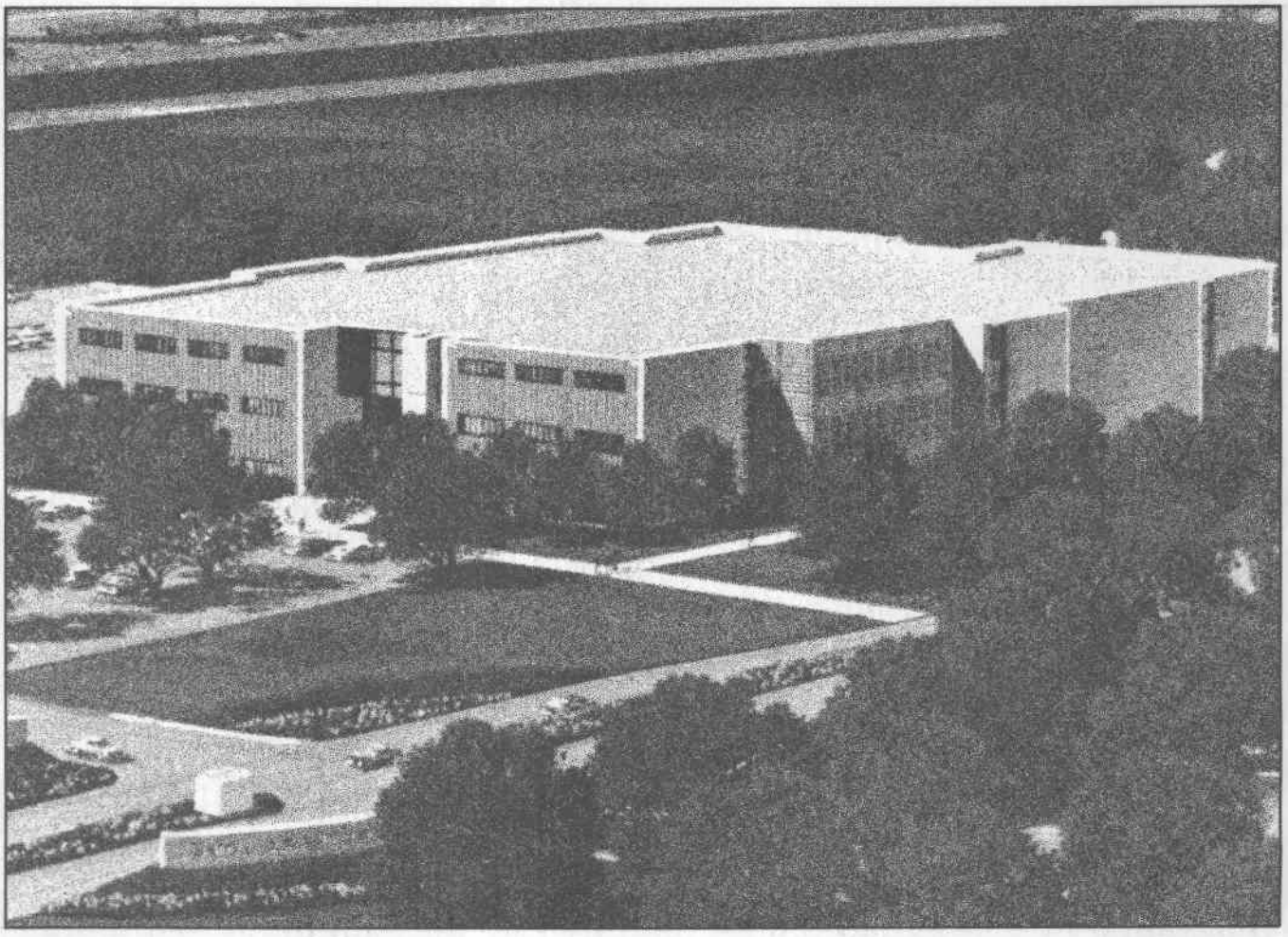
ANNUAL REPORT 1984



Bureau of Economic Geology

W. L. Fisher, Director
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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 entity of The University of Texas at Austin. It also functions as the State Geological Survey, a quasi-State agency, and the Bureau Director represents 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 State, Federal, and local agencies. The Texas Mining and Mineral Resources Research Institute is an administrative unit of the Bureau.

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 and to the Environmental and Consumer Health Protection Division of the Texas Department of Health.

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 Special Publications. Publications are sold for a nominal price to recover printing costs. A complete list of publications is available on request.

The Annual Report ad status of current research projects, publications, rces and geology that are available to governme

GEOLOGIC MAP

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WELL SAMPLE AND CORE LIBRARY

On the cover: Model of Bureau's new Research and Administration Building (courtesy of Barnes, Landes, Goodman and Youngblood, Architects and Engineers, Austin, Texas). Photography by James A. Morgan; design by Jamie S. Haynes.

ANNUAL REPORT 1984

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CONTENTS

RESEARCH

Functioning as the State geological survey and as a research unit of The University of Texas at Austin, the Bureau of Economic Geology carries out projects designed to answer basic questions about the diverse geology of the state and its diverse energy, mineral, and land resources. About 80 professional staff scientists—including geologists, engineers, biologists, and chemists—work on a variety of team research projects in such areas as energy resources, land and environmental resources, mineral resources, basin studies, coastal studies, and geologic mapping.

Energy research at the Bureau is concentrated chiefly on the vast, unconventional energy resources that are becoming and will be the energy base of the State in the future. Texas has large quantities of lignite, and Bureau researchers predict that deep surface mining of lignite will become commonplace. Since sand-body continuity and interconnectedness are critical to predicting the engineering difficulty and environmental impact of deep surface mining, studies in these areas are continuing. Specific studies in 1984 centered on investigating the geology of the Carrizo Sand in east-central Texas and geological characterization of sand-body continuity and interconnectedness in the Wilcox aquifer.

As part of their research into gas production, Bureau researchers investigated low-permeability gas sandstone reservoirs, which contain a vast supply of unconventional gas. The objective of this study is to enhance geologic understanding of blanket-geometry tight gas sandstones as part of an integrated effort to determine the genetic stratigraphic units, diagenetic history, and maturation and migration of hydrocarbons. Coring, logging, and production testing of three tight gas wells in East Texas were undertaken in 1984, facilitating classification of rock type and interpretation of depositional environments.

Bureau researchers investigating oil and gas resources in 1984 undertook reservoir characterization studies of both carbonate and sandstone oil reservoirs and studied low-permeability gas sandstone reservoirs and hydrocarbon distribution on the Texas continental shelf and margins. Carbonate reservoirs research centered on the San Andres/Grayburg Formations of the Dune field in Crane County. The objective of this study is to obtain better geological definition of the field area, which, in conjunction with engineering data, will result in improved ultimate oil recovery for these kinds of reservoirs. Bureau researchers are also investigating carbonate reservoirs on University-owned lands in the Permian Basin. During 1984, five plays deemed favorable for detailed study were identified. Study on the clastic reservoirs project shifted from barrier/strandplain facies to wave-dominated delta deposits. Reservoirs in these latter deposits generally display the highest recovery efficiencies of all clastic reservoirs. Clastics studies in 1984 centered on the Big Wells field, South Texas, a low-recovery reservoir.

Other Bureau researchers are studying the energy resources and geologic framework of the Texas continental shelf, which contains significant oil and gas plays. During 1984, a set of stratigraphic cross sections of the offshore Miocene was completed, as was detailed lithofacies mapping of the lower Miocene sediments. In another study of the shelf, Bureau researchers used new data, particularly well logs from deep wells along the lower coastal plain, paleontological reports, and newly acquired offshore well logs to update and reinterpret the downdip section of the petroleum-producing Frio Formation. Of particular importance is the projection of reservoir distribution and quality into offshore areas where drilling has been sparse. This research is also part of a multistate effort, coordinated by the Bureau, to assess the potential of the Nation's continental margins for petroleum and nonenergy mineral resources.

Salt domes remained an important focus of Bureau research in 1984. Salt domes in Texas are being considered as hosts for the disposal of toxic chemical wastes in solution-mined caverns. During 1984, researchers investigated the natural resources, storage caverns, and extraction techniques pertaining to these domes. Another salt dome project involves experimental centrifuge modeling, a technique in which small-scale models of diapirs are produced by the same forces as natural salt domes in an effort to understand better the growth history, internal structures, and external shapes of salt domes.

Another long-term Bureau study involves determining the suitability of salt beds in the Texas Panhandle as repositories of high-level nuclear wastes. During the year, researchers on this project studied the effects of evaporite dissolution on the origin and evolution of Panhandle geomorphic systems, examined DOE cores in detail to correlate interbeds in all salts, reprocessed seismic data to understand better the structure in the deeper sedimentary strata, and continued documentation of a conceptual hydrologic model.

The Bureau also maintained its diverse program of mineral resource investigations. During 1984, researchers studied the association in West Texas of certain elements—molybdenum, tin, tungsten, beryllium, and fluorine—with the generation and geochemical evolution of magmas. In another project, scientists undertook research to determine why hydrothermal veins associated with mid-Tertiary volcanism in Trans-Pecos Texas are typically silver-rich but gold-poor compared with similar veins worldwide.

During the year the Bureau also continued its extensive mapping programs, including the Submerged Lands of Texas atlas, the Geologic Atlas of Texas, and the Tectonic Map. Further details about these and other research programs are listed in the following summaries of Bureau research programs.

ENERGY RESOURCES INVESTIGATIONS

EVALUATING THE GEOLOGY AND GROUND-WATER HYDROLOGY OF DEEP-BASIN LIGNITE IN THE WILCOX GROUP OF EAST TEXAS

W. R. Kaiser, project director; Mary L. Ambrose, W. B. Ayers, Jr., Graham E. Fogg, Mary L. W. Jackson, and Susan J. Tewalt; assisted by David B. Mazza, Susan Shultz, and Audrea M. Sutley

Now supported by special legislative appropriation, this study is a continuing effort to evaluate Wilcox deep-basin lignite in East Texas. Major effort in 1984 centered on preparing data for publication that were collected in earlier work funded by the Texas Energy and Natural Resources Advisory Council (TENRAC). Detailed research results will be published in four geology and hydrogeology folios—one of each for the Sabine Uplift and east-central Texas areas. The Sabine Uplift, centered in Panola County, comprises 12 counties, including those in the semicircular Wilcox outcrop and those downdip, ringing the outcrop. The east-central Texas area comprises 15 counties between the Neches and Colorado Rivers and extends along the outcrop and into adjoining downdip counties. Each geology folio will contain 12 to 18 lithofacies, lignite-occurrence, structure, and resistivity maps (scale: 1 inch = 6 mi), regional cross sections illustrating the stratigraphic occurrence of lignite and major aquifers, descriptive text, and tabulated supporting data. Each hydrogeology folio will contain 12 to 18 head, vertical gradient, vertical head-differential, hydrochemical, and base of fresh water maps, graphs and plots, text, and data. The first folio published in 1985 will be the geology folio of east-central Texas. A separate publication will deal with chemical characterization of Texas lignite and will include tabulated chemical analyses, statistical analysis of the results, and comparisons by stratigraphic occurrence, region, and depth.

Research results were summarized in a final report to TENRAC and will be published in 1985 by the Bureau as a Geological Circular. Findings to date suggest that deep surface mining (extending to depths of at least 300 ft) will be commonplace in Texas and that only minimal tonnages will be recovered by underground gasification between now and 2000. The paucity of thick seams and the presence of aquifer sands make gasification applicable only on a site-specific basis. The engineering and environmental success of a deep mine or underground gasifier will depend on its hydrogeologic setting. Because aquifer sands and low-permeability sediments alternate vertically and horizontally, deep recovery of lignites roofed and floored by the latter could be carried out with minimal engineering difficulty and environmental impact. The effects of deep mine depressuring and dewatering can be regional in scope; that is, the effects of drawdown, or the lowering of the water surface, may encompass a whole county. Very slow ground-water flow rates and dispersion of potential pollutants and their dilution will minimize impact on regional water quality. Consequently, deep mining is of greater concern for ground-water resources than for water quality in the Wilcox-Carrizo aquifer system. Lignite quality should present no major obstacles to utilization. High sulfur overburden is inferred from facies analysis for upper Wilcox lignite in the east-central and Sabine Uplift areas, requiring extra care in the placement of spoil during reclamation of mined lands.

Research initiatives in 1984 centered on the geology of the Carrizo Sand in east-central Texas and geostatistical characterization, or modeling, of sand-body continuity and interconnectedness in the Wilcox aquifer. The Carrizo Sand is a major aquifer, deposited as a fluvial-deltaic sequence, that rests unconformably on the upper Wilcox Calvert Bluff Formation in the shallow subsurface. Carrizo sediments were derived mainly from the north and entered the Houston Embayment primarily on the south and north flanks of the area, filling the Garwood subembayment in Lee, Bastrop, and Fayette Counties and issuing along the East Texas Embayment into Leon, Anderson, and Houston Counties. In these areas, fresh water extends basinward tens of miles farther than in underlying Wilcox aquifers. The Carrizo aquifer is potentially at environmental risk northeast of the Brazos River where thick upper Calvert Bluff lignites will be eventual targets of deep mining.

Sand-body continuity and interconnectedness are critical to predicting the engineering difficulty and environmental impact of deep surface mining. Well-interconnected sand networks will be more difficult to depressurize; depressurization of them may affect ground-water resources over large areas. Because data are inadequate to map directly continuity in the Wilcox, a geostatistical method is being developed that combines conditional simulation and depositional models to predict continuity and interconnectedness of sand bodies. Nearly all computer software for the method has been developed and tested. Simulations of actual conditions in north-central Nacogdoches County (Trawick gas field) began in December.

COMPUTERIZED CALCULATION OF LIGNITE RESOURCES IN TEXAS

W. R. Kaiser, project director; Susan J. Tewalt; assisted by Curtis W. Black

This ongoing project, funded by the U.S. Geological Survey (USGS), provides estimates of remaining near-surface lignite resources (those under less than 500 ft of cover) in the state of Texas. The computerized data base and graphics software of the National Coal Resources Data System (NCRDS) are used to calculate resources according to the criteria of USGS Circular 891. Seam thickness, depth, and data locations are coded from geophysical logs and entered into the data base. Access to NCRDS is through a Tektronix 4054 terminal at the Bureau. Resource estimates and maps are reported on an aggregate basis by stratigraphic unit and geographic region; point sources of proprietary data remain confidential.

Resources in the Wilcox Group have been estimated for three geographic regions: east-central Texas (between the

Colorado and Trinity Rivers), northeast Texas (north of the Trinity River to Texarkana), and the Sabine Uplift (in East Texas). In each region, resources have been calculated for three degrees of certainty—measured, indicated, and inferred. Five seam-thickness categories are used. Three are standard USGS categories for low-rank coals (2.5 to 5 ft, 5 to 10 ft, and greater than 10 ft [0.76 to 1.5 m, 1.5 to 3.0 m, and greater than 3 m]). The other two seam-thickness categories (2 to 3 ft, and greater than 3 ft [0.61 to 0.91 m, and greater than 0.91 m]) reflect current surface mining practice in Texas.

Resource estimates generated by this study can be compared with Bureau estimates from Report of Investigations No. 104, *Lignite Resources in Texas*, because the two studies used the same data base and seam-thickness categories. NCRDS estimates of total resources are consistently greater than those from RI 104 (see table). Larger acreages are used for the NCRDS calculation, and a more conservative, geologic approach was used in RI 104. On the average, the inferred category constitutes 64 percent of the total NCRDS resource estimates, indicating a low degree of certainty for a large portion of the resource.

Data entry for the Yegua/Jackson units in East Texas was completed in 1984, and resource estimates should be available in 1985. A Bureau report including results for the three Wilcox Group regions is also expected to be available in 1986.

Comparison of total resource estimates for all seams greater than 2 ft thick (in millions of short tons remaining as of January 1982).

Region	NCRDS estimate	RI 104 estimate
east-central	10,370	8,641
northeast	11,637	8,359
Sabine Uplift	13,113	5,433
Total	35,120	22,433

GEOLOGICAL CHARACTERIZATION OF TEXAS OIL RESERVOIRS (CARBONATE RESERVOIR STUDIES)

Don G. Bebout, project director; C. M. Garrett, Jr., and Eric S. Cheng; assisted by David Leary, Karen Meador, and Scott Schmidt

Focus of the Reservoir Characterization project for the past year has been on detailed study of the San Andres/Grayburg Formations of the Mobil University 15/16 unit, Dune field, Crane County, Texas. The Dune field was selected for study using the earlier broad-based examination of geological and engineering data available from all fields in Texas that have produced more than 10 million barrels of oil. This statewide compilation resulted in the publication of the Bureau's *Atlas of Major Texas Oil Reservoirs*. High cumulative production, low recovery efficiency, and operator cooperation were considered during the selection process. The objective of the San Andres/Grayburg study is to integrate detailed geological data obtained from cores and logs with engineering data available from the many wells in the field to characterize better the nature and distribution of the porosity, the controls of carbonate facies on porosity distribution, and the relationship of these rock parameters to production characteristics in individual wells and in fields. It is thought that better definition of the field will aid in the locating of later infill wells and will result in improved ultimate oil recovery.

Continuous cores through the entire reservoir section were obtained from the University unit 15/16 from Mobil Oil, and from the surrounding area from Gulf Oil and Getty Oil. These cores have been logged in detail, and selected thin sections have been prepared. The core facies have been correlated with the geophysical logs and core analyses and have been essential in interpreting the distribution of facies along the detailed log cross sections. Identification of the various carbonate facies in the many wells without cores has been aided by cross plots of sidewall neutron or sonic and resistivity logs. Thickness of individual correlation units and distribution of facies and porosity within these units have been mapped. A report summarizing the results obtained thus far is now being prepared.

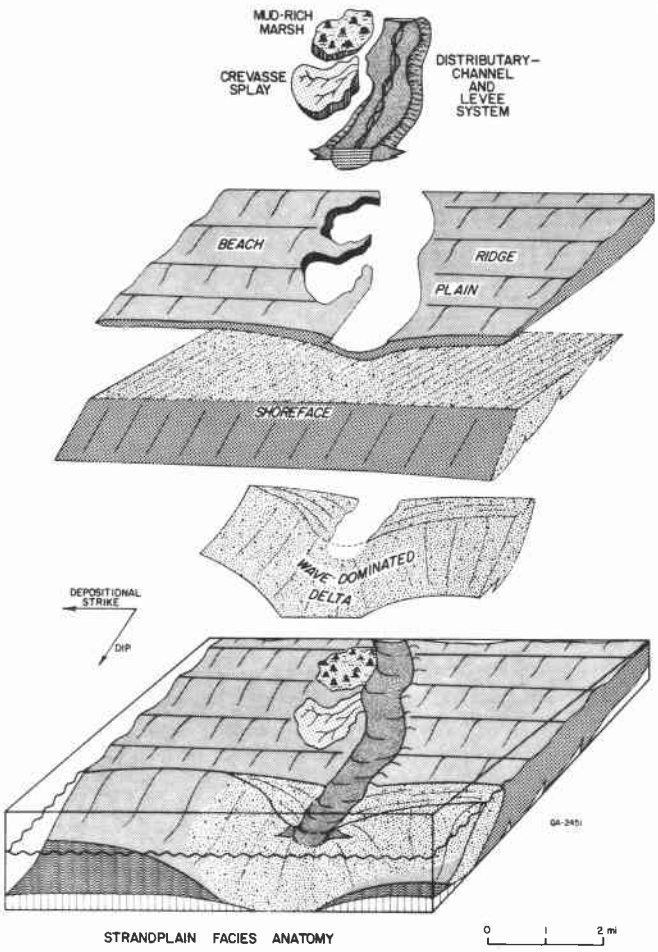
GEOLOGICAL CHARACTERIZATION OF TEXAS OIL RESERVOIRS (CLASTIC RESERVOIR STUDIES)

Noel Tyler, project director; assisted by William A. Ambrose, Koso Idigbe, J. Crispin Gholston, and Anjan K. Mitra

Clastic reservoir studies shifted emphasis in 1984 from barrier/strandplain facies to wave-dominated delta deposits. Wave-dominated deltaic reservoirs, as exemplified by the East Texas field and other Woodbine fields in East Texas, display the highest recovery efficiencies of all clastic reservoirs. Primary and secondary recovery is generally about 60 to 80 percent of the original oil in place. However, one of the wave-dominated delta plays, the San Miguel - Olmos play of South Texas, is characterized by significantly lower yields of about 20 to 30 percent. The Big Wells (San Miguel) reservoir of this South Texas play was selected as the site to investigate reasons for the wide disparity in recovery efficiency.

The Big Wells (San Miguel) reservoir is subdivided into a lower oil-productive, composite sandstone and an upper tight and water-saturated sandstone that seals the reservoir. The lower sandstone is composed of six offlapping and laterally overlapping lobes. Net- and percent-sand maps of the entire lower unit show two distinct depositional patterns. In the southern half of the field, trends are strike parallel, whereas to the north both dip-elongate and strike-parallel axes are present. Preliminary interpretation is that the northern half of the field contains the distributary entrant into the basin; the southern end includes the associated beach-ridge facies of this wave-dominated delta system. Of sedimentological interest are two sediment plumes basinward of the delta. Both display elongation toward the south, indicating counterclockwise longshore drift consistent with the architecture of the remaining deltaic deposits.

Access to eight cores taken by the field operators aided in the mapping of vertical and lateral facies changes in the San Miguel sandstone. All of the cores displayed massive



Facies anatomy of a sand-rich strandplain modeled on Tertiary shore-zone systems in the Texas Gulf Basin. Component facies foster or hinder oil production in heterogeneous Frio reservoirs.

bioturbation; primary sedimentary structures were almost totally destroyed. However, it is possible to document vertical and lateral changes in ichnofacies, which when used in conjunction with vertical trends in sorting, glauconite content, and matrix content, allow a first approximation of depositional facies. The overall trend is one of thinner foreshore and upper-shoreface facies and thicker lower-shoreface facies toward the north. This trend coincides with, and probably causes, poorer ultimate recoveries in the northern half of the field.

Three preliminary conclusions have been reached:

(1) Resistivity cross sections show that lateral heterogeneity is moderate to absent in the Big Wells (San Miguel) field; however, vertical heterogeneity (and attendant porosity/permeability stratification) is pronounced.

(2) Recovery will be better than first expected probably as a result of a successful waterflood program.

(3) Comparatively poor recoveries (when contrasted with wave-modified deltaic reservoirs of the Woodbine Group and Frio Formation) are a response to low permeabilities and an inefficient solution-gas drive rather than internal compartmentalization.

Publication of two reports describing results of the clastic reservoirs research program is anticipated for 1985.

CARBONATE RESERVOIRS ON UNIVERSITY LANDS

Don G. Bebout, project director; C. M. Garrett, Jr., and Claude R. Hocott (The University of Texas at Austin, Department of Petroleum Engineering); assisted by Cristina Siqueira and Robert Murray

The University of Texas Board of Regents has funded a four-year research program by the Bureau to conduct detailed geological and engineering studies of reservoirs on University lands. University lands are all located in the West Texas Permian Basin, and most of the reservoirs are in carbonate rocks.

As the first phase of this project, five plays most favorable for detailed study have tentatively been identified: San Andres/Grayburg (Central Basin Platform), San Andres/Grayburg (Ozona Arch), Clear Fork Reservoirs (Central Basin Platform), Fractured Ellenburger, and Silurian-Devonian (Central Basin Platform). These plays were selected on the basis of volume of unrecovered movable oil, considerations of depth and related drilling cost, status of secondary operations now underway, and volume and treatability of residual oil.

The objective of this project is to carry out detailed studies of reservoirs representative of these five plays. Study of selected reservoirs on University lands with high potential for improved recovery will have direct benefit to the University, and because these reservoirs are representative of reservoirs throughout the West Texas area, the results should have wide application to West Texas reservoirs.

GEOLOGICAL INVESTIGATION OF LOW-PERMEABILITY GAS SANDSTONE RESERVOIRS

Robert J. Finley, project director; A. Eugene Saucier, Shirley P. Dutton, and Zsay-Shing Lin; assisted by Robert C. Murray, Janet L. Bader, and Bruce Gates

Geological research on low-permeability gas sandstones is helping to unlock a vast supply of unconventional gas with the potential to contribute 200 to 600 trillion cubic feet (Tcf) of gas to the Nation's resource base. At present many tight gas sandstones are not being efficiently evaluated, hydraulically fractured, or produced from because of a lack of appropriate technology to stimulate near-term development of the tight gas resource at competitive prices. The objective of this project, funded by the Gas Research Institute, is to enhance the geological understanding of blanket-geometry tight gas sandstones as part of an integrated effort by multiple disciplines involved in tight gas resource development. These disciplines include geophysical well logging and reservoir engineering efforts aimed at improved formation evaluation and resource extraction keyed to better understanding of genetic stratigraphic units, diagenetic history, and the maturation and migration of hydrocarbons. The formations selected for study are the Lower Cretaceous Travis Peak (Hosston) Formation of the East Texas and North Louisiana Basins, and the Upper Cretaceous Corcoran and Cozzette Sandstone Members of the Price River Formation (Mesaverde Group) in the Piceance Creek Basin of Colorado. The Travis Peak

Photos/Robert J. Finley

Aligning the orientation equipment as the core barrel is assembled, catching the core in trays on the rig floor, and preliminary examining of core, here showing a conglomerate, for the first Travis Peak well studied in cooperation with an operator on the GRI tight gas sandstone project.

was chosen primarily for its high resource potential (14 to 23 Tcf), and the Corcoran-Cozzette (4 Tcf resource) because of expected transferability of research results to geologically similar units throughout the Rocky Mountain region.

In the past year, coring, logging, and production testing have taken place in cooperation with operators of three Travis Peak tight gas wells in East Texas. Each coring program was designed to encompass potential reservoir rock based on operator-provided data from offset wells. Fine to very fine sandstone, siltstone, and shale recovered thus far are interpreted to be primarily from a marginal-marine depositional setting that includes tidal-flat, distributary-channel, and bay/estuarine environments. Upper Travis Peak sandstones are mineralogically classified as quartzarenites or subarkoses containing limited amounts of feldspars or rock fragments. In contrast to many other tight gas sandstones, quartz overgrowths and some carbonate cement, rather than authigenic clay minerals, occlude much of the primary reservoir porosity. One unexpected result of core studies has been identification of solid organic matter, or "dead oil" (possibly pyrobitumen), in Travis Peak sandstones from several gas fields. The dead oil appears to be an important factor that, in addition to mineral diagenesis, reduces the porosity and effective gas permeability of some Travis Peak reservoirs, and requires modifications in the analysis of porosity logs.

The depositional environments inferred from core studies are consistent with a regional depositional framework developed for the eastern counties of the East Texas Basin over the Sabine Uplift and parts of the North Louisiana Basin. This framework defines two major depocenters in North Louisiana and East Texas; the East Texas depocenter is interpreted as a complex of high-constructive deltaic lobes formed by progradation over a broad, shallow, clastic and carbonate shelf more than 100 mi wide. As this complex grew, it eventually covered all or part of nine counties in Texas and three parishes in Louisiana and is now the most active part of the Travis Peak tight gas play. Regional cross sections have defined a major fluvial-deltaic wedge forming the central part of the 500- to 2,500-ft-thick Travis Peak Formation, and a delta fringe facies occurs above, and probably below, this wedge. The marginal-marine facies that form the shallower hydrocarbon reservoirs in the Travis Peak, and that have been cored extensively to date, are part of the upper delta fringe deposits that were in turn overlain by the Sligo/Pettet carbonates.

Within the Piceance Creek Basin of northwest Colorado, studies of the Corcoran and Cozzette Sandstones have proceeded more slowly than those of the Travis Peak. The relatively slow pace of recent tight gas drilling in that region has led to no cooperative coring and logging operations through 1984. However, existing core has been studied, and reservoir properties in three contiguous fields that are the most productive in the basin have been mapped. The Corcoran-Cozzette consists of seven individual barrier/strandplain depositional units that include facies such as lower- and upper-shoreface, foreshore, and bay/lagoon deposits, along with highly lenticular coals. Variations in shoreline progradation, stabilization, or retreat along the western margin of the Cretaceous Interior Seaway account for differences in distribution of individual shoreline units. The Colorado Geological Survey is cooperating with the Bureau on major parts of the Corcoran-Cozzette studies.

The Corcoran-Cozzette and Travis Peak (Hosston) present important contrasts as natural laboratories for solving tight gas sandstone development problems.

Individual Corcoran-Cozzette sandstone reservoirs have excellent blanket geometry over several or more townships, and adjacent shales are likely to contain the hydraulic fractures emplaced to increase gas production. The Travis Peak (Hosston) is a more consistent and much more widespread blanket as a formation, but individual reservoir sandstones are broadly lenticular and are correlatable as packages rather than as individual units. Shale barriers to out-of-zone growth of hydraulic fractures are limited in much of the Travis Peak (Hosston). These reservoirs represent contrasting gas-productive environments, and detailed studies of both types of reservoirs are taking place that involve extensive interchange between geologists, well log analysts, and reservoir engineers. Expansion of geological studies into structural geology and remote sensing in 1985 will lead to distinguishing between matrix and fracture permeability as it relates to gas productivity. Areal differences in these permeability types will affect the location of fairways for the first Gas Research Institute test well in the Travis Peak, now scheduled for drilling in 1986. A Corcoran-Cozzette well for coring and logging in cooperation with operators will be sought in 1985.

GEOLOGICAL AND ENGINEERING RESEARCH SUPPORT FOR GULF COAST COPRODUCTION PROGRAM

Robert A. Morton, project director; Thomas E. Ewing and Malcolm P. R. Light

This project, which was initiated in 1984, is funded by the Gas Research Institute and is being conducted jointly by the Bureau and the Center for Energy Studies, The University of Texas at Austin, as part of their unconventional gas resource programs. The purpose of the project is to identify techniques that will increase the gas-to-water ratio and improve hydrocarbon recovery from gas reservoirs that have been abandoned or are beginning to water out. Reservoir management techniques involve high-rate fluid production, mainly water, and pressure reduction in an attempt to increase hydrocarbon concentrations. If successful, these techniques would improve the economics of producing wells after water encroachment has caused a decline in gas production.

Preliminary efforts focused on two topics: (1) geological studies of the Northeast Hitchcock field in support of a new well test and (2) a generic study of fluid withdrawal, subsidence, and fault activation.

Geology of the Hitchcock Field

Malcolm P. R. Light

In 1984, the Secondary Gas Recovery De Lee No. 1a coproduction well penetrated the Frio A (9100) sandstone in the Northeast Hitchcock field; 130 ft of core was recovered from this depleted gas-condensate reservoir. Cutting samples of the Anahuac and Frio Formations were also collected in this well. The core was described and tested under ultraviolet light for the presence of liquid hydrocarbons. Scanning electron microscope studies of the shales and sandstones were combined with a regional diagenetic model for the Frio Formation to decipher the diagenetic history of the Frio A sandstone.

The Frio A sandstone was correlated using more than 200 electric logs from the Hitchcock and Northeast Hitchcock fields to the Alta Loma, Sara White, and Chocolate Bayou oil and gas fields to the west. Regional sandstone-thickness and -percentage and log-facies maps and cross sections will allow an assessment of the depositional environment and reservoir quality of the Frio A sandstone.

Future work will include studies of shale dewatering and local sources of hydrocarbons in the Northeast Hitchcock field; total organic carbon content, pyrolysis data, X-ray diffraction, and inductively coupled plasma elemental analyses and scanning electron microscope photographs of shales adjacent to the Frio A sandstones will be used in this investigation. Detailed gas chromatography - mass spectrometry and isotope analyses will be combined with shale maturity studies to estimate the source of the hydrocarbons. A three-dimensional diagram showing variations in facies, salinity, temperature, and pressure in Oligocene and Miocene rocks along the Gulf Coast will be constructed and used in conjunction with geochemical and fluid composition data to devise a hydrocarbon migration model.

Environmental Effects of Large-Volume Fluid Withdrawals

Thomas E. Ewing

The major task of this project, which began in 1984, is to distinguish naturally occurring faulting and subsidence from activity related to deep or shallow fluid withdrawal. Production of large volumes of water is expected to result from both geopressured geothermal energy production and enhanced gas recovery (coproduction) techniques. The withdrawal of millions of barrels of fluid may cause significant subsidence or surface-fault reactivation. Such faulting and related subsidence have been observed in the High Island - Caplen area, where shallow ground-water withdrawal is minimal, as well as the Houston - Clear Lake area, where heavy ground-water extraction has taken place.

GEOLOGICAL FRAMEWORK AND ENERGY RESOURCE STUDIES, TEXAS CONTINENTAL SHELF

W. E. Galloway, project director; Robert A. Morton and L. A. Jirik; assisted by Emil Bramson and Charles Yager

This long-term research program is focused on the regional genetic stratigraphy, structure, and energy resources of the Texas portion of the continental shelf and upper slope. The primary data base, which has been gathered during the past two years, includes more than 1,000 conventional well logs, numerous paleontologic reports, and complete scout ticket and production records. During 1984, the project was partially funded by the Minerals Management Service and the U.S. Geological Survey.

Three reports, which will be published by the Bureau, were prepared in 1984. A set of regional stratigraphic cross sections, including nine dip and two strike sections, was completed. The dip sections extend previously published onshore sections across the shelf. In addition, a report reviewing general structural trends, Miocene facies distribution, and production history was prepared and is in press.

Most recently, detailed lithofacies mapping of the lower Miocene section has been completed. Completed maps and facies interpretations have been integrated with results of earlier studies of the equivalent onshore section to produce a regional synthesis of the depositional systems, structural framework, and petroleum resources of the lower Miocene depositional sequence. This report documents the major lower Miocene fluvial and wave-dominated delta systems in South Texas, the extensive barrier/lagoon and strandplain system that extends northeastward beneath the modern Texas shore zone, and the western fringe of a second, large fluvial and deltaic system beneath the upper Texas Coastal Plain and inner shelf. Greatest volumes of petroleum, principally oil, have been produced from fluvial and deltaic reservoirs pierced by salt domes. However, significant gas and condensate plays extend across shallow State waters of the inner shelf and offer targets for ongoing exploration in the deeper waters of the Federal Outer Continental Shelf as well.

FRIO FACIES AND HYDROCARBON DISTRIBUTION: TEXAS CONTINENTAL SHELF

W. E. Galloway, project director; L. A. Jirik; assisted by Emil Bramson

This project is a follow-up to the regional Bureau study of the stratigraphic framework and petroleum geology of the Frio depositional episode, which was summarized in Report of Investigations No. 122, *Frio Formation of the Texas Gulf Coast Basin*, published in 1982. New data, particularly well logs from deep wells along the lower coastal plain, paleontologic reports, and a recently acquired file of offshore well logs provided the impetus for updating and reinterpreting the downdip Frio section. The project is supported by a grant from Sohio Petroleum Company to the Petroleum Research Fund.

Goals of the project include preparation of a suite of lithofacies maps of the distal Frio, concentrating on its extensions into State and Federal waters, extension of previously compiled cross sections, and interpretation of major facies assemblages that constitute the deep Frio section. Of particular importance are the delineation of the Frio paleocontinental margin at maximum progradation and the projection of reservoir distribution and quality into offshore areas where drilling has been sparse.

Quantitative mapping is complete, and publication of a report, supplementing the earlier Report of Investigations, is anticipated for 1985.

STUDIES RELATED TO CONTINENTAL MARGINS

Robert A. Morton, project director; D. C. Ratcliff, coordinator

The Bureau, as a member of the Continental Margins Committee of the Association of American State Geologists, monitors a multidisciplinary special studies program conducted by the members of the Committee. The Continental Margins Committee is made up of the geological surveys of the coastal states. The surveys conduct geological studies relevant to their state's needs as well as studies related to the Department of the Interior's (DOI) offshore leasing program. The DOI is primarily involved with leasing tracts for petroleum resource potential, but nonenergy minerals are included in the program. Doug Ratcliff coordinates the efforts among the states.

The Bureau's research effort under this program is titled "Evaluation of the Potential for Extension of Frio Hydrocarbon Plays onto the Texas Outer Continental Shelf." Robert A. Morton is the principal investigator.

OLMOS DEPOSITIONAL SYSTEMS AND OIL AND GAS PLAYS

Noel Tyler, project director; William A. Ambrose

The Upper Cretaceous Olmos Formation of South Texas has been a regionally important oil and gas producer since the mid-1950's, yet little is known about the genetic stratigraphy or distribution of sandstones in this unit. Detailed subsurface studies of the Olmos completed as part of the Geological Characterization of Texas Oil Reservoirs project confirm that in South Texas the Olmos is primarily deltaic in origin. Sandstone deposition was concentrated in two subbasins. The western subbasin contains the oldest Olmos sediments; these range from wave-dominated deltaic facies at the base, through wave-modified, high-constructive deltaic facies, to barrier/strandplain deposits at the top of the formation. High-constructive, elongate deltas were deposited in the eastern subbasin contemporaneously with the upper-shore-zone facies of the western subbasin.

Updip oil and gas plays include unconformity-related stratigraphic traps and structural traps over volcanic mounds and in the Charlotte fault zone. Downdip delta-front and shelf sandstones have been designated as tight gas producers, and furthermore yield gas from fault-bounded structures at, and seaward of, the Cretaceous shelf edge. A publication presenting results of this study is in preparation.

CONSOLIDATION OF GEOLOGIC STUDIES OF GEOPRESSURED GEOTHERMAL RESOURCES IN TEXAS

Robert A. Morton, project director; Thomas E. Ewing, Malcolm P. R. Light, and Noel Tyler

Assessment of geopressured geothermal resources began in 1974 with funding from the U.S. Atomic Energy Commission and the Center for Energy Studies at The University of Texas at Austin. Initially, the project involved only an evaluation of the Frio Formation of South Texas. Later, the geothermal project was expanded to include studies of the Frio Formation and the Vicksburg and Wilcox Groups of the entire Texas Gulf Coast. These later studies, funded by the U.S. Department of Energy, Division of Geothermal Energy, were completed in 1979. As a result of this work, the General Crude Oil Company and U.S. Department of Energy Pleasant Bayou No. 2 geothermal well was drilled in the Austin Bayou Prospect, Brazoria County, to evaluate geothermal resources in the lower Frio Formation. This well demonstrated the existence of large sandstone reservoirs having high formation temperatures, high fluid pressures, and excellent pore properties. Subsequent research addressed the consolidation history and diagenetic

sequences of the sediments, the continuity of deeply buried sandstone reservoirs, and the chemical composition and concentration of geopressured formation waters.

In 1984, several tasks were essentially completed, including a synthesis of data near the Pleasant Bayou well and a regional evaluation of onshore structural styles. Other tasks involved continued investigation of liquid hydrocarbons in overpressured brines and the potential environmental impacts of producing geopressured geothermal fluids.

Liquid Hydrocarbons

Malcolm P. R. Light

A natural convection system was investigated in 1984 as a possible mechanism for introducing aromatics into the geopressured Frio C (Andrau) sandstone at Pleasant Bayou No. 2 test well from the base of a gas cap farther updip. A convective system may also cause the low maturity and diagenesis in this geopressured well. A model was constructed using porosity data, burial history plots, and core porosity-permeability information for geopressured bar sandstones. Calculated fluid velocities indicate that convection may be a possible explanation for the aromatic content in the saline brines. Rough calculations of secondary porosity formation and destruction suggest that time intervals are of the correct order to produce the leaching and diagenesis in the test wells as a result of convective flow. Fluid flow is too slow to produce a measurable reduction in maturity.

In 1984, seven shale samples from four wells were analyzed for thermal maturity in an attempt to fix the regional paleogeothermal gradient in Brazoria County. Reinterpretation of thermal maturity data at Pleasant Bayou indicates that the geothermal gradient has been consistent in the last 25 Ma, but an overmature anomaly exists in the middle and upper Frio. The thermal maturity, porosity, permeability, diagenetic minerals, temperatures, pressures, and salinities of several wells were statistically compared to see if any relation exists between high thermal maturity and other parameters.

Scanning electron microscope studies were made on samples from the lower, middle, and upper Frio sandstones. Intergrown authigenic halite and albite suggest that migrating fluids were hot and saline.

The maturity and age of formation of gasoline-range hydrocarbons in the shales at Pleasant Bayou were estimated. Graphs relating theoretical hydrocarbon maturity to geologic age and depth were drawn and compared to actual and theoretical thermal maturity data for the enclosing shales.

Studies will continue using geochemical, isotope, and structural data of hydrocarbons, fluids, and source and reservoir rocks to quantify more accurately the hydrocarbon migration model.

Resource Assessment and Seismic Studies

Thomas E. Ewing; assisted by Olufemi O. Babalola

This project, funded by the U.S. Department of Energy, is a continuing effort to assess the distribution of producible geopressured geothermal energy on the Texas Gulf Coast. The current phase of this project focuses on the structural evolution of the successive Tertiary shelf margins that created geopressured reservoirs. Understanding the nature of shale-tectonic and salt-tectonic structures will lead to a definition of those areas where structures allowed large geopressured reservoirs to be developed.

In 1984, work was completed on regional assessment of fault geometry and fault compartment size and shape in the geopressured trends of the onshore Texas Gulf Coast. A comprehensive report on structural styles of the Gulf Coast Tertiary has been submitted for publication by the Bureau.

Integration of Geologic and Fluid Data in the Geopressured Gulf Coast Basin

Thomas E. Ewing, Noel Tyler, and Malcolm P. R. Light; assisted by Victor Lombeida

The studies conducted by the Bureau related to geopressured geothermal resources on the Texas Gulf Coast have created a large amount of regional and subregional information on structural style, depositional systems, sandstone petrology and diagenesis, and fluid properties such as salinity, pressure, and temperature. In addition, the drilling of the Pleasant Bayou test well led to a wide variety of studies by many researchers on shale mineralogy, organic geochemistry, vitrinite reflectance, and reservoir continuity and diagenesis. This project, funded by the U.S. Department of Energy, attempts to draw together all of the information for the area surrounding the Pleasant Bayou test well, to analyze its limitations, and to integrate it into a comprehensive geologic history.

In 1984, additional work centered on scanning electron microscope and microprobe analyses of core samples from the test well, and on geochemical analysis of liquid hydrocarbons recovered. Results of the research conducted for this project were presented at the 1984 annual meeting of the Gulf Coast Association of Geological Societies.

Environmental Monitoring of the Pleasant Bayou Test Well

Thomas E. Ewing

A first-order leveling survey was conducted for the Bureau in 1984 by the Meyer Group for the geopressured geothermal research program. The results of this survey will provide a firm baseline for assessing future relative subsidence of the test well area that might be caused by large-volume production of geothermal fluids.

A preliminary examination of the feasibility of precisely surveying the radioactive bullets that were placed in the wells to monitor compaction was also completed.

SPECIAL PROJECTS RESEARCH AND COORDINATION ASSISTANCE

Robert A. Morton, project director

The purpose of this multifaceted project is to assist the U.S. Department of Energy's geopressured geothermal research program by furnishing geological materials and information to other researchers. In 1984, representatives from industry, university, and government research laboratories received sediment samples and electric logs for thermal conductivity measurements, nonproprietary seismic lines for structural interpretations, thin sections for

studies of sandstone diagenesis, water samples and water analyses for studies of subsurface hydrochemistry, seismometers for field monitoring potentially active faults, subsurface maps for calculating aquifer volumes, and shale samples for organic analysis. In addition, numerous requests were received for contract reports that contain the basic data, interpretations, and conclusions relevant to the geology of the Texas Gulf Coast.

NEGATIVE REVISIONS OF NATURAL GAS RESERVES—TEXAS GULF COAST

C. M. Garrett, Jr., project director; C. R. Hocott (The University of Texas at Austin, Department of Petroleum Engineering), R. J. Finley, W. E. Galloway, W. L. Fisher; assisted by Cristina Siqueira, Michael Davis, and Robert Murray

This project, funded by the Gas Research Institute, analyzed the role of negative revisions in the large-scale decline in natural gas reserves that occurred in the Texas Gulf Coast during the late 1960's and most of the 1970's. These negative revisions were so large that they affected national gas reserves.

Interrelated factors that were for the most part unique to the Texas Gulf Coast when they occurred were found to be responsible for the large volume of negative revisions. Principal among these was an overestimation of natural gas reserves that resulted from original optimism encouraged in many cases by market-related incentives. These estimates were not subjected to early critical review and assessment because high reserves to production ratios obscured the underlying weakness in reserves. Water saturation, degree of reservoir heterogeneity, and recovery factors were determined to be significant technical variables; non-technical variables included economic climate and regulatory controls.

Net negative revisions of reserves in the three Gulf Coast districts were greater than in the state as a whole for total gas; Texas Railroad Commission District 4 alone was found to account for 56 percent of the state total. Nonassociated gas, which provides most of the state's total gas production, also suffered most of the negative revisions.

Reserve estimates declared in times of excess supply may not have been confirmed by decline projections and thus provide reason for concern. However, the study concludes that a return of extensive negative revision over the next 10 to 20 years is avoidable provided that technical, economic, and regulatory factors that affect gas reserves continue to be closely monitored.

LOWER CRETACEOUS SHELF-MARGIN CARBONATES—TEXAS GULF COAST

Don G. Bebout, project director; assisted by Julie Kupecz

Cores from wells along the shelf-margin Stuart City Trend are being examined in detail at the Bureau as part of the ongoing project to study the facies, depositional environments, and diagenesis. Results will be used to update earlier studies published by the Bureau.

IN SITU URANIUM LEACHING: GEOLOGICAL ASPECTS

Jonathan G. Price, project director; Long-Cheng Liang; assisted by Patricia Bobeck (The University of Texas at Austin, Department of Geological Sciences)

Mineralogical, geochemical, and hydrological aspects of in situ leaching of uranium were investigated as part of a project with the Department of Petroleum Engineering, The University of Texas at Austin. The project was completed in 1984. Results of pilot studies of a new leaching solution at a South Texas mine were reported in a Society of Mining Engineers preprint for the 1984 annual meeting. Uranium phases identified by electron microscopy and microanalysis were discussed at the 1984 annual meeting of the American Association of Petroleum Geologists. An article describing the geological and mineralogical features that were causes of low recovery at one South Texas mine appeared in the journal *Uranium*. The project was funded in part by the Texas Mining and Mineral Resources Research Institute.

LAND AND ENVIRONMENTAL RESOURCES INVESTIGATIONS

TEXAS SALT DOMES

S. J. Seni, project director; H. S. Hamlin and W. F. Mullican III

Texas salt domes are being considered for the ultimate disposal of toxic chemical wastes in solution-mined caverns. The suitability of these domes, in both general and specific cases, is being evaluated to ensure that neither human intrusion nor natural geologic processes could result in leakage of these wastes to the land surface or into the valuable ground-water resources. Unlike nuclear wastes, some of these wastes will not eventually degrade to nontoxic compounds. The Texas Department of Water Resources is the State agency that issues permits for disposal of toxic chemicals. The Department is funding this research to determine whether the disposal of toxic chemicals in salt domes is technically feasible and what type of guidelines should be established to regulate the practice.

Two critical issues must be addressed: (1) Can the wastes be safely and permanently contained within a salt dome? and (2) If toxic wastes were to leak from a dome, what path would they follow, and would they contaminate the biosphere?

Phase I of this project has been completed. The following documents have been submitted to the Texas Department of Water Resources: (1) Computerized inventory of data on Texas salt domes, (2) Texas salt domes: natural resources, storage caverns, and extraction technologies, and (3) Technical issues for chemical waste isolation in solution-mined caverns in salt domes. Phase II, which was completed at the end of the year, addresses three

main areas: (1) near-dome structure and stratigraphy, (2) physical properties of rock salt, with emphasis on mechanical properties, and (3) geology and geohydrology of cap rocks and cap-rock lost-circulation zones. Critical information on the timing and rates of dome growth, the volumes of salt flow, and the potential for future growth or stability is available through careful analysis of the influence of dome growth on surrounding strata. Such an analysis of post-Oligocene strata around Boling salt dome indicates that dome growth rates were between 16 m/Ma and 309 m/Ma over the past 22.5 Ma.

SOUTHWEST TEXAS RIVER BASINS REGIONAL STUDY

E. G. Wermund and Thomas C. Gustavson, project directors; Richard L. Dillon and David M. Ridner, cartographers

This long-term project is a comprehensive environmental geologic analysis of 30,558 mi² (79,145 km²) of the Nueces, San Antonio, Guadalupe, and Lavaca River basins of South Texas. The project was initiated in June 1972 under a contract with the Texas Water Development Board (now Texas Department of Water Resources). That contract continued through August 1975; thereafter, the Bureau has supported completion of all remaining work.

Results of this program include a series of maps that were hand-colored on scribed plastic base maps. The bases are reproductions of the standard Army Map Service topographic maps (scale 1:250,000). The hand-colored series includes maps of (1) environmental geology, (2) physical properties, (3) active processes, (4) biologic assemblages, and (5) land use. Environmental geologic maps are compiled at a scale of 1:125,000; all other map types are presented at a scale of 1:250,000.

Maps of environmental geology and land use represent original mapping. For the biologic assemblage map, the assemblages were identified in the field, and their boundaries were located in general conformity to environmental geologic boundaries. Maps of active processes and physical properties were derived directly from the environmental geologic map.

Environmental geologic units were mapped initially on standard topographic sheets (scale 1:24,000) or on black-and-white, controlled aerial photomosaics. Land use was interpreted from 1973 color-infrared aerial photographs (scale 1:120,000).

All the hand-colored maps, topographic maps (scale 1:24,000), and controlled photomosaics showing original compilation that were prepared during the project are on file at the Bureau and are available for study.

In 1984, the final editing of the maps of the Seguin West and San Antonio East areas was completed. Cartographic revisions and publication of these two 1-degree map sets are expected in 1985.

EVALUATION OF THE BASIN AND RANGE PROVINCE FOR THE SUITABILITY OF GEOLOGICAL AND HYDROLOGICAL ENVIRONMENTS FOR ISOLATION OF HIGH-LEVEL RADIOACTIVE WASTES

Christopher D. Henry, project director; Jonathan G. Price; assisted by Rebecca C. Smyth

This study of the Basin and Range province, done in conjunction with the U.S. Geological Survey (USGS) and states of the Basin and Range, was completed in September 1984. The purpose was regional screening of the province for potential high-level-waste isolation sites. The Texas part of the project has focused on characterization of geology and hydrology in the Trans-Pecos region. Reports and maps from the project are being published by USGS, and subjects include (1) mineral resource areas, (2) distribution of potential host rocks, including intrusive rocks, tuffs, and basalts, (3) ground-water flow systems and regional hydrology, and (4) tectonic conditions. A series of regional cross sections in the Trans-Pecos area (scale 1:250,000) will be placed on open file at the Bureau. A summary report, to be published as a USGS Professional Paper, is in press; it will discuss the overall geological and hydrological characteristics of the Basin and Range in Trans-Pecos Texas as they bear on waste isolation.

MINERAL RESOURCES INVESTIGATIONS

MAGMA GENERATION, MAGMA EVOLUTION, CALDERA DEVELOPMENT, AND ORE DEPOSITION

Christopher D. Henry, project director; Jonathan G. Price, Long-Cheng Liang, and Steven W. Tweedy; assisted by Rebecca C. Smyth and Jeffrey N. Rubin

Certain types of ore deposits are clearly associated with the generation and geochemical evolution of magmas. In West Texas, associations with molybdenum, tin, tungsten, beryllium, and fluorine have been recognized. Fundamental questions regarding the origin of igneous rocks of the region are being addressed through field mapping, petrologic studies, and geochemical analyses of rocks and individual minerals. The research is funded by the Texas Mining and Mineral Resources Research Institute.

By volume, most of the igneous rocks of the region were extruded from or intruded into calderas. Numerous mineral deposits formed within and near the calderas. An article on the variability of caldera development in Texas was published in 1984 in the *Journal of Geophysical Research*. Extent of hydrothermal activity and size of ore deposits may be in part a function of the size of the caldera. Several ore deposits occur in the Chinati Mountains caldera, the largest (30 km in diameter) in the region, whereas none have been found in the Van Horn Mountains caldera, the smallest (4 km). A Report of Investigations on the geology of the Van Horn Mountains caldera is expected to be published by the Bureau late in 1985 and will complement the report on the Chinati Mountains caldera published in 1983, *Oligocene Volcanism and Multiple Caldera Formation in the Chinati Mountains, Presidio County, Texas*.

Magma generation and evolution are being studied in the Infiernito caldera, where apparently three cycles of differentiation and eruption occurred. Initial results were

David Wark

Bureau researchers enter the Black Hill mine to examine and sample silver veins that formed near the margin of the Eagle Mountains caldera.

presented at the annual meeting of the Geological Society of America. The chemical and thermal evolution of one cycle of lavas has been investigated in detail by examining whole-rock and trace-element geochemistry and chemical compositions of phenocrysts. Fractional crystallization appears to be the most likely process to have yielded the magma chamber compositionally zoned from 62 to 75 percent SiO_2.

Intrusive rocks of the Marble Canyon stock are being studied because they may provide clues concerning the magmatic evolution that gave rise to the nearby Cave Peak molybdenum deposit. The stock exhibits unusual compositional zonation from a nepheline-bearing basic rock to a quartz-bearing acidic rock. A combination of magma mixing and fractional crystallization appears to be necessary to generate the rocks of intermediate composition.

GOLD-POOR HYDROTHERMAL SYSTEMS

Jonathan G. Price, project director; Christopher D. Henry; assisted by Allan R. Standen and Mark R. Ulrich

Hydrothermal veins associated with mid-Tertiary volcanism in Trans-Pecos Texas are typically silver-rich and gold-poor relative to comparable epithermal veins in other parts of the world. Research, supported by the Texas Mining and Mineral Resources Research Institute, is being conducted to determine why these veins are depleted in gold and what implications the origin of the veins might have on exploration for silver and gold in general. Lithogeochemical studies of unaltered, unmineralized igneous rocks from Texas and elsewhere will test the hypothesis that source-rock geochemistry can be a useful exploration tool.

Preliminary results of this research were presented at the 1984 annual meeting of the Geological Society of America. Studies of vein mineralogy, wall-rock alteration, and fluid inclusions indicate that the physical and major-element chemical conditions of vein formation in Texas were similar to those of gold-rich epithermal systems elsewhere in the world. Results of limited analyses of fresh igneous rocks suggest that the igneous rocks were the sources of the metals in the veins and that they are depleted in gold relative to average igneous rocks.

STATE OF STRESS WITH TIME AND RELATION TO ORE DEPOSITION

Christopher D. Henry, project director; Jonathan G. Price; assisted by Sean T. Conlon and Rebecca C. Smyth

Research in the Trans-Pecos region has revealed that stress orientations changed dramatically during the Tertiary Period, when most of the metallic mineral deposits of the region were formed. Changing stress orientations record major plate-tectonic readjustments that affected North America. Certain types of ore deposits appear to be favored during particular tectonic episodes. Current research in Texas, supported by the Texas Mining and Mineral Resources Research Institute, is focusing on potassium-argon dating and geochemical and structural analysis of dikes to determine better the state of stress and related tectonic setting as a function of time. Dikes from the Rim Rock region, Black Gap area, and Big Bend National Park are being studied.

Initial results, published in 1984 in the journal *Geology*, indicate that most of the epithermal veins in the Trans-Pecos region, which are typically small, formed during a time of compression, whereas many large epithermal veins in the Western United States formed in the Basin and Range province during a time of extension. Research is underway to examine the relation between the state of regional stress and the size of vein deposits on a worldwide basis. This research may lead to new exploration concepts involving sizes of exploration targets, preferred orientations of veins, and regional tectonic history.

A tectonic map of Trans-Pecos was an outgrowth of this project. The map and an accompanying text are planned for publication by the Bureau in 1985.

MINERALIZATION IN TRANS-PECOS TEXAS: ORE DEPOSITS IN CLASTIC SEDIMENTARY ROCKS

Jonathan G. Price, project director; Christopher D. Henry, Steven W. Tweedy, Allan R. Standen, and Jan S. Posey.

A Report of Investigations on the silver-copper-lead deposits in Precambrian, Permian, and Cretaceous red-bed sequences of Trans-Pecos Texas is scheduled for publication in 1985. The research, funded by the Texas Mining and Mineral Resources Research Institute and completed in 1984, involved geologic mapping, structural analysis, mineralogical and fluid-inclusion studies, and chemical analyses. The report focuses on the origin of the deposits. Unlike most silver-lead deposits in the Trans-Pecos region, silver-copper-lead deposits are not clearly associated with Oligocene igneous activity. Unlike many copper-silver deposits in red beds, these deposits probably formed much later than sedimentation and diagenesis. The Texas deposits in host rocks of different ages share common structural and geochemical characteristics. They probably formed during Miocene or younger Basin and Range extension.

THE BARITE INDUSTRY AND RESOURCES OF TEXAS

J. Richard Kyle (The University of Texas at Austin, Department of Geological Sciences), principal investigator

This project, funded by the Texas Mining and Mineral Resources Research Institute, is a study of economic aspects of the barite industry and geology of barite resources, with emphasis on Texas. Texas has a strong barite-processing industry that produces ground barite for use in drilling

fluids in the Gulf Coast and elsewhere, but in-state primary barite production has been insignificant. The geologic setting of several barite occurrences in Texas suggests the potential for substantial barite-rich ores, but known in-state deposits are not large enough or of commercial grade to compete with present domestic and foreign sources. A report on this project is planned for publication late in 1985.

NONPETROLEUM MINERAL PRODUCERS LIST

Mary W. McBride

Information regarding the nonpetroleum mineral industry in Texas in late 1983 and 1984 is on file at the Bureau. Changes in the list of producers should be incorporated into the computer data base during early 1985.

BASIN STUDIES

GEOLOGICAL AND GEOHYDROLOGICAL INVESTIGATIONS IN THE TEXAS PANHANDLE

E. G. Wermund, project director; Thomas C. Gustavson and Charles W. Kreitler, principal investigators

Since 1977, the Bureau has been conducting extensive geological and geohydrological research in the Texas Panhandle, chiefly in the Palo Duro Basin. This research has been conducted under a University of Texas contract with the U.S. Department of Energy (DOE) as a part of DOE's nationwide investigation of potential nuclear waste repositories. Bureau research has been coordinated with the Nuclear Waste Programs Office of the Governor's Office - General Counsel, and results are made available to the public through Bureau publications.

During 1984, research principally involved the analysis of previously collected data. Previous years of active field work involved drilling, coring, logging, testing, and seismic reflection surveys that resulted in an extensive and complex data base. These data have been analyzed intensively for regional interpretations designed to answer a variety of critical questions.

Surficial and Geomorphic Studies

T. C. Gustavson, J. R. DuBar, W. W. Simpkins, R. W. Baumgardner, Jr., S. C. Caran, M. D. Machenberg, and D. A. McGookey; assisted by D. Robinson-Poteet, R. G. McMurry, R. M. Myers, and E. Thorakos

Research addressing surface and near-surface problems in 1984 was concentrated on the effect of evaporite dissolution on the origin and evolution of drainage systems in the Panhandle region. Interrelationships among basement structure, dissolution sites, and thickness of Quaternary deposits were documented by various techniques and data sources. Long-term research continued on the interrelationship of rainfall and erosion at the Buffalo Lake National Wildlife Refuge. Formation of drainage basins and landscape development around the High Plains were analyzed by morphometric techniques and distribution of drainage density. Recognition of well-developed buried soils in Lubbock County similar to the paleosol beneath the 0.6 Ma Lava Creek "B" ash in Swisher County showed that deposition of eolian sand was not restricted to Illinoian time but was episodic during the Pleistocene.

Robert W. Baumgardner, Jr.

Quaternary sediments cropping out along Los Lingos Creek, Floyd County, Texas, have been studied to determine rates and environments of deposition in the western Rolling Plains.

Structural Geology and Tectonics

T. C. Gustavson, R. T. Budnik, and E. W. Collins; assisted by J. D. Corrigan and T. M. Simmons

During 1984, reprocessing of seismic data provided by DOE permitted more precision in locating faults in the basement and in pre-San Andres rocks in the Palo Duro Basin. The data also confirmed that the basement comprises at least 30,000 ft of undeformed volcanic sequences. Fracture studies using outcrop, cores, and geophysical logs indicated that stress regimes changed following fracturing of Triassic strata. Fractures in cores from Oldham, Deaf Smith, and Swisher Counties reflect salt dissolution.

Stratigraphy and Sedimentology

T. C. Gustavson, S. C. Ruppel, M. A. Fracasso, R. D. Conti, T. C. Greimel, M. J. Herron, S. D. Hovorka, D. A. Johns, and H. S. Nance; assisted by O. O. Babalola and T. M. Lemmer

In 1984, stratigraphic studies shifted toward analyses of post-Triassic strata, but some work was directed at definition of the Pennsylvanian-Permian boundary in the Palo Duro Basin and correlation of Upper Mississippian rocks with those in the Hardeman Basin. Studies of the porosity of the Wolfcamp "Brown Dolomite" in shelf and shelf-edge facies continued, and the Wolfcamp-Wichita contact was reviewed.

Extensive analysis of the San Andres was designed to clarify the nature and extent of cyclic sequences. Regionally extensive cycles document tectonic stability and the areal distributions of paleoenvironments influenced by the interplay of eustasy, subsidence, and sediment influx. Local, recurrent thickness anomalies in San Andres/Blaine strata in Potter County coincide with structural anomalies and indicate that the Amarillo Uplift was active during deposition. Similar studies of the Queen and Grayburg Formations and preliminary research on the Dockum Group were part of the 1984 research program.

Analyses of geophysical logs supported stratigraphic and hydrologic research in the Palo Duro Basin. Crossplotting neutron- and density-porosity data was the basis of porosity analysis of Wolfcamp carbonates, and the results were verified with laboratory tests.

Hydrogeology and Hydrochemistry

C. W. Kreitler, A. R. Dutton, R. S. Fisher, Z. S. Lin, R. Nativ, W. W. Simpkins, E. D. Orr, H. H. Posey, B. C. Richter, R. K. Senger, and D. A. Smith; Clara L. Ho, Steven W. Tweedy, Cynthia A. Mahan, Judith A. Mazoh, and Long-Cheng Liang (Mineral Studies Laboratory); assisted by M. S. Akhter, J. B. Chapman, R. P. Brock, H. E. Dunbar, and G. N. Gutierrez

Considerable progress was made during 1984 on development of a conceptual hydrologic model of the Palo Duro Basin. Three principal hydrogeologic units recognized are the shallow Ogallala and Dockum aquifers, the Permian evaporite aquitard, and the deep confined, underpressured Permian and Pennsylvanian brine aquifer. Computer modeling of the deep-brine aquifer verified that flows within the permeable Wolfcamp rocks and within Pennsylvanian granite wash near the Amarillo Uplift are the key components and that selection of proper permeability values is critical for proper flow modeling. Underpressuring probably results from drainage by highly permeable granite wash and by discharge of water along the Pecos River that would otherwise move into the deep-brine system. Cross-sectional and areal modeling of regional ground-water flow and use of oxygen and hydrogen isotopic composition and Cl/Br ratio suggest that the Permian evaporite aquitard apparently supplies about 25 percent of the deep-brine water by leakage through matrix or fracture flow. Ground-water travel time in the deep aquifer is between 1.2 and 4 Ma. The chemical composition of the brines is related to lithology of the aquifer, whereas variations in oxygen isotope values are related to possible leakage through the evaporite strata. Brines sampled in the western and northern parts of the basin remain unequilibrated isotopically, evidence of mixed young and old waters. Studies of fresh-water and salt-water heads in the Hardeman Basin indicate a potential for mixing and discharge at the surface.

Studies in 1984 show that the salt-dissolution zone around the Palo Duro Basin exhibits moderate hydrologic conductivity and that it is confined. Dissolution results from solution of halite by young meteoric waters. Water in the Dockum Group moves through coarse clastic rocks in directions controlled by topography.

Considerable attention was given to determining accurately the water content of halite in the potential host salt units of the San Andres Formation. Soxhlet extraction and Karl-Fischer titration were used to measure the intergranular water of 149 samples. Mean water content of halite samples with less than 10 percent impurities is 0.4 ± 0.2 weight percent. Clay or mudstone impurities increase the value significantly. The fraction of total water in pure salts of intergranular versus intragranular origin could not be predicted.

Core Analyses and Petrology

T. C. Gustavson, S. C. Ruppel, S. P. Dutton, S. D. Hovorka, H. S. Nance, and S. F. J. Thomas; assisted by B. A. Luneau, L. A. Elliott, P. M. Granger, G. N. Gutierrez, P. M. Hester, V. D. Northen, C. D. Salinas, and J. N. Vogt

Petrographic analysis of Pennsylvanian and Wolfcampian granite wash from cores in Deaf Smith and Donley Counties identified a variety of diagenetic fabrics. Extensive alteration of arkosic sandstones in the Palo Duro Basin confirms the enhancement of secondary porosity by dissolution of feldspars.

During 1984, intensive study of halite of San Andres unit 4 addressed detailed lateral correlation of 0.5- to 4-m-thick anhydritic and muddy halite zones among the DOE-cored wells in the Palo Duro Basin using three regionally extensive, thin, primary anhydrite beds. The anhydrite beds were inferred to represent rapid, short-duration marine transgressions, and hence, they may be correlative and approximately isochronous. Detailed fabric analysis resulted in scenarios to explain primary sedimentary structures in halite and anhydritic halite and secondary processes evidenced by corrosion surfaces, various stages of recrystallization textures, and karst pits beneath mudstone beds.

Mudstone/halite mixtures reflect complex processes of primary depositional interbedding, displacive growth of halite in mud, and karst collapse into bedded halite. These studies of mudstone/halite fabrics, as well as the textures of halite and anhydritic halite provide the basis for recognizing the myriad primary and early/late diagenetic processes responsible for the present variations in the evaporite units.

Analysis of the Alibates Formation using cores from eight DOE wells defined two transgressive-regressive cycles composed of five diagenetically altered lithic types. Similarly, core of the Queen and Grayburg Formations from Oldham County records alternating transgressive, hypersaline mud flat and regressive, prograding eolian flat, dune, and interdune environments fringing an episodic evaporite basin.

EXPERIMENTAL MODELING OF SALT DOMES

Martin P. A. Jackson and Christopher J. Talbot (University of Uppsala, Sweden), project directors; assisted by Reinold Cornelius and Ronald Arvidsson (University of Uppsala).

Structural geologists understand little of the internal structure of salt stocks. Yet salt diapirs are one of several types of rock body being considered by the National Waste Terminal Storage program as hosts for storage of high-level nuclear waste. The structural geology of salt domes contributes to important practical aspects such as rock mechanics and fabrics, in situ stresses, the mapping of inclusions of leaky country rock, and prediction of diapir shape at depth. This study, funded by the U.S. Department of Energy, aims at a better understanding of the internal structures and external shapes of salt domes in general. Resulting information could guide the detailed exploration of any salt dome selected as a repository for nuclear waste.

The study began in January 1984 and is built around eight weeks of intensive experimental modeling at the Hans Ramberg Tectonic Laboratory at the University of Uppsala in Sweden. Of 33 experiments, 30 were conducted in a centrifuge under artificial acceleration generally equivalent to 1,200 times that of normal gravity. Most model diapirs, which developed in layered mixtures of silicone putty and modeling clay, were dynamically scaled to resemble their natural analogs in the U.S. Gulf Coast. The experiments were designed to elucidate four aspects: (1) internal structure revealed by passive marker layers; (2) effects of downbuilding (syndepositional diapir growth beneath aggrading cover) versus upbuilding (postdepositional diapir growth beneath static cover); (3) differential loading, especially by prograding cover; and (4) large-scale movement cells and the relation between diapiric jets and diapiric walls.

The internal structure is being analyzed from enlarged images of vertical and horizontal slices through the models. This analysis shows that the internal structure of even the simplest model domes is complex. Infolded overhang floors, downfolded peripheral lobes, spurs, vortices, and multistalked and multicapped diapirs have been recognized. Concurrently with model analysis, natural examples of these features are being searched for and complemented with theoretical work on flow dynamics and energy budgets of diapirism.

GULF COAST STRATIGRAPHIC NOMENCLATURE

Thomas E. Ewing, project director

The goal of this project is to compile a user-oriented packet of charts and text to summarize Texas Gulf Coast stratigraphy. This packet will include Cenozoic and Mesozoic time scales, correlation charts, and a lexicon of stratigraphic terms with suggested usage.

Stratigraphic nomenclature in the Gulf Coast area has been confusing and inconsistent. Major difficulties have arisen, both because of mixing of biostratigraphic, chronostratigraphic, and lithostratigraphic usages and because of poor correlations of surface and subsurface data. Recent genetic stratigraphic studies at the Bureau and elsewhere have often used informal nomenclature. This project attempts to reconcile genetic stratigraphic units and formal nomenclature within the guidelines of the *North American Code of Stratigraphic Nomenclature*. Information has been compiled on data sheets, from which a final report will be constructed in 1985.

STRUCTURE AND TECTONICS OF THE WEST TEXAS BASIN

Thomas E. Ewing, project director

Regional structure mapping on deep horizons within the West Texas Basin was undertaken as an aid to compilation of the *Tectonic Map of Texas*. As a result, the large data base of the University of Texas Lands Office in Midland has yielded a comprehensive map at a scale of 1:250,000 of the major deep structural features of this oil- and gas-rich basin. This mapping, along with construction of cross sections and evaluation of previous structural and tectonic models, will lead to a tectonic synthesis for the basin. In addition, eight structure maps at a scale of 1:250,000 have been submitted for Bureau publication to assist other geologists interested in the region.

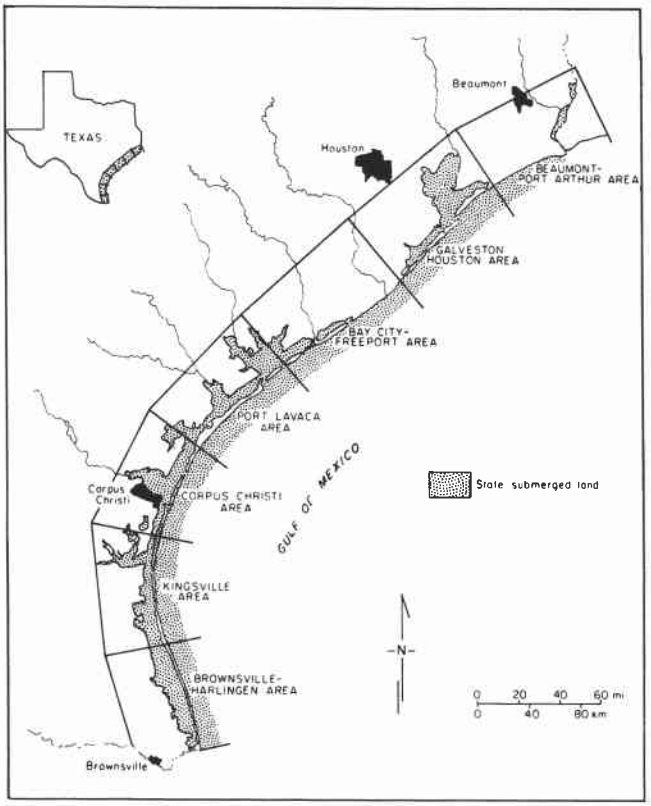
COASTAL STUDIES

SUBMERGED LANDS OF TEXAS—SEDIMENTS, GEOCHEMISTRY, BENTHIC MACROINVERTEBRATES, AND ASSOCIATED WETLANDS

E. G. Wermund, project director; William A. White, principal investigator; Thomas R. Calnan, chief biologist; Robert A. Morton and H. Seay Nance; assisted by Barbara Hartmann and Richard L. Dillon, cartographers; Steven W. Tweedy, chemist; and Daniel Ortuño, sedimentology lab technician

This multiphase study of Texas coastal submerged lands and associated wetlands encompasses the entire coast from Sabine Pass to the Rio Grande. It is based primarily on a completed, detailed sampling effort in which more than 6,500 benthic sediment samples were collected at 1-mi centers in the bay-estuary-lagoon and inner continental shelf systems. During 1984 this project was funded, in part, by the Minerals Management Service, U.S. Department of the Interior.

Results of the submerged lands project are being published in a series of seven atlases of the Texas coast. Map areas are similar to those used in the Bureau's *Environmental Geologic Atlas of the Texas Coastal Zone* series. Each atlas consists of a series of 17 maps, with accompanying text, depicting sediment distribution, concentrations and distribution of selected trace and major elements, and distribution of benthic macroinvertebrates and wetlands. The first submerged lands atlas, of the Corpus



Seven areas along the Texas coast selected for study in the Submerged Lands of Texas project.

Christi area, was published in early 1984; contract reports of the Galveston-Houston and Brownsville-Harlingen areas were completed later in the year.

During 1984, supplementary sediment analyses were conducted by the Bureau's sedimentology laboratory for the Brownsville-Harlingen, Beaumont-Port Arthur, and Bay City-Freeport areas. The additional analyses of approximately 90 sediment samples will help to determine the relationship between sediment and trace-metal distribution patterns on the inner continental shelf. Results of sedimentological and geochemical data are entered into computer files for bivariate correlation analysis of bay-estuary-lagoon and inner-shelf systems. These analyses were completed for the Brownsville-Harlingen and Beaumont-Port Arthur areas in 1984.

Biological analyses are complete for all areas of the Texas coast. Data were processed by computer for cluster analyses to help delineate macroinvertebrate assemblages and for species diversity. Hand-colored maps of the results have been prepared for the Galveston-Houston, Brownsville-Harlingen, Beaumont-Port Arthur, and Bay City-Freeport map areas. Among the eventual products of the biological analyses will be full-color maps (scale 1:125,000) showing the distribution of macroinvertebrate assemblages and species diversity.

Delineation of wetlands continued during the year. The objective is to produce full-color updated regional maps of wetlands distribution. Photographic interpretation and delineation of wetlands were completed for the Brownsville-Harlingen, Galveston-Houston, and Beaumont-Port Arthur areas. Cartographically scribed blackline prints were also completed for these areas, as were hand-colored maps. In addition, a color-separated proof of wetlands and benthic macroinvertebrates in the Galveston-Houston area was prepared for review.

COASTAL CHANGES ASSOCIATED WITH HURRICANE ALICIA

Robert A. Morton, project director; Jeffrey G. Paine; assisted by James A. DiGiulio and David J. Adilman

Although Hurricane Alicia was not an extreme storm by meteorological standards, it caused substantial property damage, eroded the beach, and caused landward retreat of the vegetation line along the upper Texas coast. Especially hard hit was west Galveston Island, which experienced Alicia's highest winds and largest waves.

This study, partly funded by the Texas Office of the Attorney General, provided measurements of the changes along the Gulf shoreline caused by the storm and an analysis of the physical processes that caused those changes. Primary data prepared for the study during 1984 include maps of the vegetation lines shown on aerial photographs before and after Alicia, as well as field observations and ground measurements. A second part of the study dealt with post-storm processes and the potential recovery of the beach and adjacent environs in both developed and undeveloped areas. Of particular interest are the magnitude and rate of natural recovery of the vegetation line following hurricanes in 1942, 1961, and 1980 and following Alicia. During the first year after Alicia, the forebeach recovered considerably, but the backbeach was still substantially lower than before the storm. A better understanding of the rapid shifts in coextensive geological and legal boundaries will be achieved by studying beach response after major storms in Texas.

GEOLOGIC MAPPING

GEOLOGIC MAP OF TEXAS

Virgil E. Barnes, project director; Dan F. Scranton, cartographer

The preparation of a new geologic wall map of Texas began in May 1978. This map will be published in four quadrants at a scale of 1:500,000 and will replace the U.S. Geological Survey's *Geologic Map of Texas*, which was published in 1937 and has been out of print for many years.

The new map is being derived from the *Geologic Atlas of Texas* map sheets (scale 1:250,000). Scribing is complete for the four quadrants.

GEOLOGIC ATLAS OF TEXAS

Virgil E. Barnes, project director; L. F. Brown, Jr., and Tucker F. Hentz; Richard L. Dillon, Dan F. Scranton, and Thomas M. Byrd, cartographers

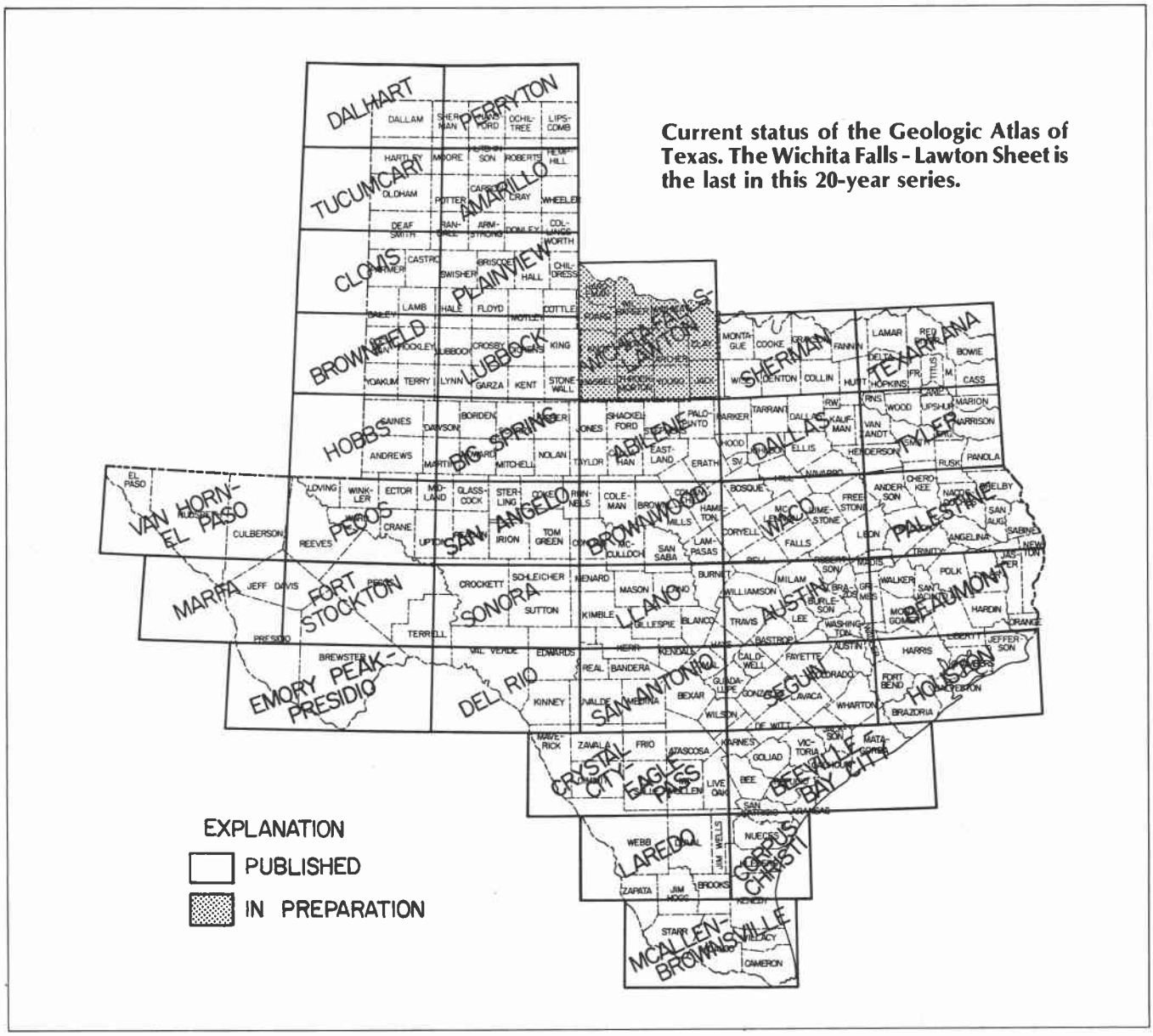
A geologic map of Texas showing the distribution of outcropping rock units is being published as a series of separate sheets. Each sheet is printed in full color on a topographic base at a scale of 1:250,000 (1 inch equals about 4 mi). Most of the map sheets depict areas within 1 degree of latitude and 2 degrees of longitude, but some sheets cover larger or smaller areas to accommodate cartographic presentation. When completed, the *Geologic Atlas of Texas* will consist of 38 map sheets depicting all of Texas and parts of adjacent states.

The Dalhart Sheet, published during 1984, brings to 37 the number of sheets completed. Scribing has been finished for the final sheet of the series, the Wichita Falls-Lawton Sheet. Field work for that sheet was done by Tucker F. Hentz under the supervision of L. F. Brown, Jr.

Revision of geologic atlas sheets continues; however, none were reprinted this year. Sheets that are being revised for reprinting include the Abilene, Beaumont, Beeville-Bay City, Big Spring, Dallas, Emory Peak-Presidio, Lubbock, Palestine, Perryton, Sherman, and Tyler.

TECTONIC MAP OF TEXAS

Thomas E. Ewing, project director; Martin P. A. Jackson, Christopher D. Henry, Roy T. Budnik, Stephen C. Ruppel, Charles M. Woodruff, Jr., William R. Muehlberger (The University of Texas at Austin, Department of Geological Sciences), James R. Garrison (consultant, Arlington, Texas), Richard L. Nicholas (Shell Oil Company, Houston, Texas), and Arthur G. Goldstein (Colgate University, Hamilton, New York); assisted by Stephen E. Lovell and Melissa A. Sandstrom



The last systematic statewide compilation of structural and tectonic information was by E. H. Sellards in the 1940's. Since then, much new surface and subsurface information has been acquired, and the concepts of tectonic mapping have advanced. This project will incorporate these new data in a detailed display of surface and subsurface structural history for the state and adjoining areas of New Mexico, Oklahoma, Mexico, and the Gulf of Mexico. The map will be constructed at a scale of 1:750,000, in full color, showing exposed lithotectonic units in areas of surface structure, and contours on selected deep horizons in areas of subsurface structure. Inset maps will show gravity, magnetics, and basement terranes and/or radiometric provinces. A companion illustrated text will both describe systematically and synthesize the Proterozoic to the Recent tectonic evolution of Texas.

A final draft copy of the tectonic map was prepared, after an extensive review process, in early 1984. It is now in cartographic preparation; scribing and color separation will be underway during 1985. An extensive set of sections with 1x and 5x vertical exaggerations and 1:750,000 horizontal scale is also being compiled to accompany the map and text.

GRAVITY AND MAGNETIC MAPPING OF TEXAS

G. R. Keller (The University of Texas at El Paso, Department of Geological Sciences) and C. L. V. Aiken (The University of Texas at Dallas, Department of Geological Sciences), project directors

Gravity and magnetic maps of Texas are being prepared at a scale of 1:250,000 to complement the surface-geology maps of the *Geologic Atlas of Texas* series. The project involves considerable computer reprocessing, compilation, and cartography. Gravity (Bouguer) maps are being prepared by combining the results of many different surveys, many of which have been provided by the U.S. Department of Defense, into a single datum. These gravity data are then smoothed with a high-order polynomial surface. Gravity maps of the following quadrangles are in cartographic preparation: Clovis, Plainview, Amarillo, Tucumcari, Perryton, Dalhart, Brownfield, and Lubbock.

Magnetic maps are being prepared using National Uranium Resource Evaluation (NURE) aeromagnetic surveys. The U.S. Department of Energy in Grand Junction, Colorado, is cooperating with the Texas program by reprocessing NURE data as required to develop integrated statewide contour maps. Individual maps will be published over the next several years as each is completed.

OTHER RESEARCH

SITE SELECTION FOR SUPER-CONDUCTING SUPER COLLIDER FACILITY

L. F. Brown, Jr., and Priscilla Nelson (The University of Texas at Austin, Department of Civil Engineering), coordinators; Edward W. Collins and Mary L. W. Jackson; assisted by Steven Glaser (Department of Civil Engineering), John Worrall, and Francis Fong (Department of Civil Engineering)

This project involved preliminary evaluation of possible sites for a large high-energy particle research facility in Texas. The project was designed to determine the economic and technical feasibility for an advanced particle accelerator research facility in Texas in response to a search by the U.S. Department of Energy for a national laboratory site. Location of an appropriate site could lead to a formal proposal by the State of Texas for consideration as a site for the proposed national particle research laboratory.

The Bureau coordinated the Geologic and Geotechnical aspects of the program, which were assigned to The University of Texas at Austin. Dr. Richard Phelps and Dr. Carl Norman, University of Houston, and Dr. Christopher Mathewson and graduate student Dale Conover, Texas A&M University, contributed geotechnical information on the Houston area sites and the east-central Texas area site, respectively. Tunnel Design and Costing, Socioeconomics, and Systems Analysis were coordinated by Texas A&M University, Rice University, and the University of Houston, respectively.

Geologic, hydrologic, topographic, and engineering studies were designed to evaluate six potential sites in Texas. The SSC facility requires geologic and engineering characteristics that will permit excavation of a ring-shaped tunnel 10 ft in diameter at least 30 ft below the land surface. Circumference of the SSC ring may range from 60 to 100 mi.

The project was conducted from September through December 1984. Generic sites evaluated included two Houston area sites, two Central Texas sites, a Dallas-Fort Worth area site, and a West Texas site. Circular cross sections were prepared of typical SSC ring locations in each generic area, including lithologic, hydrologic, and structural information based on outcrops and subsurface data. Engineering parameters for typical tunnel segments and shafts were based on information from dam site cores and other sources. Resulting geotechnical/geologic information was supplied to the Tunnel Design and Costing group at Texas A&M University for cost analysis. A final report of the Geology and Geotechnical group was completed at the end of the year.

CRETACEOUS VOLCANISM IN TEXAS

Thomas E. Ewing, project director; S. Christopher Caran

This project aims to supply a regional context for the distribution of middle to Upper Cretaceous igneous rocks along the Balcones trend of South and Central Texas on the basis of integrated surface mapping, subsurface core

description, and geophysical interpretation. Continued cooperation with companies and individuals actively prospecting for volcano-related hydrocarbon reservoirs has allowed a much better understanding of models for Late Cretaceous volcanism. A Geological Circular summarizing this magmatic event is in preparation. A paper on the regional setting of the Late Cretaceous magmatism and uplift of the Monroe Disturbance was presented at the 1984 annual meeting of the Geological Society of America.

COMPOSITION AND ORIGIN OF TEKTITES
Virgil E. Barnes, project director

This long-term study of tektites and meteorites began in 1935 and has resulted in 66 publications. The tektite collection and associated materials were inventoried during the year. Otherwise, during 1984 the project was mostly curatorial—furnishing material for other researchers, answering questions, and identifying specimens.

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 University of Texas contracts and grants with Federal, State, and local agencies and with other 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 1984, the following 21 contracts, each of which had reporting requirements, were active at the Bureau:

Federal

"Computerized Calculation of Lignite Resources in Texas": supported by the U.S. Geological Survey, U.S. Department of the Interior.

"Consolidation of Geologic Studies of Geopressured Geothermal Resources in Texas": supported by the U.S. Department of Energy.

"Environmental Geologic Atlases of the Texas Coastal Zone": supported by the Minerals Management Service, U.S. Department of the Interior.

"Geological Framework and Energy Resource Studies, Texas Continental Shelf": supported by the Minerals Management Service, U.S. Department of the Interior.

"Geologic Studies of West Texas Bedded Salt Deposits": supported by the U.S. Department of Energy.

"Printing Environmental Maps of Texas": supported by the U.S. Geological Survey, U.S. Department of the Interior.

"Studies Related to Continental Margins": supported by the Minerals Management Service, U.S. Department of the Interior.

"A Study Designed to Identify Geohydrologic Environments Suitable for Isolation of High-Level Radioactive Waste from Man's Environment": supported by the U.S. Geological Survey, U.S. Department of the Interior.

"Texas Mining and Mineral Resources Research Institute—Fifth, Sixth, and Seventh Allotments, Scholarship and Fellowship Grants": supported by the Bureau of Mines, U.S. Department of the Interior.

"United States Gulf Coast Geopressured Geothermal Program": supported by the U.S. Department of Energy.

"United States Gulf Coast Geopressured Geothermal Program: Consolidated Research Program": supported by the U.S. Department of Energy.

State

"Examination of Texas Salt Domes as Potential Sites for Permanent Storage of Toxic Chemical Wastes": supported by the Texas Department of Water Resources.

"Effects of Hurricane Alicia on the Texas Coast": supported by the Office of the Attorney General.

"Geological and Fluid Behavior Characterization of Oil Reservoirs on University Lands": supported by The University of Texas System.

"Preparation of Vegetative Type Map of Texas": supported by the Texas Parks and Wildlife Department.

"Site Selection for the Super-Conducting Super Collider (SSC) Facility": supported by the Office of the Governor.

Other

"Completion of Frio Offshore Research Publication": supported by Sohio Petroleum Company.

"Coordination of Geological and Engineering Research in Support of Gulf Coast Co-Production Program": supported by the Gas Research Institute.

"Geologic Analysis of Primary and Secondary Tight Gas Sand Objectives": supported by the Gas Research Institute.

"Mineral Resource Evaluation of the Texas Big Sandy Project for the Sabine River Authority of Texas": supported by the Sabine River Authority of Texas.

"On the Origin and Causes of the Negative Revisions to Natural Gas Proved Reserves in Texas": supported by the Gas Research Institute.

CONTRACT AND GRANT REPORTS

A variety of reports are prepared annually under terms of grants and contracts with sponsoring entities. Some of these reports are eventually published by the Bureau as part of its own series. Contract reports are kept on open file at the Bureau and may be consulted by interested persons. The following reports were prepared during the year:

DuBar, J. R., Andrews, E. M., Hubby, K. C., and Noe, D. C., 1984, Miocene depositional systems and hydrocarbon

resources: the Texas Coastal Plain: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for the U.S. Geological Survey under contract no. 14-08-0001-G-707, 99 p.

Ewing, T. E., Tyler, Noel, Morton, R. A., and **Light, M. P. R.,** 1984, Consolidation of geologic studies of geopressured geothermal resources in Texas: The University of Texas at Austin, Bureau of Economic Geology, annual report prepared for U.S. Department of Energy under contract no. DE-AC08-79ET27111, 142 p.

Finley, R. J., Garrett, C. M., Jr., Han, J. H., **Lin, Z. S., Seni, S. J., Saucier, A. E.,** and **Tyler, N.,** 1984, Geologic analysis of primary and secondary tight gas sand objectives (November 1982-October 1983): The University of Texas at Austin, Bureau of Economic Geology, annual report prepared for Gas Research Institute under contract no. 5082-211-0708, 334 p.

Kaiser, W. R., Ambrose, M. L., Ayers, W. B., Jr., Blanchard, P. E., **Collins, G. F., Fogg, G. E.,** Gower, D. L., **Ho, C. L., Holland, C. S., Jackson, M. L. W.,** Jones, C. M., Lewis, A. H., Macpherson, G. L., **Mahan, C. A.,** Mullin, A. H., Prouty, D. A., **Tewalt, S. J.,** and **Tweedy, S. W.,** 1984, Evaluating the geology and ground-water hydrology of deep-basin lignite in the Wilcox Group of East Texas: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for the Texas Energy and Natural Resources Advisory Council under contract no. IAC(82-83)-0822, 257 p.

Kreitler, C. W., Collins, E. W., Fogg, G. E., Jackson, M. P. A., and **Seni, S. J.,** 1984, Hydrogeologic characterization of the saline aquifers, East Texas Basin—implications to nuclear waste storage in East Texas salt domes: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for U.S. Department of Energy, under contract no. DE-AC97-80ET46617, 55 p.

The Meyer Group (subcontractor), 1984, First order leveling: Pleasant Bayou geothermal test site, Brazoria County, Texas: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for U.S. Department of Energy, Division of Geothermal Energy, under contract no. DE-AC08-79ET27111, 107 p.

Seni, S. J., Hamlin, H. S., and **Mullican, W. F., III,** 1984, Technical issues for chemical waste isolation in solution-mined caverns in salt domes: The University of Texas at Austin, Bureau of Economic Geology, report prepared for Texas Department of Water Resources under contract no. IAC(84-85)-1019, 8 p.

Seni, S. J., Mullican, W. F., III, and **Hamlin, H. S.,** 1984, Texas salt domes—aspects affecting disposal of toxic-chemical waste in solution-mined caverns: The University of Texas at Austin, Bureau of Economic Geology, report prepared for Texas Department of Water Resources under contract no. IAC(84-85)-1019, 94 p.

Seni, S. J., Mullican, W. F., III, and **Hamlin, H. S.,** 1984, Texas salt domes: natural resources, storage caverns, and extraction technology: The University of Texas at Austin, Bureau of Economic Geology, report prepared for Texas Department of Water Resources under contract no. IAC(84-85)-1019, 161 p.

Seni, S. J., Mullican, W. F., III, and **Ozment, R. W.,** 1984, Computerized inventory of data on Texas salt domes: The University of Texas at Austin, Bureau of Economic Geology, report prepared for Texas Department of Water Resources under contract no. IAC(84-85)-1019, 34 p.

Teledyne Geotech (subcontractor), 1984, Microseismic monitoring of Chocolate Bayou, Texas, the Pleasant Bayou No. 2 geopressured/geothermal energy test well program: The University of Texas at Austin, Bureau of Economic Geology, final technical report prepared for U.S. Department of Energy, Division of Geothermal Energy, under contract no. DE-AC08-79ET27111, 160 p.

Woodruff, C. M., Jr., and **Caran, S. C.,** 1984, Lineaments of Texas—possible surface expressions of deep-seated phenomena: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for U.S. Department of Energy, Division of Geothermal Energy, under contract no. DE-AS07-79ID12057, 68 p.

Woodruff, C. M., Jr., and Gever, Christine, 1984, Integration of geothermal data along the Balcones/Ouachita trend, Central Texas: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for the U.S. Department of Energy, Division of Geothermal Energy, under contract no. DE-AS07-79ID12057, 21 p.

Woodruff, C. M., Jr., Macpherson, G. L., Gever, Christine, **Caran, S. C.,** and El Shazly, A. G., 1984, Geothermal potential along the Balcones/Ouachita trend, Central Texas—ongoing assessment and selected case studies: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for U.S. Department of Energy, Division of Geothermal Energy, under contract no. DE-AS07-79ID12057, 75 p.

The following Bureau publications served as final contract reports during 1984: Reports of Investigations Nos. 139 and 143 and Geological Circulars 84-1, 84-3, and 84-5. These publications were prepared for the U.S. Department of Energy under contract no. DE-AC97-80ET46617.

PUBLICATIONS

In its role as a public geological research unit, the Bureau disseminates the results of research projects and programs primarily through its own publication series. During its 75-year history, the Bureau has published nearly 1,200 reports, bulletins, circulars, special publications, and maps covering major aspects of the geology and natural resources of Texas. Publications are sold at nominal prices to recover printing or duplication costs. To date, about 1.58 million publications have been distributed worldwide, mostly through direct sales. During 1984, about 77,000 volumes were distributed. The Bureau issued the following publications in 1984:

REPORTS OF INVESTIGATIONS

RI 138. Geology and Engineering Characteristics of Selected Low-Permeability Gas Sandstones: A National Survey, by R. J. Finley. 220 p., 91 figs., 110 tables ($6.00).

Synthesis of geological and engineering data collected from 31 blanket-geometry, tight gas sandstones in 15 sedimentary basins across the United States. Basins included in this survey range from the Appalachian Basin to basins of the Rocky Mountain region. The author describes depositional systems and associated facies of each sandstone to provide a basis of comparison between formations of different ages in different structural and sedimentary settings. Most of these previously unpublished data were submitted through 1982 by operators seeking tight-formation designations under the Natural Gas Policy Act and were collected directly from the files of state oil and gas commissions. The West Virginia Geological and Economic Survey assisted the Bureau in collecting data from the Appalachian Basin. Data for each major sandstone are displayed in detailed tables that allow easy comparison of general attributes, economic factors, geological parameters of the basin or trend, geological and engineering parameters of the stratigraphic unit, and operating conditions. This work provides a convenient reference on porosity, permeability, mineralogy, flow rates, hydraulic fracture treatments, and many other specifics of tight gas reservoirs. It also lists more than 200 references for further reading. The Gas Research Institute funded this survey.

RI 139. Sedimentary Record of Cretaceous and Tertiary Salt Movement, East Texas: Times, Rates, and Volumes of Salt Flow and Their Implications for Nuclear Waste Isolation and Petroleum Exploration, by S. J. Seni and M. P. A. Jackson. 89 p., 57 figs., 7 tables, 2 appendices ($4.50).

Reconstruction of the history of Cretaceous and Tertiary salt flow through the East Texas Basin based on the subsurface sedimentary record around salt domes. The East Texas Basin, one of several inland Mesozoic salt basins flanking the northern Gulf of Mexico, lies in one of the most highly explored salt-dome provinces in the world. This study primarily relies on syndepositional thickness variations in strata surrounding the salt domes to reveal the history of salt movement. The work was funded by the U.S. Department of Energy through the National Waste Terminal Storage program. It can be applied to the evaluation of salt domes for permanent isolation of nuclear or chemical waste or for temporary storage of hydrocarbons and to exploration for oil and gas in salt-dome provinces. The authors assess growth of the 16 shallow and intermediate-depth diapirs in the East Texas Basin from 112 to 48 million years ago. Data base includes electric, density, and sonic logs from 2,000 wells, core control for the shallow stratigraphic section, more than 400 mi (700 km) of sixfold common-depth-point seismic data, a residual-gravity map, and gravity models of specific salt domes. The authors examine the effects of evolutionary stages of dome growth on depositional facies, lithostratigraphy, and thickness of surrounding sediments. They also identify the timing and patterns of halokinesis and measure the volumes and rates of salt flow. From their findings about the history of salt movement in the basin, the authors identify specific stages of salt-dome growth, each characterized by different combinations of subtle petroleum traps as well as by more obvious structural ones. In addition, they conclude that halokinetic rise of East Texas domes by more than 50 ft (15 m) in the next 250,000 years is unlikely.

RI 140. Atlas of Salt Domes in the East Texas Basin, by M. P. A. Jackson and S. J. Seni. 102 p., 79 figs. ($4.00).

Illustrated compendium of detailed information on the 15 shallow salt domes in the East Texas Basin. Salt diapirism has played a primary role in deforming Upper Jurassic and Cretaceous strata above the Louann Salt in the central part of the East Texas Basin. These salt domes are a key source of rock salt, brine, and petroleum. The domes are also used to store liquefied petroleum gas and natural gas. Some domes are being considered for use as repositories for toxic industrial wastes, high-level nuclear waste, methane-producing urban trash, and off-peak electrical energy. This atlas is made up mostly of tables and illustrations containing specific information about each of the 15 shallow salt domes in the East Texas Basin: Bethel, Boggy Creek, Brooks, Brushy Creek, Bullard, Butler, East Tyler, Grand Saline, Hainesville, Keechi, Mount Sylvan, Oakwood, Palestine, Steen, and Whitehouse. Tables detail the shape, structure, resources, and past and current uses of each dome, as well as inferred dome growth history and structural and hydrologic stability. Geometry and fault history of strata adjacent to the domes are also described. Illustrations include topographic maps, block diagrams, and cross sections. The authors also discuss the regional geologic setting of the East Texas salt domes and define terms used to describe the domes. Information in this atlas was collected from diverse sources during a 5-year research program conducted by the Bureau of Economic Geology for the U.S. Department of Energy.

RI 141. Hydrogeology of the Edwards Aquifer, Austin Area, Central Texas, by R. K. Senger and C. W. Kreitler. 35 p., 29 figs., 5 tables ($2.00).

Study of the hydrogeology and hydrochemistry of the Edwards aquifer in the Austin area and of Barton Springs, the aquifer's major discharge site. The Edwards Underground Reservoir is the main source of municipal and private water for many Central Texas counties along the Balcones Fault Zone. Urban development in and near Austin, Texas, is expected to affect both the usability of the Edwards aquifer in that region as a source of drinking water and recreational features such as Barton Springs, the aquifer's major point of discharge. This study describes the stratigraphic and lithologic setting of the Edwards aquifer in the Austin area and identifies its dominant flow directions. Hydrologic characteristics of the aquifer were evaluated using recession curves of the outflow at Barton Springs, water-level decline from wells in the area, and a two-dimensional ground-water flow model simulating the water-level response near the springs. The study also characterizes the water chemistry in the aquifer and evaluates the chemical variations of Barton Springs water. Among the authors' findings: Water chemistry in the Edwards aquifer is characterized by a calcium bicarbonate water in the fresh-water section, a sodium sulfate water in the "bad-water" zone, and, further downdip, a sodium chloride water. The influx of "bad water" (water having 1,000 mg/L total dissolved solids or more from downdip in the Edwards Formation) into the fresh-water aquifer occurs during low-flow conditions. This theoretically results in a decrease of calcite saturation of the water, which would enhance carbonate dissolution. In some locations, however, leakage from the Glen Rose Formation associated with large fault displacements can be identified by a change in the water chemistry (an increase in sulfate and strontium concentrations).

RI 142. Enhanced Gas Recovery from Watered-out Reservoirs—Port Arthur Field, Jefferson County, Texas, by A. R. Gregory, Z. S. Lin, R. S. Reed, R. A. Morton, and T. E. Ewing. 58 p., 45 figs., 7 tables, 2 appendices ($2.50).

Geologic and economic analysis of applicability of enhanced gas recovery techniques on the watered-out reservoirs of Port Arthur field, Jefferson County, Texas. Enhanced gas recovery methods, which involve the coproduction of gas and water, are an alternative to conventional gas recovery techniques and can be used to extend production in watered-out reservoirs. Large volumes of water are deliberately produced to reduce reservoir pressures; the lower pressure allows expansion of the free gas that was trapped in the water-invaded zone during the primary production stage. Some of the free gas becomes mobilized and producible. After more than 150 fields were screened, the Port Arthur field was selected for this study on the basis of its substantial gas production, thick sandstone aquifers, and high abandonment pressures. Available core data and well logs were analyzed to determine porosity, permeabilities, salinities, and methane solubilities, and the results are presented in figures. Researchers also acquired and reprocessed seismic data from around Port Arthur field to (1) provide structural information, (2) locate boundaries of aquifers and gas reservoirs, and (3) evaluate seismic response to low saturations of free gas in water-invaded zones. In addition, the authors selected Reservoir C within the Hackberry for numerical modeling. A three-dimensional, two-phase (gas and water) model, described in the text, was used to perform history matches and to predict reservoir behavior if a new well were drilled. The authors conclude that an additional 9 percent of original gas in place from Reservoir C could be recovered by the coproduction method. Funding was by the Gas Research Institute.

GEOLOGICAL CIRCULARS

GC 84-1. Suitability of Salt Domes in the East Texas Basin for Nuclear Waste Isolation: Final Summary of Geologic and Hydrogeologic Research (1978 to 1983), by M. P. A. Jackson and S. J. Seni. 128 p., 61 figs., 8 tables, appendix ($3.00).

Final summary of a 5-year research project conducted by the Bureau of Economic Geology to assess the suitability of salt domes in the East Texas Basin for isolation of nuclear waste. The project is part of the U.S. Department of Energy's National Waste Terminal Storage program to assess the suitability of dome salt, bedded salt, basalt, tuff, and crystalline rock as hosts for deep underground storage of high-level nuclear waste. Sixty-seven scientists and research assistants pursued 33 lines of research during the Bureau project, which was carried out from January 1978 through March 1983. This report concisely summarizes the findings of each of these research areas, which include studies of the tectonic, structural, and stratigraphic framework of the East Texas Basin; regional geologic and hydrogeologic studies; and detailed core and hydrogeologic studies of Oakwood Dome and surroundings. It includes more than 120 references for additional reading on the East Texas Basin. Research focused on three salt domes in the basin—Oakwood, Keechi, and Palestine—as potential repositories of high-level nuclear waste. Researchers concluded that although none of these three domes is suitable for this purpose, nothing inherent in salt domes precludes their use for nuclear waste storage.

GC 84-2. Oil Accumulation, Production Characteristics, and Targets for Additional Recovery in Major Oil Reservoirs of Texas, by Noel Tyler, W. E. Galloway, C. M. Garrett, Jr., and T. E. Ewing. 31 p., 16 figs., 6 tables, appendix ($2.00).

Study of the relation between reservoir genesis, oil accumulation trends, and recovery efficiency of the major clastic and carbonate oil reservoirs in Texas. Nearly two-

thirds of the 156 billion barrels of oil that has been discovered in Texas is now classed as unrecoverable by conventional means. To investigate the potential for additional recovery of this vast resource, the Bureau of Economic Geology in 1982-83 conducted a survey of the 500 most productive oil reservoirs in the state. The reservoirs were characterized according to geological, engineering, and production attributes and then grouped into 48 plays on the basis of similar geological and petrophysical character. Unpublished hearing files of the Railroad Commission of Texas were the main source of data for this survey. This Geological Circular, one of several publications resulting from the survey, examines the role of reservoir genesis in defining oil accumulation and production patterns. The authors found that although in-place oil in clastic reservoirs is distributed fairly evenly among fluvial/deltaic, deltaic, barrier/strandplain, and slope/basin sandstones, the deltaic sandstones are projected to yield nearly half of all oil obtained from clastic reservoirs. Likewise, recovery efficiencies of carbonate reservoirs vary according to depositional facies: Restricted-platform reservoirs, which trapped 61 percent of the original oil in place in carbonate reservoirs, have a recovery efficiency of only 30 percent, whereas deep-water atoll/pinnacle-reef reservoirs, containing only 11 percent of the original oil in place, have a 50-percent recovery efficiency. The authors also found that most of the 20 billion barrels of oil now targeted for additional recovery from major Texas reservoirs is trapped in restricted-platform carbonates and slope/basin sandstones of the Permian Basin.

GC 84-3. Observations from the East Texas Seismic Network (June 1981 - August 1982), by W. D. Pennington and S. M. Carlson. 48 p., 33 figs., 3 tables ($3.00).

Description of the operations of the East Texas Seismic Network and summary of observations made from it. A network of several microearthquake recording stations was set up to monitor seismic activities in the East Texas Basin from June 1981 through August 1982. One purpose of this monitoring was to find out whether earthquakes are likely to occur near any of the salt domes in the basin that were then being considered as potential repositories for nuclear waste. The East Texas Seismic Network relied primarily on a three-station telemetered array having a central recording site. Portable units were used occasionally for backup. This circular reports that six certain and two probable earthquakes were recorded by the network, along with hundreds of events of undetermined origin. The authors conclude that the earthquakes could not be assigned to any one fault in the East Texas Basin and that the depths of the earthquakes were not well constrained. However, they did find that all the earthquakes occurred near the Mount Enterprise fault system; thus they may represent activity along that fault system or along nearby secondary faults. The circular includes more than 30 photographs of parts of seismograms recorded by the network and a detailed catalog of the arrival times of all recorded seismic events. This study was funded by the U.S. Department of Energy with support from the Department of Geological Sciences of The University of Texas at Austin and from the Geology Foundation of that Department.

GC 84-4. Styles of Deformation in Permian Strata, Texas Panhandle, by E. W. Collins. 32 p., 24 figs. ($2.00).

Description of the different styles of deformation in Permian strata of Caprock Canyons State Park, Palo Duro Canyon State Park, and the Canadian River Valley, Texas Panhandle. Permian strata cropping out in the Texas Panhandle display a variety of structural styles, including folds associated with synclinal depressions, subparallel cylindrical folds and broad drape folds that bound regional basement uplifts, gypsum veins, fractures, and clastic plugs and dikes. Understanding the origin and characteristics of these structures is vital because Permian evaporite strata in the area are being considered as storage sites for high-level nuclear wastes. Data the author presents in this study include maps of structural features in the various study areas, equal-area net plots of faults and veins, histograms of systematic joints and axes of synclinal depressions, rose diagrams of joint and fracture orientations, and cross sections of exposed Permian strata and clastic dikes and plugs. The author uses these data to describe (1) structures attributed to tectonic stresses and (2) structures caused by evaporite dissolution collapse. Data indicate that systematic regional joints older than dissolution collapse have influenced salt dissolution in some areas. The study was funded by the U.S. Department of Energy.

GC 84-5. Cotton Valley (Upper Jurassic) and Hosston (Lower Cretaceous) Depositional Systems and Their Influence on Salt Tectonics in the East Texas Basin, by M. K. McGowen and D. W. Harris. 41 p., 24 figs., 1 table, 2 appendices ($2.50).

Investigation of the effects of early basin infilling on salt mobilization in the East Texas Basin. Understanding the mechanisms responsible for early salt movement is essential to predicting domal growth evolution and ultimate stability. This study focuses on a seven-county area in the northwestern part of the East Texas Basin. Data base included electric logs from more than 230 wells, Bouguer residual gravity maps, and two dip-oriented, six-fold conventional CDP seismic profiles. Five Mesozoic seismic reflectors were used. Well and seismic data were integrated using velocity conversion tables. The authors constructed isopach, net-sandstone, and sandstone-percentage maps of the Cotton Valley Group and the Hosston Formation and stratigraphic cross sections through the study area. The circular presents four major conclusions regarding the role of basin infilling in initiating salt movement in the northwestern part of the East Texas Basin: (1) A prograding fan-delta system comprises the Cotton Valley and Hosston stratigraphic units. (2) The first salt movement occurred in proximal parts of the East Texas Basin during Smackover (Late Jurassic) deposition and resulted from downward creep that was induced by loading of carbonates enhanced by basinward tilting. (3) Salt mobilization by mass imbalance was induced by Cotton Valley and Hosston deltaic deposition. (4) Parallel salt ridges that formed during deposition of the Cotton Valley and Hosston apparently were the first stage in the development of salt anticlines and domes. This study is part of a research project done by the Bureau of Economic Geology for the U.S. Department of Energy. This circular is reprinted from the Proceedings volume for the Third Annual Research Conference of the

Gulf Coast Section, Society of Economic Paleontologists and Mineralogists Foundation.

GC 84-6. Historical Shoreline Changes in Corpus Christi, Oso, and Nueces Bays, Texas Gulf Coast, by R. A. Morton and J. G. Paine. 66 p., 26 figs., 1 table, 3 appendices ($3.00).

Study documenting changes in the position and stability of shorelines around Corpus Christi, Oso, and Nueces Bays, Texas Gulf Coast. Field observations and regional mapping suggest that many Texas bay shorelines are unstable and are retreating landward at rates ranging from a few feet to a few tens of feet per year. In some bays, biologically productive wetlands are diminishing, and erosion of land areas (previously unquantified) is contributing to significant economic losses, both to the State and to private landowners. Researchers conducting this study quantified the significant shoreline changes that have occurred near Corpus Christi during the past century by comparing shorelines depicted on vintage topographic surveys and recent aerial photographs, by measuring shoreline movement at 103 bay stations, and by calculating the rates of change for particular time periods ranging from the late 1800's to 1982. The authors describe the origin of Texas bays and discuss and illustrate with photographs the four main types of unstabilized bay shorelines in Texas and what is being done to stabilize them. They also discuss the causes of shoreline movement, including climate, changes in relative sea-level position, sediment budget, coastal processes, and human activity. Historical data on these causes of shoreline movement indicate, the authors conclude, that warming temperatures, rising sea level, decreased sediment supply, recurring severe storms, and ongoing human activities are promoting the continual erosion of most of the unprotected shorelines in Corpus Christi Bay and adjacent bays. The study was funded by the Texas Energy and Natural Resources Advisory Council.

GC 84-7. Depositional Systems and Structural Controls of Hackberry Sandstone Reservoirs in Southeast Texas, by T. E. Ewing and Ronee S. Reed. 48 p., 20 figs., 2 tables, appendix ($2.00)

Investigation into the structure and stratigraphy of Hackberry sandstone reservoirs in the Beaumont - Port Arthur area of southeast Texas. Deep-water sandstones of the Oligocene-age Hackberry unit of the Frio Formation host nearly 50 oil reservoirs and 100 gas reservoirs in Texas. Understanding the depositional environments represented by the discontinuous and complex lithologies of the sandstones will aid continuing hydrocarbon exploration. The study area centers on the Port Arthur field and extends from the updip limit of the Hackberry wedge to the downdip limit of well control in Jefferson County, Orange County, and adjacent parts of Louisiana. The authors merged information from seismic sections and well logs to produce structure and sand maps; these resulted in delineation of six main sand channels within the Hackberry. They also studied the geophysical logs of wells in the Port Arthur field and found that each sandstone includes numerous facies; the junctions of these facies represent significant reservoir discontinuities. On the basis of studies of sandstone facies and geometry, the authors conclude that Hackberry sandstones were laid down by an onlapping submarine canyon - fan complex and that overlying shales represent an infill of a deep-water embayment caused by normal subsidence and sediment starvation. The two major hydrocarbon plays within the Hackberry are also discussed. The authors note that additional prospects in the channel complex of Play II are likely to be found and that continued study could lead to discovery of a new play downdip. Funding was by the Gas Research Institute and the U.S. Department of Energy.

GUIDEBOOK

GB 21. Geology of Monahans Sandhills State Park, Texas, by M. D. Machenberg. 39 p., 34 figs., 1 pl., 3 appendices ($2.50).

Nontechnical guide to the geology and ever-changing environments of Monahans Sandhills State Park. The Monahans Sandhills, on the western margin of the Southern High Plains in West Texas, began accumulating several thousand years ago. Monahans Sandhills State Park, which encompasses about 3,840 acres of active and stabilized dunes, was established in 1957. The park is an hour's drive west of the Midland-Odessa area. Written for the interested layperson, this guidebook describes the origin of the sandhills, their geological characteristics, and the interaction of physical and biological processes within the sandhills. The author discusses the various types of dunes formed in the park: akle dunes in large expanses of unvegetated sand; smaller wind-shadow, coppice, transverse, barchan, and parabolic dunes; and blowout dunes in the heavily vegetated cover sands of the Pecos Plain surface. She also describes the seasonal migration of the dunes caused by changes in wind regimes. The guidebook is illustrated with more than 30 photographs and drawings and includes an oversized, pullout map of dune environments in the park. A glossary defines technical terms used in the guidebook. Appendices list birds sighted in the park, points of interest nearby, and suggestions for further reading.

HANDBOOK

HB 5. Handbook for Logging Carbonate Rocks, by D. G. Bebout and R. G. Loucks. 43 p., 21 figs., full-scale logging form ($3.00); 25-sheet pad of logging forms ($2.00).

Fully illustrated, step-by-step guide to graphic logging of carbonate rocks. This handbook describes techniques for logging porosity, mineral composition, nature of contact, structures, textures, fabrics, grain size, crystal shape, color, fossils, and cement of carbonate rocks. Detailed instructions are illustrated by many drawings and charts. The handbook contains a full-scale, pullout copy of a logging form used extensively by the authors. This form, which may be purchased separately in pads of 25, is applicable to research and industry exploration and production projects. The authors also include 14 sets of photographs, most at low magnification, of core surfaces from the Lower Cretaceous Pearsall Formation in South Texas to illustrate fossils and structures commonly encountered when logging core. The illustrated cores are also logged using the method described in the handbook to show how to use the form.

GEOLOGIC ATLAS OF TEXAS

Geologic Atlas of Texas, Dalhart Sheet, John Emery Adams Memorial Edition, V. E. Barnes, project director. Scale 1:250,000, full color, topographic base ($4.00).

Geologic map sheet covering all of Dallam and parts of Sherman, Moore, and Hartley Counties in Texas, all of Cimarron County and part of Texas County in Oklahoma, parts of Union and Harding Counties in New Mexico, parts of Las Animas and Baca Counties in Colorado, and part of Morton County in Kansas. The Dalhart Sheet belongs to the Bureau's *Geologic Atlas of Texas,* a series of 38 map sheets showing the distribution of outcropping rock units in all of Texas and parts of adjacent states. Mapping for this sheet in Texas was compiled and field checked by G. K. Eifler, Jr., in Oklahoma by R. O. Fay, and in Harding County, New Mexico, by Fred Trauger and Eric G. Lappala. Mapping in Union County, New Mexico, was compiled from published sources. The map was reviewed by the Panhandle Geological Society. It is printed in full color on a topographic base at a scale of 1:250,000.

This sheet is a memorial edition honoring John Emery Adams (1899-1970). Mr. Adams worked for the Bureau in 1926-27 while doing graduate work in geology at the University of Texas. After that time he worked primarily in the Permian Basin and Gulf Coast regions for Standard Oil Company of Texas. His concepts of facies changes and Permian reef development apply to finding oil far beyond the borders of Texas.

MINERAL RESOURCE CIRCULAR

MRC 75. The Mineral Industry of Texas in 1982, by A. E. Ward. 18 p., 1 fig., 13 tables (free on request).

Annual summary of all nonfuel minerals of Texas. This circular is a preprint of the chapter on Texas in the *Minerals Yearbook 1982* of the U.S. Bureau of Mines. It was produced through a cooperative agreement between the U.S. Bureau of Mines and the Bureau of Economic Geology.

OTHERS

Clastic Depositional Systems—A Genetic Approach to Facies Analysis—Annotated Outline and Bibliography, by W. L. Fisher and L. F. Brown, Jr. 105 p. (includes 73 pages of references) ($7.50).

Revised and reprinted course outline, short descriptive text, and extensive bibliography analyzing, on a genetic basis, the stratigraphy and sedimentology of nine clastic depositional systems. The genetic approach emphasizes sedimentary environments, depositional processes, origin of sedimentary facies, and the interrelationships of facies and depositional processes. Depositional systems included in the analysis are (1) fluvial, (2) delta, (3) barrier bar and strandplain, (4) bay, lagoon, estuarine, and tidal flat, (5) terrigenous shelf, (6) slope and abyssal, (7) terrigenous fan, (8) lacustrine, and (9) eolian. The text has been reorganized since its last printing in 1975, and additional references through 1978 have been added.

Current Geologic Research in Texas: A Directory of University Faculty and Student Research, compiled by J. G. Price, T. E. Ewing, A. R. Masterson, and S. C. Ruppel. 24 p. (unbound photocopy, $3.00).

Survey of academic research on Texas geology now being done by geoscience departments in Texas and adjoining states and by selected institutions in other states. The Bureau compiled this 24-page directory from questionnaires returned by faculty and students at more than 30 universities now researching some aspect of Texas geology. A total of 124 projects are indexed by principal investigator, subject, and geographic area. Listings also include project coworkers, principal investigator's and coworkers' affiliations, project title, expected completion date, and expected place of publication. This is the second survey of this kind conducted by the Bureau.

SERVICES

COMPUTING

During 1984, the computing staff continued to provide services to the research staff and to administrative and support personnel. The group provided services ranging from keypunching and operating computers to developing new programs. In addition to its routine duties, the computing staff wrote detailed specifications for the purchase of new equipment.

Preparations have been made for a major upgrade of hardware in the Bureau's new Research and Administration Building, and an order has been placed for a VAX 11/780 computer. The VAX will become the nucleus of a network of terminals and personal computers throughout the building; through the network Bureau staff members will be able to make a connection from their offices to the Bureau's VAX as well as to the University's network of mainframe computers. The VAX will be used for research and administrative purposes. The computing staff also assisted the publications preparation staff to specify a network of word processors for their use that will be linked to terminals used by other staff members through the VAX.

The computing staff has been developing administrative tracking software for the cartographic and mineral studies activities and has undertaken many other tasks, including the design of a data base of salt dome information. Present full-time staff are a systems analyst, who has special responsibility for developing the VAX as an effective support system for the Bureau, one senior and two junior programmers, and a computer operator, under the direction of Michael P. Roberts.

PUBLIC INFORMATION

Requests for information about Texas geological, energy, mineral, and land resources come to the Bureau from a wide spectrum of the public, including geologists, educators, students, landowners, and other interested individuals, as well as companies, governmental agencies, and other organizations.

Many members of the full-time research staff provide advisory and technical services in their areas of expertise. In addition, Mary W. McBride, Research Scientist Associate, handles requests for information about Texas geology, mineral resources, references, and Bureau programs and publications.

READING ROOM AND OPEN FILES

The Bureau's Reading Room, supervised by Kay Forward, is open for public use from 8 a.m. to 5 p.m., Monday through Friday. It contains journals and other publications pertaining to Texas geology and mineral resources.

The Bureau's collection of open-file reports and maps includes unpublished reports that have been prepared by the Bureau and materials received from the U.S. Department of Energy (DOE), formerly the Energy Research and Development Administration (ERDA), and other sources. Kay Forward maintains these open files and makes arrangements for copying reports requested by the public. Because of limited space, only those reports pertaining to Texas, plus reports of special interest, are filed at the Bureau. Others are transferred to the Geology Library of The University of Texas at Austin. Information concerning DOE and ERDA open-file reports may be obtained from the Technical Library, Grand Junction Office, U.S. Department of Energy, Box 2567, Grand Junction, Colorado 81502 (telephone: 303-242-8621, ext. 279).

A limited number of open-file reports of the U.S. Geological Survey are also on file at the Bureau. Information concerning additional reports of that organization may be obtained from the Open-File Services Section, Branch of Distribution, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225 (telephone: 303-234-5888).

MINERAL STUDIES LABORATORY

The Bureau's expertise in analytical geochemistry and its sample characterization capabilities are incorporated into the Mineral Studies Laboratory (MSL), which includes a staff of professional chemists and an array of sophisticated analytical instruments. The MSL provides analytical research and services to the Bureau staff in support of their programs

as well as to other individuals and organizations with common interests in Texas geology. The MSL is headed by Dr. David W. Koppenaal, who assumed the duties of Chief Chemist in October. Before then, Dr. Clara L. Ho and Mr. Steven W. Tweedy were responsible for the direction of the MSL.

Major technical activities during 1984 included the geochemical characterization of rock salts and brines sampled for the West Texas Waste Isolation project. Particular emphasis was placed on the determination of the water content of undisturbed core samples of rock salt. This determination required development of methodology using Soxhlet extraction with methanol and subsequent determination of the released water in the extracts. Mineralogical characterization of the residue and its clay fraction was also performed using X-ray diffraction techniques. The unextracted rock salt residue and associated brine samples were extensively analyzed for a variety of chemical constituents.

The characterization of coal and lignite reserves in Texas was also a major MSL endeavor. Coal samples taken from cores in East Texas were analyzed for carbon, hydrogen, nitrogen, sulfur, forms of sulfur, calorific value, and major or minor oxides in coal ash. Mineral constituents of the samples were identified by X-ray diffraction after a low-temperature ashing procedure. Certain potentially toxic elements were also determined on the whole coal sample.

Other activities at the MSL included the development, refinement, or application of new analytical techniques. New methods or new applications of existing methods introduced during 1984 included the following: (1) the determination of gold and silver at sub-ppm levels in ore deposits from the Trans-Pecos region of Texas; (2) the use of a modified procedure to determine water content and its intergranular versus intragranular distinction in rock salt; (3) the use of an improved method to determine arsenic in coal by graphite-furnace atomic absorption techniques; (4) the initial development of methods to determine mineral-associated trace elements in mixed-phase anhydrite-dolomite-calcite samples; and (5) the colorimetric determination of chloride in concrete samples.

The electron microprobe system acquired during 1983 was further developed and applied more widely during the past year. The system, which includes an energy-dispersive X-ray spectrometer and four wavelength-dispersive X-ray spectrometers, was used for the quantitative analysis of feldspar, pyroxene, carbonate, uranium, sulfide, mica, and jarosite minerals. Clay minerals, windblown dusts, and inorganic matter in coal have been examined qualitatively.

The MSL participated actively in several professional societies and associations. The MSL is an active member of the International Geostandards Working Group and has recently become an organizational member of the American Society for Testing and Materials (ASTM). Several staff members participated in activities of ASTM's Coal and Coke (D.05), Water (D.19), and Hazardous Waste (D.34) Committees, including task groups and standards development. These activities are part of the MSL's commitment to maintain high standards and stay abreast of new analytical techniques and developments. Currently practiced analytical techniques are continually being evaluated to ensure their reliability and accuracy, and quality assurance guidelines have been developed or are being developed for all utilized methods.

The new Mineral Studies Laboratory and Well Sample and Core Library will provide almost 19,000 ft^2 of modern laboratory space. In addition, many new instruments have been acquired for use in the new facility, including sample preparation equipment and state-of-the-art analytical instruments. Computer and automation facilities have also been purchased.

New instruments of particular research potential are an inductively coupled plasma mass spectrometer and a stable isotope ratio mass spectrometer. The former instrument, of which there are relatively few in North America, should considerably extend the Bureau's trace element analysis capability. The latter will give the Bureau capability for stable isotope ratio analysis for isotope geochemistry studies. Other newly acquired or to-be-acquired instruments include an ion chromatograph (for trace level anion analysis), an automatic sample fusion device, a modern titration instrument, a coulometric carbon analysis system, and a fire-assay analysis system (for determination of precious metals). To accommodate the use of these instruments and maximize their applicability to Bureau research programs, several staff additions are also contemplated. Thus, the year 1985 holds much promise as the MSL expands its capabilities, quarters, and staff and sets out for new directions that will further establish the MSL as a respected analytical facility in the geological community.

WELL SAMPLE AND CORE LIBRARY

The Well Sample and Core Library (WSCL) provides information and services to geologists, students, and other persons interested in Texas geology. The library may be visited from 8 a.m. to 5 p.m., Monday through Friday. Information regarding holdings, policies, or computer listings may be obtained by calling 512-835-3042. George A. Donaldson is curator of the library.

The WSCL holds cores from about 3,100 wells, drill cuttings from more than 55,000 wells, scout tickets for about 610,000 wells, and driller's logs for about 500,000 wells. Copies of scout tickets and driller's logs may be made at the library. Cores and cuttings may be checked out for viewing; the borrower pays shipping costs. Binocular scopes and other equipment are available for use at the WSCL. Authorization to sample cores and cuttings for thin sections or for destructive analysis is determined on a well-by-well basis. Patrons are asked to report the results of their analyses to the WSCL. Test results and donations of core or cuttings may be held confidential for up to 18 months if requested by the patron.

Donors of materials to the library during 1984 were ARCO Oil & Gas Co., Bass Enterprises Production Co.,

Ballard Exploration Co., Paul E. Cameron, Jr., Inc., Centenary College, Conoco, Inc., Elf Aquitaine Petroleum, William G. Ellis, Energy Reserves Group, Exchange Oil & Gas, Florida Exploration Co., Forest Oil Corp., Getty Oil Corp., A. G. Hill, Mitchell Energy Corp., Mosbacher Production Company, Oklahoma Geological Survey, Petro-Lewis Corp., Rosewood Resources, John Ruggles, Santa Fe Minerals, Sun Exploration & Production Co., Texaco U.S.A., and Wheless Industries. Gulf Oil Corp. donated about 270,000 pounds of core from West Texas. Diamond Shamrock Exploration Co. donated more than 600,000 scout tickets from 9 districts in Texas.

During the year, 115 non-Bureau patrons visited the library. Cores and cuttings checked out by non-Bureau patrons totaled 315 and 164, respectively. Cores checked out by Bureau personnel totaled 102. More than 350 cores were slabbed and reboxed in preparation for the move into the new library facilities. Some of the slabbed core that was normally discarded is now being saved for donation to other universities. Slabs from South Texas are being saved for Texas A&I University, and slabs from certain Central Texas counties are being saved for Abilene Christian University. More than 2,550 samples for various analyses and petrographic thin sections were cut during 1984. A computerized listing of all cores and cuttings, titled *Catalog of All Wells in Well Data File*, can be purchased from the Bureau.

Construction of the new 35,000-ft^2 Mineral Studies Laboratory/Core Research Facility and the 103,000-ft^2 Repository Building is progressing and should be completed by spring of 1985. The WSCL will have the latest core slabbing saws and a hydraulic drill press for taking plugs from cores. Core and cutting transactions, as well as inventory procedures, will be partly automated by the use of radio-linked portable computer terminals equipped with bar code scanners. Each box of core and cuttings will have a universal product code that will be read by the scanner and relayed by radio to a controller box connected to a computer.

HIGHLIGHTS OF THE YEAR

PERFECTING THE GEOLOGIC AND RESOURCE MODEL OF TEXAS

by William L. Fisher

This article originally appeared in **Discovery**, *research magazine of The University of Texas at Austin.*

The Bureau of Economic Geology, one of the oldest and largest research units at The University of Texas at Austin, marks its 75th anniversary on the occasion of its move to new facilities at Balcones Research Center. With the move, the Bureau looks to the future and the challenges of its continuing goal to perfect the geologic and resource model of Texas.

For most of its existence the Bureau has been a relatively small organization—staffed with a dozen or fewer professional scientists. In recent years, as the demands on all kinds of Texas resources have increased dramatically, the Bureau has grown to a professional staff of 80, including geologists, chemists, biologists, engineers, and computer scientists, and a support staff of 70 in administration, editing, cartography, word processing, curation, and rock analysis. But with changes in size, the Bureau's mission—to understand the state's geology and resources—remains the same.

The roots of the Bureau go deeper than its 75 years. Predecessors of the Bureau date to 1858, when the Eighth Texas Legislature established the Geological and Agricultural Survey of Texas. This first survey existed for four years, being suspended by the Legislature in the face of the Civil War. It was reestablished in 1866 and survived another year. The second geological survey was created by the Legislature in 1870 but did not begin work until 1873. Like the first, it was a subject of political squabble and lasted only three years, producing a report of only marginal value on Texas resources. Texas' third survey of the 19th century, the Geological and Mineralogical Survey, was established in 1888. It ran for six years with State appropriations and an additional five years without appropriations; it was officially terminated in 1901. For a total appropriation of $80,000 the third survey, directed by E. T. Dumble, performed an astonishing amount of work. The annual reports of the survey include papers on the general geology of the several regions of the state, along with special papers on mineral commodities, among them the fastest developing resource of the time—lignite. The foundation of Texas geology was laid by the Dumble survey. Together, the 19th century geological surveys expended a total of $120,000, with a research investment of 60 man-years.

In 1901 the transition from the 19th century State agency surveys to the University-supported survey was begun with the creation by the Legislature of the University of Texas Mineral Survey. The Mineral Survey reported to the Board of Regents and was attached to the University, but not a part of it. The survey had a specific mission—to survey only lands belonging to the public schools, the University, and asylums and to determine the mineral value of these lands. The survey existed until 1905; it expended a total of $25,000 and produced eight publications and maps on mineral districts, commodities, and problems of the State mining laws.

The full transition from State agency geological survey to a University-administered geological research organization came with the creation of the Bureau of Economic Geology in 1909 by the Board of Regents.

The Bureau charge and mission, not unlike those of many other state geological surveys, are given in a July 1909 press release issued by the Board:

> The Board of Regents recently established a Bureau of Economic Geology for the purpose of collecting and distributing information concerning the mineral resources of the State. . . .
>
> In taking this step the Board realizes the necessity of keeping the University in close touch with all of the affairs of the Commonwealth, in multiplying the bonds of mutual interest that connect it with the progressive citizens of the State, and in furthering the development of its material resources. . . .
>
> It is hoped that all of those who are in any wise interested in the development of the mineral resources of the State will consider this Bureau as established for their advantage and that they will frequently consult it.

And for 75 years the Bureau has pursued its defined mission and purpose.

The products of public-sector research of the Bureau are many. But the essential product is the communication of the results of its research in reports and maps. In its 75-year history some 1,000 professional man-years have been invested in Bureau research, which has produced some 615 reports and monographs and 375 maps on the geology and resources of Texas, published by the Bureau and the University. In addition Bureau staff have published some 1,500 papers in professional journals. The Bureau professional staff has historically been less than 0.5 percent of the geologic population of the state; yet it has produced nearly 20 percent of all published reports and articles on Texas geology and resources. The recognized quality and objectivity of Bureau reports, consistent with the highest standards of University research, remain the hallmark of the Bureau and the basis of its reputation in the state, in the nation, and throughout the world.

Bureau reports and maps have covered, in varying degree, nearly every aspect of Texas geology and resources. To date, approximately 1.5 million reports and maps have been distributed by sales to individuals, by other public agencies, and by private organizations as aids to the discovery and development of the state's vast energy and mineral resources, as well as the utilization of its diverse land resources.

Geologic and resource activity in the state has been intense. At any time over the past 70 years some one-third of the total geologic population of the United States has been at work in Texas. Approximately 1 million wells, a significant portion of the total world effort, have been drilled in the state in search for oil, gas, coal, lignite, uranium, hard minerals, and water. The results of these geologic and resource activities have been unparalleled. Ground water supports major agricultural and industrial productivity. Texas was and again is one of the largest producers of coal and lignite. It is the second-leading state in the nation in the production and consumption of nonfuel minerals, from salt and sulfur to gravel and crushed stone. It has long been the third-ranked state in the production of uranium. Texas has historically produced nearly 40 percent of this nation's supply of petroleum; it now produces 30 percent of the nation's domestic oil, 34 percent of its natural gas, and 45 percent of its natural gas liquids.

Texas is a populous and industrial state with large demands on its other natural resources. Water and land use is critical. Safe disposal of waste materials is a major challenge, as it is for any industrial and populous state. A significant part of the state's population and industrial base lies in the Coastal Zone, where dynamic natural processes such as shoreline erosion, land subsidence, flooding, and hurricanes continuously affect the environment and must be understood to avoid or reduce loss of life and property.

While many geologic and resource investigations have been accomplished and the results have been ample, the demands on resources remain. Fortunately, the potential for meeting the demand also remains, but the realization of the potential depends largely on continued research dedicated to perfecting the geologic and resource knowledge of the state.

Much of public-sector geologic research depends upon anticipation of future resource needs, potentials, and problems. Such anticipation has long characterized the basic thrust of Bureau research. When the state turned again in the 1970's to the surface mining of its lignite resources, Bureau reports assessing and delineating the resource were available. As lignite mining increases in the rest of this century, existing Bureau reports on land and environmental resources of the lignite belts will aid in prudent regulation and land reclamation. Current lignite research at the Bureau concerns the vast deep-basin deposits and their hydrogeology in anticipation of when these deep seams, through in situ gasification, will be an important source of gas energy for the state. As the population of the Texas Coastal Zone grows, Bureau reports on natural hazards of the zone, from erosion to subsidence to flooding, as well as maps and descriptions of land and environmental resources, supply the technical information necessary for living in harmony with these natural processes. Through the years Bureau research on oil and gas trends has aided the discovery of these resources so critical to the state and its economy. Today and in coming years, as conventional production of oil and gas declines, Bureau research on Texas oil and gas focuses on geologic characterization of reservoirs so that more of the some 100 billion barrels of oil now considered unrecoverable can ultimately be recovered.

Safe disposal and isolation of wastes, especially those that are toxic or radioactive, in geologic formations is one of the most challenging and demanding technical jobs of our society; it will continue to be. Assurance that disposal is safe and secure requires critical assessment and understanding of rock and soil composition, geochemistry, and especially the behavior and movement of formation waters.

Hard minerals, many strategic and critical, have been mined intermittently in Central and Trans-Pecos Texas. Many of these mineralized areas hold resources of marginal concentration. Yet as prime deposits throughout the world are being exhausted, the marginal hard mineral districts in Texas assume potential. Future realization of the potential depends largely on detailed understanding of mineral origin and emplacement. The work of the Bureau-administered Texas Mining and Mineral Resources Research Institute is dedicated to such understanding.

In Texas, and indeed in many areas of the United States and the world, we are entering a new era of natural resources. The conventionally recoverable portion of our natural resources is diminishing. But the remaining resources are vast. Our lands have been tilled, but with sound agricultural practices they can sustain future harvests.

Texas water resources so critical to our existence will continue to be in high demand. But with wise and innovative development and use, essential demands can be met.

Our problems in disposing of waste products are technically demanding and politically vexing. But with adequate geologic and hydrologic understanding, these products of our society can be handled with the assurance of safety that all citizens rightfully demand.

Many of the natural hazards and processes of our Coastal Zone and other regions cannot be altered. But they can be understood and appreciated in such a way that we can live with them without loss of life and property.

As a populous and industrialized state, Texas consumes large quantities of basic construction minerals—sand and gravel, crushed stone, lime, limestone, gypsum, and the like. Resources of these materials are vast, but they are being depleted near areas of major consumption. Careful delineation of these resources can permit a balance of resource and urban space demands and reduce the expense of distant transportation.

And finally, what is the future of energy, the most prominent of all Texas natural resources? Historic exploration and production of energy resources have constituted about 25 percent of Texas' Gross State Product. Production taxes on oil and gas, plus the contribution of energy activities to the State sales tax, make up about 45 percent of State revenues in support of governmental and educational services. But total production of Texas energy resources has declined since the early 1970's, despite major increases in production of lignite, coal, and uranium. The total value of energy production has declined over the past two years for the first time in history. About 85 percent of our known conventionally recoverable resources of oil and gas has already been produced. But the role of oil and gas in the Texas economy can be substantial for many years to come. We have produced about 47 billion barrels of crude oil in Texas, and our proved reserve is less than 8 billion barrels. But we estimate some 5 to 10 billion barrels yet to be discovered, and we have known in existing reservoirs more than 100 billion barrels of oil now classed as conventionally unrecoverable. We have produced 250 trillion cubic feet (Tcf) of natural gas, and our proved reserves are only 20 percent of our historic production. But there exists in Texas up to 500 Tcf of natural gas in harder-to-find reservoirs, in tight formations, in deep reservoirs, and in geothermal waters. And the deep-basin lignite resources, if gasified, would amount to 400 Tcf in resources. Converting increments of these vast resources to recoverable reserves will not be easy. It will depend heavily on economics, but it will also depend greatly on the degree to which we can perfect our understanding of the geologic and fluid complexities of the reservoirs that hold the resources. Both the volume and the potential merit sustained research efforts.

The Bureau does not, nor as a public agency should it, drill oil wells, mine lignite, or develop land. Such is the domain of a prudently regulated private sector. But the results of Bureau research as published in its reports aid progressive activity. The fact that 1.5 million Bureau reports have been sold and that the volume increases each year is ample evidence of the utility and value of public-sector research.

The continued perfection of the geologic and resource model of Texas will not be the sole determinant in our state's future success in winning its resources and living with the natural processes, but it will be, as it has been in the past, a fundamental and critical determinant. Future Bureau research will continue to be dedicated to that perfection for the benefit of the state and its citizens.

FISHER VOTED AAPG PRESIDENT

Bureau Director W. L. Fisher was announced as 1985-86 president of the American Association of Petroleum Geologists at the Association's annual convention in May in San Antonio. He was elected to the post by AAPG active members in a mail ballot held before the convention.

Fisher is the first Bureau or University of Texas staff member to be elected AAPG president. He is serving as president-elect through June and will become president on July 1, 1985. His primary responsibility as president-elect, in addition to serving as understudy, will be to develop a budget for his year as president.

AAPG is the world's largest geological society, with 42,000 members in 93 countries. Its headquarters are in Tulsa, Oklahoma. AAPG was formed in 1917. Since that time, three other organizations have developed from AAPG: the Society of Economic Paleontologists and Mineralogists, the Division of Professional Affairs, and the Energy Minerals Division.

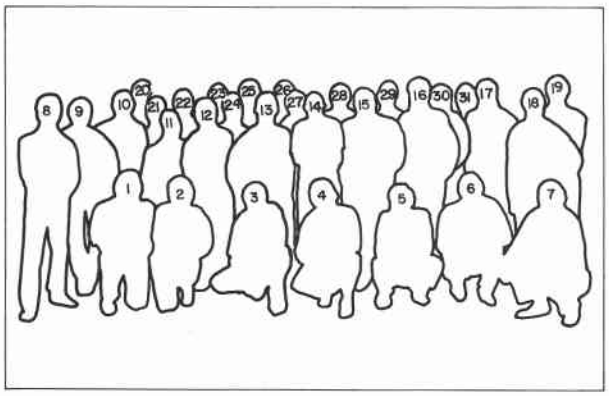
James A. Morgan

W. L. Fisher, Bureau Director

FISHER NAMED DEPARTMENT CHAIRMAN

In addition to duties as Bureau Director, W. L. Fisher assumed the position of Chairman of the Department of Geological Sciences at The University of Texas at Austin, effective September 1, 1984. He is the first geologist in UT history to hold both positions. He also serves as Director of the Geology Foundation and is the Morgan J. Davis Centennial Professor of Petroleum Geology. The Department includes 35 faculty and about 800 graduate and undergraduate majors. The Geology Foundation has endowments and special funds in excess of $10 million.

James A. Morgan



Bureau's moving crew gathers in front of new Research and Administration Building.

The November move to Balcones Research Center could not have been accomplished without the help of many volunteers among the staff. Some of those staff members are shown in the accompanying photograph:

1. Sarita Null
2. Marcie Machenberg
3. Tom Byrd
4. Doug Ratcliff
5. Chuck Stone
6. Warren Wood
7. Jerry Wermund
8. Kelly Carter
9. Cris Gholston
10. Bruce Gates
11. Pat Downs
12. James Doss
13. Roger Harrell
14. Dick Dillon
15. Andy Smith
16. Alan Dutton
17. John Ames
18. Byron Ellington
19. Noel Tyler
20. Jeff Thurwachter
21. Pat Smolka
22. George Donaldson
23. David Drake
24. Daniel Ortuño
25. Jerel McGuffin
26. Bubba Talley
27. Dick Hunter
28. Dow Davidson
29. Mike Davis
30. Rick Platt
31. Paulo Mosmann

Not pictured:

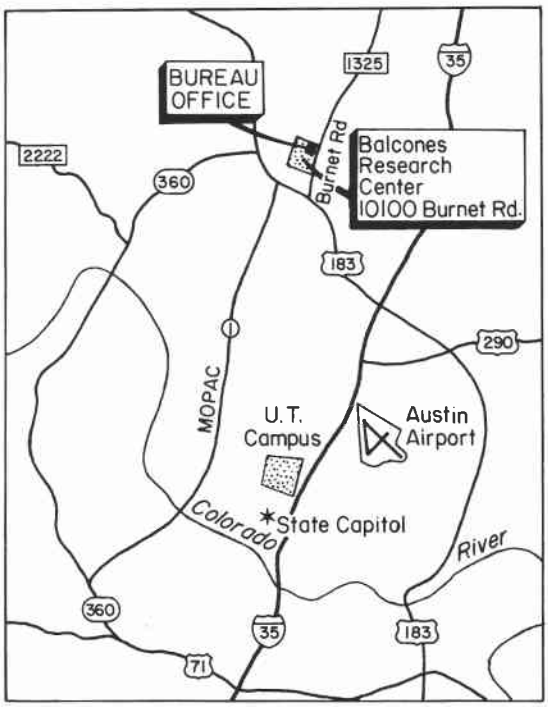
Zain Abdulrazak
Saleem Akhter
Walt Ayers
Robert Baumgardner
Russell Birkelo
Ronald Brock
Eddie Collins
Reinold Cornelius
Erik Davidsen
Carol Fant
Mike Fracasso
Scott Hamlin
Barbara Hartmann
Nan Minchow-Newman
Bob Murray
Will Pickens
Don Ruisinger
Scott Schmidt
Steve Seni
Becky Smyth
Susan Tewalt
Scott Underwood
Gautam Vaswani
David Wallace
Kelly Webb
Robert Wynne

BUREAU MOVES TO NEW OFFICES

By the end of the year, the Bureau had moved into its new three-story Research and Administration Building at the University's Balcones Research Center in north Austin. The 150,000-ft² building reunites research staff who were previously housed in three separate offices on and off campus. The Bureau's laboratory and core library facilities were already at the Balcones Research Center site. Also part of the new research complex are a two-story building of 35,000 ft² housing a center for core processing and analysis and a laboratory for geochemical analysis and a one-story core storage facility of 100,000 ft², both still under construction, that will replace the older facilities.

The Bureau staff has more than tripled since 1967, when a staff of 50 professional and support personnel moved from the Little Campus to offices on the fifth floor of the newly built Geology Building on the Main Campus.

The new headquarters features modern furniture and equipment in an attractive facility. An exterior wall of fossiliferous limestone decorates the main entrance to the building. Tinted glass is used generously throughout. Exterior offices feature large windows and glass walls to the inside, which allow natural light to pass into hallways and central work areas. Each floor has a glassed-in reception area. Almost every hallway ends in a window. Selected walls throughout have been painted blue-gray and mauve,



accenting the beige color scheme of most of the building. A multipurpose conference room features panels of handsome pink polished granite. This room has several sets of furniture for arranging in five different configurations to suit various meetings and seminars.

A greatly expanded Reading Room/Data Center and a large publication display area offer visitors ample room to view maps and reports. A staff information specialist is available to answer questions on the geology of the state.

AWARDS AND HONORS

Bureau Staff Receive Service Awards

Four Bureau staff members were among those honored in May at the President's Reception for University Staff and the 23rd Annual Service Awards Program. Cartographer Barbara M. Hartmann was honored for 20 years of service to the University. Research Scientists Thomas C. Gustavson and Charles W. Kreitler and Word Processing/Typesetting Supervisor Lucille C. Harrell were honored for 10 years of service.

Ewing Receives Best-Paper Award from HGS

Thomas E. Ewing received the Best-Paper Award of 1983-84 from the Houston Geological Society for a paper titled "Growth Faults and Salt Tectonics in the Houston Diapir Province—Timing and Exploration Significance." The award was announced at the June meeting of HGS. Ewing presented the winning paper in February 1984.

Jackson Named to AAPG Subcommittee, *Bulletin* Staff

Martin P. A. Jackson was appointed to serve a three-year term on the Structural Geology Subcommittee of the AAPG Committee on Education. The Education Committee is chiefly responsible for stimulating and guiding the upgrading of existing AAPG schools and field seminars and the creation of new ones. About two years are required to propose, organize, arrange, advertise, and present a new school. The Committee is also responsible for the Single-Speaker Program, the Course Note Series, and the Slide-Tape Series. Jackson's subcommittee, which deals with structural geology topics, meets several times a year, including at the annual AAPG meeting. Jackson was also appointed to a three-year term as Associate Editor of the AAPG *Bulletin*.

Kreitler Chosen as Birdsall Distinguished Lecturer by GSA

Charles W. Kreitler was named the Eighth Birdsall Distinguished Lecturer by the Geological Society of America. The Birdsall lectures are funded by an endowment from the late John M. Birdsall to acquaint students with professionals in the field of hydrogeology. Kreitler will present lectures to universities throughout the country during 1984-85 on the following topics: the interaction between hydrologic and geologic processes and the hydrology of the Palo Duro Basin.

Maxwell Honored by National Park Service

The National Park Service honored former Bureau geologist Ross Alan Maxwell by naming Park Route 15 in Big Bend National Park "Ross Maxwell Scenic Drive."

Maxwell, now in his 80's, worked at the Bureau from 1952 to 1969, during which time he was senior author of a UT publication and author of a Bureau guidebook on Big Bend, among other works.

The honor is particularly meaningful, as Maxwell planned Park Route 15 himself, designing it to pass by scenic, historic, and geologic sites that would be interesting to all park visitors but especially those oriented toward geology. A public dedication ceremony naming the road in his honor was held in October at Sotol Vista on Castolon Road in Big Bend.

Maxwell has had a long association with Big Bend National Park, beginning right after his graduation with a Ph.D. from Northwestern University in 1936. His early work at Big Bend involved geologic mapping and mineral exploration for the National Park Service. In 1940 he was appointed Regional Geologist, directing national parks in an eight-state area. In 1944, he became the first superintendent of Big Bend National Park, a year after the park was officially established. He held that position until joining the Bureau. Since his retirement from the Bureau, he has taught summer courses at Sul Ross University on the geology of Big Bend, led field trips there, and assisted students studying the area.

Ratcliff Elected AGS President

Associate Director Douglas C. Ratcliff was elected president of the Austin Geological Society in April. His term of office is from May 1, 1984, through April 30, 1985. He previously served as Vice President for a one-year period. His duties this year have included making arrangements for the 1985 GCAGS Annual Meeting, which the AGS will host in October 1985.

Seni and Jackson Receive AAPG's Sproule Award

Steven J. Seni and Martin P. A. Jackson have been chosen by AAPG to receive the J. C. "Cam" Sproule Memorial Award for their paper "Evolution of Salt Structures, East Texas Diapir Province." The Sproule Award is given to recognize younger authors of papers applicable to petroleum geology. Candidates must be 35 years of age or younger at the time the paper is submitted. The award-winning paper was published in two parts in the AAPG *Bulletin* in 1983 (v. 67, no. 8). Seni and Jackson will receive the award—a $500 cash gift and a certificate bearing the names of the authors, the title of the paper, and the publication reference—at the opening session of the 1985 annual meeting of AAPG.

NEW RESEARCH STAFF MEMBERS

Carolyn E. Condon

Carolyn E. Condon, formerly a water resource analyst with the Idaho Department of Water Resources, joined the Bureau staff as a Research Scientist Associate in January 1984. Her areas of expertise include ground-water pollution investigations, water quality analyses, and application of environmental rules and regulations. She is currently a member of the Bureau's Quality Assurance Group. Bureau responsibilities include maintenance of the Quality Assurance program and supervision of contract requirements for the West Texas Waste Isolation project and monitoring of all Bureau contract requirements. Condon received a bachelor's degree in geology from Texas Tech University in 1968.

Claude R. Hocott

Claude R. Hocott, a Professor Emeritus in Petroleum Engineering at UT, is working part time as a Senior Research Engineer on a Bureau project concerning future oil potential of University lands. He received a Ph.D. in chemical engineering from the University in 1937 and worked as a research engineer at Humble Oil & Refining Company in Houston for 38 years. His career in research has involved studies of hydrocarbon phase behavior, formation evaluation, fluid mechanics, oil and gas recovery, reservoir engineering, and geochemistry. After retiring as Executive Vice-President of Exxon Production Research Company in 1974, he joined the University engineering faculty, teaching chemistry, chemical engineering, and petroleum engineering and serving as Chairman of the Petroleum Engineering Department from 1974 to 1975. He was Director of the Texas Petroleum Research Committee from 1974 to 1979, at which time he was named Professor Emeritus. He is a "Distinguished Engineering Graduate" of the University and is a member of the National Academy of Engineering, as well as numerous other professional organizations. He was the recipient of the AIME Anthony F. Lucas Gold Medal in 1981, and in 1984, the Claude R. Hocott Lectureship in Petroleum Engineering was established in his honor.

David W. Koppenaal

David W. Koppenaal assumed the duties of Chief Chemist of the Mineral Studies Laboratory (MSL) in October 1984, following a nationwide search for candidates for this position. Koppenaal was formerly manager of the Fuel and Environmental Sciences Section of the Kentucky Center for Energy Research Laboratory, Institute for Mining and Minerals Research Laboratory, at the University of Kentucky in Lexington. His education includes a Ph.D. in chemistry from the University of Missouri in 1978 and a bachelor's degree from Southwest Missouri State University in 1974. His dissertation research involved the fate and transport of trace elements during coal gasification processes. Koppenaal is overseeing the MSL move to its new laboratory quarters, the acquisition of new instruments to improve Bureau capabilities, and the selection of new MSL staff. His major priority is developing the MSL's research capabilities in geochemical analysis and fuel characterization.

Ronit Nativ

A magazine article by former Bureau researchers Randy Bassett and Mike Bentley led Ronit Nativ of Israel to come to the Bureau in August 1984 for a year of postdoctoral research. The article, concerning the deep aquifer in the Palo Duro Basin, attracted her interest since she had been doing research on the water potential of deep aquifers in her homeland. The past year, she has worked with Bureau researcher Charles Kreitler on continued studies of the Ogallala aquifer, specifically in the area of aquifer characterization. Nativ received a Ph.D in hydrology from Ben Gurion University of the Negev. The title of her dissertation was "The Water Potential of the Deep Aquifers (Paleozoic to Jurassic) in the Negev, Israel." She also held the post of research associate at Ben Gurion University's Institute for Desert Research and served as a lecturer in the Department of Geology.

Harry S. Posey

Three months after his original appointment as a Research Assistant, Harry Posey was named a Research Fellow in September 1984. He is assigned to the West Texas Waste Isolation project and is a member of a research team analyzing the geochemistry of the Wolfcampian aquifer of the Palo Duro Basin. Originally from Chattanooga, Tennessee, Posey has a master's degree from the Missouri School of Mines and is completing his Ph.D. in geology from the University of North Carolina at Chapel Hill. His dissertation is on "Strontium, Carbon, and Oxygen Isotopic Characteristics of Gulf Coast Salt Domes." Before his Ph.D. studies, Posey worked for 5 years with Cominco in southeast Missouri, central Tennessee, and northwest Alaska exploring for base metals.

DISTINGUISHED GUESTS VISIT BUREAU

Awadh S. Al-Zahrani, curator for the core and sample facilities of Arabian American Oil Company, visited the Bureau in March. His purpose was to learn about the plans for the new core research and storage facilities and about Bureau thin-section technology. Roger Y. Anderson, Professor of Geology at the University of New Mexico in Albuquerque, visited in March to discuss his research relating to salt dissolution in Permian salts in southeastern New Mexico and to cyclic deposits in the Castile Formation. Guntarto Sockadas of the Environmental Geology Division of the Indonesia Geological Survey visited in February. His purpose was to learn about the use of remote sensing at the Bureau and to discuss the application of Bureau land resources technology to Indonesian problems.

VEGETATION TYPES MAP OF STATE COMPLETED

In fulfillment of a contract with the Texas Parks and Wildlife Department, the Bureau completed the scribing and color separation of *The Vegetation Types of Texas Map*, which is now available from the Department. Fifty-three different vegetation types were mapped from Landsat imagery and compiled onto a USGS base map. A booklet explaining each vegetation type accompanies the map, which was printed in full color at a scale of 1:1,000,000. Cartography was by David M. Ridner, under the direction of Richard L. Dillon.

MINIATURE MODELS MAY REVEAL WORKINGS OF REAL DIAPIRS

Martin P. A. Jackson and his assistant, Reinold Cornelius, have been analyzing the 500 photographic slides of diapir models that Jackson brought back from eight weeks of research at the Hans Ramberg Tectonic Laboratory in Sweden. The laboratory is part of the Institute of Geology at the University of Uppsala in southern Sweden near Stockholm.

The University of Uppsala is the largest university in Sweden. "It's half the size of UT, and that's big by European standards," Jackson said. The Ramberg Laboratory was the first and, until recently, the only lab in the world to have a diapir-modeling centrifuge.

Jackson used the laboratory's centrifuge, which increases natural forces to 2,000 times the acceleration of gravity, to make miniature diapir models out of mixtures of silicone putty, modeling clay, and mercury. The models were sliced in different orientations. Photographs of their internal layers, some of which are less than a hair's width, reveal the way in which flow folds form. During the design stage, the models are scaled in size and in mechanical properties to mirror the stresses and strains of real diapirs.

James A. Morgan

Martin Jackson (right) and Reinold Cornelius map the internal structure of Iranian salt diapirs (foreground) to compare with sections through scaled model diapirs (background) created in a centrifuge.

The models don't travel well, and most were left in cold storage at the Institute. Jackson did, however, bring back a few sample models and modeling materials along with the slides.

Jackson worked closely with the laboratory's director, Christopher Talbot, during their 30 experiments there in March and April. He also had a discussion with Hans Ramberg, now retired, whose book on gravity tectonics is the standard reference. Ramberg invented the modeling technique used by Jackson.

The Department of Energy is funding Jackson's research. DOE wants to know if high-level nuclear waste can be stored safely in salt diapirs. This kind of assessment requires, among other things, a better understanding of the stresses and strains in diapirs.

Jackson will publish his results in several papers over the next few years, but he has only begun to scrutinize the slides of the models. He is impressed that even in the simplified geologic models, the shape and internal structure of model domes are far more complex than they are currently visualized in the literature on salt domes.

TEXAS MINING AND MINERAL RESOURCES RESEARCH INSTITUTE

The Texas Mining and Mineral Resources Research Institute (TMMRRI) is one of 31 State organizations funded and administered by the U.S. Bureau of Mines and dedicated to research and academic training in mineral science and technology. The Bureau administers the Institute, which is now directed by Jonathan G. Price. L. F. Brown, Jr., was the previous TMMRRI director. The University of Texas at Austin, Texas A&M University, and Prairie View A&M College are members of the Institute.

During the 1983-84 academic year, 11 fellowships and scholarships were awarded for a total of $40,000. During the 1984-85 academic year, 13 were awarded to students at member universities for a total of $53,500. These funds supported undergraduate and graduate training in mineral-related fields of science and engineering.

The Institute also supported mineral resource research in Trans-Pecos Texas and compilation of statistics on Texas minerals and producers. In addition, it provided partial funding for deep-basin lignite research. Reports published by the Bureau that were fully or partly funded by TMMRRI during 1984 include Report of Investigations No. 136 and Mineral Resource Circulars 73 and 74.

In August 1984, the President signed into law HR 4214, which reauthorizes the Mineral Institute programs for another five years.

RESEARCH STAFF ACTIVITIES AND PUBLICATIONS

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

PAPERS

Ayers, W. B., Jr., and **Kaiser, W. R.,** 1984, Lacustrine-interdeltaic coal in the Fort Union Formation (Palaeocene), Powder River Basin, Wyoming and Montana, U.S.A.: International Association of Sedimentologists Special Publication 7, p. 61-84.

Brown, L. F., Jr., 1984, Seismic stratigraphic analysis of depositional systems: American Association of Petroleum Geologists, Seismic Stratigraphy School, Course Notes, 35 p.

Edgar, T. F., and **Kaiser, W. R.,** 1984, Resources, properties, and utilization of Texas lignite: a review, *in* Schobert, H. H., ed., The chemistry of low-rank coals: Washington, D. C., American Chemical Society Symposium Series 264, p. 53-76.

Ethridge, F. G., **Tyler, Noel,** and Burns, L. K., 1984, Sedimentology of a Precambrian quartz-pebble conglomerate, southwest Colorado, *in* Koster, E. H., and Steel, R. J., eds., Sedimentology of gravels and conglomerates: Canadian Society of Petroleum Geologists Memoir 10, p. 165-174.

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Fisher, W. L., 1984, Offshore oil and gas activity and its socioeconomic and environmental influences: Subcommittee on Panama Canal/Outer Continental Shelf, Committee on Merchant Marine and Fisheries, U.S. House of Representatives, Committee Print Series No. 98-27, Washington, D. C., Government Printing Office, p. 100-104.

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LECTURES AND PUBLIC ADDRESSES

R. W. Baumgardner, Jr.

"Quaternary Stratigraphy and Paleoenvironments of the Western Rolling Plains of Texas": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Don G. Bebout

"Reservoir Characterization—Permian San Andres/Grayburg Formations": presented to Society of Economic Paleontologists and Mineralogists, Southwest Section, Midland, Texas.

"Reservoir Characterization—San Andres/Grayburg Formations, West Texas": presented to University of South Carolina, geology seminar, Columbia, South Carolina.

"San Andres/Grayburg Reservoirs, Dune Field, West Texas": presented to Dallas Geological Society, Dallas, Texas.

"What Is Happening in West Texas Carbonate Reservoir Studies": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

L. F. Brown, Jr.

"Seismic Stratigraphy": presented to The University of Texas at El Paso, Department of Geological Sciences.

Roy T. Budnik

"Structural Geology and Tectonic History of the Palo Duro Basin, Texas Panhandle": presented to North Texas Geological Society, Wichita Falls, Texas, and The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Thomas R. Calnan

"Benthic Communities in Espiritu Santo Bay, Texas": presented to Texas Academy of Science, annual meeting, San Antonio, Texas.

S. Christopher Caran

"Geologic Interpretation of Remote Images": presented to The University of Texas at Austin, Department of Geography, graduate and undergraduate classes in remote sensing.

"Geology of Westcave Preserve, Travis County, Texas": presented to Friends of Westcave Preserve, patrons' day, Dripping Springs, Texas.

"Quaternary Stratigraphy and Paleoenvironments of the Western Rolling Plains of Texas": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

R. D. Conti

"Distribution of Effective-Porosity Ranges in Wolfcamp Deep-Basin Aquifer, Palo Duro Basin": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Richard L. Dillon

"Cartographic Problems and Suggested Solutions": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Cartography—Map Making for the Petroleum Industry": presented to Desk and Derrick Club, Austin, Texas.

"Products, Services, and Future Plans for Mapping at the Bureau of Economic Geology": presented to American Library Association, Map and Geography Round Table, Government Mapping Update, Dallas, Texas.

Susann Doenges

"How to Be Your Own Best Editor": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Alan R. Dutton

"Hydrogeology of the Salt-Dissolution Zone, Texas Panhandle": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Shirley P. Dutton

"Geologic Evolution of the Palo Duro Basin: Pennsylvanian to Lower Permian": presented to Society of Economic Paleontologists and Mineralogists, Permian Basin Section, Geologic Evolution of the Permian Basin—A Symposium, Midland, Texas.

T. E. Ewing

"Growth Faults and Salt Tectonics, Houston Area": presented to Houston Geological Society, Houston, Texas, and San Antonio Geophysical Society, San Antonio, Texas.

"Monroe Disturbance": presented to The University of Texas at Austin, Institute for Geophysics.

"Paleozoic Structural Evolution of the Permian Basin": presented to San Antonio Geophysical Society, San Antonio, Texas; The University of Texas at Austin, Department of Geological Sciences, technical sessions; and The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Robert J. Finley

"Environment of Deposition as a Factor in Reservoir Properties of Tight Gas Sandstones": presented to Society of Petroleum Engineers, Gulf Coast Section, Bryan/College Station Study Group, Bryan, Texas.

R. Stephen Fisher

"West Texas Waste Isolation Geochemistry Program Update": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

W. L. Fisher

"Area-Wide Resource Evaluation—Mature Areas": presented to Outer Continental Shelf Policy Advisory Committee, Washington, D.C.

"Future Oil and Gas Exploration Potential in Texas": presented to Corpus Christi Chamber of Commerce, Energy Impact Conference, Corpus Christi, Texas.

"Intrastate Projection on Natural Gas Supply: The Texas Situation": presented to Gas Research Institute, annual meeting, Sun Valley, Idaho.

"Oil Exploration and Exploitation: New Trends and New Geologic Challenges": presented to Seventh Australian Geological Congress, keynote address, Sydney, Australia.

"Recent Trends and Outlook for Natural Gas in Texas": presented to Texas Petroleum Research Committee, Conference on Natural Gas in Texas, Austin, Texas.

"Reserve Growth and Oil Exploitation Strategies: New Trends and Challenges": presented to Society of Exploration Geophysicists, annual meeting, Atlanta, Georgia.

Graham E. Fogg

"Impacts of Lignite Mining in Texas": presented to the symposium "Groundwater, Crisis or Opportunity," San Antonio, Texas.

"Results of Hydrogeologic Testing, Deep-Basin Lignite Program, Sabine Uplift Region": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Modeling Ground-Water Flow in Macroscopic Heterogeneities": presented to Gordon Research Conference on Modeling Flow in Permeable Media, poster session, Andover, New Hampshire.

"Regional Ground-Water Systems: Concepts, Data Analysis, and Modeling": presented to The University of Texas at Austin, Department of Civil Engineering, class in underground injection and recovery.

Michael A. Fracasso

"Ancestry of Reptiles—Indirect Paleobiologic Approach to a Historic Evolutionary Problem": presented to The University of Texas at Austin, University Students Geological Society.

"Hunting for Dinosaurs": presented to kindergarten class, Highland Park Elementary School, Austin, Texas.

"Regional Analysis of Cyclicity in the San Andres Formation": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

William E. Galloway

"Reservoir Characterization: Barrier Islands and Strandplains": presented to The University of Texas at

Austin, Bureau of Economic Geology, research seminar.

"Seismic Expression of Depositional Systems": presented to University of Arizona, Department of Geology, Tucson, Arizona.

Chester M. Garrett, Jr.

"What Is Happening in West Texas Carbonate Reservoir Studies": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

H. Scott Hamlin

"Depositional and Ground-Water Systems of the Carrizo - Upper Wilcox in South Texas": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Fluvial Depositional Systems of the Carrizo - Upper Wilcox in South Texas": presented to Houston Geological Society, Houston, Texas.

Lucille C. Harrell

"How to Get Fast Turnaround on Your Manuscripts in Word Processing": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Christopher D. Henry

"Caldera Development and Tectonic Setting of the Trans-Pecos Volcanic Field": presented to The University of Texas at Arlington, Department of Geology, departmental seminar, Arlington, Texas.

"Minerals Related Research at the Bureau of Economic Geology": presented to meeting of State Geologists and U.S. Bureau of Mines, Denver, Colorado.

Clara L. Ho

"A Critical Evaluation of Sample Dissolution Techniques and Application of ICP-AES to Analysis of Geological and Brine Samples": presented to the 1984 Winter Conference on Plasma Spectrochemistry, San Diego, California, and The University of Texas at Austin, Bureau of Economic Geology, research seminar.

S. D. Hovorka

"Cyclicity in the San Andres Formation": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

M. P. A. Jackson

"Deformation Mullions in Incompetent Metabasite Dikes": presented to Institute of Geology, University of Uppsala, graduate students and faculty, Uppsala, Sweden.

"Dynamics of Flow Inside Diapirs and Other Salt Structures, with Excursions to Ethiopian Skating Rinks and Iranian Namakiers": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Experimental Modeling of Salt Diapirs Under Static, Aggrading, and Prograding Overburdens": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Experimental Simulation of Downbuilding, Upbuilding, and Progradation during Salt Diapirism and Relation to Internal Structure": presented to Institute of Geology, University of Uppsala, graduate students and faculty, Uppsala, Sweden.

"Salt Diapirism in a Marginal Rift Basin of the Gulf of Mexico": presented to Institute of Geology, University of Uppsala, open lecture, Uppsala, Sweden.

Mary L. W. Jackson

"Update on Land Resource Studies at the Bureau of Economic Geology": presented to Soil Survey and Land Resource Workshop, College Station, Texas.

W. R. Kaiser

"Geologic and Hydrologic Factors for Lignite Development": presented to Texas Mining and Reclamation Association, annual meeting, San Antonio, Texas.

Charles W. Kreitler

"Deep-Basin Hydrology": presented to The University of Texas at Austin, Department of Civil Engineering, graduate class in deep-well injection and recovery.

"Hydrogeology of the Palo Duro Basin: Interactions with the Ogallala Aquifer": presented to Second Symposium on the Ogallala Aquifer, Lubbock, Texas.

"Observations on the Application of Geochemistry for the Disposal of Nuclear Wastes in Salt Formations": presented to Los Alamos National Laboratory, Fundamental Geochemistry Needs for Nuclear Waste Isolation Workshop, Los Alamos, New Mexico.

"Regional Aquifer Geochemistry": presented to The University of Texas at Austin, Department of Civil Engineering, graduate class in deep-well injection and recovery.

Long-Cheng Liang

"What the SEM and Microprobe Can Do for You": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Malcolm P. R. Light

"The Limpopo Belt: An Archean (Southern African) Analog of the Ouachita Fold Belt": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Zsay-Shing Lin

"Early Time Pressure Transient Test Analysis": presented to Marathon Research Center, seminar, Littleton, Colorado.

"Engineering Studies of Tight Gas Reservoirs in the Travis Peak Formation, East Texas": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Marcie D. Machenberg

"The Geology and Natural History of the Galapagos Islands": presented to Austin Jewish Professional Singles, Austin, Texas.

Mary W. McBride

"A Geologist at Work": presented to Faubion Elementary School, fifth grade students, Cedar Park, Texas.

"Rocks and Minerals All Around Us": presented to Austin Independent School District, in-service workshop for fifth grade teachers, Austin, Texas.

Douglas A. McGookey

"Cenozoic Epeirogenic Uplift of the Palo Duro Basin, Texas, and Its Influence on Structure, Salt Dissolution, and Topography": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

R. A. Morton

"Diversity and Dynamics of the Texas Coast": presented to Outdoor Nature Club, Houston, Texas, and The University of Texas at Austin, University Students Geological Society.

"Legal and Geological Implications of Hurricane Alicia": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Rocks and Minerals": presented to third grade class, Doss Elementary School, Austin, Texas.

"Techniques for Monitoring Beach Movement": presented at Open Beaches Conference sponsored by the Texas Attorney General's Office, Galveston, Texas.

Ronit Nativ

"The Water Potential of the Deep Aquifers in the Negev Desert, Israel": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Jeffrey G. Paine

"A Higher Holocene Sea-Level Highstand in Texas?": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Legal and Geological Implications of Hurricane Alicia": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Xenoliths at Mount St. Helens: Do They Represent Major Volcanic Arc Constituents?": presented to The University of Texas at Austin, University Students Geological Society.

Jonathan G. Price

"Geologic Aspects of In Situ Uranium Leaching": presented to The University of Texas at Austin, Department of Petroleum Engineering, graduate seminar.

"A Minitest of an In Situ Uranium Leach Solution": presented to Society of Mining Engineers of American Institute of Mining, Metallurgical, and Petroleum Engineers, Solution Mining Session, annual meeting, Los Angeles, California.

"Porphyry Copper and Molybdenum Deposits": presented to The University of Texas at Austin, Department of Geological Sciences, geology class.

Alva E. Saucier

"The Gibsland Salt Stock Family in Northwestern Louisiana": presented to Gulf Coast Association of Geological Societies, annual meeting, Shreveport, Louisiana, and The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Rainer K. Senger

"Cross-Sectional Ground-water Flow Modeling, Palo Duro Basin, Texas Panhandle": presented to The University of Texas at Austin, Department of Geological Sciences, hydrogeology class.

"Effect of Hydrostratigraphy and Basin Evolution on Ground-Water Flow in the Palo Duro Basin": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Hydrogeology of the Edwards Aquifer and Barton Springs": presented to Austin Geological Society, Austin, Texas.

Steven J. Seni

"Evolution of the East Texas Basin and Mechanisms of Dome Growth": presented to The University of Texas at Austin, Department of Geological Sciences, graduate class in research in geohydrology.

"Storage Technology and Natural Resources in Texas Salt Domes": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

David A. Smith

"Drill-Stem Tests—A Tool for Hydrologic Studies": presented to The University of Texas at Austin, Department of Geological Sciences, hydrogeology class.

Susan J. Tewalt

"Trends in Texas Lignite Quality": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Steven W. Tweedy

"A Critical Evaluation of Sample Dissolution Techniques and Application of ICP-AES to Analysis of Geological and Brine Samples": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"General Overview of Analytical Capabilities of the Mineral Studies Laboratory—Past, Present, and Future": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

Noel Tyler

"Oil Accumulation and Production Characteristics in Major Texas Oil Reservoirs": presented to East Texas Geological Society, Tyler, Texas.

"The Pilgrims Rest Goldfield: Stratiform Gold-Silver Mineralization in Early Proterozoic Platform Carbonates, South Africa": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Reservoir Characterization: Barrier Islands and Strandplains": presented to The University of Texas at Austin, Bureau of Economic Geology, research seminar.

"Restricted Platform and Shallow Shelf Carbonates of the Malmani Dolomite: Relation to Gold-Silver Mineralization in the Pilgrims Rest Goldfield: presented to the University of the Witwatersrand, Economic Geology Research Unit, research seminar, Johannesburg, South Africa.

E. G. Wermund

"Geologic Concerns in Siting a High-Level Waste Repository": presented to Education Committee of Texas Mid-Continent Oil and Gas Association, Texas Energy Education Day Project, Austin, Texas.

"1974-1983 Oil and Gas Activities within Texas Submerged Lands": presented to Minerals Management

Service, Fall Information Transfer Meeting, New Orleans, Louisiana.

"Status of the Search for a High-Level Waste Repository in the Texas Panhandle": presented to The University of Texas at Austin, Center for Energy Studies, Energy Seminar Series.

"Texas Nearshore Habitat Mapping": presented to Minerals Management Service, Environmental Studies Ternary Meeting, Metairie, Louisiana.

William A. White

"Active Processes and Hazards along the Texas Coastal Zone": presented to The University of Texas at Austin, Department of Geological Sciences, geologic hazards class.

CONGRESSIONAL, LEGISLATIVE, AND SPECIAL TESTIMONY

R. A. Morton

Cooperated with the Governor's Office, General Land Office of Texas, and the Texas Department of Parks and Wildlife regarding State property on the Texas coast.

R. A. Morton and Jeffrey G. Paine

Cooperated with the Texas Attorney General's Office regarding beach conditions and changes in the vegetation line along the Texas Gulf shoreline.

Cooperated with the Texas Department of Water Resources regarding impact of the *Alvenus* oil spill and subsequent cleanup activities on West Beach, Galveston Island.

COMMITTEE SERVICES, OFFICES, AND OTHER PROFESSIONAL RESPONSIBILITIES

M. L. Ambrose

Co-editor (1983-84), Newsletter of the Austin Geological Society.

Member (1984-85), Newsletter Committee, Austin Geological Society.

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Alternate Member, Remote Sensing and Cartographic Committee, Texas Natural Resources Information System.

Co-leader of field trip, "Elements of the Geomorphology and Quaternary Stratigraphy of the Rolling Plains of the Texas Panhandle," U.S. Department of Energy and its subcontractors and Friends of the Pleistocene, South-Central Cell.

Don G. Bebout

Co-chairman, Fifth Annual Research Conference, "Modern and Cenozoic Slope and Deep-Water Sediments, Gulf of Mexico," Society of Economic Paleontologists and Mineralogists, Gulf Coast Section.

Member, Committee for *Gulf of Mexico* volume of the Decade of North American Geology series, Geological Society of America.

Member, Committee on Preservation of Samples and Cores, American Association of Petroleum Geologists.

Member, Cross Section Committee, American Association of Petroleum Geologists.

Member, Publication Committee, American Association of Petroleum Geologists.

President (1983-84), Society of Economic Paleontologists and Mineralogists, Gulf Coast Section.

L. F. Brown, Jr.

Associate Editor, American Association of Petroleum Geologists Bulletin.

Co-leader of field trip, "Contemporaneous Deposition of Clastic and Calcareous Facies of Pennsylvanian Age, North Texas," American Association of Petroleum Geologists, annual meeting.

Member, Awards Committee, Department of Geological Sciences, The University of Texas at Austin.

Thomas R. Calnan

Chairman, Benthic Community Session, Texas Academy of Science, annual meeting.

S. Christopher Caran

Co-leader of field trip, "Cretaceous Volcanism in the Austin Area, Texas," American Association of Petroleum Geologists, annual meeting.

Co-leader of field trip, "Elements of the Geomorphology and Quaternary Stratigraphy of the Rolling Plains of the Texas Panhandle," U.S. Department of Energy and its subcontractors and Friends of the Pleistocene, South-Central Cell.

Co-leader of field trip, "Remote Sensing in the Texas Hill Country," American Society of Photogrammetry - American Congress on Surveying and Mapping, annual joint meeting.

Leader of field trip, "Geology of the Honey Creek Preserve, Comal County, Texas," The University of Texas at Austin, Department of Geography, graduate and undergraduate classes in remote sensing.

Member, Committee for *Geomorphic Processes in the Great Plains* volume of the Decade of North American Geology series, Geological Society of America.

Member, Editorial Committee, Gulf Coast Association of Geological Societies.

Edward Wilson Collins

Co-leader of field trip, "Elements of the Geomorphology and Quaternary Stratigraphy of the Rolling Plains of the Texas Panhandle," U.S. Department of Energy and its subcontractors and Friends of the Pleistocene, South-Central Cell.

E. Dow Davidson

Conferee, Committee on Preservation of Samples and Cores, American Association of Petroleum Geologists.

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Editor, *Blueline*, Association of Earth Science Editors.

Shirley P. Dutton

Member, Committee for *Sedimentary Cover of the Craton: U.S.* volume of the Decade of North American Geology series, Geological Society of America.

Member, Committee on Stratigraphic Correlations, American Association of Petroleum Geologists.

Secretary, Society of Economic Paleontologists and Mineralogists, Mid-Continent Section.

T. E. Ewing

Chairman (1984-85), Publication Committee, Austin Geological Society.

Chairman (1983-84), Technical Programs Committee, Austin Geological Society.

Co-leader of field trip, "Cretaceous Volcanism in the Austin Area, Texas," American Association of Petroleum Geologists, annual meeting.

Member, Editorial Board, Rio Grande Rift Consortium.

Robert J. Finley

Alternate Representative, House of Delegates, American Association of Petroleum Geologists.

Alternate Representative, Task Force, Texas Natural Resources Information System.

Judge, Poster Sessions, American Association of Petroleum Geologists, annual meeting.

Member, Remote Sensing and Cartographic Committee, Texas Natural Resources Information System.

W. L. Fisher

Associate Editor, American Association of Petroleum Geologists Bulletin.

Chairman, Committee on Hydrocarbon Assessment in the Outer Continental Shelf, National Research Council, National Academy of Sciences.

Chairman, Continental Margin Committee, Association of American State Geologists.

Chairman, Faculty Review Committee, Geology Foundation, The University of Texas at Austin.

Chairman, Nominating Committee, Association of American State Geologists.

Chairman, Policy Advisory Board, Outer Continental Shelf, U.S. Department of the Interior.

Chairman, Site Selection Committee for the Super-Conducting Super Collider, Texas Universities Consortium.

Chairman, Vice Chairman, Texas Low-Level Radioactive Waste Disposal Authority.

Co-director, Energy and Natural Resources Division, Policy Research Institute, The University of Texas at Austin, Lyndon B. Johnson School of Public Affairs.

Director, Geology Foundation, The University of Texas at Austin.

Member, Advisory Committee, The University of Texas at Austin, Institute for Latin American Studies.

Member, Board on Mineral and Energy Resources, National Research Council, National Academy of Sciences.

Member, Committee on Academic Liaison, American Association of Petroleum Geologists.

Member, Committee on Marine Geology, American Association of Petroleum Geologists.

Member, Committee on Outer Continental Shelf, Office of Technology Assessment, U.S. Congress.

Member, Executive Committee, American Association of Petroleum Geologists.

Member, Futures Committee, Association of American State Geologists.

Member, Geology Advisory Group, Southern Illinois University.

Member, Geology Associates Board, University of Kansas.

Member, High-Level Nuclear Waste Disposal Committee, Association of American State Geologists.

Member, Research Committee, Interstate Oil Compact Commission.

Member, Resolution Committee, Interstate Mining Compact Commission.

Member, Texas Mapping Advisory Committee.

Member, U.S. National Committee on Geology, National Academy of Sciences and U.S. Department of the Interior.

Past-President, Association of American State Geologists.

President-elect, American Association of Petroleum Geologists.

William E. Galloway

Editor, *Uranium.*

Geological Consultant, International Boundary and Water Commission.

Chester M. Garrett, Jr.

Delegate (1982-85) of Austin Geological Society to American Association of Petroleum Geologists.

Member (1984-85), Public Information Committee, American Association of Petroleum Geologists.

Thomas C. Gustavson

Co-leader and organizer of field trip, "Elements of the Geomorphology and Quaternary Stratigraphy of the Rolling Plains of the Texas Panhandle," U.S. Department of Energy and its subcontractors and Friends of the Pleistocene, South-Central Cell.

M. P. A. Jackson

Lecturer, Continuing Education Program, American Association of Petroleum Geologists.

Member, Education Committee, American Association of Petroleum Geologists.

Mary L. W. Jackson

Chairman, Newsletter Committee, Austin Geological Society.

Leader of field trip on fossils, Travis Audubon Society.

David A. Johns

Member, Speakers Assistance Committee, Gulf Coast Association of Geological Societies, 1985 annual meeting.

W. R. Kaiser

Editor, *In Situ.*

Charles W. Kreitler

Editor, *Science.*

Member, Athletic Committee, Gulf Coast Association of Geological Societies, 1985 annual meeting.

Member, Editorial Board, *Journal of Ground Water.*

Member, Steering Committee, Water for Texas Conference, The University of Texas at Austin and Texas A&M University.

Marcie D. Machenberg

Chairperson, Arrangements Committee, Gulf Coast Association of Geological Societies, 1985 annual meeting.

Treasurer (1983-84), Austin Geological Society.

Amanda R. Masterson

Member, Membership Committee, Association of Earth Science Editors.

Member, Planning Committee, Third International Conference on Geoscience Information, Geoscience Information Society.

Mary W. McBride

Chairman, Speakers Assistance Committee, Gulf Coast Association of Geological Societies, 1985 annual meeting.

Member, National Minerals Research Database Committee, Mining and Mineral Resources Research Institutes.

Member, Science Curriculum Review Committee, Texas Advisory Committee on Environmental and Energy Education.

R. A. Morton

Chairman, Legislative and Governmental Committee, American Institute of Professional Geologists, Texas Section.

Member, Committee for *Gulf of Mexico* volume of the Decade of North American Geology series, Geological Society of America.

Member, State Affairs and Registration Committee, American Institute of Professional Geologists.

Jonathan G. Price

Field trip chairman, Gulf Coast Association of Geological Societies, 1985 annual meeting.

Douglas C. Ratcliff

Chairman, Session on Cretaceous Stratigraphy and Exploration, Gulf Coast Association of Geological Societies, 1984 annual meeting.

Member, Membership Committee, American Association of Petroleum Geologists.

Treasurer, Gulf Coast Association of Geological Societies, 1985 annual meeting.

Vice President (1983-84), President (1984-85), Austin Geological Society.

Steve J. Seni

Chairman (1984-85), Technical Programs Committee, Austin Geological Society.

William W. Simpkins

Co-leader of field trip, "Elements of the Geomorphology and Quaternary Stratigraphy of the Rolling Plains of the Texas Panhandle," U.S. Department of Energy and its subcontractors and Friends of the Pleistocene, South-Central Cell.

Susan J. Tewalt

Co-editor (1983-84), Newsletter of the Austin Geological Society.

Judge, Poster Sessions, American Association of Petroleum Geologists, annual meeting.

Member (1984-85), Newsletter Committee, Austin Geological Society.

Member (1984), Nominating Committee, Austin Geological Society.

Member, Tobin Theater Committee, Gulf Coast Association of Geological Societies, 1985 annual meeting.

E. G. Wermund

Alternate member, Texas Mapping Advisory Committee.

Co-leader of field trip, "Contemporaneous Deposition of Clastic and Calcareous Facies of Pennsylvanian Age, North Texas," American Association of Petroleum Geologists, annual meeting.

Member, Environmental Geology Committee, American Association of Petroleum Geologists.

Member, Interagency Task Force, Texas Natural Resources Information System.

Texas Representative, Regional Technical Working Group for Gulf of Mexico Outer Continental Shelf Leasing, U.S. Department of the Interior.

Vice President (1983-84), President (1984-85), Gulf Coast Association of Geological Societies.

William A. White

Co-leader of field trip, "Padre Island Development," American Planning Association, state conference.

UNIVERSITY TEACHING/ CONTINUING EDUCATION

Don G. Bebout

Carbonate Core-Logging Exercise: Permian Basin Graduate Center, Midland, Texas.

Carbonate Core-Logging Exercise: American Association of Petroleum Geologists, Carbonate Exploration School, Boulder, Colorado (with Robert G. Loucks).

Cretaceous Field Seminar: American Association of Petroleum Geologists, Austin, Texas (with Clyde Moore).

L. F. Brown, Jr.

"Seismic Stratigraphy": Dallas Geological Society, Dallas, Texas; French Petroleum Institute, Paris, France; and University of Houston, Geophysics for Geologists School, Houston, Texas.

"Seismic Stratigraphy" (Geology 383): The University of Texas at Austin, Department of Geological Sciences (with Richard T. Buffler).

"Seismic Stratigraphy in Petroleum Exploration": American Association of Petroleum Geologists, Seismic Stratigraphy School, Palm Springs, California, and San Antonio, Texas.

Shirley P. Dutton

"Fan-Delta Arkoses of the Texas Panhandle": Oklahoma City Geological Society, Oklahoma City, Oklahoma.

T. E. Ewing

"Hydrocarbons in the Permian Basin—Tectonic and Stratigraphic Controls": Professional Seminar Group, Houston, Texas, and Midland, Texas.

"Plate Tectonics": Region XIII Science Center, Austin, Texas.

Robert J. Finley

Digital Image Processing Workshop: Texas Natural Resources Information System, Austin, Texas (with Charles Palmer and Robert Aanstoos, TNRIS).

William E. Galloway

"Basin and Trend Analysis in Exploration" (Geology 330K/391): The University of Texas at Austin, Department of Geological Sciences, Leslie Bowling Professor.

"Depositional Systems in the Exploration for Sandstone Stratigraphic Traps": American Association of Petroleum Geologists, Corpus Christi, Texas.

"Fluvial Systems: Their Economic and Field Applications": American Association of Petroleum Geologists, Salt Lake City, Utah (with R. Flores, F. Ethridge, and T. Fouch).

"Seismic Stratigraphic Models and Field Documentation": American Association of Petroleum Geologists, San Antonio, Texas.

"Structural and Depositional Styles of Gulf Coast Tertiary Continental Margins: Application to Hydrocarbon Exploration": South Texas Geological Society, and American Association of Petroleum Geologists, San Antonio, Texas.

C. M. Garrett, Jr.

"Hydrocarbons in the Permian Basin—Tectonic and Stratigraphic Controls": Professional Seminar Group, Houston, Texas, and Midland, Texas.

M. P. A. Jackson

"Growth Faulting and Salt Tectonics": American Association of Petroleum Geologists, School of Structural Geology, Park City, Utah.

"Structural and Depositional Styles of Gulf Coast Tertiary Continental Margins: Application to Hydrocarbon Exploration": South Texas Geological Society, and American Association of Petroleum Geologists, San Antonio, Texas.

Charles W. Kreitler

"Interaction of Hydrology and Geology" (Geology 391C): The University of Texas at Austin, Department of Geological Sciences (with John M. Sharp, Jr.).

SUPPORT STAFF

ADMINISTRATIVE/SECRETARIAL

The administrative/secretarial staff is responsible for administrative, accounting, payroll, and secretarial work essential to day-to-day operation of the Bureau. These staff members are, in many respects, the Bureau's closest contact with the general public. They assist visitors who wish to purchase Bureau publications, and they also handle mail and telephone requests. Bettye A. Blitch, Executive Assistant, coordinates the work of the administrative/secretarial staff.

CARTOGRAPHY

The excellent capabilities of the cartography department have done much to enhance the Bureau's reputation in geologic and land resource mapping. Although perhaps best known for its high-quality, full-color maps, the cartography section also produces a wide range of other maps, cross sections, text illustrations, slide copy, posters, and display materials. Within the cartography department, a publication design section designs all covers and publications and pastes up camera-ready copy. A photography section provides cover and text photographs for Bureau publications, slides for lectures and public addresses, and negatives and color proofs for maps. Richard L. Dillon, Chief Cartographer, directs the work of the cartography department.

Cartographic technician John Ames drafts logs correlated for one of the Bureau's cross-section series.

PUBLICATIONS PRODUCTION

A Bureau report undergoes many steps in the transformation from rough manuscript to final publication. Manuscripts are typed and electronically transferred to the phototypesetter by the word processing/typesetting staff, which is supervised by Lucille C. Harrell. The editorial staff, directed by Susann Doenges, edits and proofreads manuscripts and coordinates production throughout the publication process. Reports are designed and pasted up by the graphic design staff, which is supervised by Richard L. Dillon.

Photos/James A. Morgan

Typesetter operator Phyllis J. Hopkins inserts typesetting codes in document transferred from word processing equipment.

BUREAU OF ECONOMIC GEOLOGY

Dr. W. L. Fisher, Director

Dr. L. F. Brown, Jr., Associate Director
Dr. Robert A. Morton, Associate Director
Dr. E. G. Wermund, Associate Director

Douglas C. Ratcliff, Associate Director for Administration
Bettye A. Blitch, Executive Assistant

SENIOR RESEARCH SCIENTISTS

Dr. Virgil E. Barnes
Dr. Don G. Bebout
Dr. William E. Galloway

RESEARCH SCIENTISTS

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Dr. Robert J. Finley
Dr. Thomas C. Gustavson
Dr. Christopher D. Henry
Dr. Clara L. Ho
Dr. Claude E. Hocott
Dr. Martin P. A. Jackson
Dr. William R. Kaiser
Dr. David W. Koppenaal
Dr. Charles W. Kreitler

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Dr. Walter B. Ayers, Jr.
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Gary F. Collins
Dr. Alan R. Dutton
Shirley P. Dutton
Dr. Thomas E. Ewing
Dr. R. Stephen Fisher
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Dr. Malcolm P. R. Light
Dr. Zsay-Shing Lin
Dr. Jonathan G. Price
Dr. Stephen C. Ruppel
A. Eugene Saucier
Steven J. Seni
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Dr. Noel Tyler
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Edward W. Collins
Carolyn E. Condon
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Lee A. Jirik
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Steven W. Tweedy

WELL SAMPLE AND CORE LIBRARY

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Curator
Richard L. Akins
Ronald P. Brock
Ethel E. Butler
Marshall W. Gibson
Jerel McGuffin
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Clarence C. Talley, Jr.
David B. Wallace

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Tim L. Gregory
Gay Nell Gutierrez
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