

# ANNUAL REPORT 1974



**Bureau of Economic Geology**

The University of Texas at Austin

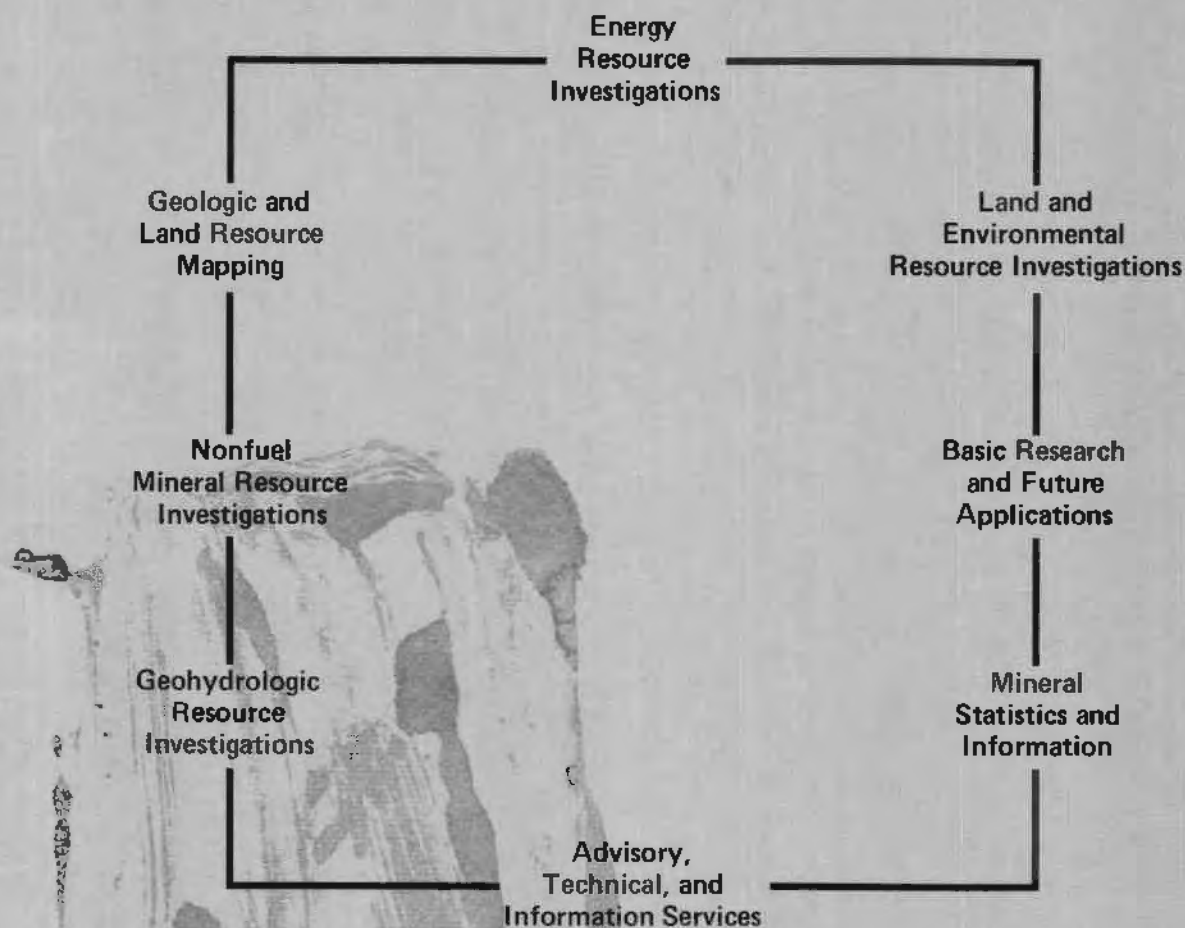
Austin, Texas

W. L. Fisher, Director

# BUREAU OF ECONOMIC GEOLOGY

The University of Texas at Austin

## RESEARCH AND PUBLIC SERVICE IN TEXAS RESOURCES AND GEOLOGY



Cover photograph: Lignite mining operation with reclaimed land in the foreground. Mine is located at Big Brown Steam Electric Generating Station near Fairfield in Freestone County, Texas. Courtesy of Texas Utilities Services, Inc.

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**The University of Texas at Austin  
Austin, Texas  
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## 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 The University of Texas Publication series and in its own series of Reports of Investigations, Atlases, Geological Circulars, Geologic Quadrangle 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.



## PUBLICATIONS IN 1974

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 65-year history of the Bureau, nearly 700 reports, bulletins, and maps have been published covering all major aspects of the geology and natural resources of Texas. To date, approximately one million publications have been distributed, principally through direct sales. Distribution and publication inventory have steadily increased through the years.

Bureau publications are made available to interested persons at a price determined to recover printing costs. A complete list of publications of the Bureau of Economic Geology is available on request.

### NATURAL HAZARDS OF THE TEXAS COASTAL ZONE



SHORELINE EROSION



SUBSIDENCE



FAULTING

Distribution and Occurrence  
Processes and Causes  
Impacts  
Mitigation and Reduction

1974



By  
L. F. Brown, Jr.  
Robert A. Morton  
Joseph H. McGowen  
Charles W. Kreitler  
W. L. Fisher



STREAM FLOODING



HURRICANE FLOODING



HURRICANE WINDS

**Special Publication. Natural Hazards of the Texas Coastal Zone**, by L. F. Brown, Jr., R. A. Morton, J. H. McGowen, C. W. Kreitler, and W. L. Fisher. 13 folio pages, 18 figs., 6 tables, 7 maps (\$3.00).

Natural hazards in the Coastal Zone of Texas cause millions of dollars damage, and certain hazards, such as hurricanes and stream flooding, result in the loss of many lives. Delineation and cartographic presentation of areas and zones of hazard, along with degree of severity, have been presented on a series of seven maps (scale of 1:250,000) covering the Coastal Zone. Natural hazards treated in the atlas include hurricane tidal-surge flooding and washover channels (loca-

tions), stream flooding and ponding, shoreline erosion (locations and rates), land-surface subsidence (areas and amounts), and active faults. Information about areas delineated on the maps of the atlas is based on historical observations.

A text that accompanies the atlas provides in-depth descriptions of the hazards—their causes, severity, mitigation, and aggravation. Tables and figures provide complementary information. Sources of data used in compiling the natural hazards maps include the Bureau of Economic Geology, U. S. Army Corps of Engineers, and U. S. Geological Survey. The atlas was prepared in cooperation with the Texas Coastal and Marine Council.

## REPORTS OF INVESTIGATIONS

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

Exploration for oil and gas along the Stuart City Trend in South Texas has continued for more than 30 years, spurred on largely by the discovery of the enormous fields of the Golden Lane and the Poza Rica Trend along the Gulf Coast of Mexico. The several gas fields discovered along the Stuart City Trend in South Texas during this period were considered noneconomical or marginally economical. Because of the recently increased need for natural gas, however, exploration activity along the trend in South Texas has accelerated.

This report is based on the detailed study of all cores available from the Stuart City Trend. It includes discussions of carbonate facies, environments of deposition, and diagenesis. Various kinds of porosities—intraparticle, moldic, fracture, and interparticle—have been identified from the core studies. Intraparticle porosity (primary openings within the body chambers of fossils contained in the rock) is the most commonly occurring kind, but unless openings are connected by another type of porosity, the permeability is low. The most effective porosity is the primary interparticle type, which occurs between particles in grainstone facies. Most of the primary interparticle porosity has been destroyed by several stages of carbonate cementation, which occurred in various diagenetic environments—submarine, vadose, phreatic-meteoric, and deep subsurface.

**Report of Investigations No. 79. Texas Lignite: Near-Surface and Deep-Basin Resources,** by W. R. Kaiser. 70 p., 22 figs., 7 tables, appendix (\$2.50).

This report summarizes past and recent developments in the exploitation of Texas lignite, describes the geologic setting drawing analogies with modern environments, outlines principal and potential deposits on a series of maps combining near-surface and deep-basin distribution, provides clues for exploration, and presents new resource estimates. The report also includes over 300 previously published analyses, discusses the relationship of grade and geologic setting as well as statewide variations in grade, evaluates the environ-

mental factors of utilization, and in some detail reviews the current technology in underground gasification and its applicability to Texas lignite.

The most important near-surface lignite deposits are found in the coastal plain north of the Colorado River. Already these deposits are being used as an energy source by three steam-electric plants. Additional plants are planned for the future. Statewide resources of near-surface lignite are set at approximately 10 billion short tons. About ten times that amount has been delineated in the deep-basin deposits. This vast potential resource is available only through in situ recovery methods. Underground gasification is one such method that is technically feasible. Ultimate utilization will depend on energy needs and on dwindling reserves of easily obtained fossil fuels coupled with unrealized potential of nuclear energy.

The present energy dilemma is real and immediate. In view of our shrinking oil and gas reserves, lignite will play an important role in meeting the State's energy needs in the years ahead. Besides its utilization as a boiler fuel, Texas lignite will likely be used extensively in the future for the production of synthetic gases, liquid fuels, and chemical feed stocks.

**Report of Investigations No. 80. Depositional Systems, San Angelo Formation (Permian), North Texas—Facies Control of Red-Bed Copper Mineralization,** by Gary E. Smith. 74 p., 20 figs., 9 plates, 1 table, 9 appendices.

Occurrence of copper in North Texas was noted more than 100 years ago in red-bed rocks of Permian age. Subsequent attempts to mine the copper minerals have been unsuccessful.

The aim of this investigation was to define—through surface and subsurface studies—the stratigraphic framework of the host rock and to determine the control, if any, that facies played in localizing copper mineralization. The study shows that copper occurs principally within specific facies associated with tidal-flat deposits, both intertidal and supratidal. The report presents a depositional model to explain the distribution of host facies and to provide the basis for determining possible geochemical factors involved in mineralization. Accompanying the report are subsurface maps showing net sandstone, surface geologic maps, and appendices describing measured sections, sample localities, chemical analyses, and thin sections and

polished sections. Also included are lists of core-hole and sample localities and chemical analyses previously published by the U. S. Bureau of Mines. The report provides a complete picture of the Texas red-bed copper prospects.

**Report of Investigations No. 81. Approaches to Environmental Geology**, E. G. Wermund, editor. 268 p., 125 figs., 52 tables (\$3.50).

This work presents the application of geology, geologic techniques, and geologic reasoning to the broad environmental concerns of society. It includes philosophies, concepts, experiences, procedures, and results from inventorying environmental variables of many different settings. The techniques and approaches, developed and utilized by the Bureau of Economic Geology, are applicable in many other regions of the United States and the world.

The report contains the following papers: (1) *Approaches to Environmental Geology*, by W. L. Fisher; (2) *Environmental Inventory: Innovation in Geology and Geologic Presentation*, by L. F. Brown, Jr.; (3) *Texas Statewide Resource Capability Mapping and Inventory*, by Robert S. Kier; (4) *Environmental Geologic Atlas of the Texas Coastal Zone*, by L. F. Brown, Jr., and W. L. Fisher; (5) *Environmental Units in Carbonate Terranes as Developed from a Case Study of the Southern Edwards Plateau and Adjacent Interior Coastal Plain*, by E. G. Wermund; (6) *Preliminary Environmental Geologic Mapping on the Inner Coastal Plain, Southwest Texas*, by Thomas C. Gustavson and P. Jan Cannon; (7) *Environmental Geology—An Aid to Urban Planning: Austin Area, Texas*, by L. E. Garner; (8) *Environmental Geology of the Greater Houston Area*, by C. V. Proctor, Jr., and W. Douglas Hall; (9) *Environmental Geology and Lakeshore Development*, by C. M. Woodruff, Jr.; (10) *Quantification of Resource Capability Units, Corpus Christi Area*, by Robert S. Kier and Dennis L. Bell; (11) *Coastal Zone Shoreline Changes: A Function of Natural Processes and Man's Activities*, by J. H. McGowen; (12) *Delineation and Environmental Application of Active Processes Mapped in Recharge Area of the Edwards Aquifer*, by Robert A. Morton; (13) *Environmental Geologic Mapping of Flood-Prone Areas: An Alternative to Engineering Methods*, by E. J. Dickerson; (14) *The Application of Radar Imagery to Environmental Geologic Mapping*, by P. Jan Cannon; (15) *Adapting Biologic Assemblage Data for Environ-*

*mental Needs*, by E. G. Wermund and Claudia True Waddell; and (16) *Statewide Mapping of Surface Mines—A Texas Inventory*, by C. G. Groat.

## HANDBOOKS

**Handbook 3. Fluorspar in Texas**, by W. N. McNulty, Sr. 31 p., 19 figs. (\$1.00).

Fluorspar is a basic raw material in the chemical, metallurgical, and ceramic industries. Texas deposits have assumed greater significance for future development with the increased fluorspar consumption in the United States during the past decade and with the depletion of many conventional deposits. This handbook describes the occurrences, grades, geology, uses, and prospects of development of fluorspar in the State.

**Handbook 4. Bituminous Coal in Texas**, by Thomas J. Evans. 65 p., 18 figs., 1 plate, 9 tables, 2 appendices (\$2.00).

Present uncertainty and forecasted decline in the availability of petroleum and natural gas have renewed interest in other energy resources in Texas. This handbook is a survey of bituminous coal in Texas and constitutes an initial step toward delineating the occurrence and nature of bituminous coal within the State.

Bituminous coal occurs in several areas in Texas. The most significant deposits are in North-Central Texas, where coal is widely distributed, and in South Texas, where a distinctive cannel coalfield is located in Webb County and where Late Cretaceous coals are found near Eagle Pass in Maverick County.

Texas bituminous coal occurs in thin beds (rarely more than 3 feet thick), beneath overburden of varying thickness and degree of consolidation. It is generally high-volatile C bituminous coal. The U. S. Geological Survey estimates that over 6 billion tons of coal is present in beds at least 14 inches thick and overlain by 0 to 3,000 feet of overburden.

Handbook 4 compiles the history of bituminous coal production, discusses the geologic setting, characteristics, and quality of the coal, lists all known chemical analyses, and briefly considers the potential for developing Texas bituminous coal as a contributing energy resource.

## CIRCULARS

**Geological Circular 74-1. Depositional-Episodes: Their Relationship to the Quaternary Stratigraphic Framework in the Northwestern Portion of the Gulf Basin,** by David E. Frazier. 28 p., 18 figs., 3 tables, appendix (\$0.75).

This circular describes the relationship of depositional-episodes to the stratigraphic framework of clastic deposits in the northwestern Gulf of Mexico basin, a classic area for the study of deltaic sedimentation. Three phases of development of depositional-complexes are described. Delta lobe development characterizes the first phase, floodplain and hemipelagic sediments mark the second phase, and marine transgression the third. The bounding surfaces developed during marine transgression are related to hiatal conditions and have considerable significance in worldwide correlation of Quaternary depositional-complexes.

**Geological Circular 74-2. Shoreline Changes on Galveston Island (Bolivar Roads to San Luis Pass): An Analysis of Historical Changes of the Texas Gulf Shoreline,** by Robert A. Morton. 34 p., 12 figs., 3 appendices (\$0.75).

The Texas Gulf shoreline, like other shorelines of the world, is dynamic and changing. Factors affecting change include storms, tides, sediment supply, relative sea level, and human activities such as jetty construction. Some of the change is expressed in shoreline erosion or loss of land. With current and projected waterfront development along the Texas Coast, the impact of shoreline erosion is being felt.

During the past two years, the Bureau of Economic Geology, authorized by a special appropriation of the 63rd Texas Legislature, has made a special study of Texas shoreline change. This Geological Circular presents results of a portion of that study. Six additional reports, each covering a different section of the shoreline, will be issued later.

Change and rate of change in the Texas shoreline are documented by historical monitoring, a technique developed by the Bureau of Economic Geology. Basically, the technique involves mapping the shoreline at selected historical intervals, utilizing existing photographs and coastal charts spanning the past century or more. Through

comparison of the position of the shoreline at selected intervals over a long period of time, the amount of change is determined. Such data are supplemented by ground surveys of beach profiles and by historical comparison of the shoreline to such fixed objects as wellheads and buildings or other structures.

Geological Circular 74-2 contains descriptions of the methods and procedures used in shoreline monitoring. It also describes present beach characteristics of Galveston Island and changes in the shoreline position during prehistoric time and in historic time (between 1838 and 1973). It discusses factors affecting shoreline and vegetation-line changes and predicts future changes along the Galveston Island shoreline.

**Geological Circular 74-3. A Numeric Code for Describing Rocks in Sedimentary Basins,** by E. G. Wermund and Charles A. Caughey. 28 p., 4 figs., 3 tables, 2 appendices (\$1.00).

The circular presents a numeric system of encoding rock data for multiple uses, including (1) mapping subsurface stratigraphy for economic exploration, (2) cataloging borings used in subsurface waste disposal, and (3) building a library of natural resource information. The system utilizes color, texture, structure, minerals, fossils, and porosity to describe the rock. The numeric encoding of lithology for sedimentary basins is employable in Universal Transverse Mercator or longitude-latitude coordinates. It can be used to describe rock outcrops, borehole samples, and logs of subsurface rocks.

**Geological Circular 74-4. Potential Geothermal Resources of Texas,** by Myron Dorfman and Ralph O. Kehle. 33 p., 17 figs., 3 tables (\$0.75).

With demand for energy raw materials now exceeding supply, geothermal deposits are a potentially major source of energy in some areas. This report, prepared by Myron Dorfman, Department of Petroleum Engineering, and Ralph O. Kehle, Department of Geological Sciences, The University of Texas at Austin, presents results of a preliminary investigation of the potential geothermal resources of Texas.

The circular outlines general features of the Earth's heat system, processes leading to the formation of geothermal waters, and the major

types of geothermal deposits. It places special emphasis on potential geothermal resources of two regions of Texas: the Trans-Pecos country and the Gulf Coastal Plain (and adjacent offshore areas). Hot water convective systems and hot-dry rock deposits, similar to the geothermal deposits of the western United States, probably occur in the Rio Grande rift system of the Trans-Pecos country. Portions of the Texas Gulf Coastal Plain and adjacent offshore areas are underlain at depth by abnormally pressured deposits of hot water, known as geopressed geothermal deposits. The Gulf Coast deposits, discovered in drilling for oil and gas, are the best documented deep, abnormally pressured deposits of hot water in the world.

The report summarizes work to be completed before a definitive assessment of Texas geothermal resources can be made. It also includes discussion of the technology of exploration and development, costs of geothermal power, and environmental effects of the production of geothermal waters.

**Mineral Resource Circular No. 55. The Mineral Industry of Texas in 1972**, by S. O. Wood, Jr., and Roselle Girard. 32 p., 1 fig., 26 tables (free on request).

This circular is a preprint from the U. S. Bureau of Mines, "Minerals Yearbook 1972." It was prepared through a cooperative arrangement between the U. S. Bureau of Mines and the Bureau of Economic Geology. A table showing the value of mineral production in individual Texas counties during the year, a review of production of mineral fuels, industrial minerals, and metals in 1972, and a list of principal mineral producers in Texas are included. The circular is an annual issue of the Bureau.

## GEOLOGIC ATLASES

**Geologic Atlas of Texas. Austin Sheet.** Francis Luther Whitney Memorial Edition; mapping compiled by C. V. Proctor, Jr., T. E. Brown, J. H. McGowen, and N. B. Waechter; V. E. Barnes, project director; reviewed and edited by the Geologic Atlas Committee of the Austin Geological Society. Scale 1:250,000, in full color, topographic base (\$2.50).

The Austin Sheet, an areal geologic map with topography and culture, covers all or part of

Austin, Bastrop, Bell, Brazos, Burleson, Burnet, Caldwell, Fayette, Grimes, Hays, Lee, Leon, Madison, Milam, Robertson, Travis, Waller, Washington, and Williamson Counties within an area of 1° of latitude (30°00' to 31°00' N) by 2° of longitude (96°00' to 98°00' W). The map is a memorial edition honoring Francis Luther Whitney. Dr. Whitney, professor of geology at The University of Texas at Austin for more than 40 years, died in 1962. During his chairmanship in the 1920's, the Department of Geology changed from a purely academic department to one that recognized the role of geology in industry. Many of Dr. Whitney's students became oil company executives and otherwise distinguished themselves in their profession.

**Geologic Atlas of Texas. Big Spring Sheet.** Vincent Charles Perini, Jr., Memorial Edition; mapping compiled by G. K. Eifler, Jr.; V. E. Barnes, project director; reviewed and edited by the Geologic Atlas Committee of the West Texas Geological Society. Scale 1:250,000, in full color, topographic base (\$2.50).

The Big Spring Sheet, an areal geologic map with topography and culture, covers all or part of Borden, Coke, Dawson, Fisher, Garza, Glasscock, Howard, Jones, Kent, Lynn, Martin, Midland, Mitchell, Nolan, Runnels, Scurry, Sterling, Stonewall, and Taylor Counties within an area of 1° of latitude (32°00' to 33°00' N) by 2° of longitude (100°00' to 102°00' W). The map is a memorial edition honoring Vincent Charles Perini, Jr. (1895-1965). An independent geologist and oil producer for many years, Mr. Perini was considered by his colleagues to be the dean of geologists in West-Central Texas. He was a founder and the first president of the Abilene Geological Society. After his death, that Society established the V. C. Perini, Jr. Fellowship as a memorial to him and to his accuracy in mapping surface geology.

**Geologic Atlas of Texas. Brownfield Sheet.** Nelson Horatio Darton Memorial Edition; mapping for the Texas portion compiled by G. K. Eifler, Jr., and for the New Mexico portion by C. C. Reeves, Jr.; V. E. Barnes, project director; reviewed and edited by the Geologic Atlas Committee of the West Texas Geological Society. Scale 1:250,000, in full color, topographic base (\$2.50).

The Brownfield Sheet, an areal geologic map with topography and culture, covers all or part of

Bailey, Cochran, Hale, Hockley, Lamb, Lubbock, Lynn, Terry, and Yoakum Counties in Texas and Chaves, Lea, and Roosevelt Counties in New Mexico within an area of 1° of latitude (33°00' to 34°00' N) by 2° of longitude (102°00' to 104°00' W). The map is a memorial edition honoring the late Nelson Horatio Darton. Dr. Darton, a pioneer geologist of the U. S. Geological Survey, is remembered for many accomplishments. Among them are his investigations of the geology and ground water of the Great Plains and the West and his detailed and reconnaissance geologic and topographic mapping. His "Geologic Map of New Mexico," scale 1:500,000, was published by the U. S. Geological Survey in 1928. "Geologic Map of Texas" (preliminary edition), which he prepared with L. W. Stephenson and Julia Gardner, was issued by that Survey in 1932, with a later edition published in 1937.

**Geologic Atlas of Texas. San Antonio Sheet. Robert Hamilton Cuyler Memorial Edition, mapping compiled by T. E. Brown and N. B. Waechter; V. E. Barnes, project director. Scale 1:250,000, in full color, topographic base (\$2.50).**

The San Antonio Sheet, an areal geologic map with topography and culture, covers all or part of Atascosa, Bandera, Bexar, Blanco, Comal, Edwards, Frio, Guadalupe, Hays, Kendall, Kerr, Medina, Real, Uvalde, Wilson, and Zavala Counties within an area of 1° of latitude (29°00' to 30°00' N) by 2° of longitude (98°00' to 100°00' W). The map was sent to San Antonio for review by the Geologic Atlas Committee of the South Texas Geological Society. The map is a memorial edition

honoring Robert Hamilton Cuyler. Dr. Cuyler, professor of geology at The University of Texas at Austin, was on leave for military service at the time of his death in 1944. He was killed in a plane crash in Blanco County. Dr. Cuyler was an enthusiastic and capable teacher and is remembered also for his work on Lower Cretaceous rocks and on the use of vegetation in identification of geologic formations.

**Geologic Atlas of Texas. Seguin Sheet. Donald Clinton Barton Memorial Edition; mapping compiled by C. V. Proctor, Jr., T. E. Brown, N. B. Waechter, and Saul Aronow; V. E. Barnes, project director; reviewed and edited by Geologic Atlas Committees of the Austin Geological Society and the Houston Geological Society. Scale 1:250,000, in full color, topographic base (\$2.50).**

The Seguin Sheet, an areal geologic map with topography and culture, covers all or part of Austin, Bastrop, Caldwell, Colorado, DeWitt, Fayette, Fort Bend, Gonzales, Guadalupe, Hays, Jackson, Karnes, Lavaca, Matagorda, Victoria, Waller, Wharton, and Wilson Counties within an area of 1° of latitude (29°00' to 30°00' N) by 2° of longitude (96°00' to 98°00' W). The map is a memorial edition honoring Donald Clinton Barton. Dr. Barton, geologist and geophysicist, was noted for his comprehensive contributions to the understanding of salt dome structures in Texas and Louisiana. Dr. Barton held geological positions with various oil companies and was an independent consultant from 1927 to 1935. At the time of his death in 1939, he was working with Humble Oil & Refining Company (Exxon).

## PUBLICATIONS IN PRESS OR IN FINAL PREPARATION

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

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

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

**Report of Investigations.** Depositional Systems in the Canyon Group (Pennsylvanian System) of North-Central Texas, by Albert W. Erxleben.

**Report of Investigations.** Environmental Geology in Coastal Zone Development, An Analysis of Physical Properties and Processes, San Jose, Mustang, and North Padre Islands, Texas, by R. A. Morton and M. Amdurer.

**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.** Historical Changes and Related Coastal Processes, Gulf and Mainland Shorelines, Matagorda Bay Area, Texas, by J. H. McGowen and J. L. Brewton.

**Report of Investigations.** Inventory and Environmental Effects of Surface Mining in Texas, by C. G. Groat.

**Report of Investigations.** Land and Water Resources of the Corpus Christi Area, by Robert S. Kier, Dennis Bell, Michael Dildine, James Woodman, and William L. Fisher.

**Report of Investigations.** The Moore Hollow Group of Central Texas, by V. E. Barnes and W. C. Bell.

**Geological Circular.** Geothermal Resources—Frio Formation, South Texas, by D. G. Bebout, M. H. Dorfman, and O. K. Agagu.

**Geological Circular.** 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.

**Mineral Resource Circular.** Gold and Silver in Texas, by Thomas J. Evans.

**Mineral Resource Circular.** Native Bituminous Materials in Texas, by Thomas J. Evans.

**Geologic Atlas of Texas.** Beeville-Bay City Sheet, V. E. Barnes, project director.

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

**Geologic Atlas of Texas.** San Angelo Sheet, V. E. Barnes, project director.

**Geologic Quadrangle Map.** Kingsland Quadrangle, Llano and Burnet Counties, Texas, by V. E. Barnes.



## PUBLICATIONS REPRINTED

The following publications were reprinted during 1974 and are again available for distribution.

**Geological Circular 71-1.** Resource Capability Units—Their Utility in Land- and Water-Use Management With Examples from the Texas Coastal Zone, by L. F. Brown, Jr., W. L. Fisher, A. W. Erxleben, and J. H. McGowen. 22 p., 4 figs., 1971 (3rd printing; \$0.50).

**Geologic Quadrangle Map No. 26.** Geology of the Eagle Mountains and Vicinity, Hudspeth County, Texas, by J. R. Underwood, Jr. Scale 1:48,000, 32-page text, 1963 (2nd printing; \$2.25).

**Report of Investigations No. 61.** Hurricanes as Geological Agents: Case Studies of Hurricanes Carla, 1961, and Cindy, 1963, by M. O. Hayes. 56 p., 30 figs., 1967 (2nd printing; \$1.25).

**Special Publication.** Delta Systems in the Exploration for Oil and Gas, by W. L. Fisher, L. F. Brown, Jr., A. J. Scott, and J. H. McGowen. Syllabus for research colloquium held in Austin, Texas, August 27-29, 1969. 212 p., 168 figs., 1969 (7th printing; \$5.00).

## OPEN-FILE MATERIAL

The Bureau of Economic Geology maintains an open file of reports, maps, and manuscripts obtained from various sources. Most are unpublished, although a few are progress reports that ultimately will be published. Work maps and data developed in connection with Bureau projects now underway may be examined and studied at the Bureau offices. Placed on open file during 1974 were: (1) "Aeromagnetic Map of Part of the Texas Coastal Plain," U. S. Geological Survey Open-File Report 74-100, 1 plate, scale 1:250,000 (the map on file at this Bureau is not of reproducible quality; orders for copies should be directed to Public Inquiries Office, U. S. Geological Survey, Room 1-C-45, 1100 Commerce Street, Dallas, Texas 75202); (2) "Geologic Evaluation of a Central Texas Kaolinite Prospect, Falls County, Texas," by Ray E. Ferrell, Jr., 46 p., 13 figs., appendix, 15 corehole logs, 1969 (presented by A. M. Rozeman, Shreveport, Louisiana); (3) work notes and data, including maps, charts, and other material developed during an iron ore investigation in Anderson County, Texas, 1957-1961, by DeGolyer and MacNaughton, Inc., for Sovereign Research, Inc. (presented by Texas Power & Light Company); (4) "Preliminary Report on Permian Red Bed Copper Deposits, North-Central Texas," by W. E. Galloway, 19-page typescript report, maps, charts, and additional data. Materials placed on open file from outside sources may be examined and copied, but publication rights are reserved.

## PAPERS BY BUREAU OF ECONOMIC GEOLOGY STAFF IN OUTSIDE PUBLICATIONS

Barnes, V. E. (with Margolis, S. V.), 1974, Electron microprobe examination of inhomogeneities in tektites (abstract): West Berlin and Regensburg, International Mineralogical Association, Collected Abstract, IMA 1974, Ninth General Meeting, p. 149.

Bebout, D. G., and Loucks, R. G., 1974, Cementation of carbonate grainstone body—Lower Cretaceous Stuart City Trend, South Texas (abstract): American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, Annual Meetings Abstracts, v. 1, p. 4-5.

Bebout, D. G., 1974, Lower Cretaceous Stuart City Shelf margin of South Texas—its depositional and

diagenetic environments and their relationship to porosity: Gulf Coast Association of Geological Societies, Transactions, v. 24, p. 138-159.

Bebout, D. G. (with Hoover, R. A.), 1974, Structural and topographic control of sediment deposition, Magdalena Slope, offshore northern Colombia (abstract): American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, Annual Meetings Abstracts, v. 1, p. 46.

Brown, L. F., Jr., 1974, Critical role for geologists in resource and environmental management: American Association of Petroleum Geologists, Bulletin, v. 58, no. 9, p. 1771-1780.

Brown, L. F., Jr., Cleaves, A. W., and Erxleben, A. W., 1974, Deltaic systems within evolving foreland and cratonic basins, North-Central Texas (abstract): American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, Annual Meetings Abstracts, v. 1, p. 12-13.

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## NEW STAFF

The Bureau staff increased in 1974 with the addition of six research scientists and five full-time research assistants.

### Richard L. Andersen

Richard L. Andersen completed studies for his M. S. degree at the University of California at Berkeley in June 1974 and joined the Bureau staff in September. His thesis involved geological and soil engineering studies of the Mt. Diablo landslide in California. At Berkeley, he participated in a Sea Grant study of the sequential environmental effects of human activities in the California Coastal Zone. He earlier received his B. S. degree (1968) from Utah State University. Between degrees, Andersen served in the U. S. Army as a microwave radio repairman.

Andersen is a member of the Geological Society of America and the Austin Geological Society. At present, he is working on the South Texas environmental mapping project.

### Joyce M. Basciano

Joyce M. Basciano received a B. A. degree (1971) in geology from Hunter College, The City University of New York, and an M. A. degree (1971) from Indiana University, Bloomington. Her Master's research involved a fracture study of a karst drainage basin in southern Indiana. From June 1973 to May 1974, she was a research assistant for the Water Resources Research Center at Indiana University. Her duties included monitoring water quality at three local landfills.

Since joining the Bureau staff in September, she has been working on the South Texas environmental geology project and East Texas lignite project.

### John L. Chin

John L. Chin, who joined the Bureau of Economic Geology staff in September, received a B. A. degree from The University of Texas at Austin in May 1974, with a major in botany and a minor in geology. During the summers of 1973 and 1974, he was a research assistant and student at The University's Marine Science Institute at Port Aransas; in the spring of 1974, he was a student assistant in the Department of Geological Sciences.

Chin's research interests are primarily in coastal geology and marine science including barrier island formation and evolution, Pleistocene depositional systems, and correlation of ancient shorelines. He currently is working with R. A. Morton on the historical monitoring of the Texas Gulf Coast shoreline.

Chin is a member of the Paleontological Society.

### Edgar H. Guevara

Edgar H. Guevara joined the full-time Bureau research staff in October. He previously worked for Compañía Shell de Venezuela, Caracas, as an exploration geologist (1965-1970) and as a production geologist (December 1973-September 1974). He also taught at Universidad Central de Venezuela, Caracas, in 1974. He was a part-time research assistant at the Bureau of Economic Geology from January to August, 1972.

Guevara received the degree of Geólogo in 1965 from Universidad Central de Venezuela, Caracas, and his M. A. (1972) and Ph.D. (1974) degrees in geology from The University of Texas at Austin. His graduate work dealt with sedimentary facies and depositional systems of Cenozoic stratigraphic units of the Texas Coastal Plain.

During 1974, he worked on the stratigraphy of Late Tertiary-Quaternary sediments of the subsurface of the Houston area as part of a Bureau project on active faulting and subsidence of this region.

Guevara is a member of the Colegio de Ingenieros de Venezuela, Sociedad Venezolana de Geólogos, Asociación Venezolana de Geología, Minería y Petróleo, and the American Association for the Advancement of Science.

### Christopher D. Henry

Christopher D. Henry joined the Bureau of Economic Geology in December. He received a B. S. degree in geology from the California Institute of Technology in 1969 and an M. A. degree in geology from The University of Texas at

Austin in 1972. He has completed final requirements for a Ph.D. degree from The University of Texas at Austin. His dissertation work involves geologic mapping and geochemical study of granitic intrusions in Sinaloa, western Mexico.

Henry is a member of the Geological Society of America, the American Geophysical Union, and The American Geochemical Society. At present, he is working on the South Texas environmental geology project. His research interests include geochemistry applied to environmental and economic geology problems.

#### Ernst H. Kastning, Jr.

Ernst H. Kastning, Jr., who joined the Bureau of Economic Geology research staff in December, holds a B. E. E. degree (1966) in electrical engineering from Rensselaer Polytechnic Institute and an M. S. degree (1974) in geology from the University of Connecticut. His thesis concerned cavern development in the Helderberg Plateau of East-Central New York. He worked as an analytical engineer for Pratt & Whitney Aircraft from 1966 to 1971 and as a geophysicist with Texaco from 1973 to 1974.

Kastning is a member of the Geological Society of America, Phi Kappa Phi, Cave Research Foundation, and the Explorers Club. His research interests are hydrogeology and geomorphology. He is working on active faulting in the Houston region.

#### Maryann M. McGraw

Maryann M. McGraw received her B. A. degree in geology from The University of Texas at Austin in May 1974 and became a full-time Bureau research assistant the following September. Her main research interests are sedimentology and petrology. At present, she is working on the Bureau's South Texas environmental geology project.

#### Tom L. Rowland

Tom L. Rowland joined the Bureau of Economic Geology research staff in September. He received his B. S. (1956), M. S. (1959), and Ph. D. (1970) degrees in geology from the University of Oklahoma. Between graduate degrees, Rowland worked three years in the lime industry and four

years with the Oklahoma Geological Survey. In 1969, he returned to the Oklahoma Geological Survey where he remained until coming to the Bureau.

Stratigraphic analysis of carbonate rocks, sedimentation, surface and subsurface lithostratigraphy, and economic evaluation of carbonate rocks for potential industrial use are his specialties. At yearend, he was working on the South Texas environmental mapping project.

Rowland is a member of the Geological Society of America, American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, Oklahoma City Geological Society, and the Society of The Sigma Xi.

#### Anita R. Trippet

Anita R. Trippet joined the Bureau of Economic Geology staff in April. She received her B. A. (1965) and M. A. (1967) degrees in geology from Baylor University and previously was employed by Texaco, Inc., in New Orleans. Her Master's thesis is a study of the effect of geology on human environmental factors.

Mrs. Trippet's research interests center on environmental geology, and during the year she contributed to the Bureau's Environmental Geologic Atlas of the Texas Coastal Zone project. Her current primary responsibility at the Bureau is with the Geologic Atlas of Texas project; since joining the staff, she has worked on the Brownwood, Beeville-Bay City, and Laredo-Corpus Christi Sheets of the atlas.

Mrs. Trippet is a member of the Austin Geological Society.

#### Preston M. Walters

Preston M. Walters, after having worked for the Bureau in several capacities on a part-time basis, became a full-time research assistant in June on a summer appointment, which was extended in September. He received a B. S. degree (1973) in geology from The University of Texas at Austin and has completed one year of course work toward the requirements for a Master's degree, also at The University. His principal research interests are depositional systems, petrology of shales, and environmental geology. He currently is working on the Bureau's Environmental Geologic Atlas of the Texas Coastal Zone.

### Bonnie R. Weise

Bonnie R. Weise received her B. S. degree in geology from The University of Texas at Austin in August 1974, and joined the Bureau staff in September as a full-time research assistant. During the fall, she participated in the Bureau's study of Texas surface-mined land. She currently is assisting

with a study being conducted by the Center for Energy Studies on the impact of nuclear power in the State. As a member of the Bureau staff, she also is helping coordinate plans for the meeting of the South-Central Section of the Geological Society of America that is to be held at The University of Texas at Austin in March 1975.

## 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 has been maintained in energy and mineral resource investigations. 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.

In recent years, substantial interest has developed in the nature, use, and conservation of the land resources of Texas. The Bureau's program in land resources, conducted through its Land Resources Laboratory, 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, a number of projects in basic research, systematic geologic mapping, mineral statistics, and cataloging are maintained.

### Energy Resource Investigations

**Evaluation of Geothermal Resources of the Texas Gulf Coast.**—D. G. Bebout and Myron Dorfman, Department of Petroleum Engineering, assisted by O. K. Agagu, G. E. Granata, G. B. Sanders, Jr., and J. H. Seo.

The presence of a geopressed zone containing fluids with high temperatures has been established for a number of years by wells penetrating Tertiary sediments in search for oil and gas reservoirs along the Texas Gulf Coast. As few wells produce oil or gas from the high-temperature zone, the regional sand distribution within the zone has not received much attention. Limited data, however, indicate that the pore spaces within the sandstones in the geopressed zone are filled with very hot, methane-saturated waters that contain a relatively low percentage of dissolved solids.

The objective of this project is to assess the potential of the geopressed, high-temperature waters as a source of thermal energy and methane gas. The project involves a regional study of sandstones of the Frio Formation, which is one of the primary reservoirs in the geopressed zone.

The first part of the study dealing with the southern Gulf Coast of Texas was funded in June by the U. S. Atomic Energy Commission through the Lawrence Livermore Laboratory and the Center for Energy Studies, The University of Texas at Austin. That phase of the project was completed in October and a report, "Preliminary Evaluation of Geothermal Resources of South Texas," was prepared.

Funding for an additional five-month period will be received from the U. S. Atomic Energy Commission for the purpose of continuing the study into the middle Gulf Coast of Texas. The project was underway at yearend.

**In Situ Gasification of Texas Lignite.**—W. R. Kaiser.

The project, initiated in November 1974, is a study of the geology and resources of the deep-basin lignite of the upper Texas Gulf Coastal Plain. Such lignite, which occurs at depths of 200 to 5,000 feet below the surface, is a potential source of low-Btu gas that can be produced by igniting

and burning the lignite underground. Resources in excess of 100 billion tons have previously been delineated. The current investigation focuses on the lignite deposits of the Calvert Bluff Formation (Wilcox, Tertiary) north of the Colorado River in East and Central Texas. The project, which has as its purpose the eventual selection of suitable sites for gasification operations, is scheduled for completion in November 1975.

**Uranium Potential and Genetic Stratigraphy of the Triassic Dockum Group of the Texas Panhandle.**—J. H. McGowen and research assistants.

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 minerals, 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 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 to warrant it. Both surface and subsurface trends are being considered. The entire sequence of terrigenous clastic facies will be evaluated within the Texas Panhandle.

A report on the results of the study will be prepared late in 1975, with publication expected in 1976.

**Lower Cretaceous Carbonates, South Texas.**—D. G. Bebout, assisted by F. G. Cornish and R. L. Loucks.

The initial study for this project dealt with the Lower Cretaceous carbonates along the Stuart City shelf-margin trend. All cores available from wells along this trend were studied in detail. Bureau Report of Investigations No. 78 summarizes the results of this work.

Subsequent studies have concentrated on the older carbonates of the Pearsall and Sligo Formations from throughout the South Texas area. The goal of this phase of the project is to obtain a better understanding of the depositional environ-

ments and diagenetic alteration, both of which control the distribution of porosity and location of prospective areas for exploration for oil and gas.

The study of the Pearsall Formation is in progress by R. L. Loucks as his doctoral dissertation; it will be completed by August 1975. The study of the Sligo Formation is being conducted by D. G. Bebout and F. G. Cornish; most cores have been logged, and core data are being assembled into cross sections for interpretation. A report will be prepared during 1975.

**Virgil-Wolfcamp Facies, Eastern Shelf, North-Central Texas.**—L. F. Brown, Jr., assisted by Raul Solis.

This regional study of the surface and subsurface in a 30-county area of North-Central Texas involves the examination of approximately 10,000 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 being tabulated during late 1974; maps are expected to be completed in 1975.

A Ph.D. dissertation by A. W. Cleaves on the Strawn Group of North-Central Texas was near completion in late 1974; this study was an outgrowth of the project. Studies of the Canyon Group by A. W. Erxleben, which also developed from the project, will be published as a Report of Investigations in 1975.

**Miscellaneous Bituminous Materials: A Survey of Asphaltic Limestone, Tar Sands, and Oil Shale Deposits in Texas.**—Thomas J. Evans.

This project represents a compilation of information concerning the various deposits of native bituminous materials in the State. Interest in alternative energy resources has focused on such diverse deposits as asphalt-impregnated limestones and sandstones, oil-bearing sandstones, and oil-shale deposits. Designed as an initial survey of publicly available information with additional unpublished information included, this report is in final manuscript form and will be published in 1975.

**Analysis of the Impact of Various State Nuclear Policies on Nuclear Power Plant Development in**



**Texas.**—C. G. Groat and C. W. Kreitler, assisted by B. R. Weise, W. P. Bartow, and R. S. Fox.

The project, funded by the National Science Foundation, is being conducted by several departments of The University of Texas at Austin. The portion of the project assigned to the Bureau of Economic Geology calls for an analysis of the availability of uranium, the environmental impact of uranium mining, and the criteria for power plant siting. The project was nearing completion at yearend.

**Uranium in Volcanic Terranes.**—C. G. Groat and W. B. Anderson.

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. Work on the project will continue in 1975.

**Salt Domes for Radioactive Waste Disposal.**—W. R. Kaiser, assisted by M. P. Plamondon.

The project, initiated in April and completed in November, was funded by the U. S. Atomic

Energy Commission. It involved an investigation of the suitability of salt domes of the Gulf Coast region of Texas, Louisiana, Mississippi, and Alabama as sites for the disposal of high-level radioactive waste. The investigation included an assessment of the tectonic stability of the domes to determine if any are moving at a rate that threatens long-term isolation of the waste. Studies also were made of the hydrologic integrity of the domes to determine if the waste materials would be protected from dispersal by circulating ground waters. A report on the project is scheduled for publication as a Bureau Geological Circular.

**Texas Public Lands—Estimate of Future Oil and Gas Production from Established Fields of Texas Gulf Coast, Offshore Areas, Bays, and Estuaries.**—W. R. Stearns.

The project is an investigation of oil and gas reserves of State-owned lands in the Gulf Coast and offshore areas. Necessary oil and gas data have been acquired and processed. The first phase of the study, pertaining to the lower Gulf Coast, has been completed, while investigation of the upper Texas Coast and offshore areas is continuing. The aim of this long-term project is to survey and evaluate the mineral resources of all lands owned by the State of Texas.

### Land and Environmental Resource Investigations

**Environmental Geologic Atlas of the Texas Coastal Zone.**—L. F. Brown, Jr. (project coordinator), W. L. Fisher, J. H. McGowen, C. G. Groat, J. L. Brewton, T. J. Evans, and research assistants.

When completed, this atlas series will comprise 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 1974, the maps for the Kingsville, Corpus Christi, and Port Lavaca areas were completed and printed. At yearend, manuscripts for the Port Lavaca Atlas and for the Bay City-Freeport Atlas had been prepared, and texts were being reviewed. Manuscript for the Kingsville Atlas also is

scheduled for review in 1975. Writing for the Corpus Christi Atlas began late in the year. Initial color proofs of the final atlas of the series, the Brownsville-Harlingen area, were completed in late 1974. 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."

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 five years. The atlas set 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.

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

The purpose of this two-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 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 the 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 1974, preliminary reports were completed for Gulf shoreline areas, including Galveston Island, Follets Island, Brazos delta, Sargent Beach, south Padre Island, and Brazos Island. Reports for the remaining Gulf shoreline will be completed in 1975. A final report, with cartographically scribed, precise maps, will be published in 1976. Work copies of all detailed maps are on open file at the Bureau of Economic Geology.

**Land Resources of Texas: Mapping and Classification.**—R. S. Kier, A. E. St. Clair, L. E. Garner, L. F. Brown, Jr., E. G. Wermund, and J. L. Brewton; assisted by F. B. Vann, S. A. Scanlon, E. E. Theilig, and L. P. Jones.

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 78 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 78 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.

The text, for which data were compiled during the year, is expected to be ready for editorial review during 1975. It will include descriptions of the capability units, related geologic formations and soils units, physical and engineering properties, associated faunal and floral types, topography and slope, regional distribution, current land use, limitations on land use, and resource attributes.

**Statewide Current Land-Use Map.**—P. J. Cannon and A. E. St. Clair, assisted by J. L. Boone, G. O. Dent, and R. M. Summer.

The objective of this project, begun in December 1973, is to compile an up-to-date statewide land-use map, using ERTS (Earth Resources Technology Satellite) imagery. Map units follow the national land-use classification system developed by the U. S. Geological Survey (1967), but are modified to reflect more precise current land use in Texas. 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 placed on open-file status at the Bureau of Economic Geology and will be available for reproduction by anyone interested. 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, the open-file maps will be updated.

**Environmental Analysis and Mapping of the Nueces, San Antonio, Guadalupe, and Lavaca River Basins.**—E. G. Wermund (project director), R. L. Andersen, P. J. Cannon, L. W. Epps, L. E. Garner, T. C. Gustavson, C. D. Henry, R. A. Morton, T. L. Rowland, and C. M. Woodruff, Jr., assisted by J. M. Basciano, J. L. Boone, G. O. Dent, S. A. Holden, P. E. Luttrell, M. M. McGraw, H. L. Sadik, R. M. Sumner, and E. E. Theilig.

This long-term project, initiated in June 1972 under contract with the Texas Water Development Board, 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. Objectives of the project call for preparation of the following maps as a part of the environmental inventory: basic environmental geology map and slope map (scale 1:125,000), and physical properties map, active processes map, biologic assemblages map, current land-use map, man-made features map, and mineral and energy resources map (scale 1:250,000).

The first phase of the project was concerned with an area that includes the southern Edwards Plateau and Cretaceous coastal plain to south of U. S. Highway 90 and east of U. S. Highway 81. 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 3,700 square miles of croplands.

During 1973, 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 in the region 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. Many private wells in the aquifer supply water both for households and for animals in this predominantly agricultural-ranching region. In recent years, there also has been an increasing demand for irrigation water from the Carrizo-Wilcox sand aquifer.

By yearend, mapping in all of the project area was completed, and boundaries among the various river basins were corrected. The river-basin mapping of this project ties in directly and congruently with the mapping of the Corpus Christi Sheet of the Bureau's Environmental Geologic Atlas of the Texas Coastal Zone.

Project plans for 1975 include (1) completion of scribing, corrections, and final hand coloring of all the required maps, and (2) initiation of the writing of a report on the environmental geology of the Upper Nueces, Upper Guadalupe, Lower Nueces, Frio-Atascosa, and Lower Guadalupe River basins. Maps are scheduled for completion by September 1, 1975.

**Reactor Siting Hazards: Faulting and Fault Activation in the Texas Coastal Zone.**—L. F. Brown, Jr., C. W. Kreitler, E. H. Guevara, and research assistants; 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 one of the continuing, comprehensive investigations of the interrelated roles of ground-water level declines, subsidence, and fault activation in the Houston area. Recent activation of faults in the region of maximum ground-water withdrawal and subsidence points to possible relationships that must be understood in order to evaluate and to mitigate fairly the future impact of massive use of ground water.

Studies of aquifer composition and of subsurface stratigraphy are being carried out by Edgar H. Guevara. Charles W. Kreitler is involved in the analysis of structural lineations and geohydrologic aspects of the program.

The uncertain nature of structural lineations that are noted on aerial photographs and the degree of their relationship to faulting in the coastal plain are urgent problems that warrant continued study. The coincidence of linear zones

with active faults and with zones of accelerated differential subsidence is an important relationship that is being investigated.

A report on the results of the project is expected in late 1975 with publication expected during 1976.

**Environmental Geology in Coastal Zone Development.**—R. A. Morton, assisted by M. Amdurer.

An analysis of physical properties and processes on San Jose, Mustang, and north Padre Islands, Texas, was conducted as part of this project, funded by the Sid W. Richardson Foundation. Emphasis was on the role of environmental geology in barrier island development and on some of the potential limitations to development, such as resource capability, natural hazards, and legal constraints. The project was initiated and completed during 1974. A report containing maps of environmental geology, eolian landforms, wetlands, and active processes was submitted to the Sid W. Richardson Foundation and is scheduled for publication by the Bureau of Economic Geology.

**Matagorda Bay and Environs, A Pilot Study.**—J. H. McGowen and W. D. Oliver, General Land Office, assisted by J. R. Byrne.

This cooperative project initiated in 1971 between the Bureau of Economic Geology and the General Land Office was coordinated by J. H. McGowen of the Bureau and Wayne D. Oliver of the General Land Office. The study was conducted in two phases. The first phase was designed to document the direction and rate of Gulf and mainland shoreline changes and to determine the geologic processes effecting these changes. A report on the results of this phase is in press.

The purpose of the second phase of the study was to map the distribution of surface sediment, trace metals, and molluscs within Matagorda Bay and associated bays and within the fluvial systems that discharge into these bays.

Field and laboratory work has been completed for phase two, maps have been generated, and the report is in preparation. J. R. Byrne, who made the textural analyses and clay mineral determinations, is also assisting with the report writing.

**Criteria for Coastal Zone Management.**

During 1971, an interdisciplinary 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. It 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 of 1972, the research team continued work under a two-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 two years.

Participating in the interdisciplinary research team are: R. S. Kier (project coordinator), W. L. Fisher, 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 1974 were D. L. Bell, J. T. Woodman, P. C. Patton, R. S. Kerr, and W. D. Kuenzi.

During 1974, the team continued to focus 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. The reports present: (1) an assessment of the natural ability of the land and water resource units to withstand various uses; (2) quantification of physical properties of the land-capability units based on soils test data gathered from Nueces, San Patricio, Aransas, and Refugio Counties; (3) determination of hydrogeology of the entire 13-county area, including amount, distribution, and quality of ground water available for future use (data in part derived from Master of Science thesis work by J. T. Woodman and D. L. Bell at The University of Texas at Austin); (4) documentation in general terms of the kinds and rates of natural and man-induced changes in dynamic environments along the coastline; and (5) development of an automated data processing system combining land and water resource information with current and predicted land-use data to

assess the direct environmental impacts of demographic and economic growth in the Corpus Christi area projected to 1980 and 1990.

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 the second half of 1974, the research team began studying community development and public park utilization on Mustang and northern Padre Islands. Bureau objectives during this phase of the study include: (1) preparation of an updated land and water resource map at a scale of 1:24,000; (2) historical documentation of Gulf and bay shoreline changes, including directions and rates of change; (3) establishment of standards by which dunes can be evaluated in terms of importance and criticality, and the identification of critical dune areas; (4) determination of natural stability of certain environments and interpretation of historical changes in those environments, which include grassflats, marshes, and washover channels; and (5) delineation of historical land-use patterns and associated changes in natural environments.

Information and data gathered by the Bureau, in addition to data gathered by the other research teams, will be used to evaluate the environmental and economic effects of planned recreational developments on Mustang and northern Padre Islands. During the final year of study, 1975-1976, the established methodology will be transferred and applied to another region in the Texas Coastal Zone.

**Land and Water Resources Map of the Houston-Galveston Area Council of Governments (HGACOG) Region.**—A. E. St. Clair, L. F. Brown, Jr., and E. G. Wermund, assisted by L. P. Jones, E. E. Theilig, and A. R. Trippet.

This project, initiated in 1974 under contract with the Houston-Galveston Area Council of Governments, is designed to provide a map for planning land and water development in the HGACOG region. The final product is to be a colored map (scale 1:125,000) that indicates land and water resource units in 13 counties with a legend and a table of engineering properties. The map will consist of four sheets, each approximately 30 x 42 inches.

The project involves preparation of a new base map (scale 1:125,000) of the HGACOG region and compilation of land and water resource data for the map. The base map is constructed mostly from the U. S. Geological Survey standard 7.5-minute quadrangles, scale 1:24,000. The new base map shows culture, drainage, and topography. Urban boundaries and drainage systems are updated from 1972 photography.

The land and water resource units are derived from two sources. For the southern half of the project area, units are derived from the environmental geology maps of the Bureau's Environmental Geologic Atlas of the Texas Coastal Zone—the coastal areas were mapped for the atlas by J. H. McGowen and W. L. Fisher. The units in the northern half of the project area are derived from a resource capability map of the National Aeronautics and Space Administration's Houston Area Test Site; C. V. Proctor, Jr., mapped this area in 1973. A. E. St. Clair has checked unit boundaries, described the units for the legend, and compiled a table showing the relation of land and water resource units to natural suitability of use according to known engineering properties.

An accurate hand-colored copy of the map was completed in December 1974. The map is scheduled to be printed in June 1975. A report on the inventory of land and water resources will be published at a later date.

**Land and Water Resources of the Corpus Christi Area.**—R. S. Kier and W. A. White, assisted by D. L. Bell, P. C. Patton, and J. T. Woodman.

This project was initiated in 1972 as part of the Bureau's work with a University-based multidisciplinary research effort, "Establishment of Operational Guidelines for Texas Coastal Zone Management," described in this Annual Report. The project is nearing completion, and a report is in preparation.

During the project, 39 natural land and water resource units were delineated in the Corpus Christi area, which encompasses Nueces, San Patricio, Aransas, and Refugio Counties. The units are depicted on a full-color map at a scale of 1:125,000. Also indicated on the map are topography, culture, urban areas, and lineations (noted on aerial photographs) that may represent fracture zones or potentially active faults. Text descriptions accompanying the map present geological and biological origins, distribution, and relationship of the units to adjacent land and water areas. Natural suitability for use and potential hazards (to man

and the environment) associated with use of the land and water areas are detailed.

The text emphasizes two aspects of natural environmental carrying capacity: (1) quantification of physical properties of land resource units, and (2) determination of the hydrogeologic character of the units. Soils test data obtained from various public agencies and private firms provided a means to determine representative values for important physical parameters, such as those used to assess foundation strength and permeability. Water-well data collected by the U. S. Geological Survey and the Texas Water Development Board formed the basis for determining the distribution and quality of ground water in the Corpus Christi area (data derived in part from Master of Science thesis work by D. L. Bell and J. T. Woodman).

**Land Resources in the Capital Area Planning Council (CAPCO) Region, Texas.**—C. M. Woodruff, Jr., assisted by R. C. Lentz.

The project, which was completed in the spring of 1974 and submitted to CAPCO, involved the preparation of environmental geologic and physical properties maps of the 10-county CAPCO region (Llano, Blanco, Burnet, Travis, Williamson, Hays, Caldwell, Bastrop, Lee, and Fayette Counties). The scale of mapping is 1:250,000. Results of the study will be published in 1975 as a Bureau report.

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

In this investigation, field work has been completed for environmental and physical properties maps of the San Antonio area. The maps show interactions between substrate and surface materials, landforms, and processes that affect various uses of the land. The maps will accompany a report that will be published by the Bureau of Economic Geology at a later date.

**Environmental Geology of the Austin Area, Texas—An Aid for Urban Planning.**—L. E. Garner and K. P. Young, assisted by J. A. Broyles.

This study of the geology and physical properties of rock units of the Austin area is designed to provide data for planners, engineers, and other interested persons. Field mapping by L. E. Garner, P. U. Rodda, and K. P. Young has been completed, and a report on the project is being reviewed. Maps indicating rock types, land use, slope, drainage basins and flood-prone areas, physical properties, and soils will accompany the report, which is scheduled for publication in 1975.

**Land Resources and Environmental Impact of East Texas Lignite Belt.**—E. G. Wermund (project director), C. D. Henry, E. H. Kastning, Jr., J. M. Basciano, S. A. Holden, M. M. McGraw, and M. Pattarozzi.

Environmental impact in the East Texas lignite belt concerns both natural and human resources. The purpose of this project, which began at the end of 1974, is to provide a geological and mining inventory to guide the exploitation of the extensive lignites of the East Texas region within a sound environmental-economic framework. The study will provide a model of the interactive effects of mining a relatively pristine area. It includes base inventories of surficial geology, surface and ground waters, biologic assemblages, economy, and land use.

The project is designed for four years of investigation. Initial funding by the U. S. Geological Survey is for one year.

The investigation is based on concepts, developed at the Bureau of Economic Geology, that deal with environmental inventories, assessment of potential exploitation of lignites, and inventory of surface mining. It is, at the same time, an extension of other ongoing Bureau projects in the lignite-rich area. One involves measuring the chemical properties in potential strip-mining overburden, mapping the sedimentary facies of the overburden, and characterizing the influence of chemistry and facies in future strip mining and reclamation near Fairfield, Texas. A second project is the mapping of generalized land use from black-and-white satellite imagery (spectral bands 4, 5, and 7; scale 1:250,000). An additional related project is an investigation and economic assessment of land values and reclamation potential of prospective lignite mines in Bastrop County. The ongoing projects will be integrated into the first phase of the new study.

Some essential and integral parts of the investigation include: (1) mapping of the surface geology and characterizing its natural suitability for man's use, (2) analyses of the availability and chemistry of surface and ground waters, (3) studies of current mining and reclamation methods and projected future methods, (4) mapping of the biologic assemblages with emphasis on the rich timber resources of the region, (5) studies of the present economy and the effects of an expanding new lignite mining industry, and (6) measures of the impact of lignite as one element of Texas energy resources.

A pilot study of lignite occurrence, reclama-



tion potential, land use, and economic effects of mining was completed for Bastrop County in 1974. Also, bibliographic data for the entire East Texas

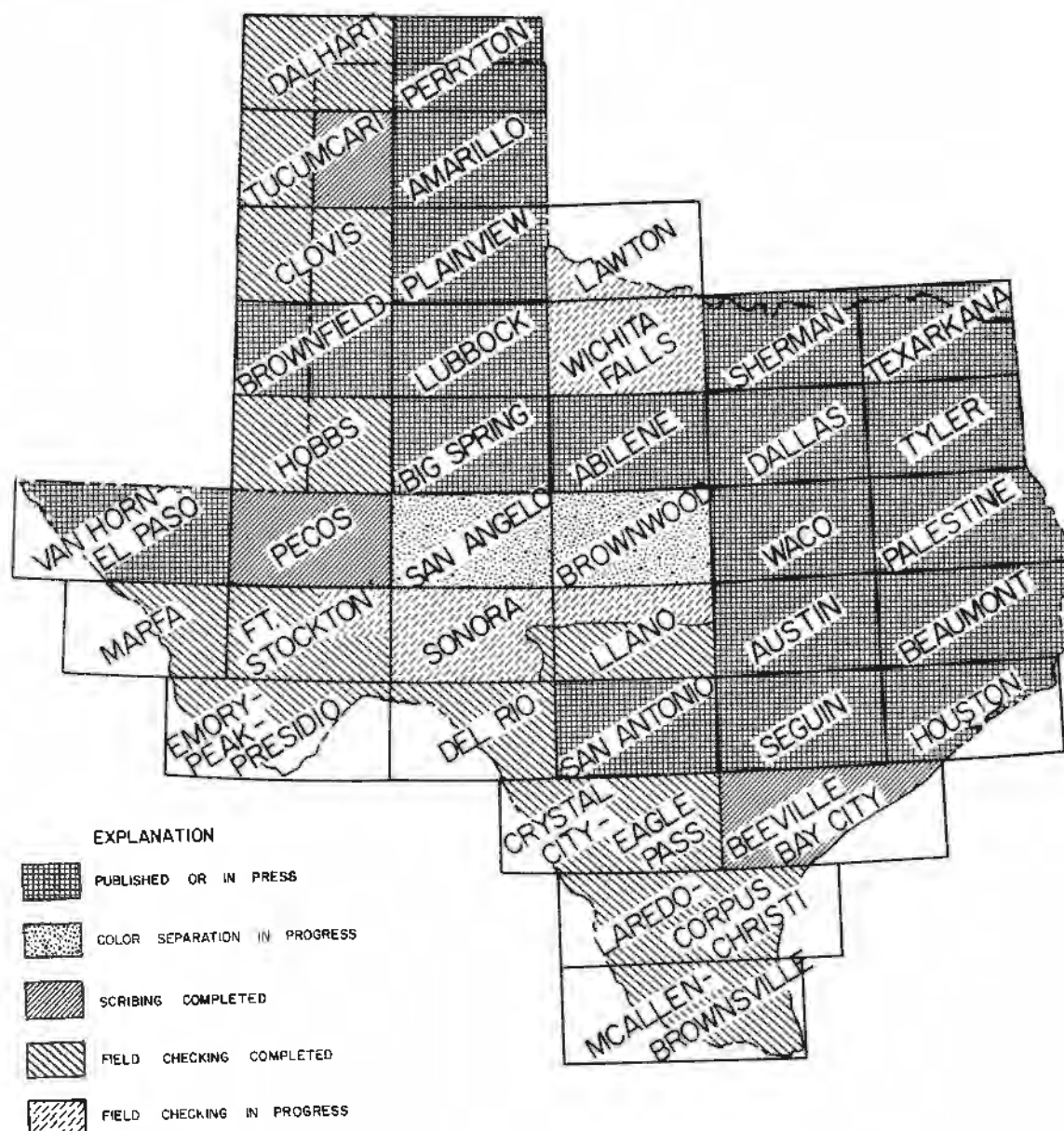
lignite belt were collected for geology (70% complete), hydrology (60% complete), and cultural geography (10% complete).

### Geologic Mapping

**Geologic Atlas of Texas**—V. E. Barnes, project director, and R. S. Kier, L. F. Brown, Jr., A. R. Trippet, and J. L. Brewton.

A geologic map of the State is being prepared as a series of 37 separate map sheets. Each map is being printed in multicolor on a topographic base at a scale of 1:250,000. Although most of the maps cover an area of 1° of latitude by 2° of longitude, several include somewhat larger areas.

The project was initiated in 1961 and is expected to be completed in 1978. Nineteen sheets of the Atlas have been published, including five—the Austin, Big Spring, Brownfield, San Antonio, and Seguin Sheets—that were issued during 1974. At yearend, the Brownwood and San Angelo Sheets were in color separation, and Bureau cartographers had completed scribing the Beeville-Bay City and Pecos Sheets of the atlas.





## Nonfuel Mineral Resource Investigations

### Gold and Silver in Texas.—Thomas J. Evans.

In response to the upsurge of interest in precious metals, a review of all known occurrences of gold and silver mineralization in Texas was prepared in 1974. Geologic setting, history of mineralization, controls on ore localization, history of production, and future prospects are indicated for all localities, where applicable. Attention is focused on the Presidio mine, Hazel mine, and related West Texas operations, as well as on the Central Mineral Region west of Austin. The manuscript has been completed, and publication is scheduled for 1975.

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

The project 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.

The project is expected to be completed in 1975.

### Texas Carbonate Materials: Suitability for Sulfur Dioxide Removal.—Thomas J. Evans.

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 will 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, will evaluate Texas carbonate materials in terms of suitability for use in sulfur dioxide removal systems likely to be employed on Texas power plants. The project is scheduled for completion in late 1975.

### Zeolites in Texas.—C. G. Groat and A. W. Walton.

Texas has large reserves of zeolites, chiefly clinoptilolite, in Tertiary rocks of the Coastal Plain and in volcanic tuffs in Trans-Pecos Texas. This study will provide maps and descriptive information useful in evaluating and developing Texas zeolites. A preliminary report will be prepared in 1975, and more detailed investigation will continue.

## Geohydrologic Resource Investigations

### Depositional Systems and the Occurrence of Fresh Water in the Ogallala Formation.—W. R. Kaiser.

The project involves a long-term investigation of the Ogallala Formation (Tertiary). The formation, which underlies most of the Texas High Plains, is the chief fresh-water aquifer in the area. A lithofacies analysis of the Ogallala, using subsurface data obtained from driller's logs, will be employed in the reconstruction of the principal depositional systems. Hydrologic data also are being compiled for eventual integration with the depositional model.

### Environmental Geology of the Recharge Zones for Principal Aquifers of Southwest Texas.—E. G. Wermund (project director), J. C. Cepeda, and P. E. Luttrell.

In connection with mapping of environmental aspects of several major river basins in South Texas, studies have been directed toward determining how infiltration is naturally controlled in

recharging the Edwards Limestone aquifer and Carrizo-Wilcox sand aquifer. These are two of the five principal ground-water aquifers in Texas.

To gain an understanding of the vertical movement of water in the recharge and productive zones of the Edwards Limestone aquifer, a project was initiated in 1973 to map surface fractures (lineations) in the southern Edwards Plateau and Cretaceous coastal plain—an area that includes nearly 200 quadrangles (7.5-minute). As surface fractures or lineations provide passageways for rainwater and other surface water to enter and recharge the underground aquifer, those areas containing greatest concentrations of fractures are the areas of highest infiltration. The fracture data are of importance in locating infiltration zones, and they supplement the environmental geologic mapping. The quantitative fracture data will be an essential part of the Texas Water Development Board computer model of the Edwards Limestone aquifer.

In 1974, all the mapped fracture zones (lineations) in the southern Edwards Plateau and Cretaceous coastal plain were digitized at the Texas Water Development Board and are available for computer processing. Maps of all known caves were located, their orientation measured, and the data encoded for computer processing. In addition, the water levels and production data for all ground-water wells in the Edwards area were located and encoded.

In 1975, the interrelationships of fracture zones, caves, and water wells will be determined. Also, the results of fracture-zone mapping in the test area of 36 quadrangles will be published, and maps of fracture intensity and orientation throughout the Edwards aquifer region will be plotted and examined.

For future study, cores of the productive Edwards aquifer are being deposited in the Bureau's Well Sample and Core Library. Study of the cores will relate horizontal movement of ground water to primary and diagenetic porosity.

A final aspect of infiltration, which has been mapped in recharge zones of both the Edwards Limestone and the Carrizo-Wilcox sand aquifers, concerns slope. Low slopes provide broad areas of efficient recharge, whereas steep slopes produce areas of high runoff and possible flooding. Maps indicating slopes of 0-5 percent, 5-15 percent, and more than 15 percent have been prepared for each aquifer. Furthermore, related geomorphic phenomena have been delineated on maps of environmental geology.

**Subsidence Susceptibility from Ground-Water Production in the Texas Coastal Zone.**—E. H. Guevara and C. W. Kreitler.

Ground water is a major natural resource of the Texas coastal area. Its extensive use results in saving millions of dollars that otherwise would be spent for transporting and treating surface water. Yet conversely, a possible consequence of ground-water production is land subsidence that results in economic impact through an actual loss of land or an increase of flood-prone areas. The coastal aquifers vary significantly in geologic and

hydrologic characteristics, and these variations mean that disparate amounts of water can be withdrawn in different areas within a specified range of pressure decline and subsidence. This project will attempt to determine the maximum rate of withdrawal compatible with a minimum amount of subsidence.

The project involves an evaluation of the hydrology, structure, and subsurface stratigraphy of the aquifers as interrelated factors controlling subsidence. Studies of the subsurface stratigraphy include delineation of the three-dimensional distribution of sand and shale facies, determination and mapping of sand-shale ratios of discrete intervals in the aquifer, and determination of thicknesses and number of clay beds in each interval. Studies of the structure of the Gulf Coast include the relationship of faulting to decline of the ground-water level and to facies variations in the producing aquifers.

**Land Capabilities of the Lake Travis Vicinity, Texas.**—C. M. Woodruff, Jr.

A Bureau publication on land capabilities of the Lake Travis vicinity is expected in 1975. The report evaluates natural land-use capabilities of lakeshore areas and will include physical properties, environmental geology, soil, slope, and fracture-intensity maps.

The study is based on C. M. Woodruff's doctoral dissertation work completed at The University of Texas at Austin in 1973.

**Nitrogen Isotopes in Surface Waters and Ground Waters of Central Texas.**—C. W. Kreitler and L. S. Land.

This project, initiated in November 1974 with the support of the National Science Foundation, is an attempt to determine the source of nitrogenous compounds that contaminate surface waters and ground waters in Central Texas. It is a continuation of Kreitler's earlier study, "Determining the Source of Nitrate in Ground Water by Nitrogen Isotopes Studies" (manuscript in review for a Bureau Report of Investigations). This current study has as its aim the establishment of criteria for evaluating the role of nitrogen in eutrophication problems.

#### Other Research Projects

**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 late in 1974; J. H. McGowen is in charge of the studies. 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 to 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 two-year study, by J. H. McGowen and L. E. Garner, 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.

**Linear Analysis.**—C. W. Kreitler, assisted in December by E. H. Kastning, Jr.

The project began in September 1973 as a

study of active faulting in the upper Gulf Coast of Texas. During the past year, the structural nature of lineations in the Pleistocene coastal sediments of Texas was analyzed. This involved extensive field work in locating active faults, particularly in the Houston-Galveston area of subsidence, to see if the faults coincide with the lineations that are observed on aerial photographs. The investigation has revealed a number of good correlations between faults and lineations. In the Ellington Air Force Reserve Base area, southeast of Houston, a lineation is coincident with the surface expression of a fault graben. A lineation also coincides with the strike of the Hockley scarp, which is over 40 feet high in the area northwest of Houston. A report on this work is in preparation.

**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 of tektites—the small, glassy objects that have been found in Texas and in other parts of the world. During 1974, S. V. Margolis collected chemical data pertaining to the inhomogeneities and inclusions in tektites.

### FISHER ELECTED VICE PRESIDENT OF AASG

W. L. Fisher, Director of the Bureau of Economic Geology, was elected in May to serve as Vice President of the Association of American State Geologists. Association membership includes the state geologist from each of the states and territories of the United States. As Director of the Bureau of Economic Geology, the organization that serves as the State Geological Survey of Texas, Dr. Fisher functions as State Geologist.

By tradition in the Association, the elected vice president ascends, in sequential years, to the posts of president-elect and president. Dr. Peter T. Flawn, former Director of the Bureau and now President of The University of Texas at San Antonio, served as President of the Association in 1969-1970.

During the past year, Dr. Fisher chaired the Association's environmental geology committee. He currently is chairman of the governmental liaison committee, which has the responsibility of maintaining contact with a number of Federal agencies and presenting state perspectives.

### WERMUND NAMED

E. G. Wermund, Research Scientist with the Bureau of Economic Geology, was appointed in April by the Director to the position of Coordinator for the Bureau's newly established Land Resources Laboratory. The various projects of the Bureau related to land and environmental resource investigations now are administered by the Laboratory. As Coordinator, Dr. Wermund holds the rank of Associate Director. L. F. Brown, Jr., continues as Associate Director for Research and C. G. Groat serves as Associate Director for Administration.

## INDICES AND CATALOGS

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

Plans were made late in 1974 to prepare an updated index of Texas mineral producers. 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 to be used in compiling the directory will 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. The directory is expected to be issued by late 1975.

**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 1974, a report on 1973 production of industrial minerals in Texas was prepared for publication in the Texas chapter of the U. S. Bureau of Mines "Minerals Yearbook 1973." A preprint of the chapter will be issued during 1975 as Bureau of Economic Geology Mineral Resource Circular, "The Mineral Industry of Texas in 1973." Compilation of Texas mineral production data is a continuing cooperative program between the Bureau of Economic Geology and the U. S. Bureau of Mines.

**Bibliography and Index of Texas Geology, 1961-1973.—Elizabeth T. Moore.**

This project is a compilation, with detailed index, of publications pertaining to Texas geology. Initiated in 1973, this is a continuation of earlier bibliographies: (1) University of Texas Bulletin 3232-Part 4, 1933, (2) University of Texas Publication 5910, 1959, and (3) Bureau of Economic Geology special publication, "Bibliography and Index of Texas Geology, 1951-1960," 1972.

**Addendum to Index to Well Samples, 1963-1973.—M. L. Morrow and E. T. Moore.**

Compilation of data on well cuttings and cores, received during 1963 through 1973 at the Bureau's Well Sample and Core Library, has been completed. The addendum was in press at yearend.

This compilation supplements the indices issued previously: (1) University of Texas Publication 5015, "Index to Well Samples," 1950 [lists materials processed up to June 1, 1948], and (2) a special publication of the Bureau of Economic Geology, "Index to Well Samples and Cores (Revised through 1962)," 1963 (out of print).

**History of the Bureau of Economic Geology (1909-1960).—W. K. Ferguson.**

The history of the Bureau of Economic Geology, from its inception in 1909 through the directorships of W. B. Phillips, J. A. Udden, E. H. Sellards, and J. T. Lonsdale, has been assembled through analysis of official correspondence and publications of the Bureau and through interviews with numerous individuals aware of the workings of the Bureau during its earlier years. The history is a study of the whole concept of public geologic research and the goals of that research, and the story of the Bureau's contributions to the knowledge of the geology and resources of Texas. The 1909 to 1960 history is a sequel to Ferguson's earlier history, "Geology and Politics in Frontier Texas, 1845-1909," published by The University of Texas Press. At yearend, the manuscript was in editorial review.

## VIRGIL E. BARNES



Texas is a State with geologic diversity and immense geologic resources. As a result, Texas has long had a large population of geologists. Some of them, through their work, have become giants in the profession. Among these giants is Virgil Barnes. In his years of service to the Bureau of Economic Geology, The University of Texas, and Texas geology, he has amassed a research record not commonly achieved and very rarely matched. At 71, Virgil Barnes is now technically on modified service. But this is recorded only on paper and in his paycheck, not in his activity. He still pursues his work with his long-time dedication, vigor, and intensity.

Virgil Everett Barnes was born in Chehalis, Washington, on June 11, 1903, the only child of Charles and Della Barnes. He grew up on a farm and worked at times in a lumber mill. He went to Washington State to become a civil engineer. But he switched to geology, influenced by a course taught by Olaf Pitt Jenkins, long-time State Mineralogist of California. Barnes completed a Master's degree in geology at Washington State under Harold E. Culver. For his doctoral work, he chose the University of Wisconsin whose faculty at that time boasted such names as Leith, Winchell, Twenhofel, Mead, and Shrock. There Barnes' major interests were hard-rock geology, mining, and metallurgy. He completed his dissertation under Professor A. N. Winchell.

While pursuing his education, Dr. Barnes spent two field seasons with the Washington Geological Survey, one season with the Wisconsin Geological Survey, and one summer prospecting in northern Manitoba for Dominion Explorers, Ltd. He emerged from the Canadian wilderness in October 1929 to witness the beginning of the Great Depression. On finishing his doctorate in 1930 he had two possible jobs, one as a metallurgist in Chicago for U. S. Steel, and the other for the terminal year of a three-year research project of the American Petroleum Institute on oil-field waters and earth temperatures. He took the second job and came to Texas, where the Bureau of Economic Geology provided laboratory and office space.

In Austin, he met a University of Texas student, Mildred Adlof; they were married in 1932. The Barneses have three children: Virgil E. Barnes II, an associate professor of physics and assistant dean of science at Purdue University; Louise Barnes Seeman, a graduate student in developmental psychology at George Peabody College in Nashville; and Elizabeth Barnes Thompson, a research biologist at New York University Medical School.

In 1933, Dr. Barnes joined the Topographic Branch of the U. S. Geological Survey as topographic engineer. He worked at Amarillo, Kilgore, and Longview, in Texas, then in Minnesota, and again in East Texas until late in 1935. He left the U.S.G.S. and joined the Bureau of Economic Geology where he began work organizing the jumble of well samples stored on the lower floor of what is now the Extension Building on the Little Campus.

When Virgil Barnes joined the Bureau of Economic Geology 40 years ago, times were hard and Bureau funds were meager. Barnes, with a Ph.D. in geology and five years of experience, was working for hourly wages. But he worked so many hours a day that soon he was given a regular appointment—for reasons of economy. The ensuing years have not diminished his enthusiasm or his capacity for hard work.

Dr. Barnes' first field work for the Bureau was in the Llano country—the Central Mineral Region of Texas. His first effort resulted in a bulletin on the "Building Stones of Central Texas." In 1939, he began systematic mapping in the Central Mineral Region, and in ensuing years published 24 geologic quadrangle

maps and numerous papers and bulletins on mineral deposits, stratigraphy, and geophysical investigations of the area. His works on the Llano area were published by the Bureau and by numerous national and international journals. So thorough has his work been that no one thinks of Central Texas geology without thinking of Virgil Barnes.

During the years of World War II, Dr. Barnes continued work in Central Texas. This period was marked by a splendid example of informal cooperation between two outstanding geologists of two fine organizations—Virgil Barnes of the Bureau and Preston Cloud of the U. S. Geological Survey. This union resulted in the “Ellenburger Group of Central Texas,” published by the Bureau in 1948. The report is a classic. It includes a serious effort in paleoecology, preceding most of the work in that discipline by two decades. Another monographic work headed by Barnes was the “Stratigraphy of Pre-Simpson Paleozoic Subsurface Rocks of Texas and Southeast New Mexico,” published in 1959. A comprehensive report by Barnes and W. C. Bell on “The Moore Hollow Group of Central Texas,” is now being processed for publication by the Bureau.

While putting Central Texas geology on the map and making that region a part of the common parlance of geology, Virgil Barnes was also to become well-known for another quite different subject—black glassy specimens called tektites. These first came to Dr. Barnes’ attention in 1936 when the Bureau was sponsoring a Works Progress Administration (WPA) mineral resource survey in Grimes County. At that time tektites were commonly thought to be meteorites. The Grimes County find piqued Barnes’ interest; subsequent research and a review of the world tektite literature resulted in the 1940 publication of his now classic “North American Tektites.” That work has been a basic reference during the Space Age. Although some researchers had the mistaken belief that tektites came from the moon, Dr. Barnes had earlier concluded that tektites had an earth-bound origin. In fact, students commonly jested that the origin of tektites was “out behind the Barnes.” Investigations during the great surge in tektite research in the sixties simply verified the conclusion earlier reached by Barnes.

Since 1960, the National Science Foundation has supported Barnes’ research on tektites. During the ensuing years, Dr. Barnes has visited all the tektite-strewn fields: australites in Australia, javanites in Indonesia, indochinites in Thailand, Cambodia, South Viet Nam, and Malasia, philippinites in the Philippines, Libyan Desert glass in Egypt, Ivory Coast tektites in the Ivory Coast, West Africa, and moldavites in Czechoslovakia. He also visited and studied certain impact structures, including among others, the spectacular Vredefort structure in South Africa, the Bosumtwi crater in Ghana, the Sudbury structure in Canada, and the nearly inaccessible craters of Wabar in the Rub’ al Khali of Saudi Arabia and of the Oasis structure in Libya. In his worldwide travel and study of tektites, Dr. Barnes was accompanied by his wife, Milla, a remarkable person also. In many of the French-speaking countries, her facility in French was a true asset. Mildred Barnes has become a student of tektites in her own right, serving with Virgil as co-editor of “Tektites,” a book in the Benchmark series of Dowden, Hutchinson & Ross, and co-authoring popular articles on tektites.

Although tektites are earthly objects, Dr. Barnes has published several papers on meteorites. He also participated in the study of lunar samples brought back by the first two Apollo landings.

Since 1961, Virgil Barnes has directed the Bureau’s extensive Geologic Atlas of Texas project, which is designed to produce a modern geologic map of the State in 37 sheets and at a scale of 1:250,000. This long-term project is in its final stages, with four or five atlas sheets now being published each year.

From 1961 to 1968, Dr. Barnes served as Associate Director of the Bureau of Economic Geology, and since 1960 he has been a professor of geology in the Department of Geological Sciences as well as a research scientist at the Bureau.

Virgil Barnes had arthritis most of his adult life, an ailment that hit him before the days of cortisone. A lesser man might have been deterred. Not Virgil Barnes. His dedication to geology and to the rigors of field work needed only some aid from aspirins to put him up and down the hills of Central Texas or through the jungles of Southeast Asia.

In his 40 years at the Bureau, Virgil Barnes has published well over 200 articles and reports, some of them major and comprehensive monographs. He adds to that list each year with no sign of slowing.

Few members of the geologic profession throughout the world do not know the name of Virgil Barnes. He has achieved an international reputation of the highest order and has brought worldwide attention to the Bureau of Economic Geology and The University of Texas at Austin. His is a record of which he can be justly proud and which we all envy.

The Bureau of Economic Geology salutes this senior member of its staff.

## 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 1974 include:

**Land Resources of the Capitol Area Planning Council Region, Texas.**—Partial support from Capital Area Planning Council.

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

**Analysis of the Impact of Various State Nuclear Policies on Nuclear Power Plant Development in Texas.**—National Science Foundation, through the Center for Energy Studies of The University of Texas at Austin. (Studies carried out by Bureau of Economic Geology and several departments of The University.)

**Criteria for Coastal Zone Management.**—National Science Foundation, Research Applied to National Needs (RANN), and Office of the Governor, Division of Planning Coordination.

**In Situ Gasification of Texas Lignite.**—Partial support from National Science Foundation.

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

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

**Environmental Geology in Coastal Zone Development.**—Sid W. Richardson Foundation.

**Natural Hazards of the Texas Coastal Zone.**—Partial support from the Texas Coastal and Marine Council.

**Environmental Mapping, Inventory, and Analysis of South Texas, Including the Guadalupe, Lavaca, Nueces, and San Antonio River Basins.**—Texas Water Development Board.

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

**Primary Evaluation of Geothermal Resources of South Texas.**—U. S. Atomic Energy Commission through the Lawrence Livermore Laboratory and the Center for Energy Studies of The University of Texas at Austin.

**Salt Domes for Radioactive Waste Disposal.**—U. S. Atomic Energy Commission.

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

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

## FISHER REAPPOINTED TO COASTAL ZONE ADVISORY COMMITTEE

Dr. W. L. Fisher, Director of the Bureau of Economic Geology, was reappointed in November to a two-year term on the National Coastal Zone Advisory Committee. The 14-member committee was created by Congress as a part of the Coastal Zone Management Act of 1972. It is directed to make broad recommendations on conservation, development, and protection of the Nation's coastal lands to the U. S. Department of Commerce. The Coastal Management Program of Texas is conducted and administered by the General Land Office.



## LAND RESOURCES LABORATORY

In April 1974, the Land Resources Laboratory was created as a new unit within the Bureau of Economic Geology in order to assure a sustained program of land resources research at The University. The Laboratory is a natural outgrowth of the special land and geologic resource studies begun in 1967 by W. L. Fisher and L. F. Brown, Jr., which have culminated in the Bureau's "Environmental Geologic Atlas of the Texas Coastal Zone."

There is a real need to improve the presentation and understanding of geologic data applicable to man's use of the surficial Earth and to extend proved environmental geologic mapping technology into critical unmapped areas of the State. In response, the functions of the Land Resources Laboratory include both research and service.

As coordinator of the Land Resources Laboratory, E. G. Wermund holds a newly created administrative position that carries with it the responsibilities of an associate director of the Bureau of Economic Geology. Prior to his appointment as coordinator, Dr. Wermund was administering several Bureau programs that now are a part of the Laboratory's research activities.

In 1974, the Land Resources Laboratory encompassed approximately 30 percent of the Bureau's current research programs, including: (1) statewide inventory of land and water resources, map scale 1:500,000; (2) statewide inventory of land use compiled from ERTS (Earth Resources Technology Satellite) imagery, map scale 1:250,000; (3) environmental geologic mapping of Nueces, San Antonio, Guadalupe, and Lavaca River basins, scale 1:125,000; (4) urban environmental geologic research projects in Austin and San Antonio; (5) an inventory of Coastal Zone management criteria; and (6) Council of Government (COG) land resource inventories—land and geologic resources were inventoried for the Coastal Bend COG and the Houston-Galveston COG. Laboratory programs to date have involved mapping and analysis of land and environmental resources, land use, carrying capacity, physical properties, biologic assemblages, economic resources, slope and terrain, and geologic hazards, including fault activation, subsidence, shoreline erosion, landslides, and flooding of barrier islands, bay margins, and floodplains by hurricanes and lesser storms.

As part of its service functions during 1974, the Laboratory monitored and participated in the efforts of State of Texas agencies to formulate a remote-sensing plan and to develop a conceptual design of a natural resources information system (NRIS). The Laboratory also has supported the development of the Coastal Management Program of the General Land Office and the efforts of the Texas Coastal and Marine Council. In addition, several testimonies requested by committees of the Texas Legislature in considering future legislation were drawn from the results of Laboratory programs.

Two new programs of the Land Resources Laboratory are funded for 1975. One is a program to inventory and integrate studies of land use, land reclamation, surface and ground waters, timber and other biologic resources, and economic impacts of mining in the East Texas lignite belt. This is designed as a four-year study in which a separate phase will be completed each year. It will be partly funded by the U. S. Geological Survey. The other is a program to examine the utility of ERTS imagery for determining geological and biological factors affecting coastal zone management; it is a cooperative effort with the General Land Office, Texas Water Development Board, and the Texas Parks and Wildlife Department. This 18-month program is funded by the National Aeronautics and Space Administration.

Programs of the Land Resources Laboratory are summarized in the following table. They concern areas most actively impacted by human activities, considered critical areas, which represent about 30 percent of the land surface of Texas. Projects designated in the table as "completed" indicate that work maps are available for examination; data are not always published with colored maps. Projects designated as "underway" presently are administered in the Laboratory. Projects are listed with the designation "scheduled" only if there is reasonable expectation of funding support.

## Land Resource Inventory of Texas Critical Areas

Regional, Statewide Inventory	Status	g. Local Urban Areas (with population greater than 50,000; 11 areas in addition to those listed above)	Scheduled
1. Land Resources of Texas: Delineation of 78 basic land types by physical, biological, and chemical characteristics and in terms of main use potential and consideration; scale 1:500,000	Completed	Land Areas Associated with Major Water Resources	
2. Current (1972) Land Use of Texas: Delineation of major land use by broad classes for entire State; scale 1:250,000	Completed	1. Aquifer Recharge Zones:	Completed
		a. Gulf Coast Aquifer	Underway
		b. Edwards Aquifer	
		c. Carrizo-Wilcox Aquifer in South Texas	Underway
		d. Balance of Major Aquifer Recharge Areas (Ogallala, Trinity, and Alluvium): Delineation of current and projected land use	Scheduled
Comprehensive Inventory of Major Critical Areas		2. Land Areas Adjacent to Major Inland Surface-Water Bodies, Under or Subject to Residential Development: Comprehensive inventory	Scheduled
(Comprehensive denotes delineation of environmental and land resources, physical properties, biologic assemblages, current land use, mineral and energy resources, topography and slope analysis, surface-water systems, and active natural processes)		Hazard-Prone Lands	
1. Environmental Geologic Atlas of the Texas Coastal Zone: Delineation of above features at a scale of 1:24,000, but published at smaller scales; area of 20,000 square miles	Completed	1. Natural Hazards of Texas Coastal Zone (area of 20,000 square miles): Main elements delineated at a scale of 1:24,000; includes Gulf shoreline erosion rates, hurricane impact, flooding, subsidence, and active faulting	Completed
2. Land Resources of the San Antonio, Guadalupe, and Nueces River Basins: Delineation of above elements at a scale of 1:24,000, but to be published at smaller scales; area of 30,000 square miles	Underway, near completion	2. Bay Shoreline Erosion Rates in Critical Areas (estimated to be about one-fourth of total bay shoreline)	Scheduled
3. Inner Texas Coastal Plain: Delineation at a scale of 1:24,000; area of 20,000 square miles	Underway	3. Geologic Delineation of Flood-Prone Areas (critical areas outside of Coastal Zone)	Scheduled
4. Areas Within and Adjacent to Major Metropolitan Areas:		Unique Mineral and Agricultural Lands	
a. Greater Houston Area	Completed	1. Economic and Environmental Impact of East Texas Lignite Lands: Projected mining activity; lands impacted, land types, reclamation potential, and water requirements; resource conflicts	Underway
b. Beaumont-Port Arthur-Orange Area	Completed		
c. Corpus Christi Area	Completed		
d. San Antonio Area	Underway		
e. Austin Area	Completed		
f. Dallas-Fort Worth Area	Scheduled		

2. Delineation of Mineral and Agricultural Lands Subject to Loss by Urbanization and Industrial Development	Scheduled	2. Capitol Area COG 3. Coastal Bend COG	Completed Completed
Councils of Government Land Resource Inventory		Preliminary Cost-Benefit Analysis of Alternate Land Use:	
1. Houston-Galveston COG	Completed	Mineral, agricultural, and hazard-prone lands subject to loss	Scheduled

The Land Resources Laboratory provides assessments of geologic, biologic, and land resources in Texas. Its work to date was accomplished internally. A goal of the Laboratory is to develop multidisciplinary research relating social and economic aspects to the natural system inventoried by the Bureau of Economic Geology, including the Laboratory, in past and ongoing programs. The Laboratory will look to external sources—in departments and groups of The University and in Texas State agencies—to study social and economic aspects. Future efforts are expected to require more emphasis on remote-sensing technology and on machine processing of data.

#### GROAT APPOINTED TO CES

C. G. Groat, Associate Director for Administration with the Bureau, accepted a quarter-time appointment with The University's Center for Energy Studies as Associate Director for Resources and Environment. With the Center, Dr. Groat assumed responsibility for the development of coal and lignite research programs and for the coordination of environmental aspects of the Center's programs, including land- and water-use studies. In addition, he maintains liaison between Bureau and Center energy research programs. W. L. Fisher, Bureau Director, serves on the executive committee of the Center for Energy Studies.

#### WOODRUFF ON LEAVE

C. M. Woodruff, Jr., Research Scientist with the Bureau of Economic Geology, is currently on leave from the Bureau. Dr. Woodruff is serving as geologist in the Coastal Management Program of the Texas General Land Office.

## BUREAU PRESENTS RESEARCH COLLOQUIUM IN APPROACHES TO ENVIRONMENTAL GEOLOGY

Approximately 150 scientists and engineers representing a wide spectrum of industry, national and state agencies, and university faculty attended a Bureau-sponsored colloquium, "Approaches to Environmental Geology," this spring. The group was an international one—among those present were registrants from 22 states, as well as from Canada, Italy, Jamaica, Mexico, and Spain. E. G. Wermund organized the meeting, which took place on May 13-14 at the Thompson Conference Center of The University of Texas at Austin.

During the four sessions of the colloquium, Bureau geologists gave 16 illustrated lectures and conducted workshops that were open between the sessions. Speakers focused on philosophies, concepts, experiences, and procedures in developing environmental geologic data for an entire state or for a single community.

Keith Arnold, Director of The University's Division of Natural Resources and Environment, gave the welcoming address. The first session, A Geologic Perspective of the Environment, was chaired by E. G. Wermund. Speakers included W. L. Fisher, L. F. Brown, Jr., and R. S. Kier. At the second session, Comprehensive Environmental Analysis, W. L. Fisher served as chairman and L. F. Brown, Jr., E. G. Wermund, L. E. Garner, C. V. Proctor, Jr. (formerly with the Bureau, now with Conoco), and T. C. Gustavson presented papers.

On the second day of the colloquium, L. F. Brown, Jr., presided at the session on Mapping and Monitoring Critical Environments. Participants were J. H. McGowen, C. M. Woodruff, Jr., R. A. Morton, P. J. Cannon, E. G. Wermund, and R. S. Kier. R. L. Shipman chaired the afternoon session, Environmental Inventories, and speakers were C. W. Kreidler, C. G. Groat, and W. L. Fisher. The colloquium closed with a question and answer panel session, entitled Forum: After the Geologist—How are Environmental Inventories Used? Panelists were three State government officials—Bob Armstrong, Commissioner of the Texas General Land Office, Representative Bill Clayton of the Texas House of Representatives, and Marcus Yancey, assistant State highway engineer of the Texas Highway Department. Papers presented at the daily sessions were published as Bureau Report of Investigations No. 81, "Approaches to Environmental Geology," edited by E. G. Wermund.



**Representative Bill Clayton**



**Land Commissioner Bob Armstrong**

**Address Bureau Colloquium**



**Colloquium Participants**

## 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.

In 1974, one continuing education presentation was a two-day colloquium and workshop, Approaches to Environmental Geology, sponsored by the Bureau of Economic Geology. During the colloquium, twelve Bureau geologists lectured on methods of developing and interpreting data and maps pertaining to environmental geology and land and water resources.

In other continuing education activities, D. G. Bebout taught a short course, Carbonate and Evaporite Facies and Environments, at Southwestern Louisiana University, in Lafayette. L. F. Brown, Jr., presented a short course in Fluvial and Deltaic Systems for the Instituto Mexicano del Petroleo in Mexico, D. F.; he participated in a day-long closed-circuit television course in Environmental Geology at Oklahoma State University, Stillwater, that involved 15 colleges and universities in Oklahoma. W. L. Fisher participated in the American Association of Petroleum Geologists Continuing Education program with courses in Clastic Facies in Mineral Exploration; he also presented a short course for the Royal Norwegian Research Council in Oslo. In addition, C. W. Kreidler taught a short course, Environmental Geology, at St. Lawrence University, in Canton, New York.

Four Bureau of Economic Geology staff members taught or participated in regularly scheduled courses of The University's Department of Geological Sciences: D. G. Bebout (with A. J. Scott) taught Geology 394, Biogenic and Evaporite Facies and Environments; L. F. Brown, Jr., and W. L. Fisher (with A. J. Scott) taught Geology 383, Terrigenous Depositional Systems; and C. G. Groat taught Geology 362K, Mineral Resources and the Environment. R. S. Kier participated in the Division of Comparative Studies University Course 380, Coastal Resources Management.

## 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.

## WELL SAMPLE AND CORE LIBRARY

Rock materials from each Texas county are included in the collections that are on file at the Bureau's Well Sample and Core Library. Most of the materials at the repository are rock samples and cores obtained through the drilling of oil and gas wells, water wells, engineering test holes, and mineral exploration holes. In addition, the Library has some driller's logs, sample logs, surface rock samples, and a few maps and electrical logs. The various materials were presented by companies, government agencies, and individuals. Each year, the collections grow through further contributions.

During 1974, the Library received a significant number of cores and samples. Amoco Oil Company presented cores from one well in Fayette County and one well in Newton County, and Hunt Oil Company gave cores from a well in Webb County. Mobil Oil Corporation contributed cores from a well in Lavaca County. Tenneco Oil Company provided cores from seven wells in Atascosa County, two wells in Bastrop County, one well in Bexar County, two wells in Caldwell County, eleven wells in Frio County, one well in Jackson County, one well in Karnes County, seven wells in Medina County, one well in Starr County, two wells in Wilson County, and four wells in Zavala County. Tesoro Petroleum Corporation gave cores from one well in Dimmit County and one well in Trinity County; the Texas Water Development Board provided cores from one well in Medina County and one well in Uvalde County.

Samples from seven uranium test holes were received from Continental Oil Company. MGF Oil Corporation gave samples from one well in Dimmit County, and Pioneer Nuclear, Incorporated, presented samples from a well in Gonzales County. In addition, the U. S. National Park Service gave samples from one well in Brewster County, one well in Hutchinson County, and one well in Potter County.

The Well Sample and Core Library maintains a card index of the wells and test holes from which the rock materials are available. Each card indicates the county in which a specific well is located, the name of the well, and the depths from which the samples or cores were taken.

The well samples and cores on file at the Library are invaluable sources of basic information about the composition, structure, origin, and history of the rocks that lie beneath the surface in Texas. They are examined in the exploration for oil, gas, coal, uranium, and other minerals, and in the determination of the suitability of sites for construction, waste disposal, and other uses.

The facilities and collections of the Well Sample and Core Library are available for use by the public in Building 18B of The University's Balcones Research Center. The Library is open Monday through Friday from 8:00 a.m. to 5:00 p.m. Personnel at the Library are Douglas C. Ratcliff, administrative clerk, John A. Kieschnick, Harry J. Madsen, and Steven J. Seni. Marce L. Morrow, after more than 19 years of dedicated service, retired from the Library staff on April 30, 1974.

## MINERAL STUDIES LABORATORY

The Mineral Studies Laboratory of the Bureau of Economic Geology performs chemical and spectrographic analysis and physical tests of Texas rocks and minerals for Bureau of Economic Geology research projects. Work is performed for various departments of The University of Texas at Austin, Texas State agencies, and Texas residents.

A major portion of the Laboratory's work during the year involved analysis of samples for the Matagorda Bay and Environs pilot study. The project, which was completed in 1974, was a cooperative effort of the Bureau of Economic Geology and the General Land Office of Texas.

As part of the Bureau's investigations of energy sources, the Laboratory analyzed numerous samples of bituminous rocks and of potential oil shales. The bituminous rocks were analyzed for bitumen content by solvent extraction, and the shales were analyzed qualitatively and quantitatively for yield of oil. The quantitative analysis was performed by destructive distillation according to U. S. Bureau of Mines methods.

The Laboratory also processed samples for Texas residents. Such work included the evaluation of brick clays, the qualitative and semiquantitative spectrographic analysis of a variety of Texas rocks, and the preparation of slides for the observation of oriented X-ray diffraction patterns.

The Laboratory continued to cooperate with other departments of The University of Texas at Austin, including the Balcones Research Center. Activities in this category ranged from consultations to the analysis and testing of samples for research studies. For one such study, the Laboratory determined the amounts of



boron and sodium (in parts per million) present in several soil samples from University of Texas lands—purpose of the analysis was to determine the suitability of the soils for growing grapes.

During the year, work also was performed on archeological samples for the Archeological Laboratory of the Texas Historical Commission. In addition, the Department of Geological Sciences of The University of Texas at Austin utilized the Laboratory's crushing, grinding, and pulverizing facilities in the preparation of rocks and minerals.

A grinding and pulverizing mill was added to the Laboratory's facilities in 1974. The unit is a high-speed line-contact, centrifugal pulverizer that is capable of pulverizing up to 100 grams of rock sample to a size of minus 200-mesh in a few minutes.

The Mineral Studies Laboratory is located at The University's Balcones Research Center in northwest Austin. Daniel A. Schofield is Chemist-in-Charge. Laurence C. McGonagle, who previously worked as a part-time laboratory assistant, was promoted to the position of assistant chemist on June 1, 1974. McGonagle holds a Bachelor's degree in chemistry from The University of Texas at Austin. Also in 1974, Ron W. Favor replaced Bill Ed Weldon as part-time laboratory assistant.

## STAFF ACTIVITIES

### Meetings Attended

**American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, Annual Meetings, San Antonio, Texas**—V. E. Barnes, D. G. Bebout, J. L. Brewton, L. F. Brown, Jr., P. J. Cannon, L. W. Epps, T. J. Evans, W. L. Fisher, L. E. Garner, R. M. Girard, C. G. Groat, T. C. Gustavson, W. R. Kaiser, R. S. Kier, C. W. Kreitler, J. H. McGowen, R. A. Morton, M. J. Pieper, T. L. Rowland, A. E. St. Clair, R. L. Shipman, P. M. Walters, E. G. Wermund, C. M. Woodruff, Jr.

**American Association of Petroleum Geologists, Southwest Section, Annual Meeting, El Paso, Texas**—V. E. Barnes, W. L. Fisher, R. L. Shipman

**American Association of Petroleum Geologists, Symposium on Hydrology of Deep Sedimentary Basins, Tulsa, Oklahoma**—D. G. Bebout

**American Institute of Professional Geologists, Annual Meeting, Denver, Colorado**—R. L. Shipman

**American Institute of Professional Geologists, Texas Section, Annual Meeting, El Paso, Texas**—W. L. Fisher

**Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas**—V. E. Barnes, D. G. Bebout, J. L. Brewton, L. F. Brown, Jr., P. J. Cannon, L. W. Epps, T. J. Evans, W. L. Fisher, L. E. Garner, R. M. Girard, C. G. Groat, T. C. Gustavson, W. R. Kaiser,

R. S. Kier, C. W. Kreitler, R. A. Morton, M. J. Pieper, A. E. St. Clair, R. L. Shipman, A. R. Trippet, P. M. Walters, E. G. Wermund, W. A. White, C. M. Woodruff, Jr.

**Association of American State Geologists, Annual Meeting, Bend, Oregon**—W. L. Fisher, C. G. Groat, T. L. Rowland, E. G. Wermund

**Association of American State Geologists, Semi-annual Meeting, Miami, Florida**—W. L. Fisher, C. G. Groat, E. G. Wermund

**Association of Earth Science Editors, Annual Meeting, Pacific Grove, California**—K. E. Kennedy

**Association of Western Land Commissioners, Annual Meeting, Lakeway, Texas**—W. L. Fisher, R. L. Shipman

**Beyond Today's Energy Crisis: Future of the American Environment, Conference, sponsored by Lyndon B. Johnson Library and The University of Texas at Austin, Austin, Texas**—R. L. Shipman

**Capital Area Planning Council (CAPCO), Solid-Waste Task Force, Workshop, Austin, Texas**—C. M. Woodruff, Jr.

**Center for Biology of Natural Systems, Nitrogen Workshop, St. Louis, Missouri**—C. W. Kreitler.

**Coastal Zone Management, Conference, sponsored by General Land Office of Texas, Austin, Texas**—L. F. Brown, Jr., R. L. Shipman, C. M. Woodruff, Jr.

**Coastal Zone Management, Conference and Workshop,** sponsored by Gulf States Organization, Biloxi, Mississippi—R. S. Kier

**Colloquium and Dedication of U. S. Geological Survey National Center** (John Wesley Powell Federal Building), Reston, Virginia—C. G. Groat.

**Environmental and Resource Programs, Conference,** sponsored by The University of Texas at Austin, Kerrville, Texas—W. L. Fisher, R. L. Shipman

**Geochemistry Group of the Gulf Coast, Annual Meeting,** Port Aransas, Texas—C. W. Kreitler

**Geological Society of America, Annual Meeting,** Miami Beach, Florida—V. E. Barnes, D. G. Bebout, W. L. Fisher, C. G. Groat, T. C. Gustavson, E. G. Wermund

**Geological Society of America, Field Seminar on Water and Carbonate Rocks of the Yucatan Peninsula,** Meridan, Yucatan, Mexico—D. G. Bebout

**Geological Society of America, Penrose Conference on Pleistocene Stratigraphy of the Northeast,** Amherst, Massachusetts—T. C. Gustavson

**Geological Society of America, South-Central Section, Annual Meeting,** Stillwater, Oklahoma—P. J. Cannon, C. G. Groat, T. C. Gustavson, J. H. McGowen, T. L. Rowland, E. G. Wermund

**Geology of Industrial Minerals, 10th Annual Forum,** Ohio State University, Columbus, Ohio—T. L. Rowland

**Geothermal Energy Conference,** sponsored by National Science Foundation, Pasadena, California—C. G. Groat

**Governor's Office, Division of Planning Coordination, A-95 Review and Comment Workshop,** Austin, Texas—R. L. Shipman, C. M. Woodruff, Jr.

**Ground-Water Quality Symposium, 2nd,** sponsored by Environmental Protection Agency and National Water Well Association, Denver, Colorado—C. W. Kreitler

**Gulf Coast Association of Geological Societies, Annual Meeting,** Lafayette, Louisiana—D. G. Bebout, L. F. Brown, Jr., R. L. Shipman

**Highway Geology Symposium, 25th,** sponsored by North Carolina State Highway Commission, Raleigh, North Carolina—L. F. Brown, Jr.

**International Mineralogical Association, General Meeting,** West Berlin and Regensburg, West Germany—V. E. Barnes

**Interstate Mining Compact Commission, Annual Meeting,** Muskogee, Oklahoma—C. G. Groat

**Land Use Conference,** sponsored by Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin, Austin, Texas—R. L. Shipman

**Mineralogical Society of America, Regional Meeting,** Tucson, Arizona—V. E. Barnes

**National Speleological Society, Annual Meeting,** Decorah, Iowa—E. H. Kastning, Jr.

**Portable Energy Technology Assessment, Workshop,** Monterey, California—W. L. Fisher

**Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), Annual Meeting,** Dallas, Texas—L. E. Garner, C. G. Groat

**Soil Survey Technical Work-Planning Conference,** Texas A & M University, College Station, Texas—L. E. Garner

**State/Federal Coastal Zone Mapping Conference,** Washington, D. C.—W. L. Fisher

**State Geologists from Central Region of United States, Cluster Meeting with U. S. Geological Survey Regional Geologist,** Hebron Springs, Arkansas—W. L. Fisher, C. G. Groat

**Technical Advisory Committee, Water Task Force, Meetings,** Houston, Texas, and Austin, Texas—W. L. Fisher

**Texas Advisory Committee on Conservation and Environmental Education, Meetings,** Galveston, Texas, and Buchanan Dam, Texas—W. L. Fisher

**Texas Assembly on Land Use,** Texas A & M University, College Station, Texas—E. G. Wermund

**Texas Mapping Advisory Committee, Meeting,** Austin, Texas—W. L. Fisher

**Texas Sea Grant Advisory Council, Meetings, Houston, Texas, and College Station, Texas—W. L. Fisher**

**The University's Role in Coal Research, Conference and Workshop, sponsored by National Science Foundation and Office of Coal Research, Buffalo, New York—C. G. Groat**

**U. S. Department of Commerce, Bureau of the Census, Workshop, Dallas, Texas—W. L. Fisher**

**U. S. Department of Commerce, Coastal Zone Management Advisory Committee, Meetings, Santa Barbara, California, Milwaukee, Wisconsin, and Washington, D. C.—W. L. Fisher**

**U. S. Department of Commerce, Coastal Zone Management Conference, Charleston, South Carolina—R. L. Shipman**

**U. S. Department of Commerce, Technical Advisory Board Panel on Project Independence Blueprint, Workshops, Chicago, Illinois, and Washington, D. C.—C. G. Groat**

**U. S. Geological Survey and Association of American State Geologists, Central United States, Joint Meeting, Estes Park, Colorado—L. F. Brown, Jr., W. L. Fisher, E. G. Wermund**

**U. S. National Park Service, Southwest Regional Natural Science Conference, Santa Fe, New Mexico—R. L. Shipman**

**Water for Texas, Annual Conference, College Station, Texas—C. W. Kreitler**

**Zeolite Occurrence and Utilization, Joint United States-Japan Conference, sponsored by National Science Foundation, Las Vegas, Nevada—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. These are given both within the State and throughout North America. 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 and sponsored research colloquia are important means of presenting the results of Bureau research prior to final publication.

Following are lectures given by Bureau staff members during 1974.

#### V. E. Barnes

—**Petrography of Libyan Desert glass:** presented at International Mineralogical Association, General Meeting, Regensburg, Bavaria, West Germany.

#### D. G. Bebout

—**Cementation of a carbonate grainstone body—Lower Cretaceous Stuart City Trend, South Texas:** presented at Society of Economic Paleontologists and Mineralogists, Annual Meeting, San Antonio, Texas.

—**Evaporite basin fill, Elk Point Basin, Alberta, Canada:** presented at Panhandle Geological Society, Meeting, Amarillo, Texas; and at West Texas Geological Society, Meeting, Midland, Texas.

—**Geopressure geothermal resources—Frio Formation of South Texas:** presented at American Institute of Mining, Metallurgical, and Petroleum Engineers, Meeting, Austin, Texas.

—**Preliminary evaluation of geothermal resources of South Texas:** presented at Geothermal Conference, The University of Texas at Austin, Austin, Texas.

—**Stuart City Trend depositional and diagenetic environments and their relationship to porosity distribution:** presented at Fort Worth Geological Society, Meeting, Fort Worth, Texas.

—**Stuart City Trend, South Texas, and Golden Lane, Mexico—a comparison:** presented at Corpus Christi Geological Society, Meeting, Corpus Christi, Texas.

#### L. F. Brown, Jr.

—**Deltaic systems within evolving foreland and cratonic basins, North-Central Texas:** presented at American Association of Petroleum Geologists, Annual Meeting, San Antonio, Texas.

—**Environmental Geologic Atlas of the Texas Coastal Zone:** presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Environmental Geologic Atlas, Texas Coastal Zone—the role of geology in land-use planning: presented at Gulf Coast Association of Geological Societies, Annual Meeting, Lafayette, Louisiana.

—Environmental geology and land resources, Houston Area Test Site: presented before Earth Resources Division, National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas.

—Environmental inventory—innovations in geology and geologic presentation: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Fluvial-deltaic sandstone reservoirs, West Texas Basin: presented at Fort Worth Geological Society, Meeting, Fort Worth, Texas.

—Geologic hazards of the Texas Coastal Zone: keynote address presented at Conference on Coastal Zone Management, sponsored by General Land Office of Texas, Austin, Texas.

—The role of environmental inventory in land-use management: presented during a closed-circuit television program, Oklahoma Educational TV System, Stillwater, Oklahoma.

—The role of geology in land-use management: presented at 25th Annual Highway Geology Symposium, Raleigh, North Carolina.

#### P. J. Cannon

—Applications of radar imagery to environmental geologic mapping: presented at American Association of Petroleum Geologists, Annual Meeting, San Antonio, Texas.

—Drainage anomalies of the upper Nueces River in South-Central Texas: presented at Geological Society of America, South-Central Section, Annual Meeting, Stillwater, Oklahoma.

—The application of radar imagery to environmental geologic mapping: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

#### T. J. Evans

—Mineral resources of Texas—development and conservation: presented at Environmental Education Workshop, sponsored by Texas Education Agency and East Texas State University, Commerce, Texas.

#### W. L. Fisher

—A look into the future: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Approaches to environmental geology: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Delta systems—genetic analysis in exploration: presented at American Association of Petroleum Geologists, Annual Meeting, San Antonio, Texas.

—Facies analysis in stratigraphic exploration: presented at American Association of Petroleum Geologists, Annual Meeting, San Antonio, Texas.

—Land use in the Texas Coastal Zone: presented at Texas A & M University, College Station, Texas.

—Natural hazards and land use: presented to Land Use Committee, Intergovernmental Affairs, Texas House of Representatives, Houston, Texas.

—Natural hazards in the Texas Coastal Zone: presented to the Water Resources Committee, East Texas Council, Orange, Texas.

—Potential for geothermal resources, Texas: presented to Division of Planning Coordination, Office of the Governor and General Land Office, Austin, Texas.

—Programs and activities of the Bureau of Economic Geology: presented at U. S. Geological Survey and Association of American State Geologists, Central United States, Joint Meeting, Estes Park, Colorado.

—Terrigenous depositional systems—a genetic approach to facies analysis: presented as a lecture of the American Association of Petroleum Geologists Continuing Education Lectures, Dallas, Texas, and Houston, Texas.

—The land in land-use management: presented at Association of Western States Land Commissioners, Annual Meeting, Lakeway, Texas.

#### L. E. Garner

—Environmental geology—an aid to urban planning: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Mineral resources of Texas: presented at Environmental Education Workshop, sponsored by Texas Education Agency and Texas A & I University, Kingsville, Texas.

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

—**Resources and environmental planning:** presented at Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Dallas, Texas.

#### C. G. Groat

—**Mined land inventory—data for reclamation and multiple-use planning:** presented at Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Annual Meeting, Dallas, Texas.

—**Statewide inventory of open-pit mining operations:** presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—**Texas mineral resources:** presented at Environmental Education Workshop, sponsored by Texas Education Agency and The University of Texas at El Paso, El Paso, Texas.

#### T. C. Gustavson

—**Deposition on braided gravel outwash fans, Malaspina Foreland, Alaska:** presented at Geological Society of America, South-Central Section, Annual Meeting, Stillwater, Oklahoma.

—**Pleistocene stratigraphy of Long Island, N. Y., and southern New England:** presented at Geological Society of America, Penrose Conference on Pleistocene Stratigraphy in the Northeast, Amherst, Massachusetts.

—**Preliminary environmental geologic mapping in rural areas of rolling mud and sand terrane:** presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—**Sedimentary processes, sediment distribution and collapse features in proglacial Malaspina Lake, Alaska:** presented at Geological Society of America, Annual Meeting, Miami Beach, Florida.

#### W. R. Kaiser

—**Coal and the national energy mix:** presented at Short Course for High School Science Teachers, Austin, Texas.

—**Sedimentology of Texas lignite:** presented at Corpus Christi Geological Society, Meeting, Corpus Christi, Texas.

#### R. S. Kier

—**Identifying the Coastal Zone subject to the management program:** panel presentation and discussion at Conference on Coastal Zone Management, Gulf States Organization, Biloxi, Mississippi.

—**Land resources of Texas—a statewide inventory of natural capability:** presented at American Association of Petroleum Geologists, Annual Meeting, San Antonio, Texas.

—**Quantification of resource capability units:** presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—**Technical bases for the inventorying and designation of areas of particular concern for Coastal Zone management:** panel presentation and discussion at Conference on Coastal Zone Management, Gulf States Organization, Biloxi, Mississippi.

—**Texas statewide land resource mapping and inventory:** presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—**The Texas Coastal Zone natural resource inventories:** presented to Class in Special Topics in Coastal Zone Management, Texas A & M University, College Station, Texas.

#### C. W. Kreidler

—**Land-surface subsidence and active faulting in the Texas Coastal Zone:** presented to Special Interim Committee on Water Supply and Waste Disposal in Metropolitan Areas, Texas House of Representatives, Houston, Texas.

—**Lineations and active faults in the Houston-Galveston subsidence zone:** presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—**Natural soil nitrate—the cause of nitrate contamination in Runnels County, Texas:** presented at Ground-Water Quality Symposium, 2nd, sponsored by Environmental Protection Agency and National Water Well Association, Denver, Colorado.

—**Nitrogen isotopes—a method for tracing environmental pollutants:** presented at Nitrogen Workshop, Center for Biology of Natural Systems, St. Louis, Missouri.

—**Studying the nitrogen cycle with nitrogen isotopes:** presented before Geochemistry Group of the Gulf Coast, Port Aransas, Texas.

—Subsidence and faulting, and methods of fault activation: presented at Austin Geological Society, Luncheon Meeting, Austin, Texas.

#### J. H. McGowen

—Coastal Zone shoreline changes—a function of natural processes and man's activities: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Modern coastal environments and facies—Texas Gulf Coast: presented before staff of U. S. Geological Survey, Menlo Park, California.

—Sedimentary processes and facies of alluvial fans and fan deltas: presented before staff of U. S. Geological Survey, Menlo Park, California.

#### R. A. Morton

—Active processes, southern Edwards Plateau: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Environmental geologic mapping and natural hazards, Matagorda and Brazoria Counties, Texas: presented before Texas Offshore Terminal Commission, Austin, Texas.

—Modern and ancient shallow-water deltas—Texas Gulf Coast (Holocene) and northern West Virginia (Pennsylvanian): presented at American Association of Petroleum Geologists, Annual Meeting, San Antonio, Texas.

—Natural hazards in the Texas Coastal Zone: presented at Technical Session, Department of Geological Sciences, The University of Texas at Austin; and at Austin Geological Society, Luncheon Meeting, Austin, Texas.

#### R. L. Shipman

—Petropolitics: presented at American Association of Petroleum Geologists, Annual Meeting, San Antonio, Texas.

—Presidential address: presented at Texas Professional Geologists, Annual Meeting, Lafayette, Louisiana.

—The professional geologist—certification and registration: presented at Austin Geological Society, Luncheon Meeting, Austin, Texas.

#### E. G. Wermund

—Adapting biologic assemblage data for environmental needs: presented at Approaches to Environmental Geology, Workshop and Collo-

quium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Economic applications from environmental geologic mapping in the southern Edwards Plateau: presented at Austin Geological Society, Luncheon Meeting, Austin, Texas; and at American Association of Petroleum Geologists, Annual Meeting, San Antonio, Texas.

—Environmental geologic mapping—its utility in oil industry problems: presented before Environmental Control Engineers of Mobil Oil Corporation, Lakeway, Texas.

—Environmental units in carbonate terranes as developed from a case study of southern Edwards Plateau: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Fracture patterns in the southern Edwards Plateau: presented at Geological Society of America, South-Central Section, Annual Meeting, Stillwater, Oklahoma.

—Land resource mapping: presented before Regional Council Directors of Planning, Austin, Texas.

—Potential for geothermal resources in South Texas: presented at Interagency Council on Natural Resources and the Environment of the State of Texas, September Meeting, Austin, Texas.

—Status of geological investigations of the recharge and producing zones of the Edwards aquifer: presented before Regional Development Review Committee, Alamo Council of Government, San Antonio, Texas.

#### C. M. Woodruff, Jr.

—Environmental geology and lakeshore development: presented at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas.

—Texas mineral resources—economic and environmental factors: presented at Environmental Education Workshop, sponsored by Texas Education Agency and Abilene Christian College, Abilene, Texas.

#### Legislative Committee Hearings

Texas Coastal and Marine Council, Senator A. R. Schwartz, Chairman: meetings at South Padre Island, Texas—R. A. Morton (testimony given); and Corpus Christi, Texas—R. L. Shipman (testimony given).

Texas House of Representatives and Texas Senate, Joint Interim Mining Study Committee, Senator Max R. Sherman, Chairman: meeting at Austin, Texas—C. G. Groat (testimony given).

Texas House of Representatives, Land-Use Study Committee of the Intergovernmental Affairs Committee, Representative Lyndon Olson, Jr., Chairman: meeting at Houston, Texas—W. L. Fisher (testimony given), C. W. Kreidler.

Texas House of Representatives, Special Interim Committee on Water Supply and Waste Disposal in Metropolitan Areas, Representative W. J. Blythe, Chairman: meeting at Houston, Texas—C. W. Kreidler (testimony given).

#### Committee Service and Offices

##### V. E. Barnes

—American Commission on Stratigraphic Nomenclature: Vice-Chairman at meeting in Miami Beach, Florida.

—American Association of Petroleum Geologists: House of Delegates.

##### D. G. Behout

—American Association of Petroleum Geologists: Carbonate Rock Subcommittee.

—Society of Economic Paleontologists and Mineralogists: Evaporite Research Group.

##### L. F. Brown, Jr.

—American Association of Petroleum Geologists: Environmental Geology Committee.

—Interagency Council on Natural Resources and the Environment of the State of Texas: Land Use Subcommittee.

##### T. J. Evans

—Geological Society of America, South-Central Section: Local Arrangements Committee, Chairman.

##### W. L. Fisher

—Advisory Council for Sea Grant Colleges in Texas.

—American Association of Petroleum Geologists: Continuing Education Committee; Technical Editor, Annual Meeting.

—American Geological Institute: Committee on Geoscience and Public Policy.

—American Institute of Professional Geologists, Texas Section: Environmental Geology Committee, Chairman.

—Association of American State Geologists: Environmental Geology Committee, Chairman; Governmental Liaison Committee, Chairman; Vice President.

—Austin Geological Society: President, 1973-1974.

—Geological Society of America: Committee on Environment and Public Policy.

—Governor's Water Task Force: Technical Advisory Committee.

—Interagency Council on Natural Resources and the Environment of the State of Texas: Council Member; Land Resources Management Committee, Vice-Chairman.

—National Aeronautics and Space Administration: Lyndon B. Johnson Space Center, Hazards Advisory Committee.

—Texas Advisory Committee on Conservation and Environmental Education: Chairman.

—Texas Mapping Advisory Committee.

—The University of Kansas: Geology Associates, Advisory Board.

—The University of Texas at Austin: Center for Energy Studies, Executive Committee; Center for Research in Water Resources, Advisory Committee; Geology Foundation, Executive Committee; Publications Committee; various *ad hoc* committees.

—United Nations Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas: Technical Advisor.

—U. S. Department of Commerce: Coastal Zone Management Advisory Committee.

##### L. E. Garner

—Austin Natural Science Association: Board of Directors.

##### C. G. Groat

—Austin Geological Society: Program Chairman, 1974-1975.

—Society of Mining Engineers of American Institute of Mining, Metallurgical, and Petroleum Engineers, Corpus Christi Minerals Subsection: 2nd Vice-Chairman, 1974.

—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: Subpanel on Geothermal and Solar Energy of Panel on Operation Independence Blueprint, 1974-1975.



**R. A. Morton**

—Austin Geological Society: Entertainment Committee, 1974-1975.

**A. E. St. Clair**

—Austin Geological Society: Treasurer, 1973-1974.

**R. L. Shipman**

—American Association of Petroleum Geologists: House of Delegates; Membership Committee.

—American Institute of Professional Geologists: Advisory Committee; Editor; Executive Committee.

—American Institute of Professional Geologists, Texas Section: Legislative Committee Chairman; President.

—Gulf Coast Association of Geological Societies: Executive Committee.

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

—Remote Sensing Task Force of the Interagency Council on Natural Resources and the Environment of the State of Texas: Representative of The University of Texas at Austin.

—The University of Texas at Austin: Joint Council on University and State Relations.

—U. S. National Park Service: Coordinator for Coastal Research.

**E. G. Wermund**

—Alamo Council of Government: Resource Conservation and Development Technical Advisory Committee.

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

**Other Professional Responsibilities****V. E. Barnes**

—Co-leader of field trip, Precambrian and Paleozoic Rocks of Central Mineral Region, Texas, for Society of Economic Paleontologists and Mineralogists, 1974 Annual Meeting.

**L. F. Brown, Jr.**

—Chairman of session, Mapping and Monitoring Critical Environments, at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin.

—Organized symposium, Delta Systems: Significance of Stratigraphy and Facies in Exploration, for American Association of Petroleum Geologists, 1974 Annual Meeting.

**W. L. Fisher**

—Chairman of session, Comprehensive Environmental Analysis, at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin.

—Host of evening session, Delta Systems in Exploration, at American Association of Petroleum Geologists, 1974 Annual Meeting.

—Leader of session, U. S. Department of Commerce, Bureau of Census, Workshop, Dallas, Texas.

—Moderator of forum, After the Geologist, How are Environmental Inventories Used? at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin.

—Participant, Portable Energy Technology Assessment, Workshop, Monterey, California.

—Participant and delegate, State/Federal Coastal Zone Mapping Conference, Washington, D. C.

—Technical Editor, American Association of Petroleum Geologists, 1974 Annual Meeting.

**C. G. Groat**

—Associate Director for Resources and Environment at Center for Energy Studies, The University of Texas at Austin.

—Organizer and Co-chairman of session, Regional Mapping Programs—Data for Land Use and Resource Planning, at American Association of Petroleum Geologists, 1974 Annual Meeting.

—Organizer and Co-chairman of symposium, Industrial Minerals Exploitation and the Environment, at Society of Mining Engineers of American Institute of Mining, Metallurgical, and Petroleum Engineers, 1974 Annual Meeting.

—Program Chairman for Geological Society of America, South-Central Section, 1975 Annual Meeting (to be held in Austin, Texas).

**W. R. Kaiser**

—Co-chairman of session, Sedimentation, at Society of Economic Paleontologists and Mineralogists, 1974 Annual Meeting.

—Co-leader of Arkansas-Texas Economic Geology Field Trip, for Society of Economic Geologists, 1974 Annual Meeting.

—Invited participant at Commission on Critical Choices for Americans, April Meeting, Austin, Texas.

#### J. H. McGowen

—Chairman for Mineralogy Section at Society of Economic Paleontologists and Mineralogists, 1974 Annual Meeting.

—Co-chairman of session, Sedimentary Petrology, at Society of Economic Paleontologists and Mineralogists, 1974 Annual Meeting.

#### R. A. Morton

—Assisted Texas Coastal and Marine Council on Hurricane Awareness Program, Corpus Christi and Houston, Texas.

—Conducted investigation and wrote report, Historical Changes in Shoreline and Vegetation Line—West Beach of Galveston Island, Texas, for Office of the Texas Attorney General.

#### T. L. Rowland

—Co-leader of field trip, Depositional Environments of Selected Pennsylvanian Sandstones and Carbonates of Oklahoma, for Geological Society of America, South-Central Section, 1974 Annual Meeting.

#### R. L. Shipman

—Chairman of session, Environmental Inventories, at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin.

—Presided at Science Section of U. S. National Park Service, Southwest Regional Natural Science Conference, Santa Fe, New Mexico.

—Statement to U. S. Bureau of Land Management at Public Hearing, Corpus Christi, Texas.

#### E. G. Wermund

—Chairman of session, A Geologic Perspective of the Environment, at Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin.

—Co-chairman of session, Stratigraphic Exploration II, at American Association of Petroleum Geologists, 1974 Annual Meeting.

—Co-chairman of session, Sedimentation I—Recent and Ancient Examples of Alluvial and Submarine Fans, at Society of Economic Paleontologists and Mineralogists, 1974 Annual Meeting.

—Consultant on stability of limestone cliff at Garner State Park for Texas Parks and Wildlife Department.

—Organized Approaches to Environmental Geology, Workshop and Colloquium, sponsored by Bureau of Economic Geology, The University of Texas at Austin.

#### C. M. Woodruff, Jr.

—Chairman of Bureau of Economic Geology Display at Showcase—1974, Texas Union Building, The University of Texas at Austin.

—Co-leader of Austin Geological Society 1974 Spring Field Trip, Geomorphic and Hydrologic Features of the Central Texas Hill Country.

—Coordinator for Environmental Impact Review for Governor's Office, Division of Planning Coordination.

## BUREAU OF ECONOMIC GEOLOGY

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  - Dr. Charles G. Groat, Associate Director (Administration)
  - Dr. E. G. Wermund, Coordinator, Land Resources Laboratory
- Eloise Hill, Executive Assistant  
Ross L. Shipman, Research Program Manager

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- Dr. Joseph H. McGowen
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- Bonnie R. Weise
- William A. White
- Dr. Charles M. Woodruff, Jr.

### Special Consultants and Research Associates

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Dr. Ralph O. Kehle  
Dr. W. David Kuenzi

### Visiting Scientists

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Dr. Antonio U. Cendrero

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Administrative Clerk  
Harry J. Madsen

### Mineral Studies Laboratory

Daniel A. Schofield,  
Chemist-in-Charge  
Laurence C. McGonagle, Jr.

Additional staff worked on a part-time basis as research assistants and in support of the publications, cartographic, and clerical-secretarial sections, and the Mineral Studies Laboratory and Well Sample Library.

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

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