ANNUAL REPORT
1975

BUREAU OF ECONOMIC GEOLOGY

THE UNIVERSITY OF TEXAS AT AUSTIN
AUSTIN, TEXAS
C. G. GROAT, ACTING DIRECTOR

RESEARCH AND ADMINISTRATIVE OFFICES
Geology Building, Main Campus
University Station, Box X
Austin, Texas 78712
(512)471-1534

LABORATORIES
Balcones Research Center
10100 Burnet Road
Austin, Texas 78758
(512)836-0440

BUREAU OF ECONOMIC GEOLOGY

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 functions also as the State Geological Survey—a quasi-state agency—with membership on the State Interagency Council on Natural Resources and the Environment. The Bureau Director serves as State Geologist and represents Texas in the Association of American State Geologists.

The Bureau provides extensive advisory, technical, and information 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, land and environmental resources, nonfuel mineral resources, geohydrologic resources, mineral statistics, and systematic geologic and land resource mapping. Certain projects are conducted jointly with other units of the University as well as with State, Federal, and local governmental agencies.

The Bureau of Economic Geology publishes results of its research in its own series of Reports of Investigations, Atlases, Geological Circulars, Geologic Quadrangle Maps, Land Resources Laboratory Maps, Handbooks, Special Publications, and Mineral Resource Circulars. 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, staff activities, and those services in the area of Texas geology and resources available to agencies, corporations, and the citizens of Texas. The Annual Report is available on request.

CONTENTS

FISHER APPOINTED TO INTERIOR POST

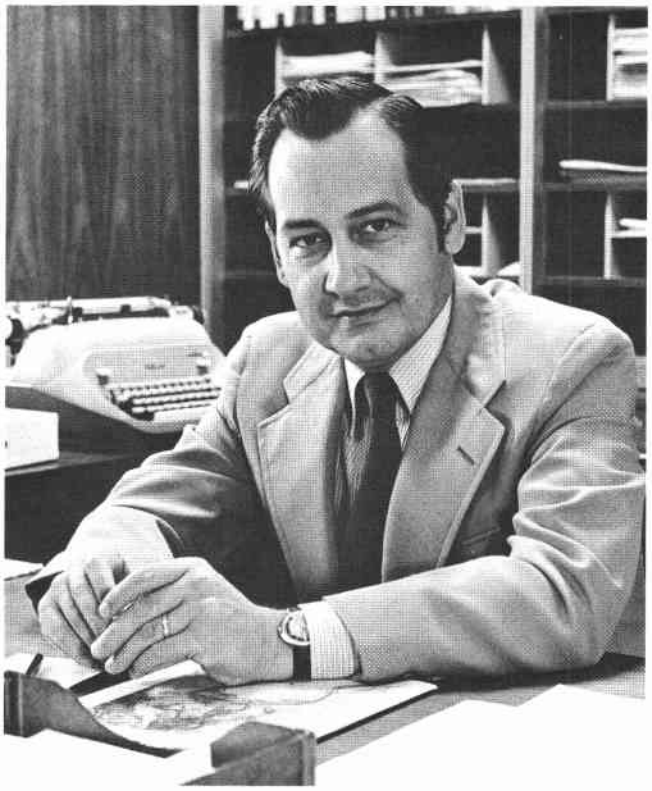
Dr. W. L. Fisher, Director of the Bureau of Economic Geology, was named Deputy Assistant Secretary for Energy and Minerals by the Secretary of Interior, effective May 1, 1975. Dr. Fisher has taken leave of absence from the University to assume this important policy-level position. In describing his new position, Dr. Fisher said, "I am going to the new post with two basic assumptions. I think it is important that the United States achieve an adequate supply of minerals and energy, and also to the greatest extent possible that we be as self-sufficient as possible." Regarding his outlook on the assignment, he stated, "From a strictly personal point of view, I am interested in contributing to important policy decisions, and I want to learn how government works in making decisions."

Dr. Fisher joined the University in 1960 as a research scientist with the Bureau. He became Associate Director in 1968 and Director in 1970. He joined the Department of Geological Sciences faculty in 1964 as a lecturer and became a professor in the department in 1969.

Dr. Fisher has been a leader in the development of genetic concepts in the interpretation of ancient rocks and, with Bureau colleagues, has pioneered the application of those concepts to energy and mineral resources exploration and development.

In addition to research in the application of geology to mineral exploration and development, Dr. Fisher has been involved in the application of geology to problems of land and environmental resources. In the 1960's, a number of programs in environmental geology were initiated by Dr. Fisher, Dr. Peter Flawn, and Dr. Frank Brown; these programs have brought national acclaim to the Bureau.

Dr. Fisher has served on a number of national committees, including the Coastal Zone Management Advisory Committee of the Department of Commerce, the Environment and Public Policy Committee of the Geological Society of America, the Committee on Geoscience and Public Policy of the American Geological Institute, and the Continuing Education Committee of the American Association of Petroleum Geologists. Before taking leave from the Bureau, he served as vice president of the Association of American State Geologists; he is a past chairman of the Association's Environmental Geology Committee and its Governmental Liaison Committee.



Dr. William L. Fisher

GROAT NAMED ACTING DIRECTOR, WERMUND AND GUSTAVSON ASSUME NEW DUTIES

University officials appointed Dr. Charles G. Groat Acting Director of the Bureau during the leave of absence of Dr. W. L. Fisher. Groat previously served as Associate Director for Administration. In this capacity he performed general

NEWS NOTE: As this report was going to press, Dr. W. L. Fisher was appointed by President Gerald Ford to the post of Assistant Secretary for Energy and Minerals of the U. S. Department of the Interior. This appointment has been confirmed by the Senate, and Dr. Fisher was formally sworn in as Assistant Secretary on March 26, 1976. In this position, Dr. Fisher has major responsibility for Department of Interior policy related to energy and minerals.

From left: Drs. L. F. Brown, Jr., E. G. Wermund, T. C. Gustavson, and C. G. Groat.

administrative duties and had responsibility for energy and mineral resource programs. Since joining the Bureau full-time in 1968, Dr. Groat has been involved in geological investigations in West Texas, environmental geologic mapping of the Texas Gulf coast, mineral resource studies on University Lands, and a comprehensive survey of surface mining in the State. He has had a major role in the University's geothermal energy program.

In addition to Bureau responsibilities, Groat is an associate professor in the Department of Geological Sciences where he teaches a course dealing with mineral resources and environmental geology. He received an A.B. degree from the University of Rochester, an M.S. from the University of Massachusetts, and a Ph.D. from The University of Texas at Austin.

Dr. E. G. Wermund has been appointed Acting Associate Director for Administration. Wermund was formerly coordinator of the Bureau's Land Resources Laboratory. Since joining the Bureau, Dr. Wermund has been active in several areas of research including facies analysis of Pennsylvanian carbonate rocks, rock description utilizing numeric codes, environmental geologic mapping for the South Texas river basins study, and ground-water hydrology within carbonate terranes. Dr. Thomas C. Gustavson is serving as Acting Coordinator of the Land Resources Laboratory, which administers Bureau projects related to land and environmental resources. Dr. Gustavson has been active in other research areas, including environmental geologic mapping for the South Texas river basins study, use of gilgai structures as keys to identifying unstable soils, and evaluation of Texas sand and gravel resources. Dr. L. F. Brown, Jr., continues in the key position of Associate Director for Research. In addition to his duties as Associate Director, Dr. Brown is project director for the Environmental Geologic Atlas project. His research activities include depositional systems analysis of Pennsylvanian and Permian strata in north-central Texas and coordination of other Bureau environmental geologic mapping projects.

PUBLICATIONS IN 1975

In its role as a public geologic research unit, the Bureau of Economic Geology disseminates the results of research programs and projects primarily through its own publication series. During the 66-year history of the Bureau, reports, bulletins, and maps have been published covering all major aspects of the geology and natural resources of Texas. Publications are made available to interested persons at prices that are set to recover printing costs. To date, approximately one million publications have been distributed, principally through direct sales. During 1975, the Bureau issued the following publications:

REPORTS OF INVESTIGATIONS

Report of Investigations No. 82. Depositional Systems in Canyon Group (Pennsylvanian System), North-Central Texas, by Albert W. Erxleben. 76 p., 33 figs., 9 plates, 3 appendixes ($3.50).

Analysis of 1,200 to 1,800 feet of Middle Pennsylvanian (Canyon Group) sandstone, shale, and limestone facies within 15 counties (12,000 square miles) of North-Central Texas indicates that the facies were deposited as components of major deltaic, shelf, and shelf-edge bank depositional systems. Report of Investigations No. 82 describes the composition, vertical sequences, and distribution of the variety of facies in the Canyon Group and integrates them into depositional systems that were active in the region during the Middle Pennsylvanian. Principal depositional systems include the Perrin delta system, Henrietta fan-delta system, and several carbonate depositional systems. Supplied with sediment from the Ouachita Mountains, the Perrin delta prograded westward into the Midland Basin during three major clastic depositional episodes.

Oil and gas occur within some of the carbonate systems, as well as within sandstone facies associated with the Henrietta fan-delta system. Local coal deposits are associated with the Perrin delta system. Deltaic sandstones constitute local ground-water aquifers in the shallow subsurface; deeper in the basin, the sandstones are potential reservoirs for injection of waste fluids.

This report presents a detailed analysis of the characteristics of ancient deltaic facies and provides a depositional model documented by outcrop studies and an analysis of electric log and sample data from 1,500 wells. One of a continuing series of basin-analysis studies by the Bureau of Economic Geology, the report develops fundamental criteria that should be useful in the exploration for oil, gas, minerals, and ground water within similar stratigraphic sequences.

Report of Investigations No. 83. Determining the Source of Nitrate in Ground Water by Nitrogen Isotope Studies, by Charles W. Kreitler. 57 p., 25 figs., 23 tables, 6 appendixes ($2.00).

Average nitrate concentration in the ground water in 18 Texas counties approaches or is greater than 45 mg/l, the recommended limit for public water supplies. Nitrate in ground water can originate from cultivation, fertilizers, septic tanks, and livestock waste.

The study of nitrogen isotopes (N^{14} and N^{15}) provides a method of monitoring the migration of nitrate into natural waters. Nitrogen isotope ratios of nitrate ions from soil and water samples can be analyzed reproducibly with an experimental error of approximately ±1 parts per thousand (ppt). Two isotopic ranges of soil nitrate are found in the soils of southern Runnels County, Texas. Nitrate from the decomposition of animal waste nitrogen has a del N15 ($\delta\ N^{15}$) of +10 ppt to +22 ppt. Nitrate derived from the mineralization of organic nitrogen in cultivated soils has a del N15 of +2 ppt to +8 ppt.

In southern Runnels County, the major source of nitrate in ground water is natural soil nitrate. It may contribute as much as 1,000 times more nitrate to the ground water than animal wastes. The isotopic composition of ground-water nitrate beneath cultivated fields corresponds with del N15 of natural soil nitrate. Ground waters beneath farmhouse-barnyard complexes have a higher average del N15, indicating the addition of animal waste nitrate.

Eleven samples of ground water from Macon County, Missouri, have del N15 of +10 ppt to +19 ppt, indicating that the waters are contaminated with nitrate from animal wastes. Nitrates in ground waters from the Upper Glacial aquifer in Queens County, New York, appear to be from an animal waste source, whereas nitrates in ground waters from the Magothy aquifer in Nassau County, New York, appear to be from either natural soil nitrogen or artificial fertilizer.

Report of Investigations No. 84. Land Capability in the Lake Travis Vicinity, Texas—A Practical

Guide for the Use of Geologic and Engineering Data, by C. M. Woodruff, Jr. 37 p., 22 figs., 13 tables, 3 plates ($2.00).

Lake Travis is a man-made impoundment in the "hill country" of Central Texas; land around the lake is undergoing rapid residential and recreational development. Intensive human activities impose pressures on natural regimes, such as quality and quantity of both surface water and ground water, erosion of soils or bedrock, and ground stability. Likewise, some activities may endanger human life or property by the unwitting exposure to natural (hazardous) processes, such as flooding or mass wasting. This report attempts to evaluate the Lake Travis vicinity in terms of natural features of the land and their capabilities for sustaining selected human uses.

Detailed geologic mapping is the basis for evaluation of land capability in the Lake Travis vicinity. However, a "traditional" geologic map, replete with formal stratigraphic nomenclature, was not deemed germane to problems of human use of lakeshore lands. Instead, two complementary maps were constructed—a physical properties map and an environmental geologic map. The physical properties map shows expected areal variations in engineering properties, such as slope stability, permeability, excavation potential, foundation strength, shrink-swell, and corrosion potential. Physical properties units are also projected into the subsurface by means of a cross section. The environmental geologic map shows a composite of ambient processes, landforms, and materials in the Lake Travis vicinity. Knowledge of the interactions among these factors gives the users of the land information on water regimes, erosion potential, possibility for ground failure, and probable types and thicknesses of soils. In addition to these two basic maps, this report also includes depictions of various soil characteristics, ground slope, and bedrock fracture intensity.

Report of Investigations No. 84 shows the Lake Travis vicinity to consist mainly of steeply sloping terrain with very thin soils covering mostly resistant carbonate bedrock. These lands make scenic and generally stable homesites, but environmental problems may occur because of intensive use of septic tanks as a domestic waste disposal method. With information regarding natural constraints on human uses of lakeshore lands, many problem areas can be avoided or the problems can be mitigated. It is part of the aim of this report to communicate with the non-geologist regarding the natural capabilities of these lands. However, it is also hoped that the techniques for describing the interactions among processes, materials, landforms, soils, and water regimes might aid other geologists who attempt to translate the complexities of natural systems for public dissemination.

GEOLOGICAL CIRCULARS

Geological Circular 75-1. Geothermal Resources—Frio Formation, South Texas, by D. G. Bebout, M. H. Dorfman, and O. K. Agagu; Research Assistants: G. E. Granata and G. B. Sanders, Jr. 36 p., 25 figs. ($.95).

A zone of undercompacted, overpressured sand and shale occurs in deeply buried Tertiary sediments along the Texas Gulf Coast. The top of this geopressured zone lies at depths ranging from 5,000 to 12,000 feet below sea level. Fluids produced from sand reservoirs in the geopressured zone are low-salinity waters that have relatively high temperatures (up to 350° F) and that contain dissolved methane gas. Large water reservoirs in this geopressured zone are the targets of geothermal exploration along the Texas Gulf Coast.

This geological circular summarizes the results of a preliminary evaluation of the geothermal resources in the Frio Formation, one of the Tertiary units in South Texas. A number of cross sections showing the dip and strike of the Frio Formation were constructed from electrical logs of moderately spaced wells. Sand-percentage maps of small subunits of the Frio delineate the areas of main sand deposition. A map showing the top of the geopressured zone also was prepared; this top was determined on the basis of various parameters derived from electrical logs. Temperature maps were prepared by using the uncorrected bottom-hole temperatures indicated on all logs. The combined use of the sand-distribution, geopressure, and temperature maps leads to the identification of several prospective areas in which more detailed study is warranted prior to selecting a site for a geothermal well.

Geological Circular 75-2. Shoreline Changes on Brazos Island and South Padre Island (Mansfield Channel to Mouth of the Rio Grande), An Analysis of Historical Changes of the Texas Gulf Shoreline, by Robert A. Morton and Mary J. Pieper. 39 p., 12 figs., table, 3 appendixes ($1.00).

Geological Circular 75-4. Shoreline Changes in the Vicinity of the Brazos River Delta (San Luis Pass to Brown Cedar Cut), An Analysis of Historical Changes of the Texas Gulf Shoreline, by Robert A. Morton and Mary J. Pieper. 47 p., 12 figs., table, 3 appendixes ($1.00).

Geological Circular 75-6. Shoreline Changes Between Sabine Pass and Bolivar Roads, An Analysis of Historical Changes of the Texas Gulf Shoreline, by Robert A. Morton. 43 p., 11 figs., table, 3 appendixes ($1.00).

During the past 2 years, the Bureau of Economic Geology has conducted a special study of shoreline changes along the Texas Gulf shoreline. Geological Circulars 75-2, 75-4, and 75-6 are the second, third, and fourth of eight reports to present results of that study.

The magnitude of accretion and erosion as well as the rate of change in the Texas Gulf shoreline are documented by historical monitoring, a technique developed by the Bureau of Economic Geology. The technique involves mapping the shoreline at selected historical intervals, utilizing existing photographs and coastal charts that span the past century or more. Through comparison of the positions of the shoreline over a long period of time, the amount of change is determined. Data are supplemented by historical comparison of the shoreline to such fixed objects as wellheads, highways, or seawalls.

Geological Circulars 75-2, 75-4, and 75-6 describe: (1) methods and procedures used in shoreline monitoring, (2) present beach characteristics of the Gulf shoreline, and (3) changes in the shoreline position between the middle to late 1800's and 1974. The study indicates that the major shoreline and vegetation line changes along the Texas Coast are largely the result of natural processes.

Geological Circular 75-3. Upper Pennsylvanian Limestone Banks, North Central Texas, by E. G. Wermund. 34 p., 14 figs., 2 tables ($1.50).

Upper Pennsylvanian limestone banks are skeletal deposits of loose organisms—dominantly phylloidal algae, osagiid algae, fenestrate bryozoans, and echinoderms—which built extensive deposits in an epeiric or shallow cratonic sea. Circular 75-3 summarizes the stratigraphic, geometric, and lithologic characteristics of the banks and relates them to modern calcareous deposits.

Subsurface lithofacies maps prepared from data obtained from 2,500 wells within an area of 18,000 square miles show that limestone banks commonly extend for more than 100 miles and exceed 1,000 square miles in area. They commonly are a few hundred feet thick; only rarely do they approach 1,000 feet in thickness. Most banks are biostromal; scattered local banks are bioherms. All the banks occur in a section dominated by terrigenous mudstones. Subsurface dip-oriented cross sections show that the banks terminate abruptly seaward but intercalate with muds over extensive areas toward the former shoreline. Regional maps of polynomial surfaces fitted to limestone and sand indicate that currents apparently sapped the seaward edge of the banks. The limestone banks commonly developed on foundered deltas and were displaced by contemporaneous delta building.

Bank-forming limestone types are identified in this report, and calcareous facies are reconstructed from surface mapping and preliminary analyses of cuttings. Recognition of varied faunas, compositions, grain sizes, and bedding structures of limestones leads to the reconstruction of bank facies, such as open marine mudstones, arenaceous bars and channel fills, bay and lagoonal mudstones, phylloidal algal mudstones, and shoreface grainstones. These facies are discussed relative to other ancient deposits, principally in the Mid-Continental region, and to modern environments, particularly in the Floridian-Bahamian region. All calcareous facies were deposited in shallow water, and depositional relief was a maximum of 10 meters.

As shown in the circular, it is not possible to develop a depositional model for Pennsylvanian limestone banks from study of calcareous deposits alone. Regional and local studies of the limestone and contiguous terrigenous facies indicate that the deposition of bank limestones and deltaic clastics must be evaluated in an integrated depositional model.

Geological Circular 75-5. Flood Hazards along the Balcones Escarpment in Central Texas—Alternative Approaches to their Recognition, Mapping, and Management, by Victor R. Baker. 22 p., 12 figs., 2 tables ($.75).

This circular is a preliminary report on the flood problems of Central Texas; it suggests alternative approaches to their evaluation and relates these scientific goals to the managerial goals of the State and of local communities.

Perhaps the most catastrophic rainfall regime in the conterminous United States occurs in Central Texas. Over $400 million already has been invested in flood control works, but flood losses remain substantial because people occupy river-valley bottoms, flood plains, and other flood-prone areas.

This report concentrates on alternative approaches toward recognition of flood hazards. To be truly effective, though, flood hazard information must be brought to the local level of government and then it must serve as a basis for flood-plain regulation, land use planning, and flood control by various levels of government. The report further discusses steps involved in formulating an adequate local flood-plain management program.

Geological Circular 75-7. Microrelief (Gilgai) Structures on Expansive Clays of the Texas Coastal Plain—Their Recognition and Significance in Engineering Construction, by Thomas C. Gustavson. 18 p., 14 figs., table ($.75).

Cracked pavements, undulating road surfaces, broken curbs, stairstep fractures of brick and stone building walls, and tilted power poles are common occurrences in areas underlain by cracking, expansive clay soils of the Vertisol order. These soils, which underlie 15 to 20 percent of the Coastal Plain of Texas, are composed predominantly of montmorillonite and develop distinctive microtopographic features known as gilgaies. Relief between adjacent microknolls or ridges and microdepressions ranges up to 18 inches (45.7 cm). Cracks develop in these soils to depths of 60 inches (152.4 cm) and to widths of 4 inches (10.2 cm).

As illustrated in the circular, gilgai microtopography forms as montmorillonitic clay soils expand with the adsorption of water introduced via deep cracks, root holes, animal burrows, and normal gravity infiltration. The expansion of subsoil clay and of dry clay soil that has fallen into cracks from the surface causes subsoil material to move both laterally and upward. Areas of marked vertical movement produce diapirlike ridges of light-colored clay subsoil extending upward into dark surface soils. The subsoil diapirs underlie surface microknolls and microridges.

As a consequence of large hydration pressures, vertical soil movements in areas of gilgai microrelief may place severe limitations on the construction of roads, buildings, power lines, buried transmission lines, and pipelines.

The circular includes a brief review of current engineering techniques for the mitigation of damage to highways and buildings. These techniques include lime stabilization, ponding, and subgrading of highways and use of steel reinforcing bars or post-tension cables in concrete-foundation slabs of buildings.

Geological Circular 75-8. Geothermal Resources—Frio Formation, Middle Texas Gulf Coast, by D. G. Bebout, O. K. Agagu, and M. H. Dorfman; Research Assistants: G. E. Granata, G. B. Sanders, Jr., and J. H. Seo. 43 p., 38 figs. ($1.00).

Geological Circular 75-8, which evaluates the geothermal resources of the Frio along the middle Texas Gulf Coast, is the second in a series of three reports that outlines the distribution of sand facies in the Frio Formation along the Texas Gulf Coast and that contains maps indicating the downhole fluid temperatures and the top of geopressure. The reports aid in evaluating the potential for production of geothermal energy. The first report (Geological Circular 75-1) has been previously discussed; the third report will consider the geothermal potential of the upper Texas Gulf Coast and will be published in 1976.

Studies of the six subunits of the Frio described from the lower Texas Gulf Coast have been extended into the middle coast area. Sand-percentage and net-sand maps show that the Frio consists dominantly of strike-aligned sand bodies along the main sand depocenter. These thick sand bodies are not within the geopressured zone, and fluid temperatures are less than 200° F. Downdip of the main depocenter, sand bodies which are 100 to 300 feet thick do occur. Three of these areas are outlined as potential geothermal fairways.

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., table ($1.00).

This article was originally published in "Sedimentology," volume 14, 1970, by Elsevier Publishing Company and was reprinted with their permission.

The report describes the sequence of stratification types and associated depositional features that occur in streams having a low suspended load/bed-load ratio. It also provides a depositional model based on observations of both modern and ancient fluvial deposits.

Fundamental differences between bed-load streams and mixed-load streams are that upper point-bar sediments with small trough sets and parallel-inclined laminae occur only in fine-grained (mixed load) fluvial deposits, and large-scale foresets of chute bars are common to coarse-grained (bed load) fluvial deposits. Upward-fining sequences characteristic of fine-grained fluvial deposits are uncommon in sediments of bed-load streams.

Characteristics of bed-load streams include short-duration peak flow, moderate stream gradient, channel pattern of low sinuosity, and a broad, shallow, symmetrical to asymmetrical channel cross section.

This circular should be of interest to geologists involved in the analysis of depositional environments and fluvial processes.

MINERAL RESOURCE CIRCULARS

Mineral Resource Circular No. 56. Gold and Silver in Texas, by Thomas J. Evans. 36 p., 14 figs., 5 tables, appendix ($1.00).

Rising prices and changing governmental policies have stimulated interest in occurrences of gold and silver in Texas. This mineral resource circular presents a summary and compilation of known occurrences of these precious metals in Texas and includes information on past development, geologic setting, and modes of occurrence and discussion of the historical perspective of such information in light of growing citizen interest.

The production of gold and silver in Texas was never equal to its promise. From the legends of Indian and Spanish mines to the reasoned analysis of early geologists, estimates of production potential far exceeded any eventual reality. Presidio mine in far West Texas produced over 92 percent of the State's total silver output and at least 73 percent (and probably much more) of the State's gold output. Presidio mine was operated to exploit silver-lead ore occurring as mantos in Permian limestones near Shafter, Texas. Hazel mine was the second largest producer of silver, accounting for about 6 percent of total State production. With the exception of these two mines, the efforts embodied in more than a hundred known mines and prospects have resulted in little financial gain. Probably even more numerous are the unknown or unnamed prospects which add to the story of gold and silver in Texas—a story more of sweat than reward, more of hope than fact.

Mineral Resource Circular No. 57. Native Bituminous Materials in Texas, by Thomas J. Evans. 18 p., 6 figs., 3 tables ($.75).

Several deposits of native bituminous materials occur in the State of Texas. Deposits include rock asphalt (asphaltic limestone, asphaltic sandstone, and heavy-oil-bearing sandstone), oil shale, mineral wax, and asphaltite. This mineral resource circular represents an initial step toward evaluating the significance of these native bituminous materials. A review of available literature, the results of field checks of major deposits, and discussion of new samples collected for bitumen-content testing are included in this report.

Texas native bituminous materials constitute insignificant mineral or energy resources with two exceptions—Uvalde district asphaltic limestone and Central Texas oil shale. Rock asphalt in Uvalde district has been used for several decades as a natural paving material. Large reserves of asphaltic limestone indicate a continuing contribution to the State's mineral economy. Central Texas oil shale deposits are an energy resource of potential importance, but existing information is contradictory and otherwise inadequate for conclusive evaluation.

Uvalde district rock asphalt has been extensively developed since the turn of the century. Also, minor commercial development of rock asphalt in the Palestine, Burnet, and St. Jo-Muenster districts has occurred. Future utilization of these other native bituminous materials depends on expansion of demand for natural asphalt materials for paving projects or identification of reserves of extractable hydrocarbons sufficient to support production of synthetic crude oil. Should a more complete study suggest that development is warranted, the Central Texas oil shale deposits may eventually contribute to the State's energy resource base. Mineral Resource Circular No. 57 is, thus, a starting point from which to initiate more detailed evaluations of Texas' native bituminous materials.

SPECIAL PUBLICATION

Special Publication. Historical Changes and Related Coastal Processes, Gulf and Mainland Shorelines, Matagorda Bay Area, Texas, by J. H. McGowen and J. L. Brewton. 72 p., 27 figs., 4 tables, 3 appendixes including 21 detailed profiles of Gulf and mainland beaches, plate; 8 Gulf and mainland

shoreline change maps, full color, scale 1:24,000; 8 marsh distribution maps, full color, scale 1:48,000 ($6.00).

In October 1971, a pilot study of Gulf and bay shoreline and marshland changes was initiated jointly by the Bureau of Economic Geology and the General Land Office of Texas. This report presents the results of shoreline and marshland changes in the Matagorda Bay area.

Through this study, the technique of historical shoreline monitoring was developed; the technique has been applied to the study of Gulf shorelines along the entire Texas Coast. Historical monitoring involves the use of vintage photographs and coastal charts to determine changes in the shoreline position and marsh distribution through time. The magnitude and direction of shoreline change was determined for the past 125 years.

Multicolor maps document shoreline and marsh changes between 1856 and 1972, and coastal processes affecting these changes are discussed. Coastal processes along both Gulf and mainland shorelines were observed during the winter of 1971 and spring of 1972; many topographic profiles included in the report illustrate the variety of erosional and depositional shorelines.

The availability of sand for beach nourishment is vital for shoreline stability; this report evaluates modern river sand and relict shelf sand as primary sources of sediment for beach nourishment in the Matagorda Bay area. Some human activities, such as jetty construction and spoil disposal, have an immediate effect on shoreline stability; these activities and their consequences also are evaluated in the report. Since 1856, the dominant trend in the bay system has been shoreline erosion and loss of marshlands. The study has indicated that most of the shoreline changes in the Matagorda Bay area are the result of natural processes.

GEOLOGIC ATLASES

Geologic Atlas of Texas. Beeville-Bay City Sheet, Alexander Deussen Memorial Edition, V. E. Barnes, project director. Scale 1:250,000, in full color, topographic base ($3.00).

The Beeville-Bay City Sheet, an areal geologic map with topography and culture, covers all or part of Aransas, Bee, Brazoria, Calhoun, De Witt, Goliad, Jackson, Jim Wells, Karnes, Live Oak, Matagorda, Refugio, San Patricio, Victoria, and Wharton Counties. Mapping was compiled by T. E. Brown, J. L. Brewton, and Saul Aronow, Bureau of Economic Geology, and D. H. Eargle, U. S. Geological Survey. The map was reviewed by the Geologic Atlas Committee of the Corpus Christi Geological Society.

The Beeville-Bay City Sheet is a memorial edition honoring Alexander Deussen (1882-1959). Deussen is the geologist most closely identified with early regional studies of Gulf Coast geology and with oil and gas exploration in the area. He attended The University of Texas obtaining Bachelor's and Master's degrees in 1903 and 1904 respectively. He taught geology as a member of The University of Texas faculty for 10 years and concurrently for part of the time was assistant geologist, United States Geological Survey. Alexander Deussen, known widely as "dean of Gulf Coast petroleum geologists," established a consulting practice in Houston in 1916 after a year with Guffey Petroleum Company, forerunner of Gulf Oil Corporation. This consulting practice was interrupted by 6 years with Marland Oil Company, during which time he initiated and directed the operations of the first seismograph party on the Gulf Coast.

Geologic Atlas of Texas. San Angelo Sheet, Helen Jeanne Plummer Memorial Edition, V. E. Barnes, project director. Scale 1:250,000, in full color, topographic base ($3.00).

The San Angelo Sheet, an areal geologic map with topography and culture, covers all or part of Coke, Concho, Crockett, Glasscock, Irion, Menard, Midland, Reagan, Runnels, Schleicher, Sterling, Tom Green, and Upton Counties. Mapping was compiled by G. K. Eifler, Jr., Bureau of Economic Geology. The map was reviewed by the Geologic Atlas Committee of the San Angelo Geological Society.

The San Angelo Sheet is a memorial edition honoring Helen Jeanne Plummer (1891-1951). Mrs. Plummer, a consulting paleontologist and micropaleontologist specializing in foraminifera, was associated with the Bureau of Economic Geology in Austin from 1933 to 1948 as consulting geologist. Following that period and until her death, she was a regular member of the Bureau staff. Mrs. Plummer began her career as a geologist with the Illinois Geological Survey in 1914 and was with Roxana Petroleum Company before her marriage to F. B. Plummer in 1918. After her marriage she continued her own scientific work.

Because of the bulk and quality of that work, many were not aware of her tremendous expenditure of energy and time in helping Mr. Plummer in his scientific studies.

LAND RESOURCES LABORATORY MAP SERIES

Land Resources Laboratory Map Series. Land and Water Resources—Houston-Galveston Area Council, by A. E. St. Clair, C. V. Proctor, Jr., W. L. Fisher, C. W. Kreitler, and J. H. McGowen. Map: 4 sheets, scale 1:125,000, in full color; text: 25 p., 5 figs., 11 tables, appendix, plate ($5.00).

This project was initiated under contract with the Houston-Galveston Area Council. The publication is designed to aid in planning land and water development in the 13-county HGAC region.

Forty-four land and water resource units are shown on the full-color Land and Water Resources Map (scale 1:125,000) which is divided into four sheets. The map also includes topography, drainage, culture, active surface faults, surface mines, and developed areas (updated from 1970 photographs).

An explanatory text accompanies the map and includes a discussion of the vegetation, geology, and natural hazards of the HGAC area. The report contains several tables designed to aid in evaluating the natural suitability of land and water resources for various uses. The text also contains information on mapping techniques, interpretation of the Land and Water Resources Map, derivation of special-purpose maps, and application of the map to planning.

PUBLICATIONS IN PRESS OR IN FINAL PREPARATION

Energy Resources of Texas, by T. J. Evans, L. E. Garner, and A. E. St. Clair.

Environmental Geologic Atlas of the Texas Coastal Zone—Bay City-Freeport Area, by J. H. McGowen, L. F. Brown, Jr., T. J. Evans, W. L. Fisher, and C. G. Groat.

Environmental Geologic Atlas of the Texas Coastal Zone—Corpus Christi Area, by L. F. Brown, Jr., J. L. Brewton, J. H. McGowen, T. J. Evans, W. L. Fisher, and C. G. Groat.

Environmental Geologic Atlas of the Texas Coastal Zone—Kingsville Area, by L. F. Brown, Jr., J. H. McGowen, T. J. Evans, C. G. Groat, and W. L. Fisher.

Environmental Geologic Atlas of the Texas Coastal Zone—Port Lavaca Area, by J. H. McGowen, C. V. Proctor, Jr., L. F. Brown, Jr., T. J. Evans, W. L. Fisher, and C. G. Groat.

Geologic Atlas of Texas. Brownwood Sheet, V. E. Barnes, project director.

Geologic Atlas of Texas. Corpus Christi Sheet, V. E. Barnes, project director.

Geologic Atlas of Texas. Pecos Sheet, V. E. Barnes, project director.

Geological Circular. Environmental Geology and Lignite Strip Mining, by Christopher D. Henry.

Geological Circular. Geothermal Resources of the Texas Gulf Coast, by Thomas C. Gustavson and Charles W. Kreitler.

Geological Circular. Hydrogeologic Significance of Depositional Systems and Facies in Lower Cretaceous Sandstones, North-Central Texas, by W. Douglas Hall.

Geological Circular. Shoreline Changes on Matagorda Island and San Jose Island (Pass Cavallo to Aransas Pass)—An Analysis of Historical Changes of the Texas Gulf Shoreline, by Robert A. Morton and Mary J. Pieper.

Geological Circular. Shoreline Changes on Matagorda Peninsula (Brown Cedar Cut to Pass Cavallo), An Analysis of Historical Changes of the Texas Gulf Shoreline, by Robert A. Morton, Mary J. Pieper, and Joseph H. McGowen.

Geologic Quadrangle Map. Geology of the Kingsland Quadrangle, Llano and Burnet Counties, Texas, by V. E. Barnes.

Mineral Resource Circular. The Mineral Industry of Texas in 1973, by Charles J. Jirik and Roselle Girard.

Report of Investigations. Environmental Geology of the Austin Area, by L. E. Garner and Keith Young.

Report of Investigations. The Gulf Shoreline and Barriers of Texas: Processes, Characteristics, and Factors in Use, by J. H. McGowen.

Report of Investigations. Lineations and Faults in the Texas Coastal Zone, by C. W. Kreitler.

Special Publication. Addendum to Index to Well Samples and Cores, 1963-1973, by M. L. Morrow and Elizabeth T. Moore.

Special Publication. Bibliography and Index of Texas Geology, 1961-1974, by Elizabeth T. Moore.

PUBLICATIONS REPRINTED

The following publications were reprinted during 1975 and are again available for distribution.

Bulletin No. 3232. The Geology of Texas, Vol. 1, Stratigraphy, by E. H. Sellards, W. S. Adkins, and F. B. Plummer. 1007 p., 54 figs., 10 plates, 1932 (6th printing accompanied by Geological Highway Map of Texas, published by the American Association of Petroleum Geologists; $5.00).

Geological Circular 67-4. Depositional Systems in the Wilcox Group of Texas and Their Relationship to Occurrence of Oil and Gas, by W. L. Fisher and J. H. McGowen. Reprinted from TRANSACTIONS of the Gulf Coast Association of Geological Societies, Vol. XVII, p. 105-125, 1967 (3rd printing; $1.00).

Geological Circular 72-1. Mineral Deposits in the West Chinati Stock, Chinati Mountains, Presidio County, by W. N. McAnulty, Sr. 13 p., 7 figs., 1972 (2nd printing; $.75).

Geologic Atlas of Texas. Tyler Sheet, John T. Lonsdale Memorial Edition, V. E. Barnes, project director. Scale 1:250,000, 1965 (2nd printing; $3.00).

Geologic Atlas of Texas. Van Horn-El Paso Sheet, E. Russell Lloyd Memorial Edition, V. E. Barnes, project director. Scale 1:250,000, 1968 (2nd printing; $3.00).

Report of Investigations No. 72. Van Horn Sandstone, West Texas: An Alluvial Fan Model for Mineral Exploration, by J. H. McGowen and C. G. Groat. 57 p., 36 figs., 1971 (2nd printing; $1.50).

Special Publication. Clastic Depositional Systems—A Genetic Approach to Facies Analysis, Annotated Outline and Bibliography, by W. L. Fisher and L. F. Brown, Jr. 211 p., 1972 (2nd printing; $5.00).

SPECIAL LIMITED-DISTRIBUTION PUBLICATIONS

The following publications were prepared at the Bureau of Economic Geology in 1975 for limited distribution and are not a part of the Bureau's regular series of publications. They are, however, available for examination and use at the Bureau.

A Preliminary Study of Biologic Assemblages of East Texas Lignite Belt, by Melody Holm. 23 p.

Relationships in Contiguous Deposition of Clastic (Deltaic) and Calcareous (Bank) Facies of Missourian (Canyon) Age, North-Central Texas, A. W. Erxleben and E. G. Wermund, leaders. The American Association of Petroleum Geologists Field Trip Guide Book, April 5-6, 1975. 19 p.

Stratigraphy of the Austin Chalk in the Vicinity of Pilot Knob, Keith Young, D. S. Barker, and E. C. Jonas, leaders. The Geological Society of America, South-Central Section, 9th Annual Meeting, Field Trip Guide Book, March 15, 1975. 28 p.

Utilization of Land Resources in the Austin Area, L. E. Garner, leader. The Geological Society of America, South-Central Section, 9th Annual Meeting, Field Trip Guide Book, March 15, 1975. 26 p.

OPEN-FILE MATERIAL

The Bureau of Economic Geology maintains an open file of reports, maps, manuscripts, and other materials obtained from various sources. Most are unpublished, although a few are progress reports of projects that ultimately will be published. Work maps and data developed in connection with Bureau of Economic Geology projects currently underway may be examined and studied at the Bureau offices. Materials placed on open file from outside sources may be examined and copied, but publication rights are reserved. Materials placed on open file during 1975 include the following:

Aerial Radiometric and Magnetic Survey of Lubbock and Plainview National Topographic Maps, NW Texas [portions of the Midland and Palo Duro Basins]: U. S. Energy Research and Development Administration (ERDA) Open-File Report GJO-1654, 3 volumes, 2 geologic black-line base maps, 12 black-line prints; prepared by Geodata International, Inc., 1975. (Copies may be purchased from Geodata International, Inc., 9731 Denton Drive, Dallas, Texas 75220.)

Areal Geologic and Structural Interpretation Map of Oakville Area, Texas [portions of Bee, Duval, and Live Oak Counties]: U. S. Atomic Energy Commission (now ERDA) Project 7088-2, 5 blue-line map sheets, scale 1:24,000; compiled from color aerial photographs by Knox-Bergman-Shearer Corp., Denver, Colorado, 1970.

Areal Geologic and Structural Interpretation Map of South Texas Cross Section [portions of Duval, Jim Hogg, and Webb Counties]: U. S. Atomic Energy Commission (now ERDA) Project 7088-1, 2 blue-line map sheets, scale 1:24,000; 2 blue-line, color-anomaly overlay sheets; compiled from color aerial photographs by Knox-Bergman-Shearer Corp., Denver, Colorado, 1970.

Bibliography of Conodonts, revised edition, compiled by Samuel P. Ellison, Jr.: Department of Geological Sciences, The University of Texas at Austin, 1975. (Computer-printout copies available for $10.00 donation to Geology Foundation, The University of Texas at Austin, c/o Dr. Samuel P. Ellison, Jr.)

Chemical Analyses of Ground Water for Saline-Water Resources Studies in Texas Coastal Plain Stored in National Water Data Storage and Retrieval System, by R. E. Taylor: U. S. Geological Survey Open-File Report 75-79, 2 volumes, 669 p., 7 tables, plate, 1975.

Electric-Log Sections from Uranium Areas in the South Texas Coastal Plain, Atascosa, Bee, Duval, Karnes, Live Oak, and McMullen Counties, Texas, by D. Hoye Eargle, Kendall A. Dickinson, and Beth Ogden Davis: U. S. Geological Survey Open-File Report 75-122, 11 black-line sheets, 1975. (Reproducibles at U. S. Geological Survey Public Inquiries Office, Room 1C45, Federal Building, 1100 Commerce Street, Dallas, Texas 75202.)

Gamma Radiation Spectral Survey of the Jackson/Goliad Formations in Texas [aerial radiometric and magnetic survey of a region extending in an arcuate shape from the Rio Grande in South Texas to Louisiana]: U. S. Energy Research and Development Administration (ERDA) Open-File Report GJO-1632, 106-p. text and 253 sheets consisting of maps, profiles, and contour plots; prepared by Geodata International, Inc., 1974. (Copies may be purchased from Geodata International, Inc., 9731 Denton Drive, Dallas, Texas 75220.)

Geological and Operational Summary, Continental Offshore Stratigraphic Test (COST) No. 1, South Padre Island East Addition, Offshore South Texas, by A. S. Khan and others: U. S. Geological Survey Open-File Report 75-174, 27 p., 5 figs., 4 tables, 1975. (Reproducibles at U. S. Geological Survey Public Inquiries Office, Room 1C45, Federal Building, 1100 Commerce Street, Dallas, Texas 75202.)

Geological and Operational Summary, Continental Offshore Stratigraphic Test (COST) No. 2, Mustang Island, Offshore South Texas, by A. S. Khan and others: U. S. Geological Survey Open-File Report 75-259, 32 p., 8 figs., 4 tables, 1975. (Reproducibles at U. S. Geological Survey Public Inquiries Office, Room 1C45, Federal Building, 1100 Commerce Street, Dallas, Texas 75202.)

Materials Used in Studies, 1972-1974, Depositional Systems in Canyon Group (Pennsylvanian System), North-Central Texas, by Albert W. Erxleben. Includes: (1) names and total depths of all wells used in Erxleben's studies in Archer, Baylor, Clay, Jack, Montague, Palo Pinto, Shackelford, Stephens,

Throckmorton, Wichita, Wilbarger, Wise, and Young Counties; and (2) appendixes from Erxleben's Master of Arts thesis, "Depositional Systems in the Pennsylvanian Canyon Group of North-Central Texas," prepared at The University of Texas at Austin, 1974—Appendix 1, "Measured Sections in Canyon Group Rocks of Jack, Wise, and Palo Pinto Counties, Texas" (p. 112-141); Appendix 3, "Core Descriptions, Northwestern Wise County" (p. 144-154); and Appendix 5, "Net Sandstone and Net Limestone Values in Feet for Wells Used in Subsurface Mapping, Listed by County" (p. 157-193). Erxleben's study on depositional systems in the Canyon Group was published by the Bureau as Report of Investigations No. 82.

Selected Stratigraphic Sections of Cambrian and Ordovician Rocks in Arizona, New Mexico, and Western Texas, by Philip T. Hayes: U. S. Geological Survey Open-File Report 75-178, 51 p., fig., 1975. (This collection of 10 measured sections, including one of northeast-facing slope of Sugarloaf Mountain in southeastern part of Franklin Mountains in El Paso County, Texas, supplements U. S. Geological Survey Professional Paper 873, "Cambrian and Ordovician Rocks of Southern Arizona and New Mexico and Westernmost Texas," 1975.)

PAPERS BY BUREAU OF ECONOMIC GEOLOGY STAFF IN OUTSIDE PUBLICATIONS

Barnes, V. E. (with Oriel, S. S.), 1975, Stratigraphic Commission Note 43—Records of Stratigraphic Commission for 1972-1974: American Association of Petroleum Geologists Bulletin, v. 59, p. 2031-2036.

Bebout, D. G., and Agagu, O. K., 1975, Depositional framework of the Frio Formation (Oligocene)—lower and middle Texas Gulf Coast: Gulf Coast Association of Geological Societies, Transactions, v. 25, p. 44-61.

Bebout, D. G., and Agagu, O. K., 1975, Regional sand distribution in the Frio Formation (Oligocene)—a preliminary study in "the search for geothermal energy in South Texas" (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 145.

Bebout, D. G., Agagu, O. K., and Dorfman, M. H., 1975, Regional sand distribution of the Frio Formation, South Texas—a preliminary step in prospecting for geothermal energy, *in* Dorfman, Myron H., and Deller, Richard W., eds., Proceedings, First Geopressured Geothermal Energy Conference: The University of Texas at Austin, Center for Energy Studies, p. 101-130.

Bebout, D. G., and Pendexter, C., 1975, Secondary carbonate porosity as related to Early Tertiary depositional facies, Zelten Field, Libya: American Association of Petroleum Geologists Bulletin, v. 59, no. 4, p. 665-693.

Brown, L. F., Jr., 1975, Role of sediment compaction in determining geometry and distribution of fluvial and deltaic sandstones, *in* Chilingarian, G. V., and Wolf, K. H., eds., Compaction of coarse-grained sediments, I, Developments in sedimentology, Volume 18A: Amsterdam, The Netherlands, Elsevier Scientific Publishing Co., p. 247-292.

Brown, L. F., Jr., and Fisher, W. L., 1975, Environmental atlas of the Texas Coastal Zone and its role in land use planning: Raleigh, North Carolina, 25th Annual Highway Geology Symposium, May 23, 24, 1974, Proceedings, p. 94-120.

Finley, R. J., 1975, Inlet morphology and hydrodynamic processes, North Inlet, South Carolina (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 4, p. 489.

Finley, R. J., 1975, Inlet shoal and shoreline development in relation to seasonal wave energy flux, North Inlet, South Carolina (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 7, p. 1073.

Garner, L. E., 1975, Aggregate resource conservation in urban areas (abstract): Coeur d'Alene, Idaho, 26th Annual Highway Geology Symposium, Program and Abstracts, p. 19.

Garner, L. E., 1975, Resources and environmental planning (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 166.

Groat, C. G., 1975, Resource assessment methodology, *in* Background papers on the

analysis of the ERDA plan and program: United States Congress Office of Technology Assessment, p. 87-106.

Groat, C. G., and Weise, B. R., 1975, Uranium resources for nuclear power plants, *in* Woodson, H. H., and Vanston, J. H., Jr., eds., Texas nuclear power policies, a study of alternatives, v. 3, Supporting industries: The University of Texas at Austin, Center for Energy Studies, p. 102-106.

Groat, C. G., Weise, B. R., and Kreitler, C. W., 1975, Physical features affecting the siting and structural design of nuclear power plants in Texas, *in* Woodson, H. H., and Vanston, J. H., Jr., eds., Texas nuclear power policies, a study of alternatives, v. 4, Environmental effects: The University of Texas at Austin, Center for Energy Studies, p. 41-70.

Gustavson, T. C., 1975, Bathymetry and sediment distribution in proglacial Malaspina Lake, Alaska: Society of Economic Paleontologists and Mineralogists, Journal of Sedimentary Petrology, v. 45, p. 450-461.

Gustavson, T. C., 1975, The formation, recognition and environmental significance of microrelief (gilgai) developed on Ca montmorillonitic clays and shales of the Texas Coastal Plain (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 170-171.

Gustavson, T. C., 1975, Glaciofluvial and glaciolacustrine depositional processes on the Malaspina Glacier foreland, Alaska (abstract): Alaska Geological Society, Symposium on Recent and Ancient Sedimentary Environments in Alaska, Program with Abstracts, p. 33-34.

Gustavson, T. C., 1975, Sedimentation and physical limnology in proglacial Malaspina Lake, Alaska, *in* Jopling, A., and MacDonald, B., eds., Glaciofluvial and glaciolacustrine sedimentation: Society of Economic Paleontologists and Mineralogists Special Publication no. 23, p. 249-263.

Gustavson, T. C., Ashley, G. M., and Boothroyd, J. C., 1975, Depositional sequences in glaciolacustrine deltas, *in* Jopling, A., and MacDonald, B., eds., Glaciofluvial and glaciolacustrine sedimentation: Society of Economic Paleontologists and Mineralogists Special Publication no. 23, p. 264-280.

Henry, C. D., 1975, Geology and geochronology of the granitic batholithic complex, Sinaloa, Mexico (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 172.

Henry, C. D., and Kastning, E. H., 1975, Toward evaluating the potential environmental impact of lignite strip mining in East Texas (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 7, p. 1110.

Kaiser, W. R. (with Ledbetter, J. O., and Ripperger, E. A.), 1975, Radioactive waste management by burial in salt domes: The University of Texas at Austin, Engineering Mechanics Research Laboratory, EMRL 1112, 82 p.

Kastning, E. H., 1975, Cavern development in the Helderberg Plateau, East Central New York (abstract): NSS Bulletin (Quarterly Journal of the National Speleological Society), v. 37, no. 4, p. 95.

Kreitler, C. W., 1975, Lineations and active faulting in the Houston-Galveston area of subsidence (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 180.

Kreitler, C. W., and Jones, D. C., 1975, Natural soil nitrate—the cause of the nitrate contamination of ground water in Runnels County, Texas: Ground Water, v. 13, no. 1, p. 53-62.

Kreitler, C. W., Lewis, C. R., and McKalips, D. G., 1975, Geologic control of land subsidence, Houston-Galveston, Texas (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 7, p. 1154.

Loucks, R. G., 1975, Depositional environments in a carbonate-terrigenous shelf system—subsurface Lower Cretaceous Pearsall Formation of South Texas (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 211.

Loucks, R. G., 1975, Porosity development in carbonate grainstones in subsurface Lower Cretaceous Pearsall Formation of South Texas (abstract): American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, Annual Meetings Abstracts, v. 2, p. 45.

Loucks, R. G. (with Mueller, H. W., III), 1975, Low-magnesium rhombic calcite mud from the

brackish-water border of a recent shallow marine carbonate province (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 219-220.

McGowen, J. H., and Scott, A. J., 1975, Hurricanes as geologic agents on the Texas coast: Estuarine Research, v. 2, pt. 1, p. 23-46.

McGowen, J. H. (with Wilkinson, B. H., and Lewis, C. R.), 1975, Ingleside strandplain sand of central Texas Coast: American Association of Petroleum Geologists Bulletin, v. 59, no. 2, p. 347-352.

Morton, R. A., 1975, Natural hazards of the Texas Coastal Zone (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 218-219.

Wermund, E. G., 1975, Land resource units for planning in carbonate terranes (abstract), *in* International Association of Hydrogeologists, 12th International Congress, Karst hydrogeology: Geological Survey of Alabama, Abstracts and Program, p. 88.

Wermund, E. G., Brown, L. F., Jr., and Fisher, W. L., 1975, Regional inventories and mapping of land resources and environmental geology using remotely sensed data, *in* Smistad, Olav, coord., Proceedings of National Aeronautics and Space Administration Earth Resources Survey Symposium: NASA TM X-58168, JSC-09930, p. 1029-1058.

Wermund, E. G., Cepeda, J. C., and Bell, A. E., 1975, Relation of fracture zones to the Edwards limestone aquifer (abstract), *in* International Association of Hydrogeologists, 12th International Congress, Karst hydrogeology: Geological Survey of Alabama, Abstracts and Program, p. 89.

Woodruff, C. M., Jr., 1975, Substrate and soils in San Antonio—environmental geologic mapping problems in an urban area (abstract): South Texas Geological Society Bulletin, v. 15, no. 9, p. 3.

Woodruff, C. M., Jr., and Steed, D. L., 1975, The Texas Coastal Management Program—synthesizing data on resource capability for public policy decisions (abstract): Geological Society of America, Abstracts with Programs, v. 7, no. 2, p. 246.

ADVISORY, TECHNICAL, AND INFORMATION SERVICES

In addition to conducting basic and applied research programs, the Bureau of Economic Geology provides a variety of advisory, technical, and information services relative to the geological, mineral, and land resources of the State. These services are available to individuals, companies, and governmental bodies and agencies.

Principal dissemination of information is through the publication of reports and maps; these are sold at a price designed to recover the cost of printing. All materials developed as part of ongoing research programs are available for examination and study at the Bureau offices.

Staff members respond to individual requests for information that are received daily by letter, by telephone, and from visitors. The Bureau maintains cooperative programs with several State and Federal agencies and local units of government. A variety of information is made available through research colloquia and workshops, continuing education, public lectures, and invited legislative testimony.

The Bureau maintains a Mineral Studies Laboratory at Balcones Research Center. This lab supports research programs of the Bureau and makes tests and evaluations of rock and mineral samples submitted by Texas residents. The Bureau also maintains a Well Sample and Core Library, established by the Texas Legislature in 1937. This library, housed at Balcones Research Center, is the public repository for cores and samples from a large number of wells drilled in Texas. Facilities are provided at the library so that any interested person may examine and study these materials.

The Bureau of Economic Geology maintains a Reading Room located on the fifth floor of the Geology Building on the main campus of The University of Texas at Austin. This facility is open to the public and houses publications pertaining to Texas geology and natural resources.

BUREAU NEWS AND SPECIAL ACTIVITIES

ASSESSMENT OF GEOPRESSURED GEOTHERMAL RESOURCES, TEXAS GULF COAST

Large sand reservoirs in the deep subsurface along the Texas Gulf Coast contain hot water which is relatively fresh to moderately saline and is believed to be saturated with methane gas. These reservoirs occur deeper than 10,000 feet in the geopressured or overpressured zone. The geopressured zone is largely the result of early movement along major growth faults which isolates thick sand bodies and prevents further escape of water as overburden increases; thus, trapped pore fluids assume part of the overburden pressure. Because of the insulating effect of these undercompacted sediments and because the pore fluids are not circulating, the geothermal gradient within the geopressured zone is higher than that within the overlying hydrostatic zone. Bottom-hole temperatures normally recorded from the geopressured zone range from about 200 to 350° F. An extensive Bureau project is now underway to evaluate the potential of producing thermal energy, methane gas, and water from reservoirs in the geopressured zone.

Shortages in domestic oil and gas over the past several years have encouraged state and Federal agencies to search for alternate energy sources. As a result of this interest, the Bureau of Economic Geology received a grant in May 1974 from the United States Atomic Energy Commission (through the Lawrence Livermore Laboratory) to conduct a 5-month study to evaluate the potential of producing geothermal energy from the geopressured Frio Formation along the lower Texas Gulf Coast. The objective of the study was to identify fairway areas in which sand bodies are greater than 300 feet thick and contain formation fluid with bottom-hole temperatures recorded higher than 250° F. The results of the lower Texas Gulf Coast Frio study were published by the Bureau in 1975 as Geological Circular 75-1. Subsequently, the AEC funded the Bureau for another 5-month study to evaluate the geothermal potential of the Frio sands along the middle Texas Gulf Coast with the same objective as the lower Texas area study; the middle Texas study was completed and the final report has been published in 1975 as Geological Circular 75-8. Primary contributors to both studies were D. G. Bebout (Principal Investigator) and O. K. Agagu of

Geothermal fairways of the lower and middle Texas Gulf Coast.

the Bureau of Economic Geology and M. H. Dorfman of this university's Department of Petroleum Engineering. More substantial funding has now been awarded the Bureau by the United States Energy Research and Development Administration (ERDA) to locate large geothermal reservoirs throughout the onshore Texas Gulf Coast from the Frio down to and including the Wilcox and to assess the geopressured geothermal resources in the region. C. G. Groat is Project Manager of this extensive project; the Principal Investigator is D. G. Bebout; R. G. Loucks of the Bureau and M. H. Dorfman of the Department of Petroleum Engineering constitute the remainder of the senior staff.

The Bureau's approach to evaluating the geopressured geothermal resources of the Gulf Coast is predicated by the belief that in order to identify the geometry and lateral extent of porous sand bodies it is first necessary to develop an understanding of the depositional systems. Previous studies at the Bureau have well established this concept and proven the validity of the approach for oil and gas and lignite exploration.

This resource assessment project being conducted by the Bureau is only one area of several which must be investigated prior to producing geopressured geothermal energy from the Texas Gulf Coast. A broad planning phase managed by the Center for Energy Studies, The University of Texas at Austin, is now underway to locate problems and initiate research in four major areas: (1) resource assessment, (2) advanced research and technology, (3) legal, institutional, and environmental, and (4) resource utilization. The environmental problems which could result from producing large quantities of water from reservoirs along the Gulf Coast include land subsidence and fault activation. Water disposal is also a major environmental consideration. The estimated fluid production for each geothermal electrical power generating facility is approximately 150,000 bbls per day or nearly 7,500 acre-feet per year. The composition of geothermal waters is not precisely known. The Bureau is playing a major role in planning these environmental studies through the involvement of T. C. Gustavson and C. W. Kreitler.

Preliminary studies by Kreitler show that the potential for land subsidence and fault activation from this geothermal production must be carefully evaluated. In an attempt to evaluate the potential for land subsidence and fault activation over a geothermal field and to determine whether these problems will be environmental constraints, three studies have been undertaken: (1) the subsurface faults related to the potential geothermal fairways have been extrapolated to land surface; (2) a preliminary estimate has been made of the potential reservoir compaction and subsequent land subsidence; and (3) an evaluation has been made of the possible environmental impact of these phenomena on the present land use of the area to be impacted.

Studies designed to predict the impact of geothermal fluid production and disposal on the environment are multidisciplinary and are being carried out in conjunction with legal and socio-economic research conducted by the Center for Energy Studies. The responsibilities of Bureau efforts, under the direction of T. C. Gustavson, are primarily to characterize the physical environments of the Gulf Coast geothermal fairways, to predict the environmental impact of geothermal fluid production and disposal, and to suggest alternative methods for geothermal fluid disposal and methods for mitigation of environmental impacts. Resource capability, materials, and current land use maps are being compiled for each fairway, as are salinity and depth of fresh ground-water maps. Biologic assemblages and geologic and man-made hazards maps will also be compiled for each fairway. Based on map data and on inferred physiochemical water data, models of potential environmental impacts for alternative methods of fluid disposal are being constructed.

The next geologic phase in the Gulf Coast geothermal project will be the selection of several potential sites for a test well and subsequently a final test site. The Bureau will continue its involvement in this and in several of the environmental aspects of reservoir testing and fluid disposal.

BROWN SELECTED FOR SEA GRANT ADVISORY POST

Dr. Jack Williams, President of Texas A&M University, has selected Dr. L. F. Brown, Jr., to serve on A&M's Sea Grant Advisory Council. This group advises Dr. Williams and the director of the Texas A&M Sea Grant Program on the program's role in meeting State needs, on its administration, and on its relationships with governmental agencies and with industries. Texas A&M is one of eight universities in the United States to be formally designated a sea grant college.

Dr. Brown, Associate Director for Research with the Bureau, has been a leader in the development of the Bureau's research programs in the Coastal Zone. He coordinates the coastal atlas program in addition to having general administrative responsibility for Bureau research.

SHIPMAN MOVES TO MARINE SCIENCE INSTITUTE

Ross L. Shipman, the Bureau's Research Program Manager since 1971, was appointed Associate Director for Administration of the Marine Science Institute of The University of Texas at Austin effective September 1. Shipman, who was employed half-time by the Bureau and half-time by the University's Division of Natural Resources and Environment, relinquished his Bureau post and now is dividing his time between the Marine Science Institute and the Division of Natural Resources and Environment. He continues to serve as the Division's Research Program Manager on a half-time basis.

The Marine Science Institute, which has administrative headquarters in the Geology Building on the main campus of The University of Texas at Austin, includes the Galveston Geophysical Laboratory and the Port Aransas Marine Science Laboratory. Director of the Marine Science Institute is Dr. Creighton A. Burk.

PUBLIC SCHOOL PROGRAM

The Bureau of Economic Geology is experimenting with a program oriented toward public school education. The goal of this program is to produce materials suitable for use by earth science and geology students and teachers throughout Texas.

The first effort in this direction is an Energy Resources of Texas curriculum. The set of courses, including a teacher's guide and student materials, will also use the Energy Resources Map of Texas being prepared for publication in spring 1976. The curriculum is divided into three independent units: (1) Energy from Start to Finish, (2) Economics, Environment, and Energy, and (3) Energy in the Future. The units are designed so that any one or all may be used by the classroom teacher and adapted to fit available teaching time.

In the future, the Bureau hopes to produce additional materials to fill the needs of earth science teachers in Texas. Teachers and administrators across the State are being asked to aid in shaping this development by replying to questionnaires designed to rate teacher preferences about both type of material and priority.

KIER AND WOODRUFF CONTINUE LEAVE OF ABSENCE

Two staff geologists remained on leave of absence from the Bureau during 1975. Dr. C. M. Woodruff, Jr., a Bureau of Economic Geology research scientist, has been serving since 1974 as geologist in the Coastal Zone Management Program of the Texas General Land Office.

Dr. R. S. Kier, also a Bureau research scientist, remains on leave while coordinating a research project at The University of Texas at Austin to develop criteria for coastal zone management. The project is sponsored by the RANN (Research Applied to National Needs) Program of the National Science Foundation.

HOUSTON-GALVESTON AREA COUNCIL WORKSHOP

On December 11, 1975, E. G. Wermund and A. E. St. Clair presented a 1-day workshop on how to use land and water resource maps. Attending the workshop were the staff and guests of the Houston-Galveston Area Council. The vehicle for the workshop was the recently published map and description of the area by St. Clair and others.

The map is entitled "Land and Water Resources in the Houston-Galveston Area Council." It is printed in color at a scale of 1:125,000 and includes a detailed legend and a table listing natural suitability and recommended uses of the units mapped. The legend describes the geological, engineering, and biological characteristics of 41 land and water resource units in the 12,444-square-mile area. The accompanying text describes: (1) vegetation, geology, mineral and energy resources, and natural hazards of the region, (2) delineation of the land and water resource units, (3) use of the maps, and (4) applications for the land and water resources map. The text includes 11 tables designed to aid the user in construction of special purpose maps from the land and water resources map. The tables and small scale maps also provide supplemental information on the nature of the map units.

The morning program included a general introduction to land and water resource mapping, an explanation of the HGAC package, and a session on how to use the information. The last objective was accomplished by pursuing a series of selected questions taken directly from the maps. Participants located map units, measured distances, estimated area, and considered potential land suitability for various units.

The afternoon session included workshops in two separate groups. At each workshop Wermund and St. Clair derived thematic maps. Examples included maps of solid-waste disposal potential, flood-prone areas, sand and gravel prospects, recharge areas, and construction suitability. Participants were able to see the derivation of a variety of planning maps. Thereafter, the workshop members suggested other possible maps which they needed to solve their own special problems. Bureau scientists suggested possible approaches to solving these problems using the HGAC package of maps and tables.

The Bureau has been successful in transferring its environmental geology programs and land and water resource mapping to fellow geologists through publications and oral presentations. Workshops appear the best method to transfer a technology to non-geologist users. More workshops are planned for 1976 to extend communication to users—predominantly planners at various levels of government.

BUREAU TO SPONSOR CONFERENCE ON LIGNITE

The Bureau of Economic Geology, the U. S. Energy Research and Development Administration, and the National Science Foundation (RANN) will sponsor in cooperation with the Center for Energy Studies a conference titled "Gulf Coast Lignite: Geology, Utilization, and Environmental Aspects." The conference will be held in Austin, Texas, June 2, 3, and 4, 1976, at the Austin Hilton Inn.

The conference will feature 2 days of technical sessions (June 2 and 3) and 1 day of field trips (June 4). Twenty-seven technical papers will be presented. Some representative session topics are Holocene peat deposits, ancient depositional environments, palynology, conversion processes, mining, hydraulic transportation, direct firing, reclamation of mined lands, environmental geology, and flue gas desulfurization. The speakers, several nationally known, represent industry (14), universities (8), and government (5). They have been selected to provide a comprehensive overview of Gulf Coast lignite development and technology. Each is being asked to identify future research and development needs.

Two concurrent field trips are planned, one featuring lignite geology and the other mine-site reclamation. The geology trip is titled "Calvert Bluff (Wilcox Group) sedimentation and the occurrence of lignite." Participants will visit the Elgin-Butler Brick Company's clay pits and the Alcoa strip mine. These exposures will allow observation of lower alluvial/upper delta-plain sedimentation and occurrence of lignite in the lower Calvert Bluff Formation. The environmental trip is titled "Reclamation at the Big Brown strip mine near Fairfield, Texas." Participants will visit the Big Brown strip mine. Here, Texas Utilities Generating Company is conducting an extensive reclamation program of reshaping spoil, revegetation, water-quality monitoring, and research.

Conference registration is $25 and includes a copy of the conference proceedings. Field trip participants will pay an additional $15 fee. W. R. Kaiser is program chairman for the conference. Details are available upon request.

CONTINUING EDUCATION AND UNIVERSITY TEACHING

Information developed in various research projects at the Bureau of Economic Geology is included in continuing education short courses and in regularly scheduled university courses that are taught each year by members of the Bureau staff.

During 1975, four Bureau geologists presented short courses. D. G. Bebout, with A. J. Scott of the Department of Geological Sciences, taught a short course, *Carbonates*, at The University of Texas at Austin. The course was sponsored by the Geology Foundation, the Department of Geological Sciences, and the Bureau of Economic Geology.

The Bureau's Associate Director for Research, L. F. Brown, Jr., taught *Terrigenous Depositional Systems in Oil/Gas Exploration* as a part of the American Association of Petroleum Geologists Continuing Education Program. This short course was presented to the Colombian Geological Society in Bogota, Colombia, to the Venezuelan Geological Society in Caracas, Venezuela, to the U. S. Geological Survey staff in Lexington, Kentucky, and with W. L. Fisher and A. J. Scott, to the Billings Geological Society in Billings, Montana. He also taught a similar short course at the Instituto Mexicano del Petroleo in Mexico, D. F.

Before departing on a leave of absence from the Bureau, W. L. Fisher taught two short courses. One of the courses was presented in Billings, Montana, as mentioned above. The other was taught in Midland, Texas.

The Bureau's Acting Director since May 1, C. G. Groat, participated in the teaching of a short course at Texas A&M University in College Station, Texas. The course, *Mining and Economics*, was sponsored by the Texas Aggregates and Concrete Association. He also served as an instructor in a short course, *Coal Geology Fundamentals*, at the University of Oklahoma.

Regularly scheduled courses at The University of Texas at Austin were taught during 1975 by D. G. Bebout (Geology 383N, *Biogenic and Evaporite Depositional Systems*), L. F. Brown, Jr. (Geology 383, *Clastic Depositional Systems*), and C. G. Groat (Geology 362K, *Mineral Resources and Environmental Geology*).

NEW MEMBERS OF RESEARCH STAFF

The Bureau staff increased in 1975 with the addition of three Research Scientist Associates and one full-time Research Scientist Assistant. Their employment with the Bureau brings the total number of research scientists to 32. Their background and current work in depositional systems related to mineral energy resources, coastal processes, and structural geology particularly in relation to the Gulf Coast will measurably strengthen the Bureau's efforts in these areas.

ROBERT J. FINLEY

Robert J. Finley, currently working on applications of LANDSAT imagery to management of the Texas Coastal Zone, joined the Bureau of Economic Geology research staff in August. His professional experience includes employment at Chevron Oil in Houston, where he worked in subsurface exploration between 1969 and 1971.

Finley holds a B. S. degree (1967) from City University of New York and an M. S. degree (1969) from Syracuse University. He received his Ph.D. (1975) from the University of South Carolina where he conducted research on tidal inlet hydraulics and development of adjacent barrier islands on the South Carolina coast.

Finley's research interests include coastal geomorphology and coastal geologic processes. He is a member of the Society of Economic Paleontologists and Mineralogists, American Geophysical Union, and Sigma Xi.

WILLIAM E. GALLOWAY

William E. Galloway joined the Bureau research staff in November and is now principal scientist for the Bureau's Catahoula uranium project. He previously worked in the Exploration Research Division of Continental Oil Company at Ponca City, Oklahoma, where he was Director of Geological Research.

Galloway received a B. S. degree in geology at Texas A & M University in 1966 and moved to The University of Texas at Austin for M. A. (1968) and Ph. D. (1971) degrees, both in the Department of Geological Sciences. His graduate work centered on depositional systems analyses of the Wilcox Group (Tertiary) of Louisiana and Upper Pennsylvanian Cisco rocks of North-Central Texas.

Galloway is a member of the American Association of Petroleum Geologists and the International Association of Sedimentologists. His research interests are primarily in physical stratigraphy, origin and stratigraphy of sedimentary mineral resources, diagenesis, and seismic stratigraphy.

ROBERT G. LOUCKS

Robert G. Loucks joined the Bureau of Economic Geology staff in November. He received a B. A. degree (1967) in geology from the State University of New York at Binghamton. Before coming to The University of Texas at Austin for his Ph.D. in geology (to be conferred in 1976), he worked for 3 years as a petroleum geologist for Texaco Inc., in Midland, Texas. His dissertation is an investigation of the relationship of porosity to depositional and diagenetic facies of the Pearsall Formation (Cretaceous) of South Texas.

Loucks is a member of the American Association of Petroleum Geologists and the Society of Economic Paleontologists and Mineralogists. At present, he is participating in the Bureau's evaluation of geothermal resources of the Texas Gulf Coast.

DAWN G. McKALIPS

Since joining the staff in January, Dawn G. McKalips has been taking part in Bureau research studies of faulting and subsidence in the Texas Gulf Coast. Her main research interest is structural geology. She holds a B. A. degree in geology from Wittenberg University and currently is working on a part-time basis toward a Master's degree in geology at The University of Texas at Austin.

BUREAU OF ECONOMIC GEOLOGY RESEARCH PROGRAMS AND PROJECTS

Bureau research programs and projects attempt to address many of the State's major concerns in the areas of geological, mineral, land, and environmental resources. Through the years, an extensive research program in energy and mineral resource investigations has been maintained. This program includes continuing appraisal of the State's mineral and energy resources, investigations of resources that may be of importance in the future, and basic research aimed at developing new and better understanding of the distribution, occurrence, and potential development of Texas energy and mineral resources.

Efforts in the area of mineral and energy resources were stepped up during 1975 with a new program in uranium resources of the Catahoula and related rocks, initiation of a mineral atlas, development of energy curriculum materials for the public schools, and increased activity in geothermal studies. The environmental aspects of the development of lignite and geopressured geothermal resources are being evaluated through the Land Resources Laboratory.

The Bureau's program in land resources, conducted through its Land Resources Laboratory, continues and is aimed principally at inventory and analysis of such critical land areas as the Coastal Zone, lands in and adjacent to major metropolitan areas, lands of unique value such as mineral and agricultural lands and wetlands, lands that are hazard prone, and lands related to water resources such as aquifer recharge lands and lands adjacent to major surface water bodies.

In addition to projects that are parts of these major programs in basic research, systematic geologic mapping, mineral statistics, and cataloging are maintained.

ENERGY RESOURCE INVESTIGATIONS

Resource Assessment of the Geopressured Geothermal Resources of the Texas Gulf Coast.—D. G. Bebout and R. G. Loucks, assisted by S. C. Bosch, J. H. Seo, G. B. Sanders, Jr., J. D. Potter, R. A. Jones, and P. E. Luttrell.

Many oil and gas wells along the Texas Gulf Coast penetrate a geopressured zone in the Tertiary sand and shale section. Sand reservoirs in the geopressured zone contain waters that are hot, saturated with methane gas, and low in dissolved solids. These waters are believed to be important sources of thermal energy and methane gas.

Essential to evaluating the potential of producing geopressured geothermal energy and determining the quantity of the resource is an understanding of the regional distribution of major sand trends and their depositional environments. A study of the Frio Formation of the lower and middle Texas Gulf Coast has been underway for the past year. As a result of this work, several prospective geothermal reservoirs have been delineated. Preliminary reports summarizing the results of the study were published by the Bureau of Economic Geology in 1975 as Geological Circulars 75-1 and 75-8. During the latter part of the year, an additional study was in progress to identify in more detail the characteristics of these geothermal reservoirs.

Funding for the first year of the study of the Frio Formation was from the U. S. Atomic Energy Commission, through the Lawrence Livermore Laboratory. Additional funding was obtained from the U. S. Energy Research and Development Administration to extend the project for a 2-year period. This will permit an investigation of the geothermal potential of other Gulf Coast formations, including the Wilcox Group.

In Situ Gasification of Texas Lignite.—W. R. Kaiser, assisted by W. N. Bach, L. C. Johnson, and D. L. Simmons.

This 2-year study, being carried out in conjunction with T. E. Edgar of the Department of Chemical Engineering, is funded in part by the National Science Foundation, Research Applied to National Needs Program (NSF-RANN). The project, initiated in November 1974, is a study of the geology, resources, and geohydrology of the deep-basin lignite (more than 200 ft deep) of the upper Gulf Coastal Plain of Texas. The underground gasification of these vast resources and the production of low-Btu gas (125 Btu/ft^3) would markedly broaden the State's energy base.

In the past year, lithofacies maps were prepared and exploration models were developed for the Wilcox Group (north of the Colorado River) and the Yegua Formation (between the Colorado

and Angelina Rivers). Several thousand bits of data were collected from a total of 2,222 geophysical logs of wells from 55 counties.

Emphasis in 1976 will shift to the environmental impact of in situ gasification. The factor of greatest concern is the potential threat of groundwater contamination. A thorough review of the literature was underway during 1975 to compile data on the stability, solubility, analysis, and health effects of toxic compounds freed during gasification. The effectiveness of coal and char as adsorbers of organic materials will be assessed. An extensive effort will be made to relate published hydrologic parameters and water chemistry to the Wilcox and Yegua lithofacies.

Objectives of the project are the selection of prospective gasifier sites and the preparation of an environmental assessment. Considerations for site selection are lignite reserves, nature of overburden, hydrology, geographic location, and land availability. Geologic results will be published in 1976.

Uranium Potential and Genetic Stratigraphy of the Triassic Dockum Group of the Texas Panhandle.—J. H. McGowen, assisted by S. J. Seni, G. E. Granata, and J. L. Boone.

This study of fundamental facies distribution and mineralization within the Dockum Group began near the end of 1974 as a joint project funded in part by the U. S. Geological Survey, Uranium/Thorium Branch. The project involves investigations of the surface and subsurface continental Triassic facies in Texas. Some uranium has been produced from the Dockum, but the potential for future production has not been determined. With the growing need for radioactive materials, a thorough investigation of the Dockum Group will be required to evaluate its full energy potential.

The project is concerned chiefly with the development of a stratigraphic framework and depositional models, as well as with the accurate delineation of uranium mineralization and the determination of probable controlling or localizing factors. A prospecting or exploration model likely can be devised if sufficient uranium mineralization is present. Both surface and subsurface trends are being considered. The entire sequence of terrigenous clastic facies will be evaluated within the Texas Panhandle.

At yearend, a preliminary report on the results of the first year of the study was written. Publication is expected in 1976.

Uranium Potential of the Catahoula Formation, Texas Coastal Plain—A Stratigraphic, Depositional, and Geochemical Evaluation.—W. E. Galloway, assisted by R. C. Belcher and T. D. Murphy.

Continued expansion of uranium exploration in the Texas Coastal Plain indicates that not only are requisite host and source facies present, but that substantial uranium reserves are present in Eocene through Miocene strata. The Catahoula project is a 2-year program, begun in late 1975, designed to examine the stratigraphic and geochemical systems controlling the distribution of known ore and to delineate significant parameters in less explored areas of the upper coastal plain. Funding for the first year is through a grant by the U. S. Energy Research and Development Administration.

Primary goals of the first year include (1) regional mapping of principal Catahoula fluvial systems to determine areal extent and favorability of potential host sands and source volcanic ash, (2) analysis of petrographic and diagenetic facies, and (3) construction of a model or models expressing geological parameters controlling known mineralization. Results will be integrated with data derived from the deep-basin Frio study to complete the picture of energy reserves in the Catahoula/Frio system.

A preliminary report reviewing results of the stratigraphic study will be published in late 1976.

Uranium in Volcanic Terranes, Trans-Pecos Texas.—C. G. Groat and A. W. Walton.

The volcanic rocks of Trans-Pecos Texas contain an abnormally high amount of uranium. Numerous, slightly to moderately mineralized areas are present in tuffaceous sediments that fill the basins between Tertiary volcanic centers. This study is aimed at mapping these occurrences and relating them to stratigraphic facies of the basin fills. The migration and concentration of uranium during diagenesis also is being studied. During the summer of 1975, A. W. Walton of The University of Kansas spent 3 months in the field describing, sampling, and mapping the Tascotal Formation south of Marfa in Presidio County. Two graduate students from The University of Texas at Arlington are studying the Pruett Tuff in Brewster and Presidio Counties. Their work was supported by the Bureau of Economic Geology during the summer of 1975. Work on the project will continue in 1976.

Earth Science Education—Curriculum Materials on Energy Resources of Texas.—J. E. Anderson, Jr., and A. R. Trippet, assisted by R. G. Christie and C. Haynie.

A new program of service to Texas public school education was initiated by the Bureau of Economic Geology in June. In the first phase of the program, curriculum materials pertaining to Texas energy resources were prepared for classroom use in earth science and related courses. This energy resources unit was piloted in actual classroom situations during the fall semester. The unit's student materials and teacher's guide—accompanied by a new energy resources map of Texas—are scheduled for publication in 1976.

Later phases of the program will provide curriculum materials on Texas geology, resources, and environmental concerns. Toward this goal, Texas public education teachers and administrators are being asked to contribute ideas and opinions regarding the needs and priorities for earth science education materials.

NONFUEL MINERAL RESOURCE INVESTIGATIONS

Texas Mineral Atlas.—T. J. Evans, L. E. Garner, and A. E. St. Clair, assisted by K. E. Nemeth and W. P. Bartow.

The Texas Mineral Atlas Project is divided into three parts: an energy resources map, mineral/commodity data sheets, and a mineral resources map.

At yearend, compilation of data for the energy resources map was almost complete. The map will be prepared at a scale of 1:1,000,000, and will show locations of oil and gas fields, near-surface and deep-basin lignite, bituminous coal-bearing units, uranium occurrences, and potential geothermal resources. In addition, the map will indicate major energy distribution systems, including electric transmission lines, power generation stations, oil and gas pipelines, major highways, railroads, and waterways. A text will accompany the map and will include general information on energy resources, production trends, and the future outlook for Texas energy resources. The map is expected to be completed in 1976.

The second part of the Texas Mineral Atlas Project consists of a series of mineral/commodity data sheets that are designed for distribution individually or as a complete set. Approximately 60 data sheets will be prepared, and these will include statements about mineral occurrences, past production, potential for development, and other pertinent information. Compilation of data began in 1975, and the sheets will be released as they are completed. This phase of the project is scheduled for completion in the summer of 1976.

Finally, a mineral resources map will be prepared, utilizing the information collected for the mineral/commodity data sheets. The map will be prepared at a scale of 1:1,000,000; it will be a companion to the energy resources map. The mineral resources map is scheduled to be ready for cartography by September 1976.

Sand and Gravel Resources of Texas.—T. C. Gustavson, assisted by J. P. Ferguson.

The project, initiated in 1973, involves the location and mapping of sand and gravel deposits in Texas, with special emphasis placed on those near areas of high population. Detailed maps of sand and gravel resources adjacent to urban areas are being prepared to determine the extent of available sand and gravel, the extent of sand and gravel already mined, and areas of sand and gravel that have been lost because of urban development.

Mineral Production in Texas.—R. M. Girard, in cooperation with the staff of the U. S. Bureau of Mines.

This project involves the annual compilation of Texas mineral production data and other mineral information. During 1975, a report on 1974 production of industrial minerals in Texas was prepared for publication in the Texas chapter of the U. S. Bureau of Mines "Minerals Yearbook 1974." A preprint of the chapter is expected to be issued as a Bureau of Economic Geology Mineral Resource Circular, "The Mineral Industry of Texas in 1974." Compilation of Texas mineral production data is a continuing cooperative program between the Bureau of Economic Geology and the U. S. Bureau of Mines.

Index of Texas Mineral Producers (Exclusive of Oil and Gas Producers).—R. M. Girard.

An updated index of Texas mineral producers was in preparation late in 1975. It will supplant an earlier directory, "Texas Mineral Producers (Exclusive of Oil and Gas)," published by the Bureau of Economic Geology in 1970.

The new directory, like the previous one, will consist of three sections: (1) an alphabetical list of minerals or mineral commodities—with the producers, counties, nearby towns, geologic strata, and uses indicated for each commodity; (2) an alphabetical list of counties in which the raw materials or mineral commodities are produced—with commodities, producers, and nearby towns indicated for each county; and (3) an alphabetical list of the producers and their addresses—with mineral commodities and counties indicated for each producer.

Sources of information used in compiling the directory include U. S. Bureau of Mines data, publications of the Bureau of Business Research of The University of Texas at Austin, trade journals, Texas geologists, and publications and files of the Bureau of Economic Geology.

Texas Carbonate Materials: Suitability for Sulfur Dioxide Removal.—T. J. Evans, assisted by M. G. Moseley and M. Pattarozzi.

Increasing use of fuels other than oil and natural gas for generating electricity in Texas will involve lignite and bituminous coal, some of which have moderate to high sulfur content. When burned, such fuels produce sulfur dioxide in excess of current Federal regulations. Removal of excessive sulfur dioxide from power plant stack gases will involve, in part, wet-scrubbing systems using calcium carbonate materials, such as limestone, or carbonate-derived absorbents, such as lime.

This project, begun in late 1974, has as its aim the evaluation of Texas carbonate materials in terms of suitability for use in sulfur dioxide removal systems likely to be employed in Texas power plants. Samples of carbonate materials were collected from currently operating quarries and lime plants in the State and, in late 1975, were being evaluated. At yearend, the project was nearing completion.

Depositional Systems in the Ogallala Formation of the Llano Estacado and the Occurrence of Ground Water.—W. R. Kaiser.

The Ogallala Formation (Pliocene) is the principal aquifer on the Llano Estacado (or Southern High Plains) supplying almost all the water for agricultural, municipal, industrial, and residential needs. Despite the fact that the Ogallala supplies the economy's lifeblood, surprisingly little is known about its geology and the geologic control exerted on water yield, quality, and recharge. The goal of this long-term study is to provide the geologic framework for the development of water resources on the Llano Estacado.

To unravel Ogallala depositional history and systems, a regional subsurface-oriented, sedimentological, rock-stratigraphic study is planned. Lithofacies and isopachous maps will be prepared from data obtained from driller's logs. Extensive field work along the Caprock Escarpment will be done. Existing data on production history, productivity, permeability, and water chemistry will be compiled in order to test the correlation between geology and hydrology.

LAND RESOURCES AND ENVIRONMENTAL GEOLOGY PROGRAMS

Land Resources of Texas: Mapping and Classification.—R. S. Kier, L. E. Garner, L. F. Brown, Jr., assisted by L. P. Jones and M. J. Pieper.

The project, initiated in April 1972 with partial support from the Texas Water Development Board and the Division of Planning Coordination, Office of the Governor, is designed to provide a statewide classification of Texas lands. A wall map (scale 1:500,000) will show distribution of the various land types and their natural capacity to sustain diverse kinds of land use. This statewide analysis complements detailed environmental mapping programs of the Bureau of Economic Geology and provides a regional technical base for land and natural resource conservation and development.

The classification includes 71 land capability units broadly grouped as (1) hydrogeologic units, (2) mineral land units, (3) physical properties units, (4) geomorphic units and structural features, (5) active process units, (6) biologic units, (7) subaqueous coastal units, and (8) man-made units. Each of the 71 capability units is indicated by a unique color and symbol on a U. S. Geological Survey topographic, physical, and cultural base map (scale 1:500,000). A legend—including color inset maps depicting such features as regional

physiography, generalized soils distribution, climate, and major drainage basins—and a descriptive text will accompany the map.

A scribed, hand-colored copy of the map was completed in 1974. Color separation, preparatory to printing, was started on the northeast quarter of the map. Cartographic preparation of the northeast and southeast quadrants is scheduled for completion in 1976.

Statewide Land Use Map.—A. E. St. Clair, assisted by J. L. Boone.

The objective of this project, begun in December 1973, is to compile an up-to-date statewide land use map, using LANDSAT (formerly ERTS—Earth Resources Technology Satellite) imagery. Map units follow the national land use classification system developed by James R. Anderson of the U. S. Geological Survey (1967) but are modified to reflect more precise current land use in Texas. These are gross units generally referred to as Level I. Land use was interpreted from imagery (scale 1:250,000) using three spectral bands. The bands are 4 (blue green), 5 (red), and 7 (near infrared). Interpretations are being transferred directly to Army Map Service topographic bases (scale 1:250,000). Land use maps to be completed in 1975 will be transferred to the U. S. Geological Survey's standard base map of Texas (scale 1:500,000) and published in 1976. A circular will be published to explain the mapping procedure and to clarify the interpretations of land use. As more detailed land use interpretations are made in the future, they will be published separately.

Landslide Incidence and Susceptibility in Texas.—T. C. Gustavson and B. R. Weise.

This brief investigation of landslide incidence and susceptibility indicates that landslides do not pose serious threats to life and property in Texas. Areas of susceptibility to landsliding occur primarily on the outcrops of portions of the Del Rio Clay and the Eagle Ford and Cook Mountain Formations. The investigation, which was funded by the U. S. Geological Survey, was completed during August 1975.

Environmental Geologic Atlas of the Texas Coastal Zone.—L. F. Brown, Jr. (project director), T. J. Evans, J. H. McGowen, W. L. Fisher, and C. G. Groat, assisted by A. R. Trippet, P. M. Walters, and B. R. Weise.

Almost completed, this atlas series comprises seven publications covering seven areas of the Coastal Zone: Galveston-Houston (published 1972), Beaumont-Port Arthur (published 1973), Kingsville, Bay City-Freeport, Port Lavaca, Corpus Christi, and Brownsville-Harlingen. Each atlas of the series consists of a descriptive text, a basic environmental geologic map (scale 1:125,000), and eight special-use maps (scale 1:250,000). All the maps are multicolored on a specially constructed base.

In 1975, the maps for the Corpus Christi, Port Lavaca, and Bay City-Freeport areas were completed and printed. At yearend, texts for the Port Lavaca and Bay City-Freeport Atlases were ready for composing; manuscripts for Corpus Christi and Kingsville were being reviewed and edited. Color proofs of the final atlas of the series, covering the Brownsville-Harlingen area, were completed in late 1975. The Environmental Geologic Atlas of the Texas Coastal Zone provided base maps and much of the data for a special Bureau report, "Natural Hazards of the Texas Coastal Zone." In 1975, the atlas provided much of the resource inventory data for the Coastal Zone Management Program, Texas General Land Office.

The Environmental Geologic Atlas of the Texas Coastal Zone is the product of an extensive study conducted by the Bureau of Economic Geology during the past 6 years. The entire Atlas covers approximately 20,000 square miles of the Texas Coastal Zone within an area extending from about the 5-fathom line offshore to 50 miles inland. Mapping was accomplished with the use of detailed photographic mosaics, topographic maps, and existing maps of many types. Photomapping was supplemented by many hours of low-level aerial reconnaissance and selected field studies. The special-use maps were derived from basic mapping and from compilation of diverse existing data. The Environmental Geologic Atlas of the Texas Coastal Zone is designed to provide a thorough inventory of natural and man-made resources and to serve as a basic document in planning, development, and conservation of the Texas Coastal Zone.

The Guadalupe-San Antonio-Nueces River Basins Regional Study.—E. G. Wermund (project director), R. A. Morton, R. L. Andersen, J. M. Basciano, L. E. Garner, T. C. Gustavson, and C. M. Woodruff, Jr., assisted by G. L. Macpherson, M. M. McGraw, S. Griffiths, S. A. Holden, P. E. Luttrell, C. R. Lewis, B. R. Van Allen, P. M. Walters, P. S. Cariker, K. Miller, R. N. Fiore, and S. W. Shannon. Cartography by R. L. Dillon.

This long-term project is a comprehensive environmental geologic analysis of approximately 33,000 square miles of the Nueces, San Antonio, Guadalupe, and Lavaca River basins of South Texas. It was initiated in June 1972 under contract with the Texas Water Development Board.

The first phase of the project was concerned with an area that includes the southern Edwards Plateau and Cretaceous coastal plain. The region is of prime environmental significance as it includes the infiltration and productive areas for the subsurface Edwards Limestone aquifer, which supplies water to nearly one million people in metropolitan San Antonio, San Marcos, New Braunfels, Hondo, and Uvalde. The aquifer also supplies irrigation water for about 2,000 square miles of croplands.

In the second phase, maps showing environmental geology, biologic assemblages, slope, and mineral and energy resources (except sand and gravel resources) were completed for the area of Cretaceous substrate. The map data were compiled on topographic sheets (scale 1:24,000) and controlled aerial photographic prints of the same scale, augmented by stereoscopic pairs of black-and-white photographs (scale 1:40,000). Interpretations were checked both on the ground and by means of low-level flights.

In 1974, environmental geologic mapping included areas having Tertiary and Pleistocene substrates. Those areas are important as they include several major and numerous minor sand aquifers. Therefore, many recharge (or infiltration) zones are critical elements in the environmental mapping. The most important sand aquifer is the Carrizo-Wilcox aquifer, which extends over about 10,000 square miles (including both the infiltration and productive zones). The aquifer yields potable water to eight or more of the prominent communities in South Texas. In recent years, there also has been an increasing demand for irrigation water from the Carrizo-Wilcox sand aquifer.

In 1975, mapping and initial cartography were completed for the region of Tertiary and Pleistocene substrates. Available maps are hand-colored on stable plastic sheets. The environmental geology map and the slopes map are drawn at a scale of 1:125,000 on a base—showing culture and drainage—that was prepared from enlargements of U. S. Army Map Service maps. The derivative maps of active processes and physical materials and also the maps of biologic assemblages, economic resources, and land use are drawn at a scale of 1:250,000. The base showing culture and drainage that was used for these maps also was prepared from U. S. Army Map Service maps.

The up-to-date land use map was compiled from data obtained from recent (1974-1975) color-infrared photography (scale 1:120,000). It includes approximately 20 map units.

Each map category—for example, the environmental geology map—consists of 16 sheets. Individual sheets are bounded by 1° of longitude and 1° of latitude unless such a quadrangle would contain only a small portion of a river basin. Sheets showing smaller areas are used to depict these portions. On the southeast margin of the region, areas included in another of this Bureau's mapping projects—the Environmental Geologic Atlas of the Texas Coastal Zone—were not remapped.

The hand-colored maps will be deposited at the Texas Water Development Board. Topographic maps (scale 1:24,000) and controlled photographic mosaics with original compilation and interpretation will remain at the Bureau of Economic Geology. These data are expected to be the bases for numerous reports of investigations in the near future.

Land Resources and Environmental Impact, East Texas Lignite Belt.—C. D. Henry, J. M. Basciano, and E. H. Kastning, assisted by T. W. Duex and M. R. Holm.

Initiated in 1974 under contract with the U. S. Geological Survey, the project is concerned with providing a geologic-mining inventory of the extensive lignite belt in East Texas and evaluating environmental and economic aspects of exploitation of these deposits. Objectives of the project are: (1) preparation of a suite of environmental geology and land use maps for the lignite belt; (2) location of historical, operating, and planned lignite strip mines; (3) measurement of the physical and chemical properties of overburden and evaluation of its reclamation potential; and (4) examination of systematic mapping of sedimentary facies of overburden as a predictive tool.

During 1975, environmental geology maps (scale 1:24,000) were compiled from air-photo interpretation for an area extending from the Colorado River to the Trinity River and containing outcrops of the Wilcox Group and Carrizo Sand. Mappable units were derived from studies of the substrate, geologic processes, geomorphology, and biologic assemblages. Interpretations were checked in the field and compared with existing data such as geologic, soil, and flood-prone-area maps.

Additional work during the year included: (1) compilation of available water quality data and

computer-analysis programming of records for baseline data; (2) preliminary investigation of biologic assemblages associated with undisturbed, farmed, and reclaimed lands; and (3) analysis of infiltration-runoff characteristics of mappable units over a selected 10-quadrangle test block.

Project plans for 1976 include: (1) mapping of present land use; (2) continued environmental geologic mapping into the northeast portion of the Wilcox Group outcrop belt from the Trinity River to Texarkana and the Sabine uplift area; (3) chemical analysis of ground water, surface water, and lignite samples; (4) continued monitoring of strip-mine activity, power plant siting, hydrology, and water quality; and (5) investigation of the effect of mine-effluent water on plant life.

Reactor Siting Hazards: Faulting and Fault Activation in the Texas Coastal Zone.—C. W. Kreitler and E. H. Guevara, assisted by D. G. McKalips, C. R. Lewis, G. E. Granata, and E. H. Kastning; complementary studies by Earl Verbeek of the U. S. Geological Survey, Denver, Colorado.

Initiated in late 1974 with partial funding by the U. S. Geological Survey, this project is a continuing, comprehensive investigation of the interrelationship of ground-water withdrawal, fault activation, and land subsidence in the Houston area. One of the objectives is to determine how information developed during this study can be used as a predictive model for fault activation in other sections of the Texas Coastal Zone.

The study, to date, shows a very close interrelationship among ground-water usage, subsidence, and faulting. Decline of the ground-water level in the area is activating some faults, which are forming hydrologic boundaries and causing the land to subside in unique discrete blocks. Detailed stratigraphic analysis of one of the major water-producing Pleistocene sands, the Alta Loma Sand, has shown this unit to be a complexly-faulted, fluvial-deltaic, delta-front sand.

At yearend, a report on the relationship between lineations and faults was being edited, and a report on the mechanisms of fault activation was in preparation.

Criteria for Coastal Zone Management (Methodology to Evaluate Impacts of Alternative Policy Decisions: Applications in the Texas Coastal Zone).

During 1971, a multidisciplinary team of scientists, engineers, and economists was formed at The University of Texas at Austin under the auspices of the Division of Natural Resources and Environment. The research team is charged with outlining criteria for land and water management of the Texas Coastal Zone and establishing a methodology by which the environmental and economic consequences of management policies can be assessed. The team began initial work in early 1972 under funding from the Coastal Resources Management Program of the Division of Planning Coordination, Office of the Governor. Beginning in June 1972, the research team continued work under a 2-year grant from the RANN (Research Applied to National Needs) Program of the National Science Foundation, augmented by funds from the Office of the Governor. In 1974, renewal proposals were successful, and funding was secured for an additional 2 years.

Participating in the interdisciplinary research team are: R. S. Kier (project coordinator), W. L. Fisher, E. G. Wermund, R. A. Morton, and W. A. White (Bureau of Economic Geology); E. Gus Fruh (project director), J. F. Malina, Jr., and James E. Dailey (Department of Civil Engineering and Environmental Health Engineering Laboratories); Carl H. Oppenheimer (Marine Science Institute); Kingsley E. Haynes (LBJ School of Public Affairs); Herbert Grubb (Office of the Governor); and Joe C. Moseley II (Texas Coastal and Marine Council). Assisting in the Bureau's work on the project during 1975 were M. R. Holm, R. S. Kerr, and W. D. Kuenzi.

During 1974, the team focused its efforts on the Corpus Christi Bay area. In the first half of the year, Bureau staff completed two reports on land and water resources of the 13 counties included in the Coastal Bend Council of Governments area. As part of these reports, Bureau staff members produced two full-color maps. The first map (scale 1:250,000) depicts 43 land and water resource units in the 13 counties of the Coastal Bend Council of Governments area. The second map shows land and water resources in the Corpus Christi area—Nueces, San Patricio, Refugio, and Aransas Counties—in considerably more detail (40 units, scale 1:125,000).

During 1975, the research team studied community development and public park utilization on Mustang and northern Padre Islands. The Bureau of Economic Geology: (1) prepared an updated land and water resource map at a scale of 1:24,000; (2) documented historical shoreline changes of Gulf and bay, including directions and rates of change; (3) established standards by which dunes

can be evaluated in terms of importance and criticality and identified critical dune areas; (4) determined natural stability of certain environments and interpreted historical changes in those environments, which include grassflats, marshes, and washover channels; and (5) delineated historical land use patterns and associated changes in natural environments.

Also in 1975, current land use and resource capability units of land and water were mapped for Cameron, Hidalgo, and Willacy Counties. Based on estimated 1990 statistics, the impact of an increased population on land use and resource capability was estimated.

Urban Geology of the Greater San Antonio Area.—C. M. Woodruff, Jr., and L. E. Garner.

This project was initiated in 1974. The maps and accompanying report will be designed to provide a comprehensive environmental geologic analysis of the San Antonio area. Field work has been completed and environmental geologic and physical properties maps of the San Antonio urban area will be compiled for publication at a scale of 1 inch equals approximately 1 mile. This mapping comprises twelve 7.5-minute topographic quadrangles. The environmental geologic map will present units based on interaction among substrate materials, active or potentially active processes, and landforms. The physical properties map will show generalized characteristics of substrate and selected soils of the region.

Environmental Aspects of Geothermal Energy Production.—T. C. Gustavson and C. W. Kreitler, assisted by K. A. Cortés and D. G. McKalips.

This project was initiated in July 1975 for the Center for Energy Studies, The University of Texas at Austin. Funding was provided under a contract with the U. S. Energy Research and Development Administration.

Two phases of this investigation into the effects of geothermal energy production are being conducted concurrently. In one phase, C. W. Kreitler, assisted by D. G. McKalips, is assessing the potential environmental impact of land subsidence and faulting that may be induced by geothermal fluid production along the Texas Gulf Coastal Plain. The locations of expected surface faults—extrapolations of known subsurface faults—are being mapped, and estimates of amounts of subsidence to be expected are being prepared for each area of potential geothermal fluid production.

In the other phase of the project, T. C. Gustavson and K. A. Cortés are compiling available data on the chemistry of geothermal fluids and surface waters. Maps of environmental geology, resource capability, and current land use are being prepared for each geothermal reservoir area. The environmental effects of geothermal fluid storage and disposal are being assessed.

From information developed in this project, which is actually a scope-of-work study, recommendations will be made for detailed, additional investigations. To be considered are faulting and subsidence (including monitoring), physical properties of surface materials, bay and estuary circulation, plant and animal ecology, and infiltration of the spent geothermal fluids that would be stored or transported on the land surface.

COASTAL GEOLOGY

Historical Monitoring of the Texas Gulf Coast Shoreline.—R. A. Morton, M. J. Pieper, and J. L. Chin, assisted by W. E. Jones.

The purpose of this 2-year project, initiated in September 1973 under special appropriation by the 63rd Legislature, is to document changes in position of the Texas Gulf shoreline through time. Segments of the coast that have undergone accretion and erosion or have remained in equilibrium are described, and long-term rates of change are determined and presented in graphic and tabular form. Maps of time-sequential shorelines from the Rio Grande to the Sabine River are being prepared, with data compiled from (1) topographic and hydrographic charts dating from 1850 to the early 1920's, (2) aerial photographs dating from 1930 to 1974, and (3) miscellaneous reports and surveys. Supplementary data on seasonal changes and effects of storms will be provided by monitoring beach profiles at selected locations.

Factors affecting changes in shoreline position are being investigated and related to natural and man-induced processes. During 1975, preliminary reports were completed for Gulf shoreline areas, including McFadden Beach, Bolivar Peninsula, Matagorda Island, San Jose Island, and Matagorda Peninsula. Reports for the remaining Gulf shoreline will be completed in 1976. Work copies of all detailed maps are on open file at the Bureau of Economic Geology.

LANDSAT Investigation for the Texas Coastal Zone.—R. J. Finley, assisted by S. W. Shannon.

The LANDSAT investigation aims to evaluate satellite imagery as a tool for mapping features and processes important in coastal zone management programs of the General Land Office. The repetitive nature, relatively low cost of the film products, and multiband coverage of LANDSAT imagery make it attractive as a potential tool for the inventory and continued monitoring of coastal resources. A determination of lower limits of resolution, mapping of coastal wetlands, and interpretation of tonal variation due to normal seasonal changes are included in this study. High and middle altitude aerial photography and on-site field studies are being used to verify actual ground conditions.

This project was initiated in June 1975 and is one phase of a contract between the Bureau of Economic Geology and the Texas General Land Office. It is scheduled to last for 18 months. Aerial photographs made in February 1975 are being used to provide an updated Coastal Zone map base. The first group of satellite imagery was received, and the various imagery formats were being evaluated in late 1975.

Sediment Budget of Galveston Island.—R. A. Morton, assisted by S. L. Waisley.

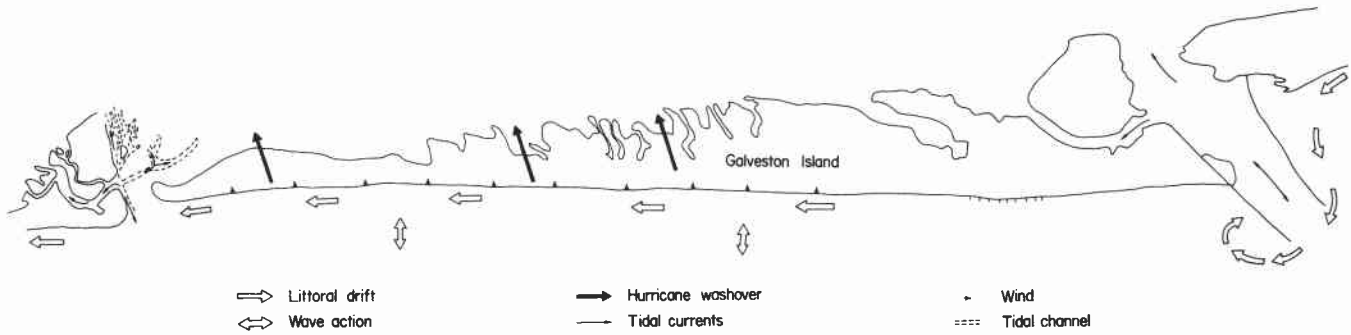
This is a 1-year project supported in part by the National Oceanic and Atmospheric Administration Sea Grant Program, administered through Texas A&M University. It is designed to utilize and augment the data gathered for the historical shoreline monitoring project (described in this Annual Report) in order to determine the volume of material removed from and added to the Gulf shoreline of Galveston Island.

A map showing volumetric changes along the Gulf shoreline and at the entrance to Galveston harbor will be developed by comparing hydrographic surveys made in the mid-1800's with more recent surveys by the U. S. Army Corps of Engineers and the National Ocean Survey of the National Oceanic and Atmospheric Administration. A comparison of the net volume of material with the net areal change—as determined by shoreline change—is being made to calculate the ratio of areal change to volume change.

The ultimate goals of this project are to document the volumetric changes of beach sand through time, to determine the source of the sediment, and to understand the processes that cause shoreline erosion on Galveston Island. The continuation of this kind of investigation is anticipated so that, eventually, the sediment sources and sinks of the entire Texas Gulf shoreline will be identified, and quantitative estimates of their individual contributions will be made.

Geology of Padre Island National Seashore.—B. R. Weise and W. A. White.

Initiated in September 1975, this project of mapping from 1975 color-infrared aerial photos will serve to update the Padre Island National Seashore section of the Bureau's Environmental Geologic Atlas of the Texas Coastal Zone. One final product will be a full-color environmental geologic map used as part of a nontechnical guide to the environmental and natural history of Padre Island National Seashore. To be produced in cooperation with the National Park Service, the guidebook will include supplementary maps, figures, and a road log. It also will contain descriptions of the origin, present morphology, environments, and active processes of Padre Island, plus historical information provided by Keene Ferguson, a former Bureau staff member. The dynamic character of the island and the importance of maintaining a balance between its sensitive natural environments will be stressed.



Sediment transport directions in the vicinity of Galveston Island. From historical shoreline monitoring studies by R. A. Morton.

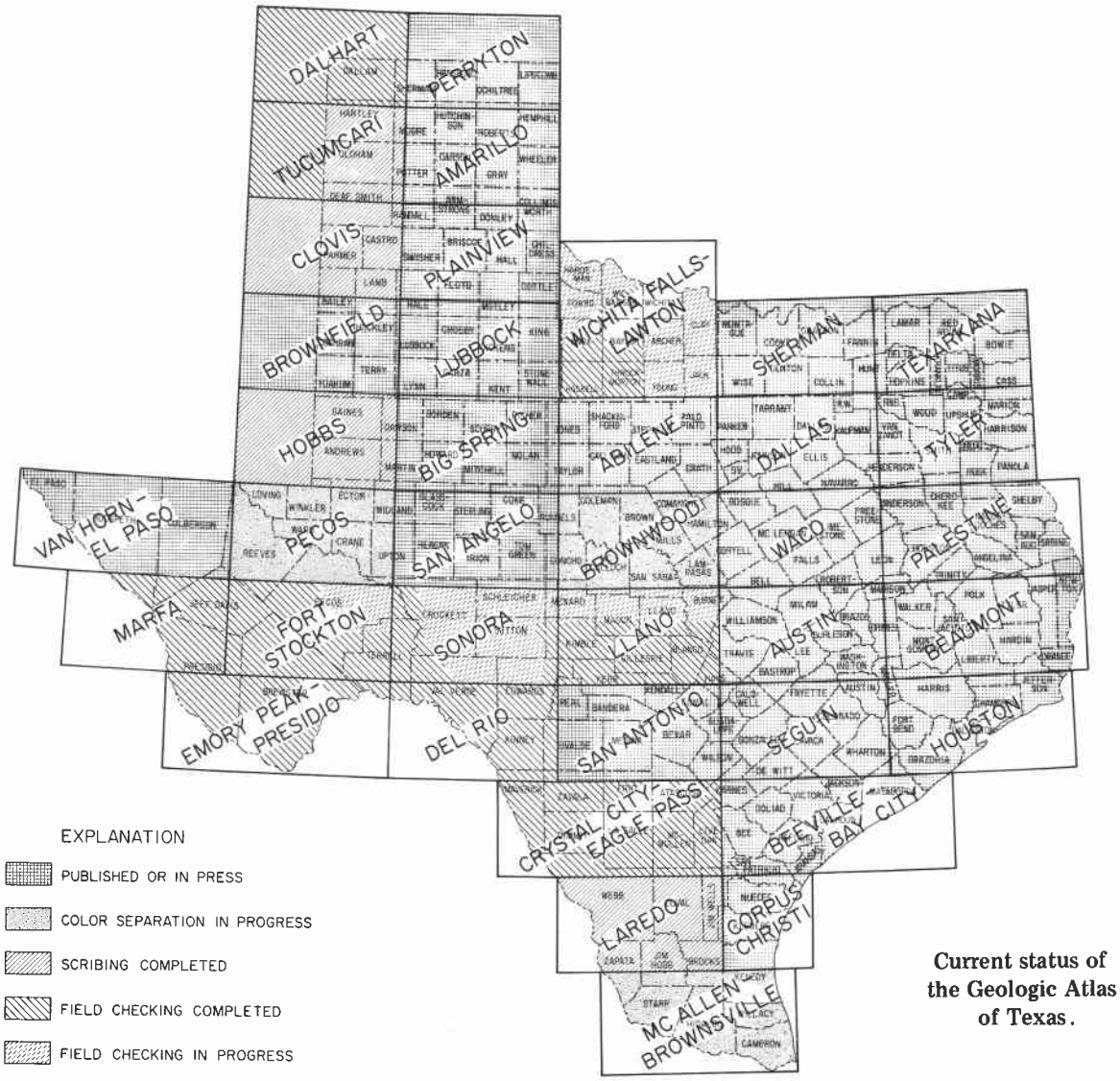
GEOLOGIC MAPPING

Geologic Atlas of Texas.—V. E. Barnes (project director), L. F. Brown, Jr., R. S. Kier, A. R. Trippet, J. W. Macon, R. L. Dillon, D. F. Scranton, J. C. Cepeda, W. C. Parrish, A. W. Cleaves II, G. K. Eifler, Jr., and C. C. Reeves, Jr.

A new geologic map of Texas, showing the extent of outcropping rock units, is being published as a series of separate map sheets. Each sheet is printed in multicolor on a topographic base at a scale of 1:250,000 (1 inch on the map represents almost 4 miles). Most of the sheets pertain to areas within 1° of latitude by 2° of longitude, but some include larger or smaller areas. Current plans call for the publication of a total of 38 separate map sheets.

Twenty-one of the sheets have been issued, including the Beeville-Bay City and San Angelo Sheets which were published in 1975. At yearend, the Corpus Christi and Pecos Sheets were in press. Other sheets were in various stages of completion as indicated on the index map. Only small areas on the Llano, Fort Stockton, Wichita Falls-Lawton, and Tucumcari (New Mexico part) Sheets had not been geologically mapped by the close of 1975. The Geologic Atlas of Texas project, which began in 1961, is expected to be completed in 1978 or 1979.

Geologic Quadrangle Mapping in Central Texas.—V. E. Barnes and cartographic section.



Current status of the Geologic Atlas of Texas.

The project involves geologic mapping of quadrangles in Central Texas, including portions of Blanco, Burnet, Gillespie, Hays, Kendall, Kerr, Kimble, Llano, Mason, and Travis Counties. It was initiated in 1939 and will continue until all of the remaining maps are published on U. S. Geological Survey topographic bases at a scale of 1:24,000.

Since 1952, the Bureau has published geologic maps with accompanying texts of 20 of the quadrangles. These early maps were printed in multicolor on planimetric bases at a scale of 1:31,680. Three of these original 20 maps have since been republished in multicolor on U. S. Geological Survey topographic bases at a scale of 1:24,000, and four additional geologic maps of quadrangles in the area have been published on similar topographic bases.

At yearend, the previously unpublished Kingsland geologic quadrangle map was in press, and the Cap Mountain, Click, and Dunman Mountain geologic quadrangle maps were in various stages of compilation and scribing. The Howell Mountain, Pedernales Falls, and Round Mountain geologic quadrangle maps were ready for drafting. Field work has been completed on Hammetts Crossing, Longhorn Cavern, Marble Falls, and Spicewood quadrangles, but the accompanying texts have not yet been written.

OTHER RESEARCH PROJECTS

Virgil-Wolfcamp Facies, Eastern Shelf, North-Central Texas.—L. F. Brown, Jr., assisted by R. F. Solis, and A. W. Cleaves II.

This regional study of the surface and subsurface in a 30-county area of North-Central Texas involves the examination of approximately 6,000 well logs. The goal of the project is the mapping and recognition of fluvial, deltaic, and related marine depositional systems and their component facies. The resulting regional picture of Late Pennsylvanian and Early Permian depositional features will serve as a guide in the search for oil, water, clay, and other resources in the study area and in similar depositional systems elsewhere. Final data were tabulated during late 1975; maps are expected to be completed in 1976.

A Ph.D. dissertation by A. W. Cleaves II on the Strawn Group of North-Central Texas was completed in late 1975; this study, which developed from the project, will be published as a report of investigations in 1976.

Carbonate Facies and Porosity Distribution of the Subsurface Sligo Formation, South Texas.—D. G. Bebout, assisted by F. C. Lucas.

The limestone and dolomite units of the Lower Cretaceous Sligo Formation have been the targets of many deep wells drilled in the search for oil and gas in South Texas. A large number of these wells have yielded cores of portions of the Sligo. The objective of this project is to examine in detail all cores available from the Sligo in order to determine the distribution of carbonate facies and also to interpret depositional and diagenetic environments of that formation. A knowledge of the relation of porosity distribution to primary depositional environments combined with an understanding of secondary trends resulting from dolomitization, leaching, and cementation should aid significantly in the exploration for oil and gas in the Sligo.

All Sligo cores known to exist have now been described, and strip logs of the cores have been prepared. At yearend, facies maps and cross sections were being assembled. The study is expected to be completed during 1976.

Comparative Sedimentology of Modern and Ancient Coarse-Grained Terrigenous Clastics.—J. H. McGowen and L. E. Garner.

The Bureau of Economic Geology initiated a new series of research projects in coarse-grained clastics in late 1974. Both Modern and ancient coarse-grained clastics, specifically fluvial systems, alluvial fans, and fan deltas, are being investigated. Relationships between sedimentary processes and facies of various Modern coarse-grained systems will be determined, and this knowledge will be used to interpret the depositional environments of ancient coarse-grained terrigenous clastics. The typical depositional patterns of coarse-grained clastics—the depositional models—can be applied in prospecting for oil and gas, uranium, heavy-mineral placers, and ground water.

One aspect of Modern coarse-grained deposits, the three-dimensional distribution of facies, previously has not been studied in detail. This series of projects is designed to determine the geometry of Modern coarse-grained deposits.

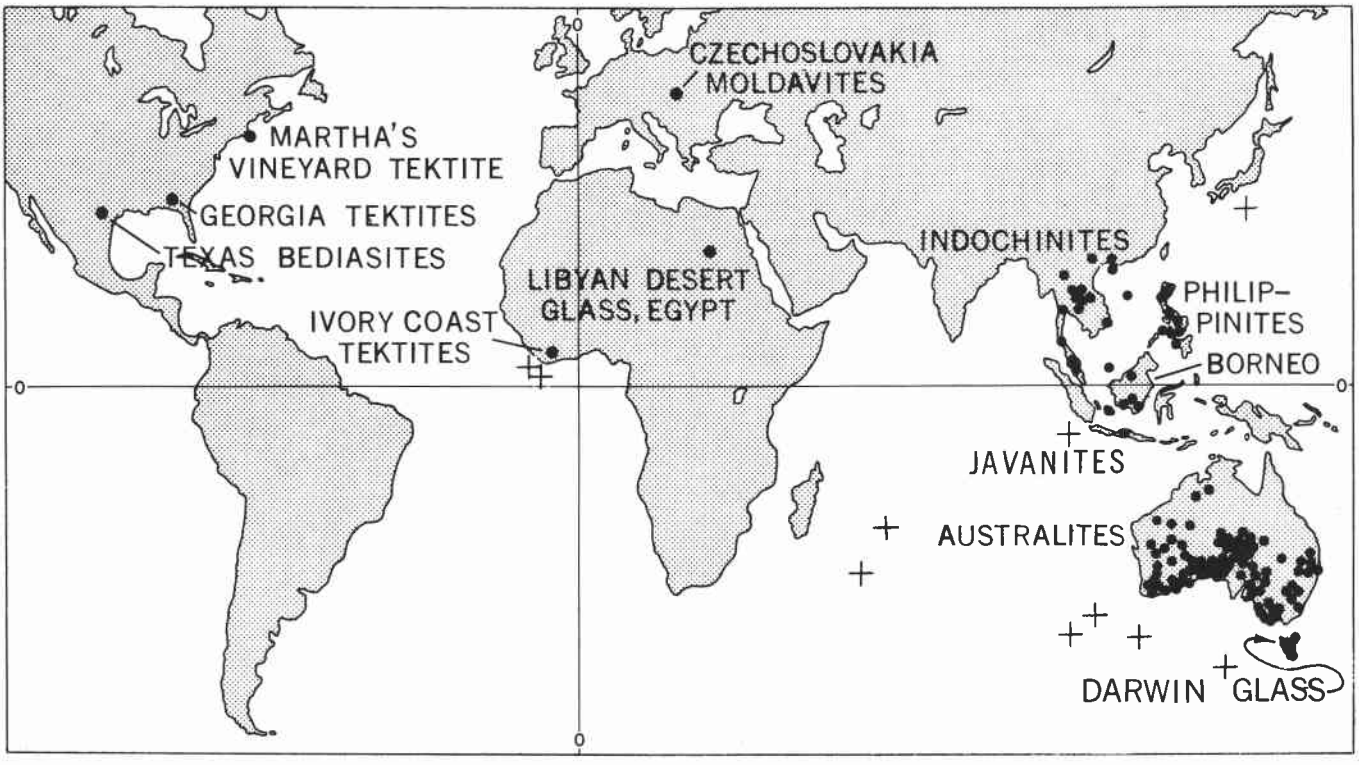
The first project in the series is a 2-year study of the Colorado River and its Modern-Holocene deposits between Smithville and Bay City, Texas. Objectives of this project are: (1) to define the floodplain in terms of fluvial processes and resulting deposits; (2) to map the various fluvial environments; (3) to determine the geometry of the valley fill; (4) to establish the relationships between flow conditions, bedforms, and sediment parameters; and (5) to develop from this study a comprehensive depositional model.

Nitrogen Isotopes of Nitrate and Ammonium in Natural Waters, Texas.—C. W. Kreitler and L. S. Land, assisted by D. R. Prezbindowski and S. J. Lindquist.

This project began in November 1974 with the support of a 2-year grant from the National Science Foundation. Its aim is to determine the source of nitrate in surface waters and ground waters. Progress on the project during 1975 included: (1) analysis of nitrogen isotopes of nitrate in the soils and waters associated with the gravel fan deposits at Lockhart (Caldwell County) and Taylor (Williamson County); (2) studies of the potential for nitrate pollution resulting from lignite strip mining; and (3) studies of the water chemistry and isotope chemistry of the Highland Lakes of Central Texas.

Composition and Origin of Tektites.—V. E. Barnes, Director of Tektite Research, The University of Texas at Austin, and S. V. Margolis, University of Hawaii at Manoa.

This project is a phase of a long-term investigation, initiated in 1935, of the small glassy objects that are found in Texas and in other parts of the world. The tektite investigation has resulted in numerous publications, and others are planned. During 1975, S. V. Margolis continued the collection of data to aid in determining the composition and origin of tektites.



Generalized worldwide distribution of tektite occurrences. From tektite studies by V. E. Barnes.

CONTRACTS AND GRANT SUPPORT

The Bureau of Economic Geology maintains formal and informal cooperative arrangements with several governmental entities. A part of the Bureau research program is supported by contracts and grants with State agencies, local units of government, and Federal agencies. Contracts and grants in effect during all or part of 1975 include:

Assessment of Shoreline and Wetland Changes Along the Texas Coast.—Texas General Land Office.

Criteria for Coastal Zone Management (Methodology to Evaluate Impacts of Alternative Policy Decisions: Applications in the Texas Coastal Zone).—National Science Foundation, Research Applied to National Needs (RANN) and Office of the Governor of Texas, Division of Planning Coordination.

Environmental Aspects of Geothermal Energy Production.—U. S. Energy Research and Development Administration and the Center for Energy Studies of The University of Texas at Austin.

Geologic Atlas of Texas.—Partial support from Texas Water Development Board.

Guadalupe - San Antonio - Nueces River Basins Regional Study.—Texas Water Development Board.

Historical Monitoring of the Texas Gulf Coast Shoreline.—Special appropriation by the 63rd Legislature of Texas.

Identification of Natural Hazards of the Texas Coastal Zone and Contributions Toward Development of Minimum Building Standards.—Partial support from the Texas Coastal and Marine Council.

In Situ Gasification of Texas Lignite.—Partial support from National Science Foundation, Research Applied to National Needs (RANN).

Land and Water Resources of the Houston-Galveston Area Council of Governments Region.—Houston-Galveston Area Council of Governments.

Land Resources and Environmental Impact, East Texas Lignite Belt.—U. S. Geological Survey.

LANDSAT Investigation for the Texas Coastal Zone.—Texas General Land Office.

Landslide Incidence and Susceptibility in Texas.—U. S. Geological Survey.

Nitrogen Isotopes in Surface Waters and Ground Waters of Central Texas.—National Science Foundation.

Preliminary Evaluation of Geothermal Resources of the Middle Texas Gulf Coast.—U. S. Atomic Energy Commission (now U. S. Energy Research and Development Administration), administered through the Lawrence Livermore Laboratory and the Center for Energy Studies of The University of Texas at Austin.

Reactor Siting Hazards: Faulting and Fault Activation in the Texas Coastal Zone.—Partial support from U. S. Geological Survey.

Resource Assessment of the Geopressured Geothermal Resources of the Texas Gulf Coast.—U. S. Energy Research and Development Administration.

Sediment Budget of Galveston Island.—Partial support from the National Oceanic and Atmospheric Administration Sea Grant Program, administered through Texas A&M University.

Tektite Research.—National Science Foundation, administered through The University of Texas at Austin.

Uranium Potential and Genetic Stratigraphy of the Triassic Dockum Group of the Texas Panhandle.—Partial support from U. S. Geological Survey, Uranium/Thorium Branch.

Uranium Potential of the Catahoula Formation, Texas—a Stratigraphic, Depositional, and Geochemical Evaluation.—U. S. Energy Research and Development Administration.

CARTOGRAPHIC SECTION

The Bureau of Economic Geology is a research organization that depends primarily on its own publications for the dissemination of the results of its investigations. Geologic mapping has always been the key element in most Bureau projects, and the quality of Bureau maps is widely acclaimed. The reason for this reputation is the Bureau's Cartographic Section which is at least among the finest in the United States and more than likely is the best there is.

One of the outstanding accomplishments of the Cartographic Section is the preparation of full-color maps. Some of these maps accompany Bureau reports; some are issued as individual series, such as the Geologic Atlas of Texas, the Environmental Geologic Atlas of the Texas Coastal Zone, Geologic Quadrangle Maps, and the new Land Resources Laboratory Map Series.

Under the guidance of James W. Macon, the Cartographic Section has expanded greatly in size and scope during the past 25 years. When Macon began working for the Bureau on a part-time basis in 1948 while attending The University of Texas, the Bureau did not have an actual, organized Cartographic Section; instead, a draftsman would work with an individual staff geologist to prepare maps and illustrations for a specific project as required from time to time. In 1950, when he became a regular, full-time member of the Bureau staff, Macon began introducing modern map-making techniques and processes to the newly formed Cartographic Section, consisting of himself and two draftsmen. Today the 11-member staff produces a full range of maps, illustrations, slide copy, and display materials. Their expertise and

From left: Cartographers Barbara K. Hartmann, James W. Macon, Dan F. Scranton, and Richard L. Dillon.

workmanship are evident in the high quality of maps and other graphics they produce.

Three full-time cartographers have assisted Macon through the years in shaping the progress of the Cartographic Section: Dan F. Scranton, with the Bureau since 1953; Barbara M. Hartmann, who first joined the Bureau staff in 1957; and Richard L. Dillon, with the Bureau since 1968. Other members of the Cartographic Section are Margaret R. Day, Claudia J. Farmer, Stephen M. Johnson, Margaret K. Langford, Stacy Peoples, and David M. Ridner, and a technical staff assistant, Gail C. Larimer.

WELL SAMPLE AND CORE LIBRARY

New demands for energy resources made 1975 an active year at the Bureau's Well Sample and Core Library. Computerization of the collection was initiated, and monthly reports of new acquisitions were prepared for Bureau staff. Increased use of the depository is anticipated; although storage space is at a premium, a program of consolidation has enabled the library to continue accepting new donations.

The collections include rock materials from each Texas county. These materials—samples and cores—are obtained as a result of drilling oil and gas wells, engineering test holes, and mineral exploration holes. A very significant core and sample donation consisting of materials from more than 335 individual wells in a wide area of North-Central Texas was received from the Mobil Oil Corporation in 1975. Also during the year, Tesoro Petroleum Corporation presented cores from two wells in Dimmit County and two wells in Zavala County. The Texas Water Development Board provided cores from three wells in McCulloch County, one well in Mason County, and one well in Zavala County. The Shell Development Company contributed cores from wells in Lynn, Reeves, Val Verde, Culberson, and Gonzales Counties.

Samples from one well in Fayette County were donated by W. J. Briggs, and the Shell Development Company presented outcrop samples from five locations in Mexico near the Texas border. Porter Montgomery donated samples from three wells in Frio County, two wells in Bexar County, and one well each in Atascosa, Bastrop, Caldwell, Kerr, Medina, and Wilson Counties.

In addition to rock materials, the library maintains large collections of driller's logs and sample logs with smaller quantities of electrical logs and maps. During 1975, the electrical log file was vastly improved by the presentation of approximately 4,000 logs by Joseph Hornberger and of more than 200 electrical logs of wells in Ochiltree County by Porter Montgomery.

Another important donation is the Rittenhouse Brine Collection that was received in 1975 from Shell Development Company. The brine samples, contained in over 2,000 plastic bottles, were obtained throughout the United States and Canada. Accompanying the collection of samples are pertinent reports and data.

Thin sections are now being produced for the Bureau staff by H. J. Madsen of the Well Sample and Core Library. The acquisition during 1975 of a Hillquist thin-section machine and an impregnating apparatus enables him to complete a number of thin sections within only a few days.

The well samples and cores maintained at the library are valuable and irreplaceable sources of information. They provide geologists, students, and other interested persons with basic information pertaining to Texas geology. Access to this material is provided by a card catalog located at the library. An index to the collection, "Addendum to Index to Well Samples and Cores, 1963-1973," will be published in 1976.

The facility, located at Balcones Research Center, is open to the public from 8:00 a.m. to 5:00 p.m. Monday through Friday. The library is staffed by Douglas C. Ratcliff (Administrative Clerk) and Harry J. Madsen, assisted by T. Dale Bagwell, John A. Kieschnick, and Guy L. Tidmore.

MINERAL STUDIES LABORATORY

The primary function of the Mineral Studies Laboratory is to perform chemical and spectrographic analysis and physical testing of Texas rocks and minerals for Bureau of Economic Geology research projects. Occasionally, the laboratory also performs similar work for various departments of The University of Texas at Austin, for Texas State agencies, and—under certain conditions—for Texas residents.

Much of the laboratory's activity during 1975 was centered on the 500 samples that were submitted in connection with a Bureau of Economic Geology project, "Uranium Potential and Genetic Stratigraphy of the Triassic Dockum Group of the Texas Panhandle." Uranium is one of the elements that was determined quantitatively in the samples. Such analysis was facilitated by the laboratory's acquisition of a Galvanek-Morrison reflectance fluorometer, which is the instrument that governmental and commercial laboratories use for the analysis of uranium-bearing rocks.

The laboratory also performed work for other projects of the Bureau of Economic Geology during the year. In support of the Bureau's search for potential alternate fossil fuels, the laboratory determined the oil yield of a number of Texas oil shales. This was a continuation of work that began in 1974.

In connection with this Bureau's study of the suitability of limestones for use in removing sulfur dioxide from flue gases of coal-burning power plants, the laboratory tested various Texas limestones. Work on the limestone samples included chemical and spectrographic analysis and the determination of particle-size distribution and sulfur dioxide reactivity.

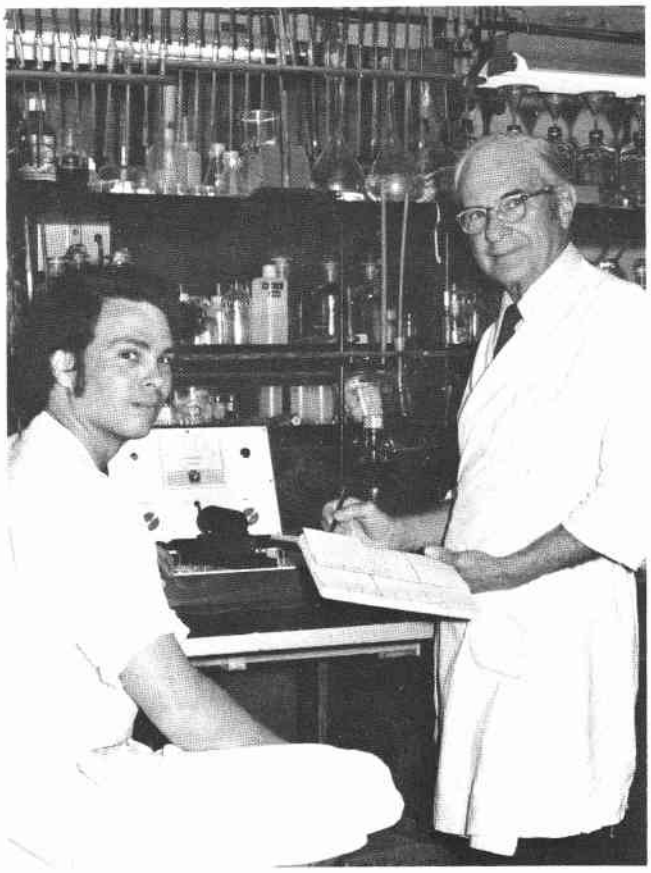
Additional Bureau projects also required the assistance of the Mineral Studies Laboratory. Sieve analysis, determination of particle-size distribution, clay testing, and chemical and spectrographic analysis were included in the laboratory's contributions to these projects.

Texas residents submitted a wide assortment of Texas rocks and minerals to the Mineral Studies Laboratory. Preliminary tests were performed on these samples with the purpose of finding materials of potential commercial value. The laboratory's reports on samples showing such potential included recommendations for further testing by specialized commercial laboratories.

Services provided by the Mineral Studies Laboratory to departments of The University of Texas at Austin included consultation, testing, or use of facilities. Receiving these services during 1975 were the Departments of Anthropology, Art, Chemical Engineering, Chemistry, and Geological Sciences.

Branches of the Texas State government receiving services of the Mineral Studies Laboratory included the Texas Water Development Board, Texas Historical Commission, and Texas Antiquities Committee. Work performed for these groups ranged from consultations on methods of chemical analysis and physical testing to trace-element analysis of pottery shards (with the aim of locating the place of origin of the pottery and determining early trade routes).

The Mineral Studies Laboratory is located at the University's Balcones Research Center in northwest Austin. Daniel A. Schofield is Chemist-in-Charge, and Laurence C. McGonagle is Assistant Chemist. Part-time laboratory assistants, appointed during 1975, are John W. Mullins and Kelly C. Street.



Larry McGonagle (l) and Dan Schofield record reading from the reflectance fluorometer.

STAFF ACTIVITIES

MEETINGS ATTENDED

Staff members represented the Bureau of Economic Geology or The University of Texas at numerous scientific and professional meetings in 1975. Principal meetings attended during the year include:

American Association for the Advancement of Science, Annual Meeting, New York, New York—E. G. Wermund.

American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, Annual Meetings, Dallas, Texas—V. E. Barnes, D. G. Bebout, L. F. Brown, Jr., W. L. Fisher, C. G. Groat, C. W. Kreitler, R. G. Loucks, J. H. McGowen, R. L. Shipman, E. G. Wermund.

American Institute of Professional Geologists, Annual Meeting, Tucson, Arizona; and Executive Committee Meetings, Denver, Colorado, Dallas, Texas, and Hidden Valley, Pennsylvania—R. L. Shipman.

Association of American State Geologists, Annual Meeting, Asheville, North Carolina—C. G. Groat, E. G. Wermund.

Big Eight Resource Conservation and Development Project Area, Planning Conference, Bryan, Texas—L. E. Garner.

Conference on Coal—Processing, Use, and Environmental Considerations, Central State Universities Incorporated, Argonne National Laboratory, Annual Conference, Chicago, Illinois—T. J. Evans.

Electric Power Research Institute, Program Briefing, Dallas, Texas—C. G. Groat.

Forum on Geology of Industrial Minerals, Annual Meeting, Kalispell, Montana—C. G. Groat.

Geological Society of America, Annual Meeting, Salt Lake City, Utah—V. E. Barnes, R. J. Finley, C. G. Groat, T. C. Gustavson, C. D. Henry, C. W. Kreitler, R. A. Morton.

Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas—R. L. Andersen, V. E. Barnes, J. M. Basciano, D. G. Bebout, J. L. Chin, T. J. Evans, W. L. Fisher, L. E. Garner, R. M. Girard, C. G. Groat, T. C. Gustavson, C. D. Henry, E. H. Kastning, C. W. Kreitler, C. R. Lewis, R. G. Loucks, J. H. McGowen, D. G. McKalips, R. A. Morton, M. J. Pieper, A. E. St. Clair, R. L. Shipman, A. R. Trippet, B. R. Weise, E. G. Wermund, W. A. White, C. M. Woodruff, Jr.

Geological Society of America, South-Central Section Management Board, Meeting, Salt Lake City, Utah—C. G. Groat.

Geological Society of America, Southeastern Section, Annual Meeting, Memphis, Tennessee—R. J. Finley.

Geopressured Geothermal Energy Resources—Research and Development, Conference, sponsored by Center for Energy Studies and College of Engineering, The University of Texas at Austin, Austin, Texas—D. G. Bebout, C. G. Groat.

Gulf Coast Association of Geological Societies, Annual Meeting, Jackson, Mississippi—D. G. Bebout, E. G. Wermund.

Highway Geology Symposium, 26th Annual Meeting, Coeur d'Alene, Idaho—L. E. Garner.

International Association of Hydrogeologists, 12th International Congress, Huntsville, Alabama—E. H. Kastning, E. G. Wermund.

Interstate Mining Compact Commission, Spring Meeting, Annapolis, Maryland; Fall Meeting, Hilton Head, South Carolina; and Executive Committee Meeting, Columbia, South Carolina—C. G. Groat.

Meteoritical Society, Annual Meeting, Tours, France—V. E. Barnes.

National Oceanic and Atmospheric Administration, Coastal Zone Management Conference, Asilomar, California—C. M. Woodruff, Jr.

National Science Foundation, Research Applied to National Needs, Regional Seminar, Dallas, Texas—R. S. Kier.

National Speleological Society, Annual Meeting, Angels Camp, California—E. H. Kastning.

Practices and Problems of Land Reclamation in Western North America, Conference, sponsored by U. S. Bureau of Mines and University of North Dakota, Grand Forks, North Dakota—C. G. Groat.

Science Teachers Association of Texas, 22nd Annual Conference for the Advancement of Science Teaching, Edinburg, Texas—A. R. Trippet.

Soil Survey Technical Work-Planning Conference, Texas A&M University, College Station, Texas—R. L. Andersen, L. E. Garner, C. M. Woodruff, Jr.

Southern Environmental Resources Conference, sponsored by Speaker of the Texas House of Representatives Bill Clayton, Austin, Texas—R. S. Kier, E. G. Wermund.

Southern Regional Workshop on Remote Sensing and Land Use Information Systems, Southern Growth Policies Board, New Orleans, Louisiana—T. C. Gustavson.

Texas Advisory Committee on Conservation and Environmental Education, Fall Meeting, Lake Livingston, Texas—C. G. Groat.

Texas Education Advisory Committee on Conservation of Natural Resources and Environment, Semiannual Meeting, Del Rio, Texas—E. G. Wermund.

Texas Mapping Advisory Committee, Annual Meeting, Austin, Texas—C. G. Groat.

Texas Water Development Board, Water Resources Orientation Training Program, Ground Water, Series 150, Austin, Texas—J. M. Basciano.

Workshop on Coastal Sedimentology, Engineering Geology, and Related Environmental Studies, The University of Texas Marine Science Institute, Port Aransas, Texas—J. L. Chin, R. J. Finley, R. S. Kerr, R. S. Kier, C. W. Kreitler, J. H. McGowen, R. A. Morton, M. J. Pieper, A. E. St. Clair, W. A. White.

U. S. Energy Research and Development Administration, Laramie Energy Research Center, 1st Annual Underground Coal Gasification Symposium, Laramie, Wyoming—W. R. Kaiser.

U. S. Geological Survey, Review of State Research Contracts, Meeting, Denver, Colorado—L. F. Brown, Jr., J. H. McGowen.

U. S. Geological Survey and State Geologists, Seminar on Geological Programs in the Central Region of the United States, Estes Park, Colorado—L. F. Brown, Jr., C. G. Groat.

LECTURES AND PUBLIC ADDRESSES

A measure of the interest in Bureau of Economic Geology research programs and their results is shown by the number of public lectures presented each year. Lectures are given to a wide audience, including professional societies, universities, and Federal, state, and local units of government.

Although the prime means of disseminating the results of Bureau research is through publication, formal and informal lectures are important means of presenting information on Bureau research prior to final publication.

Following are lectures given by Bureau staff members during 1975.

D. G. Bebout

Depositional framework of the Frio Formation (Oligocene)—lower and middle Texas Gulf Coast: presented at Gulf Coast Association of Geological Societies, Annual Meeting, Jackson, Mississippi.

Evaporite deposition in the Devonian Elk Point Basin, Alberta, Canada: presented at Society of Economic Paleontologists and Mineralogists, Evaporite Research Group, Annual Meeting, Dallas, Texas.

Exploration for geopressure geothermal resources—Frio Formation, lower and middle Texas Gulf Coast: presented at Houston Geological Society, Meeting, Houston, Texas; and Department of Geological Sciences, The University of Texas at Austin, Technical Session, Austin, Texas.

Geothermal resources of Texas: presented at Desk and Derrick Club, Monthly Dinner Meeting, San Angelo, Texas.

Regional sand distribution of the Frio Formation (Oligocene)—a preliminary study in the search for geothermal energy in South Texas: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

Regional sand distribution of the Frio Formation, South Texas—a preliminary step in prospecting for geothermal energy: presented at Geopressured Geothermal Energy Resources—Research and Development, Conference, sponsored by Center for Energy Studies and College of

Engineering, The University of Texas at Austin, Austin, Texas.

Stuart City Trend, South Texas, and Golden Lane, Mexico—a comparison: presented at Society of Economic Paleontologists and Mineralogists, Permian Basin Section, Meeting, Midland, Texas.

L. F. Brown, Jr.

Depositional systems and petroleum potential, Santos Basin, Brazil: presented at Petroleo Brasiliero, Rio de Janeiro, Brazil.

Depositional systems on the eastern flank of the Midland Basin: presented at Society of Economic Paleontologists and Mineralogists, Permian Basin Section, Monthly Meeting, Midland, Texas.

Geology and Coastal Zone management and inventory: presented before Graduate class in Coastal Zone Management, Texas A&M University, College Station, Texas.

Resource capability and natural hazards in the Texas Coastal Zone: presented before class in Environmental Management, The University of Texas at Austin, Austin, Texas.

Seismic stratigraphic exploration: presented at Chevron Oil Field Research Laboratories, La Habra, California.

T. J. Evans

Texas minerals and commodities: presented at Environmental Education Workshop, sponsored by Texas Education Agency and Abilene Christian College, Abilene, Texas.

R. J. Finley

Inlet morphology and hydrodynamic processes, North Inlet, South Carolina: presented at Geological Society of America, Southeastern Section, Annual Meeting, Memphis, Tennessee.

Inlet shoal and shoreline development in relation to seasonal wave energy flux, North Inlet, South Carolina: presented at Geological Society of America, Annual Meeting, Salt Lake City, Utah.

L. E. Garner

Aggregate resource conservation in urban areas: presented at Highway Geology Symposium, Annual Meeting, Coeur d'Alene, Idaho.

Geology and mineral resources of the Big Eight Resource Conservation and Development Project Area: presented at Big Eight Resource Conservation and Development Project Area, Planning Conference, Bryan, Texas.

Projects and progress of the Bureau of Economic Geology: presented at Texas A&M University, Soil Survey Technical Work-Planning Conference, College Station, Texas.

Resources and urban planning: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

C. G. Groat

Bureau of Economic Geology pilot program to provide materials for use in Texas public schools: presented at Texas Advisory Committee on Conservation and Environmental Education, Fall Meeting, Lake Livingston, Texas.

Bureau of Economic Geology research programs and priorities: presented at U. S. Geological Survey and State Geologists Seminar on Geological Programs in the Central Region of the United States, Estes Park, Colorado.

Geopressured geothermal resources of the Texas Coastal Zone: presented to Texas congressional delegation, Washington, D. C.

Lignite resource assessment: presented at The University of Texas at Austin, Center for Energy Studies, Public Briefing Session, Austin, Texas.

Mining and economics: presented at Texas Aggregates and Concrete Association, 17th Annual Short Course, Texas A&M University, College Station, Texas.

Proposed Bureau of Economic Geology river basins mapping project: presented at Texas Water Conservation Association, River Authorities Panel, Quarterly Meeting, Conroe, Texas.

Texas mineral resources—occurrence and environmental aspects: presented at Environmental Education Workshop, sponsored by Texas Education Agency and The University of Texas at El Paso, El Paso, Texas (2 lectures—in April and November).

T. C. Gustavson

Fluvial and lacustrine depositional processes on the Malaspina Foreland, Alaska: presented at Geological Society of Alaska, Meeting, Anchorage, Alaska.

The formation, recognition, and environmental significance of microrelief (gilgai) developed on Ca montmorillonitic clays and shales of the Texas Coastal Plain: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

The geography of southeastern Alaska: presented before classes at Cunningham and Joslin Elementary Schools, Austin, Texas.

C. D. Henry

Geology and geochronology of the granite batholithic complex, Sinaloa, Mexico: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

Toward evaluating the potential environmental impact of lignite strip mining in East Texas: presented at Geological Society of America, Annual Meeting, Salt Lake City, Utah.

W. R. Kaiser

Environmental aspects of in situ gasification: presented at The University of Texas at Austin, Center for Energy Studies, Public Briefing Session, Austin, Texas.

Resources and utilization of Texas lignite: presented at Longview Community Development Team of Sabine River Development Association, Monthly Meeting, Longview, Texas.

Site selection factors for in situ gasifers in the Texas Coastal Plain: presented at 1st Annual Underground Coal Gasification Symposium, sponsored by U. S. Energy Research and Development Administration, Laramie Energy Research Center, Laramie, Wyoming.

E. H. Kastning

Cavern development in the Helderberg Plateau, East-Central New York: presented at National Speleological Society, Annual Meeting, Angels Camp, California.

R. S. Kier

An approach to determining environmental and economic impacts of potential recreational community developments on barrier islands: presented at The University of Texas Marine Science Institute, Workshop on Coastal Sedimentology, Engineering Geology, and Related Environmental Studies, Port Aransas, Texas.

Methodology to evaluate impacts of Coastal Zone management policies—an example: presented at Southern Environmental Resources Conference, sponsored by Speaker of the Texas House of Representatives Bill Clayton, Austin, Texas.

C. W. Kreitler

Fault activation, Houston, Texas: presented before Graduate class in Engineering Geology, The University of Texas at Austin, Austin, Texas.

Geologic control of land subsidence, Houston-Galveston, Texas: presented at Geological Society of America, Annual Meeting, Salt Lake City, Utah.

Growth faults in the Gulf Coast sedimentary basin: presented before Graduate class in Advanced Structural Geology, The University of Texas at Austin, Austin, Texas.

Increased potential of hurricane flooding caused by land subsidence: presented at The University of Texas Marine Science Institute, Workshop on Sedimentology, Engineering Geology, and Related Environmental Studies, Port Aransas, Texas.

Interrelationship between faulting and subsidence, Houston-Galveston area: presented at The University of Texas Marine Science Institute, Geophysical Laboratory, Galveston, Texas.

Land subsidence, Texas Coastal Zone: presented before Graduate class in Hydrogeology, The University of Texas at Austin, Austin, Texas.

Lineations and active faulting in the Houston-Galveston area of subsidence: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

R. G. Loucks

Depositonal environments in a carbonate-terrigenous shelf system—subsurface Lower Cretaceous Pearsall Formation of South Texas: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

Low-magnesium rhombic calcite mud from the brackish-water border of a recent shallow marine carbonate province: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

Porosity development in carbonate grainstones in subsurface Lower Cretaceous Pearsall Formation of South Texas: presented at American Association of Petroleum Geologists, Annual Meeting, Dallas, Texas.

J. H. McGowen

Sedimentary framework of the Matagorda Bay Complex: presented at The University of Texas Marine Science Institute, Workshop on Coastal Sedimentology, Engineering Geology, and Related Environmental Studies, Port Aransas, Texas.

Triassic lacustrine deltas of Texas: presented before geologists of U. S. Geological Survey, Uranium/Thorium Branch, Denver, Colorado.

R. A. Morton

Natural hazards of the Texas Coastal Zone: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

Shoreline changes along the Texas Gulf Coast: presented at The University of Texas Marine Science Institute, Workshop on Coastal Sedimentology, Engineering Geology, and Related Environmental Studies, Port Aransas, Texas.

Shoreline changes in the vicinity of Freeport, Texas: presented at Surfside Beach Association, Noon Meeting, Freeport, Texas.

A. E. St. Clair

Application of land and water resource mapping to planning and management—Houston-Galveston area: presented at The University of Texas Marine Science Institute, Workshop on Coastal Sedimentology, Engineering Geology, and Related Environmental Studies, Port Aransas, Texas.

Mineral resources of Texas: presented before class in Resources and Conservation, Stephen F. Austin State University, Nacogdoches, Texas.

E. G. Wermund

Considerations for recognizing sensitive zones in the recharge zone of the Edwards limestone aquifer: presented before Task Force on the Edwards Recharge Zone, sponsored by the City Council of San Antonio, San Antonio, Texas.

Image interpretation in remote sensing analysis: presented at Remote Sensing Overview Course, sponsored by Texas Natural Resources Information System, Austin, Texas.

Measuring carrying capacity from natural parameters: presented at Southwest Parks and Recreation Training Institute, Lake Texoma, Oklahoma.

Purpose and use of land suitability mapping: presented at Houston-Galveston Area Council of Governments, Executive Committee, Monthly Meeting, Houston, Texas.

Texas Bureau of Economic Geology programs to map environmental resources—land and water: presented at Southern Environmental Resources Conference, sponsored by Speaker of the Texas House of Representatives Bill Clayton, Austin, Texas.

The resource capability unit methodology in the RANN Coastal Zone Management Program: presented at International Estuarine Research Conference, Biennial Meeting, Galveston, Texas.

W. A. White and R. S. Kerr

Historical changes in the distribution of natural and man-made environments, Mustang and North Padre Islands: presented at The University of Texas Marine Science Institute, Workshop on Coastal Sedimentology, Engineering Geology, and Related Environmental Studies, Port Aransas, Texas.

C. M. Woodruff, Jr.

Substrate and soils in San Antonio—environmental geologic mapping problems in an urban area: presented at South Texas Geological Society, Meeting, San Antonio, Texas.

The Texas Coastal Management Program—synthesizing data on resource capability for public policy decisions: presented at Geological Society of America, South-Central Section, Annual Meeting, Austin, Texas.

LEGISLATIVE COMMITTEE HEARINGS

Bureau of Economic Geology staff members are invited to testify as expert witnesses by Texas legislative committees considering bills on surface mining, land use, and other resource and environmental matters. During 1975, Bureau geologists appeared before the following committees:

Texas House of Representatives, Committee on Energy Resources, Representative Joe C. Hanna, Chairman: hearing at Austin, Texas—C. G. Groat (testimony given).

Texas House of Representatives, Subcommittee of Committee on Environmental Affairs, Representative Phil Cates, Chairman of Subcommittee: hearing at Austin, Texas—C. G. Groat (testimony given).

Texas House of Representatives, Committee on State Affairs, Representative D. R. Uher, Chairman: hearing at Austin, Texas—E. G. Wermund (testimony given).

Texas Senate, Committee on Natural Resources, Senator Max R. Sherman, Chairman: two hearings, on different bills, at Austin, Texas—C. G. Groat (testimony given).

COMMITTEE SERVICE, OFFICES, AND OTHER PROFESSIONAL RESPONSIBILITIES

V. E. Barnes

American Association of Petroleum Geologists: House of Delegates.

American Commission on Stratigraphic Nomenclature.

Co-leader of field trip, Paleozoic Stratigraphy and Paleontology of the Llano Region, Central Texas, held in conjunction with Geological Society of America, South-Central Section, 1975 Annual Meeting.

Participant in field trip, Northern Colorado Plateau: Sedimentary Environments, held in conjunction with Geological Society of America, 1975 Annual Meeting.

Participant in field trip, Rochechouart-Chassenon Astrobleme (Impact Structure) West of Limoge, France, held in conjunction with Meteoritical Society, 1975 Annual Meeting.

D. G. Bebout

Society of Economic Paleontologists and Mineralogists: Carbonate Rock Subcommittee.

Co-Chairman of session, Carbonates, at Geological Society of America, South-Central Session, 1975 Annual Meeting.

Gulf Coast Association of Geological Societies: Awards Committee for 1975 Annual Meeting.

L. F. Brown, Jr.

American Association of Petroleum Geologists: Environmental Geology Committee.

Texas A&M University: Sea Grant Advisory Committee.

Co-Chairman of session, Sedimentology, at American Association of Petroleum Geologists, 1975 Annual Meeting.

T. J. Evans

Austin Geological Society: Entertainment Committee, 1975-1976.

Geological Society of America, South-Central Section: Local Arrangements Committee for 1975 Annual Meeting, Chairman.

Co-leader of (coal part of) Triple Energy Field Trip (to Duval, Webb, and Zapata Counties, Texas) for Corpus Christi Geological Society.

L. E. Garner

Austin Natural Science Association: Board of Directors.

Co-leader of Field Trip, Environmental Geology, Austin, Texas, for Sigma Gamma Epsilon (geology organization) of The University of Texas at Austin.

Leader of Field Trip, Utilization of Land Resources in the Austin Area, held in conjunction with Geological Society of America, South-Central Section, 1975 Annual Meeting.

Prepared Report, "Geology and Mineral Resources of Big Eight Resource Conservation and Development Project Area," for Big Eight Resource Conservation and Development Project.

R. M. Girard

Austin Geological Society: Publications Committee, 1975-1976.

C. G. Groat

Association of American State Geologists: Continental Margins Committee.

Austin Geological Society: Program Committee, Chairman, 1974-1975; Vice President, 1975-1976.

Center for Energy Studies, The University of Texas at Austin: Associate Director for Resources and the Environment; Executive Committee.

Geological Society of America, South-Central Section: Program Committee for 1975 Annual Meeting, Chairman.

Interagency Council on Natural Resources and the Environment of the State of Texas: Council Member; Land Resources Management Committee.

Society of Mining Engineers of American Institute of Mining, Metallurgical and Petroleum Engineers, South Texas Minerals Section: Director, 1975-1976; 2nd Vice Chairman, 1974-1975.

Texas Education Agency: Texas Advisory Committee on Conservation and Environmental Education.

Texas Governor's Office, Water Resource Conservation and Development Task Force: Technical Advisory Committee.

Texas Mapping Advisory Committee.

Texas Utilities Generating Company: Environmental Steering Committee.

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

U. S. Department of Commerce, Technical Advisory Board: Panel on Project Independence Blueprint; Subpanel on Geothermal and Solar Energy.

Chairman of session at Conference on Geopressured Geothermal Energy Resources—Research and Development, sponsored by The University of Texas at Austin, Center for Energy Studies.

R. S. Kier

Austin Geological Society: Public Relations Committee, Chairman, 1975-1976.

C. W. Kreitler

Appeared in the Texas General Land Office Coastal Management Program motion-picture presentation, "Faces of the Coast."

Citizens' Environmental Coalition: Panelist at Citizens' Workshop on Galveston Bay, Galveston, Texas.

Panelist for U. S. Congress, Office of Technology Assessment to review the environmental aspects of the U. S. Energy Research and Development Administration's National Plan for Energy Research, Development and Demonstration: Creating Choices for the Future.

J. H. McGowen

Chairman of General Session at American Association of Petroleum Geologists and Society of Economic Paleontologists, 1975 Annual Meetings.

Participant in an informal field conference on lacustrine deposits of the northwestern United States conducted by Drs. Jerry Smith and Bruce Wilkinson of the University of Michigan; purpose of the participation was to make a comparison between these deposits and the Dockum (Triassic) deposits of Texas.

R. A. Morton

Austin Geological Society: Entertainment Committee, 1974-1975; Technical Program Committee, 1975-1976.

Chairman of workshop, Impact of Economic Development on Barrier Islands, sponsored by Geological Society of America, Corpus Christi, Texas.

Consulted with Texas Attorney General's Office and General Land Office on determination of coextensive geological and legal boundaries.

Consulted with Texas Coastal and Marine Council on development of building code for Texas Coast as called for in Texas Senate Resolution 268.

A. E. St. Clair

Austin Geological Society: Finance Committee, 1975-1976.

Geological Society of America, South-Central Section: Local Arrangements Committee for 1975 Annual Meeting.

R. L. Shipman

American Association of Petroleum Geologists: Membership Committee; Strategic Committee on Public Affairs.

American Institute of Professional Geologists: National Editor; National Executive Committee; State Legislative Committee, Chairman; State Executive Committee.

Interagency Council on Natural Resources and the Environment of the State of Texas: Alternate Representative of The University of Texas at Austin.

A. R. Trippet

Co-presenter (with J. E. Anderson, Jr.) of workshop at the 1975 Conference for the Advancement of Science Teaching, Edinburg, Texas.

B. R. Weise

Geological Society of America, South-Central Section: Local Arrangements Committee for 1975 Annual Meeting.

E. G. Wermund

Association of American State Geologists: National Coal Data System Committee.

Austin Geological Society: Gulf Coast Association of Geological Societies, 1977 Annual Meeting, General Chairman.

Interagency Council on Natural Resources and the Environment of the State of Texas: Task Force on Texas Natural Resources Information System.

Co-leader of field trip, Relationships in Contiguous Deposition of Clastic (Deltaic) and Calcareous (Bank) Facies of Missourian (Canyon) Age, North Central Texas, for American Association of Petroleum Geologists, 1975 Annual Meeting.

Referee of abstracts of papers pertaining to environmental geology, for Geological Society of America, 1975 Annual Meeting.

Gulf Coast Association of Geological Societies: Awards Committee for 1975 Annual Meeting.

Part-Time Bureau Staff Members*

William N. Bach
T. Dale Bagwell
William P. Bartow
Elsie A. Begle
Pamela K. Bettis
John L. Boone
Silverio C. Bosch
Julie A. Broyles
Craig L. Burton
James R. Byrne
Paul S. Cariker
Robert G. Christie
Frank G. Cornish
Karen A. Cortés
Margaret R. Day
Timothy W. Duex
Jack B. Evans
John P. Ferguson
Richard N. Fiore
Raymond A. Foutch
James D. German
Christine R. Gever
Denise M. Girard
Scott A. Griffiths
Glenn D. Hatcher
Cecille Haynie
Carl D. Hill
Scott A. Holden
Melody R. Holm
Charles P. Humphrey
L. Chris Johnson
Stephen M. Johnson
Rosalyn A. Jones
Wayne E. Jones
Ralph S. Kerr
John A. Kieschnick
Raymond C. Leonard
Gary W. Lich
Sandra J. Lindquist
Frederic C. Lucas
Jennifer Lundelius
Pamela E. Luttrell
Robert D. Manson
Richard T. Martin
David J. May
Kurt D. Miller
Marianne G. Moseley
John W. Mullins
T. Dennis Murphy
Kenneth E. Nemeth
Walter C. Parish
Michael Pattarozzi
Jeffrey D. Potter
Dennis R. Prezbindowski
Sharon E. Polensky
Gus B. Sanders, Jr.
Shirley M. Seagle
Jung H. Seo
Audrey C. Sellars
Samuel W. Shannon
Dale L. Simmons
Nathaniel G. Smith
Paul A. Smith
Raul F. Solis
David M. Stephens
Kelly C. Street
Eilene E. Theilig
Guy L. Tidmore
Bruce R. Van Allen
Sandra L. Waisley
Preston M. Walters
Kenneth R. Whaley
John D. Williams
Charles R. Williamson

*Worked as research assistants and in support of the publications, cartographic, and clerical-secretarial sections and the Mineral Studies Laboratory and the Well Sample Library.

BUREAU OF ECONOMIC GEOLOGY

BUREAU OF ECONOMIC GEOLOGY
The University of Texas at Austin
University Station, Box X
Austin 78712

Return Requested