Forward

BUREAU OF ECONOMIC GEOLOGY

1981 ANNUAL REPORT

W. L. FISHER, DIRECTOR
THE UNIVERSITY OF TEXAS AT AUSTIN • AUSTIN, TEXAS 78712

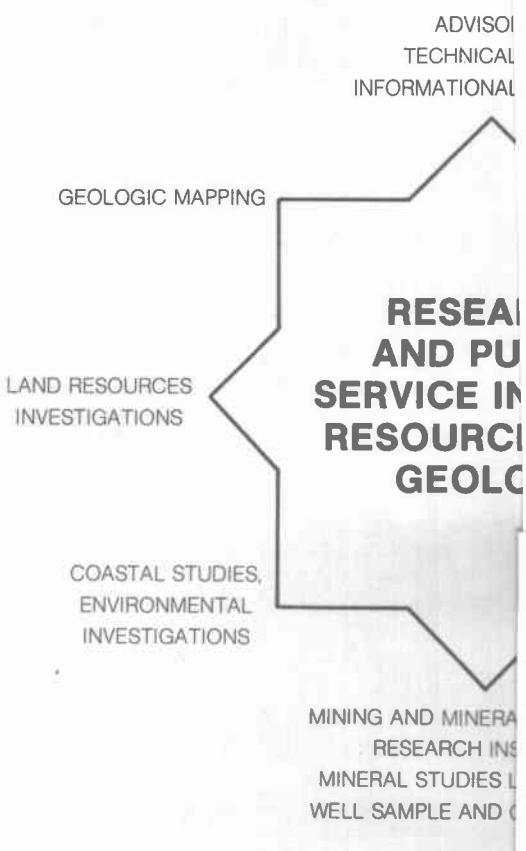
FOREWORD

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. The Bureau Director is a member of the Texas Energy and Natural Resources Advisory Council, as well as several interagency committees. The Director represents Texas in the Association of American State Geologists.

The Bureau provides extensive advisory, technical, and informational services relating to the geology and resources of Texas. In addition, it conducts a large number of basic and applied research projects in energy resources, mineral resources and statistics, land resources, systematic geologic mapping, and a variety of other research programs in such areas as hydrogeology, basin analysis, geochemistry, and coastal studies. Certain projects are conducted jointly with other units of the University as well as with State, Federal, and local governmental agencies. The Texas Mining and Mineral Resources Research Institute functions as an administrative unit of the Bureau.

The Bureau of Economic Geology publishes major reports in The University of Texas Publication series; it also has its own series of Reports of Investigations, Geologic Quadrangle Maps, Geologic Atlas Sheets, Environmental Geologic Atlases, Guidebooks, Handbooks, Geological Circulars, Mineral Resource Circulars, and several Special Publications. Publications are sold for a nominal price designed to recover printing costs. A complete list of publications is available on request.

The Annual Report of the Bureau of Economic Geology outlines the [illegible] programs and projects, publications, professional perso[illegible] geology and resources available to agencies, industry, [illegible] on request at no charge.



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RESEARCH

Bureau research programs and projects are designed to address many of the State's major concerns in the areas of geologic, energy, mineral, land, and environmental resources. Through the years, an extensive research program in energy and mineral resources has been maintained. This substantial research emphasis is broadened by comprehensive investigations of land and water impacts. The Bureau's projects are directed toward solving existing problems of resource utilization; they are aimed at research programs incorporating geologic concepts that will build toward an understanding of a specific resource and its impact on human activities.

The diverse range of Bureau research is typified by the programs dealing with the Federal National Waste Terminal Storage (NWTS) program. These projects require in-depth, comprehensive evaluations of subsurface hydrology, resource distribution, depositional systems, and land-surface configurations and denudation rates. Such programs call for expertise in areas such as geomorphology, hydrology, basin analysis, tectonics, environmental geology, geochemistry, and rock physics. This research integrates complex geologic subdisciplines into a coordinated assessment of a critical problem needing scientific, objective review.

The Texas Mining and Mineral Resources Research Institute, embracing both research and training, operates as an administrative unit of the Bureau of Economic Geology. The Land Resources Laboratory coordinates the numerous land resources programs within the Bureau of Economic Geology.

In 1981, Bureau research on geopressured geothermal energy focused on seismic identification as well as engineering and geological properties of reservoirs. These studies have led toward characterization of varied gaseous reservoirs. Work continued on such long-standing projects as the submerged lands of Texas and the Lavaca-Guadalupe-San Antonio-Nueces river basins regional study. Programs concerning minerals and energy resources continued to be a major part of Bureau research. In addition to resource assessments in uranium, lignite, and geopressured geothermal energy, the Bureau continued research into analysis of governmental policy related to the availability of energy raw materials or resources. Studies were initiated to understand better the potential mineral deposits in the Trans-Pecos region.

Systematic geologic mapping, coastal studies, basin analyses, and investigations in other areas of economic geology further indicate the range of research programs carried forward in 1981.

ENERGY RESOURCES INVESTIGATIONS

GEOLOGIC STUDIES OF GEOPRESSURED AND HYDROPRESSURED ZONES IN TEXAS

Robert A. Morton, Project Director; Bonnie R. Weise, Lee A. Jirik, Marc B. Edwards, and Noel Tyler; assisted by H. Scott Hamlin, Susan L. Hallam, Richard A. Schatzinger, Donald W. Downey, Victor H. Lombeida, Jackson J. S. Yoong, and Evans U. Jegbefume

This project, sponsored by the Gas Research Institute, was initiated in January 1979. The objective of the study was to identify prospect areas for testing solution gas resources of the shallow geopressured and deep hydropressured zones along the Texas Gulf Coast. The study concentrated on Tertiary sandstone reservoirs that have fluid temperatures less than 300°F.

In the first phase of the project, prospects were identified within fairways, which are areas of high net-sandstone thickness. Supplementary tasks conducted during 1981 included (1) examination of interfairway areas of the Tertiary sandstone trends to locate additional solution gas prospects and (2) screening of watered-out gas fields along the Texas Gulf Coast to identify reservoirs in which the gas-to-water ratio might be greater than that expected from saturated conditions.

CONTINUITY OF GEOPRESSURED RESERVOIRS

Robert A. Morton, Project Director; Thomas E. Ewing and Noel Tyler

Reservoir volumes and energy drives associated with Gulf Coast geopressured sandstones are being studied in conjunction with the assessment of geopressured geothermal energy resources. This study, funded by the U.S. Department of Energy, compared estimates of reservoir volume determined (1) from engineering techniques using pressure depletion curves, abandonment pressures, and cumulative production and (2) from geological correlation and mapping of fault block structure and net-sandstone distribution.

Generic investigations associated with this study include (1) the lateral and vertical distribution of porosity and permeability in both modern and ancient Gulf Coast sandstones and (2) the structural and stratigraphic hierarchy that limits the extent of the reservoir.

During 1981, detailed field studies were completed for several geopressured reservoirs in the Wilcox Group and the Frio Formation. These studies included the areas encompassing the Lear Koelemay No. 1 in Jefferson County and the Riddle Saldana No. 2 in Zapata County, two well-of-opportunity tests in Texas. Also included were detailed descriptions of cores from the Pleasant Bayou No. 1 and No. 2 design wells. Of particular interest are the relations between reservoir pore properties (porosity and permeability), primary sedimentary structures, and inferred environments of deposition.

SALINITY OF DEEP FORMATION WATERS, TEXAS GULF COAST

Robert A. Morton, Project Director; Chester M. Garrett, Jr., Jong H. Han, Lee A. Jirik, and Jan S. Posey, geologists; Cynthia A. Mahan, chemist; assisted by Richard Debus, Mark A. Jarecki, Thomas A. Sikes, and James O'Connell

This study is funded as part of the U. S. Department of Energy's geopressured geothermal research program. The study will provide information on the geographic and stratigraphic variations in the salinity of formation water produced from Tertiary geopressured sandstones, primarily of the Frio Formation of Texas. Knowing the chemical composition of subsurface fluids is important because salinity partly controls the solubility of methane in water and the scaling and corrosion of production equipment. Moreover, high-temperature brines may cause physical and chemical reactions with the clay minerals in shallow aquifers, thus adversely affecting brine injection.

During 1981, chemical analyses of waters produced from geopressured and hydropressured reservoirs were compiled from two primary sources: (1) data files of field operators, and (2) water samples collected specifically for this study and analyzed at the Bureau's Mineral Studies Laboratory. Values for total dissolved solids from selected fields were plotted on structural and stratigraphic cross sections to depict lateral and vertical variations in salinity and to delineate depth-dependent trends. Salinity values and concentrations of major rock-forming elements were also compared to temperature gradient, pressure gradient, sandstone thickness, thickness of surrounding shales, and proximity to salt.

SPECIAL PROJECTS RESEARCH AND COORDINATION ASSISTANCE

Robert A. Morton, Project Director; Chester M. Garrett, Jr., and A. R. Gregory; assisted by Jackson J. S. Yoong

The purpose of this multifaceted project is to assist the U. S. Department of Energy in (1) selecting sites for testing geopressured geothermal resources and (2) analyzing geological and reservoir data from those tests. Other responsibilities include (3) integrating the test results in other ongoing research projects and (4) initiating studies of specific factors that are critical in evaluating geothermal resources.

In 1981 the Bureau of Economic Geology participated in reviews of geological and engineering characteristics and test results for design wells and wells of opportunity in Texas and Louisiana. Special projects work included comparison of log-derived salinities using various proposed methods for geopressured sandstones. In addition, well data, core samples, and research results were provided to individuals and corporations desiring information related to the geopressured geothermal research program.

RESOURCE ASSESSMENT AND TEST-WELL SITE SELECTION—GEOPRESSURED GEOTHERMAL ENERGY, TEXAS GULF COAST

Robert A. Morton, Project Director; Charles D. Winker, Thomas E. Ewing, and Deborrah D. Garcia; assisted by Richard G. Anderson, Ricardo J. Padilla y Sanchez, Chong Lock Ping, Rhonda Rascoe, and Kevin Crossland

Assessment of geopressured geothermal resources began in 1974 with funding from the U. S. Atomic Energy Commission and the Center for Energy Studies at The University of Texas at Austin. Initially, the project involved only an evaluation of the Frio Formation of South Texas. Later, the geothermal project was expanded significantly to include studies of the Frio Formation and the Vicksburg and Wilcox Groups of the entire Texas Gulf Coast. These later studies, funded by the U. S. Department of Energy, Division of Geothermal Energy, were completed in 1979. As a result of this work, the General Crude Oil Company and U. S. Department of Energy Pleasant Bayou No. 2 geothermal well was drilled in the Austin Bayou Prospect, Brazoria County, to evaluate geothermal resources in the lower Frio Formation. This well is currently producing from 14,650 ft and undergoing long-term tests to determine downhole changes in temperature, salinity, pressure, and gas-to-water ratio as well as the performance of the surface equipment and the salt-water disposal well.

In 1981, this project included interpretations of seismic data, construction of synthetic seismograms, and geological mapping of three areas having contrasting structures in the geopressured zone. Existing seismic lines and electric logs were used to delineate better the fault block and sandstone reservoir from which the Pleasant Bayou No. 2 is producing. In addition, new seismic surveys were conducted near Cuero, in De Witt County, to examine the deep structure of the lower Wilcox Group. Interpreted seismic sections and log correlations were also used in a detailed study of the Frio Formation near Blessing in Matagorda County. This Blessing prospect was recommended for testing by a design well.

The structural evolution and shelf margin histories of these detailed study areas are also being considered in a regional context. Reconnaissance seismic lines between the field areas that cross the major structural trends are being interpreted to determine the differences in structural-stratigraphic relationships along the Gulf Coast Basin of Texas.

SAN ANDRES OIL AND GAS STUDIES

Mark W. Presley, Project Director; Paul J. Ramondetta and Amos Bein, geologists; Clara L. Ho, chemist

San Andres oil production of the Northern Shelf of the Midland Basin constitutes nearly 13 percent of the state's total production. The San Andres and Clear Fork carbonate rocks of the Northern Shelf contain sufficient amounts of lipid-rich organic material to rank them as potential

petroleum source beds. Organic maturation of these rocks, however, is not sufficient to have initiated catagenesis.

San Andres oils have a common source, as evidenced by their remarkably uniform composition. Wolfcampian basinal clastics and dark argillaceous limestones of the northern Midland Basin are the most likely source rocks for this oil. Vertical expulsion of basinal oil through fractures into overlying shelf and shelf-margin carbonates has occurred along the Lower Permian Abo Reef trend. These oils have been biodegraded because of their presence in relatively shallow sulfate-rich reservoirs.

The trapping mechanism in the Northern Shelf is a combination of structural and facies control. Good reservoir conditions exist in San Andres strata that are draped and subsequently fractured over the subjacent shelf-margin buttress. Above the Abo Reef trend, a thick porous zone exists in the lower San Andres and upper Clear Fork Formations; shelfward, this porous zone grades into discrete porous layers resulting from cyclic sedimentation in shallow inner-shelf and sabkha environments. These Upper Permian carbonates tend to lose porosity in a northward (updip) direction, where conditions were more evaporitic. This updip change from porous to nonporous facies provides the porosity pinch-out in the vast Levelland-Slaughter-Cato trend of Texas and eastern New Mexico.

A report on source rocks and petroleum composition is in press. Another report about stratigraphy, facies, and trapping mechanisms will be published in 1982.

DEPOSITIONAL TRENDS AND DIAGENETIC SEQUENCES IN THE SAN ANDRES CARBONATES—NORTHERN SHELF AND PALO DURO BASIN

Amos Bein, Project Director; Clara L. Ho, Josefina R. Calvo, and Steven W. Tweedy, chemists

Petrographic and geochemical analyses of core from four sites in the study area were undertaken to determine depositional trends and diagenetic sequences in San Andres strata. San Andres carbonates are divided into six lithofacies, namely, dolostones, pellet-oolite packstone-grainstone, filamentous-algal (Girvanella-like) grainstone, sponge-spicule packstone, wispy-laminated crinoidal packstone, and skeletal packstone and grainstone. Facies distribution was controlled by salinity, which increased from south to north. The style of sedimentation shifted from mostly marine with long periods of steady-state circulation during early San Andres time to shallow restricted marine with terrigenous input in late San Andres time.

Despite differences in depositional regimes, the entire section was influenced by a hypersaline Mg-Ca-Cl brine, which affected carbonate strata in the following ways: (1) dissolution of unstable skeletal material, (2) pore filling by either anhydrite or halite, and (3) dolomitization.

A report dealing with the above material will be published in 1982.

GEOLOGIC FRAMEWORK AND ENERGY RESOURCE STUDIES, TEXAS CONTINENTAL SHELF

William E. Galloway, Project Director; Bonnie R. Weise and Lee A. Jirik; assisted by Mark A. Jarecki

The initial phase of this 2-year program funded by the U. S. Geological Survey entails the generation of a series of cross sections in the Texas Outer Continental Shelf province. Sections will synthesize both available well and seismic data to provide a regional stratigraphic framework for further analysis of hydrocarbon or geothermal resources. During 1981, well data were collected, a base map was constructed, locations for cross-section lines were selected, and correlation of the offshore Miocene stratigraphic units was begun.

RESOURCE EVALUATION OF LATE OLIGOCENE THROUGH MIOCENE MAJOR STRATIGRAPHIC UNITS, TEXAS GULF COAST BASIN

William E. Galloway, Project Director; assisted by Victor J. Gavenda and Emil Bramson

This project, funded in part by the U. S. Geological Survey, will expand earlier studies of the Frio Formation to examine the origin and potential resource significance of down-dip producing reservoir facies. In addition, regional resource evaluation will be extended up section and offshore to include lower Miocene producing strata. Geologically defined productive plays will be delineated and their remaining producible hydrocarbon endowment estimated using combinations of volumetric, historical, and geologic parameters. During 1981, regional correlation of the onshore Miocene section was completed, and calculation of net-sandstone thickness within Miocene intervals was begun.

ESTIMATION OF UNCERTAINTY IN COAL RESOURCE AND COST ASSESSMENTS

W. C. J. van Rensburg, David Mathew, and John W. Barnes (Department of Mechanical Engineering), Project Directors; Mary A. Bauer, Elizabeth D. Orr, M. P. Roberts, and Susan J. Tewalt; assisted by Walter B. Ayers, Jr., Nae-Heon Kim, and Clayton H. Wilson

Technical work for this study, which was funded by the Electric Power Research Institute (EPRI) and coordinated by the Texas Energy and Natural Resources Advisory Council (TENRAC), was completed in May 1981. Work on the final contract report is continuing.

The objective of the study was to develop a conceptual methodology for characterizing uncertainty in coal resource estimates using geological, chemical, and statistical analyses of available data. The integration of ancient depositional systems into this methodology reflects the belief that the identification and quantification of uncertainties associated with resource estimates is partly dependent on geologic history. Four lignite deposits from the Texas Gulf Coast Basin representing four ancient depositional environments were evaluated. Important sources of uncertainty, including seam thickness and continuity, were tested for their contribution to resource evaluation for each environment. At the deposit scale, resources were calculated for individual seams by manual, computer, and geostatistical techniques to investigate uncertainties associated with each method. Classical statistical methods were used to determine the number of boreholes required to obtain resource estimates within given confidence intervals for seams in each of the ancient

depositional environments. The required number of boreholes varied from 33 to 5.

This project is part of the overall EPRI-funded supply program to assess the costs and conditions affecting the future availability of coal in the United States. A national resource figure, including an estimate of the associated uncertainty, cannot be generated in a realistically short time by combining resources of individual seams. Therefore, a methodology capable of calculating resources over areas of a regional scale, where seam-by-seam analysis is not possible, was developed. The Wilcox Group of east-central Texas was chosen as the test region to develop these alternative methods of resource evaluation. Geostatistics was found to be of little use at the regional scale; hence, more conventional statistical methods were evaluated: equal weighting over the entire area, equal weighting within grid cells, and equal weighting within internally homogeneous blocks chosen on the basis of statistical or geologic parameters.

The methods developed in Texas were applied to two additional areas: the Fort Union Formation in Wyoming and the Allegheny Formation in Ohio. Data were collected for these areas, and ancient depositional systems were interpreted. The type and distribution of available data were found to affect the results of the various methods. Of all the methods, the grid method produced the most reliable and easily obtainable estimate. Homogeneous block methods, based on geologic data, also provided good estimates. Depositional models alone were used to generate resource estimates for the entire Gulf Coast region, but should be considered as first approximations. Reserves cannot be calculated from the resource estimates generated by the regional methodology used in this study.

PREDICTING DIAGENETIC HISTORY AND RESERVOIR QUALITY IN THE FRIO FORMATION, TEXAS GULF COAST

W. R. Kaiser, Project Director; Robert J. Finley, Kinji Magara, and Debra L. Richmann; assisted by Susan L. Hallam, B. Daniel Legett, and James F. O'Connell

DOE/ET/27111-6

This project, initiated in July 1980, is funded by the U. S. Department of Energy as part of a larger effort to evaluate geopressured geothermal resources in Texas. Diagenesis studies have progressed from broad regional reservoir quality assessments stressing sandstone petrography to detailed comparison of sandstone mineralogy and elemental composition of carbonates. Current work is more geochemical in nature. Water-rock interaction, distribution of high-resistivity shale (cap rock), and petrography of sandstone and shale are being investigated as potential indicators of reservoir quality. The prediction of reservoir quality remains an elusive goal.

Water-rock interaction is being evaluated by thermodynamically testing for relative stability of authigenic and detrital minerals and for supersaturation of authigenic minerals with respect to formation waters. In other words, a solution-mineral equilibria approach is being used. Thermodynamic functions for nine key minerals and nine ionic species have been estimated over the temperature range of 25° to 350°C in 25° or 50°C increments. Estimating functions for layer silicates was a major accomplishment.

Published analyses of Frio waters were used initially. Approximately 100 waters have been collected and analyzed by the Bureau's Mineral Studies Laboratory. Waters from the upper and middle Texas coast have been tested. Water data complement rock data, adding new insight into diagenetic sequence, in situ pH, and relative mineral stabilities. The inferred diagenetic sequence is consistent with that established petrographically, giving cause for confidence in our thermodynamic data, especially that for layer silicates. The conclusion drawn from petrographic studies that most diagenesis occurs in the hydropressured interval is supported by equilibrium thermodynamics. Inferred in situ pH values are 2 to 3 pH units lower than those measured at the wellhead. The use of solution-mineral equilibria as a predictor of reservoir quality is inconclusive and cannot be decisively tested until comparison of areas of good and poor reservoir quality is made. The South Texas Frio Formation of Kenedy County, noted for deep, low-permeability reservoirs, is being evaluated for comparison with the upper Texas coast, an area of good reservoir quality. Clustering of activity indices for upper Texas coast waters indicates that comparisons between regions will probably be possible. Preliminary indications are that shallow waters provide clues about reservoir quality at depth. Efforts continue to obtain more and better compositional data for authigenic minerals to improve our thermodynamic data base.

High-resistivity shale or cap rock occurs near the top of the geopressured interval. Cap rock as a potential indicator of deep secondary porosity is also linked to authigenic minerals, according to the premise that high resistivity is due to calcite leached from underlying sandstones developing secondary porosity. Solutes then moved upward and were precipitated to form cap rock. It was hoped that cap rock would be found to overlie areas of good reservoir quality. The thickness of the high-resistivity interval and peak resistivity value within the interval were mapped. Thick intervals have been mapped in Kleberg, Kenedy, Willacy, Cameron, and Hidalgo Counties of South Texas, an area of poor reservoir quality. Peak resistivities are located in the Rio Grande Valley and decrease northward along the coast toward areas of better reservoir quality on the upper Texas coast. Resistivity mapping clearly shows that thickness and peak resistivity correlate with poor reservoir quality. Indeed, cap rock appears to be an indicator of poor reservoir quality.

Using regional, dip-oriented cross sections, we will relate the high-resistivity interval to the Frio stratigraphy and depositional systems. Our mapping has shown that high resistivity is centered over two Frio delta systems and is absent or poorly developed over an intervening barrier/strandplain system. The lack of high-resistivity shale within areas of general development will receive special attention. Where pressure data are available, data will be related to the pressure regime.

The nature of the high-resistivity shale interval remains enigmatic. Shale petrography in Brazoria County indicates that most of the carbonate is microscopically and isotopically skeletal in origin. Few authigenic components have been identified. Iron-bearing carbonate rhombs were observed in extremely minor quantities and are far less abundant than skeletal carbonate. Brazoria County cap rock

will be petrographically compared with that of Kenedy County.

HYDROGEOLOGIC EVALUATION OF TEXAS DEEP-BASIN LIGNITE

W. R. Kaiser, Project Director; Walter B. Ayers, Jr., and Graham E. Fogg; assisted by Gregory J. Gilson and David A. Prouty

This study, begun in January 1981 and funded by the Texas Energy and Natural Resources Advisory Council, is an initial effort to integrate geology and hydrology to identify regions of the state having high potential for deep recovery of lignite, probably by in situ gasification or deep surface mining. Lithofacies, base of fresh water, potentiometric surface, and hydrochemical facies will be mapped in four or five regions in the Wilcox and Jackson Groups. Resource evaluation will concentrate on lignite in seams greater than 5 ft thick at depths of 200 to 2,000 ft. Log pattern mapping will be done in the lignite-bearing intervals in an attempt to predict seam continuity. Hydrochemical and hydraulic gradient mapping is proposed to unravel regional hydrology. Emphasis will be on qualitative rather than quantitative analysis. Because of the complexity of the system, minimum effort will be devoted to calculating rates of ground-water recharge, discharge, and movement. Rather, objectives are location of recharge and discharge areas and directions of ground-water movement. Water resistivity, obtained from electric logs, will be used to evaluate salinity. Regional salinity mapping provides qualitative information about recharge and discharge through the configuration of isohalines. Additional clues will come from water chemistry. Ground-water flow patterns and mechanisms of recharge and discharge are defined and explained through an integrated analysis of aquifer geometry, hydraulic gradients, and water chemistry. Mapped patterns will be compared with lithofacies mapping to characterize qualitatively the relationship between geology and hydrology.

Work is underway in the Wilcox Group of the Sabine Uplift. Laterally extensive, deep lignites have been identified at two stratigraphic horizons in the Wilcox—in the lower Wilcox above the first Wilcox progradational sequences and in the upper Wilcox, as much as 100 ft below the overlying Carrizo Sand. The lower interval covers the western two-thirds of Panola, much of Shelby and extends into Rusk, Nacogdoches, San Augustine, and Sabine Counties. The upper interval is best developed in western Rusk County and into northeast Cherokee County and northern Nacogdoches County. Lower Wilcox lignites are thicker and more numerous. They are separated from potential aquifer sands (resistivity greater than 20 ohm-meters) by as much as 50 ft of muddy sediment.

COMPUTERIZED CALCULATION OF LIGNITE RESOURCES IN TEXAS

W. R. Kaiser, Project Director; Susan J. Tewalt; assisted by Guy G. Cleveland and Clayton H. Wilson

This ongoing project is funded by the U. S. Geological Survey to establish a computerized data base and to calculate lignite resources for the state of Texas according to criteria of U. S. Geological Survey Bulletin 1450-B. Information on near-surface lignite seams is obtained from geophysical logs and recorded on U. S. Geological Survey stratigraphic sequence forms. U. S. Geological Survey personnel enter these data into the National Coal Resources Data System (NCRDS). The NCRDS computer data base is used by Bureau of Economic Geology personnel to calculate lignite resources on an aggregate basis by stratigraphic unit and geographic region. Point source of proprietary data remains confidential.

In the first phase of this project, resources for the Wilcox Group between the Colorado and Trinity Rivers were calculated. Remaining resources were reported in seam thickness categories of 2.5 to 5 ft, 5 to 10 ft, and greater than 10 ft for three degree-of-certainty categories (measured, indicated, and inferred). Identified resources (measured and indicated) for all three thickness categories totaled 6,528 million short tons, comparable to 5,905 million tons calculated in Report of Investigations No. 104 for seams greater than 3 ft thick. Resources calculated for the inferred category in east-central Texas were unrealistically large. Maps limiting the extent of the inferred resources in the southern half of the area were resubmitted to the U. S. Geological Survey. These maps reflect the updip limit of the Calvert Bluff Formation. Inferred resources for east-central Texas are currently being recalculated.

Lignite data for the Wilcox Group of northeast Texas (between the Trinity River and the Arkansas border) have been entered into the NCRDS. Resource calculations for this region will be completed in 1982. Currently being input into the NCRDS are lignite data for the Wilcox Group of the Sabine Uplift area in far East Texas.

EXPLORATION AND PRODUCTION PROGRAM FOR LOCATING AND PRODUCING PROSPECTIVE AQUIFERS CONTAINING SOLUTION GAS AND FREE GAS—TEXAS GULF COAST

A. R. Gregory, Project Director; Robert A. Morton, Ronée S. Reed, Zsay-shing Lin, Sam Jae Cho, Lee A. Jirik, and Bonnie R. Weise; assisted by Victor H. Lombeida, Jackson J. S. Yoong, Evans U. Jegbefume, Wahiduzzaman Mirza, Jose R. Solares, and Donald W. Downey

This project is a comprehensive exploration and reservoir engineering program designed to locate and evaluate a prospective watered-out gas reservoir in the Texas Gulf Coast area. The prospective reservoir may be geopressured or hydropressured and should be suitable for application of secondary gas recovery methods for producing unconventional gas after primary gas production ceases. Unconventional gas consists of solution gas, immobile dispersed gas trapped in the water-invaded zone, mobile gas located in thin non-commercial stringer sandstones, and mobile gas remaining in the gas reservoir. Dispersed gas will be recovered by withdrawing large volumes of water to depressure the reservoir. The test well should produce at a gas to brine ratio that substantially exceeds the solution gas to brine ratio to improve economic viability.

The first phase of the project consisted of establishing guidelines for screening and selecting a favorable prospect. The Port Arthur Field, Jefferson County, Texas, was selected from over 150 gas fields that were screened. This field contains multiple watered-out gas sandstones, multiple,

thick aquifers, and gas stringer sandstones in the lower Hackberry (Frio) sandstone interval at depths from 10,850 to 11,700 ft. The field covers about 1,900 acres (3 mi^2) and originally produced gas condensate from an anticlinal closure on the downthrown side of a major fault. The fault separates the Port Arthur field from the Port Acres field lying to the west. Some of the lower Hackberry reservoirs are laterally extensive and have excellent reservoir characteristics. The average net-sandstone thickness is 350 ft. Core data and well log analyses show that porosities average 30 percent, and permeabilities average 60 md. Initial pressure gradients in the C, D, and E reservoirs average 0.73 psi/ft but fall to an average of 0.45 psi/ft at abandonment pressure. Salinities average 95,000 ppm NaCl, and the average methane solubility is 20 scf/bbl.

The first phase of this project will be followed by a detailed study of the Port Arthur field using various methods that are broadly classified as geological, reservoir engineering, geophysical, well log analysis, and economic. An evaluation of the relative effectiveness of the methods employed is an important objective of the project. Recommendations based on this evaluation will influence the choice of methodology to be used in future projects of this type. A test well site will be delineated.

Over 31 mi of existing raw seismic data on lines located in or near the Port Arthur field have been acquired. The data will be processed and interpreted to help define reservoir boundaries, locate faults, and indicate reservoir areas that contain low free gas saturation (dispersed gas).

A computer reservoir simulation study was initiated in 1981 using a two-dimensional gas/water areal simulator and "dynamic pseudo functions" to model a three-dimensional reservoir. The model is being used to match historical production pressures and water-gas ratios for various reservoirs in the lower Hackberry sandstones. Predictions of reservoir performance and additional gas recovery at various assumed high rates of water production over specified time intervals will be made. Economic evaluations of the gas production forecasts will also be made for various water production rates. Results of reservoir simulation and economic evaluations are not yet available. The project is scheduled for completion in mid-1982.

GEOTHERMAL RESOURCE ASSESSMENT FOR THE STATE OF TEXAS

C. M. Woodruff, Jr., and Arthur G. Goldstein, Project Directors; S. Christopher Caran, Christine Gever, Mary W. McBride, G. L. Macpherson, and Almed G. El-Shazly, geologists; Clara L. Ho and Cynthia A. Mahan, chemists; assisted by Laura Caprio Dwyer, Patricia Bobeck, Eric J. Thompson, Mark R. Ulrich, Clayton H. Wilson, David Robert Wuerch, and Steven E. Lovell

This project is a continuation of efforts to delineate and assess hydrothermal/geothermal resources throughout Texas. During 1981, the project comprised two tasks of statewide scope and several area-specific studies along the Balcones/Ouachita structural trend in Central Texas.

One of the statewide tasks includes the ongoing compilation and collection in the field of temperature data from water wells. The second task involves the compilation onto a single map of lineaments perceived using Landsat imagery and the numerical analysis of densities and orientations of these lineaments.

Area-specific studies focus on geothermal resource attributes near Bexar, Travis, Falls, and Dallas Counties. These studies are assessments of water temperature and quality, and quantity of thermal waters in relation to the local lithic (especially structural) setting. Each area was chosen because warm-water-bearing aquifers occur beneath major potential users of the resource. In each area, however, different research approaches were employed because of variations in the local geologic setting. For example, in Bexar County we focused on the possible effects of the Ouachita "basement" complex; in Travis County we concentrated on the correlation of lineaments with various thermal anomalies; and in Falls County we tried to present a quantitative hydrologic depiction of that part of the Balcones/Ouachita hinge.

The current findings indicate that the Cretaceous aquifers along the Balcones/Ouachita trend have greatest promise for resource use because of the potential users concentrated in the numerous cities and towns along this trend. The hottest hydrothermal waters, however, occur in the Trans-Pecos area and within Eocene aquifers of the inner Gulf Coastal Plain. There are also thermal aquifers in Paleozoic strata that rim the Llano Uplift in Central Texas, and at several horizons within the lower Coastal Plain. In local areas where a user exists, these areas have considerable promise.

Beginning in November 1981, the U. S. Department of Energy is supporting a final 16-month research effort to consolidate findings made during previous grant periods and to present this information to the public. Tasks include the publication of a nontechnical, user-oriented map showing generalized geothermal resources of the state; a statewide technical rendering of geothermal waters compared to geothermal gradients; and an integration of structural, stratigraphic, and geophysical data as they pertain to geothermal waters along the Balcones/Ouachita trend of Central Texas.

GEOLOGICAL CHARACTERIZATION OF TEXAS OIL RESERVOIRS

William E. Galloway, Project Director; Chester M. Garrett and Noel Tyler

This study, funded in part by the Texas Energy and Natural Resources Advisory Council, is designed to address the long-term potential of increasing oil recovery by better recognition of the geologic variables that currently restrict conventional oil recovery to about 40 percent of the oil in place. The magnitude of the potential resource, on the order of 100 billion barrels of oil, justifies a reexamination of the geologic factors that influence recovery from reservoirs.

The initial phase of the research program consists of the collection and synthesis of basic geologic and production data on major Texas reservoirs (defined as those having produced at least 10 million barrels of oil). Much of the information is being assembled from files of the Texas Railroad Commission, supplemented by published sources and public data bases. These data provide the starting point for comparison of the interrelationships between ultimate recovery efficiency and variables, such as the lithology,

permeability, depositional origin of the reservoir, drive mechanism, oil characteristics, geologic age, and trapping mechanism. Subsequent research will be directed toward those classes of reservoirs where lithologic parameters substantially limit hydrocarbon recovery.

TEXAS ENERGY: RECENT TRENDS AND OUTLOOK TO YEAR 2000
W. L. Fisher, Project Director

Conducted and prepared for the Texas 2000 Commission, this project is designed to characterize the major energy reserves and resources of the state of Texas and analyze recent production trends. Production levels of oil, gas, natural gas liquids, coal, lignite, uranium, and unconventional sources will be projected to the year 2000.

OIL AND GAS OF THE U.S. GULF COAST BASIN
W. L. Fisher, Project Director

Recent trends in oil and gas exploration and development in the U.S. Gulf Coast Basin, including both onshore and offshore areas of the Texas Gulf Coast, are being analyzed. Future outlook will be projected on the basis of undiscovered resource base, rate of finding, level of drilling, and future oil and gas prices.

LAND AND ENVIRONMENTAL RESOURCES INVESTIGATIONS

ENVIRONMENTAL GEOLOGY OF THE EAST TEXAS LIGNITE BELT—JACKSON AND YEGUA UNITS
E. G. Wermund, Project Director; Mary L. W. Jackson, principal scientist

Funded by the Energy Lands Program of the U.S. Geological Survey, environmental geologic maps are developed in this study for use as a source of basic data for lignite mine and reclamation planning. Floodplain and sand outcrop designations help miners estimate mining costs for reclamation of riparian vegetation and identify potential ground-water problems early in the planning process. Environmental geologic maps relate directly to recent regulations on surface mining of lignite, but they can also be used for more general land use planning. Slope designations and soil types indicate areas suitable for industries, outdoor recreation, or sanitary landfills.

Field work and mapping for this 2-year project were completed in mid-1981. Five color maps being prepared at a scale of 1:250,000 will exhibit 32 environmental geologic units, which are defined according to substrate, soil, topography, geologic process, vegetation, and land use. Completion of the maps and an accompanying Bureau Report of Investigations is scheduled for 1982.

ENVIRONMENTAL MONITORING—GEOPRESSURED GEOTHERMAL TEST WELL, BRAZORIA COUNTY
Thomas C. Gustavson, Project Director; Rory Howard and Douglas A. McGookey

The Bureau of Economic Geology, under contract to the U.S. Department of Energy, has undertaken management and coordination of environmental monitoring at the Brazoria County, Texas, geopressured geothermal test-well site. Effects on local ecosystem quality from the accidental release of geothermal brines and from the possible initiation of land-surface subsidence as a result of withdrawal of large volumes of geothermal fluids are the primary concerns of this project.

Baseline environmental studies include repeated analysis of air and water quality, a microseismicity survey, repeated first-order leveling surveys, a liquid tilt-meter survey, an archeological resources survey, and a noise survey. These studies were underway both before and during the test-well drilling. The air- and water-quality analysis, microseismicity survey, first-order leveling surveys, and liquid tilt-meter survey will be continued during the production phase of the test-well operation. Production testing of more critical zones began in late 1979 and continued to the end of the year. Following several months of inactivity, production testing was resumed in September 1980. Environmental monitoring was continuous throughout FY81.

Microseismic monitoring near Pleasant Bayou No. 1 and No. 2 wells shows evidence of naturally occurring seismic activity of extremely small values within 4 km of the test-well site. Seismic activity of the same magnitude and distance from the test-well site, but which was probably induced by disposal of geothermal fluids or by other commercial-waste-fluid disposal in the vicinity, was also observed.

Air quality at the Pleasant Bayou test-well sites was monitored for particulates, methane, hydrogen sulfide, and sulfur oxide; results show that air from the test-well site does not exceed national ambient air-quality standards for particulates or sulfur oxides.

Water chemistry of Chocolate Bayou, which is adjacent to the test well, is highly variable because mixing with marine waters of West Bay occurs in this part of the bayou. Water quality has not been affected by drilling and testing of the well.

Air- and water-quality studies were completed in 1981, as well as a long baseline tilt-meter survey. Microseismic monitoring will continue through FY82.

APPLICATION AND TRANSFER OF REMOTE SENSING TECHNOLOGY FOR STATEWIDE NEEDS IN TEXAS
Robert J. Finley, Project Director; Robert W. Baumgardner, Jr., Katherine E. Schmedes, Christopher D. Henry, and Jonathan G. Price; assisted by Marcie D. Machenberg

Funded by the National Aeronautics and Space Administration through the Texas Natural Resources

Information System, this project is aimed at adapting remote sensing technology to State agency needs in the areas of natural resources and the environment. A Remote Sensing Information Subsystem has been established to process remotely sensed data using computer-assisted and conventional interpretation techniques. Test sites in the Coastal Zone, the Trans-Pecos region, and the High Plains of the Texas Panhandle have been investigated using Landsat imagery supported by aerial photography.

In the Coastal Zone, extraction of land/water boundaries from two scenes of Landsat imagery suggests the feasibility of using Landsat for repetitive, but approximate, delineation of shorelines at different tide levels. Land cover/land use mapping using Landsat imagery of areas surrounding Nueces Bay and Lavaca Bay yielded an 84-percent accuracy when checked against aerial photographs. Certain coastal environments, such as wet, muddy agricultural areas and similar substrates in wetlands, remain difficult to differentiate on a spectral basis. Semi-interactive use of a color graphics display and a color camera for image output has significantly improved Landsat digital processing over previous capabilities.

Determination of irrigated acreage on the High Plains is being made on the basis of the high infrared reflectance of irrigated crops. In the Trans-Pecos region, Landsat band-ratio images clearly bring out the iron oxide cap overlying a copper-molybdenum deposit at Red Hill. After calibration over Red Hill, band ratios will be used to examine other areas in relation to lineaments defined on 1:120,000-scale aerial photographs and side-looking airborne radar of the Chinati Mountains. Such procedures are designed to locate other zones of surface alteration and increase understanding of the relations between potential mineralized zones and Tertiary-age volcanism.

SOUTHWEST TEXAS RIVER BASINS REGIONAL STUDY

E. G. Wermund and Thomas C. Gustavson, Project Directors; cartography by Richard L. Dillon and David Ridner

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

Results of this program are included in a series of maps, which were hand-colored on scribed plastic base maps. The bases are reproductions of the standard Army Map Service topographic maps (scale 1:250,000). The hand-colored series includes maps of (1) environmental geology, (2) physical properties, (3) active processes, (4) biologic assemblages, (5) economic resources, (6) land use, and (7) slopes. Environmental geologic maps and slope maps are compiled at a scale of 1:125,000; all other map types are presented at a scale of 1:250,000.

Maps of environmental geology and land use represent original mapping. The biologic assemblage map is also essentially original mapping because the biologic assemblages were identified in the field, and their boundaries were located in general conformity to environmental geologic boundaries. Maps of active processes and physical properties were directly derived from the environmental geologic map. The economic geology map was synthesized from previous Bureau publications. The slope maps were made only for the northern third of those regions where Edwards (Lower Cretaceous) through Carrizo (Tertiary) stratigraphic units crop out.

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

All the hand-colored maps prepared during the project are currently available for examination. Topographic maps (scale 1:24,000) and controlled photographic mosaics showing original compilation, which are on file at the Bureau of Economic Geology, are also available for study.

In 1978, an up-to-date topographic base map was compiled by transcribing data from topographic quadrangle maps (scale 1:24,000) to facilitate the eventual color separation and publication of all mapping done for this project. Final scribing, labeling, and color separation proceeded during 1979 and 1980. Over the next several years the maps will be published in varied combinations of two or more colors at a scale of 1:250,000. Maps of the Seguin West and San Antonio East 1° Quadrangles are nearly completed for publication. A text, which explains the regional setting and methodology, is in preparation.

MINERAL RESOURCES INVESTIGATIONS

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

Jonathan G. Price, Project Director; Arthur G. Goldstein, geologist; Clara L. Ho, Steven W. Tweedy, Josefina R. Calvo, and Nam P. Bui, chemists; assisted by Allan R. Standen

Determining the origin of silver-copper deposits in Trans-Pecos clastic rocks is the goal of this project, which is funded by the Texas Mining and Mineral Resources Research Institute. Deposits occurring in Precambrian, Permian, and Cretaceous sandstones near Van Horn are similar in that they are in red-bed sequences, are generally structurally controlled, and are enriched in silver, copper, lead, zinc, cadmium, arsenic, and molybdenum. Detailed mapping at the Plata Verde Mine, where oxide deposits occur in Permian sandstones, has revealed some features similar to red-bed copper deposits and other aspects indicative of fault-related sulfide mineralization. Direct

connections between ore deposition and Tertiary igneous activity in the region have not been demonstrated. Research is focusing on the relations between structure and ore deposition, the mineralogy and chemistry of the ore and its host rocks, and the source of the metals.

MINERALIZATION ASSOCIATED WITH CALDERAS, TRANS-PECOS TEXAS

Christopher D. Henry, Project Director; Jonathan G. Price, geologist; Clara L. Ho, Nam P. Bui, Steven W. Tweedy, and Josefina R. Calvo, chemists; assisted by John C. Wilson, Keith S. Pollman, and Allan R. Standen

Exploration for base and precious metal deposits in Trans-Pecos Texas has increased dramatically in the last few years, and mineable deposits of molybdenum and silver have been discovered. This project is examining the relation between the ore deposits or hydrothermal alteration and the igneous activity, especially associated with the numerous calderas in the area. Work in the first year focused on the Chinati caldera complex, and a preliminary report on the area and its mineral potential was published in 1981. Work is continuing in that area and has expanded to include several other volcanic and intrusive centers, such as the Quitman Mountains, Eagle Mountains, and Christmas Mountains. This study includes (1) detailed mapping of selected calderas to determine their overall geology and the relation of ore deposits or hydrothermal alteration to the geology, (2) examination of known mineral occurrences to determine their origin, and (3) geochemical analyses to determine which calderas are most favorable for mineral deposits. The project is funded by the Texas Mining and Mineral Resources Research Institute.

UNITED STATES DEPENDENCE ON IMPORTED SOURCES OF NONFUEL MINERALS

W. C. J. van Rensburg, Project Director; assisted by Allen R. Standen

The reasons for growing U. S. dependence on imported strategic minerals were analyzed, and conclusions were that the loss of political control over foreign resources, the increasing competition for available supplies from other industrial countries, the decline of mining and metallurgical research in the U. S., and the increased consumption of these minerals in the U. S. have contributed to the problem.

Improving the situation would require incentives for greater domestic production of strategic minerals, stockpiling, improved sea-lane control, and diversification of foreign sources of supply where possible.

MINING IN THE TEXAS ECONOMY

W. L. Fisher, Project Director

This project analyzes the contribution of mining in Texas to the state's economy. Recent trends and future outlook for construction raw materials, chemical raw materials, energy raw materials, metallic minerals, and specialty industrial minerals are being studied.

BASIN STUDIES

GEOLOGIC AND GEOHYDROLOGIC INVESTIGATIONS IN THE TEXAS PANHANDLE

L. F. Brown, Jr., Thomas C. Gustavson (Project Director), R. L. Bassett, Robert J. Finley, Arthur G. Goldstein, J. H. McGowen, Mark W. Presley, Robert W. Baumgardner, Jr., E. Dow Davidson, Jr., Shirley P. Dutton, Ann D. Hoadley, Rory Howard, Douglas A. McGookey, Paul J. Ramondetta, Katherine E. Schmedes, William W. Simpkins, John Griffen, Anderson D. Smith, S. Christopher Caran, Susan D. Hovorka, James K. Gluck, Stephen C. Ruppel, and Amos Bein; assisted by Steven D. Mann, E. A. Duncan, J. Williams, Amy Wanamaker, Vicki J. Prestwood, J. Sullivan, Melissa A. Sandstrom, Stephen Weiner, D. D. Guetzow, J. A. Middleton, R. A. Merritt, Nancy Allen, Erika Everret, Adel Moustafa, Dominic Roques, Dave Palmer, James R. Smits, Ellen Naiman, Ron B. Nickel, Gerald Craig, Bruce A. Pridgen, Richard W. Ozment, Marcie D. Machenberg, Bryan R. Bracken, Leslie M. Thomas, Jr., David Noe, and Mary Nelis

Since 1977, the Bureau of Economic Geology has conducted extensive geologic and hydrologic research in the Texas Panhandle, chiefly in the Palo Duro Basin. These research projects are being conducted under University contract with the U. S. Department of Energy as a part of the Department's nationwide investigation of potential nuclear waste repositories. Bureau research efforts are coordinated with the Texas Energy and Natural Resources Advisory Council, and results of research projects are made available to the public through Bureau publications.

The program to date has evolved through the following three phases: (1) 6 months of preliminary data collection and initiation of basic research tasks (late FY77); (2) 1 year of intensive research to produce a basic stratigraphic/structural/facies framework for the basins and to initiate ongoing studies of surficial and near-surface processes that affect erosion, denudation, and salt solution (FY78); and (3) 1 year of research aimed at initial analysis of deep cores, initiation of basin resource studies, calibration of subsurface logs (using cores), discrimination of general depth/salt/thickness fairways, initiation of deep-basin hydrologic studies, and continuation of surface and near-surface analyses of erosion, denudation, and salt solution rates (FY79).

Studies initiated in FY80 involved more specific discrimination and determination of salt character, natural resources potential, hydrologic integrity, host-rock properties, and surface and near-surface process rates, among others. The program in FY80 also passed into a more discriminating, intensified stage of evaluating priority items recognized during the earlier framework studies. The FY81

program was designed to continue to address dynamic aspects of salt dissolution, deep-basin fluid circulation/movement, and shallow aquifer hydrodynamics/hydrochemistry, as well as integration of these factors within the three-dimensional facies framework and resource potential of the basin. In addition, analyses of structural deformation, tectonic environment, and regional gravity anomalies were initiated.

The Palo Duro Basin is part of a province in the interior of the North American plate, which was deformed in response to late Paleozoic compressive deformation at the continental margin. The deformation within this province was the result of non-collisional orogeny and northward subduction beneath North America. Regional gravity data have been analyzed using two-dimensional modeling techniques and standard stratigraphic cross sections. Results show that the major anomaly associated with the Amarillo Uplift may be due to faulting of the entire crust along a steep fault. At the structurally complex northwest margin of the Palo Duro Basin, structural controls exerted by crystalline basement rocks have had both obvious and subtle effects on the distribution of facies and lithologies, thickness of sedimentary units, and post-depositional deformation of strata.

Brittle deformation associated with salt dissolution zones has been identified in the Caprock Canyons State Park, Briscoe County, Texas, and the Randall County stratigraphic test well. The sequence of structural events suggests a horizontal extension preceding major collapse as a result of dissolution. In addition, it appears that systematic regional joints predated dissolution collapse and could have been pathways for fluid migration.

Fluvial, deltaic, and lacustrine deposits of the Dockum Group accumulated in a continental basin. The Dockum Basin was the relict Permian (Delaware, Midland, Palo Duro) Basin which, along with the relict positive structural elements, was reactivated during late Paleozoic - early Mesozoic time by tectonism that created the Gulf of Mexico. The Dockum was deposited during alternating wet and dry climatic cycles. Small, relatively high concentrations of uranium contained within the Dockum are related to interconnected Ogallala-Dockum ground-water systems and to the leaching of uranium from volcanic ash of overlying Pleistocene deposits.

Oil and gas fields in granite-wash reservoirs are controlled by both structural and stratigraphic traps. Porosity and permeability within granite wash are related to the amount and kind of authigenic cements present. Large amounts of oil are trapped in the San Andres Formation in a discontinuous, structurally high and stratigraphically thin belt that rims the deep basin and overlies older shelf margins. Additional oil is trapped in a series of steplike updip porosity pinch-outs having little or no structural control.

The mud, anhydrite, or mud-anhydrite content of bedded salt of the San Andres Formation, Palo Duro Basin, Texas, correlates with gamma-ray intensity, neutron porosity, bulk density, and interval transit time (sonic log).

Individual crystals from the Permian Palo Duro Basin salt beds show a very regular pattern that may reflect diurnally changing conditions during crystallization. The band thickness (0.40 to 0.85 mm) is such that they may correspond to evaporation of a maximum of 4 to 8 mm of water per day. They indicate very shallow water conditions. These rhythmic alternations are much smaller features and appear to be distinct from the well-known, presumably annual cyclic mineralogy in many saline deposits.

Permeability estimated from analysis of drill-stem test charts ranges from 0.1 to 260 md in the Wolfcamp carbonates. The range of 1 to 10 md probably is representative of average permeability for carbonates in the region, except for zones along the dolomitized shelf edge where porosity is extremely high and permeabilities may consistently average greater than 100 md. Brines in the deep aquifers of the Palo Duro Basin primarily derive their salinity from dissolution of halite in the overlying evaporite section or from evaporites encountered early in the flow path. Brines appear to be near saturation with respect to anhydrite, except in regions of active sulfate reduction and generation of hydrogen sulfide. Brines in the Wolfcamp carbonates are probably in equilibrium with calcite, according to chemical analyses of samples collected during wildcat drilling. Mass transfer computations that correct for carbon dioxide outgassing indicate that the partial pressure of carbon dioxide of Palo Duro brines is remarkably similar to that observed in producing gas fields in the basin.

Because of its ability to predict the potential for reaction, or the likelihood of equilibrium, the AQ/SALT model reliably evaluates the reaction state between brines and host rock. Calibration with well-controlled experimental data verifies the algorithms employed. A two-dimensional finite-element ground-water model was constructed in the vertical plane along a stratigraphic cross section of Tertiary Ogallala Formation, Triassic Dockum Group, and Permian sediments in Swisher, Briscoe, Hall, and Childress Counties. Preliminary runs of the model suggest that the salt dissolution process is sustained by (1) downward flow of fresh ground water from the Ogallala aquifer into the salt dissolution zone, (2) upward movement of resultant brine waters through transmissive dolomite/anhydrite beds of the Blaine Formation, and (3) discharge of the brine water to saline springs in topographically low areas.

Thinning of the upper portions of salt strata of the Salado and Clear Fork Formations in subcrops beneath the High Plains, structural collapse of overlying strata, and surface expression of subsidence as topographic and lake basins suggest, collectively, that salt dissolution occurred during the Quaternary. The lake basins contain Pliocene to early Pleistocene faunas. The Pecos River Valley on the western margin, the Canadian River Valley on the northern margin, and the Palo Duro Canyon on the northeastern margin of the High Plains all originated as subsidence troughs as a result of dissolution of Permian bedded salts.

The Seymour Formation contains eroded alluvial material of the Ogallala Formation, deposited from the westward-retreating Caprock Escarpment. Volcanic ash deposits within this unit in North-Central Texas yield a minimum age for the Seymour deposits, and from this, maximum rates of stream incision (0.071 to 0.091 mm/yr) and escarpment retreat (19 cm/yr) have been calculated.

Erosion and climatic data have been collected at five erosion-monitoring localities in the Texas Panhandle for approximately 2 years. Net erosion predominates at four sites, and mean annual net-erosion rates measured at erosion pins do not differ significantly from site to site.

Although previous correlations of erosion rate with slope and vegetation are indicated, linear multivariate analysis of rain, slope, vegetation, and their interactions on erosion rate suggests that erosion rate may be best represented by a rainfall-times-slope-interaction term. Morphometric studies of drainage basins along the Caprock Escarpment are used to describe regional geomorphic characteristics. Localized erosion-monitoring results are thereby placed in a regional perspective.

Studies in FY82 will continue to focus on salt character, natural resource potential, hydrologic integrity, host-rock properties, ground-water geochemistry, surface and near-surface process rates, tectonic environment, and basin seismicity.

GEOLOGIC AND GEOHYDROLOGIC INVESTIGATIONS IN THE EAST TEXAS BASIN

Charles W. Kreitler, Project Director; Edward W. Collins, Robert D. Conti, E. Dow Davidson, Owen R. Dix, Shirley P. Dutton, Graham E. Fogg, M. P. A. Jackson, Mary K. McGowen, H. Seay Nance, Wayne D. Pennington, Steven J. Seni, Debra H. Wood, and H. Victor Wuerch, geologists; Clara L. Ho, Josefina R. Calvo, Cynthia A. Mahan, and Steven W. Tweedy, chemists; assisted by Bryan R. Bracken, Samir A. Ghazi, Stephen E. Lovell, Deborah Magouirk, Steven D. Mann, Donald E. Miser, Keith S. Pollman, Rainer K. Senger, Thomas M. Simmons, Bruce D. Wilson, Bruce Pridgen, and Bernd Richter

The goal of this research program, funded by the U. S. Department of Energy, is to investigate geologic and geohydrologic features critical to DOE's evaluation of the suitability of underground salt domes in the Gulf Coast Basin as possible sites for long-term isolation of nuclear wastes. Major considerations in this evaluation are the hydrologic and tectonic stability of the domes. To develop information related to these concerns, a Bureau research team began geologic, structural, stratigraphic, petrologic, and geochemical investigations of specific salt domes and also of the entire region in 1978. The resolution of these problems will provide approaches and solutions to the suitability of any salt diapir being considered for long-term storage of chemical and nuclear wastes.

Hydrologic investigations include studies of ground-water flow around the domes in the shallow meteoric aquifers and preliminary studies of ground-water flow in the deeper saline parts of the basin. These studies have addressed the role of aquifer geochemistry in retarding potential nuclide migration away from a repository, the effect of permeability distribution on ground-water flow around domes, and the potential for upward leakage of saline waters from deeper aquifers. Results include the following:

(1) Impacts of local topography on flow in the Wilcox-Carrizo aquifer appear minimal, thereby reducing considerably the probability that contaminants escaping from the dome could discharge into the area near the dome.

(2) The saline plume to the northeast of Oakwood Dome may not be related to dissolution of dome salt or cap rock because the model suggests that no reasonable distribution of permeability and/or discharge sites could generate flow in the direction of the plume.

(3) The uplift of Oakwood Dome and other domes in the basin during Wilcox deposition shifted major axes of sand deposition away from the domes, thereby creating a zone of relatively low-permeability facies around the domes. This low-permeability zone represents a barrier that had not been previously considered and that may explain why the domes in contact with the Wilcox aquifer in the East Texas Basin do not appear to have dissolved appreciably.

(4) Because of the mineralogy of the aquifer (high ion-exchange capacity) and chemistry of the ground waters (basic and reducing) in the shallow meteoric aquifers, the migration of many radionuclides away from a potentially breached repository should be significantly retarded.

(5) The deep Woodbine aquifer is underpressured because of oil and gas production. Fluid migration should not be expected from the Woodbine to overlying meteoric aquifers, such as the Carrizo-Wilcox.

(6) Petrographic analysis of a sample from beneath the overhang of Oakwood salt dome (at a depth of approximately 6,000 ft) shows that "sheath material" is composed of deformed anhydrite crystals. The anhydrite is the result of salt dissolution and accumulation at depth.

Regional subsurface studies are in progress to determine the mechanisms that control salt diapirisms and whether salt domes will remain stable in the future. Some important findings are as follows:

(1) From the Jurassic-Early Cretaceous to Holocene, declining rates of sedimentation and subsidence were the major factors influencing an associated decline in rates of dome growth.

(2) The greatest amount of dome growth occurred during the Jurassic-Early Cretaceous as a result of uneven sediment loading around the western, southwestern, and eastern margins of the basin.

(3) During Late Cretaceous and Tertiary times, dome growth seems to have controlled sedimentation patterns.

Tectonic studies have been evaluating the two major fault systems in the basin, the Mexia-Talco fault zone and the Elkhart-Mount Enterprise fault zone, to determine whether there is any potential seismic activity. Results indicate the following:

(1) The Mexia-Talco fault zone is a peripheral graben that formed as a pull-apart structure between a stable platform to the north and west and unstable strata in the East Texas Basin that crept basinward over a lubricating décollement layer of Louann Salt. This movement would have been aseismic, and it ended by middle Tertiary.

(2) The Elkhart section and the Mount Enterprise section of the Elkhart-Mount Enterprise fault zone are separate entities. Most of the movement on the Elkhart Graben occurred in the Mesozoic, whereas Mount Enterprise faulting is predominantly younger. Minor earthquakes have been recorded on Mount Enterprise faults.

The Elkhart Graben is spatially associated with a large, deep salt pillow and appears to have formed by crestal extensions of overlying strata above this anticlinal salt structure. The structural configuration of the Mount Enterprise zone is poorly understood. Faulting has been both into the East Texas Basin (Cretaceous age) and into the Gulf of Mexico (Tertiary age).

Results of Bureau research have shown the East Texas interior salt domes to be relatively less suitable for nuclear waste isolation repositories than other domes. Current

Bureau research is generic in nature and chiefly for application to salt domes outside Texas.

PENNSYLVANIAN AND PERMIAN FACIES, EASTERN SHELF, NORTH-CENTRAL TEXAS

L. F. Brown, Jr., Project Director; and Raul Solis; assisted by David Johns and Diana Morton Thompson

At the end of 1981, 22 dip and strike cross sections of the Virgil and Wolfcamp strata on the Eastern Shelf were being drafted for a publication expected in 1982. The cross sections will be released as part of the Bureau's cross-section series.

Net-sand maps of 12 lithogenetic units between the Home Creek Limestone and the Coleman Junction were also going into drafting at the end of 1981. These maps, along with other illustrations and data, will constitute the basis of a Bureau report on the depositional systems and oil exploration on the Eastern Shelf. This report should be in preparation during 1982.

COASTAL STUDIES

SOUTH LAGUNA MADRE WIND-TIDAL FLATS

J. H. McGowen, Project Director

This study, which was funded by the General Land Office of Texas, was conducted to ascertain the origin of and depositional and erosional history of South Padre Island and environs near Los Bancos de en Medio. Emphasis of the study was on the wind-tidal flats; these low-lying sand flats are adjacent to the shallow South Laguna Madre. Wind-tidal flats, as the name implies, are inundated by wind-driven lagoonal waters. The wind-tidal flats are flooded frequently when barometric pressure is low and winds are calm, by the normal wind regime when winds blow from any direction but east or southeast, and during the passage of tropical storms and hurricanes. This project is complete, and a manuscript is being reviewed.

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

L. F. Brown, Jr., and E. G. Wermund, Project Directors; J. H. McGowen, Robert A. Morton, William A. White (Project Coordinator), Thomas R. Calnan (Chief Biologist), Russell S. Kimble, Thomas G. Littleton, Katherine E. Schmedes, H. Seay Nance, and Tom C. Freund; Clara L. Ho, Josefina R. Calvo, and Steven W. Tweedy, chemists; assisted by James A. DiGiulio, David H. LeComte, Janice L. Smith, Gary J. Steck, and John H. Wilkins

Work continued through 1981 on this long-term multiphase Coastal Zone project; efforts centered on the analyses phase of the project in which sediment samples were examined to determine (1) sediment type and mean grain size, (2) major and trace element concentrations, and (3) benthic macroinvertebrate makeup. In addition, efforts continued toward providing updated regional distribution maps of wetlands to complement the maps of State submerged lands.

Grab samples, from which the analyses are being completed, were collected on 1-mile centers from (1) the inner continental shelf extending from the Texas Gulf shoreline seaward for 10.36 statute miles (3 marine leagues), and (2) the bay-estuary-lagoon system of the Coastal Zone from the Rio Grande to Sabine Lake. A major goal of the project is to produce a comprehensive data base for State-owned lands before the anticipated increase in offshore activities and multipurpose use of these lands. Research has been conducted in cooperation with the Marine Geology Branch of the U. S. Geological Survey and has been funded in part by the General Land Office of Texas and the Office of the Governor, through the Coastal Zone Management Act of 1972, administered by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration.

Publication of results will be in the form of a series of atlases of the Texas coast divided into map areas similar to those defined and published in the Bureau's *Environmental Geologic Atlas of the Texas Coastal Zone* series (L. F. Brown, Jr., coordinator). The first atlas to be published will be of the Corpus Christi area. Atlases will consist of a text that focuses on a series of maps depicting sediment distribution, geochemistry, and benthic macroinvertebrates. Additionally, the distribution of wetlands and related environments will be included on the map of invertebrate assemblages.

During 1981, sediment analyses, conducted by the Bureau's sedimentology laboratory under the direction of Seay Nance, were completed for the Bay City-Freeport, Port Lavaca, and Kingsville areas. Sediment maps of submerged lands, which depict the distribution of (1) shell, sand, and mud, (2) sand, silt, and clay, (3) percent sand, and (4) mean phi, were completed for the Bay City-Freeport and Port Lavaca areas.

The Bureau's Mineral Studies Laboratory conducted geochemical analyses of selected samples in the bay-estuary-lagoon systems to supplement data analyzed by the U. S. Geological Survey to complete the analyses for the Beaumont-Port Arthur, Port Lavaca, Brownsville-Harlingen, and Kingsville map sheets. Using these data, hand-colored geochemical maps showing the distribution of 11 elements were completed for these areas. The cartographic section of the Bureau prepared 12 geochemical maps of the Corpus Christi area for eventual publication.

To investigate further and understand more precisely the relation between sediment types and trace element concentrations, a series of derivative maps, combining sediments and associated geochemistry, were produced. These maps will provide the basis for selecting samples for additional analyses using more refined geochemical and X-ray diffraction methods.

Live benthic macroinvertebrates were identified and counted for 88 samples in the Beaumont-Port Arthur area

and 135 samples in the Bay City-Freeport area. Data were processed by computer for cluster analyses and species diversity. Preliminary results were presented in two separate contract reports submitted to the Budget and Planning Office of the Office of the Governor. Analyses of samples taken from the Port Lavaca area are in progress. Among the eventual products of the biological analyses will be color-separated maps, scale 1:125,000, showing the distribution of invertebrate assemblages and species diversity.

Delineation of wetlands continued in 1981 with the objective of producing updated regional distribution maps of wetlands. Wetland map units are patterned after the Bureau's *Environmental Geologic Atlas of the Texas Coastal Zone* series. Interpretation and delineation of map units on 1979 color-infrared photographs were completed for the Galveston-Houston area and the Brownsville-Harlingen area. Delineations have previously been completed for the Corpus Christi area; the delineations have been scribed on base maps (1:125,000) by Bureau cartographers, and a hand-colored map has been produced. Pending approval of this draft map, final color separation of map units will begin.

Also during 1981, the sampling phase of the project was reopened for a short period to collect approximately 120 additional sediment samples in the Matagorda Bay/estuarine complex to supplement existing textural and benthic invertebrate data in this area. The samples were added to the approximately 6,700 samples collected in submerged lands along the entire Texas coast during the initial sampling phase (completed in 1977) of the project.

GEOLOGIC MAPPING

GEOLOGIC ATLAS OF TEXAS

Virgil E. Barnes, Project Director; cartography by James W. Macon and Richard L. Dillon

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

During the year, the Llano and Sonora Sheets were published, bringing to 34 the number of sheets in print. Four more sheets remain to be completed. The Tucumcari Sheet is being reviewed by the New Mexico Bureau of Mines and Mineral Resources for final approval before printing of the New Mexico portion of that sheet. The Dalhart Sheet is ready for color separation, and review of the Fort Stockton Sheet has been completed. Field work for the Wichita Falls-Lawton Sheet progresses.

Atlas sheets are rapidly going out of print. Some have been reprinted without revision, some with limited revision, and others are being completely revised. The USGS 7.5-minute series of topographic maps is indispensable in revising the mapping of Quaternary deposits and in correcting the 1:250,000 scale base. The Quaternary mapping of the San Antonio Sheet has been revised using these 7.5-minute quadrangles; several missed outliers were found. When color separation is completed, the San Antonio Sheet will be reprinted. Revision of Quaternary mapping for the Beeville-Bay City Sheet has been completed, and the sheet is ready for color separation. The Houston Sheet is being completely revised using the *Environmental Geologic Atlas of the Texas Coastal Zone* and other recent Bureau mapping as well as USGS 7.5-minute quadrangles. The same sources are being used for revising the Beaumont Sheet; however, 12 USGS 7.5-minute quadrangles are still unavailable. The Palestine Sheet is in the process of revision, but will be delayed until the remaining 27 USGS 7.5-minute topographic quadrangle maps are received.

GEOLOGIC MAP OF TEXAS

Virgil E. Barnes, Project Director

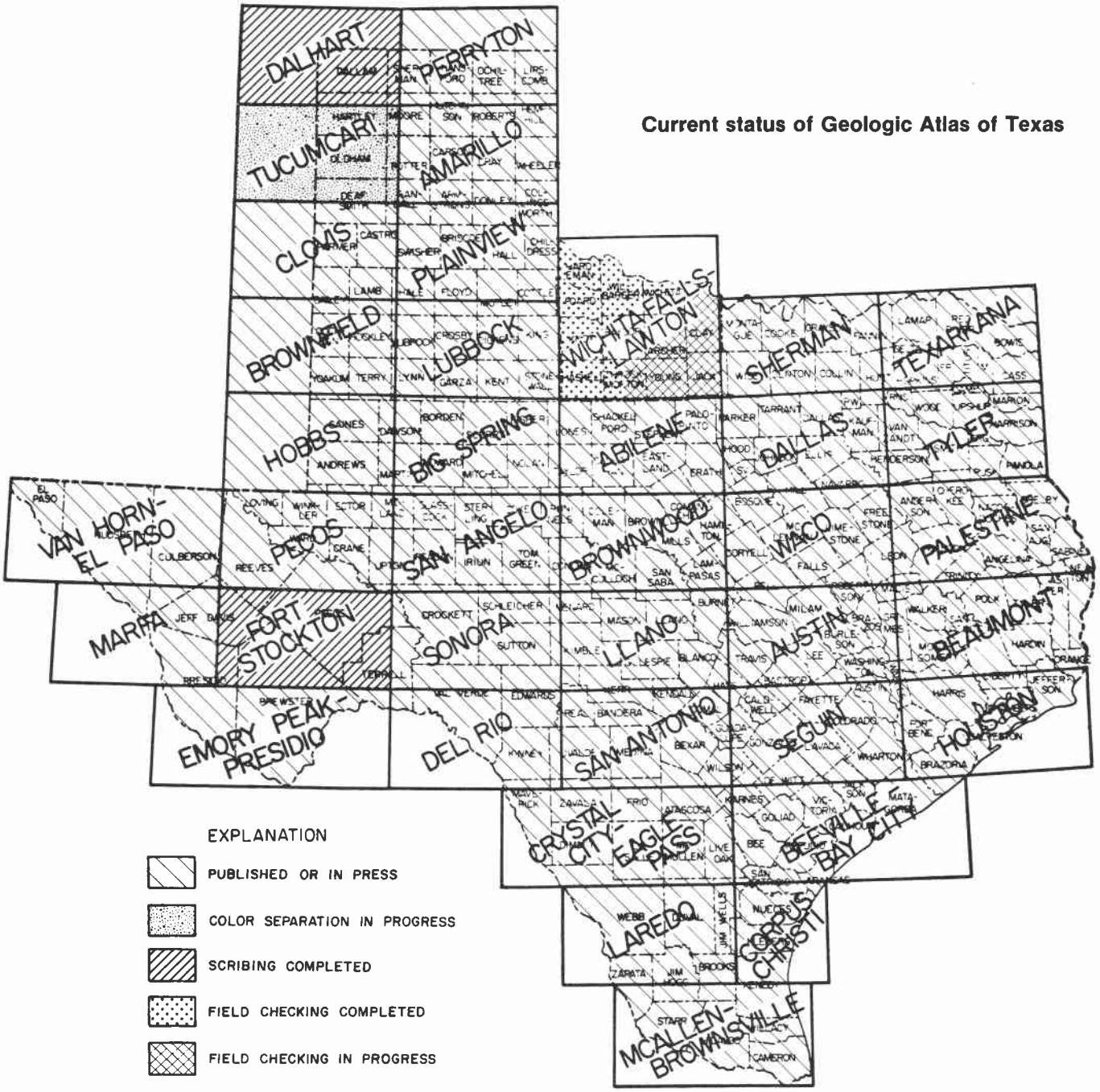
The preparation of a new geologic wall map of Texas began in May 1978. To be published in four quadrants at a scale of 1:500,000, the new map will replace the 1937 U. S. Geological Survey Geological Map of Texas, which has been out of print for many years.

The new map is being derived from the *Geologic Atlas of Texas* map sheets (scale 1:250,000). A set of completed sheets of the *Geologic Atlas of Texas* has been marked for use in drafting the new map. As soon as revisions of the San Antonio, Beeville-Bay City, Houston, and Beaumont Sheets are available, the southeastern quadrant can be scribed. This quadrant is completely covered by 7.5-minute topographic maps except for 12 quadrangles on the Beaumont Sheet. Quaternary mapping has been revised on all 7.5-minute topographic quadrangles in the southeastern quadrant not available at the time the atlas sheets were originally compiled and will also be used for scribing this quadrant. The southwestern quadrant can be scribed when the Fort Stockton Sheet is completed. The northern two quadrants will be delayed until the Wichita Falls-Lawton Sheet is finished.

GEOLOGIC QUADRANGLE MAPPING IN CENTRAL TEXAS

Virgil E. Barnes, Project Director

Geologic mapping of 7.5-minute quadrangles in Central Texas was initiated in 1939 to provide basic geologic maps for use in economic, stratigraphic, structural, and geophysical investigation. Thirty-three of the geologic quadrangle maps have been published. The final four maps of this series, which depict the geology of the Marble Falls, Pedernales Falls, Spicewood, and Hammetts Crossing Quadrangles, are ready for publication.



TECTONIC MAP OF TEXAS

Arthur G. Goldstein, Project Director; M. P. A. Jackson, Thomas E. Ewing, C. M. Woodruff, Jr., and Christopher D. Henry; assisted by Ricardo J. Padilla y Sanchez

Nearly every North American orogenic cycle since the late Precambrian has affected the crust of Texas. The tectonic map of Texas will show the broad structural framework and evolution of each region of the state, illustrated mostly by structure contours on appropriate horizons. This entails new regional compilations for nearly every tectonic province, including the late Paleozoic Ouachita-Marathon foldbelt and deformed foreland, the Basin and Range Province of Trans-Pecos Texas, and the Mesozoic-Cenozoic passive margin of the Coastal Plain and the East Texas Basin.

GRAVITY AND MAGNETIC MAPPING OF TEXAS

G. R. Keller, The University of Texas at El Paso, and C. L. V. Aitken, The University of Texas at Dallas, Project Directors

Gravity and magnetic maps of the state are being prepared at a scale of 1:250,000. The procedure for gravity mapping involves the merging of numerous different surveys, many available from the U. S. Department of Defense, onto one datum. Those data are then smoothed with a high-order polynomial surface. Magnetic maps are being prepared from National Uranium Resource Evaluation (NURE) aeromagnetic surveys. Both maps will be prepared as 1° by 2° quadrangles over the next several years.

OTHER RESEARCH

COMPOSITION AND ORIGINS OF TEKTITES
Virgil E. Barnes, Project Director

This long-term study of tektites and meteorites began in 1935 and has resulted in 66 publications. The project during 1981 was mostly curatorial—furnishing material for other researchers, answering questions, and reviewing manuscripts.

MAGNETIC SUSCEPTIBILITY ANISOTROPY AS AN INDICATOR OF FINITE DEFORMATION
Arthur G. Goldstein, Project Director; T. Engelder (Lamont-Doherty Geological Observatory, Columbia University), M. P. A. Jackson, D. Gray (Virginia Polytechnic Institute and State University), L. Brown (University of Massachusetts), W. Gose (Department of Geological Sciences, The University of Texas at Austin)

Determination of the finite strain state of deformed rocks frequently requires the presence of objects of known predeformational shape. Magnetic susceptibility anisotropy is a strain-related geophysical property that does not require such objects and is easily measured. Research for this project centers on techniques for measurement using a cryogenic magnetometer and studies of the following rocks: the Devonian clastic sequence of western New York, halite from the Oakwood salt dome; mylonites from the Fries fault zone, Virginia, and the Brevard fault zone, North Carolina; and Jurassic basalts from western Massachusetts.

CONTRACTS AND GRANT SUPPORT

The Bureau of Economic Geology maintains formal and informal cooperative arrangements with several governmental entities. Parts of the Bureau's research program are conducted under University contracts and grants with State agencies, local units of government, Federal agencies, and other organizations.

Contract management personnel perform a variety of duties associated with Bureau contract performance. Duties include preparing proposals and budgets, negotiating contracts, and monitoring expenditures. During the contract period, technical and financial reports are formatted and distributed at monthly, quarterly, and annual intervals.

During 1981, contract management personnel initiated a quality assurance program in accordance with Nuclear Regulatory Commission requirements for certain Bureau contracts. Other duties performed by this office include computer accounting, student placement, legislative reports, and publication inventory.

In calendar year 1981, 29 contracts were active at the Bureau, each of which had reporting requirements:

Federal

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

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

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

Evaluating the Potential of East Texas Interior Salt Domes as Areas for Isolation of Nuclear Waste: supported by the U. S. Department of Energy.

Geologic Framework and Energy Resource Studies, Texas Continental Shelf: supported by the U. S. Geological Survey.

Geothermal Resource Assessment for the State of Texas: supported by the U. S. Department of Energy.

Land Resources and Environmental Impact for East Texas Lignite Belt, Jackson-Yegua Trend: supported by the U. S. Geological Survey.

Locating Field Confirmation Study Areas for Isolation of Nuclear Waste in the Texas Panhandle: supported by the U. S. Department of Energy.

Predicting Response of a Natural System to Uranium Extraction: Oakville Aquifer: supported by the U. S. Environmental Protection Agency.

Resource Evaluation of Late Oligocene through Miocene Major Stratigraphic Units, Texas Gulf Coast Basin: supported by the U. S. Geological Survey.

Rheology of Viscoelastic Fluids for Oil Recovery: supported by the U. S. Department of the Interior, Office of Surface Mining.

Texas Mining and Mineral Resources Research Institute, Administration, Third and Fourth Allotments, and Scholarship and Fellowship Grants: supported by the U. S. Department of the Interior, Office of Surface Mining.

Identification of Geohydrologic Environments Suitable for the Isolation of High-Level Radioactive Waste: supported by the U. S. Geological Survey.

State

Applied Coal Geoscience and the Electric Utilities: supported by the Electric Power Research Institute through the Texas Energy and Natural Resources Advisory Council.

Assessment of Lignite Exploitability in the Deep Basin of Texas: supported by the Texas Energy and Natural Resources Advisory Council.

Texas Universities Coal Research Consortium, Administration Grant: supported by the Texas Energy and Natural Resources Advisory Council.

Coordinate the Development and Documentation of Procedures for General Use of the Hardware and Software

Available as Part of the Remote Sensing Information Subsystem (RSIS) Which Will Be Used in the Analysis of Remotely Sensed Data: supported by the Texas Department of Water Resources.

Coordination of OCS Leasing Activities for Texas Government as a Result of Committee Memberships to the OCS Advisory Board of the Department of Interior: supported by the U. S. Department of Commerce through the Governor's Budget and Planning Office.

Estimation of Uncertainty in Coal Resources and Cost Estimates: supported by the Electric Power Research Institute through the Texas Energy and Natural Resources Advisory Council.

Geologic Characterization of Texas Oil Reservoirs: supported by the Texas Energy and Natural Resources Advisory Council.

Hydrologic Evaluation of Deep-Basin Lignite: supported by the Texas Energy and Natural Resources Advisory Council.

Map the Biota, Wetlands, and Sedimentary Grain Size of Texas Submerged Lands for Planning the Impact of OCS Production Transported Onshore: supported by the U. S. Department of Commerce through the Governor's Budget and Planning Office.

Proposal to Establish Coal Analytical Capabilities at The University of Texas at Austin: supported by the Texas Energy and Natural Resources Advisory Council and The University of Texas at Austin.

State Submerged Lands Study: supported by the Governor's Budget and Planning Office.

Other

Description and Interpretation of Test Cores—Brooks and Adjacent Counties, South Texas: supported by Bendix Field Engineering Corporation and U. S. Department of Energy.

Exploration and Production Program for Locating and Producing Prospective Aquifers Containing Solution Gas and Free Gas—Texas Gulf Coast: supported by the Gas Research Institute.

Geologic Studies of Geopressured and Hydropressured Zones in Texas: supported by the Gas Research Institute.

Geology and Engineering Characteristics of Selected Low-Permeability Gas Sands: A Survey: supported by the Gas Research Institute through the CER Corporation.

U. S. Dependence on Imported Sources of Non-Fuel Minerals: supported by the Scaife Family Charitable Trusts.

CONTRACT REPORTS

During 1981, Bureau staff members prepared the following reports on research conducted under contract with various governmental agencies and other organizations. (Some of the reports were issued by those agencies in 1981; some will be published by the Bureau of Economic Geology.)

Bein, A., and Land, L. S., 1981, Carbonate sedimentation and diagenesis associated with Mg-Ca-chloride brines: the Permian San Andres Formation in the Texas Panhandle: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46615, 37 p.

Calnan, T. R., Kimble, R. S., and Littleton, T. G., 1981, Preliminary report on the distribution of benthic macroinvertebrates—Brownsville-Harlingen area: The University of Texas at Austin, Bureau of Economic Geology, report of research supported by the U. S. Department of Commerce Coastal Energy Impact Program grant through an interagency agreement with the Texas Governor's Budget and Planning Office.

Calnan, T. R., Kimble, R. S., Littleton, T. G., DiGiulio, J., Steck, G., and Wilkins, J., 1981, Distribution of benthic macroinvertebrates—Beaumont - Port Arthur area: The University of Texas at Austin, Bureau of Economic Geology, report of research supported by the U. S. Department of Commerce Coastal Energy Impact Program grant through an interagency agreement with the Texas Governor's Budget and Planning Office.

Dix, O. R., and Jackson, M.P.A., 1981, Lithology, microstructures, and fluid inclusions in rock salt and the cap-rock contact in Oakwood Dome, East Texas: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract Nos. DE-AC97-79ET-44605 and DE-AC97-80ET-46617, 109 p.

Dutton, S. P., 1981, Pennsylvanian fan-delta and carbonate deposition, Mobeetie Field, Texas Panhandle: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46615, 24 p.

Finley, R. J., and Baumgardner, R. W., Jr., 1981, Plan for economic evaluation of products from the Remote Sensing Information Subsystem (RSIS) (revised and updated): The University of Texas at Austin, Bureau of Economic Geology, report prepared for the Texas Natural Resources Information System under Interagency Contract No. (80-81)-1676, 10 p. plus appendices.

Finley, R. J., and Baumgardner, R. W., Jr., 1981, Test plan for Remote Sensing Information Subsystem products, test site 1 (coastal): The University of Texas at Austin, Bureau of Economic Geology, report prepared for the Texas Natural Resources Information System and the Texas Department of Water Resources under Interagency Contract No. (78-79)-2045, revised under Interagency Contract No. (80-81)-1676.

Finley, R. J., and Baumgardner, R. W., Jr., 1981, Test plan for Remote Sensing Information Subsystem products: test sites 2 and 5 (High Plains and Trans-Pecos Texas): The University of Texas at Austin, Bureau of Economic Geology, report prepared for the Texas Natural Resources Information System under Contract No. TDWR/TNRIS IAC NO. (80-81)-1935, 32 p.

Finley, R. J., Ledbetter, J. O., and Wermund, E. G., 1981, The feasibility of locating a Texas salt test facility: The

University of Texas at Austin, Bureau of Economic Geology and Bureau of Engineering Research, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46617, 171 p.

Galloway, W. E., 1981, Epigenetic zonation and fluid flow history of uranium-bearing fluvial aquifer systems, South Texas uranium province: The University of Texas at Austin, Bureau of Economic Geology, report prepared for U. S. Geological Survey under Grant No. 14-08-0001-G-633, 59 p.

Galloway, W. E., and Morton, D. A., 1981, Description and interpretation of test cores—Brooks and adjacent counties, South Texas: The University of Texas at Austin, Bureau of Economic Geology, report prepared for Bendix Field Engineering Corporation under Subcontract No. 80-476-E, 62 p. plus 28 unnumbered data sheets.

Giles, A. B., and Wood, D. H., 1981, Petroleum accumulation patterns in the East Texas salt-dome province: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46617, 9 p.

Gregory, A. R., Dodge, M. M., Posey, J. S., and Morton, R. A., 1980 (1981), Volume and accessibility of entrained (solution) methane in deep geopressured reservoirs—Tertiary formations of the Texas Gulf Coast: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC08-78ET11397, 390 p. plus 28 cross sections.

Gustavson, T. C., Bassett, R. L., Finley, R. J., Goldstein, A. G., Handford, C. R., McGowen, J. H., Presley, M. W., Baumgardner, R. W., Jr., Bentley, M. E., Dutton, S. P., Griffin, J. A., Hoadley, A. D., Howard, R. C., McGookey, D. A., McGillis, K. A., Palmer, D. P., Ramondetta, P. J., Roedder, E., Simpkins, W. W., and Wiggins, W. D., 1981, Geology and geohydrology of the Palo Duro Basin, Texas Panhandle: A report on the progress of nuclear waste isolation feasibility studies (1980): The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46615.

Kaiser, W. R., and others, 1981, Using presence of calcite cap rock in shales to predict occurrence of reservoirs composed of leached secondary porosity in the geopressured zone: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC08-79ET27111, 31 p.

Kreitler, C. W., Collins, E. W., Davidson, E. D., Jr., Dix, O. R., Donaldson, G. A., Dutton, S. P., Fogg, G. E., Giles, A. B., Harris, D. W., Jackson, M. P. A., Lopez, C. M., McGowen, M. K., Muehlberger, W. R., Pennington, W. D., Seni, S. J., Wood, D. H., and Wuerch, H. V., 1981, Geology and geohydrology of the East Texas Basin II: A report on the progress of nuclear waste isolation feasibility studies (1980): The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46617, 207 p.

Kreitler, C. W., and Dutton, S. P., 1981, Preliminary report on Oakwood Dome cap rock: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy, under Contract No. DE-AC97-80ET46617, 16 p.

McGillis, K. A., and Presley, M. W., 1981, Tansill, Salado, and Alibates Formations: Upper Permian evaporite/carbonate strata of the Texas Panhandle: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46615, 27 p.

McGowen, J. H., Seni, S. J., Andersen, R. L., and Thurwachter, J. E., 1981, National uranium resource evaluation, Lubbock Quadrangle, Texas: The University of Texas at Austin, Bureau of Economic Geology, report prepared for U. S. Department of Energy, Grand Junction Office, Open-File Report GJQ-012(81), 48 p.

Palmer, D. P., 1981, Clay mineralogy of Permian sabkha sequences, Palo Duro Basin, Texas: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46615, 94 p.

Ramondetta, P. J., 1981, Genesis and emplacement of oil in the San Andres Formation, Northern Shelf of the Midland Basin, Texas: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Department of Energy under Contract No. DE-AC97-80ET46615, 52 p.

Schmedes, K. E., Baumgardner, R. W., Jr., and Finley, R. J., 1981, Economic and accuracy evaluation of mapping techniques used in the coastal applications test site: The University of Texas at Austin, Bureau of Economic Geology, report prepared for Texas Department of Water Resources and Texas Natural Resources Information System, TDWR/TNRIS IAC No. (80-81)-1935. May 1982

Seni, S. J., McGowen, J. H., and Risner, R. S., 1981, National uranium resource evaluation, Amarillo Quadrangle, Texas: The University of Texas at Austin, Bureau of Economic Geology, report prepared for U. S. Department of Energy, Grand Junction Office, Open-File Report GJQ-013(81), 24 p.

Tewalt, S. J., Garner, L. E., and Kaiser, W. R., 1981, Computerized calculation of lignite resources in Texas, report on phases 1 and 2: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U. S. Geological Survey under Grant No. 14-08-0001-G-639.

Weise, B. R., Edwards, M. B., Gregory, A. R., Hamlin, H. S., Jirik, L. A., and Morton, R. A., 1981, Geologic studies of geopressured and hydropressured zones in Texas: test-well site selection: The University of Texas at Austin, Bureau of Economic Geology, report prepared for Gas Research Institute under Contract No. 5011-321-0125, 308 p.

Weise, B. R., Jirik, L. A., Hamlin, H. S., Hallam, S. L., Edwards, M. B. Schatzinger, R. A., Tyler, N., and Morton, R. A., 1981, Geologic studies of geopressured and hydropressured zones in Texas: supplementary tasks (draft): The University of Texas at Austin, Bureau of Economic Geology, report prepared for Gas Research Institute under Contract No. 5011-321-0125.

Woodruff, C. M., Jr., Caran, S. C., Gever, Christine, Henry, C. D., Macpherson, G. L., and McBride, M. W., 1981, Geothermal resource assessment for the State of Texas—status of progress, November 1980, final report (draft): The University of Texas at Austin, Bureau of Economic Geology, report prepared for U. S. Department of Energy, Division of Geothermal Energy, under Contract No. DE-AS07-79ID12057, 248 p. and 8 appendices.

PUBLICATIONS

In its role as public geologic research unit, the Bureau of Economic Geology disseminates the results of research projects and programs primarily through its own publication series. During the 72-year history of the Bureau, more than 700 reports, bulletins, circulars, special publications, and maps have been published covering major aspects of the geology and natural resources of Texas. In addition, more than 500 reports and maps are available to the public through open-file holdings at the Bureau. Publications are sold to interested persons at nominal prices designed to recover printing or duplication costs. To date, more than 1 million publications have been distributed on a worldwide basis, principally through direct sales. During 1981, the Bureau issued the following publications:

REPORTS OF INVESTIGATIONS

Report of Investigations No. 108. Upper Tertiary and Quaternary Depositional Systems, Central Coastal Plain, Texas—Regional Geology of the Coastal Aquifer and Potential Liquid-Waste Repositories, *by Raul Fernando Solis I. 89 p., 41 figs., 12 tables ($3.00).*

This report delineates the distribution of sediments of late Tertiary to Quaternary age in the subsurface of the central Texas Coastal Plain and infers sediment dispersal trends, geometry, and distribution of facies within these depositional systems. The study area constitutes the last major regressive depositional sequence in the Gulf Coast Basin after deposition of late Miocene coastal marine shales.

Subsurface distribution of late Miocene, Pliocene, and Pleistocene sediments, sand-dispersal patterns, depositional systems, and constituent facies define the depositional history of the younger strata beneath the central Coastal Plain of Texas. A determination is made of the relation between depositional systems, faulting, and fresh ground water and shallow gas or petroleum accumulations. The potential for liquid-waste disposal in the subsurface is also evaluated.

Report of Investigations No. 109. Depositional and Diagenetic History of the Sligo and Hosston Formations (Lower Cretaceous) in South Texas, *by D. G. Bebout, D. A. Budd, and R. A. Schatzinger. 69 p., 55 figs., 4 tables ($4.00).*

Over the past seven years, the Bureau of Economic Geology has undertaken a study of the Lower Cretaceous in South Texas, bringing together the available core and summarizing depositional facies, environments, diagenetic histories, and porosity types. This investigation is the final and comprehensive report on the Sligo and Hosston Formations.

Fifty cores were examined from the South Texas area. Facies patterns from nearshore sabkha and tidal flats to shelf-margin coral and rudist reef complexes are described. Diagenetic histories of shelf and shelf-margin sediments are also compared. Fifty-three photographs of core slabs and thirty-two thin-section photomicrographs are included to document and explain these features. The depositional-diagenetic model of the Sligo Formation in South Texas presented here is directly applicable to exploration activity in the Lower Cretaceous around the entire Gulf of Mexico, and to the extensive Early Cretaceous carbonate shelves and shelf-margin banks in many other basins worldwide.

Report of Investigations No. 110. Statistical Analysis of Lineaments and their Relation to Fracturing, Faulting, and Halokinesis in the East Texas Basin, *by Owen R. Dix and M. P. A. Jackson. 30 p., 27 figs., 4 tables ($1.50).*

Lineament analysis is part of a broad spectrum of studies that assess the tectonic stability of the basin to provide generic information on the suitability of salt domes as repositories of high-level nuclear wastes. Black-and-white aerial photographs, at scales between 1:17,400 and 1:25,500, and band-5 Landsat imagery were analyzed. A sequence of statistical operations, designed for this study, enabled lineament preferred orientations to be weighted according to their significance. The effects of photographic scale, land use, and random ordering were also studied.

Northeast-trending and northwest-trending lineament peaks are present throughout the basin. Each main peak is bimodal, with trends of 045° and 055°, and 310° and 325°. The main trends are thought to result from preferential directions of fracture induced by interference folding at depth. This folding is caused by salt flow and is reflected in the regional gravity field. Areas above shallow salt domes, particularly in the southern part of the basin, are associated with higher lineament densities and lower preferred orientation of lineaments than are areas away from domes. This probably reflects radial and concentric fractures above the shallow domes.

Report of Investigations No. 111. Factors Controlling Reservoir Quality in Tertiary Sandstones and Their Significance to Geopressured Geothermal Production, *by R. G. Loucks, D. L. Richmann, and K. L. Milliken. 41 p., 47 figs., 4 tables, 3 appendices ($1.50).*

Comparison of Frio Formation sandstones from the Chocolate Bayou/Danbury Dome area in Brazoria County, Texas, and Vicksburg Formation Sandstone from the McAllen Ranch Field area in Hidalgo County, Texas, reveals that diagenetic modification is influenced by (1) detrital mineralogy and (2) regional geothermal gradients. Other factors, including relative proportions of porosity types, pore geometry as related to permeability, and local

depositional environment, must also be considered in predicting the reservoir quality of a particular site, and, therefore, the geothermal production potential of a specific sandstone unit. This report examines the occurrence and distribution of deep subsurface geothermal reservoirs and aids in identification of areas favorable for geopressured geothermal exploration.

Report of Investigations No. 112. Smackover and Lower Buckner Formations, Jurassic, South Texas: Depositional Systems on a Carbonate Ramp, *by D. A. Budd and R. G. Loucks. 38 p., 26 figs., 3 tables ($2.25).*

This report is a regional stratigraphic investigation of the Smackover and lower part of the Buckner Formations in the South Texas area. The Smackover Formation, a significant hydrocarbon-bearing unit throughout the Gulf Coast Basin, has been deeply buried in South Texas and thus poorly explored. The stratigraphic framework, facies distribution, and depositional histories of these units are outlined, and a model for the depositional systems is presented with analogies to modern carbonate environments. The study is based on detailed core descriptions of four wells that penetrated the Smackover along a regional dip section. Facies patterns and compositions indicate that the potential for both hydrocarbon sources and reservoirs exists. The understanding of the basic depositional and stratigraphic observations presented in this investigation is important to the further exploration of these subsurface units.

GEOLOGICAL CIRCULARS

Geological Circular 81-1. A Preliminary Assessment of the Geologic Setting, Hydrology, and Geochemistry of the Hueco Tanks Geothermal Area, Texas and New Mexico, *by Christopher D. Henry and James K. Gluck. 48 p., 9 figs., 2 tables ($2.00).*

This circular presents available data on the Hueco Tanks geothermal area and recommends further study to evaluate more thoroughly the resource potential of geothermal water there. The area, which contains five known but now inactive hot wells (50° to 71°C), trends north-south along the east side of Tularosa-Hueco Bolson astride the Texas-New Mexico border approximately 40 km northeast of El Paso. Because of its proximity to El Paso, geothermal water in the Hueco Tanks area could be a significant resource.

Hueco Bolson is an asymmetric graben with greatest subsidence along the western side. Faults along the eastern side may allow the rise of thermal waters from depth. Ground water in the central part of Hueco Bolson flows southward to the Rio Grande. However, four of the five hot wells occur in a ground-water trough along the eastern margin of the bolson. The trough may be bounded by one of the postulated faults serving as a barrier to ground-water flow. Data on permeability of potential reservoir rocks, including basin fill and fractured bedrock, suggest that they may be sufficiently permeable for development of geothermal water. Maximum temperatures in shallow reservoirs estimated from chemical compositions of thermal water are about 80° to 110°C.

Geological Circular 81-2. Calderas and Mineralization: Volcanic Geology and Mineralization in the Chinati Caldera Complex, Trans-Pecos Texas, *by Timothy W. Duex and Christopher D. Henry. 14 p., 6 figs., 1 table ($0.75).*

This report describes preliminary results of a continuing study of the volcanic geology, caldera development, and known and potential mineralization in the volcanic field of Trans-Pecos Texas. The recent discoveries of significant hard mineral deposits in Trans-Pecos and the similarity of the area's volcanic geology to that of other areas of known mineral production have spurred interest and exploration in Trans-Pecos. This first report discusses the Chinati caldera complex, one of the most promising areas for mineral exploration in the region.

The Chinati caldera complex consists of at least two resurgent calderas. The youngest and best exposed is the Chinati Mountains caldera; its extrusive products show a systematic whole-rock and trace-element chemical variation that can be related to fractional crystallization of a parent magma. The older Infiernito caldera is truncated by the Chinati Mountains caldera. Mineral deposits in the Chinati Mountains area are genetically related to caldera structures and activity. The most favorable environments for deposits are the ring-fracture zones around the edges of the calderas and the resurgent domes near the center of the calderas.

Geological Circular 81-3. Geology and Geohydrology of the Palo Duro Basin, Texas Panhandle, A Report on the Progress of Nuclear Waste Isolation Feasibility Studies (1980), *by T. C. Gustavson, R. L. Bassett, R. J. Finley, A. G. Goldstein, C. R. Handford, J. H. McGowen, M. W. Presley, R. W. Baumgardner, Jr., M. E. Bentley, S. P. Dutton, J. A. Griffin, A. D. Hoadley, R. C. Howard, D. A. McGookey, K. A. McGillis, D. P. Palmer, P. J. Ramondetta, E. Roedder, W. W. Simpkins, and W. D. Wiggins. 173 p., 92 figs., 11 tables, 1 plate ($4.50).*

The Bureau of Economic Geology is conducting a study of the Palo Duro and Dalhart Basins in the Texas Panhandle as part of the National Waste Terminal Storage program. This report summarizes progress in FY 1980 and is the third in a series of annual reports that cover basin analysis, surface geomorphic studies, host-rock analysis, basin hydrology, and tectonic environment. Significant new data were acquired for direct analysis in the research areas of basin analysis, geomorphology, host-rock analysis, hydrology, and structural geology. Among these were (1) statistical data related to the purity of bedded salt, (2) geochemical and thermal data related to hydrocarbon-bearing rocks and hydrocarbon source beds within the basin, (3) drill-stem test data for regional hydrologic studies of Wolfcampian and Pennsylvanian aquifers, and (4) quantitative geomorphic, erosional, and shallow subsurface salt dissolution data needed to understand the geomorphic processes acting upon the Texas Panhandle area.

Detailed analysis of two salt-bearing cores from the basin has tended to confirm interpretations of depositional

environments developed from analysis of geophysical logs. Core analysis has confirmed estimates of salt quality and has allowed the calibration of geophysical logs. Examination of organic detritus from drill cuttings has established that the thermal maturity of some Pennsylvanian and Wolfcampian shale was sufficient to begin the process of hydrocarbon generation. Hydrologic mapping based on carefully evaluated drill-stem data indicates that flow in Wolfcampian and Pennsylvanian aquifers is toward the east-northeast. An integrated program of hydrologic, geomorphic, and shallow stratigraphic studies continues to provide results describing the processes of erosion and salt dissolution and the rates at which they occur.

Geological Circular 81-4. Impact of Evaporite Dissolution and Collapse on Highways and Other Cultural Features in the Texas Panhandle and Eastern New Mexico, *by William W. Simpkins, Thomas C. Gustavson, Alan B. Alhades, and Ann D. Hoadley. 23 p., 10 figs. ($1.25).*

Thick sequences of Permian evaporites compose a significant part of the sedimentary fill in the Permian Basin of the southwestern United States. The Palo Duro and Dalhart Basins in Texas are under study by the Bureau of Economic Geology as part of the U. S. Department of Energy's National Waste Terminal Storage program. Documentation of environmental hazards caused by evaporite dissolution is a necessary part of this evaluation.

This report reviews the extent of evaporite (primarily salt) dissolution in the Texas Panhandle and eastern New Mexico region. Types of collapse features, such as sinkholes, are discussed. The effects of these collapse features on highways, reservoirs, and stock tanks are documented from information obtained from the U. S. Soil Conservation Service, Agricultural Stabilization and Conservation Service, and the Texas Department of Highways and Public Transportation. The text is accompanied by a map displaying selected collapse features affecting highways, as well as by black-and-white photographs of those features. Some responses to the problem of collapse features are presented.

Geological Circular 81-5. Lineament Analysis Based on Landsat Imagery, Texas Panhandle, *by Robert J. Finley and Thomas C. Gustavson. 37 p., 16 figs., 3 tables, 1 plate ($2.25).*

Analysis of Landsat imagery centered over the Texas Panhandle revealed linear physiographic features including stream channels, stream valleys, scarps, and aligned playa-lake depressions. These lineaments show preferred orientations of 300°- 320°, 030° - 050°, and 0° - 020°, with the 300° - 320° orientation best developed on the surface of the Southern High Plains. Lineament orientations are similar to orientations of joints measured in the field and to regional structural trends, suggesting that development of physiographic lineaments is controlled or influenced by geologic structure. Similarity in orientation is noted between lineament trends and (1) structurally positive features such as the Amarillo Uplift and (2) basement faulting in Texas and eastern New Mexico. A prominent belt of lineaments trends northwest across the Palo Duro Basin; maximum density of lineaments occurs in southern Castro County, Texas.

Included with the circular is a 1:1,000,000-scale map showing more than 4,600 lineaments in the Texas Panhandle, parts of eastern New Mexico, and a small part of the Oklahoma Panhandle. Text figures show lineament length by azimuth summaries for each of 10 1° x 2° map sheets within the study area and show lineament density for a 2° latitude by 4° longitude area over the Palo Duro Basin. Criteria for selection of Landsat imagery and the lineament mapping techniques described may be adapted for use in other areas.

Geological Circular 81-6. Oakwood Salt Dome, East Texas: Surface Geology and Drainage Analysis, *by Edward W. Collins, O. R. Dix, and D. K. Hobday. 23 p., 26 figs., 3 tables ($1.25).*

Over the Oakwood Dome, the Claiborne Group has been uplifted, exposed, and eroded as a result of dome growth. The Carrizo, Reklaw, and Queen City Formations crop out over the dome. Vertically repetitive patterns of stratal thinning of these formations over Oakwood Dome suggest growth contemporaneous with deposition.

Quaternary terrace deposits are poorly preserved and reveal no evidence of warping or faulting related to dome movement. However, geomorphic anomalies, such as cut-off channels, recent stream incision into bedrock and related Holocene terraces, abundant nickpoints in homogeneous bedrock, and evidence from drainage patterns, suggest the possibility of minor dome movement during the Pleistocene Epoch.

Geological Circular 81-7. Geology and Geohydrology of the East Texas Basin, A Report on the Progress of Nuclear Waste Isolation Feasibility Studies (1980), *by C. W. Kreitler, E. W. Collins, E. D. Davidson, Jr., O. R. Dix, G. A. Donaldson, S. P. Dutton, G. E. Fogg, A. B. Giles, D. W. Harris, M. P. A. Jackson, C. M. Lopez, M. K. McGowen, W. R. Muehlberger, W. D. Pennington, S. J. Seni, D. H. Wood, and H. V. Wuerch. 207 p., 119 figs., 15 tables ($5.00).*

The Bureau of Economic Geology is conducting a study of the East Texas Basin as part of the National Waste Terminal Storage program. This report summarizes progress in FY 1980 and is the second in a series of annual reports that cover the tectonic, geologic, and hydrogeologic stability of salt domes in the East Texas Basin. Significant new data sources were acquired that were instrumental in developing new and more detailed understanding of problems associated with salt dome geology and the East Texas Basin. Among these were (1) 636 ft (194 m) of core from calcite and anhydrite cap rock and salt section of Oakwood Dome; and (2) microseismic data from a seismometer on the Mount Enterprise fault system and five hydrologic monitoring wells completed around Oakwood Dome.

The acquisition of the core of the Oakwood cap rock has resulted in a more detailed interpretation of the origin of cap rock. With the salt core from Oakwood, researchers have been attempting to reconstruct the deformation history of the salt by using techniques of strain analysis. The microseismic data suggest that earthquakes are being generated in the Mount Enterprise fault zone. The data from hydrologic monitoring wells have aided in integration of hydrologic and geologic information in constructing

ground-water flow models around salt domes. Continued effort was directed toward reconstructing the geologic history of the basin and the salt domes. Both the basin and the salt domes were most geologically active during Late Jurassic to Early Cretaceous. Rates of basin infilling and dome growth have been declining since that time. Geomorphic studies reveal no evidence of dome growth during Pleistocene or Recent time.

Geological Circular 81-8. Tansill, Salado, and Alibates Formations: Upper Permian Evaporite/Carbonate Strata of the Texas Panhandle, *by K. A. McGillis and M. W. Presley. 31 p., 15 figs., 2 tables ($1.50).*

This report discusses the stratigraphy and facies of the Tansill, Salado, and Alibates Formations, as well as the depositional processes by which these units were formed. The Tansill, Salado, and Alibates Formations are the youngest evaporite and carbonate facies within a thick sequence of Permian evaporites, carbonates, and red beds in the Texas Panhandle and adjacent areas of New Mexico. Salado-Tansill salt originally extended throughout most of the Palo Duro Basin, but its distribution has been modified by dissolution. Determination of extent and lithologic variability of evaporite deposits and analysis of past salt dissolution trends are important components of the Bureau's ongoing geologic and hydrologic analysis of the Texas Panhandle. This report is part of a study funded by the U. S. Department of Energy to determine the feasibility of long-term storage of nuclear waste in Permian salts of the Panhandle area.

MINERAL RESOURCE CIRCULARS

Mineral Resource Circular No. 67. The Aluminum Industry of Texas, *by Terry Barron. 16 p., 5 figs., 16 tables ($1.50).*

Although alumina raw materials are not mined in Texas, imported ores support an important Texas industry. Salient aspects of the Texas aluminum industry are described in this report.

Mineral Resource Circular No. 68. The Mineral Industry of Texas in 1977, *by Murphy E. Hawkins and Thomas J. Evans. 20 p., 1 fig., 15 tables (free on request).*

Mineral Resource Circular No. 69. The Mineral Industry of Texas in 1978-79, *by Murphy E. Hawkins and L. E. Garner. 17 p., 1 fig., 13 tables (free on request).*

A cooperative agreement between the U. S. Bureau of Mines and the Bureau of Economic Geology produces this annual summary of the mineral industry of Texas. These circulars are preprints of the U. S. Bureau of Mines "Minerals Yearbook 1977" and "Minerals Yearbook 1978-79" chapters on Texas. Each year the chapter preprint is distributed by the Bureau free on request.

GEOLOGIC ATLAS OF TEXAS

Geologic Atlas of Texas, Llano Sheet, Virgil Everett Barnes Edition. *Virgil E. Barnes, project director. Scale 1:250,000, in full color, topographic base ($4.00).*

The Llano sheet includes all of Llano, Mason, and Gillespie Counties, most of Burnet, Blanco, Kerr, Kimble, and Menard Counties, and smaller parts of McCulloch, San Saba, Travis, Hays, Comal, Kendall, Real, and Edwards Counties. Mapping is mostly from published sources and by Virgil E. Barnes; some data are from unpublished sources. The map was reviewed by the Geologic Atlas Committee of the Austin Geological Society.

The Llano sheet is the only sheet of the atlas series that is not a memorial edition. Instead the edition is named for a living geologist, the Bureau's own Dr. Virgil E. Barnes, who has served as project director of the Geologic Atlas of Texas project since 1961. Dr. Barnes has been with the Bureau since 1935 and served as associate director from 1961 to 1968. Dr. Barnes' first work for the Bureau was in the Llano area, and he has more than 200 articles and reports to his credit, many of them concerning that area. In the preface to the Llano sheet, Dr. Fisher noted that dedication of the sheet to Dr. Barnes is "not an act of vanity on his part, but rather the sincere feeling of his colleagues at the Bureau, and I am certain, of many others elsewhere that Llano geology is too synonymous with Virgil E. Barnes for the dedication to be otherwise."

Geologic Atlas of Texas, Sonora Sheet, Roy Thorpe Hazzard Memorial Edition, *Virgil E. Barnes, project director. Scale 1:250,000, in full color, topographic base ($4.00).*

The Sonora sheet includes all of Sutton County, most of Crockett and Schleicher Counties, and smaller parts of Edwards, Val Verde, Terrell, Pecos, Menard, and Kimble Counties. Mapping was done mostly by Shell Development Company and Dawn McKalips. The map was reviewed by the Geologic Atlas Committee of the West Texas Geological Society.

The Sonora sheet is a memorial edition honoring Roy Thorpe Hazzard, 1893-1975. Hazzard, during his professional career in oil geology, mapped extensively in West Texas and later collaborated with the Bureau in publishing the stratigraphy of Big Bend National Park.

SPECIAL PUBLICATIONS

Bibliography and Index of Texas Geology, 1975-1980, *by Amanda R. Masterson. 334 p. ($8.00).*

The fifth in a series of bibliographies and indexes of Texas geology published by the Bureau of Economic Geology, this volume joins University of Texas Bulletin 3232 (covering material published before 1932), University of Texas Publication 5910 (1933 to 1950), a Bureau Special Publication by Elizabeth T. Moore and Margaret D. Brown (1951 to 1960), and a Bureau Special Publication by Elizabeth T. Moore (1961 to 1974). The present volume lists more than 3,600 abstracts, articles, reports, books, maps, and theses and dissertations on Texas geology and related fields published or reprinted from 1975 through 1980 that were available in early 1981.

Articles were selected for inclusion in this bibliography according to the following criteria: (1) the area discussed is located in Texas or in the Gulf of Mexico near Texas; (2) the work was published or reprinted during the years 1975 through 1980, and was available in early 1981; (3) the subject matter pertains to geology or to a related scientific discipline; and (4) the work addresses an audience composed of both general readers and scientists or technical experts. This volume contains a list of abbreviations and addresses of the sources used in compiling the *Bibliography,* the bibliography itself, a subject index, and an author index.

History of the Bureau of Economic Geology, 1909-1960, *by W. Keene Ferguson. 329 p., photos, 7 appendices ($6.00; clothbound, $11.00).*

A companion to *Geology and Politics in Frontier Texas, 1845-1909* (University of Texas Press, 1969) by the same author, this volume looks at the Bureau of Economic Geology during its first 50 years.

CROSS SECTIONS

Middle and Upper Permian Salt-Bearing Strata of the Texas Panhandle: Lithologic and Facies Cross Sections, *by Mark W. Presley. 10 p., 3 figs., 3 tables, 7 pls. ($4.00).*

Regional cross sections of Middle and Upper Permian rocks in the Texas Panhandle illustrate the lithology, depositional systems, and structure of these salt-bearing strata. This report explains the interpretative techniques used in preparation of the cross sections that accompany the text, and highlights significant geologic relationships displayed on the cross sections.

Regional Cross Sections of the Texas Panhandle: Precambrian to Mid-Permian, *by C. Robertson Handford, Shirley P. Dutton, and Paul E. Fredericks. 8 p., 2 figs., 1 table, 7 pls. ($3.00).*

The Texas Panhandle traditionally has been an important source of mineral resources, especially petroleum, and resources will continue to contribute heavily to the economy of the area. Since 1977 the Bureau of Economic Geology, with funding provided by the U. S. Department of Energy, has been conducting intensive basin-analysis studies in the Texas Panhandle. The seven cross sections of this report synthesize the subsurface geology of the region. They illustrate the genetic stratigraphic framework of the pre-evaporite, principally Pennsylvanian and Lower Permian, rocks in those parts of the Anadarko, Dalhart, Palo Duro, and northern Midland Basins that lie within the Texas Panhandle. Six depositional systems and component facies are delineated and illustrated on the cross sections: wadi plain, sabkha, fan delta, delta, shelf and shelf margin, and basin and slope.

The cross sections are all published at a vertical scale of 1 inch = 800 ft and a horizontal scale of 1 inch = 12 mi. In addition to the cross sections, the report also contains a bibliography of papers on Panhandle geology and modern and ancient depositional systems similar to those of the Panhandle.

Regional Structural Cross Sections and General Stratigraphy, East Texas Basin, *by Debra H. Wood and Edgar H. Guevara. 21 p., 9 figs., 1 table, 8 pls. ($5.00).*

Jurassic, Cretaceous, and Tertiary sediments in the East Texas Basin have been structurally modified by movement of Middle Jurassic Louann Salt. Important structural elements in the basin include salt diapirs, deep salt anticlines and turtle-structure anticlines as well as prominent fault systems. This set of eight regional structural cross sections shows the general stratigraphy and structure of the basin and illustrates the effect of salt movement. Accompanying the cross sections is a brief discussion of the regional structure and stratigraphy. A table of lithologic descriptions for each formation, correlation notes, and selected references is also included.

Structural Cross Sections, Tertiary Formations, Texas Gulf Coast, *by M. M. Dodge and J. S. Posey. 6 p., 2 figs., 32 pls. ($7.00).*

As part of the regional assessment of solution methane in the formation waters of the Texas Gulf Coast, a grid of structural cross sections was constructed. Included are 24 structural dip cross sections, spaced 15 to 20 mi apart along the Texas coast, and 4 structural strike cross sections. Dip sections extend from near the Wilcox outcrop to the coastline.

Tops of formations were chosen by correlations with Wilcox, Vicksburg, and Frio stratigraphic cross sections constructed in previous geothermal investigations. Formations include upper Oligocene to Pleistocene (undifferentiated); Frio; Vicksburg-Jackson (undifferentiated); upper and lower Claiborne (upper Claiborne being the Yegua Formation); and upper, middle, and lower Wilcox.

Salt domes and growth faults shown on cross sections were taken from structural maps prepared by GeoMap Company. Areas of high fault density are commonly shown schematically as a single fault with average dip and cumulative displacement. Bottom-hole temperatures are shown on the cross sections as well as the 200°, 300°, and 350°F isotherms where calculations were possible. Mud weights from well headers and paleontological markers are also shown where available. The top of geopressure (0.7 psi/ft) is marked on wells where possible.

The cross sections are accompanied by a base map showing well locations and a text briefly describing the geologic history of the Tertiary sediments in the Texas Gulf Coast.

PUBLICATIONS REPRINTED

Guidebook 2. Texas Fossils: An Amateur Collector's Handbook, *by W. H. Matthews III. 123 p., 26 figs., 49 pls., 1960 (eighth printing, $1.00).*

Guidebook 10. Geologic and Historic Guide to the State Parks of Texas, *by R. A. Maxwell. With contributions by L. F. Brown, Jr., G. K. Eifler, Jr., and L. E. Garner. 197 p., 98 figs., 2 tables, 1 plate, 1970 (third printing, $3.00).*

Report of Investigations No. 75. Depositional Systems and Shelf-Slope Relationships in Upper Pennsylvanian Rocks, North-Central Texas, *by W. E. Galloway and L. F. Brown, Jr. 62 p., 31 figs., 5 pls., 1972 (second printing, $3.00).*

Report of Investigations No. 86. Environmental Geology of the Austin Area: An Aid to Urban Planning, *by L. E. Garner and K. P. Young. 39 p., 21 figs., 7 tables, 7 pls., including 3 in color, 1976 (second printing, $3.00).*

Report of Investigations No. 87. Catahoula Formation of the Texas Coastal Plain—Depositional Systems, Composition, Structural Development, Ground-Water Flow History, and Uranium Distribution, *by W. E. Galloway. 59 p., 31 figs., 2 tables, 4 pls., 1977 (second printing, $3.00).*

Report of Investigations No. 89. Cretaceous Carbonates of Texas and Mexico—Applications to Subsurface Exploration, *D. G. Bebout and R. G. Loucks, Editors. 25 papers, 322 p., 1977 (second printing, $8.50).*

Bulletin 3232. The Geology of Texas, Vol. I, Stratigraphy, *by E. H. Sellards, W. S. Adkins, and F. B. Plummer. 1,007 p., 54 figs., 10 pls., including frontispiece, 1932 [1933], accompanied by Geological Highway Map of Texas provided by American Association of Petroleum Geologists (eighth printing, $8.00).*

Research Note 10. Lower Cretaceous Carbonate Tidal Facies of Central Texas, *by R. G. Loucks, A. J. Scott, D. G. Bebout, and P. A. Mench. 45 p., illus., 1978. Reprint of a field trip guidebook prepared for Gulf Coast Association of Geological Societies, 27th Annual Meeting, 1977, Austin, Texas (second printing, $1.50).*

Energy Resources of Texas. *Mapping compiled by A. E. St. Clair, T. J. Evans, and L. E. Garner; assisted by K. E. Nemeth and W. P. Bartow. Scale 1:1,000,000, in full color, 1976 (second printing, $4.50).*

Geologic Atlas of Texas: Amarillo Sheet, Leroy Thompson Patton Memorial Edition, *V. E. Barnes, Project Director. 1969 (second printing, $4.00).*

Geologic Atlas of Texas: Austin Sheet, Francis Luther Whitney Memorial Edition, *V. E. Barnes, Project Director. 1974 (second printing, $4.00).*

OPEN-FILE MATERIAL

The Bureau of Economic Geology maintains open files of reports, maps, manuscripts, and various data. Some have been obtained from private and governmental sources; some are unpublished materials developed at the Bureau of Economic Geology. These files may be examined and copied at the Bureau offices.

The Bureau of Economic Geology is a repository for open-file reports of the U. S. Department of Energy (DOE), formerly U. S. Energy Research and Development Administration (ERDA). Because of limited space, only those reports pertaining to Texas, plus reports of special interest, are filed at the Bureau. Others are transferred to the Geology Library of The University of Texas at Austin. Information concerning DOE and ERDA open-file reports may be obtained from the Technical Library, Grand Junction Office, U. S. Department of Energy, Box 2567, Grand Junction, Colorado 81502 (telephone: 303-242-8621, ext. 279), and also from the Bureau of Economic Geology.

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

SERVICES

COMPUTER SERVICES

The computer services staff, now consisting of five full-time employees, continued to provide expanded programming and hardware services in 1981 to support Bureau administrative and research needs. Tasks initiated in earlier years and continued or completed in 1981 include a publication sales data base and data systems for geothermal and nuclear waste isolation studies. A comprehensive data storage and reporting system for contract personnel cost management was initiated. To support scientists in computer applications, additional data lines, terminals, and technical consultancy have been provided in the Bureau's various locations. A 36-inch Houston Instrument DPS three-color drum plotter and a 3 ft x 4 ft Summagraphics digitizing tablet have been installed to enhance the computer mapping and graphics capabilities.

PUBLIC INFORMATION SERVICES

The Bureau of Economic Geology, functioning as an information center, a repository of geological materials, and a publisher of geological reports and maps, provides a variety of information services to the public.

Daily requests for information about Texas geology and geological resources come to the Bureau from a wide spectrum of the public, including geologists, teachers, hobbyists, students, landowners, and other interested individuals, as well as representatives of companies, governmental agencies, and other organizations.

Much information is available in the Bureau's published reports and maps, which present data developed through Bureau research programs. The publication sales group, supervised by Eloise Hill and Bettye Blitch, responds to requests for Bureau publications. Staff members who, in addition to other duties, handle mail and telephone requests and assist visitors who wish to purchase publications include Debbie Gandy, Harpreet Kang, Frances Kirkpatrick, Lauren Moffatt, Natalie Potts, and Betty Sarrels.

The Bureau also responds to requests for special information. Many members of the full-time research staff provide advisory and technical services, as requested, in their areas of expertise in mineral, land, and energy resources. In addition, Roselle Girard and Mary McBride handle many requests for information about general Texas geology, mineral resources, references, and Bureau programs and publications.

The Bureau's Reading Room, located on the fifth floor of the Geology Building, is open for public use from 8 a. m. to 5 p. m. Monday through Friday. It contains publications pertaining to Texas geology and mineral resources, various journals, and other publications.

Also of interest to the public is the Bureau's collection of open-file reports. Included in the collection are reports received from the U. S. Department of Energy and other sources and also an assortment of unpublished reports that have been prepared by the Bureau of Economic Geology. Bureau staffer Kay Forward maintains these open files and makes arrangements for copying specified reports requested by the public.

The Bureau of Economic Geology provides ongoing services to governmental agencies by participating (1) in reviews of environmental impact statements that are submitted to the Office of the Governor of Texas and (2) in reviews of permit applications that are submitted to the Surface Mining and Reclamation Division of the Railroad Commission of Texas. Mary L. W. Jackson coordinates the Bureau's participation in these reviews.

MINERAL STUDIES LABORATORY

The Mineral Studies Laboratory (MSL) has added new analytical capabilities in support of the Bureau's expanded areas of research. New fumehoods were installed, and a new coal lab has been set up for characterization of Texas lignite. The Texas Energy and Natural Resources Advisory Council and The University of Texas at Austin each contributed $50,000 for instruments for the coal lab. In addition, a new Norelco X-ray diffractometer has also been added through a DOE contract.

The existing facility and the newly acquired equipment increase the scope of analytical research capabilities especially for coal characterization. The MSL will develop

techniques for characterization as follows: Proximate analysis will be determined with a thermogravimetric analyzer; the analysis provides quantitative data on moisture, volatile matter, fixed carbon, and ash content. Heat content (or Btu/lb) and thermal characteristics will be analyzed using a pressurized scanning calorimeter and Parr calorimeter. Ultimate analysis (CHN) includes analysis by an automatic CHN analyzer. Further, total-S (organic-S, sulfate-S, and sulfide-S) will be obtained by an automatic sulfur analyzer, and halides determined by methods already established at the MSL. The determination of oxide composition in coal ash will utilize an ICP (inductively coupled plasma atomic emission spectrometer). Coal mineralogy can be determined by X-ray diffraction following low-temperature ashing with an oxygen plasma asher. Determination of metals in coal, especially the toxic metals such as Hg, U, Cd, As, Se, and so on, will use ICP and methods previously established at the MSL.

The ICP at the MSL has been upgraded this year with four new channels (Si, La, Ce, and Rb), thus enabling the spectrometer to analyze a total of 34 elements simultaneously once the elements are rendered in solution.

During 1981 the MSL analyzed 3,758 geologic samples and 2,916 water samples for various Bureau projects. The requirement for high accuracy and precision in many of these analyses has led to the development of many improved analytical techniques, especially by ICP.

During 1981 the sedimentology laboratory completed textural analyses for 950 samples on the State-Owned Submerged Lands Project, including Beaumont-Port Arthur, Port Lavaca, Bay City-Freeport, Kingsville, and Corpus Christi sheets, and for 362 samples related to the East Texas Waste Isolation Project, the West Texas Waste Isolation Project, and a Monahan's dune migration study. Total carbonate analysis was completed on 63 Sabine Lake and Neches-Sabine Channel samples.

The MSL has also participated in round-robin test programs conducted by subcommittees of the American Society for Testing Materials (ASTM), the National Bureau of Standards (NBS), the Bureau of Mines in North Dakota, the United States Geological Survey (USGS), and the International Geostandards working group for analyses of water, coals, peats, and iron ores.

WELL SAMPLE AND CORE LIBRARY

The Well Sample and Core Library (WSL) provides the public as well as Bureau researchers and UT students with access to more than 2,500 well cores, 90,000 sets of drill cuttings, and approximately 400,000 driller's logs of oil, gas, and water wells primarily from Texas. Interested persons may visit the facilities located at Balcones Research Center from 8 a.m. to 5 p.m. Monday through Friday. Cores and cuttings may also be checked out for study; the borrower pays transportation costs. Binocular scopes and other equipment are available for use at the library.

With the possibility of a new well sample library becoming greater, the Bureau has been actively soliciting core and cuttings. The staff has been rearranging the current inventory to provide space for new donations. Three major donations were received during 1981. Cities Service Oil of Tulsa, Oklahoma, donated core and cuttings from approximately 100 wells. West Texas State University at Canyon donated drill cuttings of more than 600 wells from the Panhandle area, and Houston Oil & Minerals of Denver, Colorado, donated core from 32 wells, totaling more than 44,000 ft from the Brownwood area. Other donors to the library include Andover Oil Co., Dow Chemical Co., Elf Aquitaine Oil & Gas, William G. Ellis, Forest Oil Co., McCormick Oil & Gas, Hunt Energy Corp., Cities Service Oil of Houston, L. L. & E., Jennings Exploration, Jones Exploration, Reading & Bates Petroleum, Shell Oil Co., Tenneco Oil & Gas, Napeco, Pruet Production Co., and Core Lab of Oklahoma City and Carrizo Springs. Donations during 1981 totaled approximately 120 cores and 650 sets of drill cuttings.

Other activities at WSL included the impregnation and slabbing of 118 ft of unconsolidated cores from the Persian Gulf. This project was contracted by Gulf Research and Development of Houston. After the cores were impregnated and slabbed, both halves were mounted on acrylic sheet with polyester resin, giving Gulf Research and Development and the Bureau each an excellent teaching set.

The Nuclear Waste Isolation Program has completed coring 3,933 ft from Donley County and is now coring another well to a depth of approximately 5,000 ft in Oldham County. WSL is participating in this project by providing transportation from the well site to Austin, where we will slab the core, apply permanent orientation and footage marks, seal the core in plastic, and place it in boxes. The library will then shelve and catalog both the archival and sampling halves of the core and keep a permanent log of all samples taken from the core.

Generation of a computer printout of drill cuttings housed here has long been a goal of WSL. Data of all drill cuttings have been entered onto Fortran sheets. These data must now be entered into the computer, checked for accuracy, corrected, and rechecked before the printout will be available.

Although the number of non-Bureau patrons visiting WSL dropped slightly in 1981, the number of borrowed cores and cuttings has increased. Between January 1 and December 1, 1981, 234 cores and 311 sets of drill cuttings were checked out to non-Bureau patrons. Also during this same period, the petrographic thin-section laboratory produced 1,043 thin sections.

PERSONNEL

RESEARCH STAFF

REGENTS COMMIT TO NEW BUREAU OF ECONOMIC GEOLOGY FACILITIES AT BALCONES RESEARCH CENTER

In an October meeting, The University of Texas Regents committed nearly $53 million for construction of new energy research facilities on the grounds of the Balcones Research Center, located on more than 475 acres in northwest Austin. As a result, the Bureau of Economic Geology will have all new buildings, located at the entrance to the new complex. One set of buildings will include a new two-story building, which will house the Well Sample Library (WSL) preparation and study rooms on the ground floor and the Mineral Studies Laboratory (MSL) on the second floor. This building will connect with forklift passages to a large core and sample warehouse.

A Bureau committee is working with the architectural firm of Barnes, Landes, Goodman and Youngblood. At the end of the year, a conceptual design for MSL/WSL facilities was well along. Meetings to design a new administrative research building, to be located across the entry boulevard, will begin in mid-January.

Other facilities in the new energy center include buildings for the Center for Electromechanics, the Center for Energy Studies, a Commons, and a Service Center.

TEXAS MINING AND MINERAL RESOURCES RESEARCH INSTITUTE

The Texas Mining and Mineral Resources Research Institute (TMMRRI) is one of 31 similar state institutes operating with partial Federal funding administered by the Office of Surface Mining, U. S. Department of the Interior. Created in 1978, the state institutes administer Federal and certain matching State funds dedicated to developing and improving educational opportunities and research programs in the field of minerals and mining science and technology. Long-range goals are to strengthen the nation's capability to provide mineral commodities vital to the national interest.

The Texas Mining and Mineral Resources Research Institute operates as a component of the Bureau of Economic Geology. The Institute administers research grants, fellowships, scholarships, and certain State-Federal cost sharing programs for The University of Texas at Austin, Texas A & M University, and Prairie View A & M University.

During 1981, TMMRRI supported research in "Estimating Uncertainties in Coal Resources and Cost Estimates," "Mineralization in Trans-Pecos Texas," "Rheology of Viscoelastic Fluids for Oil Recovery," "Hydrologic Evaluation of Deep-Basin Lignite," and "Applied Coal Geoscience and the Electric Utilities." Twelve graduate fellowships and undergraduate scholarships at The University of Texas at Austin, Texas A & M University, and Prairie View A & M University were administered in 1981 by TMMRRI.

The first director of TMMRRI, Dr. W. C. J. van Rensburg, resigned his position in August to accept full-time teaching duties in the UT Department of Petroleum Engineering. Dr. L. F. Brown, Jr., Associate Director of the Bureau, assumed the directorship in August.

STUDENT RESEARCH ASSISTANTS

For its research programs, the Bureau of Economic Geology each year employs graduate and undergraduate students as part-time research assistants. During 1981, 128 students were employed, chiefly from the area of geology, but also from chemistry, biology, engineering, and computer science.

These students contribute substantially to the conduct and completion of Bureau research programs, while receiving valuable on-the-job research experience as an important extension of their academic training.

In addition, the Bureau awards a number of scholarships to students at The University of Texas at Austin, at Texas A & M University, and at Prairie View A & M University from Federal funds provided by the Texas Mining and Mineral Resources Research Institute. A few students at other universities in the state also received modest support of their graduate research.

UNIVERSITY COAL RESEARCH CONSORTIUM

The Texas University Coal Research Consortium (UCRC) met at 2-month intervals during 1981. Bureau Associate Director E. G. Wermund is chairman of the Consortium.

Principal activities during the year were evaluations of proposals and initiation of efforts to formulate a 10-year plan for coal research in Texas. UCRC helps the Texas Energy and Natural Resources Advisory Council evaluate proposals by directing reviews by expert University faculty and staff members and by conducting a final review for recommending the offer of contracts. Ten-year planning is in an early process of data gathering and correlation.

The UCRC gives the characterization of deep-basin lignite the highest priority for research on Texas coals.

NEW RESEARCH STAFF MEMBERS

Walt Ayers

Walt Ayers, assigned to the Deep-Basin Lignite project, joined the research staff as a Research Scientist Associate IV in September. Walt has a B.S. degree and an M.S. degree, both in geology, from West Virginia University. He is a Ph.D. candidate at UT, where he is doing research on clastic depositional systems. Walt was with the Bureau previously from 1979 to June of this year, working as a research assistant on the Lignite Resources in Texas and the Coal Uncertainties projects. Before that he taught geology at Winthrop College, South Carolina, and at Tidewater Community College in Virginia.

Sam-Jae Cho

Sam-Jae (Paul) Cho joined the Bureau staff as a Research Engineering Associate III in February. A native of Korea, he has a bachelor's degree in mineral and petroleum engineering from Seoul National University, Korea, and a master's degree in petroleum engineering from The University of Texas at Austin. His postgraduate studies at UT have involved reservoir simulation in geopressured reservoirs, and he is currently involved with the Bureau's Dispersed Gas project. He previously worked with the Center for Energy Studies at UT as a part-time research assistant.

Zsay-Shing Lin

Zsay-Shing Lin joined the Bureau staff in June as a Research Associate after completing his Ph.D. in petroleum engineering at the University of Kansas. He received a B.S. in physical oceanography in 1970 from the University of Chinese Culture and in 1974 received an M.S. in geophysics from the National Taiwan University; both universities are in Taiwan, Republic of China.

Before working on his Ph.D. degree, Zsay-Shing was employed as a geophysicist for several years with the Chinese Petroleum Corporation (CPC) and taught geophysics, dynamic oceanography, and physical oceanography at the University of Chinese Culture and the National Taiwan College of Marine and Oceanic Technology. His Bureau duties involve petroleum engineering and economic studies as part of the Dispersed Gas project.

Jonathan Price

Jonathan Price joined the Bureau staff in January as a Research Scientist Associate V. Before moving to Austin, Jon worked for U. S. Steel Corporation in Corpus Christi, where his research centered on exploration for uranium deposits in Tertiary sandstones of South Texas.

Jon received a B.S. in geology from Lehigh University prior to earning his M.A. and Ph.D. degrees from the University of California at Berkeley. His studies there were concentrated in geochemistry, mineralogy, petrology, and structural geology. His Bureau research concerns the potential for mining mineral resources in Texas, initially focusing on Trans-Pecos Texas.

Stephen C. Ruppel

Stephen C. Ruppel joined the Bureau staff in June as a Research Associate to work on the West Texas Waste Isolation project. His major areas of research involve facies, petrography, and geochemistry.

He received his B.S. from the University of Illinois, Urbana, in 1969; his M.S. from the University of Florida, Gainesville, in 1971; and his Ph.D. from the University of Tennessee, Knoxville, in 1979.

Previous employment has included working as a research associate for McGill University, as a teaching assistant at the University of Tennessee, and as a teaching assistant at the University of Florida. He has also worked as a development geologist for Chevron Oil Company in New Orleans, as a field geologist for Instituto Geografico Nacionale de Guatemala in Guatemala City, and as a technical and research assistant for the Illinois State Geological Survey.

David Anderson (Andy) Smith

Andy Smith joined the Bureau staff in August as a Research Scientist Associate II. He has a bachelor's degree in geology from Florida State University, Tallahassee, Florida, and a master's degree in geology from the University of South Florida in Tampa. His master's thesis involved the geochemistry of a sewage sludge disposal pond.

Andy previously worked with the U. S. Geological Survey Water Resources Division, Tampa, Florida, as a hydrologist. He is assigned to the Bureau's West Texas Waste Isolation project.

Noel Tyler

Noel Tyler joined the Bureau staff in January as a Research Scientist Associate IV. A South African, Noel graduated from the Economic Geology Research Unit, University of the Witwatersrand, S. A., earning an M.Sc. (cum laude) degree. He recently completed his doctoral study at Colorado State University, where he conducted research on sedimentary controls on uranium-vanadium mineralization on the Colorado Plateau.

Noel's current research interests include the study of ore deposits in sedimentary basins and the importance of unconformities in the rock record.

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

In addition to reports published by the Bureau of Economic Geology, staff members also write papers that are issued by other organizations in journals, proceedings, and other professional publications. During 1981, the following papers by Bureau staff members were published outside the Bureau:

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Macpherson, G. L., and Woodruff, C. M., Jr., 1981, Regional hydrologic trends and their relation to sediment textures of Cretaceous aquifers, North-Central Texas: Geological Society of America, Abstracts with Programs, v. 13, no. 5, p. 241.

McBride, M. W., 1981, Fluvial and deltaic sediments of Late Jurassic - Early Cretaceous age along the western margins of the East Texas Basin: Geological Society of America, Abstracts with Programs, v. 13, no. 5, p. 241.

Magara, Kinji, 1981, Capping rock and its formation: American Association of Petroleum Geologists Bulletin, v. 65, no. 5, p. 952.

Mathew, D., Bauer, M. A., and Tewalt, S. J., 1981, Near-surface lignites of the Wilcox Group in east-central Texas: Gulf Coast Association of Geological Societies Transactions, v. 31, p. 148.

Morton, R. A., 1981, Factors critical to the development of energy resources from geopressured aquifers in Texas: Geological Society of America, Abstracts with Programs, v. 13, no. 5, p. 259.

Ruppel, S. C., 1981, Omission surfaces in the Quebec Middle Ordovician: nature and possible origin: Geological Society of America, Abstracts with Programs, v. 13, no. 7, p. 543.

Simpkins, W. W., Bassett, R. L., Bentley, M. E., and Fogg, G. E., 1981, Processes of salt dissolution and saline ground-water discharge in the Rolling Plains region of the Texas Panhandle: Geological Society of America, Abstracts with Programs, v. 13, no. 5, p. 262.

Solis, R. F., 1981, Late Tertiary and Quaternary depositional systems in the subsurface of central Texas Coastal Plain: Gulf Coast Association of Geological Societies Transactions, v. 31, p. 389.

Thompson, E. J., Woodruff, C. M., Jr., and Caran, S. C., 1981, Lineaments and correlative surface and subsurface features near Austin, Texas: Geological Society of America, Abstracts with Programs, v. 13, no. 5, p. 263.

Tyler, Noel, 1981, Deltaic and associated shallow marine deposits in the deep Frio Formation, Brazoria County, Texas: Society of Economic Paleontologists and Mineralogists, Gulf Coast Section, Second Annual Research Conference, p. 68-74.

Tyler, Noel (with *Button, A.*), 1981, Unconformity controls on mineralization through Precambrian time with special reference to southern Africa, *in* Sediments through the ages: Perth, Geological Society of Australia, abstract volume, p. 2.

Tyler, Noel, and Ethridge, F. G., 1981, Fluvial architecture of Jurassic uranium-bearing sandstones, Colorado Plateau, U. S. A.: University of Keele, U. K., Symposium on Modern and Ancient Fluvial Systems: Sedimentology and Processes, abstract volume, p. 123.

Winker, C. D., 1981, Structural style and evolution of three geopressured geothermal prospect areas, Texas Gulf Coast: Geological Society of America, Abstracts with Programs, v. 13, no. 5, p. 264-265.

Winker, C. D., and Edwards, M. B., 1981, Unstable progradational clastic shelf margins: American Association of Petroleum Geologists Bulletin, v. 65, no. 5, p. 1008.

Woodruff, C. M., Jr., Caran, S. C., and Thompson, E. J., 1981, Lineaments in Texas perceived through Landsat imagery: Texas Academy of Science, Supplement to 84th Annual Meeting, p. 82.

Woodruff, C. M., Jr., and Henry, C. D., 1981, Edwards aquifer "bad-water line" in Bexar County, Texas—lithic, geochemical, and geothermal attributes: Geological Society of America, Abstracts with Programs, v. 13, no. 5, p. 265.

LECTURES AND PUBLIC ADDRESSES

Walter B. Ayers, Jr.

Deep-basin coal in the Powder River Basin, Wyoming: presented to the Mobil Field Research Laboratory, Mobil Research and Development Corporation, Dallas, Texas.

Randy L. Bassett

Geochemistry and hydrogeology of the Palo Duro Basin: presented to the Office of Nuclear Waste Isolation Geologic Review Group, U.S. Department of Energy, Austin, Texas.

Geohydrology of the West Texas Waste Isolation project: presented to the Nuclear Regulatory Commission Review Committee, Austin, Texas.

Robert W. Baumgardner, Jr.

Flood hazards of Central Texas: presented at the Travis Audubon Society, July general meeting, Austin, Texas.

The Remote Sensing Information Subsystem: applications in the Coastal Zone, the High Plains, and the Trans-Pecos region of Texas: presented (with Robert J. Finley) at the Regional Conference on the Operational Land Remote Sensing Program (sponsored by the National Oceanic and Atmospheric Administration and the Texas Natural Resources Information System), Austin, Texas.

S. Christopher Caran

Brushy Creek lineament in Central Texas—a zone of geologic discontinuity perceived using Landsat imagery: presented (with C. M. Woodruff, Jr.) at a poster session, Remote Sensing Short Course, Regional Conference on the Operational Land Remote Sensing Program (sponsored by the National Oceanic and Atmospheric Administration and the Texas Natural Resources Information System), Austin, Texas.

Inferring function from form: physiological interpretation of vertebrate fossils: presented at the summer enrichment program for gifted science students, Texas Memorial Museum, Austin, Texas.

Sam J. Cho

An application of the variational method to the diffusivity equation: presented at the New Mexico Institute of Mining and Technology (sponsored by the Department of Petroleum Engineering, New Mexico Institute of Mining and Technology), Socorro, New Mexico.

E. Dow Davidson

Establishing a continental curatorial communications network: how do we stay in touch?: presented at the Workshop on Core and Sample Curation for the Continental Scientific Drilling Program, National Security and Resources Study Center, Los Alamos National Laboratory (sponsored by the Office of Basic Energy Sciences, U.S. Department of Energy), Los Alamos, New Mexico.

Shirley P. Dutton

Combination structural and stratigraphic traps in Pennsylvanian granite wash, Mobeetie Field, Anadarko Basin: presented at the Southwest Section of the American Association of Petroleum Geologists, Annual Meeting, San Angelo, and at a meeting of the Permian Basin Section of the Society of Economic Paleontologists and Mineralogists, Midland, Texas.

Pennsylvanian fan-delta and carbonate deposition, Mobeetie Field, Texas Panhandle: presented at an Oklahoma City Geological Society meeting, Oklahoma City, Oklahoma, and at a Tulsa Geological Society meeting, Tulsa, Oklahoma.

Thomas E. Ewing

Cretaceous volcanism in the Austin area, Texas: presented at the Austin Geological Society spring field trip.

Mountains and volcanoes: presented to a third-grade class, Sunset Valley Elementary School, Austin, Texas.

Robert J. Finley

The Remote Sensing Information Subsystem: applications in the Coastal Zone, the High Plains, and the Trans-Pecos region of Texas: presented (with Robert W. Baumgardner, Jr.) at the Regional Conference on the Operational Land Remote Sensing Program (sponsored by the National Oceanic and Atmospheric Administration and the Texas Natural Resources Information System), Austin, Texas.

W. L. Fisher

Developments in national energy issues: presented at the World Oil Show and Conference, Dallas, Texas.

Elements of oil and natural gas policy: presented at the Symposium on Energy Policy in Perspective (sponsored by LBJ School of Public Affairs, LBJ Library, and Brookings Institution), Austin, Texas.

Future trends in geologic employment: presented as the Banquet Address, Geological Society of America, South-Central Section, 15th Annual Meeting, San Antonio, Texas.

Geological parameters in enhanced oil recovery: presented as the Keynote Address, U.S. Department of Energy, Workshop on Geologic Impact in Enhanced Oil Recovery, Tulsa, Oklahoma.

Issues of the U.S. Federal Offshore: presented at a press conference, American Association of Petroleum Geologists, San Francisco, California.

Mining in the Texas economy: presented to the Texas Mining and Reclamation Association, South Padre Island, Texas.

On oil and gas in the Gulf Coast Basin: a look at the recent past with some observations on the future: presented as the Keynote Address, Gulf Coast Association of Geological Societies, Annual Meeting, Corpus Christi, Texas.

Perspectives on energy: presented at Western Michigan University, Symposium on Energy and the Economy, Kalamazoo, Michigan.

U.S. energy: are we heading toward solution?: presented as the Banquet Address, Texas Chapter, Society of Sigma Xi, Austin, Texas.

Graham E. Fogg

Radionuclide transport around salt domes in the East Texas Basin: presented at the Symposium on Geological Disposal of High-Level Radioactive Wastes (sponsored by the Association of Engineering Geologists), Dallas, Texas.

William E. Galloway

Energy resources of an offlapping coastal plain sequence: presented at a South Texas Geological Society meeting, San Antonio, Texas.

Hydrogeologic controls on accumulation of sedimentary uranium: presented at Mining and Minerals Resources Seminar (sponsored by the College of Engineering, University of California at Berkeley), Berkeley, California.

Seismic stratigraphy case histories: presented at Stratigraphic Interpretation of Seismic Data School (sponsored by the American Association of Petroleum Geologists), Houston, Texas, and Singapore.

Arthur G. Goldstein

Late Paleozoic tectonics of the southern margin of North America: presented to a class on advanced geophysical interpretation, Department of Geological Sciences, The University of Texas at Austin.

Christopher D. Henry

Volcanogenic uranium deposits of Trans-Pecos Texas: presented at a Uranium Geology Symposium (sponsored by the U. S. Department of Energy, the U. S. Geological Survey, and Bendix Field Engineering Corporation), Golden, Colorado.

M. P. A. Jackson

Early-Precambrian gneiss tectonics in Swaziland and implications for greenstone-belt development: presented at an open lecture/technical session (sponsored by the Department of Geology, The University of Texas at Dallas), Dallas, Texas.

Charles W. Kreitler

Application of nitrogen isotope studies to environmental problems: presented to the Department of Environmental Engineering, Rice University, Houston, Texas.

Geochemistry of a sandstone aquifer: ground-water chemistry, diagenesis, flow and reaction rates: presented at a College of Earth Science Colloquium, University of Arizona, Tucson, Arizona.

Meteoric versus formation water origin of salt dome cap rock: presented at a Department of Hydrology Colloquium, University of Arizona, Tucson, Arizona; and at a poster session, Gulf Coast Association of Geological Societies, Annual Meeting, Corpus Christi, Texas.

Problems of faulting in the Greater Houston area: presented to the Texas Mortgage Bankers Association, Houston, Texas.

Thomas G. Littleton

Distribution and abundance of the family Pyramidellidae in lower Laguna Madre and South Bay, Texas: presented at the American Malacological Union Annual Meeting, Fort Lauderdale, Florida.

Mary W. McBride

Bureau of Economic Geology publications as energy and environmental science teaching aids: presented to the Texas Advisory Committee on Energy and Environmental Education (sponsored by the Texas Education Agency), Austin, Texas.

Geothermal energy: presented to the fifth grade, Travis Heights Elementary School, Austin, Texas.

Minerals in the economy of Texas: presented at a teachers' workshop, East Texas State University, Commerce, Texas.

Your McKinney Falls State Park—field trip guide: presented at a science teacher training program, St. Edwards University, Austin, Texas.

Robert A. Morton

Development of Gulf Coast geopressured geothermal energy resources: presented at a Corpus Christi Geological Society monthly meeting, Corpus Christi, Texas.

Effects of impermeable structures on shoreline stabilization and land loss—the Texas experience: presented at the Conference on Coastal Erosion and Wetlands Modification in Louisiana (sponsored by the Louisiana Universities Marine Consortium), Baton Rouge, Louisiana.

Fluvial, deltaic, and strandplain environments: presented at a Society of Economic Paleontologists and Mineralogists, Gulf Coast Section, field trip meeting.

Geomorphology and shoreline dynamics of the Texas Gulf Coast: presented at the Conference on America's Eroding Shoreline (sponsored by the Skidaway Institute of Oceanography), Savannah, Georgia.

Methane entrained in Gulf Coast geopressured aquifers: presented at a Houston Geological Society monthly meeting, Houston, Texas.

Status of geopressured geothermal research and resource assessment in Texas: presented at an Industry Forum (sponsored by the U. S. Department of Energy), New Orleans, Louisiana.

Elizabeth D. Orr

Use of CPS-1 mapping program in a lignite resources project: presented (with M. P. Roberts) at the Fifth Annual CPS-1 Users' Meeting (sponsored by the Radian Corporation), Austin, Texas.

Jonathan G. Price

Geochemistry of South Texas uranium deposits: presented at a Division of Earth and Physical Sciences Seminar, The University of Texas at San Antonio.

Sedimentary uranium deposits: presented to an undergraduate class on mineral deposits, Department of Geological Sciences, The University of Texas at Austin.

Texas mineral resources: presented to an undergraduate class on mineral resources, Department of Geological Sciences, The University of Texas at Austin.

Paul J. Ramondetta

San Andres oil occurrence in Northern Shelf of Midland Basin: presented at the Southwest Section of the American Association of Petroleum Geologists, Annual Meeting, San Angelo, Texas.

M. P. Roberts

Use of CPS-1 mapping program in a lignite resources project: presented (with E. D. Orr) at the Fifth Annual CPS-1 Users' Meeting (sponsored by the Radian Corporation), Austin, Texas.

Stephen C. Ruppel

Distinction of Middle Ordovician carbonate buildups: presented at a carbonates seminar, Department of Geological Sciences, The University of Texas at Austin.

William W. Simpkins

Environmental geology of the Austin area: presented at a Lutheran Campus Center retreat, Austin, Texas.

Geologic research of the Bureau of Economic Geology in the Texas Panhandle: presented at the Technical Advisory Committee meeting, North Rolling Plains Resource Conservation and Development Area, Pampa, Texas.

Ground-water modeling of the salt dissolution zone: presented to the Office of Nuclear Waste Isolation Geologic Review Group, U. S. Department of Energy, Austin, Texas.

Mountain building: presented to the third grade, Pease Elementary School, Austin, Texas.

Rocks: presented at the Children's Discovery Center, Austin, Texas.

Water: presented to a fifth-grade science class, Smith Elementary School, Austin, Texas.

Water resources of the Austin area: presented to an earth science class, Anderson High School, Austin, Texas.

Noel Tyler

Recognition and interpretation of sedimentary facies in the deep Frio Formation, Brazoria County, Texas: presented at a core workshop, Society of Economic Paleontologists and Mineralogists, Gulf Coast Section, Second Annual Research Conference, Dallas, Texas.

W. C. J. van Rensburg

Coal research: presented to the Chemistry Department, The University of Texas at Arlington.

The dependence of the United States on imported strategic minerals: presented at the U. S. Army's Nineteenth National Junior Science and Humanities Symposium (sponsored by the United States Military Academy), West Point, New York.

The future role of coal in the United States economy: presented at the 1981 Alternate Energy Sources for Texas Conference (sponsored by the University of Houston), Houston, Texas.

Mineral economics: presented to the Department of Petroleum Engineering, The University of Texas at Austin.

Our import dependence on strategic minerals: presented to the Men's Club of Lakeway Yacht and Country Club, Austin, Texas.

Overview of energy resources: presented at Summer Workshop for Energy Education Teachers in Texas (sponsored by the Science Education Center, College of Education, The University of Texas at Austin), Austin, Texas.

The role of coal in the world economy: presented to the Government Department, The University of Texas at Austin.

Synthetic fuels from coal: presented to the Geography Department, The University of the Texas at Austin (sponsored by the Center for Energy Studies, The University of Texas at Austin).

World energy resources: short- and long-term implications: presented at the Thirteenth Annual AIESEC Economic Congress, Cape Town, South Africa.

Bonnie R. Weise

Wave-dominated delta systems of the Upper Cretaceous San Miguel Formation, Maverick Basin, South Texas: presented at the Ancient Wave-Dominated Delta Field Seminar (sponsored by the American Association of Petroleum Geologists), Salt Lake City, Utah.

E. G. Wermund

Environmental geologic mapping for planners: presented at the U. S. Geological Survey/National Planners Association Workshop on Environmental Planning, Houston, Texas.

Research on deep burial of radioactive waste in Texas salts: presented to the Governor's Task Force on a High-Level Waste Repository, Salt Lake City, Utah.

William A. White

Hurricane flooding and coastal processes: presented at Workshop on Earth-Science Data Applications to Land-Resource Planning (sponsored by the U. S. Geological Survey, Southmost Section of the Texas Chapter of the American Planning Association, Texas Energy and Natural Resources Advisory Council, and Corpus Christi State University), Corpus Christi State University, Corpus Christi, Texas.

Debra H. Wood

Careers in the geological sciences: presented to eighth grade earth science classes, Bedichek Junior High School, Austin, Texas.

C. M. Woodruff, Jr.

Brushy Creek lineament in Central Texas—a zone of geologic discontinuity perceived using Landsat imagery: presented (with S. Christopher Caran) at a poster session, Remote Sensing Short Course, Regional Conference on Operational Land Remote Sensing Program (sponsored by the National Oceanic and Atmospheric Administration and the Texas Natural Resources Information System), Austin, Texas.

Energy and mineral resources of East Texas: presented to Huntsville Chamber of Commerce Leadership Institute, Huntsville, Texas.

Environmental geology of the Lake Travis vicinity: presented to Lakeway Men's Breakfast Club, Lakeway, Texas.

Geology, geomorphology, and soils—current land resource investigation efforts at the Bureau of Economic Geology: presented at Soil Sciences Work/Planning Conference (sponsored by Texas A & M University and the U. S. Soil Conservation Service), College Station, Texas.

Hydrodynamics and geothermics of the Edwards Limestone, south-central Texas: presented at a poster session of Hydrothermal/Geothermal Resource Assessment Teams (sponsored by the U. S. Department of Energy), Seattle, Washington.

CONGRESSIONAL, LEGISLATIVE, AND SPECIAL TESTIMONY

Federal Energy Regulatory Commission, Hearings, Santa Fe, New Mexico—W. L. Fisher (testimony given: "Geological and Engineering Considerations in Definition of Tight Gas Resources").

Texas Energy and Natural Resources Advisory Council, Austin, Texas—W. L. Fisher (testimony given: "Status of High-Level Waste Feasibility Studies in Texas").

Texas House of Representatives, Committee on Energy Resources, Austin, Texas—W. R. Kaiser (testimony given: "Recovery of Deep-Basin Lignite in Texas, A Statement of Hydrogeologic Research Needs").

Texas Senate, Committee on Energy and Natural Resources, Austin, Texas—W. L. Fisher (testimony given: "Lignite Resources and Development Programs in Texas").

Texas Senate, Committee on Natural Resources, Austin, Texas—R. A. Morton (testimony given: "Shoreline Changes Along the Texas Coast and the Effects of Concrete Structures on Beach Erosion").

U. S. Senate, Joint Hearings of Committee on Energy and Natural Resources and Committee on Environment and Public Works, Washington, D. C.—W. L. Fisher (testimony given: "High-Level Nuclear Waste Disposal Issues").

COMMITTEE SERVICES, OFFICES, AND OTHER PROFESSIONAL RESPONSIBILITIES

Virgil E. Barnes

Co-leader of Field Trip 3, "Cambrian and Lowest Ordovician Lithostratigraphy and Biostratigraphy of Southern Oklahoma and Central Texas," Second International Symposium on the Cambrian System, Golden, Colorado.

Co-leader of Llano field trip, Houston Geological Society.

Randy L. Bassett

Member of writing group appointed by the Office of Nuclear Waste Isolation to draft guidelines for Earth Science Data Acquisition, Geochemistry and Geohydrology Section, Houston, Texas.

Robert W. Baumgardner, Jr.

Co-leader of a field trip, "Selected Aspects of the Geology of the Palo Duro Basin, Texas Panhandle," Geologic Review Group, Nuclear Regulatory Commission.

L. F. Brown, Jr.

Associate editor, American Association of Petroleum Geologists.

Leader, Field conference of students and faculty, Baylor University and The University of Texas at Arlington.

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

S. Christopher Caran

Chairman, Public Relations Committee, Austin Geological Society.

Co-leader of field trips on Cretaceous volcanism in the Austin area, Austin Geological Society, and Society of Independent Earth Scientists, San Antonio and Houston chapters.

Vice chairman and field trip coordinator, Earth Sciences Section, Texas Academy of Science.

Edward W. Collins

Member, Publications Committee, 1980-1981, Austin Geological Society.

Thomas E. Ewing

Co-leader of field trips on Cretaceous volcanism in the Austin area, Austin Geological Society, and Society of Independent Earth Scientists, San Antonio and Houston chapters.

Secretary, Austin Geological Society, 1981-1982.

Robert J. Finley

Co-leader of field trip to the South Texas uranium province, Gulf Coast Association of Geological Societies.

Member, Citizens Environmental Board, City of Austin.

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

W. L. Fisher

Chairman, Energy Committee, Texas 2000 Commission.

Chairman, Executive Committee, Council on Energy Resources, The University of Texas at Austin.

Chairman, Nuclear Energy Committee, Texas Energy and Natural Resources Advisory Council.

Chairman, Select Committee on the Outer Continental Shelf, American Association of Petroleum Geologists.

Chairman, Committee on Producibility of Oil and Natural Gas, National Research Council, National Academy of Sciences.

Chairman, Geology and Resource Recovery Task Force, Gulf Universities Research Consortium (GURC).

Commissioner, Texas 2000 Commission.

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

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

Member, Advisory Board, Center for Energy Studies, The University of Texas at Austin.

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

Member, Advisory Council for Marine Science and Technology, Texas A&M University.

Member, Advisory Group, Southern Illinois University.

Member, Committee on Access to Public Lands, American Institute of Professional Geologists.

Member, Committee on Committees, Geological Society of America.

Member, Committee on Engineering Consideration for Deep Sea Drilling, National Research Council, Assembly of Engineering, Marine Board.

Member, Committee on Evaluation of Mineral Land Assessment Program of U. S. Bureau of Mines, Association of American State Geologists.

Member, Environmental Geology Committee, American Institute of Professional Geologists.

Member, Executive Committee, Geology Foundation, The University of Texas at Austin.

Member, General Exploration Affairs Committee, American Petroleum Institute.

Member, Governmental Liaison Committee, Association of American State Geologists.

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

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

Member, Policy Development Council, Gulf Universities Research Consortium.

Member, Public Affairs Committee, Association of American State Geologists.

Member, Publications Committee, Society of Economic Geologists.

Member, Renewable Resources Committee, Southern States Energy Board.

Member, Research Committee, Interstate Oil Compact Commission.

Member, Resolution Committee, Interstate Mining Compact Commission.

Member, Technical Program Committee (AAPG/OTC), American Association of Petroleum Geologists.

Member, Texas Energy and Natural Resources Advisory Council.

Member, Texas Mapping Advisory Committee.

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

President, Association of American State Geologists.

William E. Galloway

Member, Graduate Studies Committee for Master's Degree Program in Mining and Mineral Resources, The University of Texas at Austin.

Chester M. Garrett, Jr.
Member, Finance Committee and Ad Hoc Nominating Committee, Austin Geological Society.

Arthur G. Goldstein
Co-leader of a field trip, "Selected Aspects of the Geology of the Palo Duro Basin, Texas Panhandle," Geologic Review Group, Nuclear Regulatory Commission.

Thomas C. Gustavson
Co-leader of a field trip, "Selected Aspects of the Geology of the Palo Duro Basin, Texas Panhandle," Geologic Review Group, Nuclear Regulatory Commission.

Clara L. Ho
Member, International Working Group of the Association Nationale de la Recherche Technique, Paris.
Member, Subcommittees D-19 (Water) and D-5 (Coal and Coke), American Society for Testing and Materials.

Charles W. Kreitler
Consultant to the Texas Attorney General's Office, on gasoline pollution of ground water, San Angelo, Texas.
Invited lecturer, Department of Hydrology, University of Arizona, Tucson, Arizona.
Judge of Presentations, Gulf Coast Association of Geological Societies Annual Meeting, Corpus Christi, Texas.
Member, Editorial Board, *Journal of Ground Water.*
Member of writing group appointed by the Office of Nuclear Waste Isolation to draft guidelines for Earth Science Data Acquisition, Geochemistry and Geohydrology Section, Houston, Texas.
Participant in workshop, "Techniques in Isotope Hydrology Applicable to Evaluating Nuclear Waste Repositories," Tucson, Arizona.

Joseph H. McGowen
Co-chairman, Sedimentology-Stratigraphy Session, Regional Geological Society of America Meeting, San Antonio, Texas.
Co-leader of field trip, "Selected Aspects of the Geology of the Palo Duro Basin, Texas Panhandle," Geologic Review Group, Nuclear Regulatory Commission.
Member, Academic Liaison Committee, Society of Economic Paleontologists and Mineralogists.

Mary K. McGowen
Chairwoman, Publications Committee, Austin Geological Society.
Delegate of Austin Geological Society, American Association of Petroleum Geologists House of Delegates.

Robert A. Morton
Co-leader of a field trip to Queen City (Eocene) deposits of East Texas, Gulf Coast Section, Society of Economic Paleontologists and Mineralogists.
Convenor and session chairman, Symposium on Geopressured Zones in the Gulf Coast Region, annual meeting, South-Central Section, Geological Society of America.
Member, Academic Liaison Committee, Texas Section, American Institute of Professional Geologists.
Member, Well Review and Selection Committee, U.S. Department of Energy, Division of Geothermal Energy.
Session Chairman, Fifth United States Gulf Coast Geopressured Geothermal Energy Conference, U.S. Department of Energy.

Paul J. Ramondetta
Co-leader of field trip, "Selected Aspects of the Geology of the Palo Duro Basin, Texas Panhandle," Geologic Review Group, Nuclear Regulatory Commission.

Douglas C. Ratcliff
Chairman, Entertainment Committee, Austin Geological Society.
Member, Membership Committee, American Association of Petroleum Geologists.

William W. Simpkins
Member, Technical Advisory Committee, North Rolling Plains Resource Conservation and Development Area.

W. C. J. van Rensburg
Member, Academic Advisory Committee, The University of Texas Press.
Chairman, Ad Hoc Committee on Resource Economics, The University of Texas at Austin.
Chairman, Executive Committee, Texas University Coal Research Consortium.
Director, Texas University Coal Research Consortium.
Member, Coal and Lignite Advisory Committee, Texas Energy and Natural Resources Advisory Council.
Panel member, Committee on National Statistics, National Research Council, National Academy of Sciences.
Vice chairman, Association of Mineral Institute Directors.

Stephen C. Ruppel
Chairman of technical session, "Sedimentology II: Ancient Clastic Sediments," annual meeting, Geological Society of America, Cincinnati, Ohio.

Bonnie R. Weise
Member, Membership Committee, Austin Geological Society.

E. G. Wermund
Chairman and Texas representative, Gulf of Mexico Technical Working Group, Outer Continental Shelf Policy Board of the U.S. Secretary of the Interior.
Chairman, Executive Committee, Texas University Coal Research Consortium.
Member, Environmental Geology Committee, American Association of Petroleum Geologists.
Member, Publications Committee, American Association of Petroleum Geologists.
Member, Publications Committee, Geological Society of America.
Member, Texas Low Level Waste Disposal Advisory Committee.
Member, Texas Mapping Advisory Committee.
Session chairman, hydrology papers, Geological Society of America, South-Central Section meeting, San Antonio, Texas.
Vice chairman, Texas Natural Resources Information System Task Force.

William A. White
Co-leader of a field trip for Workshop on Earth-Science Data Applications to Land-Resource Planning (sponsored by U.S. Geological Survey, Southmost Section of the Texas Chapter of the American Planning Association, Texas Energy and Natural Resources Advisory Council, and Corpus Christi State University), Corpus Christi, Texas.

C. M. Woodruff, Jr.

Coordinator for Texas, Hydrothermal/Geothermal Resource Assessment Teams, U.S. Department of Energy, Division of Geothermal Energy.

Leader of a field trip to Llano area, American Petroleum Institute Subcommittee on Outer Continental Shelf/ Coastal Zone Management.

Member, Ad Hoc Technical Advisory Committee, the Committee for Wild Basin Wilderness, to assess damage from the Memorial Day flood.

Member, Geothermal Review Panel, Texas Energy and Natural Resources Advisory Council, to assess program by Radian, Inc.

President, Austin Geological Society, 1980-1981.

UNIVERSITY TEACHING/ CONTINUING EDUCATION

ACADEMIC COURSES

Department of Geological Sciences, The University of Texas at Austin

L. F. Brown, Jr.—Depositional Systems (Geology 394).

L. F. Brown, Jr., Milo M. Backus, and Richard T. Buffler—Seismic Stratigraphy (Geology 380N).

William E. Galloway and W. R. Kaiser—Sedimentary Economic Geology (Geology 391).

Charles W. Kreitler—Hydrogeology (Geology 391).

W. C. J. van Rensburg—Geology of Energy Resources (Geology 368) and Economic Evaluation of the Petroleum Industry (Petroleum Engineering 389).

C. M. Woodruff, Jr.—Geologic Hazards (Geology 353K).

LBJ School of Public Affairs, The University of Texas at Austin

W. L. Fisher—Evaluating Federal Energy Policy, Policy Research Project (PA 882B).

SHORT COURSES/CONTINUING EDUCATION

L. F. Brown, Jr.—Seismic Stratigraphy in Exploration (presented at the American Association of Petroleum Geologists School on Seismic Stratigraphy, Dallas, Texas).

L. F. Brown, Jr.—Seismic Stratigraphy in the Exploration for Deep-Water Reservoirs (presented to the Lafayette Geological Society, Lafayette, Louisiana; the Tulsa Geological Society, Tulsa, Oklahoma; and the University of Houston, Houston, Texas, January and May).

Robert J. Finley—Landsat Image Interpretation Short Course (sponsored by the Texas Natural Resources Information System Task Force and presented in Austin, Texas, May 1981).

W. L. Fisher—Seismic Stratigraphy in Exploration (presented at the American Association of Petroleum Geologists School on Seismic Stratigraphy, London).

William E. Galloway—Fourth Short Course on the Fluvial System with Applications to Economic Geology (presented at Colorado State University, Department of Earth Resources, Fort Collins, Colorado).

William E. Galloway—1981 Geophysical Society of Oklahoma City Continuing Education Program—An Update on Seismic-Stratigraphic Techniques, Oklahoma City, Oklahoma.

Charles W. Kreitler—Investigative and Monitoring Procedures for Ground-Water Contamination Studies (presented to the Texas Water Conservation Association, Austin; the Texas Department of Water Resources, Austin; and the U.S. Environmental Protection Agency, Dallas).

SUPPORT STAFF

ADMINISTRATIVE/SECRETARIAL

The administrative/secretarial staff fulfills an important role in achieving the goals of the Bureau. These staff members are, in many respects, the Bureau's closest contact with the general public. In support of various research programs, staff members complete administrative, accounting, and secretarial tasks essential to the day-to-day operation of the Bureau. Mrs. Eloise Hill, Executive Assistant, and Mrs. Bettye Blitch, Administrative Assistant, coordinate the work of the administrative/secretarial staff.

CARTOGRAPHY

Dan F. Scranton, Chief Cartographer, directs the work of the Cartography Section for the Bureau. Much of the Bureau's reputation in the areas of geologic and land resource mapping is a reflection of the excellent cartographic capability of these staff members. Besides the high-quality, full-color map products that are the hallmark of the Cartography Section, the present staff also produces a full range of other maps, text illustrations, slide copy, and display materials.

James A. Morgan provides technical photographic support for the Bureau's publications, lectures and public addresses, and research projects. Most of the photographic work consists of slides and cover and text photographs.

PUBLICATIONS PREPARATION

A central part of the Bureau's function as a public geological research organization is to make available the results of its research programs. This is accomplished chiefly by means of its publications. Preparing Bureau reports for publication involves word processing and typesetting, editing, graphics design, and layout.

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