

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

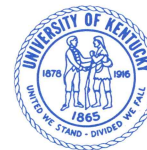
ANNUAL REPORT 1981-1982



**1981-1982
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**KENTUCKY GEOLOGICAL SURVEY
UNIVERSITY OF KENTUCKY
LEXINGTON, KENTUCKY
Donald C. Haney, Director and State Geologist**

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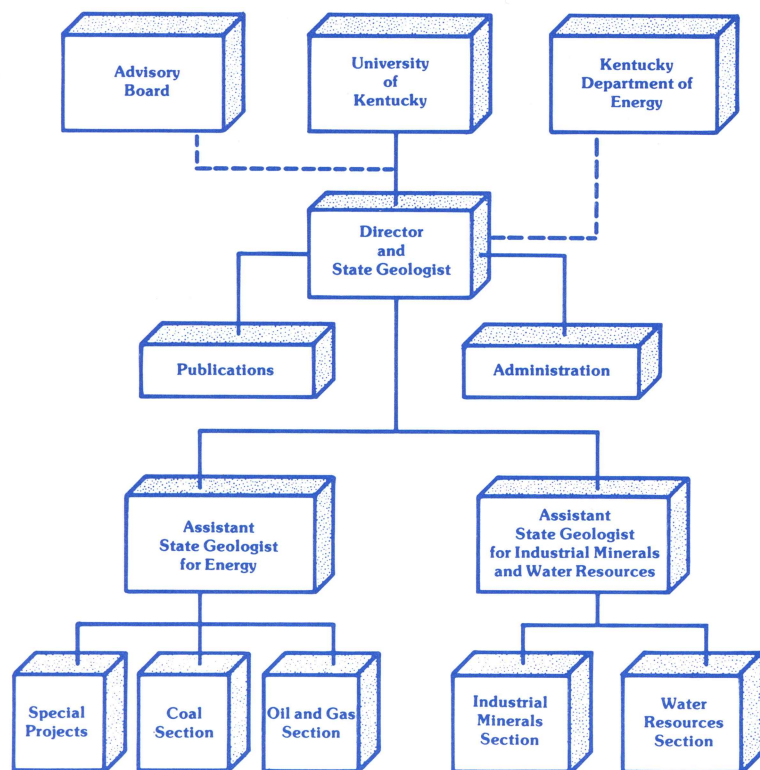
FOREWORD

The Kentucky Geological Survey was established in 1854 as the official geologic research organization in the Commonwealth. Since that time the Survey, which is part of the University of Kentucky, 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.

Some of the Survey's ongoing and future research objectives include: studies of coal bed continuity, quality, and characteristics in the Eastern and Western Kentucky Coal Fields; a hydrogeology study to collect baseline ground-water quantity and quality data in the Eastern Kentucky Coal Field; a study of the hydrogeology of the oil shale regions of Kentucky; various mineral resources investigations including a major study of limestone resources in eastern Kentucky; subsurface investigations of structure and stratigraphy related to the occurrence of oil and gas including special projects on tar sand and oil shale; initiation of geologic hazards research throughout the Commonwealth; and a study to characterize specific aquifers in Kentucky that have the potential to supply potable water.

As an ex-officio member of the Kentucky Department of Energy, the Survey serves in an advisory capacity to local, regional, and various State and Federal agencies. Additionally, the Survey places great emphasis on maintaining a dialogue with the general public through multifaceted public service activities. Close cooperation with industry and public awareness and participation are essential to the Kentucky Geological Survey in attaining its goal of defining, understanding, and properly utilizing the natural resources of the Commonwealth of Kentucky.

The objective of this annual report is to provide a brief summary of the activities in which the Kentucky Geological Survey has been involved during the past fiscal year (July 1, 1981-June 30, 1982).



Organization of the Kentucky Geological Survey

RESEARCH

Basic research in geology and hydrology has formed the cornerstone of the Kentucky Geological Survey since its inception. This dedication to the identification and characterization of the Commonwealth's vast natural resources has continued throughout the Survey's 128 years of service to the people of Kentucky.

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

Although research at the Kentucky Geological Survey covers a wide variety of subjects, it has a unified goal: a better understanding of the geology of the Commonwealth and utilization of the State's resources for the greatest benefit to the citizens of Kentucky and the Nation.

Coal

Kentucky continues to lead the Nation in the production of coal. This production comes from two great coal fields, a situation unique in the United States and one requiring a special effort in order to satisfy the demands for geologic information about these diverse coal resources. Demand for coal information continues to increase due to the concern about coal quality and remaining resources, mine safety, land reclamation, and interest in the syn-fuels industries. The principal objectives of the Coal Section are to collect geologic information about the coal resources of Kentucky and make this information available to the public.

The Coal Section conducts a variety of research projects designed to obtain vital information about the coal resources of Kentucky. These research projects involve coal resource estimation and mapping, coal-mining geology, coal characterization, lignite, stratigraphy, and geophysical well logging. Data collected are placed in the public files maintained by the Survey and reports generated are published by the Kentucky Geological Survey or other cooperating agencies, or placed on open file.

Many of the research projects conducted by the Coal Section are funded by State and Federal agencies. These agencies include the Kentucky Department of Energy, the University of Kentucky Institute for Mining and Minerals Research, the U. S. Geological Survey, the Nuclear Regulatory Commission, the Minerals Management Service, the Office of Surface Mining, and the University of Kentucky.

COAL RESOURCES OF EASTERN KENTUCKY

BRANT, Russell A., CHESNUT, Donald R., FRANKIE, Wayne T., GILL, Kenneth L., HAMILTON, Joseph P., SLUCHER, Ernie R., and SMATH, Richard A.

This project evaluates the coal resources of the Eastern Kentucky Coal Field. Field measurement of coal beds, which dominated earlier phases of the project, continued during the past year, although emphasis was on data checking and storage, coal bed mapping, and resource estimation and reporting. Nearly 20,000 coal bed thickness measurements have been electronically processed and stored in the computer. This data set may be the largest of its kind in the Nation.

Resource estimates are being done on a district basis. The Princess District was completed and a report is now in press.

The Southwestern District resource estimate has been completed and a report is in preparation. The estimated 7,430.16 million short tons is 62 percent greater than previous estimates for the district. The resource occurs in 25 coal beds; 12 of the 25 coal beds contain 85 percent of the estimate. The estimate is based on 3,600 data points and 458 isopach maps.

The Licking River District resource estimate has been completed. This involved plotting 2,000 thickness measurements to prepare 308 isopach maps, and subsequent measuring and calculation.

Field work for the Hazard District was completed, and the entire data set of 7,700 measurements was stored in the computer. The measurements were used in a computerized mapping program that prints out 7 1/2-minute coal map bases at a scale of 1:24,000 and identifies adjacent quadrangles, latitude and longitude at the corners, and 1-minute marks at the margins. The computer program also identifies the quadrangle and coal bed and plots the location and thickness of measurement points.

Field work for the Upper Cumberland District is complete, and approximately 1,300 of the thickness measurements are stored in the computer. Resource mapping and estimation will begin after

Hazard District is complete.

Work on the Big Sandy District continues; five quadrangles remain to be examined, and data from 11 quadrangles in which field work has been completed remain to be entered into the computer.

Data are continually acquired from geophysical logging of exploratory wells, other Kentucky Geological Survey projects, and other validated sources and are incorporated into the data set.

District reports generated by the project will be published in the Kentucky Geological Survey-University of Kentucky Institute for Mining and Minerals Research Energy Series. These reports will summarize the coal resource characteristics with tables showing the estimated resource by coal bed and maps for the major coal beds. In addition, microfilming of field notes and coal cards derived from field notes and other sources is in progress. This will provide public access to the basic data set when the project is completed. All data generated by this project will be available to the public at the conclusion of the project.

COLLECTION OF DATA FOR THE NATIONAL COAL RESOURCES DATA SYSTEM

BRANT, R. A., and PORTIG, E. R.

Access to Statewide coal information requires a data system that is capable of accommodating the tremendous interest that exists in both the public and private sectors. The objective of this project is to collect and organize coal data for the National Coal Resources Data System (NCRDS), a Federal program designed to disseminate coal information using computer technology and access terminals Nationwide. This project is funded in part by the U. S. Geological Survey.

Coal information is being collected from roadcuts, drill holes, and mine exposures in eastern Kentucky. The data are organized into a coal resource data set that includes coal name, coal and parting thicknesses, geographic location, and analysis number if applicable. These data are stored in a computer for rapid and easy retrieval of data by coal bed, county, or reserve district. At this time, nearly 18,000 data points are in the data set. The computer data set for the Princess, Southwestern, Hazard, and Upper Cumberland River Reserve Districts is complete. The Big Sandy Reserve District lacks approximately 15 quadrangles for completion. Information for all of the eastern Kentucky reserve districts will be available by 1983.

This project provides a central, easily accessed file for coal measurements that will be of use in resource mapping, coal resource estimations, and other coal research. It can be readily updated as additional information becomes available. As coal deposits are depleted through mining and new mineable deposits are sought, this data file will be a valuable asset to Kentucky.

GEOLOGY AND COAL RESOURCES OF THE PRINCESS DISTRICT, EASTERN KENTUCKY

BRANT, Russell A., SERGEANT, Richard E., and CURRENS, James C.

This report on the Princess Reserve District (Boyd, Carter, Greenup, and Lawrence Counties) will be the first in a series of six reserve district reports that will describe in detail the geology of the Eastern Kentucky Coal Field. This comprehensive report on the Princess District will consist of detailed stratigraphic descriptions compiled from measured sections, core data, and geologic quadrangle maps; a discussion of the district's structural setting (with particular emphasis placed on the Princess structural basin) and its effect on the formation of coal; a historical overview of the district including historic coal, clay, iron, oil, and gas production statistics; coal-quality data for major coal beds in the district; and coal-bed and stratigraphic-section descriptions and bed maps for the more important coals to demonstrate their extent and thickness variations. Additionally, this report will discuss methods, criteria, and definitions that were used to calculate and summarize Princess District coal resources.

To date, the bed maps, resource calculations, structural geology, and general geology sections of the report have been completed and the coal-quality data have been gathered. Completion of this report is expected in the early part of fiscal year 1982-83; publication will follow.

SULFUR IN KENTUCKY COAL

COBB, James C., CURRENS, James C., BLACKBURN, Kim, and REEVES, Paul

This is a new project initiated by the Kentucky Department of Energy and the Kentucky Geological Survey. Coal resources are routinely assessed by bed thickness, which is a major factor in their utilization. However, since the Clean Air Act of 1977, sulfur content is also a major determinant in the utilization of coal. This project will assess Kentucky's coal resources by Environmental Pro-

tection Agency (EPA) standards, which combine sulfur and Btu values into a standard for compliance with air emissions regulations. The current standard for coal is 1.2 pounds of SO_2 per million Btu. To meet this standard a Kentucky coal with a Btu value of 14,500 would need to contain no more than 0.9 percent sulfur.

The distributions of sulfur and Btu content for 12 major eastern Kentucky coals and four major western Kentucky coals are being investigated. The organic and pyritic sulfur distributions in these coals are also being determined. When the sulfur and Btu distributions are combined with the calculated resources for each individual coal, then histograms and probability curves relating the percentage of resources that occur within the EPA classes for compliance and noncompliance can be constructed.

Statistical inferences from these studies enable the prediction of the percentages of coal that would be affected by changes in the Federal Clean Air statutes. Congress is currently considering such changes, which would have profound effects on Kentucky's coal industry.

A publication that will present sulfur, Btu, organic sulfur, pyritic sulfur, and coal resources for 16 major Kentucky coal beds is being planned. A format for this publication has not been decided.

COAL RESOURCES OF THE DANIEL BOONE NATIONAL FOREST

COBB, James C., SCHREIBER, Anne, GROSSNICKLE, Effie, CHESNUT, Donald R., SMATH, Richard A., and SLUCHER, Ernie R.

The Bureau of Land Management and the Minerals Management Service have determined that an assessment of Federally owned coal in the Daniel Boone National Forest is needed for forest-land management. The Kentucky Geological Survey is cooperating in the project by providing data on coal in the National Forest and expertise in core description and stratigraphy.

Twenty-one cores have been drilled. Coals in these cores were sampled for chemical analysis. The cores are stored at the Well Sample and Core Library of the Kentucky Geological Survey and will be available for public inspection upon their release by the Minerals Management Service. A data file listing all coal core and outcrop information for the Daniel Boone National Forest was completed.

A publication giving all core descriptions, chemical analyses, and geophysical logs is being prepared by the Minerals Manage-

ment Service. Assessment of the Federally-owned coals is still underway.

GEOPHYSICAL WELL LOGGING

COBB, James C., and SMATH, Richard A.

Geophysical well logging is an important data-collection tool used in geological research. It is particularly valuable for studies related to coal, oil shale, tar sands, ground water, and engineering problems. Well logging involves the lowering of wireline devices into boreholes in order to record properties of the rocks with respect to depth. Properties such as electrical potential and resistivity, radioactivity, rock density, and borehole diameter are measured.

The geophysical logs give important information such as depth and thickness of coal beds, aquifers, and aquicludes. Geophysical logs are valuable in coal resource estimates. They are important for stratigraphic and coal correlation studies. They also provide data on coal and ground-water quality.

Well logs constitute a permanent record of subsurface information and are placed on open file for use by the public. The Coal Section has geophysical logs for purposes of coal geology from approximately 110 boreholes in Kentucky.

An open file of all Kentucky Geological Survey logs, indexed by county, 7.5-minute quadrangle, and Carter coordinate location, has been developed. Geophysical logging is a continuing program in support of a broad spectrum of Survey activities.

ACQUISITION, STORAGE, AND CLASSIFICATION OF ENGINEERING AND GEOLOGICAL DATA FOR SURFACE-MINE DESIGN AND RECLAMATION

COBB, James C., UNRUG, K., TURNER, J. G., and BOLTON, J. C.

This project is a cooperative effort of the Kentucky Geological Survey and the Mining Engineering Department of the University of Kentucky. It is supported by the Federal Title III program (Public Law 95-87), administered through the University of Kentucky Institute for Mining and Minerals Research. Information has been collected on cores from Kentucky coal fields, and engineering tests were performed on rock samples from these cores. Over 1,200 tests were performed, and the results have been stored in the University's IBM 370 computer.

A series of programs that allow the user interaction with the

data base was developed. Program 1 gives the results of all engineering tests on each rock type. Engineering tests include slake durability, punch shear, direct shear, and Brazilian. Program 2 allows the user to examine engineering test results of the rocks with respect to depth. Program 3 allows the user to compare test results with each other. Only two tests can be compared at a time. The information is given in tables and graphs. Program 4 allows the user to list geologic descriptions of the cores in a three-digit number code in the classification of Melton and Ferm (1971).

A report on this testing program and a description of the use of the data base are being assembled. A final report including all results and methods and the significant findings will be published by the Kentucky Geological Survey. The computer programs and data file will become a permanent part of the Kentucky Geological Survey data base.

STRUCTURAL AND STRATIGRAPHIC STUDIES OF LIGNITE IN THE JACKSON PURCHASE AREA OF KENTUCKY

COBB, James C., and WILLIAMS, David A.

The great emphasis now placed on domestic fossil fuels has come to include resources previously thought to be of only marginal economic interest. Lignite (low-rank coal) is one such fossil fuel that occurs in Kentucky. While lignite has been used as a fuel in Kentucky only locally, it represents a resource of unknown potential. Therefore, the Survey, in cooperation with the Nuclear Regulatory Commission, undertook a limited study of lignite in the Jackson Purchase region. One purpose was to collect general data not previously available on lignite. Another purpose was to determine faults caused by earthquake activity in the area. Lignite beds were used as marker horizons to assess offset.

Data from four bore holes drilled for this project and other subsurface data were analyzed to determine possible offset on a suspected fault near an earthquake epicenter in the New Madrid Fault Zone in western Kentucky. The drill holes penetrated unconsolidated Eocene and younger sediments of the Mississippi Embayment. These holes were located along an east-west line that intersected the northeast-trending lineament of the suspected fault.

Lignite was found in each drill hole. Maximum thickness of the lignite was 3 feet. Correlation of lignite layers, geophysical logs, and drill cuttings suggests that the lignite was deposited on a gently rolling, westward-dipping surface. This surface dips westward

at approximately 23 feet per mile. The underlying Wilcox Formation is reported to dip westward at 23 feet per mile.

No evidence was found to support the presence of offset on the suspected fault, but the inability to unequivocally correlate the lignite deposits made it impossible to rule out the possibility of a fault. Furthermore, the similarity between the dip of the Wilcox Formation and the dip of the lignite horizon suggests no offset along the line of the drill holes. Five possibilities about the occurrence of a fault in the area investigated are: no offset due to faulting exists, the suspected fault was not intersected by the line of drill holes in this report, the presence of unconsolidated deposits may have dampened effects of faulting, offset due to faulting exists but is too small to detect, and offset on the lineament occur only to the south and died out before reaching the study area.

This study was completed during the year and will be published by the Nuclear Regulatory Commission. The report is titled, "Correlation of Lignite Beds for Fault Identification in the Mississippi Embayment Area of Western Kentucky."

SAMPLING AND ANALYSIS OF EASTERN KENTUCKY COALS

CURRENS, James C.

In May 1979 an ambitious 3-year program to collect 600 channel samples of coal from eastern Kentucky, for conventional and trace-element analysis, was funded by the U. S. Geological Survey. The purpose of the program is to develop an extensive coal-quality data base for the evaluation of the State's coal resources and to provide data to the coal industry. The project is now drawing to a close, having successfully collected over 90 percent of its sampling goal.

The Kentucky Geological Survey described the coal and its enclosing rocks and sampled the coal, using procedures established by the U. S. Bureau of Mines that were adopted by the U. S. Geological Survey. The U. S. Geological Survey analyzed the samples for basic coal-quality parameters and trace-element content. The objective was to collect samples from as many coal beds as possible with as wide a distribution as possible. This goal was largely met.

Through the end of May 1982, over 540 full-thickness channel samples had been collected. Approximately 40 samples were collected by other Kentucky Geological Survey researchers and seven were contributed by the University of Kentucky Institute for Mining

and Minerals Research (IMMR). IMMR also provided assistance with sample preparation and analytical support. A detailed set of records has been kept to record the location of each sample site and its geologic conditions.

Currently, these data are being edited and compiled for an open-file report on samples collected through January 1, 1981. It is anticipated that this report will be available in late 1982. A second report on all samples will be compiled at a later date.

A comprehensive file consisting of over 2,000 analyses of coal channel samples has been constructed as part of this project. These analyses are the products of published and unpublished data from a variety of sources from 1913 to 1978. This has become a valuable source of coal-quality data for Kentucky.

Coal-quality maps that delineate the variations in moisture, ash, sulfur, and Btu contents for each of the major coal beds in eastern Kentucky are being prepared. Coal-quality maps of the Fire Clay coal are completed and on open file. As coal-quality maps from other coal beds are finished they will be made available for public use.

COMPUTERIZATION OF COAL-RELATED DRILLING RECORDS FOR KENTUCKY

SERGEANT, Richard E.

The Kentucky Department for Natural Resources and Environmental Protection is compiling an index of information pertinent to the Federal Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87). This index will be used by coal operators who are seeking data necessary to prepare mine permit applications and by the Department for evaluating these applications. An important component of this index is a listing of coal-related drilling records available to the public for the Eastern and Western Kentucky Coal Fields.

With the support of the Department for Natural Resources and Environmental Protection, the Kentucky Geological Survey is compiling and computerizing such a list. Existing drill record files at the Kentucky Geological Survey are being encoded into a standardized format. These sheets contain information on drillhole location, elevation, total depth, and operator's name. Additionally, if there is a core available and if geophysical logs have been run, it is noted. These data are then entered into Survey computer files, and copies of the computer files are transferred to the Department for Natural Resources and Environmental Protection. Most of the western Kentucky records have been computerized and are being

checked. Eastern Kentucky records will be completed by early 1982. This system allows new records to be added as they become available.

FACTORS AFFECTING COAL DEVELOPMENT IN THE WESTERN KENTUCKY PART OF THE ILLINOIS BASIN

SERGEANT, Richard E., and BINGEMER, Roxanne

The United States has established the goal of energy independence by the year 2000. To accomplish this it will be necessary to accelerate the development of the coal resources in the Illinois Basin (parts of Kentucky, Illinois, and Indiana). Increased coal production and development of synfuel alternatives require heavy concentrations of people from the mining and construction industries and capital investment for equipment and construction.

Development of this nature could have a severe impact on rural settings such as western Kentucky. It is essential that this impact be mitigated wherever possible by comprehensive regional and local planning. To this end, the U. S. Geological Survey has funded the Geological Surveys of Kentucky, Illinois, and Indiana to compile coal and coal-mining-related data for their respective portions of the Illinois Basin. These data, which include information concerning reserves and resources, coal quality, mined-out areas, hydrology, reclamation, hydrocarbon exploration and production, and limestone have been compiled into "easy to use" manuals by the School for Political and Environmental Affairs at Indiana University. These manuals will direct the user to sources of specific information. Data compilation was initiated in January 1980 and was completed in June 1981. Presently, these manuals are being prepared for publication.

Workshops to acquaint the public with the results of this project are planned for the fall of 1982.

INVENTORY OF MINED-OUT AREAS IN THE WESTERN KENTUCKY COAL FIELD

SERGEANT, Richard E., and BINGEMER, Roxanne

The Western Kentucky Coal Field includes all or parts of 17 counties in western Kentucky. It is the southernmost extension of the Eastern Interior Basin (Illinois Basin), and is contiguous with coal-producing regions in Indiana and Illinois.

Coal has been mined in western Kentucky since 1820, but despite this long history of mining activity, estimated remaining coal resources indicate continued production well into the twenty-first

century. A recently completed study by the Kentucky Geological Survey estimated that original resources in the Western Kentucky Coal Field exceeded 40 billion short tons, while coal remaining is estimated to exceed 38 billion short tons.

Because of its extensive coal resources, plentiful water supply, and central geographic location, western Kentucky will probably be the site of synfuel plants and new electric power plants by the year 2000. These facilities as well as increased mining activity will accelerate urban and industrial development. To properly plan for this accelerated growth, it is imperative to have precise knowledge about areas where coal has been mined on the surface and underground. Although a considerable amount of data on mined-out areas exists, records from public and private sources must be compiled and synthesized to create a comprehensive file on mined-out areas.

This project, funded by the U. S. Geological Survey, will undertake an extensive inventory of the more than 4,000 known underground mine maps for western Kentucky. During the first year of the project more than 1,500 maps were photoreduced, most of the reductions having been plotted and digitized for computer storage and retrieval. Additionally, maps of areas mined underground were secured and photographed from a number of private sources to augment official records. The results of this project will be a comprehensive index of the geographic location and magnitude of mined-out areas in western Kentucky.

This project is scheduled for completion in the summer of 1983.

STRATIGRAPHIC ANALYSIS OF THE AMOS AND FOSTER COALS IN THE WESTERN KENTUCKY COAL FIELD

WILLIAMS, David A.

Although limited in extent, the Amos and Foster coals of the Western Kentucky Coal Field are mined and represent sources of medium- and low-sulfur, low-ash coal. The purpose of this project is to investigate these coals by use of borehole and outcrop data, analytical work on coal quality and composition, and stratigraphic determination. Approximately 100 outcrop and core descriptions have been made, and preliminary cross sections and isopach maps have been completed. Twenty coal samples have been analyzed by the U. S. Institute for Mining and Minerals Research.

A study of the macerals in these coals is also underway in conjunction with the stratigraphic study. The petrographic research is being done in cooperation with James C. Hower of the University

of Kentucky Institute for Mining and Minerals Research.

This project is scheduled for completion in 1983, and the results will be published by the Kentucky Geological Survey. A preliminary report on this work was presented to the Geological Society of America at Purdue University in April 1982.

STRATIGRAPHIC FRAMEWORK OF COAL-BEARING ROCKS IN THE WESTERN KENTUCKY COAL FIELD

WILLIAMS, David A., WILLIAMSON, Allen D., and BEARD, John G.

The coal deposits of western Kentucky are an important energy resource for Kentucky and the Nation. The purpose of this project is to present a stratigraphic framework, based on 32 core holes, to enhance coal exploration and development of this region. West-east and north-south cross sections have been constructed to illustrate correlations of major stratigraphic units in the Western Kentucky Coal Field.

Stratigraphic determinations in the Pennsylvanian System of the Western Kentucky Coal Field are difficult because of the cyclic nature of the deposits. However, certain stratigraphic markers are found to be useful. The Springfield coal (W. Ky. No. 9) and Lead Creek Limestone are the principal stratigraphic markers used in this project. Stratigraphic correlations above the Davis coal (W. Ky. No. 6) are considered reliable, but correlations below the Davis coal (W. Ky. No. 6) remain provisional. Lateral continuity of the coals in the Pennsylvanian strata decreases below the Davis coal (W. Ky. No. 6).

To preserve the geological details in the 32 cores that were analyzed for this study, the core descriptions are being published as an appendix to the report. The cores themselves are available for examination at the Kentucky Geological Survey Well Sample and Core Library.

This project was completed during the year and is being published as Kentucky Geological Survey, series 11, Information Circular 8.

PENNSYLVANIAN STRATIGRAPHY OF WESTERN KENTUCKY

WILLIAMSON, Allen D.

Although the Western Kentucky Coal Field contains approximately half of the coal resources in Kentucky, and although a significant fraction of Kentucky's coal production is derived from this coal field, no comprehensive classification has been prepared for

the coal-bearing strata of this region. The objective of this study is to establish a comprehensive rock-stratigraphic classification for the coal-bearing rocks of western Kentucky. Secondary objectives are to designate and describe type and reference sections for the Pennsylvanian System, to correct various miscorrelations, and to develop an informal coal bed nomenclature.

Over the past 20 years, detailed studies have been made of small parts of the Western Kentucky Coal Field; however, the lack of a standard for classification has resulted in some invalid regional correlations and confused estimates of coal reserves, quality, and stratigraphic position. This study will enable coal industry personnel to make more accurate estimates of the extent, quality, and mineability of coal in western Kentucky, and will provide a necessary basis for future coal development.

A tentative biostratigraphic framework has been constructed and criteria for defining rock-stratigraphic units have been developed. Construction of isopach maps for each major rock unit is in progress. Surface data are being utilized where available; however, a major task of this project is the interpretation of subsurface data, most of which consist of oil-test records.

Subsequent work will involve a compilation of western Kentucky coal bed names and their positions in the stratigraphic section. Redundant, archaic, and miscorrelated coal bed names will be rejected and new names will be selected if necessary. Insofar as is possible, each named coal bed will be assigned a reference locality or reference core.

The final phase will involve the construction of a standard stratigraphic section for the Pennsylvanian System of western Kentucky.

Upon completion of this 5-year project, a report outlining the Pennsylvanian rock-stratigraphic classification for western Kentucky will be prepared and a bulletin of stratigraphic names, their correlation type sections, lithologic characteristics, and stratigraphic position will be published by the Kentucky Geological Survey.

THE PENNSYLVANIAN-AGE CASEYVILLE FORMATION IN WESTERN KENTUCKY

WILLIAMSON, Allen D., and BEARD, John G.

The Caseyville Formation of the Western Kentucky Coal Field may contain resources of high-Btu, low-sulfur coal. This study is to aid in the exploration and development of coal beds in the Caseyville Formation. Most of the coal currently mined in the Western

Kentucky Coal Field has sulfur and Btu contents that render it unacceptable under current Federal regulations. The high-sulfur coal can, however, be blended with low-sulfur coals to produce an acceptable feedstock in compliance with Environmental Protection Agency standards.

This study has been extended because of the acquisition of four new boreholes that penetrate the Caseyville. Two cross sections of the Caseyville have been completed and an isopach map is being prepared. A rough draft is nearing completion.

This study is expected to be completed by January 1983.

INDEX TO COAL BEDS IN THE WESTERN KENTUCKY COAL FIELD

WILLIAMSON, Allen D., BINGEMER, Roxanne, and BRANT, Russell A.

The purpose of this project is to catalog the important coal beds of the Western Kentucky Coal Field and to summarize their distribution, thickness, stratigraphic relationships, and quality. This index is expected to be used by coal industry personnel who wish to identify and correlate coal beds in their locality, private citizens who wish to obtain information about the coal on their property, and others interested in obtaining information for a variety of reasons on western Kentucky coal beds.

The most widespread and economically important coal beds in the Western Kentucky Coal Field are the Mulford (W. Ky. No. 9) and the Herrin (W. Ky. No. 11) of the Carbondale Formation. These beds are restricted to the central part of the coal field, where they have been mined extensively. Of secondary importance are the Paradise (W. Ky. No. 12), Wheatcroft (W. Ky. No. 13), and Coiltown (W. Ky. No. 14) coal beds, which are mined near the center of the Western Kentucky Coal Field, and the Davis (W. Ky. No. 6) and Mannington (W. Ky. No. 4) coal beds, which have been mined near the southern rim of the coal field; all of these coal beds have been mined in western Kentucky. Other less extensive coal beds are found throughout the Western Kentucky Coal Field.

Industrial and Metallic Minerals

Industrial and metallic minerals play important roles in the ceramic, chemical, construction, metallurgical, and related industries. Mineral commodities produced in Kentucky during the 1981-82 fiscal year included clay, dolomite, fluorite, gravel, limestone, sand, sandstone, shale, and sphalerite. Investigations by staff geologists were focused primarily on the identification and characterization of carbonate rocks, fluorite, sand and gravel, and zinc.

One of the areas for growth for the carbonate-rock industry is for sulfur dioxide removal in coal-burning power plants. Through cooperative endeavors with the University of Kentucky's Institute for Mining and Minerals Research and the Kentucky Center for Energy Research Laboratory, the Kentucky Geological Survey is addressing this subject.

ZINC DEPOSITS OF SOUTH-CENTRAL KENTUCKY

ANDERSON, Warren H.

This project is a subsurface investigation of the Cambro-Ordovician Knox Dolomite in south-central Kentucky. During the past decade, zinc mining in middle Tennessee has increased interest and exploration activity in southern Kentucky. This investigation is providing a basic geologic framework for determining stratigraphic and lithologic relationships in the Knox Dolomite in Cumberland, Clinton, and Monroe Counties, Kentucky.

Descriptions of cores and oil-well cuttings, and identification and correlation of marker beds are the basis of this investigation. Information generated from these data will be used to characterize the carbonate rocks of the Knox Dolomite in south-central Kentucky.

Detailed descriptions of two cores and one set of oil-well samples from Cumberland County have been released as open-file reports. Mining companies have allowed the Kentucky Geological Survey to examine three additional cores; stratigraphic information obtained from these cores will be used in this investigation. One Kentucky Geological Survey core from Clinton County has been studied, and a detailed description will be released as an open-file report during the 1982-83 fiscal year. Subsurface studies will continue as cores become available.

BARITE DEPOSITS OF KENTUCKY

ANDERSON, Warren H., TRACE, Robert D., and MCGRAIN, Preston

A recently completed investigation indicates that barite is a potentially important mineral resource in Kentucky. Barite has been recognized at more than 170 mines, prospects, and outcrops in 23 counties in central, south-central, and western Kentucky. No mines were active at the time of this investigation.

Most of the Kentucky barite deposits are classified as vein or residual deposits that range in thickness from a fraction of an inch to a few feet and in length from tens to hundreds of feet. Bedded deposits of barite have not been mined in Kentucky.

The vein deposits are generally mixed ores. Most common co-products are fluorite (fluorspar), galena, and sphalerite. Because mixed ores, particularly barite and fluorite, were once considered difficult to separate economically, many deposits were bypassed in mining activities.

A report describing the known occurrences of barite in Kentucky was published as Bulletin 1 (ser. 11).

CHEMICAL CHARACTERISTICS OF CARBONATE ROCKS IN THE HIGH BRIDGE GROUP (MIDDLE ORDOVICIAN) OF CENTRAL AND NORTH-CENTRAL KENTUCKY

DEVER, Garland R., Jr.

The High Bridge Group (Middle Ordovician) is a thick (430-570 feet), widespread body of limestone and dolomite, which, in central and north-central Kentucky, is a major source of stone for construction, industrial, and agricultural uses. It is mined at seven sites in central Kentucky, primarily for construction and agricultural stone. Limestone from two deep mines along the Ohio River is used in the production of lime for flue-gas desulfurization, flux, chemical industries, and water treatment. Objectives of the project are to determine the chemical characteristics of High Bridge rocks across the region and to define the occurrence of deposits suitable for industrial uses that require carbonate rocks of high chemical purity.

Analysis of foot-by-foot samples from cores; taken in Boone, Fayette, and Grant Counties shows that deposits of high-carbonate stone, as much as 67 feet thick, occur at four positions within the High Bridge. Correlation between deposits in the three cores indicates that large reserves of high-carbonate stone are available in the region. Analyses of the cores from Boone and Fayette Counties

have been published by the Survey (1974, ser. 10, Information Circular 22; 1980, ser. 11, Information Circular 4). Phosphorus and sulfur analyses remain to be completed for the Grant County core. The availability of low-silica stone in the High Bridge of central Kentucky, shown by analyses of the Fayette County core, has resulted in one mine operator starting production of rock dust for underground coal mines in eastern Kentucky, and a second rock dust plant in the area is under construction.

Project duration is dependent upon the availability of cores to define the regional chemical characteristics of the High Bridge.

CARBONATE-ROCK RESOURCES IN KENTUCKY FOR ENVIRONMENTAL-CONTROL MEASURES USED BY COAL PRODUCERS AND COAL-CONSUMING INDUSTRIES

DEVER, Garland R., Jr., and MOODY, Jack R.

Carbonate rocks, principally limestone, are employed by coal producers and coal-consuming industries in environmental-control measures to meet Federal and State standards for mine safety and reclamation, water quality, and air quality. Limestone, for example, has uses as diverse as rock dust for underground coal mines and a reagent for flue-gas desulfurization. The principal objective of the project is to determine the availability of carbonate rocks in Kentucky with chemical characteristics suitable for use in the environmental-control measures. Thick limestone deposits exposed along Pine Mountain in the southeastern part of the Eastern Kentucky Coal Field currently are being sampled for chemical analysis.

A secondary objective is to evaluate the limestone and dolomite resources of the State specifically for potential use in fluidized-bed combustion systems. Work currently is directed toward determination of porosity values (point counting of petrographic slides with dyed epoxy) and petrographic characteristics of the carbonate rocks. Of the samples studied to date, dolomites (16 samples) have an average porosity value of 2.9 percent (range, 0.0-17.0 percent); limestones (72 samples) have an average value of 0.2 percent (range, 0.0-4.4 percent). Dolomite and limestone deposits with highest average porosity values are, respectively, the Laurel Dolomite of central Kentucky (average, 6.4 percent; very fine- to medium-crystalline dolomite) and Warsaw Limestone of western Kentucky (average, 0.5 percent; bioclastic grainstone, packstone, and wackestone).

The project is funded by the University of Kentucky Institute for

Mining and Minerals Research. Its proposed duration is 1976-83.

GEOLOGY OF CONSTRUCTION MATERIALS IN KENTUCKY

McGRAIN, Preston

This project was undertaken because of an invitation from the Program Chairman, Forum on Geology of Industrial Minerals, to present a geological review paper on the potential and produced construction materials of Kentucky at the 18th Annual Meeting of the Forum at Indiana University.

Kentucky contains a variety of industrial minerals that are or have been used as construction materials. Classified broadly as stone, sand and gravel, and miscellaneous or common clays and shales, one or more of these resources are present at the surface or at mineable depths in most of the State's 120 counties. Although seemingly widespread, individual mineral commodities are irregularly distributed, range widely in geologic age, and have a diversity of chemical, lithologic, and physical characteristics.

This paper was presented at the Forum in April 1982 and has been submitted, with other papers from the meeting, for publication by the Indiana Geological Survey. Preprints have been issued as Kentucky Geological Survey Reprint 13 (ser. 11).

NONFUEL MINERAL STATISTICS

McGRAIN, Preston

The Kentucky Geological Survey cooperates with the U. S. Bureau of Mines in the collection and compilation of statistics on nonfuel mineral activities and production. Joint efforts with Kentucky and other states provide a basic source of data for the Bureau's *Minerals Yearbook*, an accepted reference for anyone seeking information on the nonfuel mining industry, and other annual mineral commodity reports.

Nonfuel mineral production in Kentucky declined in 1980 and 1981 due to economic conditions affecting the construction industry. On the plus side, fluorspar mining resumed in the Western Kentucky district, sphalerite (zinc ore) was produced as a by-product of limestone mining at an underground operation in Jessamine County in central Kentucky, and new mine-dust operations were initiated in Garrard and Madison Counties.

The Kentucky chapter for the 1980 *Minerals Yearbook* was compiled and submitted for publication. Off-prints have been issued as Kentucky Geological Survey Reprint 12 (ser. 11).

OVERVIEW OF SAND AND GRAVEL RESOURCES IN KENTUCKY

McGRAIN, Preston

This project was designed to provide a summary of the geologic occurrence and characterization of the sand and gravel resources of Kentucky. It will serve as a guide for those concerned with exploring and developing mineral aggregates and a base for future detailed studies characterizing specific deposits.

In terms of both value and volume, sand and gravel constitutes the second-most important source of mineral construction raw material in Kentucky, being exceeded only by limestone. However, deposits that meet most requirements and specifications for aggregates are not evenly distributed.

On the basis of current use, most Kentucky deposits are classified as construction sands and gravels. Some deposits, however, contain sufficiently high silica content to classify them as industrial sands and gravels.

Principal production is concentrated in the channels and valleys of the Ohio and Mississippi Rivers. Sand and gravel are obtained from the valley of the Ohio River from land-based pits in fluvio-glacial and alluvial deposits and from the channels of the Ohio and Mississippi Rivers by floating operations.

Problems facing the sand and gravel industry in Kentucky include irregular distribution and variable composition of deposits, competition for land, costs of environmental and reclamation regulations, and zoning restrictions.

The results of this project were published as Report of Investigations 1 (ser. 11).

GEOLOGY AND ORE DEPOSITS OF THE TABB AREA, TABB FAULT SYSTEM, CRITTENDEN AND CALDWELL COUNTIES, KENTUCKY

TRACE, Robert D.

The Tabb area, in the south-central part of the highly faulted Western Kentucky Fluorspar District, has been the locale of the largest mineral production in the district. Approximately 1 million tons of finished fluorspar and small quantities of zinc, lead, and barite have been recovered from vein and residual deposits.

The project was part of a long-term investigation of the geology and mineral deposits of the Western Kentucky Fluorspar District. Although the Tabb area has been the most productive part of the district, little has been published on the area for more than 50 years. Under favorable economic conditions, parts of the Tabb area appear to have the potential to produce substantial tonnages

of fluorspar and byproduct zinc and lead, particularly from near or along the hanging wall of the Tabb Fault System.

A report, which includes detailed surface and underground maps, is being reviewed for publication.

Oil and Gas

One of the basic responsibilities of the Kentucky Geological Survey is to provide industry, government agencies, academic institutions, and the general public with information pertinent to the exploration and development of oil and gas in Kentucky.

The new county and regional oil and gas information file is being kept up to date with the addition of current data. This file contains such information as cumulative annual oil production, oil and gas pool maps (1:250,000 scale), pool indexes, geologic quadrangle indexes, and bibliographies. This file has proven to be a great aid in expeditiously handling general information inquiries.

The Survey, being the official repository for oil and gas well records, maintains a library containing approximately 125,000 well records for public use. In addition to providing a public service, the Survey's Oil and Gas Section is also involved in basic geologic research such as regional and local studies of subsurface structure and stratigraphy.

STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS OF LOWER MERAMECIAN AND OSAGIAN ROCKS IN THE SUBSURFACE OF WESTERN KENTUCKY

BEARD, John G.

Oil and gas production in the Kentucky portion of the Eastern Interior Basin has been restricted principally to reservoirs in Lower Pennsylvanian and Upper and Middle Mississippian rocks. The potential for oil and gas production from these rocks is not exhausted and they will continue to be the principal target for explorationists and the source of future reserves. However, as the shallower reservoirs within the Chester and upper Meramecian Series are exhausted and as the economic climate permits, petroleum exploration will be directed to older and more deeply buried reservoirs.

Rocks of the lower Meramecian and Osage Series, although sparsely drilled, offer considerable potential for future oil and gas development. This study deals with the regional aspects of the stratigraphy, lithology, and depositional environments of these units, with particular emphasis on the location and geometry of potential petroleum reservoirs.

The preliminary phase of this project is a study of a reservoir in rocks of lower Meramecian age in Daviess County, Kentucky. The cumulative production from this reservoir to date has been 345,000

barrels of oil from 10 wells, for an average of 34,500 barrels per well. Maps and cross sections of the stratigraphic interval encompassing the productive zone have been constructed, and a paper on this initial phase was presented at the annual meeting of the Kentucky Oil and Gas Association. Geophysical logs and studies of well cuttings will be used to project this zone eastward to the outcrop belt in Meade County, Kentucky, where it will be correlated with identified surface units.

The major object of this study is the construction of a stratigraphic and environmental framework that the petroleum industry can use to focus exploration activities on sparsely tested deeper objectives on the eastern flank of the Eastern Interior Basin.

GEOLOGIC ASSESSMENT OF OIL-BEARING SHALE IN CENTRAL KENTUCKY

BEARD, John G.

The New Albany-Chattanooga-Ohio black shale of Devonian age and the Sunbury black shale of Mississippian age are undergoing an investigation as to their potential as a source of synthetic crude oil. A resource assessment is being conducted in cooperation with the University of Kentucky Institute for Mining and Minerals Research; it is supported by the U. S. and Kentucky Departments of Energy and private sources. This evaluation will cover the outcrop belt within strippable limits around the Lexington Dome and in the Cumberland Saddle.

In 1981, the University of Kentucky Institute for Mining and Minerals Research published a technical report, "Resource Assessment of Oil-Bearing Shales in Lewis and Fleming Counties, Kentucky"; within this two-county area it was determined that a resource potential of 1.3 billion barrels of synthetic crude oil existed, at a stripping ratio of 2.5:1.

Another technical report, "Stratigraphy and Resource Assessment of the Oil Shales of East-Central Kentucky," is to be published in 1982 (it is currently at the printer); it estimates that Rowan, Bath, Montgomery, and Powell Counties contain 3.88 billion barrels of synthetic crude oil at a stripping ratio of 2.5:1.

An additional 35 sites in 17 counties have been drilled, and the cores have been described and are currently being analyzed. Information derived will be combined with data already on file to produce a resource assessment of the entire outcrop area in Kentucky. In addition to the resource assessment, the reports cover the stratigraphy, organic and inorganic chemistry, and physical prop-

erties of the oil shale in their subject areas.

The Kentucky Geological Survey has completed its obligations to this project, and the final reports will be compiled and published by the University of Kentucky Institute for Mining and Minerals Research.

SUBSURFACE STUDY OF THE KNOX GROUP IN KENTUCKY

GOODING, Patrick J.

South-central Kentucky is currently undergoing a very active period of oil and gas exploration. The primary unit of interest in this area is the Knox Group of Cambro-Ordovician age. The purpose of this study is to investigate the structural configuration of the top of the Knox Dolomite in a 12-county area in south-central Kentucky. To date, 1,725 control points have been documented over 1,000 geophysical logs, 400 sets of well sample cuttings, and 50 cores have been examined. Structure maps and transects have been prepared for the Knox and for the Middle Ordovician Wells Creek Dolomite and Upper Ordovician Pencil Cave bentonite, two very important marker beds. In addition, four cross sections, five isopach maps, and a geologic column are in preparation. Completion of the project is scheduled for mid-1983. A talk summarizing work on the project was presented at the Kentucky Oil and Gas Association Annual Meeting.

CORRELATION OF STRATIGRAPHIC UNITS OF NORTH AMERICA (COSUNA)

NOGER, Martin C., DEVER, Garland R., Jr., SMITH, J. Hiram, SCHWALB, Howard R., and WILLIAMSON, Allen D.

This project deals with the long-term need to update the series of North American correlation charts of geologic units published by the Geological Society of America. The new charts will be enhanced by the large amount of subsurface data that have accumulated in recent decades. An adjunct effort is the creation of a central stratigraphic data bank.

Working areas designated for the United States are based on the provinces set up by the American Association of Petroleum Geologists (AAPG) Committee on Statistics on Drilling (CSD). Kentucky encompasses parts of the following CSD provinces: 250 (Mississippi Embayment), 300 (Cincinnati Arch), 315 (Illinois Basin), and 160 (Appalachian Basin).

The Kentucky Geological Survey COSUNA Committee has compiled 10 columns for the Kentucky portions of provinces 300, 135,

and 160. The seven columns for provinces 300 and 315 have been reviewed and incorporated into the Lowland Basins and Arches Region (LOBAR) chart, which consists of 29 columns covering all or parts of Wisconsin, Michigan, Ohio, Indiana, Illinois, Kentucky, Tennessee, and Alabama. The LOBAR sheet will be the first COSUNA chart published and has been submitted to Gulf Oil Company, which will prepare all charts for publication. Stratigraphic data sheets have been compiled for each unit on the seven Kentucky columns and submitted to the Regional Coordinator.

The three columns for province 160 have been compiled, reviewed locally, and submitted to the Regional Coordinator for incorporation into the Appalachian Basin chart, which will consist of 53 columns covering all or parts of New York, New Jersey, Pennsylvania, Ohio, Maryland, West Virginia, Virginia, Kentucky, Tennessee, Georgia, and Alabama. Stratigraphic data sheets have been compiled for the Kentucky columns and submitted to the Regional Coordinator. The Survey's contributions to this project have been completed.

INVESTIGATION OF SUBSURFACE TAR-SAND DEPOSITS IN WESTERN KENTUCKY

NOGER, Martin C., GOODING, Patrick J., and WILLIAMS, David A.

Tar sands (also referred to as asphaltic sandstones, heavy oil deposits, or bitumen-impregnated sandstones) in western Kentucky have been recognized as a potential mineral resource for over 100 years. These occurrences are the largest known tar sand deposits east of the Mississippi River. The principal tar sand units in western Kentucky are the Kyrock and Bee Spring Sandstones of Early Pennsylvanian age and the Big Clifty, Hardinsburg, and Tar Springs Sandstones of Late Mississippian age.

Past commercial development has been restricted largely to use as paving material. However, because of the ever-expanding demands for energy, these deposits have become the subject of increasing interest as a potential petroleum resource. Two pilot plant projects, in Logan and Edmonson Counties, are currently recovering heavy oil from the Big Clifty Sandstone. Another pilot plant is under construction in Logan County, and reportedly construction is planned for a pilot plant in Butler County for extraction of heavy oil from the Big Clifty.

Previous studies have provided estimates of the potential resources of shallow mineable tar sand deposits. These investiga-

tions have concentrated on the outcrop areas where tar sands are present at or near the surface. Data on subsurface deposits have been lacking, however, and currently no reports are available that evaluate the potential oil resources associated with the occurrences of deeper tar sand deposits in western Kentucky.

The Kentucky Geological Survey initiated a project in 1981 to inventory and evaluate the oil resource potential of asphaltic sandstones in the subsurface of western Kentucky. The project will consist of: (1) a canvass of industry for existing information that can be made available, (2) compilation of existing data in the files of the Kentucky Geological Survey, (3) publication of preliminary reports on individual tar sand units, (4) core drilling for acquisition of additional data, and (5) compilation of all available information and publication of a final report.

A preliminary study (ser. 11, Information Circular 7) of the Big Clifty Sandstone of Late Mississippian age in Butler County and parts of Edmonson, Grayson, Logan, and Warren Counties has been published. This study suggests that major heavy oil resources are present in the Big Clifty in these areas.

Bitumen-impregnated sandstones in western Kentucky, north of this initial study area, are currently being investigated. Subsurface occurrences are being cataloged, and isopach and structure maps of individual tar sand units will be prepared.

COMPUTERIZATION OF OIL AND GAS WELL RECORDS

NUTTALL, Brandon C.

The purpose of this project is to provide a unified storage and retrieval system for oil and gas records on file at the Kentucky Geological Survey. The computerization of the well record library is expected to considerably enhance the speed and efficiency of data retrieval. Programs have been developed to provide proofreading and error checking aids, well lists, and to manipulate computer data sets.

Approximately 5,400 well completions have been encoded, keypunched, and proofread to date. These data are being reported on magnetic tape to the American Petroleum Institute in cooperation with the American Association of Petroleum Geologists Committee on Statistics on Drilling. Programs to compile statistical summaries from these data have been developed, and year-end activity statistics are available (for 1981).

In conjunction with the county oil and gas base map project, well record data sets have been computerized and are now avail-

able for Anderson, Bell, Boyle, Bourbon, Caldwell, Carter, Casey, Clark, Fayette, Fleming, Garrard, Grant, Grayson, Greenup, Harlan, Jessamine, Larue, Letcher, Lewis, Logan, Madison, Mercer, Montgomery, Nicholas, Oldham, Todd, Washington, and Woodford Counties and the Horton Quadrangle. Data are being compiled and keypunched for the Hartford and Equality Quadrangles.

An index of deep test wells has been computerized as part of a subsurface study of the Cambrian of Kentucky.

In cooperation with private industry, well records data are being collected and encoded for computerization on heavily drilled areas of eastern Kentucky. This project is designed to collect information needed to help industry qualify natural gas produced from formations with low permeability under pricing guidelines set forth by the Federal Energy Regulatory Commission. Data from approximately 2,500 wells in Pike and Lawrence Counties have been processed. Data for Perry County have been received and are being processed.

FEASIBILITY ASSESSMENT OF UNCONVENTIONAL GAS IN KENTUCKY

PONSETTO, Louis R.

Unconventional gas in Kentucky consists of methane gas produced from coal beds and gas produced from Devonian shales. The Kentucky Department of Energy has received a grant from the U. S. Department of Energy to investigate the feasibility of developing this resource as a supplement to conventional natural gas for rural areas, municipal public utilities, and local industries.

Prestonsburg, Kentucky, is the only one of three proposed test sites that was drilled in 1981. The test well was drilled to a total depth of 2,230 feet, penetrating 692 feet of Devonian shale. Nine individual stratigraphic units were identified within the Devonian shale. In ascending order, they are the Rhinestreet, Angola, Pipe Creek, Hanover, Lower Huron, Middle Huron, Upper Huron, Three Lick Bed, and Cleveland. Several gas shows were noted on the geophysical logs in the Middle Huron and Hanover units. While drilling the well, a good show of conventional gas was encountered at 1,086 feet in the bottom of the Newman Limestone (Big Lime) of Mississippian age. Upon completion of the test, the city of Prestonsburg took over the hole and completed a gas well in the Newman Limestone with an initial natural open flow of 130 mcf.

The Prestonsburg site was also tested for coal bed methane gas in the Pennsylvanian. A 2-inch continuous core was taken to a

depth of 605 feet. Three coal seams were tested, with negative results. The coals encountered were too shallow and thin to be productive.

The Hazard and Henderson sites have been abandoned in lieu of a proposed site at Harlan, Kentucky. The Harlan site will test for both coal bed methane and Devonian shale.

The Kentucky Geological Survey will provide technical assistance necessary to evaluate this resource as a potential supplement to conventional supplies.

OIL AND GAS BASE MAPS

PONSETTO, Louis R.

The purpose of this project is to build a file of current oil and gas base maps that give location, identification, and well status for each county in Kentucky. Individual county maps are being compiled on a planimetric base at a scale of 1:48,000 and will be accompanied by an index of wells and a generalized columnar section. The original program has been modified to include 7.5-minute quadrangle oil and gas maps on a planimetric base at a scale of 1:24,000. These maps and columnar sections are prepared on mylar to facilitate updating and reproduction. As the individual counties and quadrangles are completed, the data will be placed on open file and maintained for the use of industry, government, educational institutions, and the general public.

To date, Anderson, Barren, Boyle, Carter, Clark, Garrard, Grayson, Greenup, Jessamine, Letcher, Lewis, Madison, Mercer, Rowan, Todd, Washington, and Woodford Counties have been completed and placed on open file; Bell, Caldwell, Fleming, Harlan, and Montgomery Counties are also on open file, although they need generalized stratigraphic columns to be complete. Casey, Logan, and Oldham Counties are in final drafting and should be available in July. Counties in progress are Adair, Fayette, Larue, Lawrence, McCreary, Menifee, Pulaski, and Simpson.

THE CAMBRIAN SYSTEM OF KENTUCKY

WALKER, Frank H.

This is a subsurface study of a little-understood section of the rock column. Few wells have reached the top of this unit and even fewer have penetrated the entire Cambrian section. Each year a few additional wells are drilled that penetrate all or part of this section, adding further to our knowledge. To date, all of the wells on which the Kentucky Geological Survey has any record have

been identified and entered into our developing computer system. There is now available an open-file map at a scale of 1:500,000 showing the location and total depth formation of each well. A computer printout accompanying the map gives details concerning the wells.

As completion reports are received on all new wells that reach the Cambrian, the data from these wells are added to the map and to the computer printout.

Water Resources

The Kentucky Geological Survey plays an important role in the development, protection, and management of water resources in the Commonwealth. It is the charge of the Water Resources Section at the Survey to collect data and to conduct basic research in hydrology and hydrogeology in order to provide for the optimum development, utilization, and management of the State's water resources. As has been the case over the past several years, emphasis has been placed in the area of ground water, and many of our projects are carried out in cooperation with the U. S. Geological Survey Water Resources Division.

Over the past several decades, a new awareness of the tremendous potential and the overall critical importance of the Nation's ground-water resource has been generated. With that awareness has come the realization of the difficult problems associated with the management and the protection of that resource. Nationwide, more than 80 percent of our total water use presently comes from surface-water sources, yet our lakes and rivers make up only a small percentage of our total reserves of fresh water. Ground water comprises a large and extremely important part of our total water reserve and holds our hope for future development in many areas of the Commonwealth.

Despite an apparent relaxation in environmental regulations safeguarding our surface- and ground-water supplies, our need for water, and therefore our need for understanding and protecting this resource, is greater than ever. If one considers the basic needs of modern civilization—food, clothing, shelter, and energy—there is virtually nothing that can be produced without large quantities of water. In addition, there is the need to dispose of the large quantities of waste water our system generates. Certainly the efficient development, utilization, and protection of our water resources is a major challenge of the 80's. It is our goal to meet that challenge.

GEOHYDROLOGY OF THE OIL SHALE AREAS OF KENTUCKY

CORDIVIOLA, Steven

The purpose of this Kentucky Geological Survey-U. S. Geological Survey cooperative study is to describe the general hydrology of the oil shale areas of Kentucky, including an inventory of ground-water yields from the shale and adjacent units, methods and directions of ground-water flow through the shale, and

ground-water quality studies. In addition, streamflow data and water-quality samples will be collected from the Red, Kentucky, Ohio, Licking, and Rolling Fork Rivers.

The study includes the entire area along and adjacent to the outcrops of the shale, and focuses on areas in which initial development of the oil shale is most likely to occur. Three areas along the oil shale outcrop belt (Carters Quadrangle in Lewis County, Palmer Quadrangle in Clark and Estill Counties, and Loretta Quadrangle in Nelson and Marion Counties) have been selected for more detailed study, and other areas may be selected as the project progresses.

The study will add to the hydrologic knowledge of a region of Kentucky that has been generally ignored in previous studies, and it will assist regulatory agencies and industry in the proper development of the oil-shale resource. During the past year, two complete sets of surface-water samples have been analyzed for various parameters, which include total dissolved solids, total organic content, phenols, and radio chemicals. These samples were collected during low-flow periods in the fall and high-flow periods in the spring. Each set was collected upstream and downstream of the shale outcrop belt along the Red, Kentucky, and Licking Rivers. These analyses supplement the U. S. Geological Survey North American Stream Quality Accounting Network (NASQUAN) samples, which are collected on a regular interval as part of the Kentucky network. Ground-water samples have also been collected from various wells and springs throughout the shale belt.

The final report is planned to be published in January 1983 as a U. S. Geological Survey Water-Resources Investigation.

IDENTIFICATION OF SELECTED FRESH-WATER AQUIFERS

CORDIVIOLA, Steven, TOWNSEND, Margaret A., WRIGHT, Terry, HOLLADAY, Robert, WAYMIRE, Kelly, and COUCH, David

The purpose of this study is to identify and delineate ground-water aquifers in Kentucky presently supplying or having the potential to supply potable water. The Federal or State Underground Injection Control Program will protect these aquifers from possible contamination resulting from injection of liquid wastes underground.

The part of the project funded by the Kentucky Department for Natural Resources and Environmental Protection, Division of Water, is completed. The final report was presented to that agency

in August 1981.

Additional money was granted by the U. S. Environmental Protection Agency in 1981 to extend the project and to include an inventory of injection wells in Kentucky. Records on file at various State and local agencies were searched for data on oil and gas secondary recovery injection wells. This part of the project was completed in fall 1981.

Guidelines set forth by the U. S. Environmental Protection Agency set a minimum of 10,000 parts per million total dissolved solids concentration in ground water as the criteria for protecting aquifers. In Kentucky, very little is known about ground water having total dissolved solids concentrations within the indicated range, as most of the potable water presently being used is well below this figure.

Drillers' logs, brine analyses, and various indirect techniques, which include the use of geophysical logs, are being utilized to delineate salt-water zones on a county-by-county basis.

As of June 30, 1982, the project was completed and the final report is being prepared for submittal to the U. S. Environmental Protection Agency. The final products consist of multicounty cross sections, maps, and reports. These products will enable the Federal or State agency in charge of the program to make sound judgments on any requests for permits to inject liquid wastes underground.

HYDROGEOLOGY OF THE EASTERN KENTUCKY COAL FIELD

DINGER, James S., LAWRENCE, Fred, KIPP, James, MORFORD, Edwin A., and HAYES, Douglas

The objectives of this program are to provide baseline geologic and hydrogeologic information about ground water in the Eastern Kentucky Coal Field and to assess the effects of surface mining on ground-water quality and quantity. Information gained from this project will add to the understanding of the ground-water system throughout the Eastern Kentucky Coal Field and aid regulatory agencies and the mining industry in developing reliable ground-water monitoring programs.

A network of approximately 10 permanent ground-water observation sites will be established in the 1,100-square-mile drainage basin of the North Fork of the Kentucky River, upstream of Jackson, Kentucky. Rather than individual wells, each site will consist of a series of observation wells drilled to various depths. These observation wells will provide long-term information necessary to

assess the existence of a regional aquifer system and define its hydrologic response.

Within the larger watershed, several first- or second-order watersheds will be selected for detailed study. These smaller drainages include a pristine watershed in which no mining will occur during the term of the project, a watershed in which some part will be mined and reclaimed during the project, a watershed on which mining and reclamation have occurred, and a watershed on which mining has occurred but on which there has been no reclamation. Approximately 40 borings will be drilled for the detailed studies. Hydrogeologic, stratigraphic, and water-quality information will be collected and compiled.

A conceptual model of the hydrogeology of the coal field will be developed. Products of this project will include reports and maps that will be useful in preparing pre-mining, mining, and post-mining plans and in assessing environmental impacts resulting from surface and deep mining of coal.

Observation borings utilizing continuous coring have been drilled at Jackson and at two sites in the vicinity of Hazard. The cores were utilized for hydrogeologic and stratigraphic information, and geophysical logs were run on the holes. Several ground-water monitoring wells have also been drilled at these sites. Monitoring wells have also been completed in a first-order watershed in which surface mining has recently commenced, and several ground-water quality samples have been collected.

This project began in January 1980 and was scheduled for completion in January 1985 under precarious funding from the Water Resources Division of the U. S. Geological Survey. However, a severe reduction in funding occurred in 1982 and other funds are being sought to continue work through 1985.

GROUND-WATER RESOURCES OF THE MISSISSIPPIAN PLATEAU

KIEFER, John D., TOWNSEND, Margaret A., COUCH, David, WRIGHT, Terry, RAST, Diana, HOLLADAY, Robert, and WAYMIRE, Kelly

The purpose of this Kentucky Geological Survey-U. S. Geological Survey cooperative investigation is to provide information on water levels, directions of ground-water movement, and ground-water quality to aid in locating additional ground-water supplies and to guide planning agencies in making decisions regarding the conflicting uses of karst regions.

Major objectives are: (1) to construct maps of the potentiometric

surface to show the general direction of ground-water movement, (2) to provide drillers, planners, and users with information on the Mississippian aquifers, (3) to gain a better understanding of the areas of recharge and discharge, and (4) to provide a data base for future studies. The project was recently redesigned to place more emphasis on water-quality aspects, particularly in the area of trace elements.

The project area coincides with the area of outcrop of Mississippian-age rocks in central and western Kentucky. Currently, the final phase of field work is underway. The study area for this phase of field work is underway. The study area for this phase consists of 20 topographic quadrangles in south-central Kentucky. Field work will be completed by October 1, 1982. The final report on the area will be completed in 1983.

The first report resulting from this project, U. S. Geological Survey Water Resources Investigation 78-25, "Potentiometric Surface of the Mississippian Aquifer in Parts of Trigg, Lyon, Caldwell, and Christian Counties, Mississippian Plateau Region, Kentucky," by R. O. Plebuch, has been published. A report covering Meade and parts of Breckinridge and Hardin Counties and a report covering parts of Hardin, Larue, Hart, Grayson, and Green Counties are in review.

Other Research

CONTRIBUTION TO U. S. GEOLOGICAL SURVEY PROFESSIONAL PAPER, "THE GEOLOGY OF KENTUCKY—A TEXT TO ACCOMPANY THE GEOLOGIC MAP OF KENTUCKY"

McGRAIN, Preston

The U. S. Geological Survey is preparing a report on the recently published "Geologic Map of Kentucky" that will present background and descriptive material that may be of use in reading and interpreting the map. This report, which is based largely on information obtained during the cooperative U. S. Geological Survey-Kentucky Geological Survey mapping program, describes the method of compilation, provides lithologic descriptions of the map units, and includes brief discussions of the structural and economic geology, stratigraphy, and physiography of the State. The Kentucky Geological Survey is participating in this project by contributing a chapter on the economic geology of Kentucky.

The report, which has been designated Professional Paper 1151, will be edited and published by the U. S. Geological Survey. It will be prepared, for the most part, by geologists who were assigned to the cooperative mapping project and who have first-hand familiarity with the rocks.

ECONOMIC GEOLOGY OF ROWAN COUNTY, KENTUCKY

McGRAIN, Preston, and NOGER, Martin C.

Geologic resources, broadly interpreted as land, minerals, and water, are important in the economic growth and development of Rowan County. Building stones, ceramic raw materials, coal, limestone, oil and gas, oil shale, sand and gravel, and water are potential resources. Geologic and mineral resource maps, compiled from previous investigations and original field work, are included in a recently completed report and provide an overview of the economic geology of the county.

Geologic conditions and processes are present in Rowan County that have environmental implications that may affect humanity and the management of geological resources. The competition for land for housing and plant-site development, highway networks, and recreational areas might encourage expansion into areas with potentially unstable ground conditions or the elimination of potential resource sites. Data included in this report should assist those responsible for such land-use decisions.

The rugged, rock-capped hills and the picturesque knobs are also important geological resources of the region. The combination of these natural scenic features and the recently man-made Cave Run Lake on Licking River offer many opportunities for the growth of the tourist-trade industry in Rowan County.

A well-illustrated text with accompanying geologic and mineral-resource maps is being processed for publication.

THE GEOLOGIC STORY OF KENTUCKY

McGRAIN, Preston

In 1981 the Kentucky Nature Preserves Commission undertook a project to compile a comprehensive book on Kentucky's natural environment and history. It was to be a multi-authored volume, written by authorities on the wildlife, plants, forests, soil, water, history, and geology of the Commonwealth. The Kentucky Geological Survey was requested to contribute a section on the geology of Kentucky and assist with the preparation of maps for other chapters.

The Kentucky Nature Preserves Commission abandoned the project early in 1982 because of budgetary and personnel considerations. Materials prepared by the Kentucky Geological Survey were returned and are being restructured for publication by the Survey as a semitechnical overview of the geology of the Commonwealth. The report will be profusely illustrated, with photographs, maps, and charts being an important part of the story. The booklet should be of interest to those travelling in Kentucky, and find use for both casual enjoyment in the home and as a supplement for courses in natural history.

A manuscript is scheduled to be submitted for editorial processing during the 1982-83 fiscal year.

KENTUCKY CARTOGRAPHIC INVENTORY

McHAFFIE, Patrick H.

The purpose of this project is to locate and catalog all existing cartographic materials in the Commonwealth of Kentucky that can be made available for public use. These materials include aerial photography, maps, charts, and other cartographic products. The search for data is being conducted at State, regional, and local levels, and both public and private sources are being contacted. As cartographic materials are located, they are cataloged and added to the National data system.

Funding for this project, which began in September 1981, is

through a cooperative agreement between the Kentucky Geological Survey and the U. S. Geological Survey. At present, three researchers, in addition to the principal investigator, are working part-time on the inventory. Through June 30, 1982, more than 1,300 maps and 140 aerial-photography projects in Kentucky had been cataloged and added to the National Cartographic Information Center data system.

GEOLOGIC STUDIES OF THE FAULTS AND TERRACES OF CENTRAL AND WESTERN KENTUCKY

SERGEANT, Richard A., and DUGAN, Thomas E.

This is a field-oriented research project sponsored by the Nuclear Regulatory Commission to determine recent movement along the Kentucky River and Rough Creek Fault Systems. The first year has consisted of examining in detail the relationship between selected bedrock faults in the Kentucky River Fault System and the late Tertiary-Quaternary terrace deposits that overlie them. Aerial photographs and field reconnaissance were used to identify terraces that were juxtaposed to surface faults. When such fault-terrace relationships were identified, they were field mapped in detail, and extensive shallow seismic and resistivity surveys were carried out. Upon completion of these surveys a series of holes were augered through the terrace deposits to bedrock. Auger hole sites were located across projected fault traces and augered terrace deposits were carefully examined for stratum offset. Additionally, efforts were made to collect materials (woody or carbonaceous) from these terraces suitable for carbon-14 age dates.

Suitable sites were selected in the southern part of the Winchester Quadrangle, and more than 60 holes were augered.

COOPERATIVE PROGRAMS

Geologic Mapping

New Geologic Map of Kentucky

The new "Geologic Map of Kentucky" at a scale of 1:250,000 was released by the U. S. Geological Survey in late 1981. This map, compiled from 1:24,000-scale geologic quadrangle maps, resulted from the cooperative geologic mapping program between the Kentucky Geological Survey and the U. S. Geological Survey. Under this program, which was completed in 1978 and represents a significant joint effort between State and Federal agencies, 707 maps were prepared to show in detail the geology of the entire Commonwealth. The new maps, produced by synthesizing and generalizing these detailed maps, make it possible to comprehend the overall distribution of geologic units in the State and to delineate major structural trends and other features that are difficult to see on the larger-scale quadrangle maps.

The "Geologic Map of Kentucky" is designed as a wall map and printed in color on three sheets; 1 inch on the map equals 4 miles on the ground. It is accompanied by numerous columnar sections, stratigraphic diagrams, correlation charts, and structure sections. Copies of the map may be purchased from the Survey's publication sales office.

Topographic Mapping

The Kentucky Geological Survey has an ongoing cooperative program with the U. S. Geological Survey for topographic map revision in Kentucky. This program, which is designed to maintain revised and up-to-date maps for all areas of the Commonwealth, has been active since Kentucky became the first major state to be entirely mapped topographically at a scale of 1:24,000, more than 20 years ago.

During 1981-82 fiscal year, 40 7.5-minute quadrangles were revised. Of this total, 25 maps were limited revisions, which involve recontouring in areas where there have been changes in the topography. The remaining 14 maps were photorevisions on which changes are shown in a purple overprint on the original map; these changes are compiled from aerial photographs and are not field checked. Additional orthophotoquads, which are corrected aerial photographs overprinted with minimum geographic infor-

mation in standard 7.5-minute quadrangle format, were made available for parts of eastern Kentucky.

The sector revision program, initiated in fiscal year 1980-81, has been progressing well in Kentucky. This program allows photoin-spection and revision of areas where change has taken place on a recurring, 5-year cycle. As of June 30, 1982, new aerial photography had been acquired for nearly half of Kentucky, and contracts had been let to photograph the remainder of the State.

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

National Cartographic Information Center

In March 1980 the Kentucky Geological Survey became the State affiliate of the National Cartographic Information Center (NCIC). NCIC was established by the U. S. Geological Survey in 1974 as the national repository for information regarding maps, charts, aerial photography, space imagery, digital map data, and geodetic control. Its mission is to organize cartographic data of national significance into a usable information system while the data themselves remain with the original holder.

During 1981-82 fiscal year, the Kentucky Geological Survey affiliate office of the National Cartographic Information Center recorded a marked increase in the number of information requests. A total of 1,436 individual inquiries were processed by KGS-NCIC during the year, an increase of more than 70 percent over the previous year.

In September 1981, the Kentucky Geological Survey entered into a cooperative agreement with the U. S. Geological Survey to prepare an inventory of cartographic materials available in the State of Kentucky. This project is described under "Other Research."

Work was begun on a "Linear Features Map of Kentucky." Compilation of this map involves the identification of lineaments on Landsat imagery and the transfer of these features to 1 degree by 2 degree bases. When completed, the "Linear Features Map of Kentucky" will consist of 10 separate sheets at a scale of 1:250,000. Two sheets, Corbin and Johnson City, have already been finished and placed on open file along with a brief explanatory text. Work is currently underway on the Jenkins sheet.

In May 1982 the KGS-NCIC office moved to 147 Washington Avenue.

Water Resources

The cornerstone of the Kentucky Geological Survey Water Resources Program is our cooperative agreement with the U. S. Geological Survey Water Resources Division. Water-related cooperative programs with the U. S. Geological Survey date back to as early as 1920. The cooperative programs have covered a wide range of needs on both Federal and State levels and have provided data for more than 200 maps, publications, and open-file reports, most of which are currently available from the Kentucky Geological Survey. These data provide the basis for answering several hundred requests annually from individuals, industry, and State and Federal agencies. Most of the current information is summarized in an annual report, "Water Resources Data for Kentucky," published yearly by the U. S. Geological Survey. This report combines streamflow data, water-quality data for surface and ground water, and ground-water-level data from the basic network of observation wells, which is funded under the cooperative agreement. Additional information on ground water can be found in the 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 ever to evolve from the cooperative program is a 963-page document entitled, "A Compilation of Ground Water Quality Data for Kentucky." Published in 1980, it lists all ground-water data for Kentucky, including chemical analyses, in the files of the U. S. Geological Survey through 1979. All of the publications noted above are available from the Kentucky Geological Survey, Publication Sales Division.

The present cooperative program for water resources calls for a total funding of about \$900,000. Following are brief descriptions of individual projects funded under the 1982 cooperative agreement.

1. *Surface-Water Stations*—A Statewide network to collect 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 publication, "Water Resources Data for Kentucky."

2. *Ground-Water Stations*—The purpose of this Statewide network is to collect water-level data for a long-term base that will allow data collected for more site-specific projects to be compared against the baseline data. This information can also be used to predict future conditions, to detect and define pollution and supply problems, and to manage ground-water resources. The program has been continuous since 1943. The entire network is currently undergoing a detailed review for the purpose of initiating the changes necessary to make this network more relevant to today's needs.

Prior to 1975, ground-water levels and artesian pressures in observation wells in Kentucky were reported in the 5-year U. S. Geological Survey Water-Supply Paper series, "Ground-Water Levels in the United States, Southeastern States." Records since 1975 are found in the U. S. Geological Survey annual publication, "Water Resources Data for Kentucky." A summary of ground-water data through 1979 can be found in "A Compilation of Ground Water Quality Data for Kentucky."

3. *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 1964-1974, 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."

4. *Ground-Water Resources of the Mississippian Plateau Area*—This project is designed to provide detailed information on water levels, directions of ground-water movement and ground-water quality in order to aid in locating additional ground-water supplies and to guide planning decisions regarding the conflicting uses of karst regions. This project has been reoriented to some extent in order to place more emphasis on the aspect of ground-water quality, particularly in the area of trace elements. The project area coincides with the area of outcrop of Mississippian-age rocks in

central and western Kentucky. The first report resulting from this project, U. S. Geological Survey Water-Resources Investigation 78-25, by R. O. Plebuch, was published in 1980 and encompasses most of Trigg County and parts of Lyon, Caldwell, and Christian Counties. Similar reports covering Meade and parts of Breckinridge and Hardin Counties and a report covering parts of Hardin, Larue, Hart, Grayson, and Green Counties are being prepared. A comprehensive final report covering the entire Mississippian Plateau region is scheduled for completion in the summer of 1983.

5. *Water from Coal Mines in Johnson and Martin Counties*—The purpose of this project is to provide some preliminary data on the quantity and quality of water that may be available from abandoned coal mines in eastern Kentucky. This information can be useful in planning for future public and industrial water supplies. It is hoped that water in these abandoned mines can, at a minimum, provide reliable auxiliary water supplies in times of drought or other water emergencies. A summary report for this project was published in June 1982. It is hoped that it will serve as the basis for an expanded study of water from coal mines in the future.

6. *Statewide Flood Studies*—Formerly designated as "Hydraulics of Bridge Sites," this project has been continuous since 1939. Information on hydraulic factors at bridge sites is provided to assure that adequate information is available for proper bridge design.

7. *Sediment Characteristics of Kentucky Streams*—The purpose of this study, begun in 1977, is to define sediment yields and particle-size distribution of suspended and bed-load material transported by streams draining the major physiographic and land-use areas of the State. Sediment stations are also installed for selected problem drainage areas.

8. *Geohydrology of the Oil Shale Areas of Kentucky*—This project to describe the general hydrology of Kentucky's oil shale areas includes an inventory of ground-water yields from the shale and adjacent units, mechanisms and directions of ground-water flow, and preliminary analyses of both surface- and ground-water quality. The study will concentrate on areas in which initial development of the oil shale is most likely to occur. Field work and water-quality sampling is scheduled for completion during the summer of 1982 and a final report is to be submitted for review early in 1983.

PUBLICATIONS

Publications are the means by which the results of research projects and field investigations of the Kentucky Geological Survey are made available to the public. Making this information readily available is one of the major functions of the Survey as a public geologic research organization. These publications serve as a vehicle for the dissemination of geologic data generated by Survey staff members, members of cooperating agencies, and other earth scientists doing research on 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 at a nominal cost and have received widespread distribution. Distribution of maps and publications is handled through the sales office, which is located in the basement of Breckinridge Hall on the University of Kentucky campus. Total sales for 1981-82 fiscal year amounted to about \$149,000.

During the past fiscal year, the Kentucky Geological Survey issued the following publications:

Bulletin

Bulletin 1. Barite Deposits of Kentucky, by Warren H. Anderson, Robert D. Trace, and Preston McGrain, 56 p., 21 figs., 2 tables, 1 plate.

Barite deposits are known to be present in 23 counties in Kentucky, principally in the Central Kentucky Mineral District and the Western Kentucky Fluorspar District. Field investigations and a literature search indicate the presence of barite at more than 170 outcrops, prospects, and abandoned mines.

Geologically, most of the Kentucky barite deposits are classified as vein or residual deposits. The vein deposits are cavity and breccia fills along faults and joints, commonly in limestone. Residual deposits occur in an unconsolidated clayey residuum formed by weathering of preexisting vein or breccia deposits. Most deposits are mixed ores commonly containing calcite, fluorite, galena, and sphalerite. Host rocks are almost exclusively formations of Ordovician and Mississippian ages.

Barite production in Kentucky has been small, and most has been from residual or "gravel" deposits in weathered material

above fault zones. Since barite is commonly associated with fluorspar and the two minerals have been difficult to separate in milling operations, mixed ores have been bypassed in a number of instances and little quantitative information is available on them. Further evaluation will require additional exploration and, particularly, more core drilling. There were no active barite mines in Kentucky at the time of this investigation.

Information Circulars

Information Circular 5. Quality of Surface Water in Bell County, Kentucky, by Robert B. Cook, Jr., and Reese E. Mallette, 11 p., 1 plate, 2 tables.

Reconnaissance data for surface waters in Bell County, Kentucky, have been gathered in response to the anticipated need for baseline information related to Federal and State surface-mining regulations. Bell County is particularly well suited for such a study due to past and current coal mining, the widespread distribution of mining and diversity of stratigraphic units affected, the diverse array of both disturbed and undisturbed drainage basins, and the relative ease of access within the county.

Estimated flow rate, temperature, pH, conductivity, and concentration of iron, manganese, and suspended solids were determined for flowing waters collected at 71 scattered sites. Sample localities range from major tributaries of the Cumberland River to first-order streams directly draining both mined and undisturbed areas.

The quality of Bell County streams with respect to criteria of Federal and State surface-mining regulations is good. Streams unaffected by mining have an average pH of 7.4, and conductivity is uniformly less than 500 micromhos/cm. Iron, manganese, and suspended solids contents of these streams are low, averaging 0.7, less than 0.1, and 3.0 milligrams per liter, respectively. Streams draining basins affected by surface coal mining show geochemical and sedimentological characteristics within current statute guidelines, with only three exceptions. These exceptions are the North Fork of Straight Creek and its tributaries in the immediate Crockett vicinity, Back Branch at Pruden, and Little Clear Creek in the vicinity of Clear Creek Springs.

Information Circular 6. Trends in the Industrial Minerals Industries in Kentucky, by Preston McGrain, 8 p., 4 figs.

Industrial minerals and their related industries make significant contributions to the economic development of Kentucky. The principal commodities are clay, fluorspar, sand and gravel, and stone. The associated industries are not static and are affected by a variety of conditions.

Information Circular 7. Investigation of Subsurface Tar-Sand Deposits in Western Kentucky, by David A. Williams, Martin C. Noger, and Patrick J. Gooding, 25 p., 3 figs., 2 plates.

Tar sands (also referred to as asphaltic sandstones, heavy-oil deposits, or bitumen-impregnated sandstones) in western Kentucky have been recognized as a potential mineral resource for over 100 years. Past commercial development has been restricted largely to use as paving material. However, because of the ever-expanding demands for energy, these deposits have become the subject of increasing interest as a potential petroleum resource.

Previous studies have provided estimates of the potential resources of shallow mineable tar-sand deposits; these investigations have concentrated on the outcrop areas where tar sands are present at or near the surface. Data on subsurface deposits have been lacking, however, and currently no reports are available which evaluate the potential oil resources associated with the occurrences of deeper tar-sand deposits in western Kentucky.

The Kentucky Geological Survey has initiated a project to inventory and evaluate the oil-resource potential of asphaltic sandstones in the subsurface of western Kentucky.

The purpose of this report is to evaluate the subsurface occurrences of asphaltic sandstones in the Big Clifty Sandstone Member of the Golconda Formation in a portion of the tar-sand area of western Kentucky. This evaluation is based on a compilation of published information and data available in the files of the Kentucky Geological Survey. Acquisition of new data, primarily by core drilling, will be necessary before any reliable estimate of the total volume of this potential oil resource can be attempted.

Report of Investigations

Report of Investigations 1. Overview of Sand and Gravel Resources of Kentucky, by Preston McGrain, 19 p., 16 figs., 1 table.

Sand and gravel represent Kentucky's second-most important source of mineral construction material, being exceeded only by limestone. However, deposits which meet most requirements and

specifications for aggregates are not evenly distributed. This report is an overview of the sand and gravel resources of Kentucky, summarizing data gathered from literature search and personal observations.

Principal production of sand and gravel in Kentucky is concentrated in the channels and valleys of the Ohio and Mississippi Rivers. Approximately two-thirds of Kentucky's current production is derived from floating dredge operations in the Ohio River itself and glacial outwash deposits of Wisconsin age along its valley.

Extensive deposits of fresh-water chert gravels and unconsolidated, fine-grained, quartzose, marine sands are present in the Mississippi Embayment area of western Kentucky, but because of their gradation and lithologic characteristics are used relatively little at this time.

A few small, high-level terrace sand and gravel deposits are present on uplands adjacent to or relatively near some of Kentucky's major waterways. These represent remnants of ancient stream deposits and generally are of small areal extent and variable composition. Consequently, they have limited commercial significance.

Highly weathered or poorly indurated conglomerates and sandstones of Pennsylvanian and Mississippian ages have been exploited locally for miscellaneous construction and industrial purposes when conventional deposits were not available. Poor gradation and deleterious accessory minerals have limited their use.

On the basis of current use, most Kentucky deposits are classified as construction sands and gravels. Some deposits, however, contain a sufficiently high silica content to classify them as industrial sands and gravels; they are used on a limited scale in foundry, metallurgical, and miscellaneous industries.

Reprints

Reprint 9. The Mineral Industry of Kentucky, 1977, by William T. Boyd and Preston McGrain. Reprinted from U. S. Bureau of Mines Minerals Yearbook 1977, 9 p., 1 fig., 6 tables.

The total value of mineral production in Kentucky in 1977 was \$3.2 billion. The coal industry produced a record total of 143.3 million tons valued at more than \$2.9 billion. Between 1972 and 1977 the total value of Kentucky's mineral production almost tripled, largely because of national energy problems and the resultant increases in the unit values of fossil fuels. Eleven mineral com-

modities were produced in 1977, four were fossil fuels and seven were nonmetals or industrial minerals.

Reprint 10. The Mineral Industry of Kentucky, 1978-1979, by Donald K. Harrison and Preston McGrain. Reprinted from U. S. Bureau of Mines Minerals Yearbook 1978-1979, 7 p., 1 fig., 7 tables.

The value of Kentucky's nonfuel mineral production in 1978 and 1979 was \$191.3 million and \$207.9 million, respectively. Stone continued as the leading nonfuel mineral commodity produced, accounting for more than half of the State's total nonfuel value. Other commodities produced during the biennium were cement, clays, fluorspar, sand and gravel, and lime. Small quantities of zinc and lead were produced in 1978 as a byproduct of the fluorspar industry.

Reprint 11. Exploration for Tar Sands in Western Kentucky, by Preston McGrain and Louis R. Ponsetto. Reprinted from Proceedings of the 16th Intersociety Energy Conversion Engineering Conference, v. 2, p. 1208-1211, 1981.

Bitumen-impregnated sandstones are present along the eastern and southeastern rim of the Eastern Interior (Illinois) Basin in western Kentucky. Principal deposits in western Kentucky are found in the Bee Spring and Kyrock Sandstones of Early Pennsylvanian age and the Big Clifty Sandstone of Late Mississippian age. The deposits are lenticular in shape, and erratic in distribution and concentration of bituminous materials.

Development in Kentucky to date has been from surface and near-surface deposits for almost exclusive use as a paving material. Published reserve estimates of western Kentucky deposits indicate more than 450 million metric tons of shallow strippable tar sands having equivalent bitumen content of 35 to 55 liters per metric ton. Unknown to date is the quantity of heavy oils present in these same sandstones where they are buried below surface-mining depths.

Reprint 12. The Mineral Industry of Kentucky, 1980, by Donald K. Harrison and Preston McGrain. Reprinted from U. S. Bureau of Mines Minerals Yearbook 1980, 8 p., 1 fig., 7 tables.

The value of Kentucky's nonfuel mineral production in 1980 was \$204.3 million, down from \$207.9 million in 1979. Output of most construction mineral commodities declined during 1980, primarily

because of high interest rates and a slowdown in construction activity. Although the State's total nonfuel mineral value also decreased, the percentage was lower than output because of increased unit values for most mineral commodities produced. Stone continued to be the leading nonfuel mineral commodity produced, accounting for more than 50 percent of the value. Other commodities included cement, clay, gravel, lime, and sand. Kentucky produced one-fifth of the Nation's ball clay and one-fifth of the lime.

Reprint 13. Geology of Construction Materials in Kentucky, by Preston McGrain. Reprinted from Proceedings of the 18th Forum on Geology of Industrial Minerals: Indiana Geological Survey Occasional Paper 37, 16 p., 8 figs.

Kentucky contains a variety of industrial minerals that are or have been used as construction materials. Principal resources are classified broadly as stone, sand and gravel, and miscellaneous or common clays and shales; these materials have been produced for aggregates, bricks, building stones, mortar sand, portland cement, roofing gravel, drain, floor, and sewer tile, and miscellaneous related industrial purposes. The resources are widely but irregularly distributed in the State and range in age from Ordovician to Quaternary. Deposits of anhydrite and gypsum are present in subsurface rocks of Mississippian age in northwestern Kentucky but commercial thicknesses have yet to be demonstrated.

Special Publication

Special Publication 5. Proceedings of the Technical Sessions, Kentucky Oil and Gas Association Forty-First Annual Meeting, June 15-17, 1977, ed. by Margaret K. Luther, 55 p., 54 figs., 20 tables.

Contains "The Potential of the Knox Dolomite in the Illinois Basin for Petroleum Production," by David L. Stevenson; "A Regional View of the Knox," by Howard R. Schwalb; "Evaluation of Coal Mines and Coal Reserves," by Charles A. Beasley; "Status and Results of ERDA's Devonian Shale Program," by A. E. Hunt and W. K. Overbey, Jr.; "An Overview of Micellar Flooding," by John A. Davis; and "Stratigraphic Geophysics—A Tool for the Future," by Brian E. Ausburn, John R. Butler, Jr., Robert G. Rives, and T. R. Wittick.

Miscellaneous

Annual Report, 1980-1981, 48 p.

Kentucky Geological Survey: A Plan for the Future, 1980-1985, 78 p.

The Kentucky Geological Survey has prepared this report to serve as a guide for planning and coordinating its efforts and to inform others about the Survey's research and service activities. The plan includes not only currently active projects, but also considers projects for which a definite need has been demonstrated and which could be accomplished within the next 5 years if sufficient funds to obtain personnel and facilities become available.

Informing other organizations and individuals of current and proposed research projects should lead to less duplication of effort and result in a considerable saving of time and resources. It should also foster an increased number of cooperative projects involving joint efforts between the Survey and organizations both within Kentucky and outside the State.

This plan is arranged generally by mineral resource and organizational framework within the Survey. Most sections of the report list individual research projects with a discussion of background, goals, implementation, and results. Charts showing the time framework for implementation follow the research projects in each section. The time period covered by this plan is July 1980 through June 1985; cutoff date for information in the report was April 1981. The plan has been designed to provide an established framework for the Survey's research and service activities; however, it will be reviewed periodically in order to remain responsive to the changing needs of the Commonwealth.

List of Publications: November 1981, 52 p.

Middle Chesterian Rocks in the Stevens Hill Cut, Caldwell County, Kentucky, by Robert D. Trace, 1 sheet 7 figs.

Rocks of the Cypress, Golconda, Hardinsburg, Glen Dean, and Tar Springs Formations of middle Chesterian age are exposed in the Stevens Hill cut area along the Western Kentucky Parkway about 4 miles east of the Princeton interchange.

The excellent exposure of these rock units is at a point between the Western Kentucky Fluorspar District and the outcrop to the southeast in south-central Kentucky. These facies changes include

(1) the presence of the Big Clifty Sandstone Member in the Golconda Formation, (2) the upper Golconda 45-foot-thick calcareous and silty shale above an 8-foot-thick limestone unit of the Haney Member of the Golconda Formation, and (3) the abundance of shale and sandstone in the Glen Dean Formation.

Information taken from this cut helped to correct earlier stratigraphic interpretations and geologic mapping of the Cypress, Golconda, and Hardinsburg formations in the nearby Olney, Crider, and Princeton East Quadrangles.

Guidebooks for Geology Field Trips

Coal and Coal-Bearing Rocks of Eastern Kentucky, by James C. Cobb, Donald R. Chesnut, Norman C. Hester, and James C. Hower (Annual Geological Society of America Coal Division Field Trip, November 5-8, 1981), 169 p., 65 figs., 12 tables, 26 plates.

Contains roadlog and invited papers dealing with aspects of coal such as coal resources estimation, geophysical logging, paleontology, hydrogeology, stratigraphic correlation, petrology, mineralogy, geochemistry, and palynology.

Energy Resources of Devonian-Mississippian Shales of Eastern Kentucky, by Wayne A. Pryor, J. Barry Maynard, Paul E. Potter, Roy C. Kepferle, and John Kiefer (Annual Field Conference of the Geological Society of Kentucky, April 9-11, 1981), 44 p., 33 figs., 6 tables.

The Devonian-Mississippian shales of eastern Kentucky are one of the State's valuable energy resources, and today much information is available to help develop their gas, oil, and uranium potential. Most of this information has been generated by the Eastern Gas Shales Project, 1976-1980, administered by the Morgantown Energy Technology Center, U. S. Department of Energy, Morgantown, West Virginia. The Devonian-Mississippian black shales extend throughout most of the central Appalachian Basin.

This meeting has two different but related parts—a seminar to develop a better understanding of the energy resources of the shale and a field trip to directly tie resulting ideas and information to the stratigraphy of the shale sequence. Also included in this guidebook are prior classifications of shales and annotations of recent articles on organic-rich shales. Natural Bridge State Park was chosen as a meeting place because it is close to outcrops that

show most of the facies and units that must be worked with when developing the energy resources of the shale sequence.

The seminar will present a general overview of shales and a summary of the stratigraphy of the Devonian shales in the Appalachian Basin. It will also touch on biostratigraphy and maturation and stress the resource potential of the black shale, including gas, oil, and uranium. Attention will also be given to oil extraction and gas well completion techniques.

Maps

Structure of the New Albany-Chattanooga-Ohio Shale (Devonian and Mississippian) in Kentucky, by Paul E. Potter, Howard R. Schwalb, and Linda P. Fulton. Scale 1:1,000,000.

Satellite Image Map of Kentucky, comp. by Roger B Potts. Scale 1:1,000,000.

In Press or Editing Completed

County Report 2. *Economic Geology of Rowan County, Kentucky*, by Preston McGrain and Martin C. Noger.

Information Circular 8. *Stratigraphic Framework of Coal-Bearing Rocks in the Western Kentucky Coal Field*, by David A. Williams, Allen D. Williamson, and John G. Beard.

Special Publication 6. *Proceedings of the Technical Sessions, Kentucky Oil and Gas Association, Forty-Second Annual Meeting, June 14-16, 1978*, ed. by Margaret K. Luther.

Special Publication 7. *Proceedings of the Technical Sessions, Kentucky Oil and Gas Association, Forty-Third Annual Meeting, June 13-15, 1979*, ed. by Margaret K. Luther.

Thesis Series 2. *Kimberlite of Elliott County, Kentucky*, by Stephen L. Bolivar.

Open-File Material

The Kentucky Geological Survey maintains an open file of re-

ports, maps, manuscripts, theses, and other material including logs of core holes, sample descriptions, and gravity base station networks. Some of this material will eventually be published but has been placed on open file in order to make the data available prior to publication.

The Survey's Oil and Gas Section maintains an open file of oil and gas county base maps. These maps show the locations of all known wells drilled for oil and gas in a county. They are prepared at a scale of 1:48,000 and indicate whether the wells produced oil or gas, have been abandoned, or were completed as dry holes. A well index and columnar stratigraphic section accompany the maps. Base maps for 17 counties are presently available, and work is in progress for 17 counties.

Open-file reports are available for inspection at Survey offices in Breckinridge Hall on the University of Kentucky campus during regular office hours. Copies of reports that consist of page-size material or for which the Survey has reproducible copy are available for purchase. The Kentucky Geological Survey also maintains copies of most open-file reports dealing with Kentucky geology prepared by the U. S. Geological Survey.

PAPERS BY STAFF MEMBERS IN OUTSIDE PUBLICATIONS

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TALKS BY STAFF MEMBERS TO PROFESSIONAL GROUPS

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SERVICES

Well Record Library

The Oil and Gas Section of the Kentucky Geological Survey is the official repository for records of all 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 125,000 wells. Records for approximately 4,000 wells are processed and recorded annually by the Survey.

The Survey is obligated to make all such data and records available and open to the public. Facilities in the Well Record Library for examination of records are used daily by representatives of industry, government, academic institutions, and the general public. An estimated 60,000 records are duplicated annually in reply to mail orders, telephone requests, and walk-in requests.

Sample Library

The Kentucky Geological Survey Well Sample and Core Library is the official repository for well cuttings and core samples of wells drilled in Kentucky. Approximately 400,000 feet of well cuttings are processed, cataloged, and filed annually. At the present time there are cuttings from over 14,000 wells and approximately 600 cores on file in the library.

The objective of the Survey is to selectively provide, wherever possible, a representative set of well cuttings or core samples for every Carter coordinate section (approximately 1 square mile) in the State. Also, the Survey strives to make these samples available to industry, government, academic institutions, and the general professional community by providing adequate space and facilities in the library for sample examination.

Public Information Services

Questions concerning various aspects of Kentucky geology come in to the Survey almost daily. These questions come from land-owners, teachers, businessmen, farmers, students, spelunkers, rock and mineral collectors, persons planning vacations in Kentucky, and many others residing within the Commonwealth and outside the State. Most inquiries are answered by providing leaflets, maps, and pamphlets designed for this purpose, or by recommending available publications and maps that deal with the

topic of interest.

Services include identification of rock, mineral, and fossil specimens and the distribution of rock and mineral sample sets to students. Displays are prepared for conferences, fairs, rock and mineral shows, and other public functions. These exhibits are designed to inform people about the many interrelationships of geology to everyday life and educate them in the use of maps and other geologic publications.

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