'To bring together, correlate, and preserve'

a history of the Kansas Geological Survey, 1864–1989

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Foreword
by
Grace Muilenburg

100 years of science and service

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Foreword

When Rex Buchanan asked me if I would write a foreword to this delightful story of the now 100-year-old State Geological Survey of Kansas, I accepted the honor, albeit with a bit of trepidation. You see, the story is self-contained and really needs no foreword. Nonetheless, to have the opportunity to endorse it and add a little to it pleases me greatly. This Geological Survey was scarcely past middle age when I entered the organization's domain and remained therein and under its spell for nearly two decades. So I hope I shall be pardoned if my comments seem heavily tinged with personal reminiscences and feelings.

My first rub with geology—and I believe the work of the Survey—came, though unbeknown to me at the time, as far back as the 1920's. In that decade, I spent a goodly portion of my childhood and preteens in southeastern Cowley County, Kansas, near where the high ridge crowning that major east-facing, north-south-trending escarpment of the Flint Hills begins to bow into Oklahoma. A favorite pastime of mine was roaming over my maternal grandparents' farmstead, located on the western flank of that ridge. I remember collecting crinoid stems ("Indian beads" in child language) and vaguely wondering what they really were and how they came to be; stubbing my toes on sharp, angular pieces of flint rock and feeling sorry for the cattle that had to stumble over such terrain while grazing; and now and then pondering the origin of the layers of rock, some solid and some crumbly, in a cut in the country road along the eastern edge of the homestead.

From the school yard at Hooser (today a ghost town) on that ridge about two miles northeast of the homestead, on one or two occasions I watched with a passing interest as some strangers appeared on a nearby hillside and began hammering on rocks and digging with picks and putting samples of stuff in little bags. The local citizenry paid scant attention, having become accustomed to the occasional presence of people called "geologists" at that "good fossil-collecting locality." Seemingly, regular visitors included students from Southwestern College at Winfield, about 30 miles to the northwest. On the other hand, as I surmised later, those strangers I observed at that locality could well have been geologists from the State Geological Survey, from away up northeast in Lawrence, more than 200 miles distant. Anyway, about that time field work was in progress on the geology of Cowley County—field work that became the substance of a report issued by the Geological Survey in 1929.

Geological Survey. Then, in the 1940's after World War II, by some quirk of fate, I walked into the main office of the State Geological Survey, in relatively new Lindley Hall at the west end of the University of Kansas campus on Mount Oread, that scenic ridge over-looking the Kansas and Wakarusa valleys and the oldest part of Lawrence. There I obtained a part-time drafting job with the Survey, a job intended simply to put food on the table while I re-entered school to study journalism. It so happened that when I received my journalism degree, I stayed on. Having learned something about Survey publications and activities, I began releasing for public consumption items on some of the Survey's work and personnel, gradually slipping into a position having to do with "public information and education." One might say that I was "in the right place at the right time." The time had come, it seems, for some concentrated effort by the Survey on public relations.

In the years from the end of World War I to after the end of World War II—years during which I knew only faintly what a geological survey was—the Kansas Geological Survey had been expanding in staff, budget, and scope of research and other activities. Paralleling the growth was an increase in the number of publications annually released and made available to Kansas taxpayers and others. As a result, the Survey was reaching out for greater contact with that public. Indeed, more and more Kansans were requesting Survey publications and other information and inquiring about available services.

During that time, especially from the mid-1930's on, the Survey began strengthening ties with the public through several promotional efforts. Many Kansans who were adults in the 1930's and 1940's likely will remember two pamphlets, *Resource-full Kansas* and *Scenic Kansas*, prepared by Kenneth K. Landes, assistant director of the Geological Survey (and state geologist with R. C. Moore) until 1941. There were radio talks on Survey activities and a series on "Kansas Then and Now." A series of articles first known as "Kansas Surveys" and then as "Resource-full Kansas" had been started, released weekly to the Kansas press through the K.U. News Bureau. Articles—"observations on rocks, mineral deposits, and fossils of Kansas"—were written by the professional staff; especially regular contributors, as I recall, were John C. Frye and long-time members John M. Jewett, Walter H. Schoewe, Norman Plummer, and, yes, Raymond C. Moore.

John C. Frye, by the time I had joined the Geological Survey staff, had become executive director and essentially was in charge of all research and other activities. (R. C. Moore, though still state geologist and director in name, by that time commonly was out-of-state or out-of-country on some scientific mission, bringing renown to himself and to the Geological Survey, the University of Kansas Department of Geology, and the State of Kansas.) A capable administrator and research geologist (especially well known for his work on Pleistocene geology), Frye also had a down-to-earth approach toward keeping the public informed on Survey activities and Kansas geology. Anxious to keep alive and build on the public-relations efforts he and Landes and others had initiated, he encouraged me, with his help and backing, to develop within the Survey a program devoted to public information.

Such a program did not materialize fully until after Frye had left (in 1954) to head the Illinois Geological Survey and Frank C. Foley had arrived from Illinois to become state geologist and director of the Kansas Geological Survey. A geologist whose principal interest was ground-water resources and who could easily fraternize with State legislators, Foley supported a program oriented toward informing and educating the public on Survey activities and Kansas geology. So did William W. Hambleton, who, after receiving his Ph.D. degree in geology (with geophysics a specialty) from the K.U. Department of Geology in the late 1950's, joined the staff as assistant state geologist and assistant director (later advancing to associate state geologist and associate director and finally, a few years after my departure in 1966, state geologist and director). So during the greater part of my tenure with the Survey, Foley and Hambleton were the administrators. And Hambleton under Foley, like Frye under Moore, was the one especially attuned to Survey projects and director of research.

Within that time, the Kansas Geological Survey remained housed in Lindley Hall, sharing space with the cooperative United States Geological Survey division of ground-water resources and mineral fuels and several University departments: geology, geography, petroleum engineering, and metallurgy. Yet between the end of World War II and the mid 1960's, the staff had more than doubled to nearly 80 persons, counting those in the cooperative divisions. Increases were especially notable in the divisions of ground-water resources and oil and gas. In addition, changes in direction had begun to take place, reflecting advances in technology and changing industrial and societal needs.

In the 1940's and 1950's, it was routine for many staff geologists, come late spring or early summer, to don their field clothes, pick up their picks and shovels and measuring devices and notebooks, and head for some county or other geographic unit to map its geology and collect samples and information to analyze in the laboratory or "write up" in the office when snow covered the ground. And some geologists

Introduction

1989 marks the centennial of the Kansas Geological Survey's location at the University of Kansas. That anniversary is a particularly appropriate time to complete and publish a history of the Geological Survey and its activities. The Survey was established at the University of Kansas (KU) in 1889, with the expressed purpose of making "a complete geological survey of the state of Kansas, giving special attention to any and all natural products of economic importance." For 100 years, the Kansas Geological Survey has been doing just that. In fact, the Survey's history reaches beyond those 100 years to the early geologic reconnaissance in Kansas, followed by the time of more detailed exploration during territorial days. The story then moves to creation of the first geological survey of Kansas in 1864, an important precedent in state-funded science in Kansas. The 1864 Survey, and its successor in 1865, were instrumental in establishing and synthesizing much of the early information about Kansas geology.

The period from 1865 to 1889 was a time of interruption in the Survey's existence, and yet it was a particularly important period in the state's geologic exploration, with the discovery of vertebrate fossils in western Kansas and the rise of a variety of mineral industries throughout the state. Thus, while there was no survey during that 24-year period, it is a time that deserves discussion, at least in part because events within that period influenced the creation of the Survey that followed. In 1889, a new incarnation of the Survey was founded at the University of Kansas, a decision by the Kansas legislature that had, and continues to hold, profound consequences for the character of the Survey.

The Survey's history since 1889 is filled with a long cast of characters. Some, such as Samuel Wendell Williston and Raymond C. Moore, were scientists of ultimate reputation within their fields. Others are less famous in the scientific community, but at least as readily recognized within the state and state government. Nearly all of those Survey staff members, and especially their leaders, have struggled, at one point or another, with defining the Survey's role (and thus their own role) within the scientific community, within the University, and within state government. Is the Survey simply a state agency, designated to provide information and service in matters related to geology? Clearly that is something of the Survey's role, though it is certainly not its overriding mission. Is the Survey a research organization whose staff are interested only in developing geologic-related research tools and techniques, along

met. Grace wrote reams about Kansas geology in the 1950's, 1960's, and 1970's; she often wrote with an historic consciousness that is as helpful as it is rare. Because of that consciousness, and because of her dexterity with words, I asked Grace to write the book's foreword. She graciously agreed, and I am indebted to her for the skillful contribution. Perhaps most of all, this book owes its existence to William W. Hambleton, the Survey's director when I was hired, who encouraged my work on the project. William Hambleton thought much about the past, and gained perspective from it. I appreciate the help of Lee Gerhard, Hambleton's successor, who allowed me to complete this book. Janice Sorensen, the Survey's librarian and archivist, helped track down elusive references and photographs and was the spark behind the idea of the cover photograph. John Charlton reproduced many of the photographs. The staff at the University of Kansas archives at the Spencer Research Library were patiently helpful and allowed us endless access to their material. I appreciate the assistance from any number of people who read all or parts of the manuscript, including Hambleton, Gerhard, Don Steeples, Chris Maples, John Doveton, Lawrence Skelton, Marla Adkins–Heljeson, and Howard O'Connor, all of the Kansas Geological Survey, as well as Clifford Nelson of the U.S. Geological Survey and Daniel Merriam of Wichita State University. Dan Merriam also supplied several of the photographs. Finally, I would like to express appreciation to John Dahlquist, of Arkansas College, and Ronald Numbers, of the University of Wisconsin–Madison, for their patient and encouraging teaching.

Of course, I am responsible for any factual errors that remain in the book. I am also responsible for any of the judgments made. In this book, I made little attempt to assess the correctness of long-ago scientific theories, compared to today's interpretation of geological observations. In part, that is because I lack the geological background to make such judgments. It is also because there is no certainty about today's interpretations (and there are already plenty of books about today's ideas). What's more, it strikes me as both unfair and beside the point to judge yesterday's geologists by today's methods, standards, and ideas (see Rudwick, 1985). I attempted to contrast only those theories that were contemporary, and to make judgments not based on who was later proved right or proved wrong. Instead, I attempted to make judgments about the scientific (and in some instances, political) significance of past events, trying to determine which were important and which were not, and to provide some of the basis for that judgment. Such judgments are always difficult, but particularly so when they occur within the recent past. This book may seem weighted toward the late 1800's and the first half of the twentieth century; if so, it is the result of the proximity of time.

Perhaps the significance of relatively recent events can be sorted out more ably in another 100 years. In the meantime, this book is meant to contribute to the understanding of an institution's history. If it casts some light on the Survey's past, on the history of geologic study in Kansas, or on state-supported science in Kansas, it will have achieved its purpose.

1

A place 'wholly unfit': geology in Kansas, 1541 to 1864

On a summer's day in 1541, a group of weary Spanish explorers looked across the seemingly endless plains they called Quivira. Though the boundaries of the place were not yet established, the Spaniards were in Kansas, somewhere north of the Arkansas River, as far north as they would go. No geologists made the trip—geology as a distinct science did not exist at the time—and yet the explorers made the first European observation about Kansas geology: there was no gold. That conclusion was certain and stark and final. The Spanish expected to see cities with gold-paved streets and inhabitants wearing ornaments made of marvelous metals. Instead they found natives wearing practically nothing, living in houses of grass and mud. They found fertile prairie and herds of buffalo. But no gold or silver.

During the years from 1541 to 1864, other explorers followed the Spanish and in the process came across deposits of coal and lead and zinc. Settlers had found oil seeps and salt marshes; by 1864, oil wells had been drilled in eastern Kansas. A few frontiersmen developed an awareness of the geologic part of their environment. Yet they did not know if other minerals remained to be found in eastern Kansas, and they knew virtually nothing about the geology of western Kansas (Merriam, 1984). What was known had usually been learned by happenstance, not by design. When, in 1864, Governor Thomas Carney signed a law creating the first geological survey of Kansas, he was attempting to end that ignorance of Kansas's geologic wealth.

Even before Carney's action, Kansas had been the scene of several hundred years of exploration, most of it tangential to geology. Those early years of geological reconnaissance are described in this chapter. That reconnaissance was important because it turned up information about the state's resources, such as coal. It was important because it produced a tantalizing glimpse of the geology in western Kansas, where major discoveries awaited only the westward progress of the frontier. But mostly that reconnaissance was important because it set the stage for later geologic study of the state, providing the background for the detailed studies that would come.

European and early American exploration

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they were profitably working" (in Barnes, 1945, p. 422).

Geologic reconnaissance begins

As exploration and travel across Kansas accelerated in the 1830's and 1840's, so did the pace of geologic observation. Most efforts were connected with railroad and government surveys (see Gries, 1984), and much was learned through incidental observations of the geology by military expeditions (Goetzmann, 1965; Bartlett, 1962). Again, the reports were concerned largely with the availability of water, building stone, and valuable minerals. Reports of coal excited special interest.

At this point, however, geologic notations took on a different tone. Certainly explorers were still on the lookout for minerals that might have economic benefit. But at the same time—mostly in the eastern third of Kansas—naturalists were making geologic observations. They had more than just an economic interest in whether or not coal, for instance, was available in the state. Now, in the late 1840's and early 1850's, scientists were beginning stratigraphic classification in Kansas, going beyond the exploration that frontiersmen and survey parties had undertaken. In essence, geologists were beginning to stir in Kansas, and the first phase of detailed geologic reconnaissance was beginning.

Not that interest in the economic aspects of the state's geology had waned. If anything, concern over mineral deposits and fuel sources had burgeoned. Kansas was not organized as a territory until 1854, and prior to that time relatively few whites had settled in the area. But with the passage of the Kansas–Nebraska Act in 1854, the state took on territorial status and settlement began in earnest. Entering the picture was the issue of slavery. The Kansas–Nebraska Act allowed the slavery question to be settled by popular sovereignty, and in Kansas that amounted to a slavery versus abolitionist free-for-all as both sides made valiant efforts to influence the decision. Even geology was pressed into service in an attempt to attract settlers favorable to one side or the other. One abolitionist writer declared that "with her coal and mineral resources in general, she [Kansas] has the elements of an empire State .... If Kansas should become a free state and attract to herself an emigration which should introduce eastern mechanical skill and experience, she would at once furnish manufacturers of wood, iron, leather, hemp and a countless variety of articles, for an immense country both above and below here . . .." (Boynton and Mason, 1855, p. 40, 76). The propaganda effort, for it was basically that, even extended to trying to erase the lingering notion of Kansas as the Great American Desert. "We conclude, that what we have called the eastern district, does not end abruptly at the edge of a sandy desert, but that its western portion changes its character gradually .... We are, however, quite satisfied, that a good farming region extends much farther westward, in Kansas, than has been generally supposed, and that future investigation will very much reduce the dimensions of what has been called the American Desert" (Boynton and Mason, 1855, p. 33–34). Geology was enlisted in the propaganda effort, the efficacy of which it is difficult to gauge. Still, the influx of settlers in the 1850's did renew the demand for raw materials and resulted in a clamor for building stone and coal.

As the pace of geologic investigation quickened, so did its sophistication. In 1853, George C. Swallow (1817–1899), the first state geologist of Missouri (and later the second state geologist of Kansas), undertook systematic studies of the geology of western Missouri that often carried him into eastern Kansas, making his some of the earliest and most extensive investigations of Kansas geology. Born in Maine, he studied in Bowdoin College under Parker Cleaveland (1780–1858), whose *Elementary Treatise on Mineralogy and Geology* was a landmark synthesis of American mineralogy and made the author one of the foremost mineralogists in America during the first half of the 1800's. Graduating in 1843, Swallow taught in Maine schools and then accepted the chair of chemistry and natural sciences at the University of Missouri in Columbia (Broadhead, 1899). Swallow must have cut an impressive figure during his study of frontier geology. He was over six feet tall and wore a long, full beard. His eyes were deep set.

Swallow's work was as notable as his appearance. In the first annual report on the geological survey of Missouri, Swallow discussed the geology of northeastern Kansas, describing the Carboniferous rocks north of the Kansas River. Although Swallow did not find economically important amounts of coal during the trip, he was convinced that the strata of eastern Kansas—which had previously been correlated with the lower Carboniferous age, a coal-lacking period—were actually of the upper Carboniferous. The result, he was convinced, was that "the whole of this vast region is underlain by productive coal beds" (Swallow, 1855, p. 153–154).

This increasing knowledge of the state's geology coincided with the final stages of geology's coming of age as a discipline. As it was practiced during the initial phases of the west's exploration, geology was far different than at the time of Swallow's investiga-

after they were discovered, they posed stratigraphic problems well in to the 20th century.

The fossils Hawn discovered were from Flint Hills formations, and if they were actually Permian, their importance was evident. Realizing exactly that, Meek wrote to Hawn and asked that he send the rest of his samples, including the ones sent to Swallow at Missouri. But Swallow never mailed the remaining fossils, and while Meek waited, Swallow and Hawn prepared a paper (without telling Meek) announcing the discovery of the first North American Permian fossils and read it at a meeting of the Academy of Sciences of St. Louis on 22 February 1858. On 2 March 1858, Meek and Ferdinand V. Hayden (1829–1887)—his collaborator in studies of the geology and paleontology of the upper Missouri country since 1853—announced the same discovery (Meek and Hayden, 1858) to the Albany Institute and the Academy of Natural Science of Philadelphia. The outbursts that followed were predictable, with Meek and Hayden claiming that it was only through Meek's identification that Hawn knew the fossils were Permian. Meek and Hayden charged that in the rush to announce, Hawn had clearly usurped their right. The dispute's high point, or perhaps its low point, came later that year at the Baltimore meeting of the American Association for the Advancement of Science, when James Hall and Meek debated briefly about who claimed what and when they claimed it (Nelson and Fryxell, 1979, p. 194; see also Nelson, 1987).

In strictest terms, the priority for discovery went to Swallow and Hawn because their paper was, by a matter of days, the first published announcement of discovery. But in other terms, Meek's claim is certainly substantial: his announcement of the discovery was included in a letter dated 16 February 1958, while Hawn and Swallow transmitted their news in a letter dated 18 February of the same year; and it is clear, from correspondence now in Smithsonian Institution Archives, that Meek first noticed the possible Permian age of the fossils (Merrill, 1924, p. 370). But because of Swallow and Hawn's publication, the race for priority had no clear-cut winner and, as in any dispute, the jockeying for position went on for some time. As late as 1867, Hayden wrote in the *American Journal of Science* (Silliman's Journal) that in Swallow's 1865 report on Kansas geology "we regret to see that Prof. Swallow (doubtless inadvertently) here in an official report, uses language, which when taken in connection with the fact that he nowhere alludes to the labors of others in that region would lead some to think he had intentionally ignored the agency of any other parties in that discovery and was claiming it as wholly his own" (Hayden, 1867, p. 38).

In short, by 1858 scientific controversy had arrived in full force in Kansas. With it came other elements of geology that accompanied increased scientific activity. By 1858, more detailed geologic maps of part of Kansas were being produced. Before the mid-1850's, maps of the region's geology were little more than guesses, sometimes educated and sometimes not. For example, Edwin James drew a geologic map that included Kansas after his trip with Long in 1819 and 1820. In 1858, Hayden produced a map of Nebraska that showed the Permian extending well into Kansas, as far south as Butler County. A year later Hawn produced a geologic cross section across the Territory from east to west.

By 1864, then, many of the principals of geologic reconnaissance had made their appearance. Swallow was among the first on the scene and continued to write prolifically about Kansas geology for some time (Swallow, 1858; Swallow and Hawn, 1860). Hawn too continued to publish and map, although his conclusions often had to wait for further study and confirmation by others (Hawn, 1860). Finally, Meek and Hayden continued to publish, often carefully examining and criticizing the contentions of Swallow and Hawn. The work of these scientists, and others, established the following conclusions about Kansas geology: loess and red glacial erratics were common in northeastern Kansas; rocks of Carboniferous age, including coal, were common in eastern Kansas; Permian fossils occurred in the state; gypsum and rocks of Cretaceous age cropped out in central and western Kansas; and sandy alluvium covered much of western Kansas.

The upshot of this geological activity was that by 1864, when the first geological survey in Kansas was authorized, geologic investigations were already thriving in the state, but most were based on regional studies by the federal government operating in Missouri. Thus, much was left untouched because no organized, institutional source existed within the state to give impetus to systematic geologic reconnaissance. The economic stimulus of minerals, and the role they played in the settlement of frontier Kansas, were later almost certainly important in the creation of an organized survey. At the same time, the profession of geology was maturing, nurturing an intrinsic interest in geology, not only for the sake of economic benefits but for its contributions to knowledge about the earth. These two forces weighed not only in the coming debate over creation of a survey, but also influenced the shape of the institution once it was formed.

2

Science and 'The disciples of progress': creation of the first Kansas Geological Survey

Ten years passed between the organization of Kansas as a territory in 1854, and the creation of the state's first geological survey. In some ways, those years were for Kansas like Dickens' England, filled with the best and worst of times. The state's pioneers faced all the typical troubles that accompanied life on the American frontier: hostile natives, crop failures, awesome and impetuous weather. As if those impediments were not sufficient, Kansans also suffered through the turmoil of the dispute over slavery, until something akin to guerilla warfare began to dominate nearly all affairs in the eastern third of the state. Although the free-versus-slave dispute culminated with the sacking of Lawrence by Quantrill's raiders in 1863, border troubles were dangerously common during many of the years from 1854 to 1864. Yet the economy of the state was good and Kansas remained relatively isolated from the Civil War.

Still, it is surprising that the Kansas legislature established a scientific institution so early. The first geological survey of the state, established in 1864, was not the initial attempt to begin a formal reconnaissance of the state's geology; the legislature tried at least four times before 1864, representing remarkable attempts at science in a state so embroiled in other problems. However, too much can be made of those attempts; legislative interest in science was generally limited to geology, at least until the foundation of state-supported universities, and geology aroused concern only because of the economic returns it seemed to promise (for a comprehensive discussion of the early history of science in Kansas, see Peterson, 1987).

Kansas was hardly the first state to conceive of a geological survey. In 1823, Denison Olmstead, trained at Yale by Benjamin Silliman, Sr., undertook a study of North Carolina's rocks and minerals. A full-blown, state-supported survey appeared seven years later in Massachusetts (Hendrickson, 1976, p. 133), and between 1830 and 1850, 22 states created surveys of one sort or another for various durations, with seemingly only one thing in common: surveys flourished, for the most part, when the economy was healthy and their existence was threatened when times were hard. In spite of lofty speeches about attaining scientific knowledge, most legislators felt they could risk money on state surveys only when they could afford to lose it. Even though the funders realized the prospect was a gamble, they always expected hard and practical returns. Those great expectations led

Creation of the first survey

Certainly the political process that succeeded in creating a survey was the most elaborate and drawn out of all the attempts, filled with intrigue, twists and turns, and old-fashioned political horse trading. It began with Governor Thomas Carney, a rather unlikely sort who had previously demonstrated no inordinate interest in the problems of science or geology. Born in Ohio, Carney built a thriving wholesale business before moving west to Leavenworth in 1858. Elected to the Kansas House in 1861, Carney won the governorship in 1863 with the support of Charles Robinson. Though he held office during some of the most turbulent times in Kansas history, Carney—whose picture has an almost priestly, calm air about it—ran a staid and solid administration and for the most part was able to protect Kansas through the treacherous years of early statehood and Civil War.

Less noted by contemporaries was the creation of the survey. Carney introduced the subject in his 1864 message to the legislature and based his defense of a survey appropriation on the state's ignorance of minerals, the need to classify soils for agricultural purposes, and especially the demand for coal: "The almost fabulous prices which fuel commands in our cities and principal towns must retard their growth, and occasion distress and suffering among the poorer classes" (House Journal, 1864, p. 26). Carney concluded that because "the wealth of Kansas lies in her soils . . . it seems to be eminently proper that this subject [a geological survey] should engage your careful and considerate attention" (House Journal, 1864, p. 26).

The matter received attention almost immediately, though the attention was not always considerate. Four days after Carney's speech, Representative J. B. Laing from Leavenworth introduced a bill appropriating $3,500 for a geological survey. Entitled "An Act for Establishing a Geological Survey," the bill charged the survey with classifying soils and rocks, analyzing salt springs, reporting on valuable mineral deposits, and building "a geological cabinet, illustrating the geology of Kansas . . ." (House Journal, 1864, p. 111). The bill was referred to the five-man Committee on Agriculture, Manufacture, and Mining.

For the most part the newspapers of the state gave the bill a polite and, in some cases, enthusiastic reception. In nearly all instances that enthusiasm was based not so much on what might be learned from such a survey, but instead upon how that knowledge might be applied. "The age in which we live has brought to clear light the fact that the sciences may be applied to agriculture and the various branches of common industry, with most favorable results," wrote John Speer in the *Kansas Tribune* from Lawrence. " . . . it is a fact that this State, notwithstanding it has been travelled over so much, is still *terra incognita* in the strict sense of the term" (*Kansas Tribune*, 19 January 1864, p. 2). Chimed in the *Leavenworth Daily Conservative*, "It is hoped that the bill will be liberal and thorough in its provisions" (*Leavenworth Daily Conservative,* 16 January 1864, p. 2).

But the House Committee was hardly enthralled with the idea. Only five days later it reported unfavorably on the bill and turned its critical attention to nearly every aspect of the proposal, defining the survey an extravagance. Surely, reasoned committee members, the state should not pay for basic research, when "the simple arrangement and classification of rocks and soils is a work, which . . . can well be performed by the amateur students and professors of our colleges . . ." (House Journal, 1864, p. 92). And, the committee report continued, even the application of such knowledge did not require such an expenditure. "We regard experience as the great teacher," the report said, "and the only sure guide in agriculture, and the best apparatus for testing the adaptation of the soils of the several counties . . ." (House Journal, 1864, p. 92–93). The report then ended in a devastating classic of nineteenth-century metaphor:

> In conclusion, we may be permitted to remark that, though we are disciples of progress, and are willing and eager to learn, we deem it advisable, for the permanent growth and future prosperity of our State, that we should 'hasten slowly,' lest, peradventure, we should make 'more haste than speed,' and that, in view of the limited population and tax-payers' ability of the State, instead of running the car of progress, 'high pressure' system, we should decidedly incline to favor the narrow gauge, *single track*, low pressure style, with Prudence ever on the lookout—Economy, master and conductor of the train—Caution standing ready to 'put down the brake,' and all hands on watch to prevent *deadheads* from stealing rides at the expense of the honest stockholders (House Journal, 1864, p. 93).

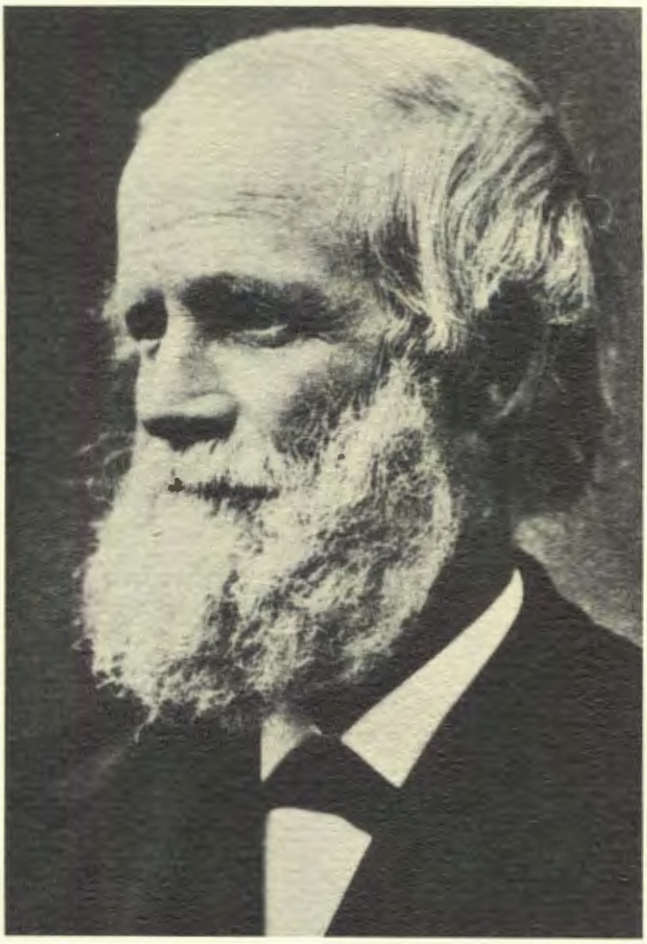
Yet the the bill survived that diatribe. It did so because of a crowded cast of characters and a series of coincidences that managed to put the proposal

geologic reconnaissance in eastern Kansas and held the proper academic credentials; at the beginning of the legislative session he was probably the betting favorite for the post. But on 19 January 1864, the *Leavenworth Daily Conservative* published a letter from one E. N. O. Clough that implicated Swallow in charges over the border war between Kansas and Missouri.

> I desire to State that I understand he (Swallow) has been a prisoner for disloyalty since the commencement of this rebellion; and I know that in 1856, in Columbia, Brown County, Missouri, at which place both he and myself lived, he gloried in the name of *border ruffian*... (Swallow) is not such a man as we in Kansas desire to see placed in any position whatever, unless it be in a *dependent* one, when a good hemp rope would form the means of dependence (*Leavenworth Daily Conservative*, 19 January 1864, p. 2).

These charges obviously must have concerned legislators throughout the session, with the Civil War still being fought and only a few months following the burning of Lawrence by Quantrill's raiders. Foster refused to let such charges die. In his final letter to Carney, Foster added in a postscript, "I have in my possession an affidavit showing beyond doubt that Swallow did voluntarily pay the expenses of one border ruffian in fifty-five to invade the state" (Foster to Carney, 22 February 1864, Carney Collection, State Historical Society). Those charges, regardless of their substantiation, were probably enough to trouble Swallow's supporters. On February 24, a resolution was introduced in the House proclaiming support for Swallow, but it was "laid over" for lack of support, and Swallow's candidacy was effectively ended (House Journal, 1864, p. 454).

With the decline of the two most obvious candidates, Swallow and Foster, there was no certain contender for the job. No contender, that is, except for the Kansas City schoolteacher who happened to be in Topeka, delivering a lecture series on geology smack in the legislature's own hall. By the time the bill creating the survey had passed both houses, Mudge was the consensus candidate to be its leader. No record remains of Mudge's reaction to those who mentioned his name as a candidate for state geologist; if he did any self-promotion it must have been subtle, at least compared to that by Watson Foster. At any rate, a petition from the House of Representatives listed 42 legislators in favor of Mudge's appointment, and a similar entreaty from the Senate was signed by 20 members, although three other names on the list were crossed off with no explanation. At the bottom of the Senate petition, also, is the following note, signed by Mudge: "This petition was started without my knowledge or consent. I am in favor of the appointment of Prof. W. Foster" (Senate petition, no date, Carney Collection, State Historical Society).



Benjamin Franklin Mudge, the first director of the Kansas Geological Survey.

Regardless of Mudge's attitude toward the job, on 29 February 1864, Carney sent his nomination to the Senate and it was approved (Senate Journal, 1864, p. 459). With that, the struggle to establish a survey and appoint its leader was over. What were

3

The first incarnation:
the geological surveys of 1864 and 1865

In the spring of 1864, Benjamin Franklin Mudge faced an enormous task. With a staff of five scientists—only one of them educated as a geologist—Mudge was to lead a geological survey of Kansas: over 82,000 square miles of hills and prairie, most of it entirely new to geologists. In 1864, Kansas had few towns of any size west of Topeka; Army outposts were established in places such as Hays to protect settlers and travelers, and towns such as Council Grove had sprung up to handle pioneer traffic along the Santa Fe Trail. Otherwise, towns were few and small; railroad lines had not reached much of the state. Transportation was by horseback over a few established trails. In addition, much of the state was occupied by, or at least occasionally visited by, Indian tribes with various degrees of antipathy toward white encroachment. These tribes suffered through the 1850's in relative silence as they were shoved into shrinking pockets of remaining land. But in the 1860's, native retaliation became more pronounced. While attacks in western Kansas were not common, they occurred with enough regularity to frighten travelers in the area, and they must have been especially frightening to geologists, fresh from the east, who faced the prospect of traveling in small groups to linger off the beaten path looking at rocks and fossils.

In the face of such circumstances, Mudge was given $3,500 and less than a year to complete the survey. Allowing a month to write a report, which was to be delivered to the legislature by 30 November 1864, Mudge had about eight months to visit all the counties in the state, take soil samples, investigate the geology, and take extensive notes on any minerals that might have economic importance, all while fending off natives who saw him as more evidence of white movement onto the plains.

Mudge and the first Survey

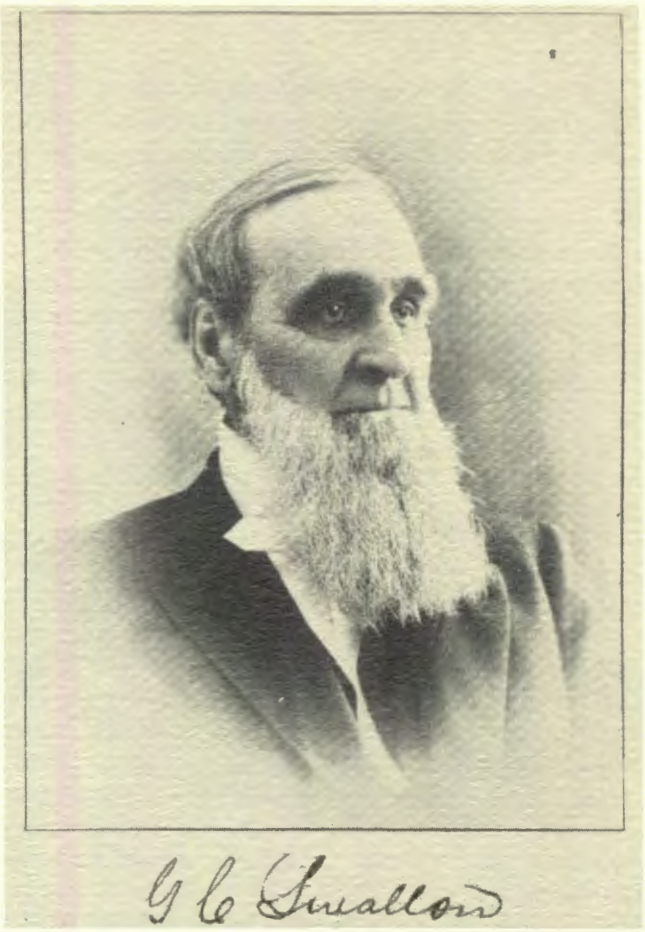
Only an optimist could have cheerfully faced such a task, and it is difficult to discern, in retrospect, how much of the job Mudge actually thought he could accomplish. In early pictures, Mudge appears to be a warm and somehow gentle man; later photographs give the impression of someone tired and worn, yet retaining the gentleness in spite of the years. Mudge grew up in Maine, graduated from Wesleyan University in Connecticut in 1840, and practiced law in Massachusetts until 1859. After a brief stint as a

from Leavenworth where he used coal-mine shafts to establish strata. Thus the report contains much discussion of the eastern third of the state, evidence of extensive field work in that location, but little discussion of eyewitness accounts of the geology west of Fort Riley. At one point Mudge admitted that "the Indian troubles prevented us from visiting those (salt deposits) on the Saline River" (Mudge, 1866, p. 35).

The first system Mudge discussed in detail was the Coal Measures, known today as the Pennsylvanian System. The Coal Measures strata received much of the report's attention because of their coals. Mudge referred over and over again to Kansas' coal-producing potential: "As population and the consumption of coal increases, coal mines will probably be sunk in all parts of the 22,000 square miles of the Coal Measures of the State" (Mudge, 1866, p. 3). Mudge also listed the other strata represented in the state: Permian, Triassic, Cretaceous, Drift (represented today in the glaciated northeastern corner of Kansas; see Aber, 1984), loess, and alluvium. With the exception of the delineation of the Permian and the identification of Triassic outcrops, Mudge's division of the surface into various geological ages was fairly accurate, although he published no geologic map of Kansas, probably because of his inability to visit the entire state. Mudge's study was not nearly as detailed as it could have been; contemporary geologists were producing more detailed work, as would George Swallow in his report on the activities of the 1865 survey (Swallow, 1866).

While the report concentrated on the geology of the eastern end of the state, it ignored questions of paleontology altogether. This seems a fairly conspicuous absence, given the importance of fossils in establishing the geological age of rock formations. That lack of information may have been because George Swallow refused to report on Kansas paleontology, at least in part because Swallow and Mudge did not get along. Mudge had collected fossils to be studied by Swallow, but Mudge said that Swallow let the fossils sit "in an open office in Leavenworth" so that they became mixed up and worthless (Mudge, as cited in Page, 1984). Mudge at least suspected that Swallow had designs on the job of state geologist and felt that his lack of effort was an attempt to undercut Mudge's survey.

If Mudge made no spectacular contributions to basic science, he was more helpful in taking inventory of the economically important minerals found in Kansas and the state of their development in 1864. Because he had not visited all of Kansas, Mudge relied on several contributed reports about the state's minerals, and while he discussed limestone, gypsum, building stone, metallic minerals, and petroleum, his primary interests were in salt and coal. Salt alone occupied the last 28 pages of the report, in which Mudge concentrated not so much on giving descriptions of the locations of salt marshes, springs, and visible deposits—probably again because most salt deposits were in central Kansas, where he had not visited—as he did on describing the manufacture of salt in several places around the world and encouraging Kansans to begin producing salt for their own use. Again, preoccupation with an economically important mineral reflects not only Mudge's concern, but the legislature's mandate.

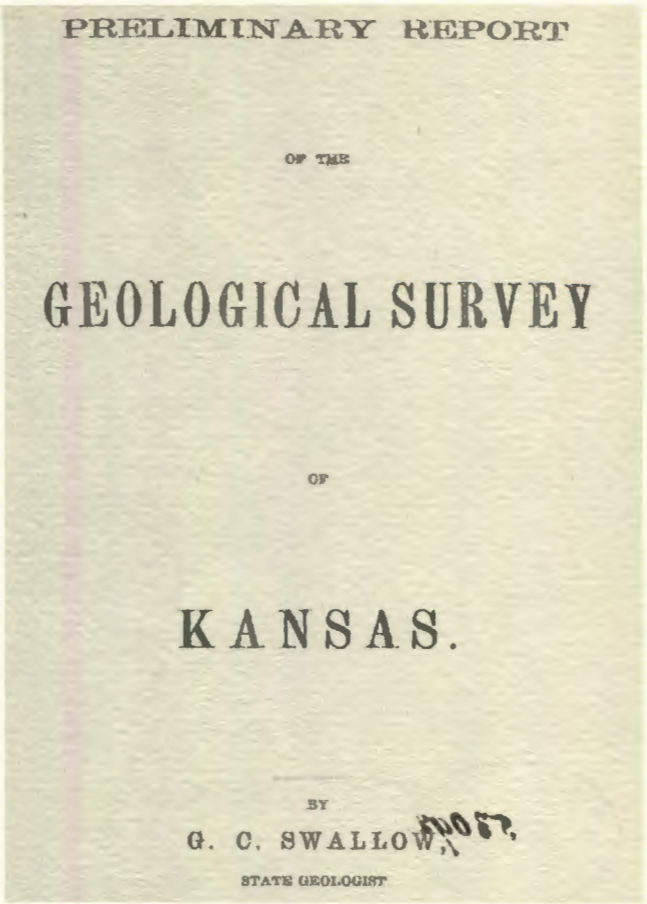


George C. Swallow, the Survey's second director.

footnote that "The discovery was first announced by myself February 22, 1858," (Swallow, 1866, p. 42) which understandably gave the impression that he alone had identified the specimens. Hayden used the disagreement as a starting point for his complaints about Swallow, and while it is clear that the two did differ on several notions about the stratigraphy of the state, their differences would probably have been expressed more quietly and with far more diplomacy had the business of Permian fossils not come between them. "We regret to see that Prof. Swallow uses language, which . . . would lead some to think he had intentionally ignored the agency of any other parties in that discovery . . ." (Hayden, 1867). Swallow was not above answering the charge with some invective of his own: "It would be much more agreeable, if those who feel duty bound to correct our errors would, in doing it, exhibit a little more of the *suaviter* and the amenities so common to, and inseparable from, scholarly men of science" (Swallow, 1868, p. 33). Complaining about the length of the debate, Swallow concluded, "They will not let it rest; they keep its miserable ghost in an everlasting perambulation to the infinite disgust of the scientific world" (Swallow, 1868, p. 510).

The disgust of the scientific establishment seems none too evident at this point in the debate, but its weariness was. Swallow's blast in 1868 was the final explosion in the disagreement. Perhaps more problematic, the disagreement over the Permian investigation served to cloud the reviews of Swallow's report and probably resulted in less acclaim than it might have otherwise received. Certainly there remained a number of questions about the boundaries Swallow had drawn between statigraphic units, but without a geologic map it is difficult to tell precisely where Swallow intended those lines to be drawn. Still, the report was a vast improvement over previous studies of Kansas geology, and represents the first systematic approach to explicating the state's geology. In fact, its rude reception in the eastern scientific establishment may have been in part because it was the first systematic study from Kansas to be worthy of any reception whatsoever. Flaws and all, Swallow's report seems a worthy accomplishment in terms of basic geology.

But the report wasn't restricted to geology. The section on "Economical Geology" contained the first soils analyses done by the Survey, though they were hardly as numerous as the original legislation had envisioned. Swallow's report included chemical analyses of just two soil samples and suggested few steps that farmers could take to insure the continuing productivity of their land. Swallow also discussed coal, gypsum, iron ore ("The tertiary strata in the western part of the state probably contain extensive lead, clay, marble, building materials, salt, oil, timber, and water" [Swallow, 1866, p. 58]). In all this, however, there was none of the detail so evident in the first report, probably because Swallow felt it would be duplicative.


PRELIMINARY REPORT

OF THE

GEOLOGICAL SURVEY

OF

KANSAS.

BY

G. C. SWALLOW,

STATE GEOLOGIST

Cover of George C. Swallow's 1866 report on the geology of Kansas.

The report contained two other sections of special note. One, written by Tiffin Sinks, contained a number of observations about the Kansas climate, and included several tables showing temperatures and rainfall as recorded by government personnel at forts throughout the state. For the most part, Sinks made few subjective interpretations of the data, and seemed relatively unconcerned about defending the state from the lingering label as the Great American

solution. In addition, such an organization could register births, deaths, marriages, and enforce the vaccination of all children.

Such suggestions were not unusual at the time in the United States. The public health movement was beginning to pick up steam, especially when the New York Public Health Board prevented a serious outbreak of cholera in 1866. Thus, while Logan was the first to make such recommendations in Kansas—and was particularly unusual in that he made such recommendations from a state geological survey—his ideas were neither singular nor visionary (Buchanan, 1983).

In summary, then, the 1865 report is probably more noteworthy as a whole than for its individual parts. The report carries a sense of finality, of completing what was started in 1864. When the first survey submitted its report, it was clear that much was left undone, that time had allowed only a cursory look at the state's geology. Even with the second report, much remained. Geologic knowledge of western Kansas was based on second-hand reports. Soils analyses, which weighed so heavily in the initial creation of the survey, and were touted constantly by newspapers as a reason to fund a scientific institution, were never undertaken to the extent that the original legislation envisioned.

Yet the second report implies that the Survey had finished all that geologists could accomplish at the time. The stratigraphy reported by Swallow was detailed, under the circumstances. While it was clear that additional work might better define the boundaries of geologic formations, it was equally clear that such definition probably would have little economic impact on the state and could deliver on none of the promises of practical results that other aspects of the survey had made. In addition, the inventory of economically important minerals had been completed and in some instances, such as coal, the survey probably did help clarify the amount, location, and availability of such resources. Additionally, a report had been finished for one county of the state. Perhaps in that respect, the report carries a sense of unfinished business. Swallow and his staff may have wanted to write equally detailed reports for other counties in the state, but such reports would have represented a commitment to a permanent geological survey, and the Kansas legislature never indicated that it was prepared to take such a step. But the format of county-wide geological investigations was influential, and it remained an important mode of publication well into the 1960's.

With the completion of that second report, then, the Survey's funding lapsed. Not that such an event was particularly unusual in the lifetime of a 19th-century geological survey. Of the 33 state surveys that came into existence prior to 1900, none existed continuously from the time of its creation until the end of the century (Merrill, 1920). In all cases, funding came in starts and stops. As surveys completed the tasks that state legislatures perceived at the time of their creation, or as economic conditions forced cuts in state spending, state surveys came into and out of existence. Thus the failure of the 1866 Kansas legislature to provide funding for a third year of the survey was hardly unusual. It would have been more uncharacteristic of the legislature to have lengthened the survey's life indefinitely.

By allowing the survey to go out of existence at that moment, however, the legislature profoundly affected the course of the history of geology and paleontology in Kansas. Just two years after the survey stopped, the first large vertebrate fossil from the Cretaceous was found in Wallace County near the Colorado border. That discovery, and many others that followed in the early 1870's, made the period from 1866 to 1889 one of the most exciting times in the history of geologic study of the state. But for the state survey, those 22 years served only as a hiatus.

4

The hiatus: 1866–1889

By 1865, Kansas had weathered the Civil War, survived guerilla raids on its border towns, and withstood the usual travails of the frontier. All the while, its citizens were putting down economic roots and establishing the state's educational and governmental institutions. The state's first few years were spent in survival, but the next few decades—the late 1860's, the 1870's, and the 1880's—were spent in adding the amenities of civilization in eastern Kansas and settling the western part of the state. Perhaps in no other time did the state's landscape change quite so drastically, particularly in western Kansas where the railroads snaked their way across the plains, dotting the landscape with small settlements and cow towns. During those decades, massive hunts wiped out the buffalo in western Kansas, and the native nomadic Indians were completely removed. In short, during the period from 1865 to 1890, the line of the frontier passed across the state and moved on west, leaving a dramatically different Kansas in its wake.

The state's geologists made progress in about the same fashion. By 1865, they had mapped the stratigraphy of eastern Kansas in some detail, although they had much to learn about the area's subsurface geology and mineral resources. They had only a sketchy idea of the geology in western Kansas. In the years after the Civil War, they undertook careful follow-up studies in eastern Kansas, and began detailed reconnaissance of western Kansas, where the years from 1866 to 1889 were a time of heroic geologic exploration, the stuff that created scientific legends.

After the Civil War and with the larger presence of government troops on the plains, Indian activity provided less of an impediment to settlers. At the same time, railroads opened western Kansas to ever faster rates of settlement, so that geologists were finally able to examine the area with the same care and precision that they had earlier given the eastern part of the state. When geologists arrived in western Kansas, they discovered wondrous things. In spite of the flat horizon and relatively uncomplicated geology, western Kansas held geologic treasures of profound consequence for scientists, finds that were eventually publicized throughout the world. The most dramatic discoveries were fossils that not only captured the public's imagination but were particularly notable in a time when the Darwinian synthesis was giving fossils an increasingly important scientific role. These fossils included the remains of huge swimming and flying reptiles, fierce-looking beasts with razor-sharp teeth. These were animals unlike

Badlands in the Niobrara Chalk of Gove County, one of many sites of extensive vertebrate fossil collecting in the 19th and 20th centuries.

physician named Theophilus Turner (1841–1869) stationed at Fort Wallace unearthed the bones of *Elasmosaurus platyrurus* (Williston, 1898; Turner's letters describing the find have been reproduced in Almy, 1987), a huge, fishlike reptile commonly called a mosasaur, that resembled, if anything, modern ideas of a sea serpent, with a long, narrow body and a gaping mouth filled with rows of teeth. Turner sent the specimen back east with J. L. LeConte. Other collectors soon came to western Kansas, unearthing a variety of other animals, including species of reptiles, fish, sharks, swimming birds, and giant turtles (Zakrzewski, 1984). The fossil hunters even found remains of flying reptiles that fell into the ocean and drifted to the seafloor. For geologists and paleontologists, the incredible variety of lifeforms and the sheer volume of fossils from the Cretaceous made western Kansas an astonishing place to work. The fossils revised many ideas about Cretaceous organisms, changing notions about the size and nature of the former residents of Kansas.

These western Kansas discoveries came at a propitious moment in the history of paleontology. Shortly after the first round of Kansas discoveries, paleontologists began uncovering huge dinosaur bones in Colorado, Utah, and Wyoming—as paleontologists moved west with the frontier—and the size and abundance of those fossils turned the spotlight on the West as the important location for study. For a time before those finds, however, news of the Kansas discoveries dominated paleontology in this country.

The fossil hunters

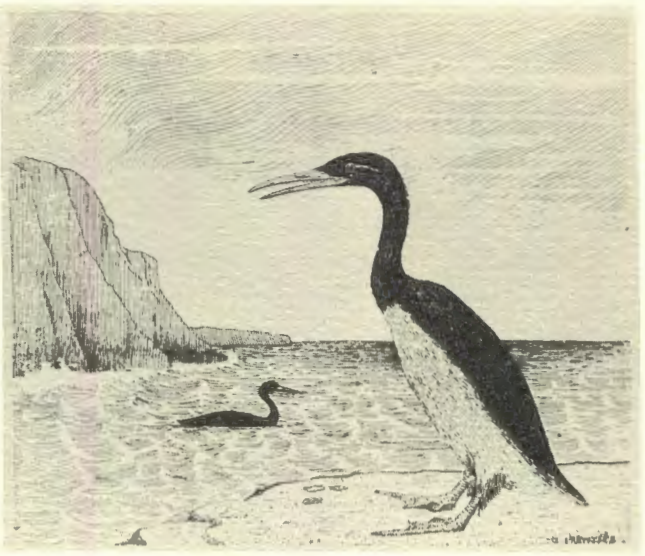
Two of the earliest and best-known paleontologists to visit Kansas were Prof. Edward Drinker

"the greatest naturalist America has produced" (Sternberg, 1909, p. 33).

Just as he said he would, Sternberg spent the rest of his life searching for fossils, usually collecting for Cope but occasionally selling on the open market. Sternberg's son George later joined him in the enterprise, and the pair became famous for their finds in the Cretaceous chalk. The Sternberg Memorial Museum at Fort Hays State University contains a number of the fossils recovered by the Sternbergs, including a famous fossilized fish of the genus *Xiphactinus*, with a smaller fish in its stomach.

Another well-known fossil collector on the western Kansas plains was Benjamin Mudge, who left Kansas State in 1873 and subsequently worked for Yale University and the Kansas State Board of Agriculture. He influenced a generation of geologists from his teaching post at Kansas State and when he left Manhattan and joined the State Board of Agriculture, he became the closest thing in Kansas to an official state geologist, and he continued to influence other scientists through publications—including several revisions of the state geologic map—and through activity in the Kansas Academy of Science. Mudge corresponded regularly with national leaders in geology and wrote a treatise on the Cretaceous for Ferdinand V. Hayden's Geological and Geographical Survey of the Territories, one of the predecessors of the U.S. Geological Survey (Page, 1984). Mudge made many collecting trips to western Kansas and found a variety of new organisms. Probably the best known of his discoveries was *Ichthyornis,* a swimming bird that looked a little like today's penguin. With one important exception. *Ichthyornis* had teeth, and its discovery marked the first time scientists had identified a bird with teeth. Mudge found the original fossil that led to the identification of the bird, although Marsh published the first information about the fossil and received much of the credit for the find.

Perhaps Mudge's most notable product was not a fossil but a student, Samuel Wendell Williston (1851–1918), a native of Massachusetts, who spent most of his childhood in Manhattan, Kansas, and then attended Kansas State. Williston collected fossils throughout Kansas, Colorado, and Wyoming, working mostly for Marsh until a disagreement caused Williston to move to the University of Kansas. In Lawrence, he not only taught geology but also became a renowned collector of insects, and worked for a time with the Kansas Geological Survey, a stint that included writing a series of some of the first Survey publications. Williston later left Kansas for the University of Chicago, but his work was probably as influential as any geologist in the late 1800's in Kansas.



Sydney Prentice's drawing of the Cretaceous swimming bird Hesperornis*; from Survey volume IV.*

The sum of the labors of these men—Cope, Marsh, Williston, Mudge, Sternberg, and many others—was remarkable. Together they published widely and identified hundreds of fossils (according to Schoewe, 1965, 261 papers on Kansas geology were published from 1865 to 1895. Of those, 115 dealt with paleontology). In addition to *Ichthyornis*, they found previously unreported species of reptiles and fishes, fossilized dinosaur skin, several new species of pterosaurs, as well as hundreds of fossilized ammonites, clams, crinoids, and other ocean dwellers.

Fossil hunting on the plains

Those discoveries not only led to scientifically important conclusions, but also produced legendary stories of brave and sometimes arcane behavior on the part of geologists. In the beginning, simply venturing onto the plains to collect fossils took a certain amount of courage. Hostile Indians still roamed western Kansas in the 1870's, although the final Indian attack in Kansas, at Oberlin in 1876, was really more of an accident of geography—a group of Northern Cheyennes from Indian Territory were attempting to move north and cut a swath through western Kansas on their way—than any real evidence of ongoing hostility. Troops from area forts occasionally escorted the collecting parties, but usually the geologists were on their own. "The few

other geologists. The Cope–Marsh dispute was especially bitter. By the time they moved on to Wyoming and Colorado, the two men used bribery and spying as standard tools to keep abreast of each other, and even took their argument to the popular press (Shor, 1974). In Kansas, they were just getting started. Cope and Marsh communicated with their collectors in the field in Kansas via coded telegrams so that their competitors could not discover where they were or what they had unearthed. When they made a discovery, they were sure to avoid giving it up to the competition. Once, when Sternberg learned of a new fossil in Scott County, he instructed the finder to cover the fossilized bones with a "small mountain over the top of it to hide it" until he could get there (Sternberg, 1909).

At other times, fossil collecting inspired more mysterious behavior. Yale's Professor Marsh recounted the tale of returning to camp late one evening after a long day's work, when he noticed a fossilized bone protruding from a creek bank. He dug the bone out and in the darkness tried to mark the spot of his find. The next day Marsh left for Yale, where he later identified the fossil as a bone from the wing-tip of a pterodactyl, a particularly large species of the animal. Over a year later, Marsh came back to Kansas, rode straight to the same spot and found more bones from the same specimen (Marsh, 1972).

Charles Sternberg produced an equally remarkable tale when he recalled dreaming one night of a fossil along a river bank. The next day he rode directly to the location and uncovered the fossil of his dreams, although he didn't find the method of discovery especially mysterious. "Probably my eyes saw the specimen while I was chasing an antelope or stray cow and too much occupied with the work in hand to take note of them consciously, until they were revealed to me by the dream, the only one in my experience that ever came true" (Sternberg, 1909, p. 36).

Over the years the presence of fossil collectors on the plains became more and more commonplace in western Kansas, to the point that residents not only accepted the geologists but became a little proud of the fame their fossils were producing. One newspaper reported in 1871, that "Prof. B. F. Mudge, of the Kansas State Agricultural College of Manhattan, who exhibits such untiring zeal in the cause of science, has sent a box of fossils collected in Saline County to the Smithsonian Institute (sic), at Washington, which have been examined by the distinguished paleontologist F. B. Meek. Among them he found fifteen new species of marine shells. The description of these fossils fully illustrated, appears in the Smithsonian publications" (*Salina County Journal*, March 23, 1871, p. 3).

Throughout the 1870's, the primary figures in eastern Kansas geology were either from outside the state, or were working as surrogates. Charles Sternberg worked for Cope, Williston worked for Marsh, and Mudge, probably the most independent of the lot, still sent a number of specimens to Yale and other points east. In short, there was no geological institution within the state to direct the collection of Cretaceous fossils in western Kansas, and the state's colleges simply did not have the resources to take on the task.

A geologic map of Kansas

The only state agency that continued geologic research outside of an academic setting was the Kansas State Board of Agriculture, formed in 1872 to encourage immigration to Kansas and to educate farmers about new agricultural techniques. A year after the Board's formation, it created the position of staff geologist and hired Mudge for the job. In the 1874 edition of the Board's report to the Kansas legislature, Mudge wrote a general report on Kansas geology—a sort of state-of-the-art review of what was known about the state, patterned along the lines of his 1864 report as state geologist—and included what was probably the first published geologic map showing only the state of Kansas.

On that page-sized map Mudge showed four major geologic divisions in Kansas: the Coal Measures of southeastern Kansas (where most rocks at the surface are today labeled Pennsylvanian); the Upper Carboniferous, covering most of the Flint Hills and northeastern Kansas (mostly Permian rocks, but also including some glacial deposits); the Cretaceous, which included almost all of the western two-thirds of the state; and a small patch in the northwest corner labeled Pliocene (usually referred to today as Tertiary in age). Although Mudge did not differentiate Permian strata on the map, he knew that the Permian existed in Kansas. "The line of demarkation between the Cretaceous and Pliocene is well-defined and sharp; but adjoining the Permian it is not so clear, as at many points the fossils are not to be seen, and the shales of both periods have a common appearance" (Mudge, 1875). Finally, in the text accompanying the map, Mudge discussed the Lower Carboniferous (or Mississippian) in extreme southeastern Kansas, although it was not shown on the map itself.

In all, Mudge's map by itself probably represented no great leap forward in geologic knowledge, although it did finally give the state's residents and the country's geologists a workable map to use in

Brown's venture, wells were drilled from time to time in eastern Kansas during the 1860's and 1870's, but they represented no real flurry of activity.

In the 1870's, much of the drilling activity centered instead around natural gas. By the time Mudge had completed his 1875 report on the state's geology, gas wells were relatively common in eastern Kansas, and gas was supplying heat and light to many of the homes in area cities, including Iola, Wyandotte, and Fort Scott (Haworth, 1908, p. 27–29). In fact, one of the earliest wells—drilled in 1873 near Iola—was originally bored in search of coal, but at about 600 feet hit a mixture of gas and mineral water, providing water for bathing and natural gas for a sanatorium that was soon built at the site (Patrick, 1877).

In the 1880's and 1890's, the abundance of natural gas created an economic boomlet in southeastern Kansas, where residents discovered several minerals that required heat for manufacture or smelting. Thus, the fortuitous combination of natural gas with clay and lead and zinc deposits led to the location of a number of brick plants and smelting operations in southeastern Kansas, nearly all dependent on the supply of cheap, plentiful natural gas. When that supply began to play out, however, factories and plants began to close, causing regional economic problems that lasted well into the 20th century (Clark, 1970).

Natural gas was not the only mineral that led to flush times. In 1870, in extreme southeastern Kansas, came the first reports of zinc ore. Those reports centered on the area covered by the Lower Carboniferous on the contemporary geologic map, and they were probably not too surprising considering that lead and zinc had been mined in Missouri for some time. Serious mining got underway in Kansas in 1876, with the discovery of lead ore near a town called Bonanza, and in March 1877, another body of lead ore was discovered near the town of Galena (Haworth and others, 1904). The resulting boom was probably the most dramatic in Kansas history. Within the next 30 days, witnesses estimated that some 10,000 people poured into the area. "It seemed to be a time when there was no other attraction of the kind, and those who had been through the California and other discoveries of valuable ores claimed never to have seen so large a collection of the tough element as was gathered in this territory at that time," wrote an area resident. "The gambler, the fakir, the confidence man, the saloon-keeper and the frail woman were masters of the situation, the 'bon ton' as it were, and nothing but the fear of each other prevented absolute lawlessness and the shedding of blood" (Stone, 1902, p. 250). Overnight the town of Empire City was formed to the north of Galena, boasting a population of over 2,000 in less than two weeks after the city was founded. On July 4, 1877, Empire City threw a barbecue that attracted, according to one estimate, 25,000 people (Stone, 1902, p. 252).

Central Kansas salt mine.

By the end of the 19th century, the Tri-state mining district, as it came to be called, was among the world's leaders in the production of zinc ore. But like the natural gas strikes in southeastern Kansas, lead and zinc mining began to play out later in the 1900's. In part the decline was due to the depletion of rich ores, and in part it was caused by the disappearance of cheap supplies of natural gas, which had made smelting an economic enterprise in southeastern Kansas. The economic attraction of the minerals had greatly declined by the Great Crash of 1929 (Clark, 1970), and by 1970, the days of lead and zinc mining and smelting in Kansas were over.

5

Finally persuaded:
the creation of the 1889 Geological Survey of Kansas

On an October afternoon in 1875, members of the Kansas Academy of Science gathered in the Senate chambers of the State capitol building in Topeka. It was the Academy's eighth annual meeting and among the first items of business was a report by a committee appointed to study a geological survey of Kansas. The Academy's members unanimously agreed with the committee that "a thorough geological survey of the state is imperatively needed (Proceedings of the Kansas Academy of Science, 1875). When the state legislature took its turn at the capitol, however, it did not concur. After funding for a survey lapsed in 1865, no geological survey of Kansas was re-created until 1889, when the Survey was established as part of the University of Kansas. The following chapter takes a look at events leading to the establishment of the 1889 version of the Survey, and at the forces that created and shaped it.

The Academy's 1875 report hardly marked the first time that the Academy had implored the legislature to create a state geological survey. Time and again, before a survey was finally established in 1889, the Academy made similar pleas (Buchanan, 1984). But the 1875 report was typical. The report began with an appeal to the legislature's sense of pride. First, said the committee report, "it is now notoriously the fact that tons of choice minerals and fossils of Kansas are being shipped by collectors to the cabinets of eastern universities" (Proceedings, 1875). No one knew better than Benjamin Mudge, a member of the committee and a regular customer in the fossil fields of western Kansas, how many fossils were being shipped outside the state. Second, and even more important, the committee said that "much money has been wasted in this state in useless mining enterprises," and there is "a constantly increasing demand for more accurate and intelligent information as to the coal, gypsum, salt, and other resources of the state" (Proceedings, 1875). The committee members were well aware that nothing appealed to the Kansas legislature like saving money, and they meant to play on that appeal.

In short, the 1875 report of the Kansas Academy was typical of the Academy's attempts to encourage a state survey. The report was typical because it based its arguments on the practical benefits a survey could produce. It was typical because it appealed to the legislature's sense of pride in the state. And it was typical because it was unsuccessful. During the period from 1875 to 1889, the same scene was played over and over again.

a quick look at funding for the University of Kansas through the 1880's. Prior to 1889, the University was governed by a Board of Regents that went to the legislature with specific requests for funding individual projects such as buildings or supplies. Legislators were able to approve, disapprove, or cut as they saw fit (Griffin, 1974). However in 1889, under the sponsorship of Senator Joel Moody of Mound City, the legislature appropriated a lump-sum $75,000 budget for KU, to be spent as the KU Regents saw fit. Included in that bill was a provision for the expenses of "any geological survey or scientific work which may be conducted under the auspices of the University for the benefit of science or the state" (State of Kansas, Session Laws, 1889). In short, the legislature suddenly had done what the Academy had been asking.

But it was done in an unusual way. First, and most obviously, the state had created a geological survey without paying for it. The Moody Act contained no specific appropriation for a geological survey, only granted KU the right to undertake such a project. In short, if there was to be a survey, it would have to be paid for out of the $75,000 appropriated for KU's budget. The legislature had taken the easy way out. It could now respond to the Academy and its members that it had created such a survey, yet it didn't have to pay the bills, at least directly. Second, it had not created a separate agency, the way previous bills would have. It made operating the survey a function of the University of Kansas.

Still, several questions remain about the legislature's action. First, why did it happen when it did? Why, after 24 years without an organized survey, did the Kansas legislature suddenly feel compelled to act? Why, after nine unsuccessful attempts during the 1880's to create a state survey, did the proponents finally succeed? It was not due to any improvement in the state's economy. Following a brief boom in the mid-1880's, there were years of drought, fantastically hard winters—the blizzard of 1886 is still famous in Kansas for the hardship it caused—and falling agricultural prices. The result, said Governor Martin, was that "Crop failure, epidemic diseases among stock, and other calamities of nature, have impoverished many of our people" (House Journal, 1889).

It seems more likely that the legislature took advantage of the lump-sum appropriation to add the survey at a time when minerals exploration was reaching a new high in the state. Natural gas was an economic force to be reckoned with. Lead and zinc mining created an unprecedented economic boom in southeastern Kansas. Coal mining was up to more than a million tons a year, and strip mining was beginning now that railroads were moving across the state. The first full-scale salt mine was established in 1888, and by the end of the year, 12 more were scattered across Kansas. By the mid-1880s, Kansas was the leading gypsum-producing state in the nation.

Taken together, the economic impact of these enterprises was great, perhaps enough to convince legislators that it was time for a geological survey to determine what other resources were available in the state. Assuming it would cost no additional taxpayer money as part of the regular University of Kansas appropriation, legislators must have thought that the time was propitious.

A second question, however, is this: why KU? Why not Kansas State College? After all, there was perceived to be a close relationship between an agricultural college and an investigation of soils, which was an important reason for the creation of the first two surveys and was often mentioned as a responsibility of a new geological survey. Wouldn't those geological investigations have gone hand-in-hand with Kansas State's agricultural emphasis? And why not put the survey at Kansas State, which had a professor of geology long before KU? At the time of the survey's establishment in 1889, KU had no expert geologist on its staff.

So why KU? It is difficult to answer that question with any certainty. There is no printed account of the discussion and deliberation that must have gone on at the time. It seems logical that KU Chancellor Joshua Lippincott was involved, although there is no record of that. Francis H. Snow, who taught the geology courses offered by KU at the time and in 1890 became chancellor, may have been involved in the dealings, although again there is no record. It is difficult to speculate just how actively KU sought the survey, if at all.

It is a little less difficult to speculate why the survey did not go to Kansas State. In 1874, John Anderson replaced Joseph Denison as president of Kansas State. Three members of the school's faculty, including geologist Benjamin Mudge, protested Anderson's appointment by going to Topeka to lobby against his confirmation. A few days later the three were dismissed for "insubordination and gross misconduct" (Carey, 1977). The dismissal severely damaged Kansas State's standing with the geologic community. Mudge left to join the State Board of Agriculture, and his prize student, Samuel Williston, left to attend medical school at Yale. Williston, among others, never forgave Kansas State's treatment of Mudge. He later said that the school offered him its presidency, and he turned it down over that long-simmering dispute. Again, while there is no

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Almost like starting over: the University Geological Survey, 1889–1907

For 23 years, from 1866 to 1889, the state of Kansas was without a formal geological survey. In some respects, the gap was filled by the work of other state agencies and state universities. But for the most part, the state had no entity whose single concern was geology, even though those years were some of the most exciting, geologically speaking, in the history of the state. The Survey's establishment at the University of Kansas in 1889 changed that. Not overnight, but slowly, the survey began to evolve within the University, a development that was characterized by fits and starts, trials and errors, periods of little activity and times of scientific excitement and accomplishment.

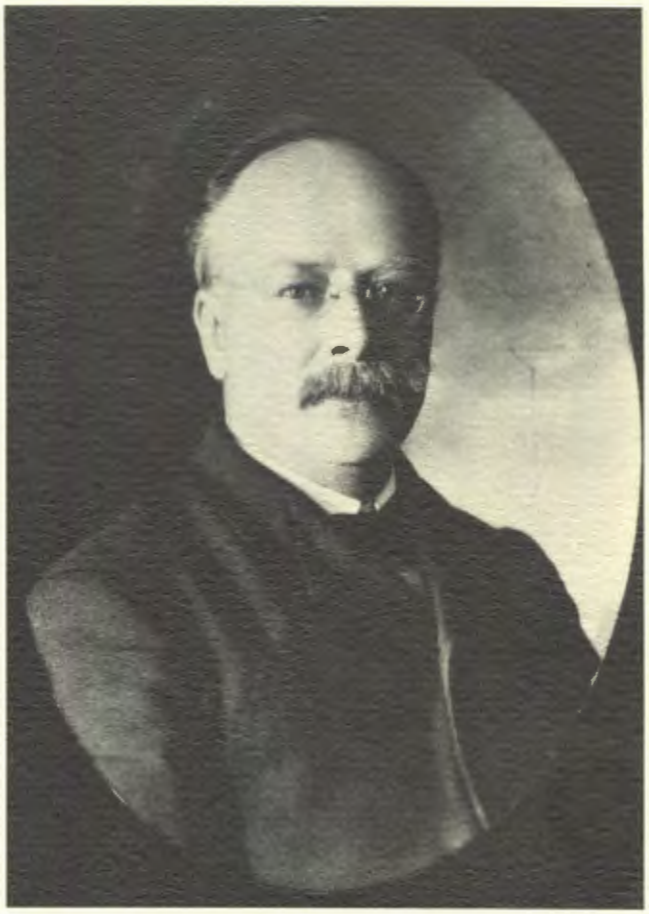
In some respects, the Survey's development mirrored that of the University and the state as a whole. For Kansas, the tail end of the 19th century was a time of economic and political turmoil, filled with good times and bad. Nearly all of western Kansas was settled by the 1880's, though that end of the state endured economic ups and downs, grasshopper plagues, and bad weather (Miner, 1986). An economic depression that began in 1893 sent another shock wave through the state's economy and forced the departure of many of the settlers from the western part of the state. The setback was generally temporary, and presently the economic climate improved. At the same time the state was alive with the political activity of the Populist Party. Kansas was among the first states to introduce many of the reforms of the Populists, and their proposals generally produced a tempest of politics.

The Survey was more directly affected by the fortunes of the University of Kansas. In 1889, the University was on the verge of a major shift in its own evolution as an educational institution. Francis Snow, a professor of natural history, was about to take over as chancellor. The University was contemplating offering a Ph.D., and before the end of the century it would divide itself into several colleges, behavior more characteristic of a university (Griffin, 1974). Yet the University of Kansas was still a handful of buildings atop a windswept hill that was grandiloquently called Mount Oread. It was still only a few hundred students learning in college departments of uneven quality. And it was still a university that suffered mightily according to the whims of the Kansas legislature. When times were hard the University suffered along with, and sometimes even more than, the rest of the state.

(Bailey, 1892). Bailey had a Ph.D. in chemistry from Illinois Wesleyan University.

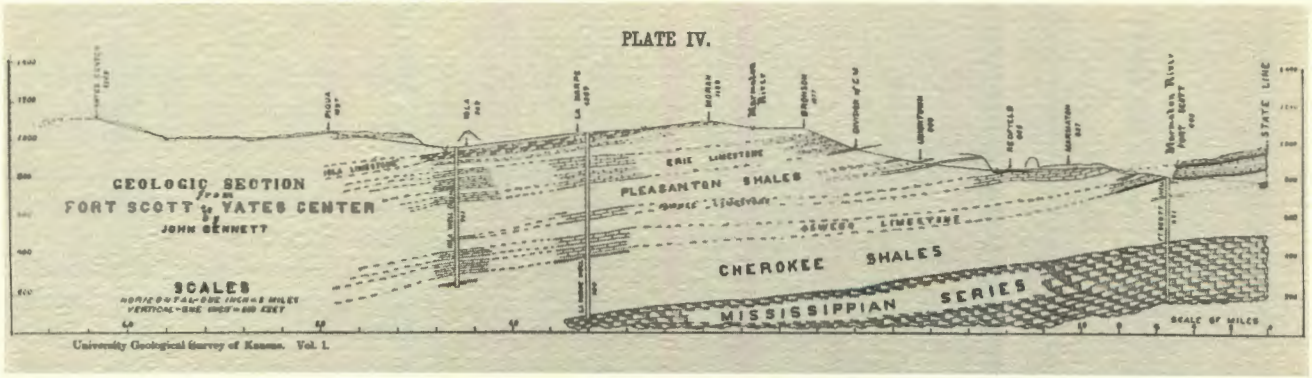
These three men—Haworth, Williston, and Bailey—formed the nucleus of that first Survey. In spite of the lack of separate funding from the state or the University, Haworth organized field work that led to extensive publication in the the second volume of the *University Quarterly*. Haworth, working with several students and other volunteers from throughout the state, published articles about the geology and topography of eastern Kansas, including some of the first detailed and accurate cross sections developed by Survey staff members (see, for example, Haworth, 1894). The *Quarterly* included sections along rivers—such as the Neosho, Cottonwood, and Verdigris—and along a railroad from Cherryvale to Lawrence and from Ottawa to Kansas City. The sections were depicted in fold-out illustrations and were scientifically significant because they contained the first published references to a number of formation names, including the Oread Limestone and the Lawrence Formation, making a permanent contribution to the statigraphic nomenclature of Kansas. That volume of the *Quarterly* included a lengthy article about the surface gravels found throughout eastern Kansas—a scientific problem that has long perplexed Kansas geologists—and several paleontological articles by Williston, again based largely on work done in western Kansas. In short, Haworth appeared to lead a fairly significant scientific effort, done largely with students and volunteer help, and Williston continued to establish a base of knowledge in paleontology.

That base continued to expand with the next edition of the *Quarterly*. Williston published on paleontology while Haworth discussed the geology of the so-called Coal Measures of southeastern Kansas (Haworth, 1895a, 1895b), covering roughly the same area where the rocks are today termed Pennsylvanian. Perhaps more significantly, this volume included several new geological illustrations. Haworth was credited with a drawing of the drainage, dip, and escarpments of several major formations of eastern Kansas. That map was drawn in "semi-perspective," a sort of block diagram tipped partially on its side so that the dip of the major formations was visible, along with the locations of deep drill holes that provided evidence for Haworth's subsurface characterizations. Also in that edition of the *Quarterly* was a geologic map of the state by Williston. Drawn in black and white, it was the first such published geologic map by a current member of the Kansas Geological Survey. As such, it represented a distinct refinement of the geologic map since Mudge's days



Samuel Wendell Williston. Paleontologist, entomologist, and physician, Williston was the most famous Survey scientist of the 1800's.

with the State Board of Agriculture in the 1870's. Williston divided the geology into eight stratigraphic units. The Subcarboniferous (today called the Mississippian) covered the southeastern tip of the state. The Permo–Carboniferous lumped together the Pennsylvanian and the Permian Flint Hills of eastern Kansas, with extra shading in those areas that were covered by glacial drift. Williston divided the Cretaceous into four smaller groups, probably because it was the geologic period that he knew best, and because its fossils allowed division with relative ease. Williston divided the Cretaceous into the Comanche, Dakota, Benton, and Niobrara formations, and labeled the Red Hills of south-central Kansas as belonging to the Triassic. Today the area is classified as Permian, but it caused problems for stratigraphers for years, primarily because of its lack of fossils; they placed it in the Permian, Triassic,



Section from Fort Scott to Yates Center in the first volume published by the University Geological Survey.

From volume I, this view of the Kansas River was one of the first photographs to appear in a Survey publication.

information, while the other topics, such as paleontology of the coal measures, were considerably more esoteric.

That first volume was distinguished, also, by its illustration. Like the articles in the *Kansas University Quarterly*, this volume included drawn cross sections that folded out from the book. It included drawn logs of several wells, and at least one topographic map showing contours, at 250-foot intervals, of the southern Flint Hills. More significant, however, were photographs, the first photographs in a Survey publication. The report included eight pictures, mostly of hills in southeastern Kansas and of river scenes. Though a relatively small number, the photographs were an added expense in the printing process and indicate an early concern about illustration. The book concluded with a fold-out geologic map done in semi-perspective, much in the same fashion as Williston's earlier map in the *University Quarterly*. It represents the first geologic map to appear in a Kansas Geological Survey publication.

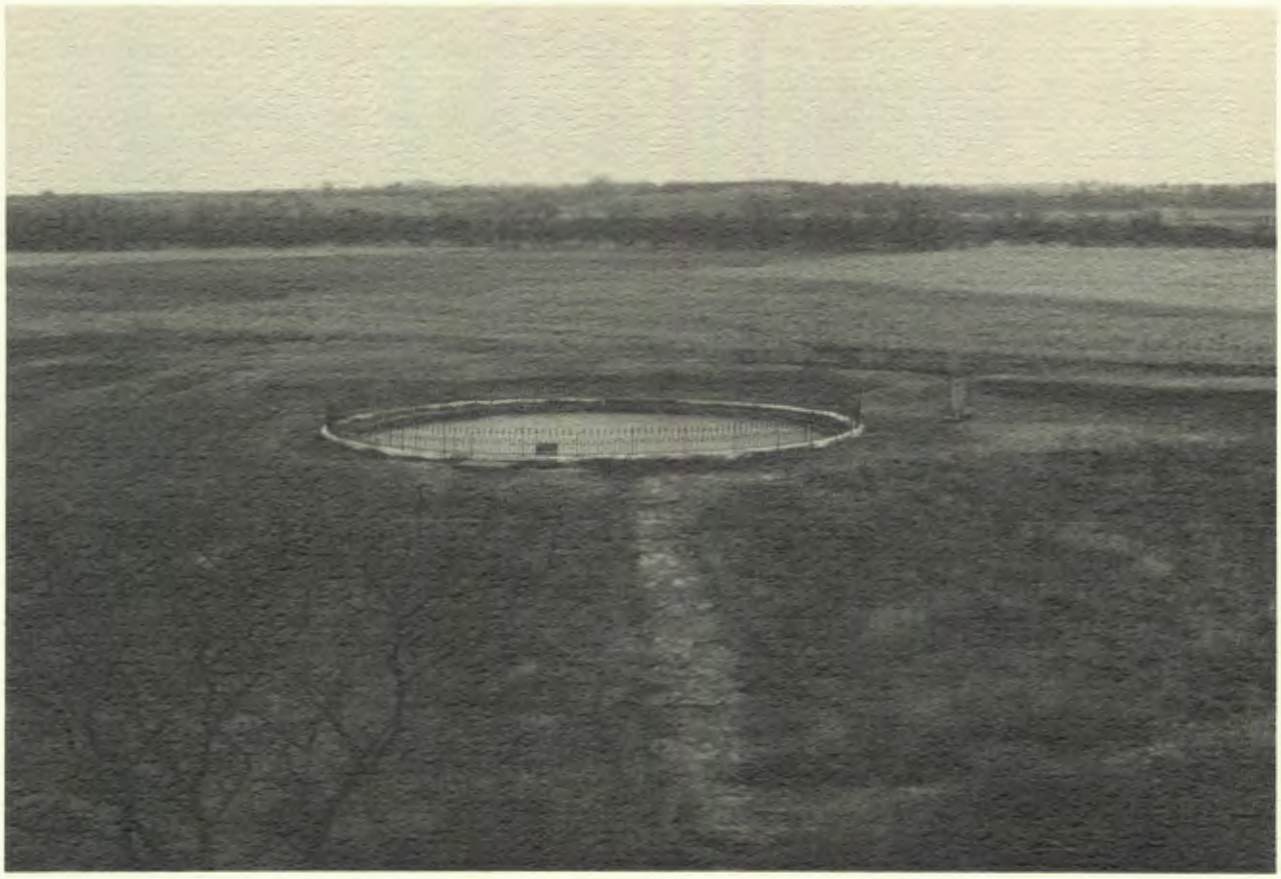
In short, volume I must have been, in its time, a handsome publication. It was hardbound, with the gold logo of the University Geological Survey of Kansas on the cover. It was substantial—320 pages long with accompanying cross sections, maps, figures, and photos. And it was scientifically important, not only because of the information it contained, but

The frontispiece from Survey volume IV, on paleontology, was reproduced widely.

sity of Chicago in 1902, Williston had made lasting contributions to knowledge of Kansas geology and paleontology and remains among the most famous of the scientists ever to work at the Survey.

With the next volume (Grimsley and Bailey, 1899), the Survey returned to reporting on economic minerals. This time the subject was gypsum. By the 1890's, Kansas was one of the leading gypsum producers in the nation, primarily through mines operated in northeastern Kansas, near Blue Rapids, and in the Red Hills. The authors of this volume were E. H. S. Bailey, who continued as a chemist at the Survey, and G. P. Grimsley, who is listed as an assistant geologist and was apparently brought on board to produce the report on gypsum. In fact, Grimsley wrote the bulk of the report, with Bailey providing some of the chemical analyses. As with earlier volumes, the report on gypsum was lavishly illustrated with both figures and photographs, and was primarily aimed at a non-technical audience. The report, wrote the authors, was "as intensely practical as possible, believing that there is no necessary incompatibility between the strictly theoretic and scientific and the economic problems connected with the geology of any region" (Grimsley and Bailey, 1899, p. 11). Figures included a number of cross sections and diagrams of the mines. Along with the Kansas section, the book included separate discussions of the technology of gypsum mining and chemical analyses.

The remainder of the volumes followed the same format. In volume VI (Williston, 1900), Williston returned to the subject of paleontology, although much of the book was written by graduate students. In volume VII (Bailey, 1902), Bailey wrote about the state's mineral-water springs and produced a remarkable little book that is filled with geochemical analyses of water and photographs of the bath-houses and hotels that sprang up around the springs in the late 1800's. Volume VIII (Haworth, Crane, Rogers,



Waconda Springs as it appeared in the early 1960's, before it was covered by the waters of Waconda Lake.

lead and zinc, coal, oil and gas, salt, gypsum, cement, building stone, and clay (see Haworth, 1898b, and following years). The reports were not strictly statistical, however. They included discussions of production techniques and photographs of mines and production sites.

The Survey produced reports on the state's mineral resources for six years and that, combined with the nature of the bulletins produced during that period, provided evidence of the organization's redefinition. Under Haworth's influence, it became economically oriented. It concentrated more on service to the state's residents, perhaps as F. H. Snow had intended when Haworth came to Kansas. By 1907, the Survey's purpose, at least as reflected in its products, was less to study and report on the state's basic geology, and more to describe those minerals that were having an economic impact on the state. That shift in orientation may be responsible, at least in part, for the changes that came with the Survey's statutory redefinition in 1907. Before that time, the organization was the University Geological Survey, and the name was a true reflection of the organization. It had published in university serials; even after the Survey began producing its own publications, Haworth and Williston published regularly in the *University Quarterly*. Students and teaching faculty were the main source of personnel within the organization. The Survey was integrated within the University structure.

But by the turn of the century, that was changing, and the Survey was beginning to take a broader look at the state, and its own role in providing information about geology. While the Survey remained at KU, and continued to be a part of the University, it was no longer the University Geological Survey. After 1907, it was the State Geological

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From Haworth to Moore

After its location at the University of Kansas, the Kansas Geological Survey existed for at least 20 years before it underwent its first transition in leadership. In 1915, when Erasmus Haworth resigned as head of the Survey (even though he retained his position as chairman of the KU geology department for another five years), he was the only director that the modern Survey had known. Survey leadership had changed hands before, in 1865, when George C. Swallow took over for Benjamin F. Mudge, but the Survey that Swallow directed was different, with a different mandate, than Mudge's. What's more, the Survey had existed for only a year when Mudge was replaced by Swallow. In contrast, Haworth had directed the Survey for 20 consecutive years when he announced his resignation (Haworth's resignation was not the only change during those years. In 1909, the Survey moved its offices from old Snow Hall, which was located north of Watson Library, to the new geology and mining building, which was subsequently named for Haworth; see Schoewe, 1965, p. 57).

Haworth's departure was important, and not only because of its impact on the Survey. Since 1907, and the rechartering of the organization as the State Geological Survey of Kansas, the number of Haworth's publications had decreased significantly. Unlike his earlier years at the Survey when he was editing or writing books at the rate of better than one per year, he produced only two Survey publications in a period of eight years (Haworth, 1913, 1915), and those were the only two publications from the Survey between 1908 and 1917. Some of that lack of productivity may be simply the result of aging in a scientist. Studies have shown that individual scientific productivity often follows a curve that rises into middle age, and then falls as the scientist gets older. Perhaps Haworth, who was 60 years old when he left the Survey, was simply on the downhill side of the productivity curve. Perhaps also there was less legislative pressure to publish, with the appearance in the late 1800's and early 1900's of the nine Survey volumes that captured much about the geology of Kansas. Finally, consulting and other business interests, particularly related to oil and gas, may have taken increasing amounts of Haworth's time, perhaps to the detriment of his publication record (see R. C. Moore, Memorial Meeting of 23 February 1933, Haworth file, KU Archives). In addition to leading the Survey and teaching in the geology department, Haworth had

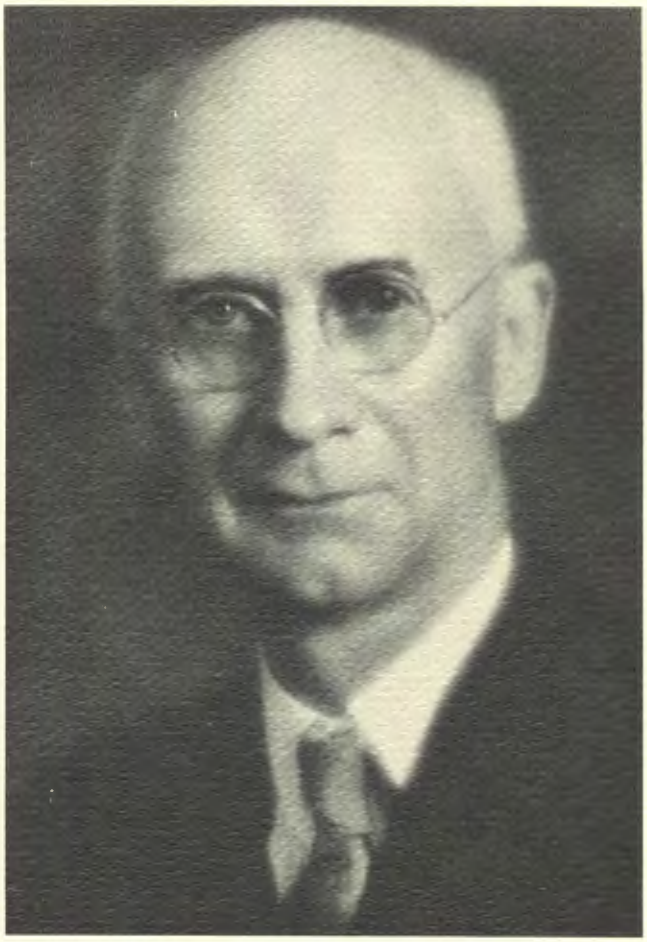
A year later he announced his retirement from the Survey (see Strong to Haworth, 22 June 1915, Strong Collection, KU Archives). In 1920, he left his chair at the geology department, blaming a low salary and the need for additional outside income as the reason for his departure (Haworth to Strong, 26 February 1920, Strong Collection, KU Archives).

Twenhofel

At the Survey, the transition from Haworth to a new director proved to be an unusual one. Haworth's immediate replacement was William Henry Twenhofel (1875–1957), a geology professor at KU who stepped in for a year, 1915–1916, before leaving Kansas for the University of Wisconsin. Twenhofel had undergraduate degrees from Lebanon College in Ohio and from Yale, along with a master's and Ph.D. in geology from Yale (Shrock, 1947, 1957). He came to KU in 1910 as a paleontologist, although his specialties at the time were the rather incongruous combination of the peridotite intrusive dome in Woodson County and vertebrate fossils from the Kansas Pennsylvanian (see, for example, Twenhofel, 1917, 1924). When he took over from Haworth as director of the Survey, he set down a series of conditions for then-chancellor Frank Strong, not the least of which was "If I find that the routine work connected with the position of State Geologist is so great as to seriously limit my (research) productivity, I wish, without question and with mutual good feeling to give up the position" (Twenhofel to Strong, 2 July 1915, Strong Collection, KU Archives). A year later, Twenhofel was gone.

The arrival of R. C. Moore

Twenhofel's departure from the Survey set the stage for the career of the man who, along with Samuel Williston, is arguably the most noted scientist associated with the Kansas Geological Survey. Raymond Cecil Moore was born in the state of Washington in 1892 (ironically, even as of this writing a native-born Kansan has never directed the Survey. Moore did have connections with Kansas, however. His mother was born in Kansas and one of his teachers at the University of Chicago was Samuel Williston). Moore earned an undergraduate degree in geology from Denison University, and in 1916 was awarded a Ph.D. in geology and paleontology from the University of Chicago (Dunbar, in Teichert and Yochelson, 1967, p. 5–7). Moore arrived in Kansas in 1916, and was named state geologist and director. The evidence of his energy was not long in coming.



William Henry Twenhofel, the Survey's fourth director.

Moore moved to a Kansas that was prospering in the flush times of World War I. Commodity prices were up, and Kansas farmers were doing well. Drilling and production were booming in the oil fields of south-central Kansas, and coal production in southeast Kansas reached a peak that it has not matched since. Moore responded to that oil boom a year after his arrival in Kansas with an impressive publication—co-authored with Winthrop P. Haynes, another member of the Survey staff—called *Oil and Gas Resources in Kansas*. This book was largely an expanded revision of Haworth's earlier special report on oil and gas, done mostly in light of the volumes of additional evidence that had been produced by twentieth-century drilling. But it was far more than that. Stitched to the front was the first color geologic map of Kansas printed by the Survey. Drawn at a scale of 1 inch to 24 miles, the map showed the geology in far greater detail than ever before in a Survey publication, including breaking the Pennsylvanian sequence into seven different groups and the Cretaceous into four.

Riley near Manhattan. The work compared the geology and topography of the area to that of the World War I European theatre. The war probably also encouraged Survey geologists to focus even more on economically important resources, particularly oil. The discovery of the El Dorado field, and the production that resulted, has occasionally been noted as important in the war effort. At the same time, the Survey budget jumped dramatically, from $2,500 per year in 1914 to $25,000 by 1920, an increase that was reduced the following year and was undoubtedly related to information produced strictly for the war (Schoewe, 1965, p. 69).

Almost from the beginning of his tenure as state geologist, Moore changed the nature of the Survey. It became less of a state service bureau than it had been under Haworth, publishing less on whatever geologic problem was dominant at the time, be it ground water or oil. Instead, Moore pushed the Survey to produce regular reports of a more scientific nature, evident from Bulletin 3, a publication designed to appeal to those who already knew something of the state's geology. Certainly Survey reports and work maintained their pragmatic value; oil and gas was the dominant concern of publication and undoubtedly the dominant source of work for Survey geologists through the 1930's and 1940's. But the tone of the work had changed. Instead of producing reports that were scientifically valid but generally accessible, as did Haworth, Moore's Survey worried less about accessibility and more about the science of geology. Publications by Moore, N. Wood Bass, and A. E. Fath (whose work on the geology of the El Dorado field, published in 1921 as Bulletin 7, marked the first cooperative project between the Kansas Survey and the U.S. Geological Survey) were scientifically important reference books that, at the same time, met a practical and everyday need in the oil fields (for background on Bass, see Lohman, 1984; for background on Fath, see Small, 1978).

It is difficult to discern just how conscious a decision this was on Moore's part. In Bulletin 3, he wrote that "the information which is presented must be that which is needed by those technically trained in the subject of geology . . ." (Moore and Haynes, 1917, p. 18). While Moore acknowledged that he also tried to make the information accessible to non-geologists, it was clear that scientific discussion came first. This may have been the predilection of a scientist who was only a year out of a Ph.D. program. Or it may have been a conscious decision on the part of an administrator to make the Survey into something that it had not been under Haworth's leadership. Published or unpublished information about

Shooting a well in southeastern Kansas in the early 1900's.

Moore's goals for the Survey is lacking. But the available information is clear. In 1924, long after he had begun the evolutionary reshaping the Survey, Moore wrote that a state survey was "first of all, a scientific research bureau" (Moore, "State Geological Surveys and the Oil Industry," 1924, p. 2, in Moore Collection, Kansas Geological Survey Archives, Moore Hall, University of Kansas, Lawrence, Kansas; hereafter referred to as KGS Archives). Those words are important, because the insertion of "research" into that phrase makes certain that Moore intended the Survey to be far more than a state agency that collected and disseminated information, though he recognized the importance of that role. He meant for the Survey to go beyond, to analyze and synthesize.

> The purpose of the state geological survey is to investigate areas, and mineral deposits, to undertake study of geologic problems within the state, and to bring together, correlate and preserve all possible

Survey to inspect a given area). Part of Moore's justification for the plan was based, again, on the impact of World War I. The reorganization would allow the Survey, Moore wrote, "to assist to the greatest possible degree the development of the state's natural resources for the present military purposes of the government and for the industrial and economic reconstruction following the war" (Moore, no date, State Geological Survey of Kansas, KU Archives). Moore even went so far as to discuss the subject with Kansas State officials, and it is unclear exactly why the plan did not come to pass (Strong to Moore, 4 December 1918, Strong Collection, KU Archives).

Ten years later, under a different chancellor, Moore revived the idea, this time in a letter to Governor-elect Clyde Reed, saying that "probably the State Geological Survey should be abolished and entirely reorganized" (Moore to Reed, 8 December 1928, Lindley Collection, KU Archives). Moore hinted that the plan had the blessing of oilman and politician Alf Landon, and apparently then-Chancellor Ernest Lindley agreed, though again, nothing came to pass.

Even though those reorganization schemes failed, Moore later was able to effect many of the changes he desired. However, he made one additional proposal for change that was radically different and never occurred. That was to involve the Survey in the regulation of the oil and gas industry. As drilling expanded in the early 20th century, state government took on increasing responsibility for its regulation, watching everything from the quality of the oil produced to the monopolistic tendencies of the large oil companies that operated in the Kansas. Moore proposed involving the Survey in the action.

> I recommend that the Oil Inspection Department be consolidated with the Oil and Gas Division of the State Geological Survey, with offices at the state capital, that a single staff of competent engineers and assistants be organized, and that all of casing and plugging for the conservation of oil and gas, and prevention of water pollution, appraisal of oil and gas securities referred to the state for approval, and the inspection of petroleum products be made to it (Moore, Efficient Organization of Oil and Gas Development, no date, Moore Collection, KU Archives).

R. C. Moore, in a photo taken during the Birdseye expedition down the Grand Canyon in 1923 (photo courtesy of the University archives, Spencer Research Library).

Such a change, had it occurred, would have drastically altered the Survey's character. Again, the circumstances of the proposal are unclear. So are Moore's motives. He may have been trying to carve for the Survey a larger stake in the realm of state government, though he would probably have done it at the expense of a number of his ideas about using the Survey as a scientific research bureau. Whatever the reason, the proposal failed and the Survey has remained (nearly always by choice) a state insitution without regulatory power.

Regardless of such efforts toward statutory change, the Survey was much the same at the end of World War I as it was at the beginning. Moore continued to direct the Survey, and at the same time continued his own highly visible professional development. One of the best-known examples of that was his participation as a geologist in the survey of the Colorado River and the dam sites between Lees Ferry and Black Canyon, led by U.S.Geological Survey chief topographic engineer Claude H. Birdseye in the summer of 1923. Moore was chosen, read one ac-

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R. C. Moore and the Survey of the 1930's and the 1940's

In the more than 100-year history of the Kansas Geological Survey, perhaps no name has been so widely known or so closely associated with the Survey as Raymond Cecil Moore. His was a remarkable career, based not only on 57 years at the Survey and the University of Kansas, but on the energy represented by vast scientific accomplishment. If there was a scientific office to be held, he held it. If there was a journal to be edited, he edited it. If there was a scientific idea to be argued, he argued it, and was nearly always remembered in the process.

Moore was, above all else, a scientific presence. William W. Hambleton, who directed the Survey from 1970 to 1986 and studied under Moore at KU, provided a visual description.

> Ray Moore was a man of medium heighth, stocky, wore glasses and always seemed rumpled. His complexion was tinged with red, especially around the nose. In earlier days, he characteristically smoked a pipe, but later consumed uncounted cartons of Pall Malls which stained his index finger yellow. A kind of sly smile always lingered about his mouth, suggesting amusement or the contemplation that his next question to you might be unusually interesting. He was a person of great appetite—for food, drink, work, play, generosity and appreciation. He possessed a large ego or, perhaps more appropriately, was comfortable in his knowledge of his own worth. His gait was sturdy, suggesting a certain inevitability about reaching a destination. He drove an automobile, not as a mode of transportation, but as an instrument of retribution (Hambleton, 1974, "Raymond C. Moore Memorial," Moore Collection, KU Archives, p. 7).

Moore was fluent in at least six langauges, part of which was due to his early work in classical languages at Denison University, work done before he changed his major to geology. He was a member of a relay team as an undergraduate; his athletic skills came in handy later in the field in geology. He played the piano. He was adroit at the game of

and over, with occasional layers of coal and sandstone, forming regular and generally predictable geology.

Moore was in a good location to study and discuss cyclothems. Regular deposition of alternating shale and limestone is common throughout the Pennsylvanian and Permian systems of eastern Kansas. Today it is spectacularly exposed in roadcuts opened up by highway construction, though it was certainly apparent in the logs and sections studied by early geologists. Moore's background in invertebrate paleontology and knowledge of stratigraphy related to oil production from Pennsylvanian formations aided his study of those limestones and shales, and his ideas about their origin. Moore determined that the basic cyclothem was composed of four limestones—he called them lower, middle, upper, and super limestones—deposited by transgressive and regressive seas, seas that rose to cover the landscape, then receded again (Moore, 1931). He said the black shale formed in shallow water. Later Moore described what he termed an "ideal cyclothem," a series of rocks composed of sandstone, shale, underclay, coal, shale, limestone, shale, limestone, shale, limestone, and shale (Moore, 1936). This, said Moore, was the order in which the changing sea levels had deposited rocks. Wherever those units were not present in that precise order, it was because they had not been developed locally or had subsequently been eroded away. But ideally, they should be present in that order. Moore also developed the notion of megacylothems: a complex sequence of related cyclothems that can be lumped together (Moore, 1936).

In short, Moore was attempting to develop a standard model of Pennsylvanian and Permian deposition, against which he could measure what he saw in the field. That is, Moore developed an ideal for the way the world should look; where it looked different, he then explained that difference in terms of unusual circumstances in each location. Because of their sweeping impact on ideas about the geologic history of the midcontinent, and because those views also held some import to people who were searching for oil, Moore's pronouncements about cyclic deposition obviously stirred up controversy. There were arguments about where cyclothems began and ended—did they start or end with a sandstone? There were arguments about the mechanisms for sea-level change. There were arguments about the number of cyclothems and megacyclothems that had occurred and were represented in the geologic record. Similarly, there were arguments about the abruptness in the change of the geologic record—the sharp break where limestone changed to shale, for example. There were arguments about how the marine-dominant cyclothems of Kansas matched up to cyclothems in other parts of the midcontinent. Most especially, there were arguments about the source of the black shale, the black shale that Moore said was probably nearshore. Moore argued that the shales, and many of the limestones, were so thin that they could only have been deposited by a sea that appeared and then withdrew over a short span of time. Such a sea must have been shallow. Deep seas, he reasoned, could not appear and disappear in such a hurry. Because the limestones and shales were so widespread, these shallow seas must have been extensive. Through the discussion of cyclothems, Moore set the stage for a geologic discussion, or argument, that has continued into the present. While several of Moore's ideas have since been cast out, there is no doubt that he defined the questions, and thus went far in determining the paradigm of twentieth-century midcontinent stratigraphy. Cyclothems continue to dominate much of the discussion of midcontinent stratigraphy, with further refinement of notions about sea-level change and subsequent deposition. Geologists continue to argue the merits and drawbacks of various theories related to cyclic sedimentation.

Moore's work with cycles of sedimentation may have indirectly led to the appearance of his first textbook, *Historical Geology*, published by McGraw–Hill in 1933 (Moore, 1933c). As the title shows, the book was, like most texts on historical geology, one of sweeping scope, one that took all of geologic time as its province. With his combination of background in geologic history and paleontology, Moore was up to the task. The book is 673 pages of text, figures, and photographs showing the rocks left behind and preserved by the geologic past, and the animals that lived in those times. Moore later revised the book, but its appearance helped push Moore beyond regional renown to national prominence.

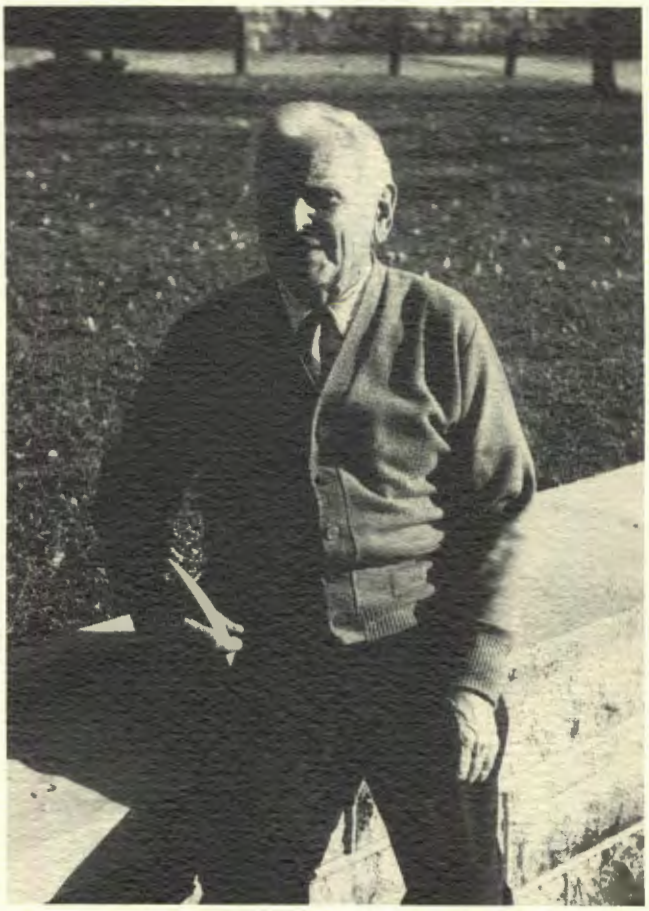
Invertebrate paleontology

Moore's second area of expertise was invertebrate paleontology, a specialty particularly handy for studying the geology of the Pennsylvanian and Permian systems, where invertebrate fossils were far more abundant than vertebrates. In fact, it was probably Moore's knowledge of Pennyslvanian paleontology that led to his 1929 publication on the "Environment of Pennsylvanian Life in North America," a paper that served as a precursor to many of Moore's ideas on cyclothems (Moore, 1929). During his career, Moore published specific articles on corals, gastropods, and bryozoans, and considered a number of other invertebrate species at one time or

Osborne, Wallace, Ness, Hodgeman, Johnson, Miami, and several other counties. There is no obvious pattern to the Survey's study of the state's geology at that point. It does not focus on oil-producing counties, or even on those in one geographic part of the state.

In the mid-1930's, the Survey began to produce reference works that were basic to study of the state's geology. In 1935, Moore published the first reasonably complete and detailed stratigraphic column of Kansas, based on work done by the Survey (Moore, 1935). In 1937 the Survey published its first large-format, full-color geologic map of Kansas at a scale of 1:500,000 (Moore and Landes, 1937). The map was credited to Moore and Landes, with a tip of the hat to Max Elias and Norman Newell; the map also acknowledged the "active interest" of former Governor Alf Landon, who got his start as a southeastern Kansas oil man before he was governor of Kansas from 1934 to 1936, and then a Presidential candidate. The geologic map was a major contribution to geologic activity in the state; work had started on it in the late 1920's. A revised edition was issued in 1964.

Moore made two other administrative commitments during the 1930's that may have been more important than any publication the Survey produced. Both were in response to contemporary state concerns. The first, in 1937, was the beginning of a formal cooperative relationship with the U.S. Geological Survey regarding water studies in the state (see Moore, 1940, p. 7). The economy of the 1930's, and accompanying drought and soil conservation problems, had an impact on the Survey's direction. Irrigation had long been used in western Kansas, where rainfall averages as little as 15 inches a year and surface water is scarce. Most of the early irrigation came through water diversions, first from springs and later from a number of ditches and canals that were built to take water from the Arkansas River, especially in southwestern Kansas. With the 1930's drought, the state began to experience problems even with domestic water supply for some of its cities. Where before basic geology and oil and gas had been the dominant focus of Survey study, and water was studied only on an emergency, irregular basis, ground water now took on a considerable, permanent role (although still not one equal to oil and gas). The first cooperative project between the state and federal surveys was in studying the Equus Beds, a shallow aquifer north of Wichita that was, and still is, the primary souce of water for the state's largest city. The Equus beds, named after horse fossils that are present there, was among the early formations studied by Erasmus Haworth, but was the subject of renewed concern with the Dirty Thirties drought, Wichita's growth, and worries about saltwater ponds that may have allowed contamination of the water. The surveys studied the local geology and drilled test wells, eventually producing a report on water in the Wichita area. Moore's commitment to cooperative water projects with the U.S.G.S. has continued up to the present, though the relationship has not always been harmonious. At the same time, the two surveys began cooperative studies of water in a number of southwestern Kansas counties, the Kansas Survey began cooperative projects with other state and federal agencies, including the Soil Conservation Service, the Water Resources Division of the State Board of Agriculture, the State Board of Health, and the U.S. Department of Agriculture.



Maxim Konrad Elias.

That role clearly fit within Moore's concept of the Survey.

> A state survey is a continuing institution—a scientific bureau which through periods of years gathers and preserves geological information which in many cases might otherwise be lost. The value of such a repository for geological data in a state is seen, for example, in the records of deep wells, samples of drill cuttings, rock specimens and fossils which are brought together for permanent record and reference (Moore, 1924).

Beginning in 1938, the Survey worked with the Geological Society to make those cuttings available, essentially establishing a joint office in Wichita whose first manager was geologist Raymond P. Keroher. That office has today grown into the Wichita Well Sample Library. In its building on Wichita's west side, the Library houses and makes available cuttings from more than 120,000 wells in the state and continues to collect cuttings from wells in localities not previously represented in the Survey's collection. That facility was built through a fund-raising drive led by the Society, and later expanded using money generated by a fee on every intent-to-drill form filed for oil and gas wells in the state. The Survey also maintains a downtown office, only a few blocks from the Geological Society, that provides information and publications. For a number of years, the Society operated a sample-preparation operation that would wash and dry cuttings, for a charge, before they were submitted to the Survey for archiving. In 1987, the Survey took over the sample-preparation part of the operation, so that it now collects, cleans, archives, and loans the library samples.

The cooperative program with the U.S. Geological Survey and the establishment of a branch office in Wichita were two of Moore's more successful attempts to deal with state service problems. By teaming with the U.S.G.S., he was able to help study state water problems without committing his own resources to the extent that would have otherwise been required. Through the Wichita Well Sample Library, Moore gave the Survey an important presence in Wichita, which had grown into the center of the state's oil industry and had a natural clientele for the Survey's products. Clearly these were both appropriate ideas, ideas that allowed the Survey to carry on its service role without dramatically detracting from the emphasis on basic geology that Moore had picked as his priority.

Boxes of cuttings at today's Wichita Well Sample Library.

Moore established one other component of the Survey that has survived into the present. In 1937, he created the Mineral Industries Council, a group of 12 people from outside the Survey who met once or twice a year to provide statewide input on research direction and Survey policies. The members were generally selected to provide geographic and vocational diversity, although their role was also equally political. Examples of early members were Howard Carey, of the Carey salt family, and Kenneth Spencer. Later the name of the Council was changed to the Geological Survey Advisory Council, and it regularly included at least a couple of legislators.

By the end of the 1930's, then, Moore had established the Survey as a larger, far more consequential organization than he inherited 15 years before, both in terms of service activities and academic accomplishment. The Survey of 1940, for example, had a staff of 20 full-time employees divided into five sections: administration; stratigraphy, paleontology, and areal geology; economic geology; subsurface geology; and mineral resources. In addition, the Survey supported staff in cooperative

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Post-World War II

World War II touched all of Kansas. By 1945 and the end of the war, nearly every community in the state, no matter how small or remote, had sent someone to the war—some 215,000 Kansans were in uniform during World War II, and 3,500 were killed in action. Several Kansas towns became homes to newly built airfields—huge landing strips that were training bases for pilots before they were shipped overseas. The larger cities, such as Wichita and Kansas City, experienced manufacturing booms, especially related to aircraft. Commodity prices increased and improved the income of those who stayed home.

Like the rest of the state, the Kansas Survey was directly affected by World War II. The war, for example, altered the Survey's direction, focusing its efforts more on resource production—not only on coal, as during World War I, but also on oil and gas, water, and other resources. Concomitantly, the war increased the Survey's budgets, to more than $80,000 per year during a couple of the war years, far beyond anything it had experienced before in its history (Schoewe, 1965, p. 69). The war brought other minor, though perhaps more noticeable, changes. The Survey shared building space with officers who were at the University for training (Griffin, 1974, p. 486). Survey personnel found their field work sometimes curtailed by the lack of gasoline and rubber for tires. And a growing number of staff members were gone from the Survey in military service.

But the war finally ended, and the ensuing times were good for the Survey, indeed for all of American science. Veterans returned from the war and enrolled in schools in record numbers, providing plenty of work for academic departments and everyone connected with them. What's more, the economic boom continued, providing jobs and, perhaps of more interest to the Survey, encouraging oil and gas exploration at a pace that peaked in the early 1950's. The years during World War II and shortly thereafter, from around 1940 into the 1950's, were again a time of transitions at the Survey. Some of those transitions were slow, some were abrupt, some were more apparent than real, and others were perhaps more difficult than was immediately apparent.

Publication

Those changes began most visibly with the start of the war. One measure of change was the pace

classic reference on the subject (Frye and Leonard, 1952).

Pleistocene geology was not the only new area of emphasis for the Survey. Beginning in the late 1940's, Norman Plummer published articles related to the resources that could be manufactured from Kansas clay. Through basic research on the presence and nature of clays in the state (see, for example, Plummer and Romary, 1947), Plummer encouraged the ceramics industry in the state, which started with brick and tile manufacture and continues to be a major Kansas industry today. The work in ceramics and Pleistocene geology, however, was hardly done at the exclusion of other efforts. The Survey continued to churn out county reports on geology and ground water, updates on oil and gas developments, and occasional volumes on the application of geophysics. It also produced standard references in stratigraphy, including, in 1951, a book describing the Kansas rock column (Moore and others, 1951), and, three years later, what became a standard reference on the oil and gas fields of eastern Kansas (Jewett, 1954).

In the fall of 1951, Moore took a sabbatical leave to serve as a visiting professor at the National University of the Netherlands. While he was gone, the KU geology department changed its chairman; Moore returned, in 1952, to take the job of chair for the third time in his career (it is possible, in describing the history of the Geological Survey, to understate its interaction with the KU geology department. For many years, the two shared the same quarters and were all but identical. Many of the staff were listed as members of both, and the Survey directors wrote official documents under KU geology department letterhead almost as often as they used Survey stationery. Moore chaired the department from 1920 to 1939, again from 1940 to 1941, and the final time from 1952 to 1954 [see Dunbar, p. 5, in Teichert and Yochelson, 1967]. With the expansion of Survey staff in the late 1940's and early 1950's, and especially once the Survey moved from Lindley Hall to a separate building on KU's west campus, it is far easier to differentiate the activities of the Survey and the department). The geology department was concerned with the demands of rapidly increasing enrollment, much of it related to veterans returning to school on the GI bill. Moore dealt with departmental issues, then, only to see John Frye resign from his executive directorship of the Survey early in 1954.

Frye left to become chief of the Illinois State Geological Survey, where he continued work in the Pleistocene, but expanded his efforts into the fledgling field of environmental geology. By the end of his career at Illinois, he was especially known for his considerable efforts to build bridges between geologists and the public and political officials who needed geologic information to make decisions. Frye retired from the Illinois Survey in 1974, but then became executive director of the Geological Society of America, a Boulder, Colorado-based organization of academic and professional geologists that is one of the two or three most important geological societies in the country. Frye left the GSA in 1982, and died only five months later.

Frye worked at Kansas under the lengthy shadow of R. C. Moore, yet he achieved distinction on his own. Frye published often and Survey staff members of the time, including R. C. Moore, recognized that Frye was in charge of the Kansas Survey. When Frye announced his resignation in 1954 to go to Illinois, KU chancellor Franklin Murphy began a national search for a replacement. Moore clearly felt left out of the process, and wrote Murphy complaining that he (Moore) had been relegated to a "largely forgotten and needless figurehead" (Moore to Murphy, 13 March 1954, Murphy Collection, KU Archives). Moore was still the Survey's director. He was still the state geologist. He was still the person most responsible for creating the Survey of the mid-twentieth century. He was still the single person most closely identified with the organization. But in some respects Moore had already been replaced. For 15 years he had not been involved in the day-to-day administrative details of the Survey. He was far less active in the statewide politicking required by the job. He was absent from KU and the Survey for four years during the period from 1943 to 1953 (in addition to active military service from 1943 to 1945, and the sabbatical for the 1951–52 school year, Moore had served as a consultant to Douglas MacArthur in Japan during 1949 [see Dunbar, in Teichert and Yochelson, 1967]) and part of the time he was occupied by the KU geology department. As far as the Survey was concerned, the transition from Moore was largely complete. In June 1954, Moore resigned as director and state geologist, though he retained the title of "principal geologist" (Moore to Murphy, 29 June 1954, Murphy Collection, KU Archives) and concentrated most of the remainder of his career on research, publication, and professional societies and their activities.

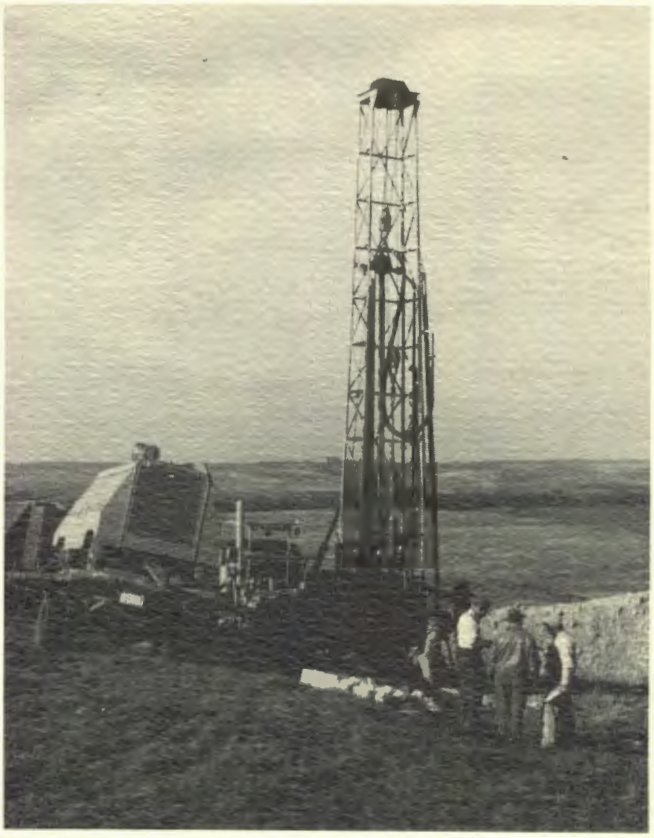
From Moore and Frye to Foley

In some transitions, there is an heir apparent. But not with Frye's departure from the Kansas Survey. KU chancellor Franklin Murphy picked,

ironically enough, a staff member from the same Illinois Geological Survey that Frye had left to direct. Frank Foley (1906–1985) was a native of Ontario, Canada. Foley had a Ph.D. from Princeton and had previously served as head of the North Dakota Geological Survey, district chief of the U.S. Geological Survey's ground-water branch in Madison, Wisconsin, and, from 1951 until he came to Kansas, head of the ground-water section of the Illinois Survey. R. C. Moore's specialities were paleontology and stratigraphy, and John Frye had pushed the Survey into the Pleistocene, but Frank Foley brought expertise on ground water. Where those previous directors had molded much of the Survey around their particular research interests, Frank Foley did not, or certainly to a lesser extent than Frye and Moore.

Much of the research direction of the Survey that Foley took on was determined by the background and talents of the staff. The ground-water portion of that staff was still part of a cooperative effort with the U.S. Geological Survey, and although the ground-water section comprised nine staff members, it was only one part of a large organization. In 1954, the Survey was organized into several major sections, including Basic Geology, Publications and Records, and Mineral Resources, which was further broken into oil and gas, subsurface geology, petroleum engineering, ceramics, and geochemistry. The Survey had established a southeastern Kansas field office in Pittsburg in the early 1950's with two staff members. In addition to the ground-water program, the Survey carried on cooperative programs with the U.S.G.S. in mineral fuels and topographic mapping. That Survey of the mid-1950's already listed a number of staff members who would, over the years, become well-known and closely associated with the Kansas Survey and Kansas geology. John Mark Jewett, A. Byron Leonard, Ada Swineford, and Walter H. Schoewe remained on the staff. In ground-water, Howard O'Connor and Charles Bayne. In ceramics, Plummer, William Hladik, and Ron Hardy. In geochemistry, Russell Runnels. Wallace Lee and Edwin D. Goebel led research related to oil, and added to the staff a young geologist named Dan Merriam. Grace Muilenburg also joined the Survey and became well known for efforts in journalism and geologic education.

In sum, the Survey of the early 1950's had accumulated a staff with expertise in basic geology and stratigraphy, oil and gas, ceramics, and ground water. With John Frye's departure and Moore's resignation as director, the emphasis on paleontology had all but disappeared. Geophysics, at least so far as the Survey was concerned, had yet to arrive. As a result of World War II and the boom times that followed, the Survey was more development-oriented than, perhaps, it had been since the days of Erasmus Haworth.



The Survey's rotary drill rig in the early 1960's .

That orientation changed, slowly, under Frank Foley, though it is difficult to say how much of that change was the result of Foley's efforts, how much came from the people who surrounded him, and how much was due to the temper of the times. Certainly there was no drastic increase in the number of ground-water investigations that took place. The Survey did begin cooperative programs with other state agencies that produced regular measurements of water-levels in observation wells in western Kansas, providing the first consistent, baseline quality data on water-levels for western Kansas, information that became particularly important in the 1960's and 1970's when irrigation boomed and water levels dropped. Occasionally the Survey looked at water problems for an entire watershed, for example, and

produced the basic materials—geologic maps, cross sections, county reports—that were so important to the state. Moore clearly believed in the Survey's service role. He worked to establish a well-sample library and began major ground-water studies, and even flirted with the notion of involving the Survey in oil and gas regulation. But at the same time, Moore continued basic work in paleontology. If the comparative roles of service and research could be gauged during Moore's time, the results would show a new emphasis on research, while exploring avenues of service to the state.

World War II changed all that. The war removed much of the bent toward basic research from the Survey's activities and replaced it with activities that would aid in the exploitation of resources. The gauge of research-versus-service would show clearly, at the end of the war, that the Survey was a service agency, albeit an academic one. With the departure of John Frye and the reduction of efforts in Pleistocene geology, basic work slowed more. Later in the 1950's, the proportion between services and research began to change again somewhat, with paleontological activities replaced by geophysics. The increasing role of geophysics may represent not so much of a trend toward research, as it was the direct application of newly developed technology toward old problems. Until the 1950's, the Survey was made up of people who took the classic field approach to geology. R. C. Moore's students called it "sharpening the mind by dulling the pick." But beginning in the 1950's and coming full force in the 1960's, was the notion that banging on rocks was not the only way to learn about geology. Geophysics may have been just the first expression of that idea, but it was certainly not the only one.

The Survey's use of those alternative tools—first geophysics and later computers—probably was not the result of force of leadership by any one person. In part, it may have been the temper of the times. In the early to mid-1960's, the concept of plate tectonics was slowly accepted, and an emphasis on structural geology came along with it. Studies of structure, especially deep structure, required all sorts of newly available, largely quantitative, tools. Even in Kansas, far from the edge of any continental plate, the shifting paradigm of geology may have had an impact. Perhaps the nucleus of people around Frank Foley—Hambleton, Merriam, later John Davis—was the right critical mass to drive the Survey in a new direction. Whether it was the time or the people or newly available tools and theories, the Survey began changing the proportion of its service and research. Service activities were still the dominant activity at the organization, but research grew, calculated or not.

In some respects, there was no competition between research and service during World War II because there was so little basic research. Also, it is difficult to draw a sharp distinction between service and research. Some Survey activities, such as loaning samples of oil-well cuttings, were clearly services. Others, such as paleontology, were clearly research. But most activities fell somewhere in between, were more difficult to define. Even so, with the gradual reappearance of research activities at the Survey, the jockeying for resources was on. Geophysics, mathematical geology, and computers had replaced paleontology as an area of research emphasis as the Survey faced the second half of the 20th century.

10

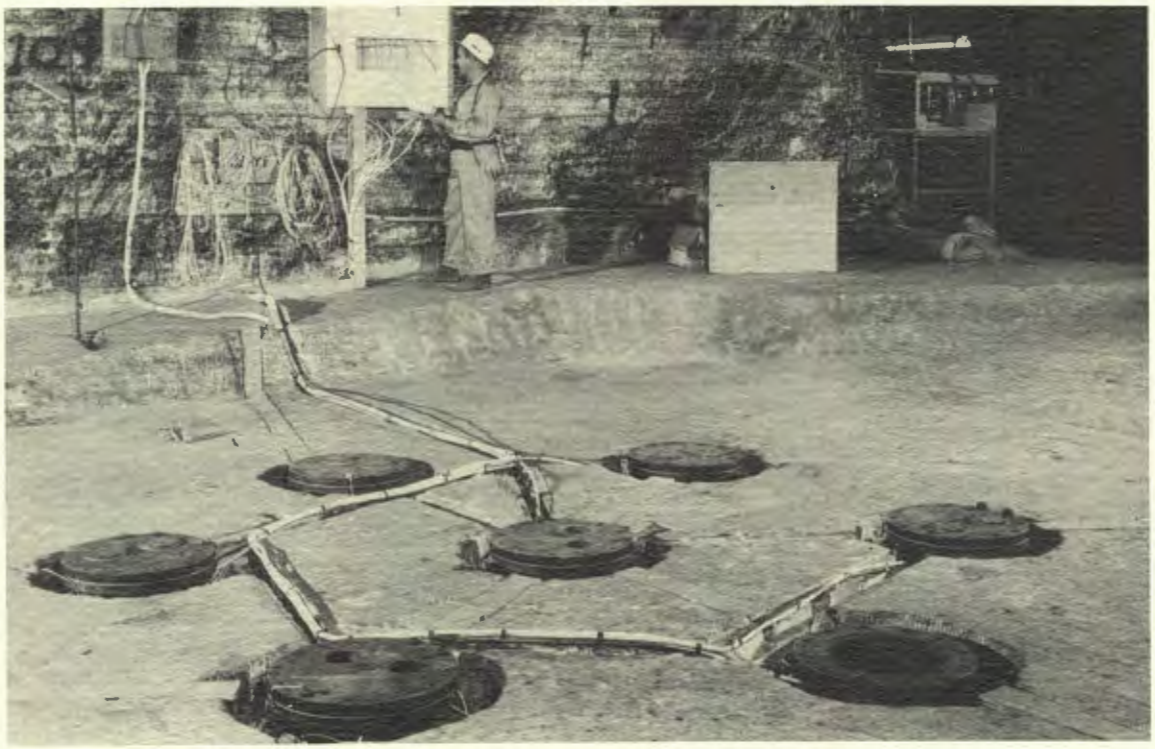
The Survey of the 1960's and 1970's

In writing history, the most immediate period is often the most difficult to describe. By definition, the recent past does not afford the perspective of time, and makes it difficult to assess the long-term impact of individuals and their ideas. The most recent past of the Survey—the 1960's, 1970's, and into the present—is difficult to evaluate for precisely those reasons. In some ways, the past 30 years may have been the most important, depending on the measure, in the Survey's existence. Certainly those years brought about change, in the buildings occupied by the Survey, in the Survey's leadership, and in the research directions pursued by its staff. Those years may also have recorded a shift in direction, from a Survey that was largely service directed to one that was more research-oriented.

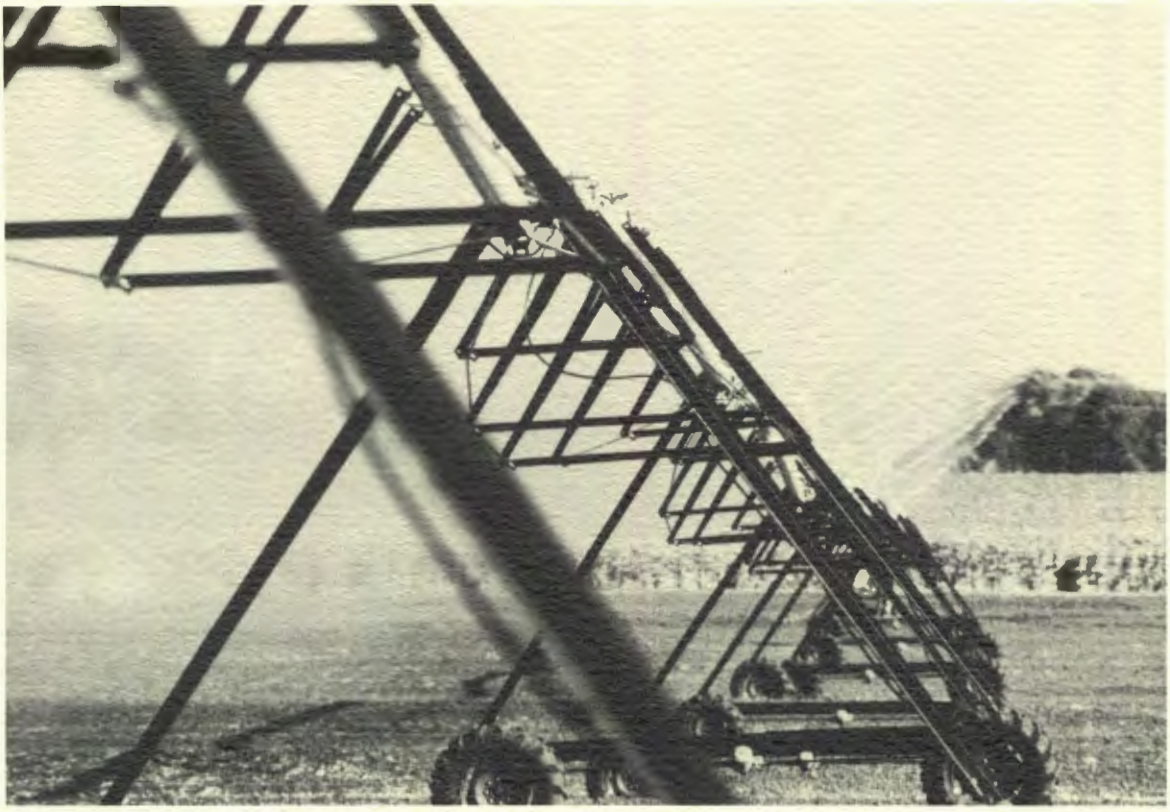
Change also took place in the subjects that Survey scientists studied. Throughout nearly all of its existence prior to 1960, the topic of oil and gas received the most attention. Though the Survey did basic work in stratigraphy and paleontology and, later, structural geology and geophysics, much of that work was done in support of oil and gas studies. Coal and metallic minerals received less attention. Beginning in the mid-1960's, other topics began to compete for attention at the Survey, mostly the result of problems faced by the state of Kansas. The Survey's ground-water effort changed from one that was largely dependent on cooperative studies with the U.S. Geological Survey to an independent research effort that was the largest program, at least in terms of full-time scientific staff, at the Kansas Survey. That switch in emphasis was the result of growing awareness of drawdowns, in some cases alarming drawdowns, in the water levels in the Ogallala aquifer in western Kansas. To a far less significant extent, the Survey also increased its efforts in environmental geology, primarily in response to concern about such issues as mined-land reclamation, storage of radioactive waste, and others. Changes also occurred in research methods, or at least in the Survey resources that went toward improving methods of studying geologic problems or producing geologic data. Mathematical geology, and as a natural outgrowth, the application of computers to geologic problems, received considerable attention. Geophysics, particularly seismology and magnetics and gravity, grew also, with much of that growth based on outside funding.

All of those changes—in research direction, leadership, and facilities—as important as they were, came slowly enough. In the early 1960's, the Survey

Three Survey directors. From left, Raymond C. Moore, William W. Hambleton, and Frank C. Foley.



The Lyons salt mine and the AEC's demonstration project in the late 1960's.



Center-pivot irrigation changed the agricultural and economic landscape of western Kansas in the 1960's and 1970's.

One of the best examples of such a quantified approach is the use of computers and appropriate programming to draw maps that show contours. Geologists generally produce maps by plotting a number of points, and then drawing in lines, usually contoured lines, of equal amounts. Scientists at the Survey, and in other organizations, developed complex statistical packages that could take the raw data and then plot the contours between the points, basing the contours on a series of mathematical formulae. The result was a somewhat more objective map—one based on objective means of determining the flow of a contour, as opposed to contours that relied on a scientific eye for extrapolation (as in most of science, no two geologists interpret data in exactly the same way, and it is often possible to identify the person who drew a map by the style of the contours). The Survey developed a contouring program, called Surface II, that not only provided an objective method of contouring, but allowed much of the work to be done automatically. John Davis, John Harbaugh, Dan Merriam, and Robert Sampson were all associated with the Survey's efforts in mathematical geology. Those researchers, and others, collaborated on a Survey-published computer contributions series that delved into the applications of computers to geology. That series continued for only a few years, but, like Surface II, was highly visible. That visibility was related to a Survey emphasis on international activity. In the 1960's, the Survey began a program of annually bringing in a visiting researcher, usually from another country. That program continues today.

The work in mathematics led naturally to Survey efforts in cartography. While the Survey had produced maps for years, they were generally hand drawn. Maps that needed updating, such as those that detailed the drawdown in a western Kansas aquifer over time, had to be laboriously and slowly updated. Using automated methods to do the plotting, at first for research-oriented maps and later for those that were published, allowed much quicker and simpler graphic presentation of scientific data. Survey work in automated cartography later became nearly as well known as its work in mathematical geology.

The Noel Poersch #1 was drilled by Texaco in late 1984 in southern Washington County. At 11,300 feet, it was the deepest hole in Kansas history.

also called, more cautiously, the Midcontinent Geophysical Anomaly). The CNARS was a billion-year-old split in the earth's crust, running from the Lake Superior region, down through Iowa and Nebraska, and into Kansas. That split, probably the result of a plate that began to break apart and then stopped, was the source of unusually high magnetic levels. Evidence for its existence also showed up in cuttings from oil wells drilled in the region, and through a deep seismic line that was run through northeastern Kansas.

That seismic line (produced by the National Science Foundation's Consortium for Continental Reflection Profiling, or COCORP, and brought to Kansas by a Survey proposal), also generated evidence for huge blocks of Precambrian sediments, a layer called the Rice Formation. Though the Rice Formation has not produced oil, it certainly provided an enticing drilling target, and in 1984 Texaco drilled a well 11,300 feet deep in Washington County, penetrating far into the Rice. The results of that well are only now being made public, showing interbedded layers of sediments and volcanic rocks (Berendsen and others, 1988). But it is clear that CNARS played an important role in the state's geologic history and may hold resources as well.

All of those activities—in energy, ground water, environmental geology, mathematical geology, geophysics—required a sizable staff. The Survey grew through the 1970's, topping out with slightly more than 50 full-time scientific specialists, a large number of support staff, and more than 70 part-time students. Those staff members, and the equipment they used, required considerable space. After several years of cultivating the legislature, a state appropriation led to a new building on KU's west campus. That building, completed in 1973 and named for Raymond C. Moore, provided the Survey with substantially increased square footage. It also took the Survey away from its Lindley Hall location with the KU geology department, and probably helped establish the Survey's sense of identity as more of a statewide entity and less a component of the geology department. At the same time, that move took the Survey off KU's main campus and probably hindered, at least in part, the Survey's cooperative ties with the KU geology department.

The additional space provided by Moore Hall was sufficient for a few years. In 1980 the Survey constructed a separate building a few hundred yards away from Moore Hall. This facility, designed to house the Survey's geohydrology effort, was named

Hambleton Hall, named after the Survey's eighth director, was completed in 1983.

native of New York, Gerhard came to the Survey from the Colorado School of Mines. Like Frank Foley, he had previously been state geologist of North Dakota. Gerhard's background was primarily in stratigraphy and oil and gas.

The ultimate significance of Hambleton's tenure, and of his successor Lee Gerhard, for the Kansas Survey cannot yet be measured. It is difficult to be certain just how much the pendulum moved from service to research since 1970, though some movement clearly took place. Certainly the past three decades have left the Survey a vastly different organization. One that focused on methods as well as subjects. One that was far larger than the days of the early 1950's, when staff members worked in two floors of Lindley Hall and remember today that they felt like a family. One that was at times a visible part of state government and is now less distinctly an arm of the University of Kansas.

These judgments, however, must remain provisional. The only thing that is clear is that the Survey has evolved far from its annual existence in the 1860's. It has come far from the days of the late 1880's, when a small staff depended largely on a

Lee C. Gerhard, the Survey's ninth director.

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Kansas Geological Survey, The University of Kansas

Student employees

Kansas Geological Survey
1930 Constant Avenue
The University of Kansas
Lawrence, Kansas 66047
1989