

KENTUCKY GEOLOGICAL SURVEY
Donald C. Haney, State Geologist and Director
UNIVERSITY OF KENTUCKY, LEXINGTON

ANNUAL REPORT 1989 - 1990



1989-1990 ANNUAL REPORT

**KENTUCKY GEOLOGICAL SURVEY
UNIVERSITY OF KENTUCKY
LEXINGTON, KENTUCKY**

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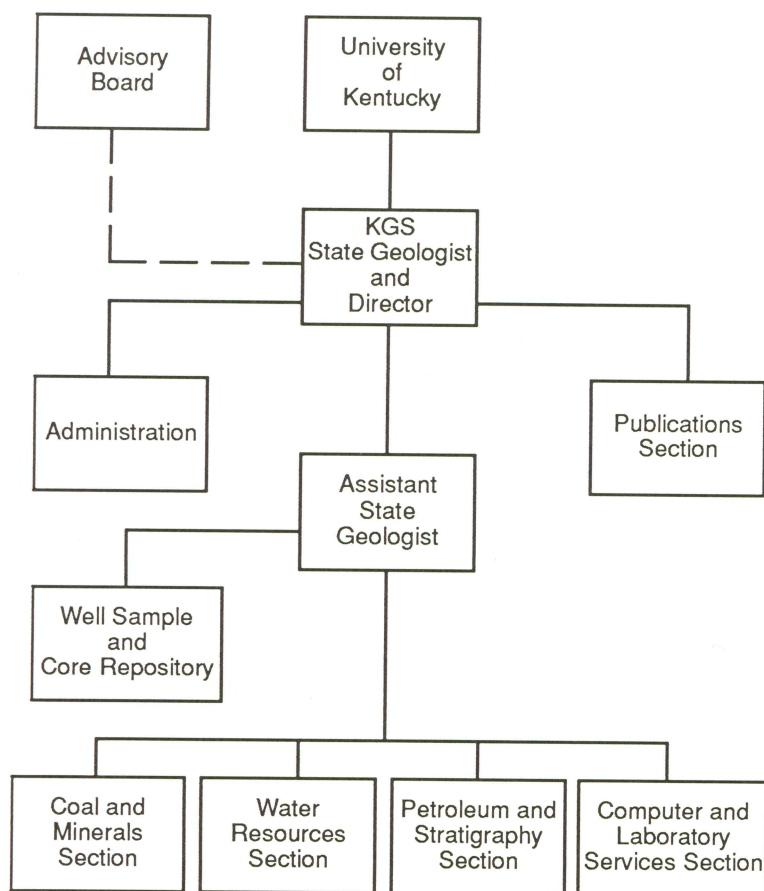
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ORGANIZATION OF THE KENTUCKY GEOLOGICAL SURVEY

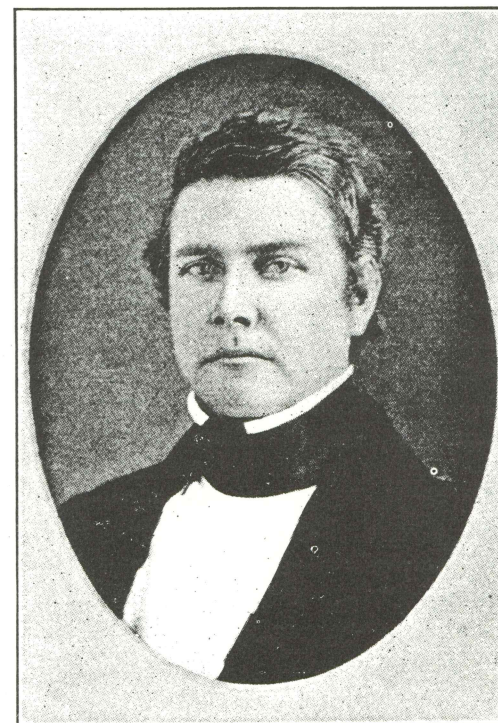


FOREWORD

Since 1838, when William W. Mather was commissioned Kentucky's first State Geologist, the Kentucky Geological Survey has continued to build its data base and perform basic research in a number of geologic areas such as energy (coal, petroleum, and natural gas), applied geology, mineral resources, hydrogeology, and geologic and topographic mapping.

KGS provides technical advice to a large number of State and Federal agencies. In addition, the Survey places great emphasis on public-service activities. Members of the Survey staff are actively involved in special committees and public-service groups dealing with coal, water, oil and gas, industrial minerals, and geologic hazards.

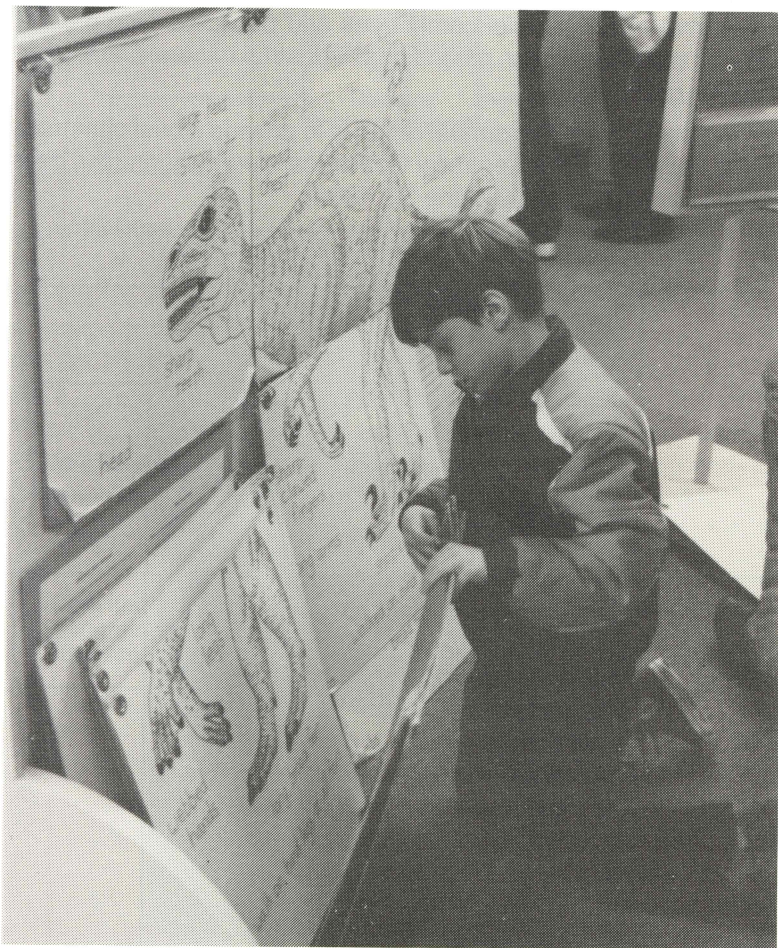
The objective of this annual report is to provide a brief summary of the activities of the Kentucky Geological Survey during the past fiscal year (July 1, 1989–June 30, 1990).



Dr. William Williams Mather (1804–1859)

RESEARCH ACTIVITIES

Basic research in geology and hydrology has formed the cornerstone of the Kentucky Geological Survey since its inception. The Kentucky Geological Survey maintains a diversified and comprehensive research program into the fields of coal geology, industrial and metallic minerals, oil and gas, and hydrology. In addition, a number of energy-related special projects are funded by grants or contracts. Projects in all of these areas of research are described in greater detail in the following sections.



A young participant studies KGS's "Geology of Kentucky" display at the "Dinosaurs Alive!" exhibit at the Lexington Living Arts and Sciences Center.

Coal

Part of the mission of the Kentucky Geological Survey is to provide scientifically based information about the State's coal resources. Recent reports attributed to the Kentucky Geological Survey have given the false impression that the Commonwealth will run out of mineable coal in 20 to 30 years. A more correct statement of the Survey's position would be that maintaining the high levels of coal production achieved in the 1980's may not be possible in 20 to 30 years because of the large amount of mined-out resources and the declining quality of the remaining resources. Of the original 104 billion tons of coal in both the Eastern and Western Kentucky Coal Fields, 6.5 billion tons have already been produced. In 30 years at current rates of production, Kentucky will have produced an additional 4.5 billion tons of coal. The concern of resource analysts is whether or not there are sufficient resources with the minimum requirements of thickness, quality, and mineability in Kentucky to supply this need. Based on preliminary results of ongoing research, the answer appears to be no.

But Kentucky does have billions of tons of coal resources in beds that are less than 28 inches thick and do not comply with sulfur emission standards. The real challenge facing Kentucky and its coal industry is to stay competitive by developing new types of mining to handle thinner seams, and to clean and burn coal more efficiently so that it will meet emission standards.

COAL AVAILABILITY FOR ECONOMIC DEVELOPMENT

COBB, James C., SERGEANT, Richard E., DAVIDSON, O. Barton, ANDERSON, Warren H., CHESNUT, Donald R., Jr., GREB, Stephen F., and HIETT, John K.

The Central Appalachian Basin in Kentucky, West Virginia, and Virginia is the principal supplier of compliance coal for the eastern United States. The pending Federal "Acid Rain Bill," which is intended to reduce emissions of sulfur dioxide into the atmosphere from coal-burning power plants, is likely to cause an increase in compliance-coal use. This probability raises a question for resource specialists—what is the availability of low-sulfur coal in the Central Appalachian Basin in general, and in eastern Kentucky in particular? To answer this question, the states of Kentucky, West Virginia, and Virginia, and the U.S. Geological Survey are cooperating on a project to determine the availability of compliance and

other coal resources in the Central Appalachian Basin. All coal resources are mapped on a 7.5-minute-quadrangle basis, and then all restrictions to mining are superimposed on the resource map. The result is the remaining coal resources available for mining. Restrictions to mining are in two categories (technological and land use), and include mined-out areas, mine barriers, oil and gas wells, cemeteries, towns, roads, streams, depth, thickness, overburden, and quality of coal.

Of the four quadrangles completed in eastern Kentucky, mined and lost coal varies from 3 to 13 percent; coal eliminated from consideration because of technological restrictions varies from 11 to 47 percent; and coal eliminated from consideration because of land-use restrictions varies from 2 to 17 percent of the original resources. The actual available resources are only 50 percent of the original resources, and available compliance resources are only about 25 percent of the original resources. Further work on coal recoverability in these quadrangles has been begun by the U.S. Bureau of Mines. Elements of engineering and economics will be added to the work on coal availability. This combination of approaches will give the best estimate possible of the potential for future mining in the Central Appalachian Basin and the Eastern Kentucky Coal Field.

SPRINGFIELD COAL STUDY

WILLIAMS, David A., SERGEANT, Richard E., and COBB, James C.

The Springfield coal is Kentucky's largest producing seam with an annual production of 33 million tons. It accounts for 75 percent of the coal mined in the Western Kentucky Coal Field and 20 percent of the coal produced in the State. When the production of Springfield coal is totaled for the entire Illinois Basin (encompassing parts of Illinois, Indiana, and Kentucky), the amount is over 52 million tons. This amount would tie the Springfield coal in the Illinois Basin with the state of Texas as the sixth largest producer of coal in the United States.

For the most part, coals are not viewed in this perspective of the geologic basin in which they exist. Rather, they are viewed from the perspective of the state in which they occur. But the basin approach better demonstrates the magnitude of the resource and puts the resource in its proper geologic context. Policy makers often refer to

coals by their basin or region. Powder River Basin coals, for example, are commonly referred to as low-sulfur coals and Illinois Basin coals are referred to as high-sulfur coals, although exceptions occur in both areas.

The state geological surveys of Illinois, Indiana, and Kentucky have been involved in a cooperative project on the Springfield coal for the past 2 years. The purpose of this project is to demonstrate the geology and resources of this significant coal over the entire basin. Computerized data on coal thickness, elevation, mined-out areas, and coal quality are being combined into a common data base. The products generated include thickness, structure, quality, and mined-out area maps. The results of this work will provide energy and resource planners and policy makers with the most up-to-date and complete overview possible of this energy resource. Positive attention for this important energy resource is needed because it is expected that passage of the "Acid Rain Bill" in 1990 will have an adverse effect on future development of this coal, even though the Springfield coal is a prime candidate for the clean coal technologies of liquefaction and gasification.

CONSTRUCTION OF GEOLOGIC CROSS SECTIONS

CHESNUT, Donald R., Jr.

Surface exposures of coal seams provide opportunities to investigate only a small fraction of the coals in the Eastern Kentucky Coal Field. Using outcrop sections and subsurface records, however, geologic models can be made that predict occurrences of coal seams in the subsurface. These models rely upon stratigraphic and paleontologic data.

Outcrop sections along three major eastern Kentucky highways have been submitted for publication. These highway cross sections cover the eastern Kentucky parts of Interstate Highway 75, Interstate Highway 64, and Kentucky Highway 80. The cross sections show mile markers, exits, highway topography, outcrop location, and identify coal beds. The highway cross sections will be helpful to educators and researchers who are studying the coal-bearing rocks of the coal field. The cross sections may be used to:

- Determine the distribution of coal-bearing rocks
- Determine the controls on the distribution of these rocks
- Investigate the potential for coal-bed methane
- Resolve stratigraphic problems.

INVESTIGATIONS OF COAL-BEARING ROCKS IN THE EASTERN KENTUCKY COAL FIELD

CHESNUT, Donald R., Jr.

The types of strata overlying coal beds can often be used to predict sulfur content in coal. Shales of marine origin overlying coals generally coincide with higher sulfur contents in the coals. Therefore, the distribution of marine fossils in coal roof rocks is important for understanding the distributions of high- and low-sulfur coals.

Paleontological data on roof rocks have been compiled into a manuscript submitted for KGS publication. This study lists all lithostratigraphic and paleontologic evidence for marine or brackish-water conditions reported in the roof rocks in the coal field.

New paleontological data are also being collected. In many cases, fossils are present in coal roof rocks but cannot be seen with the unaided eye. Shale samples are being collected from roof rocks in the coal field and then analyzed in the laboratory. Microfossils, if present, are then extracted from the shales for further analysis. To date, samples from about 10 roof rocks have been collected and disaggregated, and the microfossils are being extracted.

Both the published paleontological data and the new microfossil data will be important in:

- Mapping the distribution of marine and brackish-water facies overlying each coal bed
- Comparing the facies with known sulfur content of underlying coals and projecting sulfur content where quality data are lacking
- Developing a biostratigraphic framework for the coal-bearing rocks.

SEDIMENTOLOGICAL INVESTIGATIONS OF THE CARBONIFEROUS ROCKS IN KENTUCKY

GREB, Stephen F., CHESNUT, Donald R., Jr., and DEVER, Garland R., Jr.

Kentucky's most significant economic mineral deposits (coal, oil, natural gas, and limestone) occur in rocks of Carboniferous age. Carboniferous rocks cover more than 70 percent of the Commonwealth and are composed of limestone, shale, sandstone, siltstone, conglomerate, and coal. The rocks contain a wide assortment of bedding types, bedding structures, grain sizes, and fossils

that can be used to interpret the depositional environments. In general, Carboniferous rocks were deposited in rivers, broad deltas, and shallow seas that once covered parts of Kentucky. Understanding how Carboniferous rocks were originally deposited can help interpret trends in economic mineral distribution and quality. For example, depositional and erosional features in the St. Louis and Monteagle Limestones suggest that both growth faulting and uplift accompanied by erosion affected carbonate deposition during Mississippian time. Because the type of carbonate deposition influences the thickness and quality of limestones, it is important to delineate these structural effects.

As part of these sedimentological investigations, Coal and Minerals Section geologists contributed to a field guide prepared for the 28th International Geological Congress, and hosted (in conjunction with the Indiana and Illinois Surveys) the Geological Society of America annual Coal Division field trip.

COAL-QUALITY, PETROGRAPHIC, AND PALYNOLOGIC ANALYSES OF KENTUCKY COAL BEDS

EBLE, Cortland F.

Research at the Kentucky Geological Survey's coal analytical laboratory is being conducted to characterize Kentucky's economically important coals and promote the safe, clean, and efficient use of coal. This research involves petrographic, palynologic, and coal-quality analysis of selected Kentucky coal beds.

Petrographic and palynologic analyses of coal provide a detailed characterization of both the organic and inorganic constituents in coal. Through petrographic analysis, macerals of coal (analogous to minerals in rocks) can be identified and quantified. The maceral composition of coal provides information vital to coal utilization. Detailed petrographic studies of selected Kentucky coal beds are being done to determine the regional variability of coal macerals. These studies will also help determine how deleterious mineral matter, notably pyrite, occurs within individual coal beds and regionally across coal fields. Ultimately, it is hoped that models can be developed to predict the composition of coal throughout Kentucky.

Coal palynologic analyses provide detailed information on the kind of plants that grew in ancient swamps, and later became coal

deposits. Knowledge of the types of plants in coal may also help identify and predict areas of high-quality coal across the State.

ORIGIN OF COAL

COBB, James C., and EBLE, Cortland F.

The origin of coal has been investigated by scientists for over 200 years. Microscopic examinations of coal reveal it to be composed of many different types of organic particles derived from plants and the degradation of plants. The origin of coal from peat swamps is well established, but what is not well known is why some coals are of better quality than others or why parts of some beds are higher in sulfur or other deleterious matter.

To answer these questions, the U.S. Geological Survey, the Indonesian Directorate of Mineral Resources, and the Kentucky Geological Survey are cooperating in a project to study the origin of coal. In 1989, field work was conducted in peat swamps in Palangkaraya, Kalimantan, Indonesia. The peat reached a maximum thickness of 24 feet. Six peat cores were taken along an east-west traverse perpendicular to the Kahayan River. Two cores were from lower elevation flood-basin peat, and four cores were from a raised peat deposit 25 feet above the river, overlying a quartz-rich podzolic soil. The podzolic soil was exposed in the river cut banks, where about 60 feet of quartz sandstone with siderite and kaolinite beds could be seen.

Petrographic, mineralogic, and geochemical work by the U.S. Geological Survey is continuing on the samples that were taken in this field work. Models of coal-forming swamps for use in coal depositional studies are being developed based on the Indonesian research.

Industrial and Metallic Minerals

Industrial and metallic minerals furnish essential raw materials for agricultural, ceramic, chemical, construction, energy-related, metallurgical, and manufacturing industries. The Kentucky Geological Survey conducts resource investigations to determine the compositional and physical properties, geologic setting, and geographic distribution of industrial and metallic minerals in the State.

SAND AND GRAVEL RESOURCES OF THE OHIO RIVER VALLEY

AMARAL, Eugene J.

Kentucky's principal supply of sand and gravel was deposited along the Ohio River Valley at various times during the Pleistocene (Ice Age) by sediment-laden meltwaters from retreating glaciers. As an important source of construction material, these deposits have played and should continue to play a vital role in the economic development of the Commonwealth. They also form the principal aquifer of this region and underlie prime agricultural land. Sand and gravel extraction along the Ohio River during the 1980's has averaged nearly 7 million short tons a year, and has been carried out either by channel dredging or open-pit mining on riverbank terraces. Future utilization of this valuable resource, however, is being jeopardized by expanding urban and residential development, industrial-plant construction, and increasingly restrictive zoning ordinances. Knowledge of the lateral distribution and variations in thickness, texture, and composition of these deposits will enable more effective land-use planning, thereby enhancing the recovery of these potential aggregate resources.

A study to determine the physical, textural, and mineralogical properties of sand and gravel deposits along the Ohio River Valley was initiated this fiscal year in Boone, Gallatin, and Carroll Counties and should be completed in 1990. Approximately 150 samples collected from active and abandoned pits, excavation sites, outcrops, and boreholes are currently being analyzed in the KGS sedimentology and petrology laboratories. Such an investigation has practical applications because it helps show how closely these construction aggregates conform to local, State, and Federal specifications for size gradation, percent deleterious material, aggregate soundness, abrasion resistance, and other physical and chemical properties. It is the purpose of this study, therefore, to quantitatively analyze grain-size, particle-shape, and composi-

tional characteristics in order to reveal variations that could influence the utilization of these sand and gravel deposits.

LIMESTONE AND DOLOMITE RESOURCES FOR COAL-RELATED INDUSTRIES

DEVER, Garland R., Jr.

Coal producers and coal-burning industries use carbonate rocks in environmental-control measures to meet Federal and State standards for mine safety and reclamation, air quality, and water quality. The Kentucky Geological Survey is investigating the chemical and lithologic characteristics of the State's limestones and dolomites in order to provide industry with information on the availability of stone meeting their requirements, particularly for SO₂ emission control and for rock dusting in underground coal mines.

The use and current market for limestone, lime, and dolomite in SO₂ emission control by electric utilities and industrial plants were covered by two reports completed during the year. Work is continuing on sources of low-silica stone suitable for rock dust used for explosion abatement in underground coal mines. A report is being prepared on the occurrence of low-silica stone in Letcher County, where the Newman Limestone (Mississippian) crops out along Pine Mountain in the southeastern part of the Eastern Kentucky Coal Field. The lower part of the Newman in southwestern Letcher County contains a 41-foot interval of oolitic and bioclastic calcarenite with an average silica (SiO₂) content of 1.65 percent. However, because of increased amounts of calcilutite and argillaceous limestone in the lower Newman northeastward along Pine Mountain, zones of low-silica calcarenite in central and northeastern Letcher County are thin, ranging from 11 to 13 feet in thickness.

NONFUEL MINERAL STATISTICS

DEVER, Garland R., Jr.

The Kentucky Geological Survey collects and compiles information on activities of the State's nonfuel-mineral industry and on government actions that affect mineral industries. Nonfuel-mineral data collected by KGS and the U.S. Bureau of Mines are shared by both agencies under a Memorandum of Understanding and are disseminated through the Bureau's "Minerals Yearbook," "Mineral Industry Surveys," and commodity reports. The information also is used by KGS in answering public-service inquiries, compiling a

mineral-producer directory, and preparing reviews of State activities such as the annual review published by *Mining Engineering*.

The value of Kentucky's nonfuel-mineral production in 1989 was about \$330 million, based on preliminary data received by the Bureau of Mines. Crushed stone was the leading commodity, with a production of 48 million tons valued at \$199 million, and accounted for 60 percent of the State's total nonfuel-mineral value. Portland and masonry cement; common, ball, and fire clay; quicklime and hydrated lime; and construction and industrial sand and gravel also were produced during the year.

INDUSTRIAL AND METALLIC MINERAL RESOURCES AND MINERAL INDUSTRIES MAP OF KENTUCKY

DEVER, Garland R., Jr., AMARAL, Eugene J., and ANDERSON, Warren H.

A new map is being compiled to show the distribution of industrial and metallic mineral resources in Kentucky, encompassing both currently exploited deposits and potentially economic resources. The areal distribution of resources will be compiled mainly from geologic quadrangle maps (scale 1:24,000) produced for the entire State by the Kentucky Geological Survey-U.S. Geological Survey cooperative mapping program (1960-78). The presently available "Mineral Resources and Mineral Industries of Kentucky" map, published in 1962 and partly revised in 1974, was compiled without benefit of these detailed geologic quadrangle maps.

The principal product will be a multicolored map (scale 1:500,000) showing:

- Limestone, dolomite, clay, shale, sand, gravel, and sandstone resources
- Metallic and nonmetallic mineral deposits (e.g., sphalerite, galena, fluorite, and barite)
- Active quarries, mines, and pits
- Mineral-industry plants.

Resource boundaries, mineral deposits, producing operations, and plant sites will be digitized and archived in data files so that the information can be used to prepare not only a 1:500,000-scale resource map of the State, but also State, county, and area resource maps at various scales.

Petroleum and Stratigraphy

On-going research activities in the Petroleum and Stratigraphy Section are designed to foster and stimulate hydrocarbon exploration and production in the Commonwealth. Research related to the tectonic and stratigraphic framework of the various regional geologic provinces contributes to an understanding of the geologic evolution of the State and also to the distribution and character of its earth resources and hazards.

In response to changing national and regional energy priorities and strategies, the Petroleum and Stratigraphy Section is continuing to pursue several directions of research and service. Reservoir characterization studies should ultimately increase recovery of hydrocarbon resources from known fields and plays. New and deeper exploration plays, particularly in the central and western part of the State, are also being evaluated. These efforts are aimed at stimulating the wise and careful development of our fluid energy resources while maintaining a clean and safe environment. The following project summaries review the status of active projects.

UPDATE, SHEET TWO, "OIL AND GAS MAP OF KENTUCKY"

BEARD, John G., and NUTTALL, Brandon C.

This project is part of an overall effort to update sheets 1 through 4 of the "Oil and Gas Map of Kentucky." Sheet 2, which covers western Kentucky, was published in 1972. The project will update sheet 2 to show the location and areal extent of new fields, extensions, and consolidations since 1972. When compilation is completed, the base map, all field outlines, and supporting illustrations will be entered into a computer data base, and copies can be printed on demand. Sheet 2 is designed to be used in conjunction with the recently printed "Index of Oil and Gas Fields of Kentucky," which replaces the information on the back of the individual sheets of the "Oil and Gas Map of Kentucky." The index is arranged by county and alphabetically by field name within each county. It contains information on field name, producing formations, type of production, and date and general location of discovery well. Invalid and obsolete field names are cross-referenced to the field name currently in use. Where known, information on the consolidation of producing areas is included. The index was produced directly from a computer data base and will be periodically reprinted to update new field discoveries, consolidations, and historical data. Work is

continuing to identify the discovery well of each field and the discovery well of each pay within the field.

CINCINNATI ARCH CONSORTIUM: REGIONAL GEOLOGIC STUDIES

DRAHOVZAL, James A., and NOGER, Martin C.

The Kentucky, Ohio, and Indiana Geological Surveys have entered into a cooperative agreement to advance the geologic understanding of the Cincinnati Arch and ensure wise decisions regarding the use and development of the area's potential earth resources. Formation of the consortium was stimulated by the recent discovery of a formerly unknown basin lying near the axis of the arch and extending at least from southwestern Ohio into northern Kentucky.

To date, most of the work on this project has been related to the administration of the consortium, the promotion of the consortium to the oil and gas industry, and preliminary research into the nature of the newly discovered basin. Through a series of meetings and presentations to industry, a project proposal was formulated that five companies have agreed to fund for a 1-year period. Final approval of the proposal is pending, and research activities are expected to be initiated in mid-1990. The objective of the initial phase of the study is to delineate the areal extent and depth of the basin.

ILLINOIS BASIN CONSORTIUM: GAS POTENTIAL OF THE NEW ALBANY SHALE, ILLINOIS BASIN

DRAHOVZAL, James A., and NOGER, Martin C.

The purpose of this research is to assess the gas potential of the Devonian New Albany Shale of the Illinois Basin. The project is being carried out by the Illinois Basin Consortium (IBC), made up of the Kentucky, Illinois, and Indiana geological surveys. The project is being funded by the Gas Research Institute (GRI).

So far the technical and cost proposals have been written, negotiations have been made with the other two surveys and GRI, and final agreements have been signed. The project will be initiated in mid-1990.

PETROLEUM GEOCHEMISTRY AND SOURCE-ROCK EVALUATION OF HYDROCARBON RESERVOIRS IN KENTUCKY

GOODING, Patrick J.

The primary objectives of this investigation are to determine source-rock potential, crude-oil characteristics, and oil-source rock correlation from geochemical analysis, and to investigate geologic structures that may have influenced the maturation, migration, and accumulation of hydrocarbons in Kentucky. A model will be developed to explain the amount, timing, and depth of hydrocarbon generation. This geochemical study of source rocks and crude oils will provide information needed for successful exploration by the oil and gas industry.

The reservoir rocks in which the hydrocarbons occur are quite variable across the State, in both composition and physical properties. Hydrocarbons commonly occur in pore spaces, cavities, joints, and fractures of limestone, dolostone, sandstone, and shale that range in age from Early Pennsylvanian to Early Cambrian. The timing of petroleum maturation and accumulation in the various trap types differs considerably in the State. Also, the duration of accumulation may vary from place to place.

With cooperation from the oil and gas industry in Kentucky, visits were made to about 600 oil wells throughout the State; fresh oil samples were collected from 265 of these wells. The oils were being produced from 45 different stratigraphic zones.

Geochemical analysis has been completed on 114 of the oils. Source-rock evaluations have been made on over 8,000 rock samples. Geochemical analysis indicates that samples from several stratigraphic intervals contain high to very high quantities of organic matter of variable composition, which would have been capable of generating hydrocarbons during burial.

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS PETROLEUM BASIN SERIES—INTERIOR CRATONIC SAG BASIN VOLUME

NOGER, Martin C.

The American Association of Petroleum Geologists (AAPG) has begun compiling a five-volume Petroleum Basin Series that will provide data for analyzing potentially similar basins in other areas. The series is intended to give a broad overview of significant fundamental basin types, their evolution, their oil and gas plays, and the

resulting distribution and size of oil and gas fields. Each fundamental basin type is to be analyzed to determine the significant factors that control the plays, resulting fields, and future potential.

Various KGS personnel have contributed geologic data and compiled maps for the different chapters of the manuscript. The report has been completed and submitted to AAPG for editorial review and publication.

TAR-SAND DEPOSITS OF WESTERN KENTUCKY

NOGER, Martin C.

In 1981, the Survey initiated a project to inventory and evaluate the oil-resource potential of asphaltic sandstones in the subsurface of western Kentucky. In 1982 the project was combined with the Interstate Oil Compact Commission (IOCC) project to catalog and evaluate the tar-sand resource potential of the United States. In 1984 and 1985 IOCC published reports of these investigations; the in-place oil resource potential of subsurface and surface tar-sand deposits in western Kentucky was calculated to be 3.4 billion barrels.

In 1986-87, KGS collected samples from surface exposures of the Caseyville Sandstone (Pennsylvanian) and Big Clifty Sandstone Member of the Golconda Formation (Mississippian) for clay, metal-content, and reservoir-characteristic analyses by the U.S. Geological Survey. Analyses listing the chemical composition of the bitumen, trace-element content of the reservoir rock, and sediment residue were published in 1990 as U.S. Geological Survey Circular 1047.

The Survey continues to monitor drilling and other activities in tar-sand areas. Data bases are revised annually to further delineate and evaluate the deposits so they will be up to date when economic conditions are favorable for commercial development.

ILLINOIS BASIN CONSORTIUM: REGIONAL GEOLOGIC STUDIES

NOGER, Martin C., and DRAHOVZAL, James A.

The Kentucky, Illinois, and Indiana Geological Surveys have entered into a cooperative agreement to advance the geologic understanding of the Illinois Basin and ensure wise decisions regarding the use and development of the basin's wealth of energy, mineral, and water resources.

The initial project of the consortium is to prepare a network of cross sections depicting the structural and stratigraphic framework of the Illinois Basin. The sections will be compiled primarily from geophysical logs of oil and gas test holes. Where geophysical logs are not available, cuttings or cores will be studied. A preliminary north-south cross section, crossing Illinois, western Kentucky, and northern Tennessee, has been compiled. An east-west section from southern Illinois to the Cincinnati Arch in central Kentucky is being compiled.

Data from the individual sections will be integrated into a detailed study of the evolution of the Illinois Basin. Such information will be useful to industry, academic institutions, government agencies, and the general public.

AREAL AND STRATIGRAPHIC DISTRIBUTION OF OIL AND GAS PRODUCTION IN KENTUCKY

NUTTALL, Brandon C.

This project was initiated to provide a better understanding of the distribution of hydrocarbon production in Kentucky. The result of the project will be a report showing distribution of production for each major stratigraphic system and many individual pay zones, along with penetration maps, color-coded classification maps, and general geologic and physiographic maps. The publication will show locations of the major producing areas in Kentucky and identify stratigraphic units from which hydrocarbons are produced. The project will utilize information that is already in the KGS oil and gas data base, and the maps will be updated as new data are entered.

RECONNAISSANCE GEOLOGIC INVESTIGATION OF THE VAUGHN CREEK DISTURBANCE, CUMBERLAND COUNTY, KENTUCKY

NUTTALL, Brandon C.

An eruption of natural gas and associated oil spill on Vaughn Creek occurred in the fall of 1989. Set in a well-known area of shallow oil production, this phenomenon presented a unique opportunity to investigate the formation of a natural oil seep. A manuscript is being prepared to document this event.

RESERVOIR CLASSIFICATION OF TERTIARY OIL RECOVERY INFORMATION SYSTEM FOR KENTUCKY

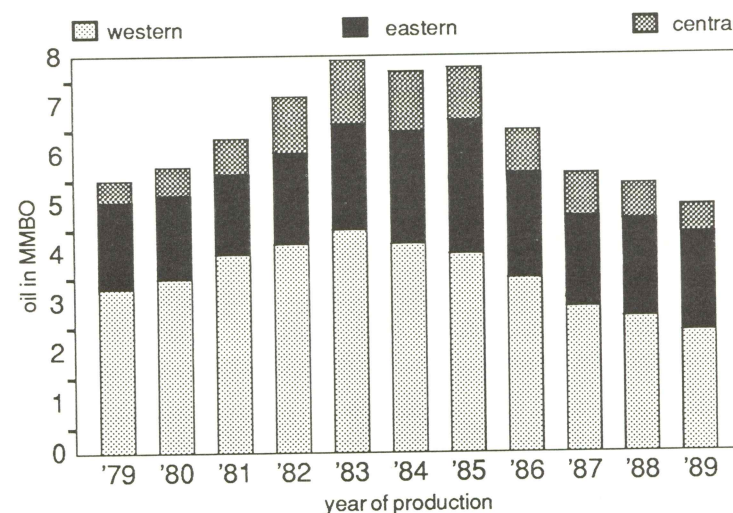
NUTTALL, Brandon C., NOGER, Martin C., BEARD, John G., and DRAHOVZAL, James A.

The U.S. Department of Energy (DOE) maintains the Tertiary Oil Recovery Information System (TORIS) for major oil reservoirs in the United States. Data for only five reservoirs in Kentucky are currently in the data base. The purpose of this DOE-funded project is to update the existing information in the data base by classifying the reservoirs.

Using data at the Survey and in publications, the five Kentucky oil reservoirs were classified in terms of their depositional system, diagenetic overprint, and structural compartmentalization.

Results of the study revealed that most often the reservoirs in the TORIS data base had been misidentified and that the primary reservoir horizons responsible for the major part of the production in a particular field were not part of the data base. In addition, the data base does not include many of the oil reservoirs in Kentucky that have significant production.

DOE realizes that a similar national data base is needed for gas reservoirs as well. The Petroleum and Stratigraphy Section plans to pursue this opportunity with the U.S. Department of Energy.



Summary of oil production in Kentucky, 1979-89. From Information Circular 30 (ser. 11).

Water Resources

Over the past several decades, a new awareness of the critical importance of the Nation's water resource has been generated. With that awareness has come the realization of the difficult problems associated with the management and protection of that resource. If one considers the basic needs of modern civilization—food, clothing, shelter, and energy—virtually nothing can be produced without large quantities of water. In addition, large quantities of waste water that our system generates must be disposed of.

Over the past 15 years, not less than 10 Federal acts aimed at protecting water have been passed. During this time, state regulatory agencies have developed programs dealing with mining and mine reclamation, solid and liquid waste disposal, sewage disposal, water supply, oil and gas recovery, and agricultural practices. The understanding of geology and hydrogeology is essential for the optimum development, utilization, and management of the State's water resources. The KGS Water Resources Section provides information to municipalities, industry, State and Federal agencies, and private citizens concerning the occurrence, movement, quantity, and quality of surface and ground water in the State. In addition, the state legislature recently designated the KGS as the repository of all ground-water data gathered in the State.

The following represent the major research efforts of the section over the past year (see also **Cooperative Programs, Water Resources**).

EFFECTS OF RIPARIAN VEGETATION ON WATER QUALITY: MODELING AND EXPERIMENTAL STUDIES

CAREY, Daniel I.

There is growing concern over non-point pollution of surface and ground water by agricultural chemicals. Riparian vegetative filter strips (VFS), narrow bands of vegetation used to remove sediment and dissolved solids from overland flow before it reaches receiving streams, have been approved by the Conservation Reserve Program of the Food Security Act of 1985, and have been increasing in use in the past few years.

Recent studies of the effectiveness of naturally occurring VFS's have indicated that existing mathematical and computer models overpredict the effectiveness of VFS's in removing sediment. This

overprediction is probably because of the failure of existing models to account for channelization of flow through the filters.

The objectives of this project are to:

- Develop models of sediment movement through VFS's that account for natural variation in microtopography and channelized flow
- Model the movement of dissolved solids through VFS's as related to sediment and chemical characteristics
- Model the movement of dissolved solids into the vadose zone of VFS's in karst regions
- Develop an experimental data base of controlled field data for evaluation of models developed under the first three objectives.

The 3-year project is being conducted cooperatively with the University of Kentucky Departments of Agricultural Engineering and Agronomy.

HYDROGEOLOGY OF THE GARRETTS SPRING (SINKING CREEK) DRAINAGE BASIN

CURRENS, James. C.

In February 1989, severe flooding occurred throughout Kentucky, and the flooding of sinkholes was widespread. Several homes across the State that were built in closed karst depressions during dry periods were damaged or destroyed during the exceptionally heavy rains. The Sinking Creek karst valley in northwestern Jessamine County remained flooded until early April. One home was destroyed and others were damaged extensively. Forecasting when the water levels would drop and advising the residents on a course of action to prevent future flooding was severely hampered by a lack of historical data and immediately available resources to monitor the flood.

Work began in the late summer of 1989 to map the hydrogeology of the basin and install instruments to record flows during storm events. These data will be used to develop an understanding of the hydrology of the karst system and a procedure to forecast the effects of larger storms and land-use changes in the drainage basin. During the winter of 1989-90, three stage recorders were installed at critical sites in the basin. Discharge measurements are being made at these and other sites to use in conjunction with the stage data and develop a continuous discharge record. Ground-water

dye-tracing experiments are in progress to define the ground-water basin divide.

THE KENTUCKY AQUIFER-RESEARCH DATA BASE (KARD)

CURRENS, James C.

The Kentucky Geological Survey has been charged by the Governor's Ground-Water Advisory Council and the Kentucky General Assembly to act as a ground-water data repository. KGS began developing the Kentucky Aquifer Research Data Base (KARD) in the spring of 1987. By the end of fiscal year 1986-87, the conceptual design of the data base was completed and programming was well underway. During 1987-88, many new data sets and programs were completed, and the data base began to be used for data storage and retrieval. During 1988-89, efforts were focused on data entry, although considerable effort was made on data base development and refinement. A series of programs to translate data acquired from the Groundwater Branch of the Kentucky Division of Water (DOW) into the KARD was written and improved upon, and is now in routine use.

During the 1989-90 fiscal year, development work on the data base was completed. Data sets for storage of isotopic and trace organics analyses were designed. Also, data sets for information specific to springs, discharge measurements, and ground-water-tracing experiments were completed. In addition, improvements were made to several preexisting data sets, and storage and retrieval programs were written for the new data sets. All future programming will concentrate on data storage and retrieval. Over 4,765 sites, including water wells and springs, are now listed in the data base, including hundreds of records on construction features and water-quality and -quantity data.

STAR FIRE PROJECT

DINGER, James S., WUNSCH, David R., and CAREY, Daniel I.

Coal mining in the Eastern Kentucky Coal Field will provide fewer and fewer jobs in the coming years. At the same time, economic growth and diversity in the coal field are limited, in part by the steep topography and lack of water resources. Most coal companies have no real interest in these limiting factors because they own only the mineral rights to the properties they mine. Cyprus Moun-

tain Coals, a subsidiary of Cyprus Minerals, Inc., is unique in that it owns the 17,000 acres at the Star Fire surface mine in Knott, Perry, and Breathitt Counties, and, therefore, has considerable interest in post-mine development of the property.

An estimated 10,000 acres of flat land will be created by the year 2010 through mountaintop removal techniques, thus providing a site for new land uses and future economic development. The Kentucky Geological Survey has been awarded a research grant to conduct initial feasibility studies for water-resources development on the site. KGS is defining surface- and ground-water resources of the reclaimed mine site, whose spoil ranges from 100 to 300 feet in thickness. Dye traces of streams entering the spoil and discharging at springs at the base indicate average linear velocities of up to 1,200 feet per day. Spring discharges ranged from 1 to 3 million gallons per day.

Three monitoring wells have been drilled into the spoil, with plans for approximately 10 more. Monthly surface- and ground-water samples show that all waters are predominantly a calcium-magnesium-sulfate type, differing only in concentration. The pH of all samples is favorable, ranging from 6.23 to 8.28. One infiltration gallery has been emplaced and instrumented to measure induced recharge through the relatively impermeable reclaimed surface that results from the compaction of the spoil material during the mining and reclamation processes. Weirs and other methods of stream gaging are being installed to aid in the understanding of the hydrologic relationship between the recharge and discharge points of the aquifer. The SEDIMOT II surface-hydrology modelling program has been used to estimate anticipated peak runoff for a 10-year period to aid in the development and design requirements for monitoring the mine site hydrology.

HYDROGEOLOGY OF BRINE OCCURRENCE IN THE KENTUCKY RIVER BASIN

KIPP, James A.

In 1987 the Kentucky Geological Survey initiated a detailed hydrologic study in the Furnace Fork Basin (Estill County) in cooperation with the U.S. Geological Survey. Two other streams, Cat Creek and Big Sinking Creek, were also monitored to compare water quality among basins with varying degrees of petroleum production. A gaging station with automatic recording of stage, water temperature, and specific conductance was installed on each stream

in the spring of 1987. In addition, monthly water–quality sampling was conducted in conjunction with the U.S. Geological Survey's Kentucky River National Water Quality Assessment study. Stream samples were collected at the gaging stations and at six locations within the Furnace Fork Basin from March 1987 through March 1989. A U.S. Geological Survey publication summarizing the results of these cooperative efforts is currently under revision following completion of colleague review.

Four monitoring wells were completed in the Furnace Fork Basin during summer 1988. Recorders were installed on these wells in August 1989 to gather information on long– and short–term fluctuations of water levels in the producing formation (Carboniferous) and overlying strata. Water–quality samples have also been collected from the monitoring wells, domestic wells and springs, and oil wells in the study basin. All of this information will be used to interpret the occurrence and quality of ground water and should lead to a better understanding of ground–water/surface–water interaction and brine transport mechanisms in the region.

PRODUCTION OF FRESH WATER FROM THE KNOX GROUP IN CENTRAL KENTUCKY

KIPP, James A.

A few deep wells (800–1,000 feet) produce fresh water in central Kentucky. These wells are generally completed in the top of the Cambrian–Ordovician Knox Group. The primary objectives of this investigation are:

- To identify areas where the Knox contains fresh water
- To determine the amount of water available from the Knox
- To locate recharge and discharge areas
- To determine the direction and rate of water movement in the Knox.

Because of the great expense of drilling these deep wells, the Survey has relied upon local well drillers and their customers to identify new wells for testing and water–quality sampling.

Interest in drilling Knox wells has declined during the past year since adequate rainfall has fallen, providing sufficient soil moisture for vegetation and recharge for domestic wells relying on shallow aquifers. A few inquiries concerning sources of water for aquaculture were received, but no new Knox wells were reported. General information on the hydraulic characteristics of the Knox was pro-

vided to several individuals interested in injecting wastes into deep wells in south–central Kentucky.

HYDROGEOLOGIC ASSESSMENT OF WATER SUPPLIES TO DETERMINE THE EFFECTS OF ABANDONED MINE LANDS

KIPP, James A., DINGER, James S., CONRAD, Philip G., and STICKNEY, John, F.

The Kentucky Abandoned Mine Land (AML) Reclamation Program, administered by the Kentucky Natural Resources and Environmental Protection Cabinet, is charged with reclaiming and restoring lands and waters adversely affected by mining prior to the enactment of the Surface Mining Control and Reclamation Act (Public Law 95–87, enacted August 3, 1977). The Kentucky Geological Survey, supported by the Kentucky Division of Abandoned Lands, initiated studies to evaluate the impact of past mining on ground–water resources in selected areas of the Commonwealth in June of 1989. These evaluations are used by the Division of Abandoned Lands to determine where the AML program should assist with restoration or replacement of affected water resources.

KGS determines the nature and extent of perceived water–quantity and –quality changes through review of literature, resident interviews, and water–sample collection and analysis. The potential role of mining that occurred before August 1977 is determined and reported to the Division of Abandoned Lands. Studies have thus far been conducted at Wheelwright in Floyd County, Hurricane Creek in Pike County, Pathfork in Harlan County, and Good Hope in Hopkins County. Five or six studies will be completed each year.

Information compiled during these studies is expected to facilitate creation of a more complete conceptual model of the occurrence of natural and mine–influenced water quality in eastern Kentucky. This project and improvement of a ground–water model for eastern Kentucky has been hindered by the lack of a comprehensive data base of ground–water quality for Kentucky.

Other Research

SELECTED GEOLOGIC FEATURES ALONG AND ADJACENT TO INTERSTATE HIGHWAYS AND PARKWAYS IN KENTUCKY

HANEY, Donald C., and NOGER, Martin C.

Numerous inquiries about geologic features along Kentucky highways have been received at the Survey. The construction of Interstate highways and parkways in Kentucky has exposed numerous new, interesting geologic features. Many prominent geologic structures are also exposed short distances from the highways and parkways, and some State and National parks have been built in the vicinity of some of these geologic phenomena. Although the Survey has publications covering some of the parks and professional excursions along parts of some of Kentucky's highways, descriptions of interest to the general public are not available. The objective of this project is to prepare illustrations and generalized descriptions of prominent geologic features that will inform people traveling or planning vacations in Kentucky of interesting localities to visit or observe. The data will also provide background information for field studies by academic institutions and excursions by professional organizations.

Strip maps showing geologic units and interesting geologic features along Interstate Highway 75 have been completed, and the report has been submitted for publication. Future plans call for preparation of a report on the geologic features along Interstate Highway 64.

CONTERMINOUS UNITED STATES MINERAL ASSESSMENT PROGRAM (CUSMAP)

NOGER, Martin C., ANDERSON, Warren H., and DEVER, Garland R., Jr.

An analysis and inventory of all mineral occurrences is being conducted in the Paducah 2-degree quadrangle in western Kentucky. Increasing interest in the Midcontinent region as a host for massive sulfide, metallic mineral deposits, and other undiscovered resources is the basis of the CUSMAP projects. This multidisciplinary project is a USGS–KGS cooperative endeavor involving minerals, coal, petroleum, and surficial materials (limestone, clays, sands and gravels) investigations.

Metallic, nonmetallic, and industrial mineral data and information are entered into a PC-based data management system. These data were compiled, mapped, and examined to determine anomalous areas for deeper base metal mineralization potential and additional resources of industrial materials. A PC-based digitizer and plotter system is also employed to record and print specific locations. Maps showing locations of all mineral occurrences were plotted at scales of 1:24,000 for each quadrangle, and a 1:100,000-scale map of the project area was plotted.

Key topics under investigation include ore genesis and models for the formation of ore deposits in the Western Kentucky Fluorspar District. Chemical analysis of insoluble residues of several well samples, paragenetic–ore chemistry studies, and detailed lithostratigraphic core descriptions of ore horizons are also conducted as part of the investigation. Locations for clay, glass sands, and gravel deposits are all present in the study area.

The project, which has been completed, covers over 25 quadrangles, and has resulted in 14,000 data points and numerous maps. Texts describing limestone, gravel, sand, clay, sandstone, and building stones in the Kentucky part of the Paducah 2-degree quadrangle have been completed and submitted electronically to the U.S. Geological Survey, which is the funding agency.

KENTUCKY RADON SURVEY

NOGER, Martin C., and KIEFER, John D.

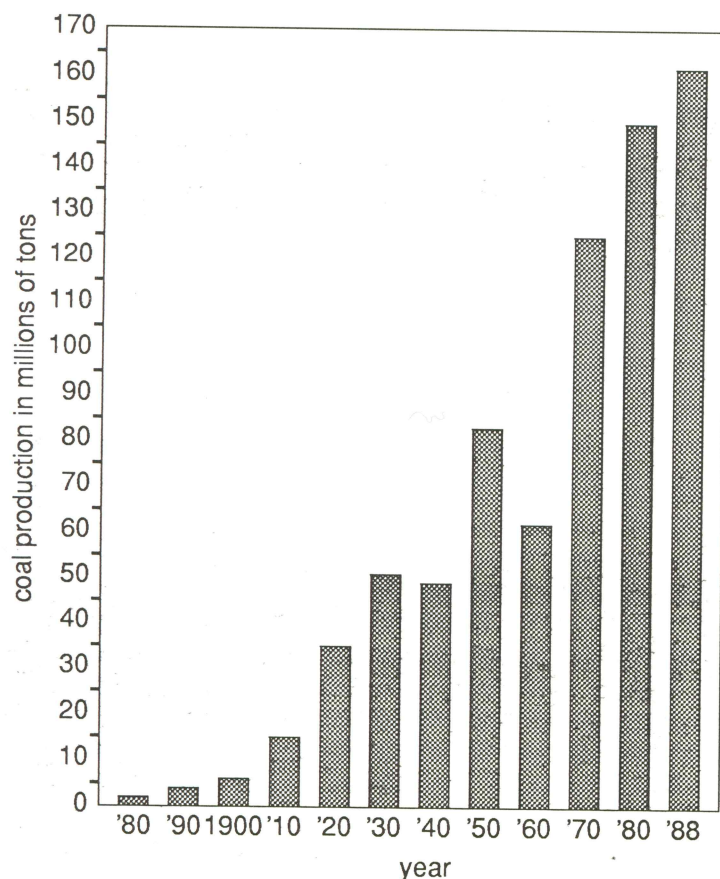
The Kentucky Geological Survey continues to monitor new developments in the radon issue and cooperate with the Kentucky Department of Health Services (DHS), Radiation Control Branch, and other State and Federal agencies. The State Geologist, acting in his capacity as president of the Association of American State Geologists, has worked out an agreement with the U.S. Environmental Protection Agency for the state geological surveys to review radon mapping by the EPA and the U.S. Geological Survey. Results from a 1987–88 survey of 879 homes conducted jointly by the KGS and the Kentucky DHS are in a data base at the DHS Radiation Control Branch office. In addition, KGS staff members gave several presentations on the geologic occurrence of radon and participated in a seminar on the sources of indoor air pollution.

GEOLOGIC MAP OF KENTUCKY

NOGER, Martin C., and POTTS, Roger B

In 1984 the Kentucky Geological Survey began compiling a 1:500,000-scale geologic map of Kentucky, taken directly from the three-sheet, 1:250,000-scale "Geologic Map of Kentucky." The single-sheet, 1:500,000-scale map, which will be of suitable size for display as a wall map, will be useful to government agencies, industry, the general public, and academic institutions.

The map has been compiled and submitted to the U.S. Geological Survey for printing.



Total coal production in Kentucky from 1880 to 1988. Modified from Information Circular 32 (ser. 11).

COMPUTER AND LABORATORY SERVICES

The Computer and Laboratory Services Section operates state-of-the-art equipment to analyze geologic and hydrogeologic samples, and acquires or develops computer software and hardware. These tools enable researchers to collect, store, and manipulate data for reports, maps, charts, and other products for use by industry, government, and the private sector.

A building-wide computer network allows KGS to interconnect various mini-, desktop, and personal computers. This versatility allows many types of operating systems to exchange information. The network in the building has also been bridged to the University of Kentucky Network (UKnet), which, in turn, is linked to most of the national networks.

KGS's six-node Local Area VAXcluster (LAVc), which is an operating environment specific to Digital Equipment Corporation's (DEC) VAX series of computers, consists of a VAX 8550, MicroVax II/GPX color-graphics workstation, two VAXstation 2000 workstations, and a VAXstation 3100. In addition, various MS-DOS-based PC's, such as Computer Aided Design (CAD), presentation graphics, and scanners, handle the extraordinary tasks that cannot be accomplished on the bigger computers. Peripheral equipment includes large-format plotters and digitizers, high- and medium-speed printers, and long-document scanners. Software includes data-base and report-writing facilities (DEC Rdb, VAX DATA-TRIEVE, and SMARTSTAR), word processing and desktop publishing (MASS-11 and INTERLEAF Desktop Publishing System), geologic modeling (MINEX and SURFACE II), and computer-aided drafting and presentation graphics (AutoCAD, FreeLance Plus, Harvard Graphics, etc).

During the past year a data-base manager has been added to the staff. This person is responsible for building and maintaining the comprehensive geologic data base for KGS.

The KGS Laboratory facilities analyze the chemical and physical characteristics of water, rock, coal, oil and gas, and other natural resources. The laboratories make use of state-of-the-art automated equipment to provide researchers with the necessary data to complete their geologic and hydrogeologic reports. Most instru-

ments have autosamplers and dedicated computers to help generate a complete set of analyses in the shortest time possible.

The laboratory facilities at KGS include the following analytical equipment:

- (a) for metals:
 - Inductively Coupled Argon Plasma (ICAP)
 - Atomic Absorption (AA) and AA with Graphite Furnace
- (b) for organic compounds and pesticides:
 - gas chromatographs with Mass Selective, Flame Ionization, and Electron Capture detectors
 - DELSI Rock-Eval chromatograph
- (c) X-Ray Diffraction and X-Ray Fluorescence
- (d) UV-visible spectrophotometers
- (e) Leco instrumentation for coal analyses:
 - Proximate; MAC-400 Determinator
 - Ultimate; CHN-600 and SC-132
 - Total Organic Carbon
 - Ash Fusion; AF-600
 - Calorimeter; AC-300
- (f) Zeiss Incident and transmitted-light microscope UEM

The lab staff now consists of four full-time scientists, two technicians, and part-time students. Beginning July 1, 1990, the staff will increase by two scientists and one technician.



Visitors at "Dinosaurs Alive!" take the "Walk Through Time," part of KGS's "Geology of Kentucky" display.

COOPERATIVE PROGRAMS

Topographic Mapping

The Kentucky Geological Survey has participated in an ongoing cooperative program with the U.S. Geological Survey for topographic map revision in the State since Kentucky became the first major state to be entirely mapped topographically at a scale of 1:24,000 more than 30 years ago.

Eight revised 7.5-minute quadrangle maps were received during the 1989–1990 fiscal year: Burnaugh, Falmouth, Fallsburg, Louellen, Louisa, Milo, Prichard, and Webb. All of these maps were photorevisions on which changes are shown in a purple overprint on the existing map.

A map showing the status of the topographic mapping revision program is available free upon request from the Kentucky Geological Survey.

Water Resources

As part of the University of Kentucky, KGS cooperates with many faculty of other academic departments and institutes and State and Federal agencies. These efforts range from participation in short courses, seminars, and professional presentations for specific educational programs to long-term research projects. In the past year, the Water Resources Section has participated in university programs in the environmental systems curriculum, hydrogeology, water resources research, agricultural engineering, agronomy, aquiculture, and with UK's Institute for Mining and Minerals Research. Since 1920, the Survey has conducted cooperative programs with the U.S. Geological Survey Water-Resources Division. This activity has produced more than 200 maps, publications, and open-file reports. Additional information on ground water can be found in the USGS's hydrologic atlases, which are available for all areas of Kentucky, including several detailed atlases for the Ohio River flood plain. One of the most important publications to evolve from the cooperative program is a 963-page document entitled "A Compilation of Ground Water Quality Data for Kentucky." Reports such as these are used to answer several hundred requests annually from individuals, industry, and State and Federal agencies.

Following are brief descriptions of the major research projects undertaken in cooperation with other university departments and State and Federal agencies.

1. Eastern Kentucky Power Cooperative Plant Waste Disposal Site Analysis—Monitoring wells and springs have been incorporated into a system to quantify the effects of the disposal of fly ash on ground and surface water. This work is in cooperation with the University of Kentucky (UK) Department of Geological Sciences and Institute for Mining and Minerals Research.

2. Characterization of Eastern Kentucky Aquifer Systems—Over 3,000 existing ground-water records were computerized and analyzed to study ground-water occurrence and quality in the Eastern Kentucky Coal Field. This work, in cooperation with the UK Department of Geological Sciences and Institute for Mining and Minerals Research, culminated in a Ph.D. dissertation by Liza Bienkowski.

3. Hydrogeology of the Western Kentucky Coal Field—The hydrogeology of the Anvil Rock Formation and associated coal zones is being studied in the vicinity of the Ohio No. 11 and Hamilton No. 2 mines operated by Island Creek Coal Company in Union County. This work is in cooperation with the UK Department of Geological Sciences and the Institute for Mining and Minerals Research.

4. Electrical Potential as a Method of Contaminant Transport—Research is beginning on the ability of an induced electrical potential to move organic contaminants in clay soil. This project is carried out in cooperation with the UK Department of Agronomy, Department of Geological Sciences, and the Institute for Mining and Minerals Research.

5. Effects of Riparian Vegetation on Water Quality; Modeling and Experimental Studies—This research determines the effectiveness of vegetation in reducing nonpoint-source pollution. It is conducted in cooperation with the UK Department of Agricultural Engineering.

6. Effect of Infiltration Basins on Mine Spoil—In an effort to enhance the development of a ground-water resource in a mine spoil, artificial infiltration basins are being installed at the Star Fire surface mine, in Knott, Perry, and Breathitt Counties, Eastern Kentucky Coal Field. This work is in cooperation with the Department of Agricultural Engineering and the UK Department of Geological Sciences.

7. Ground-Water Education and Rural Water Testing—A water-quality inventory of domestic wells and springs is being carried out in a pilot study of nine counties. Educational materials consist-

ing of brochures, a slide show, and videotape are being prepared for distribution to agencies dealing with the rural areas of the State. The inventory and distribution of materials will be extended to all 120 counties in the coming years. This work is done in cooperation with the Kentucky Natural Resources and Environmental Protection Cabinet, the UK Departments of Agronomy and Agricultural Engineering, the University Agricultural Extension Service, and Kentucky Farm Bureau, Inc.

8. Nonpoint-Source Assessment of Ground Water—Efforts have begun to study the effects of nonpoint-source pollution on ground-water resources. Land use, land treatments, and ground-water resources are being assessed in Logan County, and a program was developed to examine the water quality of several large springs in the western part of the State. Dye tracing was performed in Stanford, Lincoln County, and dye tracing and water quality and quantity are being measured in Sinking Creek in Jessamine County. These efforts are in cooperation with the Kentucky Natural Resources and Environmental Protection Cabinet, and the UK Departments of Agronomy, Agricultural Engineering, Geological Sciences, and Institute for Mining and Minerals Research.

9. Surface-Water Stations—This Statewide network collects surface-water data for a variety of uses such as research and special studies, assessment of surface-water resources, waste disposal, pollution control, planning and design of facilities, and forecasting of water levels. The program has been in operation since 1938. Prior to 1960, information from this program was published annually in the U.S. Geological Survey Water-Supply Paper series, "Surface Water Supply of the United States." Daily streamflow records for Kentucky from 1961 to 1974 were also published in annual U.S. Geological Survey open-file reports. Since 1975 all surface-water data are found in the annual USGS publication, "Water Resources Data for Kentucky."

10. Water-Quality Stations—This Statewide network of approximately 70 sites where water quality is monitored on a regular basis provides data for broad Federal and State planning and for the management of waterways. This program has been continuous since 1949. Prior to 1971 these data were published annually in the U.S. Geological Survey Water-Supply Paper series. For the years 1964-74, these data for Kentucky were also released annually in open-file U.S. Geological Survey reports. Records since 1975 are

found in the U.S. Geological Survey annual report, "Water Resources Data for Kentucky."

11. Hydrogeology of Brine Occurrences in the Kentucky River Basin—The effects of petroleum production on surface- and ground-water resources are being evaluated in a 600-square-mile area centered between the Kentucky and Red Rivers in parts of Estill, Powell, Wolfe, and Lee Counties. This research is being conducted in conjunction with the U.S. Geological Survey's National Water Quality Assessment (NAWQA) program on the Kentucky River Basin.



KGS geologist Steve Greb instructs participants on the annual Geological Society of America Coal Division field trip.

PUBLICATIONS

One of the major functions of the Kentucky Geological Survey is making the results of research projects and field investigations readily available to the public. Publication of this information serves to disseminate geologic data generated by Survey staff, members of cooperating agencies, and other earth scientists doing research pertaining to Kentucky's geology and mineral resources. The Survey also publishes the proceedings of technical sessions and symposia, and guidebooks for geologic field conferences.

Publications of the Kentucky Geological Survey are made available to the public at a nominal cost and have received widespread distribution. Maps and reports are available for purchase from the Publication Sales Office, which is located in the Mining and Mineral Resources Building at the corner of Rose Street and Clifton Avenue on the University of Kentucky campus.

In addition to printed publications, KGS maintains an extensive collection of open-file reports, maps, manuscripts, theses, and other material including coal-thickness data, logs of core holes, sample descriptions, and gravity base station networks. Copies of most U. S. Geological Survey open-file reports dealing with Kentucky geology are also maintained. Some of the material will eventually be published but has been placed on open file in order to make the data available for public use prior to publication. Open-file reports are available for inspection at Survey offices in the Mining and Mineral Resources Building on the University of Kentucky campus during regular office hours. Copies of materials that can be reproduced are available for purchase.

The following publications were issued by the Kentucky Geological Survey during the 1989–90 fiscal year.

Guidebooks

Cumberland Mountain: The Inside Story: The Geology of Cumberland Gap as Interpreted from the Federal Highway Administration Pilot Bore (Guidebook and Roadlog for Geological Society of Kentucky 1989 Field Conference), ed. by Claude S. Dean and Stephen O. Moshier, 43 p.

Depositional Environments and Geology of the Lower Pennsylvanian in Kentucky, Indiana, and Illinois (Guidebook for Annual Geological Society of America Coal Division Field Trip), coord. by James C. Cobb, 107 p.

Information Circulars

- IC 30.** Oil and Gas Drilling Activity Summary for Kentucky, 1989, comp. by Brandon C. Nuttall, 180 p.
- IC 31.** Use of Limestone, Lime, and Dolomite for SO₂ Emission Control in Kentucky, by Garland R. Dever, Jr., 14 p.
- IC 32.** Kentucky Coal Production, 1790-1988, comp. by Oscar Barton Davidson, 238 p.

Map and Chart Series

- MCS 1.** Guide to Interpretation of Structural Features Associated with the Kentucky River Fault System Along U.S. Highway 27 Near Camp Nelson, Kentucky, by J. A. Gilreath, Paul E. Potter, and George Losonsky, 1 sheet.

Report of Investigations

- RI 5.** Amos and Foster Coals: Low-Ash and Low-Sulfur Coals of Western Kentucky, by David A. Williams, Charles T. Helfrich, James C. Hower, Faith L. Fiene, Alan E. Bland, and David W. Koppelaar, 34 p.

Reprint

- R 27.** The Mineral Industry of Kentucky, 1987, by L. J. Prosser, Jr., and Garland R. Dever, Jr. (Reprinted from U.S. Bureau of Mines *Minerals Yearbook*, 1987), 7 p.

Special Publication

- SP 13.** Guide to "Progression of Life," with Notes on the History of Life in Kentucky, by Stephen F. Greb, 44 p.

Miscellaneous

Annual Report, 1988-1989, 99 p.

List of Publications, March 1990, 76 p.

In Press or Editing Completed

Map and Chart Series. Geological Highway Cross Section: Kentucky Highway 80, Hazard to Prestonsburg, by Donald R. Chesnut, Jr.

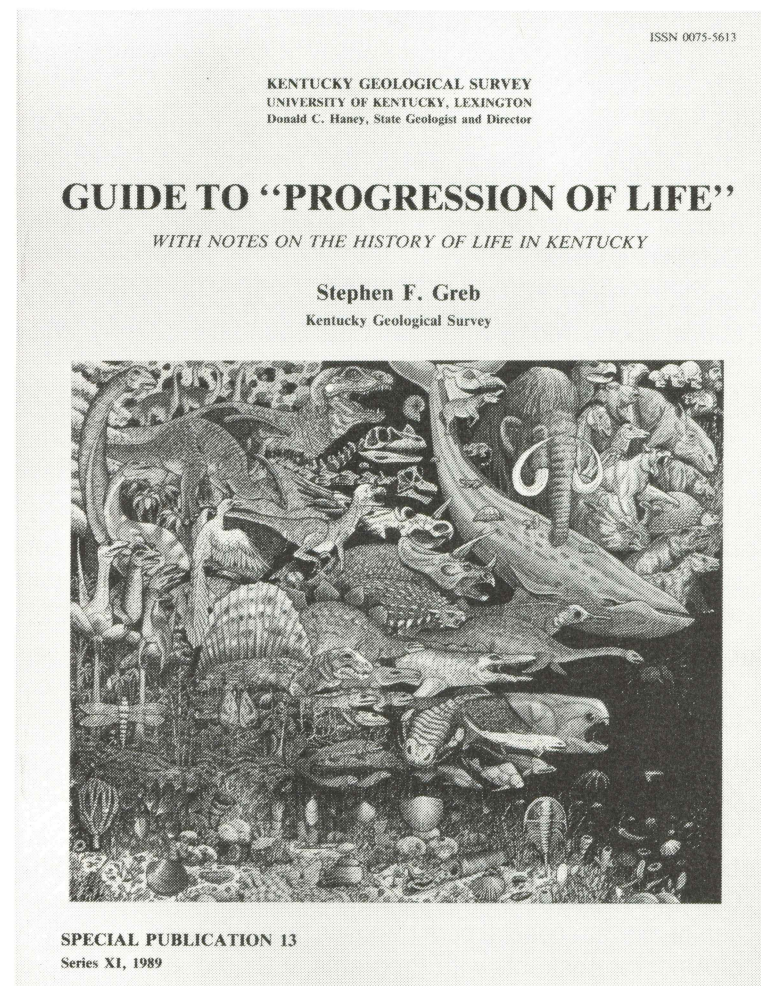
Report of Investigations. Study of the Unconformity at the Top of the Knox Group (Cambrian-Ordovician) in the Subsurface in South-Central Kentucky, by Patrick J. Gooding.

Report of Investigations. Controls on Mineralization in the Cambrian-Ordovician Mascot Dolomite of the Knox Group in South-Central Kentucky, by Warren H. Anderson.

Special Publication. The Central Mississippi Valley Earthquakes of 1811-1812, by Ronald L. Street and Otto W. Nuttli.

Special Publication. A Guide to Kentucky Place Names [rev. ed.], by Thomas P. Field.

Special Publications. Proceedings of the Technical Sessions, Kentucky Oil and Gas Association Forty-Fifth through Fifty-Third Annual Meetings, ed. by Margaret Luther Smath.



PROFESSIONAL PRESENTATIONS BY STAFF MEMBERS

- Carey, D. I., 1989**, Overland flow resistance: Agricultural Engineering Seminar, University of Kentucky Department of Agricultural Engineering, Lexington, Kentucky, October 6, 1989.
- Chesnut, D. R., Jr., and Cobb, J. C., 1989**, Comment on "Origin of the Pennsylvanian coal-bearing cyclothems of North America" by Klein and Willard (1989): *Geology*, v. 17, no. 9, p. 871–872.
- Chesnut, D. R., Jr., and Cobb, J. C., 1989**, Cycles in the Pennsylvanian rocks of the Central Appalachian Basin [abs.]: *Geological Society of America, Abstracts with Programs*, v. 21, no. 6, p. A52; presented at Geological Society of America Annual Meeting, St. Louis, Missouri, November 6, 1989.
- Cobb, J. C., 1989**, Assessing Kentucky's coal future: 18th Geochautauqua on Mineral Resources Assessment—Integrated Approaches, sponsored by International Association for Mathematical Geology: University of Delaware, Newark, Delaware, October 13, 1989.
- Cobb, J. C., 1989**, Geology of coal: Kentucky Coal Issues Workshops, sponsored by American Coal Foundation, Jenny Wiley State Resort Park, October 4, 1989.
- Cobb, J. C., 1989**, Stratigraphic trends in coal quality and trace elements: Conference on Trace Elements in Coal, sponsored by Western Kentucky University, Barren River State Resort Park, September 11, 1989.
- Cobb, J. C., 1990**, Coal resource research in Kentucky: Sponsored by the Energy Information Administration, U.S. Department of Energy, Washington, D.C., February 8, 1990.
- Cobb, J. C., 1990**, Indonesian peat geology and travelogue: Geological Society of Kentucky Spring Banquet, Lexington, Kentucky, April 20, 1990.
- Cobb, J. C., 1990**, Minerals and the environment: University of Kentucky Environmental Law Seminar, University of Kentucky Law School, Lexington, Kentucky, March 8, 1990.
- Cobb, J. C., and Chesnut, D. R., Jr [with Norris, J. W.], 1989**, Glacio-eustatic sea-level controls on the burial and preservation of modern coastal peat deposits [abs.]: *Geological Society of America Abstracts with Programs*, v. 21, no. 6, p. A26; pre-

- sented at Geological Society of America Annual Meeting, St. Louis, Missouri, November 6, 1989.
- Cobb, J. C., Chesnut, D. R., Jr., and Greb, S. F., 1989**, Coal: The story of Kentucky's greatest natural resource: University of Kentucky Saturday Seminar Program, Lexington, Kentucky, October 21, 1989.
- Currens, J. C., 1989**, Wellhead protection in rural Kentucky, contamination occurrence, and the implication for future resource development: Conference on Environment and Technology in Appalachia, University of Kentucky, Appalachian Center, Lexington, Kentucky, November 2, 1989; Kentucky Water Resources Symposium, University of Kentucky, Water Resources Research Institute, Lexington, Kentucky, December 2, 1989.
- Currens, J. C., 1990**, An overview of the hydrogeology of Kentucky: Groundwater Resource Network Training Sessions, Kentucky Conservation Foundation, Barren River Lake State Resort Park, May 15, 1990.
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PUBLIC SERVICES

Coal and Minerals Section

Borehole Data System

Core descriptions are being collected from coal companies and governmental agencies and compiled into the Kentucky Geological Survey "Borehole Data System." At present, header information from the approximately 1,000 open-file core descriptions have been entered into the system, and lithologic descriptions from about half of these have been entered. Data from important oil and gas records will also be added to this data base.

Kentucky Coal Resources Information Office

Most of the Coal and Mineral Section's 1,900 requests for information concerning coal resources and coal geology can be answered using the Kentucky Coal Resources Information System (KCRIS), a computer-based system of indexes, geologic data, coal chemical analyses, geophysical logs, core descriptions, field notes, and maps. The data bases and associated computer programs allow comprehensive data-searching and output to printers, graphics devices, plotters, and magnetic media.

Types of coal data currently available through the Kentucky Coal Resource Information Office include:

- 36,000 measurements of coal thickness for approximately 120 beds in eastern and western Kentucky
- 1,311 coal chemical analyses for eastern Kentucky and 435 analyses for western Kentucky
- Field notes and resource reports for most of the 7.5-minute quadrangles in the Eastern Kentucky Coal Field
- Field notes and geologic quadrangle maps from the USGS-KGS geologic mapping program (1960-78)
- 1,600 core descriptions from the Eastern and Western Kentucky Coal Fields
- 350 engineering records for the Eastern Kentucky Coal Field
- 536 coal petrology records containing maceral and reflectance data for the Eastern Kentucky Coal Field

- Coal-production statistics by county, year, and type of mining for both coal fields
- 200 geophysical logs from both coal fields.

The data in KCRIS are constantly revised, updated, and expanded. Additional data from all of the projects currently underway in the Coal and Minerals Section are being added on a weekly basis. The new coal-quality analytical equipment will yield a substantial number of records.

"Dinosaurs Alive!"

In the past fiscal year the Survey was able to increase the effectiveness of its educational goals by participating in the "Dinosaurs Alive!" exhibit sponsored by the Living Arts and Science Center of Lexington, which featured several robotic dinosaur replicas. The Kentucky Geological Survey and Department of Geological Sciences at the University of Kentucky sponsored the "Geology of Kentucky" exhibit, featuring a "Walk Through Time," in which display cases with fossils from the Commonwealth were on exhibit. The display cases were augmented with explanations of the geologic history of Kentucky. The exhibit also featured specimens and games for children, including a large sand box in which children could dig for actual fossils. In addition, the Survey prepared two slide shows that were presented on weekends by volunteers from the Survey and the Department of Geological Sciences. Nearly 70,000 people saw the exhibit, and the response was enthusiastic. As a result of the exhibit the request for Survey personnel to speak at libraries, grade schools, and high schools has risen dramatically.

Petroleum and Stratigraphy Section

Well Record Library

The Petroleum and Stratigraphy Section of the Kentucky Geological Survey is the official repository for records of all oil and gas wells drilled in the State. A variety of records, such as drillers' logs, wireline logs, well-location survey plats, plugging affidavits, and completion reports, are on file for an estimated 225,000 wells.

Kentucky Geological Survey staff review and enter into the computerized data base information on all newly permitted wells. Records for approximately 2,400 new wells were processed last year. The computerization of the Well Record Library is expected to

greatly enhance the speed and efficiency of data retrieval. A total of 4,399 records were added to the data base in 1989. By the end of 1990, data for approximately 98,000 wells should be available. In 1990, the library staff will begin entering stratigraphic tops to the computerized data base, further enhancing its usefulness.

The library can provide custom well-list printouts based on user specifications. In addition, similar information can be provided on 5.25-inch flexible diskettes or magnetic tape. The library also provides well-location base maps that are available as overlays for the U.S. Geological Survey, 1:24,000-scale, 7.5-minute topographic quadrangle maps. Well locations can be plotted on base maps supplied by Survey staff, industry, and the public.

To facilitate map making for the user, the library has developed and provides a set of personal-computer routines that convert Carter coordinate locations to latitude and longitude. The routines are published as Kentucky Geological Survey Open-File Report OF-88-08. In the future, routines for converting to other grid systems such as UTM will be included in this package.

To prevent deterioration because of constant use, the oil and gas well-record files are being stored electronically. Nearly 25,000 documents were scanned and their records placed on computer tape in 1989. Data for 47 counties have been stored in this fashion to date. In the future these data will be placed on optical disks.

Well Sample and Core Repository

The Kentucky Geological Survey Well Sample and Core Repository is the official repository for samples from wells drilled in Kentucky. The repository is the fifth largest of its type in the country, and contains over 17,000 sets of well cuttings and in excess of 1,500 cores, representing over 20 million feet of vertical drilling in the State.

Samples and cores submitted to the Survey are processed, cataloged, and made available to the public for inspection. Each year more than 250 researchers representing industry, academic institutions, government and the general professional community examine samples and cores at the repository. The repository is centrally located near the University of Kentucky campus at 670 South Broadway in the Reynolds Building No. 1, and is open from 8:00 a.m. to 4:30 p.m., Monday through Friday. It provides easy access and permanent storage. The ultimate objective of the Survey is to

selectively provide, whenever possible, a representative set of well cuttings or core samples from every square mile in the State.

Oil and Gas Newsletter

A newsletter listing significant oil and gas activities in Kentucky was initiated in 1988. New publications by the Survey are also listed. Periodic printing of the newsletter is determined by events in the oil and gas industry.

Publications Section

Publication Sales and Data Distribution

The Publication Sales Office of the Kentucky Geological Survey makes published information about Kentucky's mineral and water resources available to thousands of customers each year. Maps and reports published by the Kentucky Geological Survey and U.S. Geological Survey account for most of the materials sold, but publications from many other sources, as well as open-file reports dealing with Kentucky geology, are also available.

The Publication Sales Office is located on the first floor of the Mining and Mineral Resources Building at the corner of Rose Street and Clifton Avenue on the University of Kentucky campus. Convenient parking for customers is located in the University of Kentucky Faculty Club parking lot behind the Mining and Mineral Resources Building.

The office stocks 7.5-minute quadrangle topographic and geologic maps for the entire State. These maps are at a scale of 1:24,000 (1 inch on the map represents 2,000 feet on the ground) and depict in great detail Kentucky's topography and geology. All available 1:100,000-scale topographic maps of Kentucky, as well as complete coverage of Hydrologic Atlases published by the U.S. Geological Survey, are also kept in stock.

A List of Publications, which shows available maps and reports and gives complete ordering instructions, is available free upon request.

Earth Science Information Center

The Kentucky Geological Survey-Earth Science Information Center (KGS-ESIC) answers inquiries regarding the availability of current and historic map information, aerial photography, satellite

imagery, geodetic control, and digital cartographic data. The office also answers questions about the availability of all types of earth-science information in Kentucky. The KGS-ESIC office is located in Lexington on the first floor of the Mining and Mineral Resources Building adjacent to the KGS Publication Sales Office.

Since 1980, KGS has been affiliated with the U.S. Geological Survey's National Cartographic Information Center (changed to Earth Science Information Center in 1989 when it was merged with their Public Inquiry Offices). The USGS center serves as a national repository for information concerning maps, aerial photography, space imagery, digital map data, and geodetic control, as well as information about earth-science publications.

Resources available to the KGS-ESIC office for answering requests include a file of more than 5,700 microfiche indexes to aerial photography projects, satellite data, and historical maps; a microfilm file containing 37,400 historical topographic maps of Kentucky and surrounding states; and online access to Federal government data bases at the EROS Data Center in Sioux Falls, South Dakota, and the USGS Branch of Global Seismology and Geomagnetism in Denver, Colorado. Access to the USGS electronic data base of geographic names (GNIS) for Kentucky, which contains more than 30,000 place names used on Kentucky topographic maps, is also available.

Close coordination between KGS-ESIC and the KGS Publication Sales Office makes it possible for many persons to obtain desired materials or information as the result of a single visit or inquiry to the Kentucky Geological Survey. However, in some cases it may be necessary to refer persons to another State or Federal agency or a private firm as the source for a particular product.

Water Resources Section

The Water Resources Section provides daily consultation on both water quality and quantity to the public. During the past year the Section answered approximately 500 requests for surface-water and ground-water information.

Most requests can be answered through a search of available literature and maps, although a field visit may be made when necessary. Funding limitations prevent extensive field investigations; however, these visits frequently provide valuable data for the Survey, as well as for the person making the request.

COMMITTEES, BOARDS, AND ADVISORY ACTIVITIES

National

American Association of Petroleum Geologists

James A. Drahovzal, Chairperson, District 8 (Kentucky) for the American Petroleum Institute/American Association of Petroleum Geologists Committee on Drilling Statistics

Association of American State Geologists

Donald C. Haney, President; National Geologic Mapping Steering Committee, Chairman

Eastern Oil Shale Symposium

Martin C. Noger, Chairman, Technical Program Advisory Committee; Tar Sands/Heavy Oil Subcommittee
James A. Drahovzal, Technical Program Advisory Committee; Tar Sands/Heavy Oil Subcommittee

Geological Society of America

James C. Cobb, Chairman, Coal Division, 1990
Donald C. Haney, Council; Chairman, Publication Committee
John D. Kiefer, Committee on Geology and Public Policy; Agency Representative for the University of Kentucky

Interstate Oil Compact Commission

Donald C. Haney, Chairman, Research Committee
John D. Kiefer, Environmental Affairs Committee
Martin C. Noger, Enhanced Recovery Committee; Tar Sands Subcommittee

National Symposium on Mining, Hydrology Sedimentation, and Reclamation

James A. Kipp, Program Advisory Committee

National Water Quality Assessment Program

Donald C. Haney, Kentucky Liaison Committee, National Liaison Committee

U.S. Department of Energy

James C. Cobb, Steering Committee for Demonstrated Reserve Base of the Energy Information Administration

State

Geological Society of Kentucky

Garland R. Dever, Jr., Western Vice President, 1990

O. Barton Davidson, Secretary—1989
 Richard E. Sergeant, Secretary—1990
 James S. Dinger, Chairman, Membership Committee
 Patrick J. Gooding, Delegate to American Association of Petroleum Geologists House of Delegates

Governor's Earthquake Hazards and Safety Technical Advisory Panel

John D. Kiefer, Chairman, Seismic Probability Assessment Committee

Governor's Groundwater Advisory Council

Donald C. Haney
 James S. Dinger, Chairman, Data Management Committee;
 Groundwater Monitoring Committee
 James C. Currens, Richard E. Sergeant, Data Management Committee

Kentucky Encyclopedia

Garland R. Dever, Jr., Consulting Editor for Geology

Kentucky Museum of Natural History

Donald R. Chesnut, Jr., Organizing Director

Kentucky Nonpoint Source Technical Advisory Committee

Donald C. Haney, James S. Dinger, James C. Currens

Kentucky Oil and Gas Association

James A. Drahozal, Martin C. Noger, Co-Chairmen, 1990 Technical Sessions

Kentucky On-Site Sewage Disposal Advisory Committee

James A. Kipp

Kentucky Water Availability Advisory Council

James S. Dinger

Kentucky Water-Well Drillers' Certification Board

James S. Dinger

State Water Management Task Force

John D. Kiefer (assisted by James S. Dinger, James A. Kipp, and David R. Wunsch)

University of Kentucky Building Naming Committee

Donald C. Haney

University of Kentucky Department of Geological Sciences

Donald C. Haney, James C. Cobb, James S. Dinger, Adjunct Associate Members

University of Kentucky Environmental System Committee

Donald C. Haney

University of Kentucky Groundwater Center Committee

Donald C. Haney

Local

Geological Society of Kentucky, Lexington Chapter

Richard E. Sergeant, President
 James S. Dinger, Vice President

Kentucky Anthropological Research Facility

Garland R. Dever, Jr., Advisory Committee for the Kentucky Anthropological Research Facility (KARF) at the University of Kentucky

Kentucky River Basin Steering Committee

Donald C. Haney
 Daniel I. Carey, Technical Advisory Subcommittee
 John D. Kiefer, Chairman, Technical Advisory Subcommittee

Lexington-Fayette Urban County Government Committee to Review Underground Quarrying Operations

John D. Kiefer

Lexington Living Arts and Science Center

Stephen F. Greb, Science Advisory Board

Mammoth Cave Karst Area Water-Quality Oversight Committee

James C. Currens

National Speleological Society, Blue Grass Grotto

James C. Currens, Board of Directors

PERSONNEL

Professional Staff

Eugene J. Amaral, M.S.
Geologist V, Coal and Minerals Section

Warren H. Anderson, M.S.
Geologist IV, Coal and Minerals Section

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Hydrologist IV, Water Resources Section

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James C. Cobb, Ph.D.
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