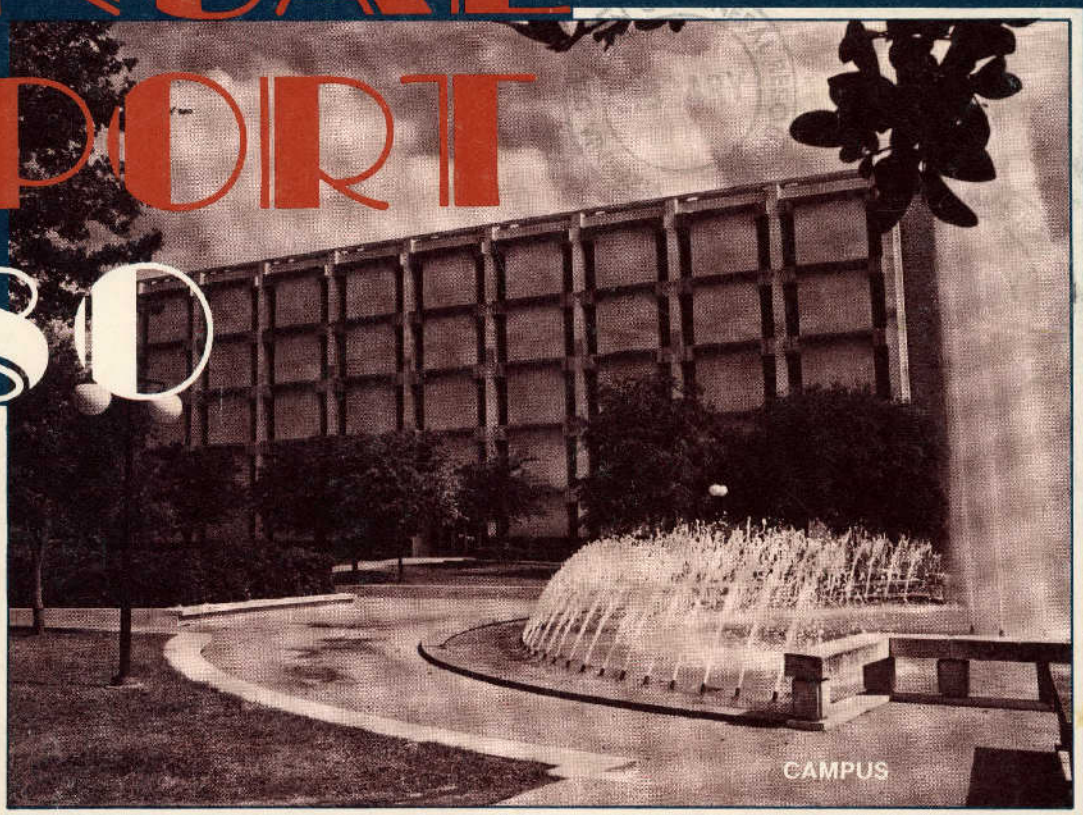
BUREAU OF ECONOMIC GEOLOGY

ANNUAL REPORT 1980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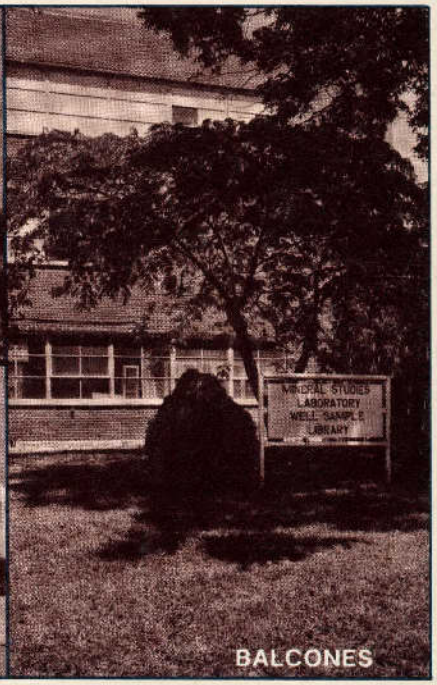


BALCONES

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

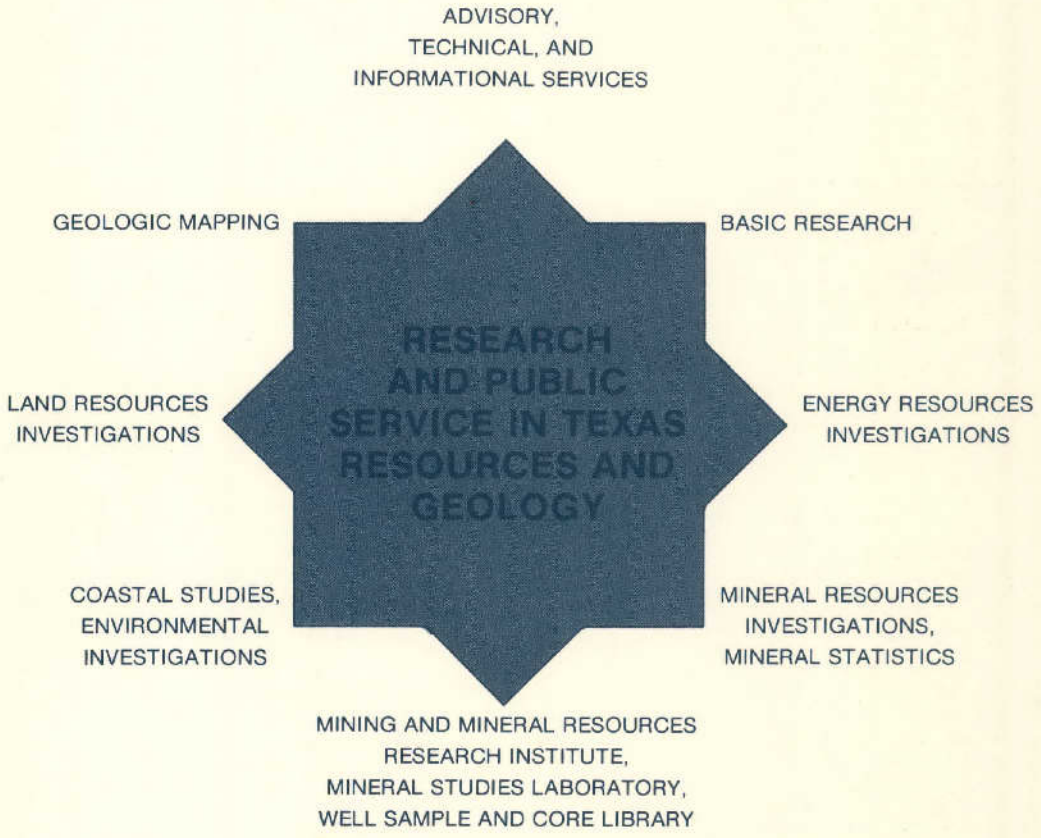
FOREWORD

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 serves as State Geologist and 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 scope and status of current research programs and projects, publications, professional personnel activities, and special services in the area of Texas geology and resources available to agencies, industry, and all citizens of Texas. The Annual Report is available on request at no charge.



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BUREAU OF ECONOMIC GEOLOGY

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CONTENTS

RESEARCH

PUBLICATIONS

SERVICES

PERSONNEL

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 resources. 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 evaluation of bedded salt deposits in the Panhandle and interior salt domes in East Texas as potential sites for isolation of nuclear wastes. 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.

Bureau research in 1980 focused on the assessment and analysis of environmental problems concerning geopressured geothermal energy production and uranium utilization, in addition to continuing work on such long-standing projects as the *Environmental Geologic Atlas of the Texas Coastal Zone* and the Lavaca - Guadalupe - San Antonio - Nueces river basins regional study. Minerals and energy resources programs 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. A comprehensive survey of mineral localities in the State was also in progress; this survey proposes to develop detailed information on hundreds of mineral sites across Texas.

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 1980.

ENERGY RESOURCES INVESTIGATIONS

LIGNITE RESOURCES IN TEXAS

W. R. Kaiser, project director; assisted by W. B. Ayers, Jr.

This project, initiated in May 1978 and completed in 1980, was undertaken with prime funding from the Texas Energy and Natural Resources Advisory Council. On the basis of calculations made using over 8,000 geophysical and lithologic logs, lignite resources in Texas are now calculated at just over 58 billion short tons (tons). Approximately 23 billion tons are near-surface resources, or those at depths between 20 and 200 ft in seams greater than 3 ft thick, and 35 billion tons are deep-basin resources, or those at depths between 200 and 2,000 ft in seams greater than 5 ft thick. About 80 percent of the resources are found north of the Colorado River, approximately 70 percent in the Wilcox Group and 30 percent in the Jackson Group. Depending on mining depth, reserves are estimated at 8.6 to 11.1 billion tons—adequate to meet State demand into the next century. The weighted average lignite north of the Colorado River has a heating value of 6,100 Btu/lb and contains 35 percent moisture, 17 percent ash, and 1 percent sulfur. Complete results and methodology are presented in Report of Investigations No. 104.

COMPUTERIZED CALCULATION OF LIGNITE RESOURCES IN TEXAS

W. R. Kaiser, project director; L. Edwin Garner, Suzanne Montano, and Susan J. Tewalt; assisted by Rick Kolb, G. G. Cleveland, and Paul Anaejionu

The objective of this project is to establish a computerized data base for the lignite resources of Texas. The U. S. Geological Survey is providing the funding and computer systems used to store and manipulate these data. From geophysical logs, near-surface lignite seams are identified and recorded on the U. S. Geological Survey stratigraphic sequence forms. These data are entered in the National Coal Resources Data System (NCRDS) by U. S. Geological Survey personnel. Bureau of Economic Geology personnel will access the computer files and calculate lignite resources on an aggregate basis by stratigraphic unit and region according to criteria of U. S. Geological Survey Bulletin 1450-B. Proprietary data remain confidential as to point source.

The first phase of this project concerns lignite deposits of the Wilcox Group in the area between the Colorado and Trinity Rivers. This phase is scheduled for completion

during 1981. A proposal has been submitted to the U. S. Geological Survey to record lignite data for the rest of the state. A schedule for future phases is as follows:

Phase 2 FY81 Wilcox deposits north of Trinity River to Texarkana
Phase 3 FY82 Wilcox deposits on Sabine Uplift
Phase 4 FY83 Jackson and Yegua deposits north of Colorado River
Phase 5 FY84 Jackson and Wilcox deposits south of Colorado River

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; M. P. Roberts, Susan J. Tewalt, and Mary A. Bauer; assisted by W. B. Ayers, Jr., C. H. Wilson, Elizabeth D. Orr, and Nae-Heon Kim

This study, funded by the Electric Power Research Institute (EPRI), is coordinated by the Texas Energy and Natural Resources Advisory Council (TENRAC); the program includes data and personnel from the Operations Research Group of The University of Texas at Austin College of Engineering. Funding is from June 1, 1979, through May 1981.

The aim of this study is to develop a conceptual model for characterizing uncertainty in coal resource estimates on the basis of geological, chemical, and statistical analyses of available data. Central to this approach is the integration of ancient depositional systems of coal in the estimation of coal resources. The conceptual model will be translated into a mathematical computer code to facilitate the development of quantitative resource estimates and measures of uncertainty. Transferability of the model will be tested by comparing the methodology for similar depositional systems in different coal basins.

During 1980, the study focused on the comparison of uncertainty in coal resource estimates in areas of different ancient depositional environments in the Texas Gulf Coast Basin. Four lignite deposits representing different depositional environments were evaluated. Important sources of uncertainty were recognized for each depositional environment and tested for their contribution to reserve evaluation. Various techniques of resource calculation (manual, computer, and geostatistical) were used to investigate the uncertainties associated with each method. Methods derived from classical statistics were used to determine the number of boreholes required to obtain resource estimates within given confidence intervals for lignite deposits. Geostatistics (variograms and kriging) were used to measure variability in resource estimates.

NATIONAL URANIUM RESOURCE EVALUATION

L. F. Brown, Jr., project coordinator; Marc B. Edwards, Christopher D. Henry, C. L. Ho, David K. Hobday, J. H. McGowen, Mary K. McGowen, Steven J. Seni, principal investigators; assisted by Richard L. Andersen, Emil Bramson, Michael S. Bumpass, Colm Chomicky, Brian Dupre, John Morton, Nancy Pearce, Keith S. Pollman, Ray S. Risner, Floyd G. Rose, Jr., Linda Seekins, Charles D. Smith, Jeffrey E. Thurwachter, and S. W. Tweedy

This project, which was initiated in mid-1978, was completed on March 31, 1980. The research program in Texas was supported by contracts with Bendix Field Engineering Corporation (funded by the U. S. Department of Energy). The goal of the national program was evaluation of uranium resources throughout the United States. In Texas, the Bureau assumed responsibility for evaluating the uranium potential of surface and subsurface rocks (to a depth of 5,000 ft) within all of the Amarillo, Lubbock, Wichita Falls, Sherman, and Palestine 1° x 2° quadrangles (National Topographic Map Series, scale 1:250,000) and volcanic parts of the Emory Peak, Presidio, and Marfa quadrangles.

Bureau geologists mapped and sampled all outcropping rock units within the eight quadrangles to determine any undiscovered uranium resources. Subsurface strata were also evaluated using available gamma logs and other geologic data. More detailed stratigraphic studies and sampling were focused on those strata of unusual interest.

Bureau chemists analyzed a total of approximately 7,800 samples of rock, sediment, and soil from the eight quadrangles. Each sample was prepared and analyzed for 30 trace elements. Samples included surface collections and some subsurface cores and cuttings. Data collected and analyzed during the Texas National Uranium Resource Evaluation (NURE) program provide a regional geochemical data base for each respective quadrangle.

Field work was completed at the end of 1979 and during the first 3 months of 1980. The Bureau's NURE staff compiled descriptive and interpretive maps and completed standardized reports for the NURE assessment teams directed by Bendix Corporation. Reports were provided for Bendix and the U. S. Department of Energy on March 31, 1980. These reports will be placed on open-file with all the other NURE quadrangle reports.

The NURE reports prepared by Bureau geologists outlined a number of potential areas of interest, verified several areas of known or suspected uranium concentrations, and outlined several areas worthy of further investigation if the price of and the demand for uranium increase substantially.

A number of scientific papers based on the NURE program are listed elsewhere in this annual report.

EFFECTS OF A GEOPRESSURED GEOTHERMAL SUBSURFACE ENVIRONMENT ON ELASTIC PROPERTIES OF TEXAS GULF COAST SANDSTONES AND SHALES

A. R. Gregory, project director; assisted by Karl K. Kendall, Akanni S. Lawal, and R. G. Anderson

The objective of this project is to evaluate the elastic properties of the geopressured geothermal sediments that are penetrated by the General Crude Oil Company and U. S. Department of Energy Pleasant Bayou No. 1 and No. 2 wells in Brazoria County, Texas. The project involves the use of elastic wave theory and measurements of velocity from waveform data obtained from conventional acoustic logs, long-spaced sonic logs, and cores, as well as density data obtained from density logs to determine the effect of high formation pressures and temperatures on the physical properties of deep geopressured sediments. Similar data are obtained in shallow hydropressured formations.

The top of geopressure in the Pleasant Bayou No. 2 geothermal well occurs at a depth of about 8,400 ft. Mean porosity in the hydropressured zone ranges from 13.3 to 32.7 percent. The range in porosity in the geopressured zone is from 13.2 to 17.6 percent. Below a depth of 10,000 ft, primary porosity is less than 2 percent, but the average porosity exceeds 15 percent. An average permeability of 175 mD was found in the primary production zone located in fluvial channel deposits in the depth interval from 14,687 to 14,716 ft.

Digital long-spaced sonic waveform logs (LSSL) were run with spacings of 3, 5, 8, 10, and 12 ft between receiver and transmitter sondes. Direct interpretation of waveform data from the LSSL provides a method for obtaining improved velocity logs in shallow hydropressured zones where conventional BHC sonic logs are often in error. The improved transit times from waveforms should permit more accurate depth-to-time correlations with seismic data. Typically, acoustic impedance contrasts between shales and brine-saturated sandstones are small in the hydropressured zone and larger in the geopressured zone. The presence of gas in these sandstones gives high contrasts in acoustic impedance at interfaces with shale and brine-saturated sandstone in the hydropressured zone and lower contrasts in the geopressured zone.

Limited amounts of S-wave velocity data and related elastic parameters are given for deep, good-quality geopressured sandstones and shaly sandstones. In general, S-wave events are stronger and more easily identified when shorter sonde spacings are used. Average values of V_p/V_s and Poisson's ratio in good-quality geopressured sandstones in the primary production interval are 1.67 and 0.220 compared with 1.75 and 0.253 for shaly sandstones located deeper in the section. In situ dynamic bulk compressibilities average 3.7×10^{-7} psi^{-1} in good-quality well-consolidated geopressured Oligocene sandstones in the primary production interval (14,665 to 14,697 ft). The average uniaxial compaction coefficient Cm of 9.8×10^{-8} psi^{-1} for the same depth interval is an order of magnitude less than values of Cm in common use for subsidence estimations.

The presence of high-quality reservoirs with enhanced dissolution porosity is indicated by acoustic impedance values that are lower than the normal trend for deep geopressured sandstones. High reflection coefficients at interfaces between shale and brine-saturated sandstone at depths below 14,500 ft indicate that these zones of enhanced leached porosity might be detected by seismic reflection methods.

The project, funded by the U. S. Department of Energy, began in 1978 and was completed in 1980.

GEOLOGIC STUDIES OF GEOPRESSURED AND HYDROPRESSURED ZONES IN TEXAS

Robert A. Morton, project director; Bonnie R. Weise, Marc B. Edwards, A. R. Gregory, and Lee A. Jirik; assisted by A. D. Allie, B. E. Castens, M. J. Darr, D. W. Downey, S. L. Hallam, H. S. Hamlin, J. C. Herwig, Mary L. W. Jackson, S. D. Mann, W. D. Masterson, D. M. Okoye, R. A. Schatzinger, D. H. Wilson, and Kingston C. W. Yong

This project, sponsored by the Gas Research Institute, was initiated in January 1979. The objective of the study is to delineate prospect areas and sites for test wells capable of long-term production of solution gas from shallow geopressured aquifers. The study concentrates on Tertiary geopressured sandstone reservoirs of the Texas Gulf Coast that have fluid temperatures less than 300°F (149°C).

During 1980, five areas were studied in detail to determine their potential for production of methane dissolved in geothermal brines. Each fairway was evaluated on the basis of detailed cross sections, structure maps, and net-sandstone maps as well as porosity, permeability, temperature, pressure, and salinity data. At yearend, a final report summarizing the geology of each prospect area had been completed. Continuative studies were directed toward identifying additional prospects on the basis of estimates of methane solubility and reservoir properties at in situ conditions. Efforts are being made to include areas where the gas-to-water ratio might be greater than that expected for saturated conditions.

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

Robert A. Morton, project director; Charles D. Winker and Deborrah A. Garcia; assisted by Jeffrey L. Lawton, Jong Hwan Han, Jeffrey Palmer, and Chong Lock Ping

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 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 down-hole changes in temperature, salinity, pressure, and gas-to-water ratio as well as the performance of surface equipment and the salt-water disposal well.

In 1980, this project included interpretations of seismic data and the geological mapping of two 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 and to provide current data for future studies. Reprocessing of tapes to enhance data displays as well as to investigate the seismic response to different lithologies and pressure gradients is expected to continue.

VOLUME AND ACCESSIBILITY OF ENTRAINED (SOLUTION) METHANE IN DEEP GEOPRESSURED RESERVOIRS—TERTIARY FORMATIONS OF THE TEXAS GULF COAST

A. R. Gregory, project director; M. M. Dodge, Jan S. Posey, and Robert A. Morton; assisted by R. F. Carroll, Chester M. Garrett, Jr., Evans V. Jegbefume, Karl K. Kendall, Akanni S. Lawal, Victor Lombeida, Michael L. Lunceford, D. M. Okoye, Rosemary Capo-Shoemaker, Stephen P. Weiner, D. G. Worrell, Kingston C. W. Yong, and Jackson J. Yoong

The higher prices obtained for commercial natural gas in recent years have stimulated interest in methane-saturated formation waters of sandstone reservoirs in the Texas Gulf Coast as a potential alternative source of energy.

The objective of this project was to appraise the total volume of in-place methane dissolved in formation waters of deep sandstone reservoirs of the onshore Texas Gulf Coast within the stratigraphic section extending from the base of significant hydrocarbon production (8,000 ft) to the deepest significant sandstone occurrence. Factors that must be evaluated to determine the total methane resource are reservoir bulk volume, porosity, and methane solubility.

The latter is controlled by the temperature, pressure, and salinity of formation waters.

Regional assessment of the volume and distribution of potential sandstone reservoirs was made from a data base of 880 electrical well logs, from which a grid of 24 structural dip cross sections and 4 strike cross sections was constructed. These cross sections extend from near the Wilcox outcrop to the coastline. Parameter plots corresponding to the cross sections were made to show how formation pressure, salinity, temperature, and porosity vary with depth in each well. Reservoir bulk volume was determined by mapping the structural and stratigraphic framework of Tertiary sandstone units. Structural and stratigraphic boundaries were used to divide the Texas Gulf Coast into 24 subdivisions. Methane content in each of nine formations or divisions of formations was determined for each subdivision. The distribution of methane in the Gulf Coast was described on the basis of five reservoir models. Each model was characterized by depositional environment, reservoir continuity, porosity, permeability, and methane solubility.

The total in-place methane for Tertiary sandstones below 8,000 ft in the Texas Gulf Coast was found to be 690 TCF. The total in-place methane for "effective" Tertiary sandstones (sandstone units greater than 30 ft thick) below 8,000 ft was 325 TCF.

This project, funded by the U. S. Department of Energy, began in 1978 and was completed in 1980.

SALINITY OF DEEP FORMATION WATERS, TEXAS GULF COAST

Robert A. Morton, project director; Chester M. Garrett, Jr., and Jan S. Posey; assisted by R. W. Debus

This 1-year 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 Wilcox Group and 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 influence reinjection by physical and chemical reaction with the clay minerals in shallow aquifers.

The project started in November 1980, and at yearend well operators were being asked to provide chemical analyses of waters produced from geopressured reservoirs.

CONTINUITY OF GEOPRESSURED RESERVOIRS

Robert A. Morton, project director; Thomas E. Ewing

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 1-year study, funded by the U. S. Department of Energy, will compare 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 the first 2 months of the project, 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.

SPECIAL PROJECTS RESEARCH AND COORDINATION ASSISTANCE

Robert A. Morton, project director; A. R. Gregory, Chester M. Garrett, Jr., and Debra L. Richmann; assisted by B. E. Bullock and R. W. Debus

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 1980, the Bureau of Economic Geology, in conjunction with the Center for Energy Studies, assisted in preparing standard methods and procedures for fluid sampling and chemical analyses, electric logging, core sampling, and rock mechanics testing of material from test wells. Thin sections of the producing sandstone reservoir in the Pleasant Bayou No. 2 well were examined petrographically to determine the extent of microdeformation in cores subjected to creep and compaction tests. Two special projects were initiated (1) to investigate the geographic and stratigraphic distribution of formation water salinities in geopressured sandstones of the Wilcox Group and the Frio Formation and (2) to determine the geometry of geopressured sandstone aquifers and the factors that govern the continuity of producing reservoirs. These special projects will be continued in 1981.

GEOTHERMAL RESOURCE ASSESSMENT FOR THE STATE OF TEXAS

C. M. Woodruff, Jr., project director; Christopher D. Henry, S. Christopher Caran, Christine Gever, and Mary W. McBride; assisted by Elizabeth M. Andrews, Cecilia M. Binig, Jeff L. Blass, Patricia Bobeck, Laura Caprio Dwyer, Steven L. Hochstein, G. L. Macpherson, Rhonda D. Rasco, Eric J. Thompson, and David Robert Wuerch

Resources from warm ground water have long been recognized for several aquifers along a belt in Central Texas from Del Rio north to the Red River. Many wells now in use along this trend supply domestic, municipal, and industrial facilities with potable water at temperatures in excess of 100°F. Increased costs of fossil fuel have now focused attention on these waters as a source of heat for direct uses such as space heating and hot water.

In Central Texas, the major apparent geologic control on the occurrence of geothermal ground water is the Balcones/Ouachita structural trend, a major hinge zone that separates the stable continental interior from the downwarping Gulf Coast Basin. Initial surveys of the Cretaceous geothermal aquifers along the Balcones/ Ouachita trend have shown several areas where waters are hot enough at a sufficiently shallow depth to be a potential economic resource. But there are still unresolved questions.

A fundamental question that bears on economic feasibility of using these geothermal resources is the ability of

the aquifers to sustain a level of pumpage that would be expected if the resource were developed for its energy content. Hence, a major task during the past year has been to assess the sustainable well yield of the Hosston/Trinity, Paluxy, and Woodbine Sand aquifers. Existing data were used to construct maps showing variations in transmissivities and hydraulic conductivities of these aquifers in the areas having the most geothermal promise.

Research has also entailed an ongoing survey of Texas Department of Water Resources files for wells having elevated water temperatures. On the basis of promising "target" wells, field measurements of water temperatures are conducted. These results are being compiled on a nontechnical map showing the extent and distribution of low-temperature geothermal resources statewide. The data on well depth, water temperature, water chemistry, and flow are being encoded into the GEOTHERM File of the U. S. Geological Survey.

A statewide assessment of Landsat images has been conducted to compile large-scale linear features that are presumably of structural origin. After establishing a standard viewing procedure, the project team examined 51 images, discerning more than 31,000 lineaments. A test was then conducted that substantiates the correlation between these lineaments and mapped faults and geothermal anomalies in Central Texas.

One area-specific assessment of geothermal potential was conducted for selected military bases as part of a DOE-DOD cooperative program. The study focused on the area near Randolph, Brooks, Kelly, and Lackland Air Force Bases (AFB) and Fort Sam Houston in Bexar County, Bergstrom AFB in Travis County, and Laughlin AFB in Val Verde County. For this survey, maps of structural, stratigraphic, and hydrologic attributes of aquifers having geothermal promise in each area were compiled.

A continuing assessment of the attributes of low- to moderate-temperature (90°F to 160°F) geothermal resources statewide, this project is now in the second year of funding by the U. S. Department of Energy.

HUECO TANKS GEOTHERMAL AREA

Christopher D. Henry, project director; James K. Gluck

The Hueco Tanks area, near El Paso, lies on the east side of Hueco Bolson, an asymmetric Basin and Range graben. Five currently inactive wells tapped hot water, up to 71°C, at depths of less than 150 m. The hot water probably results from deep circulation of meteoric water in an area of high heat flow and high thermal gradient. This study is part of a larger one, funded by the Texas Energy and Natural Resources Advisory Council and the U. S. Department of Energy, to evaluate the quantity and quality of the geothermal resource and its potential use in the El Paso area. A preliminary report on the geologic setting, hydrology, and geochemistry of the area was completed in 1980 and will be published in early 1981.

RESOURCE EVALUATION OF THE FRIO FORMATION (FRIO MAJOR STRATIGRAPHIC UNIT—TEXAS GULF COAST PROVINCE)

William E. Galloway, project director; David K. Hobday and Kinji Magara; assisted by Mark A. Helper, Diana Morton, N. G. Smith, and Victor J. Gavenda

The Frio Formation of the Texas Coastal Plain has produced over 16 billion bbl of oil and gas equivalent. This project, which was partially funded by the Oil and Gas Branch of the U. S. Geological Survey, has as its primary goal the assembly of a geological and historical data base for use in estimating the remaining exploration potential of this mature stratigraphic unit. Major tasks include compilation of a hydrocarbon inventory of the Frio, development of a regional correlation grid, preparation and interpretation of primary and derivative lithofacies maps, delineation of major structural elements and trapping configurations, and integration of geochemical, thermal, and pore fluid histories. Results allow projection of remaining potential in 10 recognized, geologically defined exploration "plays," or "fairways," that encompass Frio production. A final report is in preparation.

NATURAL GAS DEVELOPMENT IN TEXAS

W. L. Fisher, project director

This project involves an analysis of exploration, reserve additions, and production of Texas natural gas in response to higher prices of the 1970's. Also considered is projected performance in the 1980's.

SAN ANDRES OIL AND GAS STUDIES

Mark W. Presley, project director; Paul J. Ramondetta and Amos Bein; assisted by R. J. Dauzat, D. D. Guetzow, and R. W. Merritt

Much of the oil and gas produced from Permian shelf carbonates in the northern Midland and Delaware Basins, Texas, is from the San Andres Formation. Areas to the north of present production, particularly in the west-central part of the Texas Panhandle and in east-central New Mexico, are active exploration frontiers for new San Andres hydrocarbon reserves. The goals of San Andres oil and gas research by the Bureau of Economic Geology are (1) stratigraphic, structural, facies, and geochemical characterization of areas of present San Andres hydrocarbon production, and (2) development of an exploration model of controls on hydrocarbon occurrence, particularly in areas to the north of present production.

A map series in progress includes maps showing (1) structure on selected San Andres marker beds, (2) thickness of the entire San Andres Formation, and (3) thickness of selected subdivisions of the San Andres that contain genetically related facies. Paleogeographic maps and maps showing the distribution of San Andres facies are being developed to show the positions, trends, and geometries of potential reservoir beds. San Andres cross sections in progress show lithofacies interpretations and correlations.

An extensive study of San Andres organic geochemistry has dealt with questions of maturity of San Andres organics and migration of San Andres hydrocarbons.

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

Amos Bein, project director; assisted by Gerald Craig

This project is a detailed study of the San Andres carbonates in cores from wells in Randall, Swisher, Lamb, and Yoakum Counties. The spatial distribution of the entire San Andres Formation over the area and its depositional

interpretation are currently being studied by other Bureau researchers.

The carbonate units that increase in thickness from north to south are known to be shallow platform sediments, mainly dolomites. The aim of this study, which involves petrographic and geochemical methods, is to follow depositional trends and to establish diagenetic sequences that controlled the character of the San Andres carbonates. Recognition of these factors may contribute to further assessment of the oil potential of the area and to an evaluation of the area as a possible site for isolation of nuclear waste.

LAND RESOURCES INVESTIGATIONS

THE LAVACA-GUADALUPE-SAN ANTONIO-NUECES 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, as 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 of the hand-colored maps prepared during the project are currently available to the public. 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 color at a scale of 1:250,000. The Seguin West and San Antonio East 1° quadrangles are currently being prepared for publication.

ENVIRONMENTAL GEOLOGY OF THE EAST TEXAS LIGNITE BELT—JACKSON AND YEGUA UNITS

L. Edwin Garner, project director; Mary L. W. Jackson and Roger D. Sharpe; assisted by Robert A. Rountree and John C. Wilson

This project was initiated in late 1979 as a 2-year program funded by the Energy Lands Division of the U.S. Geological Survey. It will develop basic data in map form to depict the environmental impact of future mining in the Jackson and Yegua units of the East Texas lignite belt. Mapping entails field work and interpretation of aerial photographs. Twenty-three map units have been recognized and described and are being compiled in 7.5-minute topographic quadrangles. Field work and mapping are scheduled for completion in early 1981.

APPLICATION AND TRANSFER OF REMOTE SENSING TECHNOLOGY FOR STATEWIDE NEEDS IN TEXAS

Robert J. Finley, project director; Robert W. Baumgardner, Jr., Christopher D. Henry, and Alan B. Alhades; assisted by Marcie D. Machenburg and Adel Moustafa

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.

Landsat imagery, aerial photographs, and data from ground observations were collected for parts of the Texas Coastal Zone to serve as test data for system development. Procedures for computer-assisted analysis of Landsat imagery have been developed that allow the analyst maximum flexibility in classifying, combining, and separating land-cover classes. Results are displayed in color on a graphics display device, and photographic copies of classified Landsat data are compared with aerial photographs to reveal additional information. The initial Coastal Zone project has focused on the need of the General Land Office of Texas for information on (1) upland/wetland boundaries, (2) land cover/land use adjacent to wetlands, and (3) frequency of wetland inundation in coastal areas.

Collection of Landsat imagery, aerial photographs, and limited ground data was completed in parts of the Texas Panhandle and Trans-Pecos Texas. In the Panhandle region, these data will be used (1) to develop faster methods of determining the extent of irrigated cropland over the Ogallala aquifer and (2) to evaluate the condition of natural vegetation as an indication of drought severity. In the Trans-Pecos region, various combinations of remotely sensed data will be evaluated as tools for locating areas favorable for mineralization on the basis of detected alteration zones. Mineralization in the Trans-Pecos region is, in part, associated with centers of Tertiary-age volcanism.

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 FY 80.

Microseismic monitoring in the vicinity of 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 oxide.

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.

ENVIRONMENTAL EFFECTS OF IN SITU GASIFICATION OF TEXAS LIGNITE

T. F. Edgar (Department of Chemical Engineering), project director; W. R. Kaiser and M. J. Humenick (Department of Civil Engineering)

This project, funded by the U.S. Environmental Protection Agency (EPA), was a joint study of the Bureau of Economic Geology and the Departments of Chemical Engineering and Civil Engineering of The University of Texas at Austin. Initiated in October 1978 and completed in 1980, the study evaluates the potential environmental effects of in situ gasification in Texas.

That part of the study conducted by the Bureau of Economic Geology involved assessment of deep-basin lignite resources and delineation of areas of high potential for in situ gasification. Resources in thick (6 ft or more), continuous seams of uniform thickness and simple internal stratigraphy are preferred. Because gasification will be carried out in the fresh-water column, host-ground lithology, aquifer orientation, and ground-water flow direction take on added importance. Ideally, the host ground should be sand-deficient, low-permeability sediments, so that water inflow, gas leakage, and pollutant migration will be minimized. In situ gasifiers are best located in recharge areas where flow lines diverge and thus dispersion and attenuation are greatest. The essential criteria for site selection are resources in thick seams; proximity to potential markets such as brick and cement plants, existing lignite-fired power plants, and the coastal petrochemical complex; and host sediments of low transmissivity. Suitable sites can be found in the Jackson and Wilcox Groups of East Texas. However, the Jackson is a mud-rich geologic unit of low overall transmissivity and is therefore hydrologically superior to the Wilcox. Consequently, a Jackson site will probably meet more of the site selection criteria than will a Wilcox site.

A final report has been submitted to EPA's Industrial and Environmental Research Laboratory, Cincinnati, Ohio (Robert Thurnau, project monitor), and will be published in 1981 as an EPA report.

MINERAL RESOURCES INVESTIGATIONS

REGIONAL RECOGNITION OF SUBSURFACE BASE-METAL RESOURCES IN THE LLANO REGION OF CENTRAL TEXAS

Gary E. Smith, project director; assisted by Jay S. Ingram, Adrienne D. Allie, and Mary L. W. Jackson

The purpose of this 1-year project, initiated in October 1979, was to define the potential for lead, zinc, and cobalt resources in Upper Cambrian carbonates and siliciclastics peripheral to the Precambrian core of the Llano Uplift. Exposed mineralization in Central Texas occurs in lithofacies surrounding granite knobs that rise above the regional basement surface. Research has involved (1) synthesis of available surface and subsurface lithostratigraphic data, (2) multi-element spectrographic analysis of sulfide concentrates from widely spaced drill holes for the identification of metallogenetically significant regional trace metal variations, (3) detailed studies of surface prospects using surface and subsurface mapping, (4) interpretation of regional gravity and aeromagnetic data, (5) lead, sulfur, carbon, and oxygen isotope analysis of sulfides and associated host lithologies, and (6) compilation and review

of ground lineaments from Landsat photographic images.

Base-metal mineralization at the Hog Thief Bend (Scott Klett) prospect exhibits a spatial relationship to depositional pinch-out of sandstone of the Hickory Member of the Riley Formation. Regional lead and manganese anomalies correlate with areas dominated by regional thinning of the Hickory Member. Zinc, cobalt, copper, and barium broadly correlate with basement topography, but also exhibit regional vertical zoning patterns related to the movement of basinal brines across an ancestral Llano uplift. Base-metals, although found in Upper Cambrian lithofacies, were emplaced during the late Paleozoic coincident with an early phase of compression within the Ouachita orogen. Sulfur for metal precipitation was derived from Lower Pennsylvanian sea-water sulfate. Dolomitization accompanied the introduction of metal-bearing low-temperature hydrothermal solutions (approximately 200°C) and enhanced host permeability.

Regional and prospect studies resulting from this study were integrated to identify the presence of geologically and geochemically favorable areas for base-metal exploration in Upper Cambrian strata surrounding the Llano Uplift. A comprehensive report covering the results of this project is now in preparation.

CALDERAS AND MINERALIZATION, TRANS-PECOS TEXAS

Christopher D. Henry, project director; Timothy W. Duex

This project, funded by the Texas Mining and Mineral Resources Research Institute, is evaluating the potential for base and precious metal mineralization in Trans-Pecos Texas. Emphasis is on the spatial and genetic relationship of mineralization to calderas. Work in the first year has focused on the Chinati Caldera Complex, an area of abundant mineralization, including the Shafter silver district, which will soon be reopened. The structural and igneous evolution of the caldera complex, the timing of igneous activity, the timing of mineralization, and the relationship of mineralization to caldera structures and volcanism are being investigated through a combination of detailed geologic mapping, geochemical sampling, and isotopic analysis. An initial report summarizing the findings to date has been completed.

HANDBOOK OF TEXAS MINERAL RESOURCES

L. Edwin Garner, project director; Roger D. Sharpe, Gary E. Smith, W. C. J. van Rensburg, and Terry J. Barron

The *Handbook of Texas Mineral Resources* will provide a comprehensive statewide survey of mineral resources. Topics covered will include metallic minerals, nonmetallic minerals with emphasis on end-use relationships, and nonpetroleum fossil and nuclear fuels. Introductory material includes Federal and State mining and reclamation laws, mineral taxation, economic analysis, and infrastructure of the mineral industry in Texas.

Areas of investigation include (1) description of known deposits and favorable areas for exploration, (2) physical and chemical properties, (3) geologic setting, (4) production and uses, (5) exploration, evaluation, and development of new deposits, (6) economic factors of production and marketing, (7) production/demand trends and projection, (8) environmental factors, and (9) potential resources in Texas.

The handbook is a vital addition to the mineral resource knowledge of Texas. It provides current information on the distribution of Texas strategic mineral resources. Deposits that were marginal or uneconomical in the past need to be reevaluated in light of new developments in mining and beneficiation techniques.

Potential benefits of the handbook include (1) providing current information on exploration and evaluation techniques related to special problems in the analysis of Texas mineral resources, (2) answering many of the questions received by the Bureau of Economic Geology concerning the geology and economics of Texas mineral resources, (3) disseminating information in a form that the nongeologist as well as the professional can use, and (4) providing a reference for college courses in mineral resources.

A circular (MRC 64) by Roger D. Sharpe, *Development of the Mercury Mining Industry: Trans-Pecos Texas*, was published this year. Two other circulars, *Portland Cement and Cement Raw Materials in Texas*, by Sharpe and Tom S. Patty, and *The Aluminum Industry in Texas*, by Terry J. Barron, are in preparation.

UNITED STATES DEPENDENCE ON IMPORTED SOURCES OF NONFUEL MINERALS

W. C. J. van Rensburg, project director; assisted by Allan Standen

This study, funded by the Scaife Family Charitable Trusts, was initiated in July 1980. The study comprises an investigation into the nature and extent of United States dependence on imported sources of selected nonfuel strategic minerals, including manganese, chromium, platinum-group metals, cobalt, aluminum, vanadium, copper, lead, zinc, cobalt, and tin. The extent to which current and potential foreign sources of these minerals can continue to supply the United States and the risks of disruptions are analyzed, and the effects of increased energy costs on the local processing of these metals are evaluated. The extent to which dependence on foreign supply sources could be reduced by encouraging domestic production is investigated. The economic and strategic effects of the mineral import dependence of the United States are evaluated.

BASIN STUDIES

LOCATING FIELD CONFIRMATION STUDY AREAS FOR ISOLATION OF NUCLEAR WASTE IN THE TEXAS PANHANDLE

Thomas C. Gustavson, project director; R. L. Bassett, Robert J. Finley, Arthur G. Goldstein, C. Robertson Handford, J. H. McGowen, Mark W. Presley; Alan B. Alhades, Joyce M. Basciano, Robert W. Baumgardner, Jr., M. E. Bentley, E. Dow Davidson, Shirley P. Dutton, Ann D. Hoadley, Rory Howard, W. P. Jenkins, Kathy A. McGillis, Douglas A. McGookey, Paul J. Ramondetta, Katherine E. Schmedes, Steven J. Seni, William W. Simpkins; assisted by W. Bath, B. E. Castens, R. J. Dauzat, E. A. Duncan, Jennifer

Forman, J. Griffin, D. D. Guetzow, R. A. Merritt, J. A. Middleton, F. M. Mikan, D. E. Miser, E. Naiman, M. A. Sandstrom, D. J. Young, Stephen Weiner, J. Williams, and G. Hummel.

The goal of this Bureau research project, funded by the U. S. Department of Energy, is to evaluate the Palo Duro and Dalhart Basins of the Texas Panhandle to determine if the bedded Permian salt strata in those basins are suitable for safe isolation and long-term storage of nuclear wastes. 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 FY 77); (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 (FY 78); 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 (FY 79).

Studies initiated in FY 80 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 FY 80 also passed into a more discriminating, intensified stage of evaluating priority items recognized during the earlier framework studies. The FY 80 program was designed 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, land-resources evaluations were initiated to provide the basis for later social and economic decisions relative to host-rock feasibility.

The Palo Duro Basin is a small subbasin of the Permian Basin of southwest Texas and southeastern New Mexico. This larger province underwent crustal depression from the Early Pennsylvanian Period through the Permian Period; this allowed thicker accumulations of sediments. Within this depressed region, smaller blocks of the crust were displaced along deep-seated faults, creating a system of subbasins separated by basement uplifts. Those uplifts that we have studied in detail have apparently formed by movement along high-angle reverse faults. The Palo Duro Basin is bounded on the north by the Amarillo Uplift, upthrust toward the north-northeast, and on the south by the Matador Arch, upthrust toward the south. Thus, the basin sits on an uplifted block of crust that must have experienced north-northeast extensional deformation during its formation.

Upper Permian salt-bearing rocks in the Palo Duro and Dalhart Basins have been subdivided into four lithogenetic units: (1) the combined lower Clear Fork and Tubb Formations, (2) the combined upper Clear Fork and Glorieta Formations, (3) the San Andres Formation, and (4) post-San Andres (Guadalupian and Ochoan) strata. Each of these units contains bedded salt at depths between 300 and 900 m, and net salt thicknesses exceed 100 m. These salt-bearing units are composed of an upward succession of carbonates overlain by evaporites and red beds. This succession is a record of deposition in marine-shelf and coastal-evaporite environments, with a gradual seaward shift of environments through time. Salt quality (presence of mud and other impurities and bulk rock chemistry) is predictable from knowledge of the geometry of the original depositional systems.

Clay mineral assemblages within Permian evaporites in the Palo Duro Basin have been identified by chemical analyses and X-ray diffraction and consist of (1) combinations of the mixed-layer clays, chlorite-swelling chlorite, chlorite-vermiculite, and chlorite-smectite, and (2) discrete phases of illite and chlorite. The in situ water content of bedded salt and the nature of its occurrence are being determined by optical evaluation of water content, titration by Karl-Fischer method, and heat treatment. Values obtained in the preliminary investigation range from 0.15 to 2.44 percent free water, which does not include hydroxyl water.

A conceptual model has been developed for regional ground-water flow in the Texas Panhandle and eastern New Mexico. Flow is governed by the heterogeneous distribution of permeability associated with the multiple genetic depositional units, rather than by local topographic influences. There is a potential for fluid movement through the evaporite section. A steady eastward decline of potentials in the deep brine systems indicates a regional hydraulic connection between outcropping recharge areas in eastern New Mexico and discharge areas in the eastern parts of the Texas Panhandle and western Oklahoma.

Pennsylvanian and Wolfcampian (Lower Permian) basinal shales contain up to 2.4 percent organic carbon and are fair to very good hydrocarbon source rocks. Physical characteristics of the organic matter indicate maximum paleotemperatures. Pennsylvanian and Wolfcampian kerogen is yellow-orange to orange; vitrinite reflectance averages 0.5 percent. This indicates that temperatures were probably high enough to begin generation of hydrocarbons from lipid-rich organic material.

The Little Red River heads along the eastern Caprock Escarpment of the Southern High Plains. Field studies within the basin have revealed that there has been considerable recent erosion and that exported suspended-sediment load for the 1979 water-year was 375,500 tons. Assuming specific weights of 801 to 1,161 kg/m^3, this equals a basinwide denudation rate of 0.81 to 1.18 mm. Rates of basin development and denudation were estimated using hypsometric analysis. An estimated 133 km^3 of sediment has been removed from the basin.

In eastern Briscoe and Hall Counties, Texas, at least 400 sinkholes and collapse depressions were recognized, and in a smaller test area that covers approximately 13 percent of the counties, 36 sinkholes and 2 depressions have formed since 1940.

A zone of salt dissolution, recognized from geophysical logs, structural cross sections, and salt thickness maps, borders the Palo Duro Basin on the west, north, and east and parallels the escarpment of the Southern High Plains. Recently formed sinkholes, collapse depressions, or open fractures have been recognized in each of the New Mexico and Texas counties within the salt dissolution zone, suggesting that surface collapse over the entire zone of salt dissolution is an active regional process.

Studies in FY 81 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—all problems that must be answered before completion of these feasibility studies.

EVALUATING THE POTENTIAL OF EAST TEXAS INTERIOR SALT DOMES FOR ISOLATION OF NUCLEAR WASTES

Charles W. Kreitler, project director; Olusegun Agagu, Joyce M. Basciano, Edward W. Collins, E. Dow Davidson, Owen R. Dix, Shirley P. Dutton, Graham E. Fogg, Alice B. Giles, C. Robertson Handford, David W. Harris, M. P. A. Jackson, Mary K. McGowen, Katherine E. Schmedes, Steven J. Seni, Debra H. Wood, and H. Victor Wuerch III; assisted by F. Boyd, B. R. Bracken, E. Bramson, C. Chomicky, R. D. Conti, D. E. Dann, R. W. Debus, S. A. Ghazi, B. D. Legett, C. Lopez, D. Magouirk, J. F. McIntyre, G. E. Meyer, E. T. Pisasale, K. S. Pollman, R. L. Sherrill, and J. D. Smith

The goal of this comprehensive investigation, funded by the U. S. Department of Energy, is to evaluate the suitability of underground salt domes in the East Texas 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 and the potential natural resources in the basin. To develop information related to these concerns, a Bureau research team is undertaking geologic, hydrologic, geomorphic, and remote-sensing investigations of specific salt domes and also of the entire region.

Hydrologic investigations include studies of the ground-water systems of the basin and also of the ground-water flow around the salt domes. These studies determine amount and rate of salt dome dissolution and location of the saline-water plumes (resulting from the dissolution of the salt) in the fresh ground-water supplies. Results include the following:

(1) Carbon-14 age dates around Oakwood Dome show increasing age from outcrop toward discharge zones along the Trinity River.

(2) A three-dimensional ground-water flow model has been designed to test the impact of recharge, aquifer heterogeneity and structure, topography, and the Oakwood Salt Dome itself upon the direction and rate of ground-water movement in the Oakwood Dome area.

(3) The cap rock on Oakwood Dome was formed in a deep saline aquifer and does not represent a recent dissolution product.

Regional subsurface studies are in progress to determine the size and shape of specific salt domes, the geology of the strata immediately surrounding the domes, and the regional geology of the East Texas Basin. Such information will enable the research team to interpret the geologic history of the development and growth of the domes and of the filling of the basin with sedimentary rocks. In addition, the research team will use the information to evaluate potential natural resources of the basin. The subsurface team has reached the following conclusions:

(1) Initial development of Oakwood Dome began in Late Jurassic time; the dome became a diapir in Early Cretaceous time and continued to grow until Eocene time.

(2) Initial salt movement in the basin was along the periphery of the basin during Late Jurassic time, and resulted from gravity flowage.

(3) Petroleum production from shallow piercement diapirs has been minimal compared with production from turtle-structure anticlines and from anticlines occurring over deep salt domes.

Studies of the surface geology, including geomorphology, are also in progress. The objective of these studies is to determine if any dome growth or any tectonic movement such as tilting and faulting has occurred in the region during the Quaternary Period (within the past 2 million years). The important conclusions in the surficial geology section are as follows:

(1) Shallow domes in the southern part of the basin have a higher density of lineations than other sections of the basin.

(2) Holocene floodplain deposits over Oakwood Dome are in a topographic depression, which may indicate post-Eocene subsidence over the dome.

(3) Detailed studies in the vicinity of Palestine Dome of Quaternary gravels do not indicate any warping during Quaternary time.

ANALYSIS OF THE CONSOLIDATION OF TERTIARY SANDSTONES, TEXAS GULF COAST

W. R. Kaiser, project director; Kinji Magara, Robert G. Loucks, Debra L. Richmann, and Kitty L. Milliken; assisted by M. J. Darr, J. L. Forman, B. D. Legett, C. L. McCall, J. R. Suter, L. S. Underwood, and D. H. Wilson

Funding for the Sandstone Consolidation projects has been and continues to be provided by the U.S. Department of Energy (DOE), Division of Geothermal Energy. The Sandstone Consolidation I Project, completed in 1979, provided an initial assessment of reservoir quality of Tertiary sandstones along the Texas Gulf Coast. A consolidation sequence was established relating diagenesis to depth of burial.

The Sandstone Consolidation II Project was completed in 1980 and involved detailed comparison of two areas identified in Sandstone I as having greatly contrasting reservoir quality. Good reservoir quality was identified in the upper Texas coast (Chocolate Bayou/Danbury area, Brazoria County) and is characterized by excellent, deep secondary porosity and permeabilities up to 1,000 mD. Poor reservoir quality was identified in the lower Texas coast (McAllen Ranch Field, Hidalgo County) and is characterized by abundant late calcite cement that occluded secondary porosity and reduced permeabilities to less than 1 mD. Differences in the sequence and intensity of diagenesis are responsible for the differences in reservoir quality between the two areas. Intensity of reaction is largely a function of the primary detrital composition of the sandstones. The onset of specific diagenetic events is strongly influenced by temperature gradient, and reactions are enhanced by the relatively high thermal gradient.

Early consolidation of Vicksburg sandstones in the McAllen Ranch Field was promoted by the effects of an abnormally high geothermal gradient on the mechanically and chemically unstable detrital minerals. As burial depth increased, the sandstones moved through a succession of geochemical environments, causing calcite to be leached and precipitated several times; calcite thus occurs in multiple phases. Unfortunately, calcite precipitation and preservation were far more extensive than was calcite leaching, and late-forming ferroan calcite has occluded most deep secondary porosity.

In the Chocolate Bayou/Danbury area, Frio sandstones contain fewer unstable detrital constituents and have been exposed to lower temperatures during burial. These rocks have never contained authigenic carbonates on the extensive scale found in the South Texas Vicksburg. More importantly, secondary porosity was not affected by major late-stage carbonate precipitation.

A final report (DOE/ET/27111-1) for the Sandstone II Project has been approved for public release by DOE and will be available through the National Technical

Information Service in 1981. The report contains considerable compositional data on authigenic carbonates and feldspar, as well as oxygen and carbon isotopic data on authigenic carbonates.

A Sandstone Consolidation III Project was initiated in July 1980 and is the next logical step in efforts to understand and predict the occurrence of geothermal reservoirs. The project will be more geochemical in nature than earlier projects and will investigate water/rock interactions affecting diagenesis. This will be accomplished through analyses of brine chemistry, elemental and isotopic composition of detrital and authigenic minerals, volume and flow directions of compaction waters, and organic matter maturation. Whereas earlier projects concentrated on sandstones, this project will place increased emphasis on the mineralogy and chemistry of shales, especially those of the cap rock. The nature of the cap rock, its distribution, and its relationship to the occurrence of deep secondary porosity will be evaluated. The ultimate goal is to develop a diagenetic model for the prediction of secondary porosity.

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

L. F. Brown, Jr., project director; Raul Solis; assisted by Stephen C. Van Dalen, David A. Johns, and David Cunningham

This study involves interpretation of the subsurface stratigraphy and facies of Upper Pennsylvanian and Lower Permian strata within 30 counties of North-Central Texas. At the end of 1980, 22 regional stratigraphic cross sections of the Home Creek Limestone to Coleman Junction Limestone interval were being drafted. These dip and strike cross sections, as well as a location map, a list of the wells on the cross sections, and a brief description/discussion, are scheduled to be released in late 1981 or early 1982.

At the end of 1980, 12 of 16 net-sandstone maps of the 30-county area had been completed and were undergoing review. These Cisco-Wolfcamp maps and a text describing the depositional systems of the Eastern Shelf will be prepared for 1981 release.

These publications are designed to provide regional facies and stratigraphic control needed in the search for oil, water, clay, coal, and other resources in the region.

JURASSIC CARBONATE FACIES, DEPOSITIONAL ENVIRONMENTS, AND DIAGENESIS—SOUTH TEXAS

David A. Budd and Robert G. Loucks

Detailed facies patterns and depositional histories have been documented by various workers for the Smackover and lower Buckner Formations in almost the entire northern Gulf Coast Basin from northeastern Mexico to Florida. Only in South Texas have the Smackover and lower Buckner Formations not been studied.

That area of the state is the focus of this project, which documents lithofacies, determines depositional environments, and outlines depositional histories from geophysical log and core data.

A report entitled *Smackover and Lower Buckner Formations, South Texas: Depositional Systems on a Jurassic Carbonate Ramp* is now in preparation and includes the following major conclusions:

(1) The Smackover and lower Buckner sediments were deposited on a broad carbonate ramp, forming a thick regressive sedimentary sequence.

(2) Four major depositional systems existed: basinal, low-energy open shelf, high-energy shoal, and evaporitic sabkha.

(3) High-energy grainstone and packstone facies were concentrated landward, and muddier low-energy facies occurred seaward.

(4) Localized structural control of the depositional patterns, common to Smackover strata in the more northerly Gulf Coast region, is not recognized in South Texas.

DEEP-WATER FACIES OF THE SPRABERRY SANDSTONE, MIDLAND BASIN

C. Robertson Handford, project director; assisted by Holly K. Lanan

This project, initiated in late 1978, was completed during 1980. The project consisted of studying Spraberry cores and geophysical logs to determine vertical and lateral facies variations, infer depositional environments, understand diagenetic problems, and relate petroleum production to the Spraberry depositional systems.

The Spraberry trend, discovered in 1949, consists of 8.9 billion barrels of oil in place; several hundred million barrels have been produced. The Spraberry is composed of several hundred feet of basinal carbonate and shale overlain by several hundred feet of siltstone and fine-grained sandstone. The formation was deposited by episodes of suspension deposition and long-lived density flows, which produced hemipelagic and turbidite facies.

Late in 1980, results of the investigation were being prepared for publication in the 1981 Society of Economic Paleontologists and Mineralogists short course notes on deep-water sandstone.

ELLENBURGER CARBONATE FACIES, DEPOSITIONAL ENVIRONMENTS, AND DIAGENESIS—WEST TEXAS

Robert G. Loucks, project director; James H. Anderson

The initial part of this project concentrated on the Ellenburger and Bliss sections in the Puckett field, Pecos County, Texas, where a 1,700-ft core through the entire Ellenburger section was obtained and made available for detailed study.

Bliss and lower Ellenburger facies are interpreted to have been deposited by an alluvial-fan and fan-delta complex associated with a coastal sabkha. The middle and upper Ellenburger facies are interpreted to have been deposited in marine environments similar to those found around western Andros Island, Bahamas; these latter include subtidal, intertidal/supratidal channel belt, and supratidal environments. Numerous periods of subaerial exposure during Ellenburger sedimentation resulted in the formation of diagenetic terrains characterized by poorly formed soil horizons and by solution-collapse breccias up to 50 ft thick. With deep burial, tectonic stresses produced fine fractures in much of the Ellenburger section. The porosity network in the Puckett gas field consists of isolated zones of breccia porosity and intercrystalline porosity interconnected by open fractures.

FLUID FLOW SYSTEMS OF AN ACTIVELY SUBSIDING BASIN—IMPLICATIONS FOR NATURE AND LOCATION OF EPIGENETIC URANIUM DEPOSITS

William E. Galloway, project director; assisted by Allan R. Standen and John R. Suter

The constantly increasing data produced by ongoing exploration and mining in the South Texas uranium

province clearly demonstrate the complex alteration history characteristic of major uranium deposits that are hosted by syndepositionally oxidized fluvial sediments. Both regional and more local delineations of the geochemistry, mineralogy, and paragenesis of major alteration zones were utilized to interpret the nature, origin, and flow history of various ground waters responsible for the development of the uranium deposits. Distribution and features of the deposits document a complex interplay between ascending, sulfur-rich, deep-basin waters and shallow, uranium-enriched, meteoric ground water.

The project was funded by the Uranium and Thorium Branch of the U. S. Geological Survey; a report of results and conclusions is in progress.

FORMATION OF THE WINK SINK, WINKLER COUNTY, TEXAS

Thomas C. Gustavson, Robert W. Baumgardner, Jr., Ann D. Hoadley, Arthur G. Goldstein; assisted by D'nese Young, Gary A. Hummel, Melissa A. Sandstrom, and Jennifer Forman

This project, funded by the U.S. Department of Energy, began after the sudden appearance of the Wink Sink on June 3, 1980. The purpose of the study was to describe the sinkhole, its geologic setting, and the processes that led to its formation.

The investigation of this phenomenon comprised several tasks. The history of salt dissolution in the Delaware Basin was reviewed, and reports of collapse features were compared with features observed at the Winkler County sinkhole. Two vintages of aerial photographs of western Winkler County were examined for the recent appearance of subsidence features. Regional and site-specific stratigraphic cross sections, structure contour maps, and isopach maps were constructed for the sinkhole area. Because the Wink Sink formed near an abandoned oil well, records for that well and other nearby wells were studied. Analysis of a water sample taken from the sinkhole was compared with analyses of water from nearby water wells.

Results indicate that salt dissolution is occurring throughout the Permian Salado Formation, which is found between 400 and 670 m depth in the vicinity of the sinkhole. Relatively fresh water capable of dissolving salt may come from the Capitan aquifer below the salt or from near-surface aquifers above the salt. Fractures or abandoned boreholes may be conduits for the movement of water between the aquifers and the salt-bearing strata.

Preliminary results of this study were presented at the October 13-14 meeting of the Solution Mining Research Institute in Minneapolis, Minnesota. A final report is in preparation.

COASTAL STUDIES

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

J. H. McGowen, Robert A. Morton, William A. White (project coordinator), Thomas R. Calnan (chief biologist), Russell S. Kimble, Thomas G. Littleton, H. Seay Nance, and Katherine E. Schmedes; assisted by William A. Ambrose, James A. DiGiulio, Tom C. Freund, Jon P. Herber, Gary J. Steck, John Wilkins, Stephen S. Wright, and Patti A. Yates

This multiphase project is based on a completed comprehensive sampling program of State submerged lands where over 6,700 grab samples were collected for analyses of sediment types, associated geochemistry, and benthic macroinvertebrates. 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 of 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 1980, geochemical maps showing the distribution of 10 to 11 elements were completed for the following map sheets: Corpus Christi, Brownsville-Harlingen, Kingsville, Port Lavaca, Bay City-Freeport, and Beaumont-Port Arthur. Similar maps were previously completed for the Galveston-Houston area. The Bureau's Mineral Studies Lab is conducting additional geochemical analyses of selected samples in the bay-estuary-lagoon systems to supplement data provided by the U. S. Geological Survey to complete the Brownsville-Harlingen, Kingsville, Port Lavaca, and Beaumont-Port Arthur map sheets.

A series of surface sediment maps, which include the distribution of (1) shell, sand, and mud, (2) sand, silt, and clay, (3) percent sand, and (4) mean phi, were completed for the Corpus Christi and Brownsville-Harlingen areas. Sediment analyses conducted by the Bureau's Sedimentology Lab under the direction of Seay Nance have been completed for the Beaumont-Port Arthur area. Analyses are continuing on samples collected in the area of Bay City-Freeport.

Live benthic macroinvertebrates (primarily mollusks, crustaceans, and polychaetes) were identified and counted for approximately 170 samples in the Brownsville-Harlingen area. From the Galveston-Houston map sheet, 130 additional biological samples were analyzed to supplement previous analyses (130), thereby enhancing the resolution of invertebrate distribution patterns. Analyses of samples taken from the Beaumont-Port Arthur area are in progress. All data are being processed by computer for cluster analysis and species diversity. Among the eventual products of the biological analyses will be color-separated maps, scale 1:125,000, showing the distribution of invertebrate assemblages.

A new phase of the project, which is to include the distribution of coastal wetlands and related environments on the invertebrate assemblage maps, was initiated in 1980. Wetlands are being mapped using 1979 color-infrared photographs. Map units are patterned after the Bureau's *Environmental Geologic Atlas* series, and finished maps will update the biological assemblages maps of these atlases. Interpretation and delineation of the various map units have been completed for the Corpus Christi area, and photoanalysis is in progress for the Galveston-Houston area. Cartographers have begun transferring information to base maps as an initial step toward the eventual publication of color-separated maps at a scale of 1:125,000.

WETLANDS DELINEATION AND CLASSIFICATION OF THE COASTAL AND PANHANDLE REGIONS OF TEXAS

William A. White, project coordinator; Linda S. Adair, Katherine E. Schmedes, and Jeffrey A. Songer

Completed in 1980, this project is part of the National Wetlands Inventory funded by the U. S. Department of Interior, Fish and Wildlife Service. Wetlands and deep-water habitats were classified and mapped on approximately 1,000 photographs covering the Coastal Plain and Panhandle regions of Texas. The regions were mapped in accordance with a standardized classification system (*Classification of Wetlands and Deep-Water Habitats of the United States, An Operational Draft,* 1977) adopted by the Fish and Wildlife Service.

In the Texas coastal region, wetlands were mapped using existing black-and-white or color-infrared stereoscopic phototransparencies; scales of the photographs range from 1:120,000 to 1:80,000 and dates from 1972 to 1977. Phototransparencies used in the Texas Panhandle were 1977 dated, color infrared, scale 1:80,000. Photoanalysis was made with the aid of 6-power folding mirror stereoscopes and light tables.

Wetlands and deep-water habitats were classified into one of five systems—marine, estuarine, riverine, lacustrine, or palustrine—which were in turn subdivided into subsystems and classes. A coastal marsh of *Spartina alterniflora,* for example, was classified as follows: estuarine (system), intertidal (subsystem), emergent wetland (class). For mapping purposes, this unit was abbreviated E2EM. In addition, in the Texas Panhandle, water regimes and modifiers indicating human modifications were applied when classifying and mapping playa lakes.

Comparisons of the areal extent and distribution of wetlands defined and mapped in accordance with the U. S. Fish and Wildlife Classification System with those defined and mapped as part of the Bureau's *Environmental Geologic Atlas of the Texas Coastal Zone* show some differences. The more encompassing Fish and Wildlife Classification System substantially increases the acreage of wetlands mapped along the Texas coast, particularly south of the Corpus Christi area.

Mapped areas are being transferred to U. S. Geological Survey 7.5- or 15-minute quadrangle maps by the U. S. Fish and Wildlife Service, from which the final map products (scale 1:100,000) will be available.

SOUTH PADRE ISLAND-SOUTH LAGUNA MADRE WIND-TIDAL FLATS

J. H. McGowen, project director; assisted by J. P. Herber and S. S. Wright

Wind-tide flooding of the South Padre Island-South Laguna Madre flats was documented by (1) on-the-ground mapping by a General Land Office of Texas survey crew, (2) on-the-ground observations by geologists of the Bureau of Economic Geology, and (3) mapping on vertically controlled, black-and-white and color-infrared photographs, dating from 1955 through January 1980, many of which were collected by the General Land Office. The position of high water on the tidal flats was mapped on each set of photographs. Wind conditions existing during the photographing were determined from weather data from the Brownsville Weather Station and from a weather station on a National Ocean Survey (NOS) tide gage in South Laguna Madre. Flooding of the wind-tidal flats is chiefly a function of meteorological conditions (speed, direction, and duration of wind, and barometric pressure); astronomical tides caused only insignificant flooding.

Depositional and erosional effects of Hurricane Allen on South Padre Island, in the area between Mansfield Ship Channel and La Punta Larga, were documented by both on-the-ground observations and mapping on a set of vertically controlled, color-infrared aerial photographs that were taken on August 28, 1980. Transects were made from the Gulf beach, across South Padre Island, into South Laguna Madre. Bedforms were observed, described, trenched, and sampled along these transects. Most of the area was under water as Hurricane Allen approached the Texas coast, made landfall, and moved inland. Estimates of the depth of flooding produced by Hurricane Allen were determined from the height of debris lines. Detailed topographic maps (contour interval 0.1 ft; control stations on 0.5-mi centers) were made of the Los Bancos de en Medio area in late 1979 and again immediately after the passage of Hurricane Allen. A comparison of these topographic maps indicates that in the Los Bancos de en Medio area erosion predominated over deposition during the passage of Hurricane Allen.

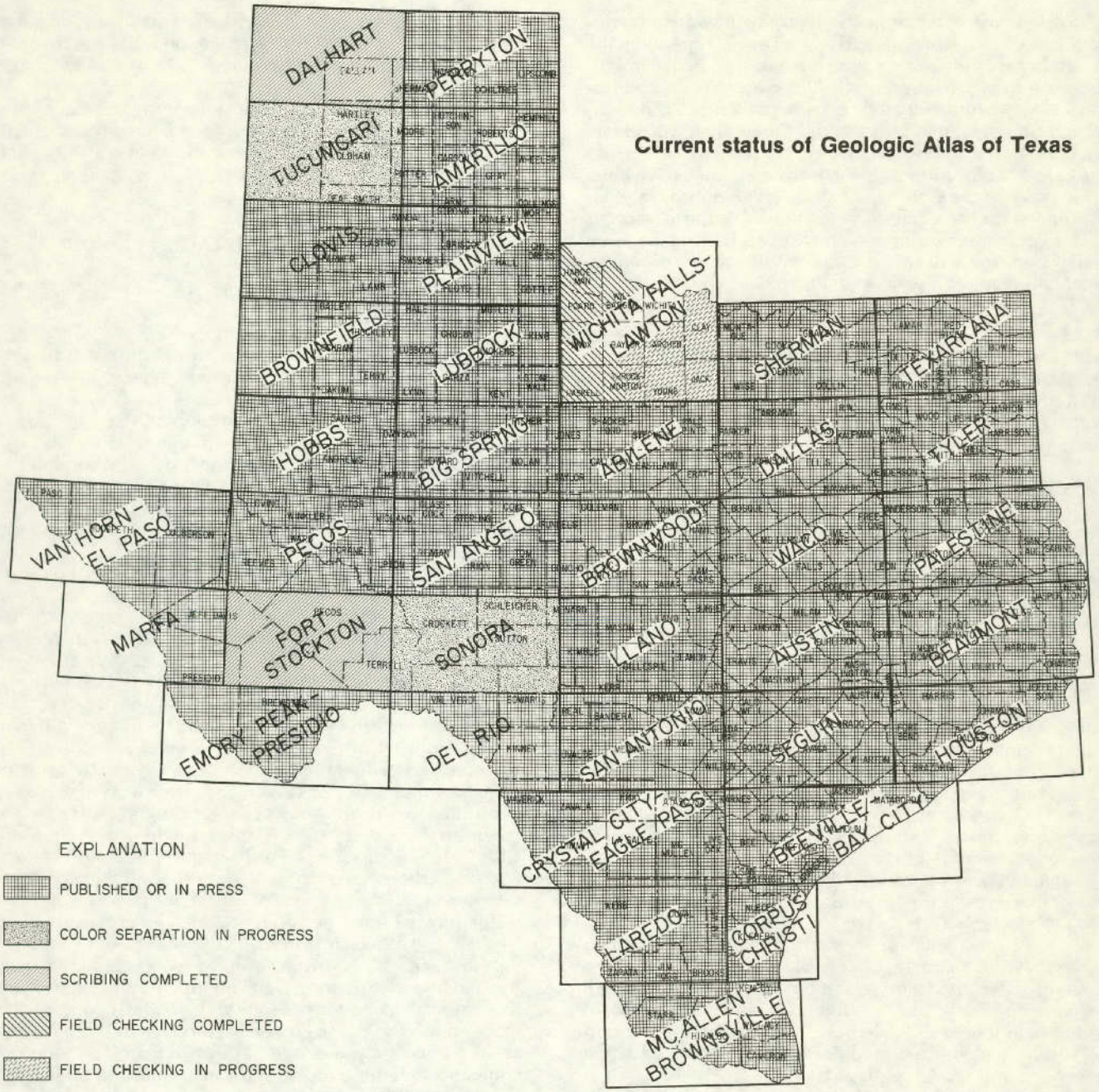
Results were reported to the General Land Office of Texas, which contributed funding to this research; formal Bureau reports are in preparation.

GEOLOGIC MAPPING

GEOLOGIC ATLAS OF TEXAS

Virgil E. Barnes, project director; J. H. McGowen; 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.



Thirty-two sheets in the series have been published. At yearend, final corrections were being made to prepare the Llano Sheet for press. Color separation had been completed for the Sonora and Tucumcari Sheets. The Fort Stockton Sheet was being reviewed at yearend, after completion of scribing, and the Dalhart Sheet was being scribed. Remaining field work for the Wichita Falls-Lawton Sheet is scheduled for 1981.

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 all completed sheets of the *Geologic Atlas of Texas* has been marked for use in drafting the new map. As soon as the Llano Sheet is published, the southeastern quadrant of the *Geologic Map of Texas* can be scribed. The southwestern quadrant can be scribed when the Fort Stockton and Sonora Sheets are available. The explanation for the *Geologic Map of Texas* has been completed and will be placed in the southwestern quadrant of the map. The completion date of the new map will depend on completion of the final sheets of the *Geologic Atlas of Texas.*

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 in preparation.

QUATERNARY MAPS OF TEXAS

E. G. Wermund and James W. Macon, project coordinators; cartography by Barbara Hartmann

This project, initiated in 1978 with funds from the U. S. Geological Survey, involves the preparation of geologic maps of Texas Quaternary rock units as this State's contribution to the U. S. Geological Survey map series, *Quaternary Geology of the United States* (scale 1:1,000,000). The Bureau's role in this nationwide program includes the compiling and scribing of the Texas Quaternary maps at a scale of 1:1,000,000 by using previously published Bureau of Economic Geology maps as the basic source material. The principal source maps are the *Geologic Atlas of Texas* (1:250,000 scale) and the *Land Resources of Texas Map* (1:500,000 scale).

Map units include both Pleistocene and Holocene stratigraphic units as well as units representative of surficial cover. In 1980, all Texas maps were scribed, colored, and forwarded to the U. S. Geological Survey. The effort located many interesting problems of Quaternary correlation; following resolution of these problems, a Quaternary map of Texas can be published at 1:1,000,000 scale by the Bureau of Economic Geology.

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 1980 was mostly curatorial—furnishing material for other researchers, answering questions, and reviewing manuscripts.

APPLICATION OF MAGNETIC ANISOTROPY AS AN INDICATOR OF FINITE DEFORMATION

Arthur G. Goldstein, projector director; W. A. Gose (Marine Science Institute, Galveston), M. P. A. Jackson, and T. Engelder (Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York)

A variety of methods may be used to determine the finite strain in deformed rocks. Most of these methods either require the presence of objects of known predeformational shape or are tedious to perform. The three-dimensional variation in magnetic susceptibility, or magnetic susceptibility anisotropy, has been related to finite strain in a number of different deformational settings and is a rapidly determined quantity.

The aims of this project are to refine measurement techniques using a cryogenic magnetometer, to describe more fully the relationship between finite strain and magnetic anisotropy, and to interpret the deformational histories of dome salt from the Oakwood salt dome, Texas, mylonites from the Lake Char fault zone, Massachusetts, and the very mildly deformed Devonian clastic sequence of western New York State.

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 supported by contracts and grants with State agencies, local units of governments, 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 1980 contract management personnel initiated a quality assurance program in accordance with Nuclear Regulatory Commission requirements for Bureau contracts. Other duties performed by this office include computer accounting, student placement, legislative reports, and publication inventory.

In calendar year 1980, 42 contracts were active at the Bureau, each of which had reporting requirements:

Federal

Analysis of Approximately Seven Hundred Feet of South Texas Core (Oakville-Goliad): supported by Bendix Field Engineering Corporation, a prime contractor for the U. S. Department of Energy.

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

Consolidated Research Program: United States Gulf Coast Geopressured Geothermal Program (joint project of Center for Energy Studies and Bureau of Economic Geology): supported by the U. S. Department of Energy.

Consolidation of Geologic 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.

Factors Controlling Reservoir Quality in Tertiary Sandstones and Their Significance to Geopressured Geothermal

Production (including modification phase entitled "Using the Presence of Calcite Cap Rock in Shales to Predict Occurrence of Reservoirs Composed of Leached Secondary Porosity in the Geopressured Zone"): supported by the U. S. Department of Energy.

Fluid Flow Systems of an Actively Subsiding Basin — Implications for Nature and Location of Epigenetic Uranium Deposits: supported by the U. S. Geological Survey.

Geologic Map: Sonora Sheet: supported by Bendix Field Engineering Corporation, a prime contractor for the U. S. Department of Energy.

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.

Quadrangle Evaluation of Uranium Favorability of the Amarillo Quadrangle (including Uraniferous Asphaltite Study): supported by Bendix Field Engineering Corporation, a prime contractor for the U. S. Department of Energy.

Quadrangle Evaluation of Uranium Favorability of the Emory Peak, Marfa, and Presidio Quadrangles: supported by Bendix Field Engineering Corporation, a prime contractor for the U. S. Department of Energy.

Quadrangle Evaluation of Uranium Favorability of the Lubbock Quadrangle: supported by Bendix Field Engineering Corporation, a prime contractor for the U. S. Department of Energy.

Quadrangle Evaluation of Uranium Favorability of the Palestine Quadrangle: supported by Bendix Field Engineering Corporation, a prime contractor for the U. S. Department of Energy.

Quadrangle Evaluation of Uranium Favorability of the Sherman Quadrangle: supported by Bendix Field Engineering Corporation, a prime contractor for the U. S. Department of Energy.

Quadrangle Evaluation of Uranium Favorability of the Wichita Falls Quadrangle: supported by Bendix Field Engineering Corporation, a prime contractor for the U. S. Department of Energy.

Resources Evaluation of the Frio Formation: 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.

Seismic Studies—Austin Bayou and Cuero Geopressured Geothermal Prospects: supported by the U. S. Department of Energy.

Study Effects of Geopressured Geothermal Subsurface Environment on Elastic Properties of Texas Gulf Coast Sandstones and Shales Using Well Logs, Core Data, and Velocity Surveys: supported by the U. S. Department of Energy.

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

United States Gulf Coast Geopressure-Geothermal Resource: Preliminary Environmental Analysis of Geopressured Geothermal Prospect Areas, Texas Gulf Coast: supported by the U. S. Department of Energy.

Volume and Accessibility of Entrained Methane in Deep Geopressured Reservoirs — Tertiary Formations of the Texas Gulf Coast: supported by the U. S. Department of Energy.

Wetland Delineation and Classification Study of the Coastal and Panhandle Regions of Texas: supported by the U. S. Department of the Interior, Fish and Wildlife Service.

State

An Investigation of the Sediment Contribution from the Brazos River to the Near-Shore Marine Environment: A Pilot Study: supported by Texas A & M Sea Grant Program.

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

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

Coordinate Procedures for General Use of Hardware and Software Available as Part of the Remote Sensing Information Subsystem (RSIS): supported by the Texas Department of Water Resources.

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 Assessments, Tasks 2, 3, and 4: supported by the Texas Energy and Natural Resources Advisory Council.

Geologic Setting and Geochemistry of Thermal Waters, Hueco Tanks and Presidio Bolson Areas, Trans-Pecos Texas: supported by the Texas Energy and Natural Resources Advisory Council.

Locating Abandoned Mines: supported by the Texas Railroad Commission.

Los Bancos de en Medio: supported by the General Land Office of the State of Texas.

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.

Reproduction (200 copies) of a report entitled "Lignite Resources in Texas," by Kaiser, Ayers, and LaBrie: supported by the Texas Energy and Natural Resources Advisory Council.

Submerged Lands of Texas — Brownsville-Harlingen Sheet: supported by the General Land Office of the State of Texas.

Surficial Biology of Marine and Estuarine Deposits in Corpus Christi Vicinity for Intergrated Environmental Planning (Phase II): supported by the U. S. Department of Commerce through the Governor's Budget and Planning Office.

Other

Geological studies of Geopressured and Hydropressured Zones in Texas: supported by the Gas Research Institute.

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

CONTRACT REPORTS

During 1980, 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 1980; some will be published by the Bureau of Economic Geology.)

Baumgardner, R. W., Jr., and Finley, R. J., 1980, Definition of optimum ISOCLS parameters for RSIS interactive data analysis, Texas coastal applications test site: prepared for the Texas Natural Resources Information System under Contract No. TDWR/TNRIS IAC No. (80-81)-1676, 18 p.

Calnan, T. R., Kimble, R. S., and Littleton, T. G., 1980, Surficial biology of marine and estuarine deposits in the State submerged lands in the Corpus Christi area: prepared for the U. S. Department of Commerce, through the Governor's Budget and Planning Office, under Agreement No. 80650338GOV, 133 p.

Duex, T. W., Henry, C. D., and Wilbert, W. P., 1980, Uranium resource evaluation, Presidio Quadrangle, Texas: prepared under Subcontract No. 78-133-E for Bendix Field Engineering Corporation, Grand Junction Operations, a prime contractor for the U. S. Department of Energy under Contract No. DE-AC13-76GJO1664, 39 p.

Edwards, M. B., and Andersen, R. L., 1980, Uranium resource evaluation, Wichita Falls Quadrangle, Texas and Oklahoma: prepared under Subcontract No. 78-157-E for Bendix Field Engineering Corporation, Grand Junction Operations, a prime contractor for the U. S. Department of Energy under Contract No. DE-AC13-76GJO1664, 33 p.

Finley, R. J., and Baumgardner, R. W., Jr., 1980, Data collection plan for geological remote sensing in the volcanic terrain of Trans-Pecos Texas, ASVT test site 5: prepared for the Texas Natural Resources Information System and the National Aeronautics and Space Administration, under TDWR/TNRIS IAC No. (80-81)-0715, 22 p.

Finley, R. J., and Baumgardner, R. W., Jr., 1980, Data collection plan for remote sensing in the Panhandle of Texas, ASVT test site 2: prepared for the Texas Natural Resources Information System, under Contract No. TDWR/TNRIS IAC No. (80-81)-0715, 20 p.

Finley, R. J., and Baumgardner, R. W., Jr., 1980, Outline of basic procedures for a Remote Sensing Information Subsystem (RSIS) analysis of Landsat data: prepared for the Texas Natural Resources Information System, under Contract No. TDWR/TNRIS IAC No. (80-81)-1676, 28 p.

Gregory, A. R., 1980, Study effects of geopressured geothermal subsurface environment on elastic properties of Texas Gulf Coast sandstones and shales using well logs, core data, and velocity surveys: prepared for the U. S. Department of Energy, Division of Geothermal Energy, under Contract No. DE-AS05-78ET-28468.

Gustavson, T. C., Howard, R. C., and McGookey, D., 1980, Environmental baseline monitoring in the area of General Crude Oil - Department of Energy Pleasant Bayou number 2 — a geopressured geothermal test well — 1979: prepared for the U. S. Department of Energy, Division of Geothermal Energy, under Contract No. DE-AS05-77ET28504 (formerly DE-AS05-77ET27031), vol. I, 61 p., vol. II, 245 p.

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., Hoadley, A. D., McGookey, D. A., McGillis, K. A., Ramondetta, P., and Simpkins, W. W., 1980, Locating field confirmation study areas for isolation of nuclear waste in the Texas Panhandle: prepared for the U. S. Department of Energy, Office of Nuclear Waste Isolation, under Contract No. DE-AC97-80ET46615.

Henry, C. D., Duex, T. W. and Wilbert, W. P., 1980, Uranium resource evaluation, Marfa Quadrangle, Texas: prepared under Subcontract No. 78-215-E for Bendix Field Engineering Corporation, Grand Junction Operations, a prime contractor for the U. S. Department of Energy under Contract No. DE-AC13-76GJO1664, 62 p.

Hobday, D. K., and Rose, F. G., Jr., 1980, Uranium resource evaluation, Sherman Quadrangle, Texas and Oklahoma: prepared under Subcontract No. 78-144-E for Bendix Field Engineering Corporation, Grand Junction Operations, a prime contractor for the U. S. Department of Energy under Contract No. DE-AC13-76GJO1664, 31 p.

Kreitler, C. W., Agagu, O. K., Basciano, J. M., Collins, E. W., Dix, O., Dutton, S. P., Fogg, G. E., Giles, A. B., Guevara, E. H., Harris, D. W., Hobday, D. K., McGowen, M. K., Pass, D., and Wood, D. H., 1980, Geology and geohydrology of the East Texas Basin, a report on the progress of nuclear waste isolation feasibility studies (1979): prepared for the U. S. Department of Energy, under Contract No. DE-AC97-79ET-44605, 112 p.

Kreitler, C. W., *with* Jones, J. W., and Schmidt, P. S., 1980, Ground-water source heat pump design development, phase I, summary report: prepared for the Texas Energy Advisory Council in cooperation with the Center for Energy Studies, The University of Texas at Austin, 63 p.

Loucks, R. G., Richmann, D. L., and Milliken, K. L., 1980, Factors controlling reservoir quality in Tertiary sandstones and their significance to geopressured geothermal production: prepared for the U. S. Department of Energy, Division of Geothermal Energy, in partial fulfillment of Contract No. DE-AC08-79ET27111, 188 p.

McGowen, J. H., Seni, S. J., Andersen, R. L., and Thurwachter, J. E., 1980, Uranium resource evaluation, Lubbock Quadrangle, Texas: prepared under Subcontract No. 78-133-E for Bendix Field Engineering Corporation, Grand Junction Operations, a prime contractor for the U. S. Department of Energy under Contract No. DE-AC13-76GJO1664, 51 p.

McGowen, M., Basciano, J., Floyd, R. G., Jr., and Fisher, W. L., 1980, Uranium resource evaluation, Palestine Quadrangle, Texas and Louisiana: prepared under Subcontract No. 78-137-E for Bendix Field Engineering Corporation, Grand Junction Operations, a prime contractor for the U. S. Department of Energy under Contract No. DE-AC13-76GJO1664, 37 p.

Morton, R. A., Wise, B. R., and Gregory, A. R., 1980, Geologic studies of geopressured and hydropressured zones in Texas: Annual Report for 1979: prepared for Gas Research Institute, under Contract No. 5011-321-0125, 44 p.

Seni, S. J., McGowen, J. H., and Risner, R. S., 1980, Uranium resource evaluation, Amarillo Quadrangle, Texas: prepared under Subcontract No. 78-158-E for Bendix Field Engineering Corporation, Grand Junction Operations, a prime contractor for the U. S. Department of Energy under Contract No. DE-AC13-76GJO1664, 28 p.

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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 71-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 475 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, over 1 million publications have been distributed on a world-wide basis, principally through direct sales. During 1980, the Bureau issued the following publications:

REPORTS OF INVESTIGATIONS

Report of Investigations No. 100. Catahoula Formation of the Texas Coastal Plain: Origin, Geochemical Evolution, and Characteristics of Uranium Deposits, *by William E. Galloway and W. R. Kaiser. 81 p., 56 figs., 8 tables, 2 appendices ($3.00).*

This report describes conclusions of the second phase of a study of the uranium potential of the Catahoula Formation, which was supported by the U. S. Department of Energy/Bendix Field Engineering Corp. Regional geologic data for the Catahoula were presented previously in R. I. 87. R. I. 100 discusses in detail (1) possible sources and mobilization processes for the uranium, (2) physical and chemical controls on uranium transport in the Catahoula aquifer, (3) the geologic setting, mineralogy, and geochemistry of three ore deposits representative of different mineralization styles, and (4) hydrochemical and geochemical processes recorded by the diagenetic products of ore and post-ore epigenesis. Results are also pertinent to the interpretation of hydrochemical sampling programs used in exploration.

Report of Investigations No. 101. Trace Elements in Soils of the South Texas Uranium District: Concentrations, Origin, and Environmental Significance, *by Christopher D. Henry and Rajesh R. Kapadia. 52 p., 23 figs., 6 tables ($2.00).*

Extensive uranium mining in South Texas has led to concern over the effects of mining on other resources, especially agricultural land and ground water. Of particular concern is the possible dispersion of the potentially toxic trace elements molybdenum, arsenic, and selenium, which are concentrated in uranium deposits, into agricultural areas by mining.

This report presents the results of an extensive survey of the concentrations of the elements in soils of the South Texas uranium district. Environments sampled include (1) natural soils distant from mining (to establish natural, baseline concentrations), (2) natural soils in areas of shallow mineralization (to evaluate possible naturally high concentrations), and (3) soils adjacent to mining areas that could have received water- or wind-borne runoff from mines (to evaluate the effects of mining). The results show that soils developed on different geologic formations have different characteristic trace element concentrations and that high concentrations occur both in areas of shallow mineralization and adjacent to some older mines as a result of water-borne transport. The report concludes with recommendations to identify potential problem areas for agriculture.

Report of Investigations No. 102. Lower Permian Facies of the Palo Duro Basin, Texas: Depositional Systems, Shelf-Margin Evolution, Paleogeography, and Petroleum Potential, *by C. Robertson Handford. 31 p., 26 figs., 2 tables ($1.50).*

The Palo Duro Basin of the Texas Panhandle is a shallow intracratonic basin filled primarily with Pennsylvanian and Permian strata. Over the past several years, it has been thoroughly investigated through funding provided by the U. S. Department of Energy for the purpose of determining the feasibility of storing nuclear waste in the middle-Upper Permian bedded salt units that compose part of the basin sedimentary fill. Thus, the Bureau of Economic Geology was tasked to conduct a complete basin analysis study of the Palo Duro Basin.

This report is a depositional systems, stratigraphic investigation of the Lower Permian Wolfcampian Series in the Palo Duro Basin. It outlines the stratigraphic framework, facies distribution, and genetic history of this part of the basin sedimentary fill. Furthermore, aspects of petroleum potential and location of potential reservoirs are discussed.

Report of Investigations No. 103. Molluscan Distribution in Copano Bay, Texas, *by Thomas R. Calnan. 71 p., 17 figs., 14 pl., 9 tables ($2.50).*

Benthic samples were collected on a 1-mi grid from Copano Bay, Texas, in March and April 1976. Seventy-four molluscan species, including 33 pelecypods, 40 gastropods, and 1 scaphopod, were taken from 93 stations in Copano Bay.

This report correlates molluscan distribution with gross sediment, salinity, feeding type, and total organic carbon content. The seven sediment types were determined from field descriptions and were based on three sediment end-members (shell, sand, and mud) and mixtures thereof. The mud and sand end-members had fewer molluscan species and live individuals, whereas the muddy sands had the most live individuals.

Fourteen of the 25 living molluscan species were euryhaline marine and could tolerate the highly variable

salinities. Dead stenohaline marine species were common, but only one living stenohaline species was found.

The two most abundant feeding types, the deposit and suspension feeders, numerically dominated in the muddy sands and muddy shells, respectively. Generally, stations with a high total organic carbon content also had a high population of deposit feeders, although there were some exceptions.

The text is accompanied by 14 plates containing photographs of the molluscan species.

Report of Investigations No. 104. Lignite Resources in Texas, *by W. R. Kaiser, W. B. Ayers, Jr., and L. W. LaBrie. 52 p., 31 figs., 18 tables ($2.00).*

Lignite resources in Texas are now calculated at just over 58 billion short tons (tons); approximately 23 billion tons are near-surface and 35 billion tons are deep-basin resources. These calculations were based on over 8,000 geophysical and lithologic logs. About 80 percent of the resources are found north of the Colorado River, approximately 70 percent occurring in the Wilcox Group and 30 percent in the Jackson Group. For the first time, near-surface resources in 2- to 3-ft seams have been assessed; these are 8 to 9 billion tons. The average seam of Texas lignite is less than 5 ft thick; a 10-ft seam is exceptional. Depending on mining depth, reserves have been estimated to be 8.6 to 11.1 billion tons, adequate to meet State needs into the next century. Individual deposits range in size from 50 to 500 million tons. Lignite north of the Colorado River is superior in grade to that south of the river. The weighted average lignite north of the Colorado River has a heating value of 6,100 Btu/lb and contains 35 percent moisture, 17 percent ash, and 1 percent sulfur.

Texas lignite is found in three ancient depositional systems: fluvial, deltaic, and strandplain/lagoonal; most of it is fluvial. The geologic setting has been established from published Bureau reports and new regional work on the South Texas Wilcox and Jackson Groups and the East Texas Yegua Formation. Near-surface resources are reported by degree-of-certainty category (measured, indicated, and inferred), geologic unit, and geographic region. Their distribution is shown on five large-scale maps (foldouts). Much new data on lignite grade has been tabulated (approximately 530 proximate, 175 ultimate, 200 forms-of-sulfur, and 300 ash composition analyses) and reported by region. Deep-basin resources are defined in terms (seams greater than or equal to 5 ft thick between 200 and 2,000 ft) thought realistic for future deep recovery.

Report of Investigations No. 105. Sand-Body Geometry and Depositional Systems, Ogallala Formation, Texas, *by Steven J. Seni. 36 p., 21 figs., 5 tables ($2.00).*

The sand-body geometry, facies associations, and depositional history of the Ogallala Formation were interpreted by analysis of over 15,000 water well driller's logs. Cross sections, an Ogallala isopach map, a sand and gravel isolith map, and a sand and gravel percentage map aided in delineation of processes that affected thickness and facies distribution in the Ogallala.

Sand-body geometry and lithofacies composition suggest that the Ogallala was deposited in a system of wet alluvial fans. Three overlapping fan lobes were deposited, and each was abandoned in sequence from north to south. A thorough understanding of sand-body geometry, facies relationships, and depositional history is a powerful tool for predicting changes that affect the distribution and occurrence of water in the Ogallala aquifer and of other natural resources, such as uranium, caliche, and aggregate, in the Ogallala Formation.

Report of Investigations No. 106. Regional Dissolution of Permian Salt in the Anadarko, Dalhart, and Palo Duro Basins of the Texas Panhandle, *by Thomas C. Gustavson, Robert J. Finley, and Kathy A. McGillis. 40 p., 31 figs., 1 table ($2.00).*

A broad zone of salt dissolution that affects parts of the Permian Salado, Seven Rivers, San Andres, Glorieta, and upper Clear Fork Formations occurs beneath the Canadian River Valley from New Mexico eastward toward Amarillo, Texas, and southeastward parallel to the eastern Caprock Escarpment. Structure contours on the base of the Tertiary Ogallala Formation show broad areas with as much as 120 m (400 ft) of relief that are attributed to salt dissolution and subsidence in the Anadarko Basin and along the northern and eastern margins of the Palo Duro and Dalhart Basins. Cumulative thickness of salt dissolution ranges up to 335 m (1,100 ft) and has resulted in the collapse of overlying beds to form breccias, chimneys filled with collapse breccias, faults, sinkholes, and complexly folded terrane.

In the Anadarko and Dalhart Basins, dissolution followed deposition of Lower Cretaceous sandstones of the Kiowa Formation and Dakota Group. Late Cretaceous and early Tertiary erosion removed most Cretaceous and Triassic sediments, leaving only plugs of brecciated Cretaceous sandstone preserved as collapse chimney fillings in Permian sediments. Dissolution probably continued throughout the Tertiary. During and following deposition of the Miocene-Pliocene Ogallala Formation, dissolution resulted in numerous large solution basins up to 310 km^2 (120 mi^2) in area and solution troughs up to 80 km (50 mi) long. Continued dissolution led to over 75 m (250 ft) of regional lowering of the Great Plains surface over parts of the Dalhart and Anadarko Basins by the late Pleistocene.

This report was sponsored by the U. S. Department of Energy.

Report of Investigations No. 107. Wave-Dominated Delta Systems of the Upper Cretaceous San Miguel Formation, Maverick Basin, South Texas, *by Bonnie R. Weise. 39 p., 36 figs., 1 table, 9 pls. ($3.00).*

Sandstone units of the Upper Cretaceous San Miguel Formation in South Texas were deposited in wave-dominated deltas during minor regressive phases, periodically interrupting a major marine transgression. Sediments accumulated in the Maverick Basin within the Rio Grande Embayment. Cross sections and sandstone maps reveal that during deposition of the San Miguel, the Maverick Basin consisted of two subbasins that received sediments from the northwest and the north.

Net-sandstone patterns show that the thickest parts of San Miguel sandstone bodies are generally strike oriented. Where preserved, updip fluvial systems are indicated by dip-aligned sandstone trends. San Miguel deltas vary considerably in morphology and compose a spectrum of wave-dominated delta types.

The purposes of this report are to (1) describe the geometry of sandstone units, vertical sequences, and depositional systems of the San Miguel Formation using detailed cross sections and net sandstone maps, (2) interpret the Maverick Basin geologic history during deposition of the San Miguel, including transgressive-regressive cycles and time relationships among individual sandstone units, (3) propose depositional models and modern and ancient analogs of San Miguel systems, and (4) discuss the influences of sediment characteristics and depositional patterns on porosity and, hence, oil and gas occurrence.

ENVIRONMENTAL GEOLOGIC ATLAS OF THE TEXAS COASTAL ZONE

Environmental Geologic Atlas of the Texas Coastal Zone—Brownsville-Harlingen Area, *by L. F. Brown, Jr., J. L. Brewton, T. J. Evans, J. H. McGowen, W. A. White, C. G. Groat, and W. L. Fisher. 140 p., 32 figs., 15 tables, 9 maps ($8.75).*

Publication of this final atlas in the coastal environmental geology series marks the completion of this long-term research program at the Bureau of Economic Geology. Begun in 1969, the project has resulted in the publication of seven atlases concerning more than 20,000 mi² of the Texas Coastal Zone from Louisiana to Mexico. More than 25 man-years of geologic and cartographic effort was necessary to complete the project.

Atlases published are of the Galveston-Houston area (1972), Beaumont-Port Arthur area (1973), Bay City-Freeport area (1976), Port Lavaca area (1976), Corpus Christi area (1976), Kingsville area (1977), and Brownsville-Harlingen area (1980). The Texas coastal atlas series includes a total of 63 full-color maps, with an environmental geologic map (scale 1:125,000) for each of the seven areas, and special-use maps (scale 1:250,000): physical properties, environments and biologic assemblages, current land use, mineral and energy resources, active processes, man-made features and water systems, rainfall, discharge and surface salinity, and topography and bathymetry. Each of the seven atlases consists of descriptive and interpretive texts, statistics on the areal and linear extent of all map units, comprehensive indexes, and numerous text figures.

Mapping was accomplished by use of aerial photographs, topographic maps, low-level aerial reconnaissance, and on-the-ground field work. Special-use maps were derived from the basic maps and from compilation of a variety of other data sources.

The *Environmental Geologic Atlas of the Texas Coastal Zone* was designed to provide an inventory of natural and man-made resources and to serve as a basic document in planning, development, and conservation of the Texas Coastal Zone. It has become a principal source of information for citizens, firms, and governmental agencies involved in Coastal Zone problems.

The atlas program has fostered many other more specific studies on the Texas Coastal Zone by Bureau scientists, such as shoreline monitoring, barrier island development, coastal hazards, faulting and land subsidence, land and water resources, and coastal management concepts. Perhaps the most comprehensive spin-off of the program is the ongoing Texas submerged lands project at the Bureau of Economic Geology, which involves comprehensive sediment, geochemical, biologic, and subsurface investigations of all submerged Texas coastal lands out to the 3-league (10.36-mi) Texas-Federal boundary.

Geologists involved in the program are W. L. Fisher, J. H. McGowen, L. F. Brown, Jr., J. L. Brewton, T. J. Evans, William A. White, C. V. Proctor, Jr., and C. G. Groat. Cartographers who prepared the maps are J. W. Macon, R. L. Dillon, D. F. Scranton, Barbara Hartmann, Cary Wilkie, Sharon Howard, Mel Eckoff, and David Ridner. L. F. Brown, Jr., coordinated the project.

Each of the seven Environmental Geologic Atlases of the Texas Coastal Zone can be purchased for $8.75 from the Bureau of Economic Geology.

GEOLOGICAL CIRCULARS

Geological Circular 80-1. Quaternary Faulting in East Texas, *by Edward W. Collins, David K. Hobday, and Charles W. Kreitler. 20 p., 13 figs. ($1.00).*

Investigations of the Mt. Enterprise - Elkhart Graben Fault System in East Texas indicate that some faults previously considered to have been inactive since early Tertiary time have been reactivated during the Quaternary. An oblique-slip fault in Leon County shows a throw of 66 cm. This report comprises field studies, subsurface information, releveling data, and a review of the seismic history of the fault system. Possible mechanisms of the Quaternary activation are discussed.

Geological Circular 80-2. Importance of Secondary Leached Porosity in Lower Tertiary Sandstone Reservoirs Along the Texas Gulf Coast, *by R. G. Loucks, M. M. Dodge, and W. E. Galloway. 8 p., 17 figs. ($0.50).*

Secondary leached porosity is common to dominant in near-surface to deep-subsurface lower Tertiary sandstone reservoirs along the Texas Gulf Coast. This secondary porosity is in the form of leached feldspar grains, volcanic rock fragments, carbonate cements, and carbonate-replaced grains. Leached porosity occurs in sandstones with compositions ranging from volcanic litharenite and lithic arkose to quartzose sublitharenite and quartzose subarkose.

Plots of secondary porosity as a percent of total porosity versus burial depth show that secondary porosity is dominant beneath 10,000 ft, ranging from 50 to 100 percent of total porosity. Above 10,000 ft more than half the samples have secondary porosity as the dominant type. Similarly, individual plots for the Wilcox, Yegua, Vicksburg, and Frio sandstones all demonstrate the predominance of secondary leached porosity.

Primary porosity is destroyed by compaction and cementation with increasing depth of burial. If this were the only porosity type, no deep, high-quality reservoirs would exist. Leaching, however, restores reservoir quality after primary porosity has been reduced. Most productive lower Tertiary sandstone reservoirs, especially deep reservoirs, along the Texas Gulf Coast exist only because of secondary leached porosity.

Geological Circular 80-3. Hydrology and Water Quality of the Eocene Wilcox Group: Significance for Lignite Development in East Texas, *by C. D. Henry, J. M. Basciano, and T. W. Duex. 9 p., 8 figs., 1 table ($0.50).*

The rapid expansion of lignite mining in Texas is placing an increasing demand on ground water either directly, for cooling water, or indirectly, by diversion of surface water uses. Mining and associated activities can alter both the quantity (by altering recharge characteristics) and the quality (by allowing drainage of mine water into an aquifer) of ground water.

This report combines surface and subsurface studies of the Wilcox Group, the major lignite host and a major

aquifer, to determine the geometry of different substrates that influence hydrologic characteristics and water quality. The report compares the distribution of substrates of varying permeability and the distribution of minable lignite in a preliminary attempt to quantify the impact of mining. Because lignite was deposited in fine-grained (and eventually low-permeability) interchannel areas, *most* mining will not intersect high-permeability channel sands. Areas where intersection will occur can be identified before mining.

Geological Circular 80-4. The Queen City Formation in the East Texas Embayment: A Depositional Record of Riverine, Tidal and Wave Interaction, *by D. K. Hobday, R. A. Morton, and E. D. Collins. 11 p., 11 figs. ($0.50).*

Five distinct facies are delineated on the basis of textural patterns, primary sedimentary structures, and trace fossils. Southward-flowing rivers were characterized by fluctuating proportions of bed load to suspended load; these supplied high-constructive shoal-water deltas that prograded across the shallow Reklaw shelf. Barriers developed as destructive components of delta abandonment, or as contemporaneous strike-fed features. Extensive tidal flats and subtidal shoals formed to the east in an area of reduced terrigenous influx. Large microtidal flood-tidal deltas developed in estuarine situations during the initial phases of Weches marine transgression.

Geological Circular 80-5. Studies of the Suitability of Salt Domes in East Texas Basin for Geologic Isolation of Nuclear Wastes, *by C. W. Kreitler. 7 p., 3 figs. ($0.50).*

Salt domes in the East Texas Basin are now being evaluated for their suitability as repositories for long-term isolation of nuclear waste. The major technical aspects that could impact the acceptability of domes are their hydrogeological and tectonic stability and potential natural resources associated with the domes.

On the basis of an initial screening, 23 domes were eliminated because of insufficient size, too great a depth to salt, major hydrocarbon production, or previous use. Oakwood and Keechi Domes were not eliminated and are now under detailed investigation.

Geological Circular 80-6. Distribution and Significance of Coarse Biogenic and Clastic Deposits on the Texas Inner Shelf, *by R. A. Morton and C. D. Winker. 15 p., 2 tables, 7 figs. ($0.50).*

This report describes the areal extent of rock fragments and biogenic detritus that occur in surface sediments of the Texas inner shelf. Maps showing (1) coarse fraction percent, (2) distribution of brackish-water mollusks, and (3) rock fragments show similar trends outlining ancestral Rio Grande, Brazos-Colorado, and Trinity deltas; a patchy, arcuate trend between Pass Cavallo and Aransas Pass is enigmatic.

Possible explanations for concentration of coarse material include high biological productivity, low rates of terrigenous clastic sedimentation, selective deposition by modern shelf processes, and reworking of locally shelly relict deposits exposed on the seafloor during the Holocene transgression.

Geological Circular 80-7. Geology and Geohydrology of the Palo Duro Basin, Texas Panhandle—A Report on the Progress of Nuclear Waste Isolation Feasibility Studies (1979), *by T. C. Gustavson, M. W. Presley, C. R. Handford, R. J. Finley, S. P. Dutton, R. W. Baumgardner, Jr., K. A. McGillis, and W. W. Simpkins. 99 p., 54 figs., 7 tables, 1 well log ($2.75).*

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 terminal waste storage program. This report summarizes progress in FY 1979 and is the second in a series of annual reports that cover basin analysis, surface geomorphic studies, host-rock analysis, and basin hydrology. Significant new data were acquired for direct analysis in the research areas of basin analysis, remote sensing/surficial studies, host-rock studies, and geohydrology. Among these were (1) 8,000 ft (2,438 m) of salt-bearing core, which is the single most important geologic sample for present and future basin analysis and host-rock studies, (2) petroleum source-rock quality and thermal maturity data for resource assessment studies, (3) drill stem test data for regional geohydrologic studies, and (4) quantitative climatic, erosional, and shallow subsurface salt dissolution data needed to predict the long-term geomorphic integrity of the Texas Panhandle.

Acquisition of two salt-bearing cores from the Palo Duro Basin provided the first opportunity to determine salt character and quality, and to conceptualize salt depositional models. Environments of depositions are thought to range from continental and coastal sabkha to shallow marine shelf. Drill cuttings from numerous wells across the Palo Duro Basin were obtained for organic geochemical analyses, which indicate that petroleum source rocks are present and that they reached the early stages of oil generation. Preliminary hydrogeologic mapping of deep-basin aquifers is based entirely upon pressure data derived from drill stem tests of oil and gas exploratory ventures. Results show that deep-basin ground water flows from west to east. Facies control over ground-water flow is also recognized. An integrated program of geomorphic, hydrologic, and shallow stratigraphic studies has provided preliminary results, presented in the circular, regarding rates of surface erosion, stream incision and development, and rates and direction of movement of salt dissolution fronts.

Geological Circular 80-8. Depositional Systems and Hydrocarbon Resource Potential of the Pennsylvanian System, Palo Duro and Dalhart Basins, Texas Panhandle, *by Shirley P. Dutton. 49 p., 42 figs., 3 tables ($1.50).*

The stratigraphy and depositional history of Pennsylvanian deposits in these two basins are presented by a series of cross sections, isolith maps, and paleogeographic reconstructions. The tectonic history of the area is interpreted through structure and isopach maps. Models for fan-delta, carbonate-shelf and shelf-margin, and deltaic deposition are applied to the Pennsylvanian strata. Diagenetic changes in the rocks are documented, and reservoir quality of various facies is evaluated. Source rock quality and thermal maturity data are used to discuss petroleum potential of the Pennsylvanian section.

Geological Circular 80-9. Facies Patterns and Depositional History of a Permian Sabkha Complex: Red Cave Formation, Texas Panhandle, *by C. Robertson Handford and Paul E. Fredericks. 38 p., 19 figs., 2 appendices ($1.25).*

The Red Cave Formation in the Texas Panhandle consists of red-bed clastic and carbonate-evaporite members that were deposited in coastal sabkha complexes during Middle and Late Permian time. The Red Cave Formation is the oldest of the major red-bed deposits in the Panhandle, and it contains stratigraphic units that record the first major

pulses of marine evaporite and continental red-bed deposition in the Panhandle. Partial analogs to Red Cave depositional elements include coastal mud flats and alluvial fans in the northwestern Gulf of California, tidal flats and the Wooramel ephemeral stream delta in Gladstone Embayment, Shark Bay, Australia, and Trucial Coast sabkhas in the Persian Gulf.

This report identifies Red Cave lithofacies and their distribution, determines their depositional environments, and outlines the depositional history of a coastal sabkha system. Approximately 400 geophysical logs, 6 cores, and numerous sample logs were used in lithofacies mapping and stratigraphic correlation. This analysis of the Red Cave Formation led to the recognition of an inner shelf carbonate system, two kinds of coastal sabkhas, and a wadi plain system.

Geological Circular 80-10. Petroleum Source Rock Potential and Thermal Maturity, Palo Duro Basin, Texas, *by Shirley P. Dutton. 48 p., 18 figs., 4 tables ($1.50).*

The Palo Duro Basin in the Texas Panhandle remains a frontier area for hydrocarbon exploration. This circular presents geochemical data from 20 geographically widespread wells used to evaluate hydrocarbon source rock quality and thermal maturity of the basin. Total organic carbon content data are presented from samples over a wide range of depths and stratigraphic intervals and are used to assess source rock quality. Organic matter type, kerogen color, and vitrinite reflectance information are used to determine thermal maturity levels of potential source rocks. All data are tabulated in an appendix.

Geological Circular 80-11. Climatic Controls on Erosion in the Rolling Plains along the Caprock Escarpment of the Texas Panhandle, *by Robert J. Finley and Thomas C. Gustavson. 50 p., 24 figs., 8 tables ($1.75).*

Circular 80-11 provides an analysis of rainfall patterns in the Texas Panhandle and relates these patterns to the mechanisms and rates of erosion around the margins of the Southern High Plains. High-intensity rainfall, primarily associated with thunderstorms, leads to erosion by rainsplash, sheetwash, and rillwash on surfaces with relatively low vegetation cover. Published rainfall data are used to illustrate the occurrence of intense rainfall events over a 22-county area. Data collected from continuously recording rain gauges and from fields of erosion pins set out as part of an ongoing slope-monitoring study show (1) peak rainfall intensities of up to 5.12 in/h (130 mm/h), (2) a maximum of 1.8 cm of erosion for a 4-month, winter-spring period, and (3) a correlation between erosion and slope angle.

Geological Circular 80-12. Geology and Geohydrology of the East Texas Basin — A Report on the Progress of Nuclear Waste Isolation Feasibility Studies (1979), *by C. W. Kreitler, O. K. Agagu, J. M. Basciano, E. W. Collins, O. Dix, S. P. Dutton, G. E. Fogg, A. B. Giles, E. H. Guevara, D. W. Harris, D. K. Hobday, M. K. McGowen, D. Pass, and D. H. Wood. 112 p., 66 figs., 5 tables ($2.50).*

The Bureau of Economic Geology is conducting a study of salt domes in the East Texas Basin as part of the national terminal waste storage program. This report summarizes progress in FY1979 and covers basin analysis, regional tectonics, dome growth history, regional and domal hydrology, and surface geologic and geomorphic studies. Significant new data were acquired to augment these studies, such as (1) 400 km of seismic reflection data, both regional and site specific, (2) regional gravity data for the basin, (3) 20 shallow boreholes over Oakwood Dome, (4) 1 hydrologic test hole downdip from Oakwood Dome, and (5) a complete core of the anhydrite-gypsum cap rock over Gyp Hill Dome in South Texas.

The acquisition of seismic, gravity, and electric log data provided new understanding of the sedimentary infilling of the East Texas Basin and how it caused salt migration and dome growth.

Analysis of the Gyp Hill cap rock showed that the cap rock was the result of salt dome dissolution and the accumulation of the insoluble residuum, anhydrite.

Work completed on the Carrizo-Wilcox aquifer, the major fresh-water aquifer in the basin, shows that this aquifer has the greatest potential for causing dome dissolution leading to radionuclide transport.

The Palestine Salt Dome is no longer under consideration as a potential repository for nuclear waste because of the occurrence of numerous collapse sinks that resulted from an earlier brining operation.

To date, studies of Quaternary strata have not found evidence of salt dome growth during the Pleistocene or Recent.

Geological Circular 80-13. Structure of the Presidio Bolson Area, Texas, Interpreted from Gravity Data, *by J. R. Mraz and G. R. Keller. 20 p., 5 figs., 1 plate ($1.25).*

The Presidio Bolson is located in a graben trending north-northwest along the western edge of Presidio County, Texas. To obtain a better understanding of the structure and tectonism of the Presidio Bolson area, an integrated geophysical-geological study of the area was undertaken using gravity measurements and deep drilling data. New gravity data were combined with existing data to construct simple Bouguer anomaly maps of the area. Two-dimensional computer modeling of gravity profiles was used to derive earth models. These data outline the major local geologic features that are dominated by the effects of Tertiary block faulting and volcanism. The Presidio Graben, the dominant tectonic feature in the area, is approximately 1.5 km deep near Ruidosa. The results obtained from the study support the hypothesis that hot springs associated with the Presidio Graben derive their heat from deep circulation along its boundary faults. However, some gravity anomalies observed could be interpreted as indicating the presence of late Tertiary intrusions that could provide heat for the hot springs.

Geological Circular 80-14. The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States — Texas, *by R. S. Kier, L. F. Brown, Jr., and E. F. McBride. 45 p., 23 figs., 2 tables ($2.00).*

This volume is the contribution from Texas to the Ninth International Congress of Carboniferous Stratigraphy and Geology, which convened in the United States during May 1979. Geologists of the Bureau of Economic Geology and the Department of Geological Sciences, The University of Texas at Austin, presented this historical review and summary of areal, stratigraphic, structural, and economic geology of Mississippian and Pennsylvanian rocks in Texas.

This report emphasizes the stratigraphy and structural geology of outcropping Carboniferous rocks in Texas. In addition, Texas geologists included a regional synthesis of contiguous subsurface geology, which has been so important in the economic development of the state. The report provides an overview of Carboniferous geology in outcrop and within adjacent basins by emphasizing depositional styles, resulting stratigraphy, and evolution of ideas used to interpret rocks of this age in Texas. The report is reprinted with permission of the U.S. Geological Survey.

GUIDEBOOKS

Guidebook 17. Padre Island National Seashore—A Guide to the Geology, Natural Environments, and History of a Texas Barrier Island, *by Bonnie R. Weise and William A. White. 94 p., 121 figs., 1 table, 1 full-color plate ($4.00).*

Padre Island National Seashore was established on one of the southernmost links in the chain of barrier islands and peninsulas along the Texas coast. This largely undeveloped island is a dynamic system of environments that change almost continuously. The face of Padre is shaped by the day-to-day action of the wind, currents, waves, and tides. Even more important, large storms, especially hurricanes, produce dramatic changes on the island. Padre Island and the adjacent waters of Laguna Madre and the Gulf of Mexico can be thought of as a natural laboratory where complex interaction of the wind, land, and sea produces unique features and environments that can be examined and questioned by all who visit the National Seashore.

This nontechnical guide discusses the origin, active processes, and present environments of Padre Island and Laguna Madre in the area of the National Seashore, as well as the history of human interaction with island and lagoon environments. Aerial and ground photographs, schematic diagrams, and a large-scale, full-color environmental geologic map are included in the guidebook to illustrate the dynamic character of the island and the importance of maintaining balances among the sensitive natural environments.

Guidebook 20. Modern Depositional Environments of the Texas Coast, *by Robert A. Morton and J. H. McGowen. 167 p., 104 figs., 2 tables ($4.00).*

This report, which was first published as a field trip guidebook co-sponsored by the Bureau of Economic Geology and the Gulf Coast Association of Geological Societies, summarizes the present state of knowledge regarding coastal processes and their influence on the distribution of sedimentary facies along the Texas coast. Within this microtidal, storm-dominated region, sediment dispersal is controlled largely by wind forces and river flooding. Historical monitoring of these physical processes and resultant geologic work contribute to an understanding of coastal changes that are attributed to natural conditions as well as to human alterations.

The broad spectrum of depositional environments found along the Texas coast includes coarse- and fine-grained fluvial channels, bayhead and oceanic deltas, coastal lagoons, tidal inlets and deltas, transgressive and regressive barriers, and a host of other nearshore deposits that are commonly preserved in ancient sedimentary basins and recognized in outcrop or by applications of subsurface methods. Vertical successions of stratification types, textural variations, sand-body geometry, and three-dimensional facies distribution are discussed for the spectrum of environments ranging from the fluvial systems to the inner shelf.

MINERAL RESOURCE CIRCULARS

Mineral Resource Circular No. 64. Development of the Mercury Mining Industry: Trans-Pecos Texas, *by Roger D. Sharpe. 32 p., 13 figs., 3 tables ($2.00).*

Cinnabar, the chief ore mineral of mercury, occurs in Cretaceous sedimentary and Tertiary igneous rocks in Trans-Pecos Texas. The Terlingua mercury district and adjacent smaller districts of Brewster and Presidio Counties in the southern part of Trans-Pecos Texas produced more than 150,000 flasks of mercury from 1899 to 1970.

This circular describes the geologic setting of the mercury-mining districts in Trans-Pecos Texas. The mining and milling of cinnabar, the uses and physiochemical characteristics of mercury, and a history and summary of production of the Texas mercury-mining industry are also discussed. Economic and resource factors that affect the price of mercury are presented; consideration is also given to the future demand for mercury.

Mineral Resource Circular No. 65. The Classification of Coal Resources and Reserves, *by W. C. J. van Rensburg. 36 p., 12 figs., 4 tables ($1.50).*

Great confusion surrounds the definition of concepts such as reserves and resources, and these terms are often erroneously used as synonyms. Unification schemes for coal resources and reserves have evolved in the United States over a period of several decades. The well-known USBM/USGS classification of coal resources and reserves contains definitions that are vague and contradictory. A recently amended version of this classification is regarded as a step backwards since it destroys the traditional distinction between resources and reserves. A number of coal resource and reserve classification schemes developed in Canada, Australia, and South Africa are compared with the U. S. system, and it is concluded that the latest South African system is superior because it was designed specifically for use on coal.

In view of recent estimates of the magnitude of synthetic fuel from coal production by the end of this century, and the recognized need to provide a greater share of our electricity from coal, it is suggested that excessive optimism about the extent of our coal reserves is unwarranted, and that a much more accurate picture of United States coal reserves is required.

Mineral Resource Circular No. 66. The Mineral Industry of Texas in 1976, *by Murphy E. Hawkins and Thomas J. Evans. 34 p., 1 fig., 25 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. This circular is a preprint of the U. S. Bureau of Mines *Minerals Yearbook 1976* chapter on Texas. Each year the chapter preprint is distributed by the Bureau free on request.

PUBLICATIONS REPRINTED

Report of Investigations No. 78. Stuart City Trend, Lower Cretaceous, South Texas, A Carbonate Shelf-Margin Model for Hydrocarbon Exploration, *by D. G. Bebout and R. G. Loucks. 80 p., 44 figs., 3 tables, 1974 (second printing, $3.00).*

Report of Investigations No. 82. Depositional Systems in the Canyon Group (Pennsylvanian System), North-Central Texas, *by Albert W. Erxleben. 76 p., 33 figs., 9 pls., 3 appendices, 1975 (second printing, $4.00).*

Geological Circular 70-4. Depositional Systems in the Jackson Group of Texas—Their Relationship to Oil, Gas, and Uranium, *by W. L. Fisher, C. V. Proctor, Jr., W. E. Galloway, and J. S. Nagle. Reprinted from* Transactions of the Gulf Coast Association of Geological Societies, *vol. 20, p. 234-261, 15 figs., 1970 (fourth printing, $1.50).*

Geological Circular 75-9. Physiographic Features and Stratification Types of Coarse-Grained Point Bars: Modern and Ancient Examples, *by J. H. McGowen and L. E. Garner. 27 p., 25 figs., 1 table, 1975 (second printing, $1.25).*

Geological Circular 76-7. Geothermal Resources of the Texas Gulf Coast—Environmental Concerns Arising from the Production and Disposal of Geothermal Waters, *by T. C. Gustavson and C. W. Kreitler. 35 p., 23 figs., 7 tables, 1977 (second printing, $1.50).*

Geological Circular 77-5. Relationship of Porosity Formation and Preservation to Sandstone Consolidation History — Gulf Coast Lower Tertiary Frio Formation, *by R. G. Loucks, D. G. Bebout, and W. E. Galloway. 12 p., 21 figs., 2 tables, 1977 (second printing, $1.00).*

Guidebook 11. Recent Sediments of Southeast Texas, A Field Guide to the Brazos Alluvial and Deltaic Plains and the Galveston Barrier Island Complex, *by H. A. Bernard, C. F. Major, Jr., B. S. Parrott, and R. J. LeBlanc, Sr. 132 p., 97 figs., 1970 (fifth printing, $6.00).*

Guidebook 13. Geology of the Llano Region and Austin Area, Field Excursion, *by V. E. Barnes, W. C. Bell, S. E. Clabaugh, P. E. Cloud, Jr., R. V. McGehee, P. U. Rodda, and K. P. Young. 154 p., 1972 (third printing, $2.00).*

Guidebook 15. The Edwards Reef Complex and Associated Sedimentation in Central Texas, *by H. F. Nelson. 34 p., 5 figs., 7 pls., 1973 (second printing, $1.50).*

Guidebook 19. Cenozoic Geology of the Trans-Pecos Volcanic Field of Texas, *A. W. Walton and C. D. Henry, Editors. 202 p., 1979 (second printing, $4.00).*

Publication 6120. The Ouachita System, *by P. T. Flawn and others. 401 p., 13 figs., 15 pls., 2 geologic maps in color, 1961 (third printing, $8.50).*

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 at the Bureau offices; on request, Mary Flores of the Bureau staff will arrange for a commercial firm to reproduce specified materials.

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 implements appropriate data files and computer programs to meet Bureau business and research needs. During 1980, comprehensive files were begun in support of geothermal, nuclear waste isolation, oil and gas, and lignite resource studies. Programs were implemented in 1980 (1) to digitize and map location data using geodetic and Universal Transverse Mercator grids, (2) to model water chemistry processes, and (3) to aid in detection of lineaments on maps. Several business and accounting systems were also installed.

Most staff requirements are satisfied by use of the University's CDC Dual Cyber 170/750 computer system. Several interactive terminals are located in the various Bureau offices. Other equipment includes a Tektronix 4054 graphics system with digitizer (20 by 20 inches) and pen plotter (15 by 11 inches), two Tektronix 4025 graphics terminals, two additional similar plotters, and two line printers.

During 1980, Michael Roberts was appointed coordinator for computer services and given responsibility for work specification and priority and goal setting. Mr. Roberts has extensive computer experience. His previous management experience has been in computation of research problems for exploration and production of natural resources, principally coal in South Africa.

PUBLIC INFORMATION SERVICES

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

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 Audie Dobbs, Debbie Gandy, 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 handles the majority of 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 Mary Flores maintains these open files and makes arrangements for local commercial firms to copy specified reports on request from 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. David Mathew coordinates the Bureau's participation in these reviews.

MINERAL STUDIES LABORATORY

The Mineral Studies Laboratory (MSL) provides the Bureau with a modern inorganic geochemical laboratory capable of analyzing rocks, soils, and water in support of various research efforts. Analytical instruments include an inductively coupled plasma emission spectrometer (ICP), two atomic absorption spectrophotometers (AA), and a spectrofluorometer. The MSL also has furnaces, digestion blocks, a high-speed centrifuge, and other apparatus for preparing samples for analyses. Although the MSL primarily supports Bureau geochemical research programs, the lab

processes samples on a limited basis for private citizens when there is clearly no competition with commercial laboratories.

During 1980 the MSL analyzed 6,206 rock or soil samples and 2,926 water samples. Samples were analyzed for single components or as many as 30 elements. MSL has the capacity to analyze as many as 8,000 samples annually; this figure assumes that most samples require routine, multi-element analysis for the same components, as was the case in the National Uranium Resource Evaluation (NURE) program.

During 1980 we made great progress in methods of digesting samples and elemental separation prior to ICP instrumental analysis of multiple elements. For example, new techniques were developed to separate the volatile elements (As, Se, and possible Sn and Sb) by distillation for subsequent analysis of these elements by ICP. New methods were also devised for analyzing ores containing extremely stable minerals, such as cassiterite, zircon, chromite, and barite, among others.

The Texas Energy and Natural Resources Advisory Council (TENRAC) and The University of Texas at Austin each contributed $50,000 toward the establishment of a coal analytical facility at the MSL. Equipment for proximate and ultimate analyses of coal and lignite will be acquired, and a data base on the properties of Texas lignites will be developed.

During 1980 the Sedimentology Laboratory performed textural analyses of 600 benthic sediment samples collected from Texas Gulf Coast waters included in the State-owned submerged lands. Additionally, dozens of samples have been analyzed in conjunction with studies of the Little Red River and with studies of the effectiveness of limestone slurries in the cleaning of industrial emissions.

The quality of results is checked regularly by using commercially available standard particles for calibration of instruments. Also, preparation and analysis are performed on representative splits of samples to assure consistency of results. Close correlation has been demonstrated in the lab between results obtained through conventional sieve-pipette analysis and those obtained using rapid analysis techniques developed by the Bureau.

WELL SAMPLE AND CORE LIBRARY

The Well Sample and Core Library (WSL), located at the Balcones Research Center, was authorized by the Texas Legislature in 1937. A total of 2,465 well cores and drill cuttings representing more than 90,000 wells make this one of the nation's largest collections of subsurface materials. The library is open from 8 a.m. to 5 p.m. Monday through Friday. Microscopes and other equipment are available for patrons who wish to examine cores and cuttings at the library. Cores and cuttings may also be checked out of the library, with the borrower paying shipping costs.

In 1980, the library recorded a 215-percent increase in core use and a 106-percent increase in drill cutting use by more than 94 non-Bureau visitors, consisting mainly of uranium researchers, geologic consultants, oil company representatives, and mineral specialists. Use of cores by Bureau personnel increased 117 percent, whereas use of drill cuttings decreased by 51 percent.

New core and drill cutting acquisitions numbered 44 and 82, respectively, with donations coming from Cities Service Oil Co., CPC Exploration, Dow Chemical Co., Elf-Aquitaine Oil & Gas, Enserch Exploration, Inc., George Grabowski, Great Basins Petroleum Co., Gulf Oil Co., Hilliard Oil & Gas Co., Mitchell Energy Co., Montgomery Stratigraphic Service, Pogo Production Co., Tesoro Petroleum Corp., and Texas Department of Water Resources. Tenneco Oil Corp. donated more than 12,300 electric logs, which are now being put on a computer list. Also being computerized is WSL's card file of drill cuttings.

Utilizing a new process, the library has been freezing unconsolidated cores taken from the Wilcox Formation prior to slabbing them. PVC half-tubes are used to hold the material together after the core thaws. This process was used successfully with only minimal disturbance of sedimentary structures on approximately 1,000 ft of the Leon County core.

The WSL also built a new and larger vacuum/pressure chamber and a curing oven, making it possible to impregnate whole core (up to 4 inches in diameter) with epoxy resin. After impregnation and curing, the unconsolidated sediments can be slabbed without disturbing the structure of the core. This technique was tested with good results on cores recovered from the Bureau drilling rig at Bristol Dry Lake, California.

Petrographic thin section production decreased from the previous year, totaling 1,334 for 1980. This decrease allowed more time for core impregnation and the ongoing task of separating and binding the library's extensive collection of driller's logs.

A major new equipment addition is an Allis-Chalmers forklift truck. The lift truck, fitted out with new shelving and pallet racks, has greatly increased handling and storage capacity.

PERSONNEL

State geologists and guests, 1980 annual meeting.

RESEARCH STAFF

BUREAU HOSTS STATE GEOLOGISTS' MEETING

In late April, the Bureau hosted the directors of sister State geological surveys with typical Texas hospitality. The 1980 annual meeting of the Association of American State Geologists (AASG) was held on South Padre Island and included strong blends of Texan and Mexican culture. Our visitors were introduced to Texas geology, mariachis and margaritas, hat dances and square dances, Gulf seafood and fishing, shell collecting on Gulf beaches, and shopping in border towns.

The meetings were attended by 43 of 51 State geologists; only Hawaii, Massachusetts, Mississippi, New Jersey, Ohio, Puerto Rico, Rhode Island, and Tennessee were not represented. In addition to the survey directors, 19 geologists from the various State surveys participated in the meetings. Seven honorary State geologists (Allen Agnew, Gene Callahan, Hollis Dole, Bill Hewitt, Leo Hough, Wilson Laird, and Sam Tuthill) added their prestige to the meetings. Thirty-four spouses of the State participants and guests joined in the social activities and held some special events of their own.

Fifteen distinguished guests included officers and managers of the U. S. Geological Survey, U. S. Bureau of Mines, American Geological Institute, U. S. Department of Energy, U. S. Nuclear Regulatory Commission, and National Academy of Science. Many of the guests presented position papers on topics important to the State geologists. For example, Lindsay Norman, Director of the U. S. Bureau of Mines, evaluated present and future strengths of his agency, and Doyle Frederick, Acting Associate Director of the USGS, chaired a group of USGS officials, who discussed present and future USGS programs.

The annual business meetings of the State geologists include diverse topics representative of the valuable contributions of State geological surveys to the geology of the nation. Liaison with Federal agencies having geological interest and responsibilities is a major topic, as is cooperation with professional societies. From AASG business meetings, contributions are made to policies concerning development of natural resources, definitions of professionalism, isolation of chemical and nuclear wastes, responses to shortages of water, and maintenance of geological research. Most of these topics are addressed by committee reports during two concentrated days of meetings.

W. L. Fisher, Director of the Bureau of Economic Geology, and State Geologist for Texas, hosted the event; at the meeting he was also chosen President-Elect of the Association. Following established precedent, he will become president of AASG in June 1981.

E. G. Wermund, Associate Director of the Bureau, served as organizing chairman of the meeting. He was assisted by his wife, Susan, Doug and Linda Ratcliff, Denise Lipford, George Donaldson, and Lee Holman.

Two field trips complemented the business meetings. L. F. Brown, Jr., explained the geology of South Texas barrier islands, emphasizing coastal processes of normal years as well as hurricane events. W. E. Galloway and R. J. Finley demonstrated the sedimentary-stratigraphic, structural, and geochemical controls on uranium deposits in south and south-central Texas in a field trip that closed the meetings.

COUNCIL PUBLISHES FOURTH REPORT

The fourth major report of the Council on Energy Resources, *Energy and the Economy*, was issued in December. Principal authors were Bureau Director W. L. Fisher, Chairman of the university-wide Energy Council, and Dr. Walt Rostow, the Rex G. Baker, Jr., Professor in Political Economy at UT. Among other contributors was Dr. W. C. J. van Rensburg, Bureau Associate Director and Director of the Texas Mining and Mineral Resources Research Institute.

The 110-page report on energy and the economy advises the Reagan administration to consider the problems of energy dependence, rising unemployment, lagging productivity, and spiraling inflation "as a package" and warns that a "piecemeal" approach to these intertwined problems "will fail" and could result in a sharp recession.

DISTINGUISHED LECTURERS

Several distinguished scientists presented talks to Bureau staff members during the year.

1. Dr. Amos Bein, while on leave from the Israeli Geological Survey, explained his interpretation for the genesis of asphalt in the Dead Sea Basin.
2. Dr. John C. Ferm, Professor at the University of Kentucky, explained a methodology developed for rapid estimation of coal resources in the United States and described his research on the thickness and continuity of Appalachian coal deposits.
3. Dr. John W. Gabelman, Manager of Exploration Research at Utah International, Inc., interpreted principles and examples of metallotectonics and explained practical applications of remote sensing analysis to mineral exploration.
4. Dr. John M. Hunt, Research Scientist at Woods Hole Oceanographic Institute, described his research on organic geochemistry and petroleum maturation and integrated his fundamental work with efforts of the many other active researchers in petroleum geochemistry.
5. Professor Desmond Pretorius, Director of the Economic Geology Research Unit at the University of the Witwatersrand, discussed models for mineralization in Proterozoic Basins and projected the utility of these models in future exploration.
6. Mr. Luc Saugy, Chief Geophysicist of Elf-Aquitaine Oil Company (U.S. Region), described seismic interpretation of several basins in which exploration is active.

In addition to their presentations, our notable visitors consulted with numerous interested scientists from both the Bureau and the Department of Geological Sciences.

VAN RENSBURG ASSUMES MINERAL ASSOCIATION POST

At the December 1980 meeting of the 31 State Mining and Mineral Resources Research Institutes, Dr. W. C. J. van Rensburg was elected Vice-Chairman of the Association of Mineral Institute Directors.

NEW RESEARCH STAFF MEMBERS

Amos Bein

Dr. Amos Bein, while on leave from the Israeli Geological Survey, joined the Bureau in July 1980 as a Research Scientist Associate V. He has been involved in carbonate stratigraphy studies for the West Texas Waste Isolation project. Before coming to the Bureau, Dr. Bein worked in the Oil Research Division of the Geological Survey of Israel.

Dr. Bein received his B.S., M.S., and Ph.D degrees from the Hebrew University in Jerusalem in 1964, 1967, and 1974, respectively.

Michael E. Bentley

Michael E. Bentley joined the Bureau as a Research Scientist Associate II in October 1979. He is currently working on the West Texas Waste Isolation project, where his responsibilities include investigation of deep-basin hydrodynamics.

Mr. Bentley received a B.S. in geology from Kansas State University in the spring of 1975, and received an M.A. in May 1980. He is a member of the National Water Well Association.

Thomas E. Ewing

Dr. Thomas E. Ewing joined the Bureau as a Research Scientist Associate IV in October 1980 after finishing work on his Ph.D. dissertation at the University of British Columbia at Vancouver. Currently his duties include determination of effective reservoir volumes for producing geopressured gas fields; this information is then compared with other data obtained in the geopressured geothermal project.

Dr. Ewing received his B.A. in geology from Colorado College in 1974 and received his M.S. in geochemistry from the New Mexico Institute of Mining and Technology in 1977.

Dr. Ewing's professional activities include membership in the Geological Society of Canada, the Geological Society of America, the Mineralogical Association of Canada, and the Society of Mining Engineers/AIME.

Chester M. Garrett, Jr.

Chester M. Garrett, Jr., joined the Bureau in February 1980 as a Research Scientist Associate V. He received his B.S. from the University of Tulsa in 1949.

Prior to joining the Bureau, Mr. Garrett's professional work was largely with oil and gas concerns. Currently he is assisting in the coordination of geopressured geothermal energy resource evaluation programs, where his contributions include coordinating meetings with industry and research groups and assisting in reviews and evaluations of prospects for design wells and proposals for wells of opportunity.

Mr. Garrett is a member of many professional organizations including the American Association of Petroleum Geologists, the Association of Professional Engineers, Geologists and Geophysicists of Alberta, the Petroleum Exploration Society of Great Britain, the Canadian Society of Exploration Geophysicists, the Houston Geological Society, and the Austin Geological Society.

Arthur G. Goldstein

Dr. Arthur Goldstein joined the Bureau in June 1980 as a Research Scientist Associate IV. He is currently working on the West Texas Waste Isolation project on tectonic structural problems. He was previously a research assistant at the University of Massachusetts.

Dr. Goldstein received a B.S. in geology from Kent State University in 1971. He received an M.S. in geology in 1976 and a Ph.D. in geology in 1979, both from the University of Massachusetts.

Martin P. A. Jackson

Dr. Martin Jackson joined the Bureau as a Research Scientist Associate IV in January 1980. He is currently

working on the East Texas Waste Isolation project, where he is the principal investigator of regional tectonics and salt mobilization in the East Texas Basin study area with regard to examining the suitability of salt domes as nuclear waste repositories.

Dr. Jackson received a B.S. in geology from the University of London in 1968. In 1969 he received a B.S. with Special Honors in geology (with distinction) from the same university. Dr. Jackson received his Ph.D., summa cum laude, in geology from the University of Cape Town in 1976. Before coming to the Bureau, Dr. Jackson attained experience in research and teaching from his positions at the University of Natal and the University of Cape Town.

Dr. Jackson is a member of the Geological Society of South Africa. In addition to his professional activities, he has authored and coauthored many publications, including *Crustal Evolution of South Africa*, which is currently in press.

Mary Jackson

Mary Jackson joined the Bureau as a Research Scientist Assistant in October 1979. In March 1980 she was promoted to Research Scientist Associate II. Since that time, she has worked on the "Environmental Geology of the East Texas Lignite Belt—Jackson and Yegua Units" project.

Ms. Jackson received a B.S. from Tufts University in 1977. She is currently completing work necessary for an M.S. degree from Colorado State University.

Roneé S. Reed

Roneé Reed joined the Bureau in November 1980 as a Research Scientist Associate I. Since coming to the Bureau, Ms. Reed has been involved in the identification of prospective areas and geological evaluation of geopressured sandstone aquifers within those areas for the Dispersed Gas Project. The research is funded by the Gas Research Institute.

Ms. Reed received a B.S. in geology from The University of Texas at Arlington in 1979 and until recently was an employee of Sun Oil Company.

PAPERS 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 1980, the following papers by Bureau staff members were published outside of the Bureau:

PAPERS

Bassett, R. L., 1980, A critical evaluation of the thermodynamic data for boron ions, ion pairs, complexes, and polyanions, in aqueous solutions at 298.15 K and 1 bar: Geochimica et Cosmochimica Acta, v. 44, p. 1151-1160.

Bassett, R. L., Perkins, S. G., and Waddell, R. K., 1980, Preliminary data describing the distribution of fluoride and silica in the Ogallala aquifer of the High Plains of Texas: U.S. Geological Survey Open-File Report No. 80-349, 109 p.

Baumgardner, Robert W., Jr., Gustavson, Thomas C., and Hoadley, Ann D., 1980, Salt blamed for new sink in West Texas: Geotimes, v. 25, no. 9, p. 16-17.

Bebout, D. G., Loucks, R. G., and Gregory, A. R., 1980, Geological aspects of Pleasant Bayou geopressured geothermal test well, Austin Bayou Prospect, Brazoria County, Texas, *in* Dorfman, M. H., and Fisher, W. L., eds., Proceedings, Fourth United States Gulf Coast Geopressured Geothermal Energy Conference: The University of Texas at Austin, Center for Energy Studies, v. 1, p. 11-45.

Brown, L. F., Jr., and Fisher, W. L., 1980, Seismic stratigraphic interpretation and petroleum exploration: American Association of Petroleum Geologists, Continuing Education Course Note Series 16, 181 p.

Brown, L. F., Jr. (with *Kier, R. S., and McBride, E. F.*), 1980, The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States — Texas, *in* The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States: U.S. Geological Survey Professional Paper 1110, p. S1-S45.

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Edwards, Marc B., 1980, The Live Oak delta complex: an unstable, shelf-edge delta in the deep Wilcox trend of South Texas: Gulf Coast Association of Geological Societies Transactions, v. 30, p. 71-79.

Edwards, Marc B., 1980, A look at the upper Wilcox Rosita delta system of South Texas: Oil and Gas Journal, v. 78, no. 19, p. 197-205.

Edwards, Marc B., 1980, The upper Wilcox Rosita delta system of South Texas: Corpus Christi Geological Society Bulletin, February, p. 5-11.

Edwards, Marc B. (with *Siedlecka, A.*), 1980, Lithostratigraphy and sedimentation of the Riphean Basonaering Formation, Varanger Peninsula, North Norway: Norwegian Geological Survey Number 355, p. 27-47.

Edwards, Marc B., Bebout, D. G., Gregory, A. R., and Weise, B. R., 1980, Wilcox Group — potential for geopressured geothermal sandstone reservoirs, *in* Dorfman, M. H., and Fisher, W. L., eds., Proceedings, Fourth United States Gulf Coast Geopressured Geothermal Energy Conference: The University of Texas at Austin, Center for Energy Studies, v. 1, p. 312-372.

Finley, Robert J., and Baumgardner, Robert W., Jr., 1980, Interpretation of surface water circulation, Aransas Pass, Texas, using Landsat imagery: Remote Sensing of Environment, v. 10, no. 1, p. 3-22.

Finley, R. J., Baumgardner, R. W., Jr., and Gustavson, T. C., 1980, Erosion in State parks: Discovery, v. 5, no. 2, p. 12-15.

Fisher, W. L., 1980, Lignite and coal in the U.S. energy future, *in* Proceedings, Tenth Biennial Lignite Symposium: U.S. Department of Energy and University of North Dakota, GF ETC/IC-7911 (CONF-790579), p. 108-116.

Fisher, W. L., 1980, Mineral resources and government: role of the federal estate, *in* Southwestern Legal Foundation, Exploration and Economics of the Petroleum Industry, v. 18: New York, Matthew Bender, p. 355-368.

Fisher, W. L., 1980, Use of a mixture of beach sand and inspissated oil for dune nourishment and stabilization: Committee on Environmental Affairs Report, IXTOC 1 Oil Spill (March 10, 1980), p. 114-116.

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Fisher, W. L., Rostow, W. W., Kozmetsky, G., and others, 1980, Energy and the economy: The University of Texas at Austin, Council on Energy Resources, 110 p.

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LECTURES AND PUBLIC ADDRESSES

Randy L. Bassett

A comparison of currently available geochemical models: presented at Montana College of Minerals, Science, and Technology (Sigma Xi invited speaker), Butte, Montana.

The energetics of clay mineral transformations: presented at the Marathon Oil Company Research Center, Denver, Colorado.

Geochemical modeling: presented to a graduate geochemistry class, Department of Geological Sciences, The University of Texas at Austin.

Mass transport and mass transfer models to simulate water/rock interactions: presented at the Marathon Oil Company Research Center, Denver, Colorado.

Robert W. Baumgardner, Jr.

Fluvial morphology of the Little Red River and erosion of the Caprock Escarpment, Briscoe and Hall Counties, Texas: presented at Geological Society of America, South-Central Section, 14th Annual Meeting, Wichita, Kansas.

Geology and hydrology of the Wink Sink, Winkler County, Texas: presented at the Solution Mining Research Institute fall meeting, Minneapolis, Minnesota.

L. F. Brown, Jr.

Basin analysis and seismic stratigraphy: presented to the Department of Geology, University of South Carolina, Columbia, South Carolina.

Seismic stratigraphy: presented to a geophysics class, Department of Geological Sciences, The University of Texas at Austin.

S. Christopher Caran

Environmental geology of abandoned bituminous coal mines, North-Central Texas: presented at a geology technical session, The University of Texas at Austin.

Mountain-building processes: field trip and lecture presented to five fifth-grade classes, St. Elmo Elementary School, Austin, Texas.

Volcanic features in the Austin area — physical manifestations of structural linear trends?: presented at the Austin Geological Society March meeting, Austin, Texas.

Shirley P. Dutton

Depositional history and hydrocarbon potential of the Pennsylvanian System, Palo Duro Basin: presented at a North Texas Geological Society meeting, Wichita Falls, Texas.

Marc B. Edwards

Geology of Spitzbergen: presented at the Austin Geological Society December meeting, Austin, Texas.

The upper Wilcox Rosita delta system of South Texas: presented to the Corpus Christi Geological Society, Corpus Christi, Texas.

Robert J. Finley

Genetic stratigraphy of a uranium host facies, Tordilla Sandstone Member, Jackson Group, Panna Maria, Texas: presented at the American Association of Petroleum Geologists, Southwest Section, Annual Meeting, El Paso, Texas.

W. L. Fisher

Background and national energy issues: presented at John A. Logan College, Carterville, Illinois.

Conflicts in energy exploration and federal land policies: an agenda for the 80's: presented at LASER, Salt Lake City, Utah.

Current perspectives on national energy issues: presented at Update-80, The University of Texas Ex-Students Association, Austin, Texas.

Current research at the Bureau of Economic Geology: presented at the American Institute of Professional Geologists, Texas Section, Annual Meeting, Houston, Texas.

Elements of the continuing energy debate: presented to the Retired Officers Association, Austin, Texas.

Energy and regulation: conflicts in the making: presented to the Mississippi Geophysical Society, Jackson, Mississippi.

Energy perspectives: presented at the Texas Winners Conference, Houston, Texas.

Energy problems facing the U.S.: presented at the Kansas Regents Telenetwork Honors Colloquium in the Sciences, Kansas State University.

Energy resources and public policy: presented at American Institute of Professional Geologists congressional briefings, Washington, D. C.

Federal land policies: constraints on energy and mineral exploration: presented at the American Institute of Mining Engineers Annual Meeting, Las Vegas, Nevada.

Mineral resources and government: the role of the federal estate: presented to the Southwestern Legal Foundation, Dallas, Texas.

Oil and gas findings rates in projection of future production: presented at the U.S. Department of Energy/National Bureau of Standards Oil and Gas Modeling Symposium, Washington, D. C.

Oil and gas outlook: Western Hemisphere through the 20th century: presented at the Second Western Hemisphere Energy Symposium, Rio de Janeiro, Brazil.

Overview of surface mining in Texas: presented at the Surface Mine Reclamation Workshop, Texas A&M University, College Station, Texas.

Tertiary and Mesozoic delta systems in oil and gas exploration: presented at the University of Texas, Permian Basin Graduate Center, Midland, Texas.

Trends in Texas energy production: presented to the Interstate Oil Compact Commission, Dallas, Texas.

U.S. energy outlook this decade: presented to the National Governors' Association Committee on Energy and Natural Resources, Winrock, Arkansas.

U.S. energy projections for the 1980's: presented to the Texas Mid-Continent Oil and Gas Association, Houston and Corpus Christi, Texas.

Graham E. Fogg

Hydrogeology of Eocene aquifers, East Texas Basin: presented at an Austin Geological Society monthly meeting, Austin, Texas.

William E. Galloway

Depositional and ground-water flow systems in exploration for uranium: presented at the American Association of Petroleum Geologists Fall Education Conference, Houston, Texas.

Oakville Formation of Texas Coastal Plain — sedimentology of a uranium-bearing fluvial system: presented at the Society of Economic Paleontologists and Mineralogists, Rocky Mountain Section, luncheon meeting, Denver, Colorado.

Uranium-bearing coastal-plain and piedmont fluvial sediments, Texas, Wyoming, and New Mexico: presented at Short Course on the Fluvial System, Colorado State University, Fort Collins, Colorado.

L. Edwin Garner

Environmental geology of Austin: presented to an environmental geology class, Department of Geological Sciences, The University of Texas at Austin.

Land resources of Texas: presented to the Austin Gem and Mineral Society, Austin, Texas.

Mineral resources of Texas: presented to an economic geology class, Department of Geological Sciences, The University of Texas at Austin.

Progress and projects of the Bureau of Economic Geology: presented at the Soil Survey Work Planning Conference, Texas A&M University, College Station, Texas.

Alice B. Giles

Petroleum accumulation patterns in the East Texas salt-dome area: presented at the Shreveport Geological Society September meeting, Shreveport, Louisiana; and at the Texas Christian University student geological society October meeting, Fort Worth, Texas.

Petroleum accumulation trends in East Texas salt-dome area: presented at the American Association of Petroleum Geologists Annual Meeting, Denver, Colorado.

Tectonic evolution of East Texas salt domes: presented at the Geological Society of America, South-Central Section, 14th Annual Meeting, Wichita, Kansas.

Arthur G. Goldstein

Ductile faulting along a proposed collisional suture, Massachusetts and Connecticut: presented at a research seminar, Department of Geology, The University of Texas at El Paso.

Motion on the Lake Char fault, normal or reverse?: presented at the Geological Society of America, Northeast Section, 15th Annual Meeting, Philadelphia, Pennsylvania.

Thomas C. Gustavson

Development of geopressured geothermal energy and its effect on the environment of the Texas Gulf Coast: presented to the Department of Education, East Texas State University, Commerce, Texas; and to the Department of Education, Texas A&I University, Kingsville, Texas.

Environmental concerns related to geothermal energy development, Texas Gulf Coast: presented at the Conference on Environmental and Geotechnical Aspects of Geopressure Energy (sponsored by the Engineering Foundation), Sea Island, Georgia.

C. Robertson Handford

Depositional systems and petroleum potential of Pennsylvanian-Permian strata, Palo Duro Basin: presented at a Dallas Geological Society monthly meeting, Dallas, Texas.

Christopher D. Henry

Potential for development of geothermal energy in Trans-Pecos Texas: presented at a Southwest Texas Electric Cooperatives business meeting, Abilene, Texas.

Uranium in volcanic rocks and processes: presented at "Uranium in Volcanogenic Environments" (sponsored by Bendix Field Engineering Corporation), Grand Junction, Colorado.

David K. Hobday

Depositional systems and mineral deposits of the Karoo Basin, Southern Africa: presented at the Geology Division Symposium, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

Lower Cretaceous shelf storm deposits, North Texas: presented at the American Association of Petroleum Geologists/Society of Economic Paleontologists and Mineralogists Annual Meeting, Denver, Colorado.

Paleoenvironments and trace fossils of a large aggrading delta margin embayment, upper Woodbine Formation of northeast Texas: presented at the Gulf Coast Association of Geological Societies Annual Meeting, Lafayette, Louisiana.

William R. Kaiser

Energy resources of Texas — an overview: presented at the Summer Institute on Energy, Economics, and the Environment (sponsored by Texas Mid-Continent Oil and Gas Association), Houston, Texas.

Lignite resources in Texas: presented to the Texas Christian University Geology Club, Fort Worth, Texas.

Charles W. Kreitler

Hydrogeology of Eocene aquifers, East Texas Basin: presented at an Austin Geological Society monthly meeting, Austin, Texas.

Studies of the suitability of salt domes in the East Texas Basin for geologic isolation of nuclear wastes: presented at the American Society of Mechanical Engineers Annual Meeting, New Orleans, Louisiana.

Robert G. Loucks

Diagenesis in a carbonate shoal water complex, Pearsall Formation, South Texas: presented at The University of Texas at Dallas.

Porosity in a giant gas field, Ellenburger Formation, Puckett Field, Texas: presented to the West Texas Geologic Society, Midland, Texas; and at Fort Worth, Texas.

Reservoir quality in Tertiary sandstones along Texas Gulf Coast: presented to the Calgary Geologic Society, Calgary, Alberta, Canada.

Kinji Magara

Significance of pressure seals for oil and gas accumulations: presented at "Seals for Hydrocarbons," American Association of Petroleum Geologists Research Symposium, Keystone, Colorado.

David Mathew

Depositional environments of coal formation: presented at the Phillips Coal Company, Tyler, Texas.

Mary W. McBride

Dinosaurs: presented to five kindergarten classes, Wooten Elementary School, Austin, Texas.

Dinosaurs and other creatures: presented to five first-grade classes, Austin Public Schools, Austin, Texas.

Mountain-building processes: presented to three fifth-grade classes, Walnut Creek Elementary School, Austin, Texas.

Texas mineral resources and our environment: presented to an Education Workshop, Abilene Christian College, Abilene, Texas.

Robert A. Morton

Critical factors in locating and testing geopressured geothermal resources: presented to the Geothermal Resources Council (sponsored by the U.S. Department of Energy), Salt Lake City, Utah.

Critical reservoir parameters for geopressure geothermal sites: presented at the Geopressure Geothermal Energy Forum (sponsored by C. K. GeoEnergy Corp.), New Orleans, Louisiana.

Evaluation of geopressure geothermal resources in Texas: presented at the Geothermal Coordinating Committee 28th meeting (sponsored by Energy Systems, Inc.), New Orleans, Louisiana.

Geological factors that control continuity of geopressured sandstones: presented at C. K. GeoEnergy Corp., Houston, Texas.

Geopressure geothermal exploration in Texas: presented to a Geology 335 class, Department of Geological Sciences, The University of Texas at Austin.

Geopressured gas: presented to an Industrial Marketing Seminar, American Gas Association, Dallas, Texas.

Methane entrained in geopressured aquifers, Texas Gulf Coast: presented at the Conference on Conventional and Unconventional World Natural Gas Resources (sponsored by International Institute for Applied Systems Analysis), Schloss Laxenburg, Austria.

Status of geopressure geothermal prospects in Texas: presented at a meeting sponsored by the U.S. Department of Energy, New Orleans, Louisiana.

Mark W. Presley

Carboniferous depositional system, central Appalachians: presented at the Carboniferous Coal Field Seminar, Morgantown, West Virginia.

Glorieta-San Andres transition in the Texas Panhandle—facies interpretation of a complex stratigraphic boundary:

presented at the Geological Society of America, South-Central Section, 14th Annual Meeting, Wichita, Kansas.

Pottsville alluvial plain coals in northern West Virginia: presented at the American Association of Petroleum Geologists, Eastern Section, Annual Meeting, Evansville, Indiana.

Red-bed, evaporite, and carbonate facies associations in interior basins—a model for resource exploration: presented at the American Association of Petroleum Geologists, Eastern Section, Annual Meeting, Evansville, Indiana.

Paul J. Ramondetta

Genesis and emplacement of San Andres Oil in the northern shelf of the Midland Basin: presented to the Geology Department, Brooklyn College, Brooklyn, New York.

Geologic processes: presented at an elementary school, Austin, Texas.

Debra L. Richmann

An introduction to rocks and minerals: presented to eighth-grade earth science classes, Porter Junior High School, Austin, Texas.

Mineralogy, diagenesis, and porosity in Vicksburg sandstones, McAllen Ranch Field, Hidalgo County, Texas: presented at the Gulf Coast Association of Geological Societies Annual Meeting, Lafayette, Louisiana.

Vicksburg sandstone diagenesis, McAllen Ranch Field, Hidalgo County, Texas: presented at a South Texas Geological Society meeting, San Antonio, Texas.

William W. Simpkins

Impact of evaporite dissolution and collapse on cultural features in the Texas Panhandle and eastern New Mexico: presented at the 31st Annual Highway Geology Symposium (sponsored by The University of Texas at Austin, Bureau of Economic Geology, and the Texas Department of Highways and Public Transportation), Austin, Texas.

Interrelationships between drift composition and water chemistry in Forest County, Wisconsin: presented at the Geological Society of America, North-Central Section, Annual Meeting, Bloomington, Indiana.

Gary E. Smith

Facies development and paleogeography as a control on base-metal deposition in shelf margin carbonates, Austinville district, southwestern Virginia: presented to a stratiform ore deposits class, Department of Geological Sciences, The University of Texas at Austin.

The geology of red-bed copper deposits: presented to a stratiform ore deposits class, Department of Geological Sciences, The University of Texas at Austin.

The role of the geologist in minerals exploration and mine development: presented to a mineral resources class, Department of Geological Sciences, The University of Texas at Austin.

W. C. J. van Rensburg

A background in coal and lignite: presented to the Reporters' and Editors' Short Course on Energy, The University of Texas at Austin.

A background on synthetic fuels: presented to the Reporters' and Editors' Short Course on Energy, The University of Texas at Austin.

Classification of coal resources and reserves: presented to the Texas Energy and Natural Resources Advisory Council, Austin, Texas.

The energy problem—possible solutions: presented at the International Energy Conference, Texas A&I University, Kingsville, Texas.

A global perspective on strategic metals: presented at the Center for the Study of Aberrant Behavior (sponsored by Scaife Family Charitable Trusts, Inc.; Pittsburgh, Pennsylvania), Dallas, Texas.

Mineral commodity economics: presented to the Australian Mineral Foundation, Adelaide, Australia.

Political changes in southern Africa and the importance of the Republic of South Africa as a raw material supplier: presented to the Friedrich Ebert Foundation, Washington, D.C.

South African and Australian minerals policies: presented at "Decision-Making in the Mineral Industries," McGill University, Montreal, Canada.

The substitution of oil and natural gas by coal: presented to the Energy Policy Review Project, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin.

Synthetic fuels from coal: presented at the National Merit Scholars Symposium, University of Mississippi, Jackson, Mississippi.

U.S. dependence on imported nonfuel minerals: presented to a Department of Geology seminar, The University of Texas at Dallas.

The U.S. energy situation: presented to a group of gifted students at William B. Travis High School, Austin, Texas.

The U.S. nonfuel minerals position: presented to the Nonfuel Minerals Policy Review Project, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin.

The utilization of Texas lignites: presented at the SMU/DOE Conference, Albuquerque, New Mexico.

E. G. Wermund, Jr.

Coastal environmental geologic mapping of the Bureau of Economic Geology: presented to high school and junior high school science classes as a part of Semana de Cine Cientifico Didactico sobre Geologia y Medio Ambiente, Santander, Spain.

Environmental geologic studies in Texas and their transfer to the public policy sector: presented at the 1ª Reunion Nacional de Geologia Ambiental y Ordenacion del Territorio, Santander, Spain.

Mapping programs of the Bureau of Economic Geology: presented to the Photogrammetry and Aerial Survey Committee, Transportation Research Board, Federal Highway Administration, Austin, Texas.

Upper Pennsylvanian limestone banks on the Eastern Shelf, North-Central Texas: presented to Sigma Gamma Epsilon, West Texas State University, Canyon, Texas.

The utility of land-resource units for planning: presented to Workshop in Land-Resource Planning, American Planning Association, Houston, Texas.

William A. White

Coastal processes in the vicinity of Mustang Island and Padre Island: presented to an ecological field class, Richardson (Texas) High School, visiting the Bureau of Economic Geology.

South Texas coastal erosion: presented to the Texas Coastal and Marine Council, South Padre Island, Texas.

Charles M. Woodruff, Jr.

Beyond Barton Springs — geologic controls on the Edwards aquifer (and some unsolved problems): presented at The Edwards Aquifer: An Issue of Today, sponsored by the City of Austin Department of Environmental Resource

Management and the Lyndon B. Johnson School of Public Affairs, Austin, Texas.

Central Mineral Region of Texas: presented to the 31st Annual Highway Geology Symposium (sponsored by The University of Texas at Austin, Bureau of Economic Geology, and the Texas Department of Highways and Public Transportation), Austin, Texas.

Edwards aquifer — its geologic setting: presented to the First Annual Austin Neighborhood Issues Conference, Austin, Texas.

Geothermal resource potential along the margins of the Gulf Coastal Plain and the Mississippi Embayment: presented at the Institute for Energy Analysis (sponsored by Oak Ridge Associated Universities), Oak Ridge, Tennessee.

Low-temperature geothermal resources in Central Texas: presented to the Austin Geological Society, Austin, Texas; at Randolph Air Force Base, San Antonio, Texas; at Bergstrom Air Force Base, Austin, Texas; and at the U. S. Department of Energy, Division of Geothermal Energy, Washington, D. C.

CONGRESSIONAL, LEGISLATIVE, AND SPECIAL TESTIMONY

City of Austin, Southwest Task Force—L. Edwin Garner (testimony given: "Geologic Limits of the Edwards Recharge Zone, Travis County").

Federal Energy Regulatory Commission hearings, Santa Fe, New Mexico—W. L. Fisher (testimony given: "Geologic and Engineering Consideration in Definition of Tight Gas Reservoirs").

Interstate Oil Compact Commission, Committee on Production Policy, Dallas, Texas—W. L. Fisher (testimony given: "Recovery Unrecovered Oil").

Texas Coastal and Marine Council, Galveston, Texas—W. L. Fisher (testimony given: "Status of Mapping and Inventory, Texas Coastal Zone").

Texas Department of Health hearings, Rosenberg, Texas—W. L. Fisher (testimony given: "Geologic Factors in Solid Waste Disposal").

Texas Energy and Natural Resources Advisory Council, Advisory Committee on Nuclear Energy, Subcommittee on Low-Level Waste—L. Edwin Garner (testimony given: "Geologic Considerations for Disposal of Low-Level Radioactive Waste").

Texas Energy and Natural Resources Advisory Council, Advisory Committee on Coal and Lignite—W. R. Kaiser (testimony given: "Lignite Resources in Texas").

Texas House of Representatives, Committee on Environmental Affairs, Subcommittee on Nuclear Waste Disposal—E. G. Wermund (testimony given: "Relation of Texas Programs on Deep Geological Burial of Nuclear Waste and the National Program of DOE").

COMMITTEE SERVICES, OFFICES, AND OTHER PROFESSIONAL RESPONSIBILITIES

Randy L. Bassett

Session chairman, Clay Mineral Society Annual Meeting, Waco, Texas.

L. F. Brown, Jr.

Associate editor, American Association of Petroleum Geologists Bulletin.

Leader of a field trip to South Padre Island, Association of American State Geologists.

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

S. Christopher Caran

Chairman, Public Relations Committee, Austin Geological Society.

Co-leader of a field trip, "Volcanism and Intrusion in the Austin, Texas, Area," Austin Geological Society.

Edward W. Collins

Member, Publications Committee, Austin Geological Society.

Timothy W. Duex

Co-leader of a field trip to West Texas, Southwest Section Annual Meeting, American Association of Petroleum Geologists.

Marc B. Edwards

Judge of presentations, Gulf Coast Association of Geological Societies Annual Meeting, Lafayette, Louisiana.

Robert J. Finley

Alternate member, Texas Mapping Advisory Committee.

Co-leader of a field trip to the Gulf Coast uranium province, Corpus Christi Geological Society.

Co-leader of a field trip to the South Texas uranium province, Association of American State Geologists.

Member, Citizens Environmental Board, City of Austin.

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

Member, Texas Ad Hoc Committee for Review of "Desertification in the U.S., Status and Issues."

W. L. Fisher

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

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

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

Member, Executive Board, Texas Section, 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, Geothermal Industrial Advisory Committee, Texas Railroad Commission and U.S. Department of Energy.

Member, Government, Energy, and Mineral Affairs Committee, American Institute of Mining, Metallurgical, and Petroleum Engineers.

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

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

Chairman, Nuclear Energy Committee, Texas Energy Advisory Council.

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

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

Member, Publications Committee, Society of Economic Geologists, Inc.

Member, Renewable Resources Committee, Southern States Energy Board.

Member, Research Committee, Interstate Mining Compact Commission.

Member, Research Committee, Interstate Oil Compact Commission.

Member, Task Force, National Plan of Action to Combat Desertification, U.S. Department of the Interior.

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

Member, Texas Energy and Natural Resources Advisory Council.

Member, Texas Mapping Advisory Committee.

Past president, Texas Section, American Institute of Professional Geologists.

President-elect, Association of American State Geologists.

William E. Galloway

Commentator, field trip to the Gulf Coast uranium province, Corpus Christi Geological Society.

Co-leader of a field trip to the South Texas uranium province, Association of American State Geologists.

Member, Ad Hoc Committee on Energy and Mineral Resources, The University of Texas at Austin.

Member, editorial board, *In Situ*.

Representative, Advisory Council, Department of Geological Sciences, The University of Texas at Austin.

L. Edwin Garner

Chairman, 31st Annual Highway Geology Symposium.

Member, National Steering Committee, Highway Geology Symposium.

Alice B. Giles

Member, Publications Committee, Austin Geological Society.

Thomas C. Gustavson

Member, Resource Group, Texas Advisory Committee on Conservation and Environmental Education.

Member, Working Group 4, INQUA Commission on Genesis and Lithology of Quaternary Sediments.

Christopher D. Henry

Co-leader of a field trip to West Texas, Southwest Section Annual Meeting, American Association of Petroleum Geologists.

David K. Hobday

Chairman, Technical Program Committee, Austin Geological Society.

Judge of presentations, Society of Economic Paleontologists and Mineralogists Annual Meeting, Denver, Colorado; and Gulf Coast Association of Geological Societies Annual Meeting, Lafayette, Louisiana.

Leader of a field trip to East Texas, Gulf Coast Section, Society of Economic Paleontologists and Mineralogists.

Member, Tertiary and Quaternary Working Groups, South African Committee for Stratigraphy.

Charles W. Kreitler

Consultant to the Texas Attorney General's Office, for litigation concerning ground-water pollution.

Member, Editorial Board, *Ground Water*.

Robert G. Loucks

Leader of a field trip to Central Texas, Austin Geological Society.

Member, Sandstone Diagenesis Research Group, Society of Economic Paleontologists and Mineralogists.

Vice chairman, Carbonate Research Group, Society of Economic Paleontologists and Mineralogists.

Vice president, Austin Geological Society.

Kinji Magara

Adjunct professor, Faculty of Marine Science and Technology, Tokai University, Shimizu, Japan.

Associate editor, Canadian Society of Petroleum Geologists.

Associate editor, Japanese Association of Petroleum Technology.

Member, Organizing Committee, Hydrology of Deep Sedimentary Basins, Tokai University, Shimizu, Japan.

Mary W. McBride

Member, Resource Group, Texas Advisory Committee on Energy and Environmental Education.

Joseph H. McGowen

Consultant to General Land Office of Texas and to Attorney General in litigation of south Laguna Madre wind-tidal flats.

Member, Continuing Education Committee, Society of Economic Paleontologists and Mineralogists.

Mary K. McGowen

Chairman, Publications Committee, Austin Geological Society.

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

Robert A. Morton

Member, Nominating Committee, Texas Section of American Institute of Professional Geologists.

Member, Program Review Committee, Offshore Technology Conference.

Member, Research Conference Committee, Gulf Coast Section, Society of Economic Paleontologists and Mineralogists.

Mark W. Presley

Business representative for Austin, Gulf Coast Section, Society of Economic Paleontologists and Mineralogists.

Chairman, Evaporite Research Group, Society of Economic Paleontologists and Mineralogists.

Douglas C. Ratcliff

Chairman, Entertainment Committee, Austin Geological Society.

Representative for the Texas Mining and Mineral Resources Research Institute at the quarterly meeting of the Gulf Coast Consortium of Mining and Mineral Resources Research Institutes, Tuscaloosa, Alabama.

Representative for the Texas University Coal Laboratory at a meeting of universities to pursue University Coal Laboratory programs, Columbus, Ohio.

Debra L. Richmann

Chairman, Publications Committee, Austin Geological Society.

Treasurer, Austin Geological Society.

William W. Simpkins

Member (Bureau of Economic Geology representative), North Rolling Plains Conservation and Development Area Technical Advisory Committee.

W. C. J. van Rensburg

Chairman, Ad Hoc Committee on Resource Economics, The University of Texas at Austin.

Chairman, Executive Committee, Texas University Coal Research Consortium.

Member, Regional Lignite Project Committee, Gulf States Mining and Mineral Resources Research Institute.

Vice-chairman, Association of Mineral Institute Directors.

Bonnie R. Weise

Chairman, Membership Committee, Austin Geological Society, 1979-1980.

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

E. G. Wermund, Jr.

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

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

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

Member, Outer Continental Shelf Tech Working Group on Gulf of Mexico, BLM, U.S. Department of the Interior.

Member, Overview Committee to Improve Balcones Research Center, The University of Texas at Austin.

Member, Publications Committee, American Association of Petroleum Geologists.

Member, Publications Committee, Geological Society of America.

Charles M. Woodruff, Jr.

Ad hoc committee member, Advisory Board for Greenbelt Acquisition, Parks and Recreation Department, City of Austin.

Co-leader of a field trip to the Central Texas Hill Country and the Llano Uplift, 31st Annual Highway Geology Symposium.

Coordinator for Texas — Hydrothermal/Geothermal Research, State-Coupled Resource Assessment Teams, U. S. Department of Energy.

Leader of Safari 1980 geology nature hike, Parks and Recreation Department, City of Austin.

President, Austin Geological Society.

Technical sessions chairman, Gulf Coast Association of Geological Societies Annual Meeting, Lafayette, Louisiana.

UNIVERSITY TEACHING/ CONTINUING EDUCATION

ACADEMIC COURSES

Department of Geological Sciences, The University of Texas at Austin

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

Timothy W. Duex — Field Methods (Geology 320K).

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

C. Robertson Handford — Biogenic Carbonate and Evaporite Depositional Systems (Geology 383N).

Charles W. Kreitler — Hydrogeology (Geology 391C).

R. G. Loucks — Carbonate and Evaporite Depositional Systems (Geology 383M).

W. C. J. van Rensburg, Peter T. Flawn, and W. L. Fisher — Mineral Resources (Geology 391).

Department of Geology, University of Massachusetts, Amherst

Arthur G. Goldstein — Geology and Man.

SHORT COURSES/CONTINUING EDUCATION

Universities

L. F. Brown, Jr. — The Role of Facies in Seismic Stratigraphic Interpretation (presented at the University of Houston, Department of Geology, courses on Geology for Geophysicists, January 1980, and Geophysics for Geologists, May 1980; and the University of Tulsa, Department of Geology and Engineering).

L. F. Brown, Jr., William E. Galloway, and W. L. Fisher — Delta Systems in the Exploration for Oil and Gas (presented at the University of Texas, Permian Basin Graduate Center, Midland, Texas).

William E. Galloway — Coastal Plain Fluvial Systems; and Uranium Resources of Piedmont Deposits (both presented at Colorado State University, Short Course on the Fluvial System, Fort Collins, Colorado).

William E. Galloway — Exploration for Sandstone Reservoirs (presented at Universitetet I Bergen Geologisk Institutt, Bergen, Norway).

American Association of Petroleum Geologists

L. F. Brown, Jr. — Principles of Seismic Stratigraphic Interpretation (cosponsored by the Oklahoma City Geological Society and presented in Oklahoma City, Oklahoma; cosponsored by the Indonesian Petroleum Association and presented in Jakarta, Indonesia; and cosponsored by the Trinidad-Tobago Geological Association and presented in Port of Spain, Trinidad).

L. F. Brown, Jr. — Principles of Seismic Stratigraphy in Oil and Gas Exploration (presented at Continuing Education Schools on Seismic Stratigraphy and Its Role in Oil and Gas Exploration in San Antonio, Texas, February 1980, and in Miami, Florida, September 1980).

L. F. Brown, Jr., and W. L. Fisher — Depositional Systems and Basin Analysis in Petroleum Exploration (presented to the Indian Oil and Gas Commission, Dehra Dūn, India, November 1980).

William E. Galloway — Case Histories and Field Documentation of Seismic Reflection Patterns (presented at the Continuing Education School on Stratigraphic Interpretation of Seismic Data in Miami, Florida).

Robert G. Loucks — Carbonate Exploration School (held in Denver, Colorado).

Other Organizations

Randy L. Bassett — Chemistry for Ground-Water Solute Transport Models (presented at the U.S. Geological Survey National Training Center, Denver, Colorado).

Robert J. Finley — An Introduction to the Interpretation of Landsat Imagery (presented to the Texas Natural Resources Information System, Austin, Texas).

W. R. Kaiser — Environments of Coal Deposition (presented at the Phillips Coal Company, Tyler, Texas).

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

Robert G. Loucks — Carbonate Depositional Systems for Engineers (presented at the Exxon Research Lab, Houston, Texas).

Robert G. Loucks — Sandstone Depositional Systems (presented at the Conoco Oil Co., Austin, Texas).

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 a majority of the public. As Bureau research programs grow in numbers and complexity, staff members help with aspects of program administration and complete an ever-increasing volume of secretarial tasks for 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

James W. Macon, 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 support provided by 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, illustrations, slide copy, and display materials.

PHOTOGRAPHY

David Stephens provides technical photographic support for the Bureau's publications, lectures and public addresses, and research projects. Most of the photographic work consists of slides, cover photos, and text photos.

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 manuscript typing and composing, editing, graphics design, and layout.

Lucille Harrell coordinates the work of the manuscript typing and composing section. Susann Doenges directs the editorial staff. Judy Culwell, under the direction of Chief Cartographer James W. Macon, designs the publications and prepares final camera-ready copy.

BUREAU OF ECONOMIC GEOLOGY

Dr. W. L. Fisher, Director

Dr. L. F. Brown, Jr., Associate Director
Dr. Robert A. Morton, Associate Director
Dr. W. C. J. van Rensburg, Associate Director; Director, TMMRRI

Dr. E. G. Wermund, Associate Director
Douglas C. Ratcliff, Assistant Director for Administration
Eloise Hill, Executive Assistant

RESEARCH SCIENTISTS

Dr. Virgil E. Barnes
Dr. Randy L. Bassett
Dr. Marc B. Edwards
Dr. Robert J. Finley
Dr. William E. Galloway
A. Ray Gregory
Dr. Thomas C. Gustavson
Dr. Christopher D. Henry
Dr. Clara L. Ho
Dr. David K. Hobday
Dr. William R. Kaiser
Dr. Charles W. Kreitler
Dr. Robert G. Loucks
Dr. Kinji Magara
Dr. Joseph H. McGowen
Dr. Charles M. Woodruff, Jr.

RESEARCH SCIENTIST ASSOCIATES

Alan B. Alhades
Richard L. Andersen
Joyce M. Basciano
Mary A. Bauer
Robert W. Baumgardner, Jr.
Dr. Amos Bein
Michael E. Bentley
Michael S. Bumpass
Thomas R. Calnan
S. Christopher Caran
Edward W. Collins
E. Dow Davidson, Jr.
Owen R. Dix
Marianne M. Dodge
Timothy W. Duex
Shirley P. Dutton
Thomas E. Ewing
Graham E. Fogg
Deborrah A. Garcia
L. Edwin Garner
Chester M. Garrett, Jr.
Christine R. Gever
Alice B. Giles
Roselle M. Girard
James K. Gluck
Dr. Arthur G. Goldstein
George E. Granata
Dr. C. Robertson Handford
David W. Harris
Ann D. Hoadley
Rory C. Howard
Dr. Martin P. A. Jackson
Mary L. W. Jackson
Lee A. Jirik
Russell S. Kimble
Thomas G. Littleton
Dr. David Mathew
Mary W. McBride
Kathy A. McGillis
Douglas A. McGookey
Mary K. McGowen
Kitty L. Milliken
Suzanne M. Montano
Jan S. Posey
Dr. Mark W. Presley
Paul J. Ramondetta
Ronee S. Reed
Debra L. Richmann
Ray S. Risner
Michael P. Roberts
Floyd G. Rose, Jr.
Katherine E. Schmedes
Steven J. Seni
Roger D. Sharpe
William W. Simpkins
Gary E. Smith
Willard R. Stearns
Susan J. Tewalt
Jeffrey E. Thurwachter
Bonnie R. Weise
William A. White
Charles D. Winker
Debra H. Wood
H. Victor Wuerch III

CARTOGRAPHIC STAFF

James W. Macon, Chief Cartographer
Dan F. Scranton, Senior Cartographer
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