

**BUREAU OF
ECONOMIC
GEOLOGY**



Annual Report 1970

BUREAU OF ECONOMIC GEOLOGY

RESEARCH AND SERVICE IN GEOLOGY

Mineral Resources
Mineral Statistics
Mineral Information

Basic
Geologic Research
in Texas

Environmental
and Conservation
Problems

Systematic
Geologic
Mapping

BEG Bureau of Economic Geology
5.5
A5 Annual Report
1970

Cover: Portion of forthcoming Bureau of Economic Geology Environmental Geologic Atlas of the Texas Coastal Zone. Description of the Atlas is given elsewhere in this Report.

**BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
University Station, Box X
Austin, Texas 78712**

**RESEARCH AND ADMINISTRATIVE OFFICES
GEOLOGY BUILDING, MAIN CAMPUS**

**LABORATORIES
BALCONES RESEARCH CENTER**

Bureau of Economic Geology

The Bureau of Economic Geology is a research bureau of The University of Texas at Austin; it also functions as a State agency. Established in 1909, it has for 62 years been recognized as the Texas State Geological Survey; its Director fills the position of State Geologist. The Bureau is engaged in research and public service in Texas geology. It carries on basic research to further understanding of the geologic architecture of the State and the natural earth processes that operate in Texas. The applied program is focused on earth resources, environmental and conservation problems, and engineering problems. The Bureau's efforts in systematic geologic mapping are designed to produce geologic and special derivative maps at several scales for all those concerned with land use in Texas. The Bureau participates in other University research efforts in the fields of resources and earth sciences, such as the Center for Research in Water Resources. The Bureau publishes major reports in The University of Texas Publication series; it also has its own series of Reports of Investigations, Geologic Quadrangle Maps, Guidebooks, Geological Circulars, Mineral Resource Circulars, and special publications. A complete list of publications is available on request.

The geologic data developed by the Bureau of Economic Geology in the form of scientific reports and geologic maps are used by many State and Federal organizations in carrying out investigations in the public service. The Texas Water Development Board, Texas Highway Department, Parks and Wildlife Department, Texas Industrial Commission, Railroad Commission, Interagency Natural Resources Council, and numerous other State departments, boards, conservation organizations, water districts, and chambers of commerce utilize Bureau publications and services on both a formal and informal basis through interagency contracts and staff conferences. The Bureau also cooperates with Federal agencies, such as the Geological Survey, Bureau of Mines, Bureau of Reclamation, Corps of Engineers, and National Park Service. The mineral and geological information service offered by the Bureau of Economic Geology is used by private groups, corporations, and citizens through correspondence and conference.

Publications in 1970

Report of Investigations No. 65. LOWER CRETACEOUS STRATIGRAPHY, NORTHERN COAHUILA, MEXICO, by C. I. Smith. 101 pp., 20 figs., 15 pls., including geologic map in color, scale 1:250,000, 1970\$4.00

Presents stratigraphic data and interpretations pertaining to the origin of a continental shelf-ocean basin sedimentary complex developed during Lower Cretaceous time in northern Coahuila, Mexico and adjacent southwest Texas. This shelf was developed within a carbonate depositional régime and provides a specific descriptive example which should be useful in the development of a comprehensive process-response model of shelf origin.

Facies patterns of outcrop and subsurface Lower Cretaceous rocks in southwest Texas trend into northern Mexico, toward the mountains of northern Coahuila. Investigations reported show the full genetic relationship between basin, shelf-edge, and shelf facies of these important Lower Cretaceous stratigraphic units. The report not only is of significance to the Lower Cretaceous stratigraphy of northern Mexico but also contributes importantly to the understanding of equivalent units in Texas. Ten measured sections are included in an appendix; the bibliography contains 61 entries.

Report of Investigations No. 66. TRILOBITES OF THE UPPER CAMBRIAN PTYCHASPID BIOMERE, WILBERNS FORMATION, CENTRAL TEXAS, by Susan Ann Longacre. Reprint of MEMOIR 4, SUPPLEMENT to JOURNAL of PALEONTOLOGY, vol. 44, 70 pp., 8 figs., 6 pls., 1970 ...\$2.00

The fossils which are the basis of this study are from the Central Texas Wilberns Formation (Upper Cambrian) and comprise 89 species assigned to 45 genera. Two new subfamilies and eight new species are described, and the complex of inter-related trilobite species and genera is named by the writer the Ptychaspis Biome. One of the text figures is an index map showing location of measured sections, and the plates are composed of photographs of the various specimens described. A list of references is included.

Report of Investigations No. 67. FACIES AND GENESIS OF A HURRICANE-WASHOVER FAN, ST. JOSEPH ISLAND, CENTRAL TEXAS COAST, by Peter B. Andrews. 147 pp., 18 figs., 22 pls., 12 tables, 1970\$3.00

Washover fans—subaerial coastal landforms which form on the bayside of many barrier islands along the Texas Gulf Coast—are composed largely of sediment that had been carried across a barrier island and dumped in the adjoining bay by catastrophic storms, such as hurricanes. This Report of Investigations concerns such a fan, measuring $4\frac{1}{4}$ by 4 miles, which occurs at the north end of St. Joseph Island, Texas. Plant and faunal communities are named and described as well as the various surface and subsurface facies and the processes that cause their deposition. Several of the photographic plates show radiographs of certain facies as well as relief peels and core sections. The 37-

page appendix contains graphic logs of trench sections used in 5 of the large plates. Eighty-seven references are listed in the bibliography.

Report of Investigations No. 68. PRE-CHAPPEL CONODONTS OF THE LLANO REGION, TEXAS, by George Seddon. 130 pp., 9 figs., 19 pls., 24 tables, 3 charts, frontispiece in color, 1970\$7.50

Describes the conodont faunas from Devonian rocks of the Llano region of Central Texas. Conodonts are microfossils of uncertain zoologic affinity but useful in dating and correlation of rocks in which they are found. Conodonts have been used as a means of clarifying local stratigraphic relations in the Llano region and for confirming or revising the correlations of previous workers. Most Devonian and some Ordovician, Silurian, and Mississippian species are illustrated on the photographic plates and numerous species are described; many others are recorded only. The report contains 24 tables and 3 correlation and range charts. The full-color frontispiece of a polished slab of Pillar Bluff Limestone shows minute iron-stained crack fillings in which conodonts of Middle and Late Devonian age are common. The bibliography contains 165 entries.

Guidebook No. 10. GEOLOGIC AND HISTORIC GUIDE TO THE STATE PARKS OF TEXAS, by Ross A. Maxwell; with contributions by L. F. Brown, Jr., G. K. Eifler, Jr., and L. E. Garner. 197 pp., 98 figs., 1 pl., 2 tables, 1970\$3.00

Contains papers on 57 State parks including description of the geology as well as the scenic and historic points in the parks and immediate vicinity. A small geologic map of most of the parks is included with the individual papers, and the volume is profusely illustrated with photographs of pertinent interest. A small generalized geologic map of Texas in color, a geologic time scale, and a "rock cycle" enhance the volume; the one plate is a physiographic diagram of the State and shows location of all the State parks. Brief descriptions of park facilities are given.

Guidebook No. 11. RECENT SEDIMENTS OF SOUTHEAST TEXAS—A Field Guide to the Brazos Alluvial and Deltaic Plains and the Galveston Barrier Island Complex, by H. A. Bernard, C. F. Major, Jr., B. S. Parrott, and R. J. LeBlanc, Sr. 24-p. text, 57 figs., and Appendix, "Résumé of the Quaternary Geology of the Northwestern Gulf of Mexico Province," by H. A. Bernard and R. J. LeBlanc, 23-p. text, 40 figs., 1970\$5.00

Presents detailed facies descriptions, maps, and log characteristics of modern or Holocene facies of the Brazos River, the Brazos Delta, and Galveston Barrier Island of the southeast Texas coast and coastal plain. This study is the result of research and field work in these areas by geologists with Shell Development and Shell Oil Companies. The models presented—based on several years of detailed investigation and three-dimensional

reconstruction—are of significant interest to individuals concerned with ancient and modern fluvial and marine clastic facies and environments not only in southeast Texas but also with similar facies elsewhere. The kind of facies described and illustrated form important oil and gas reservoirs in ancient basins throughout the world.

The 131-page report contains 97 figures in the form of maps, cross sections, and logs, and photographs of physiographic features, sedimentary structures, and cores. Three figures are large foldouts, including a colored geologic and facies map of the southeast Texas Coastal Zone. The guidebook is spiral-bound with a full-color, plastic-overlay cover.

Geologic Atlas of Texas. PERRYTON SHEET. Charles Newton Gould Memorial Edition, compiled by G. K. Eifler, Jr., of the Bureau of Economic Geology, and R. O. Fay, of the Oklahoma Geological Survey, under the direction of V. E. Barnes; reviewed and edited by the Geologic Atlas Project Committee of the Panhandle Geological Society. Scale 1:250,000, in color, topographic base, 1970 \$2.50

Areal geologic map with topography, roads, and culture covering all of Lipscomb, Ochiltree, and Hansford counties, most of Sherman County, and the northern parts of Moore, Hutchinson, Roberts, and Hemphill counties, Texas; also most of Texas and Beaver counties, Oklahoma. Twenty map units of Paleozoic, Mesozoic, and Cenozoic rocks. Published as a memorial edition honoring Charles Newton Gould, Director of the Oklahoma Geological Survey from 1923 to 1931, who was known for his areal geological mapping in the southwestern United States.

Geologic Atlas of Texas. WACO SHEET. Lloyd William Stephenson Memorial Edition, compiled by C. V. Proctor, Jr., J. H. McGowen, and W. T. Haenggi under the direction of V. E. Barnes; reviewed and edited by the Geologic Atlas Committees of the Austin and Dallas Geological Societies and by O. T. Hayward, of Baylor University. Scale 1:250,000, in color, topographic base, 1970 \$2.50

Areal geologic map with topography, roads, and culture covering all or parts of Anderson, Bell, Bosque, Burnet, Coryell, Falls, Freestone, Hamilton, Hill, Lampasas, Leon, Limestone, McLennan, Madison, Milam, Navarro, and Robertson counties. Published as a memorial edition honoring Lloyd William Stephenson, who authored many geologic studies concerning the Cretaceous rocks of Texas, as well as elsewhere in the United States. He was long associated with the U. S. Geological Survey.

Geologic Quadrangle Map No. 37. GEOLOGY OF BOFECILLOS MOUNTAINS AREA, TRANS-PECOS TEXAS, by John F. McKnight. Scale 1:48,000; 36-p. text, 1970... \$3.00

Areal geologic map in color, with five structure sections. The area covered is about 275 square miles in the Lajitas and Redford partial quadrangles, in southeastern Presidio County and southwestern Brewster County. The area contains a Tertiary volcanic vent and a varied sequence of lava flows, tuff, ash-flow tuff, and associated conglomerate, sandstone, and mudrock. The

area is block faulted and dissected into a rugged high-standing terrain with striking exposures.

Text contains detailed discussion of the Cretaceous strata and Tertiary rocks including description of the structural geology and geomorphology. Economic resources such as mercury, bentonitic clay, perlite, water, and petroleum are outlined; list of 62 references is included. One text illustration compares nomenclature of the Gulf series as used by workers in the Big Bend region, and the composition of water from three wells in the Bofecillos Mountains and vicinity is given in table 1.

Geologic Quadrangle Map No. 38. AUSTIN WEST, TRAVIS COUNTY, TEXAS, by P. U. Rodda, L. E. Garner, and G. L. Dawe. Scale 1:24,000; 11-p. text, chart, 1970... \$2.00

Areal geologic map in color on detailed topographic and cultural base. Map area extends from the western Hill Country, across the Balcones escarpment and fault zone, to the western edge of the blackland prairie and includes west, northwest, and parts of south Austin, as well as the suburban communities of Rollingwood and Westlake Hills. Distribution of bedrock and surficial units and location of major faults are shown. Each rock unit delineated has distinctive physical properties, and each is represented by a distinctive color. The text describes the geological and engineering characteristics, land use, and mineral resources of the rock units. The separate chart summarizes by map unit the general geologic features, engineering test data, and environmental geologic characteristics including slope stability, foundation and excavation characteristics, infiltration capacity, and mineral resources.

Geologic Quadrangle Map No. 39. GEOLOGY OF SOUTHERN QUITMAN MOUNTAINS, HUDSPETH COUNTY, TEXAS, by Bill R. Jones and Donald F. Reaser. Scale 1:48,000; 24-p. text, 1970 \$2.00

Areal geologic map in color, with five structure sections. The Quitman Mountains are part of a narrow mountain range that extends southeastward from near Sierra Blanca, Texas into northern Mexico. The range is divided by Quitman Gap into two parts; this study is of the southern part. Exposed Cretaceous rocks consist of about 14,000 feet of marine shale, sandstone, and limestone, and nonmarine sandstone and shale. This is the thickest sequence of Cretaceous rocks that crop out in Texas. Detailed description of the various formations is given. A detailed columnar section of the Cretaceous stratigraphy is illustrated. The text contains a list of 41 references.

Geological Circular No. 70-1. MINERAL RESOURCES AND CONSERVATION IN TEXAS, by Peter T. Flawn. Contains chart compiled by Carolyn H. Leach on Texas mining laws pertaining to State public lands. 20 pp., 1970... \$0.50

A nontechnical summary of mineral resource and conservation problems in Texas and the environmental problems produced in the extraction of mineral resources. Contains statistical information on mineral production in Texas, references on Texas mineral resources, and a chart on Texas mining laws that pertain to the State public lands.

Geological Circular No. 70-2. **GEOLOGICAL CONSIDERATIONS IN DISPOSAL OF SOLID MUNICIPAL WASTES IN TEXAS**, by Peter T. Flawn, L. J. Turk, and Carolyn H. Leach. 22 pp., 1970\$0.50

Where to put solid municipal wastes in order to prevent pollution of the environment is the subject of this publication. It contains a discussion of various geological formations in Texas that provide secure sites for sanitary landfills. The geology around each metropolitan area is described briefly together with the depth to the water table, the topography, excavation characteristics, and other factors which influence the location of landfills. The information was developed in cooperation with the State Health Department, which has been charged with setting standards for municipal waste disposal. A location map of the major cities in Texas makes up one of the illustrations, and surface waste disposal and ground-water contamination examples are also delineated.

Geological Circular No. 70-3. **EFFECTS OF HURRICANE CELIA—A Focus on Environmental Geologic Problems of the Texas Coastal Zone**, by J. H. McGowen, C. G. Groat, L. F. Brown, Jr., W. L. Fisher, and A. J. Scott. 35 pp., 9 figs., 1970\$1.00

With emphasis on the physical processes generated by Hurricane Celia, this report compares and contrasts Celia with her recent cousins Beulah and Carla. A model of hurricane types is outlined. Along with consideration of the geologic effects of hurricanes in the Texas Coastal Zone, the report describes and illustrates the effects of storms on man-made features and structures. A special section reviews hurricanes in relation to land-use planning in the Coastal Zone, with recommendations for specific kinds of planning aimed at reducing the destructive effects of hurricanes. Twenty line drawings and photographs

illustrate the report; satellite photographs of Hurricane Celia's track across Texas and the Gulf are shown on the cover and as a frontispiece.

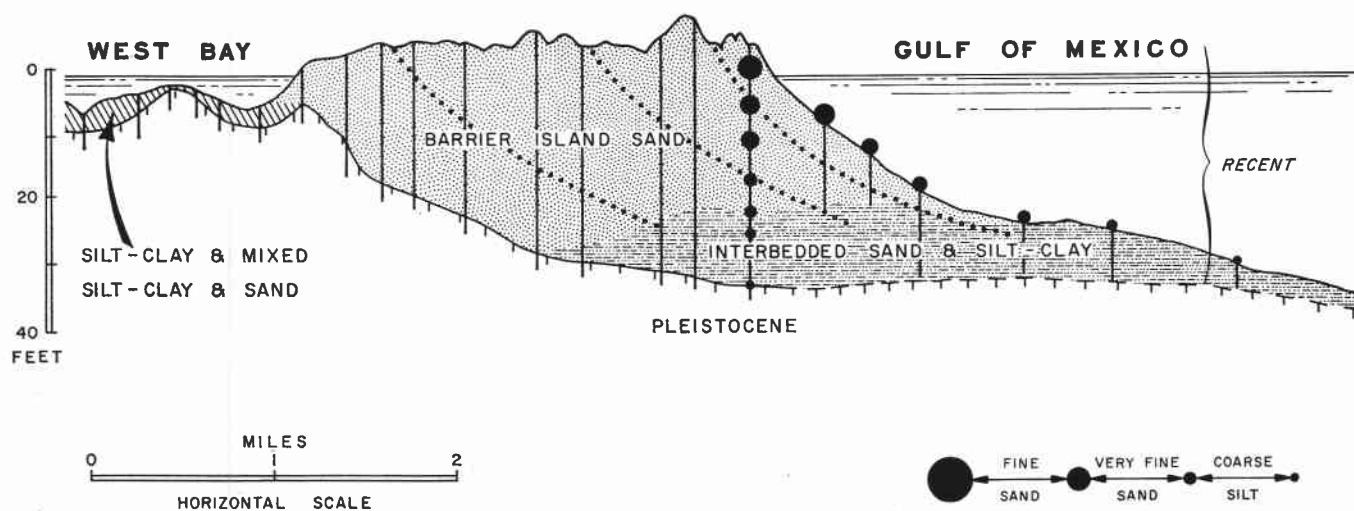
TEXAS MINERAL PRODUCERS (Exclusive of Oil and Gas), compiled by Roselle M. Girard. 62 pp., 1970\$1.25

A revision of "Texas Mineral Producers" consisting 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.

Compiled chiefly from information supplied by U. S. Bureau of Mines. Other sources consulted: "Directory of Texas Manufacturers, 1969" and "Texas Industrial Expansion," both issued by the Bureau of Business Research of The University of Texas at Austin; trade journals; Texas geologists; and Bureau of Economic Geology files.

Mineral Resource Circular No. 52. **THE MINERAL INDUSTRY OF TEXAS IN 1969**, by Owen W. Jones, F. F. Netzeband, and Roselle M. Girard, 1970 Free on request

A preprint from the *Minerals Yearbook, 1969* of the U. S. Bureau of Mines, prepared under a cooperative agreement between the U. S. Bureau of Mines and the Bureau of Economic Geology. Included are: a listing that shows value of mineral production in individual Texas counties during the year; a review of production of mineral fuels, industrial minerals (non-metals), and metals in 1969; and a list of principal mineral producers in Texas. An annual issue of the Bureau.



Generalized cross section of Galveston Island. (From Guidebook No. 11, fig. 51.)

Publications in Press

Report of Investigations No. 69. Gum Hollow Fan Delta, Nueces Bay, Texas, by Joseph H. McGowen.

Report of Investigations No. 70. Correlation of Tertiary Rock Units, West Texas, by Ross A. Maxwell and John W. Dietrich.

Report of Investigations No. 71. Stratigraphy of Lower Cretaceous Trinity Deposits of Central Texas, by F. L. Stricklin, Jr., C. I. Smith, and F. E. Lozo.

Report of Investigations No. 72. Edwards Group, Surface and Subsurface, Central Texas, by Peter R. Rose.

Handbook No. 2. Sulfur in Texas, by Samuel P. Ellison, Jr.

Geological Circular No. 70-4. Depositional Systems in the Jackson Group of Texas—Their Relation to Oil, Gas, and Uranium, by W. L. Fisher, C. V. Proctor, Jr., W. E. Galloway, and J. S. Nagle.

Geologic Atlas of Texas: Abilene and Dallas Sheets.

Bibliography and Index of Texas Geology, 1951-1960, by E. T. Moore and M. D. Brown.

Open-File Reports

The Bureau of Economic Geology maintains an open file of about 300 reports and manuscripts that are unpublished or are progress reports of projects that ultimately may be published. These reports may be examined and copied, but publication rights are reserved.

The following papers were placed on open file during 1970.

Preliminary Report of Radioactive Mineral Deposits in the Gulf Coastal Plain of Texas and Louisiana, North and East of the Guadalupe River, by Robert G. Blair: U. S. Atomic Energy Commission Technical Memorandum Report TM-D-5-2, 15 pp., 3 figs., 2 tables, March 1959. (Deposited by U. S. Atomic Energy Commission, Grand Junction, Colorado, January 1970.)

Uranium in Texas, by D. Hoye Eargle: 12 pp., 1970.

(Deposited by U. S. Geological Survey, Washington, D. C.)

Descriptions of logs of wells drilled in the Bergstrom Study Area of the Llano Region, by U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, for Space and Missile Systems Organization, U. S. Air Force Systems Command. (Deposited by Ken O'Brien & Associates, Long Beach, California, September 1970.) Supplementing these log descriptions is copy of the U. S. Army Engineer Waterways Experiment Station's Miscellaneous Paper C-70-4, entitled "Tests of Rock Cores, Bergstrom Study Area, Texas," by K. L. Saucier and A. D. Buck, 134 pages, February 1970. Cores of the wells concerned are at the Well Sample and Core Library of the Bureau.

Papers by Bureau of Economic Geology Staff in Scientific Journals

Barnes, V. E., Edwards, George, McLaughlin, W. A., Friedman, Irving, and Joensuu, Oiva (1970) Macusanite occurrence, age, and composition, Macusani, Peru: Geological Society of America Bulletin, vol. 81, pp. 1539-1546.

Brown, L. F., Jr., and Fisher, W. L. (1970) An approach to environmental geology with examples from the Texas Coastal Zone: American Geological Institute, Short Course Lecture Notes, November 9-10, Milwaukee.

Cloud, Preston, Margolis, S. V., Moorman, Mary, Barker, J. M., Licari, G. R., Krinsley, David, and Barnes, V. E. (1970) Micromorphology and surface characteristics of lunar dust and breccia: *Geochimica et Cosmochimica Acta*, vol. 34, Proceedings Apollo 11 Lunar Science Conference, supplement 1, vol. 2, pp. 1793-1798; *Science*, vol. 167, pp. 776-778.

Fisher, W. L., Proctor, C. V., Jr., Galloway, W. E., and Nagle, J. S. (1970) Depositional systems in the Jackson Group of Texas—their relationship to

- oil, gas, and uranium: Gulf Coast Association of Geological Societies Transactions, vol. 20, pp. 234-261.
- Flawn, P. T. (1970) Environmental geology in land-use planning, resource management, and conservation: Harper & Row, Publishers, New York, 313 pp.
- Flawn, P. T. (1970) *Review of Resources and man*, NAS-NRC, published by W. H. Freeman and Company, 1969: American Association of Petroleum Geologists Bulletin, vol. 54, no. 3, pp. 540-541.
- Flawn, P. T., Fisher, W. L., and Brown, L. F., Jr. (1970) Environmental geology and the coast—rationale for land-use planning: Journal of Geological Education, vol. 18, no. 2, pp. 85-86.
- Flawn, P. T., and Muehlberger, W. R. (1970) Precambrian rocks of south-central United States, in *The Precambrian*, K. Rankama, editor, Interscience Publishing Company, London and New York, pp. 73-143.
- Flawn, P. T., Fisher, W. L., Leach, C. H. (1970) Texas, in *Uranium in the southern United States: The Southern Interstate Nuclear Board and the United States Atomic Energy Commission Report*, WASH-1128 TID UC-51, pp. 97-147.
- Groat, C. G. (1970) Effects of ground water on geomorphology, Lower Mojave Valley, California (abstract): Texas Journal of Science, vol. 21, p. 336.
- Groat, C. G. (1970) Excavation of Presidio bolson, Trans-Pecos Texas (abstract): Geological Society of America, Abstracts with Programs, vol. 2, no. 7, pp. 562-563.
- Groat, C. G. (1970) Geology and hydrology of Troy playa, San Bernardino County, California, in *Geology and hydrology of selected playas in western United States*, W. S. Motts, editor: University of Massachusetts, Amherst, pp. 166-213.
- McGowen, J. H., and Garner, L. E. (1970) Physiographic features and stratification types of coarse-grained point bars—modern and ancient examples: Sedimentology, vol. 14, pp. 77-111.
- Waechter, N. B. (1970) Braided stream deposits of the Red River, Texas Panhandle (abstract): Geological Society of America, Abstracts with Programs, vol. 2, no. 7, p. 713.

Flawn Appointed Vice-President for Academic Affairs

Dr. Peter T. Flawn, Director of the Bureau of Economic Geology since 1960, assumed the position of Vice-President for Academic Affairs, *ad interim*, at The University of Texas at Austin on August 1, 1970. Flawn, also a Professor of Geological Sciences, joined the Bureau of Economic Geology staff in 1949. In June 1970 he was named Director of The University's new Division of Natural Resources and Environment, comprising the Bureau of Economic Geology, the Center for Research in Water Resources, and the Marine Science Institute at Port Aransas.

Dr. Flawn has played an important part in National and State efforts directed toward the earth and natural resources for many years. He is the author of five books and major reports and more than 50 articles. Flawn's early research centered on structural and economic geology of Trans-Pecos Texas. This led to a long-term investigation of basement rocks and the ancient Ouachita System in Texas, culminated by publication in 1962 of "The Ouachita System" as University of Texas Publication 6120. Flawn's extensive researches in the areas of economic geology and mineral resources were the bases for a book published by Rand McNally in 1966 entitled "Mineral Resources—Geology, Engineering, Economics, Politics, and Law."

Prof. Flawn is an international leader in environmental geology or the relation of geology to broad environmental problems. His efforts in this field resulted in publication this year by Harper & Row of "Environmental Geology in Land-use Planning, Resource Management, and Conservation."

Flawn has served as a director of the American Geological Institute and recently as President of the Association of American State Geologists. He holds prominent positions in other national and international professional societies as well as important positions on local, state, and national councils. He has served on several faculty committees at UT Austin and is currently Chairman of the Institute of Latin American Studies Advisory Committee. He is a former Chairman of the Faculty Committee on Publications and has served on the Library Committee.

Flawn represents The University on the Interagency Natural Resources Council of Texas and the Joint Council on University-State Relations. He serves as the UT representative on Gulf Universities Research Corporation as well as Chairman of the GURC Panel

on Man's Use of the Gulf. Flawn is a Fellow of The Geological Society of America and has held committee assignments in the American Association of Petroleum Geologists, the American Institute of Mining and Metallurgical Engineers, and the American Institute of Professional Geologists. He is a member of the Society of Economic Geologists and Sociedad Geológica Mexicana.

Flawn speaks and lectures fluently in Spanish and has been a visiting professor at the National University of Mexico. During 1960, he was a Visiting Lecturer in Geology at Northwestern University.

Dr. Flawn was recently appointed to the Committee on Technologies and Water and the Committee on Radioactive Waste Management—both committees of the National Academy of Sciences-National Research Council. Dr. Flawn's tenure as Director marked a period of significant growth and involvement of the Bureau of Economic Geology. From 1960–1970, the Bureau, under his direction, published 120 items including 38 full-color maps. Flawn initiated the Texas Geologic Atlas project, several important mineral surveys were completed, and a new program of environmental geology was developed. He continues as a consultant to the Bureau.



Peter T. Flawn

Fisher Appointed Acting Director

Dr. W. L. Fisher became Acting Director of the Bureau of Economic Geology August 1, 1970, succeeding Dr. Peter T. Flawn. Fisher joined the Bureau staff in 1960 and for the past two years has served as Associate Director. He is also Professor of Geological Sciences at UT Austin.



William L. Fisher

Fisher has published more than 40 papers and reports on several aspects of Texas geology, with emphasis on stratigraphy, sedimentology, and mineral re-

sources of the Texas Gulf Coast Basin. Work on ancient Gulf Basin clastic sediments has contributed to the concept of depositional systems and genetic integration of clastic facies. Studies of the Texas Wilcox and other Gulf Basin units have indicated the significance of deltaic and related deposition to the filling of the Gulf of Mexico Basin and the importance of these systems in oil, gas, and other mineral exploration. Along with colleagues in the Bureau of Economic Geology, Fisher currently is completing an extensive environmental geologic investigation of the Texas Coastal Zone, designed to map and delineate process-related landforms and facies basic to environmental planning and land use of the Texas coastal lands, bays, and estuaries.

Fisher is a Fellow of The Geological Society of America and the Texas Academy of Science and a member of the American Association of Petroleum Geologists, the Society of Economic Paleontologists and Mineralogists, the Society of Economic Geologists, the Society of Mining Engineers, and Sigma Xi. He serves on several National scientific, State, and University committees.

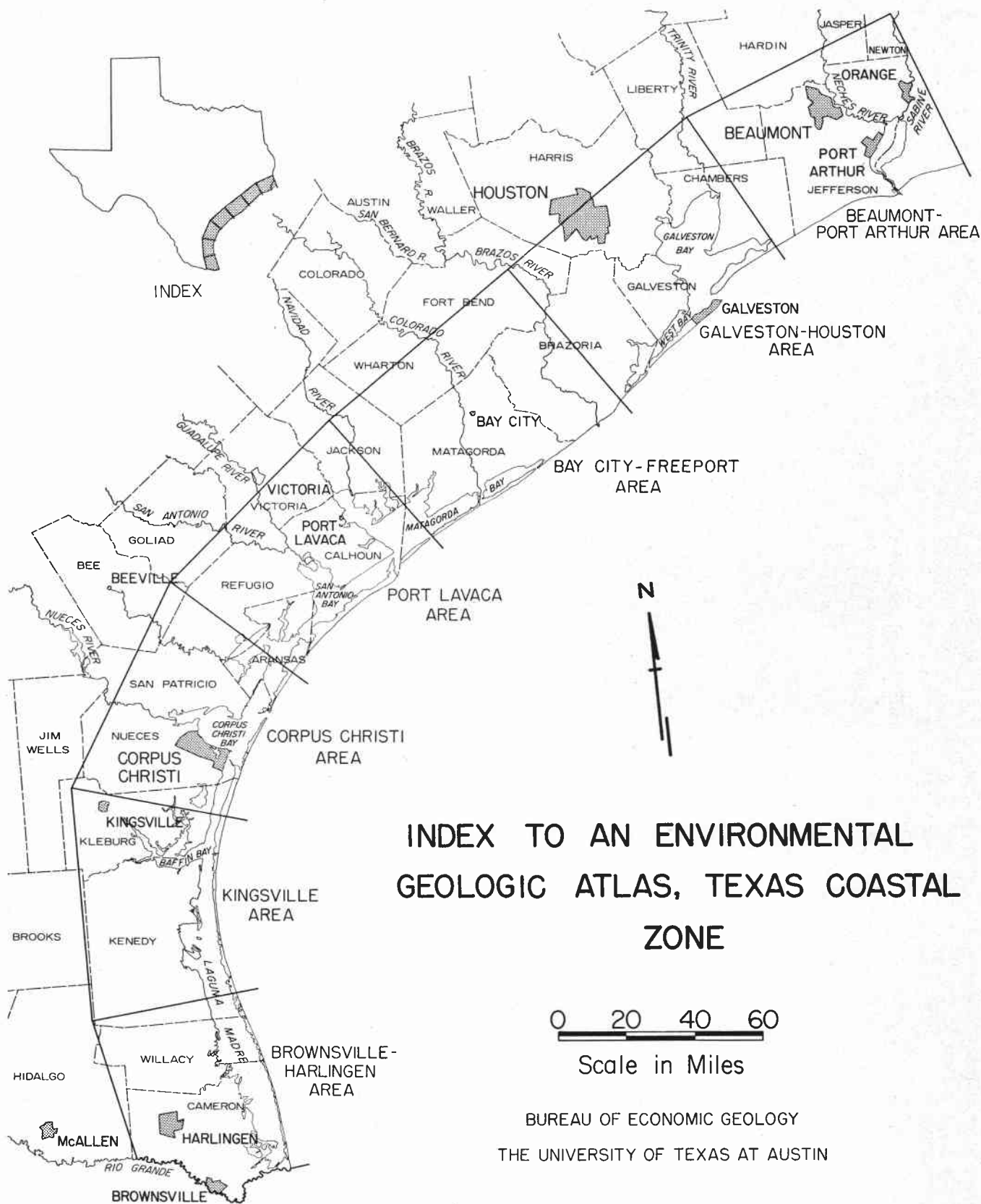
Fisher has been a Visiting Professor of Geology at Southern Illinois University and a lecturer for the Permian Basin Graduate Center. He was a leader of the Bureau's Research Colloquium on Delta Systems in the Exploration for Oil and Gas, presented originally in Austin and recently in Midland and Shreveport. During 1970-1971 he was named a Distinguished Lecturer for the American Association of Petroleum Geologists.

Environmental Geologic Atlas of the Texas Coastal Zone

During the summer of 1970, Bureau geologists completed the mapping of approximately 20,000 square miles of the Texas Coastal Zone from the Rio Grande to the Sabine River and for 40 miles inland from the shoreface to middle Pleistocene outcrops. In mid-1969, L. F. Brown, Jr., W. L. Fisher, C. G. Groat, and J. H. McGowen initiated the mapping as the principal part of an *Environmental Geologic Atlas of the Texas Coastal Zone*. The project is designed to provide environmental geologic maps of the coastal area in order to document the distribution of modern environ-

ments, landforms, sedimentary facies, and older Pleistocene facies. The maps are the basis for many special derivative maps of environmental importance in the delicately balanced coastal zone where development, industrialization, and population are increasing spectacularly.

Adequate plans to meet the potential problems of pollution, land use, and conservation are critically needed if proper development of this vital Texas region is to be fully realized during the next few decades. A thorough regional analysis or inventory of the total



coastal natural resources is vitally important and must be based on accurate and relatively detailed maps of environments, landforms, and genetic sedimentary units.

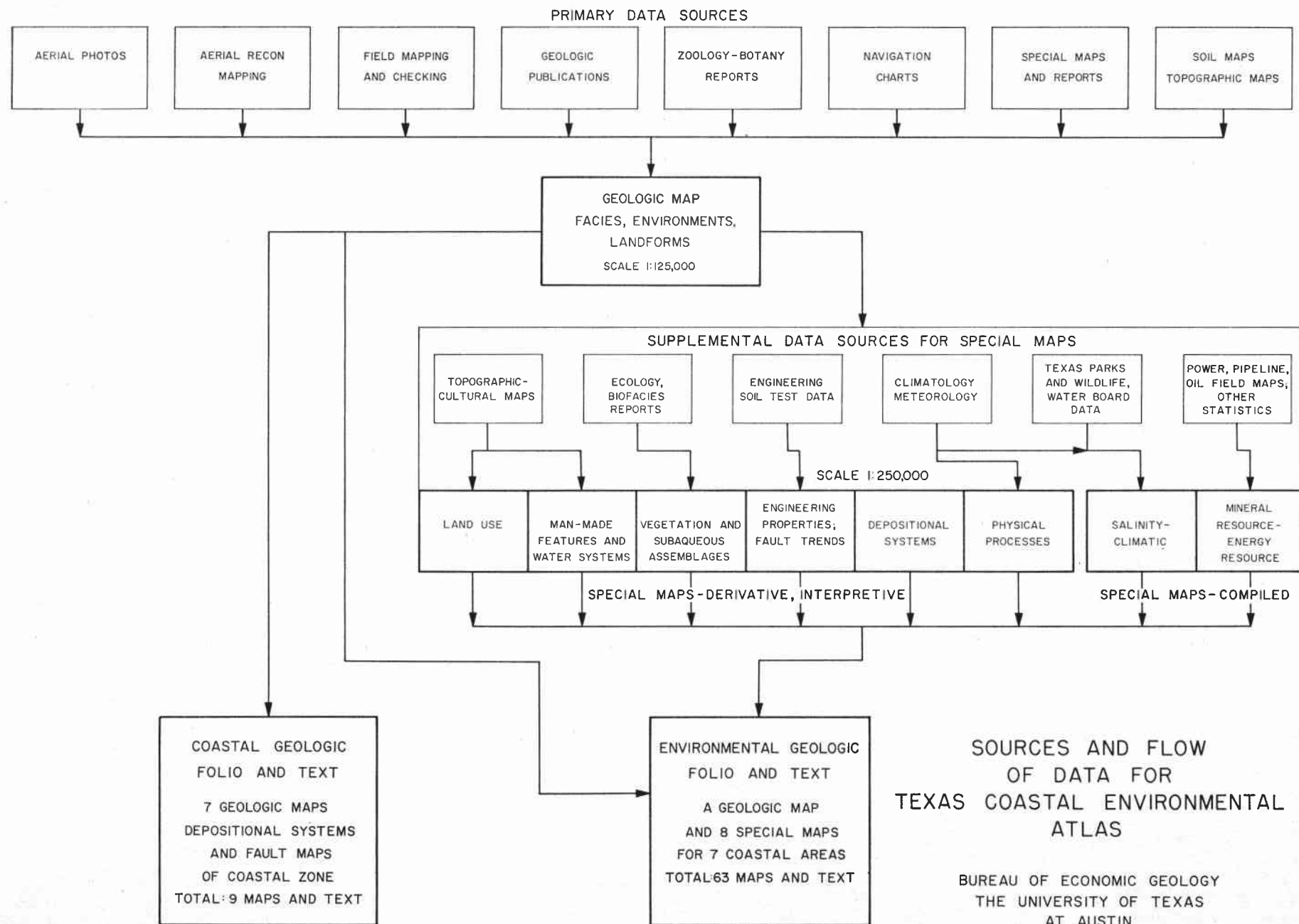
The *Environmental Geologic Atlas* is intended to provide fundamental environmental information on which planning, legislative guidance, and more specialized scientific studies can be based during the next decade. The environmental geologic map and its special derivatives provide a common language and vehicle that can bring together many divergent specialists and governmental groups and allow their collective contribution to be simultaneously focused on vital coastal environmental problems.

Part of the Texas Coastal Zone is in danger of serious and perhaps irreversible environmental imbalance. This zone has been blessed with petroleum reserves, sulfur and salt, deep-water ports, intracoastal waterways, mild climate, good water supplies, and large tracts of uncrowded land. The very things that make the Texas Coastal Zone so attractive to industrialization and development also make it susceptible to sudden pollution, drastic land damage, and other serious environmental problems. The Texas coast is almost 400 miles long and possesses about 1,100 miles of shoreline characterized by interconnecting waterways and restricted bays, lagoons and estuaries, low to moderate fresh-water inflow, barrier islands, and extremely low astronomical tidal range. Combined with the natural environment are bayside and intrabay oil fields, bayside refineries and petrochemical plants, dredged intracoastal canals and channels, and burgeoning satellite industries. The coastal area is delicately balanced between natural maintenance by physical, chemical, and biologic processes and the impinging extra-environmental effects from industry, urban areas, and coastal land developments. Because the coastal zone is the fastest developing industrial, urban, and recreational area in Texas, and is at best a delicately balanced natural complex of dynamic environments with a history of almost yearly impact of savage hurricanes, an intensive application of the principles of environmental geology is being directed toward this region.

The Bureau's coastal investigation consists of mapping and study made both in the field and from low-flying light aircraft. Mapping utilized 320 7.5-minute (1:24,000-scale) aerial mosaics and topographic maps, as well as soil maps, navigation charts, botany-zoology

reports, and other information sources. Following completion of geologic mapping, special environmental maps were derived from the genetic geologic map units or compiled from widely distributed sources. Special maps include those showing land use, man-made features, water systems, biologic assemblages, engineering properties and fault trends, physical processes, salinity-climatic data, mineral and energy resources, and depositional systems.

The *Environmental Geologic Atlas of the Texas Coastal Zone*, scheduled for publication by mid-1971, will consist of a folio of 63 multicolored geologic and environmental maps accompanied by text explaining use and interpretation. The coastal zone was divided into seven map areas: Brownsville-Harlingen, Kingsville, Corpus Christi, Port Lavaca, Bay City-Freeport, Galveston-Houston, and Beaumont-Port Arthur. For each of the areas, the following maps are being prepared: (1) *Environmental Geologic Maps* (scale, 1:125,000)—presenting a total of 125 map units including landforms, sediments, bedrock, and certain plant communities. The Bureau-constructed base map includes 5-foot topographic contours; 3-foot bathymetric lines; location of paved roads, cities, and pipelines; and other physical and cultural information. Emphasis was placed on mapping basic units from which a variety of data can be derived. (2) *Special Environmental Maps* (scale, 1:250,000)—consisting of (a) *Land-Use Maps*—an inventory (25 map units) of present land use including agriculture, range, woodland-timber, wildlife, spoil and made land, recreation, residential-urban, industrial, and sewage disposal; (b) *Water Systems and Man-Made Features Maps*—an inventory (15 map units) of made land, types of spoil land, jetties, piers, sea walls, rivers, lakes, sloughs, estuaries, reservoirs, canals and ditches, channels, and tidal inlets; (c) *Engineering Properties Maps*—showing distribution (15 map units) of properties such as water-holding capacity, compressibility, shrink-swell, drainage, relief, shear strength, plasticity, flooding, permeability, and mineral content; and of faults and other features; (d) *Biologic-Assemblage Maps*—indicating approximately 45 subaerial plant and subaqueous animal communities; (e) *Physical Processes Maps*—indicating hurricane-surge and flood areas, shoreline erosion, equilibrium and deposition, circulation patterns, sediment dispersal, and tidal data; (f) *Salinity-Climatic Maps*—presenting contours that indicate variations of salinity in bays and estuaries during



droughts and rainy seasons, contours that indicate average salinity, graphs of salinity for each bay and estuary, rainfall data, and water and sediment-discharge data for rivers entering coastal zone; (g) *Mineral and Energy Resources Maps*—presenting approximately 15 units including locations of sand and clay sources, oyster reefs, utility lines, pipelines, quarries, oil-gas

fields, sulfur wells, salt domes, cement plants, power plants, brine wells, and other data; and (h) *Depositional Systems Maps*—a display of active or ancient genetic units such as fluvial, deltaic, marsh, swamp, barrier-cheniers, bay-lagoon-estuary, eolian, and offshore systems.

Well Sample and Core Library Receives Collections

The Bureau's Well Sample and Core Library at Balcones Research Center received significant additions to its collections of subsurface materials during 1970.

Early in the year, Sun Oil Company donated rock cuttings from approximately 20,000 oil and gas wells in Texas. The Company also provided storage shelves for the samples and a card index of the wells. An independent appraiser valued this collection at more than \$110,000.

Another contribution, from the United States Bureau of Reclamation, consists of 347 boxes of cores and samples from relatively shallow test holes drilled at proposed construction sites for dams, canals, and pumping plants in Texas. The holes were drilled in DeWitt, Goliad, Hockley, Lamb, Live Oak, Refugio, San Patricio, San Saba, Wilson, and Zavala counties, and at Colorado River Basin sites between Bay City, Matagorda County, and Mills County. Location maps and geologic logs of the test holes are on file at the Well

Sample and Core Library.

Also received during the year were 123 boxes of core samples from the Bergstrom study area of the Space and Missiles Systems Organization of the United States Air Force Systems Command. The samples are from nine holes, each drilled to a depth of 200 feet into Precambrian igneous and metamorphic rocks in Burnet, Gillespie, Llano, and Mason counties, Texas. Geologic logs and a location map of the test holes are on open file at Bureau of Economic Geology offices in the Geology Building. Also on open file is an accompanying report, "Tests of Rock Cores, Bergstrom Study Area, Texas," by K. L. Saucier and A. D. Buck, 134 pp., February 1970, issued as Miscellaneous Paper C-70-4 by United States Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

The facilities and collections of this Library are described on page 20 of this Annual Report.

New UT Austin Division Established

A newly formed Division of Natural Resources and Environment, established June 1, 1970, now includes the Bureau of Economic Geology, the Center for Research in Water Resources, and the Marine Science Institute at Port Aransas. Dr. Peter T. Flawn, former Director of the Bureau of Economic Geology, was appointed Director of the new Division. In announcing the establishment of the Division, Dr. Norman Hacker-

man, then President of UT Austin, said, "The association of these three research and teaching units will provide for a more effective interdisciplinary approach to the solution of natural resources and environmental problems, and provide a central point of contact with the many Federal and State agencies concerned with these problems." Headquarters for the Division are at the Austin campus.

Fisher Lectures for AAPG

Dr. W. L. Fisher, Acting Director of the Bureau and Professor of Geological Sciences at UT Austin, was named Distinguished Lecturer for 1970-1971 by the American Association of Petroleum Geologists. He toured two weeks during the fall of 1970 and will tour five weeks in the spring, addressing several geological

societies and university departments throughout North America. Subject of Fisher's lecture is "Ancient Delta Systems of the Gulf of Mexico Basin," based principally on results of several Bureau of Economic Geology research projects involving study of Gulf Basin terrigenous clastic facies.

Bureau Contributes to INRC Report

During the summer of 1970, staff members of the Bureau of Economic Geology assumed responsibility for preparation of basic data for two important task areas of a special report on Coastal Zone Resources by the Interagency Natural Resources Council, Office of

the Governor. Task areas contributed were "Minerals and Mining" and "Land-Use Patterns." Reports and maps prepared were based on the Bureau's current investigation for the *Environmental Geologic Atlas of the Texas Coastal Zone*, described elsewhere in this Report.

Bureau Repeats Delta Colloquium

The Bureau of Economic Geology Research Colloquium on "Delta Systems in the Exploration for Oil and Gas," presented originally at Austin in August 1969, was repeated by invitation at Midland and Shreveport in 1970. The Midland presentation, sponsored by the Permian Basin Graduate Center, was given during three days and evenings in August by Drs. W. L. Fisher, L. F. Brown, Jr., A. J. Scott, and J. H. McGowen. A modified version of the Colloquium was presented as a delta short course at Shreveport in December by Fisher and Brown.

Principal presentations in the Colloquium include lectures on deltaic processes and case studies of an-

cient delta systems and their associated oil and gas trends from the Gulf Coast Basin and the North Texas Eastern Shelf.

A syllabus prepared by the Colloquium leaders in conjunction with the original Colloquium and published by the Bureau of Economic Geology is now in 3rd printing with total sales to date nearing 2,500 copies.

Future items in the Bureau's Research Colloquium Series will include "Terrigenous Clastic Depositional Systems," scheduled for summer of 1971, followed by a colloquium on "Environmental Geology of the Texas Coastal Zone."

Bureau of Economic Geology Current Projects

Basic Geology

Gulf Coast Basin

Depositional systems in the Texas Gulf Coast Basin.

W. L. Fisher, J. H. McGowen, C. V. Proctor, Jr., and graduate research assistants. Surface and subsurface investigation of major stratigraphic units in the Gulf Coast Basin. These long-term studies are designed to utilize the wealth of subsurface data in the Basin in conjunction with outcrop mapping, to reconstruct principal depositional facies, and to relate these to the occurrence of mineral deposits such as oil, gas, coal, uranium, water, and a variety of nonmetallic minerals. To date preliminary reports have been published on the Lower Wilcox, Upper Wilcox, and Jackson Groups. Currently being completed are regional studies of the Texas Upper Cretaceous sands and the Yegua Formation. A monographic report on the Texas Wilcox is now in preparation.

Depositional Facies of Colorado River System. L. E. Garner. A study of the channel and flood plain of

the Colorado River from Austin to the Gulf of Mexico. The study involves characterization of river morphology, bedrock composition, river discharge, sedimentary structures, and other factors that may have influenced deposition of modern Colorado River sediments. The purpose of the study is to determine if a causal relationship exists between some or all of these parameters. A survey of the economic importance of alluvial deposits in this river system, both as a source of aggregate and as an aquifer, will be included in the study. The project was initiated in January 1969; completion is scheduled for 1972.

Texas Barrier Islands. J. H. McGowen and C. G. Groat, assisted during June through August 1970 by R. J. Sulenski. An investigation of the depositional processes and sedimentary facies of the barrier islands that extend along the Texas Gulf Coast from the Texas-Louisiana line to the Texas-Mexico boundary. Chief aims of the project are to

determine the thickness and extent of the islands and to study the effects of human activity on geologic processes. Also included in the project is a survey of the relation of physiographic changes in the barrier islands to climate variations—chiefly annual rainfall, which decreases progressively from east to west along the Texas coast. All these data will aid in the development of plans for land use and for conservation and preservation of the barriers. The project was initiated in June 1970 and is expected to be completed during 1972.

North-Central Texas

Virgil-Wolfcamp Facies, Eastern Shelf, North-Central Texas. L. F. Brown, Jr., assisted by A. R. Smith (1968–1969), Robert Merrill (1969–1970), Alberto Belforte (summer, 1970), and Rafik Salem (1970–1971). A regional surface and subsurface study of a 30-county area of north-central Texas. Goal of the project is recognition and mapping of deltaic, fluvial, interdeltaic-embayment, shelf, slope, and basin depositional systems and their component facies. The study involves the examination of approximately 10,000 well logs and the development of sedimentary, stratigraphic, faunal, and geometric information for comparison with modern analogs. The regional picture of Late Pennsylvanian and Early Permian depositional features resulting from the study will serve as a guide in the search for oil, coal, clay, ground water, and other resources. The project was begun in 1968 and is expected to be completed in 1972. During 1969 and 1970, W. E. Galloway utilized the data and framework developed in the project in a Ph.D. dissertation at The University of Texas at Austin. Invitations to report on the project include those received from the Southwest Section of the American Association of Petroleum Geologists and the University of New Mexico.

Deposition of Upper Pennsylvanian—Lower Permian Rocks of North-Central Texas. L. F. Brown, Jr., assisted by T. H. Waller, J. R. Ray, and Mary Seals. The goal of the study has been to develop a model of depositional facies both in outcrop and in shallow subsurface of the type area of Cisco rocks. The project includes detailed outcrop mapping and stratigraphic-depositional studies within

1,500 feet of rock section located within a 1,200-square-mile area of north-central Texas. Numerous publications have resulted from the project. A final report awaits some additional mapping and revision of earlier mapping. Initiated in 1967, the project is essentially complete and should be finished in 1971.

Central and West Texas

The Moore Hollow Group of Central Texas. V. E. Barnes and W. C. Bell. A long-term study of the stratigraphy and paleontology of Cambrian rocks and contiguous overlying strata. The section on stratigraphy is completed and the section on systematic paleontology and paleoecology is in progress.

Relict Paleozoic Formations of Central Texas. V. E. Barnes and others. A comprehensive investigation of the rocks and fossils in formations that make up the sequence from the top of the Ellenburger Group to the base of the Marble Falls Limestone. The study, originally started by Preston Cloud and V. E. Barnes, has drawn on the specialties of others—namely, Helen Duncan, R. H. Flower, W. H. Hass, R. H. Miller, A. R. Palmer, and, most recently, George Seddon. Seddon's contribution appeared this year as Bureau of Economic Geology Report of Investigations No. 68, "Pre-Chappel Conodonts of the Llano Region, Texas."

Geology of Presidio Bolson, Presidio County, Texas, and Adjacent Chihuahua, Mexico. C. G. Groat. A study of the stratigraphy and geomorphology of a filled intermontane basin that has been dissected by the Rio Grande and its tributaries. The project emphasizes the areal distribution of sedimentary facies in the bolson deposits and the excavational history of the basin, particularly the development of the stepped sequence of sidestream pediment surfaces. The manuscript is completed and in editorial review. Of particular importance is the relationship of these bolson sediments to the occurrence of ground water in Trans-Pecos Texas.

Stratigraphic Studies of Lower Cretaceous Rocks. P. U. Rodda. A long-term study of stratigraphy, depositional systems, paleontology, and resources of Lower Cretaceous rocks of Texas. During 1970,

principal work concerned the stratigraphic studies that were made in connection with the Bureau's project on mineral resources of University lands.

Tektites

Tektites. V. E. Barnes. Long-term, continuous research on world tektites and natural glass. During 1970, a paper resulting from the study, "Macusanite Occurrence, Age, and Composition, Macusani, Peru," by V. E. Barnes, George Edwards, W. A. McLaughlin, Irving Friedman, and Oiva Joensuu, was published in *The Geological Society of America Bulletin*, vol. 81, pp. 1539-1546.

An opportunity to compare tektite glass to the glassy portion of the samples collected during moon landings of Apollo 11 and Apollo 12 was furnished by Preston Cloud, principal investigator of Apollo samples, University of California, Santa Barbara. Dr. Barnes studied the Apollo 11 samples at Santa Barbara in December 1969 and the Apollo 12 samples in July 1970.

Geologic Mapping

Geologic Atlas of Texas. V. E. Barnes and others. A long-term Bureau project involving geologic mapping of the State on 1° x 2° sheets at a scale of 1:250,000. Since initiation of the project in 1962, 12 sheets have been published. The Waco and Perryton Sheets were published during 1970. The Abilene and Dallas Sheets are ready for publication. Scribing has been completed for the Brownfield, Seguin, and Austin Sheets. Field checking, in addition to that reported previously, has been completed for the Crystal City-Eagle Pass, Laredo-Corpus Christi, McAllen-Brownsville, and New Mexico portion of the Dalhart, Clovis, and Brownfield Sheets. Field checking has been initiated on the Pecos and Fort Stockton Sheets.

Bureau staff members who worked on the project during the year under the direction of Dr. V. E. Barnes were: Dr. G. K. Eifler, Jr. (Pecos Sheet), Mrs. Peggy Harwood and Mr. Robert Kier (Brownwood Sheet), Dr. J. H. McGowen (Austin Sheet), Mr. J. L. Brewton (Laredo-Corpus Christi and McAllen-Brownsville Sheets), and Mr. Noel Waechter (Austin, San Antonio, and Crystal City-Eagle Pass Sheets). Other personnel working on the project in-

cluded Dr. Jay Earl Anderson, The University of Texas at Arlington, and Dr. Earl M. P. Lovejoy, The University of Texas at El Paso (Fort Stockton Sheet); Dr. Page C. Twiss, Kansas State University (Marfa Sheet); Dr. R. O. Fay, Oklahoma Geological Survey (Oklahoma portion of the Dalhart Sheet); and Dr. C. C. Reeves, Jr., Texas Technological University (New Mexico portion of the Brownfield, Clovis, and Hobbs Sheets).

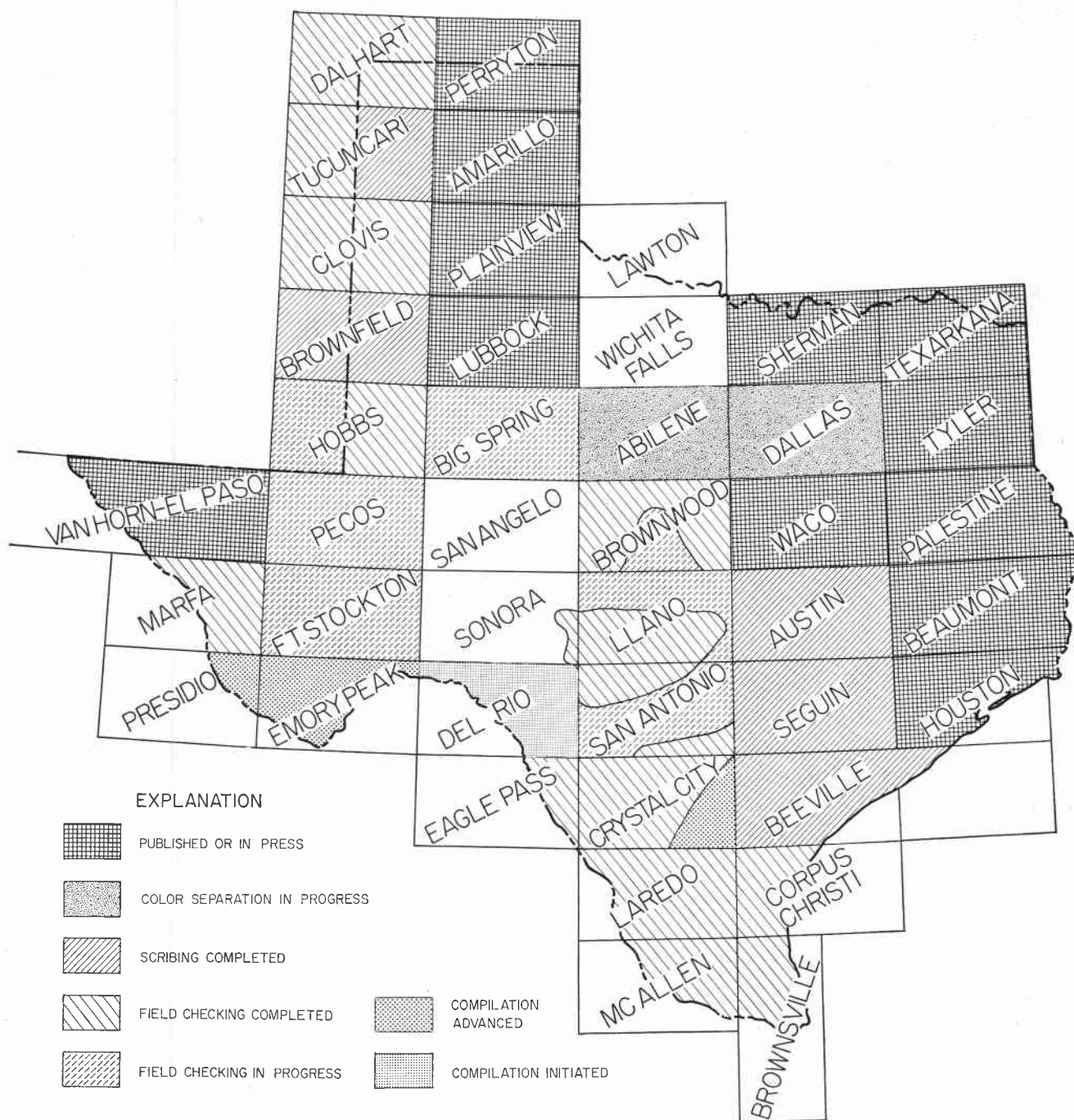
Geologic Quadrangle Maps and Reports, Blanco, Burnet, and Llano Counties. V. E. Barnes. Base material was received for the Cap Mountain, Click, Dunman Mountain, Howell Mountain, Kingsland, Pedernales Falls, and Round Mountain U. S. Geological Survey 7.5-minute topographic quadrangles covering areas mapped geologically by Barnes and others. Scribing is now in progress. Accompanying texts for these quadrangles have been completed. Geologic mapping of the Hammetts Crossing, Longhorn Cavern, Marble Falls, and Spicewood quadrangles is completed; the accompanying texts are partly prepared.

Mineral Resources and Mineral Statistics

Mineral Resources of University Lands. C. G. Groat and W. L. Fisher, coordinators, L. F. Brown, Jr., P. T. Flawn, L. E. Garner, P. U. Rodda, and W. R. Stearns, in cooperation with University Lands, Geology, Midland.

Evaluation of mineral resources, exclusive of oil and gas, of lands owned by The University of Texas System. Project was initiated in the fall of 1969 at the request and with the support of The University's Office of Investments, Trusts, and Lands. Manuscript was completed and submitted to that office during the fall of 1970; printing of the report is under way.

The report includes six geologic maps at scale 1:125,000 covering University lands in West Texas. Four additional maps and numerous text figures outline the distribution and occurrence of main mineral deposits. Text of the report includes a section on geology of University lands, a section on the occurrence, utilization, production and value, and economic considerations of mineral resources, and a section on summary and conclusions. An appendix lists analyses of rock and mineral deposits from several sampling localities. Mineral resources described and evaluated include: industrial carbonates (limestone and dolomite), ground water, sulfur, potash,



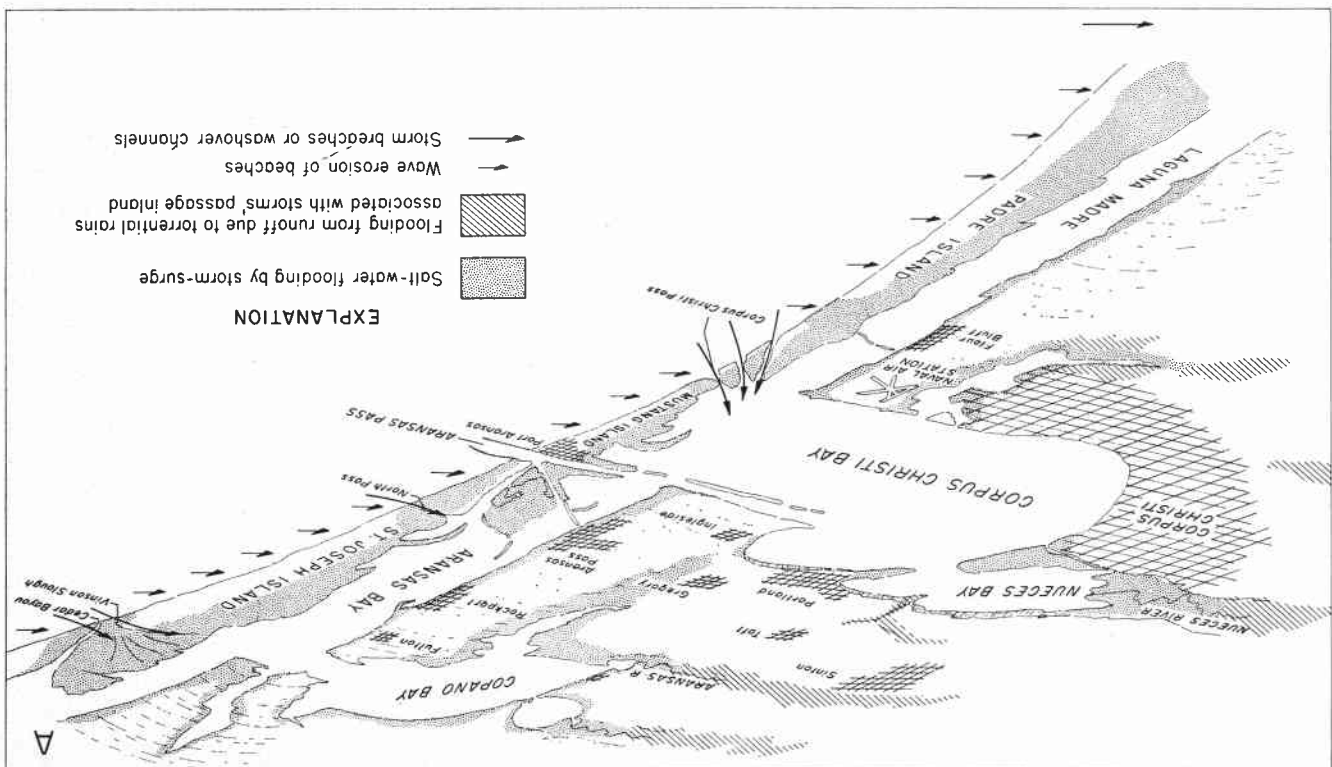
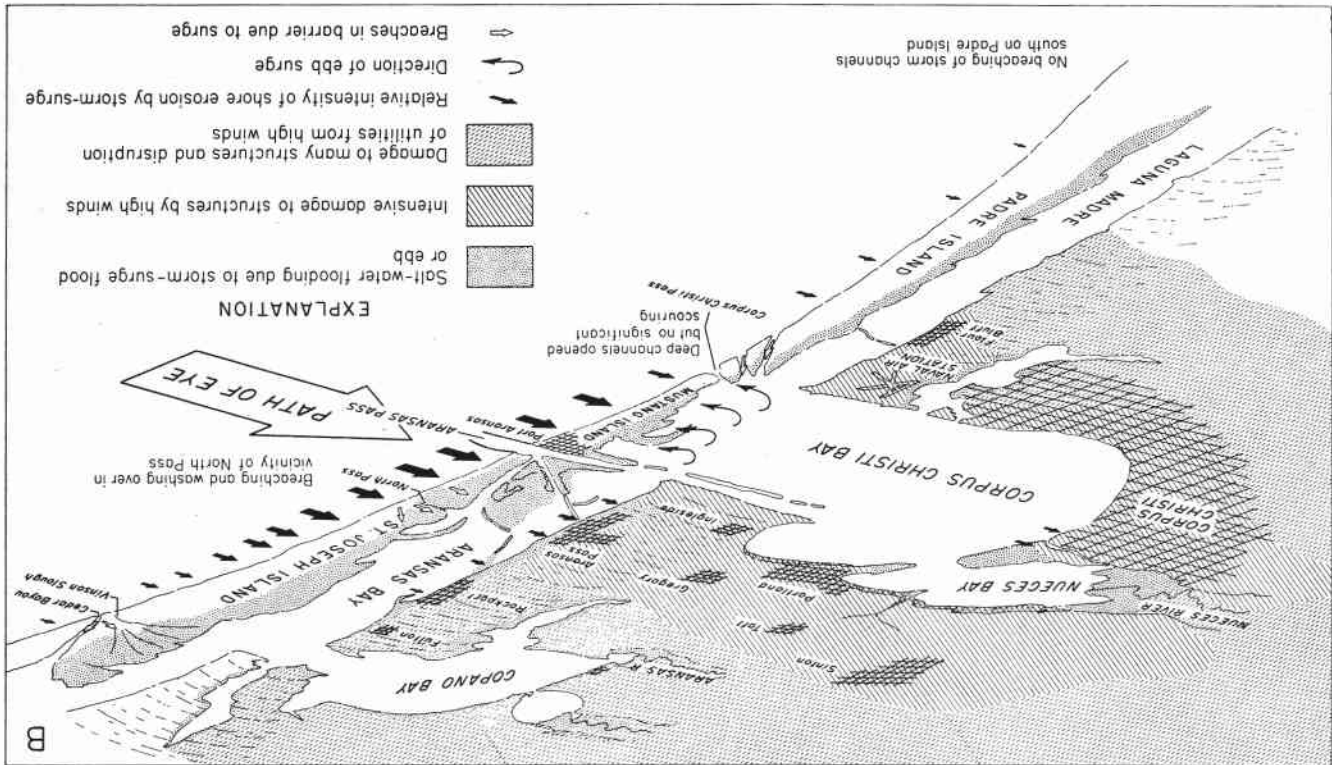
Current status of Texas Geologic Atlas

salt, gypsum, clays, crushed stone, industrial sands, and metals and miscellaneous nonmetals.

The principal aim of the project and final report is to inventory the mineral resources of University lands and to outline current or potential development.

Permian Red-Bed Copper Deposits, North Texas—A Preliminary Report. W. E. Galloway and L. F.

Brown, Jr. A study of the occurrence and distribution of copper minerals in North Texas and of their relationship to Permian deltaic and mudflat depositional systems of the Chosa, San Angelo, and Flowerpot Formations. Aim of the project is to compile available data on red-bed copper deposits of North Texas and to consider the distribution and origin of the copper in relation to depositional facies within the host rock. The project includes the presentation



of stratigraphic sections, geologic maps, chemical analyses, and other information. Initiated by W. E. Galloway during the summer of 1970, the project is scheduled for completion in 1971.

Mineral Production in Texas. R. M. Girard, in cooperation with the United States Bureau of Mines. Annual compilation of Texas mineral production data and other mineral information. During 1970, a report on 1969 production of industrial minerals in Texas was prepared for inclusion in the Texas chapter of the United States Bureau of Mines *Minerals Yearbook, 1969*. A preprint of the chapter will be issued as Bureau of Economic Geology Mineral Resource Circular No. 52, "The Mineral Industry of Texas in 1969."

Van Horn Sandstone, Culberson and Hudspeth Counties, Texas. J. H. McGowen and C. G. Groat. A study of the depositional environment and occurrence of heavy metals in the Precambrian Van Horn Sandstone. Facies were delineated by studies based on textural parameters and sedimentary structures; the facies pattern indicates an extensive alluvial-fan system with sediments transported from north to south. Although laboratory analysis revealed no gold or other heavy metals of economic importance, a study of the distribution of heavy-mineral concentrations provides information useful in prospecting for heavy metals or minerals in other alluvial-fan deposits. The report has been completed and is in editorial review. The project was in part supported by the U. S. Geological Survey.

Sulfur in the Edwards and Associated Formations, Central Texas. P. U. Rodda, assisted during the summer of 1970 by R. E. Moran. A study of the distribution and of the geologic and chemical factors related to the origin and occurrence of sulfur in Comanchean (Lower Cretaceous) limestones in Central Texas. The project includes a description of known deposits and a consideration of development potential. The study was initiated in the summer of 1970 and is scheduled for completion during 1971.

Talc Deposits of the Allamoore District, Texas. R. G. Rohrbacher. A study of the occurrence, origin, and distribution of talc deposits in Precambrian rocks of the Allamoore district, Culberson and Hudspeth counties, Texas. (Doctoral dissertation partly supported by Bureau of Economic Geology.)

Texas Public Lands—Estimate of Future Oil and Gas Production from Established Fields: Texas Gulf Coast, Offshore, Bays, and Estuaries. W. R. Stearns, assisted by Mrs. Carolyn H. Leach. An investigation of the oil and gas reserves of State-owned lands in the Gulf Coast and offshore area. This study is the first part of a long-term project to survey and evaluate the mineral resources of all lands owned by the State of Texas. Most of the basic data on oil and gas reservoirs needed for this investigation have been acquired and are now being studied and evaluated in order to determine reserves. This investigation was begun in February 1969; the estimated completion date is December 1971.

Environmental Geology

Environmental Geologic Atlas of the Texas Gulf Coast. L. F. Brown, Jr., W. L. Fisher, C. G. Groat, and J. H. McGowen. Preparation of an environmental geologic atlas of the Texas coastal area. The project is described in detail on pages 9–13 of this Annual Report.

Geology of Austin and Vicinity. P. U. Rodda, K. P. Young, and L. E. Garner. A study of the geology and resources of the Austin area designed to provide data for planners, engineers, and others. The basic data to be developed will be a series of 12 separately issued geologic maps compiled on 7.5-minute topographic quadrangle bases. Field mapping has been completed for nine quadrangles and has been initiated for the remaining three. Engineering data, such as compressive strength, shrink-swell potential, and moisture content, were obtained from State and Municipal agencies and private firms.

Derivative land-use maps of the entire Austin area will accompany the final report. Included will be maps showing slope stability, permeability of rock units, excavation potential, load-bearing capacity and shrink-swell, corrosion potential, thickness of surficial materials, slope intensity, land use, and vegetation. Compilation of the derivative maps is in progress.

The first separate geologic map of the project, "Geology of the Austin West Quadrangle," was issued in 1970. Also during 1970, Bureau geologists—at the request of City of Austin engineers—prepared geologic cross sections along the route of a proposed cross-town sewage tunnel. The Austin project was

initiated in 1964; completion of the final report is expected early in 1971.

Environmental Geology of the Austin-San Antonio Area. P. H. Townsend. A study to provide geologic information basic to environmental management in the Austin-San Antonio area. Data will include: conditions for solid and liquid waste disposal, engineering properties, ground-water conditions, and construction materials and mineral resources. These data

will be summarized, related to regional geology, and presented on maps. In addition, regional geology will be related to past, present, and future economic development, with emphasis on economic and environmental effects of probable future mineral resource development. Field mapping is completed; maps and manuscript are being prepared. (Doctoral dissertation partly supported by Bureau of Economic Geology.)

Mineral Studies Laboratory

The Mineral Studies Laboratory of the Bureau of Economic Geology continued its two main functions—the support of research projects of the Bureau of Economic Geology and the testing and evaluation of Texas rocks and minerals submitted to the Bureau by Texas residents.

A chief activity of the Laboratory during the year involved rock and mineral analyses as a part of the Bureau's study of mineral resources of The University of Texas lands. Chemical analysis of a number of sand samples and more than 200 limestone and dolomite samples was completed, in addition to the determination of potassium and sodium in samples of evaporites. Several silicate rocks required complete chemical analysis for major and minor elements, as well as qualitative and semi-quantitative determination of trace elements. Numerous samples of clay and sand were tested physically to determine possible commercial value. Mineral separation by heavy media, by elutriation, and by electromagnet was performed on many of the samples. Spectrographic analysis and mechanical analysis of copper-bearing rocks were completed as a part of a Bureau project on the red-bed copper deposits of North Texas.

Services to agencies of the State Government included the testing of a number of clay-silt-sand rocks for the Texas Parks and Wildlife Department and consultation with a member of the Texas Highway Department on the separation of organic matter and mineral matter. Service for the public included testing of samples of talc, clay, barium mineral, natural zeolites, lignite, dust for possible gold content, and rocks for possible platinum content.

New equipment received at the Laboratory during the year included a Baird-Atomic, Inc., Model RC-2 microphotometer (densitometer) comparator, which is used in interpreting a spectrogram. On order was a Jarrell-Ash 70-310 Mark IV convertible Ebert stigmatic 3.4-meter spectrograph. The high resolution attainable with this spectrograph will make possible the determination of rare earths, uranium, zirconium, and tungsten; the use of higher orders of the spectrum; and the choice of a wave length range of 2,000 to 30,000 angstrom units. The spectrograph is the most useful instrument for studying one or all (up to 70) elements in a mineral or rock.

Well Sample and Core Library

With the acquisitions received during 1970 (described on page 13 of this Report), the Well Sample and Core Library of the Bureau of Economic Geology now has on file rock cuttings and/or cores from more than 80,000 wells drilled in all of the 254 counties of Texas. These subsurface materials were obtained from a total of approximately 400 million feet of drill hole—almost 76 thousand miles. At an estimated cost of \$2.00 for each foot of hole drilled, they represent an expendi-

ture of nearly one billion dollars. The samples and cores are recovered primarily from wells drilled for oil and gas, but many come also from holes drilled for water and other minerals and for engineering purposes.

The samples and cores provide basic information on Texas subsurface geology and are used in the exploration for oil, gas, sulfur, uranium, and other economic mineral deposits. In addition, cuttings and cores at the Library can be used increasingly for basic environmen-

tal and engineering determinations in regard to waste disposal and constructional properties.

Approximately 3½ miles of shelves in two buildings at The University's Balcones Research Center are used to store the Library's vast collections. The shelves hold over one million boxes and glass vials. Each box and vial is assigned a number and an index card is prepared for each well. Personnel at the Library—Marce L. Mor-

row, administrative clerk-in-charge, and Leonard Joyner and John O. Robinson, technical staff assistants—receive, index, and store the new materials. W. R. Stearns is supervisory geologist.

Microscopes and other facilities at the Well Sample and Core Library are available for use by the public from 8:00 a.m. to 5:00 p.m. Monday through Friday.

Public Service

One of the important functions of the Bureau of Economic Geology is to provide information to individuals, companies, and governmental agencies on the mineral resources, mineral production, and basic geology of the State. Much of the geologic data developed by the Bureau is available as published reports and maps, but, in addition, the Bureau provides direct assistance to the public in response to inquiries by telephone, letters, and visits. Such inquiries come from geologists, engineers, students, teachers, tourists, realtors, prospectors, industrialists, rock and fossil collectors, and others. During 1970, all members of the Bureau research staff provided such information by conference and by correspondence. Two staff members who spent a large portion of their time in such direct public service are L. E. Garner, who examined rock and mineral specimens submitted to the Bureau for identification, and Roselle Girard, who replied to hundreds of requests for information about Texas geology and mineral resources.

Other public services of the Bureau included preliminary testing and evaluation of selected industrial rocks and minerals at the Mineral Studies Laboratory under the supervision of D. A. Schofield, chemist-in-charge. The Bureau's Well Sample and Core Library continued to provide facilities for geologists and others to examine and study subsurface materials from Texas wells. The Bureau also provides a public Reading Room that contains publications of the Bureau of Economic Geology and also reports and journals of other organizations pertaining to Texas geology and natural resources. The Reading Room, on the fifth floor of the Geology Building on the Main Campus of The University of Texas at Austin, is open to the public each week day from 8:00 a.m. to 5:00 p.m.

In addition, work maps, sections, and data developed in on-going research projects are available for examination at the Bureau's main office.

Staff Activities

Meetings Attended

Staff members represented the Bureau of Economic Geology or The University of Texas at numerous scientific and professional meetings in 1970. Principal meetings attended during the year include:

American Association of Petroleum Geologists, Annual Meeting, Calgary, Alberta, Canada—V. E. Barnes, W. L. Fisher

American Commission on Stratigraphic Nomenclature, Meeting, Milwaukee, Wisconsin—V. E. Barnes

Apollo 11 Lunar Science Conference, National Aeronautics and Space Administration, Houston, Texas—V. E. Barnes

Association of American State Geologists, Annual Meeting, Rolla, Missouri—W. L. Fisher, P. T. Flawn

Association of American State Geologists, Liaison Committee Meeting, Washington, D. C.—P. T. Flawn

Chihuahua Tectonic Belt Symposium, West Texas Geological Society and The University of Texas, Midland, Texas—C. G. Groat

Geological Society of America, Annual Meeting, Milwaukee, Wisconsin—V. E. Barnes, L. F. Brown, Jr., W. L. Fisher, P. T. Flawn, C. G. Groat, N. B. Waechter

Geological Society of America, South-Central Section, Meeting, College Station, Texas—V. E. Barnes, L. F. Brown, Jr., W. L. Fisher, J. H. McGowen, N. B. Waechter

Governor's Conference on Goals for Texas in the Coastal Zone and the Sea, Houston, Texas—W. L. Fisher, P. T. Flawn

Gulf Coast Association of Geological Societies, Annual Meeting, Shreveport, Louisiana—L. F. Brown, Jr., J. H. McGowen, C. V. Proctor, Jr.

Houston Geological Society, May Meeting, Houston, Texas—L. F. Brown, Jr.

Interstate Oil Compact Commission, Meeting, Santa Fe, New Mexico—W. R. Stearns

Marine Technology Society, 6th Annual Conference and Exposition, Washington, D. C.—J. H. McGowen

Meteorite Impact and Volcanism Symposium, Lunar Science Institute, Houston, Texas—V. E. Barnes

National Academy of Sciences—National Research Council, Committee on Technologies and Water, Advisory to the National Water Commission, Meeting, Washington, D. C.; *and* Committee on Radioactive Waste Management, Advisory to the Atomic Energy Commission, Meetings, Washington, D. C.—P. T. Flawn

New Mexico Geological Society, Meeting, Albuquerque, New Mexico—C. G. Groat

Ogallala Aquifer Symposium, Texas Technological University, Lubbock, Texas—C. G. Groat

Playa Lake Symposium, Texas Technological University, Lubbock, Texas—C. G. Groat

Rangely Field Operating Committee, Meeting, Denver, Colorado—W. R. Stearns

Society of Economic Geologists, Annual Meeting, Milwaukee, Wisconsin—W. L. Fisher, P. T. Flawn

Soil Survey Technical Work-Planning Conference, Texas A&M University, College Station, Texas—P. U. Rodda

Texas Advisory Committee on Conservation Education, Meeting, Lake Travis, Texas—P. T. Flawn; *and* Meeting, Lake Whitney, Texas—W. L. Fisher

Texas Coastal Basins Study—Information Meeting for State and Federal Agencies, Austin, Texas—C. G. Groat

Texas House of Representatives Committee Hearings on Oceanography, at Dallas, Texas—W. L. Fisher; at College Station, Texas—W. L. Fisher and P. T. Flawn; at Corpus Christi, Texas—W. L. Fisher and C. G. Groat

Texas Industrial Commission, Economic Development Conference, Houston, Texas—W. L. Fisher

Lectures and Public Addresses

V. E. Barnes—

Tektites: National Science Foundation Secondary School Students, Texas A&M University, College Station, Texas; *and* Department of Geology, The University of Texas at El Paso

L. F. Brown, Jr.—

An approach to environmental geology with examples from the Texas Coastal Zone: American Geological Institute Short Course, Milwaukee, Wisconsin

Delta systems in the exploration for oil, gas, and other minerals: Permian Basin Graduate Center, Midland, Texas; *and* Shreveport Geological Society, Shreveport, Louisiana

Depositional history of Upper Pennsylvanian and Lower Wolfcamp rocks on the Eastern Shelf of North-Central Texas: North Texas Geological Society, Wichita Falls, Texas

Environmental geology of the Texas Gulf Coast and depositional systems of Pennsylvanian and Permian age on the eastern flank of the West Texas Basin: Department of Geology, The University of New Mexico, Albuquerque, New Mexico

Environmental geology of the Texas Gulf Coast: New Orleans Geological Society, New Orleans, Louisiana

Rocks, minerals, and fossils: Webb Junior High School, Austin, Texas

W. L. Fisher—

Ancient delta systems of the Gulf of Mexico Basin [American Association of Petroleum Geologists Distinguished Lecture]: Alabama Geological Society, Tuscaloosa, Alabama; *and* Geological So-

ciety of Kentucky, Louisville, Kentucky; *and* Lafayette Geological Society, Lafayette, Louisiana; *and* Logan Club, Ottawa, Ontario, Canada; *and* Louisiana State University, Baton Rouge, Louisiana; *and* Memphis State University, Memphis, Tennessee; *and* Northern Illinois University, DeKalb, Illinois; *and* Ohio State University, Columbus, Ohio; *and* Pittsburgh Geological Society, Pittsburgh, Pennsylvania; *and* Syracuse University, Syracuse, New York

Delta systems in exploration for oil, gas, and other minerals: Permian Basin Graduate Center, Midland, Texas; *and* Shreveport Geological Society, Shreveport, Louisiana

Depositional systems of the Texas Gulf Coast Basin: Shreveport Geological Society, Shreveport, Louisiana

Texas natural resources—undeveloped potential for rural areas: Texas Industrial Commission, Houston, Texas

Environmental Geology of the Texas Coastal Zone: American Geological Institute Short Course, Milwaukee, Wisconsin

P. T. Flawn—

Coastal zone development: Governor's Conference on Goals for Texas in the Coastal Zone and the Sea, Houston, Texas

Earth resources and the industrial society: Northwestern University Environmental Teach-Out, Evanston, Illinois

Science in the State Government of Texas: Joint Council on University-State Relations, Second Kerrville Conference, Kerrville, Texas

L. E. Garner—

Mineral resources of Texas: Science Workshop, Texas A&I University, Kingsville, Texas

C. G. Groat—

Excavation of Presidio bolson, Trans-Pecos Texas: Geological Society of America, Annual Meeting, Milwaukee, Wisconsin

Texas mineral resources: Environmental Education Workshop, East Texas State University, Commerce, Texas

J. H. McGowen—

Coastal geomorphology: Department of Geography, The University of Texas at Austin

Delta systems in the exploration for oil, gas, and other minerals: Permian Basin Graduate Center, Midland, Texas

Gum Hollow delta, Nueces Bay, Texas—a depositional model for fan deltas: Gulf Coast Association of Geological Societies, Annual Meeting, Shreveport, Louisiana

C. V. Proctor, Jr.—

Depositional systems in the Jackson Group of Texas—their relationship to oil, gas, and uranium: Gulf Coast Association of Geological Societies, Annual Meeting, Shreveport, Louisiana

P. U. Rodda—

Geological factors, *in* Symposium on Soil Surveys in Land Use Planning and Evaluation: Soil Survey Technical Work-Planning Conference, Texas A&M University, College Station, Texas

Progress and plans—Bureau of Economic Geology: Soil Survey Technical Work-Planning Conference, Texas A&M University, College Station, Texas

N. B. Waechter—

Braided stream deposits of the Red River, Texas Panhandle: Geological Society of America, Annual Meeting, Milwaukee, Wisconsin

Committee Service and Offices

V. E. Barnes—

American Commission on Stratigraphic Nomenclature: Member

Austin Geological Society: Vice-President, 1970–1971; Executive Committee, 1970–1971; Affiliations Committee, Chairman, 1969–1970; Alter-

nate Delegate to House of Delegates, American Association of Petroleum Geologists (represented Society at Calgary Meeting, 1970)

L. F. Brown, Jr.—

American Association of Petroleum Geologists, Southwest Section: Program Committee for Abilene Meeting

G. K. Eifler, Jr.—

Austin Geological Society: President, 1969–1970; Executive Committee, 1969–1970

W. L. Fisher—

Association of American State Geologists: Environmental Geology Committee

Society of Economic Paleontologists and Mineralogists: Business Representative

Society of Engineering Geologists: Engineering Geology Map Committee

Texas Advisory Committee on Conservation Education

Texas Mapping Advisory Committee

The University of Texas at Austin: Committee on Publications; Geology Foundation, Executive Committee

P. T. Flawn—

American Institute of Mining, Metallurgical, and Petroleum Engineers: National Affairs Committee

American Institute of Professional Geologists: Committee on Man's Geologic Environment; Executive Committee, Texas Section, 1969–1970

Association of American State Geologists: President, 1969–1970; Liaison Committee

Geological Society of America: Penrose Committee

Gulf Universities Research Corporation: Advisory Board; Panel on Man's Use of the Gulf, Chairman

National Academy of Sciences—National Research Council: Committee on Technologies and Water, Advisory to the National Water Commission; Committee on Radioactive Waste Management, Advisory to the Atomic Energy Commission

Texas Advisory Committee on Conservation Education

Texas Mapping Advisory Committee

The University of Texas at Austin: Geology Foundation, Executive Committee; Institute of Latin American Studies, Advisory Committee Chairman; representative of The University on the Gulf Universities Research Corporation and on the Joint Council on University-State Relations

L. E. Garner—

Austin Geological Society: Publications Committee, 1969–1970

R. M. Girard—

Austin Geological Society: Publications Committee, 1970–1971

P. U. Rodda—

Austin Geological Society: Scientific Contribution Committee, 1970–1971

Austin Natural Science Association: Board of Trustees, 1970

W. R. Stearns —

Austin Geological Society: Finance Committee, 1969–1970

P. H. Townsend—

American Geological Institute, Council on Education in the Geological Sciences: Planning Committee for Environmental Geology Education

Other Professional Responsibilities

W. L. Fisher—

City of Austin Planning Commission, Austin, Texas: Presented testimony on proposed flood-plain ordinances

Permian Basin Graduate Center, Midland, Texas; and Shreveport Geological Society, Shreveport, Louisiana: Leader, Research Colloquium on Delta Systems in the Exploration for Oil, Gas, and Other Minerals

P. T. Flawn—

American Geological Institute, Short Course on Environmental Geology, Milwaukee, Wisconsin: Participation in course

Texas House of Representatives, Committee Hearing on Oceanography, College Station, Texas: Presented testimony

The University of Texas at Austin, International Ex-Students Conference, Austin, Texas: Participation in a panel discussion on environmental problems

The University of Texas at Austin, School of Law: Participation in a panel discussion in connection with the 9th Annual Lecture on Law and the Free Society

P. U. Rodda—

Environmental Science Education Workshops at Sam Houston State University, Huntsville, Texas; Stephen F. Austin State University, Nacogdoches, Texas; Texas A&M University, College Station, Texas; Trinity University, San Antonio, Texas: Special consultant on mineral resources

W. R. Stearns—

The University of Texas System: Assisting and advising The University System's Vice-Chancellor for Investments, Trusts, and Lands concerning oil and gas properties in the Rangely Field, Colorado, held in trust by The University

Teaching Duties of Bureau Staff

Several members of the Bureau research staff, who hold joint appointments with the Department of Geological Sciences at The University of Texas at Austin, taught regularly scheduled courses during 1970. They are L. F. Brown, Jr., and W. L. Fisher, who with A. J. Scott taught Geology 383, "Terrigenous Depositional Systems"; P. T. Flawn, who taught Geology 341, "Mineral Resources"; C. G. Groat, who taught Geology 377K, "Geomorphology"; and P. U. Rodda, who taught Geology 304, "Historical Geology," and Geology 322K, "Paleobiology."

Certain Bureau staff members also supervised graduate theses and dissertations. Several served on graduate student committees in the Department of Geological Sciences and as outside committee members in other departments and universities.

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DR. W. L. FISHER, *Acting Director*

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