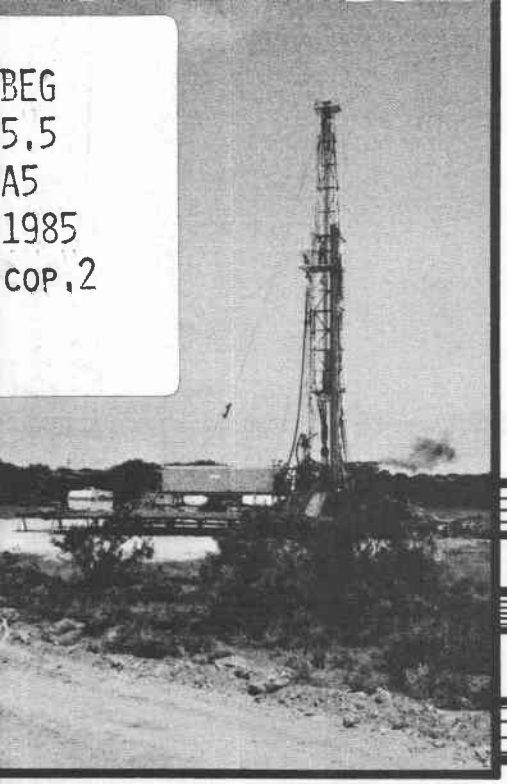

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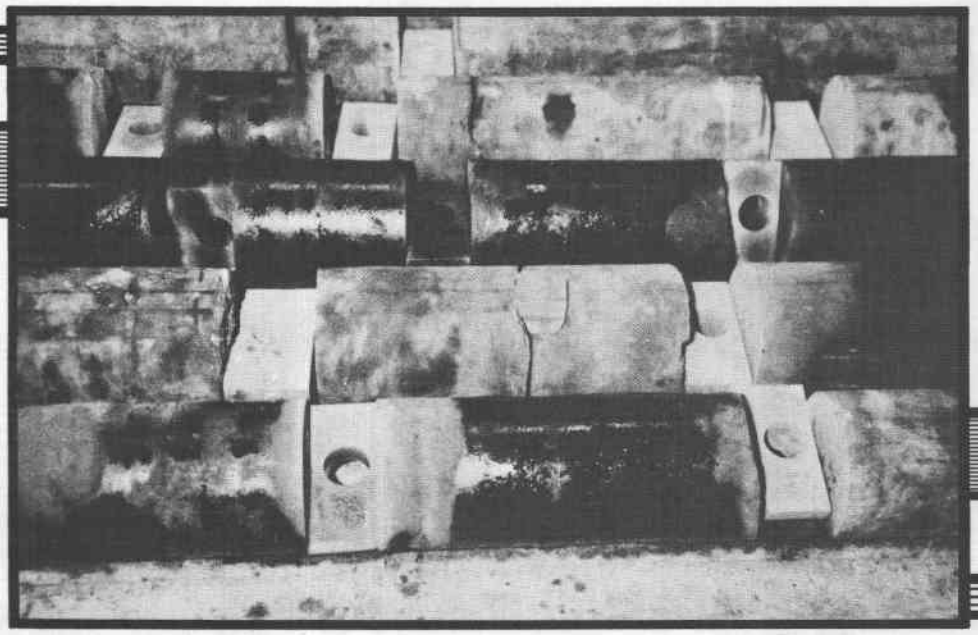

Bureau of Economic Geology
W. L. Fisher, Director

The University of Texas at Austin
Austin, Texas 78713

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 of the Bureau of Economic Geology outlines the scope and status of current research projects, publications, personnel activities, and services in the area of Texas resources and geology that are available to gover

GEOL ESEARCH

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INVESTIGA INVESTIGATIONS

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On the cover: Photographs illustrating the successful infill drilling of the Mobil University No. 1560 well in Dune field. The well was drilled on the Mobil University Unit 15/16 property in Crane County. The successful well produced about 150 barrels per day. **Upper left:** Drilling rig on Mobil University No. 1560 site. **Center:** Oil bleeding from core of Grayburg dolomite. **Lower right:** Pump jack on a well adjacent to the Mobil University 1560 site and producing from the Grayburg Formation.

Photos by Don G. Bebout; cover design by Jamie S. Haynes.

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CONTENTS

RESEARCH

Research is the principal function of the Bureau of Economic Geology and reflects the Bureau's roles as a major research unit of The University of Texas at Austin and as the State geological survey. Bureau programs are directed toward solving State problems requiring geological expertise and toward enhancing the public's knowledge of Texas geology. Studies commonly aim at inventory, assessment, and especially understanding of the natural resources of Texas, which include energy, minerals, and land and water. Much of the research is basic and can be applied worldwide.

In 1985, the Bureau continued research programs to locate both conventional and nontraditional occurrences of energy resources. Studies of conventional oil resources moved offshore Texas into State and Federal lands. A computerized data base was constructed to include a file of well logs, base maps, and subsurface maps of State lands. Correlation and quantitative mapping of the Middle and Upper Miocene stratigraphic units with emphasis on the productive trend along the Brazos Ridge began for the Outer Continental Shelf.

Research expanded to characterize better earlier identified oil reservoirs that could be expected to retain large volumes of oil in place after conventional production methods were no longer successful. The three-dimensional geometries of component depositional and diagenetic facies, which govern the spatial distribution of fluid flow properties and ultimate oil recovery, were determined. Two studies illustrated success in this approach. A pilot study of the San Andres/Grayburg reservoir of the Mobil University 15/16 Unit, Dune field, Crane County, resulted in an infill discovery well with initial production of 150 barrels per day. An important aspect of this program has been close cooperation among scientists and engineers in industry and the Bureau. In a similar reservoir study, integration of gamma-ray-log facies with sandstone mapping revealed that the more than 10 billion barrels of original oil in place in the 0.5-million-acre rich area of the Spraberry Trend is controlled by a previously unrecognized meandering to anastomosing channel/levee depositional system. Regional geologic analyses of the Ellenburger karstic play were completed for the Permian Basin.

Analyses to address the potential of unconventionally trapped gas continued in 1985. Increased availability of core from the tight gas sands of the Travis Peak Formation in East Texas permitted detailed petrographic and diagenetic studies of these gas reservoirs; low permeability was caused mainly by authigenic quartz and a high-molecular-weight bitumen. Numerical remote sensing techniques were newly developed to analyze potential fracture systems in these tight reservoirs. Current and planned development of facilities to produce cogenerated gas prompted a Bureau analysis of this fuel supply.

Manuscripts of four folios were completed describing the sedimentology and geohydrology of the shallow lignites, mineable by conventional methods with draglines, and the deep-basin lignites, mineable by new methods of exploitation. Petrographic and chemical characterization of these Wilcox Group (Eocene) lignites showed an increase in coal rank with depth.

During 1985, old and new Bureau studies of Texas land and water resources were dominated by hydrological and geochemical initiatives in waste disposal research. Since 1977, a major research commitment has been directed toward the possible disposal of high-level radioactive waste into a Permian bedded salt within a major evaporite aquitard of the Texas Panhandle. Hydrologic modeling suggested that fluids may have been transported through the aquitard, whereas the geochemistry of the host rocks indicated no alteration since deposition. New waste disposal research involving three principally hydrologic studies addressed disposal of varied wastes, petroliferous and chemical, affecting saline aquifers below potable ground water.

Investigations of mineral resources continued in the Trans-Pecos region, and in 1985 a new effort was begun to evaluate and inventory the hard mineral potential of State-owned lands. This research emphasized magma generation, magma evolution, caldera development, and the state of stress with time in relation to ore emplacement.

Excellent progress was made toward completing traditional geologic mapping of Texas at 1:250,000 and 1:500,000 scales. The Bureau published the first sheet of its *Bouguer Gravity Atlas of Texas*, the Clovis Sheet. The new series will complement the *Geologic Atlas of Texas* series and will cover the same 38 quadrangles at a scale of 1:250,000.

Several efforts emphasized the structure and tectonics of the deeper and shallow crust. An analysis of laboratory gravitational models of piercement salt domes was combined with detailed mapping of the Great Kavir (Iranian) salt domes on remote sensing imagery and aerial photographs. A new type of salt structure, a salt canopy, was recognized. The canopy is a 40-km-wide, allochthonous salt layer formed by lateral fusion of 12 overhanging bulbs connected by diapiric stems to a deep source layer of salt.

Further descriptions of Bureau research projects are provided on the following pages.

ENERGY RESOURCES INVESTIGATIONS

PETROLEUM

GENETIC STRATIGRAPHY, DEPOSITIONAL SYSTEMS, STRUCTURAL EVOLUTION, AND PETROLEUM EXPLORATION POTENTIAL: NORTHWEST GULF OF MEXICO CONTINENTAL SHELF

Robert A. Morton, project director; W. E. Galloway and L. A. Jirik; assisted by Emil Bramson, Denise Hanna, and Richard Erdlac

This long-term industry-sponsored 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 3 years, includes more than 1,500 conventional well logs, numerous paleontologic reports, scout tickets, and production records. During 1985, an industrial associates group was organized to maintain the research effort and to increase the exchange of information with potential users. Participants in the industrial associates program are Amoco, ARCO, Conoco, Louisiana Land and Exploration, Mobil, Pennzoil, Phillips, Sohio, Tenneco, Texaco, and the U.S. Geological Survey.

A set of 11 regional stratigraphic cross sections of the Miocene Series, including a report describing general structural trends, Miocene facies distribution, and production history, was completed and published in 1985. Additional work included correlation and quantitative mapping of the Middle and Upper Miocene stratigraphic units with emphasis on the productive trend along the Brazos Ridge. When completed in 1986, the maps and facies interpretations will be 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 Middle and Upper Miocene depositional sequences.

STUDIES RELATED TO CONTINENTAL MARGINS

Robert A. Morton and S. J. Seni, project directors; H. S. Hamlin

Under Douglas C. Ratcliff's direction, the Bureau coordinates a multidisciplinary program of the Continental Margins Committee of the Association of American State Geologists. Funded by the Minerals Management Service, geological surveys of the coastal states conduct studies relevant to the needs of the individual states and of the Department of Interior's offshore leasing program. The Minerals Management Service funded the Bureau's research to evaluate better the factors that control hydrocarbon accumulation beneath the Texas Outer Continental Shelf. Work will concentrate on the Frio Formation and will emphasize productive trends in State waters that extend into Federal Outer Continental Shelf leases. The downdip portion of the Frio Formation will be interpreted using electric logs, core, and regional cross sections to map structural styles, depositional facies, and productive trends. Both deep water offlap (upper slope) sediments of the Frio and Frio onlap slope deposits infilling major erosional canyons produce gas and condensate.

PETROLEUM RESOURCE ASSESSMENT OF STATE-OWNED LANDS

S. J. Seni, project director; H. S. Hamlin

State-owned lands along the Texas coast include all normally submerged lands extending offshore to the 3-league (approximately 10-mi) line. Significant oil and gas resources are recovered from State tracts offshore and in rivers, bays, and lagoons. The General Land Office of Texas (GLO) is the State agency charged with managing State lands. To evaluate effectively bids for oil and gas drilling rights on State leases, GLO must have reliable data on the oil and gas resources. Accordingly, GLO has granted a 2-year contract to the Bureau to assist in assessment of oil and gas potential of State-owned lands. With an improved subsurface geologic data base GLO can manage State resources better and institute a geologic-based system for economic evaluation of State lease tracts.

RESERVOIRS ON UNIVERSITY LANDS

Don G. Bebout, project director; G. E. Fogg, C. M. Garrett, Jr., C. R. Hocott, C. Kerans, F. J. Lucia, R. P. Major, S. C. Ruppel, and G. W. Vander Stoep; assisted by Harris Cander, Karen Herrington, Mark Holtz, and Julie Kupecz

The University of Texas Board of Regents funded this project to characterize geological and engineering details of reservoirs on University Lands in West Texas with high potential for improved recovery. To identify the most appropriate reservoirs for study, an extensive survey of West Texas reservoirs was undertaken.

The Bureau's *Atlas of Major Texas Oil Reservoirs* assigned 450 major oil reservoirs to 45 plays. Nineteen plays are located in West Texas, and 14 occur on University Lands. These 14 plays were initially ranked using cumulative production, estimated ultimate recovery, and unrecovered movable oil. The five most significant plays identified are San Andres/Grayburg (Central Basin Platform), San Andres/Grayburg (Ozona Arch), Clear Fork (Central Basin Platform), Fractured Ellenburger, and Silurian-Devonian (Central Basin Platform).

Each of these five plays was evaluated further using cores to identify subplays with unique geological or engineering attributes. From these subplays five reservoirs will be selected for detailed analyses using production characteristics (unrecovered movable oil, recovery efficiency, cumulative production, drive mechanism), geological complexity (geological age, carbonate setting, porosity type and distribution, structure), economics, operator cooperation, and availability of data (cores, high-quality logs, core analyses, and production data). These regional appraisals will be reported in early 1986.

Preliminary results from a pilot study of the San Andres/Grayburg reservoir of the Mobil University 15/16 Unit, Dune field, Crane County, are favorable. The geological study was completed, and engineering investigations are continuing. The investigation has been expanded to include the northern half of University Blocks 30 and 31.

Bradford W. Sincock, Mobil Oil Company

Rick Major, Research Associate, conducts preliminary onsite description of core from the Mobil University No. 1562 well in Dune field. Oil production at Dune field is from a Permian Grayburg Formation reservoir on University land in Crane County, Texas.

Study of a second San Andres field also has begun. The Emma field in southeastern Andrews County produces from the upper San Andres along the east side of the Central Basin Platform. Most of the field is developed over a northwest-trending, slightly asymmetric, closed structure. Recently, however, step-out production has been developed on the more gently dipping southwest limb of the fold. Three cores reveal that the reservoir comprises an upward-shallowing sequence of predominantly subtidal facies. Porosity is best developed in two zones: (1) a relatively thick lower zone containing fusulinid wackestone and associated sponge/algal wackestone, both with moldic and intercrystalline porosity; and (2) an upper porous zone of relatively thin layers of algal grainstone, with interparticle and intraparticle porosity. The thinner upper zone has permeability values considerably higher than the lower zone. Lower-zone porosity extends throughout the field; the algal grainstone facies, however, is restricted to the central area because of a northeast and east change to muddier, deeper-water facies in the uppermost San Andres. Development of off-structure production to the southwest is related to distribution of facies belts that strike perpendicular to structure.

Regional geologic studies of the Ellenburger, Silurian-Devonian, and Clear Fork plays were initiated to identify additional fields for closer study. Regional geologic analysis and assessment of production statistics for the Ellenburger play were completed. The northern Central Basin Platform (Andrews County) area was identified as having the greatest potential on the basis of the presence of paleokarst-related and secondary intercrystalline porosity in late-stage dolomites. Production statistics show that more than 80 percent of Ellenburger production on University Lands is concentrated in this area. Selection of a specific field for detailed geologic and engineering analyses is under way.

Subplay analysis of the Silurian-Devonian in the Permian Basin is nearly complete. Lowermost Silurian (Fusselman Formation) rocks are light-colored, locally dolomitized, shallow-water subtidal to peritidal wackestones to grainstones. Overlying Silurian and Devonian rocks are dark-colored, commonly cherty, shallow- to deep-water subtidal wackestones to grainstones that are locally dolomitized. Porosity is typically associated with the vugs in the dolomitized intervals. These porous dolomitized zones appear to be related to unconformities. Porosity typically occurs at the top but is also present within the Silurian-Devonian section.

GEOLOGICAL CHARACTERIZATION OF TEXAS OIL RESERVOIRS (CARBONATE RESERVOIR STUDIES)

Don G. Bebout, project director; C. M. Garrett, Jr.; assisted by David Leary and Scott Schmidt

The Reservoir Characterization Project began in 1981 with a compilation of geological and engineering data from all Texas fields that have produced more than 10 million barrels of oil. This first phase resulted in the publication of the Bureau's *Atlas of Major Texas Oil Reservoirs*. The second phase of the project involved examination of all major carbonate and clastic reservoirs in the state to identify those which may respond most favorably to improved secondary and tertiary recovery methods. Selection was based on the geological setting integrated with engineering data. The San Andres/Grayburg reservoir of the Mobil University 15/16 Unit, Dune field, Crane County, was selected as the carbonate example.

Dune field is a low-relief structure located along the east side of the Central Basin Platform. The Mobil 15/16 Unit lies on the northeast side of this structure that dips gently eastward into the Midland Basin. Several cores from this small area include the Permian Lower Guadalupian Grayburg and San Andres Formations. The primary reservoir facies occur within the Grayburg Formation. Grayburg facies occur in two major depositional units: the lower unit consists of sponge/algal framestone fringed by crinoid packstone/grainstone; the upper unit comprises a single upward-shoaling cycle with subtidal fusulinid wackestone at the base and arid tidal-flat pisolite grainstones and associated mudstones at the top. Porosity and permeability are best developed in the very shallow water pellet grainstones and crinoid packstones/grainstones. Interparticle grainstone porosity is the most effective. These porous facies change westward to nonporous tidal-flat facies in less than a mile. Porosity also disappears upward within the cored interval.

Detailed geological study of the Mobil University 15/16 Unit was completed. Engineering studies (including reservoir modeling) of the 15/16 Unit and geological investigations of an expanded area are continuing as part of the University Lands Project.

GEOLOGICAL CHARACTERIZATION OF TEXAS OIL RESERVOIRS (CLASTIC RESERVOIR STUDIES)

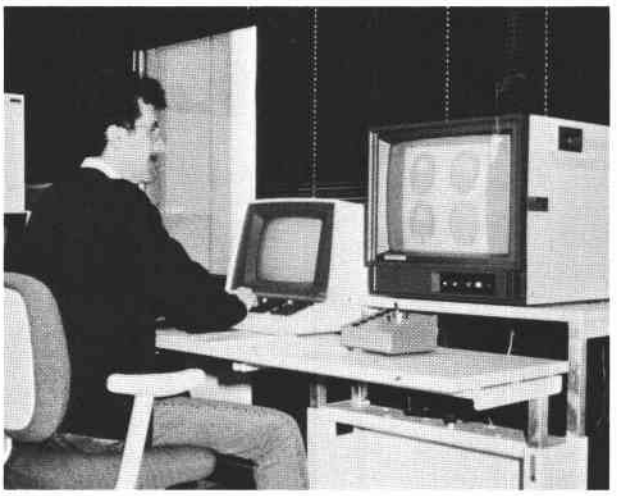
Noel Tyler, project director; Edgar Guevara; assisted by J. Crispin Gholston and Koso Idigbe

Permian submarine fan and basin-plain deposits of the Midland Basin contain more than 10 billion barrels of

original oil in place. Most of this resource is confined to a 0.5-million-acre area known as the Spraberry Trend. Ultimate recovery of oil from the Spraberry Formation (the principal producing interval in the trend) is poor, averaging about 6 percent. Approximately 9.5 billion barrels of oil will remain in the formation at abandonment. Three unitized areas in the center of the trend, the Driver, Preston, and Shackelford units, were selected for detailed geologic study to identify reasons for the extremely poor recovery.

Spraberry reservoirs are tight, naturally fractured siltstones and very fine grained sandstones that are hydrofractured to stimulate production. Producing intervals are near the base and at the top of the approximately 1,000-ft-thick formation and are separated by shales, carbonates, and lesser sandstones of the middle Spraberry. The productive upper and lower Spraberry is subdivided into nine regionally correlatable coarser intervals. Conventional sandstone mapping shows that whereas the intervals are laterally continuous, individual beds that compose the intervals display strongly defined lateral variability. Integration of gamma-ray-log-facies mapping with sandstone mapping of individual beds revealed the presence of meandering-to-anastomosing channel/levee systems superimposed on sheetlike prograded outer-fan sediment. Contrasting reservoir parameters at boundaries between facies result in pronounced compartmentalization of the reservoirs and in hydrocarbon zones left undrained or poorly drained.

To improve recovery from the vertically segregated, laterally discontinuous pools of the Spraberry, future development strategies must incorporate selective completions on the basis of interpretative facies mapping for injection and production.



James A. Morgan

Robert W. Baumgardner, Jr., Research Scientist Associate, sets up the Bureau's image processing device in preparation for digital analysis of Landsat Thematic Mapper data. Remote sensing of surface lineaments is one method being used to study structural geology and regional stress regimes.

GAS

GEOLOGICAL INVESTIGATIONS OF LOW-PERMEABILITY GAS SANDSTONE RESERVOIRS

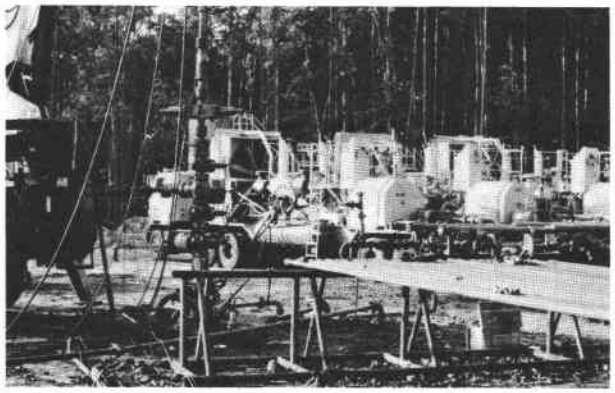
Robert J. Finley, project director; Robert W. Baumgardner, Jr., Shirley P. Dutton, Michael A. Fracasso, Mary L. W. Jackson, and Zsay-Shing Lin; assisted by Patricia Bobeck and Bruce Gates

Supported by the Gas Research Institute, this project is part of a major integrated research program involving geology, reservoir engineering, log analysis, and other disciplines applied to the production of gas from low-permeability sandstone reservoirs. Sandstones under 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 was chosen because of its high resource potential (14 to 23 Tcf), its diversity of development problems, and the moderate level of drilling activity that continues in East Texas despite the current gas surplus. The Corcoran and Cozzette (4 Tcf resource) were chosen because of expected transferability of research results to geologically similar units throughout the Rocky Mountains region.

Geological research objectives of the tight gas sandstone program are to understand fully the depositional systems of the reservoirs, to determine the diagenetic history of the sandstones and its effect on reservoir quality, and to define the maturation and migration history of hydrocarbons. Additional objectives are definition of structural influences on gas production, including distribution of natural fractures and state of stress of reservoir rocks, and regional trends of geological engineering properties in Travis Peak reservoirs. Results are being integrated with geophysical well logging and reservoir engineering research conducted by other contractors to the Gas Research Institute. The overall effort is to ensure that tight gas sandstones are being efficiently evaluated, hydraulically fractured, and produced.

Maps of the regional depositional framework and results of core studies of the Travis Peak over the Sabine Uplift, East Texas and North Louisiana, outlined two fairways for further research. Regional studies had shown that the Travis Peak formed a thick high-constructive deltaic system that prograded over a broad shallow shelf. The sand-rich Travis Peak consists of a middle fluvial-deltaic wedge overlain and locally underlain by a delta-fringe facies. The stratigraphically higher delta-fringe facies is the most hydrocarbon productive within the Travis Peak. It consists of fine to very fine grained sandstone, siltstone, and mudstone primarily from tidal flat, distributary channel, and bay/estuarine depositional settings. These facies form a less sand-rich lithologic sequence in which reservoir sandstones are better isolated between mudstones than in the fluvial-deltaic facies.

Containment of hydraulic fractures in specific sandstones requires isolation by contrasting lithologies.



R. J. Finley

Wellhead of the Prairie Producing Company No. 1A-Mast, Nacogdoches County, Texas, with pump trucks in the background, as the operator prepares a hydraulic fracture treatment of Travis Peak tight gas sandstones.

Two fairways, one in Rusk and Nacogdoches Counties, and one in Marion, Harrison, and Panola Counties, offer the best possibilities for isolated reservoirs. The Marion-Harrison-Panola fairway was selected from the two, and three play areas were defined within it. In 1986 the Gas Research Institute will operate its own test well in the Travis Peak in one of these play areas. Among many planned studies are detailed analyses of geometry, petrography, and diagenesis of the reservoir sandstones, structural studies of the stress state of the reservoir sequence, and lineament analysis in the region surrounding the well.

Petrographic and diagenetic studies of Travis Peak reservoirs, based on core from more than 10 widely spaced wells, have shown that authigenic quartz is primarily responsible for low permeability. The sandstones, classified as quartzarenites and subarkoses, are largely free of depositional matrix. Lesser amounts of ankerite, illite, and chlorite occlude porosity, but clays are not a major factor in reservoir quality. A high-molecular-weight bitumen was discovered in many reservoirs where it reduces porosity by 3 to 6 percent. This immobile hydrocarbon phase can appear as hydrocarbon-filled porosity on neutron logs; its origin is under investigation.

Ongoing remote sensing and structural studies of the East Texas Basin are designed to determine probable propagation direction of hydraulic fractures in the tight sandstones of the Travis Peak. Fracture research includes an assessment of stress states in the region and near individual wells. Lineaments have been defined from 1:100,000 and 1:250,000 Landsat images, digitized, and checked against photomosaics and aerial photographs. Dominant lineament trends at the 99-percent confidence level have been recognized at 320° to 350° and at 30° to 50° azimuths. Analysis of Landsat data has preceded analysis of higher resolution, synthetic aperture radar (SAR) data of the eastern half of the East Texas Basin. SAR imagery and digital analysis of Landsat Thematic Mapper imagery will be used in fairways and specific plays to map structural trends near wells studied in cooperation with operators and at the GRI-operated test well.

Other activities in 1985 included developing a coring program and interpreting geophysical logs for a Corcoran-Cozzette well in the Piceance Creek Basin of Colorado. Testing and completion of the well are scheduled for 1986; these studies are being conducted in cooperation with the Colorado Geological Survey.

Tight gas research in 1986 will involve studies near the GRI-operated Travis Peak test well. To plan the test well program, coring, logging, and reservoir testing will take place in several offset wells. About 300 ft of core are expected to be recovered in the test well. Results of core strain relaxation studies, lineament analysis, and geophysical fracture detection logs will be integrated to define geologic controls on hydraulic fracture direction and extent of propagation. Geochemical studies, including studies of the pervasive quartz cement, are aimed at determining the processes that operated in the Travis Peak during burial to reduce permeability in most Travis Peak sandstones. Further depositional systems studies will address local development of dip-oriented fluvial axes and strike-oriented shoreline sandstones that may control the distribution of reservoir rock and potential barriers to fracture growth.

AN ANALYSIS OF FUEL SUPPLIES FOR COGENERATION IN TEXAS

Robert J. Finley, project director; Mary L. W. Jackson

Current and planned development of cogeneration facilities in Texas prompted this analysis of fuel supplies, funded by the Center for Energy Studies, The University of Texas at Austin. Cogeneration is the generation of electricity in conjunction with production of steam or other process heat needed by an industrial facility. All or part of the electricity may become available to electric utilities. Natural gas has been most commonly used in cogeneration facilities, almost all of which are located in the Texas Gulf Coast region. Natural gas is ideally suited to the equipment involved, is easily handled and distributed through current pipelines, and is readily available. Most of this project therefore has been focused on natural gas supplies; however, oil supplies and lignite availability have also been reviewed.

Railroad Commission of Texas district 4, South Texas, is the state's leading producer of nonassociated, or gas-well, gas. Within district 4 new discoveries, on average, replaced production in the 1979-84 period, but this favorable record does not exist elsewhere in the state. Overall daily statewide deliverability of nonassociated gas has declined about 2.5 percent annually in recent years. Some areas, such as district 6 in East Texas, showed increased discoveries when Natural Gas Policy Act price incentives were effective, but current gas surpluses have resulted in declining discovery. Statewide associated, or casinghead, gas production increased in the 1980-84 period as the oil production decline rate moderated significantly.

GEOLOGICAL AND ENGINEERING RESEARCH SUPPORT FOR GULF COAST CO-PRODUCTION PROGRAM

Robert J. Finley, project director; Malcolm P. R. Light, David W. Koppenaal, Thomas E. Ewing, Mary L. W. Jackson, and Walter B. Ayers, Jr.

The Bureau of Economic Geology and the Center for Energy Studies are conducting joint investigations in the Gulf Coast Co-Production Program. The purpose of this project, funded by the Gas Research Institute, is to investigate the mechanisms of, and to improve the hydrocarbon production from, gas reservoirs that have been abandoned or are beginning to water out.

Activities have been focused in three main areas: (1) screening and evaluation of gas fields, (2) geology of the Northeast Hitchcock field, and (3) environmental effects of large-volume fluid withdrawals.

Screening and Evaluation of Gas Fields

Mary L. W. Jackson, Malcolm P. R. Light, and Walter B. Ayers, Jr.; assisted by Wendy L. D'Attilio

In a 1984 study, the Bureau selected 118 gas fields and 45 other large reservoirs and evaluated them for co-production potential on the basis of cumulative production and present bottom-hole shut-in pressure (BHSIP). From that group, 20 fields with the largest cumulative production and BHSIP exceeding 1,000 psi (pressure gradients greater than 0.25 psi/ft) were selected. Ultimately, three fields—Port Acres, Ellis, and Esther—were examined for their potential co-production of gas and water.

New cross sections, structure maps, sandstone isopach maps, net gas-sand thickness maps, and facies maps were prepared for the fields. Published regional interpretations of depositional systems were combined with field facies information to establish a reservoir facies framework. Volumetric methods were used to estimate reservoir reserves.

Work began on the Port Acres field first, and isopach maps showed that the maximum gas-sand thickness does not coincide with maximum sand thickness. Gas reserves are therefore not controlled by sandstone thickness alone. Maximum gas-sand thickness is 140 ft in the Port Acres field, 90 ft in the Ellis field, and 30 ft in the Esther field. Remaining gas reserves in the Ellis and Port Acres fields are 5 to 10 Bcf. Data from these fields and the adjacent Port Arthur field suggest that these depleted reservoirs could be economically viable if co-produced.

Geology of the Northeast Hitchcock Field

Malcolm P. R. Light; assisted by Wendy L. D'Attilio

The project at the Northeast Hitchcock field involved the following research objectives: (1) to evaluate the mechanism of secondary gas recovery by co-production in a slightly geopressured watered-out reservoir by interpreting the geology of the field and adequately defining the reservoir parameters for engineering and modeling analyses, (2) to investigate the potential for shale dewatering, which results from fast pressure drawdown during co-production of gas and water, and (3) to investigate the hydrocarbon sources for gas and condensate, that is, whether they are locally derived or have migrated from deeper levels.

Cross sections and maps were prepared to illustrate the stratigraphy of the Frio A sandstone. Depositional systems and constituent facies were defined from maps and cross sections in conjunction with published interpretations. Detailed facies mapping of the Frio A sandstone and a detailed description of a core cut from the Delee No. 1 well were used to estimate the size, extent, and compartmentalization of the reservoir.

Marine reworking of the Frio A (9100) sandstone in the Northeast Hitchcock field resulted in its broad lateral extent and internal continuity, but thin shale breaks may vertically partition the reservoir. Several minor faults displace the original pay zone and may affect gas recovery efforts in this field. Much of the excellent preserved porosity ($\pm$ 30 percent) and permeability ($\pm$ 1,000 md, 0.99 μm^2) in the Frio A sandstone are due to its distributary-mouth-bar origin; however, primary porosity and permeability have been modified by diagenetic reactions.

Investigations continue on the source of formation fluids at the Northeast Hitchcock field using major, trace, and rare earth element analyses of formation waters and rocks. Detailed interpretations of gas chromatographic and mass spectrometry analyses are under way, but petrographic investigations of the Frio A sandstone are still to be done.

CONSOLIDATION OF GEOLOGIC STUDIES OF GEOPRESSURED GEOTHERMAL RESOURCES IN TEXAS

Robert J. Finley, project director; Malcolm P. R. Light and Thomas E. Ewing

The consolidation of geologic studies of geopressured geothermal resources in Texas, funded by the U.S. Department of Energy, has been subdivided into three main tasks: (1) special projects research and coordination assistance, (2) coordination of geological and engineering research in support of Gulf Coast co-production, and (3) environmental (land-subsidence) monitoring of the Pleasant Bayou test well area.

Special Projects Research and Coordination Assistance

Malcolm P. R. Light

To assist the U.S. Department of Energy's Geopressured Geothermal Research Program in 1985, the Bureau provided representatives of government, industry, and university research laboratories with sediment samples for elemental and hydrocarbon analyses and thin sections for studies of sandstone diagenesis. Water and hydrocarbon samples for geochemical analyses and the results of water analyses for studies of aquifer and reservoir hydrochemistry were supplied to other research laboratories. Bureau publications on the geology of the Texas Gulf Coast were also supplied to the researchers.

Coordination of Geological and Engineering Research in Support of Gulf Coast Co-production

Robert J. Finley, project director; Malcolm P. R. Light; assisted by Wendy L. D'Attilio and Javier Meneses-Rocha

A major task of this project has been integrating the results of the Gas Research Institute's Co-production Program with those of the U.S. Department of Energy's Geopressured Geothermal Program.

As part of the Gas Research Institute's Unconventional Natural Gas Research Program, the Bureau of Economic Geology and the Center for Energy Studies, The University of Texas at Austin, contributed to a joint project on the Northeast Hitchcock field (Galveston County). The procedures used and the results obtained in this research are described in the previous section on Gulf Coast co-production.

In addition to the co-production research, comparisons were made of known crystallization temperatures, pressures, and fluid, mineral, and isotopic compositions of formation waters and rocks in the Gulf Coast. The sequence of formation of salt dome cap rocks was compared with diagenetic alteration and hydrocarbon generation zones and the isotopic compositions of fluids and minerals in the Gulf Coast stratigraphic succession. An initial model has been built of the sources, nature, and timing of water and hydrocarbon migration in the Gulf Coast as well as the initiation, early history, and dynamics of salt dome intrusion.

COAL

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., and Graham E. Fogg; assisted by Curtis W. Black, David B. Mazza, Susan Shultz, and Audrea M. Sutley

This study, supported by special legislative appropriation, is a continuing effort to evaluate the Wilcox Group. Major effort in 1985 centered on data synthesis and manuscript preparation for publication of four geological and hydrological folios: (1) *The Wilcox Group and Carrizo Sand (Paleogene) in East-Central Texas: Depositional Systems and Deep-Basin Lignite* (30 pls. and 4 figs.), (2) *The Wilcox Group and Carrizo Sand in the Sabine Uplift Area, Texas: Ground-Water Hydraulics and Hydrochemistry* (24 pls. and 28 figs.), (3) *The Wilcox Group (Paleocene-Eocene) in the Sabine Uplift Area, Texas: Depositional Systems and Deep-Basin Lignite* (17 pls. and 11 figs.), and (4) *The Wilcox Group and Carrizo Sand in East-Central Texas: Ground-Water Hydraulics and Hydrochemistry* (in preparation).

Folios will feature maps (scale: 1 inch=6 mi), regional cross sections, and tabulated supporting data (microfiche appendix) along with a short interpretive text. The geological folio for east-central Texas is in press and should be available for public sale in the first quarter of 1986. Drafting of plates and figures for the Sabine Uplift hydrological folio is essentially complete, the data appendix is complete, and a draft text is being written. Appropriate maps and cross sections from the geological folio will be included for integration of hydrology and geology. Draft copy plates, figures, appendix, and text for the Sabine Uplift geological folio are complete, and drafting and word processing will proceed in 1986. The east-central Texas hydrological folio was the focus of our effort in 1985; plates are in draft form, and figures, appendix, and text are being prepared. Unpublished maps, cross sections, and supporting data for all folios are available for use at the Bureau.

COMPUTERIZED CALCULATION OF LIGNITE RESOURCES IN TEXAS

W. R. Kaiser, project director; Susan J. Tewalt and Mary L. W. Jackson; assisted by Curtis W. Black

This ongoing project, funded by the U.S. Geological Survey (USGS) and begun in 1979, provides estimates of remaining near-surface lignite resources (those under less than 500 ft of cover) in Texas. The computerized data base and graphics software of the National Coal Resources Data System (NCRDS) are used to calculate resources according to criteria of USGS Circular 891. NCRDS is accessed through a Tektronix 4054 terminal at the Bureau. Seam thickness, depth, and data locations are coded from geophysical logs and entered into the data base; point sources of proprietary data remain confidential.

Resources are calculated by stratigraphic unit in five seam categories—three standard USGS categories for lignite (2.5 to 5, 5 to 10, greater than 10 ft) and two that reflect current mining practice in Texas (2 to 3 and greater than 3 ft)—and reported on an aggregate basis by geographic region. Resources in the Wilcox Group (Eocene) of East Texas have been calculated for three geographic regions, representing approximately 68 percent of available data. Data entry and validation for the Jackson/Yegua trend in East Texas (24 percent of data) have been completed; digitization of point-source data delivered to the USGS in July 1984 is pending. Eight percent of the data remain for entry and occur in the Wilcox and Jackson Groups of South Texas. Completion of resource calculation in remaining areas depends on timely digitization.

CHARACTERIZATION OF TERTIARY COALS OF TEXAS ON THE BASIS OF ORGANIC PETROGRAPHY AND GEOCHEMISTRY

Prasanta K. Mukhopadhyay

The 1985 program involved (1) setting up a new coal petrography laboratory at the Bureau, (2) collecting coal samples of Wilcox and Jackson Group from coal mines in East Texas, and (3) characterizing both deep-basin and near-surface Tertiary coals by coal petrography, physical chemistry, and organic geochemistry. Characterization required measurements of maceral composition, huminite/vitrinite reflectance, amount and forms of sulfur and other mineral matter, elemental composition, hydrogen and oxygen indices, production index, maximum pyrolysis temperature, bitumen extract, and gas chromatography of the saturate fraction of the extracts.

Wilcox coals, as measured from the huminite reflectance, rank from subbituminous B or C (deep-basin coals) to subbituminous C to lignite (near-surface coals). Preliminary results show Wilcox coals have lower ash, sulfur, and liptinite contents and have lower H/C ratios than Jackson coals. Trends apparent among Wilcox coals from northwest to southwest are a decrease in inertinite, terrestrial exinite, and ulminite and an increase in H/C ratios.

Jackson coals are subbituminous C to lignite in rank. Jackson coals contain high humo/liptodetrinite and alginite/sapropelinite, which indicate a distinctly different depositional environment from Wilcox coals. The n-alkane distribution patterns correlate well with the maceral composition for Wilcox and Jackson coals.

An important observation during petrographic and organic geochemical characterization of these coals is that some coals may have acted as a source rock for the generation of liquid and gaseous hydrocarbons for the Gulf Coast Wilcox crude oil and gas. Plots of hydrogen and oxygen indices suggest that most of the Wilcox and Jackson coals lie within the type IIB kerogen maturation path. Solid bitumen occurs either as discrete bodies or as exsudatinite.

NORTH-CENTRAL TEXAS BITUMINOUS COAL

W. B. Ayers, Jr.; assisted by Erik Davidsen, David Mazza, and Javier Meneses-Rocha

Bituminous coal has been mined in North-Central Texas for more than a century. Although several studies have addressed the depositional systems of the host sediments, none has focused on the depositional setting of the coal. The goal of this research, funded by the Texas Mining and Mineral Resources Research Institute, was to reconstruct the depositional history of the coal-bearing Harpersville Formation in a 15-county (11,700 mi^2) area that, from Stephens County, extends west through Fisher County and south through McCulloch County.

Geophysical well logs from 2,599 oil and gas tests, supplemented by driller's lithologic logs, were used to make 30 regional maps. Included were sandstone, mudstone, and limestone lithofacies maps, as well as isopach, coal occurrence, and overburden maps for three intervals of the Harpersville Formation (Breckenridge to Crystal Falls, Crystal Falls to Flippen, and Flippen to Saddle Creek). Lithofacies maps and a structure map were also made for the Saddle Creek Limestone, which overlies the Harpersville.

LAND, WATER, AND ENVIRONMENTAL RESOURCES INVESTIGATIONS

COASTAL STUDIES

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

William A. White, Thomas R. Calnan, Robert A. Morton (program coordinator), and H. Seay Nance; assisted by James K. Miller; David W. Koppenaal and Steven W. Tweedy (chemists); and Daniel H. Ortuño (sedimentology lab technician)

This comprehensive inventory of Texas coastal submerged lands and associated wetlands continued in 1985 under a contract with the Minerals Management Service, U.S. Department of the Interior. The objective of the study is to produce an extensive data base characterizing submerged lands and wetlands along the entire Texas coast. The study involves textural, geochemical, and benthic macroinvertebrate analyses of selected sediment samples that were collected on 1-mi centers from the inner continental shelf and from bay-estuary-lagoon systems. Coastal wetlands are being mapped and described using color-infrared photographs and field surveys.

The submerged lands atlas of the Galveston-Houston area was completed in 1985 and prepared for publication. It is second in a series of seven that will cover the Texas coast. Other atlas areas (in order of publication) are Corpus Christi (published), Brownsville-Harlingen, Beaumont-Port Arthur, Bay City-Freeport, Port Lavaca, and Kingsville. Atlases consist of a text and a series of 17 maps: 4 maps (scale 1:250,000) depicting the distribution of sediment textures; 12 maps (scale 1:250,000) showing concentrations and distributions of selected trace, minor, and major elements; and 1 full-color map (scale 1:125,000) depicting species diversity, distribution of benthic macroinvertebrate assemblages, and distribution of coastal wetlands and associated environments. Draft contract reports and maps of the Bay City-Freeport and Port Lavaca areas were also completed in 1985; draft reports and hand-colored maps have been completed for all areas except Kingsville.

Standardized analytical methods used for different areas of the coast have allowed comparison of parameters such as trace-metal concentrations among bay and shelf areas. Normalization of elemental concentrations using percent mud has proved to be an effective method for characterizing and defining trace-metal content of bay and shelf sediment. For example, comparisons of sediments from Corpus Christi-Nueces and Galveston-Trinity bay systems and lower Laguna Madre indicate that mud in Galveston and Trinity Bays has the highest average concentrations of chromium, copper, iron, lead, and nickel, and that mud in Corpus Christi and Nueces Bays has the

highest average concentrations of barium and zinc. Highest average concentrations of total organic carbon are in Laguna Madre, apparently related to abundant marine grasses in the shallow submerged areas. Anomalous occurrences of trace metals have been identified in several areas along the Texas coast; high concentrations in some sediments are apparently related to anthropogenic contributions of trace metals to the system.

Benthic macroinvertebrates in bay-estuary-lagoon and inner shelf sediments are primarily polychaetes, bivalves, gastropods, and crustaceans. Polychaetes are dominant in most sediments. On the inner shelf, samples having higher percentages of sand generally have more benthic species. This positive correlation between percent sand and number of species is lower in the bays than on the inner shelf. Stations on the inner shelf with very high diversity values (greater than 2.500) have sandier substrates than those stations with diversity values of less than 2.500. Diversity on the inner shelf is generally high to very high. Cluster analysis delineates benthic communities in all bays and on the inner shelf; data from stations in the bay-estuary-lagoon system generally yielded less defined station groupings and assemblages than data from stations on the inner shelf. This was expected because of greater hydrographic and sediment variability in the bays.

Delineation of coastal wetlands and associated environments continued in 1985. The objective of the study is updated regional full-color maps of wetlands; units are patterned after the Bureau's *Environmental Geologic Atlas of the Texas Coastal Zone* series. Photographic interpretation and delineation of wetlands have been completed for all areas of the coast except Kingsville. Comparing the distribution of wetlands mapped on recent photographs (1979) with mid-1950 photographs used for the *Environmental Geologic Atlas* indicates dramatic changes in some areas such as Galveston-Houston and Beaumont-Port Arthur. Many changes, which include the replacement of marshes by open water, are related to land-surface subsidence and faulting.

SHORT-TERM SHORELINE AND VEGETATION-LINE CHANGES BETWEEN SABINE PASS AND THE RIO GRANDE

Robert A. Morton, project director; Jeffrey G. Paine; assisted by L. Serena Slocum

Changes in shoreline and vegetation-line position for the Texas Gulf Coast between the mid-1800's and mid-1970's were published as a series of Geological Circulars between 1974 and 1977. The passing of a decade since the original study, together with availability of recent photographs, occurrence of hurricanes since 1975, evidence of recent rapid coastal changes, and refinements to shoreline monitoring technique, has provided impetus for updating the earlier reports.

In 1985, the Gulf shoreline and vegetation lines were mapped on 1982 photographs of the entire Texas coast. These boundaries were then compared with their former positions (mapped on 1974 and 1975 photographs), and measurements were made of their movements. These measurements have reaffirmed the dynamic nature of Texas beaches; rates of movement up to several tens of feet per year were observed for both shorelines and vegetation lines. However, because shoreline changes as interpreted from aerial photographs depend on water level, more field work is needed to differentiate between long-term and seasonal fluctuations in shoreline position. This work will include reoccupation of beach profiles measured in the mid-1970's.

COASTAL CHANGES ASSOCIATED WITH HURRICANE ALICIA

Robert A. Morton, project director; Jeffrey G. Paine; assisted by David J. Adilman and L. Serena Slocum

Although Hurricane Alicia (August 1983) 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 was subjected to Alicia's highest winds and largest waves.

This study involves measurements of changes along the Gulf shoreline caused by the storm and an analysis of the physical processes that caused those changes. Data obtained during 1985 included field observations and ground measurements of post-storm processes and the progressive recovery of the beach and adjacent environs in both developed and undeveloped areas. Figures also were prepared, illustrating the magnitude and rate of natural recovery of the vegetation line following Alicia and hurricanes in 1942, 1961, and 1980.

During the second year after Alicia, beach recovery processes slowed and long-term shoreline changes were reestablished. Erosion again became predominant west of the Galveston seawall and near the western end of the island. About 40 percent of the sand eroded by Alicia was still absent from the beach. Material continued to be transferred from the forebeach to the backbeach, yet backbeach elevations remained slightly below pre-storm levels. Consequently, advancement of the vegetation line seaward of its post-storm position was insignificant. These studies increase our understanding of the shifts in coextensive geological and legal boundaries that occur during and after major storms.

WASTE DISPOSAL STUDIES

GEOLOGICAL AND HYDROGEOLOGICAL EVALUATIONS OF THE TEXAS PANHANDLE FOR A POTENTIAL HIGH-LEVEL WASTE REPOSITORY

Surficial and Geomorphic Studies

T. C. Gustavson, J. A. Raney, and S. C. Caran; assisted by H. E. Eby, J. Mahler, L. E. Mashburn, A. Standen, and E. Thorakos

Investigations of surficial (Quaternary) geology and geomorphology of the Texas Panhandle and adjacent areas continued during 1985. Stratigraphic studies of newly recognized late Pleistocene and Holocene deposits in the

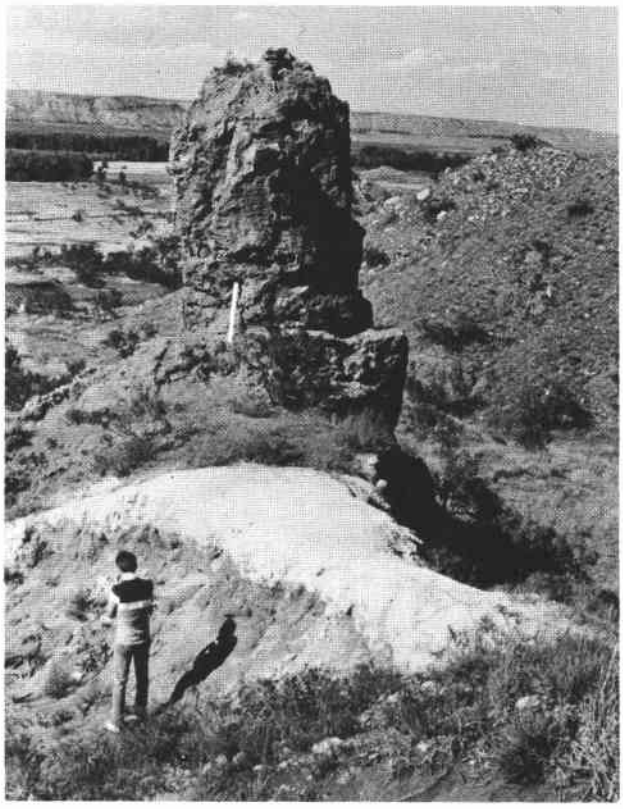
western Rolling Plains were completed. The deposits, which discontinuously cover more than 3,000 mi^2 east of the Caprock Escarpment, constitute an important aquifer supporting irrigated agriculture and the domestic needs of a number of small communities. Studies of karstic phenomena and Quaternary deposition in the Pecos River valley of eastern New Mexico provided modern analogs of late Pleistocene processes and environments in the Rolling Plains of Texas. Continuing studies in the Southern High Plains involve field examinations of the Ogallala (Neogene) and Blackwater Draw (Pleistocene) Formations and erosion-deposition monitoring of selected sites across the Plains.

Stratigraphy and Sedimentology

T. C. Gustavson, J. A. Raney, D. A. Johns, and H. S. Nance; assisted by S. Ide and T. Williams

Systematic investigations of facies relations within upper Permian evaporites and red beds of the Artesia Group expanded from the Queen/Grayburg Formation to include the Seven Rivers, Yates, and Salado/Tansill Formations in the Palo Duro Basin. The Artesia Group records numerous transgressions of marine-derived waters from the southwest, which terminated with evaporite precipitation and were followed by progradation of eolian-influenced terrestrial clastics from the northwest and west. Effects of Permian and post-Permian dissolution on individual evaporite beds were demonstrated by geophysical and core-log mapping. Documentation of geophysical log signatures of the halite dissolution zone was initiated.

Triassic lower Dockum sediments were subdivided into five sandstone-dominated depositional sequences. Sandstone thickness and lithologic data were mapped to delineate areas of major sediment input, orientation of major depositional axes, and types of depositional systems. Maps of the five units were compared to detect similarities in location, distribution, and orientation of sandstone sequences. Similarities were correlated with basement structure to detect possible structural control on deposition. Regional subsurface lithologic and depositional analyses are essentially complete.



S. C. Caran

Resistant knob of breccia, thought to be debris in a collapse chimney, Lake Meredith National Recreation Area. The phenomenon is important to understanding the processes of salt dissolution.

Structural Geology and Tectonics

T. C. Gustavson, J. A. Raney, R. T. Budnik, and E. W. Collins; assisted by V. W. Henderson

During 1985, research addressed the tectonic history of the Amarillo Uplift as an indicator of regional stress orientations. Tectonic deformation along the uplift has been episodic and closely related to orogenic activity in the southern Rocky Mountains. The distribution of pre-Pennsylvanian strata in the Anadarko and Palo Duro Basins suggests at least 75 mi of strike-slip faulting along the Amarillo Uplift during the Pennsylvanian Ancestral Rocky Mountain orogeny. Field and subsurface studies in northern Potter County indicate that basement structures along the uplift were reactivated during deposition of the Miocene/Pliocene Ogallala Formation, coincident with Basin and Range extension to the west.

Core Analysis and Diagenetic History

T. C. Gustavson, J. A. Raney, S. D. Hovorka, D. A. Johns, and E. W. Collins; assisted by L. Elliott, P. Granger, K. Thompson, J. Ramage, C. Crebbs, S. Harris, P. Krynine, M. McCrary, and S. Ide

Examination and sampling of 10 cores from DOE wells totaling 24,889 ft were completed in 1985. Core description included more than 16,400 ft of Permian evaporite core, 3,600 ft of core from above the evaporite section, and 4,890 ft from below the evaporite section. The core examination phase of regional characterization studies is now complete.

Sediments of the Permian Artesia Group exhibit a complex history. Evaporite depositional environments fluctuated between marine-dominated and terrestrially dominated conditions. Marine conditions are established by moderate bromide concentrations in halite and the isotopically heavy waters in fluid inclusions. Terrestrial conditions are documented by bromide-depleted halite and isotopically light fluid inclusions. High concentrations of magnesium during diagenesis are indicated by occurrences of magnesite and polyhalite. Later diagenetic events include dissolution of halite from the top of the Artesia Group, precipitation of diagenetic dolomite and anhydrite, and hydration of anhydrite to gypsum. Late diagenetic alteration varies among wells and can be related to present water chemistry.

James A. Morgan

Examination of core with a binocular microscope aids in core description and is one step in the detailed logging of DOE core holes in the Palo Duro Basin.

The diagenetic history of unit 4 carbonate of the Permian San Andres was examined in cores from two wells. A diagenetic sequence involves early calcite cement; neomorphic replacement of micrite by sparry calcite; development of moldic porosity; dolomitization; precipitation of halite, anhydrite, and minor celestite; and replacement of halite by calcite, dolomite, and anhydrite. Intercrystalline micropores in dolomite are the only pores not occluded by halite in the unit 4 carbonate.

Detailed petrographic analysis of the Dockum sediments was initiated, and core studies continue on the origin of fractures in the Palo Duro Basin.

Hydrogeology

Charles W. Kreitler, Robert D. Conti, A. R. Dutton, Ronit Nativ, Rainer K. Senger, William W. Simpkins, and D. Anderson Smith; assisted by M. Saleem Akhter, Gay Nell Gutierrez, Scott Hamlin, Bernd Richter, and Virginia Smith

Basin hydrology studies during 1985 include hydrogeological modeling, mapping of hydraulic head distributions, compiling data on aquifer properties, and interpreting the relations between hydrologic properties and water composition.

Progress was made in estimating hydrologic properties of Wolfcampian rocks, part of the Deep-Basin Brine aquifer. Porosity and permeability values for different rock types were based on core-plug analysis. Permeability values were also measured in drill-stem tests, and porosity values were also calculated from geophysical logs. These values were used to map distinct northerly trends of high porosity and permeability within the "Brown Dolomite" (upper Wolfcampian). The trends coincide with ancient shelf-margin positions and may represent preferential pathways for ground-water flow. The mapped distributions of porosity and permeability were put into a computer model of three-dimensional ground-water flow. Simulations with this model helped to understand better the factors controlling ground-water flow patterns and hydraulic connections among hydrostratigraphic units within the Deep-Basin Brine aquifer. Model results were compared with a 1985 potentiometric-surface map of the aquifer in Wolfcampian rocks, which was based on drill-stem-test data.

The effects of tectonic and geomorphologic events on the hydrodynamics of the Palo Duro Basin during Cenozoic time were investigated with cross-sectional modeling of ground-water flow under transient conditions. The modeling shows that the westward retreat of the eastern Caprock Escarpment during the last 1 to 2 million years was crucial for creating the significant underpressuring observed in Deep-Basin Brine aquifer below the Evaporite aquitard. The model also focused on the effects of possible fracture zones cutting through the Evaporite aquitard on regional ground-water flow within the Deep-Basin Brine aquifer.

Regional estimates of transmissivity for Triassic sandstones of the Dockum Group were derived using existing pumping-test and water-well data. Greatest transmissivities exist in thick sandstone deposits. The distribution of hydraulic head in the Dockum aquifer may be largely determined by topography of the Southern High Plains and surrounding Caprock Escarpment. Results of analyzing new and existing chemical and isotopic data

A. R. Dutton

Hand sample of gypsum that precipitated at a spring feeding the Dove Creek salt flat near Aspermont, Texas. Discharge of saline ground water in seeps and springs such as the one in the background is common in the Rolling Plains east of the Permian Basin. Saline springs and ground waters are being studied by Bureau scientists to determine sources of salinity affecting potable water supplies.

indicate that Dockum ground water varies regionally within the Southern High Plains and is chemically and isotopically distinct from ground water in the overlying Neogene Ogallala Formation and Cretaceous Edwards and Trinity Groups. A preliminary interpretation is that Dockum ground water was cut off from areas of previous recharge by erosion of the Pecos River valley during the Pleistocene and that under present conditions the Dockum aquifer is not readily recharged by water percolating downward from overlying formations.

Hydrogeologic studies of the Ogallala aquifer, the main water supply in the High Plains of Texas, were directed toward understanding the relations among aquifer recharge, sedimentary facies, and ground-water composition. Hydrochemical facies maps of Ogallala water were made using abundant chemical data. Ground-water and precipitation samples were collected at several stations in the Texas Panhandle to study the rate and isotopic composition of recharge to the Ogallala aquifer. Chemical and isotopic compositions of ground water in the Ogallala Formation are quite uniform among three areas where saturated thickness and permeability are high, coinciding with the depositional axes of Ogallala alluvial fans. The chemical and isotopic compositions vary in areas where the saturated thickness and permeability of the Ogallala Formation are less between major clastic axes. Variations in ground-water composition in the Ogallala may be due to movement of water from underlying formations, different rates of ground-water flow, and reactions between water and minerals in the Ogallala.

James A. Morgan

Steven W. Tweedy, Research Scientist Associate, prepares to determine the mineralogy of a sample using an X-ray diffraction instrument at the Mineral Studies Laboratory.

Hydrochemistry

Charles W. Kreitler, A. R. Dutton, and R. Stephen Fisher

Hydrogeochemical investigations of the Deep-Basin Brine aquifer and the Evaporite aquitard continued during 1985.

Hydrologic data and numerical modeling suggest that ground water has the potential to move across the confining Evaporite aquitard system. However, the chemical and isotopic composition of calcium-chloride and sodium-calcium-chloride brines in the San Andres Formation gives ambiguous evidence of ground-water movement since the Permian. The complex composition of two brines from San Andres carbonates within the Palo Duro Basin appears to be related to the low porosity and low permeability of the halite- and anhydrite-cemented carbonate host rock, as well as the long time since the water was in contact with the atmosphere.

Throughout the basin, the chemical composition of formation water from the Deep-Basin Brine aquifer varies systematically between the Wolfcampian Series, the uppermost permeable units, and deeper units. Wolfcamp brines are generally less saline than deeper fluids at each of the four DOE well sites, and the major ionic concentrations appear to be controlled by mineral-water equilibria. Regional differences in stable and radiogenic isotopic composition of deep-basin brines show that fluids in the northern and western parts of the basin are not in isotopic equilibrium with the host rock in that area, presumably because of short flow paths and short residence times in the deep-basin host rock. Conversely, central and eastern Palo Duro Basin brines approach or have achieved isotopic equilibrium with the host rock because of long flow paths and residence times.

Host Rock Geochemistry

R. Stephen Fisher, Susan D. Hovorka, and Harry Posey; assisted by Jeff Rubin and Keith Thompson

Bedded halite in the Permian Artesia Group was investigated to complement earlier, similar studies of San Andres salt and to evaluate the extent, if any, of alteration in a post-Permian ground-water flow regime. Post-Permian alteration of one halite bed in the Seven Rivers Formation was suggested by depleted bromide concentrations in the halite lattice and depleted oxygen and hydrogen isotopic compositions in fluid inclusions. However, the presence of similar bromide contents and stable isotopic compositions in other halite that displays unaltered, primary, chevron-type zonation shows the chemical values to be primary depositional features rather than the result of more recent processes. Textural relationships show magnesite and polyhalite in the Seven Rivers Formation to be early, syndepositional diagenetic products rather than primary precipitates or the result of late, postburial alteration.

The first phase of a study of the Wolfcampian Series shows that the rocks have had a complex diagenetic history of reflux dolomitization, anhydrite replacement and nodule

formation, anhydrite nodule silicification, sulfate reduction, and pyrite formation. Dolomitization is interpreted to have been initiated during precipitation of the overlying Wichita strata in Leonardian time. Comparison of water and rock isotopic compositions shows that the formation water now produced from the Wolfcampian Series is neither the original pore water present during deposition nor the fluid that diagenetically altered the rocks.

Clay minerals separated from a variety of host rock types were analyzed to determine both chemical and mineral composition. Analysis of individual clay particles by electron microprobe and bulk analysis of various size fractions document a progressive enrichment of magnesium in all diagenetically altered clays. Diagenetic alteration reflects the movement of magnesium-rich evaporite brines and was not restricted to salt-precipitating environments. Magnesium-rich, diagenetically altered clays in the Wolfcampian Series were apparently produced during reflux dolomitization of the sediments. The clay mineral assemblage, which contains vermiculite interlayered with swelling chlorite, is interpreted to have formed only in the presence of the most magnesium-rich brine and may serve as a potential indicator of salt-dissolution zones.

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL

J. A. Raney and C. W. Kreitler, coordinators; assisted by T. C. Gustavson, C. D. Henry, E. W. Collins, W. F. Mullican, III, and D. A. Smith

Preliminary geological evaluations of potential low-level radioactive waste sites were initiated in Culberson and Hudspeth Counties. The Texas Low-Level Waste Disposal Authority selected the sites and funded the research.

The Bureau will prepare geologic and hydrologic data bases for preliminary site evaluations by the Authority. Geologic maps of the areas based on aerial photographs with low sun angles will show both surficial deposits and bedrock. Field work will verify geologic maps and will investigate in detail the geomorphic, stratigraphic, and structural settings of the areas. Shallow core holes will provide additional stratigraphic data near the sites.

The hydrology of the unsaturated section (above water table) and the saturated section (below water table) will be investigated at each proposed site to determine depth to the water table, permeability of the potential host sediments and rocks, evidence of downward water movement in the unsaturated section, and rates and directions of flow. A water well and several shallow core holes will be drilled at each site to determine site hydrogeology. The age and chemistry of the ground water from the wells will be determined to estimate recharge rates.

INVESTIGATION OF THE SUITABILITY OF TEXAS SALT DOMES FOR THE ULTIMATE DISPOSAL OF TOXIC CHEMICAL WASTES

S. J. Seni, E. W. Collins, H. S. Hamlin, W. F. Mullican, III, and D. A. Smith

Texas salt domes are being considered for ultimate disposal of toxic chemical wastes in solution-mined caverns. The Texas Water Commission, the State agency that issues permits for disposal of toxic chemicals, funded the Bureau to determine whether the disposal of toxic chemicals in salt domes is technically feasible and to establish regulatory guidelines for such disposal.

Critical issues addressed were: (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 would be their path and would they contaminate the biosphere?

A final contract report titled *Examination of Texas Salt Domes as Potential Sites for Permanent Storage of Toxic Chemical Waste* concluded that no characteristics applicable to domes in general would disqualify all domes for toxic waste disposal. It was found that the type of resource recovery historically associated with salt domes significantly modifies the hydrologic and structural stability of domes and that these activities probably have had the greatest effect in establishing suitability of domes for toxic waste disposal. Changes in the natural system, especially pronounced around salt domes with large-scale sulfur production, include subsidence or collapse of strata over the dome and changes in ground-water flow, chemistry, pressure, and temperature.

GEOCHEMISTRY OF SALINE GROUND WATER IN THE TEXAS GULF COAST FORMATIONS USED FOR DEEP-WELL INJECTION OF CHEMICAL WASTES

Charles W. Kreitler and Bernd Richter

The chemical compositions of saline formations beneath the Texas Gulf Coast that are used for the disposal of chemical wastes by deep-well injection are being studied for the U.S. Environmental Protection Agency. Chemical data from all available sources have been computerized during phase I to provide a data base for future EPA work in evaluating the suitability of this type of disposal of chemical wastes and to determine whether the liquid wastes are chemically compatible with water and minerals in the formations used for injection. Phase II, to be initiated in 1986, will evaluate the overall hydrology of saline formations in the Texas Gulf Coast used for deep-well injection of chemical wastes.

SOURCES OF SHALLOW SALINE GROUND WATER IN CONCHO, RUNNELS, AND TOM GREEN COUNTIES

Charles W. Kreitler and Bernd C. Richter; assisted by Tonia J. Clement

The purpose of this short-term pilot study, conducted in spring 1985 and funded by the Railroad Commission of Texas, was to identify salt-water sources that contribute to the overall poor quality of ground water in the area. Results of analyses of main, trace, and isotopic constituents of water samples collected during the study permitted identification of major sources of contamination. Saline ground water derived from evaporation of shallow ground water near land surface was differentiated from saline ground water derived from mixing of fresh ground water with subsurface brines. Specific sources of these brines are unknown and will be investigated in a future study.

MINERAL RESOURCES INVESTIGATIONS

MAGMA GENERATION, MAGMA EVOLUTION, CALDERA DEVELOPMENT, AND ORE DEPOSITION, TRANS-PECOS TEXAS

Christopher D. Henry, project director; Jonathan G. Price; assisted by Rebecca C. Smyth, Jeffrey N. Rubin, Charles Stone, and James Wittke

Many Trans-Pecos mineral deposits, such as those of molybdenum, tin, tungsten, fluorine, and beryllium, were clearly derived during Tertiary igneous activity. It is important to understand the chemical evolution of the magmas, including trace elements, from their origins in the mantle or crust to their extrusion or intrusion in the shallow crust. Heat supplied by ascending magma also induces hydrothermal circulation, which is often enhanced by structures formed by calderas, large volcanic collapse features. This igneous-induced hydrothermal circulation may be a requirement for the origin of some metallic ores, such as large deposits of silver and mercury in Texas.

Fundamental petrologic questions about the origin of igneous rocks in Trans-Pecos Texas are being addressed by field mapping, geochemical analyses of rocks and individual minerals, potassium-argon dating, computer modeling of magmatic processes, and thermodynamic calculations. Research is funded by the Texas Mining and Mineral Resources Research Institute. Preliminary results of a study on magma generation and its relation to tectonic setting were presented at a Geological Society of America symposium on alkaline rocks. The Trans-Pecos region may be unique by having alkaline rocks that formed in two distinctly different tectonic settings: an early, subduction-related compressional environment and a later, continental rift or extensional environment. The chemical evolution of the alkalic Marble Canyon intrusion is unusual because it contains thermodynamically incompatible rocks—nepheline-bearing varieties low in silica content, and quartz-bearing varieties high in silica content. Modeling of possible magmatic processes suggests that magma mixing or crustal assimilation and crystal fractionation are required to explain the origin of the quartz-bearing rocks. Because the intrusion is contemporaneous and possibly comagmatic with the nearby Cave Peak intrusion, which hosts a molybdenum deposit, understanding the origin of the relatively unaltered Marble Canyon rocks will help determine the origin of hydrothermally altered rocks at Cave Peak. Initial results of the investigation were reported at the annual meeting of the Geological Society of America.

Thermodynamic calculations estimate physical and chemical conditions of magma generation and evolution. Many minerals in igneous rocks are solid solutions; therefore, calculations must account for departures from pure chemical compositions. Mineral compositions determined by electron microprobe are used to calculate activities of end members in solid solutions. Because calculations are sensitive to solid-solution models for the particular mineral phase, research has addressed improving the models. A theoretical derivation of the correct procedure for calculating the ideal or statistical mechanical contribution to activities was published in the July/August issue of *American Mineralogist*.

C. D. Henry

J. G. Price, Research Scientist, examines air-fall tuffs and tuffaceous sediments within the Van Horn Mountains caldera.

ASSESSMENT OF THE HARD-MINERAL RESOURCE POTENTIAL OF STATE-OWNED LANDS

Jonathan G. Price, project director; Tucker F. Hentz and Christopher D. Henry

A project jointly funded by the General Land Office of Texas and the Texas Mining and Mineral Resources Research Institute is assessing the potential for future production of nonpetroleum mineral commodities on certain State-owned lands. During the 2-year project, which began in October 1985, evaluations will focus on the sulfur, talc, and silver districts of Trans-Pecos Texas. Other commodities are listed below:

barite	gypsum	mica	specialty stone
bentonite	helium	molybdenum	strontium
beryllium	industrial sand	perlite	sulfur
brine	iron	potash	talc
clay	kaolin	rare earth elements	thorium
coal	lead	salt	tin
copper	limestone	sand and gravel	tungsten
dimension stone	magnesium	silver	uranium
feldspar	manganese	sodium sulfate	zeolite
gemstones	marble		zinc
graphite	mercury		

Commodities not to be included are the by-products of other production and those minerals that are geologically unlikely to be found in significant quantities in Texas. The study will compile information available from published reports and unpublished, no longer confidential, company reports submitted to State agencies. Information includes surface and subsurface geology, including ore deposits, and production and prospecting history. Locations of lease boundaries, mines, prospects, and drill holes will be plotted on U.S. Geological Survey 1:24,000-scale topographic maps.

Map data will be digitized and accessible for various computer-drawn maps. The primary product will be a computer data base providing a tract-by-tract assessment of potential hard-mineral production on State-owned lands in Trans-Pecos Texas.

STATE OF STRESS WITH TIME AND RELATION TO ORE DEPOSITION

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

Understanding the relationship between ore deposits and tectonic stress during the Tertiary Period requires knowledge of the state of stress with time. Potassium-argon dating of dikes has been used to determine paleostress orientations and studies of vein orientations and sizes as a function of time throughout western North America. Unlike most large epithermal precious metal veins in the world, which formed in environments of crustal extension, those in Trans-Pecos Texas formed chiefly in a compressional environment. These types of deposits formed during the peak of Trans-Pecos igneous activity, between 38 and 32 million years ago, when the region was under a state of mild compression residual from early Tertiary Laramide folding and thrusting. These observations may explain the small size of most igneous-related veins in Texas. Work is progressing to better characterize the states of stress both before and after the voluminous period of igneous activity. Dating has revealed that 24- to 18-million-year-old alkali basalt dikes are widespread, although volumetrically minor compared with earlier igneous rocks in Texas. These dikes were preferentially injected into north-northwest-striking fractures and are part of a general trend observed throughout the Basin and Range province at that time.

No ore deposits are known to be associated with this early extension in the Basin and Range of Texas, perhaps because of the small volume and mafic chemistry of the igneous rocks. Some deposits, notably silver-copper ores in Precambrian, Permian, and Cretaceous red beds, probably formed during a later period of Basin and Range extension, when northeast-striking fractures were preferentially filled with veins. Results of research on the origin of the silver-copper ores were published in Report of Investigations No. 145. Miscellaneous Map No. 36, a tectonic map of Trans-Pecos Texas and adjacent Mexico, was published as an outgrowth of this research. A summary of the Tertiary tectonic history of Trans-Pecos Texas was published by the West Texas Geological Society.

THE BARITE INDUSTRY AND RESOURCES OF TEXAS

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

The Texas Mining and Mineral Resources Research Institute funded this study of the economics of the barite industry and the geology of barite resources, with emphasis on Texas. Barite is used mostly as a weighting agent in well-drilling fluids and in lesser amounts for filler, chemical, and ceramic applications. Plants in Texas grind large quantities of domestic and foreign barite for use in the oil well drilling industry. Texas has produced little barite, but the geologic setting of some barite occurrences indicates substantial barite potential.

The major barite occurrences in Texas are in late Paleozoic siliciclastics of the Marathon fold belt, Permian evaporitic carbonates of the Delaware Basin, Cretaceous evaporitic carbonates of Central Texas, Gulf Coast salt domes, and Eocene siliciclastics of South Texas. Composition of fluid inclusions, barite solubility data, and comparison of the geologic settings of major barite deposits suggest that many deposits originated from mixing of low-temperature, dilute meteoric waters with higher temperature, barium-rich saline formation waters. Investigations of sulfur isotopes indicate the common presence of sulfate that is isotopically heavier than seawater sulfate of the same age as the host rocks. This relationship suggests a complex history of sulfur fractionation involving selective partitioning of ^{32}S into reduced sulfur species and the enrichment of the residual aqueous sulfate in ^{34}S.

Most known barite deposits in Texas are too small and low grade to compete commercially with present domestic and foreign sources. However, Texas may have a potential economic advantage by having barite deposits near processing and consuming areas. The relative purity of some Texas deposits suggests potential for production of chemical and glass grades of barite, which are generally more valuable than drilling mud grade.

MAPPING INVESTIGATIONS

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. To be published in four quadrants at a scale of 1:500,000, it will replace the U.S. Geological Survey's *Geologic Map of Texas* (1937), which has been out of print for many years.

The wall map is based on map sheets of the *Geologic Atlas of Texas* (scale 1:250,000). Preliminary scribing has been completed.

GEOLOGIC ATLAS OF TEXAS

Virgil E. Barnes, project director; L. F. Brown, Jr., and Tucker F. Hentz; Richard L. Dillon, Dan F. Scranton, and Margaret D. Koenig, cartographers

A surface geologic map of Texas and parts of adjacent states is composed of 38 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 cover 1 degree of latitude and 2 degrees of longitude, but some cover larger or smaller areas for cartographic efficiency.

The last sheet of the geologic atlas series, the Wichita Falls-Lawton Sheet, is being color-separated, and its publication is projected for 1986. Field work was by Tucker F. Hentz, supervised by L. F. Brown, Jr.

Revision of geologic atlas sheets continues, but none were republished this year. At the end of the year, bids were being requested for reprinting the Llano and Brownwood Sheets without revision. The Austin Sheet is scheduled to be reprinted in late 1986. Other sheets out of print and in various stages of revision include Sherman, Dallas, Emory Peak-Presidio, Abilene, Beaumont, and Palestine Sheets, in order of probable publication. Sheets expected to go out of print during 1986 include Beeville-Bay City, Crystal City-Eagle Pass, Del Rio, Lubbock, Marfa, and Tyler. These sheets are now being revised.

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. (consultant, Austin, Texas), 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); cartography by David M. Ridner

The last 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 incorporates new data to provide a display of surface and subsurface structure of the state and adjoining parts of New Mexico, Oklahoma, Mexico, and the Gulf of Mexico. The map will be published in full color at a scale of 1:750,000 and will depict exposed lithotectonic units and contours of selected deep subsurface horizons. Inset maps summarize gravity, magnetics, and basement terranes or isotopic-age provinces or both. An illustrated text will describe and synthesize the tectonic evolution of Texas.

In early 1984, a final draft copy of the tectonic map was prepared after an extensive review process. The map was being scribed in 1985.

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; cartography by John T. Ames and Richard M. Platt

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. Much of the data have been provided by the U.S. Department of Defense. Gravity (Bouguer) maps are prepared by combining many different surveys using a single datum. Gravity data are then smoothed with a high-order polynomial surface. The Clovis Sheet, the first in the series, was published in 1985. Preliminary scribing was completed for the Plainview, Amarillo, Perryton, and Dalhart Sheets.

Magnetic maps are being prepared using National Uranium Resource Evaluation (NURE) aeromagnetic surveys. In 1985, the U.S. Department of Energy, Grand Junction, Colorado, reprocessed NURE data and delivered a 1:750,000 preliminary map to the Bureau.

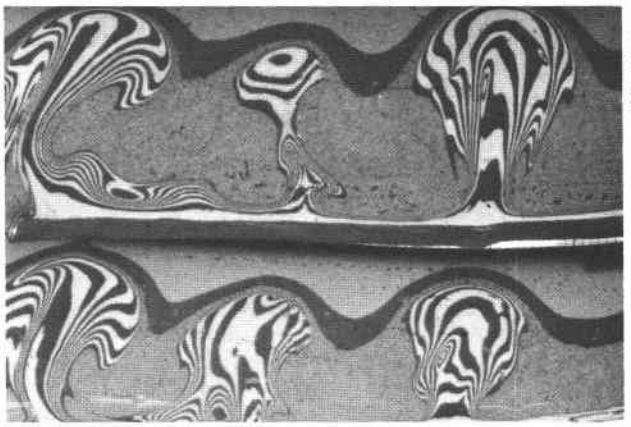
OTHER GEOLOGIC INVESTIGATIONS

EXPERIMENTAL MODELING OF SALT DOMES

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

The aim of this study, funded by the U.S. Department of Energy, was to learn how diapiric and bedded rock salt behaves during natural deformation; such information is relevant both to petroleum exploration and to possible use of salt bodies as geologic repositories for high-level radioactive waste. A centrifuge accelerated growth of dynamically scaled diapir models of silicone putty. Initially planar layers are inherently unstable if overlain by denser layers. A centrifugal body force equivalent to 1,200 times that of gravity deformed the layers into rising diapirs separated by zones of sinking cover.

The experiments were carried out in early 1984 at the Hans Ramberg Tectonic Laboratory of the University of Uppsala. Data analysis initially focused on the internal strain of the model diapirs. The highly complex fold geometry of mushroom-shaped diapirs was studied in three dimensions.



Vertical cross sections through a 10-cm-wide centrifuged model composed of silicone putty. Zebra stripes show the internal strain within buoyant diapirs that have risen through denser overburden and are analogous to deformed strata of salt domes.

The diapirs are surmounted by overhanging bulbs rimmed by downward-facing, pendant, peripheral lobes. The lobes are separated from an upward-facing central stalk by the downward-facing, infolded floor of the overhang. On the basis of these studies, similar structures in natural salt domes were identified in Iran, West Germany, Arctic Canada, and the U.S. Gulf Coast.

Subsequent analysis examined the control of the external shape of diapirs by different types of stepwise loading. This loading simulated syndepositional growth of salt domes in sedimentary environments of aggradation and progradation. The experiments addressed four aspects: (1) side-boundary effects of the model container on the growth of buoyant structures, (2) comparison of diapiric growth by (postdepositional) upbuilding versus (syn-depositional) downbuilding, (3) static differential loading, and (4) downbuilding and sidebuilding (lateral growth of diapirs) by prograding differential loading. Aspects analyzed were the wavelength, shape, and tilt of model diapirs, flow directions in different model layers, and growth history. The results illustrate growth of salt diapirs on prograding continental margins, especially under deltaic conditions. Two contract reports to DOE are available on open file at the Bureau.

GREAT KAVIR SALT DOMES: A GENERIC STUDY OF DIAPIRIC STRUCTURE AND MECHANICS

Martin P. A. Jackson, project director; Reinold R. Cornelius

Tertiary salt diapirs cropping out on the desert surface of the Great Kavir (Dasht-e Kavir) in north-central Iran appear to be the most spectacular exposed diapirs in the world. Several unusual aspects of these domes combine to provide an unparalleled opportunity to study natural salt diapirs: (1) superb exposure, (2) exposure of varying structural levels, (3) a consistent and easily recognizable diapir stratigraphy of Eocene and Miocene evaporites, and (4) prominent compositional layering in both diapirs and their country rocks enhancing delineation of folds, faults, and shear zones.

Research on the Great Kavir domes began in 1985, funded by the U.S. Department of Energy. The goal of the investigation was to learn more about natural deformation of salt to help evaluate the feasibility of storing high-level radioactive waste in rock salt. The study was carried out using high-quality aerial photographs (1:28,000 and 1:55,000 scales) augmented by space shuttle photographs, Landsat images, and published 1:1,000,000-scale regional geologic maps and cross sections. Structural maps of the 30 (out of 54 documented) best-exposed domes, which are as much as 10 km wide, were prepared to interpret their three-dimensional internal structure. This interpretation was made possible using concepts previously gained during centrifuge modeling of salt domes.

All 30 salt diapirs studied so far exhibit one of six basic map patterns. Map patterns represent successively deeper exposed horizontal sections through mushroom-shaped diapirs with highly complex internal structure; many diapirs are tilted and asymmetrical. Furthermore, a new type of major salt structure, the salt canopy, was recognized. The canopy is a 40-km-wide allochthonous salt layer formed by lateral fusion of 12 diapiric overhanging bulbs connected by diapiric stems to a deep source layer of salt. The area also includes a completely exposed salt wall 52 km long. Studies during 1986 will address kinematic and dynamic aspects of salt intrusion and extrusion by investigating the regional tectonics of the area and the strain around diapir contacts.

LOWER CRETACEOUS SHELF-MARGIN CARBONATES—TEXAS GULF COAST

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

All cores now available to the Bureau from the Lower Cretaceous shelf margin (Stuart City Trend) of Texas have been described and incorporated into the model developed from previous studies. However, the minor differences detected in new material were deemed insufficient to justify another publication at this time. Additional cores from wells along the Stuart City Trend are being sought to continue study of this classic carbonate shelf margin.

One of the cores described through this project, the Mobil No. 1 Kahanek, Lavaca County, was displayed at a 1-day core workshop titled "Lower Cretaceous Depositional Environments from Shoreline to Slope" (cochairmen, D. G. Bebout and D. C. Ratcliff). The short paper by D. G. Bebout and J. A. Kupecz, titled "Lower Cretaceous Stuart City Trend, Facies and Environments, Mobil No. 1 Kahanek Core, Lavaca County, Texas," appears in the core workshop proceedings and includes a description of this core. This core workshop was held at the Bureau's new Core Research Center on October 16 in conjunction with the 1985 annual meeting of the Gulf Coast Association of Geological Societies and Gulf Coast Section of the Society of Economic Paleontologists and Mineralogists.

STUDIES OF UPPER PENNSYLVANIAN AND LOWER PERMIAN SEQUENCES ON THE EASTERN SHELF OF THE MIDLAND BASIN, NORTH-CENTRAL TEXAS

L. F. Brown, Jr., David Johns, and Raul Solis

At the end of 1985 a manuscript titled "Regional Stratigraphic Cross Sections, Upper Pennsylvanian and Lower Permian (Virgilian and Wolfcampian Series), North-Central Texas" had completed peer review. The report will include text illustrations and 23 regional stratigraphic cross sections covering 2,000 mi with 1,100 well logs within 25 counties of North-Central Texas. This report may be available by late 1986.

Another report titled "Regional Depositional Systems and Paleogeography, Upper Pennsylvanian and Lower Permian Systems, North-Central Texas" was in manuscript preparation in late 1985. This manuscript includes paleogeographic maps of fluvial, deltaic, shelf, and slope-basin systems of 16 principal lithogenetic sequences within approximately 25,000 mi^2 of the Eastern Shelf. Including other plates and figures, this report will represent a comprehensive analysis of Virgilian and Wolfcampian strata in this mature petroleum province.

CONTINENTAL SCIENTIFIC DRILLING PROGRAM, DOSECC STUDY GROUP

John Maxwell (The University of Texas at Austin, Department of Geological Sciences), project director; W. E. Galloway and M. P. R. Light; L. S. Land and J. Sharp (The University of Texas at Austin, Department of Geological Sciences); and R. T. Buffler and D. S. Sawyer (The University of Texas at Austin, Institute for Geophysics)

There are fundamental unanswered scientific questions about the Texas and Louisiana Gulf Coastal provinces: origin of the Gulf of Mexico; nature of the subcrust; and causes and effects of long-lasting, continuing circulation of thermobaric waters throughout the thick sedimentary section.

The San Marcos Arch is probably the best location to investigate these important phenomena and problems. The arch, extending southeastward from exposed Grenville basement rocks of the Llano Uplift, is situated in an area of both lateral and vertical convergence of the sedimentary fill of the Gulf Coast Basin. The inferred edge of continental crust underlies an extensive Lower Cretaceous shelf edge a few miles southeast of recognized Ouachita (Paleozoic) rocks. Rapid thickening of Tertiary and possibly of Cretaceous sediments southeast of the shelf edge, together with geophysical indications of a relatively shallow Moho, suggests that a transitional continental crust underlies sediments basinward of the Lower Cretaceous shelf edge.

With our present understanding of deep Gulf Basin structure, it may be possible to drill a hole southeast of the shelf edge that will penetrate a thick sequence of abyssal sediments, sample sediments in an underlying rift, and enter the "transitional crust" beneath the rift sediments. To achieve optimum results the borehole should penetrate a relatively thin succession (100 to 3,000 ft [30 to 900 m]) of synrift, graben-fill sediments at depths of less than 35,000 to 40,000 ft (11,000 to 12,000 m). Consequently, a detailed seismic grid will be shot in the proposed drill-site area to clearly define the geometry and depth to basement. The detailed seismic work will precede shooting a deep-sounding COCORP profile to define the major framework of the Gulf Coast along the San Marcos Arch.

A preliminary proposal was presented to the first National Science Foundation DOSECC (Deep Observation and Sampling of the Earth's Continental Crust, Inc.) workshop in May 1985 titled "A Proposal for Deep Scientific Drilling and Associated Research, Texas Gulf Coast." This proposal was accepted, and the well will be drilled in the early 1990's.

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 1985, the following 27 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.

"Depositional Framework and Genesis of Tertiary Submarine Gorges, Eocene, Northwest Gulf Coast": supported by the National Science Foundation.

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

"Geochemical Characterization of Saline Formations in the Texas Gulf Coast That Are Used for Deep-Well Injection of Chemical Wastes": supported by the U.S. Environmental Protection Agency.

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

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

"Texas Mining and Mineral Resources Research Institute, Seventh Allotment": supported by the Bureau of Mines, U.S. Department of the Interior.

"Texas Mining and Mineral Resources Research Institute, Eighth Allotment": 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 (with the Center for Energy Studies)": supported by the U.S. Department of Energy.

State

"Assessment of the Hard-Mineral Resource Potential of State-Owned Lands": supported by the General Land Office.

"Examine Sources of Shallow Saline Ground Water in Concho, Runnels, and Tom Green Counties": supported by the Railroad Commission of Texas.

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

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

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

"Preliminary Data Base Compilation on the Geology of Two Sites for a Low-Level Nuclear Waste Repository": supported by the Texas Low-Level Radioactive Waste Disposal Authority.

"Preparation of a Petroleum Resource Data Base for Texas State Submerged Lands": supported by the General Land Office.

"Provide Assistance to the Ground-Water Data Committee": supported by the Texas Department of Water Resources.

"Provide Expert Testimony for the Villa Nova Resort, Inc., versus the State of Texas": supported by the Attorney General's Office.

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

Other

"Cogeneration Issues in Texas: The Policy Choices": supported by Houston Natural Gas.

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

"Genetic Stratigraphy, Depositional Systems, Structural Evolution, and Petroleum Potential: Northwest Gulf of Mexico Continental Shelf": supported by industry and various governmental agencies.

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

"Geological, Geochemical, and Engineering Research in Support of Gulf Coast Co-Production Program (with the Center for Energy Studies)": supported by the Gas Research Institute.

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

"Support to P. K. Mukhopadhyay on Leg 107 of the Ocean Drilling Program": supported by the Texas A&M Research Foundation.

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:

Bebout, D. G., Leary, D. A., Lucia, F. J., Hocott, C. R., and **Schmidt, S.,** 1985, Characterization of the Grayburg reservoir of the Mobil University Unit 15/16 in Dune field, Crane County, Texas: The University of Texas at Austin, Bureau of Economic Geology Interim Report prepared for the State of Texas and The University of Texas System, 50p.

Caran, S. C., 1985, Future climatic and environmental conditions in the Texas Panhandle—a geological perspective: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1985-11 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 25 p.

Caran, S. C., 1985, Reconstruction of the late Quaternary paleoclimate of northwestern Texas—progress report, 1984: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1984-53 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 14 p.

Collins, E. W., and **Jackson, M. L. W.,** 1985, Mineral resource evaluation of the proposed Big Sandy reservoir site: The University of Texas at Austin, Bureau of Economic Geology final report prepared for the Sabine River Authority under a memorandum of agreement, 55 p.

Conti, R. D., and **Senger, R. K.,** 1985, Hydrostratigraphy of the Wolfcamp aquifer, Palo Duro Basin, Texas Panhandle: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1985-38 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 45 p.

Dutton, A. R., and **Simpkins, W. W.,** 1985, Estimated hydraulic properties of the Triassic Dockum Group aquifer: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1985-31 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 18 p.

Dutton, S. P., 1985, Petrography and diagenesis of the Travis Peak (Hosston) Formation, East Texas: The University of Texas at Austin, Bureau of Economic Geology, topical report prepared for the Gas Research Institute under contract no. 5082-211-0708, 71 p.

Finley, R. J., Dutton, S. P., Lin, Z. S., and **Saucier, A. E.,** 1985, The Travis Peak (Hosston) Formation: geologic framework, core studies, and engineering field analysis: The University of Texas at Austin, Bureau of Economic Geology, topical report prepared for Gas Research Institute under contract no. 5082-211-0708, 233 p.

Finley, R. J., Morton, R. A., Dorfman, M. H., and Sepehrnoori, K., 1985, Coordination of geological and engineering research in support of Gulf Coast co-production program: The University of Texas at Austin, Bureau of Economic Geology, annual report prepared for the Gas Research Institute under contract no. 5084-212-0924, 211 p.

Fracasso, M. A., and **Hovorka, S. D.,** 1985, Cyclicity in the middle Permian San Andres Formation, Palo Duro Basin, Texas Panhandle: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1984-21, Revision 1, prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 61 p.

Garrett, C. M., Jr., Hocott, C. R., Finley, R. J., and **Galloway, W. E.,** 1985, Analysis of negative revisions to natural gas reserves in Texas: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for Gas Research Institute under contract no. 5083-800-0908, 106 p.

Gustavson, T. C., 1985, Structural control of the development of the Canadian River Valley, Texas Panhandle: an example of regional salt dissolution and subsidence: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1985-7 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 26 p.

Morton, R. A., and **Paine, J. G.,** 1985, Beach and vegetation line changes at Galveston Island, Texas: erosion, deposition, and recovery from Hurricane Alicia: The

University of Texas at Austin, Bureau of Economic Geology, report prepared for Texas Attorney General's Office under contract no. IAC (84-85)-0930, 78 p.

Posey, H. H., 1985, WTWI interim report: completion of analyses, Wolfcamp geochemistry: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1985-31 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 79 p.

Posey, H. H., Fisher, R. S., and **Tweedy, S. W.,** 1985, Initial results of the Wolfcamp geochemistry pilot study: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1985-5 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 68 p.

Richter, B. C., and **Kreitler, C. W.,** 1985, Sources of shallow saline ground water in Concho, Runnels, and Tom Green Counties, Texas: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for the Railroad Commission of Texas under contract no. IAC (84-85)-2122, 31 p.

Schechter, R. S., Lake, L. W., Guilinger, T. R., **Price, J. G.,** and Bobeck, Patricia, 1985, A minitest of an in-situ uranium leach solution, *in* Development of environmentally attractive leachants: The University of Texas at Austin, Department of Petroleum Engineering, final report prepared for U.S. Department of the Interior, Bureau of Mines, under contract no. HO282016, v. 4, 150 p.

Senger, R. K., 1985, Evaluation of numerical codes for fracture flow modeling: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1985-4 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 8 p.

Senger, R. K., 1985, Hydrodynamic development of the Palo Duro Basin and other mechanisms creating possible transient flow conditions: The University of Texas at Austin, Bureau of Economic Geology, Open-File Report OF-WTWI-1984-54 prepared for the U.S. Department of Energy under contract no. DE-AC97-83WM46651, 48 p.

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The following Bureau publications served as final contract reports during 1985:

Jackson, M. P. A., 1985, Natural strain in diapiric and glacial rock salt, with emphasis on Oakwood Dome, East Texas: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 143, 74 p.
Prepared for the U.S. Department of Energy under contract no. DE-AC97-80ET46617.

Morton, R. A., Jirik, L. A., and Foote, R. Q., 1985, Structural cross sections, Miocene Series, Texas continental shelf: The University of Texas at Austin, Bureau of Economic Geology Cross Sections, 17 pls., 8 p.
Prepared for the U.S. Geological Survey under contract no. 14-08-0001-G-666 and the Minerals Management Service under contract no. 14-12-0002-40029.

White, W. A., Calnan, T. R., Morton, R. A., Kimble, R. S., Littleton, T. G., McGowen, J. H., **Nance, H. S.,** and Schmedes, K. E., 1985, Submerged lands of Texas, Galveston-Houston area: sediments, geochemistry, benthic macroinvertebrates, and associated wetlands: The University of Texas at Austin, Bureau of Economic Geology Special Publication, 145 p.
Financial assistance was provided in part by (1) the General Land Office of Texas, with funding in accordance with section 305 of the Coastal Zone Management Act for Coastal Zone Management Program (CZMP), (2) the Governor's Budget and Planning Office, with grants in accordance with section 308 of the same act for the Coastal Energy Impact Program (CEIP); CZMP and CEIP funding was administered by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce, and (3) the Minerals Management Service of the U.S. Department of the Interior; parts of the study were conducted in cooperation with the U.S. Geological Survey. Contract numbers with the General Land Office were IAC(80-81)-1201, IAC(78-79)-1910, IAC(78-79)-0539, IAC(76-77)-1244, and IAC(76-77)-0833. Contract numbers with the Governor's Budget and Planning Office were CZ80M935019, IAC(80-81)-0865, and IAC(78-79)-1210. The contract number with the Minerals Management Service is 14-12-0001-30070.

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 76-year history, the Bureau has published nearly 1,600 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 1.65 million publications have been distributed worldwide, mostly through direct sales. During 1985, about 75,000 volumes were distributed. The Bureau issued the following publications in 1985:

SPECIAL PUBLICATIONS

Submerged Lands of Texas, Galveston-Houston Area: Sediments, Geochemistry, Benthic Macroinvertebrates, and Associated Wetlands, by W. A. White, T. R. Calnan, R. A. Morton, R. S. Kimble, T. G. Littleton, J. H. McGowen, H. S. Nance, and K. E. Schmedes. 145 p., 61 figs., 17 tables, 6 pls., 3 appendices ($12.50).

Detailed inventory of submerged lands and associated wetlands in the Galveston-Houston area of the Texas Coastal Zone. State-owned submerged lands of Texas encompass nearly 6,000 mi^2 and extend 10.3 mi from the Gulf shoreline on the inner continental shelf. This atlas, which focuses on the Galveston-Houston area of the Coastal Zone, is the second in a series of submerged land atlases to provide comprehensive sedimentological, geochemical, and biological data for management of coastal areas. Researchers collected and analyzed 6,700 surficial bottom samples across the submerged lands, from the Rio Grande to Sabine Lake, and mapped and described sediment distribution, concentrations of selected major and trace elements, and benthic macroinvertebrate populations. Adjacent wetlands were delineated using stereoscopic, color-infrared positive transparencies provided by the National Aeronautics and Space Administration and are depicted on a full-color map along with the distribution of benthic macroinvertebrate assemblages and species diversities in submerged lands. Comparisons of the distribution of wetlands with earlier maps indicate that historical changes in many areas are related to land-surface subsidence and, locally, surface faulting. The research for this atlas was funded by the General Land Office and the Governor's Budget and Planning Office of the State of Texas through programs administered by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. More recent funding has been provided by the Minerals Management Service, U.S. Department of the Interior.

The Wilcox Group and Carrizo Sand (Paleogene) in East-Central Texas: Depositional Systems and Deep-Basin Lignite, by W. B. Ayers, Jr., and A. H. Lewis. 19 p., 4 figs., 1 table, 30 pls., appendix ($12.50).

Investigation of lignite resources and the factors that control lignite seam continuity and the flow of ground water. Deeper lignite surface mining and field tests of in situ gasification will require greater understanding of the factors such as depositional framework that control continuity of lignite seams and flow of ground water. For this study, funded by the Texas Energy and Natural Resources Advisory Council and the Texas Legislature, the authors used 1,493 geophysical well logs to map framework elements, lignite occurrences, and resistivities of framework sands for the Hooper, Simsboro, and Calvert Bluff Formations of the Wilcox Group. Framework elements and resistivities of the overlying Carrizo Sand were also mapped. For the Wilcox Group, the authors estimate 6,548 million short tons of lignite in seams more than 5 ft thick, between depths of 200 and 2,000 ft. At these depths, Wilcox lignite seams occur primarily in low-sand, floodbasin deposits bounded by dip-elongate channel-fill sands. Fresh-water lobes on resistivity maps coincide with axes of channel-fill sands, suggesting that depositional framework elements control ground-water flow. Principal products of this study are 23 regional maps (1 inch=6 mi) and 7 cross sections, all on folded plates. Values used to draw the maps are included on microfiche in the appendix.

REPORTS OF INVESTIGATIONS

RI 143. Natural Strain in Diapiric and Glacial Rock Salt, with Emphasis on Oakwood Dome, East Texas, by M. P. A. Jackson. 74 p., 46 figs., 5 tables ($3.00).

A two-part study encompassing (1) a comparative review of the structural geology of crystalline gravity-driven structures: salt diapirs, salt glaciers, and ice glaciers and (2) a detailed analysis of the internal structure of part of Oakwood salt dome in the East Texas Basin. A major goal of this Department of Energy-funded study was to determine the structural stability and internal fabric of Oakwood salt dome, which was at the time being considered as a high-level nuclear waste repository. The author's thesis is that salt diapirs, salt glaciers, and ice glaciers have several features in

common, as they all represent gravity-driven movement of large masses of fairly pure crystalline metamorphic rock. Each also contains a complex array of superposed fabrics, recrystallization zones, and zones of inhomogeneous shearing and folding. Part I is a generic study of salt masses worldwide with regard to their lithology, morphology, boundary conditions, bulk-strain patterns, fabrics, flow mechanisms, strain rates, and folds. Part II builds on this survey and is specific to Oakwood Dome. It is based on core from a borehole into the dome center in Freestone County and is a companion study to RI 120 and RI 131, which describe other geologic and geochemical aspects of the same core. This study is the first geometric analysis in cross section and the first strain analysis of a Gulf Coast salt stock. Geometric analysis was used to delineate the large-scale structure of the salt intersected by the vertical drill core. Strain analysis was used to derive the orientation, type, and magnitude of finite strains at various depths and to determine the origin of the fabric. Together, these analyses resulted in an examination of the dome on all scales from 10^{-3} to 10^{1}m. The author introduces the tool of plunge-isogon mapping, provides quantitative evidence of the role of shear folding and flattening-type strain, describes the implications of Oakwood internal structure to its emplacement history, and emphasizes the critical role of intergranular water in promoting salt recrystallization and accelerating flow rates.

RI 144. Reservoir Facies Architecture in a Microtidal Barrier System—Frio Formation, Texas Gulf Coast, by W. E. Galloway and E. S. Cheng. 36 p., 30 figs., 1 table, 2 pls., appendix ($3.00).

Detailed analysis of internal facies patterns and their effect on hydrocarbon production and recovery within three representative barrier-island sand reservoirs of West Ranch field, Frio Formation. The authors discuss the petroleum reservoir geology of a typical barrier-island/lagoon depositional system in order to document the effects of barrier sand-body complexity on oil recovery and to illustrate approaches that may be applied to improving geologic description and exploitation of barrier reservoirs. Detailed isolith and log-facies maps, based on closely spaced production wells, combined with analysis of resistivity distribution and sparse core control, provide the basis for interpretation of the 41-A, Glasscock, and Greta reservoirs within the Frio. Reservoir properties, fluid properties, and production history of the reservoirs are tabulated. Numerous figures show maps of net-sand thickness, SP patterns, permeability and deep-resistivity distribution, and production response of individual reservoirs. Plates give detailed cross sections through the 41-A reservoir and show resistivity (hydrocarbon saturation) compartments and reservoir architecture of the West Ranch field. An appendix details the engineering history of the three reservoirs. Using the West Ranch reservoirs as working models, the authors (1) demonstrate the complex internal facies patterns and their effects on hydrocarbon within barrier reservoirs, (2) illustrate working methods for recognizing and delineating intrareservoir facies elements using basic well log data, (3) show that resistivity and other indirect measurements may provide semiquantitative descriptions of reservoir parameters that are necessary for accurate reservoir simulation and design of enhanced recovery programs, and (4) provide summary models of types of intrareservoir facies and petrophysical variability that are applicable to microtidal barrier-island reservoirs.

RI 145. Origin of Silver-Copper-Lead Deposits in Red-Bed Sequences of Trans-Pecos Texas: Tertiary Mineralization in Precambrian, Permian, and Cretaceous Sandstones, by J. G. Price, C. D. Henry, A. R. Standen, and J. S. Posey. 65 p., 37 figs., 15 tables, appendix ($3.25).

Field and laboratory investigation into the origin of silver-copper-lead deposits in red-bed sequences near Van Horn, Trans-Pecos Texas. Silver-copper-lead deposits near Van Horn have yielded substantial quantities of ore from Precambrian, Permian, and, to a lesser extent, Cretaceous sandstones. The largest mine produced 4,000,000 ounces of silver from 110,000 tons of ore. Although some of the ores are strata-bound, major production has been from nearly vertical veins. Problems addressed in this study, funded by the U.S. Bureau of Mines, include (1) whether the ores in different host rocks of different ages formed at the same time or at different times; (2) how the deposits relate to major tectonic events in the region; (3) what the physical and chemical conditions of ore deposition were; and (4) how understanding the origin of the known deposits applies to exploration for additional veins and strata-bound ores. The authors determined orientations of fractures and veins and mapped an area of the Indio Mountains in detail. Samples collected during field studies were analyzed geochemically to determine elemental enrichments and depletions in ores relative to unmineralized rocks. Samples were examined using X-ray diffraction and reflected- and transmitted-light microscopy to determine mineralogy and textural relationships. Fluid-inclusion studies revealed information about the temperatures and salinities of the ore-forming fluids. From their data, presented in figures and tables, the authors conclude that the origin of the geochemically and structurally similar veins involved a rise of moderate-temperature, moderately saline hydrothermal fluids along Basin and Range fractures and precipitation of metal sulfides in response to mixing with shallow ground water. This is in contradiction to a hypothesis suggested by previous workers that the deposits formed as a result of middle Tertiary magmatism. The revised hypothesis has implications for exploration of additional deposits in Trans-Pecos Texas and elsewhere, and the authors briefly discuss favorable areas.

RI 146. Facies Architecture and Production Characteristics of Strandplain Reservoirs in the Frio Formation, Texas, by Noel Tyler and W. A. Ambrose. 42 p., 29 figs., 1 table ($2.50).

Comprehensive analysis of internal facies patterns and their effect on hydrocarbon production and recovery within three representative strandplain reservoirs of North Markham - North Bay City field, Frio Formation. The authors discuss the petroleum reservoir geology of typical strandplain depositional systems to document the effects of

strandplain sand-body complexity on oil recovery and to illustrate approaches that may be applied to improving geologic description and exploitation of strandplain reservoirs. Detailed isolith and log-facies maps, based on closely spaced production wells, combined with analysis of resistivity distribution and production data, provide the basis for interpretation of the Cayce, Cornelius, and Carlson reservoirs within the Frio. Reservoir properties, fluid properties, and production history of the reservoirs are tabulated. Numerous figures show maps of net-sand thickness, percent sandstone, SP patterns, facies anatomy, and production response of individual reservoirs. Through the use of sequential water-cut maps the authors document the nature and paths of water invasion into the reservoirs. The effects of reservoir heterogeneity on oil recovery are well displayed in sequential oil-recovery-rate maps. Using the three North Markham - North Bay City reservoirs as working models, the authors (1) demonstrate the complex internal facies patterns and their effects on hydrocarbons within strandplain reservoirs, (2) illustrate working methods for recognizing and delineating intrareservoir facies elements using basic well log data, (3) show that resistivity and other indirect measurements may provide semiquantitative descriptions of reservoir parameters that are necessary for accurate reservoir simulation and design of enhanced recovery programs, and (4) provide summary models of types of intrareservoir facies and petrophysical variability that are applicable to microtidal strandplain reservoirs. This report is a companion to RI 144, by W. E. Galloway and E. S. Cheng, which deals with reservoir facies architecture in the West Ranch field, which produces from back-barrier systems also located in the Frio Formation. The authors of RI 146 report that recovery is better in strandplain systems than in the back-barrier systems described in the earlier report. Research was funded by the U.S. Department of Energy and the Texas Energy and Natural Resources Advisory Council.

RI 147. Stratigraphy and Petroleum Potential of Pre-Pennsylvanian Rocks, Palo Duro Basin, Texas Panhandle, by S. C. Ruppel. 81 p., 64 figs., 5 tables, 4 appendices ($4.50).

First detailed study of the stratigraphy of pre-Pennsylvanian rocks of the Palo Duro Basin and their hydrocarbon potential. This study, funded by the U.S. Department of Energy, was designed to (1) characterize pre-Pennsylvanian rocks in the basin and (2) determine their potential for oil and gas accumulation, an important consideration as part of the area is being considered by DOE as a possible repository site for high-level nuclear waste. The author examined well logs and sample logs from 57 counties in Texas, Oklahoma, and New Mexico and core from eight wells in the Palo Duro and Hardeman Basins. Geochemical studies of total organic carbon, kerogen, and vitrinite reflectance were done on samples from 58 wells. The author discusses stratigraphy, porosity and permeability, source rock potential (including organic matter content and type and thermal maturity), and potential traps and trends. Figures include structure-contour and thickness maps, a geothermal gradient map, a cross section through Palo Duro and Hardeman Basins, and photographs and photomicrographs of representative lithologies and porosity types. The author concludes that (1) all pre-Pennsylvanian units in the basin contain sufficient porosity and permeability to be hydrocarbon reservoirs and (2) the southern and eastern Palo Duro Basin are promising because of more plentiful source rocks and a higher geothermal gradient.

RI 148. Late Cenozoic Geomorphic Evolution of the Texas Panhandle and Northeastern New Mexico—Case Studies of Structural Controls on Regional Drainage Development, by T. C. Gustavson and R. J. Finley. 42 p., 20 figs. ($2.50).

Assessment of the impact of salt dissolution-induced subsidence on the development of drainage networks and erosional scarps in the Texas Panhandle and northeastern New Mexico. The Palo Duro and Dalhart Basins contain bedded salts being considered as potential sites for storage of high-level radioactive nuclear waste. However, zones of active salt dissolution have been identified along the margins of the area. In this study, funded by the U.S. Department of Energy, the authors present case studies of the drainage basins of stream systems draining the Southern High Plains and the Rolling Plains. Field studies were integrated with subsurface studies based on interpretation of geophysical logs and seismic reflection profiles, hydrologic and water quality data obtained from stream-gauging stations, interpretations of aerial photographs and Landsat images, and topographic maps. The authors discuss the geologic setting of the Palo Duro Basin, physiographic development of the area, structural controls on regional drainage development, and evolution of regional physiography. Figures include stratigraphic cross sections illustrating salt dissolution and collapse, net-salt maps, structure-contour maps, and diagrams showing regional drainage networks, sinkholes, fractures, and stream-segment and fracture orientations. The authors conclude that dissolution, subsidence, and mechanical disruption of the overlying sediments have contributed greatly to determining placement and rates of incision of major streams draining the periphery of the Southern High Plains and that a close spatial relation exists between surface streams and areas of dissolution and subsidence.

GEOLOGICAL CIRCULARS

GC 85-1. Investigation of Underpressuring in the Deep-Basin Brine Aquifer, Palo Duro Basin, Texas, by E. D. Orr, C. W. Kreitler, and R. K. Senger. 44 p., 19 figs., 4 tables, 2 appendices ($2.00).

Investigation into apparent underpressuring and vertical hydraulic gradients in the Deep-Basin Brine aquifer by comparing real pressure-depth data with computed hypothetical models that account for variations in surface

topography, structural dip, and potentiometric surface. Permian salt deposits in the Palo Duro Basin, which overlie the Deep-Basin Brine aquifer, are being considered as hosts for high-level radioactive wastes. A critical consideration in repository site selection is the direction of ground-water flow in the area. Because the vertical component of ground-water flow influences the length of potential paths from a nuclear repository to the biosphere, it is necessary to determine the extent of vertical flow within the area. This report (1) documents and characterizes fluid-pressure conditions in the confined Deep-Basin Brine aquifer using pressure data, (2) proposes a method for more accurate interpretation of pressure-depth plots, (3) applies the method to drill-stem-test data from the Deep-Basin Brine aquifer, and (4) delineates areas having varying potential for vertical flow and evaluates the significance of this potential in terms of vertical flux and flow volumes. The authors show that plots of pressure versus depth can be misinterpreted owing to poor data quality and distribution and because of lateral changes in the surface topography, the structural dip of the aquifer, and the potentiometric surface. To avoid these effects, drill-stem measurements from 466 petroleum exploration wells were analyzed and refined, and pressure-depth plots were constructed for small areas delineated by superposed contours of surface elevation and structure. Calculation of pressure-depth data for theoretical conditions of flow parallel to the structural dip of the aquifer and comparison of computed results to actual data permitted more accurate interpretation of vertical hydraulic gradients. Comparison of vertical and horizontal fluxes within the Deep-Basin Brine aquifer indicates that despite the potential for vertical flow components, flow paths within the aquifer will be dominated by horizontal flow. Nevertheless, large volumes of water do move vertically within the aquifer, and this phenomenon may significantly affect water chemistry within the aquifer. This study was funded by the U.S. Department of Energy.

GC 85-2. Depositional History, Facies Analysis, and Production Characteristics of Hydrocarbon-Bearing Sediments, Offshore Texas, by R. A. Morton, L. A. Jirik, and R. Q. Foote. 31 p., 17 figs. ($2.50).

Discussion of the structural styles, formation properties, depositional systems, and hydrocarbon production and potential of the Oligocene through Pleistocene sediments of offshore Texas. The thick wedge of late Cenozoic clastic sediments that underlies State and Federal waters of offshore Texas has recently become the target of increased leasing activity and hydrocarbon exploration. Even though the economic importance and exploration potential of the area is well established, large blocks of offshore Texas remain unexplored and few geological reports until now have been published on the area. This study, funded by the U.S. Geological Survey and the Minerals Management Service of the U.S. Department of the Interior, incorporates nearly 1,400 electric logs and paleontological reports on selected wells. Well log correlations and biostratigraphic markers provide the control for interpreting the geologic structure and stratigraphy of offshore sediments. General depositional systems and component lithofacies for each stratigraphic unit were interpreted using maps of electric log patterns to recognize bay-lagoon shale, proximal deltaic-barrier-strandplain sandstone, distal deltaic-barrier-strandplain sandstone, and marine (prodelta-shelf-slope) shale. This simple mapping scheme permits rapid delineation of the general limits of sandstone deposition and thus indicates reservoir potential for each major stratigraphic unit. Superimposition of current producing trends, recent discoveries, and optimal sandstone facies permitted the authors to develop a map useful in delineation of areas of greatest exploration potential where new discoveries are probable. The authors discuss historical and current exploration trends and conclude that future discoveries beneath the present-day shelf will probably be relatively small, overpressured gas fields; however, they point out that the coincidence of optimal sandstone facies with large but deep, untested structures creates the possibility of discovering several large gas fields and a substantial number of gas fields of intermediate size.

GC 85-3. Abandoned Oil Fields of the Texas Gulf Coast and the East Texas Basin, by S. P. Dutton and C. M. Garrett, Jr. 47 p., 21 figs., 3 tables, 1 pl., appendix ($3.00).

Evaluation of the geologic setting, production history, and potential for additional oil recovery within 147 abandoned reservoirs in the Texas Gulf Coast and East Texas Basin. Abandoned reservoirs, defined as those that produced no oil or gas in 1977 and 1982, are an unconventional target for increased oil recovery in Texas. Many of these reservoirs were never subjected to modern secondary or tertiary recovery methods or contain oil not previously tapped by conventional field development. This report characterizes the 147 abandoned reservoirs in Railroad Commission of Texas Districts 1 through 6 that have individually produced more than 500,000 bbl of oil. The reservoirs have been grouped into 15 plays, delineated according to reservoir genesis; each play thus consists of an assemblage of reservoirs having similar depositional origins, and consequently, similar source, reservoir, and trap characteristics. The text briefly describes the geologic setting and production history of each play and presents data on production characteristics, lithology, type of trap, drive mechanism, and production technology. Representative structure-contour maps and cross sections illustrate the structural and stratigraphic setting of most plays. The authors conclude that 253 million bbl of mobile oil remains in place in the abandoned reservoirs and that additional recovery from many of the reservoirs is likely. The study was funded by the Texas Energy and Natural Resources Advisory Council.

GC 85-4. Amount and Nature of Occluded Water in Bedded Salt, Palo Duro Basin, Texas, by R. S. Fisher. 27 p., 9 figs., 7 tables, 3 appendices ($2.00).

Analysis of the amount and distribution of water in halite of the Permian San Andres Formation, Palo Duro Basin. Bedded halite in this formation is under consideration for long-term isolation of high-level nuclear waste. Because the strength of halite is adversely affected by water, particularly at the elevated temperatures expected around nuclear waste, it is necessary to accurately measure the amount of

water in representative salt samples. In this study, funded by the U.S. Department of Energy, the author characterized 150 halite samples according to basin position, formation position, and textural type. The halite fraction of each sample was dissolved in anhydrous methanol by continuous reflux Soxhlet extraction, which allowed collection of both intragranular and intergranular water. The amount of water present was then measured by automated Karl Fischer titration. The author reports that the mean water content of samples that contain less than 10 percent clay or mudstone is 0.5 weight percent; water content of samples that contain more than 10 percent clay or mudstone is highly dependent on the amount of non-halite material present. He concludes that the amount of water that would affect a nuclear waste repository can be accurately predicted if the amount of water in clean halite as well as the amount and distribution of halite, clay, and mudstone at the proposed site are known.

GC 85-5. Beach and Vegetation-Line Changes at Galveston Island, Texas: Erosion, Deposition, and Recovery from Hurricane Alicia, by R. A. Morton and J. G. Paine. 39 p., 24 figs., 5 tables, 3 appendices ($3.00).

Description of the impact of Hurricane Alicia on shoreline and vegetation-line retreat at Galveston Island and assessment of the degree of natural and man-induced post-storm recovery. On August 18, 1983, Hurricane Alicia caused extensive damage to beachfront property on Galveston Island, particularly at West Beach. The storm removed more than 2 million yd^3 of sand from West Beach alone. Two years after Alicia, about 50 percent of the eroded sand had not returned to the beach, and the beach surface was 2 to 3 ft below its pre-storm elevation. For this study, researchers used aerial photographs, beach profiles, and beach elevations to document nearshore beach and vegetation changes, to quantify the magnitude of those changes, and to use them as a basis for estimating current and future post-storm recovery. The authors discuss sediment loss, vegetation retreat, washover deposition, shore stability, and post-storm recovery, including natural recovery by sand transport and revegetation and human-induced recovery efforts such as sand replenishment, shoreline protection, and dune construction. Despite ongoing reconstruction efforts, the authors conclude that segments of the vegetation line on West Beach may never completely recover and that additional net losses of sand caused by future storms will only add to the deficit. Research for this project was funded in part by the State of Texas, Office of the Attorney General, Environmental Protection Division.

MINERAL RESOURCE CIRCULARS

MRC 76. Texas Lignite—Status and Outlook to 2000, by W. R. Kaiser. 17 p., 4 figs., 8 tables ($2.00).

Assessment of present and future production, demand, and use of lignite in Texas through the end of the century. During the last decade, Texas has become a major producer and consumer of coal, ranking sixth in production nationwide in 1983 (39 million short tons) and first in consumption (69 million tons). Almost all lignite production (99 percent) is used to generate about 20 percent of the state's electricity. Kaiser predicts that generation of electricity will continue to be the primary use of lignite into the next century and estimates that at least 50 million tons of lignite will be required in the 1990's and possibly 100 million tons by 2000. Kaiser notes that near-surface resources in Texas of at least 23 billion tons of lignite are ample to sustain such production into the next century; he predicts that deep surface mining (to 300 feet) will become commonplace, posing potential concerns for water resources. Figures and tables in the publication present data on lignite mines, production, lignite and western coal power plants, electricity generation, and coal prices and quality. Texas lignite is compared with better-quality western coal, which is delivered by rail to Texas from the Powder River Basin of northeastern Wyoming and southeastern Montana. Texas lignite currently has a delivered-price advantage over western coal, but Kaiser predicts that lignite's advantage will diminish as railroad freight rates stabilize and deeper, more hydrogeologically complex deposits of lignite are mined, thus raising its cost. He also points out that cogeneration of electricity by gas-fired generators will cut into the demand for lignite between now and 2000. To help Texas lignite remain an economic and environmentally acceptable fuel, he recommends collection of data on variability of chemical constituents, composition of combustion by-products, and aquifer response to mining.

MRC 77. The Mineral Industry of Texas in 1983, by J. P. Ohl and M. W. McBride. 20 p., 1 figure, 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 1983* 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.

CROSS SECTIONS

Regional Cross Sections—Central Basin Platform, West Texas, by D. G. Bebout and K. J. Meador. 4-p. text, 11 pls. ($5.00).

Eleven structural sections (with text) showing stratigraphy and production zones from the surface to the Ellenburger Formation across the Central Basin Platform.

These cross sections were positioned to pass through most major oil fields—those with cumulative production of more than 10 million barrels of oil. Well logs (mostly gamma-ray/neutron or sonic) used are from the deepest available wells and are spaced approximately 5 mi apart. The cross sections and an accompanying stratigraphic chart were compiled with the aid of other published cross sections, paleontological data and cross sections from proprietary company files, compilations of oil-field studies, and records of the University Lands Office and the Railroad Commission of Texas. Information on major faults and other structures was also obtained from the above sources as well as the tectonic map now in preparation by the Bureau (Ewing). Funding was from the Texas Energy and Natural Resources Advisory Council.

Structural Cross Sections, Miocene Series, Texas Continental Shelf, by R. A. Morton, L. A. Jirik, and R. Q. Foote. 8-p. text, 3 figs., 17 pls. ($10.00).

Nine dip sections and two strike sections (with text) detailing the regional structure, stratigraphy, and producing zones of Miocene sediments of the Texas Continental Shelf. These cross sections numerically correspond to previously published onshore cross sections (Dodge and Posey, 1981) and extend those sections across the continental shelf into the Miocene, a recent target of renewed petroleum exploration. Lithostratigraphic markers, corresponding to commonly used paleontological markers, have been used to correlate and subdivide the Miocene Series, which constitutes the largest volume of sedimentary fill in the offshore western Gulf Coast Basin. The structural and stratigraphic framework was interpreted using commercially available electric logs and paleontological reports. These basic data were supplemented with published information and with proprietary data released by operators for this study. Locations of major growth faults and diapirs, fault displacements, and bed attitudes were incorporated into a few sections from proprietary and publicly available seismic profiles. Subsurface formation temperatures plotted for most wells on the cross sections were derived from well log headers where bottom-hole temperatures are recorded. Wells that were completed in hydrocarbon-bearing zones are indicated on the cross sections by conventional oil-and gas-well symbols. An 8-page text accompanying the cross sections briefly discusses the Miocene sediments. A generalized stratigraphic cross section in the text shows the relationships among onshore formations, principal offshore lithofacies, biostratigraphic zones, and depositional sequences of the Oligocene and Miocene Series. Other text figures illustrate the major producing trends of offshore Texas and adjacent Federal waters as well as the principal tectonic features and salt structures beneath the offshore areas and Coastal Plain. The study was funded by the U.S. Geological Survey, the Minerals Management Service, and the Bureau of Economic Geology.

MAPS

Bouguer Gravity Atlas of Texas, Clovis Sheet, G. R. Keller (The University of Texas at El Paso) and C. L. V. Aiken (The University of Texas at Dallas), project directors. 1 pl., 1:250,000 scale ($2.00).

First in a series of 1° x 2° Bouguer gravity maps that will cover the entire state. These transparent maps are at the same scale as the Geologic Atlas of Texas sheets and can be superimposed on them to compare gravity information with surface geology. The maps are being prepared by combining the results of numerous surveys, many of them provided by the U.S. Department of Defense, into a single datum. These gravity data are then smoothed with a high-order polynomial surface.

The Guadalupe-Lavaca-San Antonio-Nueces River Basins Regional Study, San Antonio East - Llano East Sheets. 5 pls., 1:250,000 scale ($5.00).

The Guadalupe-Lavaca-San Antonio-Nueces River Basins Regional Study, Seguin West - Austin West Sheets. 5 pls., 1:250,000 scale ($5.00).

T. C. Gustavson and E. G. Wermund, project directors

Full-color plates depicting the environmental geology, biological assemblages, physical materials, active processes, and current land use of each of the above areas. These maps are the first two in a series of eight sets of maps that will depict land resources between drainages of the Colorado River and the Rio Grande. The project is being conducted in cooperation with the Texas Department of Water Resources.

Miscellaneous Map No. 36. Tectonic Map of the Basin and Range Province of Texas and Adjacent Mexico, C. D. Henry, J. K. Gluck, and N. T. Bockoven, compilers; accompanying text by C. D. Henry and J. G. Price. 8 p., 1 pl., 1:500,000 scale ($1.00).

A two-color map showing the regional structure and tectonics of the Basin and Range Province of Trans-Pecos Texas and adjacent Mexico. The map emphasizes structures formed during late Tertiary Basin-and-Range extension, mid-Tertiary volcanism, and early Tertiary Laramide folding but also shows structures resulting from late Paleozoic and Precambrian deformation. An accompanying 8-page text, titled "Summary of the Tectonic Development of Trans-Pecos Texas," traces the tectonic history of the area, which has undergone repeated deformation from the Precambrian to Recent.

SERVICES

COMPUTING

During 1985 the Computing staff continued to provide services to research, administrative, and support personnel. They devoted many hours to the installation of the new departmental computing system (described in Highlights in this report) based on a VAX 11/780 computer.

After the VAX was installed, Computing focused on three areas: facilities and operations, information and education, and new application systems and programming. Educational services have included scheduling courses for staff members and preparing fact sheets and computer-based bulletin boards. The section continued to support many applications on the University's Cyber computers and to perform routine operating tasks such as plotting, data entry, and data base updates. Individual needs of both research and support staffs were met by programmers by developing several new applications or researching new systems.

Studies are still under way to select an appropriate graphics system to assist in the production of publication-quality slides, posters, and illustrations. A system design effort continues to automate information processing in the expanded Core Research Center. The Computing staff also administers software Quality Assurance procedures to satisfy Federal contract auditing requirements.

The staff includes a systems analyst who is also the VAX system manager, two full-time programmers and one half-time programmer, and a computer operator, under the direction of Michael P. Roberts.

PUBLIC INFORMATION

Requests for information about Texas geology, energy, mineral, and land resources come to the Bureau from a wide spectrum of the public, including geologists, engineers, educators, students, landowners, and other interested individuals, as well as companies, governmental agencies, and their organizations. During 1985, more than 1,500 such requests were handled by the Public Information Geologist. In addition, members of the research staff provided advisory and technical services in their areas of expertise.

READING ROOM/DATA CENTER

The Bureau's Reading Room/Data Center provides a wide range of geological data and information to staff members, students, and visitors interested in Texas geology. The Reading Room/Data Center, supervised by Jeffrey Thurwachter, is open for public use from 8 a.m. to 5 p.m., Monday through Friday. Materials are available to the public for reference use only. Arrangements can be made for photocopying noncopyrighted materials.

After the Bureau's relocation to its new research facility at Balcones Research Center, the Reading Room/Data Center underwent massive reorganization and expansion. Thousands of books and other data items were removed from storage and shelved or filed.

The Reading Room houses a collection of about 8,000 titles and 45 periodicals pertaining to the geology, water resources, and mineral resources of Texas and adjacent states. Included in the collection are extensive reports and open-file materials received from the U.S. Bureau of Mines, the U.S. Geological Survey, and the U.S. Department of Energy (formerly the Energy Research and Development Administration), as well as unpublished open-file reports prepared by the Bureau for various contracting agencies.

The Data Center houses an extensive collection of surface and subsurface geologic data, mostly for Texas. Original cross sections, maps, and other work data used in preparing many of the Bureau's publications are placed on open file for staff and public use. Large collections of topographic maps, geologic maps, Texas aerial photographs, and Landsat images are also on file. The Data Center also holds well logs for more than 25,000 wells in

Texas and 8,000 wells in adjacent states; scout tickets and well records for more than 200,000 Texas wells and 30,000 New Mexico wells; driller's logs for about 400,000 Texas wells; and completion cards for more than 300,000 wells in Texas and several hundred thousand wells in adjacent states.

More than 2,500 books and journals were cataloged and entered into the new title/subject catalog data base on the Bureau's VAX 11/780. Staff members can now search this data base and retrieve records by title, subject, author, or other parameters from their offices.

MINERAL STUDIES LABORATORY

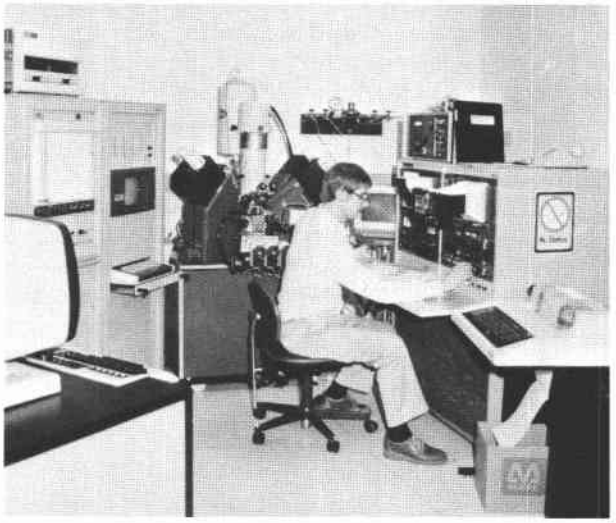
The Bureau's Mineral Studies Laboratory (MSL) is a modern analytical laboratory with a staff of professional chemists and geochemists and an impressive suite of analytical instruments. The MSL provides analytical services and research to the Bureau in support of its programs as well as to other University, government, and private organizations interested in geological resources of Texas. The MSL is directed by David W. Koppenaal, Chief Chemist.

The major technical activity of the MSL during 1985 was its participation in the West Texas Waste Isolation (WTWI) program. Samples analyzed for the WTWI program accounted for more than 60 percent of the samples submitted to the MSL for geochemical characterization. This work centered on the development of physiochemical methods to selectively dissolve mineral constituents of Wolfcampian sediments from Palo Duro Basin samples in order to use trace elements to determine diagenetic history and its relationship to safe disposal of radioactive waste. Other WTWI activities included analyses of fresh-water, brine, and rock samples to support interpretations of ground-water movement and its effect, if any, on safe waste disposal. About 740 fresh-water and brine samples have been collected, processed, analyzed, and stored since 1980 in this effort.

Other Bureau programs using MSL services during the year included Reservoir Characterization, Deep-Basin Lignite, University Lands, and Texas Mining and Mineral Resources Research Institute. In addition, about 10 percent of MSL's workload involved the analysis of geological samples submitted from outside the Bureau.

A significant effort during 1985 was development, revision, and implementation of new quality assurance/quality control procedures, primarily to support the WTWI program. New procedures were established for submitting samples, tracking analyses, and monitoring requests for sample analyses. Documentation of MSL procedures was initiated, with the ultimate goal of establishing an MSL Analysis Procedures Manual. The efforts have resulted in an improved operation that meets quality assurance/quality control requirements and accounts for results and data through established techniques that may be checked by audit.

The MSL continued its participation in several professional societies and associations devoted to standardizing and developing analytical methods. The MSL is a member of the International Geostandards Working Group and participates in the work of several committees of the American Society for Testing and Materials, including subcommittees on Coal and Coke, Hazardous Wastes, and Water. These activities help MSL to maintain high standards and stay abreast of new developments in the analysis and characterization of geological materials.



James A. Morgan

James H. Wittke, Research Scientist Associate, determines elemental zoning and chemical composition within a mineral grain using the electron microprobe at the Mineral Studies Laboratory.

During 1985 MSL was relocated to the new Mineral Studies Laboratory/Core Research Center building adjacent to the Bureau's Administration and Research Building at Balcones Research Center. This move enabled MSL to expand and modernize its capabilities. The new facility, comprising 19,000 ft^2 of modern analytical laboratories, includes 15 acid fume hoods, self-contained compressed air, vacuum, water-cooling, de-ionized water and intercommunications systems, and 4,500 ft^3 of cold-storage space. Analytical instruments acquired before and during the relocation and installed during late 1985 include an inductively-coupled plasma mass spectrometer, a stable isotope mass spectrometer, an ion chromatograph, a high-temperature sample fusion device, a coulometric CO_2 titrator, and a fire assay analysis system. The new MSL is a more attractive and effective analytical facility dedicated to the characterization of Texas' geological resources.

WELL SAMPLE AND CORE LIBRARY

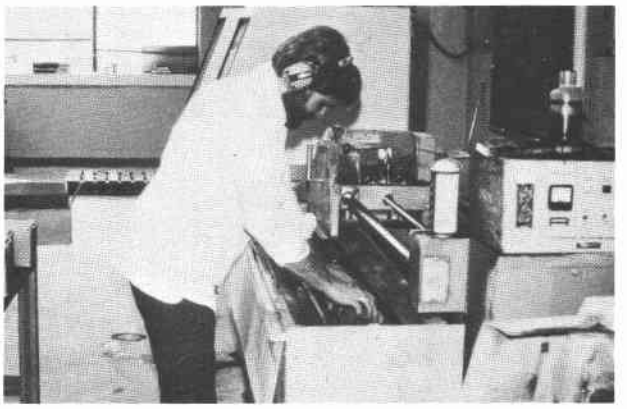
In September, the Well Sample and Core Library moved into a newly constructed facility. The Core Research Center (CRC) occupies nearly 19,000 ft^2; the adjacent Core and Well Sample Repository (CWSR) comprises about 103,000 ft^2. The CRC is open from 8:00 a.m. to 5:00 p.m., Monday through Friday. Information on holdings, policies, or computer listings may be obtained by calling Michael S. Cosper, Curator, at (512) 471-1534.

The CRC has two core examination rooms equipped with 14 examination tables, binocular microscopes, and supporting equipment available on request. The CRC also has a drill cuttings examination room capable of accommodating 16 patrons in individual compartments, each with exhaust ports to remove acidic fumes. Another room is dedicated to X-ray radiography of whole or slabbed core. A core saw room is equipped with two Ray Tech automatic saws capable of slabbing 300 ft of whole core per day, two Target masonry saws, and a Felker trim saw for cutting thin section stubs.

The CWSR houses nearly 50 linear miles of shelves to hold both core and samples. The shelves are designed to hold 180 linear feet of slabbed core per foot of shelf on pallets. About 10 percent of the CWSR is isolated and climate controlled to hold destructible core lithologies like salt. A loading dock with a mechanical lift allows fork lifts to drive directly into delivery trucks to off-load pallets. Fork lifts also deliver pallets directly to CRC rooms through covered galleries.

Cores and cuttings may be checked out in person for study on site or for use outside the Bureau. Samples sent outside may be held for 6 weeks; extensions are considered. To take samples or thin sections from cores or cuttings requires approval by the curator. Patrons are requested to provide results of analyses to the CRC to become part of the center's reference material.

Since it opened in September, 83 non-Bureau patrons have visited the Core Research Center. The CRC hosted several core workshops, which are described under Highlights in this report. Patrons checked out core from 241 wells and cuttings of 187 wells. Cores from about 390 wells were slabbed, reboxed, and filed in the new repository. The thin-section lab produced 2,496 slides requested by Bureau and non-Bureau geologists.



James A. Morgan

Mark Andreason, Research Assistant, uses one of the Bureau's Ray Tech core saws to slab core from the Tight Gas Sandstone project.

During 1985 cores and cuttings were donated by American Exploration Company; American Petrofina; Amoco Production Company; Amquest (Brock Exploration Corp.); Anadarko; Angus Petroleum; ARCO; ARKLA Exploration; Badger Logging, Inc.; Big Run Production Co.; Thomas D. Coffman; William G. Ellis; Duncan Foley; Forest Oil Company; Forney Oil Company; Hill Production; Indian Wells Oil Company; Ernest K. Lehman and Associates of Texas, Inc.; McFarlane Oil Company; Mid-American; Morris and Knudson; Mosbacher Production Company; Neumin Production Company; Palo Petroleum; Phillips Petroleum; Prairie Productions; Primary Fuels, Inc.; Santa Fe Minerals; Alan Scott; Shell Oil Company; Shield Resources, Inc.; Southport Exploration, Inc.; Sun Exploration Production Co.; Texas Gas Exploration Corp.; Texas New Gulf Minerals; Transco Exploration; Trinity University; University of Texas Department of Geological Sciences; University of Utah Department of Geology; and Wheless Industries, Inc. Texaco donated approximately 280 tons of core from West Texas.

GEOPHYSICAL WELL LOG LIBRARY

An agreement with the Railroad Commission of Texas designates the Bureau as the entity that will provide both industry and the public access to many of the logs submitted to the Commission. The agreement is the result of legislation that went into effect in September 1985 that requires all operators of oil, gas, or geothermal wells to provide the Commission with copies of well logs for new, deepened, or plugged wells. The Bureau will operate a geophysical well log library in the Research and Administration Building at Balcones Research Center.

The operation will allow the public, the petroleum industry, and commercial well log service companies to examine and duplicate well logs. The logs from the Commission are estimated to number more than 140,000 per year. In addition to these, many of the Bureau's well logs may be made available.

Paper copies of the well logs and microfiche copies will be provided to the Bureau by the Commission. The primary way of examining or duplicating the logs will be through the use of the microfiche copy. To allow examination and duplication of these logs the Bureau has recently purchased microfiche readers, a unit that makes duplicate microfiche copies, and equipment that makes paper copies from microfiche.

HIGHLIGHTS OF THE YEAR

ACTIVITIES OF THE DIRECTOR

William L. Fisher, Director of the Bureau of Economic Geology, received the 1985 Public Service Award given by the American Institute of Professional Geologists. AIPG awardees demonstrate "outstanding contributions to the public good." At the award presentation, special attention was given to Fisher's contributions to science, teaching, research administration, and both national and state public service.

In 1985 Fisher became the 69th president of the American Association of Petroleum Geologists. Since 1917, when the AAPG was founded, only five presidents have been elected from academic and government service. AAPG is the world's largest geological society, with its nearly 43,000 members in almost 100 countries.

Three committees of the National Academy of Sciences/National Research Council call on Fisher's expertise. He is the chairman of the Committee on Offshore Hydrocarbon Assessment Methodology. He also serves as a member of the Committee on Continental Scientific Drilling and the Board on Mineral and Energy Resources. For the National Academy of Sciences/U.S. Department of the Interior, Fisher is a member of the U.S. National Committee on Geology.

The Director continues his tenure as Chairman of the Department of Geological Sciences, The University of Texas at Austin. The department now includes 53 faculty, 200 graduate students, and 300 undergraduates.

BINGLER BECOMES DEPUTY DIRECTOR

Edward C. Bingler joined the Bureau in May as Deputy Director, a new position that mainly involves program development and management. Bingler was formerly Director and State Geologist at the Montana Bureau of Mines and Geology.

Concurrently with those positions, Bingler served as Director of Research at Montana College of Mineral Science and Technology (MCMST) and as vice-chairman of the Governor's Council on Science and Technology. As part of the latter job, he worked as a full-time lobbyist in a successful effort to promote legislation creating a statewide research and development investment fund.

Other positions he has held include Associate Dean of the Graduate School and Director of the Earthquake Studies Office at MCMST and Director of the Montana Mining and Mineral Resources Research Institute.

Bingler's new duties include managing the Bureau's programs through the Program Coordinators and the Associate Directors, initiating new programs (including locating sources of funding), providing directoral review of all publications, and maintaining liaison with Federal, State, and private agencies.

Bingler has a bachelor's degree in geology from Lehigh University, a master's degree in geology from the New Mexico Institute of Mining and Technology, and a Ph.D. in geology from The University of Texas at Austin. His dissertation concerned the Precambrian geology of La Madera Quadrangle in north-central New Mexico.

Bingler is a member of the American Association of Petroleum Geologists, the Geological Society of America, the Society of Economic Geologists, and the American Institute of Mining and Metallurgical Engineers, among others.

BARNES COMPLETES 50 YEARS OF BUREAU SERVICE

In October, Virgil E. Barnes, Senior Research Scientist, completed 50 years of geological research at the Bureau of Economic Geology. Barnes "officially" retired from the Bureau and University in 1977 but has continued on "modified service" since. The bureaucratic verbiage describing his work status has changed; Barnes has not. He remains a valuable, highly productive scientist on the research staff and an esteemed role model for all.

In recent years, Barnes has focused on completing the Geologic Atlas of Texas, which he has directed since 1961. The last map of that series of 38 maps will be printed in late 1986. He has also compiled the initial draft of a statewide Texas geologic map at a scale of 1:500,000.

The 1977 Annual Report of the Bureau highlighted Barnes' retirement and listed his publications—more than 160 books, articles, abstracts, guidebooks, and maps. Of course, his bibliography has grown since then:

1978

Geologic Atlas of Texas, Clovis Sheet, Edwin Theodore Dumble Memorial Edition, Virgil E. Barnes, project director. Scale 1:250,000, in full color, topographic base.

Geologic Quadrangle Map No. 43, Geology of the Click Quadrangle, Llano and Blanco Counties, Texas, by Virgil E. Barnes and R. V. McGehee. Scale 1:24,000, in full color, topographic base, 23-p. text.

Geologic Quadrangle Map No. 44, Geology of the Dunman Mountain Quadrangle, Llano, Burnet, and Blanco Counties, Texas, by Virgil E. Barnes and R. V. McGehee. Scale 1:24,000, in full color, topographic base, 10-p. text.

Geologic Quadrangle Map No. 45, Geology of the Cap Mountain Quadrangle, Llano County, Texas, by Virgil E. Barnes and R. V. McGehee. Scale 1:24,000, in full color, topographic base, 24-p. text.

Geologic Quadrangle Map No. 46, Geology of the Howell Mountain Quadrangle, Blanco and Llano Counties, Texas, by Virgil E. Barnes. Scale 1:24,000, in full color, topographic base, 11-p. text.

Geologic Quadrangle Map No. 47, Geology of the Round Mountain Quadrangle, Blanco, Burnet, and Llano Counties, Texas, by Virgil E. Barnes. Scale 1:24,000, in full color, topographic base, 12-p. text.

1979

Geologic Atlas of Texas, Emory Peak-Presidio Sheet, Joshua William Beede Memorial Edition, Virgil E. Barnes, project director, principal mapping by J. B. Brown, N. J. Cepeda, and F. W. Daugherty. Scale 1:250,000, in full color, topographic base.

Geologic Atlas of Texas, Marfa Sheet, W. H. von Streeruwitz Memorial Edition, Virgil E. Barnes, project director, principal mapping by P. G. Twiss. Scale 1:250,000, in full color, topographic base.

Barnes, Virgil E., 1979, Memorial for William Charles Bell: The University of Texas at Austin, Department of Geological Sciences Newsletter, v. 28, p. 45-46.

1981

Geologic Atlas of Texas, Llano Sheet, Virgil Everett Barnes Edition. Virgil E. Barnes, project director, principal mapping by V. E. Barnes. Scale 1:250,000, in full color, topographic base.

Geologic Atlas of Texas, Sonora Sheet, Roy Thorpe Hazzard Memorial Edition, Virgil E. Barnes, project director, principal mapping by D. McKalips and V. E. Barnes. Scale 1:250,000, in full color, topographic base.

Barnes, V. E. (with Stitt, J. H., Miller, J. F., and Taylor, J. F.), 1981, Cambrian and lowest Ordovician lithostratigraphy and biostratigraphy of southern Oklahoma and Central Texas: Denver, Second International Symposium on the Cambrian System, co-sponsored by the U.S. Geological Survey, the Subcommission on Cambrian Stratigraphy, the Commission on Stratigraphy, and the International Union of Geological Sciences, with the cooperation of the Oklahoma Geological Survey and the Texas Bureau of Economic Geology, Guidebook for Field Trip 3, 56 p.

1982

Geologic Atlas of Texas, Fort Stockton Sheet, Charles Laurence Baker Memorial Edition, V. E. Barnes, project director, principal mapping by D. McKalips, J. B. Brown, and V. E. Barnes. Scale 1:250,000, in full color, topographic base.

Geologic Quadrangle Map No. 48, Geology of the Marble Falls Quadrangle, Burnet and Llano Counties, Texas, by V. E. Barnes. Scale 1:24,000, in full color, 15-p. text.

Geologic Quadrangle Map No. 49, Geology of the Pedernales Falls Quadrangle, Blanco County, Texas, by V. E. Barnes. Scale 1:24,000, in full color, 34-p. text.

Geologic Quadrangle Map No. 50, Geology of the Spicewood Quadrangle, Blanco, Burnet, and Travis Counties, Texas, by V. E. Barnes. Scale 1:24,000, in full color, 15-p. text.

Geologic Quadrangle Map No. 51, Geology of the Hammetts Crossing Quadrangle, Blanco, Hays, and Travis Counties, Texas, by V. E. Barnes. Scale 1:24,000, in full color, 11-p. text.

1983

Geologic Atlas of Texas, Tucumcari Sheet, Henryk Bronislaw Stenzel Memorial Edition, V. E. Barnes, project director, principal mapping by G. K. Eifler, Jr., F. D. Trauger, and J. W. Hawley. Scale 1:250,000, full color, topographic base.

1984

Geologic Atlas of Texas, Dalhart Sheet, John Emery Adams Memorial Edition, V. E. Barnes, project director, principal mapping by G. K. Eifler, Jr., R. O. Fay, and F. D. Trauger. Scale 1:250,000, full color, topographic base.

NEW RESEARCH STAFF MEMBERS

Edgar H. Guevara

Edgar Guevara, who was with the Bureau in the mid- to late 1970's, rejoined the Bureau in January as a Research Fellow. A native of San Cristobal, Venezuela, Guevara returned from his home country after 4 years of employment with INTEVEP, S.A., the research and development arm of Petroleos de Venezuela, in Caracas. Before his position with INTEVEP, Guevara worked at the Bureau from 1977 to 1979 as a Research Scientist and from 1974 to 1975 as a Research Associate V. He received his bachelor's degree in geology from the Universidad Central de Venezuela in Caracas and received his master's and Ph.D. degrees in geology from The University of Texas at Austin. At the Bureau, Guevara works on the Reservoir Characterization project, which is investigating the relationships between reservoir characteristics and ultimate recovery of petroleum. He is part of a group studying oil fields in the Spraberry-Dean play of the Midland Basin. Guevara is a member of the American Association of Petroleum Geologists and the Austin Geological Society and is an advisor for the Asociación Venezolana de Geología, Minería y Petróleo, in Caracas.

Charles Kerans

A native of Connecticut, Charles Kerans joined the Bureau in May as a Research Associate on the Reservoir Characterization project. Kerans has a bachelor's degree in geology from St. Lawrence University, New York, and a Ph.D. in geology from Carleton University, Ottawa, Canada. His dissertation concerned basin analysis of the Proterozoic Dismal Lakes Group of the Northwest Territories, Canada. Kerans was formerly a Senior Research Fellow with the Western Australian Mining and Petroleum Research Institute in Perth, Australia, where he interpreted the carbonate depositional systems in the Canning Basin. He is a member of the Society of Economic Paleontologists and Mineralogists.

F. Jerry Lucia

Jerry Lucia, a native of Eau Claire, Wisconsin, joined the Bureau in March as a Senior Research Fellow. He is working on the University Lands project, studying the geological and fluid behavior characterization of oil reservoirs. Lucia has a bachelor's degree in engineering from the University of Minnesota at Minneapolis and master's degree in geology from the same institution. Before joining the Bureau, Lucia worked for 30 years as a geological engineer consultant for Shell Oil in Houston. He recently retired from Shell. He is a member of the American Association of Petroleum Geologists, the Society of Economic Paleontologists and Mineralogists, the Geological Society of America, and the American Association for the Advancement of Science. He also serves on the AAPG Publications Committee.

Richard P. Major

Rick Major joined the Bureau staff as a Research Associate in August. Major, originally from Dalton, Massachusetts, has a bachelor's degree in geology from Union College at Schenectady, New York (1973), a master's degree in geology from the University of Connecticut (1976), and a Ph.D. in geology from Brown University (1984). He was formerly employed with the University of Colorado at Denver as an assistant professor and before that was an exploration geologist with Amoco in New Orleans. This summer Major was a guest scientist with the U.S. Geological Survey workshop on the Eniwetok Atoll project. At the

James A. Morgan

New Bureau staff (clockwise from upper left) include: Edward C. Bingler, Deputy Director; research scientists Prasanta K. Mukhopadhyay, Edgar H. Guevara, Richard P. Major, and Charles Kerans; and scientists F. Jerry Lucia and Jay Raney (not present for photo).

Bureau he is working on the University Lands project. He is a member of the Geological Society of America, the American Association of Petroleum Geologists, and the Society of Economic Paleontologists and Mineralogists.

Prasanta K. Mukhopadhyay

Prasanta Mukhopadhyay, a native of West Bengal, India, joined the Bureau's lignite project in February as a Research Associate. He was involved in petrological and organic geochemical studies of Texas lignite. Mukhopadhyay has bachelor's, master's, and doctoral degrees in geology from Jadavpur University in Calcutta. He did postdoctoral research in coal petrology and coal geochemistry at the Institute of Coal and Petroleum at the Technical University in Aachen, West Germany. Before joining the Bureau, Mukhopadhyay was employed for 5 years as a research scientist with the Institute of Petroleum and Organic Geochemistry at the Kernforschungsanlage (Nuclear Research Center) in Juelich, West Germany. Mukhopadhyay is a member of the American Association of Petroleum Geologists, the International Association of Coal Petrologists, and the European Association of Organic Geochemists.

Jay Raney

Jay Raney joined the Bureau staff as a Research Scientist in August. Raney, originally from Orange, Massachusetts, has a bachelor's degree in geology from the University of Massachusetts at Amherst (1969) and a Ph.D. in geology from The University of Texas at Austin (1976). Before joining the Bureau, Raney was employed with Anaconda, a division of ARCO. At the Bureau he is co-project coordinator for the West Texas Waste Isolation project. Raney is a member of the American Institute of Mining, Metallurgical, and Petroleum Engineers and the Society of Economic Paleontologists and Mineralogists.

PROMOTIONS

Jonathan G. Price

Jon Price was promoted to Research Scientist in September. He has been with the Bureau 5 years, the last 3 as a Research Associate. Price is Director of the Texas Mining and Mineral Resources Research Institute and is studying the mineralization and igneous geology of Trans-Pecos Texas. The evolution of Trans-Pecos igneous rocks is being studied by using whole rock and electron microprobe analyses in thermodynamic and geochemical modeling. A new project to assess the mineral potential of State-owned lands, including the silver districts of far western Texas, is drawing on his earlier studies of the tectonic and geochemical controls on precious metal deposition.

Noel Tyler

Noel Tyler, who has been with the Bureau 5 years, was promoted from Research Associate to Research Scientist in April. Tyler works on the Reservoir Characterization project, where his duties involve mapping and interpreting the facies architecture of selected major clastic reservoirs in Texas. These data will be integrated with engineering and production data to construct genetic reservoir models. The project also involves identifying, for strategic infill drilling, areas within these reservoirs that potentially contain stratigraphically trapped oil.

Edward W. Collins

Eddie Collins was promoted to Research Associate in September. He was formerly a Research Scientist Associate III and has been with the Bureau 7 years. He is studying Panhandle structures as part of the West Texas Waste Isolation project and has worked previously on several Bureau projects, including the East Texas Waste Isolation project, the Super-Conducting Super Collider project, the Sabine River Authority project, and the coastal salt domes study.

BUREAU INITIATES INDUSTRIAL ASSOCIATES PROGRAM

The Bureau began a new research program in 1985 that allows sponsoring companies to participate in geological studies that directly benefit the petroleum industry.

Participants during the first year were Amoco, ARCO, Conoco, Louisiana Land and Exploration, Mobil, Pennzoil, Phillips, Sohio, Tenneco, Texaco, and the U.S. Geological Survey. Research supported by an industrial associates group is a well-established concept used by both public and private institutions to promote better cooperation and interaction among the sponsors and the individuals conducting the studies. The Bureau's initial effort is directed toward companies engaged in exploration for hydrocarbons beneath the State and Federal waters of

offshore Texas. This vast area still offers tremendous exploration potential, as demonstrated by recent discoveries that extended several known plays and established at least one new trend in deep water.

Relying on its recognized expertise in genetic stratigraphy and resource evaluation, the Bureau embarked on a 3-year project that will result in a comprehensive assessment of the structural and stratigraphic framework of the offshore region. This major effort will be accomplished using a series of cross sections, maps, and reports detailing the geologic history, depositional sequences, facies assemblages, structural styles, production characteristics, and hydrocarbon plays for several stratigraphic units within both the Miocene and Plio-Pleistocene Series. The first year of study focused on the Middle and Upper Miocene sediments that produce mainly on the Federal Outer Continental Shelf. In subsequent years, the structural and stratigraphic framework will be used as a foundation for generic studies such as salt mobilization, sediment dispersal dynamics, sandstone diagenesis, reservoir characterization, and fluid migration.

CORE WORKSHOPS HELD

The Bureau's new Core Repository and the Core Research Center have become an important educational center for logging core. Four workshops held in 1985 illustrate the educational potential of the new facilities.

In June the Bureau ran its first core workshop for a professional society. Nearly 60 oil company and academic geologists attended a 1-day AAPG Carbonate Exploration School core workshop. They examined about 500 ft of core from the Pearsall and Cow Creek Formations.

The Bureau hosted a workshop in March for contractors of the Department of Energy and another in August for contractors of the Nuclear Regulatory Commission to examine core from the Palo Duro Basin. More than 8,000 ft of Pennsylvanian to Pleistocene core was displayed. The San Andres salt beds, which are potential host rocks for a mined geological repository for high-level radioactive waste, received detailed scrutiny. Nearly 70 DOE and NRC contractors studied the core during each 2-day workshop.

In conjunction with the annual meeting of the Gulf Coast Association of Geological Societies in October, Bureau scientists hosted a core workshop titled "Lower Cretaceous Depositional Environments from Shoreline to Slope." Twenty-six contributors each displayed 30 to 100 ft of core along with explanatory posters. About 140 geologists from industry and universities attended.

The Bureau has the only laboratory in the country capable of displaying thousands of feet of core to hundreds of participants. The success of the core workshops during 1985 illustrates the Bureau's important role in continuing education. Equally important is the year-round opportunity available to all geologists to conduct core research supporting exploration and production studies in Texas.

NEW COMPUTER INSTALLED

The installation of a new computer has strongly affected the average workday at the Bureau. Many scientists now originate manuscripts on their office terminal for transfer to the word processing center. Data bases resulting from stratigraphic, structural, petrologic, geochemical, and engineering research are stored in data management software. Graphs and simple line drawings become the preliminary illustrations for the cartographic/drafting section. Most accounting and correspondence are initiated on a terminal.

The Bureau's DEC VAX 11/780 computer is the center of a building-wide network of more than 100 terminals, personal computers, and printers. The configuration includes 8 megabytes of memory, more than 900 megabytes of disk storage, and a high-speed tape drive. Most full-time research staff, and many support and services staff, have terminals in their offices that are linked to the VAX and to the University Computation Center. The VAX is also linked to the Bureau's Xerox word processing machines and Varityper typesetting machine. Staff members have access to a 12-page-a-minute QMS laser printer, a Printronix P600 line printer, a 36-inch Houston Instruments drum plotter, and a 20-inch Versatec electrostatic plotter. The system also includes a Gould-DeAnza FD5000 color image processing system that was acquired primarily for Landsat data analysis.

The VAX is supplied with FORTRAN and other computer languages and with data management tools. The MASS-11 word processing program has been installed and is becoming the preferred method of drafting correspondence and reports. Other recently acquired software includes DATAPLOT, from the National Bureau of Standards, for statistical analyses and displays, and Radian Corporation's CPS-1 for map analysis and contour mapping.

AWARDS AND HONORS

Staff Receive Awards for Papers

Walter B. Ayers, Jr., and W. R. Kaiser received the Best Paper Award from the Energy Minerals Division of the American Association of Petroleum Geologists for their paper "Lacustrine/Interdeltaic Coal in Fort Union Formation (Paleocene), Powder River Basin, Wyoming." The award was presented at the AAPG annual convention in New Orleans.

William E. Galloway received the A. I. Levorsen Memorial Award for best technical paper from the American Association of Petroleum Geologists. The award-winning paper, "Depositional Framework of the Lower Miocene (Fleming) Episode, Northwest Gulf Coast Basin," was presented at the 1985 annual meeting of the Gulf Coast Association of Geological Societies. Galloway previously received the Levorsen Award in 1977 for a paper he presented at the annual meeting of the Rocky Mountain Section, AAPG-SEPM.

Malcolm Light, along with two coauthors, was awarded the A. E. Phaup Award for 1983 by the Geological Society of Zimbabwe. Light, M. K. Watkeys, and T. J. Broderick received the award for a paper titled "A Retrospective View of the Central Zone of the Limpopo Belt, Zimbabwe." The three scientists wrote the article while employed by the Geological Survey in Zimbabwe. In selecting the paper for the award, the judges praised the paper and predicted that

"it will become the first point of reference for any future work in the Central Zone."

Ronit Nativ won the Peretz Grader Award for best paper for her dissertation, "The Water Potential of the Deep Aquifers (Jurassic to Paleozoic) in the Negev Desert, Israel." The award was presented at the annual meeting of the Israel Geological Society in March.

Brown and Dutton Named Distinguished Lecturers

The Petroleum Exploration Society of Australia selected L. F. Brown, Jr., as the 1985 Distinguished Lecturer. Brown presented lectures at Brisbane, Sydney, Melbourne, Adelaide, and Perth in June and July. The subject of his lecture was "The Role of Facies in Seismic Stratigraphic Analysis."

Shirley Dutton was invited to participate in the 1986-87 Distinguished Lecturer Program of the American Association of Petroleum Geologists. Distinguished Lecturers speak before scientific societies and university geology departments throughout the United States and Canada. The topic of Dutton's talk is "Diagenesis of Pennsylvanian Arkosic Sandstones, Anadarko Basin."

James A. Morgan

Bureau Director, W. L. Fisher (upper right), and (clockwise) Research Associate Shirley P. Dutton, Associate Director E. G. Wermund, and Associate Director Doug Ratcliff served as officers in professional societies during the year.

Jackson Named to Bulletin Staff

Martin P. A. Jackson has been appointed to a 3-year term as Associate Editor of the American Association of Petroleum Geologists Bulletin. The Bulletin is published monthly. L. F. Brown, Jr., leaves the Bulletin editorial staff at the end of 1985 after serving for 9 years.

OFFICERS IN PROFESSIONAL SOCIETIES

During the year, Bureau researcher Shirley P. Dutton was elected Secretary of the Midcontinent Section of the Society of Economic Paleontologists and Mineralogists. During her 1-year term Dutton will help coordinate a newsletter and recruit new members. Associate Director Doug Ratcliff completed a 1-year term of office as President of the Austin Geological Society in May. He also served as Treasurer of the Gulf Coast Association of Geological Societies. Associate Director E. G. Wermund completed a 1-year term as President of the Gulf Coast Association of Geological Societies in October. Both Ratcliff and Wermund were active on behalf of the Austin Geological Society in helping to host the 1985 annual meeting of the Gulf Coast Association of Geological Societies.

TEXAS MINING AND MINERAL RESOURCES RESEARCH INSTITUTE

The Texas Mining and Mineral Resources Research Institute (TMMRRI) is one of 31 state organizations nationwide funded and administered by the U.S. Bureau of Mines and dedicated to research and academic training in mineral resources and technology. The Bureau of Economic Geology administers TMMRRI, which is directed by Jonathan G. Price. The University of Texas at Austin, Texas A&M University, and Prairie View A&M College, a subdivision of Texas A&M University, are academic members of the Institute.

The Institute supports training and education of mining personnel through graduate fellowships, research assistantships, and undergraduate scholarships. The advisory board for TMMRRI is composed of the President of The University of Texas at Austin, the Vice-Chancellor and Dean of Engineering at Texas A&M University, and a senior member of the Railroad Commission of Texas. Representatives of the advisory board plus two members of the Texas mining industry compose the TMMRRI Fellowship Committee. During the 1984-85 academic year, 13 fellowships and scholarships were awarded to students at member universities. For the 1985-86 academic year, individual stipends were raised, and five fellowships and scholarships were awarded. Areas of TMMRRI-supported graduate research include rock mechanics, coal processing, metallic ore deposits, and mineral economics. During 1985, five other graduate students received support through research assistantships on Institute-funded hard mineral and coal resource projects. These students are given the opportunity to participate in organized research that is often broader in scope than that for a dissertation or thesis.

In 1985, the Bureau of Economic Geology published one map and three reports that were fully or partly funded by TMMRRI: Miscellaneous Map 36 on the tectonics of Trans-Pecos Texas, Report of Investigations No. 145 on Trans-Pecos silver deposits, and Mineral Resource Circular No. 76 and a Special Publication on lignite in Texas.

RESEARCH STAFF PUBLICATIONS AND ACTIVITIES

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

PAPERS

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Kerans, Charles, 1985, Diagenetic history of Devonian reef complexes, Canning Basin, Western Australia (abs.): Society of Economic Paleontologists and Mineralogists, second midyear meeting, Golden, Colorado, p. 48.

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Light, M. P. R., 1985, Maturity anomalies, fluid flow, and permeability preservation in Frio and Anahuac Formations, Upper Texas Gulf Coast (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 2, p. 279.

Light, M. P. R., 1985, Structure, facies, continuity, and internal properties of the Frio "A" sandstone, N.E. Hitchcock Field, Galveston County, Texas (abs.): Sixth U.S. Gulf Coast Geopressured-Geothermal Energy Conference, The University of Texas at Austin, p. 31.

Machenberg, M. D., DuBar, J. R., Gustavson, T. C., and Holliday, V. T., 1985, A depositional model for post-Ogallala sediments on the Southern High Plains (abs.): Geological Society of America, South-Central Section, Abstracts with Programs, v. 17, no. 3, p. 165.

Major, R. P., 1985, Fracture permeability and high initial water cut in a carbonate gas reservoir (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 2, p. 282.

Major, R. P., 1985, Isotopic evidence for burial diagenesis of a Permian (Wolfcampian) phylloid algal bioherm (abs.): Society of Economic Paleontologists and Mineralogists, annual midyear meeting, Abstracts Volume 2, p. 58.

Morton, R. A., 1985, Nearshore responses to great storms—catastrophic historic events but common sedimentologic features (abs.): Geological Society of America, Abstracts with Programs, v. 17, no. 7, p. 669.

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Nance, H. S., 1985, Depositional setting and facies relations in Upper Permian red beds of the Palo Duro Basin, Texas Panhandle (abs.): Society of Economic Paleontologists and Mineralogists annual midyear meeting, Abstracts Volume 2, p. 67.

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Paine, J. G., and **Morton, R. A.,** 1985, Barrier island response to major storms: erosion, deposition, and recovery at Galveston Island, Texas (abs.): Geological Society of America, Abstracts with Programs, v. 17, no. 7, p. 684.

Parker, D. F., **Price, J. G., Henry, C. D.,** Sanders, K. C., and Powell, K. H., 1985, Discrimination of widespread silicic lava flows from rheomorphic ash-flow tuffs, Trans-Pecos volcanic field, Texas (abs.): EOS, v. 66, no. 46, p. 1125-1126.

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Posey, H. H., Price, P. E., and Hurst, S. D., 1985, Anhydrite $^{87}Sr/^{86}Sr$ ratios from Gulf Coast salt domes: implications for source and age of primary materials (abs.): Geological Society of America, Abstracts with Programs, v. 17, no. 3, p. 188.

Price, J. G., 1985, Gold in Texas, or lack thereof (abs.): Austin Geological Society Newsletter, v. 19, no. 8, p. 1.

Price, J. G., Henry, C. D., Barker, D. S., and Parker, D. F., 1985, Alkalic rocks of contrasting tectonic settings in Trans-Pecos Texas (abs.): Geological Society of America, Abstracts with Programs, v. 17, no. 3, p. 188.

Price, J. G., Henry, C. D., Barker, D. S., and **Rubin, J. N.,** 1985, Magma mixing in a zoned alkalic intrusion (abs.): Geological Society of America, Abstracts with Programs, v. 17, no. 7, p. 693.

Ruppel, S. C., 1985, Facies and geochemical characterization of Mississippian rocks in Palo Duro and Hardeman Basins, Texas (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 2, p. 303-304.

Ruppel, S. C., and **Dutton, S. P.,** 1985, Thermal maturation studies in the southern Texas Panhandle (abs.): Geological Society of America, Abstracts with Programs, v. 17, no. 3, p. 189.

Seni, S. J., 1985, Utilization of solution-mined caverns in salt domes for chemical-waste disposal (abs.): Geological Society of America, Abstracts with Programs, v. 17, no. 3, p. 190.

Simpkins, W. W., and **Gustavson, T. C.,** 1985, Late Pleistocene to Holocene channel aggradation, Tierra Blanca Creek, Southern High Plains, Texas Panhandle (abs.): Geological Society of America, Abstracts with Programs, v. 17, no. 3, p. 192.

Tyler, Noel, 1985, Stable shelf deltaic sedimentation in South Texas (abs.): Society of Economic Paleontologists and Mineralogists annual midyear meeting, Abstracts Volume 2, p. 90.

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Tyler, N., Light, M. P. R., and **Ewing, T. E.,** 1985, Saline fluid flow and hydrocarbon migration and maturation as related to geopressure, Frio Formation, Brazoria County, Texas (abs.): The University of Texas at Austin, Sixth U.S. Gulf Coast Geopressured-Geothermal Energy Conference, abstract volume, p. 11.

LECTURES AND PUBLIC ADDRESSES

Edward C. Bingler

"BEG Research and Economic Development": presented to Office of Advanced Technology, Texas Economic Development Commission, Austin, Texas.

"Energy and Mineral Mining Activity in Texas—1984": presented to Texas Mining and Reclamation Association, annual meeting, Austin, Texas.

"Geology, Technology, and Economic Development": presented to Austin Geological Society, monthly meeting, Austin, Texas.

"Research Activities of the Bureau of Economic Geology": presented to U.S. Naval Reserve Officers, Central Texas Region, Austin, Texas.

"Research for Enhanced Petroleum Exploration and Production": presented to American Institute of Professional Geologists, Texas Section, annual meeting, Dallas, Texas.

L. F. Brown, Jr.

"Introduction to Geophysics": presented to undergraduate class, The University of Texas at Austin, Department of Geological Sciences.

"Petroleum Geology of the Eastern Shelf, North-Central Texas": presented to undergraduate class, The University of Texas at Austin, Department of Geological Sciences.

"Seismic Stratigraphy of Delta Systems": presented to Pittsburgh Geological Society, 40th anniversary meeting, Pittsburgh, Pennsylvania.

Roy T. Budnik

"Structural Geology of the Palo Duro Basin"; "Tectonic History of the Palo Duro Basin"; and "West Texas Waste Isolation Project—Seismic Reflection Interpretation and Reprocessing Program": presented to joint U.S. Department of Energy/Nuclear Regulatory Commission Workshop on Structure and Tectonics of the Palo Duro Basin, Columbus, Ohio.

Thomas R. Calnan

"Polychaete Identification and Taxonomy": presented to Texas Water Commission, Stream Monitoring Division, field personnel, Austin, Texas.

"Species Diversity of Benthic Macroinvertebrates on the Inner Continental Shelf in the Brownsville, Corpus Christi, and Beaumont-Port Arthur Areas": presented to Texas Academy of Science, Dallas, Texas.

"Submerged Lands of Texas Project": presented to Offshore Technology Conference, interview for PBS television documentary "The Oceans' Renewable Resources," Austin, Texas.

S. Christopher Caran

"Effects of Karstic Subsidence and Paleoclimate on Quaternary Deposition—Examples from Northwestern Texas and Eastern New Mexico": presented to Geological Society of America, South-Central Section, annual meeting, Fayetteville, Arkansas.

"Effects of Paleoclimate and Karstic Subsidence on Terrestrial Deposition—Examples from the Quaternary Terrane of Texas and New Mexico": presented to Tulane University, Department of Geology, New Orleans, Louisiana.

Edward W. Collins

"Fracture Analyses of the Palo Duro Basin Area, Texas Panhandle": presented to joint U.S. Department of Energy Nuclear Regulatory Commission Workshop on Structure and Tectonics of the Palo Duro Basin, Columbus, Ohio.

E. Dow Davidson, Jr.

"A Proposal for Core Curation and Data Management": presented to Deep Observation and Sampling of the Earth's Continental Crust, Inc., Executive Board meeting, Houston, Texas.

"Quality Assurance Procedures for Data Collection/Interpretation of Borehole Information": presented to joint NRC/SRPO U.S. Department of Energy/Nuclear Regulatory Commission Workshop on Structure and Tectonics of the Palo Duro Basin, Columbus, Ohio.

Alan R. Dutton

"Field Techniques in Vadose-Zone Hydrology": presented to The University of Texas at Austin, Department of Geological Sciences, class on field methods in hydrology.

Robert J. Finley

"Depositional Framework, Reservoir Character, and Rock Properties of the Travis Peak (Hosston) Formation, East Texas Basin": presented to Dallas Geological Society, Dallas, Texas, Friends of the Mesozoic, Houston, Texas, and Shreveport Geological Society, Shreveport, Louisiana.

"Geological Basis of Reservoir Characterization": presented to Reservoir Characterization Conference, Geological and Petrophysical Basis session, keynote address, sponsored by National Institute for Petroleum and Energy Research, Dallas, Texas.

"Innovations in Geologic Reservoir Research: Future Directions in Gas Supply": presented to Gas Research Institute, Board of Directors and Joint Advisory Council, Chicago, Illinois.

"Regional Depositional Framework, Reservoir Character, and Rock Properties of the Travis Peak (Hosston) Formation, East Texas": presented to East Texas Geological Society, monthly meeting, Tyler, Texas.

W. L. Fisher

"Domestic Crude Oil: Reserve Addition and Production Capabilities to Year 2000": presented to Committee on the Strategic Petroleum Reserve, National Research Council, National Academy of Sciences, Washington, D.C.

"Geological Projection of Reserves and Production in the Southwest States": presented to Conference on Energy and the Southwest Economy, Federal Reserve Bank of Dallas, Dallas, Texas.

"Is Oil and Gas a Sunset Industry?": presented to Interstate Oil Compact Commission, annual meeting, New Orleans, Louisiana.

"Oil Exploration and Exploitation in the New Energy Era": presented to II Simposio Bolivaniano, special conference, Bogota, Colombia.

"Outlook for Oil in the Texas Economy": presented to The University of Texas at Dallas, Second Texas Energy Symposium, Dallas, Texas.

"Reserve Growth Exploitation Strategies": presented to NRG Associates, Executive Conference on New Directions for Exploration Strategy, Colorado Springs, Colorado.

"Small Field Exploration and Large Field Reexploration—Future of Petroleum Geology": presented to American Association of Petroleum Geologists, Midcontinent Section, all-conference luncheon, Amarillo,

Texas; Society of Exploration Geophysicists, annual meeting, Washington, D.C.; Houston Geological Society, Houston, Texas; and South Texas Geological Society, San Antonio, Texas.

"Texas Crude Oil Production: A Positive Outlook after a Decade of Decline": presented to Austin Geological Society, Austin, Texas.

"Texas Crude Oil: Some Positive Trends": presented to Interstate Oil Compact Commission, annual meeting, Austin, Texas.

"Trends in Petroleum Geology": presented to American Institute of Professional Geologists, annual meeting, St. Paul, Minnesota.

Graham E. Fogg

"Derivation of Finite Element Ground-Water Flow Equations from Physical Reasoning": presented to The University of Texas at Austin, Department of Geological Sciences, class on ground-water modeling.

Michael A. Fracasso

"Hunting for Dinosaurs": presented to Highland Park Elementary School, kindergarten classes; and Sunset Valley Elementary School, third grade classes, Austin, Texas.

William E. Galloway

"Depositional and Structural Architecture of Prograding Clastic Continental Margins": American Association of Petroleum Geologists, Distinguished Lecturer tour.

"Reservoir Facies Architecture in a Microtidal Barrier System": presented to Society of Economic Paleontologists and Mineralogists, Rocky Mountain Section, Denver, Colorado.

Christopher D. Henry

"Caldera Development in Trans-Pecos Texas": presented to Sul Ross State University, Geology Department, Alpine, Texas.

Susan D. Hovorka

"Fractures in Palo Duro Cores": presented to U.S. Department of Energy, Fracture Ground-Water Flow Modeling Peer Review Panel, Columbus, Ohio.

"Palo Duro Core": presented to U.S. Department of Energy, core workshops, Austin, Texas.

"Review of San Andres Salt Composition": presented to National Research Council on behalf of U.S. Department of Energy and National Research Council, meeting on tectonics of Palo Duro Basin, Columbus, Ohio.

"Shallow-water Evaporite Deposition in the Palo Duro Basin": presented to Society of Economic Paleontologists and Mineralogists, Evaporite Research Group, American Association of Petroleum Geologists national meeting, New Orleans, Louisiana.

Mary L. W. Jackson

"Update on Land Resources": presented to Texas A&M University, Soil Survey and Land Resource Workshop, College Station, Texas.

M. P. A. Jackson

"Internal Structure of Model and Natural Salt Domes": presented to The University of Texas at Austin, Department of Geological Sciences, graduate classes in structural petrology.

"Scale Modeling of Gravity Tectonics by Centrifuge": presented to The University of Texas at Austin, Institute for Geophysics, research seminar.

David A. Johns

"Regional Depositional Patterns and Lithofacies in the Late Triassic Dockum Group, Palo Duro Basin, Texas": presented to Museum of Northern Arizona, Geology and Paleontology of Triassic Continental Deposits of the American Southwest Symposium, Flagstaff, Arizona.

"Regional Tectonic Setting and Depositional Facies of the Dockum Group, West Texas and Eastern New Mexico": presented to Museum of Northern Arizona, Geology and Paleontology of Triassic Continental Deposits of the American Southwest Symposium, Flagstaff, Arizona (with George E. Granata).

Charles W. Kreitler

"Hydrogeologic Investigations of the Palo Duro Basin": presented to U.S. Department of Energy, Fracture Ground-Water Flow Modeling Peer Review Panel, Columbus, Ohio.

"Hydrogeology of Edwards Aquifer": presented to American Society of Chemical Engineers, Texas Branch, San Marcos, Texas.

"Hydrology—The Interaction of Hydrologic and Geologic Processes" and "Hydrogeology of Sedimentary Basin, Palo Duro Basin as an Example": presented to universities and research organizations on Birdsall lecture tour, Birdsall Distinguished Lecture series, sponsored by Geological Society of America; and keynote address, Hydrogeology Section, Geological Society of America, national meeting, Orlando, Florida.

M. P. R. Light

"Archean Convergence Zones, Wrench Tectonics and the Northeastward Translation of the Rhodesian Craton": presented to The University of Texas at Austin, Institute for Geophysics, seminar.

Richard P. Major

"Diagenesis of Scorpion Mound, Laborcita Formation (Permian), Tularosa, New Mexico": presented to Louisiana State University, Basin Research Institute.

Mary W. McBride

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

Robert A. Morton

"Barrier Island Response to Natural Processes and Human Activities—Examples from the Texas Gulf Coast": presented to Minerals Management Service, information transfer meeting, New Orleans, Louisiana.

"Submerged Lands of Texas Project": presented to Offshore Technology Conference, interview for PBS television documentary, New Orleans, Louisiana.

"Submerged Lands of Texas Project": presented to Offshore Technology Conference, interview for PBS television documentary "The Oceans' Renewable Resources," Austin, Texas.

"Summary of Geopressured Geothermal Energy Exploration in Texas": presented to Interstate Oil Compact Commission, Geothermal Committee, Austin, Texas.

Harry H. Posey

"Isotope Geochemistry of Gulf Coast Salt Domes": presented to The University of Texas at Austin, Department of Geological Sciences, graduate class in sedimentary ore deposits.

Jonathan G. Price

"Gold in Texas": presented to Arizona Geological Society, monthly meeting, Tucson, Arizona; and Society of Mining Engineers, Central Texas Mining Section, bimonthly meeting, San Antonio, Texas.

"Magma Mixing in a Zoned Alkalic Intrusion": presented to The University of Texas at Austin, Department of Geological Sciences, seminar.

"Plate Tectonic Setting of Trans-Pecos Igneous Rocks": presented to Sul Ross State University, Geology Department, seminar, Alpine, Texas.

"Texas Minerals and the Bureau of Economic Geology": presented to Clear Lake Gem and Mineral Society, annual mineral show, Pasadena, Texas.

Douglas C. Ratcliff

"A Proposal for Core Curation and Data Management": presented to Deep Observation and Sampling of the Earth's Continental Crust, Inc., Executive Board meeting, Houston, Texas.

Stephen C. Ruppel

"Palo Duro Basin Stratigraphy and Depositional Setting": presented to U.S. Department of Energy, National Research Council.

Rainer K. Senger

"Investigation of the Possible Effects of Fracture Zones on Ground-Water Flow in the Palo Duro Basin, Texas": presented to U.S. Department of Energy, Fracture Ground-Water Flow Modeling Peer Review Panel, Columbus, Ohio.

Steven J. Seni

"Evolution of Salt Structures and Their Role in Localizing Sedimentary Ore Deposits": presented to The University of Texas at Austin, Department of Geological Sciences, graduate class in sedimentary ore deposits.

Noel Tyler

"Anatomy of Texas Oil": presented to Desk and Derrick Club, monthly meeting, Austin, Texas.

"Character and Economic Importance of Early Proterozoic Fluvial Sediments, South Africa": presented to The University of Texas at Austin, Department of Geological Sciences, graduate class in depositional systems.

"Depositional Systems and Oil and Gas Plays in the Olmos Formation, South Texas": presented to South Texas Geological Society, San Antonio, Texas.

"Distribution and Character of Early Proterozoic Weathering Surfaces in South Africa": presented to Symposium on Precambrian Paleosols, International Geological Correlation Program, Raleigh, North Carolina.

"Facies Architecture and Production Characteristics of Strandplain Reservoirs, North Markham-North Bay City Field, Frio Formation, Texas": presented to Corpus Christi Geological Society, monthly meeting, Corpus Christi, Texas.

E. G. Wermund

"A Comparison of Core and Sample Repositories among State Geological Surveys": presented to U.S. Geological Survey, Central Cluster Meeting, Denver, Colorado.

"Economy in the Texas Coastal Zone, 1985": presented to Minerals Management Service, sixth information transfer meeting, New Orleans, Louisiana.

"The Health of the Gulf Coast Association of Geological Societies": presented to Gulf Coast Association of Geological Societies, annual meeting, Austin, Texas.

"Needs for Barrier Island Studies—A Texas Perspective": presented to Minerals Management Service, Metairie, Louisiana.

"Oil and Gas Impacts on Barrier Islands": presented to Minerals Management Service, regional studies ternary meeting, Metairie, Louisiana.

"The Operators of the Texas Natural Resources Information System": presented to U.S. Geological Survey, Central Cluster Meeting, St. Louis, Missouri.

"Recruitment Trends for the Bureau of Economic Geology": presented to Louisiana State University, Department of Geology, Conference on Geosciences in the '90's, Baton Rouge, Louisiana.

"State/Federal Relations in OCS Leasing: A Perspective of One RTWG Member": presented to Texas A&M University, Sea Grant College, National Conference on "The States and an Extended Territorial Sea," San Antonio, Texas.

"Utilization of Core in Oil and Gas Prospecting": presented to Desk and Derrick Club, Austin, Texas.

William A. White

"Effects of Faulting and Subsidence on Coastal Wetlands": presented to The University of Texas at Austin, Botany Department, graduate class on marsh ecosystems.

"The Relationship between Depositional and Erosional Systems and Coastal Wetlands": presented to The University of Texas at Austin, Botany Department, graduate class on marsh ecosystems.

"Submerged Lands of Texas Project": presented to Offshore Technology Conference, interview for PBS television documentary "The Oceans' Renewable Resources," Austin, Texas.

Bureau of Economic Geology Seminars

The Bureau holds weekly seminars during the spring and fall to promote communication among scientists, to

encourage guidance and peer review of Bureau research, and to foster professional development of junior staff. Lectures given during 1985 follow:

S. Christopher Caran
"Depositional and Structural History of Karstic Subsidence Basins, Western Rolling Plains of Texas."
"Ground-Water Lakes—Pleistocene and Modern Examples from New Mexico and Texas."

Edward W. Collins
"Fractures and Veins in DOE Core, Texas Panhandle."

R. D. Conti
"Correlations of Porous Zones and Lithology in Wolfcampian Series, Palo Duro Basin: Implications for Nonfracture Permeability Distribution in a Deep-Basin Aquifer."
"Hydrologic Studies of the Wolfcamp Deep-Basin Brine Aquifer, Palo Duro Basin: Results of the Three-Dimensional Ground-Water Flow Model."

Alan R. Dutton
"Ground Water in the Lower Dockum Group."

Shirley P. Dutton
"Diagenesis of Travis Peak Sandstones."

William E. Galloway
"Continental Scientific Drilling Program: A Proposal for Deep Scientific Drilling and Associated Research, Texas Gulf Coast."

Edgar H. Guevara
"Geological Characterization of Basin Plain/Submarine Fan Reservoirs: Spraberry (Permian) Driver Unit, Midland Basin."

Mary L. W. Jackson
"Pin the SSC on Texas—Six Study Sites for the Superconducting Super Collider."

David A. Johns
"Depositional Systems and Lithofacies of the Dockum Group, Palo Duro Basin."

W. R. Kaiser
"Fluvial Deposition, Paleohydrology, and Lignite Occurrence in the Wilcox Group of East Texas."

C. Kerans
"Stratigraphy, Karst Features, and Porosity Types of the Ellenburger Group, West Texas."

David W. Koppenaal
"The Potential and Limitations of Inductively Coupled Plasma-Mass Spectrometry for Geochemical Research."

M. P. R. Light
"Continental Scientific Drilling Program: A Proposal for Deep Scientific Drilling and Associated Research, Texas Gulf Coast."

F. Jerry Lucia
"The Gypsum Problem."

Richard P. Major
"Diagenesis of Scorpion Mound, Laborcita Formation (Permian), Tularosa, New Mexico."

Mary W. McBride
"Aggregate Production for Metropolitan Areas of Texas."
"Work of the Public Information Office of the Bureau."

H. S. Nance
"Depositional Systems of the Artesia Group, Palo Duro Basin."

Harry H. Posey
"Geochemistry of the Wolfcamp Formation, Palo Duro Basin, Texas."
"Mixed-Fluid Origins of Salt Dome Cap Rocks."
"Sr, C, and O Isotopic Characteristics of Salt Dome Cap Rocks: Insights into Basin Diagenesis."

Jonathan G. Price
"Alkalic Rocks of Contrasting Tectonic Settings."

Jay A. Raney
"Exploration for Carlin-Type Gold Deposits, Nevada."

Bernd C. Richter
"Shallow Saline Ground Water in San Angelo Area, Texas."

Michael P. Roberts
"Bureau Computing Facilities—Past, Present, and Future."

Stephen C. Ruppel
"Petroleum Potential of Pre-Pennsylvanian Rocks in the Southern Texas Panhandle."

Rainer K. Senger
"Hydrologic Studies of the Wolfcamp Deep-Basin Brine Aquifer, Palo Duro Basin: Results of the Three-Dimensional Ground-Water Flow Model."

Steven J. Seni
"Is Boling Dome an Appropriate Site for a Toxic Waste Disposal Facility?"

Jeffrey Thurwachter
"Getting the Most out of the Reading Room/Data Center."

Noel Tyler
"Geological Characterization of Clastic Reservoirs: Big Wells (San Miguel)—A Wave-Dominated Deltaic Reservoir."

William A. White
"Effects of Faulting and Subsidence on Coastal Wetlands."

CONGRESSIONAL, LEGISLATIVE, AND SPECIAL TESTIMONY

Don G. Bebout

"Use of Electrical Logs in Geological and Engineering Research in Texas": given to Texas House of Representatives, Committee on Energy.

W. R. Kaiser

"Economics and Environmental Impact of Coal Utilization": given to City of Austin, Electric Utility Administration.

Robert 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.

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

E. G. Wermund

"Unitization of Oil and Gas, Effects on Production": given to Texas House of Representatives, Committee on Energy.

"Well Log Applications to Oil and Gas Research Problems": given to Texas Senate, Committee on Natural Resources.

COMMITTEE SERVICES, OFFICES, AND OTHER PROFESSIONAL RESPONSIBILITIES

M. L. Ambrose

Member, Newsletter Committee, Austin Geological Society.

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

Robert W. Baumgardner, Jr.

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

Don G. Bebout

Contributor, Austin Geological Society fall field trip.

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, Gulf Coast, American Association of Petroleum Geologists.

Member, Publication Committee, American Association of Petroleum Geologists.

Member, Research Conference Committee, "Timing of Siliciclastic Diagenesis— Relation to Hydrocarbon Migration," Society of Economic Paleontologists and Mineralogists, Gulf Coast Section.

Past President (1984-85), Society of Economic Paleontologists and Mineralogists, Gulf Coast Section.

Program Chairman, Society of Economic Paleontologists and Mineralogists, 1987 annual mid-year meeting.

Vice Chairman, Society of Economic Paleontologists and Mineralogists, Gulf Coast Association of Geological Societies/Gulf Coast Section, 1985 annual meeting.

Edward C. Bingler

Chairman, Cogeomap Committee, Association of American State Geologists.

Member, Committee on State Activities and Licensing, American Institute of Professional Geologists.

Member, Liaison Committee, Association of American State Geologists.

L. F. Brown, Jr.

Associate Editor, American Association of Petroleum Geologists Bulletin.

Chairman, Depositional Systems Session, Gulf Coast Association of Geological Societies, 1985 annual meeting.

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

S. Christopher Caran

Co-leader of field trip, "Cretaceous Volcanism and Associated 'Serpentine' Oil Fields," Gulf Coast Association of Geological Societies.

Leader of field trip, "Geology of Honey Creek Preserve, Comal County, Texas," Nature Conservancy/Texas Parks and Wildlife Department.

Leader of field trip, "Geology of Westcave Preserve, Travis County, Texas," Westcave Preserve.

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

Carolyn E. Condon

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

E. Dow Davidson, Jr.

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

Susann Doenges

Editor, Blueline, Newsletter of the Association of Earth Science Editors.

Judge of research papers, Austin Area Science and Mathematics Fair, representing Austin Geological Society.

Shirley P. Dutton

Alternate Representative, House of Delegates, American Association of Petroleum Geologists, Austin Geological Society.

Chairman, Awards and Judging Committee, Society of Economic Paleontologists and Mineralogists, 1987 mid-year meeting.

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 and Chairman, Nominating Committee,

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

Robert J. Finley

Co-chairman, Technical Session on Simulator Parameter Assignment, National Institute for Petroleum and Energy Research, Reservoir Characterization Conference.

Member, Program Selection Committee, National Institute for Petroleum and Energy Research, Reservoir Characterization Conference.

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

R. Stephen Fisher

Chairman, Research Groups/Continuing Education Committee, Society of Economic Paleontologists and Mineralogists, 1987 mid-year meeting.

W. L. Fisher

Chairman, Committee on Offshore Hydrocarbon Resource Estimation Methodology, National Research Council, National Academy of Sciences.

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

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

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

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

Member, Committee on Continental Scientific Drilling, National Research Council, National Academy of Sciences.

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

Member, Continental Margins Committee, Association of American State Geologists.

Member, Executive Committee, American Association of Petroleum Geologists.

Member, Futures Committee, Association of American State Geologists.

Member, General Exploration Committee, American Petroleum Institute.

Member, Geology Advisory Group, Southern Illinois University.

Member, Geology Associates Advisory Board, University of Kansas.

Member, Governing Board, American Geological Institute.

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

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

Member, Research Committee, Interstate Oil Compact Commission.

Member, Research Committee, Interstate Mining Compact Commission.

Member, Texas Mapping Advisory Committee.

Member, Texas Senate–House of Representatives Joint Special Committee on Cogeneration.

Member, Town and Gown.

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

President, American Association of Petroleum Geologists.

Vice President, Institutional Participation, Bureau of Organizing Committee, 28th International Geology Congress.

Michael A. Fracasso

Chairman, Membership Committee, Austin Geological Society.

William E. Galloway

Representative for The University of Texas at Austin, DOSECC (Deep Observation and Sampling of the Earth's Continental Crust, Inc.).

Chester M. Garrett, Jr.

Delegate, House of Delegates, American Association of Petroleum Geologists, Austin Geological Society.

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

Member, Public Information Committee, American Association of Petroleum Geologists.

Treasurer (1985-86), Austin Geological Society.

Thomas C. Gustavson

Co-chairman, Technical Session on Environmental Geology and Geomorphology, Geological Society of America, national meeting.

Member, Panel on Quaternary Geology and Geomorphology, Geological Society of America.

Christopher D. Henry

Member, Atlas Editorial Board, Rio Grande Rift Consortium.

Claude R. Hocott

Member, Long-Range Planning Committee, Society of Petroleum Engineers.

Member, Research Committee, Interstate Oil Compact Commission.

M. P. A. Jackson

Associate Editor, American Association of Petroleum Geologists Bulletin.

Chairman, Session on Geophysics and Structural Geology, Gulf Coast Association of Geological Societies, 1985 annual meeting.

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

Member, Subcommittee on Structural Geology, Committee for Education, American Association of Petroleum Geologists.

Mary L. W. Jackson

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

Co-chairman, Arrangements Committee, Gulf Coast Association of Geological Societies, 1985 annual meeting.

David A. Johns

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

C. Kerans

Chairman, Field Trip Committee, Society of Economic Paleontologists and Mineralogists, 1987 mid-year meeting.

Judge, Carbonate Geology, Society of Economic Paleontologists and Mineralogists, Gulf Coast Section, Gulf Coast Association of Geological Societies, 1985 annual meeting.

Judge, Symposium on Paleokarst and Dolomite in Modern Carbonate Platforms, Society of Economic Paleontologists and Mineralogists, 1985 mid-year meeting.

David W. Koppenaal

Member, Technical Advisory Committee, 1985 Eastern Oil Shale Symposium.

Secretary, Subcommittee D.05.29.02, X-ray Fluorescence, American Society for Testing and Materials.

Secretary and U.S.A. Delegate, Technical Committee TC27/WG14, Trace Elements in Coal, International Standards Organization.

U.S.A. Delegate, Technical Committee TC27/WG13, Major and Minor Elements in Coal, International Standards Organization.

Charles W. Kreitler

Chairman, 5-km Run, Gulf Coast Association of Geological Societies, 1985 annual meeting.

M. P. R. Light

Chairman, Technical Session on Fluid Flow, Geothermal, Geochemistry, Gulf Coast Association of Geological Societies, 1985 annual meeting.

Judge, Matson Award, American Association of Petroleum Geologists, 1985 annual meeting.

F. Jerry Lucia

Member, Publication Committee, American Association of Petroleum Geologists.

Mary W. McBride

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

Chairman, Technical Services, Society of Economic Paleontologists and Mineralogists, 1987 mid-year meeting.

Robert A. Morton

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

Co-chairman and co-editor, Sixth Geopressured Geothermal Energy Conference and Proceedings.

Co-convenor, Gulf Coast Section, Society of Economic Paleontologists and Mineralogists, Seventh Annual Research Conference.

General Chairman, Society of Economic Paleontologists and Mineralogists, 1987 mid-year meeting.

Invited Participant, National Conference on Shoreline Erosion, Skidaway Oceanographic Institute.

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

Member, Convention Policy Committee, Society of Economic Paleontologists and Mineralogists.

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

Prasanta K. Mukhopadhyay

Chairman, Nomination Committee, Society of Organic Petrology.

Member, Commission 2, International Association of Coal Petrologists.

William F. Mullican III

Chairman, Technical Program, Austin Geological Society.

Harry H. Posey

Chairman, Session on Sedimentary Petrology/ Geochemistry, Geological Society of America, South-Central Section meeting.

Jonathan G. Price

Chairman, Field Trips Committee, Gulf Coast Association of Geological Societies, 1985 annual meeting.

Douglas C. Ratcliff

Chairman, Finance Committee, Society of Economic Paleontologists and Mineralogists, 1987 mid-year meeting.

Co-chairman and co-editor, Core Workshop, Gulf Coast Association of Geological Societies.

Judge of research papers, Austin Area Science and Mathematics Fair, representing Austin Geological Society.

President (1984-85), Austin Geological Society.

Treasurer, Gulf Coast Association of Geological Societies.

D. Anderson Smith

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

Susan J. Tewalt

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

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

Noel Tyler

Chairman, Entertainment Committee, Society of Economic Paleontologists and Mineralogists, 1987 mid-year meeting.

Chairman, Session on Depositional Setting and Petrology of Oil and Gas Field Reservoirs, Carbonates, and

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

Leader of field trip, "The Upper Jurassic Salt Wash Alluvial Complex," Third International Fluvial Conference.

E. G. Wermund

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

Chairman, Field Trips Committee, Geological Society of America, 1986 annual meeting.

Chairman, Operations Review Committee, and Vice Chairman, Task Force, Texas Natural Resources Information System.

Co-chairman, Gulf of Mexico Regional Technical Working Review Group, Minerals Management Service.

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

Member, Balcones Research Center Parking Committee, The University of Texas at Austin.

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

UNIVERSITY TEACHING/ CONTINUING EDUCATION

Don G. Bebout

Carbonate Core-Logging Exercise: Shreveport Geological Society, Shreveport, Louisiana.

Carbonate Exploration School: American Association of Petroleum Geologists, Austin, Texas.

Carbonate Field Seminar: American Association of Petroleum Geologists, Austin, Kerrville, Fredericksburg, and San Antonio, Texas (with Clyde Moore).

Lower Cretaceous Depositional Environments from Shoreline to Slope: A Core Workshop: Bureau of Economic Geology, Society of Economic Paleontologists and Mineralogists, Gulf Coast Section, and Gulf Coast Association of Geological Societies, Austin, Texas (with Doug Ratcliff).

Techniques of Petroleum Exploration: A Short Course: American Association of Petroleum Geologists, New Orleans, Lousiana.

L. F. Brown, Jr.

"Seismic Stratigraphy" (Geology 380N): The University of Texas at Austin, Department of Geological Sciences.

"Seismic Stratigraphy": American Association of Petroleum Geologists, 1985 annual meeting, New Orleans, Louisiana; and Hungarian Oil and Gas Commission, Budapest, Hungary.

"Seismic Stratigraphy and Petroleum Exploration": American Association of Petroleum Geologists, Midcontinent Section, annual meeting, Amarillo, Texas; AAPG Seismic Stratigraphy School, Houston, Texas, and Washington, D.C.; and Petroleum Exploration Society of Australia, Sydney, Brisbane, Melbourne, Adelaide, and Perth, Australia.

E. Dow Davidson, Jr.

Lower Cretaceous Depositional Environments from Shoreline to Slope: A Core Workshop: Bureau of Economic Geology, Society of Economic Paleontologists and Mineralogists, Gulf Coast Section, and Gulf Coast Association of Geological Societies, Austin, Texas (core handling and logistics).

Shirley P. Dutton

Core Workshop: Travis Peak (Hosston) Formation, East Texas: Shreveport Geological Society, Shreveport, Louisiana (with Robert J. Finley).

Robert J. Finley

Core Workshop: Travis Peak (Hosston) Formation, East Texas: Shreveport Geological Society, Shreveport, Louisiana (with Shirley P. Dutton).

William E. Galloway

"Recognition of Fluvial Depositional Systems and Their Resource Potential": Society of Economic Paleontologists and Mineralogists Short Course, Golden, Colorado.

"Terrigenous Clastic Depositional Systems" (Geology 383): The University of Texas at Austin, Department of Geological Sciences.

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

Claude R. Hocott

"Petroleum Engineering" (PEN 320): The University of Texas at Austin, Department of Petroleum Engineering.

M. P. A. Jackson

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

Douglas C. Ratcliff

Lower Cretaceous Depositional Environments from Shoreline to Slope: A Core Workshop: Bureau of Economic Geology, Society of Economic Paleontologists and Mineralogists, Gulf Coast Section, and Gulf Coast Association of Geological Societies, Austin, Texas (with Don G. Bebout).

E. G. Wermund

"Texas Energy Resources Other than Oil and Gas": presented to Energy Workshop for High School Teachers, sponsored by Texas Power and Light, at East Texas State University, Commerce, Texas; North Texas State University, Denton, Texas; and Stephen F. Austin State University, Nacogdoches, Texas.

SUPPORT STAFF

ADMINISTRATIVE/SECRETARIAL

The administrative/secretarial staff is responsible for administrative, personnel, accounting, purchasing, 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 are also responsible for publication sales and assist visitors who wish to purchase publications directly from our new sales section at Balcones Research Center as well as those who phone or mail in orders. Bettye A. Blitch, Executive Assistant, coordinates the work of the administrative/secretarial staff.

CARTOGRAPHY

The cartography department has done much over the years to enhance the Bureau's reputation in geologic and land resource mapping. 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 department, a publication design section prepares all covers, designs publication formats, 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.

Productivity of the department is best shown in the lists of publications by scientists in 1985. In support of that work the cartographers and draftspersons completed 1,271 black-and-white illustrations, 791 pieces of colored slide copy or poster art, 101 black-and-white maps or cross sections, and 12 full-color maps.

Cartography suffered a major personnel loss when Dan Scranton retired in August after 32 years of service. Scranton joined the Bureau in February 1953, when the Bureau was housed on Little Campus. He held every title in cartography, from Draftsman I and II, Cartographic Technician I and II, Cartographer, and Senior Cartographer to Chief Cartographer, a position he held for a short while until he asked to return to Senior Cartographer. Major projects Scranton worked on included student maps done in the early years of his career, several Geologic Atlas of Texas sheets, the Environmental Geologic Atlas of the Texas Coastal Zone, the Padre Island Guidebook map, and the State Geological Map of Texas, his last project. Scranton's many years of cartographic experience will be missed for a long time. His ability to compile geologic maps from all sources is a talent that cannot be replaced.

EDITING

The editing section, supervised by Susann Doenges, Editor-in-Charge, includes editors and proofreaders. The staff edits and proofreads manuscripts for Bureau publications and contract reports as well as papers and abstracts that are submitted to professional journals. A monthly newsletter, distributed to all Bureau staff, is also handled by Editing. During 1985, the publications staff issued 21 new Bureau reports and 19 final contract reports.

WORD PROCESSING/TYPESETTING

The word processing/typesetting staff includes several word processing and typesetting operators who are supervised by Lucille C. Harrell. Establishing communication between the word processing system and the typesetting system was a major breakthrough during 1985. Previously, the word processing/typesetting staff transferred manuscripts between systems via hard disk but not through direct lines. Some of the research staff now type first drafts of their manuscripts on the the VAX computer, and the word processing staff then transfers the manuscripts to the dedicated word processor. This process allows the word processing staff to merge text from several authors into one document. Similarly, the typesetting staff can transfer manuscripts from the VAX computer directly to the typesetter for the final steps in the publication process. During the year, 38,016 pages of text and tables were processed by the word processing/typesetting staff.

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Dr. E. C. Bingler, Deputy Director
Douglas C. Ratcliff, Associate Director for Administration
Dr. E. G. Wermund, Associate Director for Operations, Assistant to the Director
Bettye A. Blitch, Executive Assistant

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Dr. William E. Galloway

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Address correction requested

BOOKS

BOOKS