A HISTORY of the

SOUTH DAKOTA

GEOLOGICAL SURVEY

by *Patricia M. Vanorny*

Educational Series 4
1970

STATE OF SOUTH DAKOTA
Frank Farrar, Governor

SOUTH DAKOTA GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

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Science Center
University of South Dakota
Vermillion, South Dakota
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PREFACE

In writing the history of the South Dakota State Geological Survey the author has attempted to describe the development of an institution charged with investigating the State's geology and natural resources. Therefore, the first seventy-four years of the Survey's existence involves both the growth of an institution and the advancements made in fulfilling its scientific, economic, and educational objectives.

Many people have given generously of their time and knowledge to help bring this study to a satisfactory completion. The author is especially indebted to Dr. Cedric C. Cummins, Chairman of the Department of History at the University of South Dakota, whose wise counsel during research and writing has been invaluable. Grateful appreciation is extended to Dr. Duncan J. McGregor, State Geologist, for making available the records of the Geological Survey and to all staff members of the Survey for their assistance in searching for information and their inspiring interest and encouragement. Acknowledgment is also extended to Dr. E. P. Rothrock, Bruno C. Petsch, Dr. Allen F. Agnew, and Dr. Stephen S. Visher for their informative responses to oral interviews and personal correspondence with the author and to Mrs. LaRaine Halverson for her conscientious typing.

CONTENTS

CHAPTER I

GEOLOGICAL FOUNDATION, 1893-1903

A state geological survey, seeking to serve a science and a general public, tries to pursue an inclusive goal that will contribute to geology, economics, and education. Through its activities such an institution discovers and accumulates the facts and theories concerning the geology of a state, acquires data on natural resources for their development and utilization, and gives the people access to both types of information. In order to realize these benefits over two-thirds of the states had established geological surveys by the early 1890's,[1] as did the South Dakota legislature in 1893.

The full story surrounding the establishment of the South Dakota State Geological Survey cannot be determined because of the lack of detailed records. The initiative appears to have been taken by President J. W. Mauck of the University of South Dakota who was familiar with the benefits of the Minnesota Geological Survey and by the University's professor of geology, James E. Todd. The proposal fitted in well enough with the aspirations of the people of a pioneer state to develop their natural resources that it passed both houses of the legislature on March 6, 1893.[2]

The execution of the statute was placed under the jurisdiction of the Board of Regents of Education which would appoint the necessary personnel. The act outlined very carefully the types of surveys to be conducted—complete investigations of the geology, natural history, physical features of the State, and complete analyses of mineral resources and their potential productivity. These activities were to be reported upon bienially and whenever the results warranted special publications for the public. Other duties specified by the statute included the preparation of geological, geographical and topographical maps and the collection of rock, mineral, plant, animal, and fossil specimens, the duplicates of which were to be exchanged with scientific and educational institutions. Two hundred fifty dollars per annum were appropriated to carry out the provisions of the act.

Of academic note is the fact that the statute provided not for the Geological Survey as a state institution but only that the specified surveys and other projects be executed by authorized personnel. However, the Survey did come to exist in fact, although by varying titles—South Dakota Geological Survey, South Dakota Geological Survey and Biological Survey, South Dakota State Geological and Natural History Survey, and finally South Dakota State Geological Survey. Because of common and accepted usage, the terms Geological Survey and Survey will hereafter be employed.

The first office to be officially created was that of the State Geologist. On March 9, 1893, the Regents of Education took the following action: "Be it resolved, that the Professor of Geology and Mineralogy at the State University, be and is hereby elected State Geologist . . ."[3] Accordingly, James E. Todd became the first State Geologist. He had been professor of geology at the University since 1892. His study of geology had been undertaken at Oberlin College, from which he had received his B.A. and M.A., and at Yale University and Harvard University. Thereafter he taught natural science at Tabor College and Beliot College. During this time Todd had spent eight summers studying the glacial deposits in eastern South Dakota for the United States Geological Survey.[4]

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[1]This figure was determined from George P. Merrill, *Contributions to a History of American State Geological and Natural History Surveys,* Smithsonian Institution, United States National Museum, Bulletin 109 (Washington, 1920).

[2]James E. Todd, "History of the Survey," *The First and Second Biennial Reports on the Geology of South Dakota with Accompanying Papers,* 1893-6, South Dakota Geological Survey Bulletin 2 (1898), p. 1. Hereafter all such publications cited as Bulletin, with the appropriate number. For the 1893 statute, see Appendix A.

[3]Cited in Todd, "History of the Survey," p. 3.

[4]Freeman Ward, "Historical Sketch of the Department of Geology," *South Dakota Alumni Quarterly,* XVI, 2 (July 1920), pp. 72-73; James E. Todd, Lawrence, Kansas, letter, May 26, 1919, to Freeman Ward, State Geologist, in Files. The former hereafter cited as "Historical Sketch." Most letters and some reports

Upon assuming the position of State Geologist, Todd was accepting a job whose objectives he could fulfill only when his teaching duties were not too pressing, and at that time he was the sole instructor in geology. Even without classroom responsibilities, the State Geologist faced formidable tasks. As outlined in the statute, surveys were to be made of geological and physical features, mineral resources, and natural life within South Dakota and with the information thus acquired reports and maps were to be compiled. The materials available with which to effectuate these objectives were, at the most, meager. Although the legislature may have thought otherwise, an annual appropriation of $250, even in the 1890's, was hardly sufficient for large-scale operations. Moreover, almost all of the major field work had to be done during the summer months because of Todd's classroom duties and the need for favorable weather. Work in the field was also slowed by the available means of transportation. Depending upon locality, Todd and his assistants utilized railroads, wagon teams, or canoes; reportedly, Todd once traveled with a buggy drawn by a blind white horse.[5]

At first, the Geological Survey owned little equipment itself and depended primarily upon the facilities of the science departments at the University or at other colleges and private laboratories or companies. When Todd began as State Geologist, he had in the geology department the use of mineral, rock, and fossil specimens for comparison purposes, a microscope, a machine for cutting, grinding, and polishing rock sections, and a small reference library. His office and classroom were located in University Hall which was destroyed by fire on October 15, 1893. However, the department of geology suffered less than most departments; the few specimens were easily replaced and the library was soon restored with publications from the USGS.[6] By the fall of 1894 University Hall had been reconstructed and was ready for use.

The first major task confronting Todd, when he assumed the position of State Geologist, was the determination of priorities. In conjunction with the Board of Regents he decided that a logical and practical beginning would be the collection of currently known data concerning the geology of South Dakota. Todd specifically outlined the benefits and purposes of such a report. First, it would make readily available the information sought by geologists, teachers, and those interested in developing natural resources. Second, it would serve the Survey by arousing the interests of the citizenry and by demonstrating the value of cooperation from and with them. Third, it would provide the groundwork for future geologic endeavors.[7]

In order to gather the necessary materials for this proposed project, Todd employed three approaches. The main method was the compilation of pertinent information from publications concerning the geological features and natural resources of South Dakota. This literature represented all of the pioneer work that had been done on the geology of the State, mostly in the Badlands and the Black Hills and along the Missouri River. Geologists had been attracted to these regions because of the abundance of outcroppings and the early discovery of mineral deposits and fossils. The more prominent men involved in these pioneering efforts included F. V. Hayden, F. B. Meek, Walter P. Jenny, and Henry Newton. Hayden had made several expeditions throughout western South Dakota, but was best known for his work in the Badlands. Meek was believed to have been the first to distinguish the Cretaceous beds along the upper Missouri River Valley. Jenny had provided comprehensive information on the mineral resources of the Black Hills, and Newton had outlined the geological features of the Black Hills. In addition to these authorities and

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are located in the files of the Geological Survey or on microfilm. Hereafter the former cited as in Files, the latter as Microfilm, with the appropriate number.

[5] *The Biennial Report of the State Geologist, 1940-1942,* p. 8. Hereafter all such reports cited as *Biennial Report* or "Biennial Report," with the appropriate years, depending upon whether they are separate publications or articles in other reports.

[6] *Catalogue of the University of South Dakota for the Year 1892-3 with Announcements for the Year 1894-5,* pp. 35-37. Hereafter cited as *Catalogue*, with the appropriate year.

[7] "Biennial Report, 1893-94," Bulletin No. 2, p. 5; James E. Todd, *A Preliminary Report on the Geology of South Dakota,* Bulletin 1 (1894), pp. 2-3.

others, Todd utilized data from his own previous explorations in eastern South Dakota when employed by the USGS.[8]

A second means of acquiring information was through contact with those individuals who could provide facts concerning geological features in South Dakota. In fact, Todd had begun correspondence as early as December 1892 with geologists, well drillers, prospectors, quarry operators, travelers, and anyone else able to furnish data. He created a spirit of cooperation by offering to answer inquiries and to analyze any specimens sent to him. This type of mutual inquiry and service became a vital function of the Geological Survey. Todd's third method of securing information was through his own surveys. He delayed this work until the summer of 1894, because he had already been employed by the Minnesota Geological Survey for the summer of 1893 and because he wanted to combine two annual appropriations in order to concentrate his efforts more effectively. In this way he found it possible to visit both the Black Hills and the Badlands. Although only two weeks were allotted to each area, Todd apparently fulfilled his limited objective of examining geological formations by means of the naked eye and his own knowledge.[9] Shortage of time and funds and nonexistence of proper equipment with which to ascertain accurately unexposed formations limited Todd to a mere reconnaissance of the features of surface geology.

The ultimate result of Todd's efforts was the first exhaustive report on the known, and, to some extent, the speculative, facts about the geology of South Dakota, with two chapters devoted to topography and economic geology. Todd also drew the first geological map of South Dakota, which he included in the bulletin. In depicting the geologic formations he described the origin, location, and extent of each one and characterized each one lithologically. That this report was expected to be used and understood by the general public as well as the professional man was indicated by the interspersion of definitions for geological terms.[10] This aim of serving the public had, of course, been specified in the original statute; readable publications became one means by which the Geological Survey rendered this service.

After completing this first immediate task, Todd formulated plans for long-range projects. For scientific, educational, and economic reasons he aspired to explore more completely those parts of South Dakota about which little was known geologically, to obtain additional and more recent data on those areas previously surveyed, to collect representative plants, animals, and fossils, to further investigate lignite deposits, and to determine the origin, adequacy, and needed regulation of water resources, especially artesian water.[11] Until his resignation in 1903, he concentrated upon these major objectives. The results of the projects correspondingly undertaken were seldom as complete and detailed as Todd desired. But significant beginnings and advancements were accomplished.

Todd's first efforts toward fulfilling his long-range plans consisted of field trips in the Black Hills and in northwestern South Dakota in the summer of 1895. Funds for these two trips were acquired when the Board of Regents designated the unused appropriation from the School of Mines for field work under the State Geologist. The purpose of the investigation in the Black Hills was to study further the Precambrian formations. Todd arranged that this project be undertaken by Frank C. Smith, professor at the School of Mines. An area near Rapid City was selected because it was not as well studied as other parts of the Hills and because it involved less expense. Later that same summer Todd himself, with the intention of selecting specific areas for detailed surveys, toured other parts of the Black Hills on the Burlington and Missouri Railroad, whose manager provided the services at the company's expense. Todd expressed again a particular interest in the stratigraphy of the

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[8] Todd, Bulletin 1, pp. 3-5.

[9] *Volante*, VI, 3 (December, 1892), p. 46; "Biennial Report, 1893-94," pp. 5, 7-8.

[10] For more details, see Bulletin 1.

[11] "Biennial Report, 1895-96," Bulletin 2, p. 20.

Hills, especially since such a study would provide information about the origin and distribution of mineral deposits.[12]

Smith's investigation and Todd's reconnaissance were noteworthy in two respects. Here, as in other instances, Todd found the railroad companies in South Dakota very cooperative in providing services without full compensation. Economically the railroads could eventually profit from such a policy. If some discovery by the Geological Survey led to the opening of new mines or the settling of new lands, the railroads could obviously gain from increased freight and passenger business. The second notable facet concerning the geological survey of the Black Hills was that, although Todd, like many miners and geologists at that time, desired to learn more about the stratigraphy and its relation to mineral deposits, he was never able himself to do much more than recommend such studies. Undoubtedly a combination of several factors brought about this situation. The multiplicity of tasks to be accomplished by the Survey, Todd's duties at the University, and small appropriations necessitated concentration upon the more urgent or important priorities. Perhaps a larger factor was that the School of Mines had already been designated as one agency to conduct investigations of the Black Hills area, although more from the standpoint of mining engineering. Todd, realizing this situation, suggested cooperative efforts between the School of Mines and the Survey. However, he did imply that the Survey might, of necessity, assume the lesser amount of such work.[13] The lack of any further evidence on this point suggests that the plan was left at this initial step.

The second field trip in 1895 was conducted by Todd himself in northwestern South Dakota. Although it was known that this region contained beds of lignite, little information had been gathered about the nature or extent of these deposits. This then was the primary objective of the survey which also provided an opportunity to procure a general picture of the geology of the region. Todd and his assistant traveled through this sparsely-populated area with a wagon and a team of horses. Wherever possible they set up camp on ranches which Todd, when describing topographical or geological features, frequently used in conjunction with place names. With equal familiarity he referred to Cave Hills, Slim Buttes, or the Moreau River and to the E. O. Ranch or the Turkey Track Ranch. From the expedition as a whole only generalized results were realized. Todd had found several lignite beds that varied in thickness from a few inches to several feet and that varied in quality. Because the specimens were not thoroughly analyzed, he could only conclude that the lignite, in general, seemed useful for at least ordinary heating purposes and that it compared favorably with the deposits in North Dakota. However, Todd was satisfied that his findings provided a reference for future work.[14]

Another area of the State that fascinated Todd was the Badlands, then called the White River Badlands in order to distinguish it from a similar area in northern South Dakota. He was particularly interested in starting a collection of vertebrate fossils for the Survey and the State. In addition, he wanted to reconnoiter the areas that Hayden had previously explored. With these purposes in mind, Todd and six of his students traveled by covered wagon from Vermillion to the Badlands and back in the summer of 1896. In the course of their surveying Todd discovered what he believed to be a bed of volcanic ash. This finding led him to speculate that it might contribute to an explanation of volcanic disturbances in the Black Hills. While State Geologist, Todd himself was unable to do further work with reference to this idea. The search for fossils proved to be very successful, as over 500 pounds were collected, including the skulls of a Titanotherium and an Oreodon.[15]

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[12] "Biennial Report, 1895-96," pp. 16-17; James E. Todd, "Section Along Rapid Creek from Rapid City Westward" and "The Geology Along the Burlington and Missouri Railway," Bulletin 2, pp. 27-28, 69, 82.

[13] "Biennial Report, 1895-96," p. 22.

[14] James E. Todd, "A Reconnaissance Into Northwestern South Dakota," Bulletin 2, pp. 43-44, 50-51, 63-65.

[15] James E. Todd, "The Exploration of the White River Bad Lands in 1896," Bulletin 2, pp. 117, 122, 126; "Biennial Report, 1895-96," p. 18.

T. Mark Vinson, one of the students who accompanied Todd, wrote a series of six articles about the field trip for the *Volante*, the University newspaper. His accounts of the various misfortunes aptly represented what must have been the experiences encountered in many of the early field trips. Some times a meal consisted of petrous biscuits or unpalatable herbs that the Indians had recommended. In uncharted regions travel itself presented difficulties. The six students were prepared to aid their horses by pushing and lifting the wagons up steep, rocky inclines. Travel by foot was similarly trying when Vinson and the others often found themselves in ravines or on buttes where backtracking was the only possible out or off. Or, like Vinson, one could attempt a slow climb and instead receive a fast but sore descent. Even trails were not always helpful; one man spent the night in a schoolhouse because he had taken the wrong path back to camp. When the Survey party was returning to Vermillion, three of the horses strayed off. After a few days of searching, all were found.[16]

Not until 1902, six years after the investigation of the Badlands area, did Todd undertake a major field trip, largely because the Survey's appropriations were retained at the same low level of $250.[17] In fact, he waited until 1898 to have published the reports on the studies conducted in 1895 and 1896 in order that sufficient money was available to print an adequate quantity for distribution. Another factor that complicated and delayed Todd's work as State Geologist was his assumption of administrative duties for the University, besides the regular faculty meetings in which all participated. For the school year of 1897-98 Todd was Acting President. The University had lost its regular president, J. W. Mauck, because funds were unavailable for his salary. Thus, during that year Todd found time only to have printed his second bulletin and to take care of correspondence for the Survey.[18]

By 1898 when funds were again available, Todd felt it necessary to purchase books and instruments for the Survey. The books, which concerned paleontology, were to be used in the study and arrangement of the large collection of fossils. The University provided the necessary display cases for the museum which was supervised by Todd.[19] The instruments consisted of an aneroid barometer, a prismatic compass, and a camera for field work and of drawing implements for preparing maps and illustrations. Previously the Survey had relied upon borrowed instruments which were not always of the best quality. Although the Survey was beginning to acquire its own implements in order to facilitate work, University Hall was becoming too crowded to accommodate additional equipment, or even more students. So the legislature appropriated funds for constructing a science building, which was completed in 1902. Science Hall contained the biology, chemistry, engineering, geology, and physics departments and the museum. The facilities for the geology department and the museum were also intended to serve for the Geological Survey.[20]

Upon acquiring additional equipment and space, Todd sought to increase his personnel. In this way he hoped to expand the work done by the Survey. He also planned to select personnel in a way that would promote greater cooperation and unified efforts among the state colleges. Thus, Todd requested the Board of Regents to appoint assistants who, if

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[16]T. Mark Vinson, "A Summer's Outing," *Volante*, X, 1-6 (October 1, 1896-January 18, 1897), pp. 1-2, 12-14, 24-26, 36-38, 48-49, 60-62.

[17]For the table of appropriations, see Appendix D.

[18]Ward, "Historical Sketch," p. 74; "Report of Regents of Education of the State of South Dakota" and "Biennial Report, 1896-98," *Fifth Biennial Report of the Regents of Education of the State of South Dakota to the Governor for the Fiscal Years 1897 and 1898, Ending June 30, 1898*, pp. 20, 84. Hereafter all such reports cited as *Biennial Report of the Regents of Education*, with the appropriate years.

[19]The first official mention of Todd as Curator of the Museum was in *Catalogue, 1902-03,* p. 5. Even if he lacked the title before 1902, he possessed the responsibilities; see, for example, "Biennial Report, 1893-94," p. 13.

[20]"Biennial Report, 1898-1900," *Biennial Report of the Regents of Education, 1898-1900,* pp. 94-95; "Biennial Report of the State University," *Biennial Report of the Regents of Education, 1900-02*, p. 32.

employed by any state school, would receive compensation only for work during their vacations. The three men named were C. P. Lommen of the University, assistant in botany, Cleophas C. O'Harra of the School of Mines, assistant in geology, and D. A. Saunders of the State Agricultural College, assistant in zoology. With this personnel of professionals and a larger appropriation, $700 for 1901-02, more complete plans could be made for the study of animal and plant life and of geology in South Dakota.[21]

Even with this expanded potential the Survey was still unable to undertake more than one major project at a time. In 1901 it was decided to accumulate general geological and statistical information on the minerals of South Dakota. Based upon the inquiries that he had been receiving, Todd assumed that such a report would attract capital to the State for the development of these resources. O'Harra was engaged to assemble the geological data on mineral deposits and to obtain past and current production figures for the mines in the Black Hills. Todd assumed the task of doing likewise on building materials, fuels, and water in the State. Both men relied heavily upon the information already known, but scattered throughout various sources, and supplemented that with correspondence and a few short field trips. However, like the first bulletin, this third one was intended only to furnish the basis for more detailed studies. In fact Todd tentatively proposed a plan for annual or biennial production reports from the mines so that these could be regularly compiled and published.[22] But not until 1929 was such a program effectuated.

In order to learn more about specific mineral resources Todd planned a reconnaissance survey of the northwest central part of South Dakota for the summer of 1901. Reportedly this area contained valuable deposits of coal and, possibly, occurrences of oil and gas. In addition, Todd aimed further to fulfill his long-range programs by investigating a region of the State that very few geologists had studied and by securing specimens of fossils and natural life. On this field trip, which was delayed one year because of an outbreak of smallpox among the Indians, Todd was assisted not only by two men employed to collect and study plant and animal specimens but also by two men who volunteered, one as a geologist and the other for general work. The use of volunteer services remained an important and essential feature of the Survey's field work until at least the mid-1920's. The unique member of the 1902 field party must have been the teamster who also functioned as an interpreter, presumably among the Indians. As could be expected, the accomplishments of this reconnaissance survey were acknowledgeable only in generalizations, with the aspect of the unknown always in the background. However, the Survey did contribute an excellent beginning in regards to information on geological formations and topographical features.[23]

Along with a concern about the development and use of minerals, building materials, and fuels, Todd urged just as emphatically the acquisition of data on water resources, especially artesian water. For a predominantly agricultural economy this concern was naturally vital to the State as a whole. Although Todd never accomplished what he repeatedly stressed must be done, his attempts to combat the geological and economic problems involving water resources foreshadowed what became a major activity of the Geological Survey, that is, the study of water supply and usage. That the Survey failed to embark upon this endeavor in full proportion until the 1930's, and then only sporadically until the 1950's, cannot be attributed to lack of concern on the part of the State Geologists. The explanation lies rather with a combination of factors—the lack of necessary funds, the need to meet immediate problems or goals, and the failure of the public and their legislators to recognize the urgency of water supply difficulties.

In each biennial report and bulletin Todd stressed the necessity of investigating artesian water resources and usually urged the appropriation of adequate funds for such a project. The geology of the proposed plan centered around the determination of the depth of the Dakota Formation, the most used water-bearing stratum, of how water entered this

[21] "Biennial Report, 1900-02" and "Minutes of the Regents of Education of South Dakota For the Biennial Period July, 1900–June, 1902." March 27, 1901, *Biennial Report of the Regents of Education, 1900-02,* pp. 43-44, 106-107. Hereafter cited as "Minutes."

[22] "Biennial Report, 1898-1900," p. 97; James E. Todd, "Preface," in Cleophas C. O'Harra and James E. Todd, *Mineral Resources of South Dakota*, Bulletin 3 (1902), pp. vii-viii.

[23] "Biennial Report, 1900-02," pp. 45-48.

formation, and of whether the various formations containing artesian water were separated from or connected with each other. The work of an engineering nature was to include the recording of pressure in artesian wells in order to estimate its relationship to the amount of water supply and leakage. The discovery of means to arrest the leakage from the artesian basin was also a part of the problem of conservation. Even more emphatically did Todd fear the exhaustion of water supplies through excessive and wasteful uses by the people of the State. Therefore, he strongly advised the adoption of a program that would limit the size of artesian wells and check the flow of water.[24]

Beyond advertising the need for conservation measures, Todd could do very little when faced with a lack of public concern or support for the implementation of such proposals. However, he was able to obtain some general information about the water resources in the State, in part from the USGS. In 1895 Nelson H. Darton had been directed to prepare a report on the artesian waters of the Dakotas, which was published in the 17th annual report of the USGS. Later the USGS conducted another investigation of artesian wells in eastern South Dakota in conjunction with topographic mapping of the James River Valley. The specified purpose was to gather information for the future usage of these wells for irrigation. During his vacations Todd participated in the study.[25]

In addition, Todd contacted individual well drillers during his summer field trips or through correspondence. In order to systematize the collection of information on artesian wells, he prepared and sent to well drillers a form on which they were to give the location and total depth of the well, amount and pressure of water flow, and depth and thickness of the various rock materials. He also asked that, if possible, the drillers send him cuttings from the wells. Most of the data pertained to the eastern half of South Dakota, since very few artesian wells had been drilled in the western part. However, information from wells drilled by the federal government at Rosebud and Cheyenne Agency for the Indian Reservations did confirm that the artesian basin extended west of the Missouri River; in the 1890's this fact had not been a certainty. Even with the greater availability of well logs from the eastern part of the State, they often furnished stratigraphic data of questionable accuracy because of inadequate record keeping at the time of drilling. But by 1903 Todd felt he had acquired sufficient information for a bulletin on the water resources of South Dakota.[26] However, this task was never completed because of his sudden resignation.

It was on September 18, 1903, that Todd resigned as professor of geology and mineralogy, and thus concurrently as State Geologist. He took this course of action as the result of a ruling made by the Board of Regents in a hearing that concerned President Garrett Droppers of the University. David Boot, a student at the University, had charged Droppers with intimidation and attempted bribery. Boot claimed that the President had tried to bribe him to testify on his behalf during a prior investigation of Dropper's activities. Available records do not elaborate the nature of these charges. When the Board of Regents conducted the hearing, Todd testified in support of the charge of bribery. Why he acted in this manner is also very unclear. But apparently Todd felt so strongly about the position he had taken that when the Board ruled there was insufficient evidence to confirm the charges against Droppers he promptly resigned.[27]

Even though accepting Todd's resignation as professor of geology, the Board of Regents ruled that he continue to act as State Geologist until a man was found to replace him. This apparently remained the situation until Ellwood C. Perisho was employed in late October. Then in January 1904 Todd was re-employed for two months to write a report on the 1902

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[24]"Biennial Reports:" "1893-94." pp. 10-11; "1895-96," pp. 21-22; "1898-1900," pp. 96-97.

[25]"Biennial Reports:" "1896-98," p. 86; "1898-1900," p. 96.

[26]James E. Todd, "Additional Notes on the Limits of the Main Artesian Basin," Bulletin 2, pp. 88, 92-93; "Minutes," June 19, 1903, *Biennial Report of the Regents of Education, 1902-04,* pp. 189-90; "Reports on Artesian Wells Drilled" (undated), pp. 1-3, in Files. This form sheet includes a letter written by Todd.

[27]"Minutes," September 18, 1903, *Biennial Report of the Regents of Education, 1902-04*, p. 221; "Ninth Biennial Report of the Regents of Education of the State of South Dakota," *Biennial Report of the Regents of Education, 1904-05*, pp. 9-10.

survey in northwest central South Dakota and to prepare specimens for display in the museum.[28]

As the State Geologist for ten years, James E. Todd had placed the Geological Survey and its activities on a firm foundation, not only from the standpoint of accomplishments but also recommendations that he had advanced and that were realized only in later years. Although he had augmented his staff with assistants on a temporary basis, Todd saw that the expansion of activities would entail the establishment of a permanent staff. Another change sought specified a program of cooperation with the USGS, in regards to both funds expended and investigations performed. Todd especially desired that such a procedure be organized to examine water resources, since the USGS was already doing such work in South Dakota.[29]

The proposals for a permanent Survey staff and for cooperative programs with the USGS illustrated that Todd had in mind long-range plans for not only the types of operations but also the means of rendering possible such activities. For as long as these organizational ideas were unfeasible, accomplishments stemmed more from the State Geologist as a person than from the Geological Survey as an institution. Therefore, Todd can be accredited with laying the groundwork for the Survey as an organization and for its future work in geology.

One of the later State Geologists, E. P. Rothrock, has pointed out that Todd was not alone in preparing the geological framework, because two other geologists at that time, and for several years afterwards, were also vitally concerned with geological work in South Dakota. These men were C. C. O'Harra, professor of geology and later president at the School of Mines, and N. H. Darton, a geologist with the USGS.[30] O'Harra's pursuits involved mostly the geology and minerals of the Black Hills. Darton's efforts were concentrated in the geological study of the artesian waters. Although Todd was interested in their activities, he seldom had the opportunity to work with them, except when he employed O'Harra to help assemble data on mineral resources and when he assisted the USGS with its survey of the James River Valley. However, Todd could and did use the findings of these men, along with those of earlier geologists, in his own work. Otherwise he acquired his information from his own reconnaissance trips, whenever funds and time were available.

Most of Todd's achievements represented work of a more scientific than practical nature. But detailed studies that led to practical, and possibly profitable, results for the public had to be preceded by the procurement and assemblage of the basic outlines of the geological features in South Dakota. Todd himself specified that his accumulations of information on geology and mineral resources were purposeful as bases and references for more concentrated and specialized surveys. He had fulfilled this generalized objective by pursuing the specifics of a long-range program to ascertain the geological structures in all parts of the State, to assemble a diverse and representive collection of specimens, and to investigate lignite deposits and water resources.

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[28] "Biennial Report, 1902-04" and "Minutes," September 18, 1903 and January 28, 1904, *Biennial Report of the Regents of Education, 1902-04*, pp. 59-60, 221, 239. Todd resided in Vermillion until 1907. From then until his death in 1922 he taught geology at the University of Kansas in Lawrence.

[29] "Biennial Reports:" "1896-98," pp. 90-91; "1900-02," pp. 48-49.

[30] *Biennial Report, 1940-42*, p. 8.

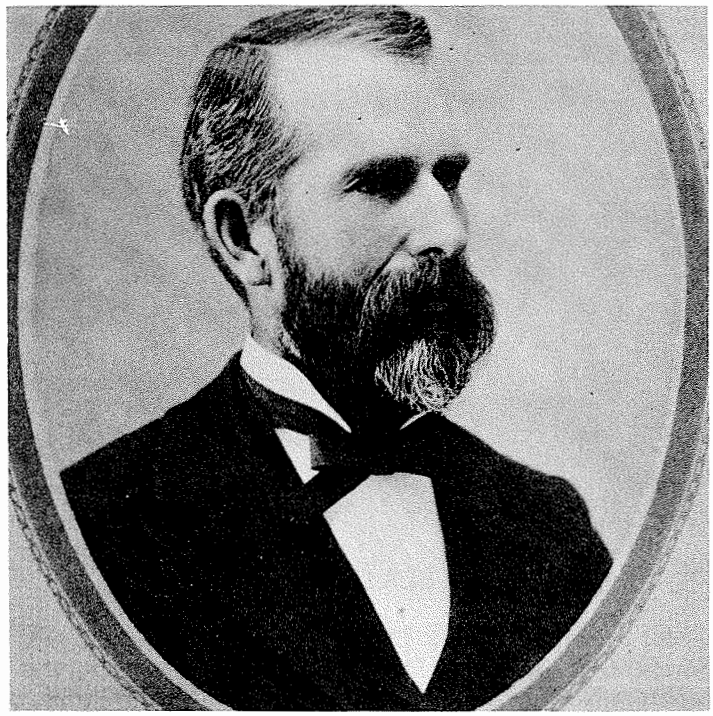


PLATE 1

James E. Todd

State Geologist, 1893-1903

PLATE 2

Geologic map—Todd's preliminary geologic map of South Dakota occurs as an insert in the back of Bulletin No. 1 of the Geological and Natural History Survey.

PRELIMINARY GEOLOGIC MAP OF SOUTH DAKOTA, by J. E. TODD, State Geologist, 1894.

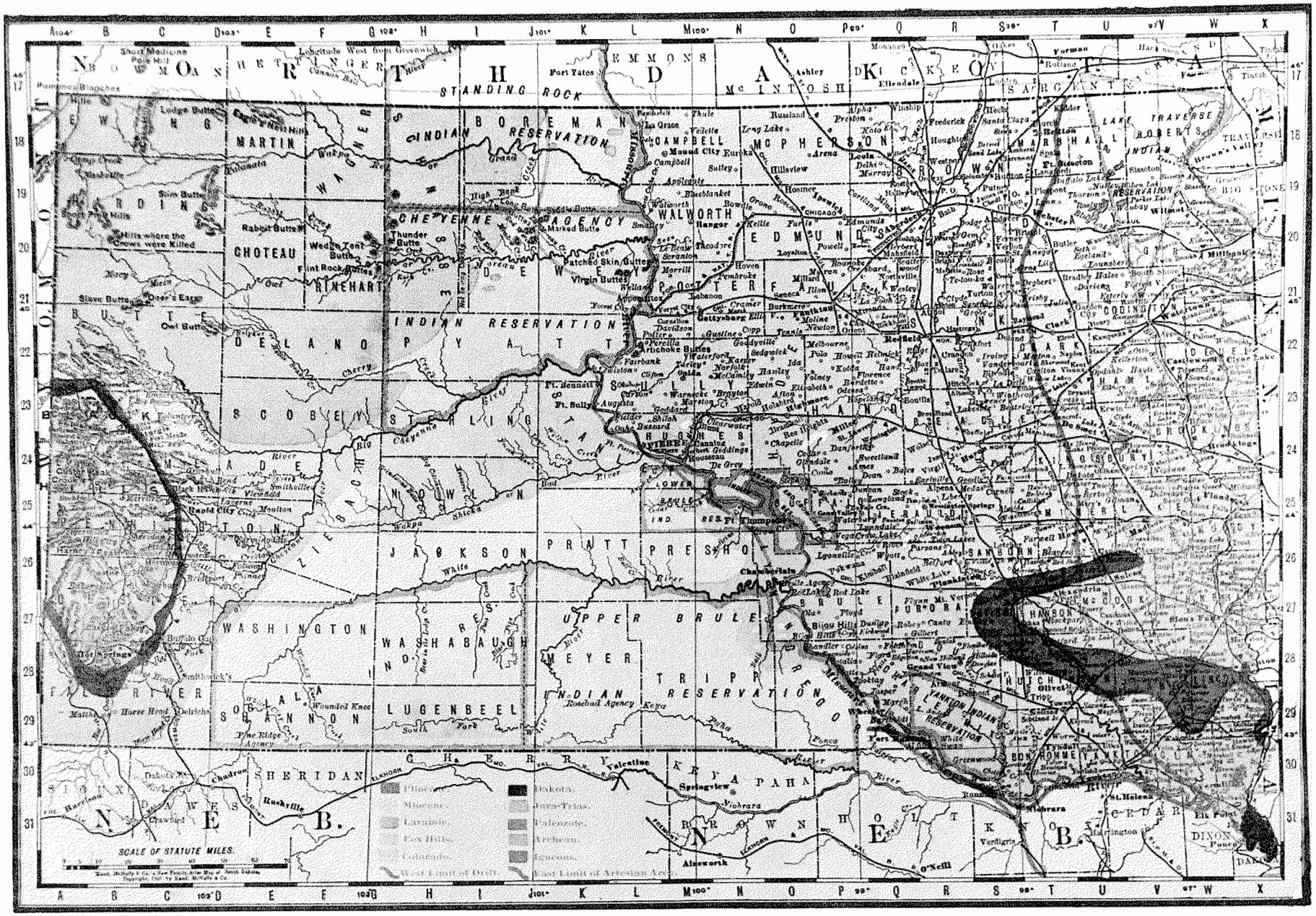


PLATE 3

This map appears as plate II in Todd's first biennial report published as Bulletin No. 2 of the South Dakota Geological Survey in 1898.

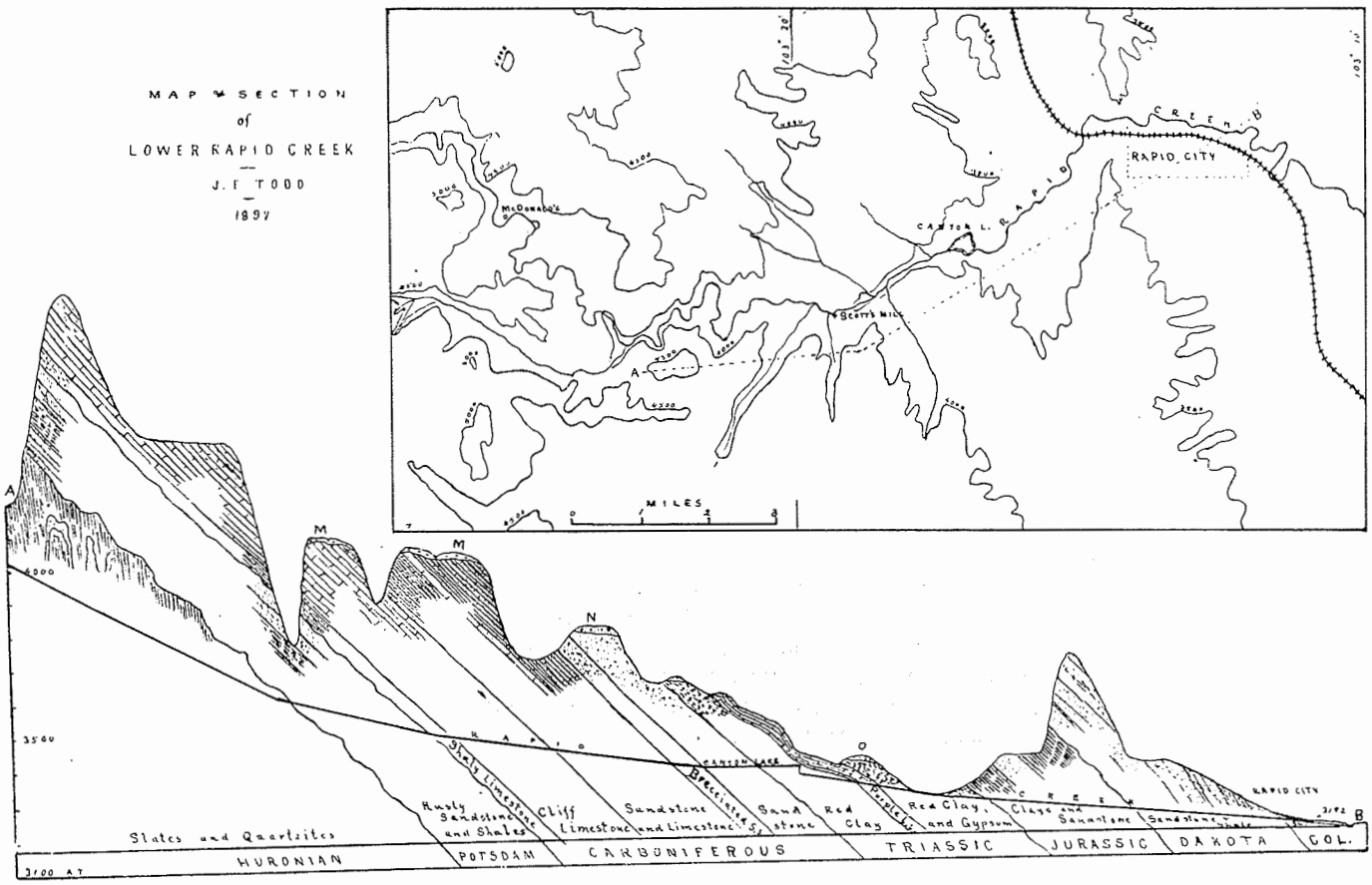

MAP & SECTION
of
LOWER RAPID CREEK
J. E. TODD
1897
RAPID CITY
CANYON LAKE
Scott's Mill
MILES
A
B
M
N
O
Slates and Quartzites
Rusty Sandstone and Shales
Shaly Limestone
Cliff Limestone
Sandstone and Limestone
Breccia
Sandstone
Red Clay
Red Clay, and Gypsum
Clays and Sandstone
Sandstone
Shale
HURONIAN
POTSDAM
CARBONIFEROUS
TRIASSIC
JURASSIC
DAKOTA
COL.

PLATE 4

Todd knew South Dakota was not blessed with abundant water statewide. He spent considerable time in collecting data on water which are now in the files of the Geological Survey. The letter and post card shown here are two of the methods Todd used to request this information.

UNIVERSITY OF SOUTH DAKOTA.
JAMES E. TODD,
PROFESSOR OF GEOLOGY AND MINERALOGY
AND STATE GEOLOGIST.

Vermillion, S. Dak., January 15, 1901.

Johnson Brothers,
Yankton, S.D.

Dear Sir:-

The State Survey is endeavoring to gather statistics concerning the artesian wells of the State. We are in possession of the data gathered by the U. S. Government in 1896. We shall be glad to have the data of all wells made by you since that time, so far as you can give them, according to the enclosed scheme. If location cannot be given to the quarter section, as called for, please give the name and address of the owner that we may ascertain it and perhaps get other facts from him. By boulder clay is meant the yellow or blue clay containing pebbles, which reaches from the surface to a bed of sand on the top of the shale or soapstone. We should be glad to receive the log of representative wells in addition to the data called for here. A few representative ones would be all that we need. We would be glad to know of any cases where you have reached the granite and would be glad to receive samples if you can give them.

An early reply will be much appreciated.

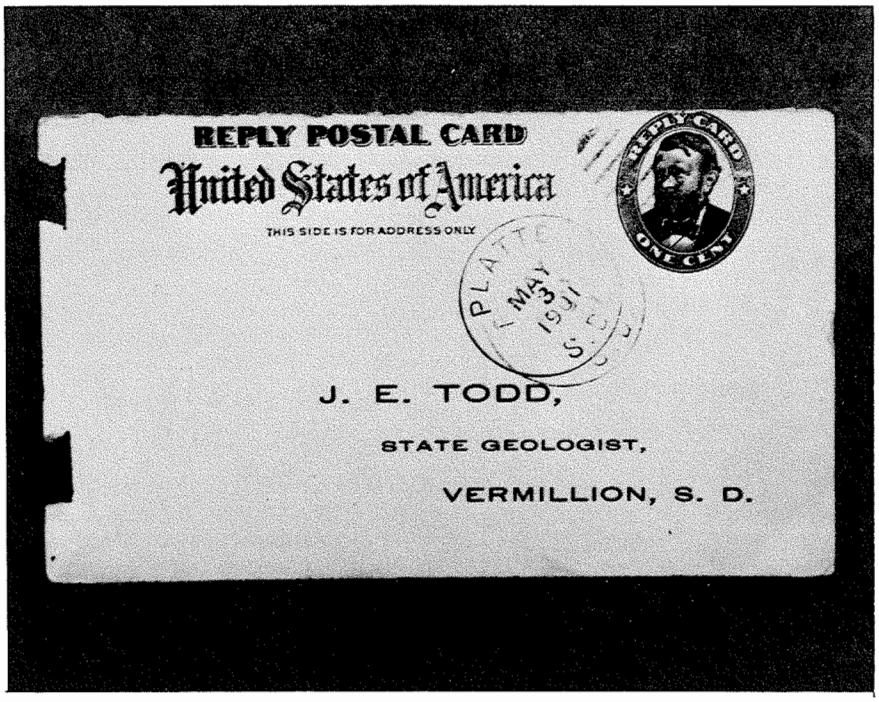
Yours very truly,

J. E. Todd

State Geologist.

P.S. Please give names and addresses of any parties who have put down their own well during the past few years, of whom you happen to know.

Yankton S.Dak. Jan 17/1901.
Mr J. E. Todd. Dear Sir: I have [illegible]
[illegible]



REPLY POSTAL CARD

United States of America

THIS SIDE IS FOR ADDRESS ONLY

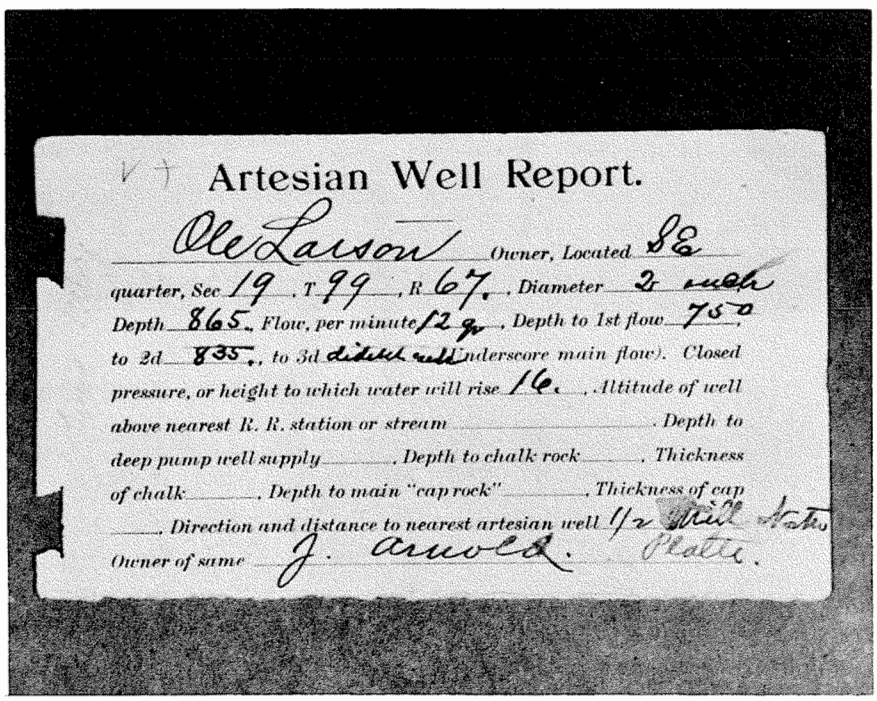
REPLY CARD ONE CENT

PLATTE 1 MAY 3 1911 S. D.

J. E. TODD,

STATE GEOLOGIST,

VERMILLION, S. D.



Artesian Well Report.

Ole Larson Owner, Located SE quarter, Sec 19, T 99, R 67, Diameter 2 inch Depth 865. Flow, per minute 12 gal, Depth to 1st flow 750, to 2d 835., to 3d dried up (underscore main flow). Closed pressure, or height to which water will rise 16., Altitude of well above nearest R. R. station or stream _____, Depth to deep pump well supply _____, Depth to chalk rock _____, Thickness of chalk _____, Depth to main "cap rock" _____, Thickness of cap _____, Direction and distance to nearest artesian well 1/2 mile North Owner of same J. Arnold. Platte.

CHAPTER II

BROADENED GOALS, 1903-14

While James E. Todd had been State Geologist, 1893-1903, he had emphasized the accumulation of generalized information concerning the geology and mineral resources of South Dakota, with a few attempts at more detailed and specific examinations. During the next eleven years, 1903-14, these facets of the Survey's responsibilities received much less attention. The new director, Ellwood C. Perisho, and his staff concentrated instead upon the study of botany, zoology, archaeology, paleontology, and geography, as these also had been itemized in the 1893 statute. In the face of low funds and increased duties at the University, Perisho, like his predecessor, found it necessary to select priorities. Therefore, his choices were based upon his own interests and judgements as to what would be most beneficial for the State.

Perisho's training and experience had oriented his interests toward science in general, especially its educational value. He had attended the Quaker college of Earlham in Indiana, from which he had received B.S., M.A., and LL.D. degrees, and the University of Chicago, from which he had received a M.S. in geology. Thereafter he taught at Guilford College in North Carolina and State Normal School in Platteville, Wisconsin, and worked with the United States Geological Survey in Wisconsin. While Perisho was at the University of South Dakota, he was well-known for his teaching abilities and was in great demand as a public speaker throughout South Dakota. His talks, many of them before teachers' summer institutes, concerned primarily the value and advancement of education.[1]

It was with this type of viewpoint that Perisho determined the purposes and goals of the Geological Survey. According to him, the Survey should accomplish two aims, economic and educational. The task of furthering economic development would entail the exploration of natural resources so as to discover the mineral deposits and to ascertain their quantity, quality, and geological and geographical environments. Although asserting the primacy of economic geology, Perisho strongly implied a preference for administering the Survey as a contribution towards its educational responsibilities. Thus, students, teachers, and the general public could know and appreciate their State and the work done by the Survey. In addition, Perisho desired that plant and animal specimens be well represented in the museum. His statement on the purpose of reports about the results of investigations aptly revealed his conception of the relationship between the economic and educational goals of the Survey. "... I should let the Report of the State Geologist include not only the discovery and general exploitation of the economic resources of the State, but let it be of such a character that ... the people, through their schools, will derive much that is of educational value."[2]

As will be seen, the major activities of the Survey, while Perisho was State Geologist, were designed to enrich the knowledge of science, particularly in relation to the collection of biological specimens and archaeological materials for the museum. This did not occur solely because of Perisho's belief in the educational value of a state geological survey. In part, lack of adequate time, funds, and personnel necessitated emphasis upon what was considered most feasible and most essential.

Actually Perisho consistently recommended a broad program of activities to include detailed studies of water resources, mineral fuels, and building materials. He wanted to supplement the little work done by Todd on artesian water, with special reference on determining means of conservation and usage regulations. Another need he specified was a chemical analysis of all water resources for sanitation, medicinal, and industrial purposes. A second feature of Todd's studies that Perisho advocated was an investigation of the deposits of lignite, the supply of natural gas, and the few reported finds of oil. In regards to building

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[1] Ward, "Historical Sketch," p. 74; "The University," *South Dakota Alumni Quarterly*, V, 2 (July 1909), p. 50.

[2] Ellwood C. Perisho, "What Should Appear in the Report of a State Geologist," *Economic Geology*, II, 4 (June 1907), pp. 436-38; Stephen S. Visher, who worked for the Survey, 1908-13, stated, in his letter of April 22, 1967, to the author, that "Perisho was an educator-publicist rather than a geologist."

materials, Perisho wished to determine the quantity and quality of the various types of clays that could be used for the manufacture of cement, brick, or pottery. He sought to acquire fossils especially from the Badlands and plant and animal specimens from the entire State for the museum. Attached to all of these recommended tasks was the perennial necessity for increased appropriations.[3]

When Perisho assumed his position on October 31, 1903, the Board of Regents devised a plan whereby it was hoped to facilitate the work of the Survey. The State was divided into two districts with the Missouri River as the line of demarcation. Therefore, two State Geologists were appointed–Perisho in charge of eastern district and C. C. O'Harra of the School of Mines in charge in the western district. Officially the Survey continued to operate under this arrangement for over four years; but available records reveal no further mention of the western section after 1904, except for its abrogation. During this period O'Harra accomplished very little for the Survey because of the lack of funds. The 1903 appropriation remained in the eastern district. Whatever amount of money O'Harra did receive in July 1904 was presumably used for an investigation of mineral resources in western South Dakota, a project he had previously begun in connection with his duties at the School of Mines. On at least two occasions he contacted Perisho by letter in regards to division of funds and coordination or proportionment of studies.[4] Whether such arrangements were ever attempted can not be ascertained. Even if they had been, the lack of an appropriation for the Survey during 1905-07 would have negated any cooperating or portioning efforts. Furthermore, Perisho disregarded the entire scheme by conducting his first field trip in an area west of the Missouri.

This experiment with two Survey districts was ended on April 15, 1907, when the Board of Regents rescinded its prior motion and redesignated the professor of geology at the State University as ex officio State Geologist for the entire State.[5] Evidently there had been little, if any, cooperation between the two State Geologists. In fact, Perisho in his reports never once mentioned O'Harra, his work, or the western district. In face of incomplete evidence, the experiment can perhaps best be viewed as an effort to prevent conflict between the School of Mines and the Geological Survey. Todd had recommended that these two institutions coordinate their geological studies; later State Geologists did likewise and achieved varying degrees of success.

As already mentioned, Perisho chose for his survey an area in western South Dakota. In the summer of 1904 a party of four or more traveled by team and wagon to the Rosebud Indian Reservation. Most of their studies were concentrated in what is now Gregory County, which was to be opened for settlement that fall, and in Tripp County. To be accomplished were three objectives: establish bench marks, collect and study the various types of plants and animals, and reconnoiter the geology of the area. In the resulting bulletin on these investigations Perisho described the geological formations, but at the same time he displayed his interest in geography by presenting equal detail about the climate (especially precipitation, topography, and water supply).[6]

The process of publishing his report and the others in Bulletin 4 became a long and frustrating ordeal. Perisho had almost completed his report by July 1, 1905, when a fire totally destroyed West Hall, the boys dormitory, where he was then residing and where he had also stored his field notes, maps, and illustrations. None of these materials were saved; so Perisho, in order to reconstruct his data, revisited the Rosebud area and used those pages

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[3] For examples, see "Biennial Report, 1902-04," pp. 64-65; "Biennial Report, 1904-06"; *Biennial Report of the Regents of Education, 1904-06,* pp. 73-75.

[4] "Report of the State Geologist, Western District" and "Minutes," October 31, 1903, *Biennial Report of the Regents of Education, 1902-04*, pp. 103-04, 229; O'Harra, letters, January 9 and December 7, 1904, to Perisho. This letter and others written to Ellwood C. Perisho are located with his papers in the library at the University of South Dakota. Hereafter, this correspondence cited as Perisho's papers.

[5] "Minutes," May 15, 1907, *Biennial Report of the Regents of Education, 1906-08*, p. 223.

[6] "Biennial Report, 1902-04," pp. 61-62; Ellwood C. Perisho, "Preliminary Report on the Geology of the Rosebud Reservation, 1908," *Report of State Geologist*, Bulletin 4 (1908), pp. 82-122.

of his first draft that had not been in West Hall. The second factor that delayed publication also began on July 1. The legislature had not appropriated any funds for the upcoming biennium. Perhaps this development had come as no surprise, because one senator had warned Perisho that the Republicans were committed to, and might succeed in, enacting a policy of cutting expenses. Despite this financial setback, Perisho kept the Survey in operation by rewriting his report and by supervising the study of the biological specimens collected from the Rosebud area.[7] When Bulletin 4 was finally printed in 1908, it had grown to include a large variety of articles, including Perisho's information about the geology and geography of the Rosebud area, two reports on the plants and animals of the area, an article on fossils from northeast Iowa, another one on drainage in South Dakota, and Todd's account of his geological studies in northwest central South Dakota in 1902.[8]

With an appropriation of $1,000, the same as for 1903-05, the investigations in the south central part of the State were resumed in the summer of 1907. Because other parts of this area were gradually being opened for settlement, Perisho wished to acquire geological and geographical information for the prospective inhabitants. In addition, the botanical studies and collections were continued. The scope of this field survey was expanded to include the acquisition of fossils from the Badlands. Todd, who was still residing in Vermillion and was employed to direct the seven-man trip, feared that unless the Survey obtained these fossils, many of the better specimens would be destroyed or damaged by the new settlers. Perisho was impressed with the results of this entire project, especially since the Survey acquired plant specimens and several vertebrate fossil pieces for the museum. The search for a complete skeleton of a large mammal had been unsuccessful, however.[9]

Until at least 1911, the Survey continued to augment the collections from the Badlands. In the summer of 1908 two homesteaders, Edmund H. Sweet and D. Dwight Evans, collected and observed plant and animal life and fossils, as did Stephen S. Visher, while on his first field trip for the Survey. During the 1908 field season, he was investigating geological formations along the creeks in western South Dakota. In 1911 Perisho and Visher supplemented further their materials from the Badlands and the Pine Ridge Indian Reservation.[10]

Although most certainly busy enough with his responsibilities as professor of geology, State Geologist, and participant in teachers' institutes, Perisho assumed another task when the Board of Regents, on May 20, 1909, appointed him Dean of the College of Arts and Sciences, a position he held until his resignation in 1914. In order to administer his multiple duties adequately Perisho employed Visher in September 1910 as an assistant in both the department of geology and the Survey.[11] Thereafter Visher actually performed the major share of activities for the Survey.[12] However, there was little change in the methods and types of operations, for he was much more interested in the fields of biology and geography than in geology itself, as evidenced by the kinds of investigations he pursued.

Prior to Visher's appointment Perisho had initiated a study of lignite deposits in Perkins and Harding Counties in the summers of 1909 and 1910. The geologist employed to carry

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[7]Perisho, "Preliminary Report on the Geology of the Rosebud Reservation, 1908," p. 85; "Biennial Report, 1904-06," pp. 72-73; J. E. Payne, Pierre, South Dakota, letter, January 26, 1905, to Perisho, Perisho's papers. Hereafter, the name of the state in an address will be omitted if the city is located in South Dakota.

[8]See Bulletin 4.

[9]*Biennial Report, 1906-08*, pp. 5-6; E. C. Perisho and S. S. Visher, *The Geography, Geology and Biology of South-Central South Dakota*, Bulletin 5 (1912), p. 5; Todd, letter, June 25, 1907, to Perisho, Perisho's papers.

[10]*Biennial Reports: 1906-08*, pp. 6-7; *1910-12*, p. 3.

[11]For a list of the personnel of the Geological Survey, see Appendix E.

[12]"Minutes," May 20, 1909, *Biennial Report of the Regents of Education, 1908-10*, p. 52; "Minutes," September 26, 1910, *Biennial Report of the Regents of Education, 1910-12*, p. 12; Visher, Bloomington, Indiana, letter, March 31, 1967, to the author.

out this project, Barthold A. Iverson, found several large deposits, most of which were useful only for local consumption. For some reason the planned report on this lignite study never appeared. Visher had been a member of the 1910 survey in Harding County and, as the biologist for the crew, had obtained for the museum over 400 varieties of plants and had observed the animal life, with special reference to birds, his hobby. However, lack of funds had prevented him from collecting any zoological specimens. He pursued these studies for two more summers (once by traveling on a motorcycle) in order to procure sufficient information for a comprehensive report on the biology of Harding County.[13]

As Visher traversed the State collecting plants and fossils, studying animal life, pursuing his hobby of bird-watching, and observing some rock formations, he examined the various geographical features. On one occasion he tried to map the countryside while riding a train to Rapid City. Its slow rate of speed, nineteen and one-half miles per hour, gave him the opportunity to achieve at least partial success. Through this and more orthodox reconnaissance methods (including detailed studies in the south central and northwestern parts of the State) and by examinations of available literature, Visher secured sufficient data on the geography of South Dakota for his doctoral dissertation at the University of Chicago, which was then printed as a Survey bulletin in 1918.[14] Though out of date, it remains a valuable study fifty years later.

Both Visher and Perisho, besides sharing a common interest in the geography and biology of South Dakota, sought to increase the museum collections. Perisho wanted these to serve a dual purpose, as materials for public exhibition and for instruction in the classroom. From the field trips described thus far, the Survey had already acquired a large number of fossils and plant specimens. In order to develop the collection of animal specimens, the Survey had to secure the services of someone trained in taxidermy. At first Sheridan Jones, an assistant in the biology department at the University, performed this task. Beginning in 1910, Harry E. Lee of Rapid City was employed periodically, whenever funds were available, to collect and mount animal skins. Perisho's ultimate aim for the museum was to have representative examples of all plants and animals in South Dakota.[15] Thus much greater emphasis was placed upon the biological collections than upon fossil materials or rocks and minerals.

As the number of specimens increased, the problem of display and storage became greater, particularly as conditions in Science Hall became more congested. By 1910 this three-story building with an unfinished basement housed the departments of physics, chemistry, geology, biology, the school of medicine, the State Food and Drug Commission, the State Health Laboratory, most of the engineering classrooms, the Geological survey, and the museum. In addition, the building was not fireproof and plaster was falling from the ceilings and walls.[16] Despite the construction of new buildings and numerous repairs for Science Hall during the next forty-five years, facilities generally remained inadequate for the Survey, as well as for the other departments.

Although Perisho as State Geologist was Curator of the museum, he felt that a qualified person should be hired to devote full-time to such work. For this reason William H. Over became a member of the Survey staff as assistant curator on January 1, 1913, in part through the efforts of Visher who, while in Harding County, had become acquainted with him. Over had not been trained for museum work but was well qualified because since childhood he had pursued the study of plant and animal life. This hobby became a major part of his lifetime occupation; he remained with the museum at the University until the early 1950's. The materials in the museum expanded very rapidly because the work was a labor of love for Over and he could give full time to the collection, classification, and

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[13] *Biennial Reports: 1908-10*, pp. 1-2; *1910-12*, p. 2; *1912-14*, p. 5.

[14] Visher, Rapid City, letter, August 2, 1908, to Perisho, Perisho's papers; Stephen S. Visher, *The Geography of South Dakota*, Bulletin 8 (1918), p. 3.

[15] *Biennial Reports:* "1902-04," pp. 60-61; *1910-12*, p. 2.

[16] "Report of the President," *Biennial Report of the Regents of Education, 1910-12*, pp. 80, 93.

arrangement of the various specimens.[17] In fact, he was the first full-time Survey employee who received no teaching duties as a part of his job.

Over first catalogued the collections, many of them still unpacked, that had accumulated through the years. After that he could more systematically augment the collections through his own field work and through donations. In addition to the biological materials, Over arranged a display of the fossils from the Badlands. Archaeological objects of the Arikaree Indians in South Dakota also became an important feature of the museum. Even before 1913 Over had begun a special study of these ancient Indian tribes and had excavated some of their mounds in Harding County. Lee had done some digging for the Survey in similar sites along the Missouri River in 1911.[18] These two collections of Arikaree artifacts marked the beginnings of later, more extensive archaeological studies and discoveries by Over.

Particular emphasis had been given to the museum as organized and expanded under Perisho because he himself stressed its development so strongly and consistently. He was attempting to build up a museum that would contain illustrative specimens representing archaeology, botany, zoology, and geology (including rocks, minerals, and fossils). Although acquisitions were made in all of these fields, the greatest advancement was realized, as already noted, in the plant and animal collections because of the types of trained personnel he could employ and because of his own special interests. Perisho viewed the museum, like many other aspects of the Survey's work, from the standpoint of its educational value for the people of the State.

There remains to be considered one other type of investigation directed by Perisho, that of artesian water. In all of his biennial reports he had pointed out the necessity for enactment and enforcement of conservation laws to regulate the usage and flow of water. He and a few others in the State felt that too much artesian water was being allowed to flow for little or no purpose. Surely one of the most bizarre examples was the reported instance of some people trying to change the climate by drilling wells to fill lake beds. In order to demonstrate concretely the need for conservation measures, someone had to investigate the artesian water supply and the conditions of the wells. Although N. H. Darton was still studying the artesian basin for the USGS, Perisho wanted the State Survey to conduct similar and more specific examinations. Iverson was employed for this purpose during the same years he was studying lignite deposits. In 1914 he was still working on the artesian water project and was scheduled to write a bulletin on his findings, which, like his report on lignite, was never issued.[19] Perhaps Perisho lacked the time or the chance to see that reports were completed or printed.

By the beginning of the 1913-14 school year Visher had left to finish his education, and Perisho had received an added administrative duty. Because no one was found to replace Benjamin F. Gault, who resigned in 1913 as President of the University, the Board of Regents directed that a commission of five Deans, including Perisho, take over the executive responsibilities. This situation existed for one-half year, until February 1914 during which time Perisho was seriously considered for the office of President. However, a split among the faculty prompted the Board of Regents to work out a compromise by electing Robert L. Slagle to the position and then selecting Perisho for Slagle's job, President of the State College of Agriculture at Brookings. Perisho assumed his position on August 1, 1914. Until the new director, Freeman Ward, took office in February of 1915, Over managed the affairs of the Survey.[20]

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[17]Ward, "Historical Sketch," p. 75; J. W. Johnson, "S. S. Visher," *South Dakota Bird Notes,* XVII, 4 (December 1961) p. 79.

[18]*Biennial Reports: 1910-12,* p. 2, *1912-14*, pp. 4-6.

[19]*Biennial Report, 1910-12,* p. 3; F. G. Butler, Mitchell, letter, April 20, 1914, to State Geological Survey, Microfilm 13; "Minutes," June 18, 1914, *Biennial Report of the Regents of Education, 1912-14*, p. 220.

[20]"University of South Dakota," *Biennial Report of the Regents of Education, 1912-14,* pp. 23, 25; Ward, "Historical Sketch," p. 76. In 1919 Perisho returned to Guilford College in North Carolina.

Sufficient attention has already been given to the manner by which Ellwood C. Perisho developed the facilities of the museum. That this was his major accomplishment for the Survey should be self-evident. Investigations to delineate the geology of the State in detail were infrequent, though explorations in the south central region were made. With numerous administrative and lecture duties outside the realm of his work as State Geologist, Perisho did not have the time to perform such studies on a regular basis. Most of the men he employed were trained in fields other than geology. Lack of adequate funds also limited the number of activities that could be completed. The combination of all these factors prevented fulfillment of the objectives that Perisho outlined in every biennial report. He had planned that the Survey should be economically beneficial for the public through comprehensive studies of building materials, mineral fuels, and water resources, particularly the means for conserving the artesian water supply. However, the substantial achievements in collecting archaeological, geological, and biological specimens for the museum demonstrated Perisho's primary concern with the educational contributions of a geological survey.

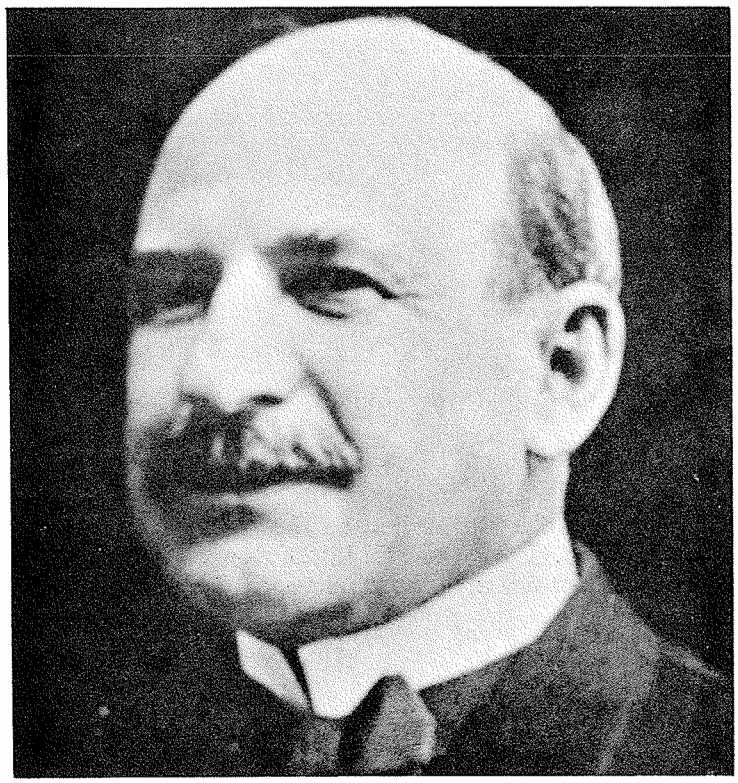


PLATE 5

Ellwood C. Perisho

State Geologist, 1903-1914

PLATE 6

A

Completion of a well drilled on the H. S. Daily farm near Ipswich, South Dakota. Initial flow of water was 90 gallons per minute. Photo taken in 1907.

B

View of canyon from the rim of Sheep Mountain Canyon. Picture taken by S. S. Visher, 1911.

A

B

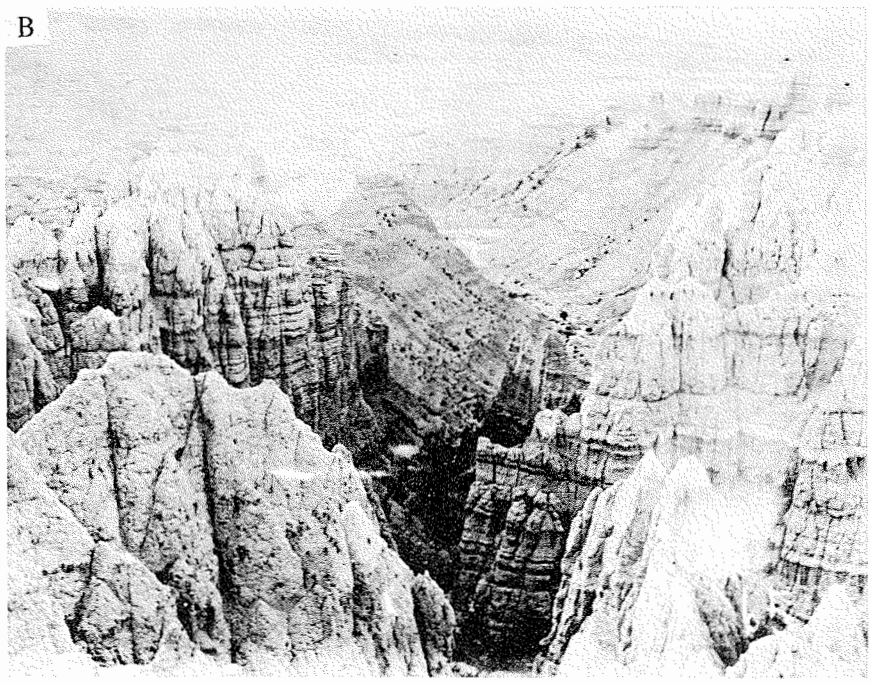


PLATE 7

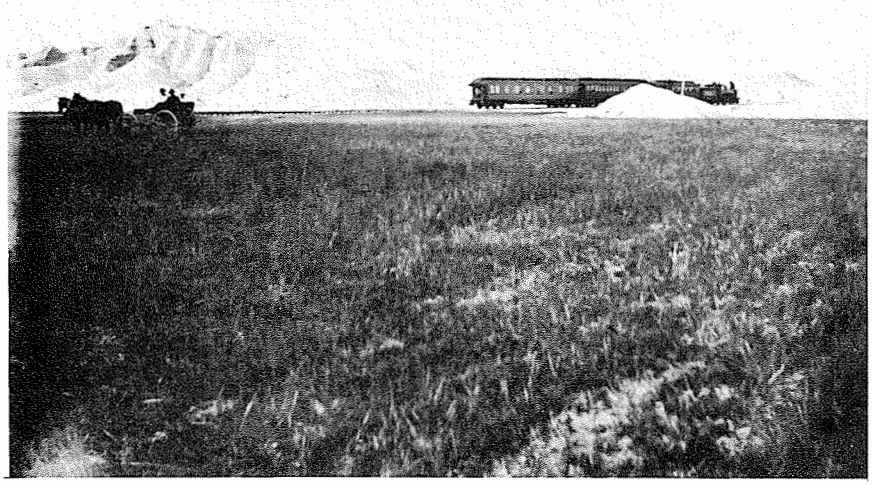
A

Picture of first train to the Black Hills on CMS&P new line through the Badlands near Interior, South Dakota. Picture taken in 1907.

B

The entrance to the Ludlow Cave in North Cave Hills, Harding County. Picture taken by S. S. Visher, 1912.

A



B

PLATE 8

A

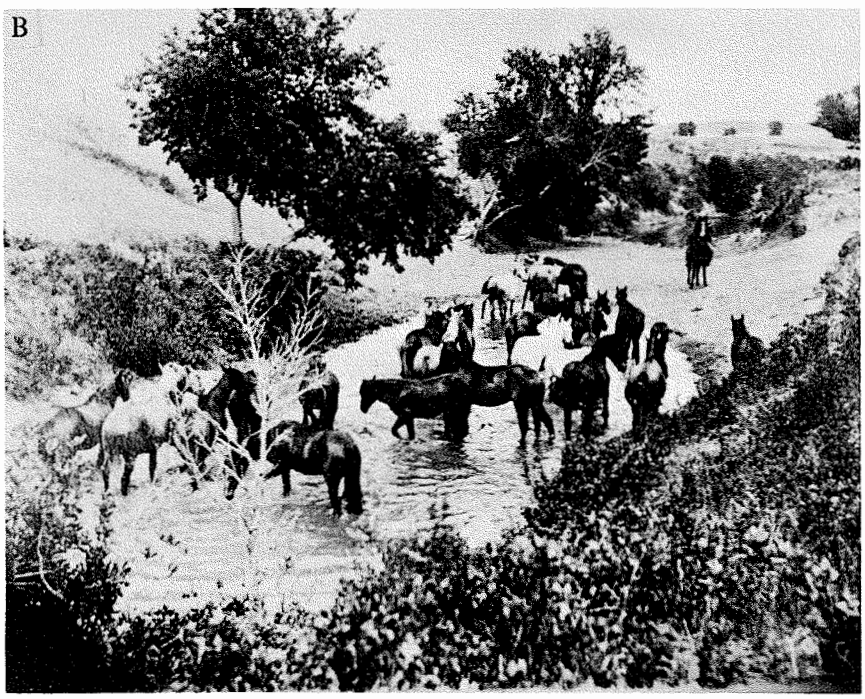
Crossing White River southeast of Kadoka at time of high water. Picture taken by S. S. Visher, 1911.

B

Range horses at water hole, Fall River County. Picture taken by S. S. Visher in 1911.

A

B



CHAPTER III

TEMPORARY EXPANSION, 1915-26

Freeman Ward, who took over the duties of the Geological Survey and the Department of Geology on February 1, 1915, was the only native South Dakotan to become State Geologist. He had been born and raised in Yankton where his father, Joseph Ward, had founded Yankton College. Ward had begun his college education at that school, 1898-1901, and completed it at Yale University from which he received a B.A. and Ph.D. and at which he taught geology, 1908-15. While at Yale he had worked with the Connecticut State Geological Survey, the United States Geological Survey, and the Federal Bureau of Soils.[1]

By the time Ward became State Geologist the Survey had been in existence for almost twenty-two years. In the first half of this period scientific geological studies had been emphasized and in the second half natural history. During the next eleven years, 1915-26, Ward, with more money and a staff of trained geologists, directed the Survey with attention to both of these facets. However, he changed the method of work from reconnaissance to more detailed investigations in regard to both the objectives and the geographic areas. Another significant change was the shift from geology in general to its specific application to natural resources, especially oil and gravel.

Before these expanded activities and increased facilities began to materialize effectively in 1921, Ward embarked upon a campaign to make the people of South Dakota aware of the benefits to be derived from the activities of an adequately organized, financed, equipped, and staffed Geological Survey. While traveling through the State in 1915, he had discovered widespread unawareness of the work done by the Survey and even of its existence. This situation definitely demonstrated the necessity for informing the public. Thus Ward compiled a report on the Survey and the economic and educational relationships between its activities and the State and its citizens. He stressed not what the Survey had done in the past but what it should do in the future. For Ward this meant a thorough examination of all natural resources in South Dakota as rapidly as possible. After first determining which resources were present in the State, the Survey would ascertain the distribution, quantity, quality, and accessibility of each. Ward felt that such information would not only increase the output of older industries but would also attract more capital and new enterprises from within and outside the State. The same information could, in addition, lead to the intelligent exploitation and conservation.[2]

After describing the benefits obtainable from data about natural resources, Ward outlined the Survey's developmental work in two phases—field and office. The main aspect of field work was, of course, geological surveying to facilitate the economically oriented investigations themselves. In these studies Ward included surveys of soil, biology, and climate.[3] In addition, he strongly urged the preparation of base, or topographic, maps as requisites for greater efficiency and accuracy in other field work. Although the geologist could construct his own map while in the field, too much time would be spent outside of the original purpose of the survey itself. The completion of any of these field studies was naturally followed by related office work which might include the study of specimens, laboratory analyses of samples, compilation of data, construction of maps, or dissemination of information. Ward emphasized the latter aspect because scientific investigations designed for utilitarian purposes must be available to those people requiring the data.[4]

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[1] Benjamin L. Miller, "Memorial to Freeman Ward," *Proceedings Volume of the Geological Society of America: Annual Report for 1943* (April 1944), pp. 243-44; *Catalogue, 1914-15,* p. 17.

[2] Freeman Ward, *The Scope, Methods and Plans of the State Survey*, Bulletin 7 (February 1916), pp. 5-6, 9-10.

[3] Although Ward was never able to conduct any formal studies of climate, he did maintain a weather observation station to record temperatures. E. P. Rothrock, after becoming State Geologist in 1926, relinquished this task because he could not keep daily records and could not find anyone else to do it. E. P. Rothrock, personal interview, May 4, 1967, with the author.

[4] Ward, Bulletin 7, pp. 10-15.

Ward evidenced a concern not only about the assembling of data but also the rapidity with which this information was distributed to the public. The Survey's past record revealed the publication of only six bulletins since 1893, and many of these only after lengthy delays because the necessary funds had been lacking. To increase both the speed and the number of publications, Ward initiated a new policy which included two types of reports, circulars and bulletins. The former were to be published frequently and the latter at longer intervals. The circulars were to be used for progress reports on long-range programs or accounts of individual phases of investigations that might yield applicable or interpretable results. The bulletins would be reserved for the more detailed and formal reports on completed projects.[5] Ward began this new policy in 1917 when he presented tentative summaries about oil possibilities in South Dakota in Circular 1.

In his bulletin on the Geological Survey, Ward had expressed a desire to investigate the origin and types of soils. In early 1916 he tried to arrange for such a study on a cooperative basis with State College. However, a conflict arose. The chairman of the department of agronomy contended that his office was the one legally organized to conduct soil surveys, because these related directly to agriculture. Ward, on the other hand, argued that certain facets were geologic in nature—origin of soils, topography, drainage, and climate— and that the 1893 statute had designated such investigations within the realm of geological surveys. Despite Ward's earnest efforts, no agreement could be reached. Consequently, the Board of Regents resolved the conflict of responsibilities in March by referring to the department of agronomy all problems or studies pertaining to soils, whether pursued through its own efforts or through cooperation with the Federal Bureau of Soils. However, because Ward was not immediately notified of this ruling, he proceeded with his own arrangements to work out a plan of cooperation between the Bureau of Soils and any county interested in soil studies. He had already contacted officials in Spink County before he learned in late April that the Survey no longer had this type of jurisdiction.[6]

This incident, besides demonstrating Ward's desire to execute his duties in a manner beneficial to an agricultural state, marked the first step in refining the multiple objectives given the Survey in 1893. The second step in this process was a legislative act in 1919.[7] The major change was that, instead of merely providing for various geological surveys, the legislature adopted the Board of Regents' resolution that the professor of geology at the University be designated ex officio State Geologist. The individual holding the office remained under the jurisdiction of the Board of Regents, but was to present the biennial reports directly to the governor. The duties were retained as before, except that they were specified in less detail. The State Geologist was to continue surveys in the fields of geology, natural history, archaeology, and anthropology, with special emphasis upon economic geology.

While Ward was State Geologist, he performed or arranged the studies involving geology and natural resources and left to William H. Over the directing of surveys concerning natural history and archaeology. From 1916 to 1924 Over made several field trips to collect plant and animal specimens and to investigate and unearth the ancient Arikaree village sites. The regions that he and his assistants covered included areas along the Missouri River and counties in the northwestern, northeastern, and southern parts of the State. Through these efforts and through loans, purchases, and donations of other materials, Over increased his earlier collections of biological specimens and of artifacts and skeletons of the Arikaree Indians. In fact, he became nationally recognized for his archaeological discoveries and studies in these fields.[8]

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[5] "Biennial Report, 1916-18," *Biennial Report of the Regents of Education, 1916-18*, pp. 37-38.

[6] A. N. Hume, Chairman, Department of Agronomy, letter, January 17, 1916, to Ward; Ward, letters, January 21, 1916, to Hume; March 20 and April 25, 1916, to E. W. Hall, Redfield, Microfilm 13; "Minutes," March 16, 1916, *Biennial Report of the Regents of Education, 1914-16*, p. 146.

[7] See Appendix B.

[8] *Biennial Reports: 1916-18*, pp. 33-35; *1918-20*, pp. 3-4; *1920-22*, pp. 4, 9; *1922-24*, pp. 4, 6; *1924-26*, p. 6.

Other matters concerning the museum pertained to the facilities and the staff. For several years Ward continued to point out the inadequate conditions of the museum. He lamented the danger to irreplaceable collections because Science Hall was not fireproof and pointed out that the small amount of available space necessitated the crowding of exhibits and the storing of other materials in boxes. Thus, he recommended the construction of a new building to house the museum. By 1920, when anticipating an increase in staff, he suggested a new building for the Geological Survey, museum, and the geology department. Part of his recommendation materialized in the summer of 1925 when the museum was moved into the basement of the newly-completed auditorium. It offered a fireproof place for exhibits, but no increase in space. The change in staff for the museum that occurred in 1925 was merely one of title. Ward promoted Over from assistant to chief curator, in which capacity he had already been functioning for several years.[9] Ward definitely maintained a lively interest in the activities of the museum, but he lacked the time to perform the work himself. He could, however, easily leave such duties to the able direction of Over and concentrate on the other functions of the Survey.

One desired objective was the accumulation of as much information as possible concerning the natural resources of South Dakota. Ward's first opportunity to do this was occasioned by the involvement of the United States in World War I in 1917. The Committee on War Minerals requested that each state assemble production statistics on minerals needed for the war effort. Ward attempted to fulfill this task through an agreement with C. C. O'Harra whereby each would be responsible for securing the data on certain minerals. According to Ward, O'Harra had second thoughts about the arrangements and decided to send his figures directly to Washington rather than through the Survey. However, by May 1918 he had failed to do so, much to Ward's embarrassment. Therefore, Ward tried to organize within the Survey a bureau to tabulate information furnished by mineral producers.[10] Apparently this effort never fully materialized, because the only references to the Survey's bureau for mineral statistics appeared in early May 1918, but not afterwards. In addition to the attempted accumulation of production statistics, Ward began a few studies related directly to war materials. He investigated oil possibilities in 1917 along the Missouri River from Pierre to Mobridge and in 1918 in northwestern South Dakota. Both studies resulted in largely negative conclusions, about which more will be said later. The 1918 field survey, reconnaissance in nature, was also undertaken to inspect coal deposits and clays, about which only very general estimates of amounts were obtained.[11] Another study related to war shortages concerned chalk. Ward acquired a large amount of this resource from near Yankton and studied its quality and possible uses. Although the end of the war removed the immediate need for this project, Ward published the results in hopes that his findings would stimulate further research.[12]

These attempts to secure information about war materials revealed little else but the immense lack of specific or even general knowledge about many of the State's natural resources. Ward must have experienced disappointment when realizing that the Survey could not even adequately assemble current production statistics, much less investigate the resources in a thorough manner. He emphatically placed the blame upon the legislature and the Board of Regents for their failure to provide sufficient funds with which to maintain a staff of trained personnel to render extensive and continuous service for the State. Even though the Survey did eventually receive more money for this purpose, Ward could not

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[9] *Biennial Reports*: "1916-18," p. 40; *1918-20*, p. 13; *1924-26*, pp. 4, 8, 18.

[10] George O. Smith, Director of USGS, Washington, D. C., letter, undated, to Ward; Ward, letter, May 3, 1918 to W. O. Hotchkiss, State Geologist, Madison, Wisconsin, Microfilm 13.

[11] One interesting sidelight of this survey, and others thereafter, was that Ward's wife, Daisy, and their young daughter, Sarah, accompanied him. Because camping was necessary on many field trips, Mrs. Ward usually did the cooking and other general work, all without pay.

[12] *Biennial Reports*: "1916-18," p. 33; *1918-20*, p. 3; Freeman Ward, *Chalk*, South Dakota Geological and Natural History Survey, Circular 6 (November 1919), p. 2. Hereafter all such reports cited as Circular, with the appropriate number.

accomplish the comprehensive inventory he desired. The nearest he came to this objective was in 1924 through a circular which provided current generalized data on some natural resources. This report was designed only to answer in part the numerous inquiries received by his office.[13]

The first long-range project executed by Ward involved the study of geological formations and the collection of fossils. He laid the groundwork for these tasks in 1916 by writing to a few of the larger museums in the United States and securing information on the number, value, and types of South Dakota fossils each possessed. He planned to use these statistics to demonstrate that the State was neglecting the preservation of its own abundant fossils, particularly from the Badlands. Ward saw no reason why South Dakota could not acquire the world's best collection of its own fossils. He felt that such a collection would be educational for students and the general public, and because scientists from other parts of the country would visit the museum, it could even serve as an advertisement for the State. Besides this appeal to pride, there was also suggested a possible financial benefit if duplicate specimens were sold. Ward concluded his arguments for a systematic effort to collect fossils from the Badlands by contending that the field work involved could yield valuable by-products, such as settlement of stratigraphic problems or development of natural resources.[14]

Because of the Survey's activities during the war, Ward was unable to commence investigation of the Badlands until the 1919 field season. Then with an annual appropriation of $2,500 and the services of Walter C. Toepelman, a paleontologist, the work began. Ward studied the geological formations and natural resources, especially oil possibilities around Interior, while Toepelman concentrated on the collection of fossils. The Survey entailed field work for three summers because of the working conditions. For the first two seasons all the work was done on foot. Then in 1921 two local residents furnished an automobile, thus making it possible to increase the area covered.[15] This practice of local people supplying cars, and sometimes food and lodging, for the Survey crews became a standard procedure during the 1920's.

When the bulletin on the survey of the Badlands was published in 1922, the most complete part dealt with the perceivable geological formations of the area. Because Toepelman had lacked sufficient time to study adequately the fossils he had collected, his report was comparatively brief. This bulletin also caused further hard feeling between Ward and O'Harra. Supposedly there had been a tacit understanding that for general subjects they would divide the State between them into eastern and western sections. During the war O'Harra's actions had displeased Ward; in 1922 it was the reverse, as Ward's report appeared shortly after O'Harra's more lengthy bulletin on the same subject, the geology of the Badlands.[16]

After this incident the two men avoided each other and Ward continued his efforts to secure fossils from the Badlands. Edward L. Toxell of Yale University was employed for this purpose in the summer of 1923, because Toepelman had left at the end of the school year. For the 1924 field season Bradford Willard was hired for the same task. His field assistant was Bruno C. Petsch, then a student at the University and later a staff member of the Survey for many years. Unfortunately, after these fossils were collected the Survey had no one on the staff to prepare them for preservation, study, and exhibition. Therefore, they remained

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[13] "Biennial Report, 1916-18," p. 39; The Departments of Geology of the University of South Dakota and the South Dakota School of Mines, *The Natural Resources of South Dakota,* Circular 16 (April 1924), p. 3.

[14] Freeman Ward, "South Dakota Fossils," *South Dakota Alumni Quarterly*, XIII, 4 (January 1918), pp. 97-99.

[15] *Biennial Reports: 1918-20*, pp. 3-4; *1920-22*, p. 4.

[16] Freeman Ward, *The Geology of a Portion of the Badlands*, Bulletin 11 (August 1922), pp. 7-73; J. P. Connolly, President, School of Mines, letter, March 16, 1937, to E. P. Rothrock, Microfilm 19; Rothrock, personal interview, February 27, 1967.

in storage until 1958 when the director of the musuem at the School of Mines agreed to take the collections in order to catalogue the specimens and prepare them for display.[17]

As previously mentioned, Ward was very much interested in the development of natural resources and the preliminary geological work that the Survey could do in this regard. While he was State Geologist, the one resource that received the most attention was petroleum. This emphasis emerged because South Dakotans, becoming excited about the chances of striking oil and instant wealth, wanted such studies undertaken. Therefore, it became necessary to provide the pertinent geological information and to introduce reliability and common sense into the intense interest. Beginning in 1916, Ward received several letters asking that he investigate certain areas for oil possibilities, supply the prospectors with available facts, or tell them where to drill. Ward shrewdly took advantage of this public agitation for information and advised those making the inquiries that they could facilitate oil studies by influencing the legislature to increase funds for the Survey.[18]

In 1916 some individuals who were assuming the probability of petroleum in the region around Pierre, because of the natural gas found there, took heed of Ward's suggestion. Wanting a geological and topographic study of central South Dakota, they circulated a petition asking the 1917 legislature to appropriate increased funds for the Survey. However, some of the people, who were too impatient to wait, organized an oil company and hired James E. Todd to survey the area around Pierre for possible drilling sites. Todd, however, found no favorable structures.[19]

As South Dakotans became increasingly interested in oil, Ward realized that systematic studies had to be made in order to secure reliable data. Much of the evidence cited by those wanting to drill was based upon someone's hunch or upon circumstantial indications, such as scum on a pond or stream or the mere presence of strata that contained petroleum in neighboring states. To counteract these undependable, yet popular, beliefs, the Survey undertook a number of geologic studies concerning oil possibilities from 1917 to 1926. As a result of the first three surveys, Ward had found a few structures that might yield oil in Harding and Pennington Counties. However, he cautiously placed special emphasis upon the limited possibility, not the likelihood.[20] Neither he nor anyone else could say much with certainty. One of the largest obstacles to these oil studies was the lack of subsurface information, especially for western South Dakota where almost all the investigations took place and where very few deep artesian wells existed. Thus, the geologists had to rely upon whatever outcrops they found, thereby necessitating work at a slow pace and the derivation of cautionary, but at least, scientific conclusions.

Words of caution were often ill-received; even more so were negative statements. During the oil survey along the Missouri River in 1917, Ward heard that oil had been found in wells being drilled near Mahto and McIntosh in Corson County. Several business men furnished funds that enabled Ward to investigate these localities for about one week. In October he released a report showing that in neither place had he discovered favorable structures for the accumulation of oil. The only indication of petroleum was that found in the wells. Ward doubted the validity of this evidence as he suspected instances of "salting"' Because of these facts he strongly advised the cessation of further drilling for oil. He saw only one justification for continuing. If the investors were willing to forego a financial profit, they could put down an exploratory well and keep a careful log of it. Such stratigraphic data would thus help eliminate much of the uncertainty about oil in that part of the State.[21]

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[17] *Biennial Reports*: 1922-24, p. 6, *1924-26*, p. 6; Allen F. Agnew, State Geologist, letters, June 6 and October 2, 1958, to J. D. Bump, in Files.

[18] For examples of such requests and replies, see C. L. Millett, President, Stock Growers Bank, Fort Pierre, letter, May 17, 1916, to Ward; Ward, letter, March 1916, to F. A. Robbins, Isabel, Microfilm 13.

[19] Millett, letters, April 12, May 17, and June 15, 1916, to Ward, Microfilm 13; Freeman Ward, *Oil in South Dakota*, Circular 1 (December 1917), p. 4.

[20] Freeman Ward, *The Possibilities of Oil and Gas in Harding County*, Circular 4 (October 1918), p. 8; Freeman Ward, *The Possibilities of Oil in Eastern Pennington County,* Circular 8 (October 1921), p. 11.

[21] "Biennial Report, 1916-18," p. 33; Freeman Ward, "Report on the Oil Situation near McIntosh and Mahto, S. Dak." (unpublished report, October 25, 1917), pp. 1-2, Microfilm 13.

The statements in Ward's report displeased the promoters of oil wells. They accused Ward of drawing conclusions from insufficient evidence because he had spent only a few days in the area. Because the oil company had hired two geologists to investigate the region and had used their findings to locate sites for drilling and to solicit funds, Ward tried to secure their reports which supposedly contradicted his conclusions. However, the oil company would not release the information, nor would the two geologists without the consent of their clients. So, in face of no concrete reason to warrant a change in his position, Ward retained his original stand, if on no other basis than to temper some of the excitement about discovering oil.[22] Ward, of course, did not oppose the public interest in petroleum; he merely sought to have the probabilities and problems approached with common sense and scientific soundness.

In the long run the Survey benefited from the popular desire to find oil, despite the many troubles that accompanied the search. Because of the public demand that State Geological Survey study the structures within South Dakota, the 1921 legislature appropriated $15,000 for 1921-22, which was six times the previous amount. This sum enabled Ward to hire an oil geologist, Roy A. Wilson, whose teaching schedule was arranged to enable his work in the field for several weeks in the spring and fall, besides the regular summer season. Eventually the Survey also found it possible to purchase several instruments, such as plane tables and stadia rods, and enough camping gear to equip five crews. Ward was even able to hire a full-time secretary for the first time in 1925. However, this advantage continued for only eight months until the young lady married. Then until 1932 the Survey resumed the previous policy of part-time secretaries, usually students.[23]

Despite the work done by Freeman Ward and private concerns, very little definite information had been gathered about the likely geographic or geologic areas for finding oil. The impreciseness stemmed from a lack of detailed knowledge about the structural characteristics and the subsurface features. So in 1921 Wilson undertook a reconnaissance examination of western South Dakota, where known geologic features indicated the more promising regions for oil and gas. When he later wrote his report, half of it was devoted to educational explanations of geology as applied to the various phases of oil field development. He discussed the origin and accumulation of petroleum, the geological features associated with oil and gas, and the methods of work used by the geologist. He also described some of the practical problems and aspects of drilling operations, such as leasing of land, organizing of companies, and recording of accurate well logs.[24]

In the second half of the report Wilson considered the petroleum possibilities in connection with geological formations and structural features. Although specifying certain regions that warranted further study, his general conclusions were very discouraging. Wilson saw little chance of commercial production of petroleum in South Dakota, except, remotely, in the northwestern and southwestern sections, where oil fields were later developed. Not to be overlooked, however, was the important qualification to this summation. Because it was based largely on evidence from outcrops, Wilson realized that the unknown factors could reveal data contrary to his general comments. Therefore, he advocated further detailed studies and then exploratory drilling on recommended structures.[25]

The usual policy when the Survey was asked to make an investigation was for the community to provide the crew's transportation and living expenses. In return it received a preliminary report in advance of publication. This cooperative arrangement was first used

[22] J. W. Harris, President, First National Bank, Mobridge, letter, October 30, 1917, to Ward; Ward, letters, November 7, 1917, and March 1, 1918, to Harris; December 13, 1917, to Roswell H. Johnson and L. G. Huntley, Geologists, Pittsburg, Pennsylvania; Johnson, letter, December 27, 1917, to Ward, Microfilm 13.

[23] Biennial Reports: 1920-22, pp. 3, 5; *1922-24*, p. 9; *1924-26*, p. 4.

[24] Roy A. Wilson, *The Possibilities of Oil in South Dakota: A Preliminary Discussion*, Bulletin 10 (March 1922), pp. 8-44.

[25] *Ibid.*, pp. 51-89.

for oil studies in Dewey and Ziebach Counties through the efforts of Isabel residents. In his bulletin on oil in South Dakota, Wilson had designated these areas as worthy of further examination. He began the surveys in May 1922 and continued them into the fall, with Ward and his wife joining him during the summer. They located a few structures, or domes, that offered promising sites for drilling, on one of which the Irish Creek Oil Company, organized by Isabel residents in 1923, put down a test well. During the next spring, after reaching a depth of 1,550 feet, the tools were lost in the well and the hole was abandoned. However, the core from the test well, donated by the oil company, proved to be useful, as it provided vital facts about the subsurface formations in that area.[26]

Although other detailed petroleum surveys did not necessarily result in the drilling of test wells, they were important from the standpoint of acquiring geologic information about the stratigraphy in western South Dakota. The Survey had secured enough such data, supplemented by special field work and by some USGS publications, so that by 1925 Ward could justifiably draw a new, although still incomplete, structural map for the western half of the State. Of interest to the geologist was his use of the Pierre formation as the index horizon, replacing the Dakota formation on Darton's map of 1908. Ward considered his map more accurate, because the Pierre formation was more easily discernable and more widespread in the outcrops in western South Dakota. From 1925 to 1926 William L. Russell, who was relieved of teaching duties, augmented this information by attempting to divide the seemingly uniform Pierre formation into different horizons; but when he wrote his report there were no funds available to publish it.[27] It remained in manuscript because of more thorough studies on the same problem in the 1930's.

Another significant consequence, besides the increase in stratigraphic information, that resulted from the petroleum studies was a gradual change in attitude about oil possibilities. Both Ward and Wilson had at first revealed pessimism. But by 1925 both had changed to a more optimistic viewpoint. Ward became more explicit in his expectations that commercial oil production would develop somewhere in western South Dakota. However, this optimism reflected only a switch in attitude, nothing more. The problems and the speculation still existed. Only continued surveys and test drilling would reveal the essential facts about the types of subsurface formations or the possible presence of oil.[28]

Throughout the years of oil searching in the State, the Survey was concerned about how test wells were promoted and drilled. The State Securities Commission controlled the licensing of oil companies to sell stock. The Commission, basing part of the authorization upon a favorable report from a reputable geologist, asked the Survey for aid. Ward agreed to ascertain the records of geologists, to help judge their reports, and to supply information about the structures upon which an oil company planned to drill.[29] In this manner it was possible for the Survey and the Securities Commission to try to lessen the number of fraudulent deals that were being instigated at that time. Another means to moderate the oil excitement, part of the background for these dishonest schemes, was through answers to various inquiries. Time and again Ward warned prospective investors that any well then drilled in the State was a gambling proposition and that the chances against striking oil were very high. In addition, he always advised oil companies and promoters to employ reliable geologists and to use their reports legitimately so as to avoid misleading the investors. If all this was understood and followed, Ward did not discourage the drilling of an oil well. In

[26] *Biennial Reports: 1920-22*, p. 5; *1922-24*, p. 4; William L. Russell, *Well Log in Northern Ziebach County*, Circular 19 (September 1925), p. 3.

[27] Freeman Ward, *The Structure of Western South Dakota* Circular 25 (October 1925), pp. 3, 6-7; *Biennial Reports: 1924-26*, p. 7; *1926-28*, p. 3.

[28] Freeman Ward, *Structures in Northern Haakon County*, Circular 22 (March 1925), p. 13; Roy A. Wilson, *Oil and Gas Possibilities in Northeastern Meade County*, Circular 23 (April 1925), pp. 11-14.

[29] W. A. Nevin, Secretary, State Securities Commission, Pierre, Letter, March 30, 1921, to Ward, in Files; *Biennial Report, 1922-24*, p. 2. In 1925 the legislature enacted a law that gave the State Geologist authority to prescribe and enforce regulations for the drilling and plugging of oil and gas wells. Because this law became a more vital subject of concern after 1926, it will be considered in Chapter IV.

fact, he sometimes offered encouragement. But he recommended the keeping of an accurate well log so that both the oil company and the Survey could use it for clarifications about the geology of a region or for further studies of stratigraphy and oil possibilities.[30]

Ward was obviously very much concerned about the vital necessity of acquiring subsurface data for the western part of the State. But the only method then was by deep drilling and the recording of a well log. Therefore, in 1924 he devised a plan whereby this could be done under professional supervision. He proposed that the legislature appropriate funds for one or two test wells, the sites to be selected by the Survey. At the same time a group of promoters was trying to acquire state funds to finish drilling the Standing Butte Well, which was located about twenty-five miles northwest of Pierre and had been started in 1921. Ward opposed this scheme because he considered that site to be one of the least promising. However, the 1925 legislature decided to appropriate $25,000 for completing the Standing Butte and to give the money directly to the oil company. When the attempt was made to drill deeper, much of the casing fell into a cavity at the bottom of the hole and could not be recovered. Because the funds had been designated for only that one well, the entire amount reverted to the general treasury. For many years afterwards the Standing Butte Well remained significant as people continued to speculate and believe that oil was present in that area. In addition, as the first truly deep oil test in the State, its log, although incomplete, provided much of the very limited information about subsurface features in western South Dakota, until other deep wells were drilled after the depression.[31]

Although the Survey during the last five years of Freeman Ward's term of office did, in face of public interest and demand, concentrate upon geologic studies for oil possibilities, there were other projects undertaken as well. As soon as Ward knew about the large increase in funds in 1921, he began to arrange for the making of topographic maps. The USGS was planning to make these maps for the entire United States on a cooperative basis whereby each state would furnish one-half of the expenses and the USGS the other half. Therefore, Ward provided $1,000 for mapping a small area around Pierre. Later this topographic mapping project ceased in South Dakota because the Survey could not afford its share of expenses, due to a $5,000 cut in the 1923-24 appropriation.[32]

Another project begun by the Survey in the 1920's was a study of sand and gravel deposits. Ward placed this task under the direction of Edgar P. Rothrock, who became State Geologist in 1926. Rothrock had received a B.A. and M.A. from Oberlin College and a Ph.D. from the University of Chicago. Between 1914 and 1922 his work in geology had consisted of teaching at the University of Oklahoma and employment with the USGS, with state geological surveys in Wisconsin, Illinois, and Oklahoma, and with several oil companies. In 1922 he became an assistant professor of geology at the University of South Dakota and in 1923 began work for the Survey.[33]

During four field seasons, 1923-26, Rothrock examined various parts of the State in an effort to locate sand and gravel deposits needed for the rapidly expanding road building program. This task, of course, involved a study of Pleistocene geology about which for South Dakota only general facts were known. Like Wilson, when he undertook the petroleum surveys, Rothrock began with a reconnaissance investigation of eastern South Dakota in order to determine areas for further study. Also like Wilson's bulletin on oil

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[30]For examples of these warnings and counsels, see Ward, letters, October 18, 1917, to F. A. Northrup, Interior; May 21, 1920, to W. H. Pine, Manager, Pine Land Agency, Faith, Microfilm 13; April 10, 1924, to John F. Schoof, Well Driller, Gettysburg, Microfilm 14.

[31]Ward, letters, December 8 and 17, 1924, to F. G. King, no address, Microfilm 14; E. P. Rothrock, "Drilling Operations in South Dakota to July 1, 1945" (unpublished report, undated), p. 11, in Files. Hereafter cited as "Drilling Operations."

[32]*Biennial Reports: 1918-20*, p. 13, *1920-22*, p. 5; *1922-24*, p. 4; Ward, letter, May 17, 1921, to George O. Smith, Microfilm 14.

[33]George E. Condra, "Dr. Edgar P. Rothrock: State Geologist of South Dakota," *Journal of the Association of American State Geologists*, XVII, 4 (October 15, 1946), p. 1; "The University," *South Dakota Alumni Quarterly*, XVIII, 3 (October 1922), p. 100.

possibilities, Rothrock's circular on gravel deposits of eastern South Dakota contained geological explanations for the general public, such as the origin and forms of sand and gravel deposits. In 1924 he conducted his first detailed study in Yankton County by locating various types of deposits and estimating the amounts of gravel in each one. For the next two summers, in Minnehaha, Potter, and Faulk Counties, he was assisted by R. V. Newcomb from the University's department of engineering. This greatly facilitated the surveys because Rothrock could concentrate on the mapping of geological features and the locating of sand and gravel deposits. Then Newcomb would collect and analyze the samples. The 1926 investigation was further aided by the State Highway Commission which agreed to furnish cars and drivers.[34] In future years this type of cooperation was continued.

Although only oil and gravel were studied extensively after 1921, there were attempts to give attention to other resources. Like Todd and Perisho, Ward concerned himself with the conservation of artesian water. For instance, he wanted to employ an expert who could study the geological features of the problem. Ward also tried to convince the legislature to enact conservation laws and to provide for their enforcement.[35] These suggestions came to nought while Ward was State Geologist. The one water conservation law that was enacted provided for inadequate enforcement. However, Ward's ideas did show his realization of the problems and of the ways to meet them; it was only within the next thirty years that his proposals were gradually effectuated, after the situation had become much worse than in the 1920's.

After completing the projects for the 1926 field season, Freeman Ward terminated his position on September 1 and went to Lafayette College in Easton, Pennsylvania, where he became chairman of the geology department.[36] Rothrock was named State Geologist, in which capacity he served for the next thirty-one years. In many respects, the years from 1915 to 1926 were distinguished by both beginnings and ends for the Geological Survey. That some features of the Survey disappeared after 1926 resulted less from actions taken by Ward than from those by his successors. For reasons that will be explained, the museum was disassociated from the Survey and along with it studies in archaeology and natural history. Another activity never again stressed in the same manner as before was a survey of the Badlands, whose uniqueness attracted early geologists. Each of the first three State Geologists had viewed as essential and exciting the collection of fossils from this area. But such fascination faded as economic geology received more emphasis.

The most significant and most obvious change was the switch from reconnaissance to detailed surveys. For the first time a State Geologist minimized the geological objectives and geographical areas for projects so that the results were more immediately useful. Of course, Ward was building upon the foundations provided by his predecessors, Todd (particularly in the field of geology) and Perisho (particularly in natural history). The Survey, while directed by Ward, accumulated a stockpile of specific information about the geology and natural resources of the State, thus providing a broader base for future studies, especially with regards to petroleum and stratigraphy. Besides the expansion in achievements, the Survey grew in other aspects, such as appropriations and staff. There also seemed to be a greater interaction, whether in the nature of cooperation or opposition, between the Survey and the public and other institutions. In one way this was revealed in the exchange of letters, which could be excluded as evidence of increased interconnections because such records were not previously well preserved. However, the state agencies, communities, and individuals that aided the Survey or sought its services demonstrated relationships not apparent in the earlier activities.

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[34] *Biennial Reports: 1922-24*, p. 5; *1924-26*, pp. 6-7; *1926-28*, p. 3; E. P. Rothrock, *Sand and Gravel Deposits in Eastern South Dakota*, Circular 15 (February 1924), pp. 5-9.

[35] Ward, letter, January 28, 1924, to George Norbeck, Vice President and Manager, Norbeck & Nicholson Company, Redfield, in Files.

[36] Miller, "Memorial to Freeman Ward," p. 244; *Biennial Report, 1926-28*, p. 3. Ward retained this office until his death in 1943.

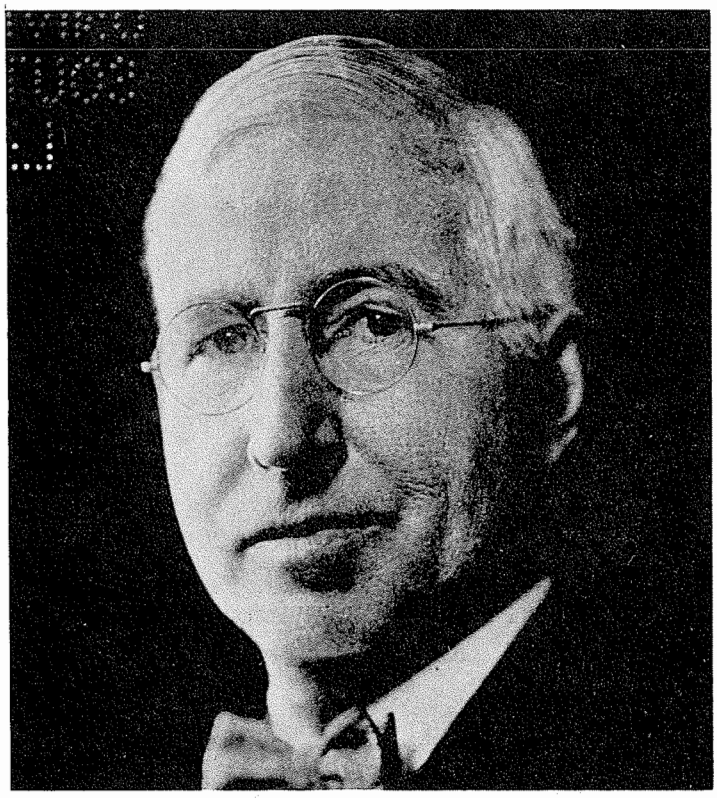


PLATE 9

Freeman Ward

State Geologist, 1915-1926

PLATE 10

A

A pit excavated for sand and gravel near Yankton, South Dakota. Photo by E. P. Rothrock, 1924.

B

Cedar Pass road in the Badlands of South Dakota. Photo taken in 1924 by E. P. Rothrock.

A

B

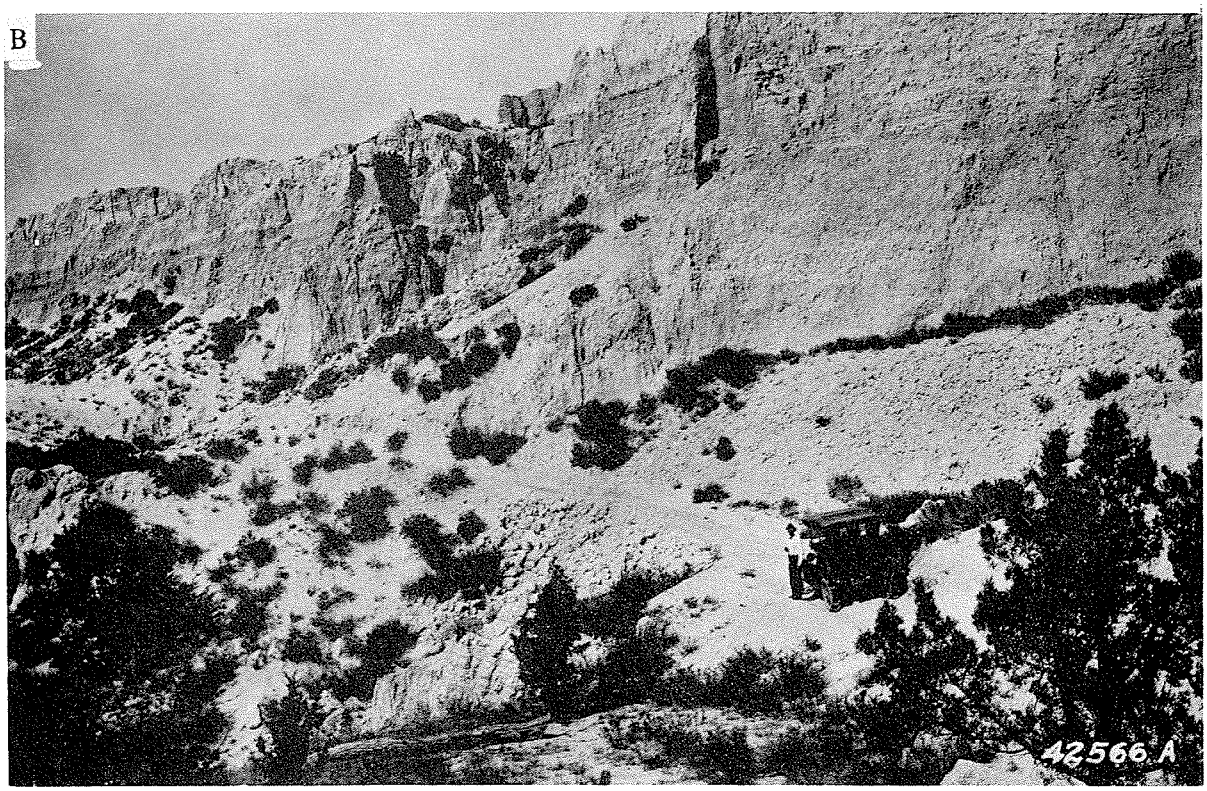


PLATE 11

A

James J. (left) and Edward L. Troxel at field camp on Everett's Ranch, Interior, South Dakota. Photo taken in 1923.

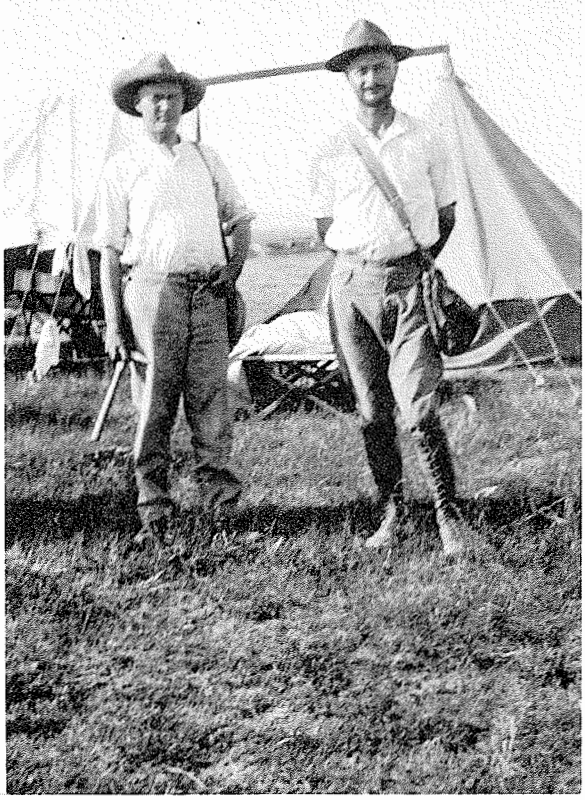
B

Dr. E. P. Rothrock standing by State-line boundary marker located in southeastern Minnehaha County. Marker is common to the states of South Dakota, Minnesota, and Iowa.

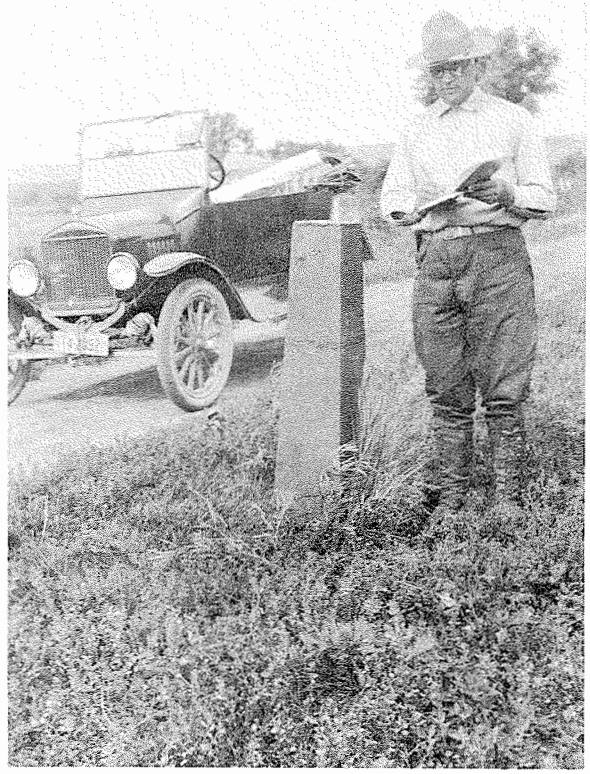
C

The Hoye sand and gravel pit near Sioux Falls, South Dakota. Photo by E. P. Rothrock, 1926.

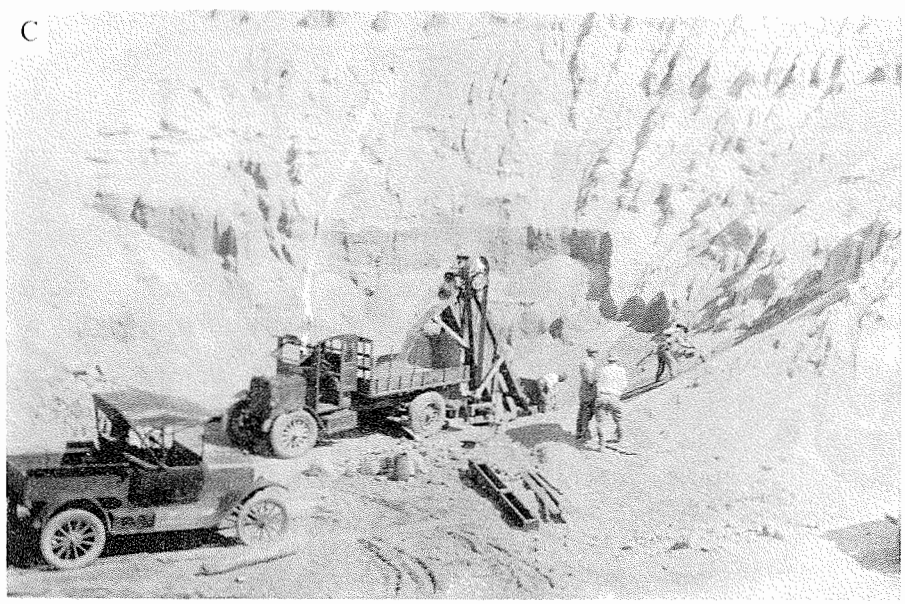
A



B



C



CHAPTER IV

RETRENCHMENT, 1926-39

E. P. Rothrock had been associated with the Survey for three years before assuming the position of State Geologist in 1926. Therefore he realized the capacities and shortcomings with which he was confronted. Data, techniques, and contacts had been accumulating during thirty-three years of Survey labors. But adequate funds and personnel would be needed to build properly on this foundation. The highest appropriation accorded the Survey had been $15,000 a year for 1921 and 1922, thereafter cut to $10,000. As for personnel, it had temporarily reached the largest number in the summer and fall of 1925 with the employment of five geologists. However, during the school year the State Geologist had to teach a full load. Thus, in the fall of 1926 Rothrock taught the departmental classes, with the assistance of only one instructor, leaving him little time for other duties.

Only one man, William H. Over, worked full-time for the Survey. However, soon after taking office Rothrock arranged for the transfer of the museum from the Survey to the University, with Over remaining the curator. The new director reasoned that the Survey should concentrate on the search for natural resources and the study of geology rather than spread its efforts into the fields of natural history and archaeology.[1]

Despite this organizational change, Rothrock found it difficult to fulfill his more urgent tasks. The major setback stemmed from the loss of the 1927-29 appropriation. The governor, William J. Bulow, vetoed the original general bill which had called for higher expenditures than the expected income for the State Treasury. At a special session that summer the legislature passed a lower general appropriation bill, more in accordance with the governor's plan to maintain a balanced budget, as the early effects of a depressed economy in South Dakota were becoming evident. However, funds for the Geological Survey were excluded entirely from the second bill.[2] Although the Survey had been denied an appropriation in 1905, the circumstances were now considerably different. Upon regaining funds in 1907, the Survey had seemed only slightly effected because its activities were few in number and were usually completed over a long period of time. In 1927, however, the loss of funds occurred after a period in which the Survey had been operating at a higher level of organization and had been conducting more major projects simultaneously. Moreover, the rapid deepening of the depression meant subsequent annual appropriations of only $5,000 from 1929 to 1937.

Dr. Rothrock's response to these difficulties was one of energetic and systematic determination flavored by his own forthright personality. He identified himself so closely with the institution he headed and its geological and economic contributions that he described his work with the Survey as a "sort of religion with me."[3] His record of achievements through thirty-one years as State Geologist gives credence to this comment. That same record also revealed his conception of the Survey as a utilitarian organization that should effectively serve the State and its citizens. In other words, "the purpose of the Geological Survey should be the collection, interpretation, and application of geological information of use in making South Dakota a more livable and prosperous state."[4]

Rothrock perceived this objective not only as the reason for the existence of a Survey but also as its prerogative. Consequently, he persistently guarded against any organization performing what he deemed the Survey's responsibility. His relationship with the United States Geological Survey, for example, was based upon this consideration. He always

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[1] Rothrock, personal interview, May 4, 1967. It was not until 1932 that Rothrock in letters and publications ceased using the words Natural History and confined the Survey's title to State Geological Survey.

[2] *Biennial Report, 1926-28*, p. 3; Herbert S. Schell, *History of South Dakota* (Lincoln, 1961), pp. 280-81. Rothrock continued to receive a regular salary as chairman of the geology department.

[3] Rothrock, letter, December 30, 1950, to George T. Mickelson, Governor of South Dakota, Microfilm 7.

[4] *Biennial Report, 1948-50*, p. 28.

preferred that his office, adequately financed and staffed, take care of the geological studies in South Dakota. He agreed to a few cooperative programs with the USGS only when assured that its geologists and funds were truly necessary and that the State Survey retained an active role.[5]

During those first two years when he possessed no funds, Rothrock, in anticipation of resumed financial support from the State, sought to keep alive at least the spirit of the Survey by maintaining contact with South Dakota citizens. Few could doubt the sincerity (or the politics) of his efforts when he answered inquiries and sent out publications as personal favors or when he persuaded his students to help identify mineral specimens. There were, however, two crucial limitations to these activities—their relative priority and his time. Since the director could not accommodate all requests, he concerned himself mostly with those people, companies, or agencies that might aid in the development of the State's resources. The second restriction, time, meant that inquiries might go unanswered for one or two months. Finally, in desperation by April 1928, Rothrock asked the University for secretarial help, either by means of two dollars a week or the loan of a secretary from another office for one or two afternoons each week.[6] He did receive some office aid, for a second set of initials appeared on letters thereafter.

As a matter of fact, the State Geologist was even able to engage in field studies during those two moneyless years. Although several smaller ones were mentioned in his first biennial report, only the examination of a landslide in the bluffs of the Moreau River was clearly done after July 1, 1927. This project was possible only because the residents of Dupree and Faith paid his expenses. The major field work consisted of a continuation of the gravel surveys. The Highway Commission had found these studies so helpful that it financed investigations for the summers of 1927 and 1928. Rothrock located gravel deposits in several areas of the State, wherever the greatest shortages existed, thus lowering the need and costs for long hauls.[7]

The Survey could survive without its own funds, but only in a haphazard manner, dependent upon the generosity of others. So in 1929 it must have been a pleasant relief for the State Geologist to have even a small sum of $5,000. Rothrock, like his predecessors, found it difficult at times to stretch funds through twelve months and yet try to complete the projects most urgently needed. In at least one instance, early 1931, the money had been exhausted before the fiscal year ended. Rothrock did find one means whereby to economize, which he intended to be only temporary. Instead of having publications commercially printed, in 1930 the Survey began to mimeograph its own reports. Although the format was probably less appealing, at least the process was less expensive and the information was available to the public. In addition, Rothrock placed a small mailing and handling charge on each publication, unless an exchange of reports had been prearranged.[8] Since then the same policies have been followed, except for an improved printing process and a higher fee.

The consequences of financial limitations, in Rothrock's opinion, were just as adverse for the Survey as for the State. If the Survey could not investigate natural resources, the State was less likely to develop its own wealth. The problem was usually not whether a particular resource existed, but rather its quality and quantity. If the Survey acted as a central bureau for the accumulation of these vital facts, its findings carried the added weight of being made

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[5] Rothrock, personal interview, February 27, 1967; Rothrock, letter, September 17, 1956, to Thomas B. Nolan, Director, USGS, Microfilm 3.

[6] *Biennial Report, 1926-28,* p. 6, Rothrock, letters, January 3, 1928, to John Hoffman; April 21, 1928, to J. H. Julian, Vice President and Dean of Student Affairs, University of South Dakota; April 27, 1928, to Assistant Secretary of State, Pierre, Microfilm 14.

[7] *Biennial Reports: 1926-28*, pp. 3-4, *1928-30*, p. 5. In 1932 the Survey, financed by the Highway Commission, undertook another study of gravel deposits in parts of western South Dakota. *Biennial Report, 1930-32*, pp. 8-9.

[8] Rothrock, letter, March 6, 1931 to F. E. Poole, Haakon County Development Company, Inc., Microfilm 12; *Biennial Report, 1928-30*, p. 7.

by professional geologists. Rothrock accordingly viewed an active Survey as a profitable investment for the State. The returns could be manifested in a variety of forms, such as leasing of land by oil companies, lessening of gravel costs for road construction, or mining of coal commercially.[9]

Related to the investigation of specific mineral resources was the collection of current production statistics that would demonstrate the economic status of each product on a continuous, and thus comparative, basis. Freeman Ward had tried to do this during the First World War; but over a decade passed before the task was again attempted, this time with success. In the summer of 1929, Rothrock and Walter V. Searight, who was the only co-worker in both the geology department and the Survey until the mid-1930's, visited all the mines, pits, and quarries to catalogue the metallic and non-metallic resources being developed. This project was intended to be preliminary to detailed investigations of all resources in the State.[10]

In 1929 the Survey also set up a program of cooperation with the United States Bureau of Mines for the annual collection of mineral production statistics. Rothrock himself was very much interested in promoting and protecting industrial and mining operations in the State. A short, but active and impressive, trip to the Black Hills exemplified this concern. In October, 1931, he attended a meeting of the Black Hills Mining and Industrial Association. In addition, during these few days, he found a supply of asbestos for one company, disproved a rumor that vermiculite was obtainable in the Black Hills, and inspected a new gold mine near Keystone, a stone quarry at Hot Springs, and oil wells at Ardmore, Wall, Kadoka, and Wagner.[11]

The three main resources which the Survey investigated between 1929 and 1939 were coal, oil, and water. The coal areas in northwestern South Dakota had been reconnoitered by James E. Todd in the 1890's and by the USGS in 1911. After that, despite attempts by Ellwood C. Perisho and Ward, no detailed studies were undertaken. By 1929 it was deemed essential that the coal deposits be re-examined, particularly in view of prospective commercial development. Searight, who performed all the coal investigations, first conducted preliminary studies in the northwestern counties in order to acquaint interested persons with the general facts about the locations and sizes of coal beds and to demark specific regions for further study.[12]

Within the next four years he examined and mapped in detail coal deposits in Dewey, Perkins, and Meade Counties. In the first area, around Isabel and Firesteel, Searight found coal of a better quality than previously supposed, which he termed sub-bituminous rather than lignite. This analysis and more data on the locations and estimated quantities of coal seams resulted in increased mining activity by the Firesteel Coal Company. The other two surveys around Bison and Stoneville disclosed coal deposits of the usual lignite grade and in sufficient quantity for local consumption, a factor of importance for the residents there. In addition to the field studies and chemical analyses (with the aid of the State Chemical Laboratory), Searight tested and compared the slacking properties and fuel values of the various types of coals from several regions of South Dakota and other states.[13]

An integral feature of most investigations pursued by Searight was a study of stratigraphy, the field in which he had been trained. Thus, included in his examinations of

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[9] *Biennial Report, 1930-32*, p. 5.

[10] *Biennial Report, 1928-30*, p. 4; E. P. Rothrock and Walter V. Searight, *Mineral Producers in 1929*, South Dakota Geological and Natural History Survey, Report of Investigations No. 1 (January 1930), p. 1. Hereafter all such reports cited as R.I., with the appropriate number.

[11] *Biennial Report, 1930-32*, p. 7; Rothrock, letter, October 20, 1931, to Herman G. James, President, University of South Dakota, Microfilm 15.

[12] Walter V. Searight, *A Preliminary Report on the Coal Resources of South Dakota*, R.I. 3 (June 1930), pp. 1-2.

[13] W. V. Searight, *The Isabel-Firesteel Coal Area,* R.I. 10 (May 1931), pp. 1, 30; *Biennial Reports: 1930-32*, p. 8; *1932-34*, pp. 7, 9.

the coal deposits was a concern with the Lance and Fox Hills formations of the late Cretaceous period.[14] Searight's most important contribution to stratigraphic studies in South Dakota came later, however, with his work on the Pierre formation.

Searight's coal investigations, despite their economic and stratigraphic value, were unfortunately limited to three scattered areas. Moreover without equipment for drilling, he had to confine himself to an analysis of outcrops. When the drought and depression began to recede in South Dakota, Rothrock sought the resumption of coal appraisals, but this was not possible until several years later.[15] Meanwhile Searight's efforts in the early 1930's had their own significance as the first detailed coal surveys undertaken by the Geological Survey and as an aid to expanded production for both local consumption and commercial marketing.

While Searight was beginning his coal studies, Rothrock was investigating oil possibilities in eastern Custer County and southern Fall River County. Although geologists and oil prospectors had long been interested in the structures known to exist in these areas, they had lacked the detailed information needed for locating drilling sites. Because of the many inquiries, Rothrock decided to obtain some of the answers through surveys in 1930 and 1931. Thus he provided in his reports structural and geologic maps, data on the possible oil bearing horizons, and recommendations for testing the structures, including estimates of depth. Although these findings did not immediately bring about new drilling activities, because of the economic straits affecting the oil industry throughout the country, they were used to settle some land leasing plans and were available for future reference.[16]

In 1925 the legislature had passed a law requiring the State Geologist to draw up regulations for the drilling, casing, and abandoning of gas and oil wells and requiring the driller to file an accurate log with the Survey. Without sufficient funds and personnel, Rothrock often found it impossible to execute his part of the law. Enforcement of plugging abandoned wells was more difficult if drilled by local companies as promotion schemes. Unfortunately, open and unused wells constituted a danger of salt water damaging fresh water supplies or of artesian water being allowed to flow wastefully. Yet the good graces and common sense of the drillers insured much compliance, and they usually furnished the logs quite willingly.[17]

The depression probably lessened the amount of test drilling in South Dakota; but enough was undertaken to create flurries of excitement and to compel Rothrock to follow developments. The southwestern part of the State was one area especially where speculation and wildcatting were prominent. In 1924-25 a well, the Red Canyon, north of Edgemont, had reportedly shown oil during drilling operations. Nothing further was done until early 1929, when an attempt was made to pull the casing. Because it was stuck, a charge of explosives was lowered that caused oil to start flowing in the hole. There ensued a rush of land leasing, including that of a group of local residents who organized the Black Hills Petroleum Company. They began drilling on the Barker structure in Custer County in June 1929, and in December struck oil. For a short time into 1930 small amounts were pumped before this first producing oil well in South Dakota was abandoned.[18] Speculation about greater oil possibilities from the Barker structure continued, and twenty-five years later a profitable producing well was drilled on this dome.

The Red Canyon Well, which had started the flurry, was not plugged until over a decade

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[14]W. V. Searight, *The Geology of Central Perkins County, South Dakota*, R.I. 21 (September 1934), p. 1; W. V. Searight, *The Stoneville Coal Area*, R.I. 22 (September 1934), p. 1.

[15]*Biennial Report, 1936-38*, p. 17.

[16]*Biennial Report, 1930-32*, pp. 8, 10; E. P. Rothrock, *The Fairburn Structure*, R.I. 6 (October 1930), p. 1; E. P. Rothrock, *The Cascade Anticline*, R.I. 8 (February 1931), p. 1.

[17]*Biennial Report, 1934-36*, p. 14; Rothrock, letter, November 17, 1931, to Warren E. Green, Governor of South Dakota, Microfilm 15.

[18]Walter W. Wright, "The Story of Black Hills Petroleum" (pamphlet, undated), pp. 1-4, in Files; Agnew, letter, February 15, 1961, to G. C. Ridgeway, Amarillo, Texas, in Files.

after it was last abandoned in 1929. An example of proper and prompt compliance with this regulation was an oil test drilled near Wall in 1931. An oil well anywhere in South Dakota was almost guaranteed to cause excitement. More so was it when Gypsy Oil Company, a major firm from Tulsa, Oklahoma, with its large, modern rig moved into the State. Although its well near Wall was completed as a dry hole, the log provided valuable information about subsurface conditions for that region.[19]

During the biennium 1932-34 public interest in mineral resources switched dramatically from the speculative to the more staple products of gold and water. Because of the standard price of gold, $35 an ounce beginning in 1934, and the widespread unemployment of these depression years, men were willing to try gold prospecting for a living. The Survey received inquiries from all parts of the nation about where and how to find gold nuggets in South Dakota. Just as prominent, but more enduring, was the demand for information about water supplies as lakes and rivers dried up and wells and springs failed, leaving towns and farms with severe water shortages.[20] For the next few years the Survey focused its attention upon activities to meet requests about water problems. The resulting investigations were assumed in a variety of ways, including the location of local water supplies, one major study of artesian waters, a program of measuring water levels, a study of irrigation possibilities, and attempts to aid the Missouri River development proposals.

To meet the interest in gold prospecting the Survey compiled two reports about placer mining to provide information for the individual prospector who had little technical training. One report described the methods of placer mining, the manner of staking out claims, and the laws regulating the mining of gold. The second report presented an account of the geological conditions that had caused the formation of placer deposits and suggested likely regions in which to search for gold. By 1935 these two publications had been reprinted four times and almost 2000 copies sent out. Even the chance to make as little as fifty cents per day must have appealed to a large number of people.[21]

Undoubtedly the information on placer gold mining aided many individuals. However, the investigations of water resources affected entire communities. During the 1930's the Survey dealt with as many of the emergency situations as possible. Despite admonitions and futile attempts by Todd, Perisho, and Ward, support for the examination and conservation of water resources had never materialized. Now, concern was awakened by the disappearance of what had been taken for granted. The Survey was called upon to select the areas with the gravest water shortages and then perform both the preliminary and specific studies simultaneously. In 1930 Rothrock had outlined the gaps among the few known facts about water in South Dakota. These included the fundamentals that had to be discovered hastily in the midst of crises–amounts and sources of available water supplies, qualities of water, and depths for drilling.[22]

Most communities obtained their water supplies from only one source, and, when that became inadequate, did not know where to acquire more. Under these circumstances the Geological Survey began its first water investigations, many of which were brief reconnaissance surveys to locate possible sources of water for various towns in the State. The communities receiving more detailed information included Watertown, Fort Thompson, and Huron. In late 1933 Rothrock, at the request of Watertown officials, helped solve their shortage problem by discerning a means to maintain a more constant water level in Lake Kampeska during dry periods. Shortly thereafter he studied the possible sources of water for the Indian Agency at Fort Thompson. Since the James River by the summer of 1934 was no longer usable as a source of water for the city of Huron, Rothrock and Bruno Petsch spent three weeks there investigating sand reservoirs for a suitable shallow water supply. During

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[19] Rothrock, "Drilling Operations," pp. 15-16.

[20] *Biennial Report, 1932-34*, pp. 4, 16.

[21] *Biennial Reports: 1932-34*, pp. 10, 17; *1934-36*, pp. 10-11; Doris L. M. Anderson, *Prospecting for Placer Gold in South Dakota*, R.I. 15 (March 1933), p. 1; J. P. Connolly, *Geologic History of Black Hills Gold Placers*, R.I. 16 (October 1933), p. 1.

[22] *Biennial Report, 1928-30*, p. 10.

this study the Survey, for the first time, used a geophysical method which consisted of transmitting an electric current into the ground and measuring the resistance to its flow at various depths. This process, employed by many oil and mineral geologists, was made possible by Petsch who had constructed a resistivity machine.[23]

In 1935 the long delayed plans to study artesian water in South Dakota were finally initiated, in cooperation with the USGS. No detailed investigations of this essential resource had been performed since 1918, when N. H. Darton had completed his series of reports on the artesian basin. Although acute water shortages existed in other areas, the west-central part of the State was selected for the first survey. As the ground and surface water supplies were being depleted, the residents were forced to rely upon artesian waters, about which they had insufficient information. Therefore, Rothrock, in charge of geologic studies, and Thomas W. Robinson, an engineer with the USGS, in charge of hydrologic studies, tried to furnish the basic data.[24]

The extent and depth of the geologic formations could only be estimated because of the necessary reliance upon the outcrops and the few deep wells in western South Dakota. The real importance of the geological descriptions rested with the tracing, for the first time, of formations outcropping in the Black Hills eastward to the Missouri River. Rothrock had accomplished this by a comparison of log records with the known outcrops and by a microscopic study of cuttings from oil tests. Time and monetary limitations restricted Robinson's endeavors and precluded particularized studies of any one locality. However, his examinations as a whole did demonstrate factually the pressing exigency to arrest the decline of artesian pressure and to make greater and more careful use of artesian basins below the Dakota formation.[25] For the future the 1935 survey represented the start of an expanded program to acquire data about the sources and supplies of artesian water and to formulate a carefully determined conservation policy.

Another aspect of the water study programs was the measurement of fluctuations in the lakes and the wells in eastern South Dakota. In 1934 and 1935 Rothrock established reading stations on twelve lakes, eleven in the Big Sioux Valley and one at Lake Andes. He appointed local residents to measure the lake levels twice a year, once in the spring and once in the late fall. These records, continued over a period of years, would not only indicate the ground water fluctuations but would also serve as guides for the maintenance of lake levels and for the use of shallow wells. Between 1936 and 1939 water level examinations were extended to include a series of observation wells in seven counties—Yankton, Union, Clay, Minnehaha, Moody, Bon Homme, and Beadle. At first the Survey alone tried to maintain the reading stations, but could visit them only at irregularly scheduled intervals. Therefore, in 1939 an agreement was reached with the USGS, which had aided in selecting the wells, whereby the State Survey furnished the funds for Robinson to supervise the measuring program. By 1940 the wells and lakes had been observed long enough to determine that the level of ground water reservoirs had risen slightly since the drought.[26]

Because of the dry conditions during the 1930's, many farmers and ranchers considered the possibility of irrigation from shallow wells, a prospect that necessitated geological information. In 1937 a Survey crew, directed by H. E. Brookman, from the applied science department at the University, undertook one such study in the White River Valley. To determine the feasibility of irrigation from the underflow of the river, a resistivity machine was used and wells were drilled and logged. At the end of the field season not enough data had been acquired to warrant definite conclusions. The completion of the project was

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[23] *Biennial Reports: 1932-34*, pp. 7-8, 19; *1934-36,* pp. 4-6; E. P. Rothrock and Bruno C. Petsch, *A Shallow Water Supply for Huron, South Dakota*, R.I. 24 (January 1935), pp. 1, 7; Rothrock, letter, October 2, 1935, to R. W. Lohman, South Pasadena, California, Microfilm 18.

[24] E. P. Rothrock and T. W. Robinson, Jr., *Artesian Conditions in West-Central South Dakota*, R.I. 26 (July 1936), pp. 1-2, 35-36.

[25] Rothrock and Robinson, R.I. 26, pp. 68-69, 84; *Biennial Report, 1934-36*, p. 7.

[26] *Biennial Reports: 1934-36*, p. 6, *1936-38*, p. 9; *1938-40*, pp. 9-10; C. G. Paulsen, Acting Chief Hydraulic Engineer, USGS, Memorandum, undated, to Rothrock, Microfilm 20.

delayed until the summer of 1941 when Rothrock headed another party that checked the original findings and accumulated additional information. The results indicated that certain areas between Kadoka and Murdo, wherever the quality of water was satisfactory, could be irrigated on a small scale.[27]

Another project proposed in the 1930's was the development of the Missouri River for navigation, irrigation, and water power. As early as 1930 Rothrock had recommended the State appropriate funds, to be matched by the federal government, for the preliminary work which would consist of topographic mapping, stream gauging, and ground water studies. Although the Survey achieved the major part of its role for this project in the 1940's, Rothrock did make a few attempts before then. He provided for the Army Corps of Engineers the use of data and maps from his office and compiled for them a report on mineral products that could profitably be transported on the Missouri. His plan to organize a topographic mapping program, as a basis for construction of dams, in cooperation with the USGS, did not succeed because the Survey lacked its share of the funds.[28]

In some ways it might seem that the Geological Survey was dispersing its water studies into a range of projects too numerous for the completion of any one unit. In actuality, such a situation was not only necessary but also impossible to avoid. First, in the midst of widespread water shortages it became a process of attacking the most severe problems regardless of the type or area. Second, the Survey could not neglect the investigation of other resources, especially coal and petroleum. Third, lack of adequate funds and full-time personnel restricted the number and types of projects for any one year, or even any one two-month field season. Fourth, Rothrock considered each attempt to solve a water shortage as part of a long-range program. The ultimate and interrelated objectives included the determination of water supplies and sources for each city and town, the investigation of all shallow water supplies for the entire state, the discovery of reservoirs usable for small scale irrigation, and the conservation and utilization of artesian flows.[29]

Because of his concern about the proper development of all natural resources in South Dakota, Rothrock enthusiastically aided the State Planning Board which had been established in the mid-1930's. From the outset he served on two of the committees, one on mineral resources and the other on surface water. Furthermore, while assembling information for its reports on mineral and water resources, which Rothrock himself outlined and criticized, the Planning Board located a branch office with the Survey for a year.[30]

In 1937 the Survey and the Planning Board organized a program for compiling information about ground water in South Dakota. The methodology called for an office in each county to collect and tabulate the data and the Survey to analyze these and write the reports. The entire study was undertaken as a Works Progress Administration project. This arrangement was not completely satisfactory because untrained personnel were employed to perform the work in the counties. But the purposes of the study could be accomplished as long as the Survey received the original questionnaires along with tabulations. For some unexplained reason, when the legislature abolished the Planning Board, effective July 1, 1939, sponsorship of the project was transferred to the Agricultural Experiment Station and the Extension Service at State College. Rothrock tried unsuccessfully to regain at least the privilege of writing and publishing the reports. Instead two experienced geologists were hired to direct the program and the first county reports began to appear in 1940.[31]

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[27] *Biennial Reports: 1936-38*, p. 7, *1940-42*, p. 27.

[28] *Biennial Reports: 1936-38*, p. 10, *1938-40*, p. 15; Rothrock, letters, September 14, 1934, to C. H. Birdseye, Chairman, Federal Board of Surveys and Maps, USGS; March 27, 1935, to Mrs. Colin F. Cambell, Aberdeen, Microfilm 18.

[29] *Biennial Report, 1936-38*, pp. 15-16.

[30] *Biennial Report, 1935-36*, p. 12.

[31] "Forward," in Walter V. Searight and Elmer E. Meleen, *Rural Water Supplies in South Dakota: Hughes County*, Extension Service, South Dakota State College, Special Extension Circular No. 47 (January 1940), p. ii; Rothrock, letter, September 13, 1939, to Bob Butts, Coordinator, WPA, Mitchell.

The work with the Planning Board also brought to the forefront once again the otherwise latent conflict of responsibilities between the School of Mines and the Survey. When the Planning Board decided to publish a report on the mineral resources of the Black Hills, its representatives asked for and received the use of facilities and staff at the School of Mines. Rothrock objected to this arrangement because the Survey was specifically charged with investigating the natural resources in the State. Accordingly, he proposed that the School of Mines limit its research activities to mining and metallurgy. J. P. Connolly, President of the School of Mines, opposed this idea as being too restrictive and instead wanted to cooperate with the Survey in a manner that would prevent duplicated efforts. The exchange of letters on this matter revealed not only the issues but also the spirit of the dispute. Both Connolly and Rothrock desired to preserve their prerogatives; yet each sought to maintain a friendly relationship with the other and between the two institutions.[32] More than likely, no definite arrangements were made to divide responsibilities. Rather, as the future demonstrated, there developed mutual respect and active assistance between the two institutions.

Although the Survey was concentrating on water studies, its director did not exclude other projects that could be useful for the development of different resources and for the accumulation of geologic information. As so aptly revealed by the investigations to alleviate water shortages, these objectives were more systematically achieved before the demand became too critical or intense. Therefore, in anticipation of a revived interest in petroleum possibilities and after seeing the many swindles that had accompanied unrestrained speculation since the early 1920's, Rothrock sought to organize long-term stratigraphic and structural studies that would eventually cover the entire State. In the campaign to sell these proposals, he pointed out that they would provide a solid basis for promotion of drilling operations, would attract legitimate and amply financed prospectors, and would facilitate the knowledgeable development of water resources.[33]

Gradually, through its various studies, the Survey had been acquiring facts about geological formations throughout the State. As interest in oil possibilities continued and as attempts to sink artesian wells in western South Dakota increased, drillers sought information about the subsurface formations. In an effort to make more readily available those facts already known, Rothrock compiled for publication in 1936 the logs from oil and water wells that the Survey had long been collecting. Moreover, during the field season of that year he and Searight pursued a structural study in Harding County, which revealed the general structural features and the areas favorable for further investigation and exploratory drilling.[34]

One great drawback in determining the depth of drilling, for both oil and artesian water, was the lack of information about the Pierre shale formation of the upper Cretaceous. The oil investigations in the 1920's had shown it to be the most prominent surface formation in western South Dakota, with the rocks within it varying in character. The difficulty of demarking these horizons stemmed from the lack of easily discernable lithological differences. In solving this problem Searight laid the foundation for future geologic studies, both scientific and economic, in which the Pierre formation had to be considered. The immediate importance pertained to the investigation and mapping of structures in the western half of the State. Searight did the field work for his project in the Missouri River Valley during the summers of 1934 and 1935. He had earlier begun the laboratory work, mainly micropaleontological, by examining well cuttings and rock samples from the Pierre outcrops. Through these means he divided the Pierre formation, on the basis of lithological differences, into five members and these into subdivisions.[35]

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[32] *Biennial Report, 1934-36*, p. 14, Rothrock, letter, April 12, 1939, to Frank Curdill, Firesteel, Microfilm 20.

[33] *Biennial Report, 1934-36,* p. 14, Rothrock, letter, April 12, 1939, to Curdill.

[34] E. P. Rothrock, *Logs of Some Deep Wells in Western South Dakota*, R.I. 4 (March 1936), p. 1; *Biennial Report, 1936-38*, p. 7.

[35] W. V. Searight, *Lithologic Stratigraphy of the Pierre Formation of the Missouri Valley in South Dakota*, R.I. 27 (January 1937), pp. 1-2, 10, Rothrock, letter, March 26, 1938, to Marvin Bauer, President, Mitchell Produce Company, Mitchell, in Files.

That Searight's work on the Pierre shale marked a breakthrough in the knowledge about the stratigraphy of South Dakota was aptly demonstrated by the use of his findings in several ensuing studies, the earliest of which were structural surveys along the Missouri River. In 1937 two plane table parties, one headed by Rothrock and the other by Monte E. Wing, professor of geology at Beliot College, investigated oil possibilities in the Pierre region. Although earlier geologists had reported unfavorably about this area, additional knowledge about the structural features seemed to warrant further study. Other purposes included the prospects of increased gas production and the practicability of making a structural survey on the beds of the Pierre formation. Only the latter point could be and was positively affirmed. However, in his report, Wing did describe the structures that offered the best sites for test wells. John P. Gries, professor of geology at the School of Mines, made similar discoveries when he mapped the structures in the Missouri Valley between the Cheyenne Agency and the mouth of the Moreau River in 1938.[36]

As the oil industry recovered from the depression, Searight's stratigraphic study and the structural surveys in Harding County and along the Missouri influenced the drilling of several test wells in these areas. The State Geologist followed the progress of these and other drilling operations as closely as possible because of his legal responsibility, desire to acquire accurate well logs, and concern about the probable development of oil production in South Dakota.[37] Although these factors were necessary, informative, and beneficial for the State and the Survey, they could also be the sources of difficulties, as exemplified to a somewhat extreme degree by the drilling activities near Wagner in the 1930's.

Between 1928 and 1940 three Wagner wells were drilled within 800 feet of each other. After the first one caved in, the rig was moved to a second site in August 1929. When this well struck quartzite, Rothrock, who was receiving the logs and cuttings, recommended cessation of drilling, for he saw no sound geologic reason for finding oil any deeper in this formation. On the recommendation of another geologist, who identified the formation as Mississippian limestone, the drilling, however, was continued until February 1931 when the equipment broke down. During the next month the legislature considered a bill, strongly supported by the promoters of the Wagner well, that was to authorize $25,000 for the completion of any well that had reached 2,300 feet (the Wagner well had gone down 2,480 feet) and that had permeated the quartzite and had entered the limestone formation. The bill failed to pass and the promoters blamed Rothrock, who had sent to the governor an unfavorable report on their well.[38]

After more funds were raised, drilling was resumed in late 1935 and was stopped in June 1936, when the casing broke. During this second attempt a fence was erected and no one was allowed near the well, including, of course, the State Geologist, who, despite his pessimism about finding oil, was still interested in the operation because of the stratigraphic information it was furnishing. In July 1936 a third well was spudded in and again reached quartzite within a few months. When asked to allow the sale of additional stock in early 1939, the State Securities Commission met with Rothrock and the Wagner residents to consider the justifications for continued drilling. Despite the Commission's refusal to grant the permit, enough funds were found to maintain the well until January 1940.[39]

Throughout these years while Rothrock was trying to prevent useless drilling and waste of money, the promoters, understandably angry with what they thought was unjustified interference, had accused him of being unqualified as a State Geologist and of accepting bribes. Yet the drillers regularly sent logs and samples to the Survey. The story of the

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[36]Monte E. Wing, *A Structural Survey of the Pierre Gas Field, South Dakota*, R.I. 29 (March 1938), pp. 4-8, 19; John Paul Gries, *A Structural Survey of Part of the Upper Missouri Valley in South Dakota*, R.I. 31 (January 1939), pp. 1-2.

[37]*Biennial Report, 1938-40*, pp. 5-6.

[38]Brewster Baldwin, "The History of the Wagner 'Oil Field'" (unpublished report, May 5, 1949), pp. 1-2, in Files; Rothrock, letter, April 15, 1936, to Attorney General, Pierre, Microfilm 19.

[39]Rothrock, letter, April 15, 1936, to Attorney General; Baldwin, "The History of the Wagner 'Oil Field'," pp. 2-4.

Wagner wells, which included two unsubstantiated shows of oil and the flooding out of a small gas field due to improper casing, ended when the third well was plugged in 1944.[40] When the drilling activities at Wagner had begun in 1928, Rothrock had possessed the authority to regulate the operations, but not the actual power to enforce them. Therefore, not until 1944 was one of his rules, proper plugging procedures, put into effect for any of the three wells. By then, as will be described later, the State Geologist had been given a more meaningful role in the regulation of oil wells.

This change must be considered as part of the overall augmentation in the means of operations accredited to the State Geologist. Beginning in 1926 E. P. Rothrock had persistently tried to demonstrate the benefits the Survey could provide for geology as a field of science and particularly as a medium to further the development of natural resources. His instruments of proof consisted of actual accomplishments, that is, the stratigraphic, coal, petroleum, and water supply studies, and potential achievements. The success of these endeavors was finally realized in 1939 when the legislature revised the statute creating the office of State Geologist and authorizing his activities.[41] The State Geologist was removed from the supervision of the Board of Regents to that of the governor and was specifically empowered to concentrate upon the investigation of natural resources. For the execution of this task, the legislature transferred to the Survey the $25,000 originally appropriated for the Standing Butte Well in 1925.[42]

As this amount was almost double that available the previous biennium, Rothrock for the first time was given the means with which to expand the Survey's staff and activities. From this point on, the development of the Geological Survey as an institution progresses with fewer of the halts evidenced in the past and more of the expectations desired for the future.

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[40] *Ibid.*, pp. 4-5; Rothrock, letter, May 17, 1939, to Harlan J. Bushfield, Governor of South Dakota, in Files; Bruno C. Petsch, personal interview, April 24, 1967, with the author.

[41] See Appendix C.

[42] *Biennial Report, 1940-42*, p. 24.

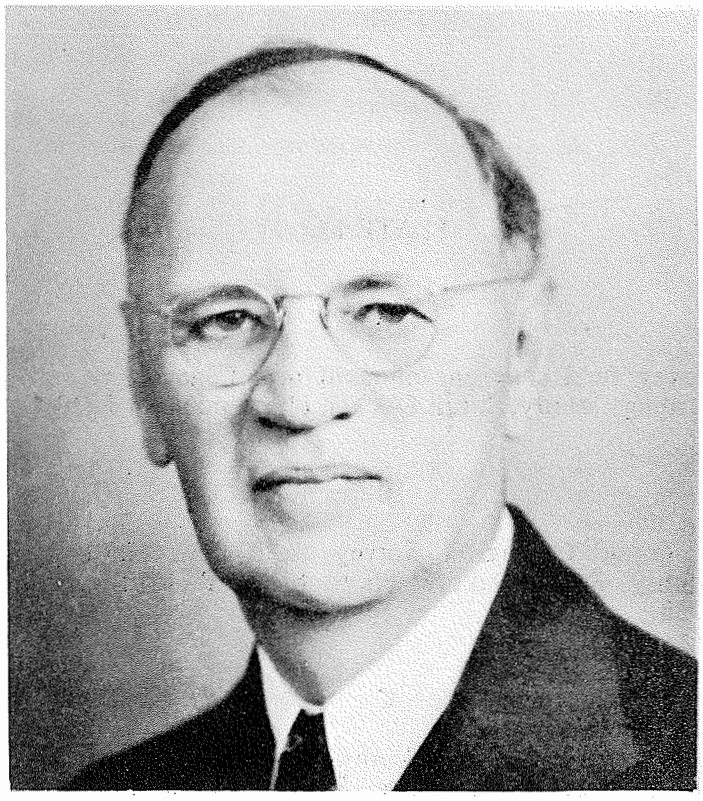


PLATE 12

E. P. Rothrock

State Geologist, 1926-1957

PLATE 13

A

Survey field crew encampment near Cedar Canyon, Harding County, South Dakota. Photo taken in 1928.

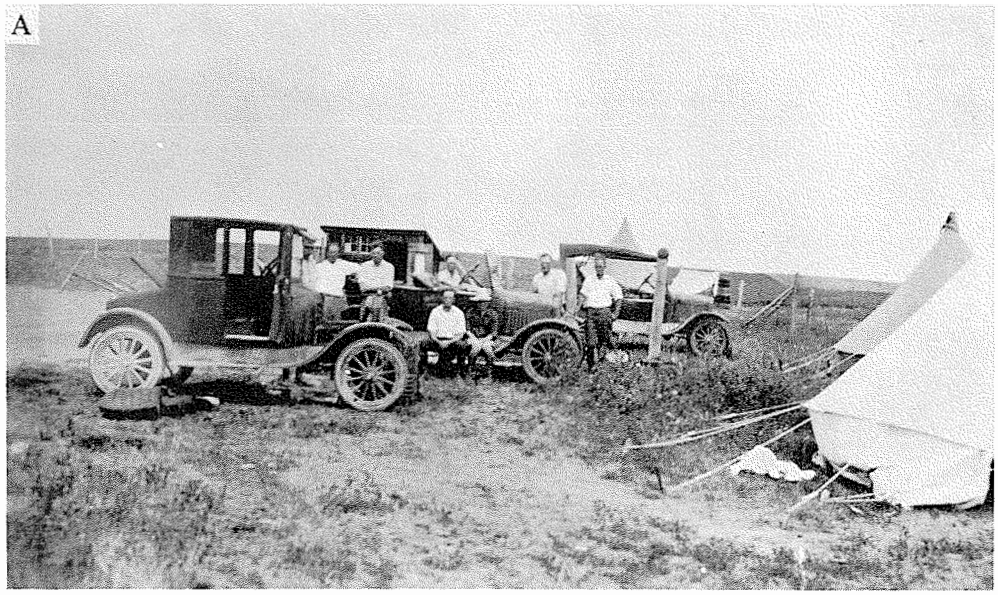
B

Camp of Geological Survey field crew, Harding County, South Dakota. Photo by E. P. Rothrock, 1928.

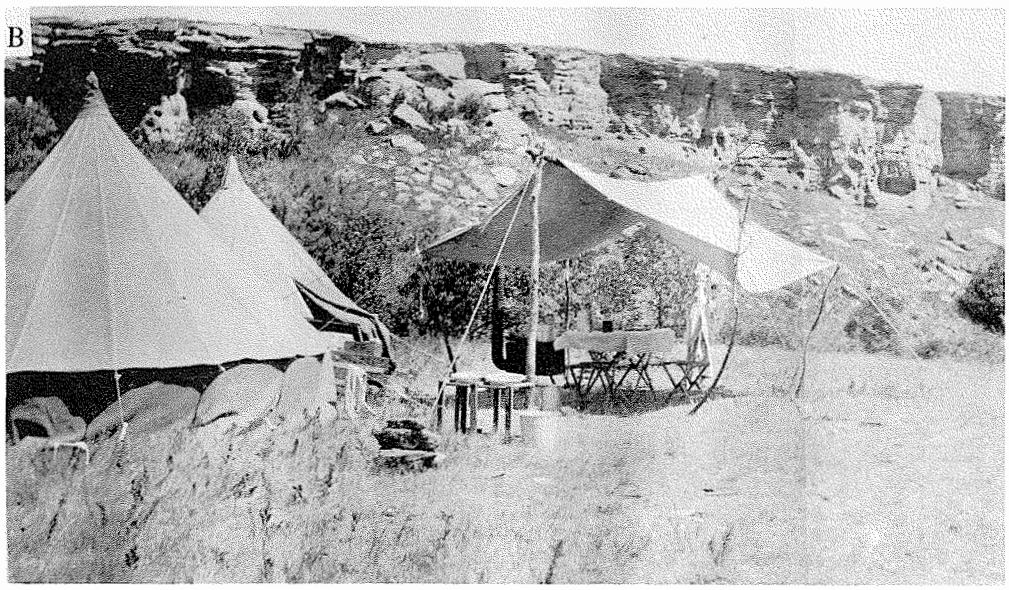
C

Field camp of South Dakota Geological Survey party headquartered near Pierre, South Dakota. Picture taken by E. P. Rothrock, 1937.

A



B



C

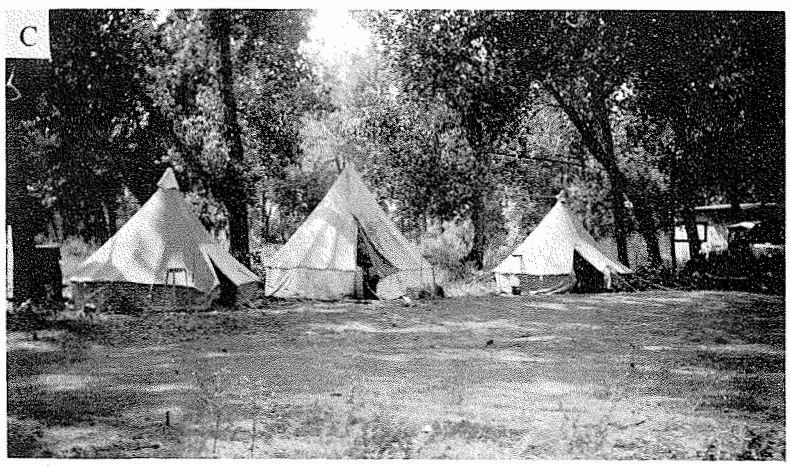


PLATE 14

A

Badlands National Monument. Photo by George E. Grant, United States Department of the Interior, 1936.

B

Road through the Badlands National Monument near the east entrance. Photo by G. A. Grant, United States Department of the Interior, 1936.

A

B

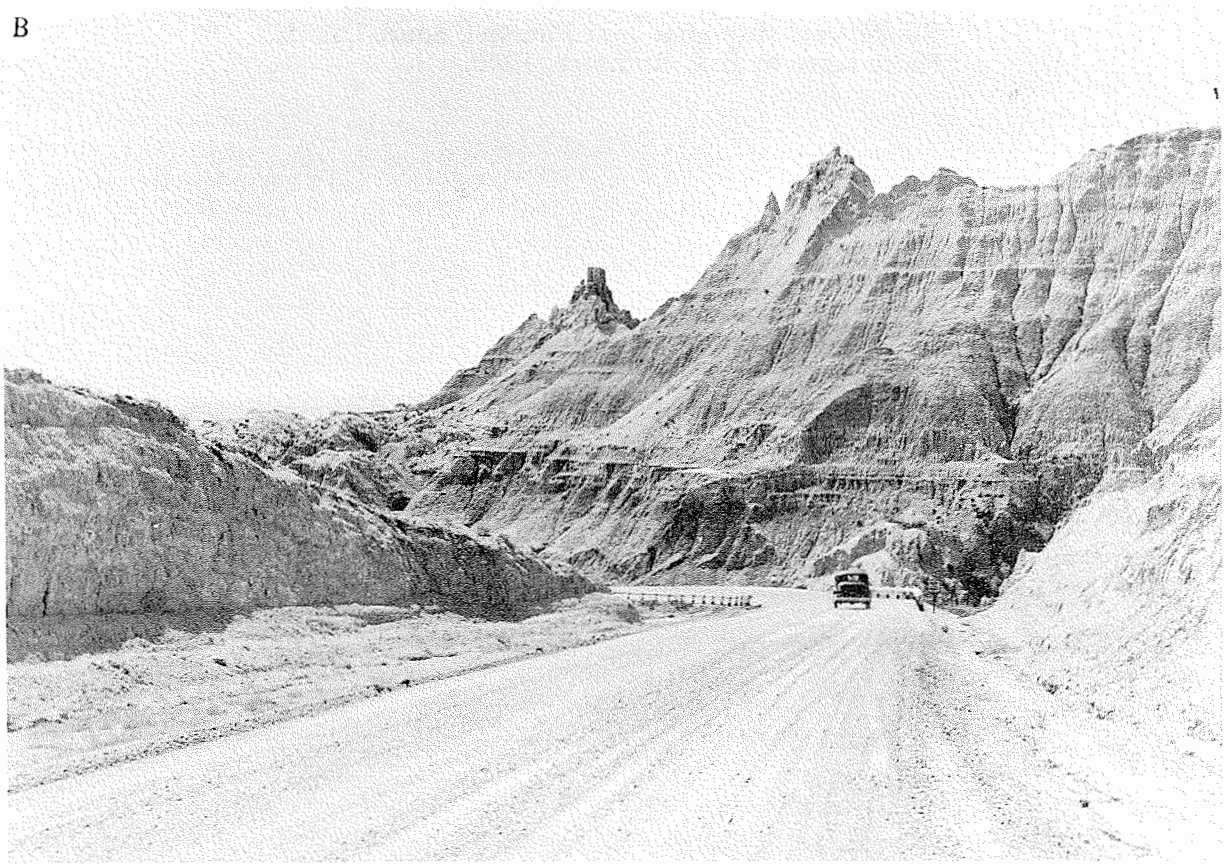


PLATE 15

A

John Tranteena, Brewster Baldwin, C. L. Baker at Ft. Randall dam construction. Photo by Bruno Petsch.

B

An adobe house near Tripp, South Dakota. This house was 50 years old when photo was taken by E. P. Rothrock in 1937.

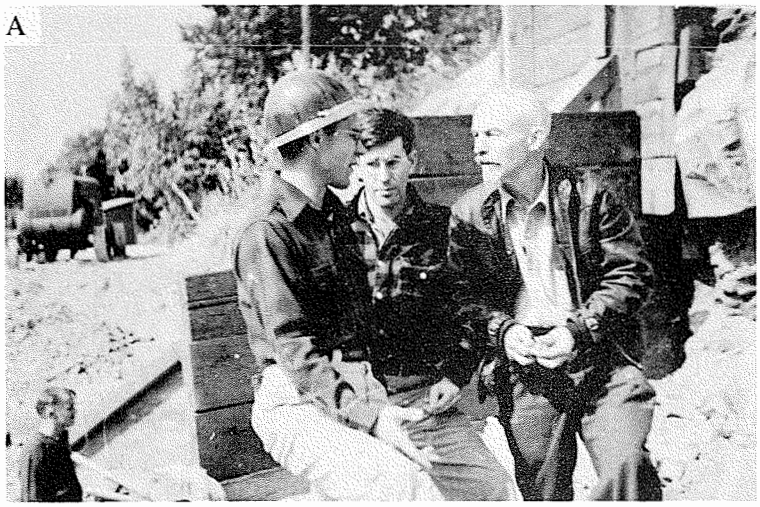
C

Plant of Dakota Granite Company, four miles east of Milbank, South Dakota. Photo taken by M. V. Searight, 1940.

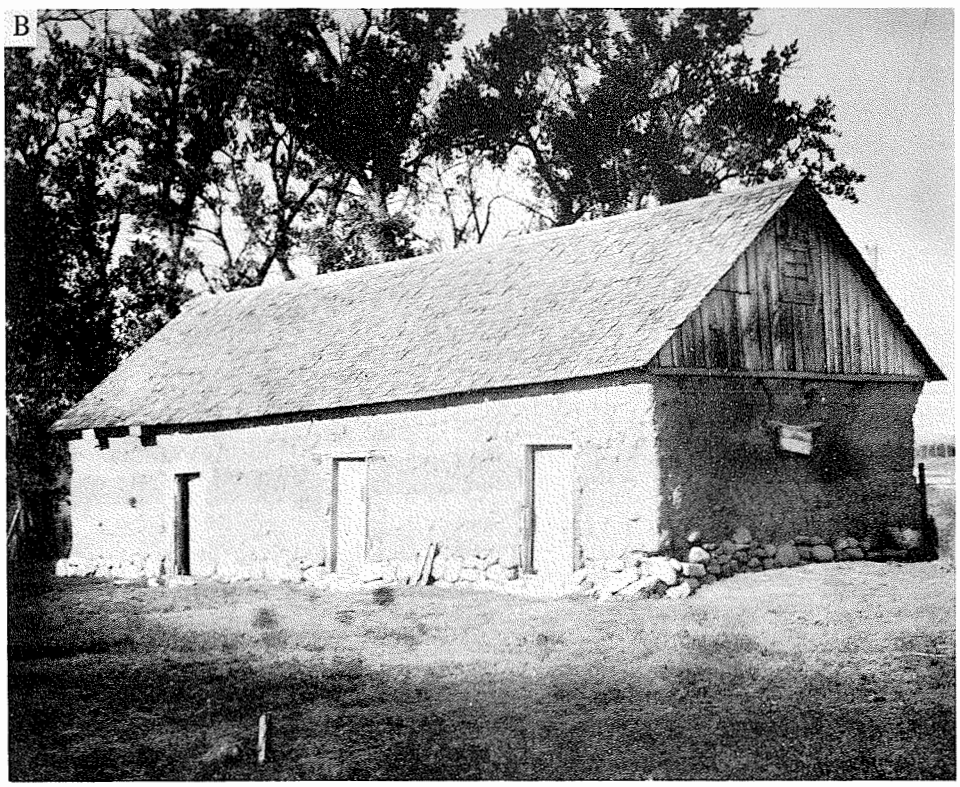
D

Runkel coal strip mine near Firesteel, South Dakota. Photo taken by E. P. Rothrock, 1940.

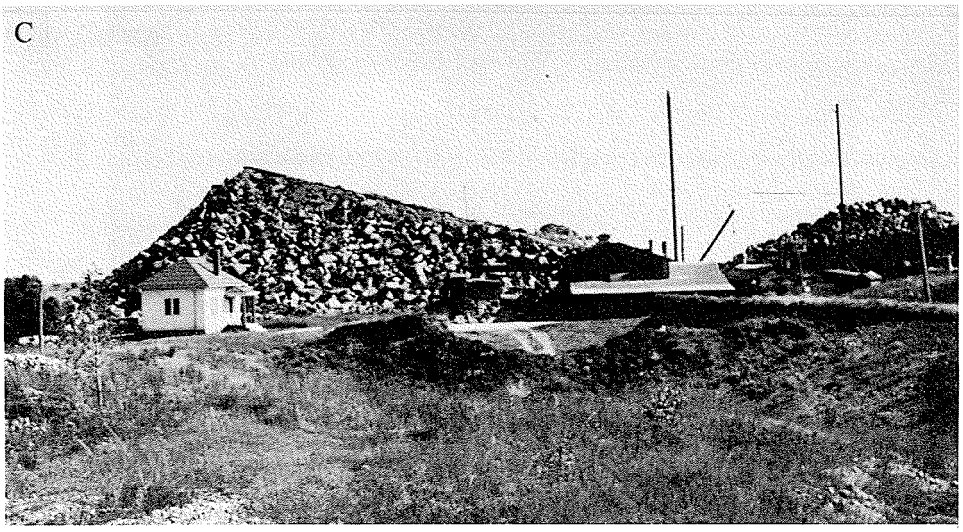
A



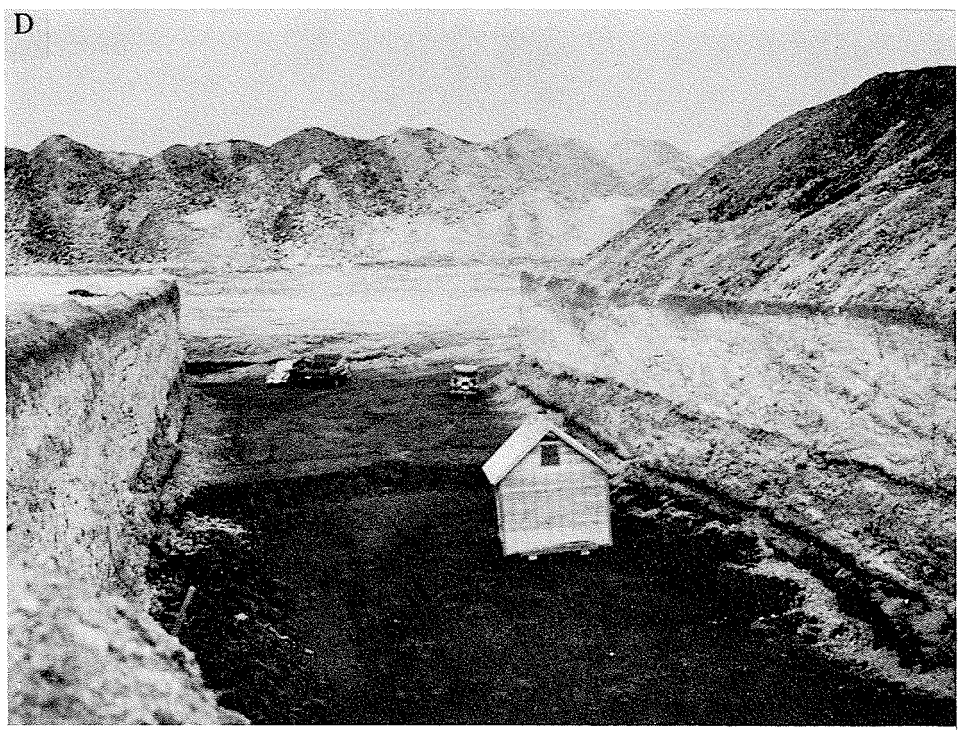
B



C



D



CHAPTER V

RENEWED EXPANSION, 1939-57

The administrative and financial changes in the 1939 laws portended both immediate and future significance for the Geological Survey. The legislature had placed the State Geologist under the direct jurisdiction of the governor only on an emergency basis in order to speed up research on natural resources. However, the efficiency of this arrangement (for example, warrants did not have to be submitted to the Board of Regents) made a removal to the prior form of administration undesirable.[1] Because of larger appropriations after 1939, the Survey found it possible to enlarge its geological activities both in number and kinds and to attain continuation and completion of these projects. Although the investigations were still designed to fulfill immediate scientific or economic needs, the Survey could concurrently work toward more long-range objectives.

Accompanying the programmed studies was a notable change in personnel policy. In 1938 Dr. E. P. Rothrock had begun to employ more than one geologist, mostly from universities and colleges, for summer field work in order to secure the services of varied talents and to obtain the maximum results from small funds.[2] But after World War II, when the manpower shortage diminished and the appropriations rose, he relied increasingly on his own staff to direct the various geologic studies.[3] In 1939 he had been able, for the first time, to hire a geologist, H. W. Buus, for the Survey alone. As chairman of the geology department, Rothrock was, of course, still required to perform his teaching duties, shared with only one other professor until 1955, when one more was added.

Throughout the 1940's and 1950's staff members, appropriations, and geological investigations interactingly increased. A contrast is obvious with only a glance at field studies for 1938 and 1939. During the 1938 field season one project, the structural survey, had been undertaken. In 1939 four investigations were in operation—another structural survey, two studies of bentonite deposits, and a magnetometer survey. Moreover, Rothrock participated in none of them. Instead he concentrated upon a previously begun bulletin on the geology of South Dakota.

The 1939 magnetometer investigation inaugurated a long-range program that was to extend over all of the State and a period of twenty-five years. The magnetometer, a geophysical instrument, measured the intensity of magnetic pull within the earth. The resultant readings indicated areas where structural conditions might permit the accumulation of oil and gas. Therefore, the physical data, interpreted into geological terms, revealed places for further investigation and possible drilling. Although several oil companies had performed magnetic surveys in South Dakota, the results were unavailable to the public. Because their value was already proven, Rothrock decided to acquire the same data to inform anyone interested in structural information. In 1939 the Survey purchased a magnetometer and sent W. H. Jordan, a professor of physics at the University, to Texas for the necessary training. During that summer he secured magnetic readings in south central South Dakota, between the Missouri and James Rivers. Besides denoting regions for structural studies, this investigation revealed the westward continuation of the quartzite ridge which outcropped east of the James River.[4]

During the next field season Jordan extended the magnetic survey northward, covering three times as much territory because an oil company had loaned a second magnetometer. In 1943 Edward L. Tullis, from the School of Mines, replaced Jordan and assembled the

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[1] Rothrock, personal interview, February 27, 1967.

[2] *Biennial Report, 1938-40*, pp. 19-20.

[3] Many of the men who served as assistants either in the field or office later became the geologists on the Survey staff.

[4] *Biennial Report, 1938-40*, p. 7; W. H. Jordan and E. P. Rothrock, *A Magnetic Survey of South-Central South Dakota,* R.I. 33 (February 1940), pp. 1-2, 19; W. H. Jordan and E. P. Rothrock, *A Magnetic Survey of Central South Dakota*, R.I. 37 (November 1940), pp. 1-2.

magnetic readings from southwest central South Dakota and from Beadle and Codington Counties. The western study disclosed that structural folding in South Dakota trended toward the northwest and not the south, as had been expected. In the fall of 1943 Bruno C. Petsch, who had joined the Survey staff in 1942, took charge of the magnetometer investigations. He first obtained readings in the southeast corner of the State, partially because gasoline rationing during World War II prevented him from traveling too far from Vermillion. During the summer of 1946 he covered areas north and south of the Black Hills. Surprisingly, some of these readings did not correspond to the expected structural pattern. Magnetic readings in the Black Hills which should have been the highest in the State had instead registered as the lowest. Therefore, Petsch collected samples from the formations and tested them for magnetic susceptibility. He reached the tentative conclusion that a magnetic high reflected some type of unusual subsurface condition. However, additional field work and laboratory studies were needed to determine if the highs were caused by structural features or sedimentary rocks.[5] Ensuing water supply studies and mapping projects prevented Petsch from returning to this problem until 1957.

Besides the magnetometer survey, Rothrock organized three other investigations in 1939. One was the third structural study along the Missouri River, during which John P. Gries mapped one large structure in northeastern Stanley County. The other two were examinations of bentonite, a colloidal clay, which was being processed at Belle Fourche and Ardmore. The latter plant had been operated since 1915. However, little attention had been accorded the bentonite deposits until the American Colloid Company moved its Wyoming plant to Belle Fourche in early 1938. In order to further the expansion of this industry, Rothrock employed R. C. Spivey, professor of geology from the University of Iowa, and Monte E. Wing to investigate the clay deposits. Both surveys discerned the extent, quantity, and quality of the previously known bentonite beds and located others of possible commercial value. Wing and Spivey estimated that enough material was available for the profitable establishment of two more processing plants.[6]

Just as World War I had affected the Survey's activities, so also did World War II. Like Freeman Ward, Rothrock realized that the Survey lacked much of the data on mineral resources that might be needed. While Ward had not been able to secure the information he actively sought, Rothrock succeeded in organizing two projects to study manganese and pegmatite deposits. In addition, he supplied information on water supplies for military establishments, such as the munitions depot at Provo and a defense plant at Sioux Falls.[7]

An anticipated curtailment of manganese exports had prompted a search for supplies in the United States. Therefore, as a means of drawing attention to the manganese in South Dakota, the Survey in 1940 appraised and mapped the deposits that occurred in the bluffs of the Missouri Valley near Chamberlain. Although the United States Geological Survey had investigated this same area in the late 1920's, more specific information was needed. For the Survey Wing and Gries did the geological work and the State Chemical Laboratory made the chemical analyses. Their findings revealed a large reservoir of low-grade manganese nodules that would be rewarding for commercial production only if a means of concentrating the ore content could be found.[8]

The United States Bureau of Mines, however, deemed the prospects valuable enough to establish a pilot plant near Oacoma. While this plant was in operation, Rothrock undertook another survey in 1942 to complete the appraisal of the deposits along the Missouri. Although the demand for manganese in the United States lessened shortly afterwards, he felt that the information acquired by the Survey could be useful in the future. In 1950 Rothrock attempted to convince the South Dakota Natural Resources Commission to

[5] *Biennial Reports: 1938-42*, pp. 25-26; *1942-44*, p. 10; *1946-48*, pp. 8, 12.

[6] *Biennial Report, 1938-40*, pp. 7-8, 16; M. E. Wing, *Bentonites of the Belle Fourche District*, R.I. 35 (April 1940), R.I. 36 (April 1940), p. 1.

[7] *Biennial Report, 1940-42*, pp. 27-28, 34.

[8] *Biennial Report, 1940-42*, pp. 24-25; J. P. Gries and E. P. Rothrock, *Manganese Deposits of the Lower Missouri Valley in South Dakota*, R.I. 38 (January 1941), pp. 1, 90, 96.

promote the development of manganese mining. When that failed, he turned to private companies with, however, the same response.[9]

One unexpected result of the manganese surveys was the discovery of a large structural fold west of Chamberlain. Wing and Gries had first detected it in 1940 and acquired enough information to map and describe the southern end of the anticline. Both geologists considered this find doubly important for oil and gas possibilities because their plane table survey and Jordan's magnetometer study, covering the same area in 1940, agreed as to results. Later, as already seen, this collaboration would become less certain. But before this fact was discovered, Petsch, as a member of the second manganese party, completed the mapping of the structure, then the largest in South Dakota.[10]

Because both the manganese and bentonite deposits occurred in the Pierre shale and because this formation extended throughout much of western South Dakota, Gries investigated its economic possibilities in 1941. But before doing this, he first had to solve many stratigraphic problems, for the subdivisions of the Pierre shale varied from place to place and contained differing lithologic properties. Previous studies along the Missouri River made work in that area the most rapid and thorough. Lack of adequate outcrops around the Black Hills prevented a correlation of the Pierre formation as found there with that along the Missouri. Although describing several mineral products occurring in this formation, Gries stated that only manganese and bentonite offered development possibilities.[11]

The Survey's second project directly related to World War II comprised a series of studies on minerals contained in the pegmatite dikes in the Black Hills. Although mica and feldspar and lesser amounts of lithium and beryl were being mined, more information was required to expand their production. During the 1941 and 1942 field seasons, therefore, D. Jerome Fischer, professor of mineralogy at the University of Chicago, investigated eight dikes in an area near Custer. As expected, he found that each pegmatite deposit usually contained one mineral that was more prominent and workable than others associated with it. In his subsequent reports, Fischer concentrated upon two objectives. First, he described the quality and quantity of the minerals and the economic ways of extracting them. Second, he explained the geologic features and principles of the pegmatite dikes as aids for geologists and prospectors studying similar deposits. That Fisher's work marked only a small beginning was shown by the 1943 survey during which Charles S. Gwynne, professor of geology at Iowa State College, mapped 1492 dikes. Even then a large area in the Hills was left for further study, which the Survey was never able to undertake.[12]

Despite the emphasis given to metal resources for the war effort, there were sufficient time and funds to carry out other significant projects. One was an examination of water supplies, which the Survey's director hoped could eventually be extended to every city in the State. Unlike the emergency studies performed at Huron and Watertown during the drought, these were designed to discover all possible sources of waters for both current and future usage in a comprehensive fashion. On the basis of need and request, Rothrock selected Miller for the onset of this long-range program in 1941. By investigating artesian reservoirs and gravel outwashes he determined that artesian water was the most easily acquired and the most dependable supply, as long as the wells were properly drilled and controlled.[13]

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[9] *Biennial Report, 1942-44*, p. 7; Rothrock, letter, August 25, 1950, to M. Q. Sharpe, Kennebec, Microfilm 6; Petsch, personal interview, April 24, 1967.

[10] M. E. Wing and J. P. Gries, *Stratigraphy and Structure of the Chamberlain Section of the Missouri River Valley*, R.I. 39 (April 1941), pp. 1, 62, 68; *Biennial Report, 1942-44*, p. 8.

[11] John Paul Gries, *Economic Possibilities of the Pierre Shale*, R.I. 43 (May 1942), pp. 1, 43-44, 54, 65-79.

[12] *Biennial Reports: 1940-42*, p. 26, *1942-44*, pp. 8-10; D. Jerome Fischer, *Preliminary Report on the Mineralogy of Some Pegmatites Near Custer*, R.I. 50 (June 1945), p. 3; Charles S. Gwynne, *Pegmatites in the Beecher Rock Basin*, R.I. 48 (April 1944), p. 3.

[13] E. P. Rothrock, *Sources of Water Supply for the City of Miller, South Dakota*, R.I. 40 (December 1941), pp. 1-2, 13-14.

During 1943 Rothrock and Petsch began a study of ground water supplies for Sioux Falls, which had lost a manufacturing plant because of uncertainty about the amount of water available. With funds from the city and engineers from the USGS, the investigation continued intermittently until 1946. Within the next eleven years only one other major study of this nature was performed. In 1948 and 1953 the Survey tried to locate a satisfactory reservoir to supply the city of Aberdeen. The number of communities receiving such aid actually reached a much higher figure. By consulting available information or briefly examining an area or well the Survey staff could help solve at least some of the minor water resource difficulties.[14]

Although Rothrock was personally performing geological surveys, supervising other Survey activities, and teaching, he took time to work on what he deemed a long-overdue project. Like James E. Todd, Rothrock felt the need to compile the known facts about the geology, physiography, and mineral resources of South Dakota. By 1936, when he began writing, this task was much more formidable than it had been in 1894 and 1900, because the Survey had accumulated an inestimable amount of information. This fact alone convinced Rothrock of the advisability of publishing three bulletins rather than one large report. The first one printed in 1943 dealt with the physiography; the second one in 1944 contained descriptions of all known mineral resources.[15] The third part on stratigraphy was later assembled by the next State Geologist, Allen F. Agnew.

It has already been related how Rothrock, in face of meager funds and vague powers, had tried to enforce the conservation law regulating oil and gas wells. As drilling activities increased in the late 1930's, he realized more than ever the need to revise the 1935 law so that he could effectively supervise any test well. Therefore, while the legislature was considering a proposal to create a control board for oil and gas drilling, Rothrock followed the proceedings closely and tried to influence the adoption of adequate measures. He tried to counteract the fears that such a board would be excessively domineering by stating that its powers would extend only to preventing overproduction and conserving water, oil, and gas resources. Furthermore, he advanced his own concept of an oil and gas board, one composed of representatives of the Attorney General, the State Engineer, the State Geologist, and the oil companies in the State. However, the bill as passed in 1943 was much less than what he thought essential. Designated as members of the Oil and Gas Board were the Governor, Secretary of State, Attorney General, State Treasurer, Commissioner of School and Public Lands, and State Auditor. The State Geologist was named consultant.[16]

When asked by Governor M. Q. Sharpe to suggest rules for procedure, Rothrock submitted two proposals. First, the Geological Survey should be delegated the executing powers, which necessitated a knowledge of geology and an ability to interpret well cuttings and logs. Second, the Board should be accorded the governing authority to formulate regulations and conduct hearings. Again, his ideas were only partially adopted. The Board retained the enforcement powers and commissioned the State Geologist to scout drilling operations, recommend regulations, and collect geological information from each well.[17]

Despite his initial skepticism about the workability of this arrangement, by 1949 Rothrock was congratulating the Oil and Gas Board for its accomplishments.[18] Without saying so, he was also complimenting himself and the Survey. Although he scouted the majority of the oil wells drilled between 1943 and 1957, he sometimes delegated the task to one of the other geologists on the staff. It was through their efforts that regulation of oil

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[14]E. P. Rothrock and E. G. Otton, *Ground Water Resources of the Sioux Falls Area, South Dakota*, R.I. 56 (March 1947), 1, pp. 1-3; *Biennial Reports: 1944-46,* pp. 13-15; *1950-52,* pp. 22-25.

[15]*Biennial Reports: 1942-44*, p. 14; *1944-46*, p. 10.

[16]Rothrock, letters, February 12, 1943, to Bryan S. Payne, Pierre, Microfilm 20; March 14, 1943, to E. G. Dahlgren, Interstate Oil Compact Commission, Oklahoma City, Oklahoma, Microfilm 12; *Biennial Report, 1942-44*, p. 19.

[17]Rothrock, letter, June 2, 1943, to Sharpe, Microfilm 12; *Biennial Report, 1942-44*, p. 19.

[18]Rothrock, letters, December 27, 1949, to Members of the Oil and Gas Board, Pierre, Microfilm 6.

drilling activities became meaningful. The manner of supervision varied from a few visits to constant surveillance, depending upon the importance or uniqueness of the test or the ability of the drillers and the oil companies to keep accurate records or to acquire proper cutting samples. With few exceptions, oil tests were abandoned and plugged, after encountering no trace of oil or a show of oil insufficient for production purposes. However, most wells could be considered successful from the standpoint of providing stratigraphic information and narrowing the search for areas where oil might have accumulated.

Of the more than 200 test wells drilled in South Dakota between 1943 and 1957 examples of only the more significant ones can be mentioned. Although Rothrock encouraged oil prospecting he generally viewed with disfavor the drilling attempts by small operators because of the difficulties they often created for the Oil and Gas Board. For example, a local company spudded in a well near Newell in Butte County in 1948 and failed to complete the drilling. The company's abandonment of the well compelled the Board to call the bond for plugging it. Another well drilled in the same county in 1951 caused the waste of a large amount of water. The drillers struck such a heavy water flow they could not handle it, and because the well was not immediately plugged, the flooding ruined any oil possibilities there might have been. Other problems plaguing the small operators included stuck tools, lost circulation, and cave-ins. The larger oil companies although often faced with the same difficulties, were financially and technically more able to overcome them.[19]

Oil wells were usually, but not always, sited and drilled on the basis of structural and stratigraphic information. The doodlebug artist with his divining rod still retained an influence. In 1949 this debatable means was used to locate a well south of Chamberliain, in which a show of oil was actually encountered. Because of insufficient subsurface information for the area, Petsch stayed at the well site during drilling operations in order to collect and examine the cuttings. During the same year Charles L. Baker, an oil geologist on the Survey staff, by written agreement with the oil company, superintended the drilling of a test well in Meade County. In this one instance the Survey deviated from its policy of avoiding direct involvement because the well was located on a very promising structure and the promoters and drillers lacked experience in bringing in an oil well. Although a few shows of oil were evidenced, no production was attemptible. The expense to the State was deemed profitable as the results encouraged several major oil companies to begin their drilling activities.[20]

In 1953 the results of some test drilling began to change as the Shell Oil Company brought in a well in Harding County that produced about 100 barrels a day. By mid-1954 another well was being pumped at the same rate. These two wells signified the development of South Dakota's first oil field, the Buffalo Field. In 1955 production was begun on a second oil field, the Barker Dome Field, in Custer County where a local company had pumped some oil in 1930. The well in 1955 was brought in by A. L. Helms, an independent driller from Texas. The petroleum obtained from these three wells did not create a flourishing industry for the State; but the drilling activities did seem to offer higher prospects for the future. In addition, the supervision of oil tests by the Survey had resulted in conservation measures that confined oil shows and water to their original horizons. Although never deviating from a confidence that oil would be produced in South Dakota, Rothrock repeatedly emphasized that water was the State's most valuable and essential resource.[21]

Along with the conservation of oil and water resources, the regulation of oil tests furnished a wealth of information about subsurface conditions in western South Dakota through the Survey's accumulation of rock samples, cores, driller's logs, and electric logs. With the employment of Baker in 1945 the interpretation and correlation of these logs and samples was begun on a regular basis. By examining the cuttings with a microscope and correlating the data with outcrops and among well sites, Baker advanced knowledge on the stratigraphy of the State and offered guides for those interested in the depths and kinds of

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[19] *Biennial Report, 1952-54*, pp. 44-45, 47-48.

[20] *Biennial Reports: 1948-50*, pp. 13-15; *1950-52*, p. 29.

[21] *Biennial Reports: 1952-54*, pp. 44-45; *1954-56*, pp. 15, 19.

oil or water horizons. Also involved in this activity was Petsch who, in addition, constructed two panel diagrams showing subsurface features by carrying the formations from one well location to the next. Until the Survey purchased an electric logger in 1952 with which to log water wells, correlation of well logs meant dependence upon oil tests, since many water well records, even when made, were unreliable.[22] But with the drilling of more wells, oil or water, the picture of subsurface geology became clearer. With more stratigraphic information, oil companies might be induced to test further the oil possibilities in the State.

In connection with the well log correlations, Edward J. Bolin, a paleontologist, discovered a means of readily identifying the Niobrara formation in both well cuttings and outcrops. He found it possible to divide the formation into upper and lower zones on the basis of differing fossil, rather than rock, content. The time of Bolin's employment, February 1950, was interesting because it stemmed from two interacting considerations. First, the State Geologist desired to have the fossil content of sedimentary deposits studied. Second, the 1949 legislature had inadvertently appropriated too much money for salaries.[23] Thus began the study of microfossils in the Niobrara chalk formation, which resulted in a contribution to stratigraphy.

Any type of geological information that would aid in the search for oil was eagerly sought by oil prospectors in the State. Therefore, many of the Survey's activities during the 1940's and early 1950's were designed with this purpose in mind. To the structural surveys already mentioned could be added eight more. Although they were certainly important for the specific area under consideration, their greater significance must be aligned with the scouting of oil and gas wells and the correlation of well logs. Taken together these three activites represented not only the vitalness of learning more about the geology of South Dakota but also the stress on systematic and scientific searches for petroleum in the State.

Not since the first half of the 1920's had the Survey so actively emphasized its own role in furthering the development of an oil industry. However, the earlier situation under Ward, when almost all investigations had involved oil possibilities, had changed by the mid-1940's so that the current director could organize a variety of geological projects on a large scale. Especially was this evidenced between 1943 and 1957, during which time the Survey pursued three extensive programs. Chronologically they included studies for Missouri River development, geological mapping of quadrangles, and investigations of water reservoirs.

To provide geological information for the proposed development of the Missouri River, a series of five major investigations were undertaken. Rothrock himself began these activities with a study of gravel terraces in the Missouri Valley to make available data about the types and locations of materials needed for construction of dams. During the 1943 field season, he and his assistants mapped and appraised twenty-four gravel deposits. The original plan of traversing the entire valley was prevented by the discovery of more terraces than anticipated. The quadrangle mapping program begun in 1948 removed part of the urgency for continuing the study, although Rothrock wished to complete it if possible.[24]

A second plan to facilitate the development proposals involved a compilation on the geology of the Missouri Valley. In 1945 Petsch assembled the data by examination of earlier reports on the structural and manganese surveys and by field work to fill in the gaps. For travel along the river he was driving the Survey's first jeep, purchased as army surplus. When printed, Petsch's maps and report outlining the strata along the valley bluffs were distributed to agencies associated with river development for their use in planning construction.[25]

During the 1930's Rothrock had recommended the establishment of stream gauging stations that would measure the yearly drainage and the run-off into the Missouri River.

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[22] *Biennial Reports: 1944-46*, p. 9; *1948-50*, pp. 17, 19; *1952-54* pp. 18, 21.

[23] *Biennial Report, 1952-54*, p. 24; Rothrock, letter, January 11, 1950, to Mickelson, Microfilm 7.

[24] *Biennial Report, 1942-44*, p. 9; E. P. Rothrock, *Sand and Gravel Deposits in the Missouri Valley Between Little Bend and White River*, R.I. 47 (January 1944), pp. 1-3.

[25] *Biennial Report, 1944-46*, p. 6; Bruno C. Petsch, *Geology of the Missouri Valley in South Dakota*, R.I. 53 (June 1946).

Although the USGS and Army Corps of Engineers already maintained several stations, he thought the State should have some control over them. Therefore, in the spring of 1944 he set up nine stations for the Survey in cooperation with the Highway Commission and the Fish and Game Commission; each agency furnished $800. This arrangement ceased one year later when an agreement was reached with the USGS. The legislature had made this possible by stipulating that $8,000 of an appropriation of $28,000 must be used for cooperative work with the USGS on ground and surface water. Part of this fund was therefore used for the stream gauging program. Within four years, however, the cooperative plans were terminated, apparently because Rothrock was convinced that some reading stations were located on insignificant streams and was displeased that others had been discontinued.[26]

The proposal to irrigate the James River Valley as a feature of the Missouri River development occasioned the need for topographic maps of level lines for the basin between Mitchell and Aberdeen, for which purpose the Survey sent out two field parties in 1945. H. E. Brookman directed the study of a probable course over which the main irrigation canal was to follow through Hyde and Hand Counties. The mapping revealed that the chief obstacle would be the point at which the elevation of the land was 100 feet higher than the proposed water level of Oahe Dam at Pierre. Rothrock's group reconnoitered all of the James Valley being considered for irrigation. As could be expected, some terrains offered easier adaptability for irrigation than others. Rothrock described these findings with only enough details to serve as bases for further investigations whenever the irrigation plans were put into effect.[27]

The Survey's fifth and largest activity connected with Missouri River development was the geological mapping of the valley into fifteen-minute quadrangles. The feasibility of this immense task was demonstrated by a pilot study near Chamberlain in 1948. The legislature was sufficiently convinced to increase the appropriations from $28,000 to $57,000 for 1949-50. During most of the next three years, therefore, the Survey concentrated its time, funds, and personnel on the geologic mapping of twenty-four quadrangles, including field and drafting work. The upcoming completion of dam constructions necessitated rapidity before some of the outcrops were flooded. The Survey purchased aerial photographs with which to draft the boundaries of geological formations. Then these sketches were transposed to base maps. Financial difficulties delayed the first printing of the quadrangle maps until January 1951 because the use of color, a first for the Survey, greatly increased the cost. Eventually, however, Rothrock and Petsch developed the idea of using differently colored plates, thereby lowering the cost and enabling commercial firms in South Dakota to print the maps.[28]

Because of the success of this geologic mapping project, the Survey turned to the coal region in the northwest in 1951. A demand for detailed information on coal resources had arisen in part from the possibility of developing by-products, especially liquid fuels. Previous coal investigations had been limited by the lack of equipment with which to explore the unexposed beds. To overcome this obstacle the Survey supplemented aerial mapping with the available well logs, records of commercial testing of the coal beds, and core drilling and geophysical measurements in the field. For the test drilling of coal beds, two jeep-mounted auger drills were purchased. Until he left the Survey in October 1955, by which time most of the field work was finished, Robert E. Curtiss directed the program of mapping and appraising the coal area. Thereafter, Petsch supervised the investigations to their completion in 1956. The study of resources for this project revealed an estimated one-half billion tons of coal obtainable by strip mining, indicated possible uranium deposits, and located gravel deposits. Unlike the quadrangle maps of the Missouri Valley, those covering the coal regions included a text on the back of each map, which depicted the prominent geological features

[26] *Biennial Reports: 1942-44*, p. 11; *1944-46*, pp. 3, 7-8, *1946-48*, pp. 10-12; Rothrock, letter, June 21, 1951, to Henry J. Hunt, Madison, Wisconsin, in Files.

[27] *Biennial Report, 1944-46*, pp. 6-7, 11-12.

[28] *Biennial Reports: 1948-50*, pp. 7, 9-10, 19; *1950-52*, pp. 9-11, 15, 33-34; Petsch, personal interview, April 24, 1967.

and the major resources within the area.[29]

While the coal mapping project was still in progress, uranium prospecting gained popularity. The possibility of discovering valuable deposits induced many people throughout the State to wander over the planes and hills with a geiger counter in hand. On a more controlled level the Atomic Energy Commission was scouting western South Dakota and had found large deposits in Fall River and Harding Counties. The Survey assisted in this prospecting, at the request of the AEC, by testing for radioactivity in the core holes during the coal surveys. In order to make available the information on uranium possibilities and to offer guides for prospecting, Curtiss prepared a special report in 1955 which included his findings and data from the AEC office in Hot Springs. He described the geological features of uranium-bearing areas, the sections of the State favorable for uranium deposits, and methods of prospecting.[30]

The public interest in uranium made possible the start of another geologic mapping program. Residents in the White River Valley signed petitions requesting an investigation of not only uranium deposits but also water resources. In 1956 Agnew, who became State Geologist a year later, and Robert E. Stevenson, professor of geology at the University, began field work on three quadrangles and completed one. The project was continued in 1957, at the same time another one was resumed. In 1951 and 1952 five quadrangles north and south of Watertown had been mapped by Rothrock and Bolin. Because of an interest in flood control and water development on the Big Sioux River, the governor had asked the Survey to study the gravel deposits and water reservoirs of the river valley.[31] Although Rothrock planned to extend mapping along the entire valley, other studies of water resources and the mapping of the coal region intervened as more essential.

In each of his biennial reports after 1940 Rothrock had recommended various types of water investigations. Those put into operation in the 1950's included studies of artesian and shallow water resources and surveys of individual wells. The assistance given to communities with water supply problems and the measurement of water fluctuations in lakes and wells in eastern South Dakota had been continued regularly since the drought of the 1930's. As the records of water levels continued over a long period of time (Rothrock suggested fifty to one hundred years), they would serve as bases for predicting the amounts of water available for domestic, industrial, and irrigation purposes. Throughout the 1940's and 1950's the same twelve lakes as before were measured, but some of the wells had caved in and were replaced by drilling new ones. The Survey assembled the data from the readings into a report in 1947 and a map in 1952. Both compilations revealed a general rise in the water table and the lake levels, with minor changes according to seasons and rainfalls. The water level measurements continued on a cooperative basis until the USGS assumed the entire program in the early 1960's.[32]

A new phase in ground water studies was introduced in 1952 with the purchase of an electric well logger. During the first four years of its use sixty-two wells were logged, mostly by Petsch who sometimes averaged three or four wells per week. The Survey thus acquired its first reliable subsurface data for eastern South Dakota, which included the essential identification of water sands and the determination of their depth. The electric logging also made possible in 1955 the first report on well log correlations that was devoted primarily to the eastern half of the State.[33]

The electric logger also facilitated three of the four artesian water studies in the 1950's.

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[29] *Biennial Reports: 1950-52*, pp. 13-14; *1952-54*, pp. 9, 36-37, 55; *1954-56, pp. 9-11, 32; 1956-58*, pp. 8-9; Rothrock letter, May 15, 1952, to Robert H. Miller, Natural Resources Commission, Pierre.

[30] *Biennial Report, 1954-56*, pp. 11, 41; Robert E. Curtiss, *A Preliminary Report on the Uranium in South Dakota*, R.I. 79 (June 1955), pp. 18-28, 99-100.

[31] *Biennial Reports: 1950-52*, pp. 14-15, *1952-54*, pp. 12-13; *1956-58*, pp. 10-11.

[32] Biennial Reports: 1942-44, *p. 8; 1946-48*, pp. 9, 11, 16; *1948-50*, p. 12; *1950-52*, p. 35; *1954-56*, p. 13.

[33] *Biennial Report, 1954-56*, pp. 14, 27, 38-39; Petsch, personal interview, April 24, 1967.

The 1935 investigation in western South Dakota had been designed to alleviate water shortages. But artesian water in the eastern part of the State was used more extensively and, over the decades, had undergone a greater amount of wastage and a greater loss of pressure. For just as long, people had lamented these problems, but little had been done to implement solution. Finally, the Survey decided to attack the difficulties by determining the geological unknowns about artesian reservoirs.

All of the east river area, excepting six counties in the northwestern part, was investigated between 1951 and 1954 by two staff geologists, Raymond C. Barkley and Harold D. Erickson. The procedure of obtaining stratigraphic information involved the microscopic examination of well cuttings to determine lithologic characteristics and, beginning in 1952, the electric logger. The surveys revealed three general conclusions which varied in detail from region to region. First, from three to four horizons existed as sources of artesian water. Second, since the early 1900's, loss of pressure had lowered the artesian head in amounts ranging from 100 to 300 feet, especially in the Dakota formation. Third, some of this loss was recoverable by proper well construction and controlled water usage.[34]

Although the Survey had located and evaluated shallow water reservoirs in some of the city water studies and the Big Sioux Valley mapping project, much more information was needed as raw materials for the increasing number of pump irrigation proposals. Between 1954 and 1956 a small beginning was made with the investigation of four gravel outwashes in parts of Edmunds, Potter, Douglas, and Turner Counties. The field parties determined the amount of water available for irrigation from these reservoirs and the depth and character of the outwashes. Studies of this type were intended to provide a geological foundation for proper usage of the water resources, whether for domestic, irrigation, or industrial purposes. But it was not enough to demonstrate the locations and the amounts of water and then to prescribe precautions without the machinery to execute the necessary forms of conservation. When the legislature did consider this type of control in the mid-1950's, Rothrock received an opportunity to present his ideas through appearances before the Legislative Research Council.[35]

The fact that the State Geologist was asked to advise in legislation indicated advancement from twenty-five years before when the legislature had not considered that office important enough to receive financial support. When Rothrock resigned on July 1, 1957, he could look back upon a career of almost thirty-one years with satisfaction.[36] He had begun with a one-man organization and ended the last few years with an office staff of four to six geologists and varying numbers of secretaries, draftsmen, and laboratory and field assistants. The appropriations had increased from zero to $69,000. Physical quarters in Science Hall were similarly improved from a situation in which the Survey was sharing facilities with the various science departments to one in which the Survey acquired its own offices, free from daily class disturbances. This occured in 1953 when the botany and zoology departments and the school of medicine were removed to a new building. Thereafter the Survey's facilities consisted of office space for the entire staff, a library shared with the geology department, a drafting room, a printing room, a well sample storage room, a storage room for fossils, rocks, and mineral collections, and an adequately equipped laboratory. In addition, the Survey owned a garage to house its ten jeeps and three drills.[37]

The utilization of these expanded funds, personnel, and facilities signified the essential contributions of the Survey. Rothrock's major purpose throughout his years as State Geologist had been to make geology an important factor in the State's economy. It must

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[34] *Biennial Reports: 1950-52*, pp. 14, 44; *1952-54*, p. 37; *1954-56*, pp. 13, 39; Raymond C. Barkley, *Artesian Conditions in the Area Surrounding the Sioux Quartzite Ridge*, R.I. 72 (April 1953), pp. 4-6.

[35] *Biennial Reports: 1952-54*, p. 61; *1954-56*, p. 12; *1956-58*, pp. 11-12.

[36] The Association of American State Geologists honored Rothrock by electing him President in 1951. See, *Biennial Report, 1950-52*, p. 23. After his resignation in 1957, Rothrock remained with the department of geology on a part-time basis.

[37] *Biennial Report, 1952-54*, p. 36.

have been very self-gratifying for him to realize the achievement of this goal.[38] From 1926 to 1957 the Survey had located water supplies during the drought, sought metal deposits during World War II, aided Missouri River development, furnished data for oil drilling, appraised coal deposits, and begun the investigation of water reservoirs. In conjunction with each project, more information was added to the knowledge about the geology of South Dakota.

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[38]In *Biennial Report, 1954-56*, p. 57, Rothrock stated, "The South Dakota Geological Survey...has reached a point where it can be a potent force in the development of the resources of the State."

CHAPTER VI

CONTINUITY, 1957-67

As the fifth State Geologist, Allen F. Agnew, executed his responsibilities from 1957 to 1963, the permanence of the Geological Survey became readily apparent. Each of his predecessors, upon assuming his position, had built upon the previous activities of the Survey. Yet each State Geologist had, in a sense, begun anew by re-establishing a staff and geological studies. Whereas Agnew, although instituting his own innovations, directed the Survey from the very first with the staff and projects in force under E. P. Rothrock. For the first time since 1893 the new administrator could begin his work without an initial interruption for revising geological programs.

Before coming to South Dakota, Agnew had pursued studies in geology at the University of Illinois, from which he had received a B.A. and M.S., and at Stanford University, from which he had received a Ph.D. Experience included work with the Illinois State Geological Survey and the United States Geological Survey on mineral deposits, oil, coal and ground water. In 1955 he became a professor of geology at the University of South Dakota and in 1956 performed his first investigation for the Survey, geologic mapping along the Little White River. When Agnew assumed the office of State Geologist on July 1, 1957, he could concentrate on its duties, for at Rothrock's suggestion, it was arranged that the State Geologist no longer act as chairman of the geology department. Dr. Robert E. Stevenson took over the latter position. However, in order to comply with the 1939 statute the State Geologist was retained as a professor of geology. This meant that during the school year Agnew devoted one-third of his time to teaching and two-thirds to directing the Survey.[1] This policy has continued, accompanied by close relations between the Survey and the geology department.

By 1957 occupancy in Science Hall had been reduced to the departments of geology and physics, the School of Education, and the Geological Survey. However, the building was in such disrepair that it was condemned in February 1958 and three days were allowed for vacating personnel and equipment. The Survey moved temporarily to the fourth floor of the Student Union. Despite the reduced amount of space and disruption of facilities, geological studies continued as before, except for less emphasis on laboratory work. For example, the program of examining well samples was maintained but held to a minimum.[2]

Four years later, in the spring of 1962, the new Science Center was ready for use. The Survey was given approximately three-fourths of the third floor. Facilities included laboratory space for analyses and experiments, a drafting room, a file room, and several individual offices.[3]

Although Agnew introduced new methodology, he continued to administer the Survey according to the basic philosophy that had developed throughout the years. Therefore, the programs of operation consisted of "fundamental and applied research geared to serve mineral industries and the public in attaining a greater knowledge and a better understanding of the geology and mineral resources of the State." These basic studies would provide the geologic foundation for economic utilization of resources.[4]

Because Agnew desired to amplify the numbers and types of geological investigations, he actively sought increased appropriations by attempting to demonstrate the usefulness of both basic and applied research. The growth in appropriations revealed his success; the legislature provided $84,824 for 1957-58 and $179,900 for 1961-62. At the same time, the Survey was compelled to consider the tax payer and to ensure careful spending of his money.[5] Among the multiple activities made possible by the larger appropriations, it will be

[1] *Biennial Reports: 1956-58*, p. 38; *1958-60*, p. 10; Rothrock, personal interview, May 4, 1967.

[2] *Biennial Report, 1956-58*, p. 40-41.

[3] *Biennial Report, 1960-62*, p. 35.

[4] *Biennial Report, 1958-60*, p. 9.

[5] Agnew, Bloomington, Indiana, letter, May 19, 1967, to the author.

feasible to consider only the significant and representative ones. These will include geophysical surveys, geological mapping programs, and several projects done in cooperation with various governmental agencies.

In 1939 the Survey had initiated a program of studies to aid in the search for oil. After an eleven-year delay because of the quadrangle mapping projects, Bruno Petsch was able to resume the recording of magnetic readings in 1957. By 1964 he had completed the study for the entire State. Over the twenty-five year period the program had entailed twelve summer field seasons and approximately 3,690 magnetometer readings. The results were both geologically and economically significant. One, the vertical intensity of the magnetic field in South Dakota became known. Two, geological interpretations of the readings indicated the extents of the major structural features in the State. Three, the maps outlined the magnetic units of Precambrian formations. Four, iron deposits were unexpectedly found in six localities in northeastern and southeastern South Dakota.[6]

Another geophysical study concerned the applicability of resistivity techniques for outlining glacial outwash deposits in ground water investigations. David Lum, a geophysicist on the Survey staff, tested two different methods in conjunction with the mapping of the Big Sioux River Valley in 1957 and 1958 and with city water studies in 1959. He found neither technique completely satisfactory for detecting buried outwash channels because of difficulties in interpreting the data. In some areas physical conditions, such as excessive water saturation, prevented the acquisition of information. A second experiment with geophysics involved the use of a gravity meter to measure the surface variations in the earth's gravitational field. With support from a National Science Foundation Grant, Lum made gravity observations across the State from the Black Hills to the quartzite outcrops near Sioux Falls. In 1960 Edward L. Tullis, chairman of the department of geology and geological engineering at the School of Mines, directed the same type of survey in the southwest central counties. The gravity observations were designed to assist in discerning regional structures and structural trends.[7]

Besides the geophysical studies, the Survey continued the geologic mapping projects in various parts of South Dakota. During the summers of 1957 and 1958 Survey geologists K. Y. Lee, Merlin J. Tipton, and Fred V. Steece directed the mapping of ten quadrangles in the Big Sioux River Basin. As usual, the surface geology was mapped on air photographs and jeep-mounted auger drills were used to locate the water-bearing sand and gravel deposits. Between 1958 and 1960 other areas of the State mapped for the purpose of acquiring information about shallow ground water supplies included three quadrangles in the southern part of the James River Basin and three in the region around Timber Lake.[8]

The geologic mapping in south central and southwestern South Dakota between 1957 and 1963 resulted in the publication of sixteen quadrangle maps. The geologists investigated the geology of the Tertiary period, supplies of ground water, and deposits of sand and gravel, volcanic ash, and clay. The mapping of part of the Pine Ridge Reservation in 1959 embodied a third purpose to provide stratigraphic descriptions for the vertebrate fossil collections of J. R. Macdonald, formerly with the School of Mines. The research venture as a whole represented a unique example of cooperation among both State and federal agencies. A National Science Foundation Grant financed Macdonald's paleontological studies. The Pine Ridge Indian Agency furnished air photographs for the mapping; the School of Mines supplied surveying equipment. The Geological Survey provided personnel, jeeps, and tents and prepared the maps and geological report for publication. The American Museum of Natural History printed Macdonald's report on vertebrate paleontology. The mapping of the Tertiary deposits by John C. Harksen, who became a full-time member of the Survey staff in 1965, substantiated Macdonald's view that a new distinct stratigraphic unit, named Sharps

[6] *Biennial Report, 1962-64*, p. 23; Bruno Petsch, "Report of Geologist-Geophysicist," *Biennial Report, 1964-66*, pp. 30-31; Petsch, personal interview, April 24, 1967.

[7] David Lum, *The Resistivity Method Applied to Ground Water Studies of Glacial Outwash Deposits in Eastern South Dakota*, R.I. 89 (March 1961), p. 2; *Biennial Reports: 1958-60*, pp. 41-64; *1960-62*, pp. 26-27.

[8] *Biennial Reports: 1956-58*, p. 40; *1958-60*, pp. 11, 38, 40; *1960-62*, p. 9.

Formation, was present in the early Miocene sediments.[9] Findings such as these enabled geologists to decipher more accurately the geological history of western South Dakota.

Cooperative projects, such as the studies in the Pine Ridge Reservation, were common throughout the years that Agnew was State Geologist. By emphasizing reciprocal liaisons with federal, state, and local agencies he made a lasting contribution to the Survey. Agnew felt that one of the most interesting challenges he successfully met was the establishment of close relations between the survey and the School of Mines. Former State Geologists, especially Rothrock, had employed their geologists for work with the Survey. But Agnew went beyond this practice by consulting with personnel at the School of Mines on matters concerning geological investigations undertaken by both institutions. At times the meetings also included representatives from State College and the Homestake Mining Company. Although Agnew would have preferred to direct the Survey through an official board of technical advisors, he realized the impracticality of the idea because there were so few geological industries and professional geologists in the State. So he continued to utilize the services of an unofficial board.[10]

The abundance of reciprocal cooperative activities through both consultations and geological studies necessitated selection of the more prominent illustrations. Most of the coordinated investigations were initiated between 1958 and 1961 with various governmental agencies and concerned ground water, topographic mapping, and highway geology. Of the three types of projects, the ground water studies received the most attention (about forty-five per cent of the Survey's non-administrative activities for 1961-63). This development was intentional, as demonstrated by testimony before the United States Senate's Select Committee on National Water Resources at a hearing in Huron in October 1959. Agnew, Tipton, and Steece outlined long-range plans to investigate ground water resources, in particular glacial deposits in eastern South Dakota and artesian basins in western South Dakota. In addition, they intended to maintain the individual studies of local water supply problems.[11]

Since the 1930's the Survey had regularly performed this service. Agnew, however, was able to apply Rothrock's prior recommendation that individual cities should receive detailed ground water studies. Thus, twenty-five reports on city water resources were published, although many other communities were similarly surveyed on a less comprehensive basis. The geologists performing these studies limited their findings to suggestions about the best aquifers and favorable sites for drilling. The information thus furnished guidelines for city officials and, in addition, enhanced the knowledge of glacial deposits and Tertiary sediments. Two alterations in the city water surveys occurred in 1961. By appropriating $30,000 for equipment, the legislature made possible the purchase of a water truck and a large rotary drill rig. The new drill enabled Survey crews to make deeper test holes up to 1,000 feet and to penetrate the harder bedrock formations. The legislature also stipulated that each community must pay one-half of the expenses for a survey of water supplies.[12]

At the state level, the Survey worked closely with the Water Resources Commission, which regulated water usage and conservation. The Survey not only provided the results of its ground water studies but also undertook special projects for the Commission. During the 1960-62 biennium, for example, two Survey geologists, Ian R. Walker and Earl J. Cox, investigated three regions where irrigation had seriously decreased the water supplies. In an area around Wagner and in Beadle County irrigation had caused a decline in water levels, thus diminishing the supplies for domestic and farm uses. In the summer of 1960 Walker

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[9] *Biennial Reports: 1956-58*, p. 41; *1958-60*, pp. 13, 40-41; *1960-62*, p. 9; *1962-64*, p. 8; J. C. Harksen, J. R. Macdonald, and W. D. Sevon, *New Miocene Formation in South Dakota*, State Geological Survey, Miscellaneous Investigations No. 3 (June 1961), pp. 1, 11. Hereafter all such reports cited as M.I., with the appropriate number.

[10] *Biennial Report, 1958-60*, p. 35; Agnew, letters, July 17, 1961, to Edward L. Clark, Director, Colorado Department of Natural Resources, Denver, Colorado, in Files; May 19, 1967, to the author.

[11] *Biennial Reports: 1958-60*, p. 54; *1962-64*, p. 23; Allen F. Agnew, Merlin J. Tipton, and Fred V. Steece, *South Dakota's Ground Water Needs and Supplies*, M.I. 4 (June 1962), pp. 8-9.

[12] *Biennial Reports: 1958-60*, pp. 15-16, 42-43; *1960-62*, pp. 12-14; *1962-64*, pp. 8-10.

examined the water-bearing sand and gravel deposits in both regions. For each he recommended a program of test pumping before planning long-term irrigation from the buried outwashes. Because of an increase in irrigation from artesian basins in the northern Black Hills and a decrease in the pressure and flow of water, Cox, at the Commission's request, mapped the outcrops and checked the wells and springs in 1961. He advised the cessation of drilling wells for irrigation until additional studies could determine the magnitude of lost pressures and flows in the artesian aquifers.[13]

In 1959 the Survey, in cooperation with the Ground Water Branch of USGS, commenced a program to study the geology and hydrology of individual counties, upon the request of county commissioners. For this purpose the 1959 legislature had appropriated $10,000.[14] Because of average size and interest in irrigation possibilities, Sanborn County was selected for the pilot study. For the State Survey, Steece mapped the surface geology and with data from test holes interpreted the subsurface geology. For the USGS, Lewis W. Howells inventoried wells in the county and made hydrologic tests of the aquifers. Because of the comprehensive objectives underlying the county investigations, information was acquired on all mineral commodities, such as sand and gravel for road construction. In 1961 Beadle County was added to the cooperative program.[15]

Work in both counties was discontinued in 1962 because of legal and financial difficulties. As originally organized, each investigation was financed by the USGS and the State Survey, each furnishing forty-four per cent of the total cost, and the county, twelve per cent. However, in April 1962 the Attorney General ruled that moneys received by the Survey from government agencies in South Dakota must go directly to the General Fund. Because of the impossibility of anticipating exactly the demand for county investigations, the Survey requested the creation of a Revolving Fund. In this manner the need to wait until the next legislative session for an increase in the regular appropriation would be eliminated. In 1963 the legislature did authorize a Revolving Fund of $25,000 so that the Survey could accept payments from any local or state government bureaus in South Dakota. This policy applied also to the city ground water studies. The financing for the county projects was altered so that the State Survey and the county each paid twenty-five per cent of the cost and the USGS fifty per cent. Under this arrangement field work in 1963 was completed in Sanborn and Beadle Counties and was begun in Clay County.[16]

A second category of cooperation with the USGS was a program of topographic mapping. Agnew began his efforts in 1958 by organizing an eleven-member Topographic Mapping Advisory Committee which was to plan the mapping project and to coordinate requests on the basis of value and priority.[17] By then, the Topographic Division of the USGS had mapped approximately one-third of the State, mostly in the Black Hills and along major river valleys. The Advisory Committee estimated that it would cost approximately $2,500,000 to complete the remaining regions. The State and the USGS would each furnish one-half of the expenditures. The USGS would also assume the responsibility for field work and for drafting and printing the maps. The 1961 legislature made possible a modest beginning by appropriating $10,000 for the project. Because the Highway Commission contributed $5,000 and the USGS more than its scheduled amount, work was started on ten

[13] *Biennial Reports: 1958-60*, p. 24; *1960-62*, pp. 17-18, 26.

[14] Part of this fund was used for a long-term cooperative study of the geology and hydrology of the Dakota sandstones. See *Biennial Report, 1958-60*, p. 44.

[15] *Biennial Reports: 1958-60*, pp. 10, 40; *1960-62*, p. 24. Cleo M. Christensen, "Ground Water: Counties," *Biennial Report, 1962-64*, p. 41.

[16] *Biennial Reports: 1960-62*, pp. 59-60; *1962-64*, pp. 12-13; *1964-66*, p. 16.

[17] A variety of interested State agencies were represented by the members of the Advisory Committee—the State Geologist, Director of the Department of Aeronautics, State Engineer, Director of the Game, Fish and Parks Department, Chief Highway Engineer of the Department of Highways, Research Director of the Industrial Development Expansion Agency, Commissioner of School and Public Lands, Director of the Department of Taxation, Chief Engineer of the Water Resources Commission, President of the School of Mines, and President of State College.

seven-and-one-half minute quadrangles in eastern South Dakota. These and other topographic maps would be useful for a variety of purposes, including detailed geologic studies, mineral resources evaluations, and highway construction.[18]

A third type of cooperation concerned studies in highway geology. For the summer of 1959 two Survey field parties, supervised by Cox, were transferred to the Department of Highways for geologic mapping of fifty-three highway strips in scattered parts of the State. Both institutions profited from the project. Highway engineers could use the information to anticipate difficulties due to geologic conditions and the Survey obtained geological data for many regions that had never been mapped in detail. Another project involving highway geology was arranged with the Highway Commission, which in 1961 requested proposals for research. It accepted the Survey's suggestion for evaluating methods of searching for coarse aggregate in eastern South Dakota. Agnew placed Richard L. Bruce in charge of the project, which was begun in May 1962. Bruce and his assistants were assigned directly to the Highway Commission until the legislature approved the Revolving Fund in 1963. Then the Survey took over the administrative responsibilities. The experiments and evaluations demonstrated that integrated use of air photographs and geologic, topographic, and soil maps would accelerate field work for aggregate studies and that use of the electrical resistivity method would lessen the number of drill holes needed to verify aggregate deposits.[19]

The cooperative programs for ground water studies, topographic mapping, and highway geology were consequential for all concerned. Each governmental entity obtained the geological information it desired for a specific purpose. The Survey could also integrate the data from several investigations as a means to learn more about the mineral resources or geology of South Dakota over a larger area or in greater detail than from individual surveys. Such advancements usually resulted from studies undertaken by the Survey alone or in cooperation with other agencies. Yet the individual layman could occasionally make a significant contribution.

The Survey served the public and the private citizen by making available its geological findings. The process was, however, reversible. In August 1958 Lawrence McElvain, a farmer in Miner County, found several unusual pieces of wood on his land. Radiocarbon dating determined that the fragments were 12,200 years old. This caused geologists to revise their maps for the area where the wood had been located. Another discovery, an ancient sea urchin from a hill of Pierre shale in eastern Fall River County, was made by Agnew's son, Allen. Fossils of this type had never before been found in the Pierre formation in South Dakota. The discovery thus meant added information about the temperature and salinity of the sea that had covered the State eighty million years before. In 1959 Don Roosa and State Representative Lawdon Heller located the bones of a mosasaur in southeastern Lyman County. Upon the Survey's recommendation, the Museum at the School of Mines was notified. A team of paleontologists then excavated the fossil.[20] Notable discoveries of fossil woods or animals were, of course, infrequent. But by giving them special emphasis Agnew demonstrated that the Survey and the citizen could aid each other in discerning the geology of South Dakota.

While State Geologist, Agnew pursued few field investigations, except, for example, the completion of the Mission quadrangle map in 1963. He did, however, complete the three-part series of bulletins on the geology of South Dakota. Rothrock had finished the writing of the first two on physiography and mineral resources in the early 1940's. From 1959 to 1963 Agnew, assisted by John M. Keach, a geology graduate student at the University, and Paul C. Tychsen, a professor of geology at Wisconsin State College, compiled data on the stratigraphy of the State. The report, written as a lexicon, described 283 stratigraphic names which were classified according to mode of usage—accepted, indefinite,

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[18] *Biennial Reports: 1958-60*, pp. 65-66, 70; *1960-62*, pp. 55, 60-61.

[19] Allen F. Agnew, "Forward," in Earl J. Cox and others, *Geology of Selected Highway Strips in South Dakota*, R.I. 93 (November 1962), pp. iii-iv; *Biennial Reports: 1960-62*, p. 34; *1962-64*, p. 11; Richard L. Bruce, "Report of Highway Geologist," *Biennial Report, 1962-64*, pp. 52-53.

[20] *Biennial Report, 1958-60*, pp. 33-34, 62-63.

rejected, or informal. Precambrian, Pleistocene, and Recent sediments were omitted, except for brief discussions, because the nomenclature had not yet been thoroughly worked out.[21]

Because of numerous responsibilities, Allen F. Agnew reorganized his staff in order to facilitate the operation of the Survey's activities. He created first in 1957 the office of Administrative Assistant to which he appointed Mrs. Elvina Stafne, who had been a secretary for the Survey since 1948. For efficiency in executing his duties as technical advisor for the Oil and Gas Board, Agnew employed Cox as the Engineering-Petroleum Geologist in 1959. Because most of the oil tests and both oil fields were located in western South Dakota, a field office with Cox in charge was established at Belle Fourche in February 1960. His main duties concerned developments in test drilling and oil and gas production. (By 1964 there were nineteen producing wells in the Buffalo Field and one in the Barker Dome Field.) It was soon found, however, that the Western Office could take care of other geological activities in that part of the State. Already mentioned have been the artesian water investigation and the mapping of highway strips. In addition, Cox undertook other miscellaneous projects, such as an examination of geological formations in the 150 silos being built for the Minuteman missiles in western South Dakota.[22]

Because of increasing commitments assumed by Agnew in his work with various governmental agencies, he appointed Merlin J. Tipton to direct all ground water investigations in 1960. As administrative duties continued to grow, Agnew felt it necessary to establish the office of Assistant State Geologist, for which he selected Tipton in 1962. In his new position, Tipton acted for the State Geologist when he was unavailable, supervised all field and office personnel and handled preliminarily any questions concerning Survey programs. At the same time, Agnew assigned specific duties to other staff geologists--Bruce as Highway Geologist, Petsch as Geologist-Geophysicist, Robert A. Schoon as Geologist-Driller, and Steece as Research Geologist. In most cases these administrative changes meant merely the official assignment of titles to staff members who were already performing the tasks connected with the position. But Agnew believed that even in a small organization, specialties and proficiencies could be emphasized.[23]

Underlying the personnel centralization was the fact of expanding activities, a process that extended from the increase in geological projects during the 1940's and early 1950's. With this foundation, similar advancements were possible which, under Agnew's direction, purported coordinated relationships between the Survey and other State agencies and institutions and cooperative investigating programs. Agnew explained these developments from the standpoint of improved public relations. The Survey geologists through their research and interpretations maintained vital contacts with the citizens of South Dakota. Agnew then applied this public image to his associations with State agencies, in particular the legislature.[24] Here again the State Geologist was pursuing what his predecessors had done. However, because the Geological Survey had become a well-staffed and well-financed organization by 1957, Agnew could consciously systematize public relations. In addition, he could act primarily as an administrator and rely upon his geologists to pursue the various field investigations. In essence, the Survey has continued to function in this manner.

On September 1, 1963, Agnew turned over the office of State Geologist to Dr. Duncan J. McGregor, Before this, McGregor had been employed with the Kansas State Geological Survey, the Sinclair Oil and Gas Company, Indiana University, and the Indiana Geological Survey.[25] Because he remains the State Geologist (1967) a discussion of the Survey's

[21] *Biennial Report, 1962-64*, p. 8; Allen F. Agnew and Paul C. Tychsen, *A Guide to the Stratigraphy of South Dakota*, Bulletin 14 (1965), pp. 4, 25.

[22] *Biennial Reports: 1948-50*, p. 25; *1956-58*, pp. 48; *1960-62*, p. 29; *1962-64*, p. 11.

[23] Agnew, form letter, July 5, 1962, in Files; *Biennial Report, 1962-64*, p. 21.

[24] Agnew, letter, May 19, 1967, to the author.

[25] Jaques Cattell, Garrison Cattell, and Dorothy Hancock, eds. *American Men of Science: A Biographical Directory* (Tempe, Arizona, 1961), p. 2573. In 1957 Agnew went to Indiana University where he became a professor of geology and Director of the Water Resources Research Center.

activities during his administration is necessarily incomplete. Already described have been some studies that were initiated earlier and terminated between 1963 and 1967. These include the magnetometer survey and the experiment with methods of locating aggregate deposits.

The program of ground water investigations was continued for both cities and counties. Between 1963 and 1966 Lynn S. Hedges supervised the completed studies of water supply for fourteen cities in various parts of the State. Cleo M. Christensen was placed in charge of the program to acquire geologic and hydrologic information for individual counties, in cooperation with the USGS. Surveys were finished for Clay and Campbell Counties and begun in Bon Homme County and, as one unit, in Charles Mix and Douglas Counties. An unexpected development in this long-range project was the rapid increase of requests for ground water investigations. By mid-1966 the waiting list included twenty-two counties.[26]

Upon initiating a study of the Dakota artesian aquifer, Schoon became involved in another attempt to acquire data about the quantity and quality of water in South Dakota. He also planned to determine the thickness and aerial extent of the formation. Other projects in the field of subsurface geology concerned the hundreds of oil tests and water wells that had been drilled before 1966. Continued use of the Survey's electric logger had furnished most of the water well logs. In an effort to keep such stratigraphic information current and available to the public, Schoon compiled two circulars on the formation tops of 448 oil tests and 250 water wells. He also assembled oil and gas maps on which were located oil tests within eleven western counties.[27]

Still being pursued were several geologic mapping projects. In 1964 Steece resumed the mapping of the Big Sioux River Valley in four quadrangles south of Sioux Falls. At the same time, Harksen continued to map quadrangles in the Tertiary area in south central and southwestern South Dakota. A new feature was a long-term proposal to complete all of Bennett County and then to compile a comprehensive report incorporating all the surveys in the county. Steece planned the same procedure for several northeastern counties. He began in 1966 by reconnoitering the region to obtain a geological framework for the detailed mapping. In addition, he was examining the various drift sheets as part of an effort by several Survey geologists to decipher the Pleistocene or glacial geology of eastern South Dakota.[28] This interest had long been a concern of investigations in that part of the State. One of the pioneers in this pursuit was James E. Todd who had surveyed glacial deposits in the 1890's.

In 1964 Bruce began a three-year study of landslides in South Dakota. In the past this had been a minor problem because most highways were built to follow the natural terrain. But increased federal funds also meant compliance with more rigid requirements, such as straighter roadways and deeper cuts, which caused landslides in some areas. During his field investigations Bruce emphasized the most troublesome regions, the Pierre Hills along the Missouri River and the Black Hills. The project was designed to aid the highway engineer by identifying the geologic units prone to landslides.[29]

Although the Survey was concerned primarily about basic and applied research in geology, it also had the responsibility to meet educational needs of students, teachers, and the general public. This task was fulfilled in a number of ways. The Survey geologists frequently presented lectures on mineral resources and geology before civic, professional, and academic organizations. At the request of the Natural Resources Commission in 1948, the Survey had begun a practice of preparing exhibits for the annual State Fair in Huron.

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[26]Lynn S. Hedges, "Ground Water: Cities," *Biennial Report, 1962-64*, p. 40: Lynn S. Hedges, "Commodity Studies: Ground Water: Cities" and Cleo M. Christensen, "Commodity Studies: Ground Water: Counties," *Biennial Report, 1964-66*, pp. 20-22.

[27]Robert A. Schoon, "Report of Subsurface Geologist," *Biennial Report, 1964-66*, pp. 31-32.

[28]Fred V. Steece, "Basic Geologic Studies: Report of Research Geologist," *Biennial Report, 1962-64*, p. 52; Fred V. Steece, "Basic Geologic Studies: Report of Research" and J. C. Harksen, "Report of Stratigrapher," *Biennial Report, 1964-66*, pp. 29, 33.

[29]Richard L. Bruce, "Report of Highway Geologist," *Biennial Report, 1964-66*, p. 30.

Petsch usually took care of this by constructing displays on varying themes, such as geophysical instruments, oil drilling, and geologic maps. Shortly after becoming State Geologist, Agnew had started a modest program of supplying to schools and State residents specimens of rocks and minerals found in South Dakota. McGregor broadened the education objectives by establishing an area of Educational Services. Petsch, assigned to supervise the program, prepared logs of the major highways in the State. These road logs, designed to aid tourists, described geological features, historical events and locations, and geographical points of interest.[30]

Coordination seems to describe the development of the State Geological Survey between 1957 and 1967. Concerted efforts to assist a community or State organization facilitated active cooperation. One obvious form was the combination of resources for geological investigations. Another was the exchange of independently acquired information. In addition, the Survey was coordinating the wealth of geological data, that it had accumulated since 1893, into broadened areas. Therefore, for example, results from a study involving glacial deposits in one region could accelerate the attempt to learn more about the history of the Pleistocene period in eastern South Dakota. Even more generally, specific findings could be applied to the ever-growing facts and theories about the geology of the entire State.

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[30] *Biennial Reports: 1948-50*, pp. 21-22; *1956-58*, pp. 31, 44-45; Bruno Petsch, "Educational Services," *Biennial Report, 1964-66*, p. 34.

PLATE 16

Allen F. Agnew

State Geologist, 1957-1963

PLATE 17

A

The South Dakota Geological Survey occupies space on the third floor of Akeley Science Center at the west edge of the University of South Dakota campus in Vermillion.

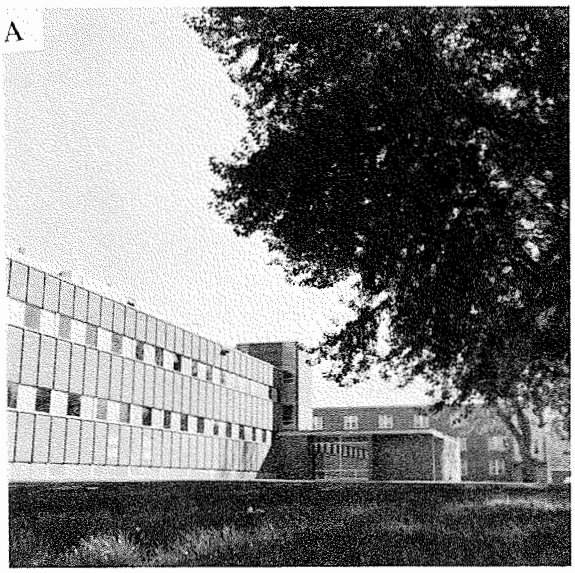
B

Dr. Allen F. Agnew editing his manuscript on possible underground storage of natural gas in South Dakota.

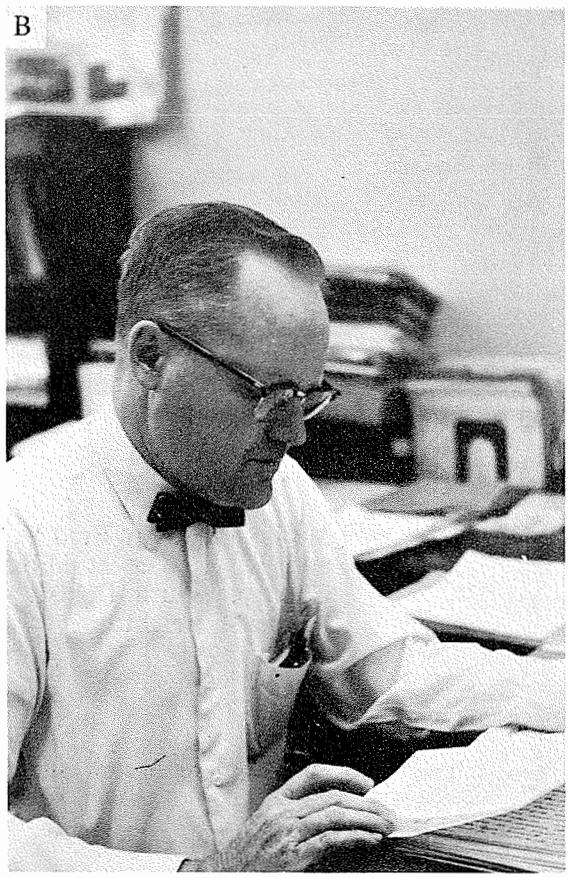
C

Drilling a core of rock over the Spink Magnetometer High two miles east of Spink, South Dakota.

A



B



C

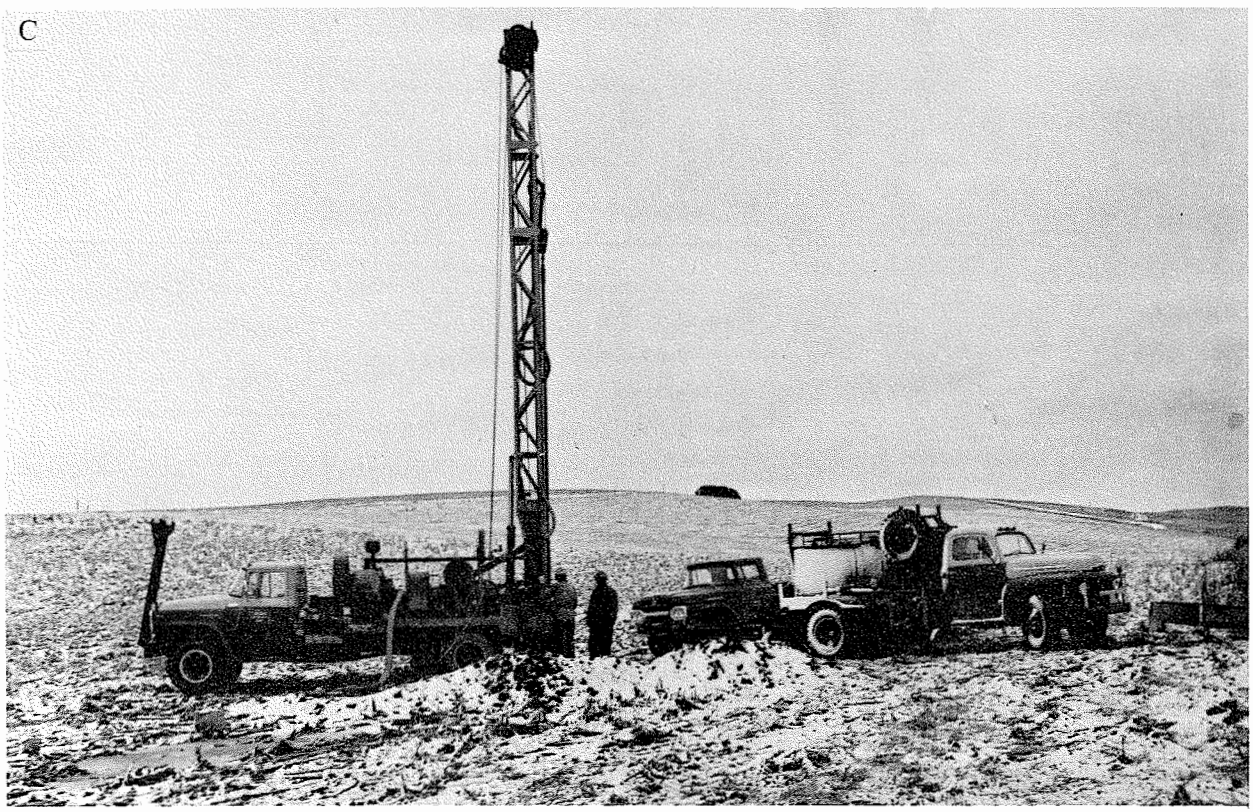


PLATE 18

A

Merlin J. Tipton, Fred V. Steece, Dr. Allen F. Agnew, and K. Y. Lee at Milbank Granite Quarry, Grant County, South Dakota. Photo taken in 1957 by Morris M. Leighton.

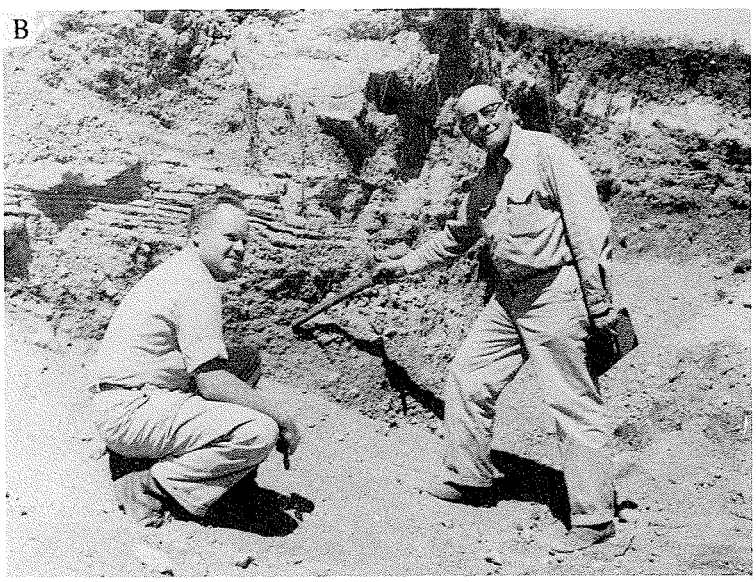
B

Dr. Allen F. Agnew and Dr. Morris Leighton viewing an outcrop of gravel. Photo taken in 1957.

C

Magnetometer reading being taken by Bruno C. Petsch. Picture taken in 1957.


A


B

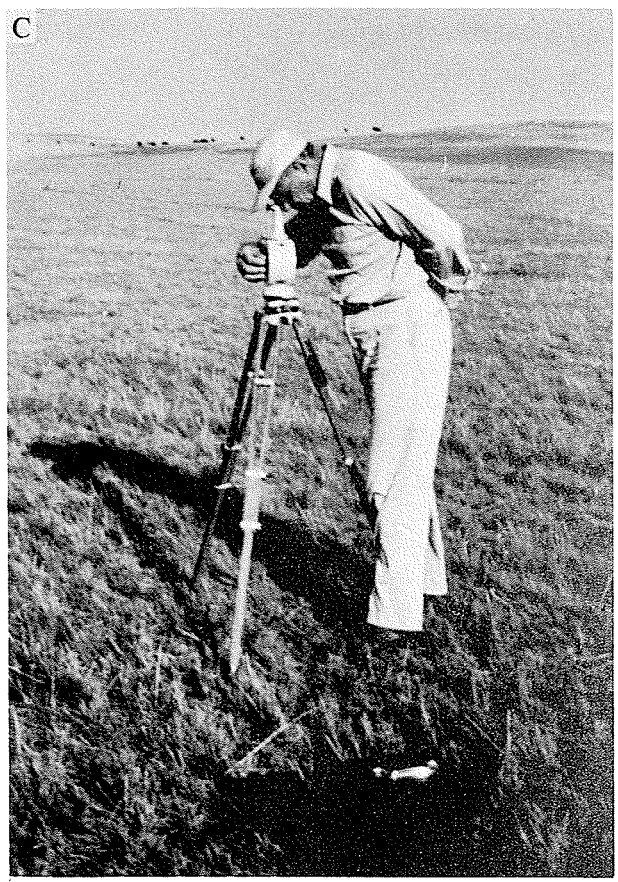

C

PLATE 19

Robert A. Schoon catching a sample from a hole being drilled by the Survey's drilling rig purchased in 1960.

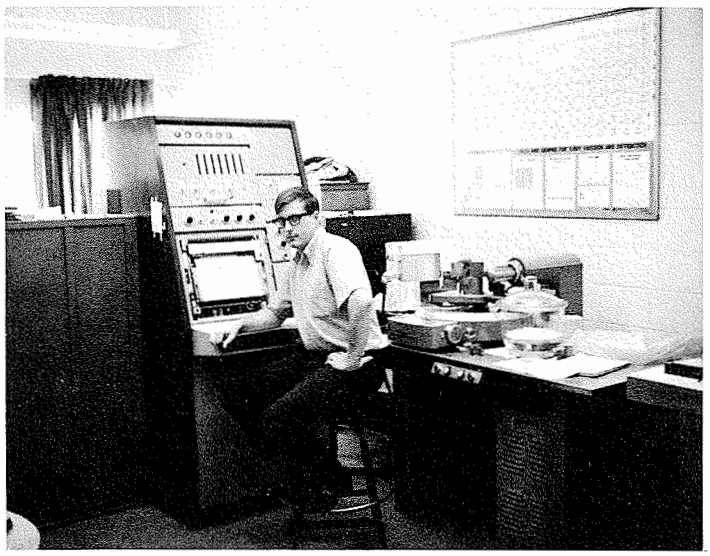
PLATE 20

Duncan J. McGregor

State Geologist, 1963-

PLATE 21

General Electric XRD-6 X-ray unit and accompanying equipment purchased in 1967 for use in the study of clays, shales, and microscopic mineral material.



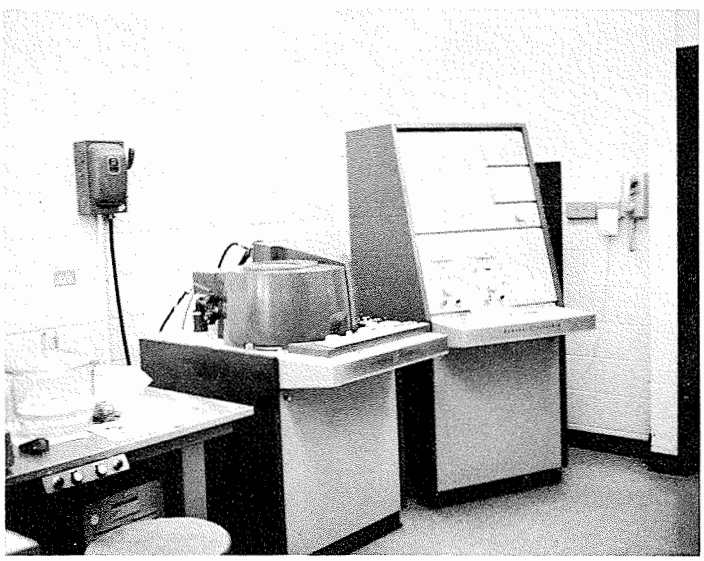
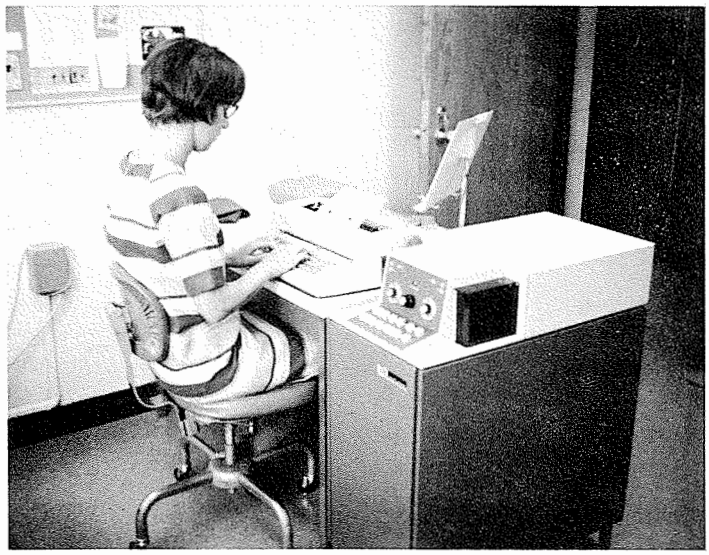


PLATE 22

I.B.M. Magnetic Tape/Selectric Composer system used in preparing manuscripts for printing processes. Equipment was used to prepare the offset masters used in printing this publication.



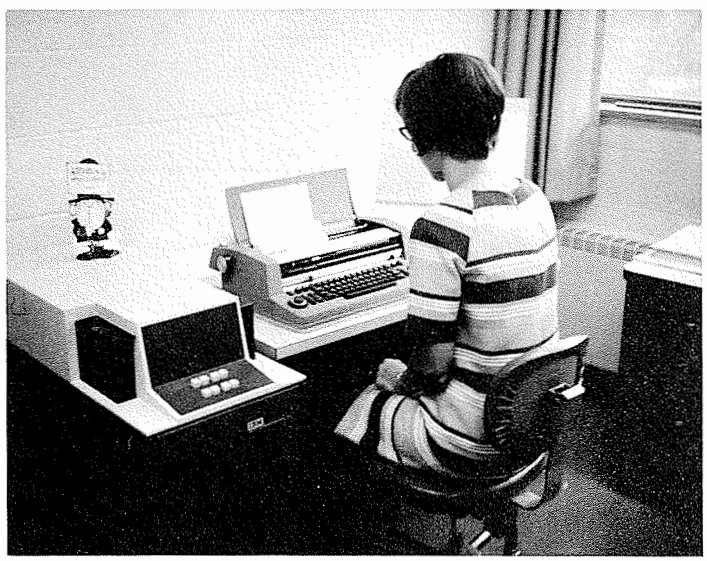
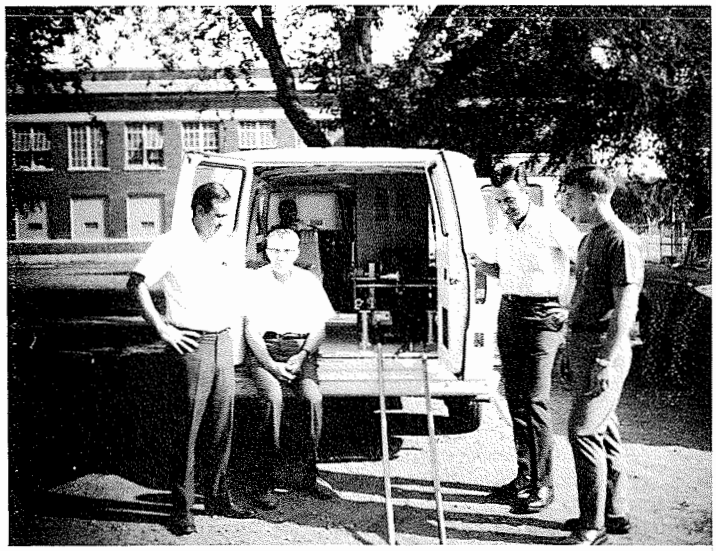


PLATE 23

Electric well-logging truck and equipment purchased by the South Dakota Geological Survey in 1969.



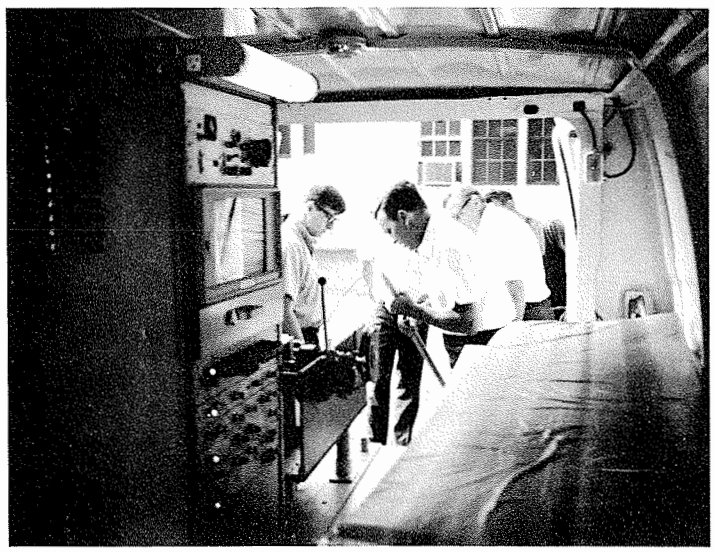
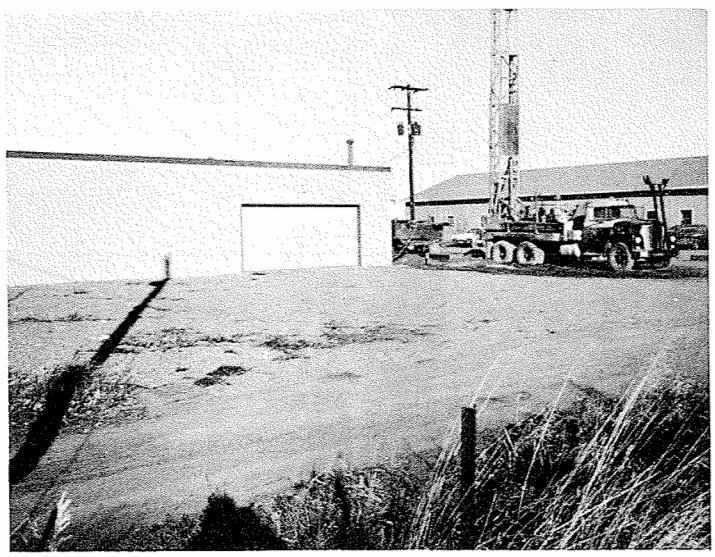


PLATE 24

Research and storage facilities located one mile west of the Science Center in Vermillion, South Dakota. A bore hole is being drilled to basement rock for use as a calibrating hole for the logger and for down hole geophysical research investigations.



CHAPTER VII

SUMMARY AND CONCLUSIONS

The history of the Geological Survey centers around its three interrelated objectives—scientific, economic, and education—and the changing emphasis among them. Their development was a product of technological, financial, and personal factors plus the groundwork from previously acquired geological data. Based upon these considerations, the history of the Survey from 1893 to 1967 was divisible into six periods.

The first period, 1893-1903, represented the pioneer efforts to establish a foundation for the Survey as a State scientific institution. The State Geologist, James E. Todd, achieved this by accumulating data from earlier findings on the State's geology and mineral resources. Lack of sufficient funds, personnel, and equipment allowed him to make only a few reconnaissance surveys. Yet, Todd, realizing the necessity of long-range planning, optimistically outlined goals that he knew lay far in the future, such as the study and conservation of artesian water. These proposals also illustrated the potential of the Survey's activities.

During the second period, 1903-14, the Survey assumed a greater role in scientific education, in which geology was only one of several fields. Ellwood C. Perisho, in his determination of priorities, directed many investigations toward the collection of plant, animal, and fossil specimens. Because of this interest he employed William H. Over who devoted the rest of his life to developing the museum. In the long-run, therefore, Perisho contributed to both the University and the Survey; in the 1960's his concept that the Survey should devise definite educational programs was re-emphasized.

More so than later State Geologists, Todd and Perisho were prominent in University affairs. Todd was Acting President for one year; Perisho was Dean of the College of Arts and Sciences for five years. They were, of course, living at a time when the faculty was small enough for all members to be vitally involved in administrative matters. All the State Geologists made their contributions to the University of South Dakota as chairmen of the geology department until 1957 and as professors thereafter.

The first period of expansion in the Survey's activities, 1915-26, saw advancements based upon prior emphases. Freeman Ward was the first State Geologist to receive adequate funds for hiring several geologists. Ironically, the same desire to find oil that had caused the increase in appropriatons also presented the State Geologist with several troublesome situations, then and later. The increase in facilities, however, made possible detailed studies of geology, evaluations of mineral resources, and collections of specimens for the museum. As the geologists investigated structures to systematize the search for oil and located gravel deposits to aid the road construction program, the Survey seemed well established for the future.

But when the appropriations were cut to zero in 1927, a period of retrenchment, until 1939, resulted. The new director, E. P. Rothrock, faced the development with forcefulness by taking the time to accommodate people who sought information. The renewal of funds, coming at the onset of a severe depression and drought, presaged a consolidation of facilties to meet a series of urgencies and, yet, not neglect other studies. Rothrock accomplished this by having Walter V. Searight investigate coal deposits and stratigraphic problems. The initial attempt to resume the petroleum surveys was slowed by the need to assist new interests in gold prospecting and to alleviate community water shortages. Although Rothrock devoted much of his time to this latter problem, the lack of information on water resources hampered the studies. He thus found another basis for continuing to stress the importance of acquiring preliminary geologic data before a critical need for solving a specific difficulty arose.

When the legislature substantially increased financial support for the Survey in 1939, Rothrock introduced a long-range project with the magnetometer survey. However, the search for minerals during World War II revealed anew the gaps in knowledge about natural resources in South Dakota. To advance economic development through geological research had long been Rothrock's philosophy and practice. From the mid-1940's to 1957 he effectuated a number of expansive projects embodying that concept, because he had the

means to purchase the new, expensive equipment and to employ a full-time staff, augmented with field and laboratory assistants. Therefore, the Survey could aid the Missouri River development, construct colored geologic maps, pursue the study of water reservoirs, and effectively regulate oil tests, including the first producing wells.

With the Geological Survey as a stabilized institution, the sixth period of its history, 1957-67, brought about a continuation of similar projects. Therefore, a greater opportunity existed for changes in methodology. By striving for closer relations with federal, state, and local agencies, Allen F. Agnew significantly increased the number and types of cooperative investigations. Furthermore, to systematize basic and applied research projects, he arranged the staff according to specific responsibilities. Duncan McGregor continued these features and gave additional emphasis to educational objectives, including tourism.

The South Dakota State Geological Survey has existed for scientific, economic, and educational reasons and thereby has served both the science of geology and the citizens of the State. The Survey has continuously sought to outline surface and subsurface rock formations and to interpret their geological history. Concurrently, the geologists have fulfilled a responsibility to discover and characterize the natural resources contained in the earth. For general knowledge and specific utilization, the Survey has made available the results of its field results of its field and laboratory investigations.

APPENDIX A

LEGISLATIVE ACT PROVIDING FOR GEOLOGICAL SURVEYS, 1893*

Be it Enacted by the Legislature of the State of South Dakota:

1. DUTY OF REGENTS OF EDUCATION. It shall be the duty of the regents of education to cause to be made as soon as practicable, surveys of the geology, natural history and physical features of the state.

2. SURVEYS–WHAT TO INCLUDE. Said surveys shall be carried on with a view to a complete account of the mineral, vegetable and animal kingdoms, as represented in the state, together with its physical features, including the several geological strata, ores, soils, clays, coals, peats, artesian and other waters, marls, building and other stones and cements and other useful minerals and materials, scientific analysis of said materials, and report upon their economic value and accessibility, and further including tests by drilling, digging or other excavation for the discovery of water, iron, silver, gold, copper, coal, gas, salt or other valuable mineral or other material that may from said surveys, appear likely to exist in the state. Said surveys shall further have in view a complete and scientific account of the vegetable and animal kingdoms of the state, including all native and naturalized grasses, herbs, plants, shrubs and trees, insects, birds, reptiles, fishes and mammalia.

3. REGENTS TO PROCURE GEOLOGICAL MAP. The said regents of education shall cause a geological map of the state to be made as soon as may be practicable, upon which the various geological formations shall be represented.

4. REGENTS TO PROCURE GEOGRAPHICAL AND OTHER MAPS. The said regents of education shall also cause to be ascertained by barometrical and other observations, the elevations and depression of different parts of the state; cause to be tabulated such meteorological and other observations and statistics as may be required to account for the variety of climate and products of the various parts of the state; and cause to be compiled, as soon as practicable, an accurate geographical, physical and topographical map or maps of the state.

5. DUTY OF REGENTS IN CARE AND COLLECTION OF SPECIMENS. The said regents of education shall cause suitable specimens; properly prepared, secured and labeled, of all soils, rocks, ores, coals, peats, fossils, cements, building and other stones, plants, woods, skins and skeletons of animals, birds, insects and fishes, and other mineral, vegetable and animal substances and organisms discovered or examined in the course of said surveys, together with reports upon all chemical or other scientific analysis made in connection with said surveys, and the results of all meteorological, barometrical and other observations and statistics, to be preserved for public inspection, and whenever the same may seem to practicable, cause duplicates in reasonable numbers and quantities, of said specimens, reports and results, to be collected and preserved for the purpose of exchange with educational, scientific or other institutions, of which the Smithsonian Institute at Washington, in the District of Columbia, shall have the preference; and for the further purpose of such donations to education and scientific institutions of this state, as shall by the said regents of education be deemed proper.

6. REGENTS TO SUBMIT REPORTS TO GOVERNOR–WHAT TO CONTAIN. No person appointed or employed to carry out the provisions of this act shall incur any expense or make known the results of his investigations, except as authorized by the said regents of education. All persons so appointed or employed shall immediately report to the said

**Laws Passed at the Third Session of the Legislature of the State of South Dakota* (1893), Chap. 98, pp. 166-67. Hereafter cited as *Session Laws of South Dakota*.

regents of education all discoveries of economic or scientific interest to the state in general and shall make, on or before the first day of November next preceding each regular session of the legislature, a complete report of the progress of said survey, accompanied by such maps, drawings, tables and other specifications and exhibits as may be proper and necessary to exemplify the same, and it shall be the duty of said regents of education on or before the first day of December, next preceding each regular session of the legislature, to submit the aforesaid report or reports to the governor, who shall by the same before the legislature, and the said regents of education, upon the completion of any separate portion or department of the said surveys, shall cause to be prepared a report which shall embody all useful and important information accumulated in the investigation of said portion or department, which report shall likewise be conveyed through the governor to the legislature.

7. APPROPRIATION. To carry out the provisions of this act, the sum of two hundred and fifty dollars per annum is hereby appropriated, to be drawn and expended by the said regents of education.

APPENDIX B

LEGISLATIVE ACT PROVIDING FOR A STATE GEOLOGIST, 1919*

Be it Enacted by the Legislature of the State of South Dakota:

Section 1. The professor of geology of the State University is hereby constituted ex-officio state geologist. As such officer he shall perform his duties under the state board of regents of education.

Section 2. It shall be the duty of the said state geologist, under the direction of said board of regents as aforesaid to continue the geological, natural, history, archaelogical and anthropological survey of the state emphasizing the economic geology and shall make to the governor, immediately after the close of the fiscal year next previous to the meeting of the legislature, a full report of his doings as such state geologist and the results thereof which report shall be published as one report of other state officers.

*_Session Laws of South Dakota_ (1919), Chap. 112, pp. 396-97.

APPENDIX C

LEGISLATIVE ACT PROVIDING FOR SURVEYS AND GOVERNOR'S SUPERVISION, 1939*

Be it Enacted by the Legislature of the State of South Dakota:

Section 1. That the natural resources of the State of South Dakota have never been the subject of a Geological survey and surveys of land and earth, and of areas beneath the surface of the lands, of this State, and of Experimental survey and surveys of the natural products by the State of South Dakota for the purpose of discovery, or aiding in the discovery, development and industrial exploitation of such natural products, consisting of minerals, oil, gas or other substances or commodities, among the natural and physical resources of said State of South Dakota, and of all by-products in connection with each and every one of the natural products of the state, is, and is hereby declared, to be, one of the proper, legitimate and valid purposes of developing the resources, improving the economic facilities, and of operating and carrying on the work of internal improvement of said state within the meaning and intent of the provisions of Section 1, Article 13 of the Constitution of the State of South Dakota and of any laws enacted pursuant to said Article of said Constitution. That such survey, or surveys, are, and are hereby declared to be, conducive to and promotive of the fostering, encouragement, development and improvement of all real property within said state and of the School and Public lands and of the various institutional lands of the State of South Dakota and of the lands in said state which the said state either owns in fee or holds mortgages taken under and pursuant to the Rural Credit laws of the State of South Dakota and of all lands now owned by the said state, whether derived under and through foreclosure of the mortgages held by the State of South Dakota or any other lands owned by the State of South Dakota, however the said lands may have been or may hereafter be secured, by the State of South Dakota.

Section 2. That the State Geologist of the State of South Dakota by and under direction and in cooperation with the Governor of the State of South Dakota, is hereby directed to make an actual geological survey of the lands, and earth, and the area beneath the surface of the lands, of this State of South Dakota, for the purpose of developing all the natural resources of every kind and nature within the boundaries of the said state including all minerals or other products of every kind.

The State Geologist, under and by direction of the Governor of the said State of South Dakota, is hereby authorized to create such expense, including equipment, men, materials and all things necessary, or which may be considered necessary by the said State Geologist, under and by direction of the Governor, in the carrying out of the provisions of this Act in the making of said survey or surveys including, of course, the cost of placing all information secured at the disposition of the Governor and the Executive Office for use in the advertising and development of the resources of said State of South Dakota, it being the intention of this Act to grant to the said Governor of the State of South Dakota and to the State Geologist full power to properly secure the actual geological facts in relation to the resources of the State of South Dakota, or the by-products of such resources, as may be found either upon the surface of the ground or in areas beneath the surface of the ground.

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*_Session Laws of South Dakota_ (1939), Chap. 166, pp. 198-99.

APPENDIX D

TABLE OF APPROPRIATIONS*

Fiscal Year	Annual Appropriation	Fiscal Year	Annual Appropriation
1893-94	$ 250	1930-31	$ 5,000
1894-95	250	1931-32	5,000
1895-96	250	1932-33	5,000
1896-97	250	1933-34	5,000
1897-98	250	1934-35	5,000
1898-99	250	1935-36	5,000
1899-1900	250	1936-37	5,000
1900-01	250	1937-38	6,500
1901-02	700	1938-39	6,500
1902-03	700	1939-40 (for biennium)	25,000
1903-04	1,000	1940-41	
1904-05	1,000	1941-42	12,500
1905-06	0	1942-43	12,500
1906-07	0	1943-44	12,500
1907-08	1,000	1944-45	12,500
1908-09	1,000	1945-46	28,000
1909-10	1,500	1946-47	28,000
1910-11	1,500	1947-48	28,000
1911-12	1,500	1948-49	28,000
1912-13	1,500	1949-50	57,000
1913-14	1,500	1950-51	52,400
1914-15	1,500	1951-52	54,905
1915-16	1,000	1952-53	54,905
1916-17	1,000	1953-54	62,000
1917-18	1,500	1954-55	57,100
1918-19	1,500	1955-56	69,000
1919-20	2,500	1956-57	69,000
1920-21	2,500	1957-58	84,824
1921-22	15,000	1958-59	81,105
1922-23	15,000	1959-60	114,250
1923-24	10,000	1960-61	114,250
1924-25	10,000	1961-62	179,900
1925-26	10,000	1962-63	153,500
1926-27	10,000	1963-64	184,000
1927-28	0	1964-65	163,000
1928-29	0	1965-66	208,833
1929-30	5,000	1966-67	274,583

*Compiled from *Biennial Report of the State Geologist* (1940-66) and *Session Laws of South Dakota* (1955-66).

APPENDIX E

LIST OF PERSONNEL*

Ellwood C. Perisho, 1903-14

Stephen S. Visher, 1908-13

William H. Over, 1913-14

Freeman Ward, 1915-26

William H. Over, 1915-26
W. C. Toepelman, 1920-23
Roy A. Wilson, 1921-24

E. P. Rothrock, 1923-26
William L. Russell, 1924-26
Willard A. Voorhees, 1925-26

E. P. Rothrock, 1926-57

William L. Russell, 1926
Willard A. Voorhees, 1926
Walter V. Searight, 1929-37
H. W. Buus, 1939-41
Dorian Lavier, 1941-42
Bruno C. Petsch, 1942-57
Ray E. Morgan, 1944-45
Charles L. Baker, 1945-53

William R. Bolenbaugh, 1949-50
Robert E. Curtiss, 1949-55
Robert E. Stevenson, 1950-51
Edward J. Bolin, 1950-51
Raymond C. Barkley, 1951-53
Harold D. Erickson, 1953-56
K. Y. Lee, 1955-57
Merlin J. Tipton, 1956-57

Allen F. Agnew, 1957-63

Bruno C. Petsch, 1957-63
K. Y. Lee, 1957-59
Merlin J. Tipton, 1957-63
David Lum, 1957-60
Fred V. Steece, 1957-63
Francis Buckmeier, 1958

Earl J. Cox, 1959-63
Robert A. Schoon, 1961-63
Richard L. Bruce, 1963
Cleo M. Christensen, 1963
Lynn S. Hedges, 1963

Duncan J. McGregor, 1963-

Merlin J. Tipton, 1963-
Bruno C. Petsch, 1963-
Fred V. Steece, 1963-
Earl J. Cox, 1963-67
Robert A. Schoon, 1963-

Richard L. Bruce, 1963-67
Cleo M. Christensen, 1963-
Lynn S. Hedges, 1963-
John C. Harksen, 1965-
Darrell I. Leap, 1966-69

*Limited to the geologists who were included as members of the Survey's office staff in *Biennial Report of the State Geologist (1906-66)*. Most of these men, except most of those employed before 1939, were full-time personnel.

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