OKLAHOMA GEOLOGICAL SURVEY
Charles J. Mankin, *Director*
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A HISTORY OF THE OKLAHOMA GEOLOGICAL SURVEY 1908–1983

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Cover

Mineral-water spring at Platt National Park (now Chickasaw National Recreation Area) near Sulphur, Oklahoma. Until fairly recent years people came from near and far to drink these sulfurous waters from springs in the area and to bathe in them at the Artesian Hotel. May it rest in peace. Photo courtesy of Western History Collections of The University of Oklahoma.

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Foreword

The author of this history, Elizabeth Awbrey Ham, is uniquely qualified to write about the Oklahoma Geological Survey. Moreover, she is probably the only person who could have done justice to such an account.

Betty first came to Norman in 1937 ("temporarily," she thought) as a graduate student in what is now The University of Oklahoma's School of Geology and Geophysics. While a student at OU, Betty met her husband-to-be, William E. Ham, who was destined to become the Oklahoma Geological Survey's acting director from 1952 to 1954.

Thus Betty Ham, OU, and the Survey have been closely linked for more than 45 years. And certainly Betty is one of the most enthusiastic boosters that the Survey, and the University, has ever had.

Betty was graduated from OU with a master's degree in geology in 1939. After rearing three sons, during which time she exercised her talents in creative writing and performed extensive volunteer work for her church, her University, and her community, she (officially) joined the staff of the Oklahoma Geological Survey, in 1971. She started out as an editorial assistant, and in 1977 she was promoted to associate editor. Now, in addition to her editorial duties, she serves as the Survey's public information officer.

In the pages of this chronicle Betty Ham has mentioned a number of geological scientists who have attained international renown, either while with the Survey or later in their careers. Many readers will recognize them, in addition to the Survey directors, of course, and acting director Bill Ham.

Finally, I would like to acknowledge, with profound appreciation, all the members of the Survey staff who have worked diligently, faithfully, and effectively on behalf of the citizens of Oklahoma. It is to this larger effort and population that this history is dedicated.

—CHARLES J. MANKIN

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Introduction

As of the summer of 1983, the Oklahoma Geological Survey was 75 years old—three-fourths of a century—a year younger than the State it serves. It is time for our own Diamond Jubilee.

It has been recounted many times before, and it is in the records for anyone to read, but it is time to restate the background of our survey: We are as old as the State of Oklahoma. Almost.

Provision was made in the 1907 Constitution of Oklahoma (Article V, Section 38) for the establishment of a "State Geological and Economic Survey." We claim the distinction of being the only state geological survey in the country to have been created under a directive of the constitution of a newly formed state.

The enabling act (Senate Bill no. 75), developed by Charles Newton Gould, was entered into the agenda of the First Legislature, was passed, and was signed into law by Governor Charles N. Haskell on May 29, 1908. "Be it enacted by the People of the State of Oklahoma."

Under the act the objectives and duties of the new bureau would consist of: "a study of the geological formations of the State with special reference to its mineral deposits"; preparation and publication of reports that would include "both general and detailed descriptions of the geological structure and mineral resources of the State"; and "consideration of such other scientific and economic questions as, in the judgement of the Commission shall be deemed of value to the people." The act stipulated that materials collected be deposited in the "State Museum," that the director present a biennial report to the Governor, that persons employed by the bureau be permitted to go on all lands within the State, and that until other facilities be provided, the survey be housed at the State University and be given use of "such rooms, laboratories, libraries and apparatus" as were necessary for carrying out its duties. A biennial appropriation of $15,000 was made to the new bureau.

The enabling act called for the creation of a three-man State Geological Commission that would be composed of the Governor, the President of the State University, and the State Superintendent of Public Instruction, all of whom would serve without compensation and who would appoint as director "a geologist of established reputation," plus necessary assistants. The act contained an emergency clause, making it effective immediately.

Two months later, on July 25, the commission, consisting of Governor Haskell, President A. Grant Evans, and Superintendent E. D. Cameron, met and adopted a resolution setting forth a working plan for the agency. Special instructions for the director, an idea which also had been presented by Gould, stated that the Survey should begin investigations of economic mineral deposits immediately. Gould himself was chosen director, and the Oklahoma Geological Survey was born.

So it all began with Dr. Gould; and it has been going and growing ever since.

Almost.

There was a period during 1923–24 when there was no Oklahoma Geological Survey—after its appropriation was vetoed by Governor Jack Walton. Governor

Walton himself then was vetoed, i.e., impeached and convicted, and the Survey was reinstituted under the Board of Regents of The University of Oklahoma, under whose control the Survey had been placed by a special session of the State Legislature, and so it has remained. In the interim period there was an attempt by the director, Charles William Shannon, to keep work going under a self-sustaining Bureau of Geology. Although the bureau was a financial failure, it did manage to issue a significant bulletin and three circulars, and a state geologic map was put out by private funding during this time. Charles Elijah Decker, professor of paleontology in OU's Department of Geology, acted as custodian of the Survey's inventory during the time of limbo. He performed this function again from 1931 to 1935, when appropriations were also cut off, this time by Governor "Alfalfa Bill" Murray.

Daniel Webster Ohern succeeded Gould as director of the OGS, serving from 1911 until 1914; Shannon served as director from 1914 until 1923; Gould returned to serve from 1924 until 1931; he was succeeded by Robert H. Dott, when the Survey was reactivated in 1935; Dott served until 1952, when he left to join the executive staff of the American Association of Petroleum Geologists; William Eugene Ham was acting director from 1952 until 1954; Carl Colton Branson was named director in 1954 and served until 1967, when Charles John Mankin, the current director, assumed the directorship.

The history of Oklahoma's geological agency actually could be said to antedate Statehood: Both the State of Oklahoma and the Oklahoma Geological Survey were preceded by what is known as the "Territorial Survey." This enterprise is described later in this section.

But the Oklahoma Geological Survey started with Charles Newton Gould—who is well worthy of special notice.

Charles Newton Gould, the "Father of Oklahoma Geology"

Dr. Gould came to The University of Oklahoma in 1900 to found a department of geology.

He didn't really come to found a department (or perhaps he did), and it wasn't a university, and he was not yet Dr. Gould. He came to teach geology with the hope of organizing a department in a young, hopeful, one-building college named "University" for its hopes and for the hopes of its even younger, hopeful, soon-to-be State. He came with only a Master of Arts degree from the University of Nebraska, but, being the man he was, he couldn't leave any of those conditions as he found them.

He started out with a bang.

It was a one-man department with no facilities: borrowed rooms for his classes, no library except his own, no collection except his own, no laboratories, no office of his own, but only a desk in a shared office. But even so, he offered eight courses the first year (Monnett, c. 1964), including not only the standard courses in elementary, advanced, and economic geology; mineralogy; and physiography; but also a course in "commer-

A field party, led by D. W. Ohern, encamped on Verdigris River in 1909. The man on the left holding the ax has been identified as Ohern. The white-shirted, bearded man in front is Charles N. Gould. Others shown include Everett Carpenter, Arthur Reeds, Ben Bolt, and Robert Wook. Photo courtesy of Western History Collections of The University of Oklahoma.

cial geography" and one in "geological biology and paleontology." He initiated a tradition of field trips to the outstanding outdoor laboratory that is the Arbuckle Mountains area, leading expeditions of men and women students first in horse-drawn wagons, then later in trains, to camp out at the field sites. (Yes, Virginia, women studied geology even that long ago. In fact, Gould's sister, Minnie Rose, was enrolled in 1902 in his class.)

His library of 200 books was destroyed in a fire that also took his collection. He began to rebuild his collection partly by obtaining for the department a collection of rocks and minerals he had assembled for display at the 1904 St. Louis World's Fair. Additions were also made from all the field trips he took his students on and from the field work he himself did working summers with the U.S. Geological Survey and the Territorial Survey.

In 1898, when Oklahoma was Oklahoma Territory and Indian Territory, a bill was introduced into the Territorial Legislature by David R. Boyd, president of The University of Oklahoma, to establish a "Geological and Natural History Survey" of the Territory of Oklahoma. What was called the Department of Geology and Natural History of the Territory of Oklahoma was authorized in the same year and was established in 1900 by an act of the Fifth Session of the Legislative Assembly of Oklahoma "for the purpose of beginning and continuing the geological and scientific survey of this territory and of discovering and developing its natural resources, and disseminating information in regard to its agriculture, mining, and manufacturing advantages" (Van Vleet, 1902). Funding was at the munificent levels of $200 per annum in 1899 and 1900 and $300 per annum in 1901 and 1902.

Under the law, the professor of biology at the Territorial university was to be *ex officio* territorial geologist; and A. H. Van Vleet was professor of biology. He was given the title of territorial geologist in 1898 and served until statehood in 1907. But he was no geologist, and to fulfill the obligations of performing a "geological and scientific survey" he needed a geologist.

Since Dr. Gould, Mr. Gould (he was granted his Ph.D. from the University of Nebraska in 1906), was already scheduled to be on the scene as professor of geology, he worked as geologist under Van Vleet, doing field work and publishing geologic and economic reports.

He also worked with Joseph A. Taff and Bailey Willis of the U.S. Geological Survey (USGS) during this period—helping Taff in 1901 to complete work on the Tahlequah Quadrangle and to investigate coal deposits in the Choctaw Nation, and accompanying Willis on a trip through the Wichita Mountains and western Oklahoma in 1902. He spent three seasons in a study of the Permian red beds and published his findings, along with a "General Geology of Oklahoma" and other informative items, in the Second Biennial Report of the Department of Geology and Natural History.

Gould also worked during the summers of 1903 through 1905 as a research hydrographer for the Reclamation Service of the USGS on a program of investigations of the water resources of the Great Plains. This work was published in Water Supply Paper no. 148.

He was chairman of his department, expanded, through 1907, although he took the 1905–06 academic year off without pay to work on his doctorate and travel the country to meet geologists he knew only by reputation and to learn what was going on geologically. He left the department in charge of Elmer Grant Woodruff, who had been hired the preceding year to aid in a growing teaching load caused by increased enrollment. Gould returned to teaching in 1906–07.

It was in 1908 that the legislature of the new State of Oklahoma passed a bill establishing the Oklahoma Geological Survey (as is described above). Charles Newton Gould was named the first director of that Survey.

So he founded both the Survey and what is now the School of Geology and Geophysics at The University of Oklahoma. "The Father of Oklahoma Geology."

He started out with a bang here, too, at the Oklahoma Geological Survey, arranging by telephone within one hour of his appointment for five geologists to begin field work immediately and putting nine parties into the field that first summer. He appointed an assistant director, Lon L. Hutchison, who led a five-man party in a five-county investigation of oil and gas fields. Other field parties during Gould's early directorship were assigned to examinations of limestone, sandstone, clays, building stone, gypsum and salt, granite and gabbro, portland-cement rock, lead and zinc, tripoli, marble, coal, asphalt, more oil and gas fields, and some basic mapping. Much was accomplished during Gould's three-year term; even more could have been accomplished but for monetary and physical limitations.

He continued to act in the capacity of director of the Survey until October 7, 1911, when he resigned to become a consulting geologist in the oil business. With his extensive knowledge of geologic structures and an awareness of the anticlinal potential for oil traps, he was ahead of the game in petroleum exploration.

During this period, geology was only beginning to be recognized as being of value in the discovery of oil. Oil was found by guess and by God, by instinct, by smell, by a feeling in the bones, by doodlebuggers, by luck, or by unidentified skill—not by identifying structural or stratigraphic traps, not by geologists. Ralph Arnold says in 1923 (Arnold, 1923, p. 613) that only a few years before, he had heard the president of a major oil company say, "When the geologist comes in to the oil industry, I go out." The year 1913 marked the approximate beginning of the modern period of oil finding, and at the time Gould entered the oil business his methods must have been about as acceptable to some of his day as "black-box" geology and computers are to some of our time.

But that didn't stop him, and he really did go "in to" the oil industry, making some remarkable discoveries. He was instrumental in locating several significant deposits of oil and gas in Oklahoma. Outside the State, too: It was his work that led to the development of the Panhandle Gas Field in Texas, the South Bend Oil Field in Texas, and the huge Augusta-Eldorado District in southern Kansas. His advice was in demand.

In 1924, however, in spite of the full lives he and his wife, Nina, had been living in the outside world, he reassumed the directorship of the Oklahoma Geological Survey and retained the position until 1931.

During these years, Dr. Gould applied himself to furthering the fulfillment of the mandated duties of the Oklahoma Geological Survey. As Carl C. Branson stated in the *Semi-Centennial Report* (Branson, 1958), Gould "initiated a period of highly significant productivity" in 1924. Results of his dedication and of the efforts of his staff are evident in 27 bulletins, 10 circulars, a geologic map of Oklahoma, and other maps issued by the Survey between 1924 and 1931. These publications include five county reports and several economic-mineral reports—one a long-awaited coal report—as well as numerous basic scientific studies of stratigraphy, sedimentation, structure, petrology, and paleontology.

Gould made a significant statement in his autobiography with regard to the Survey's pursuing such seemingly academic work (Gould, 1959, p. 218). It is worth repeating, because it holds true through the years:

> The principal work of a state geological survey is to find out all that is to be known about the geology and the mineral wealth of a state and to tell the world about it. The work is partly scientific and partly economic, but the scientific investigation must always precede economic development. It is necessary to know the rock strata, their thickness and extent, and what the rocks contain, before any permanent or lasting work can be done on the development of the economic products contained in these beds. This is particularly true of the non-metallic minerals, such as clay, shale, stone, Portland cement rock, gypsum, salt, and glass sand, all of which are so abundant in Oklahoma.

Gould was a true geologist. He wanted to know what was there and, preferably, to learn how it got that way. Applications were fine, great, economic applications; he wanted what he knew to be applied, and he worked toward it. It was the bounden duty of the organization he directed. But he was primarily interested in the geology.

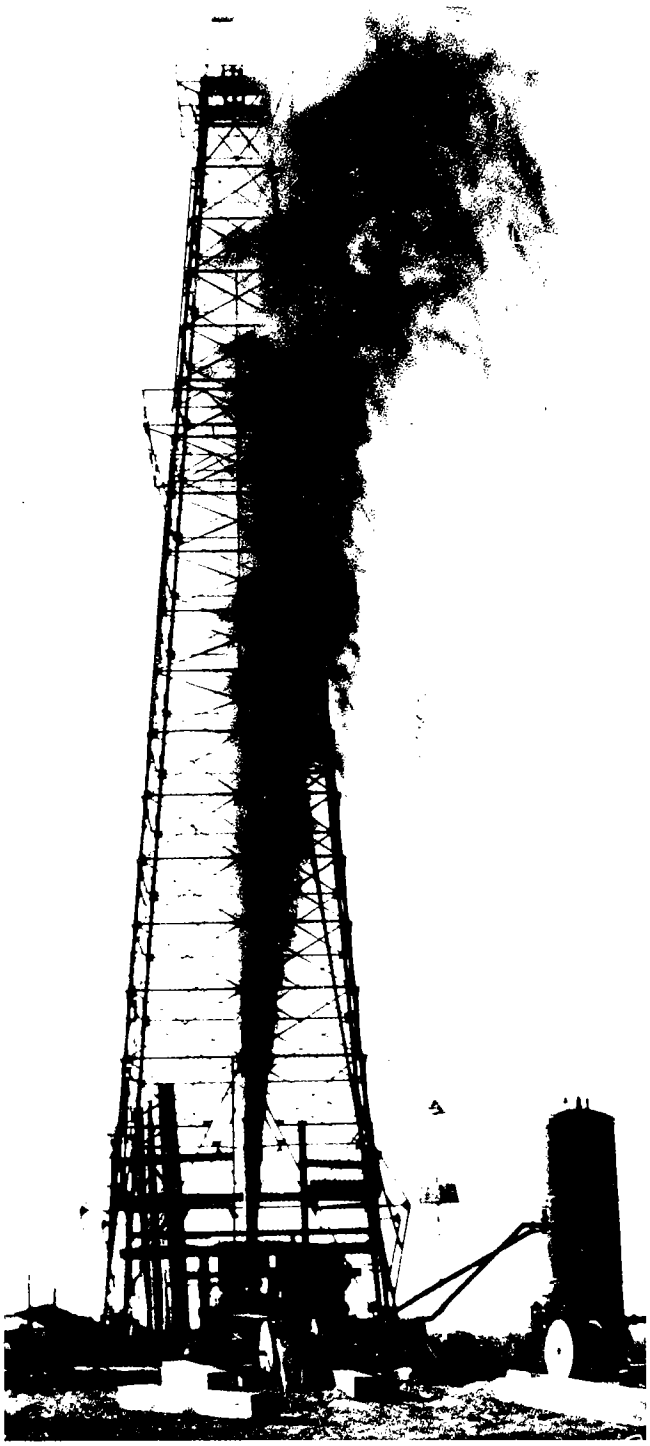
A major contribution of the Survey during Gould's directorship was the massive, multi-volume, multi-authored, county-by-county Bulletin 40 that was published under his aegis in 1928 and 1930, entitled simply, *Oil and Gas in Oklahoma.* It could be updated, but it will never be equaled in scope.

Although that bulletin was enough to send anyone out with flying colors, Gould remained with the Survey until 1931, when the Survey's appropriation was vetoed for the second time by a governor—this time by "Alfalfa Bill" Murray. From 1935 until 1941, Gould served as regional geologist for the National Park Service, and in that job too he left his mark. His work covered nine states: Arkansas, Oklahoma, Kansas, Texas, New Mexico, Utah, Colorado, Arizona, and Nevada. Seven national parks, 26 national monuments. He wrote 251 geological reports for the Service.

There is a mountain in Glacier National Park named for Dr. Gould. There are a great many people who made names for themselves as a result of the training and inspiration obtained from him.

There is a building here on the campus he loved named for him, Gould Hall, the present home of the School of Geology and Geophysics and the Oklahoma Geological Survey.

Unmentioned here for a lack of suitable space, and perhaps because it is inappropriate to our purpose, are



A traditional early-day gusher. Photo courtesy of Western History Collections of The University of Oklahoma.

the honors given to Charles Newton Gould. Unmentioned are the contributions he made to geology in general and in particular. Unmentioned is the fact made obvious in some of his writing that this was one of the greatest boosters Oklahoma ever had: His OGS Circular 3 could be called a paean of praise to his adopted State; his regret is expressed in one article in *Economic Geography,* that the State did not live up to the potential he knew it had as soon as he thought it should.

Unmentioned also is the sensitive feeling he had for people, students, his colleagues, those who worked under him, people he met in passing, people in general, the respect and affection he engendered. He was one of those people. I don't know where you fit that in.

Daniel Webster Ohern

Daniel Webster Ohern and Charles William Shannon

Ohern

Gould met Ohern when both were students at Johns Hopkins University in 1905 during Gould's "peripatetic" (as he calls it) leave of absence from his teaching duties at The University of Oklahoma. Ohern received his doctorate from Johns Hopkins and came to Oklahoma in 1908 to lead a field party for Gould and to teach in the Department of Geology. For three summers he had charge of field investigations in the oil fields of northeastern Oklahoma and worked on the geology and mapping of the Vinita and Nowata Quadrangles in a cooperative project with the U.S. Geological Survey.

When Gould assumed the directorship of the Oklahoma Geological Survey, the original plan had been that he retain the chairmanship of the department as well. But he soon found the Survey position to be more than a full-time job in itself, and upon Gould's recommendation, Ohern was named head of the Department of Geology, with Gould remaining on the faculty with the title of professor. Ohern continued to hold the chairmanship until Gould's resignation from the Survey, when, once again on Gould's recommendation, he was made director of the Survey. Charles H. Taylor, who had come in 1909 to teach mineralogy and economic geology, took over as chairman of the Department of Geology.

Ohern was director of the OGS only for slightly more than two years, October 6, 1911–January 1, 1914. He left to enter the oil business, and with him went Frank C. Buttram, one of Gould's former students who had served as chemist and as geologist for the Survey. (Buttram was the author of Bulletin 10, on glass sands, Bulletin 13, on volcanic dust, and Bulletin 18, on the Cushing Field.) The two joined with other oilmen to form Fortuna Oil Company, and both became wealthy in the industry, as have numerous other former OGS staff members.

With some additions, work done during Ohern's term of directorship was essentially a continuation of that started under Gould. Projects carried forward included investigations of oil and gas, coal, glass sand, building stone, gypsum and salt, lead and zinc, portland-cement materials, rock asphalt, road materials, the geology and mineral resources of the Wichitas and Arbuckles, the red beds, the Neva Limestone, vertebrate-fossil beds, volcanic dust, and the geology of east-central Oklahoma.

Some, in fact much, of the work done on geology in Oklahoma during the early days was done by the U.S. Geological Survey, either alone or in cooperation with the State. The USGS has contributed strongly ever since Territorial times, and many maps and results of investigations of Oklahoma have been published by the federal survey. But 11 bulletins, five circulars, some maps, and some miscellaneous pamphlets were published by the Oklahoma Geological Survey itself through Gould's and Ohern's early periods. Titles of these works can be found in the *Semi-Centennial Report* (Branson, 1958) and in a comprehensive listing issued by the Survey in 1979 that includes the total output of the OGS from Territorial time through 1978 (Ham and Kidd, 1979).

Shannon

Charles William Shannon came to Norman to work for the Oklahoma Geological Survey as a field geologist in September 1911, just before Gould's resignation. He had his academic training in general science, receiving an A.B. in 1906 and an A.M. in 1907 from Indiana University. He remained at Indiana doing further graduate work during the academic year of 1907–08, and then became a science teacher (general science, geography, nature study, botany) in a high school in Brazil, Indiana.

This background is probably the explanation for the appearance in the OGS publication list of circulars called *Trees and Shrubs of Oklahoma* and *Animal and*

Charles William Shannon

Plant Life in Oklahoma (OGS Circular 4 and Circular 6, by Shannon), although Ohern, too, stresses the importance of taking care of our trees and birds (Ohern, 1912a). Not your ordinary geological cup of tea, but worthy. Van Vleet includes the plants, birds, and snakes of Oklahoma in his *Second Biennial Report* (Van Vleet, 1902), but then Van Vleet was a biologist.

Shannon was hired on a per-diem basis by the Survey to complete investigations of the coal deposits—work that had been interrupted by the departure of Lon L. Hutchison—and to prepare a report. The publication of the coal report had been one of Gould's high priorities, and it had been assigned a number (Bulletin 4) in the publication list. Ohern predicted a publication date of 1913 (Ohern, 1912a), but, as things went, Gould inherited the unpublished manuscript of this report when he returned in 1924. The report, updated and revised by Chalmer C. Cooper, became OGS Bulletin 4, but its date is a bit out of order. It bears a date of 1926 in the midst of other bulletins dated a decade and a half earlier. Part of the problem had been a lack of funds for publishing, a problem that has arisen off and on throughout the history of the Survey.

It may be, too, that another part of the problem was that Shannon realized the need for revision. It would have required a lot of work, and he was directing the Survey—and there is a limit. As Gould himself says, "The work of the director of a state survey is not easy. There are a thousand and one things to be done" (Gould, 1959). During part of this time, Shannon was also in the throes of preparing a substantial, inclusive report with Lawrence Emory Trout on *Petroleum and Natural Gas in Oklahoma*, published as Bulletin 19, which probably took priority. (Speculation.)

At any rate, there were 16 bulletins published while Shannon was director, plus a half dozen circulars, and a number of manuscripts were in various stages of completion when things were called to a screeching halt by Governor Walton and his veto of OGS appropriations.

Shannon, as has been said, stayed on to try to keep things going as the unofficial Bureau of Geology, and somehow the classic *Geology of the Stonewall Quadrangle*, by George D. Morgan, was published as a bulletin of the bureau. Two circulars also came into print. The sum of $2,500 obtained by Sidney Powers from Walton financed publication (as OGS Bulletin 32) of a rather remarkable work (for the time), *Geology of the Southern Ouachita Mountains of Oklahoma*, by Charles W. Honess. Private funds, contributed by 260 individuals, administered by the National Research Council and matched by the USGS (Butcher, 1951), made possible the publication in 1926 of Hugh D. Miser's first geologic map of Oklahoma (Branson, 1958). But the Bureau didn't work, even though it offered to prepare geologic reports for a pittance, and so the collection was placed in the custody of Charles E. Decker, who taught paleontology in OU's Department of Geology for many years.

Upon reactivation of the Survey, the State Geological Commission was abolished, and the OU Board of Regents took on the responsibility. Frank Buttram, a member of the Board, a respected petroleum geologist and a former staff member of the Survey, was selected by the Board to find a new director and get things going again. The 30 geologists he called in to help him voted Hugh Miser their unanimous choice. Miser, however, respectfully declined: He preferred to remain where he was, with the USGS. Gould, after some reflection, accepted a second appointment to the position.

Gould Again

Gould really inherited a "bear" the second time around, and he has quite a bit to say on the subject of "political interference with scientific work": "The lost motion, the cessation of activity, the loss of interest on the investment which the state had made. The lack of continuity of service." And so forth. (Gould, 1959.)

He started by publishing what was on hand in a state of readiness, beginning with county reports on Cimarron County (by Edgar Paul Rothrock) and Love County (by Fred E. Bullard), and he kept on. As Gould says, his motto was, "Get as much geological information as possible to as many people as possible, in the shortest time possible, at the lowest possible cost."

So that is what he did. The record is in the publication lists: not only the massive Bulletin 40, but 26 other bulletins and nine circulars were issued before appropriations were cut off again in 1931.

So things went into the custodial hands of "Daddy" Decker once more and remained there for four years.

One bulletin, however—Bulletin 56, on *The Miami-Picher Zinc-Lead District, Oklahoma*, by Samuel Weidman, professor in the OU Department of Geology—was issued in 1932 under a cooperative agreement with the University of Oklahoma Press, which published and sold the book. This is the only publication printed from June 1931 until 1935.

The Survey and the Development of Mineral Resources in the Early Years

Ever since its establishment in 1908, the Oklahoma Geological Survey has been a leading force in the development of mineral resources in the State, but work done on mineral resources in the early period of the Survey was of necessity preliminary, as Dott says (Dott, 1936), and much of it could be classified as reconnaissance, exploratory.

There was not really very much known about the new State. Early expeditions that yielded geological information were made into the area in the 19th century by Thomas Nuttall, Dr. Edwin James, Capt. Randolph B. Marcy, Lt. A. W. Whipple, and Jules Marcou. The USGS did topographic mapping and geological investigations in 1895 in Indian Territory. Joseph A. Taff, Robert T. Hill, Noah F. Drake, Francis W. Cragin, and other USGS geologists did a lot of reconnaissance mapping and investigated minerals, the red beds, the Arbuckles, the coastal-plain geology of southern Oklahoma, the coal fields, and the Wichitas; but still there was little to go on in developing resources. There was only a background to start from. It was a challenge.

The early directors took it as a challenge and also as an opportunity. They were extremely optimistic, except for Van Vleet, who was tentative only.

Van Vleet (1902) only mentions the possibilities for development of deposits of clay, gypsum, salt, and building stone. There was too little known, transportation was inadequate, fuels for industry had not yet become available in Oklahoma Territory. There was too little known. He realized that salt was plentiful, that "Oklahoma has plenty of building stone of excellent quality," that the raw material (clay) was there for future manufacture of brick and tile. Gould, during this same time, had made an extensive study of the red beds and their gypsum deposits and concluded that "the gypsum deposits of Oklahoma are practically inexhaustible" (Gould, 1902).

Gould was the "true believer," an eternal optimist when it came to the potential of his State: "No state in the Union possesses a greater variety or larger amount of undeveloped mineral wealth than does Oklahoma" (Gould, 1911). Fuels (oil, gas, coal), asphalt, lead and zinc, gypsum, limestone and sandstone for building, clay, tripoli, volcanic ash, novaculite, even "considerable deposits of high grade manganese ore," and iron—Oklahoma had them all.

He was also something of a realist. Oklahoma imported nine-tenths of its manufactured articles, and this was not good: You had to pay cost plus transportation. Even salt, lime, brick and other clay products, granite, plaster from gypsum, portland cement, asphalt, glass—

A group of aspiring women geologists on a Woodford Shale outcrop in the Arbuckle Mountains in 1911. The photo is from L. Maimie Brady's 1911 B.A. thesis, which was directed by Ohern.

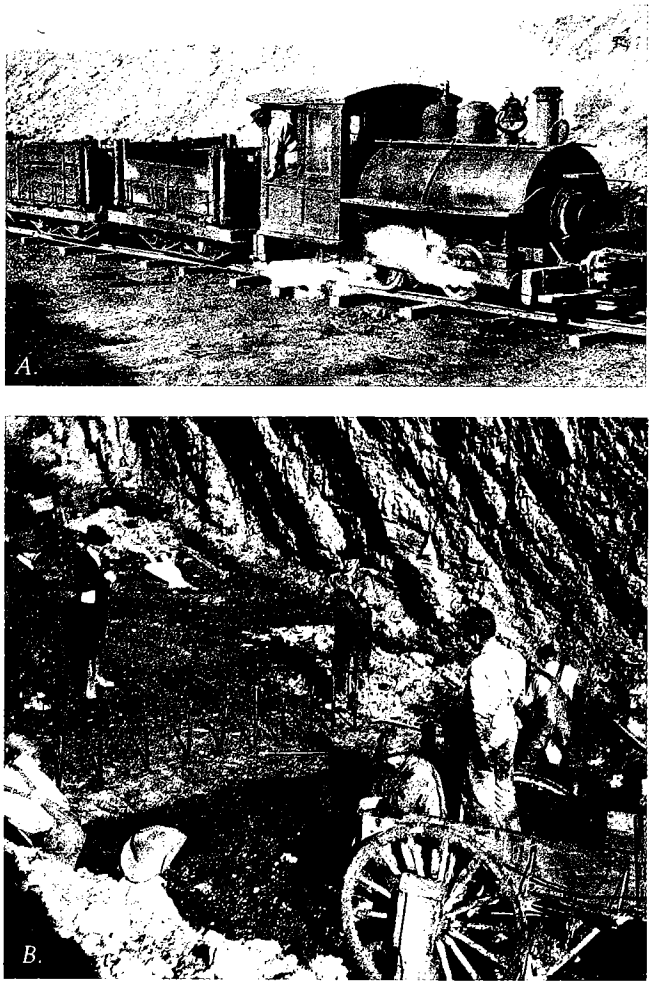
all available in the State—were imported, freight added. Gould realized you had to sell the people of Oklahoma on doing their own processing of resources. But before convincing investors to put capital into developing the resources there had to be valid and specific information on the resources, so he set about to get that information. The minerals investigated by field parties under Gould have already been listed, as have those examined under Ohern's direction.

Ohern, in his biennial report (Ohern, 1912b), seems most impressed by the growth in production: "the advance has been steady but so rapid as to be little short of phenomenal." He presents figures to show that from 1901 through 1911 there had been an increase of 839 percent in the value of mineral production. Most of this increase, of course, is attributable to petroleum and natural gas, but production of other minerals contributed: coal, lead and zinc, gypsum, limestone, sandstone, granite, clay products, portland cement, lime. Coal production, however, was a disappointment.

Shannon restates Ohern's figures. He also states the obvious fact that Oklahoma needed facilities (factories, mills) to process the mineral deposits the Survey and others were discovering. It is one thing to help an operator by providing information on deposits. As Shannon (1914a) says, "At the present time there is scarcely no [sic] available source of information on the mineral resources and natural history on the State, except such as can be furnished by the Survey." It is another thing to sell a deposit by attempting to convince a potential investor of its worth. Shannon says of the Survey: "It endeavors in every way possible to bring these materials to the notice of investors and to interest capital in their development."

It is unfortunate that the State geological survey was put into the position of promoting minerals and industrial development at that time, when it could have been using all its energy in basic scientific investigations [editorial comment].

Shannon recognized that fuels were basic to this development. Although publications came into print during Shannon's time with information on lime, granite, tripoli, volcanic ash, building stone, lime, and portland-cement materials, efforts during Shannon's tenure were strongly oriented toward the fossil fuels.



Surface coal mining by Haskell Coal Mining Company in Stigler Field in Haskell County, Oklahoma, in 1919. A. "Dinky" engine pulling cars of loaded coal. B. Miners breaking and loading coal into mule-drawn wagons. The man on the left in the business suit is S. C. Awbrey, father of the author.

Coal

Coal was the first of Oklahoma's minerals to be produced in quantity, and with coal the leading source of energy in the world at the time and apparently plentiful in Oklahoma, it offered the greatest promise for economic development in the State.

The presence of coal was recognized in Oklahoma by early 18th- and 19th-century explorers, and it was utilized domestically on an extremely local basis by the Indian residents of the area, who dug it by hand and sold it by the basketful. Commercial coal mining began in Indian Territory near McAlester in 1872 with the completion of Missouri, Kansas, and Texas railroad lines through the region. The Osage Coal and Mining Company put in a branch line and began operation the following year. Mining began in the Savanna and Lehigh districts in 1881. The coal brought in other railroads, and that resulted in the production of more coal, a chain reaction. The first official, published record of production of coal in the State is in the 1880 U.S. census (120,947 tons). By 1900 almost 2 million tons was produced, and production continued on a wavering upward course until 1920, following World War I, when a peak was reached with a yield of 4,849,228 tons. By the end of Shannon's term, production had declined to 2.8 million tons, and it was at about the same figure at the close of Gould's second term.

Although papers on Oklahoma coals were published in journals and elsewhere in the last decade of the 19th century and the first decade of the 20th century by H. M. Chance, J. J. Stevenson, N. F. Drake, David White, Joseph A. Taff, C. R. Keys, G. I. Adams, Franklin Bache, and W. R. Crane, much of the work done on Oklahoma's coal fields during that time was done and published by the U.S. Geological Survey.

Among USGS contributions were folios on the Coalgate, Atoka, Tishomingo, Tahlequah, and Muskogee Quadrangles—large, slim volumes that incorporate topographic and geologic maps and information on geology and mineral resources. The 19th, 20th, and 21st annual reports of the USGS, published in 1899, 1900, and 1902, contain reports on the Oklahoma coal fields by Taff, one in collaboration with Adams. The USGS made other contributions also, some done cooperatively.

But ever since its establishment, the Oklahoma Geological Survey has conducted investigations of coal deposits, the coal industry, and coal production.

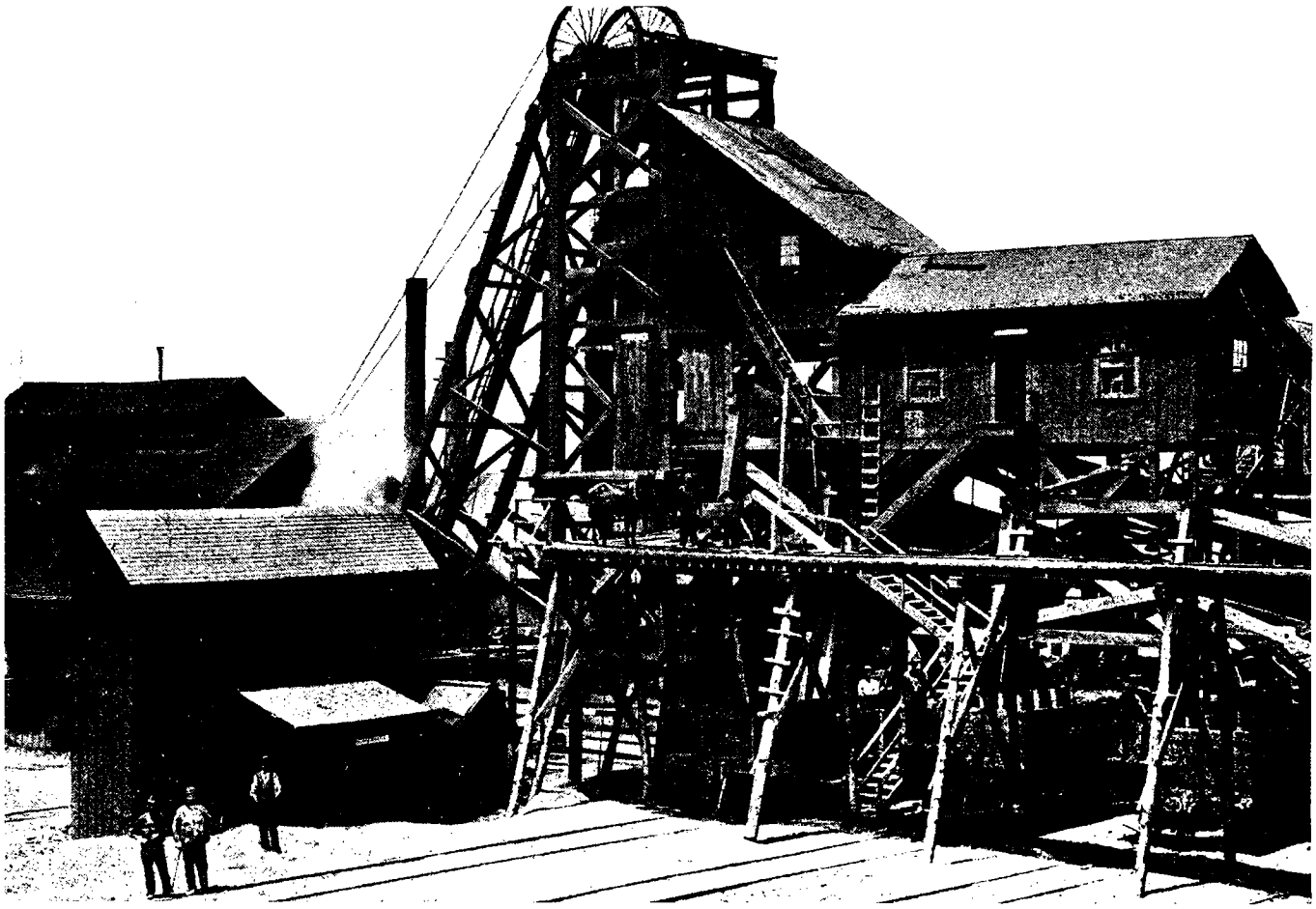
To summarize:

In 1908 one of Gould's first field parties (which started out under H. A. Everest but was placed under Ohern upon his arrival) went into Osage, Washington, Nowata, Craig, Rogers, and Tulsa Counties to study coal deposits, among other things; Ohern led another group into northeastern Oklahoma the following year for similar purposes. Low funding limited field work in 1909 and 1910, but cooperative projects with the USGS kept things going, including the mapping of the Nowata Quadrangle by Ohern and the Pawhuska Quadrangle by USGS geologist Carl C. Smith. Ohern led another party over Craig County in 1911 in a cooperative project with the USGS to investigate mineral resources, including coal. Shannon's extensive work on Bulletin 4, *Coal in Oklahoma*, was started during Gould's first term, although the project itself was begun earlier by Lon L. Hutchison, who left it unfinished when he departed the Survey.

This work was continued under Ohern, who says that Shannon "has visited every mine in the coal area." Calorimetric and chemical analyses of the samples collected were done in the OGS laboratory, and Ohern had every hope the report would be in print by February 1913. (This is the one that was published in 1926.) But the information was on file, and some of the results of analyses are included in Shannon's 1914 biennial report, as is information on the coal in general.

Other published information issued by the OGS on coal during the early period is found in Luther C. Snider's Bulletin 17 on east-central Oklahoma, in John S. Redfield's Bulletin 42 on mineral resources, in Victor Clark Searle's Bulletin 51, *A Chemical Study of Oklahoma Coals*, and scattered throughout other publications.

Ohern, as has already been touched on, was quite concerned about coal—the waste, the inefficiency in mining, the low rate of growth of production, the unreasonably high cost of Oklahoma coal in compari-



Early-day workings of an underground coal mine of the McAlester Fuel Company near McAlester, Oklahoma. The shaft was 490 feet deep, and the capacity of the mine was 500 tons per day. Photo courtesy of Western History Collections of The University of Oklahoma.

son with other Mississippi Valley coals, the industry in general. Also, the coke industry, which he thought should be thriving, had become virtually extinct in Oklahoma. Coke, made from slack processed in beehive ovens, was produced in Oklahoma in pre-statehood days, and the industry had been thriving. But a decrease in demand for this kind of coke, coupled with an increase in demand for slack for steam production and also the incursion into the energy field of the burgeoning natural-gas industry, led to a rapid decline, and by 1908 Oklahoma's coke industry was essentially defunct.

The effect of the development of petroleum and natural gas on the coal industry was predicted as early as 1902 by Taff in his report on *The Southwestern Coal Field* (see references), when he said, "The extent to which this liquid fuel will replace coal can not at present be estimated, but it will be extensive." A true prophecy, and it was fulfilled early. In 1900 coal and coke represented 90 percent of Oklahoma's mineral production; by the end of Gould's second term, 2.5 percent of production was from coal and 90.4 percent from petroleum and natural gas.

But the coal industry has made and is making a significant contribution to the economy of the State, and the Oklahoma Geological Survey has shared significantly in this contribution.

Petroleum and Natural Gas

The earliest reported oil discovery in what is now Oklahoma was in 1859, the same year Col. Edwin L. Drake drilled his famous commercial well near Titusville, Pennsylvania. But this oil discovery was accidental. A well drilled for salt in the Cherokee Nation struck oil instead, and the well flowed at the rate of about 10 barrels a day for the span of a year (Franks, 1980, p. 3).

Commercial drilling for oil in Oklahoma really began in 1884 with the drilling of two wells near Tahlequah and Atoka by the Choctaw Oil and Refining Company, a company created by an act of the Choctaw Council. The wells produced only a "show," but it was a beginning. Cudahy Oil Company drilled two promising wells near Muskogee in 1894 and had leases on 200,000 acres near Bartlesville, where they were drilling several wells, but drilling was discontinued for legal reasons. In 1901, following the opening of the Red Fork-Tulsa district, production in Oklahoma was 10,000 barrels; in 1903, 138,911 barrels was produced with most coming from the Osage Nation and the Cherokee Nation. Following 1904, when restrictions imposed by the Curtiss Bill on leasing of "unproved lands" were lifted, production started taking off, rising to 161 million barrels by the end of Shannon's directorship.

Natural gas was found in small quantities in 1882 and was produced for domestic purposes at Red Fork in the Creek Nation in 1902. Commercial production really began in 1904 and rose to more than 203 million cubic feet in 1923.

The Oklahoma Geological Survey was there from its inception, but not the Territorial Survey. Van Vleet in his 1901-02 biennial report seems almost uninterested and strangely unaware, saying only that there had been frequent newspaper reports of discoveries of oil and gas, that there were as yet no wells that "furnish these products in paying quantities," and that knowledge of the "depth of oil-bearing strata . . . would prevent much waste of money in foolish experimenting."

Gould, on the other hand, made it one of his first acts to send a party of four men into the field to Tulsa, Creek, Okmulgee, Muskogee, and Wagoner Counties to investigate the oil and gas fields. Leader of the group was Lon L. Hutchison, whom Gould had appointed assistant director. A second field party under Herbert A. Everest went to the northern part of the oil fields in Osage, Washington, and Nowata Counties. Ohern arrived on the scene that first summer and was dispatched to spend the remainder of the summer in the oil and coal fields, where he took over Everest's group. The next summer Ohern led a larger party over the oil fields in the northeastern part of the State, while Hutchison investigated the asphalts of southern Oklahoma. Hutchison's inclusive report on these asphalts is incorporated in OGS Bulletin 2, with a 162-page résumé containing most of what was known about the subject at the time. This work of Hutchison's is the first really comprehensive publication on the subject.

When he became director, Ohern sent himself into the field to study the structure around Healdton, where a well had already been brought in, and to prepare preliminary reports to be used in recommending additional localities. Snider, assistant director under Ohern, worked on the geology in east-central Oklahoma with reference to oil and gas. His work is included in Bulletin 17. L. E. Trout worked in the Blackwell vicinity, interpreting structures that would lead to further discoveries in that area. Buttram and Dean M. Stacy conducted special investigations in the oil fields of the State, acquiring information to help in answering inquiries that, by then, were coming thick and fast.

Publications on oil and gas issued under Ohern's short directorship included, in addition to Bulletin 17 and material contained in his annual report, a bulletin on the Ponca City Field and another on the Cushing Field.

Shannon's major contribution in petroleum and natural gas was the two-part Bulletin 19, published in 1917. Gould notes that the publication was soon sold out and that copies, when they could be found, were going for $50 each (Gould, 1959). The early publications of the Survey were made available without charge to the taxpayers, while at a later date reimbursement for postage was requested. (Survey publications are now sold at cost.)

Three circulars on petroleum were published under Shannon—one a correlation of oil sands (Circular 7, by Fritz Aurin), another on exploration methods (Circular 8, by George E. Burton), and one on rocks of the Hunton sequence (Circular 10, by George D. Morgan).

It might be noted here that Ralph Arnold, in his recapitulation of developments in petroleum geology in the first two decades of this century (Arnold, 1923), singles out work done for the Oklahoma Geological Survey by Gould, Buttram, Hutchison, Ohern, Shan-

non, and others as noteworthy contributions by State agencies.

In addition to published and unpublished results of investigations in petroleum and natural gas, the Survey maintained a well-log file during the early years, a file of newspaper clippings on oil development in more than 2,000 sections, a continuously updated oil and gas map full of color-coded pins, and a production-record book—all of which were available to the public. The Survey also issued oil and gas maps at irregular intervals during this period: 1908, 1915, 1926, 1928, 1931.

Water

Water resources have been a major interest from the first. Van Vleet (1902) mentions that "the United States Survey is making very thorough investigations as to the water supply of Oklahoma." These studies were made possible by the allocation of funds acquired through the sale of public lands to develop irrigation. The Territorial Survey, however, was mostly occupied with reconnoitering economic-mineral resources. Van Vleet didn't have any "specialists and high-priced experts" to work on water resources.

Gould took office in a period of drought and received many requests for assistance in finding water. The Survey answered every request and tried to help. Sometimes the new Survey was able to help individuals and communities by locating underground sources— "artesian," as Gould calls it. Sometimes they were merely able to save the expense of drilling where no water could possibly be found (Gould, 1910b).

Ohern also received many inquiries about the availability of water and says, "There is urgent need of immediate, specific information on the underground and surface water." He states that the Survey collected information on water in the process of mineral-resources investigations and that there was a great deal of useful data on the subject accumulated in the files. But he recommended also a thorough study of surface and subsurface waters as well as examination of potential reservoir sites (Ohern, 1912a).

Shannon, in his time, having received hundreds of requests about water supplies, was even more concerned about the necessity for information on water resources (Shannon, 1914a). He laments the lack of specific information "in such form that it can be readily used by the average citizen," in spite of work that had been done by the USGS, which, except for a report by Gould and one by A. T. Schwennesen, he considered to be much too general. Shannon didn't care who did the work, be it the OGS or some other "Department of State," just so it was done and done soon.

Work done by the OGS consisted of a number of investigations of reservoir sites and analyses of some surface waters, well water, and spring water. Also, Shannon sent a party of two, E. V. Woolsey and L. G. Hurst, to make a general survey of the Canadian River—its surface and subsurface water from the Norman bridge to the Texas border, flooding, flood damage, depth to water table, water usage, and stream changes.

The hazards of early-day field work: deep sand and unpaved roads. Photo courtesy of Western History Collections of The University of Oklahoma.

Conservation

It is interesting to note that Gould, Ohern, and Shannon all had a strong feeling for the need for conservation, this at a time when natural resources must have seemed virtually inexhaustible to many. If one deposit ran out, there would always be more to be found; if gas was in the way, get rid of it, vent it into the air:

Gould: "One can not drive anywhere through the gas field of northeastern Oklahoma without being shocked at the prodigal waste of fuel now going on. . . . At the present time in Oklahoma a vast amount, possibly hundreds of millions of cubic feet a day of the best fuel the world has ever known, is permitted to escape into the air" (Gould, 1910b).

Ohern was most concerned about coal: "It has become very apparent to members of the Staff in pursuing field investigations that Oklahoma is wasting her natural resources. This is especially true of our coals . . . there is an enormous waste now going on" (Ohern, 1912a). He attributed the situation to inefficient mining methods in part, "shooting from the solid," which shattered the lump coal and resulted in a high percentage of slack, much of which was unusable.

Shannon: "The need of conservation is apparent to members of the Survey. In their investigations it is found that great waste is going on in connection with the development of our natural resources. There is scarcely a line of work where waste is not evident" (Shannon, 1914a). He points to waste of coal, oil, natural gas, soils, forests, and animal life, especially birds.

So it really isn't new, the awareness of a need to conserve natural resources.

Public Service

Included in the "general instructions to the Director of the Geological Survey" that were adopted at the organizational meeting July 25, 1908, were directives to "answer all reasonable inquiries relative to the mineral resources of the State;" to "assist the colleges and high

schools in making collections;" to "disseminate as widely as possible, particularly by correspondence and public addresses" information on rocks, minerals, and ores; and to analyze without charge specimens that might contain valuable minerals or that would "further the work of the Survey."

A rather large order, but such public service has been offered since the beginning—with necessary reservations.

The Survey couldn't go out and examine every mineral prospect on which the owner thought he had found the end of the rainbow. As Shannon (1914a) says, "the entire time of the staff and field men would be consumed." But if 50 taxpayers ("freeholders") of a community entered petitions, a geologist would be sent. Besides restraining themselves from going out on wild-goose chases and wasting everybody's time, money, and energy, the Survey, especially in these early years, had to be sure its name was not taken in vain by a get-rich-quick promoter who claimed falsely to have the Survey's stamp of approval. This danger was mentioned by Gould, Ohern, and Shannon in turn.

But many valid investigations of deposits were made on request, every inquiry received a response, and any specimen brought or sent in was examined without charge and, if deemed worthy, was analyzed. If assaying was involved, however, the prospector was referred elsewhere.

In further service to the public, the Survey made itself active in educational work, providing sets of rocks, minerals, and fossils as well as sets of maps and bulletins to high schools and colleges. Geologists delivered lectures to business groups, popular audiences, schools, colleges, and clubs, and prepared and staffed exhibits at the State Fair. The Survey also prepared reports on the physiography, trees, flowering plants, and birds of the State.

Housing

According to the act that created the Oklahoma Geological Survey, the new bureau was to be housed at The University of Oklahoma:

> Section 7. Until suitable laboratories, libraries and testing apparatus are provided by the State for prosecuting the work of the survey, said survey shall be located at the State University. The commission shall enter into arrangements with the Board of Regents of the State University for the use, by members of the staff of the survey, of such rooms, laboratories, libraries and apparatus as may be necessary for the carrying on of such work.

But there was no room on the campus, which was still trying to recover from a fire that had destroyed the Administration Building. Departments were already crowded onto each other, and Gould settled the new Survey into four rented rooms near his home.

The following year, 1909, the Department of Engineering moved into a new building and the Survey moved into a wood-frame building that had housed the engineers. Here the OGS had a whole "suite of rooms," which Gould describes as being "fairly well adapted to the requirements of the bureau" (Gould, 1959). There were offices for the director, the assistant director, and the draftsman; a chemical laboratory; a library; a general work and preparation room; and a storeroom. Luxury. But the wooden building went the way of many wooden buildings of the time: It burned down.

Of what was left, what could be recovered was moved into another frame building, one of the temporary buildings on campus, which Ohern does not describe as "well adapted." He describes it as being very cold in the winter and very hot in the summer and says, "The work is seriously handicapped by lack of adequate facilities, especially laboratories" (Ohern, 1912a).

In 1913 the Survey moved into the basement of the old library, the Carnegie Building, where there was an office for the director, three small offices for staff, a general office and library, and a drafting room. The rest of the Survey was scattered across the campus. The chemical laboratory had two small rooms in a temporary building, which also housed the office and workshop of the ornithologist. (An ornithologist in the OGS? That was Ed Crabb. There were also five men on Shannon's staff working with flowering plants.) The museum was in Monnet Hall, the old law building. Supplies and field equipment were stacked here and there—under the bleachers in the athletic field, in another frame building, and in other places.

Shannon, too, was upset about the facilities. He quotes Ohern's words on the situation and adds, "This inadequacy causes much loss of time and detriment to property." He goes even further and says, "A new and separate building is needed on the campus of the University for the work of the Oklahoma Geological Survey" (Shannon, 1914a).

They didn't get that, but in 1917 an appropriation of $100,000 was made for a building to house the Survey and the Department of Geology. (This building is now Carpenter Hall, just north of the Oklahoma Memorial Union on Asp Street.) The building was ready in 1919 and, according to Gould, "the survey had ample quarters for offices, laboratories, and library" (Gould, 1959).

But during the time when the Survey was not functioning, 1923-24, the Department of Geology had expanded into the space. Gould says, "Gradually this matter adjusted itself." It must have taken some doing to make that adjustment. The Survey's occupation of the space in the geology building (six offices and a small basement laboratory) lasted until 1952, when a grand, new building, Gould Hall, was finished. Gould Hall. The new geology building, now not so new. That's where we are now.

Once again adequate—except for storage space. And an industrial laboratory.

During World War II, two U.S. Navy bases were established in Norman, and some 30,000 dry-land sailors were quartered on the North Base and the South Base. At the end of the war, these facilities became available to the University and became the North Campus and South Campus. Fine.

The Survey's Industrial Research Laboratory moved into a large concrete-block building on the South Campus in 1947, and new equipment was added. There was also space in three adjacent small buildings for storage of OGS materials and of USGS Ground Water Branch materials, plus work space and space for a spectrographic laboratory.

Late in 1951, the base was reactivated, however, and equipment had to be dismantled, shelves torn down, and everything packed up for storage in a garage that belonged to OU's physical plant. The Research Laboratory had to be deactivated.

Well. As for the rest.

It took three weeks to move into the new building in 1952 after shelves, a switchboard, and other equipment had been installed. The move entailed transporting and reestablishing 12 truckloads of publications, 25,000 aerial photographs, 40 filing cabinets well loaded with correspondence, field data, specimens, photos, maps, more specimens, 40 years of maps prepared for compilation into a new State geologic map, hundreds of thousands of samples, office and technical equipment, book collections, and miscellaneous items. Quite a job.

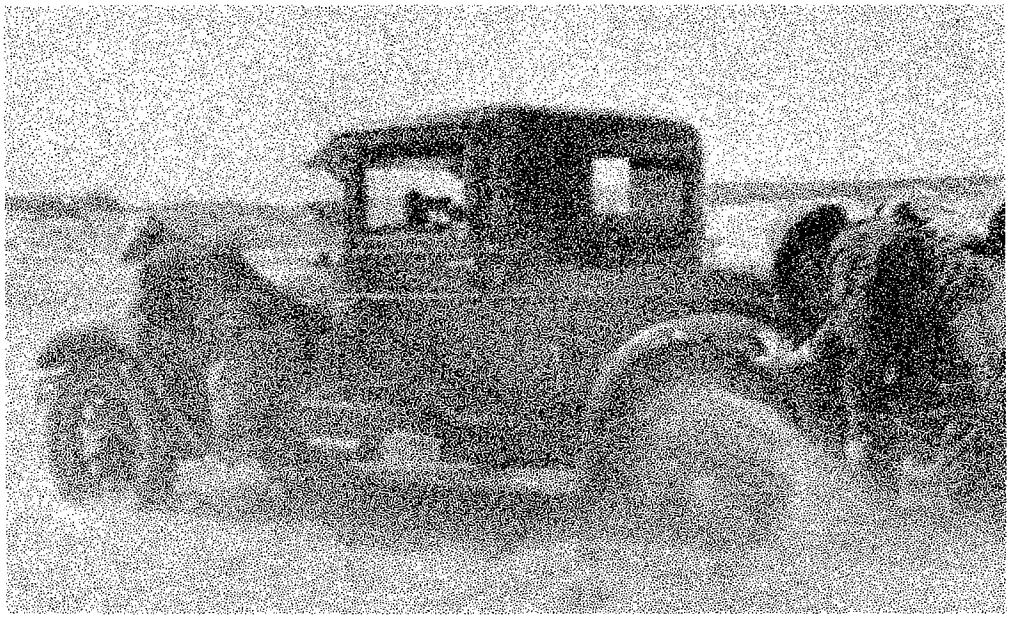
Since that time, the staff has expanded greatly, and projects have expanded; but, with a third-floor addition that was completed in 1968, the space has remained adequate, although at some sacrifice. Space allocated to one purpose has been preempted for another: A conference room was taken over to become a copy shop and printing room; a large drafting room became two offices; the third floor analytical-chemistry laboratory yielded some of its space to offices; a large basement room that held office supplies and specimens became four offices and a library; other basement space used for storage became three offices; and, finally, off-campus storage space had to be rented for overflow. And so forth.

Adequate.

The Survey currently is scheduled to move into quarters in the projected Energy Center on the campus of The University of Oklahoma, the second phase of which is under construction (1983).

All in all, it is rather remarkable what the Survey accomplished during the early years. As with the explorers and reconnaissance investigators before them, that they were able to accomplish so much is more worthy of note than that they did not do more.

Lead and zinc mining as it was done in 1911 near Miami, Oklahoma. Photo courtesy of Western History Collections of The University of Oklahoma.



Robert H. Dott

The Dott Years
1935-1952

Introduction

Following the four-year dry period that began in 1931 with Governor Murray's veto of OGS appropriations, the Oklahoma Geological Survey was reactivated in 1935 with Robert H. Dott as director.

Dott, who received his B.S. and A.M. degrees in geology from the University of Michigan, worked for 14 years as a geologist for several oil companies: Empire Gas and Fuel Company, Standard Oil Company of New Jersey, Carter Oil Company, Mid-Continent Petroleum Company, and Sunray Oil Company. He was chief geologist for Sunray during 1929–31 and then went into consulting. For the four years preceding his acceptance of the directorship of the Survey, he had been a consulting geologist.

As had his predecessors, Dott built on the foundation that had been laid by previous workers. As he says, much of the work was reconnaissance in nature, incomplete and in need of revision, and some reports were out of print (Dott, 1936), but it furnished leads for more detailed investigations.

The first post-hiatus publication to be issued under Dott's direction was OGS Bulletin 57, *Geology of the Muskogee - Porum District, Oklahoma*, by C. W. Wilson, Jr., and Norman D. Newell, a continuation of investigations done in 1929–30 by W. H. Thom, Jr., in cooperation with the USGS. This report was followed by 12 additional bulletins, nine circulars, 22 mineral reports (a new series initiated by Dott to provide answers to questions on mineral deposits from land owners and industrialists), and three circulars on traverse and leveling in Oklahoma. Dott also started publication of a mimeographed, informative periodical known as *The Hopper*, which was superseded in 1956 by *Oklahoma Geology Notes*, which is still with us.

Although considerably better than the dearth the Survey had experienced, funding when Dott became director was at a much lower level than the allocation immediately prior to the Survey's closing: $45,000 for the biennium of 1935–37, the lowest since 1911–13, in contrast to the $102,000 the Survey had received during the 1929-31 biennium. The value of the State's mineral production was also down. It was the time of the Great Depression.

State Mineral Survey

Dott's emphasis was on nonfuel mineral resources, and because of the Depression he received some help from the federal government.

At the same time the Survey resumed its functions, the Works Progress Administration (WPA) began its efforts to provide some measure of relief to out-of-work citizens by offering something worthwhile for them to do that would at the same time help the country. Under this program and in response to a project application, the President allotted $376,000 (later increased to $400,000 by the State WPA) for purposes of conducting a statewide mineral survey (known logically as the State Mineral Survey), which would gather information on mineral deposits and water resources. The work, organized into county units, began in December 1935, with

10 relief workers and a supervising geologist assigned to each three- to five-county district.

Six hundred relief workers and 60 non-relief supervisors were hired and spread across the State. The projects undertaken fell under three categories: (1) culture and water resources, (2) road and construction materials, and (3) general minerals.

(1) "Culture" meant checking and correcting inaccuracies of locations of such features as towns and cities, roads, schools, railroads, cemeteries, etc., for preparation of base maps. Data gathered in this phase of the project, combined with information acquired in projects of other agencies, formed the basis for two OGS bulletins (58, 61) and three circulars on *Traverse and Leveling in Oklahoma*, prepared by N. E. Wolfard, a civil-engineering professor at OU. Also under this part of the program, data obtained from examination of 100,000 rural water wells were assembled and made available to the appropriate agencies.

Dott (1936) describes an example of the effective application of the water investigations of the Mineral Survey in southwestern Kiowa County in July 1936, when water was so scarce the farmers were hauling it from nearby towns. When even those sources were exhausted, a cry for help came to the Oklahoma Geological Survey, which sent out a member of the Mineral Survey staff. Otto Leatherock and his county crew, armed with data gathered by the Mineral Survey, dug a well that produced water sufficient to supply 50 families. Hundreds of communities were served in the same way in that year of drought.

(2) Information was collected on every possible material suitable for road surfacing and road bases—sand and gravel, caliche, tripoli, stone for crushing, rock for making concrete, asphalt, volcanic ash for topping asphalt, even salt to be used as a road surface (salt worked surprisingly well, producing a hard, impervious surface). Investigations provided additional information on what was already known of different types of building stone—limestone, dolomite, granite, sandstone—and construction materials already listed, such as sand and gravel, crushed stone and concrete, as well as clay for brick and tile manufacture.

(3) The Mineral Survey also examined deposits of other industrial minerals such as agricultural lime, volcanic ash, barite, bentonite, and salt. The investigators left the lead and zinc in northeastern Oklahoma to the mining companies but looked for these and other metallic minerals in various other parts of the State. They also located new deposits of coal.

Although the Mineral Survey did not make any spectacular discoveries—and as Dott (1936) says, "exhaustive search cannot be expected from untrained relief workers"—Branson (1958) mentions that the information acquired made an "important file which is drawn upon for all related survey work." Data collected were recorded on field sheets that numbered 25,000 to 30,000 before the program was finished; this is in addition to sheets on the 100,000 water wells. What all this added up to was a need for hiring another crew of WPA workers to organize a filing and checking system. (Too bad computers were still in the future.)

"Oklahoma Needs Manufacturing"

Dott, as others before him, was interested not only in locating mineral deposits having economic potential but in their development and in new ways to utilize the minerals extracted and hence open up new industries for Oklahoma. He got down to specifics after all the generalities of the past. Actually, he was in the promoting business to a greater extent than were any of his predecessors.

With only 38 percent of Oklahoma's mineral production processed in-state, it was obvious the economy of the mineral industry was out of balance: 97 percent of mineral value consists of easily produced and processed, easily sold minerals. His solution lay in developing "humble materials" such as clay, glass sand, and stone that could be processed to yield finished or semi-finished products and provide employment. As Dott (1940) says, "Unused raw materials and unemployed men are worthless in themselves, but together they can make prosperity."

Dott stressed the "humble materials" because the value added in processing high-value materials like petroleum and zinc is low in comparison with the increase that is added by processing to yield pottery and tile, stoneware, brick, drilling muds, cement, concrete, glass, rock wool, lime, and other products from mineral raw materials.

Dott also urged the development of new uses for these mundane materials. He urged redevelopment of the coke industry and development of chemical industries that would use Oklahoma raw materials.

With ample supplies of coal and petroleum, there were great possibilities for chemical industries in Oklahoma. Coal could supply the raw material for the manufacture of dyestuffs, pharmaceuticals, explosives, water softeners, liquid and gaseous fuels, ammonia products, naphthalene, benzene, phenol, creosote, synthetic rubber, humic acid for restoring depleted soils, coal tar for light oils, formaldehyde, and plastics. Petroleum could yield butadiene and neoprene for synthetic rubber, acetylene for plastics, nylon, acetate, toluene and paraffin for explosives, material for making soaps and detergents, alcohols, chloroform, and carbon tetrachloride. From the wastes from zinc mining, sulfur for sulfuric acid could be recovered. Why not do it? Some of it was done.

Dott was all for the trend toward decentralization of industry from the East Coast. And why couldn't a lot of that industry come to Oklahoma, given Oklahoma's abundant raw materials and information gathered by the Oklahoma Geological Survey about those mineral resources, given an abundant supply of fossil fuels, given transportation facilities, given a safe interior location, given an ample supply of good employable work-

ers who should stay in the State instead of gravitating elsewhere for employment?

The people of Oklahoma were "neglecting their resources, and the potentialities these resources offer" (Dott, 1947). Oklahoma population was declining, and that was not right. Something had to be done.

Quite a lot was done.

The results of efforts to provide valid, current, and usable information to active and potential producers of Oklahoma's mineral resources are found in the list of publications that were issued during Dott's time. These publications include circulars on barite, dolomite, volcanic ash, and limestone; mineral reports on volcanic ash, glass sands, phosphates, dolomite and magnesium limestone, iron ores, manganese, and the St. Clair Limestone; and two bulletins, William E. Ham's classic Bulletin 65 on glass sands and Flavius C. Wood's Bulletin 60 describing rock-wool possibilities. Also, a mineral map issued in 1944 shows the location of deposits, processing plants, water supplies, availability of fuels and transportation, and power plants. These studies resulted in the establishment of numerous new industrial facilities and the expansion of others.

Further, in addition to the detailed field mapping and descriptions of the minerals listed, the work done in the Survey's laboratories provided valuable information. Dott went beyond chemical analyses of specimens and started an industrial laboratory.

The Industrial Research Laboratory

Early in Dott's administration a laboratory was set up in an annex to the Survey for analytical and experimental work on Oklahoma minerals. It had to be closed for lack of funds in 1939–40, but it was reopened in the next biennium, and a chemical engineer, Albert L. Burwell, was hired to take charge. The lab was well equipped. It had furnaces for assays and for melting stone, concentration tables and flotation cells for ore separation, crucibles, and a ceramic kiln. It had crushing, grinding, and pulverizing machines; sieves; a centrifuge; a blower; and a filter press. It had high-temperature equipment and a small steam boiler. The Survey was proud, and rightly so, of its Industrial Research Laboratory and of the work done in it. As is mentioned earlier in this history under the section on "Housing," this facility had to be deactivated in 1951, but much good work was done before it was dismantled.

One of the accomplishments of the Industrial Research Laboratory that the Survey pointed to with pride was the testing conducted in 1935–36 that resulted in the establishment of a rock-wool plant at Sand Springs. Results of these experiments are published in OGS Bulletin 60, by Flavius C. Wood. Eighty samples (some collected by the State Mineral Survey) were tested by calcining, then melted at temperatures up to 1600° F in a gas-fired furnace. The resultant slag was poured in a

Quarrying operation of the Southern Rock Asphalt Company in an asphalt deposit 3 miles south of Sulphur, Oklahoma. Photo taken in 1946 by William E. Ham.

steady stream, ¼ inch in diameter, that was subjected to a jet of live steam. The end result was masses of fine, wool-like fibers that made excellent material for insulation. Limestones, calcareous sandstones, and caliche all proved to yield a satisfactory product.

The lab also produced a lightweight, cellular, nonporous, sawable building material called "pumicell," made by expanding volcanic ash, and a light aggregate for plaster or cement blocks by expanding, "popping," individual grains of volcanic ash. (This is described in OGS Circular 27, by Burwell.) The lab experimented on making bricks from Oklahoma clays, refractory brick from novaculite and other siliceous materials, paint pigments from low-grade Arbuckle Mountains iron ores, and fertilizer from low-grade phosphate rock. Work in the industrial lab and the chemical lab also involved concentrating low-grade manganese ores, separating clays from decomposed gabbro, and extracting magnesium from oil-field brines by treating the brines with quick lime or (better) with calcined Oklahoma dolomite, which would itself add magnesium to the pot. Thus work proceeded on many things, all for the good of the cause.

The cause during part of Dott's administration was a war.

The War Years

As director, Dott not only had to contend with the greatest depression the world has ever known but also the greatest war that had ever happened and, one hopes, ever will happen. Oklahoma was thoroughly committed, and that included the Oklahoma Geological Survey. "May Oklahoma's petroleum, gasoline, zinc, lead, and many of her other products help make the Japs regret Pearl Harbor" (Dott, 1942). Dott himself was named chairman of an Association of American State Geologists advisory committee on matters in which state geologists could be of assistance to government agencies during the war.

Although the program of the Survey during these years was geared to the war needs, it also looked ahead to postwar use of Oklahoma's minerals and of whatever facilities might have been constructed for the war. An ammonia plant, for example, constructed as a war industry would be good because it could be converted to turn out badly needed nitrate fertilizers.

As early as 1939, when war broke out in Europe, Congress passed a Strategic Minerals Act that listed strategic and critical minerals that were considered essential to national defense, materials to be stockpiled by importing or by intensified investigations in this country. Of the minerals included in the first lists, Oklahoma had only two that were of satisfactory quality to meet the specifications: manganese and cadmium. Manganese ore was mined in fairly small quantities in Coal and Johnston Counties in the Arbuckles and in McCurtain County in the Ouachitas, but not enough was produced to justify building a plant to process them (these deposits are described by Clifford A. Merritt in OGS Bulletin 10). But Oklahoma was one of the largest producers of cadmium, which was recovered in smelting zinc ores (Ham, 1942).

The lists of essential materials were expanded later until more than 40 minerals and metals were placed under priority control, including abrasives, coal, gypsum, lead, petroleum, and zinc, all of which were available in quantity in Oklahoma.

Copper? Copper was on the list, and there was copper in the red beds. (See Mineral Report 8, 1940, also by Merritt.) Iron (Mineral Report 4, by Merritt) was also listed, and iron occurred in small but recoverable quantities; as with the manganese, enough for shipping but not enough for local processing. Antimony and quicksilver (mercury) had been reported in McCurtain County and were worth prospecting. Graphite we had, but not the flake type needed. Titanium was present in ilmenite, and ilmenite was present in the black sands in the Wichitas (OGS Circular 30, by Gerald Chase). There was vanadium in ash from asphaltite in Le Flore County, but not much. Platinum, asbestos, cryolite? Forget it. Fluorite? Yes, but only in small crystals in the Wichitas and Arbuckles. People, the citizenry, were encouraged to send in for identification specimens they had picked up in Oklahoma; some new source of a strategic mineral might be discovered in this way.

But war or no war, depression or no depression, life goes on, and so did the normal work of the Oklahoma Geological Survey. Unfortunately, there was a decrease in staff because of the war at a time when there was so much to be done. But somehow the available staff accomplished a great deal. There were minerals other than strategic minerals, stratigraphic relationships to be worked out, counties to be mapped geologically.

Seven county reports were issued under Dott's directorship. These include Texas County (Bulletin 59, by Stuart L. Schoff); Washington County (Bulletin 62, by Malcolm C. Oakes); Cimarron County (Bulletin 63, by Schoff and J. Willis Stovall); Haskell County (Bulletin 67, by Oakes and Maxwell M. Knechtel); northern Le Flore County (Bulletin 68, by Knechtel); Tulsa County (Bulletin 69, by Oakes, Glen S. Dille, and John H. Warren); and Hughes County (Bulletin 70, by O. D. Weaver, Jr.).

In addition to the work incorporated into the county reports and the bulletin on the Muskogee-Porum district, stratigraphic investigations were conducted on the Morrowan of northeastern Oklahoma by Carl A. Moore (Bulletin 66), the Timbered Hills and Arbuckle Groups in the Wichitas and Arbuckles by Decker (Circular 22), strata associated with the Broken Arrow coal by Oakes (Circular 24), and the Mill Creek-Ravia area by Ham (Circular 26).

Work in investigating materials for the war effort went on concurrently or was combined with these normal Survey projects, and at the same time a concerted program in the development of mineral resources was begun.

Oklahoma Mineral Industries Conference

In 1940 Dott received encouragement and assistance for his promotion of the development of mineral indus-

tries in the State. R. L. Crutcher, president of the Oklahoma Development Council, appointed a Mineral Industries Committee, which had as its goal the promotion and establishment of new industrial enterprises and increased utilization of mineral resources. Dott was named chairman of the committee.

One of the stated objectives of this committee was the "organization of a statewide Mineral Industries Conference, for discussion of mutual problems." The first of these conferences was held in Norman on November 19, 1940, with 70 people present. Participants represented every mineral industry operating in Oklahoma and included also government officials and staff members of other state surveys, the USGS, the U.S. Bureau of Mines, and the Chamber of Commerce. The conference was declared a permanent organization, to meet at least once a year.

A related program sponsored by the Tulsa Chamber of Commerce and known as the Oklahoma Industrial Conference was started in 1943. In 1947 these two conferences merged to become the Oklahoma Industrial and Minerals Conference, which was sponsored jointly by the Tulsa Chamber and the Oklahoma Geological Survey.

These conferences provided convenient and valuable forums for the exchange of information, ideas, and problems. They also made Oklahoma's industrialists aware of the accomplishments, services, and potential of their State geological agency. They sponsored *The Hopper*, and from the first issue in July 1941 through 1949, the periodical was filled with papers and abstracts of papers presented at the conferences and news of activities of the conferences. Response from industry was gratifying.

At the 1949 meeting the name of the conference was changed for the sake of brevity(?), and it was to be known henceforth as the Oklahoma Industrial Development Conference. The central office would be at the Bureau of Business Research at The University of Oklahoma.

Sic transit permanence, but the point had been made.

Photo showing group of participants at 1945 Mineral Industries Conference. Left to right: Governor Roy J. Turner; E. M. Johnson, manager of Henryetta plant of Eagle-Picher Mining and Smelting Company; W. A. "Gus" Delaney, of W. A. Delaney Interests, Ada; Hugh D. Miser, U.S. Geological Survey, compiler of Oklahoma state map; George J. Stein, manager of the Miami (Oklahoma) operations of Eagle-Picher; and Robert H. Dott, director of the Oklahoma Geological Survey. Delaney was named president of the 1946 conference at this meeting. Dott was to continue as secretary, and Johnson was a past president. Photo courtesy of Western History Collections of The University of Oklahoma.

"Made in Oklahoma"

In the same spirit as the conferences but different in focus were the "Made in Oklahoma" exhibits.

In the summer of 1947 a train left Oklahoma bound for 11 cities in the northeastern part of the country. This was the Oklahoma Industrial Tour. The train was made up of cars filled with exhibits of Oklahoma manufactured products, and the purpose of the tour was to sell Oklahoma to eastern industrialists. The Survey planned an exhibit of mineral resources, and Dott and Burwell accompanied the tour. The project received good responses.

This tour was followed by a "Made in Oklahoma" Manufacturers' Exposition held in Oklahoma City the following year in conjunction with the 1948 Oklahoma Industrial and Minerals Conference. More than 150 State manufacturers displayed their products, and some had action exhibits showing the actual process of manufacturing. Governor Roy J. Turner officiated at the opening ceremonies. This exposition drew so much interest that it was repeated. "Build Interest and Build Oklahoma."

The Survey also took exhibits of Oklahoma minerals and products manufactured from them to several State fairs held in Oklahoma, and the interest shown by fairgoers was gratifying. (Personal note—I speak from experience here, having helped staff one of these exhibits at the Muskogee State Fair. The people stopped to look and admire, and didn't realize all those great things were made in their own State.)

Coal

Badly depressed at the time Dott assumed the directorship of the Survey, the coal business in Oklahoma continued its slump in the immediately subsequent years. This was due partly to the economy and partly to labor problems, but the decline was caused chiefly by competition from cheap oil and natural gas.

With this being the situation and with Dott (1940) being of the expressed opinion that "The coal fields of the state have been well mapped in some detail," there were no formal field investigations of coal deposits undertaken in the first years of his administration. Coal resources were discussed in some detail in the 1937 Muskogee–Porum report (Bulletin 57), but no other publications on coal were issued until 1941 and 1942, when Mineral Reports 12 and 15 presented results of tests done by the U.S. Bureau of Mines (USBM) on the Henryetta coal and the McAlester coal. These coals were tested in the hope of finding coals suitable for making metallurgical coke.

The coke industry Dott saw as the salvation of Oklahoma's "sleeping giant," coal. There were, by USGS estimates, 55 billion tons of minable coal in eastern Oklahoma, mostly high-volatile bituminous, some semi-bituminous. (This was a gross overestimate, according to an OGS appraisal in 1974.) The coal industry (and the State) needed a market other than a fuel market for this resource. The solution could lie in the revival of the once-flourishing coke industry and the possible establishment of a by-product industry. There was even a possibility of developing a small iron-smelting industry from the iron ore in the eastern Arbuckle Mountains, using Oklahoma coal.

There were no funds available even for cooperating with the USBM in testing Oklahoma coals for coking, but lack of funds seems often to have been more of a hindrance than a deterrent to the Survey. In 1941 a coal producer was persuaded to pay the cost of shipping 2 tons (actually 3,800 pounds) of Henryetta coal from his mine in Okmulgee County to the USBM's experiment station in Pittsburgh, Pennsylvania, where tests showed that blends of this coal with coal from western Arkansas yielded good coke. Later tests, made in the same year and financed this time by the Survey, determined that blended McAlester and eastern Oklahoma coals made good metallurgical coke for use in the manufacture of steel. (The results of these tests are published in the Mineral Reports mentioned above.)

This coke was used in Lone Star Steel's furnaces at Daingerfield, Texas, and in furnaces of Sheffield Steel Company at Houston. New mines were opened in Oklahoma to supply coal to the steel companies' coke ovens.

By 1943 the condition of the coal industry changed: Demands for coal had increased because of the war to such an extent that Malcolm Doakes was pulled from his nearly completed field work in Tulsa County to work on coal investigations. The Tulsa County report had to be laid aside; it was not published until 1952, when it became OGS Bulletin 69.

Oakes' circular 24 on the Broken Arrow coal, with geology by Oakes and coal analyses by USBM, was published in 1944. Maxwell M. Knechtel of the fuels division of the USGS came on the scene under a cooperative agreement made with the OGS in 1942 to conduct field investigations of the geology, coal, and natural gas in Le Flore County. The report on this work became Bulletin 68. Oakes and Knechtel together investigated the geology and mineral resources of Haskell County (Bulletin 67) under a similar agreement with the USGS.

Petroleum and Natural Gas

In the first year of his administration, as a matter of declared policy, Dott left petroleum and zinc to their respective industries, explaining this decision by saying, "because the petroleum and zinc industries are so large, and so well established, it is the belief of the Oklahoma Geological Survey that its efforts should be directed to investigations which may lead to development of other materials which are at present little known, or unknown" (Dott, 1938). There was that, and also funds were too limited to build up a staff that could conduct petroleum investigations. Further, the Survey had already made a substantial contribution in publishing Bulletin 40 (Dott was himself author of two sections) and other works.

But in spite of Dott's statements and his belief in the importance of the development of other mineral resources, oil and gas were not entirely ignored.

Information on petroleum and natural-gas resources was included in the Muskogee–Porum District report

mentioned above and in reports on Washington and Cimarron Counties that were issued as Bulletin 62 (by Malcolm C. Oakes) and Bulletin 64 (by Stuart L. Schoff). A 230-page *Bibliography of Oklahoma Oil and Gas Pools*, compiled by geology librarian Alan Skelton and his geologist wife Martha Butcher Skelton, was issued in 1942 as OGS Bulletin 63, and in the same year a bibliography on the origin of petroleum, also by the Skeltons, became Mineral Report 7. Alan Skelton also compiled a bibliography of Oklahoma oil-pool names that was published in 1944 as Mineral Report 17. Not the same as geological investigations, but information on where to find information is useful, and these bibliographies must have been extremely useful at that time.

On a more intermediate, public-service level, the Survey worked with the Commissioners of the Land Office, giving advice on the leasing of State lands for oil and gas development, and also with many representatives of the petroleum industry and private citizens seeking information.

OGS was not by any means inactive in this field.

In his biennial report for 1941–42, Dott (1942) asks that the Survey do more in oil and gas, hire a full-time petroleum geologist, publish more oil and gas reports, and provide better service to operators and land owners and to other agencies. This was not to come about, however, until Carl Branson's time, when Louise Jordan joined the staff as petroleum geologist.

Water Projects

Ohern was concerned about water; Shannon was more concerned, and so was Gould. Water was essential to agriculture, and also to the mineral industries which the early-day directors strove to encourage. From the beginning the Survey did what it could to help individuals, municipalities, and industries. The Survey did help many people, but information it was able to acquire on water resources was piecemeal, and all the early directors saw a need for a statewide survey that would provide specific information on surface and subsurface waters. This need and the lack of available information have already been mentioned, but this was the time of the greatest drought in recorded history for the Great Plains.

Dott had the advantage of the water-well data collected across the State by the Mineral Survey, and those results provided the inspiration for other projects, specifically the potential of the subsurface water resources in the semiarid areas of western Oklahoma for use in irrigating croplands. It seems hard to believe now, but in 1936 there was no irrigation of the fields of the Panhandle and very little elsewhere. Dott (1936) mentions only as a possibility the use of ground water in the Panhandle for irrigation, but the Survey went into action and acquired geological, scientific, detailed hydrological information to add to the water-well data collected by the Mineral Survey in Beaver, Texas, and Cimarron Counties.

Then on July 1, 1937, the Oklahoma Geological Survey entered into a cooperative, matching-funds agreement with the Ground Water Branch of the USGS for investigations of subsurface water resources in various parts of the State. Personnel for the program were USGS geologists and engineers but had their offices with the OGS. The Oklahoma Survey supplied a staff geologist plus student assistants and published the results. This cooperative program, which continued throughout Dott's administration and beyond, contributed and is contributing valuable and long-needed information.

Investigations started—logically, as that was where there was the most need—in the Panhandle. Work on Texas County was the first to be completed; this was published as OGS Bulletin 59, by Stuart L. Schoff, issued in 1939. Cimarron County, the westernmost county, was next (Bulletin 64, also by Schoff and with a section on stratigraphy by J. Willis Stovall). These reports include geology as well as ground water and are essentially county reports. Beaver County, the third of the Panhandle counties, had to wait to be published, and that is understandable: Stuart Schoff went to war.

So the war intervened again. Mapping and groundwater investigations by counties had to be suspended. War facilities, with their concomitant influx of civilian population, put added demands on water supplies. Dott (1944) says that the USGS geologists were "spending fully three-fourths of their time on emergency problems arising from war activities within the State." Also: "... the Survey has been swamped with inquiries about local ground-water supplies for future industry." Encouraging, but distracting.

The Oklahoma Survey maintained observation wells in many parts of the State. Survey personnel gave information and advice on water problems not only to municipalities, farmers and other citizens, and industries, but also to federal, State, and county agencies and officials.

The cooperative program yielded eight more groundwater reports during Dott's directorship, including one bulletin (Tulsa County, by Malcolm C. Oakes, Glen S. Dille, and John H. Warren), one circular (on the Arkansas River flood plain, by Schoff and Edwin W. Reed), and five mineral reports that covered fairly localized areas. Also, Dott himself authored a mineral report that gave an overall picture: Mineral Report 11, *Geology of Oklahoma Ground Water Supplies*. Other reports were being prepared. Stuart Schoff came back from the war in 1946 and resumed work on Beaver County, but the report was not to be published during Dott's administration.

The Core and Sample Library

There was another resource that Mr. Dott saw a need for developing, not for promoting but for rescuing, and that was all the samples of underground rock that came to the surface when wells were drilled, and also the rock cores taken for examination. These materials were used, studied by company geologists and engineers, and stored for a while by the companies; but eventually, when they had served their purpose, they were discarded to make room for others.

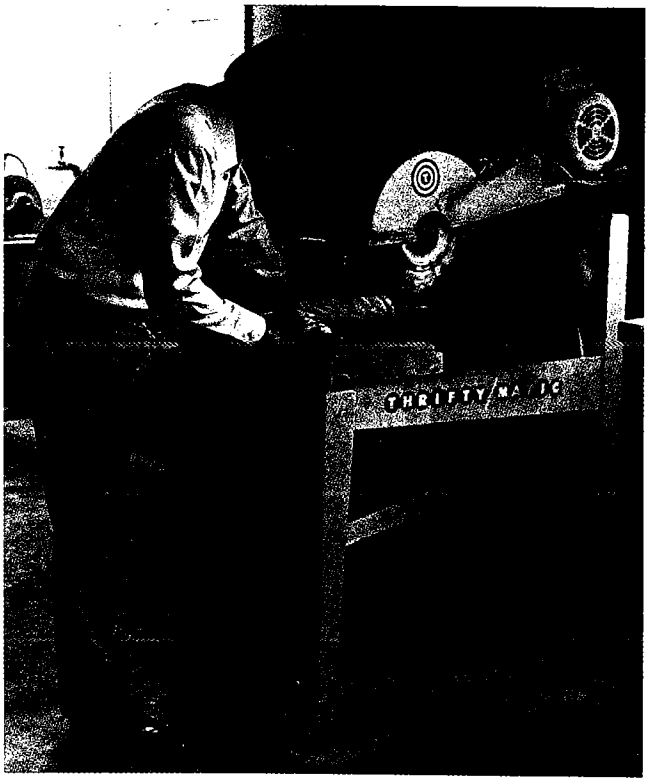
It was wasteful for such a valuable source of information to be destroyed when this resource could be made

available to researchers, professors, students, and any geologists interested in the subsurface. Dott (1936) recommended establishing a repository, a library, at the Survey, where well samples and cores could be studied.

In his biennial report for 1937–38, Dott states that such a library had been established in cooperation with the OU School of Geology. Samples began to come in. Oil companies were glad to send them because it saved them the expense and trouble of storing the material themselves. Donations were received from other industries and from government agencies as well. The Core and Sample Library quickly became the best repository in the State for rock materials that have been drilled in Oklahoma in the search for oil and gas and other mineral deposits. It still is. Considering the physical conditions under which it began, it is a wonder it survived at all.

Unfortunately, there was no satisfactory space to store all this material, and it was stacked more or less in the open under the east wing of the stadium, "where it is subject to depredation and destruction" (Dott, 1942). Cecil Lalicker, professor in the School of Geology, who helped get the collection organized, says (1978), "Our main problem was dampness; the pasteboard boxes tended to disintegrate."

After the Navy left at the close of World War II, the library was moved into two buildings on OU's North Campus, where it remained until 1957, when it was transferred to a 17,500-square-foot building (Building 139) on the South Campus, where it remains.



Eldon Cox at work in the OGS Core and Sample Library.

Because of the influx of material resulting from the intensity of drilling in recent years, the library is rapidly outgrowing these quarters. A new building, however, is in the offing under Phase V of OU's new Energy Center, now under construction (1983).

The facility has been under the able management and supervision of Eldon R. Cox since the summer of 1971, when he took over following the death of long-time manager Wilbur E. Dragoo. Louise Jordan, OGS petroleum geologist, supervised the management from 1963 until her death in 1966. John F. Roberts, also an OGS petroleum geologist, was supervisor until his death in 1978.

A New State Map

Publication of the first full-color geologic map of Oklahoma in 1926 has been mentioned earlier. Twenty years later, although it was still in demand, this map was both out of date and out of print, and the base on which it had been prepared needed correcting. Oklahoma needed a new geologic map.

Dott (1947), in his biennial report for 1945–46, stated that something would be done about this. A proposal had been made, and, provided federal funds were available, the USGS had promised their cooperation on a matching-funds agreement. Funds were made available.

Hugh D. Miser, who had prepared the earlier map and who had just stepped down at his own request from his position as chief of the fuels section of the USGS, returned to Norman in September 1947 to supervise the compilation of a new map. Plans and procedures were formulated by Miser, Dott, and Oakes. It was quite a project and involved many people.

There are 10 names in addition to Miser's given as authors on the 1954 *Geologic Map of Oklahoma*. Unidentified oil companies and independents are named as collaborators, as are the OU School of Geology, the Department of Geology and Geography of the University of Tulsa, Oklahoma A&M's Department of Agronomy, the U.S. Soil Conservation Service, and the U.S. Bureau of Reclamation; but information came from many more sources than that. Miser (1953) says the map "represents a compilation and integration of the mapping and other geologic results of many hundreds of geologists during the past 60 years." He lists the names of 82 people, including 53 graduate students, who contributed an aggregate of 50 man-years over a five-year period. This in addition to time spent in years previous by earlier geologists, whose mapping was incorporated into the map.

The years from 1947 through 1951 were given over to field mapping and the acquisition of maps from all sources. All this was essentially completed by the spring of 1952; then the maps were assembled and integrated into a manuscript copy on a new base map at a scale of 1:500,000 (1 inch = 8 miles), which had been prepared cooperatively by the USGS and the Oklahoma Planning and Resources Board.

The directors of the Oklahoma Geological Survey (Dott until July 1, 1952, when he resigned, and then William E. Ham, who took over as acting director)

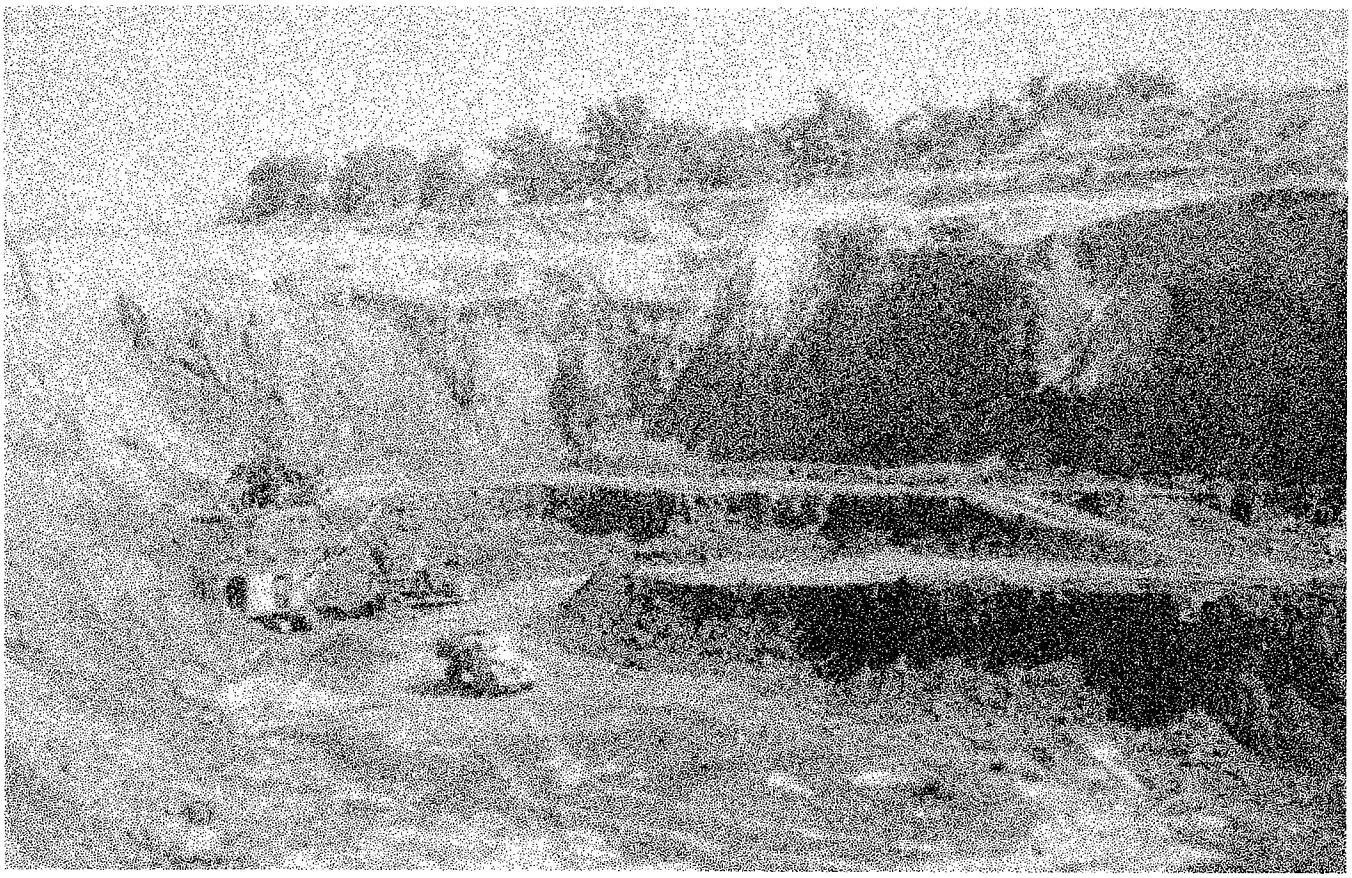
offered support, advice, and supervision. They assigned geologists to do mapping, and they provided drafting services, office space, clerical assistance, and other types of service.

Staff members of the OGS worked on special projects for the new map. Among these projects: Ham and Myron E. McKinley worked on the Arbuckle area; Oakes mapped and supervised work on the Pennsylvanian in eastern Oklahoma; George G. Huffman and Carl C. Branson and Miser supervised students' mapping in northeastern Oklahoma; John H. Warren mapped the Fort Scott Limestone; Gerald W. Chase mapped in the Wichitas; Clyde G. Beckwith, Jr., an instructor at Oklahoma City University working for the OGS, mapped the high terraces in southwestern Oklahoma (Dott and Miser supervised this work); Virginia Butcher prepared a lexicon of stratigraphic names; J. O. Beach supervised clerical work.

Miser (1953) waxes somewhat lyrical on the subject of his map and the geologists whose work went into it:

> I always like to think of their fine qualities and their notable contribution to the progress of their science. Their toil, travel, and teamwork have been performed with zeal, industry, and skill. They rose early in the morning; they went into the field at the break of day; they heard the bird chorus of the springtime; they added some of the artistry to Oklahoma's geologic map in the presence of the beautiful sunrise in the eastern sky. That's why Oklahoma's geologic map portrays a colorful sunrise! The grand-scale radial arrangement of the color bands of the sunrise on the map centers in the Arbuckle Mountains of southern Oklahoma.

At any rate, the work was completed, and in early 1953 Miser and Ham were in Washington conferring with USGS officials on plans for publishing the map. Miser (1953) expressed the hope that the map would be published by December 1954, when he would reach the mandatory retirement age of 70. And so it was. On the very last day of December (Branson, 1958). It was not published under Dott's directorship, nor under William E. Ham's, who acted as director following Dott's resignation on June 30, 1952, but under Carl C. Branson.



William Eugene Ham

William Eugene Ham
1952-1954

William E. Ham was the first (and so far the only) native Oklahoman to administer the Oklahoma Geological Survey. He was, in fact, a third-generation Oklahoman, the grandson of a Swedish pioneer who made the "Run" and homesteaded a tract near Guthrie.

Ham graduated from Guthrie High School, attended what was then Central State College for one brief year, transferred to what was Oklahoma A&M College for his second year of higher education, and then came to The University of Oklahoma. He earned a B.S. degree in 1938 and an M.S. degree in 1939, both in geology, from OU. A Ph.D. from Yale University came years later.

During the final phase of his master's work he was asked to take over the petrography and petrology classes of Professor Samuel Weidman, who had suffered a stroke, and his work was so effective he was asked to join the geology faculty at OU. He taught for two years, 1939–41, and then joined the staff of the Oklahoma Geological Survey as assistant geologist. He was promoted to associate geologist in 1945 and to assistant director in 1951. He was named acting director of the Survey by action of The University of Oklahoma Board of Regents at a meeting held July 9, 1952.

Bill Ham was very much a part of the Oklahoma Geological Survey for many years, and the same would be true in reverse. With the exceptions of a nine-months leave (1947–48) to do residence work toward his Ph.D. and another leave for an academic year (1966–67) spent as visiting professor at the University of Kansas, he served the OGS from the time of his appointment in 1941 until his death in 1970. He served more full-time professional years than anyone had before or has to this date.

During this time with OGS he authored or co-authored for the Survey four bulletins, six circulars, nine mineral reports, four OGS guidebooks, five industrial-field-trip guidebooks, two GSA guidebooks published by OGS, some maps (including what is still used as the definitive map of the Arbuckle Mountains), a catalog of rocks and minerals of Oklahoma, and part of the *Semi-Centennial Report*—more than anyone had before or has to this date. Notable among these publications are the bulletin on glass sands already mentioned, Guidebook 17 on the geology of the Arbuckle Mountains, and Bulletin 95 (with Rodger E. Denison and Clifford A. Merritt), *Basement Rocks and Structural Evolution of Southern Oklahoma.*

Of this last publication, Adolph Knopf, the geologic venerable who had been Ham's professor at Yale and later had joined the faculty at Stanford, said, "You have made the geology of Oklahoma vastly more interesting to some of us outsiders than it was before" (Toomey, 1977).

It was this publication also that led to an invited paper, prepared with James Lee Wilson of Rice University, on "Paleozoic Epeirogeny and Orogeny in the Central United States," which was included in an American Journal of Science issue on the Upper Mantle Project of the International Union of Geological Sciences. Although this was an important contribution, it was only one of an extensive list of articles published outside the Survey.

Ham, as have many other Survey geologists, carried

the knowledge of Oklahoma geology (and of the Oklahoma Geological Survey) beyond the bounds in a multitude of papers presented locally, nationally, and internationally; articles published in national and international journals; field trips organized and guided; national and international sessions chaired; national and sectional meetings arranged and supervised; visiting geologists and other dignitaries conferred with, guided to localities, entertained. Bill Ham was much in demand for such extracurricular activities.

He was also in demand as an economic geologist. In addition to the glass-sand bulletin, his OGS publications include results of investigations of volcanic ash, barite, dolomite, limestone, gypsum, borate minerals, copper, marlstone, and asphaltite. These works combined scientific geology and practicality, and he consulted with many producers and would-be producers in the office, over the telephone, and in the field on deposits of these and other minerals. He acquired an understanding of their needs and problems and had an uncommon rapport with the operators. Toomey (1977) quotes a letter to Ham from a glass-sand-company official: "Your Bulletin No. 65 is one of the finest material surveys I have ever read. I was surprised to see the good balance between mineralogy, geology and the operator's viewpoint."

And then there were the Arbuckle Mountains and the carbonate rocks and the basement rocks, and a few dozen other things.

Ham started working in the Arbuckle Mountains almost as soon as he started working for the Oklahoma Geological Survey—first the iron ores in the Arbuckles with Merritt, then the glass sands with Decker, then a detailed study of the Arbuckle carbonates under a cooperative program with the USGS to investigate rocks below the "Wilcox" sands as an aid in oil exploration (Dott, 1944); then the dolomites, the structure, the stratigraphy—

He did his Ph.D. dissertation on the Arbuckle Group, and this was in such demand that it was stolen from the Survey's storage room by some unethical person. Anyway, Ham became *the* authority on the Arbuckle Mountains.

He became something of an authority on carbonate rocks in general. He organized and led a symposium on carbonates for AAPG, was named editor of AAPG Memoir I on carbonate rocks, was invited to lecture on and study carbonate-rock formation at the Bermuda Biological Station, to join a group of experts who sailed out from the Lerner Laboratory on Bimini to examine carbonates being formed in the Caribbean seas. And so forth.

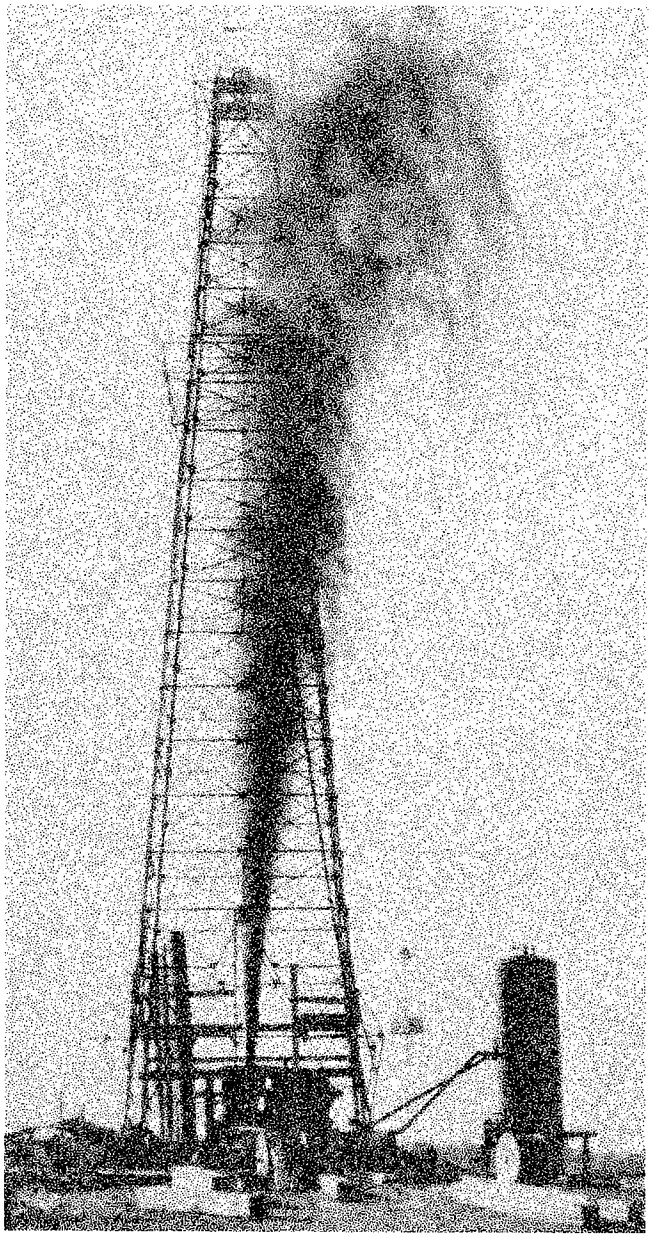
Bill Ham was a petrologist, structural geologist, stratigrapher, field geologist, sedimentologist, economic geologist, geomorphologist (his master's thesis was on a land-form problem); and what all this added up to was that a man with a lot to do was asked to take on the direction of a geological survey that had a lot going on.

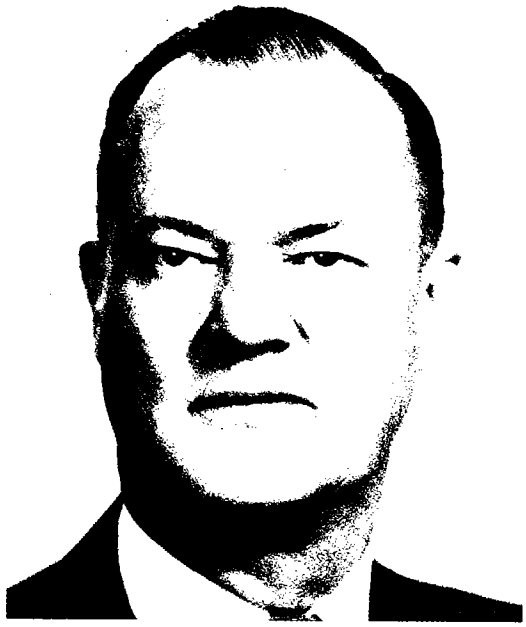
An acting director seems to be neither fish nor fowl: He has the job but not the authority. The acting director's time was consumed, and projects moved along: The new Oklahoma map went to Washington, the new building was moved into, mineral producers were provided with information, field investigations were pursued, ground water continued to be investigated, field trips were organized and guided. But no important decisions could be made. Also, the important work that he himself could be doing was not getting done, even with using a lot of midnight oil, giving up weekends, holidays.

Enough.

After a year and a half of this Bill Ham was forced to issue an ultimatum of sorts. Ultimatum—that means the end.

So on February 22, 1954, Carl Colton Branson became director of the Oklahoma Geological Survey. Ham was named associate director in 1959 and retained that title through 1966.





Carl Colton Branson

Carl Colton Branson
1954–1967

Carl Colton Branson was the son of an administrator: His father, Edwin Bayer Branson, was the long-time chairman of the Department of Geology at the University of Missouri in Columbia. So it is perhaps in the order of things that Carl Branson also became an administrator in geological circles.

Carl Branson obtained his education through the master's degree from the University of Missouri ('26 A.B., '27 M.S., geology), then he transferred to the University of Chicago, where he received his Ph.D., also in geology, in 1929, at the precocious age of 22. Needless to say, he was elected to Phi Beta Kappa. He was by training and inclination a paleontologist and biostratigrapher.

He taught paleontology for one year at what was then the State College of Washington; joined the faculty at Brown University, where he remained for 10 years; and moved to the University of Kentucky, where he taught until 1944, when he resigned to work for Shell Oil Company as a research geologist.

He joined the faculty of the School of Geology at OU in 1950 and was named director of the School in 1954. In that year the leadership of the School and of the Oklahoma Geological Survey was joined, and Carl Branson assumed the directorship of the Survey on February 22, 1954, as has been stated. This situation held only until 1963, when Branson relinquished the directorship of the School to become again a professor in the School, a position he retained until 1972, when he retired to become professor emeritus.

He retained the directorship of the Survey until 1967, when he gave it up and became a research geologist with the Survey. He became disabled from a stroke suffered in 1969, and he retired from the Survey in July 1972. He died in 1975.

One of Carl Branson's major contributions was building up The University of Oklahoma's Geology Library, a joint venture of the School and the Survey, which is now one of the outstanding collections in the country. One of his favorite occupations, even preoccupations, was library research, and he had a vast knowledge of the literature. He was able therefore to aid the geology librarian in making appropriate selections for acquisition. We now have a committee to do this.

There are interesting small items all through *Oklahoma Geology Notes* that record items, sometimes obscure, that he had gleaned from perusing the literature.

Branson, in directing the Oklahoma Geological Survey, as he himself says (1958), "continued the wise policies of his predecessors," giving mineral investigations first priority.

Mineral Resources

There was a lot of work done during Branson's administration on Dott's "humble materials" in the attempt to make what Burwell (1955) calls "good for nothing" mineral deposits into "good for something" developed resources.

Field and laboratory investigations were conducted on gypsum, clay and shale, limestone, asphaltite, salt, marlstone, copper, coal, and uranium. Results of gypsum investigations were published in Bulletin 89, the Blaine County report , which contains a section by Ham

on gypsum and anhydrite. Results of other studies are contained in Bulletin 92, on the borate minerals in Permian gypsum, by Ham, Charles J. Mankin, and John A. Schleicher; in Circular 42, on the Carter area, by George L. Scott, Jr., and Ham; in Mineral Report 29, on industrial possibilities of Oklahoma gypsum and anhydrite, by Burwell; and in Mineral Report 35, on gypsum in the Clinton–Weatherford district, by Ham and Neville M. Curtis, Jr. Robert O. Fay's Bulletin 98 on the Blaine Formation also contains a section by Ham on gypsum and anhydrite.

In Mineral Report 24 Burwell discusses the potential of some Oklahoma shales for use in lightweight aggregates. Burwell, the Survey's industrial chemist, also tested clays and shales in the laboratory for use by the ceramic and other industries. Some of his results of these analyses are presented in *The Hopper* and *Oklahoma Geology Notes*. His investigations of the commercial possibilities of the marlstone in the Henryhouse Formation were published in Mineral Report 28. Bulletin 102 contains results of a study conducted by Louise Jordan and David L. Vosburg on Permian salt and other evaporites in the Anadarko Basin. The high-purity lime of the Baum Limestone was investigated by John Rex Wayland and Ham, with results issued in Circular 33. Circular 64 describes copper deposits in the Permian Flowerpot Shale near Creta. This project was carried on by Ham and Kenneth S. Johnson, who is now associate director of the Survey, and the deposits were worked commercially until the falling price of copper made such an operation unfeasible. Ham wrote a report on the asphaltites in the Ouachita Mountains that was published as Circular 30.

Uranium came into the picture and was much in demand. A report prepared by Branson, Burwell, and Gerald Chase, *Uranium in Oklahoma*, was issued in 1955 as Mineral Report 27. The previous year a paper on radioactive material in sandstone lenses had been published as Mineral Report 26. Another mineral report (33, by James H. Hill, issued in 1957) describes uranium-bearing carbonaceous nodules in the State.

This was during the time when "uranium fever" had become rampant, and Geiger counters were ticking away in all likely and unlikely places in the search for instant wealth, and your motel in Arizona or elsewhere might likely have the tiny airplane of a uranium seeker parked in the next-door garage, instead of an automobile. The Survey lost an associate geologist, Gerald Chase, to this fever. One whole issue of the 1956 *"Notes"* (v. 16, no. 10) is devoted to Oklahoma uranium and uranium exploration.

In addition to all these reports listed as containing information on mineral resources, 22 reports covering counties, or large parts of counties were published during Carl Branson's directorship, and most of these reports contain sections on mineral resources. Many of these county reports were made possible, as Branson says (1955), by the close association between the Survey and the School of Geology. Much of the mapping was done by students under professional direction by faculty and staff geologists, with results published by the OGS.

Another contribution to knowledge of mineral resources in the State was the preparation of an updated mineral map by John Warren. This was published as GM-1, the first of the OGS "GM" series.

Also, mineral statistics were compiled annually and published by the Survey, first in *The Hopper* and the *"Notes,"* and later as mineral reports. With Mineral Report 36, a statistical volume issued in 1959, the series was discontinued, and information formerly published in these reports either was incorporated into *Oklahoma Geology Notes* or came out in other Survey serial publications.

In addition to all the accomplishments represented in the publications mentioned, the Survey offered various services to further the development of mineral resources. Branson in the *Semi-Centennial Report* (1958) mentions that the staff prepared reports for 11 communities and that Ham had supervised core drilling for the Clinton and Weatherford Chambers of Commerce and provided a map and report on gypsum occurrences and reserves. The Survey helped many industries during this time.

Petroleum and Natural Gas

Shortly after he became director of the Survey, Branson (1955) proposed that each county report contain a "description of subsurface geology and adequate subsurface maps" as an aid to the oil and gas industry. The need for a petroleum geologist had been recognized for some time. So on April 16, 1955, Louise Jordan, a graduate of Wellesley College with a Ph.D. from the Massachusetts Institute of Technology, experience with the equivalent of a national geological survey in Turkey, experience with two oil companies and as a consultant, joined the staff as the Oklahoma Geological Survey's first petroleum and subsurface geologist.

Her value is indicated in part by the increased number of publications containing information on or relating to petroleum that were issued under Branson's term of directorship.

Sections on petroleum geology were included in several county reports published during this time: Harper County (Bulletin 80), Creek County (Bulletin 81), Blaine County (Bulletin 89), Love County (Circular 63), Craig County (Bulletin 99). Circular 62, prepared by Patrick H. Clare, is devoted entirely to the *Petroleum Geology of Pawnee County*.

Also, six of the GM series and four guidebooks are petroleum related. GM-5, by Jordan, shows pre-Pennsylvanian rocks; GM-8, also compiled by Jordan, is on *Petroleum-Impregnated Rocks and Asphaltite Deposits in Oklahoma*; GM-9, by Russell S. Tarr, Jordan, and T. L. Rowland, shows pre-Woodford rocks; and GM-10, 11, 12, and 13 show oil and gas fields and pipelines.

The guidebooks (which are not all strictly guidebooks) include: Guidebook 6, by Jordan, which eliminated a lot of confusion by listing subsurface marker beds and describing their relationships to other zones; Guidebook 13, compiled by W. L. Adkisson and Mary G. Sheldon, which was prepared to assist those engaged in petroleum exploration, and which contains descrip-

tions of samples from wells along a line from Barber County in south-central Kansas southward into Caddo County, Oklahoma, just northeast of the Wichita Mountains (formations penetrated range from the surface Permian down to Cambrian rocks); and Guidebooks 8 and 14, by John C. Maher, on logging methods.

These publications are an indication of what was done in this area, but they don't give the whole picture. There were the innumerable consultations with oil-company and other geologists, the compilation of statistics, the direction of theses done on the subsurface, papers delivered, meetings participated in, etc.

John F. Roberts joined the staff in 1965 to assist as a petroleum geologist. He became senior petroleum geologist on Louise Jordan's death in 1966.

Coal

In the *Semi-Centennial Report* Branson mentions that "an extensive investigation of coal resources is more than 75 percent complete," but a coal report as such was not published during his administration. This is somewhat reminiscent of the prediction of imminent publication of Shannon's coal report in the early years.

Information on coal, however, was included in several publications, particularly Bulletin 91, a report on Okmulgee County, with geology, including coal beds, by Malcolm Oakes. The reports on Hughes County (Bulletin 70), Creek County (Bulletin 81), northern Latimer County (Circular 50), the Cavanal Syncline in Le Flore County (Circular 51), and the Featherston area in Pittsburg County (Circular 53) contain brief sections on coal deposits. Plant microfossils in coals are described in Circular 32, by Leonard R. Wilson and William S. Hoffmeister, and Circular 36, by James Leland Morgan.

An interesting development is found in Circular 54, published in 1961, in which Arthur H. Doerr, professor of geography at OU, looks at coal from a different viewpoint. Doerr is more concerned with what coal mining in Oklahoma has done to the landscape—the environment—than with the extent of resources. This publication is a forecast of coming interest in environmental geology and is in a way a forerunner of Kenneth Johnson's GM-17 on reclamation of surface-mined coal lands, which was issued in 1974.

Water

The cooperative program with the USGS to investigate water resources continued during Branson's administration. Results of these joint projects came out in county reports for Ottawa County (Bulletin 72, by E. W. Reed, Schoff, and Branson); Grady and northern Stephens Counties (Bulletin 73, by Leon V. Davis); and southern McCurtain County (Bulletin 86, also by Davis).

Also published cooperatively were Bulletin 87, on ground-water reservoirs in Canadian County, by J. L. Mogg, Schoff, and Reed; Bulletin 97, on ground water in Beaver County, by I. Wendell Marine and Schoff; Circular 61, on ground-water resources of the Rush Springs Sandstone, by Harry H. Tanaka and Davis; and Map GM-2, which shows the ground-water reservoirs of the whole State and was compiled by Schoff.

Bulletin 91 is a county report for Okmulgee County, with geology by OGS geologist Malcolm Oakes and hydrology by OGS hydrologist Ward S. Motts. In Motts the Survey had its own hydrologist, at least for a while. He joined the staff in April 1960 as ground-water geologist. He left in September 1961 for more gainful employment.

Basic Geologic Investigations

Not to downgrade all the work done on mineral resources of all kinds during Branson's directorship, but the basic scientific geologic studies whose results came into print during that time are also impressive. As Gould has been quoted above as saying, "scientific investigation must always precede economic development," and all the investigations, even those that seem strictly academic, have, or will come to have, practical applications. This includes paleontology—which involves stratigraphy, structure, sedimentation—all of which involve mineral exploration, especially exploration for petroleum reservoirs.

But regardless of economic relevance, these works add to the knowledge of the geology of the State, and there were 33 papers on fossils published as bulletins and circulars during Branson's time, not to mention the paleontological articles in the *"Notes"*. Brachiopods, crinoids, corals, ostracodes, trilobites, fusulinids, ammonoids and other cephalopods, chitons, spores, vertebrates—they all saw their way into print.

There have always been more paleontological reports written than outlets for their publication could accommodate, at least within a reasonable time, and the *"Notes"* received more than its share of paleontological submissions, most especially between 1960 and 1967. The reason for this increase was a change in the rules in regard to publishing new fossil names in *Oklahoma Geology Notes*. The policy on this was reversed twice during that period. Prior to September 1960 it had been the policy of the Survey to publish no new paleontologic or stratigraphic names in the periodical, but by 1960 circulation had grown to include all state, provincial, and national geological surveys, plus 200 universities worldwide and 500 individuals and oil companies, and it seemed that that wide a distribution justified publication of new fossil taxa (OGS, 1960). Many new species and genera and emendations appeared in the *"Notes"*, and résumés of new taxa published therein were printed periodically.

In March 1967, however, the decision was nullified, with the rationale being that, even though the *"Notes"* was widely distributed, the nature of the publication was too "parochial" (OGS, 1967), and new nomenclature was too likely to be overlooked. Paleontological papers were (and are) accepted, but no new fossil names could, or can, be published in *Oklahoma Geology Notes*. This restriction did not and does not apply to bulletins or circulars.

In addition to and in conjunction with the paleontological studies, the record of stratigraphic and biostrati-

graphic work done during Branson's time is substantial, and among the most significant are the investigations conducted on the Ordovician-Devonian-age Hunton Group by Survey geologist Thomas W. Amsden.

Amsden, with an A.B. from what was the University of Wichita, an M.S. from Iowa State University, and a Ph.D. from Yale, came on the scene in September 1955, the same year as Louise Jordan. A paleontologist and biostratigrapher of note, he had been on the faculty at Johns Hopkins University for nine years before joining the OGS staff. He had also gained experience as a geologist with the USGS and the Maryland Department of Geology, Mines and Water Resources.

The first of Amsden's reports on the *Stratigraphy and Paleontology of the Hunton Group in the Arbuckle Mountains Region* was published as Circular 44 in 1957. Five subsequent parts were issued as bulletins. In addition to this massive accomplishment, Amsden authored or co-authored during Branson's term three other bulletins (90, 94, 105) on Silurian and Devonian stratigraphy and paleontology and GM-14, a set of Silurian and Devonian maps and cross sections.

Besides these projects and the investigations included in the county reports, other stratigraphic work was done on the late Paleozoic (Bulletin 85, by Lewis M. Cline), the Rich Mountain area (Bulletin 101, by Donald R. Seely), the Winding Stair Range (Bulletin 103, by O. D. Hart), the Wapanucka Formation (Bulletin 104, by Charles L. Rowett and Patrick K. Sutherland), northeastern Oklahoma (Circular 31, by Richard D. Alexander and Branson himself), the Baum Limestone (Circular 33, by John Rex Wayland and Ham), the McAlester Basin (Circular 46, by Richard B. Laudon, and Circular 47, by Jack G. Blythe), and the Cenozoic of Roger Mills County and Ellis County (Circulars 48 and 69, by David B. Kitts).

Also published during this period were Ham's study on basement rocks, which has already been mentioned; George G. Huffman's Bulletin 77, *Geology of the Flanks of the Ozark Uplift, Northeastern Oklahoma*; O. B. Shelburne's Bulletin 88 on the Boktukola Syncline; Fay's previously mentioned Bulletin 98 on the Blaine Formation; and Pitt's Circular 34, *Geology of the Core of the Ouachita Mountains of Oklahoma*. Ham's geologic map of the Arbuckles and Kaspar Arbenz's tectonic map of the State should also be mentioned.

Quite a list, taken all together, to have been finished in one 13-year period. Charles J. Mankin took over at the end of that period.

Topographic Mapping

Topographic mapping began in Oklahoma well before the State was a state. In fact, by 1901 the USGS had mapped topographically 20 quadrangles of Indian Territory and one quadrangle (Kingfisher) of Oklahoma Territory, these at a scale of 1:125,000, or approximately 2 inches per mile (Warman, 1901). This was too small a scale and clearly not enough coverage.

Van Vleet (1902) in his *Second Biennial Report* states that "There is immediate need for a Topographical Survey of the Territory." Meaning Oklahoma Territory. He presents a good case, describing information contained on such maps—not only features of relief, but surface waters and cultural features, such as roads, railroads, structures and official names. He details the usefulness of the maps to education, engineering, legislative matters, administration of public works, preparation of statistics, and, not the least, development of natural resources. He also says, "It is impossible to secure this [a topographical survey] within a reasonable time except through the cooperation of the United States Survey." Well, yes.

Topographic mapping was a primary project of the United States Survey; after hit and miss mapping under one authority or another, it was one of the fundamental goals of the second director of the USGS, John Wesley Powell, to see complete coverage of the entire country by such maps, which would be prepared by his agency. By 1901 the USGS had a firm plan whereby the country was divided into little quadrangular districts (known logically as quadrangles) for the purpose of such mapping.

But this mapping, by law, would have to be on a fifty-fifty basis, and Van Vleet urged that the next legislature take action at once to raise the necessary funds.

Ohern (1912a) reports that the 1911 legislature appropriated $3,000 for cooperative work with the USGS and that one-third of the fund was alloted to topographic mapping of the Vinita, Claremore, Nowata, and Hominy Quadrangles. These quadrangles were in the oil country, and it is interesting to note that Ohern says that "accurate topographic maps are absolutely essential for working out the geology of oil and gas fields"—this before it was generally accepted that geological information was of value in finding oil. Another thousand dollars was allocated the following year to continue this work.

Shannon (1914) in his *Director's Biennial Report* for 1913 and 1914 repeats Ohern's report on this topographic work and adds that topographic mapping of the Foraker Quadrangle was completed and that work in the Nuyaka Quadrangle was begun. He includes a map to show that 67 quadrangles had been surveyed topographically by 1914, including those quadrangles in what had been Indian Territory. He states that all but 18 quadrangle maps had been published and asks for increased funds to continue this cooperative effort.

Dott (1936) in his first *Biennial Report* presents a strong case. He lists all the features found on "modern" topographical maps—the depths of the valleys, the heights of the hills, the steepness of the slopes, gradients of streams, widths of valleys, water features down to the smallest gullies, woodlands, bench marks, and all the man-made features. He, too, details the usefulness of the maps to engineers, land planners, school officials, agriculturists, the military, the Forest Service.

Above and beyond all that, however, such maps could be, were, and are used for geologic mapping of all kinds—surface, structure, subsurface, seismic, hydrologic—and they were needed by the Survey for such work.

At the time of Dott's report less than 10 percent of the

State was covered by what were then modern topographic sheets, i.e., 15-minute maps at a scale of 1:63,360 (1 inch = 1 mile). (Modern sheets now are for 7½-minute quadrangles at a scale of 1:24,000 (1 inch = 2,000 feet), and since 1964 all topographic mapping has been done on that base.) The early maps of Indian Territory (30-minute quadrangles) which covered another 40 percent of the State, were "obsolete, inaccurate, and wholly inadequate." Dott asked for $10,000 per year to match federal funds, which would allow for mapping two to four quadrangles each year.

It was not funding through the Oklahoma Geological Survey, however, that got the job done. In 1971 the USGS reported in the summary of activities of its Topographic Division that the federal agency had cooperative programs in Oklahoma for topographic mapping in the years 1905 through 1908, 1912 through 1915, 1928 through 1930, 1948 and 1949, 1952 through 1960, and 1966 through 1972.

Most of the matching funds for these programs, though, came from other sources than the OGS. In fact, Branson (1965) goes so far as to say, "The State has put (so far as known) no money into such mapping." Except for the parenthetical phrase, that was not strictly true. He stated in the same article that most topographic mapping in Oklahoma was done at the request of federal agencies, naming the U.S. Air Force, the U.S. Army Corps of Engineers, the U.S. Bureau of Mines, and the U.S. Reclamation Service. But numerous other organizations contributed to the effort, and among them are the Tulsa Metropolitan Commission, the Oklahoma City Metropolitan Commission, the Oklahoma City Water District, the Oklahoma State Soil Conservation Board, the Oklahoma Water Resources Board, the City of Bartlesville, and the Oklahoma Department of Transportation. It is through this last-mentioned agency that most of the mapping has been done over recent years. An Oklahoma Mapping Advisory Committee was formed in 1963 to coordinate the needs of State agencies.

According to information received from William K. Mengel, Chief of the Branch of Program Management of the USGS Mid-Continent Mapping Center in Rolla, Missouri (written communication, 1983), the Oklahoma Survey contributed a sum of $5,500 toward a topographic-mapping program of quadrangles in the Bartlesville, Oklahoma, area in 1971.

Carl Branson was most interested in the status of topographic mapping in Oklahoma and issued progress reports periodically in the "*Notes*". At one stage (1963) he became discouraged and reported, "At the current rate the mapping will be completed in some far-off year." A safe statement, but in 1970 he became bolder and predicted complete coverage within six years by 7½-minute quadrangles. Not so safe; it didn't happen. He offered an encouraging note in 1965: Boundary quadrangles touching Missouri, Kansas, Arkansas, and the Texas Panhandle were being mapped by those states, and that would take care of many Oklahoma quadrangles.

Another good thing was the preparation by the U.S. Army of a series of topographic maps of the entire country at a scale of 1:250,000, which the USGS remade into a civilian edition. The 14 sheets that cover Oklahoma were completed in 1958. The large 1° x 2° quadrangles in this series that are totally or partially in Oklahoma are: Tulsa, Fort Smith, McAlester, Texarkana, Sherman, Ardmore, Oklahoma City, Woodward, Clinton, Lawton, Wichita Falls, Perryton, Dalhart, and Enid. These large quadrangle maps served many useful purposes as bases for OGS projects.

Also, a large topographic map of the whole State of Oklahoma at a scale of 1:500,000 (1 inch = 8 miles) was issued by the USGS in 1975 (this has a 1972 date, however).

Since 1968 a project has been under way by the USGS to add changes in cultural features to the topographic sheets by a process of "photorevision," whereby new data, derived almost wholly from aerial photographs, are superimposed in purple on the maps. Many of these revised versions have been made for Oklahoma, and more are in progress.

Many quadrangles in Oklahoma have been covered by photo-image maps, or "orthophotographic" maps—aerial photographs that cover 7½-minute quadrangles. These are not contour maps, however, nor are the cultural features designated.

At any rate, Oklahoma is now covered by topographic-quadrangle maps, and even though some of these are still on 15-minute sheets, work is progressing steadily to convert these to 7½-minute maps.

This would have gratified Van Vleet, Gould, Ohern, Shannon, Dott, and Branson.

Charles John Mankin

Charles John Mankin
1967—

Charles J. Mankin became director of the Oklahoma Geological Survey on February 1, 1967.

A Texan by circumstance, he received his B.S. (1954), M.A. (1955), and Ph.D. (1958) degrees from the University of Texas at Austin. While pursuing his education, he worked as a special instructor for Shell Oil Company, an instructor of geology at the University of Texas, and a geologist for the New Mexico Bureau of Mines and Mineral Resources. He was assistant professor at the California Institute of Technology for one year following the receipt of his Ph.D. Then he came to Oklahoma to teach in the School of Geology and Geophysics.

He joined the faculty at OU as assistant professor in 1959, a title he retained until 1963. As have many faculty members of OU's School of Geology and Geophysics over the years, he worked as a "part-time-professional" geologist with OGS during this period. In 1963 Mankin was advanced to associate professorship and was named acting director of the School. In 1964 he was named professor and director of the School.

So with Mankin's accession to the directorship of the Oklahoma Geological Survey in 1967 the School and the Survey were again joined under one administrator.

This situation held until 1977, when it was decided that the two positions should be occupied by two directors. Mankin has retained the directorship of the Survey through the present date. In 1978 he added another directorship to the list, that of OU's Energy Resources Center, now renamed the Energy Resources Institute to avoid confusion with OU's upcoming Energy Center.

In addition to all this, Mankin has done more than his share of carrying the name and reputation of the Oklahoma Geological Survey far and wide through representation in many scientific, academic, and governmental organizations. He has served or chaired numerous committees, boards, and councils on various levels and has held office in several national associations, including the American Association of Petroleum Geologists (AAPG), the Geological Society of America (GSA), the American Institute of Professional Geologists (AIPG), the American Geological Institute (AGI), the Gulf Universities Research Consortium (GURC), the Interstate Oil Compact Commission (IOCC), and others. He is a past president of the Association of American State Geologists and of the AGI and is currently incoming vice-president of AIPG; he is perennial secretary-treasurer of the honorary geological fraternity, Sigma Gamma Epsilon.

A member of the Stratigraphic Correlations Committee of AAPG, Mankin is also regional editor of AAPG's massive COSUNA program (Correlation of Stratigraphic Units of North America), a long-term project to determine the relationships of geologic formations, including the subsurface, across the Continent. He is co-leader of a group working on the U.S. continental interior for D-NAG (Decade of North American Geology), the GSA's centennial megaproject to coordinate and synthesize geological, geochemical, and geophysical knowledge of the North American Plate.

These and other projects undertaken by the director have involved staff members as well.

Mankin began his professional career as a specialist in clay-mineralogy research and is active in this field upon occasion when administrative and other responsibilities permit. Unfortunately, this is not often possible.

Shepherding work encompassing the orderly development of the State's earth resources, however, has given

him a broad knowledge of many fields. With activities of the Survey over recent years focused on the fossil fuels, he has become a top authority on energy resources.

As an indication of Mankin's activities in this area:

He chairs the Board on Mineral and Energy Resources and serves on several committees of the National Research Council, the research arm of the National Academy of Sciences. In 1981 he was appointed by U.S. Interior Secretary James Watt to a five-member fact-finding board, the "Commission on Fiscal Accountability of the Nation's Energy Resources." He serves on the Research Committee of IOCC and as editor-in-chief of an IOCC publication on "Modern Reservoir Descriptions for Improved Oil Recovery." He is a member of the Board of Directors and of the Executive Committee of the Gulf Universities Research Consortium.

A partial listing only.

Things have changed, and things have remained the same during Charles Mankin's administration. During this period the development of the science in general has been rather like an explosion; developments in the Oklahoma Geological Survey have followed suit. Programs have expanded, grown, accelerated, and at the same time they have become more detailed, more sophisticated.

But there are still the same resources to be investigated—fuels, industrial minerals, water, uranium, maybe recoverable metals; there are still counties needing to be mapped on the ground; there are always basic scientific investigations, as there have been since the beginning.

Kenneth S. Johnson

Kenneth S. Johnson

Kenneth S. Johnson, a Survey stalwart, earned a B.S. in geology, a B.S. in geological engineering, and an M.S. in geology, all from The University of Oklahoma. He joined the staff of the Oklahoma Geological Survey as a geologist in 1962 and has been with the Survey since that date except for the time between 1965 and 1967, when he was working on and acquiring his Ph.D. from the University of Illinois.

He has been most active in the field of economic geology, investigating mineral resources, particularly evaporites, although his expertise extends into other areas. Before Kenneth V. Luza came to OGS in 1975, Johnson functioned also as the resident engineering and environmental geologist. He has served frequently as adjunct professor of economic and environmental geology in the OU School of Geology and Geophysics.

He is widely known for his work on Permian sedimentary rocks and waste disposal, and has lectured many times on both subjects, in this country and on several occasions before groups in Europe. He has taken an active interest in presenting geology to the lay public, "rockhounds," teachers of the young, the young themselves. He put together a colorful, simplified atlas of maps and cross sections of Oklahoma, which was published in 1972 as OGS Educational Publication 1, and initiated a series of popular guidebooks for field trips which are also published as EP's. This series, when completed, will cover the State.

He is much in demand for lecturing, conferring with industrialists, leading field trips, organizing meetings.

In 1978, Johnson accepted an appointment as associate director of the Oklahoma Geological Survey. In addition to his other duties.

Mineral Resources

It goes all the way back to Gould, and even before that to Van Vleet; and Mankin (1968) began his administration on a familiar note, decrying the deficiencies in investigation and development of mineral deposits, nonmetallic and metallic—what he called "fallow natural resources." The concern over the lopsided nature of Oklahoma's mineral economy was not new, either: in 1970 Mankin said, "Diversification of the natural-resource base from its primary dependence on fossil fuels is a major objective of the Survey's development program." Again in 1975: "The potential exists for substantial expansion of . . . mineral commodities."

That potential still exists, but the Oklahoma Geological Survey has done what it could to help the State in fulfilling its potential. There has been a lot of activity in mineral resources during Mankin's time—clays and shales, limestones and dolomites, crushed stone, copper and other metals, bentonite, underclays, salt, gypsum, uranium—industrial minerals in general and in particular. Also, in 1972, a symposium reminiscent of Dott's Industrial Minerals Conferences was held on the OU campus. Entitled "Mineral-Development Opportunities in Oklahoma," the one-day meeting was sponsored by OGS, the Oklahoma Industrial Development and Parks Department, and the Oklahoma Section of the American Institute of Professional Geologists.

The Survey has published six more county reports during this time, each of which contains a section on

mineral resources. These include: Bulletin 111, by Malcolm C. Oakes, on McIntosh County; Bulletin 114, by Robert O. Fay, on Custer County; Bulletin 120, by George G. Huffman and others, on Choctaw County; Bulletin 122, by Oakes, on Muskogee County (which was published posthumously: Malcolm Oakes died shortly before the release of the bulletin); Bulletin 126, by Huffman and others, on Bryan County; and Bulletin 128, by John W. Shelton and others, on Noble County.

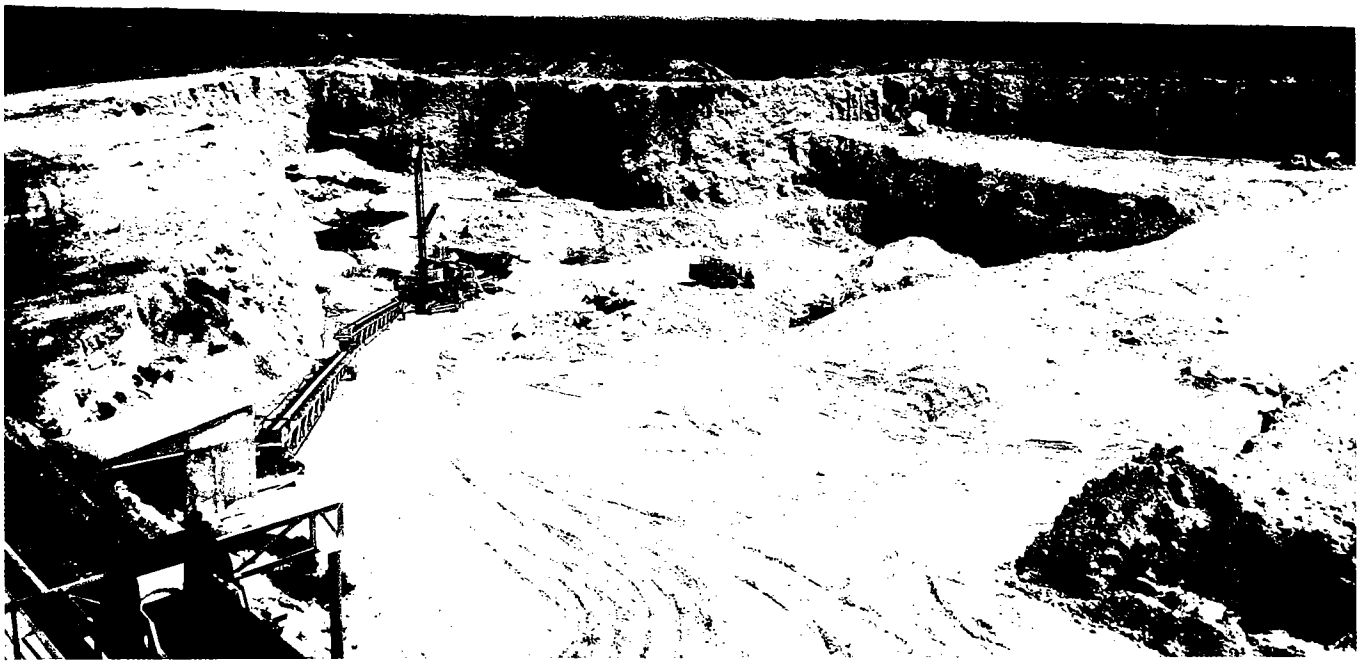
Some other OGS publications in this area of the Survey's efforts include: Circular 76, *Shale and Carbonate - Rock Resources of Osage County, Oklahoma*, by William H. Bellis and T. L. Rowland; Circular 77, which incorporates papers presented at a symposium on copper deposits that was held during a 1974 GSA sectional meeting (this contains a paper by Johnson on the copper deposits in Oklahoma's Permian shales); Circular 79, another proceedings volume, this one covering a national Forum on the Geology of Industrial Minerals that was held on the OU campus in 1977 (this contains a paper on Oklahoma's gypsum deposits by Johnson); GM-15, an updated and completely revised mineral map of Oklahoma, by Johnson; Circular 86, on the copper in the Triassic Sheep Pen Sandstone in far northwestern Oklahoma; and GM-20, a map and descriptive booklet on the Southwest Davis Zinc Field in the Arbuckle Mountains area.

The last two publications, both by Robert O. Fay, represent part of a program to locate and describe each of the metallic concentrations in the State for the purpose of assessing the potential for discovery of larger, economic concentrations. Another GM map by Fay that will describe and locate occurrences of copper, lead, and zinc in the Ouachita Mountains will be issued later.

Since the decline and closing of the lead and zinc mines in northeastern Oklahoma (once the world's largest producers of zinc), the State has hardly been known for the production of metals. Copper, which was found by OGS and which was produced by the Eagle Picher Company from Permian shales near Creta in southwestern Oklahoma, has not been mined since the mines closed in 1975. Very little metal of any kind is being recovered at present. There are, however, possibilities, and the Survey has considered those possibilities worth examining.

Among projects ongoing are studies of the evaporites of western Oklahoma, with their gypsum and salt resources; investigations of underclays in the eastern Oklahoma coal field, fine-grained, detrital material that can be used in making firebrick and special ceramics like porcelain or fine china; further investigations of sand and gravel and stone, such as limestone and granite. Site-specific investigations of these and other "humble" materials have been and are constant.

Many of these investigations are in response to special requests, and the publications listed above reflect only a portion of the work done in aiding in the development of mineral resources. Specific investigations have always been with the Survey, plus requests for information on mineral production, occurrences, and potentials, and during this latest period of history OGS geologists have been in frequent consultation with producers who have needed advice in expanding their operations or opening new deposits. Actually, it is hard



Gypsum quarry in Comanche County, southwestern Oklahoma. Photo by Kenneth S. Johnson.

to find anywhere in the State where minerals are produced that OGS has not had a hand.

Another area in which the Survey has contributed to the minerals industries is in the compilation of statistics. Statistics on nonfuel mineral production and value, most of which were compiled by the U.S. Bureau of Mines, have been issued by the Survey for many years. This function has become much more sophisticated in recent years since the establishment on the OU campus of the Oklahoma Mining and Minerals Resources Research Institute (OMMRRI).

OMMRRI, which is funded by the Office of Surface Mining, came to the campus in 1978, with Kenneth Johnson named as its first director. Because of the press of other work Johnson asked to be relieved of the directorship. Robert H. Arndt, formerly with USBM, who joined the Survey staff in late 1980, was named director of the Institute.

These minerals institutes were formed by OSM in states across the country that have significant mineral operations, and the University of Oklahoma was selected as the site for Oklahoma's office because of the presence of the Oklahoma Geological Survey on the campus. The purpose of OMMRRI is to conduct and support research on minerals and mining-oriented problems, but it has the further function of maintaining a data bank of information on mining and minerla prospects. With this facility the accessibility of mineral statistics has vastly increased. The Survey works closely with the Institute.

Another project that will make information on Oklahoma's mineral resources accessible is a bibliography being prepared under Arndt's direction that will list and index references to mineral commodities that have appeared in OGS publications over the years.

Petroleum and Natural Gas

Although Mankin, as has been noted, began his term as director professing an interest in attempting to equalize somewhat the imbalance between the development of fuel and of nonfuel minerals, circumstances intervened to alter things. So, except for the first five or six years of Mankin's administration, the major emphasis of the Oklahoma Geological Survey's efforts has been placed on energy resources.

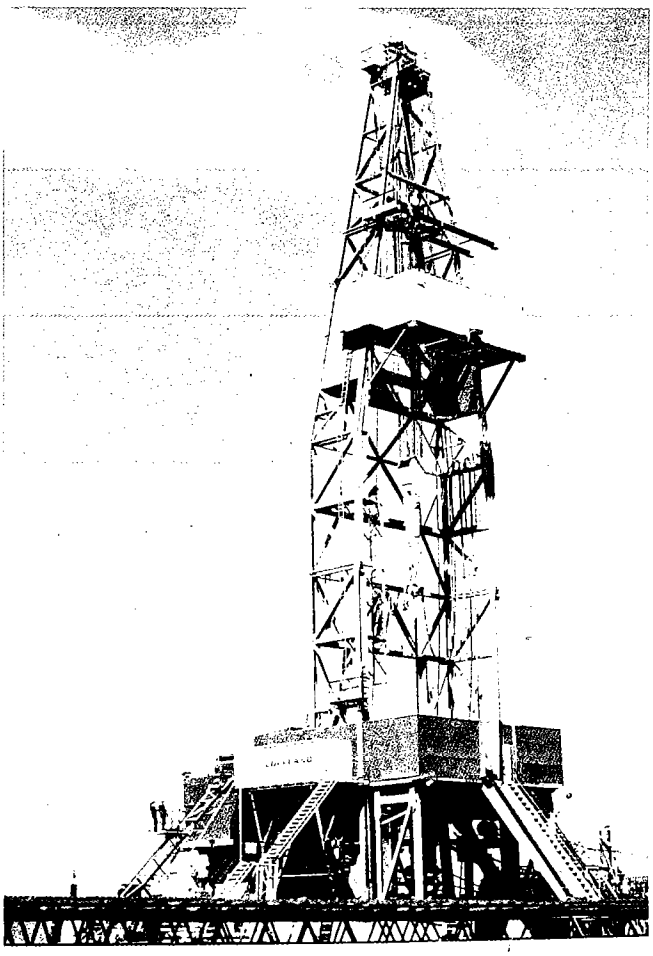
Mankin recognized as early as 1971 the impending energy crisis that was to burst upon the world in full force in 1973, culminating in the Arab oil embargo in October of that year. Schools were closed in some places. Filling stations closed on some days. People queued their cars at stations that were open. Conservation was preached.

It was at this time that the realization hit home to the public at large that domestic production was not enough to fill domestic demand for petroleum and natural gas. Production was exceeding known reserves, a situation that had been feared by many since almost the beginning. Relying too much on imports was not a satisfactory answer, and interest grew in investigating and developing alternative sources of energy.

But the real answer for the near future lay in finding more reserves, and, with increased prices that resulted from short supplies, more funds were available for exploration. It was the end of cheap energy, because it costs a great deal more to find deeper deposits, deposits at the bottom of the sea, deposits far from the eventual destination.

There was oil in Oklahoma; there was plenty of natural gas. But it had to be found to be recovered, and the Survey under Mankin developed many programs to aid in the exploration. To hit the high spots:

Amsden's work on the Hunton Group has been mentioned in the section on Branson, but this work has been much expanded. In 1976 the Survey issued a landmark publication, OGS Bulletin 121, by Amsden, on the stratigraphy, petrography, paleontology, chemical characteristics, porosity, and permeability of the Hunton rocks in the Anadarko Basin, one of the major targets in a major target area for exploration. A companion study on the Hunton in the Arkoma Basin of east-central Oklahoma was published in 1980 as OGS Bulletin 129. These two bulletins have provided much useful information on the two most important gas-producing provinces in the State.



Loffland Brothers Rig 32, the drilling rig used in setting two depth records in the Anadarko Basin of Oklahoma. The rig was used in drilling the Lone Star 1 Baden (30,050 feet) in 1972 in Beckham County and the Lone Star 1 Rogers (31,441 feet) in 1974 in Washita County. Photo by Kenneth S. Johnson.

In 1975, William E. Harrison, with a B.S. from Lamar State College of Technology in Beaumont, Texas, an M.S. from OU, and a Ph.D. from Louisiana State University and experience with three oil companies, joined the staff as petroleum geologist and geochemist. With John Roberts already serving as petroleum geologist, the Survey had two people equipped to handle the flood of inquiries that came with the increased drilling activity in the State.

Harrison undertook an investigation of Oklahoma's reservoirs for enhanced-oil-recovery projects, work that resulted in OGS Special Publication 81-1, *Reservoir and Fluid Characteristics of Selected Oil Fields in Oklahoma*, which was co-authored by Darcia L. Routh. The SP, which contains data from 17 "giant" oil fields, received quick response and is currently in its third printing.

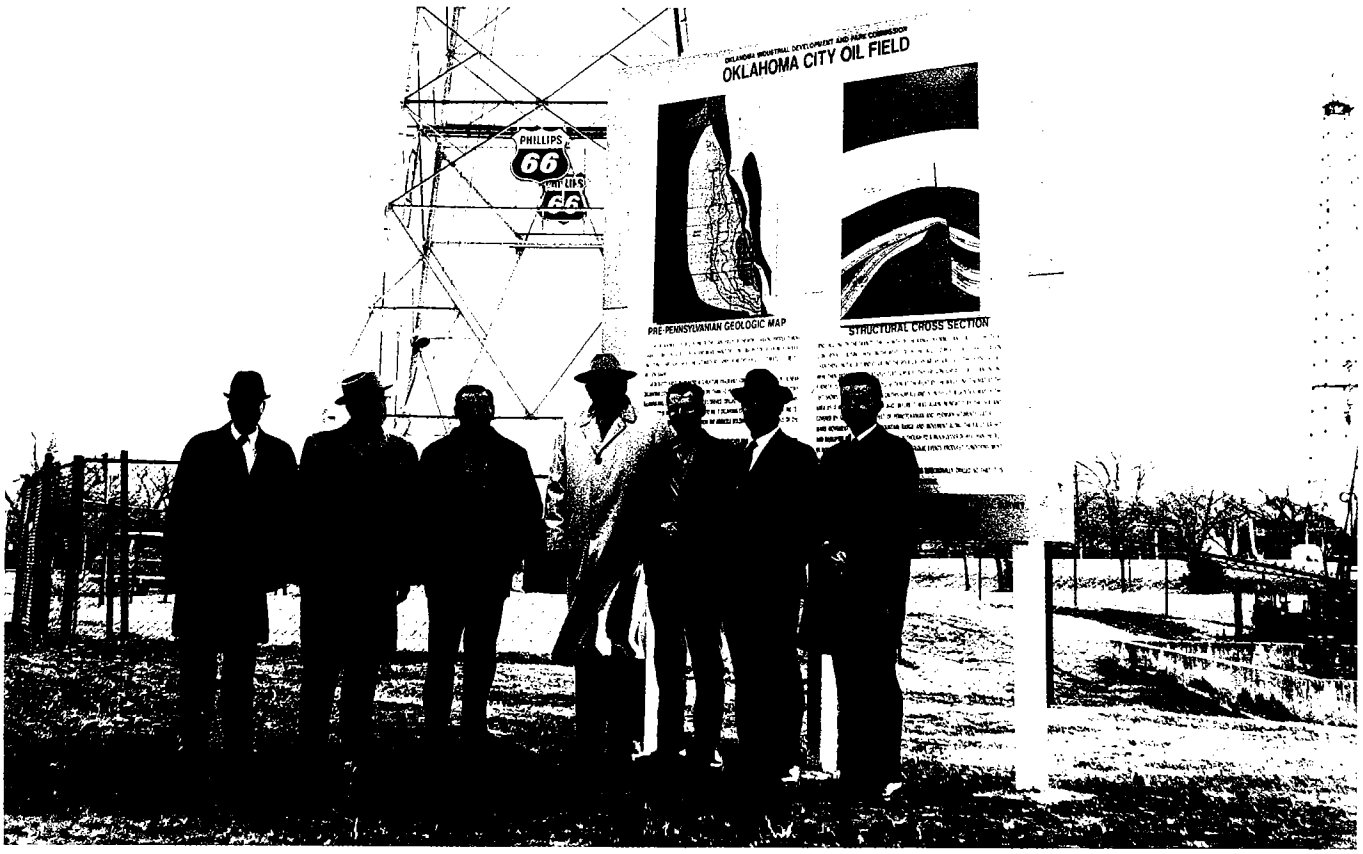
Harrison, Roberts, and Larman J. Heath of the U.S. Department of Energy (DOE) in Bartlesville, made a study of the heavy-oil deposits in shallow Pennsylvanian rocks of northeastern Oklahoma. The study involved drilling and examining cores from 18 holes, and, while results were disappointing, valuable information was gained. This work, funded in part by DOE in expectation of future demands for petroleum, was published in open file by DOE and later was issued as OGS Special Publication 81-4.

The heavy-oil project was expanded to cover examination of deposits in sands and some limestones in the Arbuckle Mountains area, and the Survey has drilled 20 boreholes to test these thick, viscous oils in Carter and Murray Counties. This time the holes were made with the Survey's own rig: in 1981, the Survey was able to purchase a much-needed and long-desired core-drilling rig, which is being used to assess hydrocarbon deposits of all kinds, including coals, as well as some nonfuel mineral deposits, and it was put to good use immediately. It is currently being operated by two worthy stalwarts, drillers Douglas L. Lemley and Dean V. Martin, in the coal field of eastern Oklahoma.

The southern Oklahoma project, also DOE-supported, has been under the direction of Harrison, with Margaret R. Burchfield, who joined the Survey staff in 1982 as a petroleum geologist, supervising the drilling. A report on results of these investigations has been submitted to DOE for open-filing; this will be published later by OGS as a Special Publication.

A study of the petroleum-source-rock potential of the asphalt deposits in the Ouachita Mountains that was conducted by Joseph A. Curiale, former OGS research assistant, is being issued this year as OGS Bulletin 135.

Another project, a study of the hydrocarbon-source potential and temperature history of the black shales of the Devonian–Mississippian Woodford Formation, has



Dedication of a sign commemorating the discovery and showing the geology of the giant Oklahoma City Field. The sign was erected as a joint effort of individual geologists, geological societies, the Oklahoma Development and Park Commission, and the Oklahoma Geological Survey. This photo, taken January 16, 1971, by Kenneth S. Johnson, shows, left to right: Jerry B. Newby, consulting geologist; Robert H. Breeden, executive director of the commission; Herbert G. Davis, president of the Oklahoma City Geological Society; George H. Shirk, president of the Oklahoma Historical Society and a former mayor of Oklahoma City; David R. Matuszak, president of the Tulsa Geological Society; Lloyd E. Gatewood, consulting geologist; and Charles J. Mankin, director of the Oklahoma Geological Survey.

been under Harrison's direction. Karen L. Sullivan, former research assistant and OU graduate student working with Harrison, prepared a thesis on the project; Brian J. Cardott, OGS organic petrographer, and Michael Lambert, former OGS minerals geologist, assisted in the temperature study; Robert L. Eutsler, former OGS minerals geologist, worked with compilation of logs.

An evaluation of quality and quantity of water available for enhanced-oil-recovery operations in the Cement Field of southwestern Oklahoma was made by former OGS petroleum geologist Donald A. Preston, and by Harrison, Luza, and others; results were published as OGS Special Publication 82-5.

Harrison developed a pyrolysis-gas-chromatograph method for determination of residual hydrocarbons in reservoir rocks for use in petroleum exploration. The University of Oklahoma has patented this technique.

A study of methane in coal beds for use in rural communities was done by OGS coal geologist Samuel A. Friedman, with results published in OGS Special Publication 82-3. This is mentioned also in the section on Coal. A *Vertical-Intensity Magnetic Map of McClain and Southern Cleveland Counties, Central Oklahoma*, that was compiled by John A. E. Norden, OU geophysicist, and others, was issued in 1972 as OGS Map GM-16. This map shows oil and gas fields. County reports issued during this time for McIntosh County (Bulletin 111), Bryan County (Bulletin 126), and Noble County (Bulletin 128) contain sections on petroleum and natural gas. A new oil- and gas-field map is being prepared by Burchfield at a scale of 1:500,000.

Also, statistical reports on petroleum and natural gas—production, economics, exploration, development, completions—have been issued annually in *Oklahoma Geology Notes*.

Statistics, however, have become much, much more sophisticated. Development of a computerized data file of statistics on Oklahoma's active oil and gas fields is an important ongoing project of the Survey. This field file, which is being organized by Michelle J. Summers, OGS data coordinator, presently contains information on the name, location, discovery year, and monthly production for each field. The programming for the data base was written by James C. Davis, a consulting systems analyst. Other data will be added to include producing formations, depth, and the history of developing fields.

Louisa Joy Hampton, OGS petroleum geologist, who joined the staff in 1982, is organizing and reviewing data for the OU Energy Resources Institute's Petroleum Data System of historical data on discovery wells, producing zones, and production. Also, she has charge of the Survey's microfilm collection of the Oklahoma Corporation Commission's logs of all wells drilled in Oklahoma. This collection currently contains logs of approximately 100,000 producing wells.

Beyond the projects listed above, and beyond the constant response to inquiries and requests for assistance in matters related to petroleum and natural gas, the Oklahoma Geological Survey has participated in innumerable forums, councils, symposia, meetings, lecture series, boards, committees, and panels that have had to do with energy resources and development, shortages, problems.

The activities of the Survey under Mankin truly have been focused on energy.

Coal

At the beginning of Mankin's administration in 1967, the coal business had gone into a decline: less than a million tons was produced in Oklahoma in that year. Expansion started in 1968 as a result of the growing use of coal in the generation of electricity, and by 1971 production was up to 2.37 million tons.

And by 1971 the Oklahoma Geological Survey had decided it needed a coal geologist. An increased interest in Oklahoma coal had brought about increased demands on the Survey for information on quantity of coal available, quality of coals, and locations of reserves in the State. Samuel A. Friedman, formerly with the U.S. Bureau of Mines and the Indiana Geological Survey, joined the staff to respond to such requests and to conduct coal investigations.

In that same year, the Survey initiated a comprehensive program to study (with the help of funding from the Ozarks Regional Commission) all of Oklahoma's coals. This massive project involved an evaluation of all previous data, followed by field investigations, followed by chemical analysis of the coals. The final report, prepared by Friedman, also covers history, economics, technology, potential uses of the coals, regulations on reclamation of mined lands, and estimates of reserves and resources. The report shows resources of 7 billion tons, with the possibility of economic recovery of about 3 billion tons. The volume, released in 1974 and designated OGS Special Publication 74-2, has been in such demand that it is now in its fifth printing.

Coal production rose to 3.6 million tons in 1976 and hit a record high of 5.8 million tons in 1981. The upswing in the coal industry came about partly because of fears of an energy shortage, but in Oklahoma partly because of the completion of the Arkansas River Navigation System, which provided a convenient form of shipment to Missouri, Tennessee, Florida, and Texas. There was a greatly increased demand during this time for low-sulfur coal for power generation and for coke, and the river barges allowed Oklahoma to fill some of that demand conveniently and without too much "freight added" tacked on to the cost.

Also, during this time, the Survey was asked to provide coal data for an engineering company that was making a study on the feasibility of setting up a coal-gasification plant in Oklahoma using a nuclear heat source. The OGS analytical-chemistry laboratory performed analyses of coal for this purpose, but the project never got off the ground, or, more appropriately, into the ground.

In 1974 Friedman offered the first of a series of short courses on "Coal Geology Fundamentals." These courses, which were held at the Oklahoma Center for Continuing Education on the OU campus, were structured for geologists, engineers, chemists, executives,

and industrialists not formally trained in coal geology. They were well attended. Friedman continued to offer these short courses annually through 1980.

Friedman also has offered courses in coal geology as an adjunct professor in the OU School of Geology and Geophysics, and he helped to develop a course in coal-geology engineering that is offered by the University's School of Petroleum and Geological Engineering.

It was in 1974 also that Johnson's environmental inventory of the coal field, *Maps and Description of Disturbed and Reclaimed Surface-Mined Coal Lands in Eastern Oklahoma*, was issued as GM-17.

In 1975 Friedman received a small grant from the USGS to support a program that provided analytical data on the quality of Oklahoma coal reserves, results of which proved valuable in determining potential uses of the coals. Most of the analyses for this project were done by the U.S. Bureau of Mines, although analyses were done by USGS for trace and minor elements.

The following year a project was funded by USBM in the amount of $54,000 to make a detailed study of the Hartshorne coals in Haskell and Le Flore Counties. This project has incorporated information on structure and stratigraphic correlations with other data on the coal beds that are thought to contain the largest coal resources in the State. A number of new mines were opened in that year. Also, the first of a series of sheets showing active coal mines in eastern Oklahoma—showing locations, producers, and coal data—was issued in 1976; another of these maps was issued in 1977. A map covering the years 1977-79 was issued in 1982 as GM-24.

Work began during this time on a long-term program that would entail the preparation of coal reports for each county in the coal field; this program is partially supported by USBM. The work, accomplished partly through OGS support of thesis work at OU and OSU, involves compilation of detailed maps showing the structure, mined areas, and resources of each coal bed.

This program involved also the hiring of a second coal geologist, LeRoy A. Hemish, who joined the staff in 1978. Work in Craig, Nowata, Rogers, Mayes, Creek, Tulsa, Wagoner, Washington, Okmulgee, Okfuskee, Muskogee, and McIntosh Counties either is completed or in various stages of progress at present.

An interesting report giving results of a study of methane resources in coal beds, a study conducted by Friedman and partially funded by the U.S. Department of Energy (DOE), contains an evaluation of methane resources in coal beds and their potential uses. This was issued in 1982 as OGS Special Publication 82-3. Another project being conducted by Friedman involves preparation of maps of abandoned underground coal mines.

Another part of the Survey's coal investigations involves developing petrographic information, including maceral and vitrinite-reflectance measurements, for each coal seam in the State. Petrographic work is being directed by OGS organic petrologist Brian J. Cardott; chemical analyses are being directed by Stephen J. Weber, chief chemist. Another coal-analysis program to show the distribution of sulfur, fixed carbon, and trace elements in Oklahoma coals is being directed by Friedman and involves a projected 1,000 analyses of typical coals.

The coal program truly has progressed in recent years.

Geothermal Resources

Another form of energy than that derived from fossil fuels was investigated in a project initiated by Harrison in 1980. This program, supported in part by a grant from DOE, involved an assessment of geothermal potential in areas of the Arkoma Basin having abnormally high temperature gradients. Data were obtained by inserting expendable temperature-sensitive devices into some of the many abandoned boreholes in Haskell, Pittsburg, and Le Flore Counties to measure the temperature at depth. These data not only provided information on heat flow, but showed a potential for use of the heat from these boreholes for space heating.

Results of these studies, which were conducted by Harrison, Kenneth V. Luza, OGS engineering geologist, M. Lynn Prater, former OGS petroleum geologist, and Paul K. Cheung, of Tangram Resources, Ltd., were published in OGS Special Publication 83-1.

Much earlier—in 1969-70—OGS cooperated with AAPG in a *Geothermal Survey of North America*, with John Roberts acting as chairman of the project for the Oklahoma district. This program resulted in a geothermal-gradient map of the continent, which was issued by AAPG in 1976.

Reclamation of surface-mined land in Rogers County, Oklahoma. The land at right has been reclaimed following extraction of coal by strip mining. Photo by Kenneth S. Johnson.

Uranium

In 1978 the Oklahoma Geological Survey received a grant from Bendix Field Engineering Corporation and the U.S. Department of Energy (DOE) to investigate uranium resources in Oklahoma as part of the NURE (National Uranium Resource Evaluation) program. The study in Oklahoma covered the large 1° by 2° Enid and Clinton Quadrangles (scale 1:250,000). The project was conducted under Johnson, as principal investigator, with Fay, Arthur J. Myers, Harrison, Roberts, and OGS analytical chemist David A. Foster assisting.

In that same year a new position was established to further these investigations, and Salman Bloch joined the staff to work on the NURE project. Two more geologists, James J. Myers and Robert L. Eutsler, came also to assist with the investigations. A report was issued to Bendix on the results.

Other projects in uranium during Mankin's time have included a study of the association of uranium with solid hydrocarbons, a water-sampling program to study radium-isotope ratios in natural waters as indicators of subsurface mineralization, and compilation of a map (by Matthew W. Totten and Fay) that shows approximately 400 reported occurrences of uranium in Oklahoma.

The uranium map and an accompanying text and bibliography were published in 1982 as GM-25. This map had a predecessor: a uranium-occurrence map of the State was compiled by OGS in 1969 for the Southern Interstate Nuclear Board.

Uranium occurrences are shown, too, on Map GM-15, the minerals map that was mentioned previously, and uranium in Custer County is discussed by Fay in Bulletin 114.

Hydrology

Mankin (1980) in his annual report for fiscal year 1979-80 describes the agreement with the U.S. Geological Survey for investigations of water resources in Oklahoma as one of the most successful cooperative programs of the Oklahoma Geological Survey. It certainly has been one of the most productive.

In 1967, at the beginning of Mankin's administration, the two surveys initiated a program that would result in a regional assessment of the availability and quality of Oklahoma's water resources. The State, except for the Panhandle (work in the Panhandle was done by the USGS in cooperation with the Oklahoma Water Resources Board), was to be covered by a series of nine hydrologic atlases, each made up of four large sheets showing the geology, ground-water resources, surface-water resources, and chemical quality of water at a scale of 1:250,000.

The first of these atlases, HA-1, *Reconnaissance of the Water Resources of the Fort Smith Quadrangle, East-Central Oklahoma*, by Melvin V. Marcher, was issued in 1969. The last, HA-9, *Reconnaissance of the Water Resources of the McAlester and Texarkana Quadrangles, Southeastern Oklahoma*, by Marcher and DeRoy L. Bergman, was issued this fall. Others are: HA-2, on the Tulsa Quadrangle, by Marcher and Roy H. Bingham, issued in 1971; HA-3, on the Ardmore and Sherman Quadrangles, by Donald L. Hart, Jr., issued in 1974; HA-4, on the Oklahoma City Quadrangle, by Bingham and Robert L. Moore, issued in 1975; HA-5, on the Clinton Quadrangle, by Jerry E. Carr and Bergman, issued in 1976; HA-6, on the Lawton Quadrangle, by John S. Havens, issued in 1977; HA-7, on the Enid Quadrangle, by Bingham and Bergman, issued in 1980; and HA-8, on the Woodward Quadrangle, by Robert B. Morton, issued in 1981.

Quite an achievement; and these HA's are useful not only for the hydrologic information they contain but also for updated geologic maps of the areas covered.

Plans were also made during the beginning of this period for detailed investigations of selected ground-water reservoirs in the State, such as the Garber-Wellington aquifer, the Antlers aquifer, the Vamoosa-Ada aquifer, the Arbuckle aquifer, and the Boone and Roubidoux aquifers. The Antlers report, prepared by Hart and Robert E. Davis, was published in 1981 as Circular 81. A report on the Vamoosa-Ada aquifer, by Joseph J. D'Lugosz and Roger G. McClaflin, and a report on the water resources in the Arbuckle Mountains area, by Roy Fairchild and others, will be issued as OGS circulars. The Boone and Roubidoux study is near completion. A report on the ground water in the Wichita Mountains area, by John S. Havens, was published this year as Circular 85. Also, an earlier report prepared by P. R. Wood and L. C. Burton of the USGS covers ground water in Cleveland and Oklahoma Counties. This was published in 1968 as OGS Circular 71.

Other hydrologic programs were and are being carried on by OGS under Mankin's administration, some in cooperation with USGS. Among these should be mentioned the investigation of water available for enhanced-recovery operations in the Cement Field in Caddo and Grady Counties, a study of the distribution and quality of water in the eastern Oklahoma coal field, an investigation (mentioned below) of water in abandoned mines in northeastern Oklahoma, and the preparation of two maps to show the principal ground-water resources and recharge areas of the whole State as an aid in planning the location of waste-disposal sites.

The water programs cannot be separated from other programs, and the close relationship of the investigations listed above to environmental geology is obvious.

Environmental Geology

Mankin realized early in his administration that work in environmental geology was needed, and in his report for fiscal year 1968-69 he expresses regret over the Survey's inability to initiate such a program at that time. Funds and personnel simply were not available. John W. Shelton, however, working on a part-time assignment for OGS, did prepare a report during this period for the City of Stillwater on Lake McMurtry.

Environmental geology was rather a new area for the Oklahoma Geological Survey, except that much of the

work done in the past was really environmentally oriented; but acceleration was rapid, and requests for environmental information came in thick and fast. Environmental-impact studies were requested by the State Highway Department on proposed new and relocated roads; land-use studies were required by one agency; hydrologic reports on water and sewage systems were needed by another; the U.S. Bureau of Reclamation wanted to know about the suitability of sites for the construction of dams; information was needed for siting of public landfill operations; and much more information was needed to supply answers to local-subsidence and foundation problems, and to identify flood-prone areas.

Some of these projects were undertaken in cooperation with other agencies, and in other instances the Survey acted only as an intermediary, collecting information obtained by other agencies and making it available to the public or merely referring inquiries to the appropriate sources. Most of these requests were handled by Kenneth S. Johnson and Robert O. Fay. Also, in 1970, Fay began compiling an environmental-geology library (known locally and facetiously as the "Robert O. Fay Living Memorial Environmental-Geology Library"), which contains an assembly of pamphlets, books, newspaper clippings, and magazine articles on such topics as water resources, pollution, conservation, remote sensing, and engineering. This ever-increasing collection, which is housed in the Survey's library in the basement of OGS, provides a convenient and up-to-date source of information in this field.

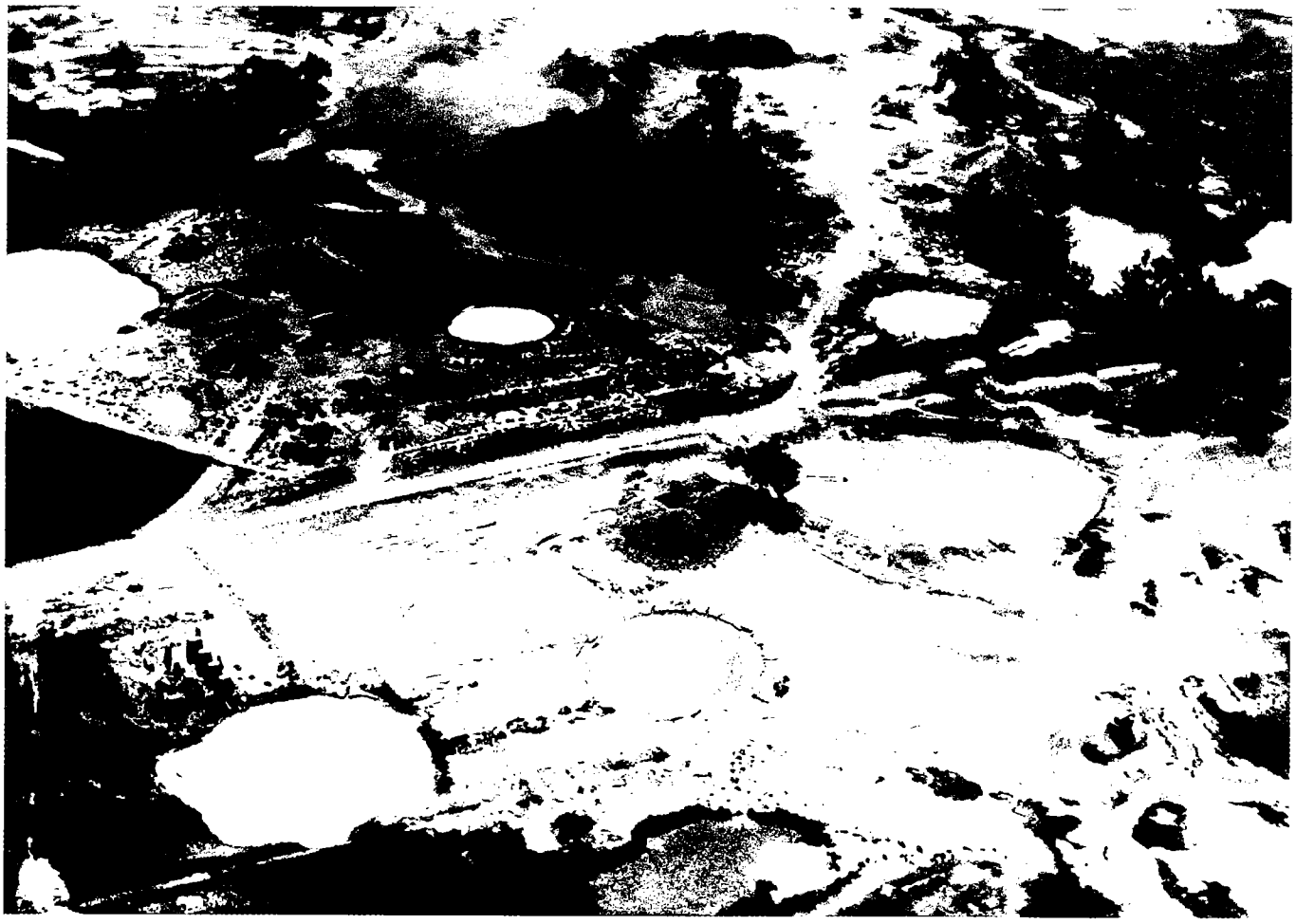
But the Survey's work in environmental geology has gone far beyond relaying information. Some instances:

Surface-mine operators needed assistance in restoring lands to conformance with regulations imposed by reclamation acts instituted in 1968 and 1971. Kenneth Johnson was most active in offering such assistance; his work in this area culminated in the publication in 1974 of OGS GM-17, which has already been mentioned.

The Tulsa Geological Society prepared an urban environmental report on their city that was published as TGS Digest, Volume 37, *Tulsa's Physical Environment.* This publication contains four maps that were prepared by OGS.

By 1975 Kenneth V. Luza had joined the staff as engineering geologist, and since that time environmental and engineering geology has become an integral part of the Survey's program.

In 1975 a study was undertaken with the aid of a grant from the USGS to examine and inventory past and



Drowned shafts of abandoned underground lead and zinc mines near Commerce, north of Picher, Ottawa County, Oklahoma. Photo by Kenneth V. Luza.

present mining activity in each of Oklahoma's 77 counties exclusive of the coal field, a massive project that will result in a map to be issued soon. This has been under Johnson's direction, and, with the aid of the Survey's extensive collection of aerial photographs, Survey geomorphologist Arthur J. Myers has located 5,166 openings, which have been field checked.

In 1976 the OGS, USGS, and the Northeast Counties of Oklahoma Development Association initiated a long-term cooperative project to evaluate the quality and quantity of the large amounts of water in the abandoned zinc mines in the Picher mining field in northeastern Oklahoma. Results, which showed the water to be unfit for just about any use without extensive treatment, were published in 1981 as Circular 82.

Also in 1976, a project was begun under partial support from the U.S. Nuclear Regulatory Commission (NRC) to study seismicity and tectonics along the Nemaha Ridge, a buried, block-faulted structure extending northward from central Oklahoma into Kansas, Nebraska, and Iowa. This investigation, carried on by Luza and James E. Lawson, Jr., of the OGS Oklahoma Geophysical Observatory, was undertaken to obtain information for the siting and designing of large-scale structures such as dams, high-rise buildings, and power plants. Two sections of the results were published as OGS special publications.

In 1977, environmental studies included an investigation of sand and gravel deposits near Oklahoma metropolitan areas, analyses of surface and subsurface waters of the eastern Oklahoma coal field, and a study of the salt-water pollution of the Arkansas and Red River drainage basins. In 1978 a study on the *Surface Disposal of Controlled Industrial Wastes in Oklahoma* was completed by Johnson and Luza. A report, including the results of this investigation, was published in 1980 as OGS Circular 80 and identifies formations with favorable characteristics for both surface and subsurface disposal.

In 1980, some large mud-filled craters suddenly appeared in the earth near Edith in southwestern Woods County, much to the consternation of inhabitants of that northwestern part of the State, and OGS was called in. Donald A. Preston, OGS petroleum and subsurface geologist, determined that 20 million cu ft per day of gas coming from Upper Mississippian and Lower Pennsylvanian reservoirs was being vented through natural fracture systems in Permian rocks at the surface. Interesting, and quite a loss into the atmosphere of a valuable resource.

It was in 1980 also that Luza and Preston (who has since left the Survey) began a study of environmental hazards associated with the abandoned underground lead and zinc mines in northeastern Oklahoma. This investigation, which was partially funded by USBM, has been completed, and a report was issued in open file by the Bureau of Mines in May 1983. Luza inventoried 1,064 shafts for the report, 485 of which are in some stage of collapse.

Concurrently with all this, preparation of environmental reviews for highway-construction projects, sewer improvements, etc., and responses to numerous inquiries requesting information and assistance have been continuous.

A major contribution is the monitoring of seismic activity in the State, "Shake and Bake," in the terminology of OGS engineering geologist Luza. This is carried on through the facilities of the OGS Oklahoma Geophysical Observatory.

Oklahoma Geophysical Observatory

In 1961 Jersey Production Research Company built a laboratory at Leonard, south of Tulsa, Oklahoma, for the purpose of receiving and recording seismic impulses. In 1964, however, Jersey Research became part of a Humble Oil & Refining Company research affiliate in Houston, and its operations were transferred to Houston. So in April 1965 Humble (now Exxon) presented the facility at Leonard to The University of Oklahoma, including in the gift the recording instruments and a library of irreplaceable recordings. It was known as the OU Earth Sciences Observatory and was maintained as a laboratory for research in geophysics and as a training ground for students.

The site on which the Observatory was built, a location selected because of its semi-isolation from human interference—highways, railroads, airports, heavy industry—was ideal for reception by the sensitive instruments of any slight disturbance of the earth. But the site was on Indian land and was leased rather than having been bought outright. The owner decided later to sell the land, creating a problem but not an insurmountable problem: funds were gathered through contributions from generous OU alumni for its purchase, which was consummated in 1974.

Then in 1978 the University dropped funding for the Observatory.

It was not very good timing, but the Observatory was too valuable an asset to be abandoned, so the Oklahoma Geological Survey squeezed its budget and came up with enough to keep the Observatory functional and still home-owned and operated. It was renamed and is now known as the Oklahoma Geophysical Observatory; since July 1, 1978, it has operated as a branch of the Oklahoma Geological Survey. Robert L. DuBois, now assistant director of the OU School of Geology and Geophysics, was director of the Observatory from 1967 to 1978. Kenneth V. Luza, OGS engineering geologist, now serves as coordinator between the Survey proper and the Observatory. James E. Lawson, Jr., who has been with the Observatory since 1970, serves as geophysicist for the facility.

Ninety percent of the Observatory's activities involve receiving, recording, and transmitting data on seismic impulses. Seven seismometers are housed in a vault that is separate from the main building, and the seismic data are recorded on 11 paper-drum recorders and 16 film recorders. Some of the seismic information is forwarded to the National Earthquake Information Center at Boulder, Colorado, and to the International Seismological Centre at Newbury, England. Also, seven seismograph stations across the State are operated by volunteers, and

three radio-telemetry stations record earthquakes throughout the State.

Complete information is now available through the Observatory on all locatable, historic earthquakes through the present. An earthquake map, GM-19, was published in 1979, and updates, prepared by Lawson and Luza, on earthquake activity in Oklahoma are published annually in *Oklahoma Geology Notes*.

But other information is also available through the facility. Geomagnetic variations have been recorded at the Observatory since 1961 on an Askania magnetic variograph. In 1981, the magnetic-recording capabilities were improved by the addition of a three-component fluxgate magnetometer supplied by the USGS. The Observatory also measures the Earth's gravity fields, Earth tides, the thermal gradient of the Earth, atmospheric pressure, wind velocity, cosmic radio noise, and solar radiation.

Not too much can go on in the world without the Observatory picking it up.

Basic Geologic Investigations and Geologic Mapping

Results of some research investigations are immediately applicable, and several such projects that were carried out during Mankin's administration already have been named. Many other research programs conducted over recent years, however, bear no apparent or direct relationship to economic mineral resources. Some of these studies were conducted by authors outside the Survey; in many of these cases the Survey offered field or other types of support.

These basic investigations include numerous paleontologic studies, such as James H. Stitt's work on Cambrian and Ordovician trilobites in the Arbuckle and Wichita Mountains (Bulletins 110, 124, and 134); K. S. W. Campbell's work on Silurian and Devonian trilobites (Bulletins 115 and 123); Robert F. Lundin's study of Devonian ostracodes (Bulletin 116); Leonard P. Alberstadt's description of Ordovician brachiopods (Bulletin 117); Amsden's extensive studies of Ordovician and Silurian brachiopods (Bulletins 119, 125, and 132); James C. Brower's descriptions of calceocrinids in the Ordovician Bromide Formation (Circular 78); Malcolm J. Heaton's work on some primitive Permian and Pennsylvanian reptiles (Bulletin 127); Everett C. Olson's investigation of Permian vertebrates (Circular 74); the plant microfossils of the Cretaceous Denton Shale, by F. H. Wingate (Bulletin 130); and the formaminifers and algae of the type Morrowan, by John R. Groves (Bulletin 133).

Results of investigations of a broader nature also have come into print during this time. Among these are a report on the *Geology of the Eastern Part of the Lynn Mountain Syncline, Le Flore County, Oklahoma,* by Garrett Briggs (Circular 75); the *Paleoenvironment of Fitzhugh Member of Clarita Formation (Silurian, Wenlockian), Southern Oklahoma,* by Amsden, Donald F. Toomey, and James E. Barrick (Circular 83); the *Stratigraphic Significance of Limestones of the Marmaton Group (Pennsylvanian, Desmoinesian) in Eastern Oklahoma,* by George W. Krumme (Bulletin 131); *Basement Rocks in Northeastern Oklahoma,* by Rodger E. Denison (Circular 84); and the *Upper Bromide Formation and Viola Group (Middle and Upper Ordovician) in*

James E. Lawson, Jr., chief geophysicist for the Oklahoma Geological Survey's Oklahoma Geophysical Observatory.

Eastern Oklahoma, by Amsden and Walter C. Sweet (Bulletin 132).

The listing of publications indicates that basic research has been extensive and intensive over recent years, but it tells only part of the story. Amsden's current work on the Ordovician-Silurian boundary is well known in this country and in Europe, and he has recently traveled to China to study this contact on the Asian Continent. There is Harrison's work on subsea sediments, kerogens, and Egyptian oil shales; Johnson's work on evaporites; Mankin's research on hydrocarbon reserves; the coal, petroleum, and water analyses; the COSUNA and D-NAG programs; Burchfield's study of the environment of deposition of the Pennsylvanian Dutcher sands—

Many results of some of these and other efforts have been presented elsewhere—at scientific meetings of all kinds—and results are published elsewhere—in journals, symposium proceedings, etc. The Oklahoma Geological Survey has been well represented on this and other continents during Mankin's time.

An interesting sidelight that involves acquisition of material for research (sidelight—according to Webster, that means information coming incidentally): The Survey was offered a rare opportunity early in Mankin's administration to acquire a new insight into the geology of south-central Oklahoma when excavations began for the extention of Interstate Highway 35 through the Arbuckle Mountains.

In 1967 and 1968 OGS was engaged in a program with the U.S. Bureau of Public Roads to make a geologic and paleontologic study of rocks exposed in road cuts along the right-of-way. A large quantity of material was retrieved and a report was submitted to the Bureau. Robert O. Fay was in charge of collecting samples and specimens.

In 1968, with the broad road still under construction, Ham conducted a field trip through the area as part of the AAPG annual-meeting program; Fay prepared a guidebook and led a field trip through the area the following year, 1969, for the Ardmore Geological Society, offering information that had not previously been available. Fay's guidebook was published by the society.

It was in 1969 also that Ham's classic Guidebook 17, *Regional Geology of the Arbuckle Mountains, Oklahoma*, was issued, complete with the Arbuckle map and sections.

Another different but, in a way, similar retrieval project was conducted 10 years later, when Coleman R. Robison joined the staff as visiting geologist under an agreement with the U.S. Bureau of Land Management (BLM) to collect and describe paleontological material that might be destroyed by coal-mining operations in seven counties in southeastern Oklahoma. Robison assembled an outstanding collection of plant and invertebrate fossils and prepared a report that was placed on open file by BLM.

Since 1967, county reports have been published for McIntosh County (Bulletin 111), Custer County (Bulletin 114), Choctaw County (Bulletin 120), Muskogee County (Bulletin 122), Bryan County (Bulletin 126), and Noble County (Bulletin 128). Reports on Payne and Marshall Counties are being processed for publication, and field mapping in Washita County has been completed, with mapping in Alfalfa County more than half finished. A new geologist, James R. Chaplin, joined the OGS staff this year to further progress toward the perennial goal of mapping each county in the State.

There has been other mapping—

In addition to the county maps, 13 geologic maps in the GM series have been issued so far under Mankin's directorship. Most of these have already been referred to in connection with their applications. Others of note include GM-14, by Amsden and Rowland, which incorporates geologic maps and cross sections of Silurian and Devonian formations in the State; GM-18, by Frank A. Melton, an aerial-photograph study of the central Ouachita Mountains; and GM-21, GM-22, and GM-26, which are referenced index maps to surface and subsurface geologic mapping in Oklahoma from 1901 through 1979.

Funding

In his annual report for 1968-69, Mankin (1969) expresses his discouragement over the "lack of anticipated increases in funding and personnel." He says, "Much that needed to be done could not be done under present circumstances; too often we have been forced to assign priorities on the basis of what is possible rather than what is necessary." Again in 1972: "The Survey's program of research and development continues to remain understaffed, because of inadequate financial support."

In these statements Mankin is only echoing the feelings and frustrations of directors through the years, who saw clearly how much needed to be done, could be done, but could not be done because of insufficient funding. It goes all the way back to Van Vleet, who said (1902), "The funds were so inadequate for the amount of work required, that the task seemed almost hopeless." Gould said (1910a): "Owing to the lack of appropriations available for field work . . . it was found necessary to discontinue a considerable amount of investigation." Again, Gould said (1927): "So little has been done, and so much remains undone."

Shannon thought he understood the reason for insufficient funding: "The nature of the Survey work is not known to many people of the State, nor is it known that the Survey works under a distinct appropriation and is not connected with other departments. This misunderstanding of the purpose and needs no doubt has prevented the department from being properly provided for by the State."

And Dott (1936) at the beginning of his administration urged proper provision for his agency: "Sufficient funds should be available to carry on the Survey's comprehensive program." He continued to present the case throughout the years. What else could one do?

What was done from the first, back as far as Van Vleet's time, was to seek out cooperative assistance from other, mostly federal, agencies. Some of these agreements with the USGS, USBM, and others have been mentioned. A partial listing of other cooperating

organizations would include the U.S. Army Corps of Engineers, the National Aeronautics and Space Administration (NASA), the U.S. Bureau of Public Roads, the Oklahoma Economic Development Foundation, the American Association of Petroleum Geologists, the Tulsa Geological Society, The Oklahoma Water Resources Board, the Oklahoma Department of Economic and Community Affairs, the Oklahoma State Board of Health, the Oklahoma Industrial Development and Parks Department, and municipalities in the State. Much good work has been accomplished in cooperation.

Mankin, however, has gone further and has sought and received not only cooperation but grant funds to carry on and expand the work of the Survey. Grants have been received from (among other sources) the USGS, USBM, the U.S. Department of Energy (DOE), the Ozarks Regional Commission, the U.S. Nuclear Regulatory Commission (NRC), municipalities, the National Science Foundation, and the Osage Tribal Council.

The current budget, a "standstill" budget because of loss of revenues to the State resulting from the current slump in activity in petroleum and natural gas, is at $1,672,231; grants for the 1983-84 year amount to $166,076, less than in recent years.

Not enough for what could be done, should be done; but what would the pioneer directors, who managed on $7,500 in 1908 to a high of $51,000 in 1931, think of those figures?

Public Service

Public service is intrinsic to the structure and function of the Oklahoma Geological Survey. The directive that this be so is spelled out clearly in the 1908 "general instructions to the Director," which are quoted in the section of this paper covering public service during the Early Years. Public service also is inseparable from the history of the organization.

Dott (1942), in his biennial report for 1941-42, describes a tally that was kept on inquiries and on samples submitted for identification. He says:

> They have come from all over the state and nation, from prospectors, land owners, operators, railroad development agents, and industrialists. Each inquiry is handled sympathetically, promptly, and as helpfully as possible. It is regrettable that most inquirers do not follow up their original inquiries, so it is difficult to determine how helpful we have been, what development may have taken place, or how much money may have been saved from the information we have furnished.

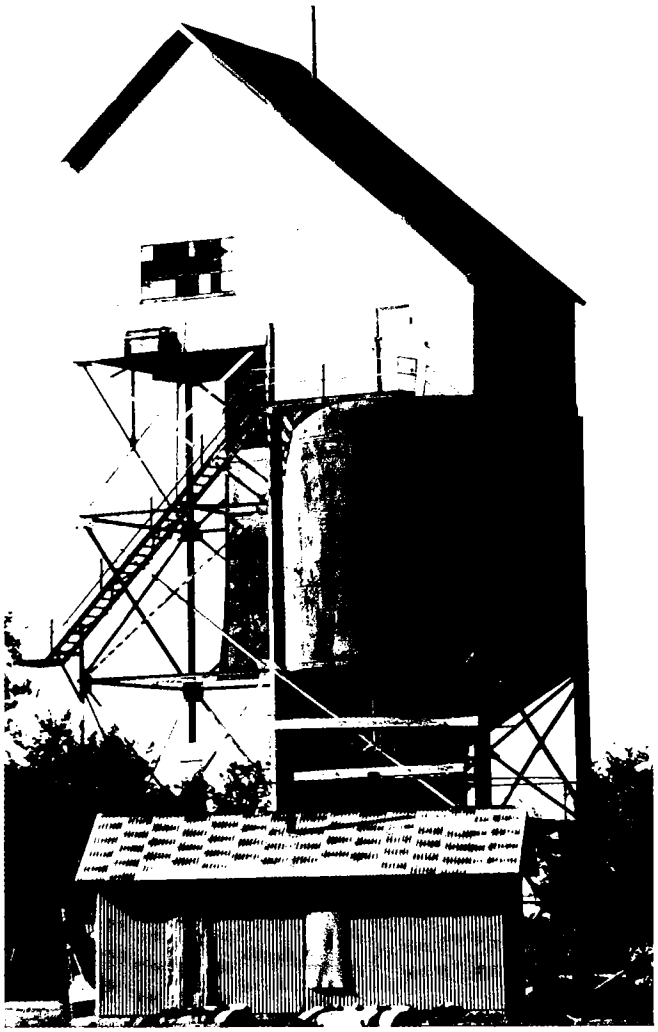
Mankin (1980) states:

> The largest single public-service category is response to requests for information. These requests range from questions concerning the presence of petroleum under a specific tract of land to identifying the best place to collect fossils. Each request is handled as a legitimate inquiry. In this endeavor, the role of the Survey cannot be overstated.

Actually, considered in a broad sense, the *raison d'etre*, the justification, of any governmental geological agency is public service: the scientific and economic examination of rocks and material contained in them; the dissemination through publication or otherwise of knowledge so gained; the compilation of maps; the maintenance of records, statistics, collections of materials, well logs, chemical analyses, bibliographies, whatever.

Considered in a narrower sense, as direct contact with the public by phone, in person, or by letter—with private citizens, industry representatives, other governmental agencies, educators and students—public service is corollary.

Both these aspects of public service have been of vital concern to the Oklahoma Geological Survey through



Steel hopper and derrick of the Little Greenback lead and zinc mine in the Picher Field, Ottawa County, Oklahoma. This hopper-derrick, according to Kenneth V. Luza, who took the picture, is one of the last remaining links to the past in an area that was once the world's largest producer of zinc.

the years. It is one area of endeavor that has not changed in 75 years, and each director in turn has mentioned it.

That the Survey has been particularly active in the broad sense is evidenced by the close to 100 publications issued since 1967. These include Bulletins, Circulars, Geologic Maps, Hydrologic Atlases, Guidebooks, Educational Publications, and Special Publications in addition to the Survey's bimonthly periodical, *Oklahoma Geology Notes*.

The Special Publication series was authorized in 1981 by OGS director Mankin in order to get information out as quickly and as inexpensively as possible. These works generally are printed in-house from author-prepared copy and undergo a minimum of editing. Several miscellaneous publications issued prior to 1981 have been designated as SP's to provide them with a serial category.

The Educational Publication program began in 1969 as a grant program with the National Science Foundation under the direction of Kenneth Johnson to provide a series of nine field-trip guidebooks for earth-science teachers in secondary schools. The first of the series is an atlas of maps and cross sections that was published in 1972; the second gives a geologic history of the State and provides instructions on leading field trips; subsequent issues (of which two have been published) cover various regions in Oklahoma. These guides, which are not only for teachers but for the lay public, are definitely in the realm of public service.

The other guidebooks and the leadership of field trips by Survey geologists represent another offering to the public. Survey geologists have led many diverse groups on numerous field excursions in recent years.

The lectures presented by Survey geologists are far too many to enumerate. The audiences have included grade-school students, high-school students, advanced students, teachers, professors, scouting groups, civic organizations, and local, regional, national, and international societies, academies, congresses, symposia.

OGS geologists have taught many courses in the OU School of Geology and Geophysics and elsewhere. They have organized and led and presided over many meetings, have held office on every level, and have volunteered their services on many occasions. They have answered inquiries from everyone from a third grader wanting a rock from Oklahoma, to a whole roomful of fourth graders wanting rocks and information, to graduate students and their professors, to a retired Methodist minister wanting to correlate geologic and Biblical ages, to scientists, industrialists, governmental officials, land owners, amateur collectors. Survey geologists have given assistance and information to whomever about whatever has to do with earth materials in Oklahoma, and frequently.

Public service.

Conclusion

Public service is really what the whole 75 years boils down to: service to the State of Oklahoma and its citizens by seeking out and providing information on the earth resources of the State of Oklahoma to aid in the orderly development of these resources for the benefit of the State of Oklahoma.

It has taken a lot of doing, through sometimes adverse circumstances, for the Oklahoma Geological Survey to accomplish what it has accomplished in the past three quarters of a century. These accomplishments have been discussed in the preceding pages. They are represented in the 135 bulletins, 86 circulars, 36 mineral reports, 21 guidebooks, 26 geologic maps in the GM series, 21 special publications, four educational publications, nine hydrologic atlases, 43 volumes of *The Hopper* and *Oklahoma Geology Notes*, and the many miscellaneous maps and publications issued by the Survey. There is no need to list them again.

The Oklahoma Geological Survey has come a long way in its 75 years; there is a long way to go.

Charles Newton Gould would be proud of what he started.

Some of the people who made all this possible are listed in the appendix that follows. That their contributions are not all mentioned individually is solely a reflection of limitations of space and time. Each one on the list has in his/her own way been a part of the effort.

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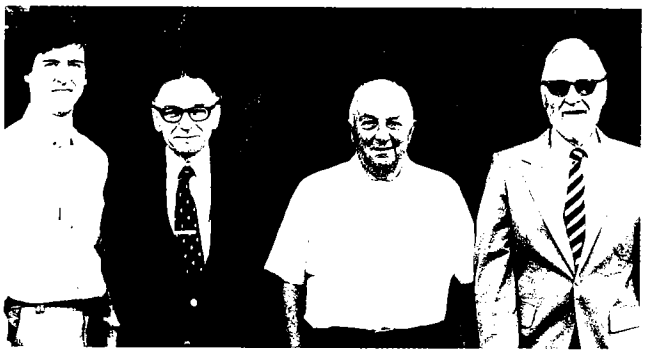
Left to right: Ginger G. Dossey, Janet R. Beyma, David O. Pennington, Mitzi G. Blackmon, Rexford J. Conrad, Gwen C. Williamson, Margarett K. Civis, Helen D. Brown, Janice S. Spurlock.

Left to right: Tari Harrington, Massoud Safavi, T. Wayne Furr, Marion E. Clark.

Left to right: LeRoy A. Hemish, Robert H. Arndt, Margaret R. Burchfield, James R. Chaplin, Charles J. Mankin.

Left to right: Robert O. Fay, L. Joy Hampton, Kenneth V. Luza, Michelle J. Summers, Kenneth S. Johnson, William E. Harrison.



Left to right: Brian J. Cardott, Samuel A. Friedman, Arthur J. Myers, Thomas W. Amsden.

Left to right: Keith A. Catto, Jr., Robert M. Powell, James W. Lea, Jane Weber, Stephen J. Weber.

Left to right: Paula A. Hewitt, Connie G. Smith, Elizabeth A. Ham, William D. Rose.

Left to right: Walter C. Esry, Eldon R. Cox.

Left to right: Richard L. Watkins, James E. Lawson, Jr., Paul H. Foster, Shirley Jackson, Barbara J. Munson.

Left to right: Dean V. Martin (drilling technician, temporary), Douglas L. Lemley.

Current Oklahoma Geological Survey Staff
(November 1983)

CHARLES J. MANKIN, *Director*
KENNETH S. JOHNSON, *Associate Director*

THOMAS W. AMSDEN, *Biostratigrapher/Lithostratigrapher*
ROBERT H. ARNDT, *Economic Geologist*
BETTY D. BELLIS, *Word-Processor Operator*
JANET R. BEYMA, *Clerk-Typist*
MITZI G. BLACKMON, *Clerk-Typist*
HELEN D. BROWN, *Assistant to Director*
MARGARET R. BURCHFIELD, *Petroleum Geologist*
BRIAN J. CARDOTT, *Organic Petrologist*
KEITH A. CATTO, JR., *Chemist*
JAMES R. CHAPLIN, *Geologist*
MARGARETT K. CIVIS, *Senior Clerk*
MARION E. CLARK, *Cartographic Technician II*
REXFORD J. CONRAD, *Geological Technician*
ELDON R. COX, *Manager, Core and Sample Library*
GINGER G. DOSSEY, *Secretary*
WALTER C. ESRY, *Core and Sample Library Assistant*
ROBERT O. FAY, *Geologist*
PAUL H. FOSTER, *Senior Electronics Technician*
SAMUEL A. FRIEDMAN, *Senior Coal Geologist*
T. WAYNE FURR, *Manager of Cartography*
ELIZABETH A. HAM, *Associate Editor*
L. JOY HAMPTON, *Petroleum Geologist*
TARI HARRINGTON, *Cartographic Aide*
WILLIAM E. HARRISON, *Petroleum Geologist/Geochemist*
LEROY A. HEMISH, *Coal Geologist*
PAULA A. HEWITT, *Supervisor, Copy Center*
SHIRLEY JACKSON, *Record Clerk*
JAMES E. LAWSON, JR., *Chief Geophysicist*
JAMES W. LEA, *Laboratory Assistant*
DOUGLAS L. LEMLEY, *Drilling Technician*
W. LANCE LOPER, *Offset Duplicating Machine Operator*
KENNETH V. LUZA, *Engineering Geologist*
BARBARA J. MUNSON, *Record Clerk*
A. J. MYERS, *Geomorphologist/Aerial-Photo Interpreter*
DAVID O. PENNINGTON, *Geological Technician*
ROBERT M. POWELL, *Chemist*
WILLIAM D. ROSE, *Geologist/Editor*
MASSOUD SAFAVI, *Cartographic Aide*
CONNIE G. SMITH, *Associate Editor*
JANICE S. SPURLOCK, *Switchboard Operator/Receptionist*
MICHELLE J. SUMMERS, *Geological Data Coordinator*
RICHARD L. WATKINS, *Electronics Technician*
JANE WEBER, *Organic Chemist*
STEPHEN J. WEBER, *Chief Chemist*
GWEN C. WILLIAMSON, *Office Manager*

Appendix

This section lists some of the many staff members who have been employed by the Oklahoma Geological Survey over the years, going back to Charles N. Gould's first period as director. The listings have been culled from the literature, mostly directors' reports, so numerous gaps appear in terms of the overall record.

Nonetheless, the names given on these pages are representative and reflect the dedicated effort which these scientists and support personnel have given during their years of service with the Survey.

The groupings are arranged under the respective periods of several Survey directors, beginning with Gould and ending with the present director, Charles J. Mankin. A complete listing of current Survey personnel is given on page 58, as of November 1983.

Charles N. Gould
1908–1911, 1924–1931

Director: Charles N. Gould
Assistant Directors: Lon L. Hutchison, Luther C. Snider
Geologists: Daniel W. Ohern, Charles H. Taylor, Chester A. Reeds, J. W. Beede, Chalmer L. Cooper
Chemists: Luther C. Snider, Frank Buttram
Draftsman: Frank Gahrtz
Assistant: Bess Mills–Bullard
Secretaries: John S. Redfield, J. O. Beach
Stenographers: Mary E. Marsh, C. W. Rose, Robert H. Wood, Florence Marsh, M. A. Cox
Field Assistants: Pierce Larkin, Frank A. Herald, Chester C. Clark, G. W. Kneisly, Gaylord Nelson, H. A. Everest, Key Wolf, John Bennett, Everette L. DeGolyer, Ben C. Belt, W. J. Cross, T. R. Corr, Everett Z. Carpenter, H. G. Powell, Jerry B. Newby, W. J. Hazeltine, J. C. Thompson, T. F. Eyerly, C. W. Hamilton, Fred Capshaw, Lloyd Maxwell, Artie C. Reeds, Robert H. Wood, John Herald

Daniel W. Ohern
1911–1914

Director: Daniel W. Ohern
Assistant Director: Luther C. Snider
Geologists: Charles W. Shannon, Charles H. Taylor, Chester A. Reeds, J. W. Beede
Chemist: Frank Buttram
Draftsmen: Frank Gahrtz, Leo Gorton
Chief Clerk: Louise S. Taylor
Stenographer: M. A. Cox
Field Assistants: Frank A. Herald, Chester C. Clark, H. A. Everest, Key Wolf, John Bennett, W. J. Cross, Everette L. DeGolyer, T. R. Corr, Ben C. Belt, Everett Z. Carpenter, H. G. Powell, W. J. Hazeltine, J. C. Thompson, T. F. Eyerly, C. W. Hamilton, Lloyd Maxwell, Artie C. Reeds, Robert H. Wood, John Herald, Jerry B. Newby, Fred Capshaw, John A. Newby, Glenn C. Clark, Robert E. Garrett, M. L. McCance, B. H. West, Burr McWhirt, Harve Loomis, G. H. Myers, L. E. Trout, Irving Perrine, George H. Burress, William A. Buttram, Sam Hodgson, George Morgan

Charles W. Shannon
1914–1923

Director: Charles W. Shannon
Assistant Director: Luther C. Snider
Geologists: L. E. Trout, Daniel W. Ohern, Charles H. Taylor, Chester A. Reeds, J. W. Beede, B. F. Wallis
Chemists: W. A. Buttram, Fritz Aurin
Ornithologist: Ed Crabb
Draftsmen: Frank Gahrtz, Leo Gorton, Leon Asbury
Chief Clerk: (Miss) Charlie Nickle
Office staff: G. W. Stevens, D. C. Books, R. W. Chestnut, Rayburn Foster, Sam Hodgson
Field Assistants: George D. Morgan, C. Z. Logan, C. E. Hyde, Carl Clarke, Don Walker, L. B. Snider, E. V. Woolsey, C. R. Thomas, Dean Stacy, L. G. Hurst, J. D. Watson, Robert Goodrich, George H. Myers, Harve Loomis, Burr McWhirt

Robert H. Dott
1935–1952

Director: Robert H. Dott
Administrative Assistant: J. O. Beach
Geologists: Gerald W. Chase, Phyllis Dale, Leon V. Davis, William E. Ham, H. Andrew Ireland, C. Lynn Jacobsen, Hugh D. Miser, Malcolm C. Oakes, Stuart L. Schoff, John H. Warren, A. Paul Wishart
Mineralogist: Clifford A. Merritt
Chemists: Albert L. Burwell, Jack F. Eberle, S. G. English, William L. Howard, Sam Houston Johnson, Laurance S. Reid, Arthur C. Shead, C. L. Workman
Hydraulic Engineer: Edwin W. Reed
Mining Engineer: Flavius C. Wood
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Draftsmen: Clyde Junior Davis, Neal T. Dilday, Robert L. Harris, Jessie Beth Irwin, Robert E. Owen, Guy M. Steele, Jr.
Clerk: Mrs. C. W. Shannon
Secretary: Jean Gardenhire
Stenographers: Marcia Cralle, Eloise Tuttle Jacobsen, Beatrice James, Florine McCune, Maxine Smith
Typist: Harry Rayl
Field Assistants: Jack O. Duggan, Harley H. Harris, Herbert S. Mayberry
Laboratory Assistant: J. H. Hargis

Carl C. Branson
1954–1967

Director: Carl C. Branson
Administrative Assistant: J. O. Beach
Geological staff: Thomas W. Amsden, Gerald W. Chase, Neville M. Curtis, Robert O. Fay, William E. Ham, Louise Jordan, Myron E. McKinley, Malcolm C. Oakes, Edward A. Stoever, Jr., John H. Warren, Leonard R. Wilson
Geochemist: John A. Schleicher
Chemists: Albert L. Burwell, Thomas E. Hamm
Editor: Alex. Nicholson
Librarian: Lucy H. Finnerty
Drafting staff: Marion E. Clark, Roy D. Davis, Dwight H. Ford, Clifford O. Walden
Administrative Secretary: Mildred E. Reeds
Secretary: Zoleta Rogers
Stenographer: Pat MacEachern
Clerk-Typist: Alyma Fae Atkinson
Receptionist: Jerrie M. Burchette
Stock-Room Clerk: Fred Englund
Laboratory Assistants: John Bland, Ralph Slate

Charles J. Mankin
1967–

Director: Charles J. Mankin
Associate Director: Kenneth S. Johnson
Assistant to Director: Helen D. Brown
Office Manager: Gwen C. Williamson
Geological staff: Thomas W. Amsden, Robert H. Arndt, William H. Bellis, Salman Bloch, Carl C. Branson, Margaret R. Burchfield, Brian J. Cardott, James R. Chaplin, Peter A. Eidson, Robert L. Eutsler, Robert O. Fay, Samuel A. Friedman, M. Charles Gilbert, William E. Ham, L. Joy Hampton, William E. Harrison, LeRoy A. Hemish, Kathryn N. Jensen, Michael W. Lambert, Kenneth V. Luza, Reza Moussavi-Harami, Arthur J. Myers, James J. Myers, John A. E. Norden, Malcolm C. Oakes, M. Lynn Prater, Donald A. Preston, Raja P. Reddy, John F. Roberts, Coleman R. Robison, T. L. Rowland, John B. Thuren, Leonard R. Wilson, Dah Cheng Wu
Geophysicist: James E. Lawson, Jr.
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Laboratory Assistants: Larry D. Fore, James W. Lea
Custodians: Ron E. Evans, R. Steven Keely, Donna R. Kenworthy

About the Author

Elizabeth Awbrey Ham was born in El Paso, Texas. Her father owned a coal-brokerage business, and later he mined his own coal, so Betty had close contact with at least one aspect of the minerals industry from an early age. She spent part of her childhood in Fort Smith, Arkansas, near the coal fields of the Arkoma Basin. Later, the family moved to Kansas City, Missouri, where Betty attended junior high and high school and was graduated from the University of Kansas City (now the University of Missouri at Kansas City).

Betty came to The University of Oklahoma in 1937 to work on her master's degree in geology, which she received in 1939. While at OU, she met and married another graduate student, William E. Ham, who became a long-time member of the Oklahoma Geological Survey staff and served as the Survey's acting director from 1952 to 1954. The Hams reared three sons, William, Robert, and Donald.

Bill Ham died in 1970, and in 1971 Betty joined the Survey staff as editorial assistant, becoming associate editor in 1977.

In addition to geological publications, including bibliographies and indexes, Betty is the author of a number of newspaper articles, memorials, book reviews, essays, poems and three novels.

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OKLAHOMA GEOLOGICAL SURVEY

HISTORICAL

TERRITORIAL SURVEY

The Oklahoma Geological and Natural History Survey was established in 1898, by a law passed by the Territorial Legislature of Oklahoma. Dr. David R. Boyd, President of Oklahoma University, and Hon. Henry E. Asp, President of the Board of Regents, were instrumental in having this law passed. A provision of the law made the professor of biology at Oklahoma University, Territorial Geologist. The sum of two hundred dollars per year was appropriated for the work of the Survey. Later the amount was raised to three hundred dollars per year.

Dr. A. H. VanVleet[1], at that time professor of biology at the University, became Territorial Geologist. During the first two years the appropriation was used for the purchase of camp equipment, including a team of horses, wagon, tent, and other articles necessary. The first field party was sent out in June, 1900. Charles N. Gould[2], a graduate student of the University of Nebraska, was secured as geologist for this field party. Paul J. White[3], served as botanist and S. R. Hadsell[4], as cook and teamster. The four men constituted the field party which started out from Norman in a covered wagon, with the camp equipment. The party spent the months of June, July, and August in the field. The principal work of the season consisted of studying the gypsum and salt deposits in the western part of the Territory.

During the next few years, the Survey sent out a field party each summer. The field work included some investigation in practically every county in the territory of Oklahoma, and during 1905 and 1906, the work extended into what was then Indian Territory, where preliminary surveys were made in the oil fields.

The Territorial Survey published three Biennial Reports containing a discussion of the geology of the territory of Oklahoma and dealing to some extent with the mineral resources. The reports also contain lists of the plants of Oklahoma, and lists of the birds, snakes, and some other animals of the territory.

ORGANIZATION OF STATE SURVEY

At the time of the Constitutional Convention in 1907, an effort was made to establish the Survey on a firm basis. Through the efforts of Dr. C. N. Gould and Professor J. S. Buchanan, who was a member of the Constitutional Convention, a committee on Geological Survey was appointed, and a provision was written into the Constitution providing for the establishment of a Geological Survey. Oklahoma is the only State in the Union that has such a provision in its Constitution.

The Constitution of Oklahoma in Section 37, of Article 5, provides for the establishment of a "State Geological and Economic Survey."

In accordance with the Constitutional provision, the first Legislature of the State of Oklahoma in 1908 established the Survey by Senate Bill Number 75. This act created a bureau to be known as the "Oklahoma Geological Survey", under the direction of a Commission, known as the State Geological Commission, composed of the Governor, the President of the State University, and the State Superintendent of Public Instruction.

The official staff of the Survey is provided for in the act, and the Commission appoints "as director of the Survey, a geologist of established reputation, who may with the approval of the Commission, appoint such assistants and employees as may be necessary to carry out the provisions of this act."

Dr. Charles N. Gould was appointed by Governor C. N. Haskell, as first director of the Survey in August, 1908. Dr. Gould served as director until in October, 1911. Upon his resignation, Dr. D. W. Ohern, Head of the Department of Geology in Oklahoma University, was appointed director by the Commission. Dr. Ohern resigned the directorship in December, 1913, and C. W. Shannon, Field Geologist of the Survey, was appointed director.

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1. Dean of the Graduate School, and Professor of Botany, University of Oklahoma.
2. Petroleum Geologist and Geological Engineer, Oklahoma City, Oklahoma.
3. Teacher of Agriculture, Huntington, California.
4. Professor of the English Language, University of Oklahoma.

OFFICES

The law creating the Survey provided, that the Survey should be located at the State University, and that offices, laboratories, libraries, and apparatus be furnished by the University for the carrying on of the work until such time as permanent quarters were provided for the Geological Survey. For several years the quarters furnished were in frame buildings on the University campus. The Survey suffered great losses in field data and collections by the burning of three buildings in different years. The Survey, in 1913, moved into the basement of the old library building and maintained the general office there until the completion of the Geology Building in 1919. During the past years the work of the Survey has been seriously handicapped by the lack of adequate facilities, especially laboratories, museum space, and storage rooms.

The Legislature of the State in 1917 made an appropriation of $100,000.00 for a bulding to be occupied by the Oklahoma Geological Survey and the Department of Geology in the University.

The offices of the Survey occupy the east one-half of the first and second floors of the Geology building. The general office and private offices of the staff members are commodious and excellently adapted to the special work of the Survey. In fact, these offices are equal, at least, to those of any Survey in the country. The laboratories, museum space, storage rooms, and rooms for special work, are, however, inadequate, and if the Survey is to meet its object fully, additional space must be secured.

The general view of the Geology building and the interior views of the principal offices as shown in this publication, give a good idea of the Survey quarters.

The Survey has a mineral exhibit building 50x100 feet on the State Fair Grounds, Oklahoma City. A general office is also maintained on the fourth floor of the Capitol building, Oklahoma City.

WORK OF THE SURVEY

The progress of the work of the Survey has been such that with the work previously accomplished, and completed to the close of 1919, geologic surveys have been made in every county of the State and information published on each county. In some of the counties sufficient work has been done so that, together with the field investigations by the United States Geological Survey, it is possible to give detailed information on the counties. In other counties the work has been more of a reconnaissance nature, but with such detail as to give the public valuable information concerning the geology and mineral resources of the State.

The Oklahoma Geological Survey co-operates with the Department of Geology in the University, the Oklahoma Academy of Science, the oil and gas division of the Corporation Commission, other State departments and institutions, with the Geological Surveys of adjacent States, the United States Bureau of Mines Stations in the State, and with the United States Geological Survey.

PURPOSE OF SURVEY

The object and duties of the Oklahoma Geological Survey as set forth in the original act providing for this particular State Department, and enlarged upon in recent years, consists of (1) detailed study and mapping of the geological formations of the State, with special reference to the mineral deposits of the State; (2) the preparation and publication of bulletins, reports, maps, charts, and illustrations concerning the geology, structure, and mineral resources of the State; (3) rock and mineral collections shall be made and; after they have served the purpose of the bureau, shall be preserved for scientific purposes and deposited in proper museums when such are provided; (4) to furnish to the various educational institutions of the State, duplicate sets of such special specimens as can readily be furnished and be of value to the institutions; (5) the consideration of such other scientific and economic questions as, in the judgment of the Commission and Director, shall be deemed of value to the people of the State.

PUBLICATIONS

The work of the Geological Survey is made known to the public chiefly through the publication and distribution of its reports and maps. Only a limited number of the various reports can be published, the number ranging from 1,000 to 5,000 copies. In the case of brief reports and maps as many as 25,000 copies have been published. All publications are available to the people of the State and to persons outside the State, interested in securing information concerning Oklahoma. All State departments, State institutions, public libraries of the State, and a large number of libraries outside the State are supplied with copies of each publication as issued.

To the present time 30 bulletins, eight circulars, two handbooks, and a large number of maps have been published. The total number of printed pages amounted to approximately 4,000, and the weight of the published material totals more than 10 tons of printed matter.

Some of the publications are entirely exhausted and the stock room supply of all publications is low. Several manuscripts of reports are practically ready for the press and in a few months a number of new publications will be issued.

APPROPRIATIONS

The first Legislature of the State of Oklahoma appropriated the sum of $15,000.00 for the salaries and maintenance of the Geological Survey. Each succeeding Legislature has granted a considerable increase. The appropriation of the fiscal year 1919-1920 is as follows: Salaries, $23,750.00; maintenance, $14,300.00; special field and office equipment, $12,090.00; for the fiscal year 1920-1921, salaries, $23,750.00; maintenance, $14,300.00. The total for the biennium is $88,190.00.