



Brutus . . . of Pittsburg and Midway at coal mine in Cherokee County

Activities of

State Geological Survey of Kansas

Biennium ending June 30, 1963

SPECIAL DISTRIBUTION PUBLICATION 5

State Geological Survey The University of Kansas
Lawrence, Kansas December, 1963

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STATE GEOLOGICAL SURVEY OF KANSAS

W. Clarke Wescoe, M.D., Chancellor of The University and ex officio Director of the Survey

Frank C. Foley, Ph.D., State Geologist and Director

William W. Hambleton, Ph.D., Assoc. State Geologist and Assoc. Director

Purpose . . . of State Geological Survey of Kansas



. . . to make as far as possible a complete geological survey of the state of Kansas, giving special attention to any and all natural products of economic importance, in order to determine the character, location, and amount of such products and to prepare reports on the same. . . .

—General Statutes of Kansas, Sections 76-322 to 325

Cover picture . . .

Brutus, one of the world's largest electric shovels, stands about 160 feet high (note man in front of crawler tread). This powerful shovel can remove overburden from coal beds at the rate of 90 cubic yards a bite, making it possible to mine coal at greater depths. Thus, the life of the strip pits of southeastern Kansas is being prolonged, in turn stimulating research on new uses for Kansas coal. During the biennium, 16 coal companies operated mines in Kansas; two—*Pittsburg and Midway Coal Mining Co.* and *Clemens Coal Co.*—each produced more than 200,000 tons of coal annually.

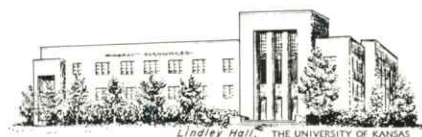
—Photographed by A. L. Hornbaker on first day of shovel's operation, June 6, 1963

Activities of

State Geological Survey of Kansas

Biennium ending June 30, 1963

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Prepared by Grace Muilenburg

SPECIAL DISTRIBUTION PUBLICATION 5

State Geological Survey The University of Kansas
Lawrence, Kansas December, 1963



as of June 30, 1963

Front row . . . **Frank C. Foley**, state geologist and director

William W. Hambleton, associate state geologist and associate director

Second row . . . **Daniel F. Merriam**, head, Division of Stratigraphy and Paleontology

Edwin D. Goebel, head, Division of Oil and Gas

Ada Swineford, head, Division of Petrography and Geochemistry

Third row . . . **W.D. Johnson, Jr.**, head, Division of Mineral Fuels, cooperative U.S. Geological Survey

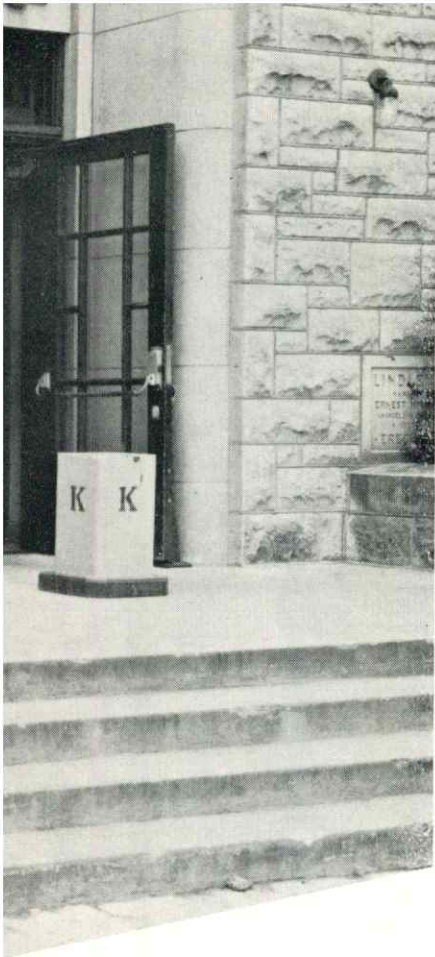
Norman Plummer, head, Division of Ceramics

V. C. Fishel, head, Division of Ground Water, cooperative U.S. Geological Survey

Fourth row . . . **Allison L. Hornbaker**, head, Division of Mineral Resources

Grace Muilenburg, head, Division of Public Information and Education

Not shown . . . **J. M. Jewett**, senior geologist (page 42)



Introduction

An overview of the activities of the State Geological Survey of Kansas for the biennium ending June 30, 1963, reveals: coordinated geologic and mineral-resource studies, developed in relation to associated factors of a changing economy and kept vigorous and up to date by use of modern tools of research, including the electronic computer. One article in this report attempts (1) to analyze the setting for this emphasis on coordinated studies; another (2) to explain the trend toward more sophisticated research. Projects of the Survey's research divisions are listed in tabular form, for ease of identification and to lend support to the articles. Services, noteworthy accomplishments of the staff, and publications issued during the biennium are mentioned in the latter part of the report. Tables on page 4 give the Survey's budget for the two-year period and Survey personnel by official position as of June 30, 1963.

STATE GEOLOGICAL SURVEY FINANCIAL SUMMARY

BIENNium 1961-1963

1961-1962

<i>Expenditures</i>		<i>Sources of income</i>	
Salaries	\$316,775.00	Appropriation	\$546,582.00
Maintenance and equipment	237,048.00	Fees (publication sales, etc.)	13,469.00
Fees carried forward	6,228.00		
Total	\$560,051.00	Total	\$560,051.00
Retirement not included			

Statement of cooperative program

State Survey funds (included in expenditures above)		Matching United States Geological Survey funds	\$210,356.00
Fuels	\$ 8,000.00		
Water resources	114,000.00		
Topographic mapping	82,356.00		
	\$204,356.00		
Other state agency funds	6,000.00		
Total	\$210,356.00	Total	\$210,356.00

1962-1963

<i>Expenditures</i>		<i>Sources of income</i>	
Salaries	\$336,684.00	Appropriation	\$596,764.00
Maintenance and equipment	272,900.00	Fees (publication sales, etc.)	22,741.00
Fees carried forward	9,921.00		
Total	\$619,505.00	Total	\$619,505.00

Statement of cooperative program

State Survey funds (included in expenditures above)		Matching United States Geological Survey funds	\$206,356.00
Fuels	\$ 8,000.00		
Water resources	109,000.00		
Topographic mapping	83,356.00		
	\$200,356.00		
Other state agency funds	6,000.00		
Total	\$206,356.00	Total	\$206,356.00

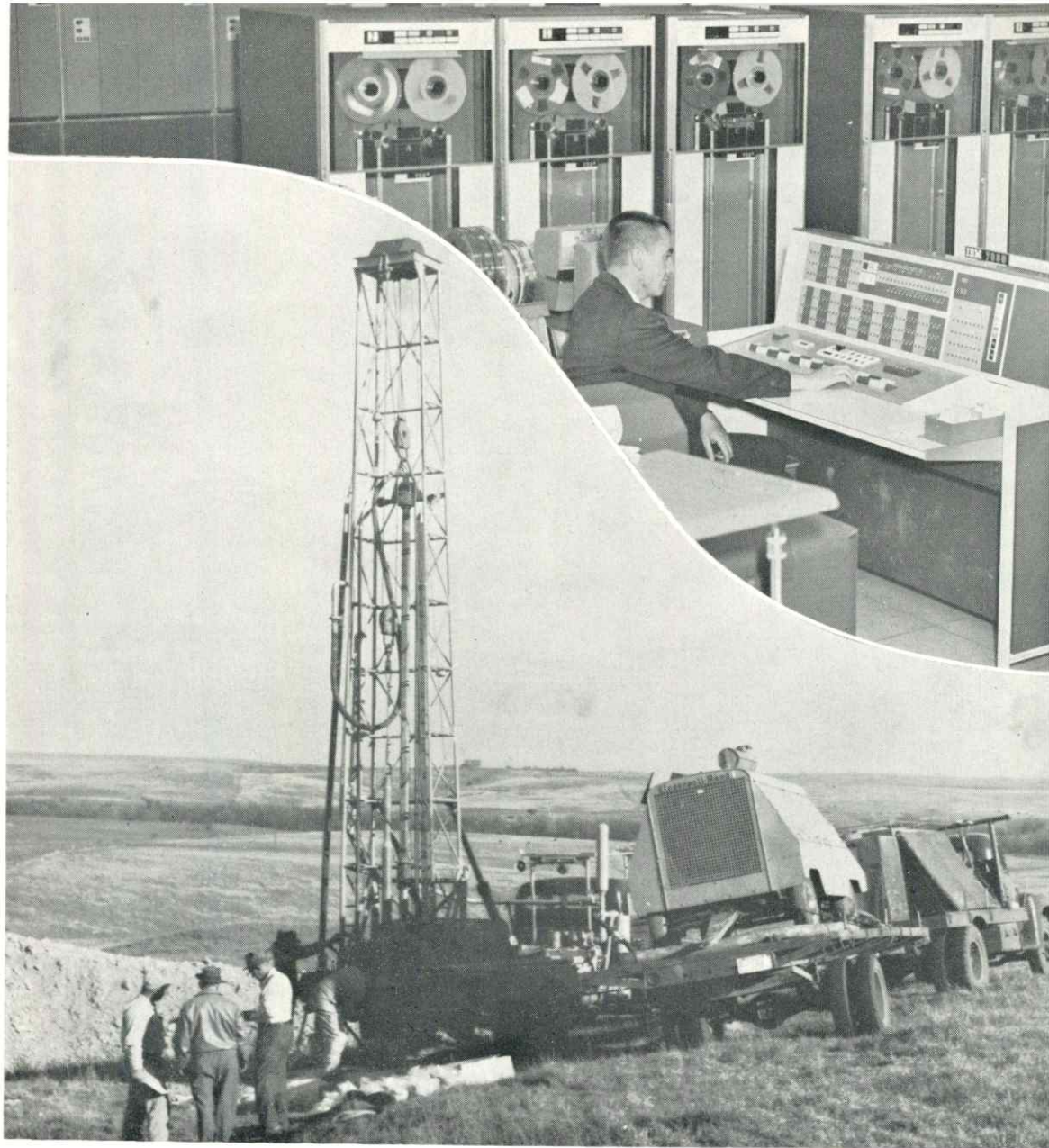
STAFF OF THE STATE GEOLOGICAL SURVEY OF KANSAS

JUNE 30, 1963

	Permanent staff	Cooperative U.S. Geol. Survey	Intermittent (½ time or less)	Total
Geologists	21*	8	16	45
Ceramists	3		1	4
Chemists	3		1	4
Engineers: Ceramic	1†		1	2
Hydraulic		3		3
Petroleum			1	1
Research and technical assistants	6	2	17	25
Draftsmen	6	2	2	10
Secretaries, clerks, editorial assistants	14	2	9	25
Public information and education director	1			1

*Four geologists, whose duties are primarily with the State Geological Survey, taught one or more courses in the Department of Geology during the biennium ending June 30, 1963.

†Also on faculty of Department of Mining and Metallurgical Engineering.



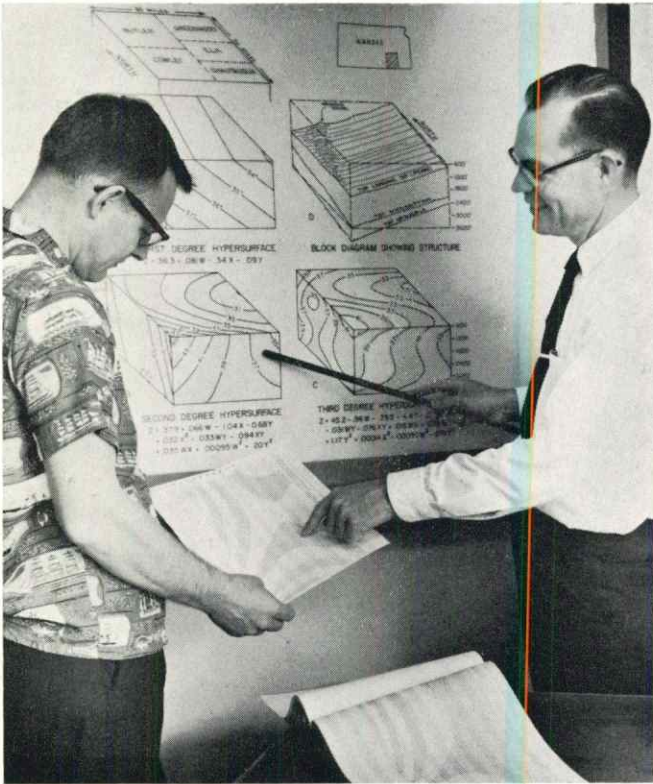
The electronic computer helps solve problems in Kansas geology (page 6).
Collecting shale samples for economic analysis, McPherson County, Kansas.

From Field to Computer

at the Kansas Geological Survey

"Weather permitting, I'll be in the field."

Among geologists, whatever their geologic inclinations and however useful they may find the electronic computer and other modern tools of research, such a pronouncement is as meaningful now as ever. To a Kansas geologist, who covets the Kansas earth as his primary



Computer techniques are being utilized to process and analyze data in studies of the Kansas subsurface. . . . In picture at left Daniel Merriam and Floyd Preston of the Kansas Geological Survey discuss a report on trend surfaces based on a computer study by John Harbaugh (at console of the large computer, Stanford University, in picture on page 5).

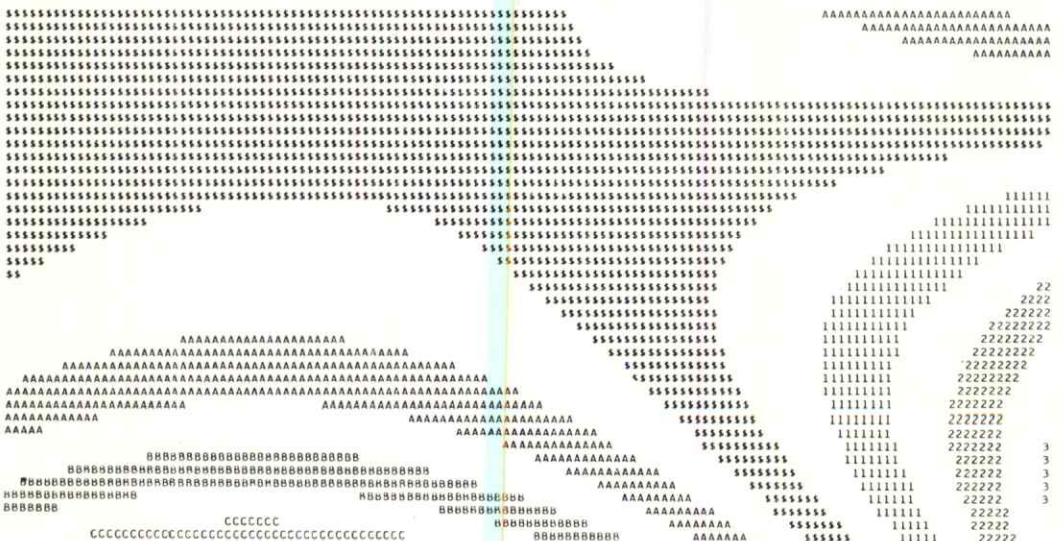
Computer-made map simulating structure on top of Arbuckle rocks in Kansas. . . . One of a series of contour maps, computer-plotted from electric-log data, made in connection with trend-surface studies.

STRUCTURE TOP ARBUCKLE (CAMBRO-ORDOVICIAN) ROCKS IN KANSAS CI = 500 FT

CONTOURS OF LINEAR + QUADRATIC + CURV TREND SURFACE
X VALUE LEFT EDGE OF MAP = -0.0
Y VALUE BOTTOM EDGE OF MAP = 26.2

X VALUE RIGHT EDGE OF MAP = 52.0
REFERENCE CONTOUR VALUE = -2060.0

Y VALUE TOP EDGE OF MAP = 0.0
CONTOUR INTERVAL = 500.0



laboratory, the field may be any place within the state's borders. Rightly so, for it is in this field that he must continue to observe and collect the data he analyzes, interprets, and shares with all Kansans who would know more about the resources so important to their economic well-being.

Kansas geology in the basic sense has been, is, and surely will remain a field science. On the other hand, as we have accumulated more knowledge about the Kansas earth, its study has become more complicated and supporting indoor research more necessary, until today Kansas geology has more facets than it could possibly have had when this state was relatively unpopulated, the resources unexplored, and the rocks unmapped. Even 50 years ago a member of the Kansas Geological Survey understandably could have been an all-around geologist who considered himself well equipped for varied research if he had a geologic hammer, a hand lens, an alidade, a camera, and a microscope. His counterpart of today is apt to be, perhaps forced to be, more specialized and he not only is equipped with the basic tools of the trade but also is familiar with or is able to make use of sophisticated techniques of modern science. Thus, present staff members of the Geological Survey include those who are primarily stratigraphers, structural geologists, or subsurface geologists; others who are petroleum geologists, engineering geologists, ceramists, or economic geologists; and still others who are mineralogists or petrographers; ground-water geologists or hydrologists; geochemists or geophysicists. Research is diversified and much of it has been refined by the use of the x-ray diffraction unit, the electron microscope, modern tools of geophysics, and other advanced precision instruments.

In the midst of but with no minimization of such geologic advances, specializations, and sophistications, a frustration seems evident among geologists who must spend a high percentage of their research time searching through files and yet more files of accumulated data in order to select that which is pertinent to their immediate projects. In this conscious effort to find speedier and more efficient ways to handle and process data, it is probably inevitable that attention should turn to the electronic computer. It is further natural that the very attempt to understand computer operation and programming should generate increased interest in computer-oriented geology and provoke many questions, centered around an encompassing query, "To what extent can computer techniques be applied effectively and justifiably in the various divisions of geologic research?"

What subsurface data, from Kansas exploratory wells for example, have sufficient re-use value or other justification to be converted into language for machine storage-retrieval and processing? What are the limitations and the potential of computers in handling interpretative data? Is the Kansas geophysicist or other research geologist, confronted with a mass of statistical data so full of unknowns that it would take years to evaluate all of them manually, justified in looking to the high-speed electronic computer for relief? What are the advantages of

computer techniques in classifying fossil assemblages, rocks, and stratigraphic units? How can the computer aid in evaluating stratigraphic relationships, in analyzing periodic phenomena?

The frequency with which questions similar to these are being asked is bringing computer technology generally into focus for the geologist. That computer technology is relatively new in geological applications, that the avenues toward effective use of the computer in geological study are not altogether clear, and that the problems to be surmounted in programming geologic data for computer processing are either still unknown or far from being solved do not alter the statement that the computer era for progressive geology is here. It is with this awareness that members of the State Geological Survey of Kansas are becoming acquainted with computer operations, techniques, and applications. Many of them are participating in short courses designed for this purpose; a few have enrolled or plan to enroll in advanced courses in computer technology and have become familiar with the digital computer and associated equipment in The University of Kansas Computation Center. In seeming corroboration of this interest, facilities at this computation center are being extended. In addition to a more powerful digital computer than the present model, the center eventually also will house an analog computer—to aid scientists in understanding specific situations, for example underground reservoir conditions, by applying electric impulses to reconstructions of the situations—and equipment for converting analog data into numerical language acceptable to the digital computer. Plans for a computer-applications laboratory in Geological Survey space as a supporting facility seem not unreasonable.

Sometimes referred to as a stupid assistant who understands only yes and no, do and don't, and questions not the validity of any data submitted for processing, the electronic digital computer nonetheless has become a symbol of automation in business and industry, and more recently in scientific disciplines, including geology. Its unwavering stubbornness in following instructions to perform logical operations on data presented to it, its split-second timing in performing such operations, its ability to compare simultaneously data from two to fifty or more data sources, and its fantastic memory are summarily the characteristics that have assured the machine's acceptance and success. A comforting observation for the geologist or other research person inclined to worry about his replacement by the electronic device is that only a human being can have an intelligent feeling about the data to be processed—only he can decide on the worth and form of the input information and on the disposition of the output information. On the other hand, by replacing manual operations in which drudgery and the element of human error are manifest, computer computation can permit more research and can extend the possibilities of research.

Computer requirements understandably differ from scientific field to scientific field, and we know more about requirements in some fields than in others. Work done in university geology departments

Jesse M. McNellis, of the Cooperative Ground-Water Division of the Kansas and U.S. Geological Surveys, punches data on cards for the digital computer to use in solving a problem in ground-water geology and hydrology in a western Kansas area. Computer processing, extremely rapid and accurate, permits solution of problems of greater complexity than previously could be considered; computer applications in Kansas ground-water studies will increase manifold in the next few years.



and in industry, especially the oil industry, however, has been sufficient to give direction to the use of computer techniques in geology. A geologist from Stanford University who has devoted much time to computer-oriented geologic research is a member of the summer staff of the State Geological Survey of Kansas, and in this capacity he is working with Geological Survey personnel on computer studies involving Kansas geology.

Several computer experiments involving programs for plotting subsurface data have been initiated at the Kansas Geological Survey through a cooperative arrangement with Stanford University. Trend-surface analysis, one such project, is concerned with methods for detecting systematic changes in data arrayed in two- or three-dimensional space; graphs and maps produced directly in the process may show for example trends in geologic structure or distribution of crude-oil gravity information. Another project involving structural procedures adapted to geology is identified as Fourier analysis of electric logs of oil wells; the major objective is to achieve a means for quantitative, as opposed to subjective, evaluation of stratigraphic relationships. Assistance in developing this project has come from members of The University of Kansas Department of Chemical and Petroleum Engineering who are engaged in computer-oriented power-spectrum analysis.

A new dimension has been added to cooperative ground-water investigations in Kansas through a computer program developed for use in analyzing pumping-test data to determine water yields of aquifers, or ground-water reservoirs. Through computer programs being developed it will be possible to determine and predict characteristics of well fields and regional aquifers and to make statistical determinations of reliable hydrologic parameters. Both digital- and analog-computer

techniques are to be used in the continuing study of the state's ground-water conditions, which must be under constant scrutiny especially in areas that depend on well water for a sustained economy—as in parts of western Kansas where irrigation by ground water is largely responsible for agricultural enterprise.

The computer technique is being used in classifying fossils, and headway is being made in setting up computer information systems in several areas of geology. Getting many types of geologic information key-punched on data cards, or where storage problems are especially critical onto magnetic tapes, in computer language, is of course one of the major concerns at this initial stage of computer studies at the Kansas Geological Survey. A foreseeable objective is to have all well-log information that could have multiple re-use and reference value coded in machine language for quick sorting and instant computer retrieval. This is seen as a logical adaptation to the computer revolution now evident in the mineral industries, notably the oil industry, and as an extension of the Survey's library service to its public. Eventually, many types of mineralogical data, chemical data, and other mineral-resource data worth filing for continued reference may be coded and programmed for computer information systems. Pertinent data thus readily available should permit significant research on interrelationships of various rock parameters and large-scale evaluation of reservoirs, not to mention automatic plotting of well data and contouring of maps.

Still the geologist will be needed, the geologist along with all the modern techniques he has devised or appropriated or will devise or appropriate to help him solve his problems. Commonplace now is the use of x-ray diffraction, electron microscopy, differential thermal analysis, and many comparable advanced scientific aids. In the area of geophysics, mantle-depth determinations are being made by use of Rayleigh and Love wave dispersion. The fact is, the usefulness of such sophisticated techniques will become more important as the use of the computer becomes more routine and understandable.

However involved the study of Kansas geology becomes, we of the Kansas Geological Survey feel that there must be more conversation, not less, with the Kansas earth. We therefore never intend to set aside our maxim, "Go first into the field, to observe, to collect your data." The techniques of the indoor laboratory are a part of our coordinated effort to interpret and understand what has been seen or what exists in the field. Simple analytical procedures once were enough perhaps to give the proper perspective to field determinations, but in the age of specialization, many complications tend to defy adequate communication even in one's own field of knowledge. Yet, to remain knowledgeable and productive, activities must be interrelated. This requires use of refined tools of research, of which the electronic computer is one of the most recent developments, certainly one of the most versatile and encompassing, and ultimately one that will be necessary for conversation not only within disciplines but among disciplines.

Hence, our subsurface geologists, paleontologists, mineralogists, petrographers, economic geologists, geochemists, geophysicists, ceramists, petroleum geologists, stratigraphers, ground-water geologists, and mineral economists are learning their lessons in computer technology, beginning with the sorting and coding of geologic data. Many are anticipating the day they will have more time for research simply because working data can be obtained routinely in a matter of minutes and further because many time-consuming manual operations can be replaced by computer problem solving and data interpretation.

Considering many variable factors and problems—from computer requirements for reliable processing of different types of geologic data to the complications of recording and performing program techniques, including programming to eliminate instruction errors—this day is not immediate, but it is coming. Also coming is the time that programmed geologic information can be exchanged readily by wire service from one laboratory to another, from one region to another. This emphasizes a present need for close cooperation and adequate communication among groups having similar responsibilities and objectives, in order to consolidate and coordinate activities and otherwise to avoid expensive duplication of effort. Development of a library of programmed material adaptable for geologic use, already in evidence, will help bring geology into a computer-oriented environment. When we have achieved many of these objectives, and when computer library systems featuring coded bibliographies make possible instant recall of all information on a particular subject—when this day comes, then the day of geologic research by computer will have arrived. The Kansas Geological Survey expects to be prepared for that day.

Margaret Oros, of the Oil and Gas Division, examines a computer-made thickness map of subsurface rocks in the Lost Springs oil field, Marion County, Kansas.

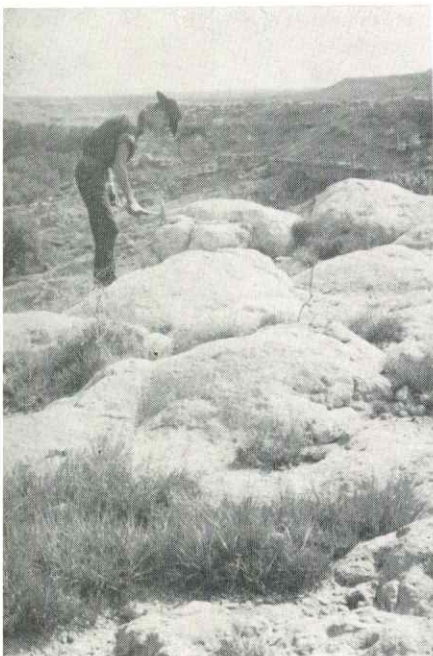


ACTIVITIES . . . *Basic Geology*

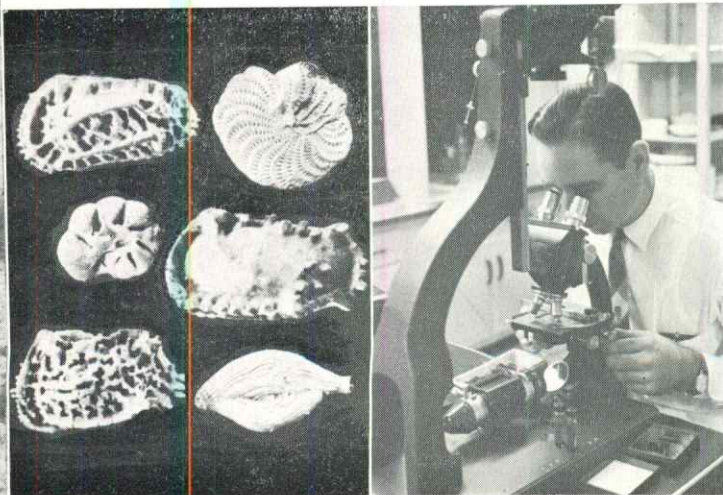
Stratigraphy and Paleontology
Divisions of . . . Petrography and Geochemistry
Geophysics

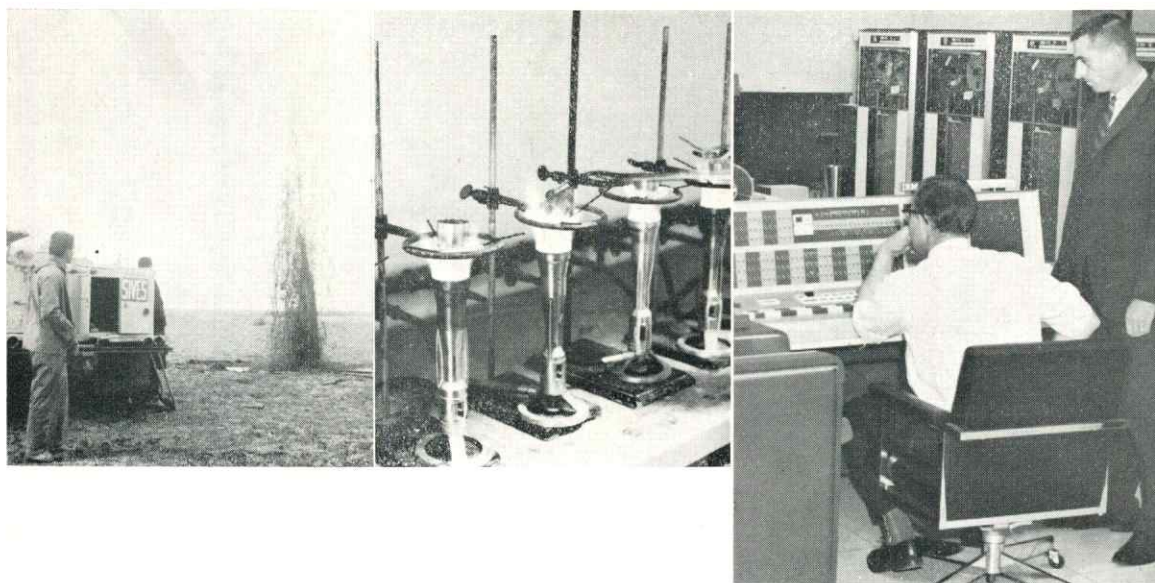
Research in basic geology shapes activities of all divisions of the Kansas Geological Survey. This is so because working data derive from results of studies on the origin, classification, distribution, and sequence of Kansas rock strata (stratigraphy); on fossils and fossil assemblages, their succession and significance in the rock column (paleontology); on the identification and description of the rocks and their contained minerals (petrography); on the chemical composition of the rocks (geochemistry); and on the physics of the earth (geophysics). Studies to obtain basic geologic data have many ramifications, may borrow from the knowledge and techniques of other sciences, and may be developed independently or simultaneously with and as a part of applied research on Kansas mineral resources.

In seven decades, geologic investigations adhering to this pattern have yielded an abundance of data on the geology and mineral resources of Kansas. Unfortunately, many of these data are obscured in many publications, it is not always clear what research results have been superseded by later research, and much information simply is not readily available. Obviously, consolidation of geologic information would be an advantage, considering especially the complexity of today's economy, technology, and the interrelation of all activities involving the Kansas earth. Hence, during the biennium ending June 30, 1963, a conscious effort was made to orient the research program of the Kansas Geological Survey toward a major objective: to bring together all possible knowledge on Kansas rocks, including mineral resources (page 27), and to initiate projects to fill in gaps so that summary studies may be as nearly complete as possible. These summary studies are being formulated according to major rock units, the geologic systems, shown on the generalized geologic map and cross section, page 15.



Photographs of fossils (ostracodes and foraminifers, magnified many times) courtesy Richard Benson, curator, Museum of Invertebrate Paleontology, The University of Kansas.



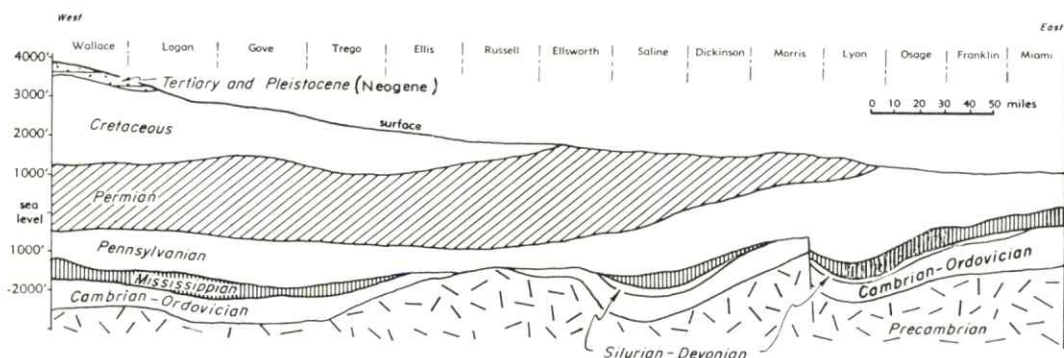
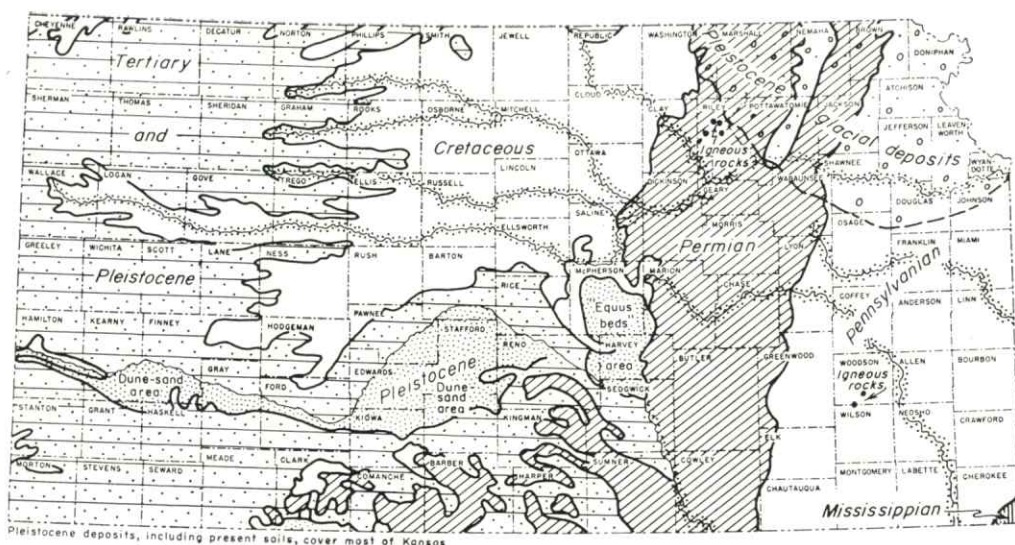


PROJECTS IN BASIC GEOLOGY

BIENNium ENDING JUNE 30, 1963

Project category	Description	Status, June 30, 1963
<i>General</i>		
Geologic map of Kansas	. . . Outcropping rock formations; 10 colors; . . . Ready for printer scale, 1:500,000 (1 inch equals 8 miles); will supersede 1937 edition	
Kansas rock column	. . . Classification and description of Kansas . . . In progress rocks; bulletin and wall chart; to supersede Bull. 89 (1951) and graphic column (1959)	
Geologic history of Kansas	. . . Comprehensive work; subsurface and areal . . . In press (Bull. 162) geology	
	. . . Geologic making of Kansas	. . . Article published (page 44)
	. . . Concept of time in stratigraphic classification	" "
<i>Special studies</i>		
Computer-oriented studies	. . . Statistical subsurface mapping projects . . . In progress	
	. . . Trend-surface analyses	" "
	. . . Trend-surface residuals	" "
	. . . Fourier analysis of electric logs of oil wells	" "
Igneous rocks in Kansas	. . . Mineralogic and petrographic descriptions . . . In progress	
	. . . Riley Co. localities	" "
	. . . Silver City-Rose Dome area, Wilson-Woodson Cos. (cooperative with mineral fuels, page 32)	" "
Techniques	. . . Acetate-peel techniques (micro- and macro-) . . . In progress	
	. . . Clay beneficiation (ceramic application, page 28)	" "
	. . . Fractures; use of fracture patterns in studying subsurface rocks	" "
	. . . Oil gravity variation; relative to geologic parameters	" "
	. . . Sandstone structures (internal; rhythmic layering)	" "
	. . . Thin sections of Precambrian rocks	. . . File being developed
	. . . Versene studies (geochemistry)	. . . In progress
	. . . Preliminary report (cooperative with oil and gas program, page 28)	. . . Report completed
	. . . Etches for acetate peels	. . . In progress
	. . . Effects on clay minerals; alteration of x-ray patterns, chemical composition	" "
	. . . X-ray diffraction techniques (clay mineralogy)	. . . Article being prepared

Project category	Description	Status, June 30, 1963
<i>Areal geology, geographic unit</i>		
Anderson Co.	. . . Stratigraphy emphasized; paleontology, petrography, economic geology included; accompanied by geologic maps	. . . Franklin Co.: Bull. 163 (page 43). Other studies in progress
Clark "		
Crawford "		
Franklin "		
(Areal geologic mapping in conjunction with cooperative ground-water investigations, page 32; projects of cooperative mineral-fuels program, page 32)		
<i>Summary stratigraphic studies and associated studies in paleontology, petrography, and geochemistry (Coordinated with projects listed under general, areal geology, and subsurface)</i>		
Neogene System	. . . Ice push in northeastern Kansas	. . . Report written
	. . . Ogallala clays (clay mineralogy)	. . . In progress
	. . . Pleistocene mapping near Wichita	. . . " "
	. . . Pearllette ash as stratigraphic marker	. . . Article; part of symposium
Triassic System	. . . Triassic rocks in Kansas	. . . Article published (page 44)
Cretaceous System	. . . Comprehensive study of Cretaceous rocks	. . . In progress
	. . . Carlile Shale (stratigraphy, paleontology)	. . . Bull. 156 (page 43)
	. . . Graneros Shale " "	. . . In progress
	. . . Greenhorn Limestone " "	. . . " "
	. . . Pierre Shale " "	. . . " "
	. . . Permian-Cretaceous contact (see below, Permian)	. . . " "
	. . . Sedimentary petrography and clay mineralogy of Dakota Formation-Kiowa Shale	. . . " "
	. . . Crossbedding in Dakota-Kiowa rocks	. . . " "
Permian System	. . . Permian-Cretaceous contact (petrography, clay mineralogy)	. . . In progress
	. . . Permian evaporites (stratigraphy, structure, petrography)	. . . Four studies; one completed
	. . . Americus Limestone (stratigraphy)	. . . In progress
	. . . Clay mineralogy of Ninnescah Shale; first of redbeds study	. . . " "
	. . . Council Grove microfauna (paleontology)	. . . " "
	. . . Red Eagle Limestone (stratigraphy)	. . . " "
	. . . Big Basin ("Taloga") clays (petrography)	. . . " "
	. . . Wrexford bryozoans (paleontology)	. . . " "
Pennsylvanian System	. . . Pennsylvanian rocks; revision of Bull. 83	. . . In progress
	. . . Penn. paleotectonics (cooperative USGS)	. . . " "
	. . . Pennsylvanian algae (paleontology)	. . . " "
	. . . Pennsylvanian clay minerals (petrography)	. . . " "
	. . . Bryozoans of Beil Limestone (paleontology)	. . . Bull. 157 Part 5 (page 43)
	. . . Deer Creek Formation shales (petrography)	. . . In progress
	. . . Desmoinesian rocks (subsurface)	. . . In press
	. . . Doug.-Pecree Gr. (stratigraphy, paleontology)	. . . In progress
	. . . Douglas-Pecree fusulinids	. . . " "
	. . . Palynology study (page 28)	. . . " "
	. . . Lansing Group studies (stratigraphy, subsurface)	. . . " "
	. . . Lansing-Kansas City paleontology	. . . " "
	. . . Lansing-Kansas City cores of western Kansas	. . . " "
	. . . Paleontology of marine banks in south-east Kansas	. . . " "
	. . . Lecompton Limestone (geochemistry)	. . . " "
	. . . Oread Ls. (stratigraphy, geochemistry)	. . . Report written
	. . . Ferrous iron distribution	. . . In progress
	. . . Palynology of Bevier (Cherokee) coal (economic study, page 28)	. . . " "
	. . . Petrography of unit in Lawrence Shale	. . . " "
Mississippian System	. . . Outcropping rocks (mapping)	. . . In progress
(Most projects developed as part of oil and gas program, page 28)	. . . Mississippian paleotectonics (cooperative USGS)	. . . " "
	. . . Mississippian rocks of western Kansas (sub-surface study of cores, microfossils, insoluble residues)	. . . " "
	. . . Conodonts from Meramecian of western Kansas	. . . In press (Bull. 165 Part 1)

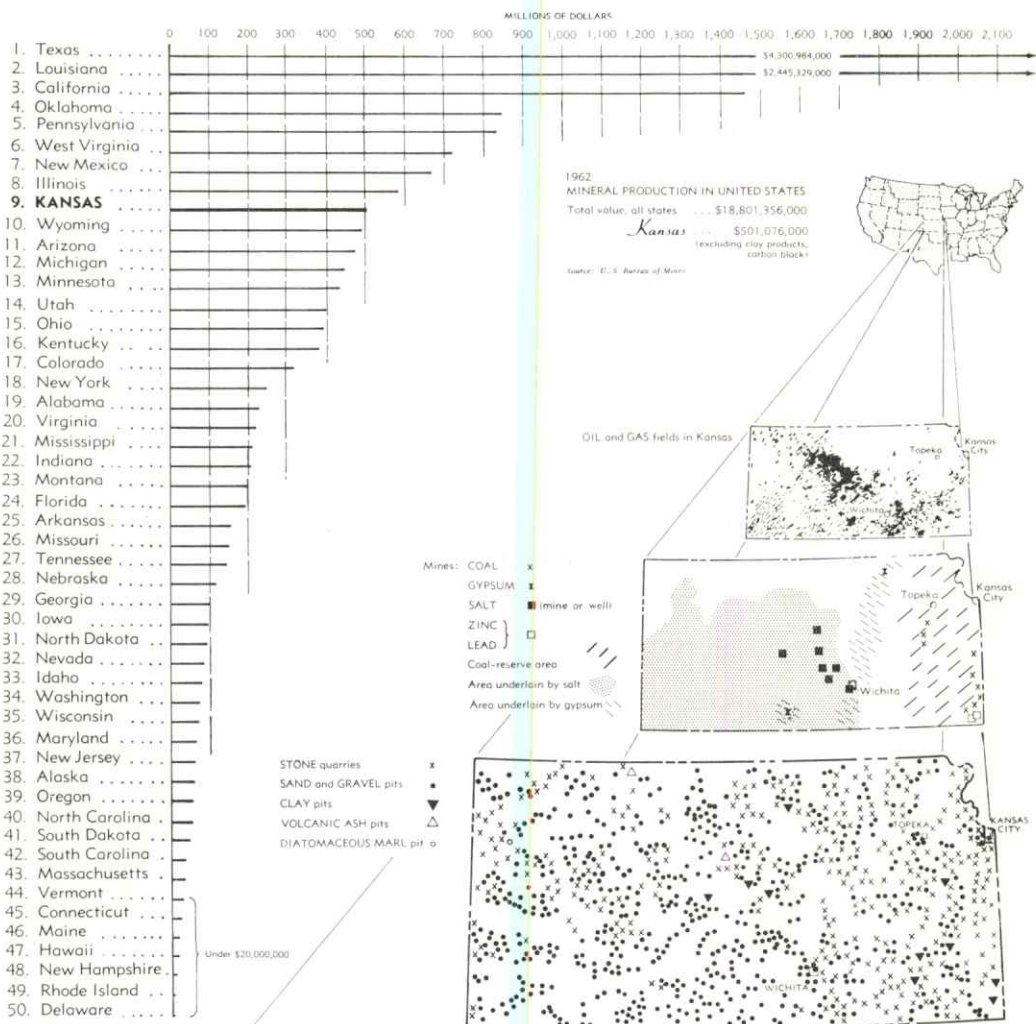


Generalized geologic map and cross section of Kansas rocks.

PROJECTS IN BASIC GEOLOGY (concluded)

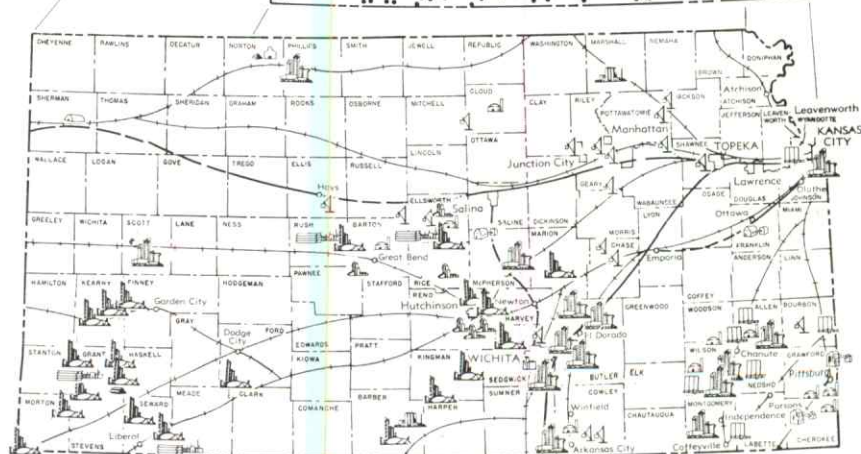
BIENNIUM ENDING JUNE 30, 1963

Project category	Description	Status, June 30, 1963
Subsurface studies		
<i>(Coordinated with summary studies and special projects. . . Cretaceous, Permian, Pennsylvanian, and Mississippian stratigraphic and structural-development studies included in summary studies, opposite page)</i>		
Silurian-Devonian rocks	. . . Sil.-Dev. foram. (pt. oil & gas prgm, p. 28)	. . . In progress
Cambrian-Ordovician rocks	. . . Arbuckle Group structural studies	. . . Map: O-G Invest. 25 (page 43)
	. . . Isopachous map	. . . In progress
	. . . Insoluble residues (part of oil and gas program, page 28)	. . . " "
	. . . Isopachous map of Simpson Group	. . . In progress
Precambrian rocks	. . . Reagan Sandstone (petrography; structure)	. . . " "
	. . . History of Precambrian studies	. . . Article published (page 44)
	. . . Precambrian rock-type distribution; petrographic description (integrated with geophysical work and economic possibilities)	. . . In progress
	. . . Precambrian configuration	. . . Map: O-G Invest. 26 (page 43)
	. . . Precambrian-Paleozoic contact	. . . In progress
	. . . Precambrian bibliography	. . . " "
	. . . Progress report, 1962	. . . Bull. 157 Part 2 (page 43)
Basinal and structural studies (refer to map, page 33)	. . . Producing wells	. . . In progress
	Nemaha Anticline	. . . Struc. study (pt. of oil and gas prgm, p. 28)
	Pratt Anticline	. . . Structural study
	Sedgwick Basin	. . . Cross sections (coop. mineral fuels, p. 32)

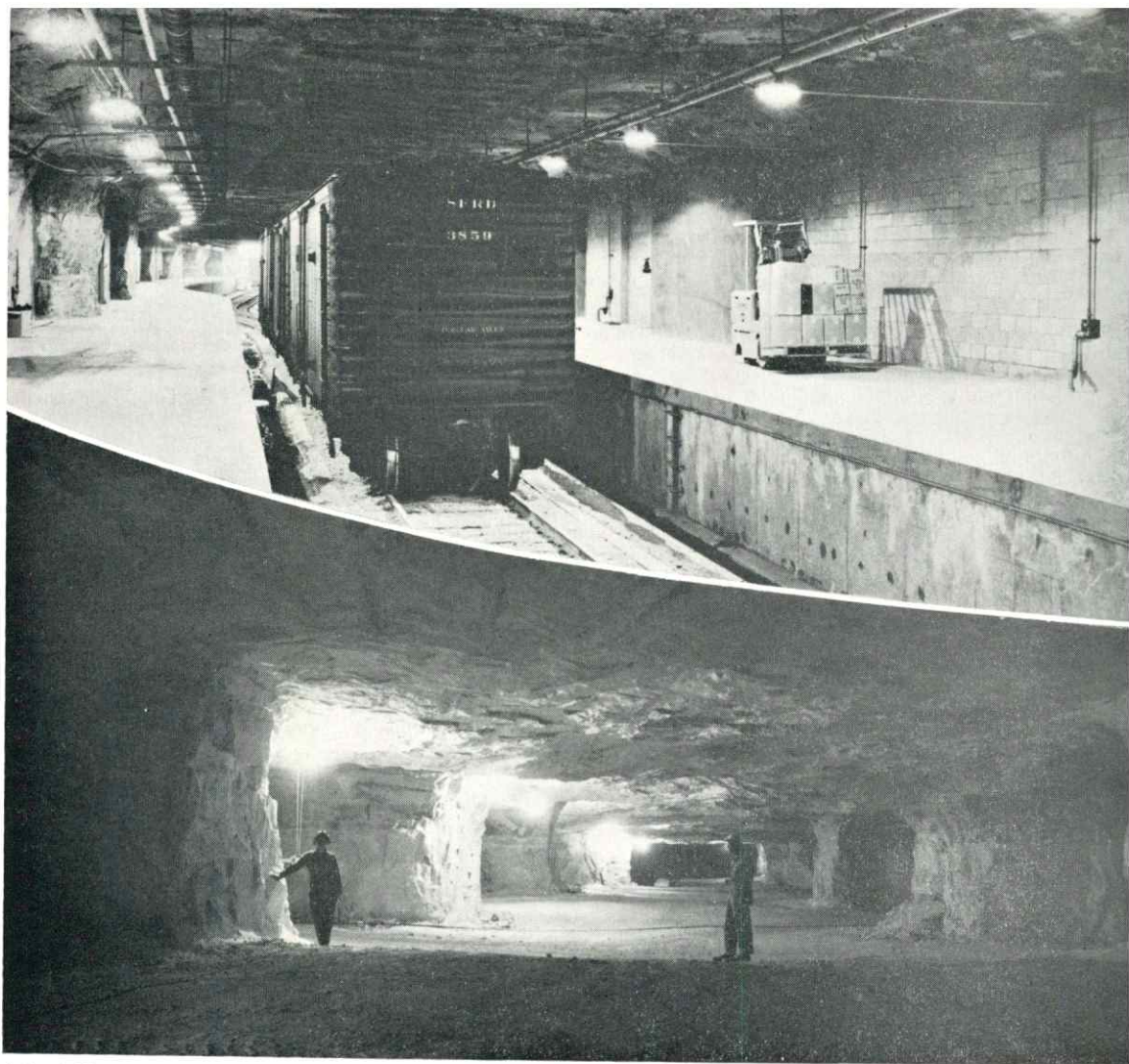


Mineral industries PROCESSING PLANTS

- Oil refinery
- Natural gasoline and LPG
- Carbon black
- Helium
- Coal washing
- Building stone (plant or quarry)
- Cement
- Clay products (brick, tile, pottery, clay pipe)
- Lightweight aggregate
- Salt
- Chemicals
- Gypsum
- Volcanic ash
- Diatomaceous marl



Among 10 leading mineral-producing states for three decades, Kansas ranked ninth in 1962.



Inland Underground Facilities, Inc., in mined-out space of underground limestone mine, Wyandotte County; near Kansas City, Kansas. (Photo credit, page 24.)

National Gypsum Co. mine near Sun City, Barber County. A superior quality gypsum is mined here and at the Bestwall Gypsum Co. mine near Blue Rapids, Marshall County.

New Emphasis on Mineral Resources

in a Changing Kansas Economy

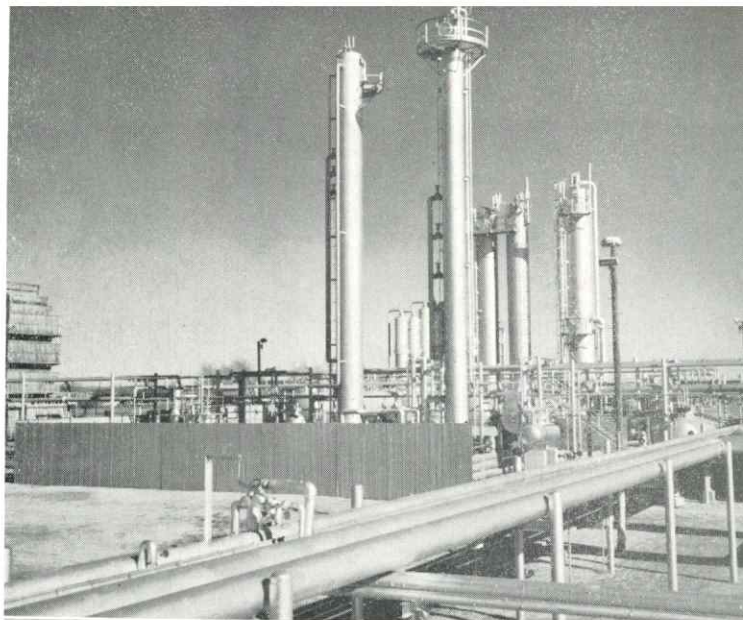
All sectors of the Kansas economy are showing as never before the frustrations of a rural-to-urban movement, and every Kansan is becoming aware of changes brought on by the movement. State agencies and private groups having responsibility for a progressive Kansas are attempting to fit their activities to the emerging structure. The Kansas Geological Survey, for example, is re-examining its program and is instituting some changes in approach and emphasis consistent with changes in the sector of mineral and water resources. Research effort is being redirected to provide types of information that will be most

useful to today's Kansans as a unit and individually: to any mineral producer or potential mineral producer in any one of the state's 105 counties who wants to know not only the amount and quality of reserves but also additional uses of the resource or resources he is exploiting or wants to exploit; to an irrigation farmer in western Kansas whose future is linked with the expected yields of irrigation wells; to an industrialist in Kansas River valley or other industrial district who is looking for a new mineral resource to utilize in product development; to a businessman in Wichita or other marketing center who is interested in knowing about the accessibility of mineral materials; to any person established within the Kansas economic community or any person about to be dispossessed by it; to anyone, Kansan, or non-Kansan, seeking a location where fuel, water, and other natural resources essential to plant operation are available.

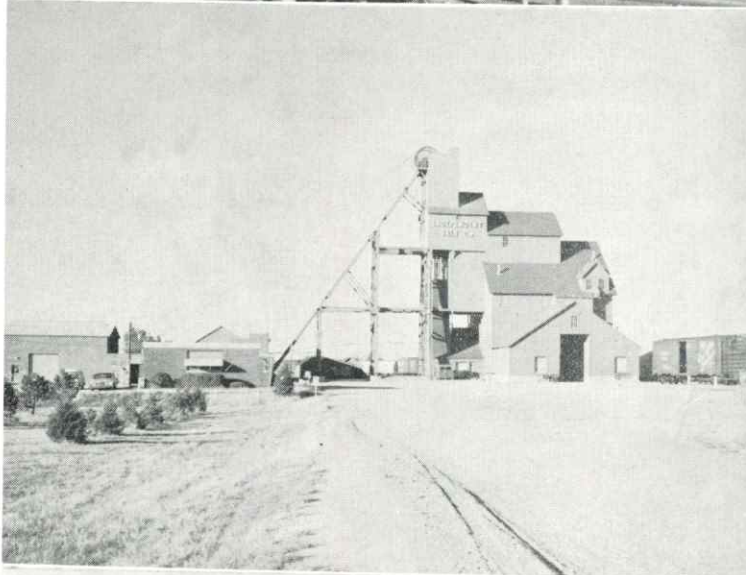
This is one view of Kansas in the 1960s, a view that seems to dictate some changes in the activities of the State Geological Survey of Kansas. To understand this view a backward glance is necessary. Changes generally do not appear suddenly but build up gradually, so gradually perhaps as to be imperceptible for many decades. This in a sense has been so in Kansas, even taking into account periods of extremes, as the drought-dominated 1930s or the defense-oriented 1940s. The 1950s, a decade that superficially at least had the look of prosperity, were well along before we were sensing consciously the impact of changes in the economic structure—changes being forced by a complication of factors, from continued decentralization and mechanization of farms to automation and technical advances in industry. This modernization process was accompanied by an obvious imbalance of labor supply and employment. Furthermore, industrial expansion depended not only on accessibility of raw materials, including water and fuel for plant operations, but also on an adequate market for products, and the market area was limited by costs of production and transportation. Big questions by this time were emerging, and many people were thinking, "Kansas needs to achieve a more diversified economy, but how?"

The staff of the Geological Survey, conscious of the basic importance of mineral resources in economic development but aware of the nonrenewable characteristics of mineral resources and of the wide range in known reserves of different materials, from almost depleted to almost unlimited, began wondering what types of research, what types of evaluations and re-evaluations of these resources could contribute most to the well-being of Kansans now and in the future. In thinking of resources for industrial development, it was becoming obvious that the whole economic structure, whatever it might be, must be taken into consideration. Research effort should surely be aligned with a clear picture of the geography of the state, especially with existing regional economies and the present role of mineral resources in these economies. Any significant population trends must be taken into account. Attitudes of Kansans themselves should not be overlooked.

Natural gasoline plant of Skelly Oil Co., Medicine Lodge, Barber County. Twenty-one natural gasoline plants currently are being operated by 14 companies in Kansas; all are located in central and southwestern Kansas, 11 in the Hugoton Gas Area.

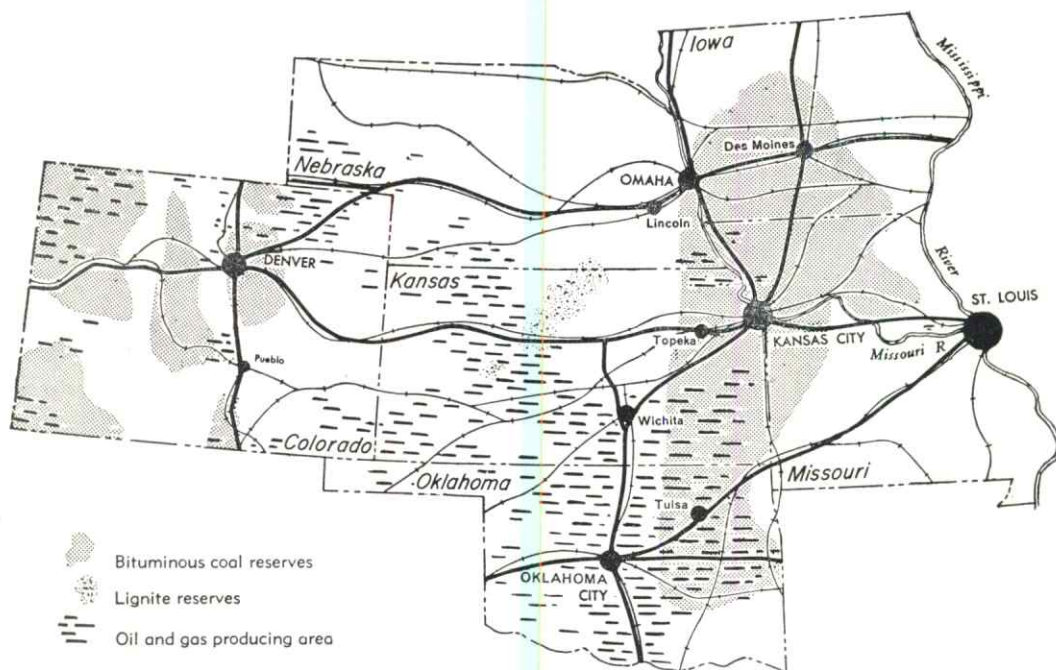


Independent Salt Co. plant and mine near Kanopolis, Ellsworth County. Three salt companies (Carey, Barton, and Morton) have plants at Hutchinson, Reno County; one company (American Salt) has a plant at Lyons, Rice County. Salt brine is produced by Pawnee Salt Co. at Pawnee Rock, Barton County, and by Frontier Chemical Co. near Wichita, Sedgwick County.

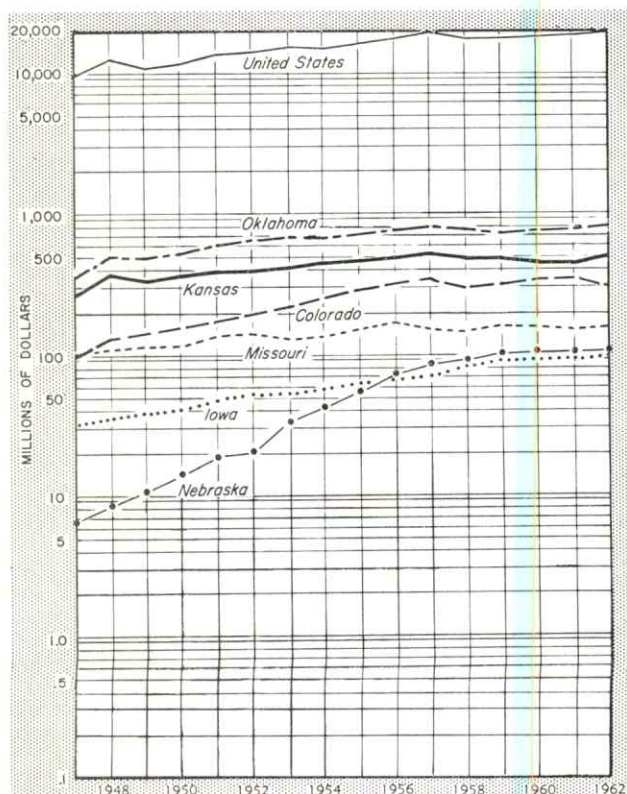


Building-stone quarry, Silverdale, Cowley County. Building stone is also produced near Manhattan, Riley County; near Junction City, Geary County; near Hays, Ellis County; and in Bourbon, Chase, Cloud, Mitchell, Pottawatomie, and Russell Counties.



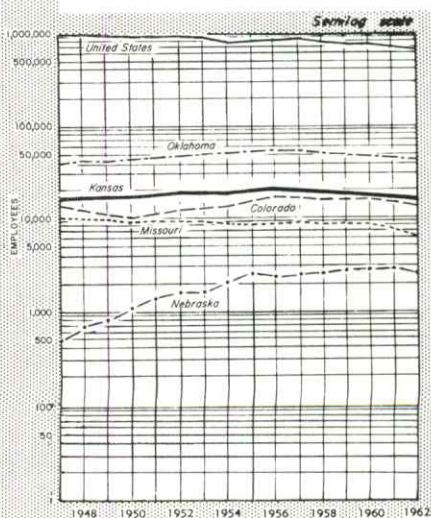


Industrial activity in the Midwest is interrelated with transportation, mineral fuels, population trends.



Total value of mineral production (left) and employment in the mineral industry (below) . . . in the United States and selected states, 1947-1962.

Sources: U.S. Bureau of Mines, U.S. Bureau of Labor Statistics, and state Departments of Labor.



It was at this stage of thinking that the Kansas Geological Survey organized the Division of Mineral Resources, began to reorient its program to shift emphasis from study of resources as entities in themselves to resources as they are related to and are interrelated within the total economy. The Governor's Economic Development Committee came into being as the Survey's reoriented program was getting under way. In fact, preparing material for the Committee's sector report, *Mineral and Water Resources*, was one of the first major projects of the Division of Mineral Resources. Members of this Division, members of the Division of Oil and Gas, and other staff members worked with and under the direction of the Survey's associate director, who was a special consultant on the Governor's Committee and member of the subcommittee responsible for the sector study. Without question work done for this sector report has enabled the Geological Survey staff to understand more thoroughly the Kansas mineral industry in all its aspects, its scope, its relation to other factors in the economy, its rating with that of neighboring states and the nation as a whole—all this not to mention the statistical facts that were assembled and are available to use as a basis for continued study.

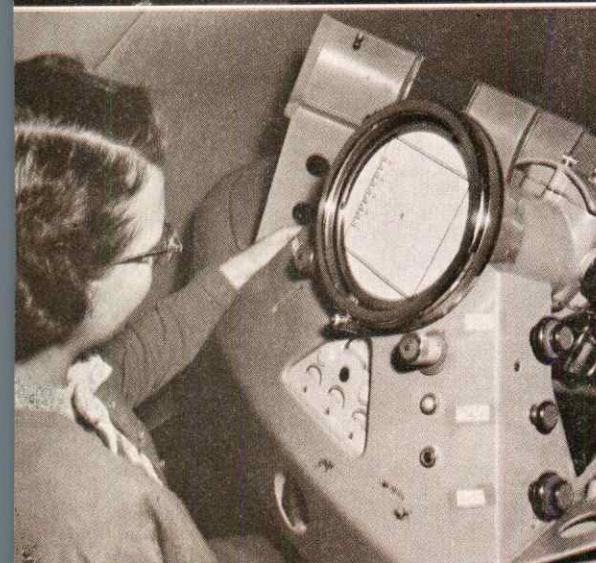
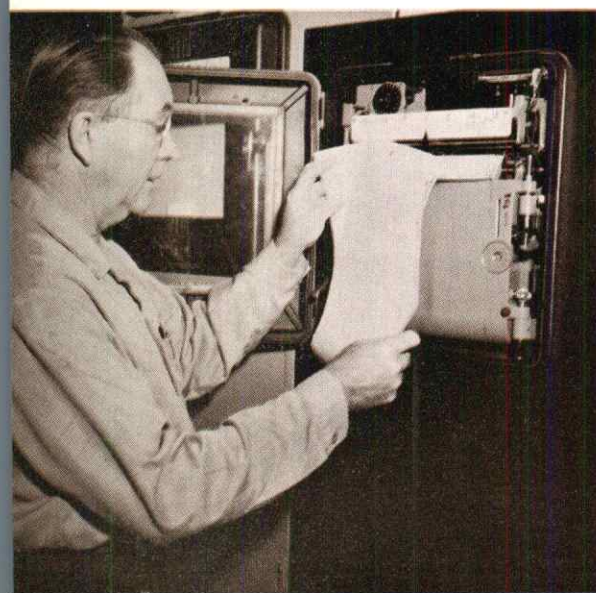
Kansas has a mature mineral industry, as do the neighboring states of Missouri and Oklahoma; in comparison, Colorado and Nebraska have a more youthful mineral industry. These facts we must accept, and by extending this broad comparison to include a closer look at the component parts of the mineral industries in Kansas and neighboring states, we can obtain a more meaningful perspective of Kansas' place now and what it might be 15 or 20 years hence in the Midwest mineral economy. Such knowledge can give direction to research.

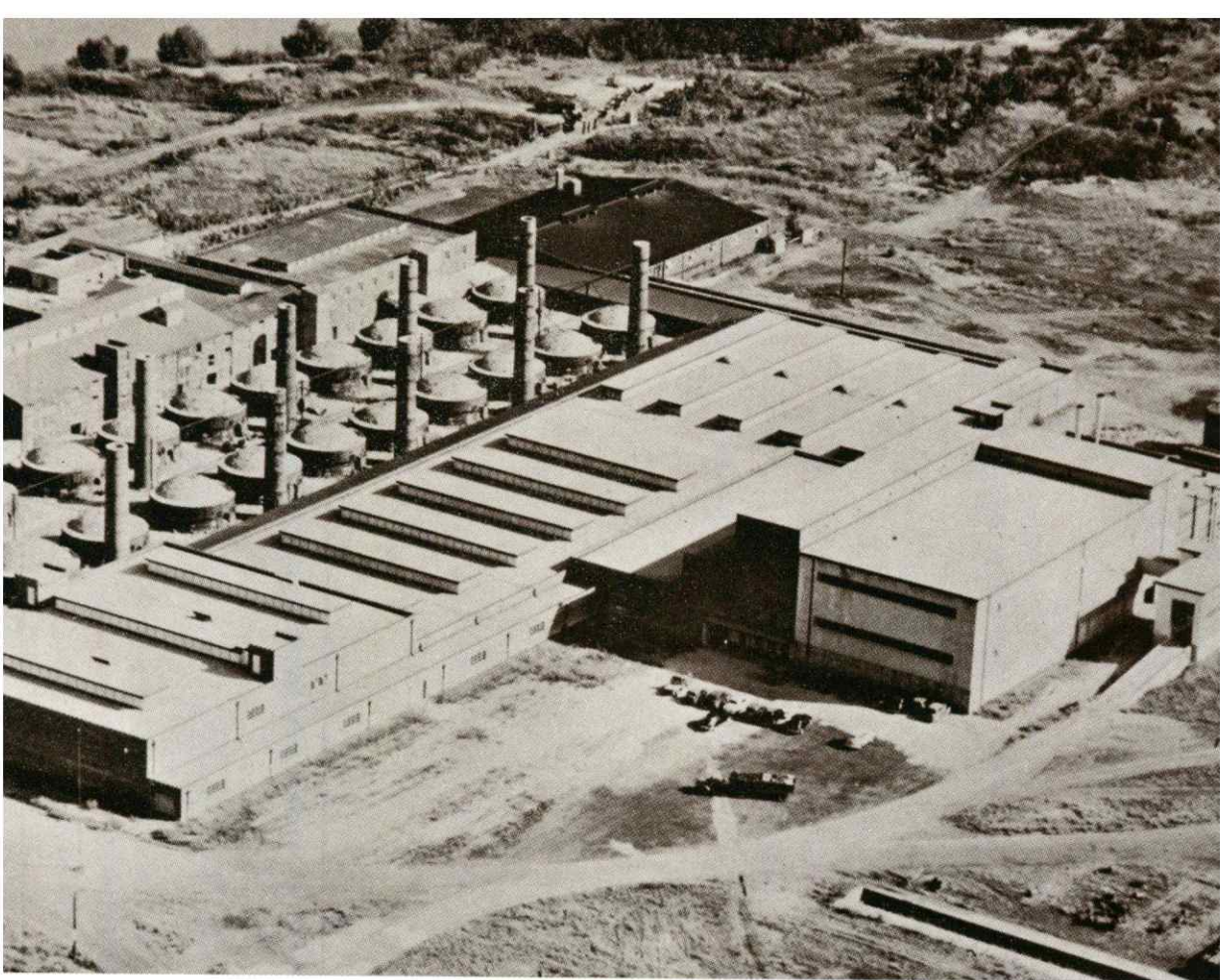
In recent years decline, or slow growth, in the mineral industries in Kansas is exhibited in value of production, employment, and wages and salaries, even though the state has maintained its share of the nation's total value of mineral production and even though Kansas has done better than the nation in employment in the mineral industries and in wages and salaries generated. We have to believe that the slow decline manifest in some segments of the mineral industry is bound to continue and that except for a reversal of current population trends and strong economic growth in other sectors, the mineral industry generally could be hard pressed to hold its own.

The effect that a serious decline in a segment of the mineral industry can have on a geographic area is illustrated in southeastern Kansas, for years basically dependent upon coal and metals mining. Today, known mineable reserves of lead and zinc are nearing depletion, the amount of coal mined annually is a mere fraction of the tonnage produced in former days, and technology and automation have reduced drastically the mine labor force. Obviously a diversified economy is badly needed in this section of the state. Motivation in this direction is coming from concerned people within the area, but also necessary are financial and research aids from outside. Rightly we ask: What activities can the Geological Survey engage in to provide useful information? Suggest-

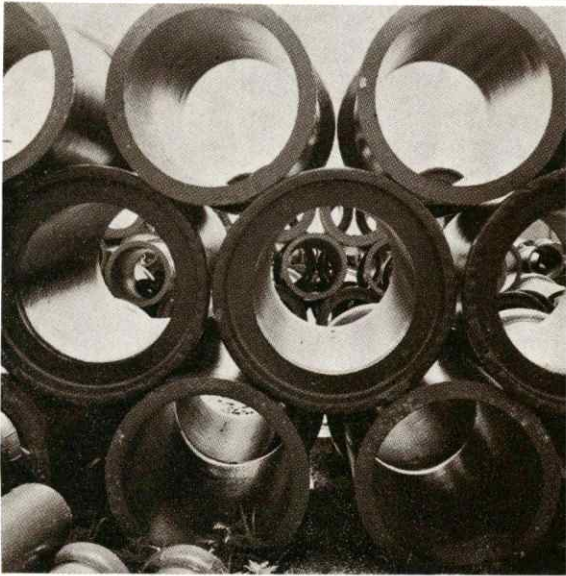


Pittsburg, Kansas, plant of W. S. Dickey Clay of clay pipe. Nearby pit where raw clay is obtained. Clay is one of our low-unit-value commodities, clay is the basis of many products (see page 26) and has high potential for extended production possible by modern scientific equipment (example below).





Manufacturing Co., one of the country's largest producers of finished product, lower right. One of several ceramics industries in Kansas (map, page development; supported by sophisticated research made as shown).



Some modern research equipment available to the Kansas Geological Survey . . . differential thermal analysis unit; electron microscope; x-ray diffraction unit; electronic computer.

tions that come to mind are laboratory experiments on and analytical studies of chat to determine possible industrial uses of the thousands of tons of this so-called waste product accessible at lead and zinc mine sites; analysis of coal samples in support of current industrial research to determine nonfuel uses of coal; special studies of the area's limestone or sandstone or clay deposits toward finding new and extended uses for these resources in area enterprise.

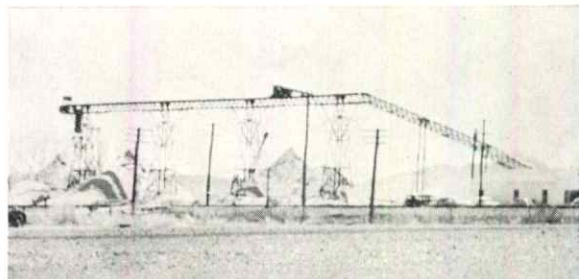
Similarly, observations can be made on the economic status of other areas and their probable industrial needs. Certain areas, including much of the farmland of western Kansas and pastureland in the Flint Hills and south-central Kansas, undoubtedly will stay predominantly rural, and in spite of the continued decrease in number of farms and number of people needed to run mechanized farms, agriculture will remain a major sector of the economy. In the rural-to-urban movement Kansas is not likely to gain any additional major metropolitan areas at least soon, but the not-so-large population centers could profit by attracting industries utilizing local materials in manufacturing products for local outlets. And this is one way industry and agriculture can complement each other to the benefit of the total Kansas economy.

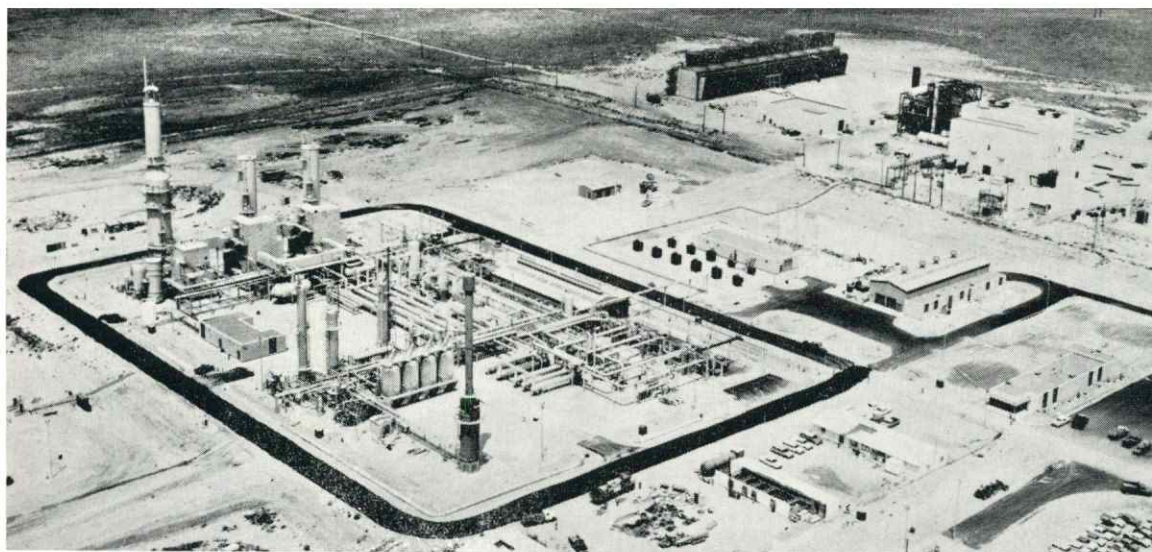
Facts revealed by the sector study on mineral resources for the Governor's Economic Development Committee are rather convincing evidence that nonmetallics of low unit value have high potential for further industrial development. This holds for such widespread mineral commodities as stone, sand, gravel, and clay, which could expand their primary use as aggregate or building material in the construction industry. Greatest returns for many nonmetallics, volcanic ash for example, can be realized in developing new uses for these commodities and by encouraging the establishment of industries that will process such products in Kansas.

It is within this range of knowledge that the Geological Survey is streamlining its research on prospects for the state's mineral resources. The Governor's report and the activation of a Division of Mineral Resources are simply the beginnings.

Sand and gravel operation in Kansas River valley, Turner district, near Kansas City, Kansas (map showing distribution of sand and gravel pits, page 26).

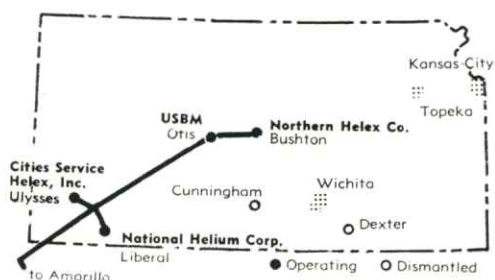
This photograph and the one of the underground storage area (page 17) courtesy Kansas City, Kansas, Chamber of Commerce.





The world's largest helium extraction plant; near Liberal, Seward County, Kansas.

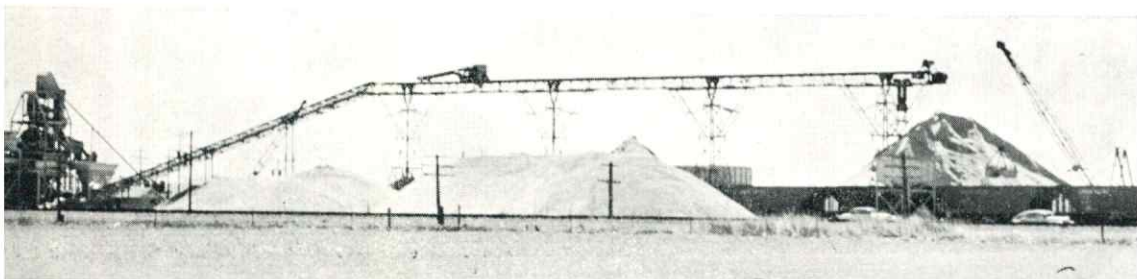
Photograph courtesy Panhandle Eastern Pipe Line Co., Kansas City.



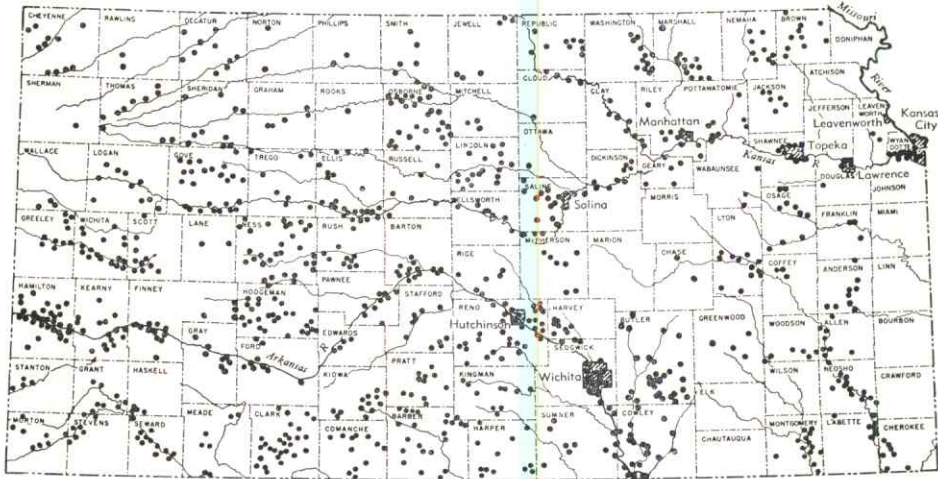
New developments in the Kansas mineral industry. . . . Three new helium plants were constructed in Kansas during the biennium (located on map above). The U.S. Bureau of Mines has operated a plant at Otis, Rush County, since 1943, and during World War II the Bureau operated one briefly at Cunningham, Kingman County. A privately-owned plant, established at Dexter, Cowley County, in 1927, operated for a short time. The world's first discovery of helium in natural gas was in gas from a well drilled near Dexter, Kansas, in 1903. Professor H. P. Cady of The University of Kansas, who made the helium discovery about three years after the well was discovered, reported on helium in natural gas in Volume IX of the University [Kansas] Geological Survey.

Once used principally to inflate balloons, this nonflammable, lighter-than-air gas is now used extensively in arc welding, has medical applications, and is a must in space-age science. About 90 percent of the world's known supply of helium is in or near the Hugoton Gas Area, and as a part of a Government conservation program, helium is being extracted from natural gas produced in this area. The helium is piped from the extraction plants to Amarillo, Texas, where it is stored for future use.

Another new development on the Kansas industrial scene, a huge coal shovel, is shown on the front cover and described on the inside front cover.

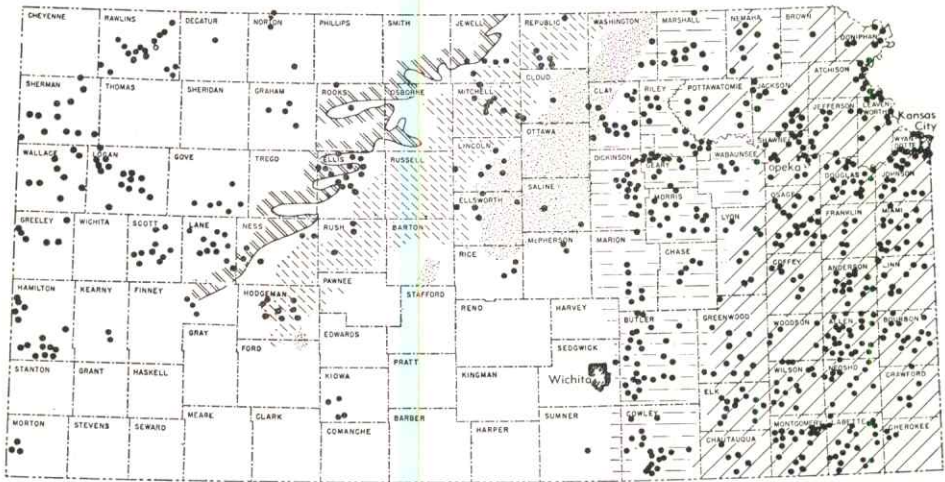


Kansas

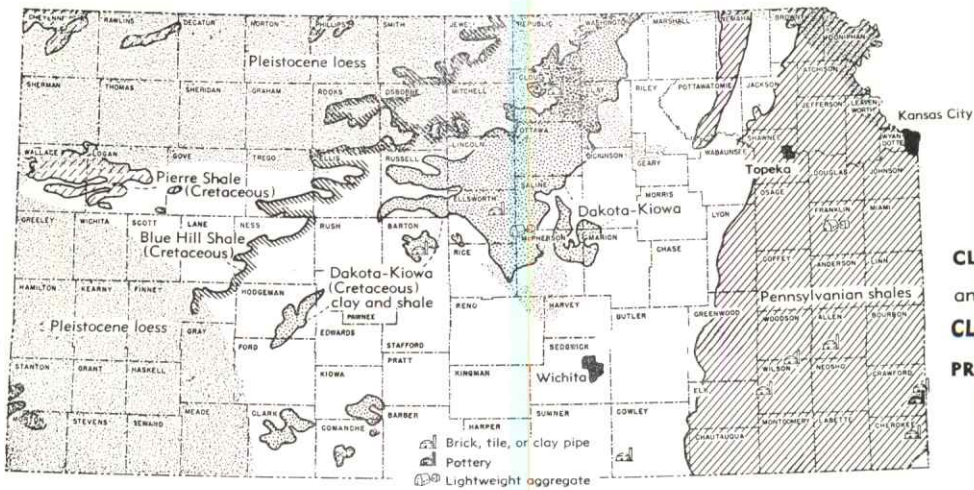


**SAND
and
GRAVEL
pits**

**STONE
quarries**



Fort Hays (Cretaceous) chalk Dakota (Cretaceous) sandstone Permian limestones
Greenhorn (Cretaceous) limestones Pennsylvanian limestones and sandstones



**CLAY
and
CLAY
PRODUCTS**

Brick, tile, or clay pipe
Pottery
Lightweight aggregate

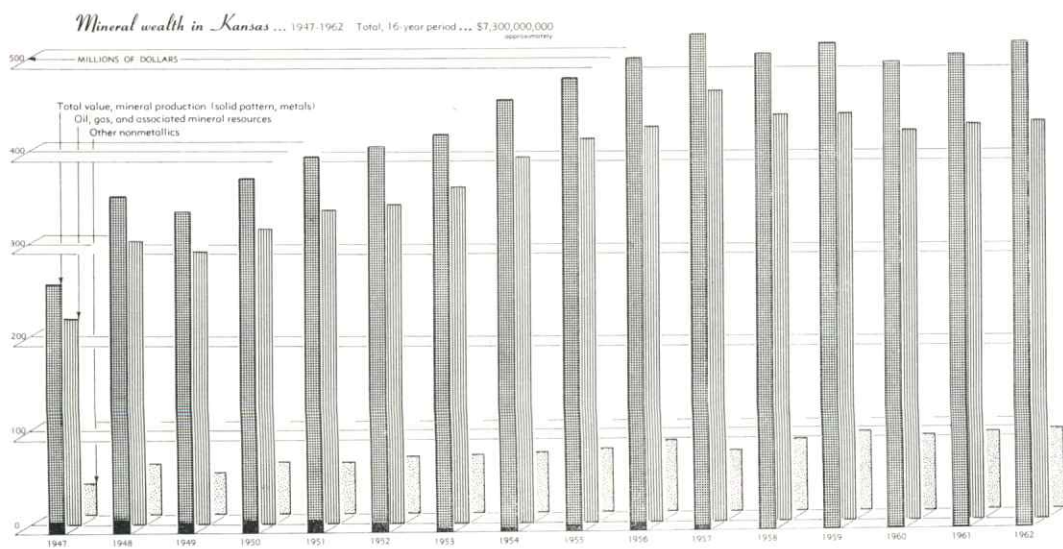
ACTIVITIES . . . *Mineral Resources*

Mineral Resources Divisions of . . . Oil and Gas Ceramics

. . . to make a complete geological survey on such portions of the State of Kansas as have any natural products of economic importance . . . and to report on the same from time to time. . . .

The objective is the same in 1963 as in 1889, the year the Kansas Legislature established the state's present Geological Survey. But the pattern of research has changed and emphasis has shifted to adjust to changing economies and to permit efficient use of accumulated information on the state's mineral resources: asphalt rock, chalk, clay, coal, gas, ground water, gypsum, helium, lead, limestone, oil, salt, sandstone, volcanic ash, zinc, and other mineral materials.

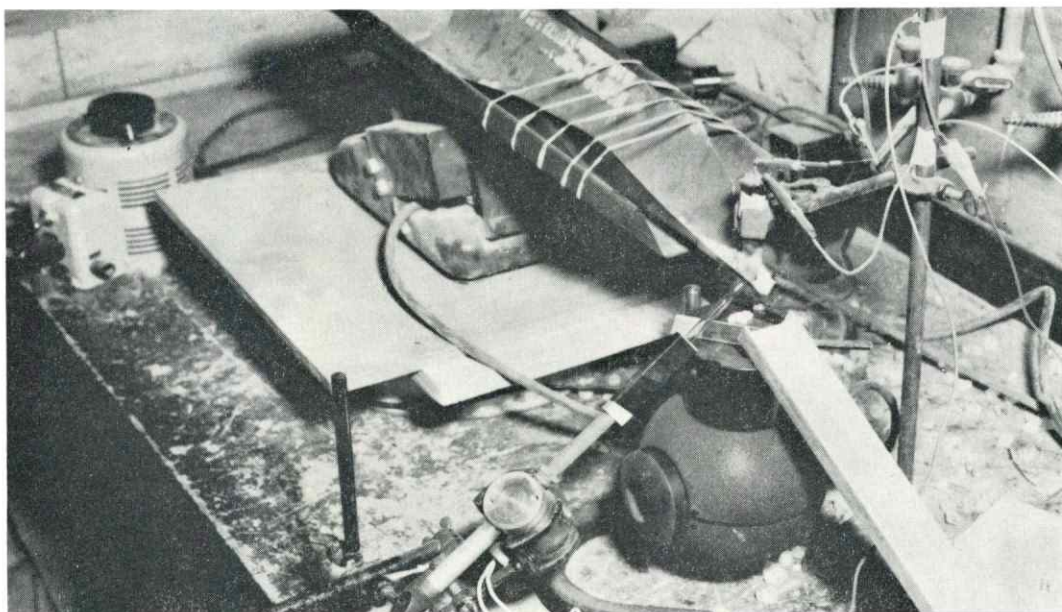
The current economy dictates that meaningful studies of resources can no longer be developed as entities in themselves, but must be made vigorous by consideration of all economic factors that influence community and regional development—technical advances, labor force, transportation, marketing, fuel, and water (pages 17 to 26, 30, 31). This broadened approach is obvious in the Survey's current research program: in the effort to consolidate information on the state's major rock units (page 12), in the reorganization of the facets of applied research, and in the separate projects. The table on page 28 lists principal projects on the agenda of the divisions of mineral resources, oil and gas, and ceramics during the biennium ending June 30, 1963. Ground-water studies, cooperative with the U. S. Geological Survey, are noted on page 32. All projects concerned with mineral resources, in the total perspective, are interrelated with basic geology (page 12) and services (page 38).



Industrial minerals included in categories noted on graph, above: Lead and zinc (**metals**); crude petroleum, natural gas, natural gasoline and LPG, carbon black, helium (**oil, gas, associated mineral resources**); cement, clay and shale products, coal, diatomaceous marl, gypsum, salt, sand and gravel, stone, volcanic ash (**other nonmetallitics**).

Project category	Description	Status, June 30, 1963
<i>General:</i>		
Study for Governor's Economic Development Committee (page 21)	... Mineral and water resources; sector report. . . (Analytical review of state's mineral resources and related economic factors)	Published (page 44) Spec. Dist. Publ. 2 (page 43)
Statistical summaries	... Mineral industry in Kansas, 1960 (Chapters in USBM Minerals Yearbook, 1960, 1961)	Bull. 152 Part 3 (page 43) Published (page 44)
	... Kansas mineral industry, 1962 with directory of mineral producers	Spec. Dist. Publ. 1 (page 43)
Map: mineral resources	... Large-scale map; distribution of mineral resources, primary mineral industries; to supersede 1951 edition	Data being assembled
<i>Oil and gas:</i>		
Annual reports	... Oil and gas developments in Kansas, 1960	Bull. 155 (page 43)
	... Oil and gas developments in Kansas, 1961	Bull. 160 (page 43)
	... Oil and gas developments in Kansas, 1962	In preparation
Map: petroleum industry	... Large-scale map; oil and gas fields, pipelines, processing plants; to supersede 1958 edition	In preparation
Secondary recovery	... Table: secondary-recovery projects, 1960 (Interstate Oil Compact Commission study, page 42)	O-G Invest. 24 (page 43)
Special studies	... Underground storage of natural gas near Kansas River valley	O-G Invest. 24 (page 43)
Mississippian rocks (Coordinated with basic research, page 14)	... Stratigraphic-structural studies (Includes subsurface in western Kansas; surface mapping; conodonts in Meramecian; insoluble residues; versene studies)	Studies in progress Report on conodonts in press (Bull. 165 Part 1)
(Other current studies in basic geology developed as part of oil and gas program include: Pleistocene geology, Silurian-Devonian Foraminifera, structure of Arbuckle rocks, geology of Crawford County, structure of Nemaha Anticline, and geochemical work on "Hunton" cores in North Kansas Basin, pages 14 and 15.)		
<i>Ceramics:</i>		
Cretaceous rocks (Coordinated with basic research, page 14)	... Mapping ceramic and other economic materials; part of stratigraphic study of Dakota-Kiowa sequence	In progress
	... Dakota Formation clay studies	In progress
	... Field investigations	" "
	... Beneficiation of clays for refractory uses	" "
Pennsylvanian shales	... Ceramic properties of Weston Shale; first part of Pennsylvanian study	Report being written
Special clay studies	... Ceramic bodies for small producers (page 38)	Continued as service
	... Soluble salts in Kansas clays, shales (page 38)	" " "
Economic study	... Diversification in clay, shale industry	In progress
Volcanic ash studies	... Popped volcanic ash	Bull. 157 Part 3 (page 43)
	... Pilot plant tests: uses for filtering, insulation	Continued study
	... Volcanic ash in glazes (page 38)	Continued as service
	... Sewer-pipe glazes	Article published (page 44)
	... Fine aggregates and pozzolans in cellular concrete	Report being written
<i>Miscellaneous projects:</i>		
Salt study	... Beneficiation of salt (photograph, page 29)	In progress
Spore studies (page 14)	... Douglas Group	In progress
	... Bevier (Cherokee) coal	" "
Lignite study	... Field exploration	In progress
	... Humic-acid extraction (photograph, page 29)	" "
Building stone	... Laboratory tests on building stone	In progress

Ground-water investigations listed on page 32. Services summarized, page 38.



Salt-beneficiation study. . . . Photograph shows improvised laboratory setup in which photoelectric cell is used to remove impure salt grains. This is the first step in a pilot study on beneficiation of salt for industrial use.



Lignite study. . . . Samples of lignite from central Kansas are being treated for production of humic acid to use as a soil conditioner.

ACTIVITIES . . . *Cooperative Studies*

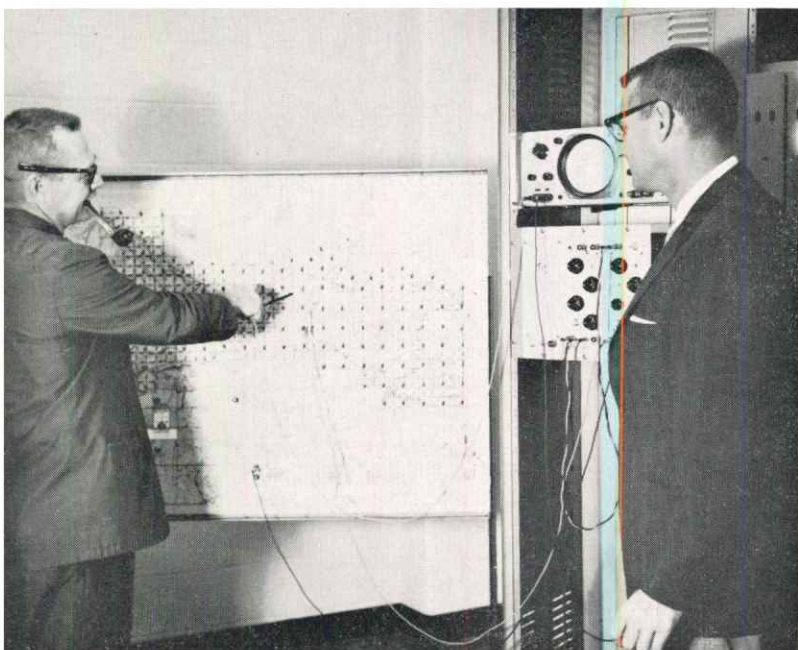
with the United States Geological Survey

Ground Water

Divisions of . . . Mineral Fuels

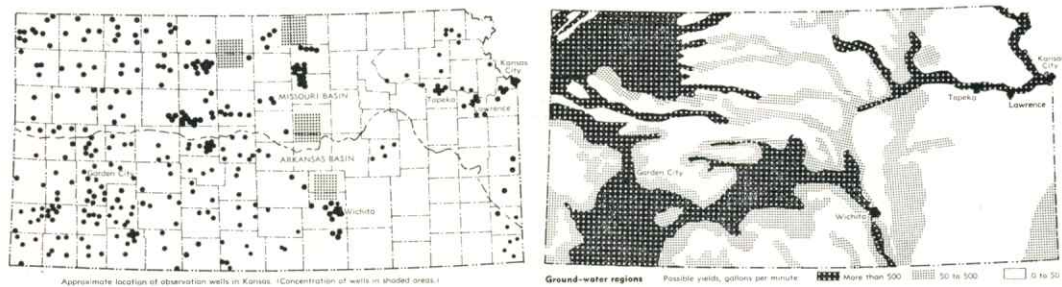
Topographic Mapping

In three areas of research—ground water, mineral fuels, and topographic mapping—the Kansas Geological Survey and the United States Geological Survey maintain cooperative programs, supported by state and federal funds. The Cooperative Ground-Water Division is staffed by both state and federally employed personnel who have headquarters in a main office in Lawrence and a district office in Garden City. (Activities are summarized on pages 31 and 32; refer also to table on page 14.) Two federally employed geologists stationed at the Kansas Geological Survey are the principal participants in the cooperative program in mineral fuels. (Status of this program is given on pages 32 and 33.) The topographic-mapping program is directed from a regional office in Rolla, Missouri, and mapping is by the U. S. Geological Survey. (Mapping status in Kansas is noted on page 33.)

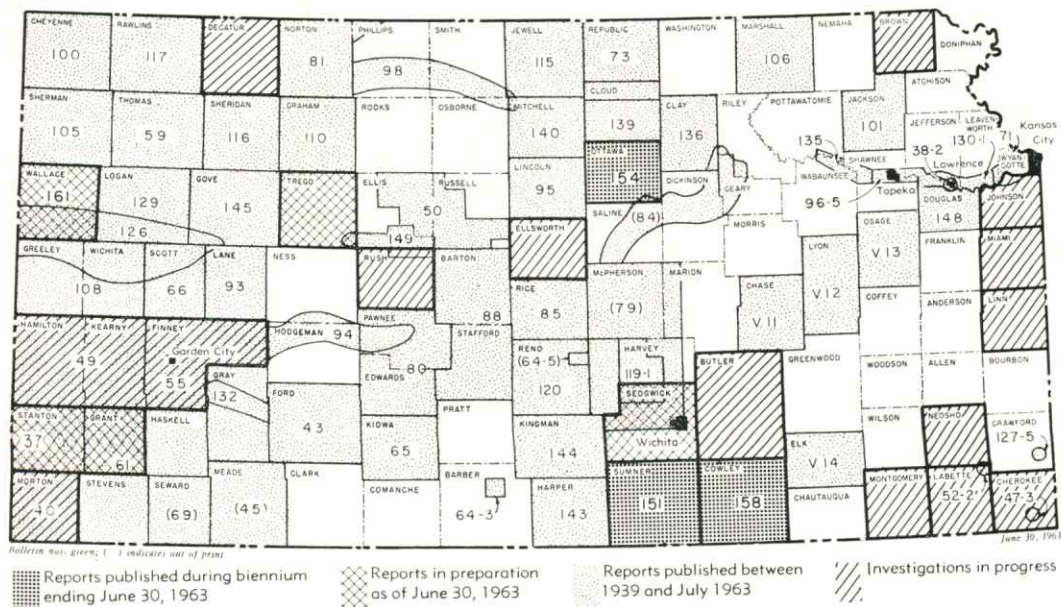


Analog model of Kansas Valley near Topeka . . . used in a special study of the area's ground-water conditions. John D. Winslow, ground-water geologist, and Robert J. Dingman, head of the Ground-Water Division as of July 1, 1963, discuss the solution of a hydrologic equation as displayed on the oscilloscope of the analyzer of the model. This model was designed by Dr. Winslow and by Carl E. Nuzman of the Division of Water Resources, Kansas State Board of Agriculture. Such models are now being used to analyze ground-water reservoirs as a source of water for irrigation, municipal, industrial, and other uses. This type of analog computer has direct application in solving a wide variety of problems in ground-water hydrology.

Of all the mineral resources none is more valuable than water, except perhaps soil, in sustaining the agricultural and industrial economy of Kansas. Much of Kansas, especially western Kansas, depends on ground water for domestic, agricultural, municipal, and industrial supplies. Hence, continued studies to determine available ground-water supplies for an expanding economy are necessary. The ground-water program in Kansas—maintained by the State and Federal Geological Surveys in co-operation with the State Boards of Agriculture and Health, the Kansas Water Resources Board, and in part the City of Wichita—has been operating in its present framework for a quarter of a century. Within this period, 78 reports on ground-water resources have been published; studies have been made on all or parts of 87 counties; and as a part of the program, about 800 observation wells are being measured periodically (see map below). A vital part of the current program is the restudy of ground-water conditions in western Kansas areas where irrigation wells are numerous and pumping for irrigation is extensive. In recognition of a need to facilitate procedures of investigation and to refine data processing, computer techniques are now being applied in special studies of ground-water conditions (opposite page and page 9).



Concentration of observation wells and ground-water investigations in western Kansas is directly related to regional ground-water supplies and regional dependence upon these supplies. To execute ground-water studies effectively in this area, the Geological Survey has a field office at 310 North Ninth Street, Garden City.



Ground-water investigations in Kansas. . . . Five reports, including two water-level reports, were issued during the biennium ending June 30, 1963; five reports were in preparation; 14 projects were in progress.

Project category	Description	Status, June 30, 1963
<i>Water-level reports</i>	. . . Water levels in observation wells, 1960	. . . Bull. 153 (page 43)
	. . . Water levels in observation wells, 1961	. . . Bull. 159 (page 43)
	. . . Water levels in observation wells, 1962	. . . In preparation

(Map showing approximate locations of observation wells being measured in 1963, page 31.)

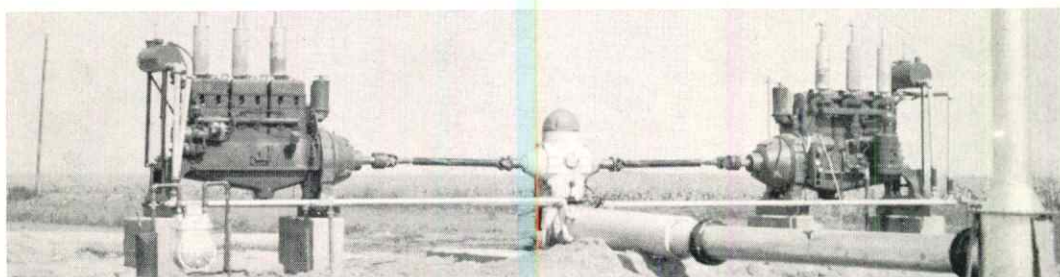
Area investigations:

Cowley County	. . . Areal geology and ground water	. . . Bull. 158 (page 43)
Ottawa County	" " " " "	. . . Bull. 154 (page 43)
Sumner County	" " " " "	. . . Bull. 151 (page 43)
Wallace County	" " " " "	. . . In press (Bull. 161)
Sedgwick Co., Trego Co.	" " " " "	. . . Reports in preparation
Grant-Stanton Cos.	. . . Restudy; emphasis on hydrology (Previous reports on ground-water re- sources: Bulls. 37, 61)	. . . Report in preparation
Finney-Hamilton- Kearny Cos., Morton Co.	. . . Restudy; emphasis on hydrology (Previous reports on ground-water resources: Bulls. 55, 49, 40)	. . . In progress
Brown, Butler, Cherokee, Decatur, Ellsworth, Johnson, Labette, Linn, Miami, Mont- gomery, Neosho, Rush Cos.	. . . Areal geology and ground water (Maps showing areal geology are a part of area investigations; see also page 14)	. . . In progress

(Map showing status of ground-water studies in Kansas as of June 30, 1963, page 31)

<i>Special projects:</i>	. . . Use of digital computer in analyzing pumping-test data (page 9)
	. . . Use of electric analog model in studying ground-water conditions (pages 9, 30)

*Cooperating agencies: Kansas Geological Survey; U.S. Geological Survey; Division of Water Resources of the State Board of Agriculture; Division of Sanitation of the State Board of Health; Kansas Water Resources Board; City of Wichita.



Irrigation pump near Garden City, Finney County. . . . Increased use of ground water for irrigation in western Kansas has necessitated restudy of ground-water conditions in that section of the state. One two-county area that in 1940 had 12 irrigation wells now has more than 500.

COOPERATIVE PROJECTS IN MINERAL FUELS

BIENNIUM ENDING JUNE 30, 1963

Project category	Description	Status, June 30, 1963
<i>Subsurface studies:</i>		
Sedgwick Basin	. . . Geologic cross section, Butler Co. to Stafford Co.	. . . O-G Invst. 28 (page 43)
	" " " " , Cowley Co. to Comanche Co.	. . . In preparation
	" " " " , Chase Co. to Rice Co.	. . . Proposed
	. . . Sedgwick Basin structural maps	. . . In preparation
Kansas segment of cross section, New York to Colorado, for publication by AAPG (American Association of Petroleum Geologists)		. . . Completed

(See index map, page 33; basic geology, page 15; services, page 38)

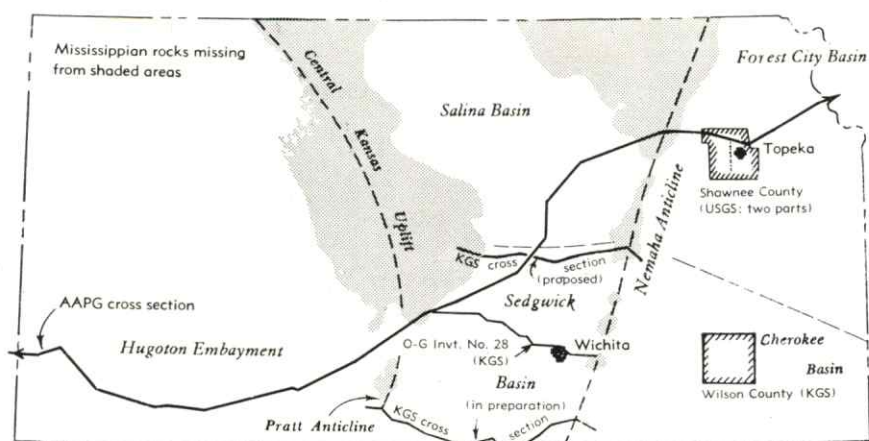
Area investigations:

Wilson County	. . . Areal geology; economic geology (Includes maps)	. . . Report being processed
Shawnee County	. . . Geology of eastern Shawnee County	. . . Reports being processed for USGS publication
	" " " western " "	

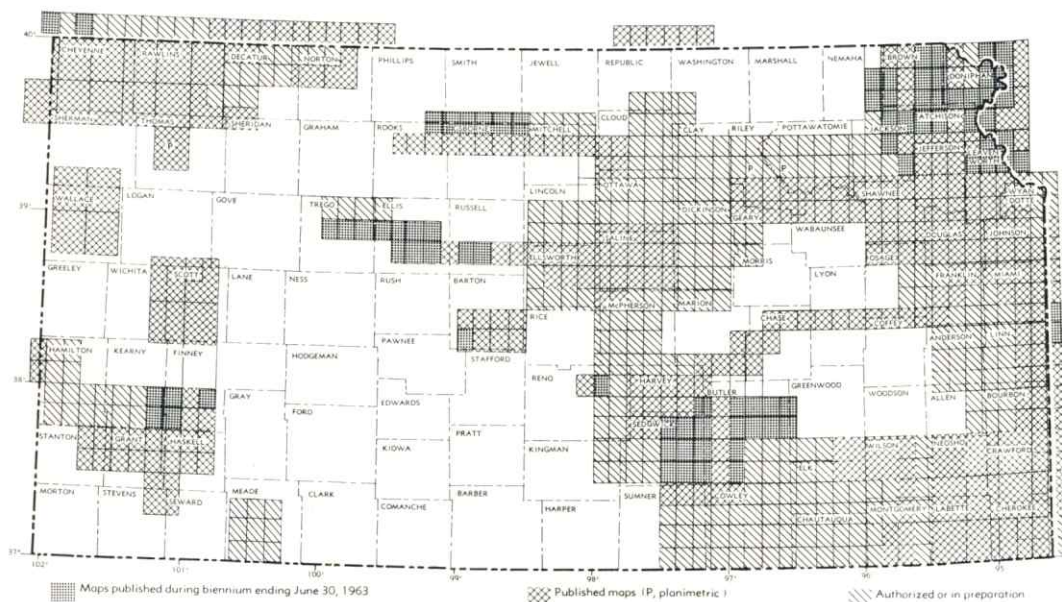
(Coordinate with area investigations, page 14)

Special projects:

Silver City-Rose Dome intrusive, Woodson and Wilson Counties, Kansas	. . . In progress
(Petrographic and x-ray identification of feldspars and other minerals; refer to special studies, page 13)	



Progress map for cooperative Mineral Fuels program. . . . Major effort is directed toward preparation of a series of cross sections showing stratigraphy and structure of subsurface rocks in the Sedgwick Basin, oil-producing province in south-central Kansas. These subsurface cross sections and a segment of a cross section prepared for the American Association of Petroleum Geologists (AAPG) are indicated on the above map and noted in the table at the bottom of the opposite page. Areas of other investigations are located on the map. (See also areal geology and subsurface projects, pages 14 and 15.)



Status of topographic mapping in Kansas as of June 30, 1963. . . . Eighty-one topographic maps of Kansas quadrangles were issued during the biennium ending June 30, 1963, by the United States Geological Survey, mostly in cooperation with State of Kansas agencies. Ninety-seven maps were authorized during the biennium; twenty-three were in final review preliminary to publication at the close of the biennium (list, page 34). A combination base map-topographic map of Kansas showing elevation contours at 200-foot intervals at a scale of 1:500,000 (1 inch equals approximately 8 miles) was also made available during the biennium.

Maps published, 7½-minute series (scale 1:24,000, or 1 inch=2000 ft.; contour interval, 10 ft. with supplemental contours at 5-ft. intervals):

Amoret (Amoret SE)	SIR	Hutchinson SE (Hutchinson 3 SE)	COOP
Amazonia (St. Joseph NW)	SIR	Hutchinson (Hutchinson 3 SW)	COOP
Andover (revision)	SIR	Kirwin SE (Phillipsburg 4 SE)	MRB
Antonino (Hays 2 SW)	MRB	Kirwin SW (Phillipsburg 4 SW)	MRB
Atchison East (Rushville)	SIR	Laird (Wray 4 SE)	MRB
Augusta (Augusta NW)	COOP	Lancaster (Effingham SE)	SIR
Bayneville (revision)	SIR	Leavenworth (revision)	SIR
Catharine (Hays 1 NW)	MRB	Maize (revision)	SIR
Circleville (Wetmore SE)	SIR	Mayetta (Holton SW)	SIR
DeGraff (El Dorado NE)	COOP	Netawaka (Horton SW)	SIR
Deerfield NE	COOP	Oak Mills (revision)	SIR
Deerfield (Deerfield NW)	COOP	Ogallah (Ellis 1 NW)	MRB
Deerfield SE	COOP	Oneida (Sabetha SW)	SIR
Deerfield SW	COOP	Pawnee Rock (Great Bend 2 SW)	SIR
Denton (Effingham NE)	SIR	Platte City (revision)	SIR
Derby (revision)	SIR	Pontiac (Rosalia SW)	COOP
Downs North (Smith Center 4 SE)	MRB	Portis (Smith Center 4 SW)	MRB
Drexel (Amoret NE)	SIR	Potwin (Whitewater NE)	COOP
Easton (revision)	SIR	Reserve (Hiawatha NE)	SIR
Easton SW	SIR	Robinson (Highland SW)	SIR
Effingham (Effingham SW)	SIR	Rock Creek Lake (Benkelman 3 SE)	MRB
El Dorado NW	COOP	Rosalia (Rosalia SE)	COOP
El Dorado (El Dorado SE)	COOP	Rosalia NE	COOP
El Dorado SW	COOP	Rosalia NW	COOP
Ellis (Ellis 1 NE)	MRB	Rose Hill (revision)	SIR
Everest (Effingham NW)	SIR	Russell SW (Russell 2 SW)	MRB
Forbes (Oregon NE)	SIR	Soldier Creek NE	SIR
Garden City East (Garden City NE)	COOP	Trego Center (Ellis 2 NW)	MRB
Gaylord (Smith Center 3 SW)	MRB	Trego Center NE (Ellis 2 NE)	MRB
Goff (Wetmore NW)	SIR	Troy (Oregon SE)	SIR
Gordon (Augusta SW)	COOP	Valley Center (revision)	SIR
Greenwich (revision)	SIR	Victoria (Hays 1 SW)	MRB
Halls (Dearborn NW)	SIR	Wathena (St. Joseph SW)	SIR
Harlan (Smith Center 3 SE)	MRB	Weston (revision)	SIR
Hays North (Hays 2 NE)	MRB	Wetmore (Wetmore NE)	SIR
Hays South (Hays 2 SE)	MRB	Whiting (Horton SE)	SIR
Hiawatha (Hiawatha SE)	SIR	Wichita East (revision)	COOP
Highland NW	SIR	Wichita West (revision)	COOP
Homer (Russell 2 SE)	MRB	Woodlawn (Sabetha SE)	SIR
Horton (Horton NE)	SIR	Yocemento (Hays 2 NW)	MRB

Maps published, 15-minute series (scale 1:62,500, or 1 inch=1 mile; contour interval, 20 ft.):

Atchison (Sugar Lake)	SIR
-----------------------	-----

Maps in final review, 7½-minute series:

Cambridge SE	COOP	Haven NW	COOP
Cambridge SW	COOP	Mankato 3 SE	MRB
Caney SW	COOP	Mankato 3 SW	MRB
Dexter NE	COOP	Mankato 4 SE	MRB
Dexter NW	COOP	Mankato 4 SW	MRB
Dexter SE	COOP	Minneapolis 3 NE	MRB
Dexter SW	COOP	Moline SE	COOP
Elgin NE	COOP	Moline SW	COOP
Elgin NW	COOP	Sedan NE	COOP
Elgin SE	COOP	Sedan NW	COOP
Elgin SW	COOP	Sedan SE	COOP
		Sedan SW	COOP

COOP—Cooperative, U.S. Geological Survey with State Geological Survey and other state agencies.

SIR —Federal Government Surveys, Investigations, and Research.

MRB —Missouri River Basin.



William W. Hambleton, director, and Marian Warriner, research assistant, for GEO-Study.
Participants in Boulder Conference of GEO-Study. (Identified on page 37.)

AGI's Geo-Study—Directed from Kansas

Colleges and universities, geological surveys, and industrial groups from New York to California are involved in or have been alerted to a project called GEO-Study. Students aspiring to be geologists a few years hence will be subjected to and hopefully will profit from the results of GEO-Study. Many of the rest of us have been hearing about GEO-Study, set up early in 1962 by the American Geological Institute and supported by a grant from National Science Foundation.

GEO-Study—Geological Education Orientation Study—came into being at about the time that critics began pointing with increasing frequency to lack of purpose and direction in geology, to obsolescence of curricula in geology, and to a seeming inability of the discipline to attract gifted students. Through GEO-Study, geological education in its present form has been observed critically in the effort to identify ideas, methods, and concepts adaptable in improving geological education. A coordinated report on GEO-Study activities from the spring of 1962 to the fall of 1963 has been prepared for publication by the American Geological Institute; and before long some changes can be expected in college curricula in the earth sciences.

Why should GEO-Study be mentioned in a report on the activities of the Kansas Geological Survey? First, the director of the project, William W. Hambleton, is associate director of the Kansas Geological Survey, in addition to being professor of geology at The University of Kansas. This in itself is recognition of a forward outlook of the geology profession in Kansas. Second, the focus on changing educational philosophy in geology will affect the activities of all geologically-oriented educational, research, and industrial groups, including geological surveys, not only now but later as geologists trained in new concepts take their places in society.

Let us then briefly review GEO-Study. Early in 1962 the American Geological Institute (AGI), a nonprofit professional service organization established and managed by the scientific societies in the fields of geology and geophysics in cooperation with the National Academy of Sciences—National Research Council, developed the GEO-Study project through a steering committee headed by Dr. Hambleton, who also then became the project director. Named to this steering committee were five well-known geologists from leading universities and four *ex officio* members, among them George R. Waggoner, dean of the College of Liberal Arts and Sciences at The University of Kansas.

In the early stages of operation, the GEO-Study group established its purpose, accepting the validity of some of the criticisms of geological education, and named as objectives: (1) to analyze the present status of geologic education; (2) to identify significant trends and develop concepts for improvement of the educational process; (3) to predict changing requirements in geological sciences in the next few decades; (4) to find ways to recognize and encourage students having the temperament and intellect to pursue careers in geological sciences; (5) to formulate a guide to aid faculties in meeting changing requirements; and (6) to achieve the broadest possible involvement of the geological profession by obtaining advice and ideas from other disciplines.

These objectives were used as frames of reference at conferences attended by small groups of men qualified to speak on problems of curriculum improvement in the physical, biological, and behavioral sciences. The conferences were followed by an intensive college-visiting program during the 1962-1963 academic year. In an attempt to determine the nature of the discipline of geology and existing educational practices, ten teams of three geologists visited 44 colleges and universities in all regions of the United States. A preliminary report on the visiting program subsequently was prepared to use as the basis of discussion at a conference in Boulder, Colorado, in July, 1963. The Boulder conference—to which approximately 40 outstanding scientists in the fields of geology, biology, physics, and mathematics were invited—thus inherited the responsibility of shaping a framework to accommodate major changes in the undergraduate curriculum in geology.

To date GEO-Study has functioned to define, as realistically as possible, the nature and character of geology; to scrutinize existing curricula; to predict needs of the discipline. The GEO-Study group has restated what experience and observation have made evident: geology is an interdisciplinary science that depends upon the use of physics, chemistry, biology, mathematics, and other sciences, and has a close affiliation with the liberal arts. In predicting the increased interdepend-

ence of geology and the other disciplines, the group has associated the changing pattern of undergraduate education in the earth sciences with a strengthened background in other disciplines. In the new pattern, courses crammed with unrelated facts and figures and trivia would be replaced by those conveying ideas, concepts, and understandings to give students entrance into the field of geology. The published report of the GEO-Study findings and recommendations should be a guide to the profession in shaping to the changing pattern—in developing courses and other means of implementing changes that need to be made.

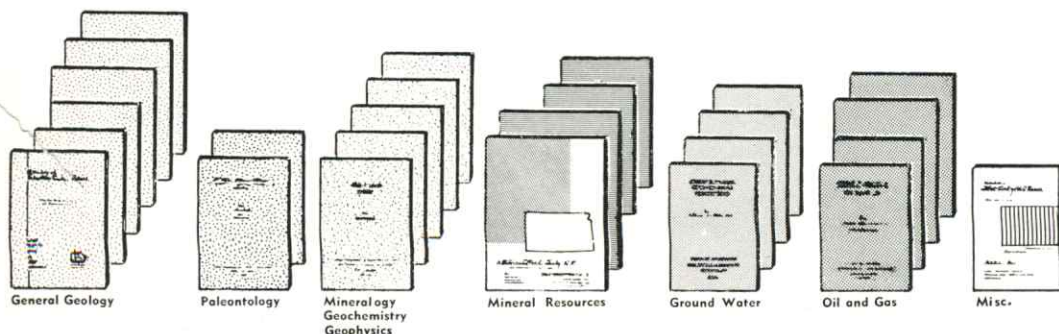
Thus the Kansas Geological Survey, through participation of its associate director as director of GEO-Study, may have a part in revitalizing the science of geology.

Participants in Boulder Conference (picture, page 37): Ian Campbell, state geologist of California; Robert Heller, director of Earth Science Curriculum Project (ESCP) of AGI, Boulder; Frederick Kruger, chief geologist for International Minerals and Chemical Corporation, Chicago; Orlo Childs, president of Colorado School of Mines, Golden; William W. Hambleton, director of GEO-Study.

ACTIVITIES . . . *General*

Services . . . Public Information . . . Special Events

All the people of Kansas—the reason for the existence of a Kansas Geological Survey—are entitled to know about the Survey's activities and to share individually as well as collectively in the services made possible because of these activities. Published Survey reports containing the results of geologic and mineral-resource investigations are a major source of information on the nature of the research and on specific research projects; these reports are available for the nominal charges noted in a list of publications, issued periodically and free on request. The Survey also maintains files of many types of data that accrue from continuing research programs; some files may be consulted directly by the public; some contain information packaged for lending; and most are a reference source for answering letters of inquiry. Thus the Kansas Geological Survey is both a research agency and a library of information on Kansas geology and mineral resources. Major services to the Kansas public during the biennium ending June 30, 1963, are summarized on pages 38-42.



Major categories of the 26 publications issued by the State Geological Survey of Kansas during the biennium ending June 30, 1963. . . . The Survey has published approximately 400 bulletins and special reports on the geology and mineral resources of Kansas since 1895.



MAJOR SERVICES . . . biennium ending June 30, 1963

Publications . . . inquiries

Twenty-six bulletins, maps (not including topographic maps, listed on page 34), and miscellaneous reports issued during biennium (page 43). . . . Approximately 43,000 copies of reports and maps distributed by mail; many also sold over counter at main office in Lawrence and at Wichita Well Sample Library (page 39). . . . Educational materials, including about 1,000 rock sets, distributed free to schools and similar groups. . . . About 16,500 letters, including inquiries on and requests for bulletins on Kansas geology and mineral resources, received and answered.

Mineral resources

Oil and gas. . . . See table, picture, opposite page.

Mineral resources, ceramics. . . . Many mineral producers visited . . . prospective limestone quarries, clay pits, volcanic ash deposits, miscellaneous mineral deposits investigated . . . specific types of clay explored, at request of Kansas clay-products manufacturers. . . . Laboratory services included: soluble-salt determinations . . . acid solubility testing of acid-resistant brick . . . composition for sand-textured and antique-finished brick . . . modification of water-suction rate in bricks . . . oxidation and firing-rate control of drain tile . . . identification of impurities in shale . . . glaze and tile production problems . . . clay-mineral identification . . . methods for bloating volcanic ash . . . Members of the Division of Mineral Resources were instrumental in organizing the Kansas Building Stone Association (officers shown, left). . . . Kansas Geological Survey was co-sponsor—with University Extension, Kansas Highway Commission, and Kansas Limestone Association—of the Fourth and Fifth Kansas Rock Products Conferences.

Ground water. . . . 112 samples of water from industrial, irrigation, and domestic wells tested . . . many citizens and citizen groups given assistance in locating well-water supplies. . . . Ground-Water Division conducted a six-week field course in ground-water hydrology for representatives of five countries—Panama, Haiti, Sudan, Egypt, Turkey; the group was in the United States under the sponsorship of the International Cooperation Administration (photograph, top left).

General geology

Survey geologists made approximately 25 inspections of dam sites and reservoir locations for cities and communities. . . . About 200 rock and mineral samples identified by petrographic examination or x-ray diffraction; about 700 chemical and spectrographic analyses made for Kansas taxpayers and educational institutions.

Foreign hydrologists attended a ground-water school in Kansas in fall of 1961.

Officers of recently chartered Kansas Building Stone Association (KBSA): Charles Lardner, Topeka, president; H. J. Born, Wichita, treasurer; Max Bayer, St. Marys, secretary and resident agent.

They wanted water and got gas . . . at this farm in Cherokee County. A representative of the Kansas Geological Survey was contacted for advice.



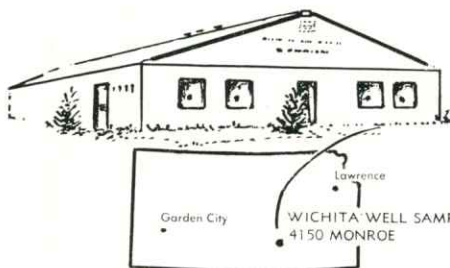
Educational . . . miscellaneous

Several members of staff took part in institutes and workshops for teachers of earth science . . . participated in Kansas Academy of Science conferences on science-teaching improvement in Pittsburg (1962) and McPherson (1963) . . . arranged lecture-visits and tours for school and scout groups . . . planned and directed geologic field trips . . . prepared several exhibits for display at national meetings and for in-state groups . . . judged exhibits at science fairs . . . advised Kansas youth on geology projects. . .

SERVICES . . . OIL AND GAS DIVISION: MAIN OFFICE . . . WICHITA WELL SAMPLE LIBRARY BIENNIUM ENDING JUNE 30, 1963

		1956-57	1957-58	1958-59	1959-60	1960-61	1961-62	1962-63
Visitors . . .	. . . Lawrence office	325	420	440	410	400	400	450
(to consult well logs, study samples, obtain oil and gas data)	. . . Wichita Well Sample Library, 4150 Monroe	565	626	665	854	1,151	1,243	1,320
Requests for well samples . . .	. . . Lawrence office	310	395	460	443	271	306	315
	. . . Wichita Well Sample Library	460	535	540	500	1,613	1,696	1,835
Boxes of well samples sent out on loan . . .	. . . Lawrence office	509	1,099	1,463	867	442		
	. . . Wichita Well Sample Library	960	1,000	600	1,432	3,770	3,899	4,853
Samples and logs on file as of June 30, 1963:								
Sets of samples . . .	. . . Lawrence	19,000	21,000	22,000	22,000	22,000	21,500	21,000
	. . . Wichita	9,500	10,500	18,000	23,000	25,500	39,000	62,000
Electric logs . . .	. . . Lawrence	27,720	30,809	34,178	36,765	39,532	42,632	45,772
Drillers logs . . .	. . . Lawrence	93,000	97,000	101,000	104,700	109,175	112,865	116,281

As of January 1, 1960, all sample-loan requests processed from Wichita Well Sample Library.



The University of Kansas—State Geological Survey Well Sample Library, 4150 Monroe, Wichita. . . . Robert Dilts (in picture) has been geologist in charge since the spring of 1962.

The Wichita Well Sample Library is a major repository for samples, or cuttings, from Kansas wells (refer to table above). During the biennium ending June 30, 1963, approximately 3,900 samples were received from new wells, about 11,900 samples (new wells and donations) were processed, and 8,752 boxes of samples—an increase of 3,550, or more than 68 percent over the previous biennium—were sent out on loan. Also, Geological Survey bulletins are now sold over the counter at this office, a center for distribution of publications and information in central Kansas.

ADMINISTRATIVE . . .

The Kansas Geological Survey is kept vigorous at home and is known abroad by what its staff does extracurricularly in representing the Survey, by what recognitions and honors may be bestowed upon members, and by what associations personnel maintain to keep abreast of professional knowledge and trends. Brief notes on such activities therefore seem in order.

Frank C. Foley, director

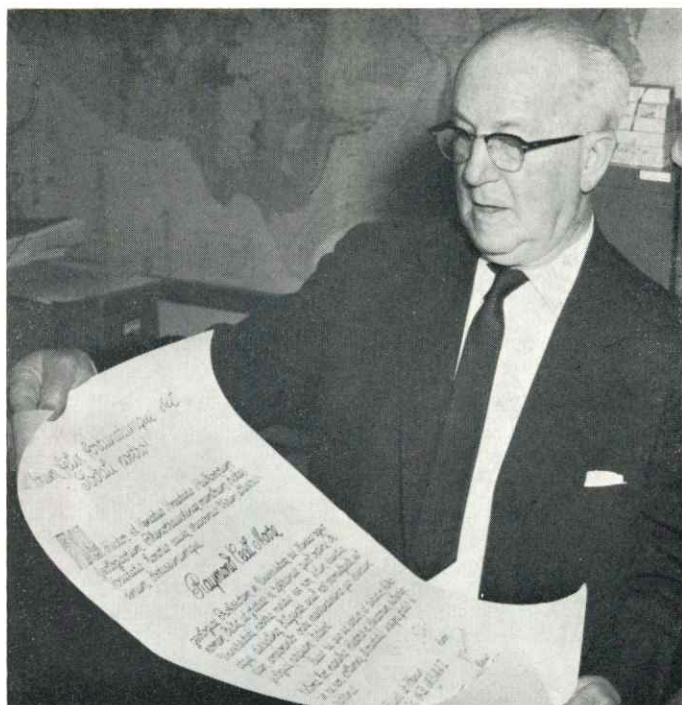
A professor of geology, Dr. Foley continued as chairman of the Department of Geology at The University of Kansas during the biennium, but tendered his resignation of this position in May 1962; William M. Merrill, formerly chairman of the Department of Geology at Syracuse University, accepted the chairmanship, allowing the Survey's director to relinquish this academic responsibility June 30, 1963. . . . Dr. Foley was statistician of the Association of American State Geologists in 1961, vice-president in 1962, and president-elect in 1963 . . . was named co-chairman for the convention of the Geological Society of America to be held in Kansas City in 1965 . . . collaborated with the Kansas Water Resources Board as required by law . . . continued as consultant to Water Resources Council of Kansas Chamber of Commerce . . . worked closely with various state agencies and Oak Ridge National Laboratory in following and evaluating experimental work at Hutchinson and Lyons on possible disposal of atomic wastes. . . . As visiting scientist for American Geological Institute—National Science Foundation, he lectured at the University of California at Riverside and at San Francisco State College. . . . During academic 1962-1963, he was president of The University of Kansas Chapter of The Society of the Sigma Xi, honorary scientific society . . . was a member of the committee that established a master's degree program in Water Resources Science and Water Resources Engineering. . . .

William W. Hambleton, associate director

During the academic year 1962-1963, Dr. Hambleton spent one-half professional time as director of GEO-Study (page 35) for the American Geological Institute (AGI) . . . was a member of the Education Committee of AGI . . . participated in the visiting-scientist program of AGI, having speaking engagements at Earlham College and Birmingham-Southern College . . . represented AGI at Ohio TEPS Conference (National Commission on Teacher Education and Professional Standards) . . . was a member of National Science Foundation (NSF) advisory group on course-content improvement and served on many NSF boards reviewing applicants for science institutes . . . was consultant for National Association of State Directors of Teacher Education and Certification (NASDTEC). . . . In Kansas he served as a research consultant to the Governor's Economic Development Committee and was responsible for preparing a report on economic activity in the mineral and water resources sector (page 17) . . . was a visiting scientist for the Kansas Junior Academy of Science . . . served on a special committee of Engineers in Government Section of Kansas Engineering Society, preparing an analysis and recommendations on Civil Service in Kansas . . . presented papers at annual meetings of several professional societies. . . . A professor of geology at The University of Kansas, he was secretary of the University Senate . . . as a member of the University research committee, helped prepare a report on "Role of Research in the University." . . .

J. M. Jewett, senior geologist

In addition to Survey responsibilities, the major one of the biennium being supervision of work for a new geologic map of Kansas, Dr. Jewett was a member of the geology faculty at The University of Kansas . . . was renamed a member of the Research Committee of the Interstate Oil Compact Commission (IOCC); served on the IOCC steering committee to plan investigation on protection of fresh water from hazards resulting from the petroleum industry . . . was a member of the executive council of Kansas Academy of Science and helped plan an Academy-sponsored conference on fresh-water pollution hazards . . . consulted with army engineers on major dam projects in Kansas. . . .



Raymond C. Moore

The principal geologist became principal geologist emeritus on June 30, 1962, after 46 years of continuous service at The University of Kansas, as teacher of geology and member of the State Geological Survey. For long periods, Raymond C. Moore served as State Geologist of Kansas, Director of the Kansas Geological Survey, and Chairman of the Department of Geology.

A Summerfield Distinguished Professor at time of retirement, Dr. Moore was further honored by the Raymond C. Moore Research Scholarship Fund of \$12,000, presented by former students and friends. Income from the fund, administered by Kansas University Endowment Association, will be used to give one or more scholarships annually to worthy students in the Department of Geology.

In retirement, Dr. Moore is continuing as editor of the "Treatise on Invertebrate Paleontology," a massive international reference work being published by the Geological Society of America and The University of Kansas Press and sponsored by national and international paleontological societies. In the fall of 1962 he was cited for this and comparable work when the Board of Regents authorized a K.U. Paleontological Institute and the Raymond C. Moore Regents Professorship.

Dr. Moore has been affiliated with The University of Kansas since 1916, the year he received his Ph.D. degree in geology from the University of Chicago. During this tenure, his activities have brought many honors to him, to The University of Kansas, to the Kansas Geological Survey, and to Kansas. He is past president of the Geological Society of America, the American Geological Institute, and other professional groups; is an honorary life member of the American Association of Petroleum Geologists and recipient of AAPG's highest award, the Sidney Powers Memorial Medal; has received the Hayden Memorial Geological Award of the Academy of Natural Sciences of Philadelphia; has represented the United States abroad in various capacities and was the first American professor of the physical sciences chosen to represent the Association of American Universities as a visiting professor abroad. He is the author of about 300 publications, including books, textbooks, and technical papers on many phases of geology. Considering further that Raymond C. Moore's achievements extend far beyond the honors and activities here mentioned, one can only comment, "Kansas has been mighty fortunate to have been chosen for a life time of allegiance by this starred man of science."

BASIC GEOLOGY . . .

Stratigraphy and Paleontology
Daniel F. Merriam

Petrography and Geochemistry
Ada Swineford

Cooperative Mineral Fuels
W. D. Johnson, Jr.

Head of Division of Stratigraphy and Paleontology was a member of Field Trip Committee of American Association of Petroleum Geologists (AAPG) and of Kansas Geological Society (KGS) . . . was field-trip chairman for the 27th annual conference of KGS in southeastern Kansas, fall of 1962 . . . spent several months doing computer research at Stanford University, and in connection with this research took part in a symposium on *Computers in the Mineral Industries*, June, 1963; he and two part-time division members presented papers and served as session chairmen. . . . Head of Division of Petrography and Geochemistry continued as member of academic faculty at The University of Kansas . . . was renamed member of Committee on Clay Minerals of National Academy of Sciences—National Research Council; continued as editor, with another division member as associate editor, of *National Clay Minerals Conference Proceedings*. . . . Member of Cooperative Division of Mineral Fuels continued as chairman of Committee on Stratigraphic Correlations of AAPG and served as editor for a regional cross section of Paleozoic rocks from New York to Colorado. . . .

MINERAL RESOURCES . . .

Mineral Resources
Allison L. Hornbaker

Oil and Gas
Edwin D. Goebel

Ceramics
Norman Plummer

Cooperative Ground Water
V. C. Fishel

Head of Division of Mineral Resources presented a paper on fossil spores in Kansas coals at annual meeting of Geological Society of America (GSA) in Cincinnati, 1961 . . . took part in International Palynological Conference in Tucson, Arizona, 1962. . . . Head of Division of Oil and Gas was appointed to Secondary Recovery Committee of Interstate Oil Compact Commission (IOCC) . . . organized a Kansas committee to assemble data on secondary-recovery projects to be incorporated in a publication of IOCC . . . was reappointed member of AAPG Committee for Oil Well Sample Preservation . . . was coordinator for KGS Salina Basin Study Group. . . . Survey was represented on KGS Kansas Nomenclature and Precambrian Basement Committees. . . . One staff member was chairman of Natural Resources Committee for Southeastern Kansas Redevelopment. . . . Head of Cooperative Division of Ground Water, on a 60-day UNESCO mission to North Africa in spring of 1963, was a consultant in a study of groundwater resources of that area. . . . After beginning of fiscal 1963, he was transferred to U. S. Geological Survey Hydrology Section and will be stationed in Tunisia; Robert J. Dingman, who has had foreign service in Chile and Korea, was named head of Lawrence division. . . . Walter H. Schoewe, geologist-emeritus, became editor of *Transactions of Kansas Academy of Science*. . . .

During biennium Kansas Geological Survey was represented at meetings of national, regional, and state geological and affiliated societies, including Geological Society of America, American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, American Ceramic Society, National Clay Minerals Conference, American Association for the Advancement of Science, Midwest Ground-Water Conference, Kansas Academy of Science, Kansas Geological Society, and Liberal Geological Society.



Edwin D. Goebel and J. M. Jewett (seated) are, respectively, members of the Secondary Recovery and Research Committees of the Interstate Oil Compact Commission (IOCC); **W. L. Addison** (standing) is chairman of the Committee on Stratigraphic Correlations for the American Association of Petroleum Geologists (AAPG). Goebel is also chairman of the Committee on Oil Well Sample Preservation for AAPG.

Publications issued by State Geological Survey of Kansas during the biennium ending June 30, 1963

Bulletins

- 152, Part 1 Methods of Chemical Analysis for Carbonate and Silicate rocks: W. E. Hill, Jr., W. N. Waugh, O. K. Galle, and R. T. Runnels. 30 pages. 1961.
- 152, Part 2 Plastic Flowage of Salt in Mines at Hutchinson and Lyons, Kansas: James D. Snyder and Louis F. Dellwig. 16 pages. 1961.
- 152, Part 3 The Mineral Industry in Kansas in 1960: Walter H. Schoewe. 44 pages. 1961.
- 152, Part 4 Relative Ages of Visibly Crystalline Calcite in Late Paleozoic Limestones: John W. Harbaugh. 36 pages. 1961.
- 152, Part 5 Factors Influencing the Precipitation of Dolomitic Carbonates: Frederic R. Siegel. 32 pages. 1961.
- 153 Ground-Water Levels in Observation Wells in Kansas, 1960: Margaret E. Broecker and V. C. Fishel. 183 pages. 1961.
- 154 Geology and Ground-Water Resources of Ottawa County, Kansas: Leslie E. Mack. 145 pages. 1962.
- 155 Oil and Gas Developments in Kansas During 1960: E. D. Goebel, P. L. Hilpman, D. L. Beene, and R. J. Noever. 229 pages. 1961.
- 156 Stratigraphy of the Carlile Shale (Upper Cretaceous) in Kansas: Donald E. Hattin. 155 pages. 1962.
- 157, Part 1 The December 25, 1961, Earthquakes in Northwestern Missouri and Northeastern Kansas: Louis F. Dellwig and Lee C. Gerhard. 12 pages. 1962.
- 157, Part 2 Progress Report of the Kansas Basement Rocks Committee and Additional Precambrian Wells: Virgil B. Cole and Daniel F. Merriam. 11 pages. 1962.
- 157, Part 3 What's new in Volcanic Ash for Industry?: Maynard P. Bauleke. 19 pages. 1962.
- 157, Part 4 Neogene (Plio-Pleistocene) Fresh-Water Ostracodes from the Central High Plains: Edwin D. Gutentag and Richard H. Benson. 60 pages. 1962.
- 157, Part 5 Some Bryozoans from the Beil Limestone Member of the Lecompton Limestone (Virgilian) of Kansas: Ronald D. Perkins, T. G. Perry, and Donald E. Hattin. 25 pages. 1962.
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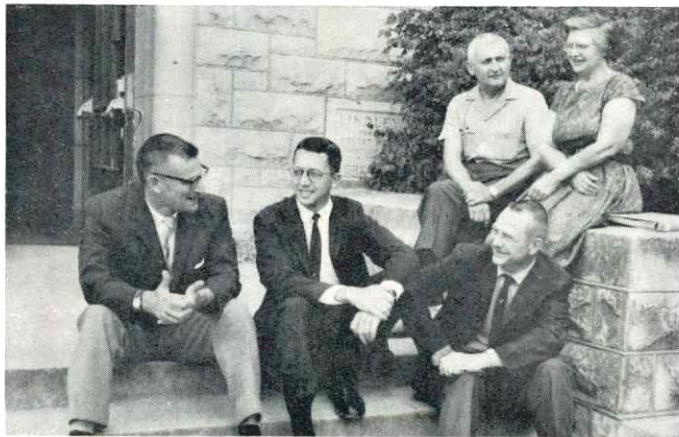
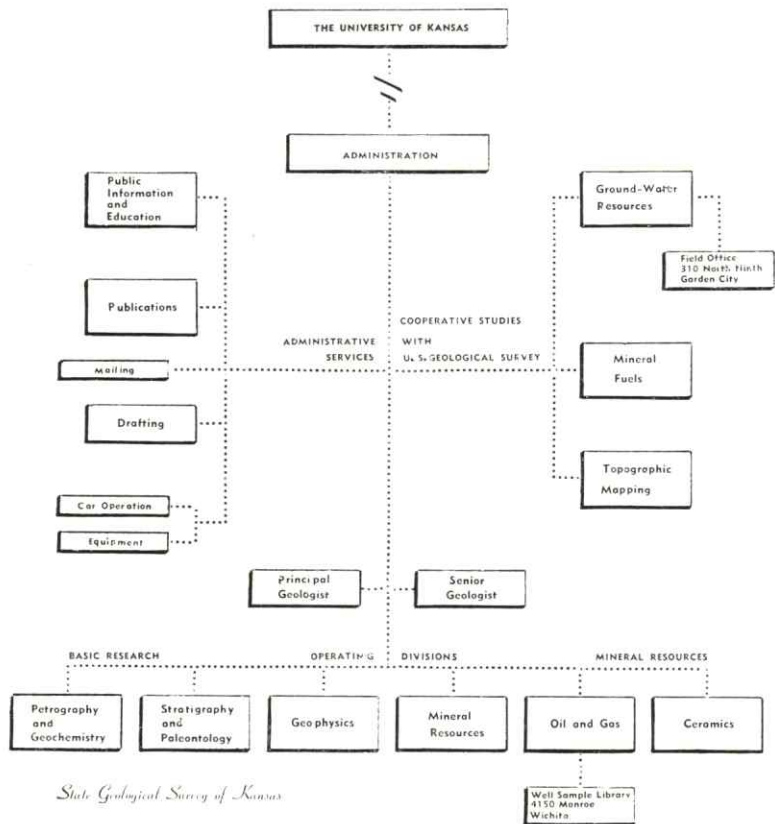
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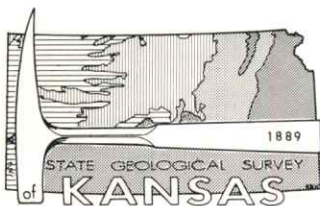
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Additions to Kansas Geological Survey's professional staff during biennium. . . . Front row; Robert J. Dingman, head of the Cooperative Ground-Water Division as of July 1, 1963; Gary Stewart, geologist, Division of Stratigraphy and Paleontology; John D. Winslow, geologist, Cooperative Ground-Water Division. Back row: Ronald G. Hardy, geologist, Mineral Resources Division; Margaret Oros, geologist, Oil and Gas Division. Robert L. Dilts (picture, page 39) was named geologist in charge of the Wichita Well Sample Library.



SPECIAL DISTRIBUTION PUBLICATION 5

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**State Geological Survey
The University of Kansas**