

2008

# Gradual development: Midwestern geological surveys in the nineteenth century

Michael Daryl Severs  
*Iowa State University*

Follow this and additional works at: <https://lib.dr.iastate.edu/etd>

 Part of the [History Commons](#)

---

## Recommended Citation

Severs, Michael Daryl, "Gradual development: Midwestern geological surveys in the nineteenth century" (2008). *Graduate Theses and Dissertations*. 11011.  
<https://lib.dr.iastate.edu/etd/11011>

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Graduate Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact [digirep@iastate.edu](mailto:digirep@iastate.edu).

**Gradual development: Midwestern geological surveys in the nineteenth century**

by

**Michael Daryl Severs**

A thesis submitted to the graduate faculty  
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Major: History of Science and Technology

Program of Study Committee:  
Hamilton Cravens, Major Professor  
Lina Del Castillo  
David Wilson

Iowa State University

Ames, Iowa

2008

Copyright © Michael Daryl Severs, 2008. All rights reserved.

## Table of Contents

Introduction	1
Chapter 1: First Attempts at Geological Surveys by Midwestern States	12
Chapter 2: The Permanent Establishment of Midwestern Surveys	36
Chapter 3: Causes of Change for Midwestern Geological Surveys	54
Conclusion	72
Bibliography	77

## Introduction

In June of 1847 a gentleman<sup>1</sup> from the State of Mississippi wrote a letter to James Hall of Albany requesting his expertise on how the state should organize its geological survey. The letter began with the plea, “Being a citizen of Mississippi by adoption, and feeling a lively interest in her success, I have with others labored to do her good. As one of the means of benefitting her, there has been some exertion made to get up a geological survey.”<sup>2</sup> Hall eagerly explained in response to the letter’s plea that a state geological survey must find a delicate balance between pure and applied science. A geologist must

---

<sup>1</sup>The letter does not reveal its author, thus Merrill simply refers to the author as a “gentleman.”

<sup>2</sup>As cited in: Merrill, George P. *The First Hundred Years of American Geology*. New Haven: Yale University Press, 1924. Pp. 295.

efficiently devote his energies to the study of mineral resources while advancing the general knowledge of the field of geology. With this balance, both the practical needs of the state and the pure needs of the field were met. The rules and limitations of state geological surveys were not well-defined. Their character and organization were unique to the state in which they were formed. Geology and applied science have always been closely associated, and as a reflection of this, geological surveys were always closely associated with practical science. However, to advance the field of geology, theories and research expeditions that do not have immediate applied goals must be pursued. The state geological societies attempted to meet both the practical and pure needs of the field as it progressed throughout the nineteenth century.

The field of geology progressed rapidly in the nineteenth century. George P. Merrill stated that in the first decades of the century, the field was largely based on observation and deduction. These process made the field of geology unique because much of the field's knowledge had to be deduced from logic, scientific reasoning, and geological dogma. It was nearly impossible for a geologist in the nineteenth century to observe forces acting below the surface of the earth. Thus, geologists reached conclusions through scientific reasoning and deduction with limited amounts of observable data and inductive scientific reasoning. By century's end, induction and synthetic research methods created a rapid progression of facts and theories for the field

upon which to build.<sup>3</sup> State geological surveys were essential institutions in the advancement of the geological sciences. The observations, data collection, and explored hypothesis by state geologists was invaluable to the advancement of American geology. There was no other institution in America that devoted more time and resources to the earth sciences than the state governments. Between the years 1830 and 1900 not a single year passed without the formation of a major expedition or state survey. By the end of the nineteenth century, American geology grew from a scarcely known offshoot of the field of natural history to one of the most publicly and privately sponsored sciences that employed some of America's best and brightest scientists such as James Hall, D.D. Owen, and Josiah Whitney amongst many others.<sup>4</sup> This transformation was largely the result of the investment and support of state geological surveys.

Minnesota, Iowa, Wisconsin, and Illinois<sup>5</sup> were important benchmarks in the history of state geological surveys because they constituted a unique balance between Eastern and Western geologic institutions. These Midwestern surveys exhibited

---

<sup>3</sup>Merrill, George P. *The First Hundred Years of American Geology*. New Haven: Yale University Press, 1924. Pp. 1.

<sup>4</sup>Not coincidentally, these scientists completed geological expeditions in the states of Iowa (Hall and Whitney, 1855-1858), Wisconsin (Hall, 1860), and the Lake Superior Region (Owen and Whitney, 1848).

<sup>5</sup>I chose these states because their geological surveys share many common ideological and developmental characteristics. Other Midwestern states, including Kansas, Missouri, Indiana, and North and South Dakota, also share many commonalities in their geological expeditions. However, I chose not to include any extensive analysis of these states in my work because they would ultimately make the study too unwieldily.

characteristics of the well-established surveys in the East, and the newly-established surveys of the unexplored West. This unique research environment for development forced the Midwestern surveys to find a balance between exploration, practical, and pure science. Directors of Midwestern surveys attempted to find a balance between the demands of the states that funded their institutions and the process of acquiring legitimacy from other geological and scientific institutions in the East. The Midwestern surveys shared a unique bond that linked all the characteristics of geological institutions in the nineteenth century. Their history exemplified most of the struggles and processes the field of geology experienced in its development in the nineteenth century.

Midwestern geological surveys underwent a significant ideological transformation in the second half of the nineteenth century. In 1858, Iowa became the first state to organize a geological survey in the Midwest. By 1872 when Minnesota formed its first survey, each of the Midwestern states funded at least one geological survey. These first surveys were temporary scientific appraisals intended to provide a quick, comprehensive report on the geological and natural resources of their states. State legislators limited the survey directors with strict mandates to insure a prompt and effective return on the state's investment, which provided the scientists with little opportunity to explore areas of research outside these practical goals and mandates. Between the years 1890 and 1910 each Midwestern state established a permanent geological survey within their state. These permanent institutions differed ideologically from previous surveys because they had more freedom from public and private influence, supported by the United States

Geological Survey, and academically encouraged by the formation of regional scientific societies. They exhibited a professional maturity that was not present in previous geological surveys. Economic interests and other practical means motivated the first surveys in the Midwest, and the exploration of pure scientific projects rarely occurred due to limited opportunities and strict public mandates. Inversely, the permanent geological surveys formed in the Midwestern states decades later, reached a balance between applied and pure scientific research. Practical science was not removed from these institutions, but rather was complimented with other aspects of scientific research.

State geological surveys were important institutions in America because they were publicly funded by representatives devoted to both the advancement of science and the demographic, economic, and educational growth of their respective territories. State legislators supported the funding of geological surveys because of the potential practical results offered by these institutions. Legislators expected state surveys to investigate the region's natural resources, produce maps, or provide other applied results for the economic or demographic advancement of the state. Lawmakers and the general public perceived state surveys as investments, and as a result, they expected that the surveys provide a return on this investment. State governments did not encourage geological surveys to pursue research projects that did not produce direct benefits for the state, at least in the first years of their organization. However, state geological surveys never strayed far from the belief that the principle motivator for science was the advancement of

knowledge without regard for utility.<sup>6</sup>

Public officials mandated by state law that directors of these surveys produced annual or final reports to the state legislator because the first surveys in the Midwest were publicly funded by state governments and legislators expected them to supply the state with the scientific expertise to ignite its economic, educational, and demographic growth. The directors wrote these reports for a non-professional audience. Geological museums and increased curriculum in both secondary and post-secondary institutions supplemented the reports to meet the applied goals of the survey. State officials perceived the first surveys in the Midwest as investments for the young states. State official expected these goals to be completed in a timely manner, and when these goals were met the surveys were disbanded. Survey directors had very few opportunities to pursue projects that did not directly benefit the state, and thus pure scientific activities usually supplemented larger, applied projects.<sup>7</sup>

Once the geological surveys acquired permanent institutional status the ideology of the geological surveys began to shift away from practical methodology to subjects more closely related to pure science. By 1910, this transition was not yet complete as Midwestern surveys continued to pursue projects that directly benefitted the state in

---

<sup>6</sup>Daniels, George H. *American Science in the Age of Jackson*. New York: Columbia University Press, 1968. Pp 21.

<sup>7</sup>A few pure scientific pursuits include Josiah Whitney's research for his book *The Mineral Wealth of the United States*, which was partially completed as a result of his research in Iowa's lead region. Another example is James Hall's work with paleontology in Iowa's first geological survey.

which they were executed. However, the Midwestern surveys exhibited a professional maturity in their organization and research as they routinely released studies that benefitted both the field of geology and their home states. During this maturation process, Midwestern surveys released bulletin series publications and participated in professional societies and journals through regular publications and involvement in scientific conferences. Members of Midwestern geological surveys actively advanced the field of geology while contributing to the financial, demographic, and educational growth of their states.

Three primary factors influenced the transition from temporary geological expeditions to permanent scientific institutions. First, Midwestern geological surveys gained the support of regional scientific societies that encouraged academic studies which were not directly beneficial to the state. Regional scientific societies encouraged the pursuit of scientific projects that did not appeal to a broad, public audience, but rather encouraged projects intended to advance the earth sciences. Second, the establishment of the United States Geological Society relieved Midwestern surveys of many practical tasks. The USGS absorbed many large-scale projects like mapmaking and natural resource investigation that had previously consumed resources from state surveys. Finally, the granting of permanent institutional status relieved state surveys of the pressures of lobbying for public resources and publically justifying each project they pursued. Permanent status provided state surveys with the freedom to pursue a variety of research topics that did not necessarily directly benefit the economic, demographic, or

educational needs of the state. These developments provided Midwestern surveys with the opportunity to mature and expand as scientific institutions. By 1910, Midwestern geological surveys were influential scientific institutions that consistently contributed to the advancement of the earth sciences both in the United States and in the international community.

George H Daniels wrote in his study of American science in the 19<sup>th</sup> century that sometime in the 19<sup>th</sup> century Americans became interested in the pursuit of science to a greater extent than ever before.<sup>8</sup> This study addresses this increased American interest in science during the 19<sup>th</sup> century. The history of State geological surveys was characteristic of the trials and challenges common to other scientific societies and institutions in the nineteenth century. Therefore, their development was an important part of the history of science in the United States. In the early nineteenth century American science was young, unorganized, and unequal to competition on the international level, and a national scientific community did not yet exist in the United States.<sup>9</sup> By the turn of the twentieth century, American science did not display any of these characteristics. The field of geology also exhibited these traits in its growth and development in the nineteenth century. The earth science's maturation process; however, may not have been as smooth or successful without the support and organization of state geological surveys.

---

<sup>8</sup>Daniels, George H. *American Science in the Age of Jackson*. New York: Columbia University Press, 1968. Pp. 3.

<sup>9</sup>Daniels, George H. *American Science in the Age of Jackson*. New York: Columbia University Press, 1968. Pp 8.

Midwestern surveys provided the structure, resources, and support needed for the geological sciences to develop in the nineteenth century.

American science experienced an incredible amount of institutional and theoretical growth in the nineteenth century. This growth can be attributed to a variety of sources including the increased organization of scientific societies and journals, increased public funding, or the growth of secondary and post-secondary institutions. A study of the growth of the geological surveys in the Midwest fits well into this historical discussion because it exhibits the institutional and professional growth of the science of geology. As the varied historical sources that address the growth of American science in the nineteenth century have shown, there is no one single cause or trend for the professionalization of American science during this period. Thus, geological surveys are an important historical topic because their formation contributed to the growth and development of American science in the nineteenth century, which must be considered by historians of science when analyzing the growth of the American scientific identity.

This study is not an historical evaluation of why geological surveys developed in the Midwest, or a discussion of the scientific growth and maturation of the geological sciences in the Midwest. Rather, this study addresses how these institutions developed professionally in the Midwest, and what goals and expectations state geologists faced as they attempted to establish legitimacy and value as scientific institutions in the recently formed Midwestern states. Like other publically funded institutions in the United States, geological surveys faced many trials and growing pains as directors attempted to establish

the merit of the surveys in the newly formed Midwestern states.

In the nineteenth century, state governments experienced many serious problems that required public funding and support to solve. These problems varied in severity and subject matter, but none-the-less necessitated public funding and support to aid their progress. Charles Rosenberg's study of the cholera epidemics in the United States in the 19<sup>th</sup> century was an excellent example of the new relationships between federalist governments and public policy issues. Rosenberg documented the growth of public health institutions, social change, and medical progress in the nineteenth century that resulted from three cholera epidemics in this time-period. These changes examined by Rosenberg share many similarities with those experienced by the geological surveys during this same period of development. Initially, both the geological surveys and the public health institutions established to combat the cholera epidemics were haphazardly organized and temporary institutions. By the end of the nineteenth century, state governments permanently supported these institutions that proved invaluable to national scientific research and medical treatment. Many publically funded institutions experienced a similar progression as the geological surveys and public health boards. This progression extended as far as the state governments as they attempted to emerge in the federalist system as public policy directors.<sup>10</sup> During the nineteenth century, there was an emerging commitment to educational, institutional, and scientific growth in American governments. Midwestern geological surveys contributed to this movement,

---

<sup>10</sup>Teaford, Jon C. *The Rise of the States: Evolution of American State Government*. Baltimore: The Johns Hopkins University Press, 2002. Pp. 5.

and thus constitute an important benchmark in the institutional, scientific, and governmental growth in the nineteenth century.

## **Chapter One: First Attempts at Geological Surveys by Midwestern States**

The first state geological surveys in the Midwest gained public and legislative support because they were based on practical goals, and public officials perceived them as long-term investments that would greatly benefit the state's economic and demographic growth. It was the intent of these surveys to advance public awareness of the state's geological history and investigate its economic potential. This was best exemplified through the establishment of public geological museums, secondary and university-level curriculum, and state-sponsored publications. Financial interests were vital to the establishment of Midwestern geological surveys, and state governments required by law that state geologists analyze and report on a state's natural resource potential. For

example, one of their first priorities was to search for deposits of coal or precious metals that would spark mining or other industrial growth within the state. In January of 1851, Governor Augustus French of Illinois appealed to the state's legislative bodies for a geological survey by stating that "we have un-mistaken evidence that this state is scarcely excelled in the extent of mineral riches."<sup>11</sup> Also, legislators pressured state geologists to focus their studies on specific counties or regions that were believed to have high economic potential. In the first years of the survey, state geologists struggled to meet the many practical demands made by lawmakers and the general public because of their lack of institutional experience and the overwhelming tasks presented to them. As a result, it was common for a state's first survey to fail or face termination before geologists completed their work. Examples of these failed surveys include those performed by James Hall in Wisconsin in the 1850's and Dr. J.G. Norwood of Illinois in 1851. Lawmakers often included strict guidelines in the text of the laws forming state surveys, including stingy time-lines for the project's completion, and any deviation from these guidelines was often met with the termination of the survey. The general public and state lawmakers set high goals with the formation of their first surveys, and it was the intent of these goals to advance the growth of the state rather than the science of geology.

State legislators only appropriated funds for periods lasting from one to five years for the first state geological surveys performed in the Midwest. Lawmakers and the general public believed that this was a reasonable period of time to complete a

---

<sup>11</sup>Hays, Robert G. *State Science in Illinois: The Scientific Surveys, 1850-1978*. Southern Illinois University Press, 1980. Pp. 8.

comprehensive analysis of the states geological and natural resources. Due to the illogical goals and expectations of the general public and state governments, it was doubtful that the permanent establishment of state surveys could have developed under these conditions.<sup>12</sup> Minnesota's legislator only appropriated funds for the state's first surveys for one-year periods, and at the end of each research season, the legislators and governors assessed whether or not another year was necessary to fund. Midwestern states did not necessitate permanent geological surveys because the goals and expectations established for the survey were finite, and the continuation of the survey was not practical once these tasks had been completed. For example, a goal of Iowa's first geological survey was to complete an analysis of the state's lead resources. Upon the completion of the project, they envisioned, there was no need for the state to continue appropriating funds to research this topic. State governments and the general public perceived the young Midwestern states' geological surveys as an investment, and the states could not afford to fund prolonged scientific studies that did not produce practical, financial, or educational results; therefore, once a geological survey studied a state's natural resources to the satisfaction of the state legislator or private industries, the study was discontinued.

It was a common request by directors of geological surveys, after completion of the survey's first year, that the establishment of a museum to house and display unique or interesting materials collected during the course of the survey. Funding for this luxury was not often granted to the first survey in Midwestern states, or its construction was

---

<sup>12</sup>Kummel, Henry B. "State Geological Surveys." *The Scientific Monthly*. 25.5. (November, 1927), pp. 445-450. Pp. 445.

overlooked or postponed after the establishment of the survey. Often, delays and interruptions forced state geologists to lobby for the museum after the completion of the first survey. For example, A.H. Worthen, of the Illinois Geological Survey, wrote to Governor Richard Oglesby in 1866 that, “I must call your attention to the importance of securing a suitable fire-proof building for the reception and display of the specimens collected during the progress of the Geological survey.”<sup>13</sup> In section four of the law authorizing the first geological survey of Illinois it stated that a building was to be available, near the capital, for the preservation and display of specimens collected.<sup>14</sup> However, by January of 1865 no building was established for this purpose, therefore necessity forced A.H. Worthen to lobby to Governor Richard Oglesby for its construction. Minnesota, Wisconsin, and Iowa experienced similar problems in the organization of these institutions. Often by the beginning of the second or third state survey, the construction of a museum was complete, and the facilities opened to the general public.

The construction of geological museums had two primary purposes: preserving valuable scientific collections and educating the general public. The first geological surveys of any state covered vast amounts of territory, and often analyzed geologic structures and specimens that had never been observed from a geological viewpoint. As a result, geologists grew very excited with their findings because they were frequently unique scientific discoveries. Their preservation was a high priority to state geologists.

---

<sup>13</sup>Illinois State Geological Survey. *Geological Survey of Illinois*. Springfield: State Journal Steam Press, 1866. Pp. xii.

<sup>14</sup>*Ibid.* Pp. x.

For example, A.H. Worthen wrote to Governor Richard Oglesby of Illinois that, “These specimens, now comprising the largest and most valuable State Cabinet in the west, are kept in a rented room. This collection is the result of many years’ labor, is now of great value, and will be constantly increasing as long as the Survey continues; consequently its destruction would be an almost irreparable loss to the people of the State.”<sup>15</sup> Because the value and importance of the survey’s findings was usually not anticipated by the state or state geologist, the construction of a storage facility was not a high priority until after the completion of the first geological survey.

The establishment of a geological museum was always included in the law founding a state’s first survey because it was an ideal solution to meet the educational needs of the general public. In clause six of Iowa’s geological survey law, it stated that specimens were to be preserved to benefit the state and for public inspection. However, it made no mention of storage or preservation of these valuable specimens. Minnesota, Illinois, and Wisconsin had similar language in their laws. Public education was a priority for the passing of a state’s first survey, and a museum was a natural way to accomplish this goal. After the establishment of a state’s geological museum, state geologists included updates in their annual reports to the general public, which informed citizens and statesmen to the progress and direction of the museum. This included, as with the case of Minnesota’s geological museum, feedback for improvements to better suit the institution’s needs and to better accommodate the general public. Although, this

---

<sup>15</sup>Ibid. Pp. xii.

was almost always a request for more funding or an increase in the size of the museum. The establishment of geological museums to educate the general public about the young science of geology was a high priority for geologists and lawmakers.

To further spark public interest in the geological sciences, members of state surveys pushed to include the science in the curriculum of public education institutions. Integral to this task, was the publication and accessibility of the state geological reports. It was a common practice to distribute the published reports amongst universities, libraries, and secondary schools to advance the general public's knowledge of the earth sciences. State geological surveys and state universities often closely associated with geological studies performed in Midwestern states, and state lawmakers included mandates for surveys to advance the knowledge of the field of geology with the general public. The advancement of education helped justify the creation of many geological surveys, and state governments and the general public perceived as an excellent return on the funds invested in geological surveys.

State universities and public officials expected members of the geological survey to function in cooperation with the state's education institutions. State universities employed the director of the geological survey and staff members as lecturers. Also, state geologists routinely served as public lecturers and museum directors at other educational facilities. State geologists thus split their time between their academic responsibilities and as field researchers during the warm months. The Minnesota geological survey did not employ full-time geologists until after World War II, except for a brief period during

World War I.<sup>16</sup> State lawmakers believed that education should be available to all men, and states benefitted from the comprehensive education of its citizens to maintain the economic prosperity of the state.<sup>17</sup> This argument was especially true for geology because of the practical nature of the science. A more educated general public led to increased agricultural production or mining, which benefitted the entire state and produced an excellent return on the investment of the geological survey. Thus, state law often required state geologists to make an active effort to enlighten the general public to their work. This was usually accomplished through geological museums and accessible annual reports, but an increase in secondary and post-secondary curriculum were also essential to this process.

The first state geological reports written by state geologists catered to an audience unfamiliar with the geological sciences. These reports targeted a vast audience with the intention of educating the general public and business entrepreneurs. State geological reports were not written to suit a professional or scientific audience because it deterred the general public from using the report as an economic or educational resource. The use of technical terminology, scientific theory, and geological jargon was virtually not existent in state geological survey reports. This practice continued for many decades, and only gradually changed as state-sponsored studies became more focused and audiences more specific and professionally trained.

---

<sup>16</sup>State Geological Surveys, Minnesota section

<sup>17</sup>Hendrickson, Walter B. "Nineteenth-Century State Geological Surveys: Early Government Support of Science." *Isis*. 52.3. (September, 1961) Pp. 363.

Charles White's 1870 geological report stated that it was directed at a vast, non-scientific audience.<sup>18</sup> It was possible for individuals to select independent sections of the text that were of special interest, and interpret them without special instruction or outside sources. An Iowan farmer potentially could refer to White's report on the geology of southwestern Iowa and understand that farming, not mining, will produce the most value from his land. Despite this, White understood that the average Iowan citizen did not have an advanced education, and if an individual was fortunate enough to receive an advanced liberal education, geology was not included in the program.<sup>19</sup> Therefore, White believed it was necessary to provide a "brief popular explanation of its principles" to aid his audience.<sup>20</sup> To accomplish this task, White included definitions of rocks, geological epochs, the significance of stratification, and many other topics to educate his audience.<sup>21</sup> It was clear that White wrote this as a practical resource for the state of Iowa. The intent of this two-volume source was to advance the economic and demographic growth of the state more than the science of geology, and to expand the field of geology through the popularization of its practical attributes.

All of the first geological reports were organized in a similar manner to White's 1870 report. Wisconsin's first published report, for example, had many similarities to

---

<sup>18</sup>Iowa Geological Survey. *Annual Report of the Geological Survey of Iowa*. Des Moines: C. Van Benthuyssen, 1870. Pp. 13.

<sup>19</sup>Ibid. Pp. 15.

<sup>20</sup>Ibid. Pp. 13.

<sup>21</sup>Ibid. Pp. 13-27.

White's work in Iowa, which suggests that its target audience was the general public of Wisconsin. It was stated in section one of the law enacting the survey that, "...so as to constitute the material for a volume suited to the wants of explorers, miners, land owners, and manufacturers, who use crude native products, and to the needs of the schools of the State, and the masses of intelligent people who are not familiar with the principles of geology; said volume to be written in clear, plain language, with explanations of technical terms."<sup>22</sup> To accommodate this edict, T.C. Chamberlin<sup>23</sup> organized and wrote the report with this vast, untrained audience in mind. This first geological report for Wisconsin resembled a reference source, that was accessible to a broad audience, as much as it resembled a scientific publication. For example, the table of contents of each volume was approximately twelve pages in length, and cited almost every page in its respective volume. Also, the report contained an abundance of illustrations, and was not written technically. Illinois' and Minnesota's publications share these same reference properties, although they did possess minor variations.

The first Midwestern geological reports included topics that potentially appealed to the general population, in addition to their non-technical authorship. These reports were free from theoretical analysis or professional criticism, and included topics that appealed to a rural or capitalist audience. The first geological report of Minnesota, Wisconsin, Illinois, and Iowa always included an economic analysis of mineral,

---

<sup>22</sup>Wisconsin Geological and Natural History Survey. *Geology of Wisconsin*. Madison: Commissioners of Public Print, 1873. Pp. v.

<sup>23</sup>Director of the Wisconsin Geological Survey from 1876-1882.

geographic, or topographical resources of the state to appeal to corporations or prospectors. Each state also included soil and topography reports in their first survey to appeal to the farmers of the state. Often in the first report, but always by the second, state geologists included specific reports of individual counties. Not only could citizens of these states comprehend the wording of the geological reports, but it was believed by the state geologists that the inclusion of county reports appealed to the public because of the topic's regionally focused nature.

Public interest was a high priority when determining which topics state geologists studied in a state's first geological survey. State geologists always made an attempt to include topographical or soil studies in the first report, though some states had more success than others in accomplishing this task. Iowa's first geological survey was the best example of the importance of soil and topographical reports amongst the Midwestern states. It was concluded by state geologists early in the state's first survey that the land contained very little mineral wealth, so attention was redirected to soil and topographical reports. Also, state geologists used regional or county geological studies to raise the general public's interest in the surveys. The Illinois geological survey included nine case-studies of counties within the state, which geologists primarily directed at a local, nonprofessional audience.

A broad geographic and topographic analysis of the state was always included in each of the first surveys of the Midwestern states. This broad survey provided valuable scientific knowledge; such as general geological research, mineralogical reconnaissance,

and mapping, for the state geologist who was often unfamiliar with the state he was hired to survey. These first surveys provided clues to the local underground geology, which was essential to the economic development of the state.<sup>24</sup> White's first estimates of rock thickness in Iowa provided valuable information for future geologists to investigate more in-depth studies.<sup>25</sup> In addition, these reports also provided valuable practical knowledge for the state's demographic growth through the definition of state boundaries, drainage patterns, topographical features, deep-wells for artesian water, and elevation.<sup>26</sup> This information had the potential to be applied to aid agriculture, forestry, and mining industries as well as to advance information available to the general public. Charles Keyes of the Iowa Geological Survey wrote of these first general surveys:

They were especially helpful in a region so deeply mantled with glacial drift as Iowa is. As guides to boring deep wells for artesian waters, to prospecting for coal and to search for other mineral wealth deeply hidden their wide serviceability was in after years recognized by the present state survey and similar work was entered into exhaustively. White's work served its purpose for a period of more than twenty-five years, until newer figures could supplant the older ones.<sup>27</sup>

These broad surveys were a natural starting point because they produced a strong

---

<sup>24</sup>Keyes, Charles. *Century of Iowa Geology*. Des Moines: Iowa Academy of Science, 1920. Pp. 417.

<sup>25</sup>An excellent example of these in-depth studies sparked by White's broad investigations includes Josiah Whitney's study of lead deposits in Western Iowa.

<sup>26</sup>Keyes, Charles. *Century of Iowa Geology*. Des Moines: Iowa Academy of Science, 1920. Pp. 417.

<sup>27</sup>*Ibid.*

scientific foundation of regional geologic structures and resources for future projects to build upon, and provided valuable information to future expeditions and for the state's economic and demographic growth.

Public interest was a high priority when state geologists determined which topics the survey pursued. However, economic issues always had precedent and their pursuit often consumed most of the resources of state geologists throughout the course of a state's first geological survey. Surveys typically began with a geographic outline, and brief geological and topographical analysis of the state as a whole. Geologists then shifted their focus to either the state's economic outlook as a whole, or an analysis of regional economic resources within the state. Whether a geologist chose a regional approach or a comprehensive analysis was determined by the length and funding of the survey.

After the completion of a broad geographic study of the state, the next priority in a state's geologic survey was mineral wealth and economic productivity. In Iowa's 1858 report, for example, the largest chapter in the book was devoted to metallic and natural wealth of the state. To ensure that economic studies were the first priority for its state geologist, Wisconsin's legislature established that an economic analysis of the state must be included in the first report. The law states in section one:

That in the preparation of his final report, the chief geologist be, and he is hereby authorized to collate the general geology and the leading facts and principles relating to the material resources of the State, together with practical suggestions as to the methods of detecting and utilizing the same, so as to constitute the material for a

volume suited to the wants of explorers, miners, land owners, and manufacturers, who use crude native products.”<sup>28</sup>

Minnesota also wrote a similar clause into the law forming the first geological survey of the state. The clause specified that the first survey must provide a comprehensive evaluation of the “mineral kingdom” and “magnitude of useful materials” within the state.<sup>29</sup>

Public officials used economic issues as the principle motivator for the establishment of state geological surveys. Henry B. Kummel wrote that economic issues rallied public and corporate sentiment within a state, which motivated the passage of surveys through state legislative offices.<sup>30</sup> Also, this practical aspect of geology often outweighed theoretical studies in the first years of surveys because the territories had not previously been scientifically examined.<sup>31</sup> Imagine the excitement when a man of science informed a state citizen that their land may include a large coal or gold deposit, or consider the benefits of the attraction of a large mining project within a state’s borders. This position was best exemplified in the introduction of Illinois’s first geologic survey when A.H. Worthen wrote:

---

<sup>28</sup>Ibid. Pp. v.

<sup>29</sup>Geological and Natural History Survey of Minnesota. *Annual Report*. 1872. Pp. 37.

<sup>30</sup>Kummel, Henry B. “State Geological Surveys.” *The Scientific Monthly*. 25.5. (November, 1927). Pp. 447.

<sup>31</sup>Ibid. Pp. 450.

The publication of these two volumes will enable the people of the State to judge how far the prosecution of a work of this kind tends to the development of the natural wealth and resources of the State, and whether its prosecution to a final completion is desirable, in an economical, as well as a scientific, point of view. The economical benefits that may be expected to result from a work of this kind are two fold: First, to determine the location and extent of whatever natural resources the State may possess, in coal, metallic ores, minerals, hydraulic and common limestone, fire clays, free-stone, flag-stones, marbles, etc., that properly belong to the various geological formations in the State; and, second, to prevent the unnecessary expenditure of money and labor in searching after valuable minerals in those portions of the State where such minerals do not exist.<sup>32</sup>

The potential for undiscovered mineral wealth of a state also helped justify the initial cost of these surveys, which was intended to attract mining and industrial ventures into the newly established states. This cost was often considered insignificant by policy makers compared to the potential economic discoveries of a state's first geologic survey, and the economic growth that resulted from these findings.

Exactly which mineral substance sought by state geologists varied greatly between states. However, due to its vital importance in nineteenth century economics, coal was often searched for first. In the Midwest, an analysis of coal deposits always accompanied regional or county studies in geological surveys. In Illinois, for example, the second chapter in volume one, and the first chapter included after the broad geographic analysis of the state, was an examination of the state's coal deposits. In Iowa, Assistant Geologist

---

<sup>32</sup>Illinois State Geological Survey. *Geological Survey of Illinois*. Springfield: State Journal Steam Press, 1866. Pp. xiii.

Worthen included a letter written to James Hall in the introduction of his report, explaining that as instructed he had finished his analysis of coal deposits in the Des Moines Valley. Worthen was not instructed to first analyze the geography of the Des Moines Valley or the significance of its stratigraphy, but rather to first study the region's coal resources. Almost every study of the individual counties in the Midwest included a brief section on the county's coal resources. However, this section often stated that the county possessed no significant coal resources. When it was concluded that the state did not possess any significant coal deposits state geologists still included references to the natural resource in subsequent county and regional surveys. Public officials continued to influence state geologists to at least briefly examine a region's coal resources even if a discovery was highly unlikely. This was best represented in Minnesota's county studies in the 1870's when coal deposits were mentioned in many of the studies, despite the fact that no significant deposits were found. There are thirty-two references to coal in the index of Illinois's first geological survey, which was more than any other listing in the index; this was not unusual amongst Midwestern states. Wisconsin and Iowa placed similar importance upon this economic resource. In Iowa, both the 1858 and 1870 reports included lengthy discussions on the state's coal resources, despite the fact that their findings contradicted each other. It was clear that an investigation of a state's coal resources was an important motivator in the establishment a state's first geological survey, and often maintained its importance in proceeding surveys as well.

In the first geological surveys of the Midwestern states, coal was the natural

resource most often sought by researchers. Despite this, state geologists did not discover any vast sources of this valuable resource in the Midwestern states, with the exception of Illinois. However, this does not conclude that the geologists' work was in vain, or that the public's tax dollars were wasted. Rather, geologists discovered and researched vast natural resources within each of the Midwestern states that encompassed a wide variety of minerals, stones, and other natural products. Peat, granite, iron, copper, lead, and clay are a few of the natural resources studied by state geologists and found in significant amounts in the Midwestern states. These resources were not the high-quality products these states were hoping to discover in their territory, but they were satisfactory and justified the formation of the state's current and future geological expeditions.

In Minnesota and Wisconsin's 1873 geological surveys, state geologists studied vast iron and copper deposits in the Northern portions of the states. Extraction of these deposits began in prior decades, but the extent of the resources was largely unknown until state surveys sponsored expeditions for their exploration. Assistant Geologist Irving of Wisconsin wrote that the iron smelting industries were still in their infancy.<sup>33</sup> It is the intention of his report to research these iron-producing regions to aid in the growth of the industry in Wisconsin.<sup>34</sup> Professor J.D. Whitney devoted most of his time to researching Northeastern Iowa, which was believed by geologists to be rich in lead deposits. Upon the publication of the state's 1858 report, J.D. Whitney's research was not complete, and

---

<sup>33</sup>Wisconsin Geological and Natural History Survey. *Geology of Wisconsin*. Madison: Commissioners of Public Print, 1873-1879. Pp. 613.

<sup>34</sup>*Ibid.* Pp. 636.

its publication was delayed until the state's next printing. J.D. Whitney's research proved to be extremely valuable for the region's economic growth, and his research also proved to be valuable to the advancement of the geological sciences. Other expeditions in Wisconsin and Illinois also proved to be beneficial for the economic advancement of the states.

In Minnesota, state officials presented State Geologist N.H. Winchell with the practical scientific problem of an absence of fuel in many of the settled portions of the state. Many of these regions, including those surrounding Minneapolis and St. Paul, had shortages of wood and did not possess any significant coal deposits. Thus, the state requested that N.H. Winchell investigate how fuel prices could be lowered in these portions of the state.<sup>35</sup> The geologist immediately researched the peat deposits in the area, and concluded that they were significant enough to supply the state with cheap fuel. In his report, N.H. Winchell explained the quality and quantity of Minnesota's peat deposits, and even explained how the resource should be mined and processed.<sup>36</sup> As a result, his work was extremely valuable to the citizens of Minnesota, and his research provided a simple solution to a potential crisis for the state.

Economic, demographic, or other practical results influenced the implementation of regional and county studies within Midwestern states. For example, in Minnesota's 1875 survey N.H. Winchell stated that surveys chose specific counties because they were

---

<sup>35</sup>Geological and Natural History Survey of Minnesota. *Annual Report*. 1873. Pp. 88.

<sup>36</sup>Ibid. Pp. 88-127.

the most likely to contain coal or other valuable resources.<sup>37</sup> The first counties selected were not chosen because they were the most densely populated, but because state geologists believed they had the largest financial potential. A county's perceived economic resources, more than any other influential factor, determined the chronological order of counties studied in detail by state geologists in subsequent years.

County surveys shared many similar scientific research goals as the broader regional studies performed by N.H. Winchell and J.D. Whitney. Each Midwestern state addressed county surveys in the same manner. They began with a general geographic analysis of the county including: location, topography, and drainage. These studies proceed to outline a general geological analysis of the territory which includes discussions of rock formations, stratigraphy, and many other geological topics. County studies concluded with an economic analysis of the territory, which outlined potential industrial and agricultural ventures and benefits to the existing population. These studies appealed both to the local citizenry that were looking to enhance their current economical status or educational base, and to prospective investors looking to expand mining or agricultural operations within the territory. A.H. Worthen of the Illinois Geological Survey stated that county studies were more focused and scientific than the comprehensive state surveys, which was exemplified in the tremendous detail reported

---

<sup>37</sup>Geological and Natural History Survey of Minnesota. *Annual Report*. 1875. Pp. 5.

upon.<sup>38</sup> However, these studies also had tremendous practical benefits, and appealed to a diverse audience that sought to benefit from them.

The laws which enacted state geological surveys in each of the Midwestern states provided similar stipends, guidelines, and time-lines for the surveys. Public officials and state geologists set financial or natural resource related goals as the most common guidelines outlined in these first laws, but they also enacted other practical agendas into the state surveys. In Minnesota, for example, the state legislator enacted the state's geological survey in ten brief sections of state law on March 1, 1872. The edict stated that the Governor and the State University had the responsibility to appointment the state geologist. The state granted the project a sum of one thousand dollars, and mandated that the report must be finished by December 31 of the same year. The law also established guidelines indicating that the survey must produce maps of the state, and emphasis must be placed on a mineralogical analysis of the state. These provisions established by the Minnesota legislator were not unusual for the establishment of a state's first geological survey. Other states, including Illinois, Wisconsin, and Iowa, appropriated similar sums of money and established similar guidelines to be followed by the state geologist, although the allowed period of time to complete the surveys varied between states. These laws provided very little resources for a state's geologist to research topics that sparked his personal scientific interest, and often the tasks required by state law were not finished upon the completion of the survey. For example, State Geologist Winchell in Minnesota

---

<sup>38</sup>Illinois State Geological Survey. *Geological Survey of Illinois*. Springfield: State Journal Steam Press, 1866. Pp. xi.

only completed a portion of the tasks outlined by the state in the allotted time, and this forced him to complete them the following year.<sup>39</sup> Practical economic, geographic, or demographic means motivated the laws that enacted the Midwestern states' first geological surveys, which left little room for state geologists to stray from them. However, state lawmakers granted more freedom to surveys that lasted for more than one calendar year. Examples include those performed by James Hall in Iowa and A.H. Worthen in Illinois. Scientists involved in these surveys often pursued their own scientific agendas in addition to completing the tasks outlined by state lawmakers.

Governor Augustus French of Illinois appointed Dr. J.G. Norwood survey director in 1851. Norwood's tenure as director was an excellent example of a survey led by a scientist in pursuit of his own scientific agenda. By 1856, the project had not produced one published source, and Governor Augustus French dismissed Dr. Norwood as director of the geological survey. The state legislators believed that Dr. Norwood had not devoted his research to subjects which the state believed to be of importance.<sup>40</sup> Furthermore, under the direction of Dr. Norwood, the geological survey wasted \$27,000 dollars in state funds, and had not produced any beneficial materials as a result of his labors for the state.<sup>41</sup> In his book, *State Science in Illinois*, Robert Hays wrote that,

---

<sup>39</sup>Geological and Natural History Survey of Minnesota. *Annual Report*. 1872. Pp. 19.

<sup>40</sup>Hays, Robert G. *State Science in Illinois: The Scientific Surveys, 1850-1978*. Southern Illinois University Press, 1980. Pp. 8.

<sup>41</sup>Ibid. Pp. 9.

“Norwood’s removal was prompted by a general feeling that a more “practical” survey was intended by the legislature.”<sup>42</sup> A.H. Worthen succeeded Dr. Norwood as director of the survey in 1858, and state officials provided him with clear instructions to pursue scientific interests that were beneficial to the state of Illinois. Unlike Norwood, Worthen did not casually follow these instructions, and produced a comprehensive geological analysis, in multiple volumes, for the state a few years later.

Practical principles provided the motivation, public and financial support for the formation of state geological surveys. It was the intent of these institutions to advance the education and economic growth of their respective states. The theoretical advancement of the geological sciences progressed very little as a result of these early expeditions. Public officials did not encourage state geologists to advance their own professional agendas, and state law bound state geologists to accomplish the tasks outlined by the state they served. State geologists did not ignore the theoretical advancement of the physical sciences, but rather forced the issue to accept a secondary role to practical results. Despite this, there were isolated examples of state geologists placing the advancement of geology ahead, or at least at par with, the practical needs of the state in which they were employed. Josiah Whitney and James Hall’s work in Iowa were excellent examples of studies for the advancement of geological sciences in conjunction with the practical needs of the state.

In 1854, J.D. Whitney published his influential book *The Metallic Wealth of the*

---

<sup>42</sup>Ibid. Pp. 9.

*United States*. Before the publication of his book, there were very few comprehensive publications devoted to mining and economical geology despite the subject's importance in the new science.<sup>43</sup> J.D. Whitney spent many years researching this publication, many of which overlapped with his work in the Midwestern states. J.D. Whitney was the head geologist on a major survey of the Lake Superior region of Wisconsin and Michigan in 1849 where he accumulated large amounts of knowledge for his publication.<sup>44</sup> Also, J.D. Whitney's research of the lead regions of Iowa, Illinois, and Wisconsin contributed to future editions of his book. In a letter to his brother in August of 1853, J.D. Whitney wrote, "I am going out to the lead region as soon as I get through here...I have business out that way in collecting information for my book."<sup>45</sup> Perhaps this was a contributing reason, in addition to instructions given to him by James Hall to collect fossils from the lead region, why his report was not completed for Iowa's 1858 publication.<sup>46</sup> Regardless, J.D. Whitney devoted portions of his time while employed by Iowa to advance his own research. James Hall had similar professional motives as J.D. Whitney when he accepted the position of state geologist to Iowa in 1855. James Hall was aware that he was unable

---

<sup>43</sup>Merrill, George P. *The First Hundred Years of American Geology*. New Haven: Yale University Press, 1924. Pp. 329.

<sup>44</sup>Whitney, J.D & J.W. Foster. *Report on the Geology and Topography of a Portion of the Lake Superior Land District in the State of Michigan*. Washington, D.C: United States General Land Office, 1851. Pp. 1.

<sup>45</sup>Brewster, Edwin Tenney. *Life and Letters of Josiah Dwight Whitney with Illustrations*. Boston: Houghton Mifflin Company, 1909. Pp. 134-135.

<sup>46</sup>Clarke, John M. *James Hall of Albany: Geologist and Palaeontologist 1811-1898*. Albany, 1921. Pp. 276.

to devote his full attention to his work in Iowa. Regardless, he chose to accept the position due to financial difficulties and to advance his own personal research.<sup>47</sup>

Despite James Hall and J.D. Whitney's attempts to impose their personal agendas upon the state surveys to which they were assigned, generally, the first state surveys were guided by practical goals, and left little time and resources for the pursuit of other areas of interest. There were very few similar examples of state geologists pursuing personal interests during these early surveys. By 1858, the work assigned to James Hall in Iowa was not completed, which was finished in the following decade by White. James Hall faced similar problems in Wisconsin in 1860 when the state refused to publish his work with paleontology, and made clear they were generally unsatisfied with the tasks completed by James Hall and his assistants.<sup>48</sup> James Hall's final report was never published by the state, and he was not reimbursed for his expenditures during the course of the survey, which totaled ten thousand dollars.<sup>49</sup> States that sponsored these first surveys had clear goals targeted from their inauguration, and any deviation from these goals had severe consequences. For example, Illinois' law stated that the state geologists needed to complete the survey with satisfactory results or they would not receive any financial compensation for their labors.<sup>50</sup>

---

<sup>47</sup>Ibid. Pp. 272

<sup>48</sup>Ibid. Pp. 293

<sup>49</sup>Ibid. Pp. 293

<sup>50</sup>Illinois State Geological Survey. *Geological Survey of Illinois*. Springfield: State Journal Steam Press, 1866-1890. Pp. x.

Public officials did not intend for the first state geological surveys to be scientific expeditions, rather they intended to aid in the economic and demographic growth of the state. One of the principle reasons the first geological surveys were heavily supported by state lawmakers and the general public, was due to the fact that public officials perceived them as investments for their respective states. Public officials did not intend fore these early surveys to directly advance the earth sciences. This ideology was evident in the simplified annual reports, legislative mandates, and applied goals of Midwestern geological surveys. A balance between pure and applied science was not obtained by state geological surveys until decades later when these institutions became permanent state institutions.

## **Chapter Two: The Permanent Establishment of Midwestern Surveys**

In the final decades of the 19<sup>th</sup> century, state geological surveys in the Midwest transformed from temporary scientific explorations to permanent scientific institutions. These surveys continued to remain closely associated with the state universities. State officials and the general public still expected the survey serve the state's economic and educational needs. Public officials still provided survey directors with practical goals and expectations, and the states still expected the survey to focus their research on topics that benefit the economic or educational needs of the state. However, the ideology, organization, and status of these institutions changed as state legislators funded the surveys as permanent institutional status. The research projects of state geologists were more focused than in previous decades, and the goals of these projects were not necessarily based on immediate applied goals for the state. Each of the geological

surveys in the Midwest established a Bulletin Series, which was a semi-annual publication of a large-scale research project sponsored by a geological survey. Bulletins addressed a variety of topics from studies on grasses to highway construction. Additional professional outlets also became more accessible for members of geological surveys. Prior to this period, geologists almost entirely limited their publications to state-sponsored annual reports or book length monographs. With the establishment of regional scientific societies, state geologists used these resources to publish their work in a variety of outlets. State geological societies in the Midwest exhibited professional maturity in the decades surrounding the turn of the twentieth century. The target audience for their research projects evolved from the general, non-professional population to professional geologists. Economic issues and other applied topics still motivated funding and resources for research projects; however, pure science grew in importance, and was the principle motivator for many research projects sponsored by state geological surveys.

When Midwestern state geological surveys attempted to establish themselves as permanent state institutions, supporters used similar political and public-opinion tactics that they used in previous attempts to secure public funding. The Board of Regents of the University of Minnesota recommended the reestablishment of the state's geological survey to associate closely with the university and to aid in the economic growth of the state.<sup>51</sup> In Illinois, Director H.Foster Bain stated that "the mineral industries of the State needed the foundation that only a well rounded out geological survey can give and...that

---

<sup>51</sup>Morey, G.B. "Minnesota." *The State Geological Surveys: A History*. Arthur Socolow. Ed. Association of American State Geologists, 1988. Pp. 238.

the consequent growth of the industries would repay many times the necessary expenditure of common funds for a common purpose.”<sup>52</sup> Supporters of geological surveys emphasized the economic and educational values, among various other applied goals, to gain support for their cause. By 1905, the states of Minnesota, Wisconsin, Iowa, and Illinois permanently established geological surveys. Although it was primarily applied goals that caused the reestablishment of these institutions, a significant shift in research and ideology occurred. Within a few decades, applied geology within the Midwestern states was almost replaced completely with pure scientific pursuits.

In the Midwestern states, the state and federal governments discontinued geological surveys because they believed that the survey’s work was complete, and there was no reason to continue funding it. Thus, state geological surveys often discontinued due to their own success rather than ineffective results or unpopular opinions. M.E. Ostrom, state geologist of Illinois, wrote in his brief history of Wisconsin’s geological survey “The fact that the Survey was allowed to lapse in spite of T.C. Chamberlin’s statement that Surveys are valuable as a “continuing service” can probably be attributed to the thoroughness and success of his survey, rather than to dissatisfaction with the products.”<sup>53</sup> This viewpoint contrasted sharply with previous attempts at the reestablishment of a state’s geological survey. In Wisconsin, Iowa, Minnesota, and

---

<sup>52</sup>Hays, Robert G. *State Science in Illinois: The Scientific Surveys, 1850-1978*. Southern Illinois University Press, 1980. Pp. 71.

<sup>53</sup>Ostrom, M.E. “Wisconsin.” *The State Geological Surveys: A History*. Arthur Socolow. Ed. Association of American State Geologists, 1988. Pp 467.

Illinois a comprehensive analysis of their territories failed commonly. James Hall's attempt in Wisconsin in 1857 and A.H. Hanchett's 1864 survey in Minnesota were perfect examples. These failed surveys provided obstacles for further legislation when public officials first considered the initial organization of geological surveys because the young Midwestern states did not want to risk their limited financial resources on expeditions that had a reputation of failure. Inversely, when Midwestern states investigated the reestablishment of their geological surveys around the turn of the century, the consequences of failure was not a primary argument against the survey. Rather, opponents poised the question of whether or not another geological survey was necessary due to previous studies performed in their territories. In response to this, the economic benefits of geological surveys were complimented by the educational and scientific benefits by supporters of another geological survey.

In addition to the usual geological goals, maps, minerals, and topography, the Iowa legislator included in the language reestablishing a permanent geological survey that:

the survey must investigate the characters of the various soils and their capacities for agricultural purposes; the growth of timber, the animal and plant life of the state, the streams and water power, and other scientific and natural history matters that may be of practical importance and interest.<sup>54</sup>

The state of Iowa still attempted to mandate that the geological survey must pursue

---

<sup>54</sup>Prior, Jean C. "Iowa." *The State Geological Surveys: A History*. Arthur Socolow. Ed. Association of American State Geologists, 1988. Pp. 139.

scientific interests that were of practical use of the state; however, these interests varied from previous survey formations. This provided state geologists with the freedom from public pressure to pursue agricultural, industrial, paleontology, or any other scientific study as long as it benefitted the state. This was best exemplified through the bulletin series that allowed state surveys to publish highly-specific scientific studies that may or may not have directly benefitted the economic welfare of the state.

The establishment of the Bulletin series in state surveys represented a significant shift in the ideology of geological surveys in the Midwestern states. It was stated in the introductory remarks of Iowa's first Bulletin publication that Iowa law requires the publication of these scientific studies on the "economic interest relating to the Natural History of the State."<sup>55</sup> Despite this statement, it was evident that studies published under the Bulletin series were not economic-related studies, but rather state geologists focused their work on scientific projects that they intended to aid in the advancement of the natural sciences. This was partially the result of the vague wording in the laws permitting these publications and was best demonstrated through the studies that were undertaken and the highly technical manner in which they were published.

In her brief narrative history of the Iowa Geological Survey, Jean C. Prior wrote that with the establishment of a permanent survey and the bulletin series, the geological

---

<sup>55</sup>Pammel, L.H. "Grasses of Iowa." Iowa Geological Survey. *Bulletin*. 1901. Pp. 1.

survey exhibited a growing diversity in its geological expeditions.<sup>56</sup> However, Iowa's bulletin publications were unique compared to other states in the region. Due to the state's unique legislative mandate in 1892, states Prior, public officials pressured members of the survey to pursue topics relevant to the agricultural industry. For example, Bulletin number one addressed the topic of "The Grasses of Iowa." This five hundred and twenty-five page volume thoroughly documented the scientific composition of Iowa's natural grasses. Samuel Calvin of the Iowa Geological Survey stated that this topic was "a subject of primary importance to the rapidly developing agricultural interests of the state."<sup>57</sup> What resulted from this study was a highly-focused scientific study of an important economic resource for the state of Iowa. This publication accomplished two goals. The first goal was the production of a reference source for the agricultural industry that further expanded its knowledge of one of the state's most valuable economic resources, grasses and cereals. The second goal was the completion of a comprehensive scientific study of a focused subject for the advancement of natural history. The scientific study of Iowa's grasses contributed to the growth of scientific knowledge, and was an excellent resource for other researchers in the earth and biological sciences. The publication thus served both the needs of the State of Iowa and the earth and biological sciences. This contrasted sharply with previous studies performed by state geological

---

<sup>56</sup>Prior, Jean C. "Iowa." *The State Geological Surveys: A History*. Arthur Socolow. Ed. Association of American State Geologists, 1988. Pp. 139.

<sup>57</sup>Pammel, L.H. "Grasses of Iowa." Iowa Geological Survey. *Bulletin*. 1901. Pp. 1.

surveys that primarily served their respective states, and as a secondary goal they advanced their respective scientific fields. This trend continued through subsequent bulletin publications as the state geological survey addressed a variety of topics that fulfilled criteria for both economic and theoretical scientific advancement. A short list of these topics include: cement materials, coal, lead, zinc, artesian wells, quarry products, and deep wells. Iowa was not the only state where the establishment of the bulletin series represented a shift in the scientific ideology of state geological surveys. In Minnesota, Wisconsin, and Illinois similar shifts were evident in the early volumes published under the bulletin series.

The Minnesota Geological Survey first began to publish its geological bulletin series in 1889. In 1885, the Minnesota legislature mandated that the geological survey must make actual explorations by drilling or digging, for the discovery of economic products, and to provide regular publications of their findings.<sup>58</sup> These publications were separate from the annual state geological reports. N.H. Winchell responded to this mandate with the statement that it was “deemed best to establish a series of minor publications or “bulletins,” which might be issued from time to time, at longer or shorter intervals.”<sup>59</sup> By 1889, the state geological survey released five bulletin publications, and each volume addressed a highly-specific and unique topic related to the earth or

---

<sup>58</sup>Geological and Natural History Survey of Minnesota. *Bulletin*. Minneapolis: University of Minnesota Press, 1889. Pp. 18.

<sup>59</sup>Geological and Natural History Survey of Minnesota. *Bulletin*. Minneapolis: University of Minnesota Press, 1889. Pp. 19.

biological sciences.

The Geological Survey of Minnesota published a variety of scientific topics in its bulletin series that did not concentrate on economic or demographic goals. For example, Bulletin #2 examined peridotites, gabbros, diabases, and andesytes found in Minnesota. It was the objective of this publication to examine the different types of rocks found within Minnesota, and to provide a comprehensive scientific analysis of them. However, at no point did the author, M.E. Wadsworth, attempt to link his results to the broader economic potential of these rocks. Furthermore, the average citizen of Minnesota would not find this publication easily accessible as an educational or referential source. Bulletin #2 was strictly a scientific publication, and was not intended to be used as an educational or economic resource by a non-scientific audience. Not all of Minnesota's geological bulletins were unaccessible to the state's broad non-professional audience. For example, "Bulletin #7: Mammals of Minnesota," was a very well-written and entertaining publication that potentially was used in secondary and post-secondary educational institutions, or was used as a reference source for Minnesota's citizens. The publication had many colorful pictures, and the text was not overly technical. Another example of the changing subject matter of the Bulletin series was "Bulletin #38: The Stratigraphy and Structure of the Mesabi Range, Minnesota." This publication, despite its focused subject-matter and scholarly style, appealed to mining companies in the Northern part of the state that sought to advance their scientific knowledge of the region for financial gain. It was evident that Minnesota's Geological Bulletin series had clear, professional goals

established before these projects began. State geologists undertook these studies with the intention of presentation to a professional audience, and it was their goal to provide a comprehensive scientific study of their unique subject. However, it was also evident that due to public pressure, the state geologists were obligated to link their work with the State of Minnesota through educational, economic, or other means.

Both the Illinois and Wisconsin Geological surveys had similar patterns of scholarly studies with a regional focus in their bulletin series publications. However, unlike Minnesota and Iowa, these bulletins focused on topics of financial interest in the states. Despite this, state geologists still catered these scientific publications for a highly-trained scholarly audience. The Illinois Geological Survey began its bulletin series in 1906, which coincided with the reformation of the state's geological survey in 1905. The first bulletin was short, only twenty-six pages, and was titled "The Geological Map of Illinois." The bulletin included a brief written analysis of the study, and included, as the title implies, a complete geological map of the state. Subsequent publications addressed the topics of the petroleum industry in Southeastern Illinois, composition and character of Illinois coal, the physiography of the St. Louis Area, and the physical features of the Des Plaines Valley; among many other topics of economic or state interest. Wisconsin's Geological Bulletin series followed similar trends as Illinois. A few of the topics published through Wisconsin's bulletin series were: clays and clay industries, lead and zinc deposits, highway construction in Wisconsin, and lakes of Northeastern Wisconsin. Like the other Midwestern states, Wisconsin's Geological Bulletin series published

professional studies that related to the general economic, demographic, or educational interests of the state.

The first publication sponsored by the Minnesota Geological Survey under the bulletin series was a short history of the state's geological survey. This history, written by N.H. Winchell, documented the growth and success of the state's geological survey, and attempted to justify the survey's continued existence within the State of Minnesota. N.H. Winchell outlined many of the survey's economic and educational contributions. He described the exploration of the state's iron resources in the north, coal and peat deposits in the south, and the appropriation of the Salt Spring Lands, amongst many other topics of economic importance. Also, Winchell described the success of the state's geological museum and the contributions the survey made to the state's university and general public education. However, one of the more interesting sections included in this history was Winchell's description of the scientific results of the survey. Winchell stated, "Many facts have been published, the value of which cannot now be estimated, but they will go with other facts, some now known, and others to be learned, in Minnesota or elsewhere, to construct, by and by, general principles of interpretation of nature by which man becomes better and better acquainted with the laws and circumstances that environ him, and with the great history of which he forms a part."<sup>60</sup> This passage from Winchell's history represented how Minnesota's geological survey evolved since its formation. N.H. Winchell attempted to prove that these surveys were more than temporary economic and

---

<sup>60</sup>Geological and Natural History Survey of Minnesota. *Bulletin*. Minneapolis: University of Minnesota Press, 1889. Pp. 32.

demographic investments for the state, but were important institutions in America's scientific community that made significant contributions to the advancement of science. Winchell listed seventy-six "scientific results" that the Minnesota Geological Survey contributed to the earth and biological sciences, and of these, sixty-six were geological contributions. A few examples of these contributions were: Ten new species of fossils in the eighth annual report, origin of kames from streams running on the ice and in gorges, origin of river gravels and of glacial lakes, eighty-seven species of mollusks named in the fourteenth and sixteenth annual reports, and thirteen species and four varieties of plants new to science published in the twelfth annual report. In his concluding remarks, Winchell stated that there were "important scientific memoirs, studies, and reports that await completion."<sup>61</sup> Winchell believed that the Minnesota Geological Society had an important role in America's scientific community, and it was important that its work continued. Although, he was careful not to lose sight of the survey's financial, educational, and demographic roles, which the State of Minnesota strongly desired.

The target audience for the studies produced by Midwestern geological societies underwent significant change as a result of the survey's shift in ideology, structure, and organization. This change was largely the result of an increase of publications intended for professional societies and organizations, but other factors like the bulletin series also influenced this trend. State geologists still intended for the general public to use their

---

<sup>61</sup>Ibid. Pp. 37

work<sup>62</sup>, but studies targeted exclusively for a highly-trained academic audience grew significantly in this period. Even annual reports exhibited traits that were intended to serve academic audiences, rather than the needs of the general public. Two excellent examples of this shift were the bulletin series and the 1924 annual report from the Illinois Geological survey.

The bulletin series was an excellent example of the changing target audience of state sponsored geological studies. Many of the publications under the bulletin series were unaccessible to the general population due to its highly technical language and lack of background information that were common features included with the more accessible annual reports. Also, studies published in regional or national journals focused its target audience, and their authors did not write them with the limits of scientific knowledge of the average citizen in mind. Studies of this caliber were non-existent in previous decades, and grew more common as geological surveys matured as scientific institutions.

The 1924 annual report of Illinois' Geological Survey was an excellent example of the shift that occurred in the target audience of the annual reports. This study, titled "Further Consideration of Prospects for Oil in the Decatur Area," exhibited many traits that appeal to a professional audience rather than the general public. The introduction of the study was brief, and did not include any explanation as to why the study was performed. It was not necessary for the author to justify his work to state lawmakers or

---

<sup>62</sup>Some of the annual reports still contained organization and style features that appealed to the general public. Also, the focus of studies performed in this era, namely natural resources and county studies, appealed to the general population, despite their organization and style shifts.

the general public because the study was not intended to cater to their lack of expertise. The report did not contain a poetic introduction, which were common in the previous era, from the director of the survey that was intended to justify the survey's existence and impress its broad audience. Furthermore, the body of the report was technically written, and offered no explanation to the significance or background of its findings. The author assumed that his audience was familiar with the subject matter, and thus did not necessitate further explanation. The study contained an abundance of statistical data and technical geologic jargon, and was both concise and focused. Finally, the study contained no colorful drawings or other appealing visual aids. It contained only one topographical map of the Decatur region, which further exemplified the study's scholarly nature. State geologists did not adopt all of these characteristics in their annual reports of geological surveys in this era, but each state's report exhibited at least some of these organization, style, and ideological traits. This demonstrated that the target audience of the geological surveys changed after the institutions acquired permanent institutional status.

In 1908, Frank Carney wrote a paper that linked the benefits of state geological surveys to the field of practical geography. Carney argued that the well established state geological institutions produced an enormous amount of geographical information that was wasted because it was not studied and interpreted by a professional geographer.<sup>63</sup> He argued that if state geological surveys employed a few trained geographers, many aspects of scientific theory and the community as a whole would benefit. He argued that teachers

---

<sup>63</sup>Carney, Frank. "State Geological Surveys and Practical Geography." *Bulletin of the American Geographical Society*. 40.9. (1908). Pp. 530-531.

and educational institutions would be aided by a better understanding of the geographic composition of their region, and they would have access to excellent educational resources to aid their geographic lessons.<sup>64</sup> This article was written in 1903, which was after the geological surveys were permanently established in the Midwest. It was an excellent example of what the scientific community was expecting to accomplish from these surveys. Carney still felt that he had to justify his cause through practical means, primarily education; however, economic topics were not at the forefront of his argument. Education continued to be a primary concern for individuals associated with geological survey. G.B. Morey, in his brief history of the Minnesota Geological Survey, described the period after the reestablishment of the state's survey as the "Academic Period."<sup>65</sup> He used this label because of the survey's close association with the University of Minnesota. All of the geologists associated with the state survey were also employed by the university, and university officials expected them to apply their expertise to both public education and the geological sciences. Public officials expected that Midwestern geological surveys take a more active role in public education than was mandated in previous decades.

The distinction between pure and applied science was often difficult to evaluate, especially when it applied to the field of geology in the nineteenth century. In his 1963 article, Gerald D. Nash stated that this dichotomy was true of the geological surveys,

---

<sup>64</sup>Ibid. Pp. 533.

<sup>65</sup>Morey, G.B. "Minnesota." *The State Geological Surveys: A History*. Arthur Socolow. Ed. Association of American State Geologists, 1988. Pp. 238.

which “constituted one of the most important activities on behalf of science.”<sup>66</sup> Nash concentrated his study on the California Geological Survey; however, he also stated that this conflict was apparent in most other state geological institutions. Nash believed that public aid was often used to start the development of natural or other economic resources, and the geological surveys were an excellent example of this process.<sup>67</sup> Nash also stated that geologists often sought employment with state surveys to accelerate their own career and research through the use of the state’s economic resources and political support.<sup>68</sup> This conflict of ideology often created tension between state officials and geological surveys. With the permanent establishment of state surveys, these conflicts were often resolved due to the ambitions of both state geologists and officials who reached a common ideological platform.

In August of 1875, the Iowa Academy of Sciences was founded at the University of Iowa campus. This institution provided a local outlet for scientists of the state’s geological survey to share and receive response to their work from a large professional audience of a diverse background. Immediately after the survey’s reformation in 1892, the Iowa Academy of Sciences was used as a professional outlet for the survey’s research. This represented a transition from previous periods of the survey when state geologists

---

<sup>66</sup>Nash, Gerald D. “The Conflict Between Pure and Applied Science in Nineteenth-Century Public Policy: The California State Geological Survey, 1860-1874.” *Isis*. 54.2 (June, 1963). Pp. 218.

<sup>67</sup>*Ibid.* Pp. 218.

<sup>68</sup>*Ibid.* Pp. 219.

did not direct their work for the publication and presentation in professional scientific societies or journals, but rather designed their research for a larger, non-professional audience. Iowa geologists published their studies in this journal as early as 1888 (the first year the journal was printed), and members of the geological survey published their state-sponsored studies as early as 1893.

State governments and elite scientific professionals formed and funded similar professional societies and publication outlets in Illinois, Wisconsin, and Minnesota. The Illinois Academy of Sciences was founded in 1908, and immediately began publication of studies from the state's geological survey. For example, in the academy's first publication, scientists published five articles related to geology, which was more than any other scientific field. The Minnesota Academy of Sciences placed similar emphasis on the geological sciences in their publications. The first three bulletin publications were devoted to the geological sciences. The Minnesota Academy of Sciences was founded in 1873 under the direction of N.H. Winchell of the State's geological survey. Winchell served the Minnesota Academy of Sciences until 1914. During his tenure the society flourished, and it aided in the growth and development of the geological sciences in the state. The society published an irregular series of journals titled *The Bulletin of the Minnesota Academy of Sciences*. This series covered a variety of topics, and published many volumes devoted to the field of geology, which included the first three bulletin volumes. The Iowa Academy of Sciences was founded in December of 1887. The Academy formed almost three years after the disbanding of an academy of the same name

that organized in 1875. The original Iowa Academy of Sciences disbanded in 1884 due to a lack of membership and professional interest in the organization.<sup>69</sup> The Illinois Academy of Sciences was not founded until 1908. The organization also placed an emphasis on the geological sciences, which was exemplified by the journal's publication of five geological articles in its first volume. There were many other influential scientific publications in the Midwest that aided in the growth and professionalization of geology including the Chicago Academy of Sciences and the Wisconsin Academy of Sciences.

Many of these articles and bulletin publications covered similar topics as those included in annual survey reports. For example, in 1882 the Minnesota Academy of Sciences published a bulletin titled "On Some Tests of Building Stones." In this bulletin, J.A. Dodge examined many common types of building materials, both scientifically and practically, and offered his expertise on which material was best suited for mining and construction. This publication resembled those published in annual survey reports because it prompted both industrial and demographic growth within the state. However, there were many geological publications that typically would not have been included in state survey reports. For example, J.E. Todd published an article in the journal for the Iowa Academy of Sciences titled "On the Folding of the Carboniferous Strata in Southwestern Iowa." This article was highly-technical, and shared few common traits with the applied scientific studies typically associated with survey reports. Regional scientific journals and organizations served as professional outlets for state geologists

---

<sup>69</sup>*Proceedings of the Iowa Academy of Science*. Volume II. 1888. Cedar Falls: Iowa Academy of Science. Pp. 9.

who might have struggled to find an organization to accept their work.

Midwestern geological societies began to exhibit institutional and academic maturity after the acquisition of permanent status. The surveys demonstrated a balance between the pure and applied sciences through the research projects pursued by state geologists and the manner in which their results were published. Midwestern surveys published a variety of projects of economic and educational importance which maintained their commitment to the applied sciences. However, the publication of a number of studies that geologists based on theoretical or pure principles that their authors intended for an academic audience complimented projects of applied research. The formation of the bulletin series and the increase in independent scientific societies served as excellent outlets for these types of studies. These types of research projects were rare occurrences in previous decades, and represent a growing maturity for Midwestern geological surveys.

### **Chapter Three: Causes of Change for Midwestern Geological Surveys**

Between 1850 and 1919 state geological surveys in the Midwest underwent a significant amount of change in ideology, structure, and character. By 1900 many surveys exhibited a maturity that did not exist in prior decades. Research projects became more focused, and publications grew in number and quality than in previous decades. Staff members became more numerous, experienced, and committed to their research and work. This maturation was thoroughly exhibited in the published work from members of the state surveys, and through national and international acclaim received by many of the Midwest geological surveys. This maturation was the result of three principle institutional and public policy factors. In his 1961 article, Walter Hendrickson listed three factors that caused the ideological shift in state geological surveys between 1850

and 1900. These factors were the permanent status of the geological survey within the state and within educational institutions, the establishment of the United States Geological Survey, and the dramatic increase in professional scientific societies and publications that increased scholarly output for the field of geology.<sup>70</sup> The increase in local scientific societies dramatically aided in the maturation of state geological surveys. These societies provided an additional outlet for publication, which allowed for a greater emphasis on pure science that was not strongly supported by the state government. The formation of the United States Geological Survey also had profound effects for state geological surveys. The USGS absorbed many of the applied research tasks that were commonly associated with state surveys. The two most important tasks absorbed by the USGS were mapping and natural resource studies. The USGS also helped stimulate research within the states through its support and motivation for large-scale research projects. Finally, the permanent status granted to the state geological surveys by state governments had dramatic ideological effects for the surveys. Survey directors did not have to justify the existence of their programs to government officials, which usually was accomplished by demonstrating the financial, educational, and other applied results the survey produced for the state. With this removed, survey directors had the opportunity to pursue other research topics that did not directly benefit the state without fear of criticism from government officials. State geological surveys matured as a result of many external and internal factors, but the establishment of the USGS, the acquisition of permanent

---

<sup>70</sup>Hendrickson, Walter B. "Nineteenth-Century State Geological Surveys: Early Government Support of Science." *Isis*. 52.3. (September, 1961). Pp. 370-71.

institutional status, and influence of professional scientific societies had the most profound effects for the maturation of state geological societies.

Professional societies and publications dramatically changed how state geological surveys functioned in the decades surrounding the beginning of the twentieth century. Walter Hendrickson wrote that, “The increasing number of outlets for publishing the results of research - the journals of the professional organizations, for example - made it less necessary for the geologist to depend on legislators.” State geologists no longer publically justified their research to receive funding from the state for publication. Prior to this period, legislators carefully selected which research projects received the highest priority for funding and publication. Public officials and state geologists determined this by a variety of means including cost-benefit analysis, public opinion, and political relationships. The State of Wisconsin, for example, refused to publish the work of James Hall in 1860 because state officials deemed his work unsatisfactory and publishing it was not beneficial to the growth of the state or its industries. Professional outlets allowed for the publication of geological research that might otherwise be rejected by state publishers or not funded by state organizations. Also, specialized societies and organizations provided state geologists with the freedom to pursue topics of their choosing. Their research was not assigned to them by state officials or survey directors, which allowed for the pursuit of specialized topics that were not justified by economic interests or applied means. An excellent example of this ideological transformation, was a series of lectures and publications by Charles Keyes in 1901. Keyes traveled to the Russian Central

Caucuses in 1899 to research igneous rock formations and compare them to formations found in Iowa. This type of international research was not typically found in state geological publications. However, the Iowa Academy of Sciences journal published his work and he presented a series of papers at the society's conferences. Prior to the establishment of the Iowa Academy of Sciences, Keyes may have been unable to find a scholarly outlet for his work, which would have made his work unavailable to the general public. Furthermore, this international project was available for Keyes partially because of the network of professional societies and publications available to him, and without this network, Keyes may have chosen not to pursue this research subject.

State geologists used state journals and scientific organizations as excellent outlets for the publication of geological research. Geological research, especially that sponsored by the state geological surveys, was often regionally focused. For example, Keyes's comparative study of igneous formations in Eastern Europe and Iowa was an excellent topic for the Iowa Academy of Sciences. The Academy's charter states that, "The Object of the Academy shall be the encouragement of scientific work in the State of Iowa."<sup>71</sup> Thus, state societies published and sponsored these regional studies because they benefitted the scientific growth of the state. State scientific societies and geological surveys often worked closely together because their organizations had similar goals and ambitions. Both organizations sought to expand the state's scientific and educational base. It is not surprising that geology was the most published field in regional and state

---

<sup>71</sup>*Proceedings of the Iowa Academy of Science*. Volume I. 1887. Cedar Falls: Iowa Academy of Science.

scientific journals. In Illinois, all of the geological articles published in the Illinois Academy of Sciences first journal directly related to the state. The titles of these articles were: “Some Problems Connected with the Coals of Illinois,” “A Virgin Prairie in Illinois,” and “Occurrence of Oil and Gas in Eastern Illinois.” Also, in the first volume published by the Illinois Academy of Sciences, the geological sciences had the most published articles of any other scientific field.

Geological publications in the Iowa Academy of Sciences before 1892 were not formal studies sponsored by the Iowa Geological Survey. The Iowa Academy of Sciences published these studies in multiple articles, which revolved around a large geographic region or subject matter. For example, in 1887, R. Ellsworth Call published his study in three different articles of geological formations in different regions of Arkansas. By 1900, the geological survey had sponsored many studies published by Samuel Calvin, Charles Keyes, and many other scientific professionals associated with the state’s geological survey in the Iowa Academy of Sciences journal. One of the more interesting topics published by a member of the state’s geological survey was a series of articles published by Charles Keyes in 1901. Keyes traveled to the Russian Caucasus in 1899 to study igneous rock formations. After his return to Iowa in 1900, he continued his research by studying Iowa’s igneous rock formations, and published his results in a series of articles beginning in 1901. His publications were brief, and primarily consisted of an exhibition of specimens. Keyes believed his study was important because there was very little interaction between geologists of different countries, and a greater diffusion of

knowledge would greatly benefit the geological sciences.<sup>72</sup>

The formation of local professional outlets also dramatically changed the potential audience for research within state geological surveys. Previously, public officials instructed geologists cater their work to a non-professional audience, which was represented in their style of writing. Generally, the writing style of the annual reports remained the same. Geologists still organized their studies by topic headings, the table of contents was highly-detailed, and the reports contained an abundance of illustrations and charts. These organizational techniques were usually at the request of state officials, and their intent was to cater to a large, non-professional audience. However, state geologists used other geological survey publications, namely the bulletin series and independently published articles, to target a professional audience. These studies included the use of professional jargon and did not necessitate the inclusion of simple introductory material. State geologists assumed that the study's potential audience did not require an explanation of how coal was formed and in what stratigraphy it was typically found.<sup>73</sup> Eventually, all publications by state geological surveys targeted a professional audience, but as state surveys first adjusted to their status as permanent state institutions both the general public and the geological sciences obligated them to split their publications between non-professional and professional audiences.

---

<sup>72</sup>Keyes, Charles R. "Igneous Rocks of the Central Caucasus and the Work of Loewinson-Lessing." *Proceedings of the Iowa Academy of Sciences*. Volume IX. Des Moines, 1902. Pg. 102.

<sup>73</sup>Introductory material similar to this was included in the Illinois Geological Survey of 1875.

In the spring of 1879, Congress appropriated funds for a national geological survey to begin field operations in July of the same year.<sup>74</sup> Unlike the state geological surveys, the United States government's enactment of the USGS was vague. The law simply stated that the director of the survey was to be paid a sum of six thousand dollars annually, and was responsible for the management and direction of the survey without influence from private or personal interests.<sup>75</sup> The only tasks for the survey established by Congress were laid out in one sentence that read, "classification of public lands, examination of the geological structure, mineral resource, and products of the national domain."<sup>76</sup> The USGS was placed under the Department of the Interior, and was to address its reports to the Secretary of the Interior. Clarence King was appointed the first director of the survey, but his tenure only lasted two years due to his resignation because he felt his personal scientific goals were overshadowed with administrative duties. Clarence King was replaced by Colonel Powell in 1881.

The National Academy of Sciences recommended the formation of the USGS to "be charged with the study of the geological structure and economical resources of the public domain."<sup>77</sup> In November of 1878, the Academy passed the resolution by a vote of

---

<sup>74</sup>Merrill, George P. *The First Hundred Years of American Geology*. New Haven: Yale University Press, 1924. Pp. 551.

<sup>75</sup>United States Geological Survey. *Bulletin*. Volume I: 1880. Pp. 3.

<sup>76</sup>Rabbit, Mary C. "The United States Geological Survey: 1879-1989." *United States Geological Survey Circular; 1050*. United States Geological Survey, 1989. Pp. 1.

<sup>77</sup>Merrill, George P. *The First Hundred Years of American Geology*. New Haven: Yale University Press, 1924. Pp. 550.

thirty-three to one after a deliberation of only three hours.<sup>78</sup> Members of Congress believed that the Academy was the only body that could provide an unbiased and logical decision as to whether or not the Survey should be formed. Members of the Academy supported the formation of the USGS because it was the ideal agency to absorb important national geological tasks. The Academy concluded that the USGS was to concentrate on large-scale economic and geological tasks that were outside the scope of localized state geological surveys.

The USGS was the consolidation of four large surveys in the Western United States: The King Survey, The Powell Survey, The Wheeler Survey, and The Hayden Survey. These four surveys operated independently from each other, and often overlapped on regions and topics studied. Members of the scientific community and Congress believed these four surveys were wasteful, corrupt, and inefficient expeditions.<sup>79</sup> Members of Congress instructed these surveys to form topographic and geological maps, investigate mineral resources, and support the advancement of military operations in the region. However, the surveys made little or no attempts to support other expeditions, and drastically needed the organization of a central governing body to coordinate their efforts. For this purpose, the formation of the USGS was essential to the scientific, military, and economic understanding of the American West.

An important question facing the USGS in its first decades of existence was:

---

<sup>78</sup>Dupree, A Hunter. *Science in the Federal Government: A History of Policies and Activities*. Baltimore: The Johns Hopkins University Press, 1986. Pp. 208.

<sup>79</sup>Ibid. Pp. 207.

What role should the institution play in local geological research? The law enacting the USGS was vague, and created no distinct boundaries between public, private, or state land. Clarence King stated in 1880 that, “I am called upon to execute, will be found in the use of the term “national domain,” and, “That term was supposed by the first framers of the law to cover the entire United States. On the other hand, it might be held to mean simply the region of the public lands.”<sup>80</sup> An article in *Science* published in 1890 stated that the national survey must be responsible for research in general geological structures, civil boundaries, and large intrastate projects, and local details and adjustments should be absorbed by state surveys. Furthermore, any additional conclusions from state surveys should then be made available as quickly as possible to the national organization for application to other regions of the study.<sup>81</sup> The Federal Government did not provide the Survey with any clear mandates, and was offered very little support from the state surveys.

The study of the nation’s natural resources for defense and economic gain was a central goal for the USGS.<sup>82</sup> As with the first years of state geological surveys, public officials pressured the USGS to place the study of natural resources as a top priority to justify their funding and role in the Federal Government. However, almost immediately

---

<sup>80</sup>United States Geological Survey. *Bulletin*. Volume I: 1880. Pp. 5.

<sup>81</sup>“The Relations of the State and National Geological Surveys to Each Other and to the Geologists of the Country.” *Science*. 16.395. (August, 1890), pp. 120-123. Pp. 121.

<sup>82</sup>United States Geological Survey. *Bulletin*. Volume I: 1880. Pp. 4-5.

the USGS faced jurisdiction problems with local surveys and private interests. Since the USGS replaced the four large surveys in the Western United States, public officials believed that the institution's projects would be centered in this vast area where few professional scientific institutions were located. Major Powell believed that for the USGS to effectively research the nation's economic resources, the institution needed to have unmediated access to the entire country. Under the leadership of Clarence King, the survey confined its research to the Western United States, and primarily concentrated on practical mining and general reconnaissance studies.<sup>83</sup> Major Powell transformed the survey away from its western focus, and included natural resource studies in the Lake Superior region, New England, and Leadville, Colorado.<sup>84</sup> Thus, by the end of Major Powell's tenure as director of the USGS in 1894, the Survey had solidified itself as a public agency and the principle geological bureau in the United States.<sup>85</sup>

The expansion of the USGS under the leadership of Major Powell created conflict between the institution and the state surveys. In Minnesota, the state survey did not solicit federal money to sponsor their research projects, and resisted any attempts the USGS made to conduct research within the boundaries of the state.<sup>86</sup> Winchell, director

---

<sup>83</sup>For example, under King's leadership the USGS completed research projects in the Grand Canyon region, mining districts in New Mexico, Colorado, Wyoming, Dakota, and Montana, and metallic studies in Colorado.

<sup>84</sup>Manning, Thomas G. *Government in Science: The U.S. Geological Survey 1867-1894*. The University of Kentucky Press, 1967. Pp. 105.

<sup>85</sup>Ibid. Pp. 105.

<sup>86</sup>Ibid. Pp. 119.

of the Minnesota survey, believed the USGS could potentially make the state survey obsolete, and was upset the agency did not consult the state's expertise when performing research projects within the state of Minnesota.<sup>87</sup> Furthermore, Winchell believed that all explorations within Minnesota should be placed under his leadership. Strong resistance also came from Wisconsin when the state's university was overshadowed by the USGS in the study of the copper resources of the Lake Superior region.<sup>88</sup> The USGS met the strongest resistance from state surveys in the East, especially surveys located in the New England region that had long-standing traditions. These surveys, namely the New York and Pennsylvania surveys, believed they were the premier geological research institutions in the United States, and the USGS needed to consult their expertise before undertaking research projects. Despite these objections, the USGS often stimulated activity rather than eliminated it, and many of the fears of the state institutions were eventually removed as it was realized that the USGS supported their work.<sup>89</sup>

The USGS actually provided the state agencies with more scientific freedom through the absorption of many large-scale projects like natural resource investigation and mapping. For example, the board of commissioners of Massachusetts and the USGS agreed to share the expense of field-work for topographic and geological mapping within the state. The project was completed in only three years and cost approximately thirteen

---

<sup>87</sup>Ibid. Pp. 119

<sup>88</sup>Ibid. Pp. 114.

<sup>89</sup>Ibid. Pp. 120.

dollars per-square mile.<sup>90</sup> Without the aid of the USGS, the Massachusetts Geological Survey may not have had the resources to complete this project. The USGS subsequently completed similar projects in New Jersey, New York, West Virginia, and North Carolina.<sup>91</sup> Beginning in 1900, similar mapping projects were completed by Midwestern surveys in cooperation with the USGS, and like the projects performed in the East, their completion came at a lower cost and shorter time-line than was possible without the aid of the USGS. Prior to the completion of topographic and geologic maps in the Midwest, cooperation in geology between the USGS and state surveys was less extensive than projects associated with mapping. However, with the completion of these projects, state surveys urged the USGS for support with projects associated with the geologic sciences.<sup>92</sup> In 1899, for example, Midwestern surveys, in cooperation with the USGS, sponsored surveys to research glaciation in the Great Lakes district, iron surrounding Lake Superior, and general stratigraphy and formation in the Great Plains District.<sup>93</sup>

In an article published in 1885, A.H. Thompson stated that “it is to the advantage of the States in every way to have the work done by the national organization as being

---

<sup>90</sup>Walcott, Charles D. *Bulletin*. The United States Geological Survey. Washington, D.C: Government Printing Office. Volume XXII: 1900. Pp. 17.

<sup>91</sup>Ibid. Pp. 17-20.

<sup>92</sup>Ibid. Pp. 34

<sup>93</sup>United States Geological Survey. *Bulletin*. Volume XXII: 1900.

better than they can do themselves.”<sup>94</sup> The research areas where this was most applicable were natural resource investigation and mapping. The construction of a comprehensive topographic and geological map was one of the largest projects absorbed by the USGS from state agencies. The project was a popular topic amongst the scientific and military communities, and was one of the principle reasons why the USGS continued to grow in its first decades of existence.<sup>95</sup> Also, economic research projects were essential to the agenda of the USGS in the nineteenth century. Congress sanctioned major projects across the United States, including studies in the Midwestern states. The adoption of these areas of study benefitted state geological surveys because they were no longer the principle scientific institution sponsoring these types of expeditions within their state. States benefitted from the use of federal funding to sponsor many applied scientific projects, and thus devoted more attention to projects more closely related to pure science. Basically, state surveys found that more projects were completed with less money with the cooperation of the USGS. More projects became available to researchers associated with state geological surveys, which inevitably became more focused and less influenced by both public and private agencies.

The permanent establishment of geological surveys led to many policy changes that allowed for the pursuit of research topics that were based on pure science rather than

---

<sup>94</sup>Thompson, A.H. “The Relation of a State Geological Survey to the Work of the National Survey.” *Transactions of the Annual Meetings of the Kansas Academy of Science*. 10. (1895-1896). Pp. 10.

<sup>95</sup>Dupree, A Hunter. *Science in the Federal Government: A History of Policies and Activities*. Baltimore: The Johns Hopkins University Press, 1986. Pp. 212.

applied results. State governments granted state surveys with permanent funding, state geologists did not have to lobby legislative bodies for a continuation of funds, and researchers were not entitled to follow government and public mandates. These external factors greatly influenced how state geological surveys operated, and when removed, surveys were provided with more scientific freedom than in previous decades.

Acquiring the status of a permanent government institution greatly benefitted state geological surveys in the Midwest. The assurance of a continued existence and funding aided removed external pressures to produce studies and conclusions that directly benefitted the economic, educational, or structural status of the state. Furthermore, personal associated with state geological surveys benefitted from increased job-security because it was not necessary for them to pursue research topics outside their area of expertise or interest, or pursue other institutions or corporations for employment for fear of unemployment for the next geological season.

Geological surveys in the Midwest were usually reestablished at the request of their respective state's scientific society. For example, in 1897 when the Wisconsin Geological Survey was reestablished as a permanent government institution, it was at the request of the Wisconsin Academy of Sciences Arts and Letters. The society recommended the reformation of the geological survey for many of the same reasons surveys were first established decades before. The Academy stated that the state benefitted from the advances in education and economics, and the permanent

establishment of the survey would continue these trends.<sup>96</sup> However, it was also common for state scientific societies to recommend that the geological survey reports to bodies other than the state legislator, usually the state's university or a separate oversight committee. Also, state scientific academies recommended that geological societies needed to diversify their areas of research. The Wisconsin Academy of Sciences stated in their recommendation to the state legislator in 1897 that, "Nor will the Survey complete its duty unless a reasonable proportion of the money granted by the state is devoted to furthering these investigations, which may seem not to have economic value at once, but which experience has shown are sure to become of value, not merely to the intellectual, but to the material progress of the state."<sup>97</sup> The Academy argued that pure science was beneficial to the state in ways that were not as evident as applied science, but it was important that both pursuits were funded by the state. In Iowa, Jean C. Prior wrote that with the permanent establishment of the survey, "There was a growing diversity in geologic investigations, which is exhibited in the state's lengthy investigations."<sup>98</sup> Charles Keyes of the Iowa Geological Survey argued in Iowa's first annual report in 1892 that "There are probably as many people interested in the geology of Iowa living outside

---

<sup>96</sup>Bean, E.F. "State Geological Surveys of Wisconsin." *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters*. Madison: Atwood & Culver. Volume 30, 1937 Pp 216.

<sup>97</sup>Ibid. Pp. 218.

<sup>98</sup>Prior, Jean C. "The State Geological Survey of Iowa." *State Geological Surveys*. Arthur A. Socolow. Editor. American Association of State Geologists, 1988. Page 139.

the state as there are those living inside the state.”<sup>99</sup> He argued that the Iowa Geological Survey was an important institution in the national and international scientific community, and the survey was obligated to support this community with studies that advance the field of geology. The state academies of science and members of the geological survey emphasized the need for a diverse field of study amongst state geologists, and it was a trend that geological surveys actively pursued after their reestablishment.

It is nearly impossible to completely remove geological studies from applied science. State scientific academies pushed for the separation of pure science from practical goals, but this separation was not possible without the removal of the geological survey from public policy and corporate interests. Thus, the removal of geological surveys from the administrative control of state legislators was crucial to the growth of pure scientific research projects within the survey’s normal scientific goals and ambitions. Most importantly, it was the director of the geological surveys that controlled the direction and ideology of the survey. The director did not have to decide whether or not a specific project would be beneficial to secure funding for the upcoming season. Public officials provided state geologists with the freedom to chose projects based on merit and importance rather than economic merit or politics. An excellent example of this was the Geological Survey of Iowa’s cooperative project with the USGS that studied

---

<sup>99</sup>Keyes, Charles. “Work and Scope of the Survey.” Iowa Geological Survey. *Annual Report of the Geological Survey of Iowa*. Des Moines: C. Van Benthuysen, 1892. Pp. 49.

the glacial period. This project was described as the most rewarding and comprehensive report on the subject of glacial history.<sup>100</sup> Without the divorce of the geological survey from the state legislator this project may have been replaced with a subject of applied importance. Public officials perceived state geological surveys as investments to government bodies, and as a result of this, it was expected that surveys must produce a return on this investment or face termination. Without the mandates laid out by the state legislator before each geological season, the geological surveys were provided with the opportunity to pursue subjects of their own choosing with little fear of backlash from state government officials.

Midwestern geological surveys underwent a significant transformation of ideology, structure, and character in the decades surrounding the turn of the twentieth century. By 1910, these surveys exhibited scientific maturity that was not present in previous decades. This maturation was demonstrated in the published work from members of the survey and the national and international acclaim directed at their work. Walter Hendrickson listed three factors that caused this shift in state geological surveys: the acquisition of permanent status from state governments, the establishment of the USGS, and the increase in professional scientific societies and publications in the United States. These factors created a change in the research projects from state geologists, which made them more focused, higher quality, and increased in number. Also, staff members became more focused, experienced, and committed to their research and work.

---

<sup>100</sup>Arey, Melvin F. "History of Geology in Iowa for the Last Twenty-Five Years." *Iowa Academy of Science*. Volume 19. 1912. Page 69.

Midwestern geological surveys were still expected to meet the practical needs of their respective states, but these goals were complimented with projects more closely related to pure science. This shift forced the surveys to mature as scientific institutions, and significantly aided in the growth of the earth sciences in the nineteenth and early twentieth centuries.

## **Conclusion**

State geological surveys in the Midwest changed what types of research projects they chose to pursue in the decades surrounding the turn of the twentieth century. Economic issues still survived as a principle motivator for research projects; however, subjects evolved from mining and general resource surveys to large-scale studies of railroad development, agriculture, roads, and soil. State geologists replaced the comprehensive general reconnaissance studies that were common in preceding decades with highly-focused studies based on pure-scientific pursuits. An excellent example of this transformation was the first volume published under the bulletin series for the Iowa

Geological Survey devoted to the types of grasses native to Iowa.<sup>101</sup> It was a natural transition for geological surveys to transfer to more focused areas of research. There was a limit to the amount of reconnaissance and broad research that could practically be completed by geological surveys, and it was a natural transition to move to more focused areas of research. It was also a common occurrence for research to transition to topics that reflected the demands and goals of their respective states. In Wisconsin for example, state geologists completed an extensive study on highway construction in the state.<sup>102</sup> The study focused on the unique nature of Wisconsin's road materials, drainage, and topography that dictate the conditions for construction that were not present in other regions of the country. Other studies published by surveys in the Midwest documented a variety of topics including: inland lakes, sod, soil, limestone, road materials, natural gas, and oil. Public officials expected state geological surveys to grow and develop as scientific institutions to address the localized needs of their geographic region. These demands remained after surveys obtained permanent institutional status, but these goals evolved to include the pure scientific needs of the state that aided its educational needs and prestige within the national scientific community.

By the mid-twentieth century, geological surveys in the Midwest progressed and matured as scientific institutions. Midwestern surveys almost completely met the goals of

---

<sup>101</sup>Pammel, L.H. "Grasses of Iowa." Iowa Geological Survey. *Bulletin*. 1901.

<sup>102</sup>Buckley, Ernest Robertson. "Highway Construction in Wisconsin." Wisconsin Geological and Natural History Survey. *Bulletin*. Madison: Wisconsin Geological and Natural History Survey, 1903.

an ideal geological survey.<sup>103</sup> These surveys achieved a balance between pure and applied science. State geologists efficiently devoted their energies to the study of mineral resources and advanced the general knowledge of the field of geology. Pure science did not replace practical science in Midwestern geological surveys. Rather, these institutions found a balance between the advancement of the earth sciences and the needs of their sponsors. Therefore, Midwestern surveys proved to be sound investments for the states of Iowa, Illinois, Minnesota, and Wisconsin, and were vital to the growth and development of the earth sciences in American science.

State geological surveys were important institutions in the growth and development of geology in the nineteenth century. They initiated research, lobbied for resources, and provided the organization necessary for the field of geology to grow as a science. Without their support, the earth sciences may not have developed as profoundly in the United States, and thus remained a European field of study. The state geological surveys underwent many of the same developmental problems as the field as a whole. In the middle decades of the nineteenth century, state geological surveys in the Midwest established themselves as valuable and influential research institutions. They successfully completed many practical research tasks, and greatly aided in the growth and development of their respective states. State geologists completed detailed geologic and topographic maps, investigated natural resources, and educated the general public to the

---

<sup>103</sup>I refer to James Hall's 1847 letter to the State of Mississippi in which he explained how a state geological survey needed to meet both the practical needs of the state and the theoretical goals of the field of geology.

natural wealth and resources of their states. Despite the tremendous advancements made to the field of geology and economic, demographic, and educational growth of their states, state legislators only granted funds to geological surveys for brief periods of time, and allowed survey directors minimal freedoms to function independently from public and private influence. This freedom was not obtained by Midwestern surveys until the end of the nineteenth century when they state governments granted them permanent institutional status. The granting of permanent funding to state geological surveys removed the pressures of lobbying for government and public support for the continuation of a survey. Also, the USGS supported and provided resources to Midwestern surveys which relieved local surveys of many geological projects and helped stimulate research and funding for geological research in states.

Midwestern geological surveys were unique institutions in the history of science in the United States. Members of these surveys never strayed far from the belief that the principle motivator for science was the advancement of knowledge without regard for utility. In the early nineteenth century, American science was young, unorganized, and unequal to competition on the international level. None of these traits were characteristic of American science by the end of the nineteenth century. American geology mirrored these same traits in the nineteenth century. The history of the Midwestern geological surveys exemplified many of the trials and growing pains of American science in the nineteenth century. The growth and development of Midwestern geological surveys influenced the path of American geology in the nineteenth century, and without their

contribution, the field may not have developed as profoundly throughout the nineteenth century.

## Bibliography

### Articles:

- “Answers to Charges Affecting the Geological Survey.” *Science*. 6.145. (November, 1885), pp. 424-425.
- Baker, Marcus. “The U.S. Geological Survey.” *The Geographical Journal*. 6.3. (September, 1895), pp. 252-260.
- Brown, R.J. “Is a Geological Survey of the State a Necessity?” *Transactions of the Annual Meetings of the Kansas Academy of Science*. 9. (1883-1884), pp. 49-56.
- Carney, Frank. “State Geological Surveys and Practical Geography.” *Bulletin of the American Geographical Society*. 40.9. (1908), pp. 530-535.
- Dodick, Jeff & Nir Orion. “Geology as an Historical Science: Its Perception within Science and the Education System.” *Science and Education*. 12. (2003), pp. 197-211.
- Hendrickson, Walter B. “Nineteenth-Century State Geological Surveys: Early Government Support of Science.” *Isis*. 52.3. (September, 1961), 357-371.
- Hendrickson, Walter B. “The Western Academy of Natural Sciences of Cincinnati.” *Isis*. 37.3 (July, 1947), pp. 138-145.
- Kummel, Henry B. “State Geological Surveys.” *The Scientific Monthly*. 25.5. (November, 1927), pp. 445-450.
- Merrill, George P. “Contributions to the History of American Geology.” *Annual Report: United States National Museum*. 1906. Pages 189-734.
- Miller, S.A. “Criticism of the U.S. Geological Survey.” *Science*. 21.522. (February, 1893), pp. 67-78.
- Nash, Gerald D. “The Conflict Between Pure and Applied Science in Nineteenth-Century Public Policy: The California State Geological Survey, 1860-1874.” *Isis*. 54.2 (June, 1963), pp. 217-228.
- Rabbit, Mary C. “The United States Geological Survey: 1879-1989.” *United States Geological Survey Circular; 1050*. United States Geological Survey, 1989.

Spencer, Larry T. "Filling in the Gaps: A Survey of Nineteenth Century Institutions Associated with the Exploration and Natural History of the American West." *American Zoologist*. 26.2. (1986), pp. 371-380.

"The Relations of Geological Surveys to Successful Mining." *Science*. 18.464. (December, 1891), pp. 351-353.

"The Relations of the State and National Geological Surveys to Each Other and to the Geologists of the Country." *Science*. 16.395. (August, 1890), pp. 120-123.

Thompson, A.H. "The Relation of a State Geological Survey to the Work of the National Survey." *Transactions of the Annual Meetings of the Kansas Academy of Science*. 10. (1895-1896), pp. 9-13.

Zakrzewski, Richard J. "Geologic Studies in Western Kansas in the 19<sup>th</sup> Century." *Transactions of the Kansas Academy of Science*. 99.3/4. (December, 1996), pp. 124-133.

#### **Books:**

Beardsley, Edward H. *The Rise of the American Chemistry Profession, 1850-1900*. Gainesville, Florida: University of Florida Press, 1964.

Bogue, Allan G. *From Prairie to Corn Belt: Farming on the Illinois and Iowa Prairies in the Nineteenth Century*. Chicago: University of Chicago Press, 1963.

Brewster, Edwin Tenney. *Life and Letters of Josiah Dwight Whitney with Illustrations*. Boston: Houghton Mifflin Company, 1909.

Clarke, John M. *James Hall of Albany: Geologist and Palaeontologist 1811-1898*. Albany, 1921.

Corgan, James X. Editor. *The Geological Sciences in the Antebellum South*. University, Alabama: University of Alabama Press, 1982.

Cravens, Hamilton. *The Triumph of Evolution: The Heredity-Environment Controversy, 1900-1941*. Baltimore: Johns Hopkins University Press, 1988.

Dana, Edward S., et al. *A Century of Science in America*. New Haven: Yale University Press, 1918.

Daniels, George H. *American Science in the Age of Jackson*. New York: Columbia

University Press, 1968.

Drake, Ellen T and William M. Jordan. Editors. *Geologists and Ideas: A History of North American Geology*. Boulder, Colorado: The Geological Society of America, 1985.

Dupree, A Hunter. *Science in the Federal Government: A History of Policies and Activities*. Baltimore: The Johns Hopkins University Press, 1986.

Gerstner, Patsy. *Henry Darwin Rogers, 1808-1866: American Geologist*. Tuscaloosa: University of Alabama Press, 1994.

Hafen, Le Roy Reuben. *Western America: The Exploration, Settlement, and Development of the Region Beyond the Mississippi*. New York: Prentice-Hall Inc., 1941.

Hays, Robert G. *State Science in Illinois: The Scientific Surveys, 1850-1978*. Southern Illinois University Press, 1980.

Keyes, Charles Rollin. *Century of Iowa Geology*. Des Moines, Iowa: Iowa Academy of Science, 1920.

Kohlstedt, Sally G. *The Formation of the American Scientific Community: The American Association for the Advancement of Science, 1848-1860*. Urbana: University of Illinois Press, 1976.

Malin, James C. *Grassland Historical Studies: Natural Resources Utilization in a Background of Science and Technology*. Volume 1. 1950.

Manning, Thomas G. *Government in Science: The U.S. Geological Survey 1867-1894*. The University of Kentucky Press, 1967.

Merrill, George P. *The First Hundred Years of American Geology*. New Haven: Yale University Press, 1924.

Owen, David D. *Mineral Lands of the United States*. Washington D.C., 1845.

Rabbit, Mary C. *Minerals, Lands, and Geology for the Common Defense and General Welfare: A History of Public Lands, Federal Science and Mapping Policy, and Development of Mineral Resources in the United States*. Washington: U.S. Geological Survey, 1979.

Reingold, Nathan. *Science in Nineteenth-Century America: A Documentary History*. Clinton, Massachusetts: The Colonial Press Inc., 1964.

Schneer, Cecil J. Editor. *Two Hundred Years of Geology in America: Proceedings of the New Hampshire Bicentennial Conference on the History of Geology*. Hanover, New Hampshire: University of New Hampshire Press, 1979.

Snow, C.P. *The Physicists*. Boston: Little, Brown, 1981.

Socolow, Arthur A. Editor. *The State Geological Surveys: A History*. Association of American State Geologists, 1988.

Whitney, Josiah D. *Metallic Wealth of the United States*. New York: Arno, 1970.

Whitney, J.D & J.W. Foster. *Report on the Geology and Topography of a Portion of the Lake Superior Land District in the State of Michigan*. Washington, D.C: United States General Land Office, 1851.

Wilson, Leonard G. *Lyell in America: Transatlantic Geology, 1841-1853*. Baltimore: John Hopkins University Press, 1998.

#### **Journals/ Survey Publications:**

Chicago Academy of Sciences. *Transactions of the Chicago Academy of Sciences*. 1867-1910.

Illinois State Geological Survey. *Bulletin*. Urbana: University of Illinois Press, 1906-1920.

Illinois State Geological Survey. *Geological Survey of Illinois*. Springfield: State Journal Steam Press, 1866-1890.

Illinois State Academy of Science. *Transactions of the Illinois State Academy of Science*. Springfield, IL: Illinois State Academy of Science, 1908-1920.

Iowa Geological Survey. *Bulletin*. 1901-1920.

Iowa Geological Survey. *Annual Report of the Geological Survey of Iowa*. Des Moines: C. Van Benthuysen, 1858, 1867, 1892-1910.

Geological and Natural History Survey of Minnesota. *Bulletin*. Minneapolis: University of Minnesota Press, 1889-1910.

Geological and Natural History Survey of Minnesota. *Annual Report*. 1872-1899.

Minnesota Academy of Science. *Bulletin of the Minnesota Academy of Science*. Minneapolis: Minnesota Academy of Science, 1873-1920.

*Proceedings of the Iowa Academy of Science*. Cedar Falls: Iowa Academy of Science, 1887-1910.

*Transactions of the Wisconsin Academy of Sciences, Arts, and Letters*. Madison: Atwood & Culver, 1872-1940.

Wisconsin Geological and Natural History Survey. *Bulletin*. Madison: Wisconsin Geological and Natural History Survey, 1898-1925.

Wisconsin Geological and Natural History Survey. *Geology of Wisconsin*. Madison: Commissioners of Public Print, 1873-1879; 1924-1926.

United States Geological Survey. *Bulletin*. 1880-1920.