisory Group, Edwards Aquifer Authority, for developing an Edwards aquifer optimization program.
Associate Editor, Applied Hydrogeology.

Shirley P. Dutton
Associate Editor, Journal of Sedimentary Research, SEPM (Society for Sedimentary Geology).


Member, Admissions and Support Committee, The University of Texas at Austin, Department of Geological Sciences.
Co-editor, Transactions of the 2002 Annual Convention of the Gulf Coast Association of Geological Societies, Austin, Texas.

William L. Fisher
Director, Geology Foundation, The University of Texas at Austin.
Chair, Faculty Review Committee, Department of Geological Sciences, The University of Texas at Austin.
Chair, Exploration Geophysicists Search Committee, Department of Geological Sciences, The University of Texas at Austin.

Foundation Trustee, American Geological Institute.
Trustee, Southwest Research Institute.
Trustee Associate, American Association of Petroleum Geologists Foundation.

Member, Research Committee, Interstate Oil and Gas Compact Commission.
Member, Committee on Future Roles, Challenges, and Opportunities for the U.S. Geological Survey, National Research Council, Board on Earth Sciences and Resources.

Member, Hedberg Award Committee, Institute for the Study of Earth and Man.

Member, Advisory Council, Gas Technology Institute.
Member, Science and Technology Committee, Gas Technology Institute.

Member, University Advisory Board, Center for Legislative Energy and Environmental Research, South/West Energy Council.

Member, Advisory Board, World Energy Update.
Member, Committee on Resources, American Association of Petroleum Geologists.

Member, Steering Committee, National Geoscience Data Repository System.

COMMITTEE SERVICES, OFFICES, AND OTHER PROFESSIONAL RESPONSIBILITIES

Sigrid J. Clift
Chairperson, Texas Environmental Awareness Network (TEAN), representing the Bureau of Economic Geology.
Member, National Petroleum Council.
Member, National Academy of Engineering.
Member, U.S. National Committee for World Petroleum Congress.
Member, Board on Energy and Environmental Systems, National Research Council.
Member, Peer Committee, Petroleum, Mining, and Geological Engineering Section, National Academy of Engineering.
Member, Energy Resource Committee, Interstate Oil and Gas Compact Commission.
Member of the Corporation, American Association of Petroleum Geologists Foundation.
Member, Past President’s Council, American Geological Institute.
Member, Honorary Member Committee, Association of American State Geologists.
Liaison for Petroleum, Mining, and Geological Engineering J (Section 11) to National Research Council in Geological Engineering.
Co-Chair, DPA/EMD/AAPG Session on “A World of Resources through the 21st Century — Vision and Opportunities,” Annual Meeting.
Member, United States Energy Association.

William M. Fitchen
Co-leader, field trip, “Classic Permian geology of West Texas and Southeastern New Mexico, 75 years of Permian Basin oil and gas exploration and development,” West Texas Geological Society (with Charles Kerans, Stephen C. Ruppel, Mark Sonnenfeld, and Scott W. Tinker).

William E. Galloway
Appointed Referee, Research Council of Norway, 2000–2004
Member, Wilson Award Committee, SEPM (Society for Sedimentary Geology).
Member, Research Concepts Committee, SEPM (Society for Sedimentary Geology).
Associate Graduate Advisor, Department of Geological Sciences, The University of Texas at Austin.
Member, Admissions and Support Committee, Department of Geological Sciences, The University of Texas at Austin.
Member, Graduate Studies Committee on Master of Arts Degree Program in Energy and Mineral Resources, The University of Texas at Austin.

James C. Gibeaut
Panelist on Sand Sources for Beach Nourishment in Texas, Texas Shore and Beach Association Annual Meeting, Houston, Texas.
Member, Texas Geographic Information Council, Texas Department of Information Resources and Texas Natural Resources Information System, representing the Bureau of Economic Geology.
Member, Texas Mapping Advisory Committee, representing the Bureau of Economic Geology.

Bob A. Hardage
Book Editor, Planning Land 3-D Seismic Surveys, Society of Exploration Geophysicists.
Member, Publications Committee, Society of Exploration Geophysicists.
Member, Development and Production Committee, Society of Exploration Geophysicists.

Charles Kerans
Member, Distinguished Lecture Committee, American Association of Petroleum Geologists.
Chair, Promotions Advisory Committee, Bureau of Economic Geology.
Member, Development Geology Committee, Society of Petroleum Engineers.
Co-chairman, Best of AAPG/SEG for SPE.

Stephen E. Laubach
Member, Technical Advisory Board, Bureau of Economic Geology.
Associate Editor, AAPG Bulletin.
Member, SPE Technical Editor Board, Society of Petroleum Engineers.
Member, Editorial Board, SPE Reservoir Evaluation and Engineering.
Instructor, Fractured Reservoirs School, American Association of Petroleum Geologists.
Member, Research Committee, American Association of Petroleum Geologists.
Member, Academic Liaison Committee, American Association of Petroleum Geologists.
Chairman, Research Group—Reservoir Deformation, American Association of Petroleum Geologists.
Lecturer and Member, Visiting Geologist Program, American Association of Petroleum Geologists.

**Robert G. Loucks**
Associate Editor, *AAPG Bulletin*
Chairman, Contributions Committee, Gulf Coast Association of Geological Societies 2002 Annual Convention, Austin, Texas
Member, Research Committee, SEPM (Society for Sedimentary Geology).
Member, Research Committee, American Association of Petroleum Geologists.
Liaison between American Association of Petroleum Geologists and SEPM (Society for Sedimentary Geology) research.

**F. Jerry Lucia**
Leader, “Carbonate and clastic reservoirs of the Permian Basin”: field trip for Occidental Petroleum Company.

**Jerry W. Mullican**
Member, Ground Water Protection Council.
President, Ground Water Protection Research Foundation.
Member, Salt Cavern Research Partnership, representing Bureau of Economic Geology.
Member, Environmental Affairs Committee, Interstate Oil and Gas Compact Commission.

**Jeffrey G. Paine**
Review Panelist, National Aeronautics and Space Administration Earth Science Enterprise Program, Solid Earth and Natural Hazards Panel.
Member, Technical Advisory Board, Bureau of Economic Geology.

**Jay A. Raney**
Member, Technical Advisory Board, Bureau of Economic Geology.
Associate Texas representative, Association of American State Geologists.
Chair, Advisory Panel, Texas STATEMAP Program.
Leader, “Geology of McKinney Falls State Park”: field trip for Bureau staff.

**Douglas C. Ratcliff**
General Chairman, Gulf Coast Association of Geological Societies 2002 Annual Convention, Austin, Texas.

**Scott D. Rodgers**
Member, Technical Advisory Board, Bureau of Economic Geology.

**Stephen C. Ruppel**
Member, 2000 Standing Technical Program Committee, American Association of Petroleum Geologists.
Chairman, Publications Committee, Austin Geological Society.
Co-editor, Transactions of the 2002 Annual Convention of the Gulf Coast Association of Geological Societies, Austin, Texas.

**Bridget R. Scanlon**
Member, National Academy of Sciences Panel on Review of Subsurface Contamination at Department of Energy Complex Sites: Research Needs and Opportunities
Member, Promotions Advisory Committee, Bureau of Economic Geology.
Member, Technical Advisory Board, Bureau of Economic Geology.
Associate Editor, *Reviews of Geophysics*, American Geophysical Union.

**James L. Simmons, Jr.**
Member, Technical Advisory Board, Bureau of Economic Geology.
Associate Editor, *Amplitude-versus-Offset (AVO)*, Geophysics.
Admissions and Awards Committee, Department of Geological Sciences, The University of Texas at Austin.

**Rebecca C. Smyth**
Bureau representative to the Legislative Subcommittee of the Texas Ground Water Protection Committee.
Treasurer, Austin Geological Society.

**Scott W. Tinker**
Chairman, Field Seminar Subcommittee, Education Committee, American Association of Petroleum Geologists.
Member, Coastal Processes Committee, Association of American State Geologists.
Member, Continental Margins Committee, Association of American State Geologists.
Member, Energy and Mineral Policy Committee, Association of American State Geologists.
Member, Executive Committee, Association of American State Geologists.
Member, Liaison Committee, Association of American State Geologists.
Member, U.S. Potential Gas Committee, Association of American State Geologists.
Member, Steering Committee, Gulf Coast Association of Geological Societies.
Member, Board of Visitors, Trinity University.
Member, Faculty Review Committee, Department of Geological Sciences, The University of Texas at Austin.
Director of Texas Regional Lead Organization, Petroleum Technology Transfer Council.
Member, PAG Committee, Petroleum Technology Transfer Council–Regional Lead Organization.

Ramón H. Treviño III
Treasurer, Gulf Coast Association of Geological Societies 2002 Annual Convention, Austin, Texas.

Bruno C. Vendeville
Member, Technical Advisory Board, Bureau of Economic Geology.
Member, Editorial Committee, Bulletin de la Société Géologique de France.

Andrew G. Warne
Member, Technical Advisory Board, Bureau of Economic Geology.

William A. White
Member, National Aeronautics and Space Administration Earth Observing-1 (EO-1) Science Validation Team.

Lesli J. Wood
Member, Margins Program Working Group, National Science Foundation.
Member, Girl Scout Committee, American Association of Petroleum Geologists.

Member, Margins Program Working Group, National Science Foundation.
Member, Girl Scout Committee, American Association of Petroleum Geologists.

TESTIMONY

William L. Fisher and Scott W. Tinker
“The future of the Texas oil and gas industry”: presented to Texas Energy Coordination Council on behalf of Texas Senate Natural Resources Committee, Austin, Texas.

James C. Gibeaut
Expert witness for the State of Texas in support of coastal property litigation.

UNIVERSITY TEACHING/CONTINUING EDUCATION

William A. Ambrose
“Siliciclastic depositional systems and component lithofacies in petroleum exploration and production”: short course presented to PEMEX Exploration and Production, S.A., Veracruz, Mexico (with William A. Ambrose and Edgar H. Guevara).

Shirley P. Dutton

William L. Fisher
“Sequence stratigraphy” (Geology 380N): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas.

“Research in basin analysis” (Geology 394): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas.

“Reservoir geology and advanced recovery” (Geology 383R): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas (with Scott W. Tinker).

William E. Galloway
“Introduction to petroleum workstations” (Geology 391): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas.

“Basin and trend analysis in petroleum exploration” (Geology 330K): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas.

“Terrigenous depositional systems” (Geology 383): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas.

“Topics in sedimentary basin analysis” (Geology 383S): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas.

“Depositional systems and sequences in the exploration for sandstone reservoirs and stratigraphic traps”: short course presented as part of American Association of Petroleum Geologists Continuing Education Program.
Edgar H. Guevara
“Siliciclastic depositional systems and component lithofacies in petroleum exploration and production”: short course presented to PEMEX Exploration and Production, S.A., Veracruz, Mexico (with William A. Ambrose and L. Frank Brown, Jr.).

Susan D. Hovorka
“Workshop on salt core”: presented to Solution Mining Research Institute, field trip to Bureau of Economic Geology, Core Research Center, Austin, Texas.

Michael R. Hudec
“Physical Geology” (Geology 1405): Baylor University, Department of Geology, Waco, Texas.

Martin P. A. Jackson
“Advanced Salt Tectonics”: short course presented to TotalFina Elf in Paris, France, and to TotalFina Elf and Sonangol in Luanda, Angola.

James W. Jennings
“Statistical analysis, flow modeling, and scale-up in Permian and Cretaceous carbonate outcrops, implications for subsurface reservoir modeling”: section of carbonate reservoir modeling workshop presented to Shell International Exploration and Production, Rijswijk, Netherlands.

Charles Kerans
“Carbonate sequence stratigraphy and reservoir modeling: 6-day field seminar presented for American Association of Petroleum Geologists (with Scott W. Tinker).

Stephen E. Laubach
Instructor, American Association of Petroleum Geologists, Fractured Reservoirs School, Austin, Texas.

F. Jerry Lucia
“Rock fabric approach to carbonate reservoir characterization”: workshop given to Agip, Milano, Italy.

Jeffrey G. Paine
“Near-surface geophysical methods in hydrogeological investigations”: lecture and field demonstration presented to The University of Texas at Austin, Department of Geological Sciences, Field Methods in Hydrogeology (Geology 376L), Austin, Texas.

Julia F. W. Stowell
“Fracture characterization in carbonate reservoirs”: short course presented to Chevron Petroleum Technology Company, San Ramon, California.

“Production response prediction and fracture analysis of carbonate reservoirs”: short course presented to Chevron International, San Francisco, California.

Scott W. Tinker
“Reservoir geology and advanced recovery” (Geology 383R): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas (with William L. Fisher). Guest lecturer for “Sequence stratigraphy” (Geology 380N): The University of Texas at Austin, Department of Geological Sciences, Austin, Texas.

“Carbonate sequence stratigraphy and reservoir modeling: 6-day field seminar presented for American Association of Petroleum Geologists (with Charles Kerans).

Bruno C. Vendeville
“Salt tectonics”: workshop presented to PanCanadian, Calgary, Alberta.

Lesli J. Wood
“Sequence stratigraphy and reservoir architecture of tide-influenced shoreline systems”: field course presented to Chevron, Grand Junction, Colorado.

K-12 AND PUBLIC OUTREACH

George Bush
“Drilling for rock samples”: demonstrations presented at Earth Science Week, Career Day Fair, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas (with Jordan Forman and Andy Graham).

Sigrid J. Clift
Volunteer, UT Interactive “Science Fun Day,” The University of Texas at Austin, Austin, Texas.

Organizer, Bureau tour, Bridge Point fifth grade classes, Westlake Hills, Texas, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

Organizer, Conference for the Advancement of Science Teaching (CAST) booth, College Station, Texas.

Co-chair, Earth Science Week, Career Day Fair, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

Susan D. Hovorka
“Bureau of Economic Geology K–12 outreach”: presented to Austin Geological Society, Austin, Texas.


“Environmental assessment of your town—water, soils, rocks, and pollution”: presented at short course for teachers at the Conference for Advancement of Science Teaching (CAST), Texas A&M University, College Station, Texas.

“Rocks from space: meteorites in the classroom”: presented at workshop for teachers at the Conference for Advancement of Science Teaching (CAST), Texas A&M University, College Station, Texas, and to National Science Teachers Association National Convention, Orlando, Florida.

“Tour of the Edwards aquifer”: presented to Honor Society, Southwest Texas Junior College, Uvalde, Texas.

“Using geoscience to solve environmental problems—Bureau of Economic Geology K–12 outreach programs”: presented as part of The University of Texas at Austin, Department of Geological Sciences, Public Outreach Program (with Sigrid J. Clift).
“Mentor training on maps, ActiveInk project”: presented to middle and high school teachers.

“Rocks from Space”: presented to North Oaks Elementary School, Austin, Texas.

“Flood”: presented at UT Interactive “Science Fun Day,” The University of Texas at Austin, Austin, Texas; in partnership with Mrs. Hernandez’ sixth-grade class, Ortega Elementary School, Austin, Texas.

“Aquifer in a tank”: hands-on experiment presented to Bridge Point fifth grade classes, Westlake Hills, Texas, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

“Virtual reality tour of earth science research in Texas”: presented to middle and high school students, teachers, school board, and citizens, Leakey, Texas (with John R. Andrews and Dallas B. Dunlap).

“Clay models of geologic maps”: presented at eeZone Online Expo 2000, Austin, Texas.


“Computer view inside 3-D Earth”: demonstrations presented at Earth Science Week, Career Day Fair, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas (with John R. Andrews, Dallas B. Dunlap, Tiffany Hepner, Scott D. Rodgers, and Ramón H. Treviño III).

Michael R. Hudec
“The age of the earth”: presented to Great Hills Christian School senior class, Austin, Texas.

Amanda R. Masterson
Tour Leader, Bureau tour, Bridge Point fifth Grade Classes, Westlake Hills, Texas, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

Volunteer, UT Interactive “Science Fun Day,” The University of Texas at Austin, Austin, Texas.

Jay A. Raney
Volunteer, “Flood,” UT Interactive Science Fun Day, The University of Texas at Austin, Austin, Texas.

Douglas Sassen
“Ground-water monitoring”: demonstrations presented at Earth Science Week, Career Day Fair, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas (organized by Rebecca C. Smyth).

Bridget R. Scanlon
“EarthView Texas: Using GIS to see local geology and hydrology”: presented at Rio Hondo and Los Fresnos ISD.

“3-D visualization of geology and use of GIS to examine geology”: presented to Math and Science TEK Teams, workshop for educators, Austin, Texas.

Rebecca C. Smyth
“Volcanoes and plate tectonics”: presented to second-grade classes, North Oaks Elementary School, Austin, Texas.

“Uses of the BEG drilling rig and ground-water monitoring techniques”: demonstrations presented during Bureau tour, Bridge Point fifth grade classes, Westlake Hills, Texas, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

Scott W. Tinker
Opening address: Earth Science Week, Career Day Fair, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.
PUBLICATIONS

In its role as a public geological research unit, the Bureau of Economic Geology disseminates the results of its research programs primarily through its publications. Bureau publications cover major aspects of the geology and natural resources of Texas as well as the results of research for international projects and U.S. projects conducted outside of Texas. In addition to publishing traditional printed reports and maps, the Bureau continues to serve the geological community through use of the Internet. Information about the Bureau’s research programs and publications may be viewed at our home page: http://www.beg.utexas.edu/.

The following publications were issued in 2000:

REPORTS OF INVESTIGATIONS

RI 258. Spatial Statistics of Permeability Data from Carbonate Outcrops of West Texas and New Mexico: Implications for Improved Reservoir Modeling,

by James W. Jennings, Jr.
RI0258, $10.00

This report presents a statistical analysis of outcrop-permeability data resulting in a quantification of spatial patterns of petrophysical heterogeneity in carbonates that are difficult or impossible to observe in the subsurface. The report includes a detailed discussion of factors affecting the accuracy of the permeability measurements and the portability of resulting spatial statistics to subsurface studies. The permeability data from these carbonate outcrops vary by two to five orders of magnitude, much of the variation occurring within distances of a few feet or less in single rock-fabric units. The short-range variability has weak spatial correlation that can be modeled by using semivariograms having asymptotic power-law behavior at small lags. A variety of longer range features, which can have a significant effect on fluid displacement, are also discussed. Funding for this research was provided by sponsors of the Reservoir Characterization Research Laboratory.

RI 259. Pavement Deflection and Seismic Refraction for Determining Bedrock Type, Depth, and Physical Properties beneath Roads,

by Jeffrey G. Paine and Michael R. Murphy.
53 p., 45 figs., 3 tables, 1 app., 2000.
RI0259, $11.00

The relationship between three data types — geologic maps, measurements of pavement deflection under load, and seismic refraction data — from diverse geologic settings in Texas was examined in this report to determine (1) whether geologic maps and seismic refraction data might be used to interpret deflections and assess pavement condition and (2) whether deflections and refraction data acquired on pavement might have geologic applications. Engineers assess pavement condition by applying a known load to a road and measuring vertical pavement deflection using the Falling-Weight Deflectometer (FWD). The authors compared deflections with mapped geologic units in four physiographic regions of Texas and discovered differences in FWD response that are related to differences in either bedrock depths or physical properties of geologic units. Seismic refraction data can be acquired on pavement to augment pavement deflection measurements in distinguishing bedrock type and depth. Pavement deflection and seismic refraction data can be combined to improve geologic maps and our knowledge of the distribution and physical properties of near-surface materials. Better geologic maps and improved knowledge of the physical properties
of mapped geologic units can aid in road design and construction, pavement-condition assessment, building construction, land use, geohazard detection, and many other potential uses. Funding for this research was provided by the Texas Department of Transportation.

RI 260. Petrophysical Characterization and Distribution of Remaining Mobile Oil: South Cowden Grayburg Reservoir, Ector County, Texas,
by F. Jerry Lucia. 54 p., 53 figs., 6 tables, 2000. RI0260, $12.00

Finding new oil in old fields is a complex challenge in today’s petroleum economy. Improved methods of visualizing reservoirs during the last couple of decades have made it possible to locate remaining oil with high levels of certainty. Permeability is one of the key controls on recovery efficiency, which in turn determines whether oil can be recovered economically. This report focuses on the South Cowden reservoir, a large Permian Basin oil field in Ector County, West Texas, that produces from a dolomitized carbonate-ramp succession in the Grayburg (Permian) Formation. The field can be divided into a western area, characterized by interparticle porosity and by diagenetic products that conform moderately well to depositional textures, and an eastern area, characterized by interparticle and touching-vug porosity and by poor conformance of diagenetic products to depositional textures. The author identifies considerable volumes of remaining mobile oil in zones that contain producible oil saturation but show no indication of floodwater. This research was funded partly by the U.S. Department of Energy and partly by sponsors of the Reservoir Characterization Research Laboratory.

RI 261. Relationship between Arid Geomorphic Settings and Unsaturated Zone Flow: Case Study, Chihuahuan Desert, Texas,
by Bridget R. Scanlon, Richard S. Goldsmith, and Richard P. Langford. 133 p., 48 figs., 8 tables, 10 apps., 2000. RI0261, $12.00

This report gives the results of a study conducted to evaluate the relationships between geomorphic settings and spatial and temporal variability in unsaturated flow at a site in the Chihuahuan Desert of West Texas. The ability to characterize unsaturated flow over large areas would be greatly enhanced if relationships between geomorphic settings and unsaturated flow could be identified. This study differed from most previous studies in that the authors examined a variety of geomorphic settings, including drainage areas and interdrainage areas, using dense sampling (~50 boreholes) and a variety of techniques to quantify unsaturated flow. Among the techniques used were surface and downhole electromagnetic (EM) induction, soil physics approaches, including water content and water potential, and environmental tracers, including chloride, chlorine-36, tritium, and stable isotopes of oxygen and hydrogen. The authors concluded that subsurface water fluxes in interdrainage areas are generally low (0.02 to 0.05 mm yr⁻¹). In contrast, most flow was focused in topographic depressions (fluxes ~100 mm yr⁻¹). Drainage areas are generally characterized by low water fluxes currently and higher water fluxes in the past (~40 mm yr⁻¹). The various techniques provide complementary data. EM induction proved useful as a reconnaissance tool. Soil physics approaches provided valuable information on current flow processes, and environmental tracers allowed quantification of fluxes and flow processes over longer time periods. The findings from this study indicate that geomorphic classification can provide valuable information on the direction and rate of unsaturated flow and underscore the importance of localized topographic depressions for focusing flow in the unsaturated zone. This research was funded by the Texas Low-Level Radioactive Waste Disposal Authority.

GEOLOGICAL CIRCULAR

GC 00-1. Characterization of Bedded Salt for Storage Caverns – A Case Study from the Midland Basin, Texas,
by Susan D. Hovorka. 80 p., 33 figs., 1 app., 2000. GC0001, $10.00

This circular describes the geometry of the Salado salt in the Midland Basin in West Texas, one of the best-known sedimentary basins of the world. The geometry of the Permian bedded salt in the basin is a product of the interaction between depo-
tional facies and postdepositional modification by salt dissolution. High-frequency cycle patterns were interpreted in cross section and map view to document the salt geometry of the Midland Basin. The author advocates using geologically based interpretation of depositional and dissolution processes as a tool for mapping the geometry of salt to assess the suitability of sites for development of solution-mined storage caverns. Solution-mined caverns are also created as a source of sodium chloride brine and have been used for disposal of oil-field wastes. This log-based regional analysis of salt character provides basic descriptive information on the geometry of salt needed to manage the development, use, and decommissioning of these facilities. Funding for this study was provided by the National Petroleum Technology Office of the U.S. Department of Energy.

**CROSS SECTIONS**

**CS 11. Regional Stratigraphic Cross Sections, Comanche Cretaceous (Fredericksburg-Washita Division), Edwards and Stockton Plateaus, West Texas: Interpretation of Sedimentary Facies, Depositional Cycles, and Tectonics,**

by C. I. Smith, J. B. Brown, and F. E. Lozo.


CS0011, $12.00.

Six interlocking, regional stratigraphic cross sections of Lower Cretaceous strata of the Edwards and Stockton Plateaus of West Texas illustrate the vertical and lateral extent of lithostratigraphic units and distribution of facies and facies tracts. The accompanying text presents previously unpublished data on the Fredericksburg-Washita Formations of the Comanche Series of the Cretaceous System from the Edwards and Stockton Plateaus and Marathon rim region of West Texas. It also integrates these data with published and unpublished (thesis) data from the study area and adjacent regions and provides a regional stratigraphic framework and synthesis of the depositional history of this division of the Lower Cretaceous in West Texas.

**DOWN TO EARTH AT TUFF CANYON**

**DE 2. Down to Earth at Tuff Canyon, Big Bend National Park, Texas,**


DE0002, $9.00

Joining the Bureau’s premier Down to Earth at McKinney Falls State Park, Texas, popular guide, this Tuff Canyon text is richly illustrated with color photographs and sketches that bring the geologic features, fauna, and flora of the park alive for casual visitors and serious students of this area. The text is written for a nontechnical audience and includes a glossary of terms that might be unfamiliar to nongeologists. Geologic and topographic maps of the Tuff Canyon area provide a rich context for visitors, who can explore the trails while learning about the landscape and history of the area.

**MISCELLANEOUS MAPS**

**MM 39. Geologic Map of the New Braunfels, Texas, 30 × 60 Minute Quadrangle: Geologic Framework of an Urban-Growth Corridor along the Edwards Aquifer, South-Central Texas,**

by Edward W. Collins. Oversize color map (scale 1:100,000) and booklet (28 p., 6 figs.), 2000.

MM0039, $12.00

This map and text set illustrates and describes the physical geology of an area that is undergoing rapid urban growth. The study area includes part of the regionally important Edwards aquifer and recharge zone, a complex segment of the Balcones Fault Zone, and the east margin of the Edwards Plateau. Characteristics of the physical stratigraphy, including lithology, thickness, and occurrence, are illustrated and discussed. Structural attributes, including fault location, length, dip, and displacement, also are presented. This report also provides general
information relating geology to aspects of land use, urban planning, construction practices, and water-resource management. Information provided by this publication is of use to a diverse audience comprising professionals in geology, hydrology, engineering, urban planning, archeology, and related fields, as well as students and the public. Research for this project was supported by the COGEMAP Program and the STATEMAP component of the National Cooperative Geologic Mapping Program, administered by the U.S. Geological Survey. Additional support was from the Texas Parks and Wildlife Department and the Texas Higher Education Coordinating Board.

**PAGE-SIZED STATE MAPS**

**SM 8. Vegetation/Cover Types of Texas,**

by Roy G. Frye, Kirby L. Brown, and Craig A. McMahan.  
Scale: 1 inch = 100 mi, 2000.  
SM0008, $0.25 each

The Vegetation/Cover Types of Texas map is a page-sized compilation of the map units delineated on the 1984 map *The Vegetation Types of Texas* published by the Texas Parks and Wildlife Department. The vegetation is divided into 53 cover types, including 47 plant associations of 2 or 3 characteristic species. The great diversity of plants in Texas and extensive modification of the landscape by land use are conveyed in the map explanation.

**SM 9. Aquifers of Texas,**

by Susan D. Hovorka.  
Scale: 1 inch = 100 mi, 2000.  
SM0009, $0.25 each

The page-sized Aquifers of Texas map depicts the nine major and other minor aquifers in Texas and describes their importance as part of the water cycle in supplying ground water for Texas. Information was compiled primarily from maps and data at the Texas Water Development Board, the State agency charged with oversight of the state’s ground-water resources.
Collins, E. W., 2000, Geologic map of the Bastrop quadrangle, Texas: The University of Texas at Austin, Bureau of Economic Geology, open-file map prepared for the U.S. Geological Survey under cooperative agreement no. 99HQAG0070, 1 sheet, scale 1:24,000.

Collins, E. W., 2000, Geologic map of the Bastrop SW quadrangle, Texas: The University of Texas at Austin, Bureau of Economic Geology, open-file map prepared for the U.S. Geological Survey under cooperative agreement no. 99HQAG0070, 1 sheet, scale 1:24,000.

Collins, E. W., 2000, Geologic map of Blanco Lake quadrangle, Texas: The University of Texas at Austin, Bureau of Economic Geology, open-file map prepared for the U.S. Geological Survey under cooperative agreement no. 99HQAG0070, 1 sheet, scale 1:24,000.

Collins, E. W., 2000, Geologic map of the Coupland quadrangle, Texas: The University of Texas at Austin, Bureau of Economic Geology, open-file map prepared for the U.S. Geological Survey under cooperative agreement no. 99HQAG0070, 1 sheet, scale 1:24,000.

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Dutton, A. R., and Reedy, R. C., 2000, Analysis of drawdown for three ground-water projects in Roberts County, Texas, and comparison to the 50-percent goal: The University of Texas at Austin, Bureau of Economic Geology, letter report prepared for Panhandle Ground Water Conservation District, 7 p. + tables, figs.

Dutton, A. R., Reedy, R. C., and Mace, R. E., 2000, Model of groundwater flow in the Ogallala aquifer in the northern Texas Panhandle: The University of Texas at Austin, Bureau of Economic Geology, data report prepared for the Panhandle Water Planning Group, Panhandle Regional Planning Commission, under contract no. UTA99-0230, CD-ROM.


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Gibeaut, J. C., White, W. A., Hepner, Tiffany, Gutierrez, Roberto, Tremblay, T. A., Smyth, Rebecca, and Andrews, John, 2000, Texas Shoreline Change Project: Gulf of Mexico shoreline change from the Brazos River to Pass Cavallo: The University of Texas at Austin, Bureau of Economic Geology, a report of the Texas Coastal Coordination Council pursuant to National Oceanic and Atmospheric Administration Award No. NA870Z0251, 32 p.


Hovorka, S. D., and Nava, Robin, 2000, Characterization of bedded salt for storage caverns — a


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PAPERS AND ABSTRACTS BY BUREAU STAFF IN OUTSIDE (NON-BUREAU) PUBLICATIONS

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Kerans, Charles, Kempter, Kirt, and Rush, Jason, 2000, Facies and stratigraphic controls on a


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Boniface, L. P., and Vendeville, B. C., 2000, Kinematic and mechanical controls on the formation and evolution of large intracontinental wrench zones in physical models (abs.): Supplement to Eos, v. 81, no. 48, p. F1234.


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Tinker, S. W., 2000, Historical and future impact of BEG reservoir characterization and implementation programs in West Texas (abs.), in The impact of integrated sedimentology and stratigraphy on reservoir characterization and field management strategies: Permian Basin Section–SEPM workshop, Midland, Texas, unpaginated.


Vendeville, B. C., Gaullier, Virginie, Loncke, Lies, and Mascle, Jean, 2000, Gravity-driven tectonics in salt provinces with implications for thin-skinned vs. thick-skinned deformation in the Mediterranean (abs.): Supplement to Eos, v. 81, no. 48, p. F1224.


CORE RESEARCH CENTERS

The Core Research Center (CRC) in Austin and the Midland Core Research Center (MCRC) are research and storage facilities managed by the Bureau to house core and rock material donated to The University of Texas. More than 12 industry and academic institutions donated core to the CRC in 2000. The centers are managed by Curator George Bush, who assisted more than 170 visitors during 2000.

The CRC, the Bureau’s central core repository, is located adjacent to Bureau headquarters on the University’s J. J. Pickle Research Campus. This 95,000-ft² facility contains more than 500,000 boxes of core and 750,000 boxes of well cuttings and outcrop samples.

The MCRC became Bureau property in 1994, when Shell Oil Company donated its core lab, containing 450,000 boxes of core, well cuttings, and outcrop samples, to the University. In September 2000, the facility received 85,000 boxes of West Texas Permian Basin core donated by Altura Energy, Ltd. A 13,500-ft² warehouse extension was built to store this additional material, which will soon store all Permian Basin rock samples maintained by the Bureau.

Both facilities are open to the public Monday through Friday from 8:00 a.m. to 5:00 p.m. Public facilities include core examination rooms, processing rooms for slabbing core, and office space. For-a-fee services, such as core photography, are available, as are computer printouts and CD-ROM-based CRC inventories. Should visitors conduct any type of sample analysis on the material, the Bureau asks that they provide a copy of the results within 1 year of finishing their research. This information will become part of the CRC’s reference material. For information, please call the Austin CRC at 512-471-0402 or visit the Bureau’s Web site at http://www.beg.utexas.edu.

PUBLIC INFORMATION GEOLOGIST

As a public institution, the Bureau receives questions about the geology, energy, and land resources of Texas from people and organizations in Texas and throughout the world. Geologist Sigrid Clift handles the daily appeals for facts and resources. Members of the Bureau’s geoscience research staff also provide advisory and technical services. For information, please call the Public Information Geologist at 512-471-0320 or e-mail sigrid.clift@beg.utexas.edu.

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The Data Center houses the Bureau’s large collection of maps, periodicals, publications, reports, well logs, and open-file materials available for public use. Geologist Sigrid Clift serves as both the Public Information Geologist and manager of the Data Center, which includes the Reading Room and Geophysical Log Facility.

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READING ROOM

The Reading Room is an open-file document storage section containing a large collection of geologic reference materials. These materials include periodicals, maps, well logs, and reports from various governmental and nongovernmental earth science entities. The Reading Room is open to the public Monday through Friday from 8:00 a.m. to 5:00 p.m. and is located on the first floor of Bureau headquarters in Austin. For information, please call the Public Information Geologist at 512-471-0320 or e-mail sigrid.clift@beg.utexas.edu.

GEOPHYSICAL LOG FACILITY

The Geophysical Log Facility is the repository for geophysical data received from private donations, Bureau research projects, and the Railroad Commission of Texas, which by law receives a copy of geophysical logs from every new, deepened, or plugged well drilled in Texas. The facility is supervised by Daniel Ortuño, who manages both the numerous daily requests for copies of well logs and the flow of new geophysical data into the facility.

Geophysical data available for public research include wireline electric logs, well records, and scout tickets from hundreds of thousands of wells located in Texas. Sample logs from the 1930’s through the 1950’s are also stored in the facility and are available for public research. Requests for copies of logs can be made in person or by mail, telephone, fax, or e-mail.
For information, please call the Geophysical Log Facility manager at 512-471-7139 or e-mail daniel.ortuno@beg.utexas.edu.

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The Bureau publishes and sells maps and reports of research conducted by Bureau staff from 1915 to the present. The office of Publication Sales, under the guidance of Publication Sales Manager Amanda Masterson, receives and processes a daily stream of publication orders. Bureau publications include reports of investigations, guidebooks, handbooks, cross sections, maps, oil and gas atlases, seismic data sets, geologic folios, geologic atlas sheets, page-sized maps of Texas, and classroom teaching aids such as rock kits. Out-of-print publications and most contract reports produced by the Bureau are also available for purchase. Best-sellers for the year 2000 included geologic atlas sheets, guidebooks, page-sized maps, and open-file STATEMAP maps.

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Free copies of the current year’s *List of Publications*, *Annual Report*, and *Comprehensive Report* are available upon request.
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Chief Editor Susie Doenges supervises the Bureau’s skilled and meticulous editing staff. These editorial and proofreading specialists are responsible for the editing, word processing, desktop publishing, and proofreading of research publications. The Editing staff works closely with the Bureau’s Graphics department to produce the outstanding Bureau publications that are available through the office of Publication Sales. Editing staff also assist in preparing contract reports, abstracts, and articles submitted to professional journals, as well as slides and posters.

ADMINISTRATIVE

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CONTRACT MANAGEMENT

Most Bureau research funding comes from Federal, State, and industry sponsors and agencies. Contract management personnel, supervised by Lynda Miller, assist Bureau researchers in preparing the budgets and proposals submitted to potential sponsors. When researchers receive the welcome news that their proposals will be funded, contract management staff serve as liaisons for the various entities involved. Contract management also involves financial reporting, database and records management, and documentation of progress and submission of deliverables, all of which are completed with timely precision.

GRAPHICS

Graphics manager Joel Lardon heads up the talented group of designers, illustrators, and computer wizards responsible for producing the design, artwork, and illustrations for Bureau research and publications. Their award-winning graphics skills include creating text illustrations and presentation materials for Bureau researchers, manual and digital photography, design and layout, and map design and finishing.

INFORMATION TECHNOLOGY SERVICES

Scott D. Rodgers is manager of the Bureau’s Media Technologies, responsible for the Bureau’s Virtual Imaging and Visualization Environment (VIVE), a program for the development of applied virtual visualization technologies for the earth sciences, as well as digital publishing and Internet development within the Bureau.

Computer Services is managed by Ron Russell, who provides vital computer technology assistance to the researchers and staff of the Bureau. Computers at the Bureau include PC’s, Macs, and Unix workstations. These resources assist researchers in interpretation, 3-D modeling, visualization, characterization, computer mapping, programming, database applications, and statistical and graphic analysis of data. ITS supports these systems and the network design, as well as handling the purchasing, testing, installation, and user training.
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- **Federal**: 28%
- **Industrial associates**: 14%
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  - Other, local accounts: 2 million dollars
  - Legislative appropriations: 4 million dollars
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  - Other, local accounts: 2 million dollars
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  - Other, local accounts: 2 million dollars
  - Legislative appropriations: 4 million dollars
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  - Legislative appropriations: 4 million dollars
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